

Oklahoma
Department of Transportation



1999

Standard Specifications
for Highway Construction

English and Metric

1999
STANDARD
SPECIFICATIONS
FOR
HIGHWAY
CONSTRUCTION

PREFACE

These Special Provisions, with the exception of Section 100, are generally written in the imperative mood. In sentences using the imperative mood, the subject, “the Contractor”, is implied. Reference to the Contractor is also implied in this language by the use of “shall”, “shall be”, or similar words and phrases. In material specifications, the subject may also be the supplier, fabricator, or manufacturer supplying material, products, or equipment for use on the project.

Wherever “directed”, “required”, “prescribed”, or other similar words are used, the “direction”, “requirement”, or “order” of the Engineer/Resident Engineer is intended. Similarly, wherever “approved”, “acceptable”, “suitable”, “satisfactory”, or other similar words are used, the words mean “approved by”, “acceptable to”, or “satisfactory to” the Engineer. The word “will” generally pertains to decisions or actions of the Engineer.

PURPOSE, INTENT, AND INTERPRETATION OF SPECIFICATIONS

The purpose of these Specifications is to establish, where applicable, minimum acceptable standards or a range for acceptable results. It is the intent of these Specifications that the Contractor be fully and exclusively responsible for producing an acceptable end product.

In producing this end product, the Contractor shall exercise control of the project. Department of Transportation personnel, except where specifically provided for herein, will make inspections for the State to document that an acceptable product is being produced.

Interpretation of these Specifications will be done in such a manner as to allow the Contractor to control his/her project to the greatest degree possible in producing an end result product which is in all respects acceptable. These Specifications should not, however, be interpreted in any manner which allows a Contractor to produce an unacceptable product or endanger the traveling public. An acceptable end result product is the essence of the Contract. Only projects in substantial conformance with the Plans and Specifications will be accepted by the Department of Transportation.

In order to avoid cumbersome and confusing repetition of expressions in these specifications, it is provided that whenever anything is, or is to be, done, if, as, or, when, or where “contemplated, required, determined, directed, specified, authorized, ordered, given, designated, indicated, considered necessary, deemed necessary, permitted, reserved, suspended, established, approval, approved, disapproved, acceptable, unacceptable, suitable, accepted, satisfactory, unsatisfactory, sufficient, insufficient, rejected or condemned,” it shall be understood as if the expression were followed by the words “by the Engineer or to the Engineer”.

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GENERAL PROVISIONS

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SECTION 101**GENERAL INFORMATION, DEFINITIONS AND TERMS**

Whenever in these Specifications and Contracts, or in any documents or instruments pertaining to construction where these Specifications govern, the following terms or pronouns are used, the intent and meaning shall be interpreted as follows:

101.01. ABBREVIATIONS.

Wherever the following abbreviations are used in Contracts, Proposals, these Specifications or on Plans, they are to be construed the same as the respective expressions represented:

AAA	American Arbitration Association
AAN	American Association of Nurserymen
AAR	Association of American Railroads
AASHTO	American Association of State Highway and Transportation Officials
ACI	American Concrete Institute
AGC	Associated General Contractors of America
AIA	American Institute of Architects
AISI	American Iron & Steel Institute
ANSI	American National Standards Institute
ARA	American Railway Association
AREA	American Railroad Engineering Association
ARTBA	American Road and Transportation Builders Association
ASA	American Standards Association
ASCE	American Society of Civil Engineers
ASLA	American Society of Landscape Architects
ASTM	American Society of Testing and Materials
AWPA	American Wood Preservers Association
AWWA	American Water Works Association
AWS	American Welding Society
DEQ	Department of Environmental Quality
EPA	United States Environmental Protection Agency
FHWA	Federal Highway Administration
FSS	Federal Specifications and Standards (General

	Services Administration)
IES	Illuminating Engineering Society
IMSA	International Municipal Signal Association
ITE	Institute of Traffic Engineers
MUTCD	Manual on Uniform Traffic Control Devices for Streets and Highways
NEC	National Electrical Code
NEMA	National Electrical Manufacturers Association
ODOT	Oklahoma Department of Transportation
OSHA	Occupational Safety and Health Administration
SAE	Society of Automotive Engineers
UL	Underwriter's Laboratory
USFWS	United States Fish & Wildlife Service

101.02. ACCEPTANCE DATE.

The date on which the contractor has satisfactorily executed and delivered to the engineer all documents, certificates, and proofs of compliance required by the contract, following completion.

101.03. ADDENDUM.

Contract revisions developed after advertisement and before opening proposals.

101.04. ADVERTISEMENT.

The public announcement, as required by law, inviting bids for work to be performed or materials to be furnished.

101.05. ALTERATION.

The Department authorized addition, deletion or revision of the work.

101.06. AWARD.

The acceptance by the Commission of a bid.

101.07. BASE COURSE.

The layer or layers of selected material of a designated thickness placed on a subbase or a subgrade to support a surface course.

101.08. BIDDER.

Any individual or legal entity submitting a Proposal.

101.09. (RESERVED)

101.10. BOND.

Maintenance Bond, Performance Bond, Proposal Guaranty, Statutory and Payment Bond. An authorized form of proposal guaranty issued by a Surety as defined in Section 101.73. A bid bond is submitted by a bidder with a bid to assure execution of the Contract if the bidder is the lowest responsible bidder and is awarded the Contract.

- (a) **Maintenance Bond.** A bond, issued by a Surety to the Department of Transportation in a sum not less than the total Contract price to protect the Department of Transportation against defective workmanship and materials for a period of one year after final acceptance of the entire project.
- (b) **Performance Bond.** A bond, issued by a Surety to the Department of Transportation in a sum not less than the total Contract price which shall ensure the proper and prompt completion of the work in accordance with the provisions of the Contract.
- (c) **Proposal Guaranty.** The security furnished with a bid in the form of a bid bond certified check, cashier's check, or irrevocable letter of credit in an amount equal to five percent (5%) of the bid to assure that the bidder will enter into the Contract if his/her offer is accepted. The Proposal Guaranty is for the purpose of repaying the Department of Transportation the cost of republication of notice to bidders, all actual and reasonable expenses incurred by reason of the bidders default and the difference between the low bid of the defaulting bidder and the amount of the bid of the bidder to whom the contract is subsequently awarded, but not to exceed the amount of said bid bond or check, in the event the apparently successful bidder fails to execute the Contract or fails to provide the required bonds and insurance to the Department.
- (d) **Statutory and Payment Bond.** A bond, issued by a Surety to the Department of Transportation in a sum not less than the total amount of the Contract guaranteeing that the Contractor shall pay all reasonable indebtedness incurred by such Contractor or its subcontractors, in the performance of the Contract; State and local taxes accruing as a result of the contract; liquidated damages as provided by the contract, and assessed by the Department of Transportation; and full refund of overpayment of progressive estimate(s) which result in a balance due and owing to the Department of Transportation, as required by the Statutes of the State of Oklahoma.

101.11. BRIDGE.

A structure, including supports, erected over a depression or obstruction, such as water, a highway, or a railway, and having a track or passageway for carrying traffic or other moving loads, and having an opening measured along the center of the roadway of more than 20 feet (6.1 meters) between undercopings of abutments or spring lines or arches or extreme ends of openings for multiple boxes; may include multiple pipes where the clear distance between openings is less than half of the smaller contiguous opening.

- (a) **Bridge length.** The length of a bridge structure is the over-all length measured along the line of survey stationing back to the back of backwalls of abutments, if present, otherwise end to end of the bridge floor, but in no case less than the total clear opening of the structure.
- (b) **Bridge Roadway Width** The clear width of the structure measured at right angles to the center of the roadway between the bottom of curbs or, if curbs are not used, between the inner faces of parapet or railing.

101.12. CHANGE IN THE WORK, SIGNIFICANT.

When the character of the work, as altered, (1) differs materially in kind or nature from that involved or included in the original proposed construction, or (2) when a major item of work as defined in Section 101.48 is increased in excess of 125 percent or decreased below 75 percent of the original Contract quantity.

101.13. CHANGE ORDER.

A written order to the Contractor for extra work, increases or decreases in Contract quantities, and additions or alterations to the plans or specifications, within the scope of the Contract.

101.13.1. CHANGE IN PLAN.

A written order that documents a change in the work that shall be accomplished by the Contractor who must comply with the changes or directions given. The Change in Plans may not change the contract price or the contract time, but is evidence that the change directed or documented by a Change in Plans will be incorporated in a subsequently issued Change Order and/or Supplemental Agreement.

101.14. CHANNEL.

A natural or artificial water course.

101.15. COMMISSION.

The Transportation Commission of the State of Oklahoma as constituted by State law and which is charged with the duty to administer the affairs of the Department of Transportation acting directly, or through the Transportation Director.

101.16. CONTRACT.

The written agreement between the Transportation Department and the Contractor setting forth the obligations of the parties thereunder, including, but not limited to, the performance of the work, the furnishing of labor and materials, and the basis of payment.

The Contract includes the Invitation for Bids, Proposal, Contract Form, all Contract Bonds, Specifications, Supplemental Specifications, Special Provisions, all Plans, and the Work Order, also any Change Orders and Supplemental Agreements that are required to complete the construction of the work in an acceptable manner, including authorized extensions.

101.17. COMPLETION DATE.

The date on which the project and any exceptions are satisfactorily completed.

101.18. CONTRACT PAY ITEM.

A specifically described unit of work for which a price is provided in the Contract.

101.19. CONTRACT TIME.

The number of work days or calendar days allowed for completion of the work required by the Contract, including authorized time extensions, or a date certain by which work must be completed.

- (a) **Calendar Day:** Any day shown on the calendar beginning and ending at midnight.
- (b) **Completion Day:** A date by which all work specified in the contract is to be completed.
- (c) **Working Day:** Every day shown on the calendar, exclusive of Saturdays, Sundays and holidays as set forth in 101.40, on which weather and other conditions not under the control of the Contractor will permit construction operations to proceed for a minimum of six hours with normal working forces engaged in performing the controlling item or items of work. Saturdays, Sundays and holidays on which the Contractor's forces engage in regular work, requiring the presence of an inspector, will be considered as working days.

101.20. CONTRACTOR.

The individual or legal entity contracting with the Department for performance of prescribed work.

101.21. CONTROL OF ACCESS.

The condition where the right of owners or occupants of abutting land or other persons to access, light, air, or view in connection with a highway is fully or partially controlled by public authority.

- (a) Full control of access means that the authority to control access is exercised to give preference to through traffic by providing access connections with selected public roads only and prohibiting crossings at grade or direct private driveway connections.
- (b) Partial control of access means that the authority to control access is exercised to give preference to through traffic to a degree that, in addition to access connections with selected public roads, there may be some crossings at grade and some private driveway connections.

101.22. COUNTY ENGINEER.

The duly appointed County Engineer of a County or the Consulting Engineer employed by a county.

101.22.1. CRITICAL PATH.

The logical progression of construction tasks necessary to complete construction of a project with each dependent element properly sequenced to follow the work on which it is dependent.

101.23. CULVERT.

Any structure under the roadway with a clear opening of 20 feet (6.1 meters) or less measured along the center of the roadway.

101.24. DELAY.

A temporary suspension or impediment of all or a portion of the work required by the contract. No delay may be found unless a Progress Schedule (bar chart or CPM) as required by these Standard Specifications has been submitted and accepted.

- (a) **Excusable Delay.** A delay caused by the acts of the Department or an otherwise unforeseeable event beyond the Contractor's control which impacts on an element or elements of work, which are demonstrably critical to the progress and completion of the project. Except as provided in Section 108.07.a., acts of suppliers, fabricators or subcontractors are considered as under control of the Contractor and will not provide a basis for an excusable delay. An excusable delay will provide the basis for an extension of contract time.
- (b) **Compensable Delay.** An excusable delay for which the Contractor may be entitled to additional money compensation.
- (c) **Noncompensable Delay.** Excusable delay for which the Contractor may be entitled to an extension of time but no additional monetary compensation.
- (d) **Nonexcusable Delay.** A delay to the contract or milestone completion date that was reasonably foreseeable and within control of the Contractor for which no monetary compensation or time extension will be granted.

101.25. DEPARTMENT.

The Department of Transportation of the State of Oklahoma, authorized by Article XVI Section 1 of the Constitution of the State of Oklahoma as provided by enactment of the Oklahoma Legislature.

101.26. DIFFERING SITE CONDITIONS.

Subsurface or latent physical conditions at the site that, (1) differ materially from those indicated in the Contract, or (2) differ materially from conditions normally encountered or those conditions generally recognized as inherent in the nature of the work required in the Contract, or (3) are unknown physical conditions of an unusual nature.

101.27. DIRECTOR.

The executive officer duly appointed and authorized by the Transportation Commission to direct and control the Department of Transportation of the State of Oklahoma.

101.28. DIVIDED HIGHWAY.

A highway with separated roadways for traffic in opposite directions.

101.29. DRAINAGE DITCH.

An open excavation or ditch constructed for the purpose of carrying off surface water.

101.30. EASEMENT.

A grant of the right of use of property of an owner for a certain purpose at the will of the grantee.

101.31. ENGINEER.

The Chief Engineer of the Department of Transportation and such assistants or representatives as authorized by the Director while acting within the scope of their assigned duties or vested authority.

101.32. EQUIPMENT.

All machinery, tools and apparatus necessary for the proper construction and acceptable completion of contract.

101.33. (RESERVED)**101.34. (RESERVED)****101.35. EXPERIMENTAL CONSTRUCTION.**

Experimental highway construction is construction in which one or more experimental features have been incorporated or utilized, regardless of whether the incorporation or utilization of the experimental feature is a primary or secondary consideration in undertaking the project.

101.36. EXPERIMENTAL FEATURE.

An experimental feature may be either a material, process, method, equipment item, traffic operational device or other feature that has not been sufficiently tested under actual service conditions to merit acceptance without reservation in normal highway construction.

101.37. EXPRESSWAY.

A divided arterial highway for through traffic with full or partial control of access and generally with grade separations at intersections.

101.38. FREEWAY.

An expressway with full control of access.

101.39. GRADE SEPARATION.

Any structure carrying highway traffic over or under another highway or street, or over or under the tracks of any railway.

101.40. HOLIDAYS.

Any day proclaimed a holiday by Executive Order by the Governor.

101.41. INCENTIVE/DISINCENTIVE PROVISIONS.

A provision within a contract which provides for an adjustment to the Contract price of a predetermined amount for: (1) Each day the work is completed ahead of or behind the specified milestone, phase or Contract completion dates; (2) Work products as specified in the contract, which is superior to or less than a specified standard.

101.42. INSPECTOR.

The Resident Engineer's authorized representative assigned to make inspections of Contract performance.

101.43. INVITATION FOR BIDS.

The Advertisement for Proposals for work or materials on which bids are requested. The advertisement will indicate the quantity and location of the work to be performed, the character and quantity of the material to be furnished and the time and place of the opening of Proposals.

101.44. LABORATORY.

The official testing laboratory of the Department or any other testing laboratory which may be designated by the Director or Engineer.

101.45. LETTER OF CREDIT.

An irrevocable letter of credit for the benefit of the State of Oklahoma issued by a financial institution insured by the Federal Deposit Insurance Corporation, or the Federal Savings & Loan Insurance Corporation.

A letter of credit shall be in the form as prescribed by the Office of Central Services. A letter of credit may be submitted in lieu of a bond as set forth in Subsection 101.10. on any Department Contract not exceeding one hundred thousand dollars (\$100,000.00).

101.46. LETTING (BID OPENING).

The time appointed for the opening of the proposals submitted by bidders.

101.47. LOT.

A lot is an isolated quantity of work or materials.

101.48. MAJOR AND MINOR CONTRACT ITEMS.

Any item to be considered as a major or minor item under the terms of the Contract will be based on the item or items percent value of the original total Contract amount.

Major items will be determined from the following schedule:

SCHEDULE FOR MAJOR ITEMS

ORIGINAL TOTAL FROM MORE THAN	CONTRACT AMOUNT TO AND INCLUDING	MAJOR ITEM ¹ ITEM VALUE IN EXCESS OF (PERCENT)
\$ 0	1,000,000	5
1,000,000	4,000,000	2-1/2
4,000,000	No Limit	1-1/2

¹ Based on the percent value of the original total Contract Amount

All other items will be considered as minor items, except when the Contract value of a minor item, due to an increase in quantities exceeds the above percentage of the original total Contract amount. The item will then be considered a major item.

101.49. MATERIALS.

Any substances used in the construction of the project and its appurtenances.

101.50. MEDIAN.

The portion of a divided highway separating the traveled ways of traffic.

101.51. NOTICE TO PROCEED.

Written notice to the Contractor to begin the Contract work; when applicable, the notice will include the starting date of Contract time.

101.52. PAVEMENT STRUCTURE.

The combination of subbase, base course, and surface course placed on a subgrade to support and distribute the traffic load to the roadbed.

- (a) **Base Course.** One or more layers of specified material thickness placed on a subbase or a subgrade to support a surface course.
- (b) **Subbase.** Layers of specified material thickness placed on a subgrade to support a base course.
- (c) **Subgrade.** The top surface of a roadbed upon which the pavement structure, shoulders, and curbs are constructed.
- (d) **Subgrade Treatment.** Modification of roadbed material by stabilization.
- (e) **Surface Course.** Layer(s) of a pavement structure designed to accommodate the traffic load, the top layer of which resists skidding, traffic abrasion, and the disintegrating effects of climate. The top layer is sometimes called the "Wearing Course."

101.53. PLANS.

Approved Contract drawings showing the location, type, dimensions, and details of Contract work to be performed.

- (a) **Standard Plans.** Detailed drawings approved for repetitive use.
- (b) **Plan Notes.** Plan notes are insertions on standard plans primarily to facilitate design considerations. Whenever there appears to be conflict in plan notes, Contractor shall notify the Resident Engineer prior to commencement of affected work. The Resident Engineer will determine the applicability of the note(s) in question to the specific project.
- (c) **Working Drawings.** Supplemental design sheets or similar data that the Contractor is required to submit to the Resident Engineer such as shop drawings, erection plans, false work plans, framework plans, cofferdam plans, and bending diagrams for reinforcing steel.
- (d) **Work Plans.** Supplemental procedures or data developed by the Contractor as his/her methodology to construct the work required by the Plans for the project, the Standard Specifications and any applicable Special Provisions.

101.54. PRE-QUALIFICATION.

The process of qualifying a prospective bidder prior to the issuance of bidding documents in conformance with the rules, regulations, policies and procedures of the Transportation Commission.

Prequalification Questionnaire. The approved form of the Department upon which the prospective bidder shall furnish information as to financial condition, experience, the equipment to be used and to indicate ability to finance and perform the work.

101.55. PROFILE GRADE.

The trace of a vertical plane intersecting the top surface of the proposed wearing surface, usually along the longitudinal centerline of the roadbed. Profile grade means either elevation or gradient of such trace according to the context.

101.56. PROJECT.

The specific section of the highway or proposed highway or other facilities together with all appurtenances and construction to be performed under the Contract.

101.57. PROPOSAL.

The written offer of the bidder, submitted on the prescribed form or electronic media, to perform the work described in the Plans and Specifications, and to furnish the labor and materials at the prices quoted by the bidder.

101.57.1. RESIDENT ENGINEER.

The direct representative of the Department for oversight of construction projects with authority for oversight of all aspects of the construction project.

101.58. RESPONSIVE BID.

A bid that meets all requirements of the invitation for bids.

101.59. RESPONSIBLE BIDDER.

A bidder that the Department determines has the ability to perform the Contract work.

101.60. RIGHT-OF-WAY.

A general term denoting land, property, or an interest therein, acquired for highway purposes.

101.61. ROAD. FRONTAGE ROAD, PUBLIC ROAD, LOCAL ROAD AND INTERCHANGE-COLLECTOR-DISTRIBUTOR ROAD

- (a) **Frontage Road.** A road constructed on Department owned right-of-way, adjacent and parallel to, but separated from the highway, and which has connections to the highway at least on both ends, for service to abutting property and for control of access.
- (b) **Public Road.** A road constructed on Department owned right-of-way to connect other public roads or streets but not connected to the highway nor allowing access to the highway.
- (c) **Local Road.** A road constructed on Department owned right-of-way to provide access to property abutting or adjacent to the highway and which has but one connection to the highway.
- (d) **Interchange-Collector-Distributor Road.** A road constructed on Department owned right-of-way, parallel to the mainline, that collects and distributes traffic between ramps and the mainline and is not connected to any crossroads.
- (e) **Highway, Street or Road.** A general term denoting a public way for purposes of vehicular travel, including the entire area within the right-of-way.
- (f) **Parkway.** An arterial highway for non-commercial traffic, with full or partial control of access, and usually located within a park or a ribbon of park-like development.
- (g) **Ramp.** A connecting roadway between two intersecting highways at a highway separation, or a road connecting the highway with other roads or entrances.

101.62. ROADWAY, ROADBED, ROADSIDE, SHOULDER, SIDEWALK, TRAVELED WAY.

- (a) **Roadbed.** The graded portion of a highway within top and side slopes, prepared as a foundation for the pavement structure and shoulders.
- (b) **Roadside.** A general term denoting the area adjoining the outer edge of the roadway. Extensive areas between the roadways of a divided highway may also be considered roadside.
- (c) **Roadside Development.** Those items necessary for the preservation or replacement of landscape materials and features that may include suitable plantings and other improvements or ground cover to preserve and enhance the appearance and stability of the highway right-of-way or acquired easements for scenic improvements.

- (d) **Roadway.** That portion of the Right-of-Way between the outer edges of the shoulder.
- (e) **Shoulder.** The portion of the roadway contiguous with the traveled way designed for emergency use, and for lateral support of base and surface courses.
- (f) **Sidewalk.** That portion of the Right-of-Way constructed for the use of pedestrians.
- (g) **Traveled Way.** The portion of the roadway for the movement of vehicles, exclusive of shoulders.

101.62.1. SHUT DOWN ORDER.

A written order issued by the Resident Engineer to the Contractor directing the Contractor to cease all or any specific part of the contract work. No work prohibited by the Shut Down Order may be resumed until a written authorization rescinding the Shut Down Order is issued by the Resident Engineer.

101.63. SPECIFICATIONS.

The compilation of provisions and requirements for the performance of prescribed work.

- (a) **Standard Specifications.** The book of Specifications approved for general application and repetitive use.
- (b) **Supplemental Specifications.** The book of approved additions and revisions to the Standard Specifications.
- (c) **Special Provisions.** Revisions to the Standard and Supplemental Specifications applicable to an individual project.

101.64. SPEED CHANGE LANE.

An auxiliary lane, including tapered areas, primarily for the acceleration or deceleration of vehicles entering or leaving the highway. Speed Change Lanes are described as Acceleration Lanes, Deceleration Lanes or Median Lanes.

101.65. STABILIZATION.

Modification of soils or aggregates by incorporating materials that will increase load-bearing capacity, firmness, and resistance to weathering or displacement.

101.66. STATE.

The State of Oklahoma.

101.67. STRUCTURE.

Bridge, culvert, catch basin, drop inlet, retaining wall, cribbing, manhole, endwall, headwall, building, sewer, service pipe, underdrain, and foundation drain and other features which may be encountered in the work and not otherwise classified.

101.68. SUBCONTRACTOR.

An individual or legal entity that performs part of the required work through a contract agreement with the Contractor.

101.69. SUBSTRUCTURE, BRIDGE.

All of that part of the structure below the bearings of simple and continuous spans, skewbacks of arches and tops of footings of rigid frames, together with the backwalls, wingwalls and wing protection railings.

101.70. SUPERINTENDENT.

The Contractor's authorized representative in responsible charge of the work.

101.71. SUPERSTRUCTURE, BRIDGE.

The entire structure except the substructure.

101.72. SUPPLEMENTAL AGREEMENT.

A written agreement signed by the Department and the Contractor for the performance of work beyond the scope of the original Contract that the Department elects to perform in conjunction with the existing Contract.

101.73. SURETY.

The insurance company or other body, authorized under the laws of Oklahoma to ensure the Contractor's faithful performance of the Contract, the payment of all indebtedness incurred in the performance of the Contract by the Contractor, and where applicable, the liability for any defects resulting from defective workmanship and/or materials furnished by the Contractor.

101.74. TITLES (OR HEADINGS).

The titles or headings of the Sections and Subsections herein are intended for convenience of reference and shall not be considered as having any bearing on their interpretation.

101.75. (RESERVED)**101.76. UNBALANCED BID, MATERIALLY.**

A bid that generates a reasonable doubt that award to the bidder submitting a mathematically unbalanced bid will result in the lowest ultimate cost to the Department.

101.77. UNBALANCED BID, MATHEMATICALLY.

A bid containing lump sum or unit bid items that do not reflect reasonable estimated costs plus a reasonable proportionate share of the bidder's anticipated profit, overhead costs, and other indirect costs.

101.77.1. UNILATERAL CHANGE ORDER.

A change order issued by the Resident Engineer in accordance with his/her determination of an equitable price and time adjustment, but to which the contractor does not agree and does not sign.

101.78. VALUE ENGINEERING.

Value Engineering is the formal technique by which contractors may voluntarily suggest methods for performing the contract requirements more economically and share in the resulting savings, without impairing essential functions or characteristics.

101.79. WORK.

The furnishing of all labor, materials, equipment, and other incidentals necessary to complete the work under the Contract.

SECTION 102 BIDDING REQUIREMENTS AND CONDITIONS

102.01. PRE-QUALIFICATION OF BIDDERS.

Pre-qualification shall be a prerequisite for bidding on all projects unless prohibited by law or waived by the Transportation Department.

Prequalification of bidders shall be accomplished in conformance with the most current issue of the Oklahoma Administrative Code, copies of which are available from the Office Engineer, 200 N.E. 21st Street, Oklahoma City, Oklahoma 73105.

102.02. NOTICE TO CONTRACTORS.

After the date is set for the receipt of proposals, the Department will give notice of bid opening to prospective bidders. The notice will contain a description of the proposed work, together with information regarding access to Proposal forms, Plans and Specifications, and the amount of Proposal Guaranty. This notice to Contractors will also be published as an advertisement giving notice of the request for bids, as required by State Law. The notice to Contractors will become part of the Contract documents.

102.03. CONTENTS OF PROPOSAL FORMS.

The Proposal Form will state the location and description of the contemplated construction, show the estimate of the various item quantities and kinds of work to be performed or materials to be furnished. A schedule of items for which unit bid prices are invited will be included along with the specified time in which the work must be completed, amount of the Proposal guaranty, and the date, time and place of the opening of Proposals. The form will also include or designate any specifications or requirements that vary from, or are not contained in the Standard Specifications.

Papers bound with or attached to the Proposal Form are considered a part of the Proposal.

The plans, specifications, and other documents designated in the Proposal Form are considered a part of the Proposal whether attached or not.

The prospective bidder will be required to pay the Department the sum stated in the Advertisement for each copy of the Proposal Form and each set of plans obtained.

102.04. ISSUANCE OF PROPOSAL FORM.

The Department reserves the right to disqualify a bidder as non-responsible or refuse to issue a Proposal Form to a bidder for any of the following reasons:

- (a) Lack of competency and adequate machinery, plant, and other equipment, as revealed by the financial statement and experience questionnaire required under Subsection 102.01.
- (b) Uncompleted work under Contract that the Department determines might hinder or prevent the prompt completion of additional work if awarded.
- (c) Failure to pay, or satisfactorily settle, all bills due for labor and material on any Contract in force at the time of issuance of Proposals.
- (d) Failure to comply with any prequalification regulations.
- (e) Default under previous Contract(s).
- (f) Unsatisfactory performance on previous or current Contract(s).
- (g) Indictment during the pendency of such indictment, for or conviction of a felony involving moral turpitude or offences against the public contracting laws of the United States or any state of the United States which may in the determination of the Department adversely affect the ability of the contractor to perform future work. For the purpose of the subsection, entry of a plea of guilty or nolo contendere to any such offense shall be considered as equivalent to conviction.
- (h) The prospective bidder is debarred or ruled unacceptable by the Department, a Federal Agency or other Government Agencies.
- (i) Failure to comply with Disadvantaged Business Enterprise requirements in previous Contract(s).
- (j) Failure to pay subcontractor or release subcontractor retainage as required by Subsection 109.11 on previous or current Contract(s).

102.05. INTERPRETATION OF QUANTITIES & BID PROPOSAL.

The quantities appearing in the bid Proposal are estimates used for the comparison of Proposals. Payment will be made for the actual quantities of work performed and accepted or materials furnished in accordance with the Contract. The estimated quantities of work to be done and materials to be furnished may be increased, decreased, or eliminated in their entirety.

102.06. EXAMINATION OF PLANS, SPECIFICATIONS, SPECIAL PROVISIONS AND THE WORK SITE.

The bidder shall examine the site of the proposed work, the Proposal, Plans, Specifications, Supplemental Specifications, Special Provisions, and Contract forms before submitting a Proposal. If no site investigation is performed, the bidder is responsible for all site conditions that should have

been discovered had a reasonable site investigation been performed. The submission of a Proposal will be considered conclusive evidence that the bidder is satisfied with the conditions to be encountered in performing the work and as to the requirements of the proposed Contract.

Boring logs and other records of subsurface investigations are available for inspection by bidders. They are made available to bidders so all have access to identical subsurface information available to the Department, and are not intended as a substitute for personal investigation, interpretations, and judgment of the bidders. Boring and subsurface investigations performed by or on behalf of the Department are conducted to determine design criteria. Bidders should not rely on Department data to assess the difficulty of the required work, or actual conditions which may be encountered.

Boring logs and other subsurface investigation records are available for inspection at Department of Transportation, Office Engineer, 200 N.E. 21st Street, Oklahoma City, Oklahoma 73105, during normal business hours.

The Department will not be bound by any statement or representation concerning conditions or description of the work unless they are included in the Proposal Form, Plans, Specifications, Supplemental Specifications, Special Provisions, or related Contract documents. Oral explanations or instructions given before the award of the Contract by Department employees or agents will not be binding.

Any request for explanation of the meaning or interpretation of the Proposal Form, Plans, Specifications, Supplemental Specifications, Special Provisions, or related Contract documents shall be submitted in adequate time to allow a reply to reach all bidders before submission of their bid Proposal. Interpretations or explanations made by the Department in response to such requests will be issued as an addendum to the proposal form, and will be furnished to all plan holders by certified letter, telegram, or facsimile before the time set for opening of Proposals. Bidders shall acknowledge receipt of addenda on the Proposal form in the space provided.

102.07. PREPARATION OF PROPOSAL.

The bidder shall submit his/her Proposal upon forms and/or electronic media furnished by the Department. The bidder shall specify a unit price in figures for each pay item for which a quantity is given, and shall show the product of the respective unit prices and quantities written in figures in the column provided for that purpose, and shall show the total amount of the Proposal by adding the amounts of the several items. All the figures shall be in ink or typed. In case of a discrepancy between the unit price and the product of the unit price, the unit price shall govern.

Any change in the unit price, the product of the unit price, or the total amount of the Proposal shall be acknowledged by the initials of the person signing the bid adjacent to each such change or alteration.

The Proposal must be signed in black or blue ink by the individual, by all members of the partnership, by a duly authorized officer of a corporation, or by all members of the joint venture. If by corporation, the name of the corporation and its business address must be shown.

102.08. IRREGULAR PROPOSALS.

Proposals will be considered irregular and may be rejected as non-responsive if:

- (a) The Proposal is on a form (or format if computer generated) other than that approved by the Department, or if the form is altered or incomplete.
- (b) There are unauthorized additions, conditional or alternate bids, or irregularities of any kind that may tend to make the Proposal incomplete, indefinite, or ambiguous.
- (c) The bidder adds provisions reserving the right to accept or reject an award, or to enter into a contract pursuant to an award. This does not exclude a proposal limiting the maximum gross amount of awards acceptable to any one bidder at any one bid letting, provided that selection of awards is made by the Department.
- (d) The Proposal does not contain a unit price for each pay item listed except in the case of authorized alternate pay items.
- (e) Any of the unit bid prices are significantly unbalanced to the potential detriment of the Department.
- (f) The Proposal is not properly signed.
- (g) The Proposal is not typed or completed in ink.
- (h) The Contractor fails to provide a properly executed Proposal Guaranty.
- (i) The bidder fails to sign the non-collusive bidding certification.
- (j) The Proposal fails to comply with any other material requirement of the invitation for bids.
- (k) The bidder fails to properly comply with Disadvantaged Business Enterprise Requirements or to properly list eligible disadvantaged businesses when such participation is required.

102.09. PROPOSAL GUARANTY.

Each separate Proposal shall be accompanied by a Proposal Guaranty as defined in Subsection 101.10. in an amount equal to or greater than 5 percent of the Contractors bid, and made payable to, or subject to forfeiture to the Department.

102.10. DELIVERY OF PROPOSAL.

Proposals shall be:

- (a) Placed in a sealed envelope plainly marked with identifying information as required; and
- (b) Addressed to the Department in care of the official in whose office the Proposals are to be received; and
- (c) Filed before the time and at the place specified in the Advertisement. Proposals received after the specified time will be returned to the bidder unopened. The title and address of the official designated to receive bid Proposals is Office Engineer, 200 Northeast 21st Street, Oklahoma City, Oklahoma 73105.
- (d) Proposals may be delivered electronically as provided for in current Department procedures, if authorized.

102.11. WITHDRAWAL OF PROPOSALS.

Any bidder upon his/her, or his/her authorized representative's notarized written request, may withdraw his/her Proposal not later than the time set for opening thereof. At the time of reading Proposals, if a request to withdraw a Proposal has been received, when such proposal is reached, it will be returned to the bidder unread.

102.12. COMBINATION BIDS.

If the Department so elects, Proposals may be issued for Projects in combination and/or separately so that bids may be submitted either on the combination or on separate Projects of the combination.

The Department reserves the right to recommend awards on combination bids or separate bids to the best advantage of the Department. No combination of bids, other than those specifically authorized by the Department in the Proposals, will be considered.

102.13. PUBLIC OPENING OF PROPOSALS.

Proposals will be publicly opened and read on the date and at the hour and place set forth in the advertisement and Notice to Contractors in the presence of the Director or his/her duly authorized representative.

102.14. REJECTION OF BIDS.

Any of the following reasons may be considered just cause for the rejection of a bid or bids.

- (a) More than one Proposal for the same work from an individual, firm, partnership, joint venture or corporation whether under the same or different names.
- (b) The prospective bidder is debarred or ruled unacceptable by the Department, a Federal Agency or other Governmental Agency.
- (c) Submission of irregular Proposal as set forth in Sec. 102.08.
- (d) Lack of competency and/or inadequate equipment, as revealed by the financial statement and experience questionnaires required under Subsection 102.01.
- (e) Unsatisfactory performance on previous work.
- (f) Uncompleted work which, in the judgment of the Department, might hinder or prevent the prompt completion of additional work if awarded.
- (g) Default under previous Contract(s).
- (h) Errors in preparation of the Proposal.
- (i) Failure to settle bills for labor or materials on past or current contracts.
- (j) Failure to meet Disadvantage Business Enterprise goal or provide a good faith effort.

102.15. MATERIALS GUARANTY.

The successful bidder shall furnish a complete statement of the origin, composition, and manufacture of materials used in the construction of the work, together with samples to be tested for conformance with the Contract provisions.

102.16. NON-COLLUSIVE BIDDING CERTIFICATION.

Every Proposal submitted to the Department shall contain the following statement subscribed or affirmed by the bidder as true under the penalties of Law. This Certification, on Department forms, shall be signed by the bidders, notarized and submitted with the bid documents. Non-Collusive Bidding Certification will be notarized and substantially in the following form:

Non-Collusive Bidding Certification

By submission of this bid Proposal, each bidder and each person signing on behalf of any bidder, certifies as to its own organization, under penalty of perjury, that to the best of their knowledge and belief.

1. The prices in this bid Proposal have been arrived at independently without collusion, consultation, communication, or agreement with any other bidder or with any competitor for the purpose of restricting competition.
2. Unless required by law, the prices that have been quoted in this bid Proposal have not been knowingly disclosed and will not knowingly be disclosed by the bidder, directly or indirectly, to any other bidder or competitor prior to opening of Proposals.
3. No attempt has been made or will be made by the bidder to induce any other person, partnership, or corporation to submit or not to submit a Proposal for the purpose of restricting competition.
4. The signers of this Proposal hereby tender to the Department this sworn statement that the named Contractor(s) has not, whether directly or indirectly, entered into any agreement, participated in any collusion, or otherwise taken any action to restrain free competitive bidding in connection with this Proposal.

(Signature)

(Print Name)

(Position in Company)

Subscribed and sworn before me this ____ day of _____ 19____ (20____).

My commission expires the ____ day of _____ 19 ____ (20 ____).

(seal)

(Notary Public)

A bid Proposal will not be considered for award nor will any award be made where there has not been compliance with the statements in the certification above.

The fact a bidder (1) has published price lists, rates, or tariffs covering items being procured, (2) has informed prospective customers of proposed or pending publication of new or revised price lists for such item, or (3) has sold the same items to other customers at the same prices being bid, does not constitute a disclosure within the meaning of part 1 of the certification above.

SECTION 103 AWARD AND EXECUTION OF CONTRACT

103.01. CONSIDERATION OF PROPOSALS.

Following the public opening and reading of the Proposals, the Department will check and verify the product (extended amount) for each bid item and the Proposal amount for each Proposal received. The product (extended amount) for each bid item is then compared to the Department's estimate for each Proposal submitted. The Proposal amount for each acceptable Proposal submitted will then be compared and the results made public. The Commission reserves the right to reject any or all Proposals, waive an administrative error in the award process that would void an otherwise valid award, to advertise for new Proposals, or proceed to do the work otherwise when the best interest of the State will be promoted thereby.

103.02. AWARD OF CONTRACT.

Award of the Contract will be made by the Commission, upon the recommendation of the Director, to the lowest responsible bidder submitting a responsive bid and meeting the requirements of the Commission. The award, if made, will be within the time allowed by law after the opening of Proposals.

103.03. CANCELLATION OF AWARD.

The Commission reserves the right to cancel the award of any Contract at any time before the execution of said Contract without liability against the Commission or the Department.

In Projects which are proposed to be funded in whole or in part by Federal Funds, it is expressly agreed and understood that the receipt of such funds is essential to the Contract and the receipt of such funds requires the concurrence of the funding Federal Agency. If the funding Federal Agency neglects, fails, or refuses to concur in the award of the Contract, the Commission reserves the right to unilaterally rescind the award of the Contract despite the full and complete execution of the Contract by all parties.

In the event the Commission elects to exercise its right of unilateral rescission, the Contract's Proposal Guaranty shall be returned to the Contractor and both parties shall thereafter be released from any and all obligations and liabilities which otherwise would exist by reason of the Contract.

103.04. RETURN OF PROPOSAL GUARANTIES.

When the lowest responsible bidder submitting a responsive bid has been determined, the Proposal Guaranties which accompanied those Proposals of the unsuccessful bidders will be returned. The bidding security of the successful bidder will be retained by the Department until the Contract and bonds have been executed and approved after which the Proposal Guaranty will be returned to the successful bidder.

103.05. BONDING REQUIREMENTS.

The bidder to whom the Contract is awarded shall, at the time of the execution of the Contract, deposit with the Department a Performance Bond, Statutory and Payment Bond and, where applicable, a Maintenance Bond as required by law. The Surety shall be acceptable to the Department and shall be in conformance with the rules, regulations, policies and procedures of the Commission. The terms of the bonds shall be provided by the Department, be executed by the Surety, and accompanied by valid and acceptable Powers of Attorney.

103.06. (RESERVED)**103.07. EXECUTION OF CONTRACT.**

The individual, partnership, joint venture, or corporation to whom the Contract has been awarded shall sign and attest, where applicable, the necessary forms for entering into a Contract with the Department, and return the executed Contract to the Office Engineer of the Department at Oklahoma City, Oklahoma, within the time limit specified in the Proposal.

103.08. APPROVAL OF CONTRACT.

The Contract shall not be binding upon the Department or Commission until it has been executed by the Director or his/her authorized designee, approved as to form and legality by the General Counsel or his/her authorized designee, and delivered to the Contractor.

103.09. FAILURE TO EXECUTE CONTRACT.

Failure to comply with any of the requirements of these Specifications, to execute the Contract, or to furnish the bonds required by law shall nullify the Award. In the event of such annulment of the award, the amount of the Proposal Guaranty shall be subject to forfeiture to the Department.

**SECTION 104
SCOPE OF WORK****104.01. PURPOSE OF CONTRACT.**

The purpose of the Contract is to provide for the construction and completion in every detail of the work described in the Proposal. The Contractor shall furnish all labor, materials, equipment and incidentals required to complete the work in a workmanlike manner and in accordance with the Plans, Specifications and terms of the Contract.

104.02. SPECIAL WORK.

Whenever deemed necessary by the Department, the Department may prepare Special Provisions for any work included in the Proposal. Special Provisions attached to or incorporated by reference with the Proposal form and shall be considered part of the Specifications.

104.03. DIFFERING SITE CONDITIONS.

During the progress of the work, if subsurface or latent physical conditions are encountered at the site differing materially from those indicated in the Contract or if unknown physical conditions of an unusual nature, differing materially from those ordinarily encountered and generally recognized as inherent in the work provided for in the Contract, are encountered at the site, the party discovering such conditions shall promptly notify the other party in writing of the specific differing conditions before the site is disturbed and before the affected work is performed.

- (a) Upon written notification as provided in Subsection 104.06., the Resident Engineer will investigate the conditions, and if it is determined that the conditions materially differ and cause an increase or decrease in the cost or time required for the performance of any work under the Contract, an adjustment, excluding anticipated profits, will be made and the Contract modified in writing accordingly. The Resident Engineer will notify the Contractor of the determination whether or not an adjustment of the Contract is warranted.
- (b) No Contract adjustment which results in a benefit to the Contractor will be allowed unless the Contractor has provided the required written notice as specified in Subsection 104.06.
- (c) No Contract adjustment will be allowed under this clause for any effects caused on unchanged work.
- (d) If the Contractor has provided written notification of differing site conditions as provided in Subsection 104.06. and the Resident Engineer determines that differing site conditions exist, payment will be made in accordance with Subsection 109.04. and adjustments to Contract time will be made as provided in Subsection 108.07.

104.04. SIGNIFICANT CHANGES IN THE CHARACTER OF WORK.

The Engineer reserves the right to make, in writing, at any time during the work, such changes in quantities and such alterations in the work as are necessary to satisfactorily complete the Project. Such changes in quantities and alterations shall not invalidate the Contract nor release the Surety, and the Contractor agrees to perform the work as altered.

- (a) If the alterations or changes in quantities significantly change the character of the work under the Contract, whether such alterations or changes are in themselves significant changes to the character of the work or by affecting other work cause such other work to become significantly different in character, an adjustment, excluding anticipated profit, will be made to the Contract. The basis for the adjustment shall be agreed upon prior to the performance of the work. If a basis cannot be agreed upon, then an adjustment will be made either for or against the Contractor in such amount as the Engineer may determine to be fair and equitable.

- (b) If the alterations or changes in quantities do not significantly change the character of the work to be performed under the Contract, the altered work will be paid for at the unit price as bid by the Contractor.
- (c) The term “significant change” shall be construed to apply only to the following circumstances:
 - 1. When the character of the work as altered differs materially in kind or nature from that involved or included in the original proposed construction;
 - 2. When a major item of work, as defined in Subsection 101.48., is increased in excess of 125 percent or decreased below 75 percent of the original Contract quantity. Any allowance for an increase in price shall apply only to that portion in excess of 125 percent of original Contract item quantity, or in case of a decrease below 75 percent, to the actual amount of work performed.
- (d) If directed changes require additional time to complete the Project, adjustments in the Contract time will be made as provided by Subsection 108.07.
- (e) Payment for changed major item quantities or altered work will be made as provided in Subsections 109.03. or 109.04. as appropriate.

104.05. SUSPENSION OF WORK ORDERED BY THE RESIDENT ENGINEER.

The Resident Engineer may suspend all or any portion of the work for any reason during performance of the Contract. Suspension of all or any portion of the work will be done by written notice to the Contractor.

- (a) If the performance of all or any portion of the work is suspended or delayed by the Resident Engineer in writing for an unreasonable period of time (not originally anticipated, customary, or inherent to the construction industry) and the Contractor believes that additional compensation and/or Contract time is due as a result of such suspension or delay the Contractor shall submit to the Resident Engineer in writing a request for adjustment within seven (7) calendar days of receipt of the notice to resume work. The request shall set forth the reasons and support for such adjustment.
- (b) Upon receipt, the Resident Engineer will evaluate the Contractor’s request. If the Resident Engineer agrees that the cost and/or time required for the performance of the Contract has increased as a result of such suspension and the suspension was caused by conditions beyond the control of and not the fault of the Contractor, its suppliers, or subcontractors at any approved tier, and not caused by weather, the Resident Engineer will make an adjustment (excluding profit) and modify the Contract in writing accordingly. The Contractor will be notified of the Resident Engineer’s determination whether or not an adjustment of the Contract is warranted.
- (c) No Contract adjustment will be allowed unless the Contractor has submitted the request for adjustment within the time prescribed.
- (d) No Contract adjustment will be allowed under this clause to the extent that performance would have been suspended or delayed by any other cause, or for which an adjustment is provided or excluded under any other term or condition of this Contract.

- (e) If the Contractor has submitted a request for adjustment within the time prescribed and the Resident Engineer determines that an adjustment is warranted, payment will be made as provided in Subsection 109.04. and adjustments to Contract time will be made as provided in Subsection 108.07.

104.06. NOTIFICATION OF DIFFERING SITE CONDITIONS, CHANGES AND EXTRA WORK.

The Contractor shall notify the Resident Engineer of alleged changes to the Contract due to differing site conditions, extra work, altered work beyond the scope of the Contract, or action(s) taken by the Department that changed the Contract terms and conditions, before beginning work not covered by the Contract or continuing work in progress but which has been altered by directed changes in methodology, location or differing site conditions.

- (a) No further work is to be performed or Contract item expense incurred with relation to the claimed change after the date the change allegedly occurred unless directed otherwise in writing by the Resident Engineer.
- (b) Immediately notify the Resident Engineer verbally of the alleged change or extra work occasioned by site conditions or actions by the Department, and within seven (7) calendar days of the date the alleged change or action was noted, provide the following information to the Resident Engineer in writing:
 1. The date of occurrence and the nature and circumstances of the occurrence that constitute a change.
 2. Name, title, and activity of each Department representative knowledgeable of the claimed change.
 3. Identify any documents and the substance of any oral communication involved in the claimed change.
 4. Basis for a claim of accelerated schedule performance.
 5. Basis for a claim that the work is not required by the Contract.

The failure of the Contractor to provide both verbal and written notices required under this Section constitutes a waiver of any and all claims that may arise as a result of the alleged change.

- (c) Following submission of the notification to the Resident Engineer, the Contractor shall not begin work not covered by the Contract, nor shall the Contractor continue work which has been altered by direction of the Department or differing site conditions, but the Contractor shall continue diligent prosecution of other work under the Contract to the maximum extent possible under the Contract provisions.

The Resident Engineer shall promptly investigate the conditions and within ten (10) calendar days after receipt of notice, the Resident Engineer shall respond in writing to the Contractor to:

1. Confirm that a change occurred and, when necessary, direct the method and manner of further performance, or
2. Deny that a change occurred and, when necessary, direct the method and manner of further performance, or

3. Advise the Contractor that adequate information has not been submitted to decide whether (1) or (2) applies, and indicate the needed information and date it is to be received by the Resident Engineer for further review. The Department will respond to such additional information within ten (10) calendar days of receipt from the Contractor.

Any adjustments made to the Contract shall not include increased costs or time extensions for delay resulting from the Contractor's failure to provide requested additional information in accordance with this clause.

104.07. MAINTENANCE OF TRAFFIC.

The Contractor shall keep all roads open to all traffic as provided for in the Plans. Where provided in the Contract, or approved by the Resident Engineer, traffic may be bypassed over an approved detour route. The section of the Project being used by public traffic shall be kept in a condition that safely and adequately accommodates traffic. The Contractor shall furnish, erect, and maintain barricades, warning signs, delineators, striping, flaggers, and pilot cars in accordance with the traffic control plan, MUTCD and Section 880, Construction and Traffic Control. The Contractor shall bear all expense of maintaining the section of road undergoing improvement including all temporary approaches or crossings and intersections with trails, roads, streets, businesses, parking lots, residences, garages, farms, and other features as may be necessary. Snow and ice removal is not required during winter work suspensions. Payment for the furnishing, installation, and maintenance of traffic control will be as provided in Section 880, Construction Signing and Traffic Control. No other additional compensation for maintenance will be made except as provided below:

- (a) **Special detours.** When the Contract contains an item for "Maintenance of Detours" or "Removing Existing Structures and Maintaining Traffic," the payment for such item covers all costs of constructing, maintaining, and obliterating detours, including construction and removal of temporary bridges and accessory features. Right-of-Way for temporary highways or bridges designated in the Contract will be furnished by the Department.
- (b) **Maintenance of Traffic During Suspension of Work.**
 1. **Suspensions Ordered by the Resident Engineer.** The Contractor shall make passable and open to traffic the sections of the Project and temporary roadways as agreed upon between the Contractor and the Resident Engineer for the accommodation of necessary traffic during the anticipated period of suspension.

During this suspension period the maintenance of the temporary roadway and sections of the Project will be the responsibility of the Department.

When work is resumed, the Contractor shall replace or restore any work or materials lost or damaged because of temporary use of the Project and remove work or materials used in the temporary maintenance and complete the project as though its prosecution had been continuous and without interference. Additional work caused by the suspensions, for reasons beyond the Contractor's control, will be paid for at Contract prices or by extra work.
 2. **Other Suspensions of Work.** When work is suspended due to seasonal or climatic conditions or, for failure to correct conditions unsafe for the workers or the general public, for failure to carry out orders of the Resident Engineer or for other reasons caused by the Contractor, all

costs for maintenance of the roadway to accommodate traffic during the suspended period shall be borne by the Contractor.

- (c) **Maintenance Directed by the Resident Engineer.** If the Resident Engineer directs special maintenance for the benefit of the traveling public not otherwise included in the Contract, payment will be on the basis of unit prices or under Subsection 104.04. - Changes in the Character of Work. The Resident Engineer will determine the work to be classed as special maintenance.

104.08. RIGHTS IN AND USE OF MATERIALS FOUND ON THE WORK.

The Resident Engineer may authorize the use of materials found in the excavation that are suitable for completing bid items of work. The Contractor will be paid both for the removal of the materials at the corresponding Contract unit price and for the pay item for which the removed materials are used.

The removed material shall be replaced with acceptable material at no cost to the Department. No charge for the materials used will be made against the Contractor. Material shall not be excavated or removed from within the highway Right-of-Way that is not within the grading limits without written authorization from the Resident Engineer. Replacement material covered under this Subsection shall be compacted to the density requirements specified for roadway embankment construction.

Unless otherwise provided, the material from any structure to be removed may be used temporarily by the Contractor in the erection of the new structure. Such material shall not be cut or otherwise damaged without approval of the Resident Engineer.

104.09. REMOVAL AND DISPOSAL OF SALVAGED MATERIALS, STRUCTURES AND OBSTRUCTIONS.

Unless otherwise shown on the Plans or in the Proposal, all salvaged materials or materials not incorporated in the work shall become the property of the Contractor and disposed of by him/her. No materials shall be buried or otherwise disposed of within the Project limits or on any publicly owned property without written permission of the Resident Engineer.

104.10. FINAL CLEANING UP.

Upon completion of the work and before acceptance and final payment will be made, the Contractor shall remove from the right-of-way all of his/her machinery, equipment, surplus and discarded materials, rubbish and temporary structures. The Contractor shall remove stumps or portions of trees, shall cut all brush and weeds within the limits of the right-of-way and shall leave the Project and his/her borrow pits in a neat workmanlike condition. Material cleared from the right-of-way and deposited on property adjacent to the right-of-way will not be considered as having been disposed of satisfactorily.

The Contractor shall leave any areas or slopes, where he/she performs any work, in a neat and workmanlike condition. The Contractor shall repair at his/her own expense any areas, slopes or turf that have been damaged by his/her operations. The cost of final cleanup shall be incidental to other items and no separate payment will be made.

104.11. RESTORATION OF SURFACES OPENED BY PERMIT.

The right to construct or reconstruct any utility service within the Project or to grant permits for same, at any time, is hereby expressly reserved by the Department for the proper authorities of the municipality in which the work is done. The Contractor shall not be entitled to any damages from the Department except as provided for in Subsection 108.07. for delay or damage due to utility service construction or reconstruction by a third party or parties.

Any individual, firm, or corporation wishing to construct a utility, driveway, or make a curb-cut, or otherwise access the highway must secure a permit from the Department. The Contractor shall allow parties bearing such permits, and only those parties, to make accesses to the highway. The Contractor shall make, in an acceptable manner, all necessary repairs due to such accesses and such necessary work will be paid for as provided for in Subsection 104.04., or as otherwise provided, and will be subject to the same conditions as original work performed.

104.12. RAILWAY-HIGHWAY GRADE CROSSINGS.

On any work to be done on railway right-of-way, or on right-of-way occupied jointly by the highway and railway, the Contractor shall take such precautions necessary to ensure the safety of railway operations. The Contractor and his/her Surety shall indemnify and save harmless the Railway Company from all actions or claims of any character, name or description brought for or on account of any injuries or damages received or sustained by any person, persons, or property resulting from any act, omission, neglect or misconduct of the Contractor or his/her employees in the performance of the work.

104.13. CONSTRUCTION OVER OR ADJACENT TO NAVIGABLE WATERS.

Work over, on, or adjacent to navigable waters shall be conducted without interfering with free navigation of the waterways and so that the existing navigable depths are not impaired except as allowed by permit issued by the U.S. Coast Guard or the U.S. Army Corps of Engineers, as applicable.

104.14. CONTRACTOR'S RESPONSIBILITY FOR WORK.

Until a final completion notice is issued by the Resident Engineer, all work and material for the Contract, including any change order work, shall be at the sole risk of the Contractor, who shall protect the work against injury or damage from all causes whether arising from the execution or non-execution of the work except as provided in Subsection 104.07.b.1.

At the Contractor's expense, the Contractor shall rebuild, repair, restore, and make good all losses, injuries or damages to any portion of the permanent or temporary work occurring before the final written notice of completion except damage to permanent work caused by (a) cataclysmic phenomenon of nature, or (b) acts of public enemy or of governmental authorities; provided, however, that these exceptions shall not apply should damages result from the Contractor's failure to take reasonable precautions or to exercise sound engineering and construction practices in conducting the work.

If the performance of the work is delayed as the result of damages by others, an extension of time will be evaluated in accordance with Section 108.07.

Nothing contained in this section shall be construed as relieving the Contractor of responsibility for, or damage resulting from, the Contractor's operations or negligence, nor shall the Contractor be relieved from full responsibility for making good any defective work or materials as provided for under Section 105.12.

The Contractor shall provide a competent supervisor on the job site who is thoroughly experienced in the type of work being performed. The supervisor shall have authority to make binding decisions on behalf of the Contractor, and have authority to provide labor, equipment, and materials required for effective progress of the job. It is the intent that the supervisor be available for contact and communication on the job site irrespective of the amount of work sublet.

104.15. ENVIRONMENTAL PROTECTION.

The Contractor shall comply with all Federal, State, and local laws and regulations controlling pollution of the environment. Pollution of streams, lakes, ponds, and reservoirs with fuels, oils, bitumens, chemicals, or other harmful materials and pollution of the atmosphere from particulate and gaseous matter shall be avoided.

Fording of streams is not permitted unless the plan for such operation meets the approval of the Resident Engineer and results in minimum siltation to the stream.

When work areas or pits are located in or adjacent to streams, they shall be separated from the main stream by dike or barrier to keep sediment from entering the stream. Care shall be taken during the construction and removal of such barriers to minimize siltation of the stream.

Water from aggregate washing or other operations resulting in sediment shall be treated by filtration, settling basins, or other means sufficient to reduce the sediment concentration to no more than that of the stream or lake into which it is discharged.

Other requirements relating to temporary and permanent erosion and water pollution controls are in Section 200, Earthwork and Roadside Development.

104.16. CONTRACTOR'S RESPONSIBILITY FOR UTILITY PROPERTY AND SERVICES.

At points where the Contractor's operations are adjacent to properties of railroad, telephone, power companies, other utilities or facilities rightfully located within the limits of the Project, damage to which might result in considerable expense, loss or inconvenience, work shall not be commenced until all arrangements that are required for the protection thereof have been made.

The Contractor shall cooperate with the owners of any underground or overhead utility lines in their removal and rearrangement operations in order that these operations may progress in a reasonable manner and that duplication of rearrangement work may be reduced to a minimum and that services rendered by those parties will not be unnecessarily interrupted.

Reference is made to the Underground Facilities Damage Prevention Act (63 O.S. Section 142.1 et. seq.), including amendments, which is made part of the Contract. Copies may be obtained from the Resident Engineer.

In the event of interruption to water or utility services as a result of accidental breakage, or as a result of being exposed or unsupported, the Contractor shall immediately notify the proper authority. He/She shall cooperate with the said authority in the prompt restoration of service. In no case shall interruption to water service be allowed to exist outside of working hours. Fire hydrants shall be kept accessible to the Fire Department at all times and no materials shall be kept or stockpiled within 15 feet (4.6 meters) of any fire hydrant.

The Contractor shall check the location of all water services, water mains, sanitary sewers and other utilities shown on the Plans and shall be responsible for damages to these facilities resulting from his/her operation in accordance with the Underground Facilities Damage Prevention Act (63 O.S. § 142.1, et seq.).

104.17. VALUE ENGINEERING PROPOSALS BY THE CONTRACTOR.

Any cost savings generated to the Contract as a result of Value Engineering Proposal(s) offered by the Contractor and approved by the Department shall be shared equally between the Contractor and the Department.

Bid prices are not to be based on the anticipated approval of a Value Engineering Proposal that may be rejected by the Department. If a Value Engineering Proposal is rejected, the Contract shall be completed at the Contract bid prices.

If the Department determines that the time for response indicated in the submittal under item b.5. below is insufficient for review, the Contractor will be promptly notified. Based on the additional time needed by the Department for review and the affect on the Contractor's schedule occasioned by the added time, the Department will evaluate the need for a noncompensable delay adjustment to the Contract.

The Contractor shall have no claim against the Department for compensable or noncompensable delay to the Contract based on the failure to respond within the time indicated in item b.5. below in the submittal if additional information is needed to complete the review.

- (a) The Value Engineering Proposals contemplated are those that could produce a savings to the Department without impairing essential functions and characteristics of the facility; including but not limited to, service life, economy of operation, ease of maintenance, desired appearance, and safety.
- (b) **Submittal of Proposal.** The following materials and information shall be submitted with each proposal.
 - 1. A statement that the proposal is submitted as a Value Engineering Proposal.
 - 2. A description of the difference between the existing Contract and the proposed change, and the cooperative advantages and disadvantages of each, including effects on service life, economy of operations, ease of maintenance, desired appearance, and safety.
 - 3. A complete set of plans and specifications showing the proposed revisions relative to the original Contract features and requirements.
 - 4. A complete analysis indicating the final estimate costs and quantities to be replaced by the Value Engineering Proposal compared to the new costs and quantities generated by the Value Engineering Proposal.

5. A statement specifying the date by which a Change Order adopting the Value Engineering Proposal must be executed to obtain the maximum cost reduction during the remainder of the contract.
 6. A statement detailing the effect the Value Engineering Proposal will have on the time for completing the Contract.
 7. A description of any previous use or testing of the Proposal and the conditions and results. If the Value Engineering Proposal was previously submitted on another Department project, indicate the date, Contract number, and the action taken by the Department.
- (c) **Conditions.** Value Engineering Proposals will be considered only when all of the following conditions are met:
1. Value Engineering Proposals, approved or not approved by the Department apply only to the ongoing Contract(s) Value Engineering referenced in the Proposal and become the property of the Department. The Proposal(s) shall contain no restrictions imposed by the Contractor on their use or disclosure. The Department has the right to use, duplicate, and disclose in whole or in part any data necessary for the utilization of the Value Engineering Proposal. The Department retains the right to utilize any accepted Value Engineering Proposal or part thereof on other projects without obligation to the Contractor. This provision is not intended to deny rights provided by law with respect to patented materials or processes.
 2. If the Department is already considering certain revisions to the Contract or has approved certain changes in the Contract for general use that are subsequently incorporated in a Value Engineering Proposal, the Department will reject the Value Engineering Proposal and may proceed without obligation to the Contractor.
 3. The Contractor shall have no claim against the Department for additional costs or delays resulting from the rejection of a Value Engineering Proposal, including but not limited to, development costs, loss of anticipated profits, increased material or labor costs.
 4. The Department will determine if a Value Engineering Proposal qualifies for consideration and evaluation. It may reject any Value Engineering Proposal that requires excessive time or costs for review, evaluation, and/or investigations, or that is not consistent with the Department's design policies and criteria for the project.
 5. The Resident Engineer will reject all or any portion of work performed under an approved Value Engineering Proposal if unsatisfactory results are obtained. The Resident Engineer will direct the removal of such rejected work and require construction to proceed under the original Contract requirements without reimbursement for work performed under the proposal, or for its removal. Where modifications to the Value Engineering Proposal are approved to adjust to field or other conditions, reimbursement will be limited to the total amount payable for the work at the Contract bid prices as if it were constructed under the original Contract requirements. The rejection or limitation of reimbursement shall not constitute the basis of any claim against the Department for delay or for other costs.
 6. The proposed work shall not contain experimental features but shall be proven features that have been used under similar or acceptable conditions on other projects or locations acceptable to the Department.

7. Value Engineering Proposals will not be considered if equivalent options are already provided in the Contract.
 8. The savings generated by the Value Engineering Proposal must be sufficient to warrant a review and processing.
 9. A Value Engineering Proposal changing the type and/or thickness of the pavement structure will not be considered.
 10. Additional information needed to evaluate Value Engineering Proposals shall be provided in a timely manner. Untimely submittals of additional information will result in rejection of the Value Engineering Proposal. Where design changes are proposed, the additional information could include results of field investigations and surveys, design computations, and field change sheets.
- (d) **Payment.** If the Value Engineering Proposal is accepted, the changes and payment will be authorized by Change Order. Reimbursement will be made as follows:
1. The changes will be incorporated into the Contract by changes in quantities of unit bid items, and/or new agreed price items, as appropriate, under the Contract.
 2. The cost of the revised work as determined from the changes will be paid directly. In addition, the Department will pay the Contractor 50 percent of the savings to the Department as reflected by the difference between the cost of the revised work and the cost of the related construction required by the original Contract computed at Contract bid prices. The 50 percent Value Engineering cost savings will be paid to the Contractor in a lump sum as soon as savings have been earned and quantities ascertained.
 3. Costs for development, design, and implementation of the Value Engineering Proposal are not eligible for reimbursement.
 4. The Contractor may submit Value Engineering Proposals for an approved subcontractor. Subcontractors may not submit a Proposal except through the Contractor.

104.18. RAILWAY-HIGHWAY GRADE SEPARATION STRUCTURES AND APPROACHES THERETO.

- (a) **General.** The construction of grade separation structures and approaches thereto is a joint undertaking of the Department and the Railway Company whose tracks are crossed, and representatives of the Railway Company shall have full authority to make inspections of the work as it progresses.

Unless otherwise specified in the Contract for a project, or a separate right of entry agreement between the Contractor and the Railway Company, the Contractor shall notify the Railway Company or companies listed on the Plans and at their office so indicated, in writing, at least ten (10) days in advance of starting work on the Railway Company's property. Additional notification shall be given to the Railway Company forty-eight (48) hours in advance of the starting of construction of falsework over the tracks of the Railway Company or the construction of piers adjacent thereto or as may be required by the Contractor's right of entry agreement with the Railway Company.

In all phases of the work affecting the Railway Company, the Contractor shall cooperate with them to the fullest extent possible. The Contractor shall plan and execute the work so that there

will be the least possible interference with the traffic and operations of the Railway Company. The Contractor will be required to maintain a clearance area for the maintenance of railway traffic during construction and said clearance area shall be kept free at all times from any falsework, equipment, materials or other obstructions. Unless otherwise specified on the Plans, or a separate right of entry agreement between the Contractor and the Railway Company, the minimum vertical clearance shall be 22 feet (6.6 meters) above the top of the highest rail and the minimum horizontal clearance shall be 8½ feet (2.6 meters) on each side of and measured at right angles to the centerline of the tracks. It shall be a responsibility of the Contractor not to disrupt the normal operation of the track drainage system. No equipment or materials shall be allowed to remain in the ditches in such a manner as to obstruct the flow of water. Any material spilling into the ditches shall be removed immediately.

In case the Contractor, by written agreement with the Railway Company, is permitted to encroach upon the clearance specified herein in, a separate right of entry agreement between the Contractor and the Railway Company or on the Plans, he/she shall at his/her own expense take such precautions and shall erect and maintain such telltales or warning devices as the Railway Company requires.

In the event the Contractor is required or elects to haul material across the Railway Company's tracks, he/she shall make his/her own arrangements with the Railway Company for necessary private crossings and all costs incurred in the installation, maintenance, use or protection of such crossings shall be borne by the Contractor.

The Contractor shall take the required precautions necessary to ensure the safety of the railway operations. He/She shall prepare, and submit for approval by the Department and the Railway Company, detailed plans for all falsework over the tracks and caissons or sheetings for piers, or abutments adjacent to or under the tracks before doing any work on same. After obtaining approval from the Bridge Engineer and the Railway Company of such plans, said falsework, sheeting and caissons shall be constructed strictly in accordance with the Contractor's plans. By approval of the Contractor's plans, the Department neither accepts nor assumes any liability for defects or error in the Plans. The Department makes no warranty either expressed or implied as to the accuracy or fitness of the Contractor's plans.

The Contractor will be responsible to the Railway Company for all damages to railroad property resulting from the Contractor's operations and may be subject to such additional conditions as are specified in the Railway Company's right of entry agreement. Contractor's final estimate will not be paid until the Contractor provides satisfactory evidence in the form of a photocopy of a letter sent by the Contractor to the Railway Company by certified mail, notifying the Railway Company of completion and acceptance of the work required by the Contract and providing the Railway Company with a thirty (30) day time in which to notify the Contractor and the Department of potential claims, to the Resident Engineer that this requirement has been fulfilled. Upon completion of the work, Contractor shall remove all equipment, unused materials, rubbish, and temporary structures, and shall leave the premises in a neat and satisfactory condition.

When specifically permitted by the Plans and the Contract, certain construction operations may necessitate the suspension of railway traffic. In order to avoid any disruptions of train schedules, such construction operations will necessarily have to be completed in as short a time as pos-

- sible. Before starting such a construction operation, the Contractor shall fully advise the Railway Company and the Department as to the method he/she proposes to follow, the amount and character of equipment which he/she proposes to use and the probable time required to complete the operation, all of which shall be subject to the approval of the Resident Engineer and the Railway Company. Such approval, however, shall not be considered as relieving the Contractor of the responsibility for the safety of his/her method or equipment or from carrying out the work in full accordance with the Contract.
- (b) **Overpass (Highway Overhead Bridge).** The Department will provide a vertical clearance of 50 feet (15 meters) measured from the base of the rail, for telegraph, telephone and signal services. In the event that the Contractor desires more clearance, such additional clearance shall be made at his/her own expense.
 - (c) **Underpass (Railroad Overhead Bridge).** The Department will provide a vertical clearance of 30 feet (9 meters) measured from the base of the rail, for telegraph, telephone and signal services crossing over the proposed construction. In the event that the Contractor desires more clearance, such additional clearance shall be made at his/her own expense.
 - (d) **Railway Company Requirements.** The Railway Company may as a condition for working on or over railroad right-of-way impose both vertical and horizontal clearance requirements. Clearance requirements for working on or over railroad right-of-way will be contained in the right of entry agreement between the Contractor and the Railway Company.

104.19. RAILROAD FLAGGING.

The Contractor shall reimburse the Railway Company directly for the cost of all railroad flagging required by the Railway Company due to construction on their property. The cost of flagging shall be included in the unit prices bid by the Contractor for other items of work. There will be no additional payment to the Contractor for this cost.

The Contractor's final estimate will not be paid until the Contractor provides satisfactory evidence in the form of a notarized certificate by Contractor that he/she has wholly reimbursed the Railway Company for flagging services.

SECTION 105 CONTROL OF WORK

105.01. AUTHORITY AND DUTIES OF THE RESIDENT ENGINEER.

The Resident Engineer will decide all questions regarding the quality and acceptability of materials furnished, work performed, and the rate of progress of the work, the interpretation of the Contract, and the acceptable fulfillment of the Contract by the Contractor.

- (a) The Resident Engineer will suspend the work wholly or in part for the Contractor's failure to:
 - 1. Correct conditions unsafe for the project personnel or general public, or
 - 2. Carry out provisions of the Contract, or
 - 3. Carry out orders of the Resident Engineer.

- (b) Work may also be wholly or partially suspended for:
 - 1. Periods necessary due to unsuitable weather, or
 - 2. Conditions considered unsuitable for the prosecution of the work, or
 - 3. Any other condition or reason determined to be in the Department's interest.
- (c) Should the Contractor disagree with any decision of the Resident Engineer in the exercise of "The authority of the Resident Engineer", he/she may appeal the decision in accordance with established dispute resolution procedures.
- (d) Resident Engineer has immediate charge of the engineering details of the Project, and is responsible for inspection and documentation of the contractor's efforts towards compliance with Contract requirements. The authority of the Resident Engineer extends to: the ability to make binding decisions on behalf of the Department within the requirements of the Contract; the designation of his/her representatives on the job site; to reject defective materials or workmanship; and to suspend any work not in compliance with Contract requirements.
- (e) The Resident Engineer has the authority to direct the removal by the contractor of any superintendent, foremen, or other supervisor or any other employee of the contractor or a subcontractor of the contractor for failure or refusal to follow orders of the Resident Engineer, for safety violations, poor workmanship, and for other good cause shown. Removal shall be effected by written notice to the contractor and the order for removal shall be effective upon receipt by the contractor.

105.02. PLANS AND WORKING DRAWINGS.

- (a) **General.** Plans furnished by the Department will show details of all structures, lines, grades, typical sections and a summary of pay items appearing on the Proposal.

Contractor will prepare working drawings and work plans, as specified and as needed, to adequately control, construct, and inspect the work. Working drawing shall include, but not be limited to, traffic control drawings, false work drawings, coffer dam drawings, MSE retaining wall drawings, post tensioned concrete structure drawings, prestressed concrete member shop drawings, precast box culvert drawings, structural steel shop drawings, anchor bolt layouts, and erection drawings. Work plans may include, but not be limited to, stress sheets for post tensioning, work plans for painting and drilling shafts, mix designs, pile hammers, other equipment lists, and quality control plans. The Contractor shall keep one set of plans and approved working drawings and work plans available on the work site for the duration of the Project.

The Contractor shall not perform the work covered by the working drawings and work plans before approval. No changes or deviations from the approved submissions may be made without prior approval. The approval of submissions not relieve the Contractor of responsibility for the successful completion of the work.

The cost of furnishing work drawings and work plans shall be included in the bid prices of related pay items.

- (b) **Submissions.** The Contractor shall furnish working drawings and work plans for approval. Work drawings and work plans, if returned for correction, will be corrected appropriately and resubmitted for approval. For the Engineer's review, allow a minimum of six weeks per submission of

railroad structures and two weeks per submission of all other structures unless otherwise specified. Contractors shall submit complete sets of working drawings except when submitting corrections or revisions. Partial sets will not be reviewed without permission of the Engineer.

Working drawings and working plans shall be submitted with a transmittal letter which contains the Project number, job/piece number, county, structure number, a list of enclosed working drawing sheets, and, when applicable, a list of changes.

- (c) **Working Drawing Requirements.** Contractor shall use drafting and lettering on the working drawings that is clearly legible under field conditions and when microfilmed. Working drawings should be oriented to be as similar as possible to those on the Plans.

Contractor shall use sheets 24 inch (610 mm) by 36 inch (920 mm) or smaller for drawings. Each sheet must include a title block in the lower right hand corner. The title block shall include the Project number, job/piece number, county, location description as shown on the Plans, structure number, sheet number, the Contractor's name, and, when applicable, the name of the supplier, fabricator, or manufacturer supplying material, product, or equipment for use on the Project. A space 2 inch (50 mm) wide by 3 inch (75 mm) high will be provided near the title block for the approval stamp. Revisions of previously approved drawings, will identify all revisions on each sheet and include a description of each revision near the title block of each sheet.

Working drawings will contain on each sheet the initials of the drafter and checker and the date each was completed. The drafter and checker shall be two separate individuals qualified in the drafting and checking of the type of item detailed.

Contractor shall describe all materials to be used in the work on the drawings, including the appropriate materials specification and any other distinguishing characteristics and ordering information, such as grade.

Working drawing and changes in engineer design shall bear the seal and signature of a professional engineer registered in the State of Oklahoma proficient in the pertinent design field. As a minimum, the following matrix will be used to determine when working drawings require approval, signature, and seal of an Oklahoma registered professional engineer. When Specific Standard specifications apply to required working drawings and the Standard Specifications differ from the following matrix, the requirements of the specific Standard Specifications will be followed:

<p style="text-align: center;">WORKING DRAWINGS FOR</p>	<p style="text-align: center;">REQUIRES REGISTERED PROFESSIONAL ENGINEERS SIGNING, SEALING & DATE</p>	<p style="text-align: center;">REQUIRES DEPARTMENTAL APPROVAL</p>
<p>1. Alternate or Optional Designs submitted by Contractor</p>	<p style="text-align: center;">YES</p>	<p style="text-align: center;">YES</p>
<p>2. Supplementary fabrication and shop drawings for structural items</p>	<p style="text-align: center;">No - unless required on the plans</p>	<p style="text-align: center;">See applicable item</p>
<p>3. Contractor proposed temporary facilities, that affect the public safety, not included on the plans</p>	<p style="text-align: center;">YES</p>	<p style="text-align: center;">YES</p>

105.03. CONFORMITY WITH PLANS AND SPECIFICATIONS.

Work performed and materials furnished shall be uniform in character and meet the Contract dimensions and material requirements, according to tolerances specified in the Contract. When either a maximum or minimum tolerance value or both is specified in the Contract, the production and processing of the material and the performance of the work shall be controlled so that the finished product is not of borderline quality or dimension.

If materials furnished, work performed, or the finished product does not conform with the Contract, but adequately addresses the design purpose, the Resident Engineer will determine the conditions under which the work will be accepted and allowed to remain in place unless there are other provisions in the Contract that provide for this determination. Where this determination is made by the Resident Engineer rather than Contract provisions, the Resident Engineer will document the basis of acceptance by Contract modification. The modification will provide for an appropriate adjustment in the Contract price for such work or materials as necessary to support the Resident Engineer’s determination.

If the materials, work performed, or the finished product do not conform with the Contract and results in an unsatisfactory or unacceptable product, the work or materials shall be removed and replaced or otherwise corrected to the satisfaction of the Resident Engineer, at the Contractor’s expense.

If there are provisions in the Contract for the acceptance of material or work that is not in full compliance with the minimum requirements stated, the use of pay adjustment factors reflecting the payment to be made for the work or materials will be included in the applicable Subsection concerning method of measurement and payment or in a separate Subsection.

105.04. COORDINATION OF PLANS, SPECIFICATIONS, SUPPLEMENTAL SPECIFICATIONS, AND SPECIAL PROVISIONS.

These Specifications, Supplemental Specifications, Plans, Special Provisions, and all supplementary documents are essential parts of the Contract and a requirement occurring in one is as binding as though occurring in all. They are intended to be complementary and to describe and provide for a complete Contract. In case of discrepancy between these Contract components, the governing ranking will be:

<u>Dimensions</u>	<u>Information</u>
1. Project Plans	1. Special provisions
2. Calculated	2. Project Plans
3. Standard Specifications	3. Supplemental Specifications
4. Standard Plan Sheets	4. Standard Specifications
5. Scaled	5. Standard Plan Sheets

Oral changes received at pre-bid conferences are not binding. Changes must be reduced to writing and issued as addenda before they can be binding.

The Contractor shall not take advantage of any apparent error or omission in the Contract. If an error or omission is discovered, the Resident Engineer shall be promptly notified so corrections and interpretations necessary to fulfill the intent of the Contract can be made. Plan notes which appear to be in conflict, or which require clarification shall be referred to the Resident Engineer for resolution prior to commencement of work. See Subsection 101.53.b.

105.05. COOPERATION BY CONTRACTOR.

The Contractor will be supplied with a minimum of two sets of Plans and one copy of the Contract. One set of Plans, Specifications and Special Provisions shall be available on the work site at all times.

The Contractor shall give the work the constant attention necessary to facilitate the progress thereof, and shall fully cooperate with the Resident Engineer, his/her Inspectors, and other Contractors.

105.06. COOPERATION WITH UTILITIES.

Utility items that are to be relocated or adjusted by the utility owner, others, and/or the Contractor will be shown in the Contract.

All utility facilities and appurtenances within the construction limits will be shown on the Contract plans and relocated or adjusted at the utility owners' expense, unless otherwise specified. The location of these utilities are as provided by the utility owners and may not be exact, particularly with regard to underground installations. Contractor work procedures are to account for the inaccuracy inherent in the representation of their locations.

The Contractor shall cooperate with utility owners in the removal and rearrangement of underground or overhead utility facilities to minimize interruption to utility service and duplication of work by the utility owners.

Facilities or appurtenances that are to remain in place during construction shall be accounted for and protected by the Contractor's work procedures.

The Department will notify utility companies, pipeline owners or other utility agencies affected by the Contract work and have all necessary adjustments of the public or private utility fixtures and appurtenances within or adjacent to the construction limits accomplished within the time limits set forth in the Proposal or prior to the effective date of the work order, whichever occurs first. The Contractor may request a waiver of these requirements to facilitate beginning of work, if Project conditions warrant.

In the event utility services are interrupted as a result of breakage by the Contractor within the construction limits, the Contractor is to notify the appropriate utility authorities and cooperate with them until service has been restored. Work shall not commence around fire hydrants until provisions for continued service has been made and approved by the local fire authority.

Repairs to damaged utilities caused by carelessness or omissions on the part of the Contractor shall be corrected at the Contractor's expense. The damaged facilities shall be restored to a condition similar or equal to that existing before the damage occurred.

If utility facilities or appurtenances are found that are not noted in the Contract documents, the Resident Engineer will determine whether adjustment or relocation of the utility is necessary to accommodate construction and proceed to make necessary arrangements with the utility owner or the Contractor if the work necessary is not otherwise specified.

105.07. COOPERATION BETWEEN CONTRACTORS.

The Department reserves the right at any time to contract for and have performed other work within or near the Project limits covered by the Contract.

When separate Contracts are let within limits of any one Project, each Contractor shall conduct his/her work so as to minimize interference with the progress or completion of the work being performed by other Contractors. Contractors working on the same Project shall cooperate with each other and coordinate their operations in such a manner as to facilitate prompt and expeditious completion of their Contracts. Contractors failing to cooperate with other Contractors may be declared in default on their Contract.

The Contractor shall arrange his/her work and shall place and dispose of the materials being used so as to minimize interference with the operations of the other Contractors within the limits of the same project. He/She shall join his/her work with that of the others in an acceptable manner and shall perform it in proper sequence to that of the other Contractors.

At all grade separations and/or bridge structures where the Plans indicate fills at abutments are to be made by the Grading Contractor, the Grading Contractor shall begin grading operations at these locations immediately upon beginning work on the Project, unless otherwise provided for in the Contract, and shall complete the fills adjacent to abutments without undue delay. No rock over 2

inches (50 mms) in the largest dimension shall be placed in fills within 30 feet (9 m) of abutment locations.

At all grade separation structures where the Plans indicate that roadway excavation through the structure location is to be made by the Grading Contractor, the Grading Contractor shall begin grading operations at these locations immediately upon beginning work on the Project and shall complete this work without undue delay. Excavation at these locations shall not extend beyond the width of excavation shown on the underpass Plans.

The Bridge Contractor shall complete the bridge boxes and the backfills around the bridge boxes to the top of the box or to the natural ground line, whichever is the lower, as soon as possible after the Contract is effective, so that the Grading Contractor may make the roadway fills over these bridge boxes.

If the Grading Contractor has completed his/her Project, except for fills at bridge boxes to be constructed by the Bridge Contractor prior to completion of these boxes, the Bridge Contractor shall make the roadway fills to the typical section and subgrade line as shown on the Plans.

Each Contractor shall be solely responsible for his/her actions for all work performed under the Contract and shall save and hold harmless the Department, its officers, agents and employees from any and all damages or claims arising from his/her conduct that may arise because of inconvenience, delay or other loss which may be experienced by him/her because of the presence of other contractors working in the Project limits.

105.08. CONSTRUCTION STAKES, LINES AND GRADES.

The Contract provisions will state whether the Contractor or the Department is to provide construction stakes, lines, and grades, in accordance with Section 642.

105.09. (RESERVED)

105.10. DUTIES OF THE PROJECT INSPECTORS.

Project Inspectors employed by the Department will be authorized to inspect all work done and materials furnished. Inspection may extend to all or any part of the work and to the preparation, fabrication or manufacturing of the materials to be used. The Inspector is not authorized to alter or waive the provisions of the Plans or the Contract.

105.11. INSPECTION OF WORK.

All materials and each part or detail of the work shall be subject to inspection. The Contractor shall allow access to all parts of the work and shall furnish such information and assistance as is required to make complete and detailed inspections and to document the Contractor's efforts towards satisfactory completion of the Project. Inspections may be made by the Resident Engineer or his/her representative, the FHWA or other federal agencies, the DEQ or other state agencies, counties, cities and other public or private entities having supervisory, regulatory or financial interest in the Project.

Contractor will make reasonable good faith effort to perform all work, and materials incorporated into the work, in the presence of a Department representative. If the Department representative is unavailable for such inspection or is otherwise absent at such time as the work is performed, the

Contractor's representative will make written documentation as to his/her efforts to contact the Inspector. In the event that such good-faith effort and documentation requirements are not complied with, any such work done or materials used may be ordered removed and replaced at the Contractor's expense.

If the Resident Engineer requests, the Contractor, at any time before acceptance of the work, shall remove or uncover such portions of the finished work as may be directed. After examination, the Contractor shall restore said portions of the work to the standard required by the Contract. If the work thus exposed or examined proves acceptable, the uncovering or removing, and the replacing of the covering or making good of the parts removed will be paid for in accordance with Subsection 104.04. Should the work so exposed or examined prove unacceptable, the uncovering or removing, and the replacing of the covering or making good of the parts removed, will be at the Contractor's expense.

Any work done or materials used without inspection by an authorized Department representative may be ordered removed and replaced at the Contractor's expense unless the Department representative failed to inspect after having been given at least 24 hours notice in writing that the work was to be performed.

When any unit of government or political subdivision or any railroad corporation is to pay a portion of the cost of the work covered by this Contract, its respective representatives shall also have the right to inspect the work. Such inspection does not make any unit of government, political subdivision, or any railroad corporation a party to this Contract.

105.12. REMOVAL OF UNACCEPTABLE AND UNAUTHORIZED WORK.

Work that does not conform to the Contract requirements will be considered unacceptable, unless accepted under the provisions of Subsection 105.03.

Unacceptable work found to exist before the final acceptance of the work, resulting from any cause, shall be removed and replaced at the Contractor's expense.

Work done contrary to instructions received from the Resident Engineer, or beyond the Plan limits, or extra work done without permission of the Resident Engineer will not be considered for payment until corrected to the satisfaction of the Resident Engineer. Corrective work meeting the Contract provisions shall be at the expense of the Contractor. If corrective work prosecution ordered by the Resident Engineer is not provided, the Resident Engineer has the authority under this Subsection to have the unacceptable work removed and remedied by the Department to deduct the costs of such work from the monies due the Contractor.

105.13. LOAD RESTRICTIONS.

The Contractor shall comply with all legal load restrictions in the hauling of materials on public roads beyond the limits of the Project. A special permit does not relieve the Contractor's liability for damage that results from moving material or equipment.

Legal load limits within the Project limits may not be exceeded unless permitted in writing by the Resident Engineer. Operation of equipment or hauling loads that cause damage to structures, roadway, or any construction is not permitted. The Resident Engineer will determine acceptable load limits for bridges. The hauling of materials over any completed work within the Project limits will be restricted as directed by the Resident Engineer. No loads will be permitted on hydraulic cement concrete construction before the minimum curing time or strength specified is obtained.

105.14. MAINTENANCE DURING CONSTRUCTION.

The Contractor shall maintain the Project work site in a satisfactory condition until the Project is accepted. This maintenance shall consist of continuous and effective work prosecuted day-by-day.

The Resident Engineer will immediately notify the Contractor of failure to meet these provisions. If unsatisfactory maintenance is not remedied within 24 hours after receipt of the notice, the Resident Engineer will proceed to maintain the Project. The entire cost of this maintenance will be deducted from monies due or to become due the Contractor.

If the Contract involves the placement of material on, or the utilization of a previously constructed subgrade, base course, pavement or structure, the previously constructed work shall be maintained by the Contractor during construction operations.

The cost of maintenance work during construction and before the Project is accepted shall be incidental to the bid price for other items of work.

105.15. OPENING SECTIONS OF PROJECT TO TRAFFIC.

The Resident Engineer may order certain sections of work to be opened to traffic before completion or acceptance of the work. Opening these sections shall not constitute acceptance of the work or waiver of any contract provisions.

On those sections opened to traffic, the cost of maintaining the roadway to accommodate traffic will be at the Department's expense and the Contractor will be compensated for costs incurred in accordance with Subsection 109.04. Compensation for additional expense and additional time if any, shall be set forth in a change order for those sections of the Project ordered opened to traffic if the opening is not due to the fault or inactivity of the Contractor.

If the Contractor is late in completing features of the work according to the Contract or progress schedule, the Resident Engineer will give written notification establishing a time period for completing these features. If the Contractor fails to complete or make a reasonable effort to complete the work according to the written notification, the Resident Engineer may order all or a portion of the project opened to traffic. The Contractor shall not be relieved of liability or responsibility for maintaining the work and shall conduct the remaining construction operations with minimum interference to traffic without additional compensation for the added cost of the work.

Damage to the Project that is not attributable to traffic (except slides) shall be repaired at the expense of the Contractor. The removal of slides shall be done on a basis determined by the Resident Engineer before removal.

105.16. FURNISHING RIGHT-OF-WAY.

The Department will secure right-of-way in advance of construction, and will ensure the right-of-way is available to the Contractor's unrestricted operations. Exceptions will be indicated in the Plans and Contract.

105.17. PROJECT COMPLETION AND ACCEPTANCE.

Upon notification from the Contractor that he/she has performed the work required by the Contract, the Resident Engineer will make an inspection. If all construction is found to have been completed

in accordance with the Contract or any change order(s) or supplemental agreement(s) applicable thereto, the Resident Engineer will declare the Project complete and the Contractor relieved of all construction site responsibilities. If, however, the inspection discloses any work, in whole or in part, not in accordance with the Contract, the Resident Engineer will give written notice to the Contractor of the exceptions found in the inspection, and the Project will not be declared complete until the Contractor satisfies the exceptions noted.

If at any time during the construction of a Project, the Contractor completes a unit or portion of the Contract, such as a structure, an interchange, or a section of road or pavement, he/she may request the Resident Engineer to make a final inspection of that unit. If the Resident Engineer finds upon inspection that the unit has been completed in accordance with the Contract and any change order(s) or supplemental agreement(s) which may be applicable thereto, the Resident Engineer may declare the unit completed. If the Resident Engineer finds on inspection that the unit has been completed, a completion date for that unit will be established and the Contractor will be relieved of further responsibility for that unit. The decision to declare a partial completion is solely at the discretion of the Resident Engineer. A partial completion does not void or alter any terms of the Contract.

Final acceptance will not occur until all documents, certificates and proofs of compliance have been executed and submitted by the Contractor. However, at the request of the Contractor and at the discretion of the Resident Engineer, the Contract time may be stopped before all required documents, certificates, or proofs of compliance are furnished. If documentation required for acceptance includes compliance documentation for materials which must normally be documented before incorporation in the work, the Contractor must establish that he/she could not reasonably or in good faith provide the compliance documentation at the appropriate time while the Project was under construction. If the Resident Engineer stops the Contract time to allow the Contractor to secure documentation, the Contractor must expeditiously provide the exempted documents, certificates, or proofs of compliance. Final acceptance and final payment will not be made until all documents, certificates, or proofs of compliance have been executed and delivered to the Resident Engineer. The date of final acceptance by the Resident Engineer will govern, in accordance with statutes and regulations, for the payment of any interest on monies due the Contractor. Final acceptance and payment will not be made until all documents, certificates, or proofs of compliance have been executed and delivered to the Resident Engineer.

105.18. CLAIMS FOR ADJUSTMENT.

If additional compensation has been requested and denied and is considered by the Contractor to be due for work or material not covered in the Contract, or for additional time in which to complete Contract requirements for completion of the work, written notification of the intent to make a claim under Subsection 104.06. shall be given to the Resident Engineer. Such notice shall be submitted before beginning work not covered by the Contract or a change of plan, or continuing work which is in progress but which has been altered by directed changes in methodology or location or differing site conditions.

Written notice of intent to file a claim before beginning or continuing affected work is a required prerequisite to the submission of a claim. Written notice will not be waived. The notice of intent to file a claim will allow the Department to evaluate options which may reduce or minimize the impact of increased Project costs.

The Resident Engineer will respond as described under Subsection 104.06.c. following notification. The Contractor shall provide necessary cooperation and information to the Resident Engineer during the period of notification, review, and evaluation to provide possible resolution of the Contract question and avoid, if possible, further claim process actions.

If written notification is not given, and if the Contractor does not afford the Resident Engineer proper facilities for keeping strict account of actual costs, the Contractor waives any claim for additional compensation. Notice by the Contractor, and the fact that the Resident Engineer has kept account of the costs shall not be construed as substantiating the validity of the claim. Within ninety (90) days after the completion of the work for which extra compensation or time is requested, the Contractor shall submit to the Resident Engineer specific cost information attributable for each element of the request for additional compensation on the latest edition of the Department's form entitled "Cost Breakdown for Support of Supplemental Agreement." If a fully documented claim is not submitted to the Resident Engineer within ninety (90) days, no extra compensation or additional time shall be allowed.

(a) **Requirements for Contractor Claims.** Claim submittals shall be in sufficient detail to enable the Resident Engineer to determine the basis for entitlement and the resulting costs. No claim will be accepted on any contract which has been bid and awarded on a unit price basis for additional costs, lost profits, or for any other compensation, which has been prepared on a total cost or modified total cost basis, for the contract work or any portion thereof, or in any other form which would, if approved, result in compensation to the contractor, on a total cost-plus or a total unit cost basis. For the purpose of these Specifications, the terms "Total cost claim" or "modified total cost claim" shall be deemed to include all work required by the Contract or any portion, unit, part or parts of the work required by the Contract however such portion, unit, part or parts of the work may be identified, categorized or isolated from remaining work and any claim for compensation for all work on the Contract or for any portion, unit, part or parts of the work of the Contract using any form, technique, method or mode which results in a "total cost" figure, sum or result from cost computation. The following minimum information must accompany each claim submitted:

1. Detailed factual statement of the claim providing all necessary dates, locations, and items of work affected by the claim, in the following form:

<u>SECTION</u>	<u>DESCRIPTION</u>
I - Introduction	The purpose of the introduction is to present a general background in sufficient detail to provide an overview of the claim.
II - Contract Requirements	The purpose of the Contract requirements is to establish what provisions in the Contract documents that the Contractor relied on to prepare the bid and schedule for the conduct of the work. This Section establishes what Contract provisions the Contractor relied on and provide

the basis for measurement of the differences between what the Contractor anticipated and what actually occurred. The Contractor must establish a right under the Contract on which the Contractor relied to provide a basis for the Contractor's claim.

III - Contractor's Schedule

The purpose of this Section is to provide an opportunity to demonstrate that the Contract element(s) identified in the preceding Section were critical to its scheduled completion of the Contract requirements. The Contractor must demonstrate in this Section that its reliance on the above identified Contract provisions was reasonable for establishing the Contractor's Progress Schedule, the means, and methods which he/she planned to do the work. The Contractor's Progress Schedule used to support this Section must be the schedule provided to the Department pursuant to Subsection 108.03.a or 108.03.b prior to commencement of project work. Estimated cost for performance of required contract work may be supported by either bid documents used in bidding the project or by empirical data from Contractor's performance on previously completed projects.

IV - Variations in the Contract Requirements Encountered on the Project

The purpose of this Section is to allow the Contractor to clearly demonstrate that the actual conditions and circumstances encountered in building the Project differed materially from the requirements of the Contract.

V - Effects of the Variations

The purpose of this Section is to allow the Contractor to explain how the changes in conditions and circumstances Contractor's Plan affected the Contractor's work.

2. The date actions resulting in the claim occurred or conditions resulting in the claim became evident.
3. A copy of the written "Notice of Intent to File a Claim," filed by the Contractor for the specific claim.
4. The name, title, and activity of each Department employee knowledgeable about facts that gave rise to such claim.

5. The name, title, and activity of each Contractor employee knowledgeable about facts that gave rise to such claim.
6. The specific provisions of the Contract that support the claim, and a statement why the provisions support the claim.
7. A weekly listing of all construction equipment in use or approved by the Resident Engineer to be held in standby condition due to the work which is the subject of the Claim to include the type, make, model and year of manufacture. The listing will reflect hours that equipment was in use or standby condition due to the work which is the subject of the claim. No equipment claim costs may be allowed for those periods of time for which the Contractor failed to file the equipment listing.
8. The identification of any pertinent documents relating to the claim.
9. A statement whether the additional compensation or extension of time is based on the provisions of the Contract or an alleged breach of Contract.
10. If an extension of time is also sought, the specific days for which it is sought and the basis for such claim as determined by an analysis of the Contractor's Progress Schedule as provided to the Department pursuant to Subsection 108.03.a. or 108.03.b. prior to commencement of Project work.
11. The amount of additional compensation sought and a breakdown of that amount as provided in Section 109.04.

Failure to submit a claim prior to final payment on the Contract shall constitute a waiver of all claims.

- (b) **Required Certification of Claims.** The claim submittal shall include the Contractor's written certification, under oath, attesting to the following:
1. The claim is made in good faith.
 2. Supportive data is accurate and complete to the Contractor's best knowledge and belief.
 3. The amount of the claim accurately reflects the Contractor's true cost incurred.
 4. The amount of the claim has been adjusted and reduced to reflect change orders related to the claim for which the Contractor has previously been compensated.

In complying with this requirement, the Contractor shall use the Department's Certificate of Claim form as shown as follows:

CERTIFICATE OF CLAIM

Under the penalty of law for perjury or falsification, the undersigned,

_____,
(Name)

_____,
(Title)

_____,
(Company)

hereby certifies that the claim for extra compensation and time, if any, made herein for work on this Contract is a true, accurate, and complete statement of all actual costs incurred and time sought, and is fully documented and supported under the Contract between the parties. I further certify that I am authorized to submit this Claim on behalf of _____ and to bind this company as to this matter. This claim has been adjusted and reduced to reflect change orders related to this claim for which this company has previously been compensated.

The above information is true and correct to the best of my knowledge

.WARNING.
IT IS A FELONY TO MAKE OR PRESENT A FALSE, FICTITIOUS OR FRAUDULENT CLAIM FOR PAYMENT OF PUBLIC FUNDS. THE STATE OF OKLAHOMA WILL PROSECUTE AND CONVICTION MAY RESULT IN CRIMINAL PENALTIES.
(21 O.S.§§ 358, 359)

Authorized Signature

Social Security No. or Federal ID No.

STATE OF OKLAHOMA)
) §:
COUNTY OF _____)

On the _____ day of _____, 19____ (20 ____), before me personally appeared _____ to me known to be the person(s) named herein and who executed the foregoing document and acknowledge to me that _____ voluntarily executed the same.

My Commission Expires:
_____, 19__ (20 ____)

Notary Public

- (c) **Documentation of Claims.** Claims for additional compensation for differing site conditions, changes in the character of work, or for extra work will be assessed and their value determined in accordance with the provisions of Section 109.04. Claims for extension of Contract time will be evaluated in the manner prescribed in Section 108.07.
- (d) **Review of Request for Additional Compensation or Time.** The Resident Engineer shall make a written response to the Contractor's request for additional compensation or time after a review of the request which shall occur within the following time periods:
1. Forty-five (45) calendar days from the receipt of the Contractor's claim including all required supporting documentation when the claim is in the amount of one hundred thousand dollars (\$100,000.00) or less;
 2. Ninety (90) calendar days from the receipt of the Contractor's claim including all required supporting documentation when the claim is in an amount of more than one hundred thousand dollars (\$100,000).

The Engineer and the Contractor may agree in writing to an extension of the time limits set forth above.

If no agreement is reached between the Contractor and the Department within fifteen (15) days after the Department's period of review, as set forth above and any extensions thereof, the Contractor may proceed as if the claim had been formally denied, in accordance with the currently adopted dispute resolution procedure, as incorporated in the Contract.

If the Engineer does not issue a written decision on the Contractor's claim within the appropriate time period set forth herein, the claim shall be deemed denied and the Contractor may appeal such as a formal denial, in accordance with the currently adopted dispute resolution procedure, as incorporated in the Contract.

Nothing in this Subsection shall be construed as establishing any claim contrary to the terms of Subsection 104.06. or 108.07.

SECTION 106 CONTROL OF MATERIALS

106.01. SOURCE OF SUPPLY AND QUALITY REQUIREMENTS.

All materials used shall meet the quality requirements of the Contract. The Contractor shall notify the Resident Engineer of the proposed sources of materials to be used in the work before delivery. The Resident Engineer has the option of conditionally approving materials at the supply source. Conditionally approved material incorporated into the work, if subsequently found to be unacceptable, shall be removed and replaced or otherwise corrected at Contractors expense to satisfaction of Resident Engineer. All materials used in the work shall be new unless otherwise specified in the Contract.

- (a) When the Contractor has an option of using one of two or more materials or products as covered by a bid item of work in the Proposal, the successful bidder shall advise the Department in writing of the specific materials or product that he/she will use on the Project.

- (b) **“BUY AMERICA”** provision as required by Title 23 Code of Federal Regulations § 634.410: Except as expressly provided herein, all manufacturing processes of steel or iron furnished under this Contract shall occur in the United States, including the application of coating, galvanizing, painting, and other coating that protects or enhances the value of steel or iron products. Pig iron, processed, pelletized and reduced iron ore materials and processed alloys, unless such alloys have been processed or refined to include substantial amounts of steel and/or iron materials, are exempt and may be used irrespective of source in the domestic manufacturing process for steel and/or iron materials.
1. The requirements do not prevent a minimal use of foreign steel if the cost of such materials does not exceed one-tenth of one percent (0.1 percent) of the total Contract cost or \$2,500.00, whichever is greater. The Contractor shall submit the origin and value of any foreign materials used.
 2. The Contractor shall submit a certification stating that all manufacturing processes involved with the production of steel or iron materials occurred in the United States.

106.02. LOCAL MATERIAL SOURCES.

Possible sources of local materials may be designated. The Contractor shall determine the amount of equipment and work required to produce a material meeting the specifications. Since it is not feasible to determine from natural deposit sampling the acceptable limits for an entire deposit, variations in materials quality within the deposits are to be considered usual and to be expected. The Resident Engineer may order procurement of material from any portion of a deposit and will reject portions of the deposit as unacceptable if the material fails to meet Specification requirements.

The Department may acquire and make available the right to take materials from sources designated and described in the Contract together with the right to use the property as specified, for plant site, stockpiles, and hauling roads. If this procedure has been chosen by the Department, the Contract will define the acquisitions or rights provided.

If material is used from other than Contract designated sources, the Contractor shall acquire the necessary rights to take materials from the sources and pay related costs, including costs for an increase in length of haul and all costs of exploring and developing the sources.

The use of material from other than designated sources will not be permitted until the Department has performed sufficient tests to indicate that the material is of equal or better quality than the Department designated source and that conditional acceptance of the material may be made. Borrow pits, gravel pits, and quarry sites shall be located so they are not visible from the highway, and in any case not closer than 500 feet (150 m) to the near right-of-way of a road or highway on the State or County System, except by written permission of the Engineer.

Pits and quarries shall be excavated so water does not collect and stand on the site during the work. Following completion of the work the site shall be left in a neat and presentable condition.

106.03. SAMPLES, TESTS, CITED SPECIFICATIONS.

Materials will be inspected, tested, and approved by the Resident Engineer before incorporation in the work. Materials found to be unacceptable will not be paid for and shall be removed from the work at the Contractor's expense.

Unless otherwise designated, materials tests will be performed by and at the expense of the Department using the most recent standard test methods of the Department, AASHTO or ASTM in effect on the date of advertisement for Proposals. If there is a difference in the test methods, the order of precedence in the test procedures used will be as follows:

- (a) The Department's Standard Materials Test Methods
- (b) AASHTO
- (c) ASTM

The sampling and sample splitting of materials tested by the Department shall be performed or observed by a qualified representative of the Department.

The Department may retest and reject unacceptable materials previously tested and conditionally accepted at the source of supply. Materials to be used are subject to inspection, testing or rejection prior to or during incorporation into the work. Copies of any or all test results will be furnished to the Contractor's representative upon request.

Quality control during the progress of construction shall be the responsibility of the Contractor and the Contractor shall not rely on the Department's acceptance testing for this purpose.

106.04. MATERIALS CERTIFICATIONS.

- (a) **Description.** This Subsection covers the requirements and procedures for the issuance and distribution of certifications of various types when designated as a part of the Plans and Contract for various materials.
- (b) **General Requirements.**
 1. The Contractor shall be responsible for obtaining all certifications and arranging for their delivery to the proper destinations as required by this Specification.
 2. Materials certifications shall be signed by a responsible representative of the company which issues the certification. The official company title of the signer must be clearly shown immediately beneath his/her signature.
 3. All certifications shall be furnished in duplicate and each copy shall show the following information:

Project number
 Name of Contractor
 Identification markings on shipment
 Quantity of material represented by the certification

Quantity information need not be furnished when certified mill tests are submitted as a Type A certification, provided that the identifying heat number is permanently rolled, stamped or otherwise affixed to each individual piece of material in the shipment covered by the certification.

- (c) Types of Certifications. Unless otherwise specified, a certification shall be one of the following types:
1. **Type A** certification shall be prepared by the manufacturer and shall consist of a certified copy of a report covering tests conducted by an approved laboratory. Such test shall have been conducted on samples obtained from the lot or lots of material in the shipment.
 2. **Type B** certification shall consist of a certification prepared by the manufacturer and shall show the limits of test values as determined by an approved manufacturer's laboratory, a qualified commercial laboratory or other approved laboratory.
 3. **Type C** certification shall be prepared by the manufacturer and shall certify that the material in the shipment conforms to the same formula and/or is essentially the same as the material previously approved by the Materials Engineer.
 4. **Type D** certification shall be prepared by the manufacturer and shall state that the materials meet the applicable Specifications. These Specifications shall be listed by number, Section reference or other appropriate identification acceptable to the Resident Engineer.
 5. **Type E** certification shall be prepared by the Fabricator to cover a composite item incorporating two or more materials which have been previously approved on an individual basis, but which lose their identity when they are incorporated into the composite item. All materials used in the fabrications shall be listed and identified. Composite items would include signs, overhead sign structures, etc. The certification shall state that all materials used in the fabrication of the item in question were previously approved for use. The fabricator shall keep test reports and/or other pertinent identifying records of the individual items incorporated into the composite item until the item has been approved and accepted by the Engineer.
- (d) **Distribution of Certifications.** Certifications shall be mailed to the Resident Engineer, with one copy to be mailed to:

Materials Engineer Oklahoma Department of Transportation 200 Northeast 21st Street Oklahoma City, Oklahoma 73105

These certifications will be checked for conformance with the applicable Specifications and approved copies forwarded to the Resident Engineer and Contractor.

- (e) **Basis of Acceptance.** Whenever a certification of one of the above types is required as part of a material Specification, such material may be accepted on the basis of certification provided that all applicable requirements are met, and that visual inspection at destination shows the workmanship and condition of the material to be satisfactory.

All material furnished under certification shall be tagged, stenciled, stamped, or otherwise marked with a lot number, heat number, order number, or other appropriate identification which can be readily recognized and checked against the certification. Material accepted on certification shall not be incorporated in the work until the certificates have been approved by the Resident Engineer.

106.05. PLANT INSPECTION.

The Engineer may inspect materials at the acquisition or manufacturing source. Manufacturing plants may be inspected for compliance with specified manufacturing methods. Material samples will be obtained for testing for compliance with materials quality requirements.

In the event plant inspection is undertaken, the following conditions shall be met:

- (a) The Engineer shall have the cooperation and assistance of the Contractor and producer of the materials.
- (b) The Engineer shall have full access at any time to all parts of the plant concerning the manufacture or production of the materials being furnished.
- (c) If required by the Contract, a building shall be provided for the use of the Inspector, located conveniently near the plant, and meeting the requirements of Subsection 106.06.
- (d) Adequate safety measures shall be provided and maintained.
- (e) Crushing or screening facilities may be required to be equipped with an automatic or semi-automatic mechanical sampling device.

In the event the Contractor chooses to use fabricated steel or precast concrete products requiring inspection and approval at a manufacturing plant or source of supply located more than 300 miles (500 kilometers) from Oklahoma City, Oklahoma, the additional expense of such inspection over the cost of providing such inspection at Oklahoma City will be borne by the Contractor. The most recent edition of the "Rand McNally Road Atlas" will be used to calculate the road miles traveled. Vicinity mileage will also be claimed when applicable. Travel expenses will be charged in accordance with the current Department's Administrative Order # B-310-1-(1) for State Travel Expenses-Reimbursement, plus the current contract price for the inspector's driving time. It is the Contractor's responsibility to contact the Materials Engineer to obtain the current contract prices and contact his/her supplier to determine the fabrication time, in order to complete his/her estimate for inspection expenses.

The Department reserves the right to retest materials that have been tested and conditionally approved at the source prior to incorporation into the project and to reject all materials that, when retested, do not meet the Contract requirements.

106.06. FIELD OFFICE LABORATORY.

The Contractor shall furnish and maintain, for each Field Office or Laboratory required, an approved weatherproof building or trailer as provided in Section 640.

106.07. FOREIGN MATERIALS.

Unless otherwise noted in the Contract, all testing shall be performed within the United States and witnessed by the Engineer. When defined in the Contract, the Contractor shall arrange and pay for any required sampling and testing that the Department is not equipped to perform. Materials or processes that require that the testing be performed or witnessed at a foreign source will be inspected at the foreign site and the Contractor shall reimburse the Department for all inspection expenses incurred outside the United States.

Each lot of foreign material shall be accompanied by a certificate of compliance meeting Subsection 106.04. Certified mill test reports shall be attached to the certificate of compliance for the materials requiring mill test reports.

Structural materials will not be accepted unless they are properly identified with mill test reports and certificates of compliance.

Structural materials requiring mill test reports will be accepted only from domestic manufacturers or manufacturers who have previously established the adequacy of their plant quality control to assure delivery of uniform material meeting Department requirements.

Adequacy of quality control shall be established by submission of detailed written proof, or through a plant inspection by the Department.

106.08. STORAGE AND HANDLING OF MATERIALS.

Materials shall be stored and handled to preserve their quality and fitness for the work. Bulk materials shall be transported in vehicles constructed to prevent loss or segregation after loading and measuring.

Materials shall be stored to facilitate prompt inspection and will be subject to inspection and retesting before incorporation in the work in accordance with Subsection 106.03.

Approved portions of the right-of-way may be used for the storage of materials and the Contractor's plant and equipment. Additional storage space required shall be provided at the Contractor's expense and option. Private property shall not be used for storage purposes without written permission of the owner or lessee. If requested, copies of such written permission shall be furnished to the Resident Engineer.

Storage and plant sites on right-of-way shall be restored to their original condition by and at the Contractor's expense.

106.09. DELIVERING AND STOCKPILING AGGREGATES.

All aggregates shall be handled in such a manner as to preserve their quality, gradation and fitness for the work. The provisions for transporting aggregates shall be such to assure a continuous and adequate supply of material to the work.

Aggregate stockpiles shall be built up in such a manner that acceptable materials will be delivered to the plant or the Project. Aggregates from different sources and different gradations shall not be stockpiled together.

The gradation requirements, for the individual stockpiles and proportioning from the stockpiles, shall be the responsibility of the Contractor. Aggregates that have become segregated, or mixed with earth or other foreign material, shall be considered unacceptable, and will not be utilized in the work until Contractor causes aggregate piles to be integrated, and all foreign materials to be removed.

106.10. UNACCEPTABLE MATERIALS.

Materials not meeting the requirements will be rejected and shall be removed immediately from the Project unless the defects are corrected and approved by the Resident Engineer.

106.11. DEPARTMENT-FURNISHED MATERIAL.

The Contractor shall furnish all materials required to complete the work, except those specified in the Contract as being furnished by the Department.

Material furnished by the Department will be delivered or made available to the Contractor at the points specified in the Contract.

The cost of handling and placing all materials after they are made available to the Contractor shall be included in the Contract price for the bid item in connection with which they are used.

The Contractor is responsible for the storage, handling, and security of all material made available to him/her, and deductions will be made from any monies due him/her for any shortages or deficiencies, from any cause, for any damage which may occur after delivery, and for any demurrage charges.

106.12. GUARANTEES AND WARRANTIES.

The Contractor shall obtain and assign to the Department all manufacturers' or producers' warranties or guarantees on all items, materials, electrical or mechanical equipment consistent with those provided as customary trade practice. Additionally, the Contractor shall furnish a Contractor's warranty or guarantee providing that all mechanical and electrical equipment and material, light bulbs excepted, furnished by the Contractor shall be free from any defects or imperfections in workmanship and materials for a period of six (6) months after acceptance by the Department and the local government. Should any defect develop during this six (6) months performance period, the malfunction or defect shall be corrected by and at the expense of the Contractor, including all labor, materials, and associated costs.

The Contractor shall supply manuals for all pieces of equipment included in the Project. Such manuals shall include operational procedures, complete nomenclature, wiring diagrams, schematics showing test voltages or procedural methods, a functional description of circuits, parts lists, cross reference to standard part numbers, flow diagrams, and, where appropriate, testing procedures and other pertinent data.

The provisions of this section shall not be construed in lieu of the requirements of the Maintenance Bond as found in state funded contracts, but run concurrently and are included therein.

**SECTION 107
LEGAL RELATIONS AND RESPONSIBILITY TO PUBLIC****107.01. LAWS, RULES AND REGULATIONS TO BE OBSERVED.**

The Contractor shall keep fully informed with, and observe and comply with all of the following that, (1) individuals engaged or employed on the Project, or (2) affects the conduct of the work on the Project:

Federal and State laws;
Local laws and ordinances; and
Regulations, orders and
decrees of bodies or tribunals having any jurisdiction or authority.

The Contractor shall protect and indemnify the Department and its representatives against any claim or liability arising from the violation of any of the above listed items, whether violated by the following companies or any employees of the following companies:

- The Contractor
- Subcontractor
- Suppliers of materials or services
- Any others engaged by the Contractor

All laws and ordinances as well as Title 29, Title 30, and Code of Federal Regulations, Part 1926 - Safety and Health Regulations for Construction (OSHA), whichever is the most restrictive, shall be followed in the use, handling, loading, transportation, and storage of explosives and blasting agents. The Contractor shall comply with Federal, State and local laws, rules and regulations that set forth unlawful employment practices including that of discrimination because of race, religion, color, sex, or national origin, and that define actions required for Affirmative Action and Minority (Disadvantaged) Business programs.

Work within or adjacent to a State or National Forest shall be accomplished under the regulations of the State Fire Marshall, Conservation Commission, Forestry Department, or other authority having jurisdiction governing the protection of forests.

The Engineer is to be notified immediately in writing if any discrepancy or inconsistency is discovered between the Contract and any law, ordinance, regulation, order or decree except as noted in Subsection 107.04.

107.02. PERMITS AND LICENSES.

In the prosecution of highway construction Contracts awarded by the Department, the Contractor will not be required to obtain work permits or licenses for operations, upon highway right-of-way, outside of or within the corporate limits of cities or towns.

107.03. PATENTED DEVICES, MATERIALS AND PROCESSES.

The Contractor’s use or employment of any of the following that are covered by letters of patent or copyright shall be provided for by suitable legal agreement with the patentee or owner.

- | | |
|-------------|--------------|
| Design(s) | Process(es) |
| Device(s) | Trademark(s) |
| Material(s) | Copyright(s) |

The Contractor and Contract Surety shall indemnify and save harmless the Department, and affected third party, or political subdivision from any and all claims for infringement by reason of the use of any such patented or copyright item listed above.

The Contractor shall indemnify the Department for costs, expenses, and damages that may be obligated for payment by reason of an infringement during the prosecution of the work or after completion of the Project.

107.04. FEDERAL AID PARTICIPATION.

When any Federal laws, rules, or regulations are in conflict with any provisions of a federally assisted Contract, the Federal requirements shall prevail, take precedence, and be in force over and against any such conflicting provisions.

If there is Federal participation in the cost of the Contract work, the work shall be under the supervision of the Department but subject to the inspection and approval of the proper officials of the United States Government. Inspections made by authorized Federal representatives shall not make the United States Government a party to the Contract and will not interfere with the rights of the Contract parties.

107.05. PUBLIC CONVENIENCE AND SAFETY.

Construction shall be conducted in a manner so obstructions to traffic are minimized. The safety and convenience of the public and the protection of persons and property shall be provided as specified under Subsection 104.07. The safety provisions of all laws, rules, codes, and regulations applicable to the class of work being performed shall be followed. No public road shall be closed except by express permission of the Engineer.

If the above requirements are not complied with, the Engineer may issue a shut down order and may do such work as required for the safety of the traveling public and deduct the cost from any monies due the Contractor for work performed on the Project.

107.06. BARRIERS, BARRICADES, AND WARNING SIGNS.

The Contractor shall provide, erect, and maintain barriers, barricades, lights, signals, signs, and other traffic control devices, and take necessary precautions to protect the work and safety of the public. Highway sections closed to traffic shall be protected by effective barriers and barricades. Obstructions to the normal flow of traffic shall be clearly delineated during darkness. Warning signs shall be provided to control and direct traffic.

The Contractor shall erect warning signs in advance of operations that may interfere with the use of the road by traffic and where new work crosses or coincides with an existing road. Warning signs shall be placed according to the Project traffic control plan and maintained in accordance with the Contract. Signs, barriers, barricades, lights, or other protective devices shall not be dismantled or removed without permission of the Resident Engineer.

Barriers, barricades, warning signs, lights, temporary signals, and other protective devices shall meet the MUTCD and Section 880-Traffic Control.

107.07. USE OF EXPLOSIVES.

When the use of explosives is necessary for the prosecution of the work, the Contractor shall exercise the utmost care to protect life, property, and completed work. When using explosives, the Contractor shall comply with any and all laws and ordinances governing such use. The Contractor shall assume all risks and shall be solely responsible for any and all damages resulting from the use or storage of the explosives on the Project.

All explosives shall be stored in a secure manner in compliance with all laws and ordinances, and all such storage places shall be clearly marked “**Dangerous Explosives.**” Where no local laws or ordinances apply, storage shall be provided in accordance with Occupational Safety and Health Act (OSHA) regulations, but not closer than 1000 feet (300 meters) from any building, camping area or place of human occupancy.

The Contractor shall notify the Resident Engineer, property owners, public utilities and railroads having facilities adjacent to the site of the work, of his intentions to use explosives and the location, date, time, and approximate duration of the blasting. The notice shall be given sufficiently in advance to enable the owners and companies to take any steps as they may deem necessary to protect their property from damage or injury.

The Contractor shall erect suitable warning signs on all roads alerting the public in the immediate vicinity of blasting operations. The signs shall also include a warning that all portable radio transmitters, cellular telephonic devices and any other electronic transmitting device should be turned off while in the vicinity. If required, the Contractor shall control traffic by use of flaggers and guards in the danger zone of blasting.

107.08. PROTECTION AND RESTORATION OF PROPERTY AND LANDSCAPE.

Public and private property shall be preserved in the prosecution of the work. Land monuments and property marks shall not be moved, disturbed or damaged until the Resident Engineer has witnessed or referenced their location.

The Contractor is responsible for damage to public or private property resulting from any act, omission, neglect, or misconduct in the Contractor’s method of executing the work, defective work or materials, or nonexecution of the Contract. This responsibility shall not be released until the Project has been accepted.

Damaged property shall be restored to a condition similar or equal to that existing before the damage or injury occurred. The repairing, restoring, rebuilding, or making good such damage or injury shall be at the Contractor’s expense.

When construction operations encounter remains of prehistoric dwelling sites or artifacts of historical or archaeological significance, the operations shall be temporarily discontinued. The Resident Engineer will contact the State archaeological authorities to determine the disposition of the remains or artifacts. When directed, the Contractor shall excavate the site to preserve the artifacts and remove and deliver them to the custody of the proper State authorities. Such work will be paid for as extra work and Contract adjustments will be made according to Subsection 104.06.

107.09. FOREST, PARK, AND PUBLIC LAND PROTECTION.

In carrying out work within or adjacent to State or National Forests, Parks, or Public Lands, the Contractor shall comply with all regulations of the State Fire Marshal, Conservation Commission, Forestry Department, or other authority having jurisdiction. He/She shall keep the areas in an orderly condition, dispose of all refuse, obtain permits for the construction and maintenance of all construction

camp, stores, warehouses, residences, latrines, cesspools, septic tanks, and other structures in accordance with the requirements of the duly authorized official.

The Contractor shall take all reasonable precautions to prevent and suppress forest fires and shall require his/her employees and subcontractors, both independently and at the request of the authority having jurisdiction, to do all reasonably within their power to prevent and suppress and to assist in preventing and suppressing forest fires and to make every possible effort to notify a Forest official at the earliest possible moment of the location and extent of any fires seen by them.

107.10. THIRD PARTY BENEFICIARY CLAUSE.

It is specifically agreed between the parties executing this Contract that it is not intended by the Contract provisions to create in the public or any member thereof a third party beneficiary hereunder, or to authorize anyone not a party to the Contract to maintain a suit for personal injuries or property damage pursuant to the provisions of the Contract.

107.11. RESPONSIBILITY FOR DAMAGE CLAIMS.

The Contractor shall protect, indemnify, save and hold harmless the State of Oklahoma, the Commission, the Department, their officers, agents, and employees from all suits, actions or claims of any kind or character brought because of injuries or damages received or sustained by any person, persons, or property on account of any operations of the Contractor, his/her agents, employees, his/her subcontractors or any others authorized by the Contractor to perform work on the Project.

The Contractor shall carry insurance of the following kinds and amounts on all Department Contracts:

- (a) **Contractor's Public Liability and Property Damage Liability Insurance.** The Contractor shall furnish satisfactory evidence to the Department that, with respect to the work to be performed by him/her under the Contract, he/she carries regular Contractor's Public Liability Insurance providing for a combined amount of not less than one million (\$1,000,000) dollars of coverage for all damages arising out of bodily injury, death, and property damage for each occurrence with an aggregate limit of two million (\$2,000,000) for the term of the policy or as otherwise specified in the bid documents. If required, the Contractor shall have the Department endorsed as an additional named insured on the Contractor's Public Liability and Property Damage Liability Policy to the extent of the State's liability under the provisions of the Governmental Tort Claims Act. (51 O.S. Section 151 et. seq.)
- (b) **Insurance for Subcontractor's and Contractor's Protective Public Liability and Property Damage Liability Insurance.** In the event that any of the work to be performed by the Contractor on the Project is sublet or assigned, or is otherwise to be performed by any one other than the Contractor's own employees, then such insurance shall cover all operations of any such contractor of any tier and shall be maintained until final acceptance of the Contract.
- (c) **Workers' Compensation Insurance and Employers' Liability Insurance.** The Contractor shall furnish satisfactory evidence to the Department that, with respect to the work to be performed by him/her on the Project, he/she carries regular Workers' Compensation and Employers' Liability

Insurance covering his/her liability under the Workers' Compensation Law of the State of Oklahoma. The Contractor shall maintain the aforementioned insurance in full force and effect for the duration of the Contract. Should the Contractor fail or neglect to maintain the aforementioned insurance, the Department specifically reserves the right to withhold all funds due and owing the Contractor until such time as the required insurance is in effect.

- (d) **Railroads' Protective Liability and Property Damage Insurance.** In addition to the above, the Contractor shall furnish satisfactory evidence to the Department that, with respect to the work to be performed by him/her under the Contract, he/she has provided for and on behalf of the Railway Company or Railway Companies involved, Protective Public Liability and Property Damage Liability Insurance in an amount as may be required by the Railway Company, which amount shall be specified in the bid documents. Policies shall not include liability for negligence on the part of the Railway Company, its agents or employees, except as set out in Coverage A, B, or C of the form of policy, or amendments thereto, referred to under paragraph 6 below. This insurance applies to each and all Railway Companies involved in the work.
- (e) **General.** The insurance hereinbefore specified shall be acquired from insurance companies properly licensed by the State of Oklahoma to provide such coverage in the State of Oklahoma, during all times when work is being carried on under the terms of the Contract, until all work required to be performed under the Contract is satisfactorily completed as evidenced by the formal acceptance by the Department.
- (f) **Form of the Railroad Protective Liability Policy.** For the purpose of uniformity, the American Association of State Highway and Transportation Officials (AASHTO), with the assistance of the Association of American Railroads (AAR), the Federal Highway Administration (FHWA), the National Bureau of Casualty Underwriters of New York, and the Mutual Insurance Rating Bureau of New York, has drafted the:

**STANDARD PROVISIONS FOR GENERAL LIABILITY POLICIES
RAILROAD PROTECTIVE LIABILITY FORM
(STATE OR FEDERAL HIGHWAY PROJECTS)**

Copies of this form are available upon request from the Office Engineer of the Oklahoma Department of Transportation.

The Contractor shall furnish the original and one copy of the Railroad Protective Liability Policy and two copies of Certificate of Insurance, indicating the amounts of coverage in effect, to the Office of Rail Programs of the Department, for submission to the Railroad Company for approval.

Any questions by the Contractor or his/her Surety regarding this insurance should be directed to the Office of Rail Programs, 200 Northeast 21st Street, Oklahoma City, Oklahoma 73105.

107.12. PERSONAL LIABILITY OF DEPARTMENT EMPLOYEES.

The Department's authorized representatives are acting solely as agents and representatives of the Department when carrying out and exercising the power or authority granted to them under the Contract. While acting within the scope of their employment, Department representatives shall not be liable for actions taken on behalf of the Department, either personally or as Department employees.

107.13. NO WAIVER OF LEGAL RIGHTS.

The Department shall not be precluded or estopped by any measurement, estimate, or certificate made either before or after the completion and acceptance of the work and payment therefore, from showing the true amount and character of the work performed and materials furnished by the Contractor, nor from showing that any such measurement, estimate or certificate is untrue or is incorrectly made, nor that the work or materials do not, in fact, conform to the Contract. The Department shall not be precluded or estopped, notwithstanding any such measurement, estimate, or certificate and payment in accordance therewith, from recovering from the Contractor or his/her Sureties, or both, such damage as it may sustain by reason of Contractor's failure to comply with the terms of the Contract. Neither the acceptance by the Department, or any representative of the Department, nor any payment for, or acceptance of, the whole or any part of the work, nor any extension of time, nor any possession taken by the Department, shall operate as a waiver of any portion of the Contract, or of any power herein reserved, or of any right to damages. Acceptance shall be final and conclusive except as otherwise provided in the Specifications, or as regards latent defects, or frauds, or such gross mistakes as may amount to fraud, or as regards the Department's rights under any warranty or guaranty. Latent defects are nonconformities included in the completed Contract work which were not visible or apparent at the time of construction and remained hidden and dormant until discovery of the nonconformity. Upon discovery of a disputed nonconformity in the completed Contract work, which the Department has designated as a Latent Defect, the Department and Contractor agree to submit to arbitration whether or not the disputed nonconformity in the Contract work is a Latent Defect. The arbitration shall be administered in accordance with the dispute resolution procedure, as incorporated in the Contract. A waiver of any breach of the Contract shall not be held to be a waiver of any other or subsequent breach. Nothing contained in this section shall operate as a waiver or extension of any applicable statute of limitations with respect to the time within which an action may be brought for the breach of a Contract.

107.14. HAZARDOUS MATERIAL.

If any abnormal condition is encountered or exposed that indicates the presence of a hazardous material or toxic waste, construction operations shall be immediately suspended in the area and the Resident Engineer notified. Work shall be continued in other areas of the Project unless otherwise directed by the Resident Engineer.

Abnormal conditions include but are not limited to the following: presence of barrels; obnoxious odors; excessively hot earth; smoke; or any other condition that indicates a hazardous material or toxic waste. These conditions shall be treated with extreme caution.

Disposition of the hazardous material or toxic waste shall be made under the requirements and regulations of the applicable State agency. Work required to dispose of these materials shall be performed under a supplemental agreement. If the waste material disposal requires special procedures, the Department will make arrangements to dispose of the material.

107.15. STORMWATER MANAGEMENT.

The Contractor and the Department shall be jointly responsible as Co-Permittees for compliance with the requirements of the Department of Environmental Quality (DEQ) general permit for construction

concerning Stormwater Management on State Construction Project Right-of-Ways, with assignment of responsibilities as follows:

The Department's role as Co-Permittee shall be that of the Owner. This shall be limited to development of the original Stormwater Management Plan (SMP) that shall be included in the Project Plans. For Projects that do not include a specific SMP, the Contractor shall use the applicable portion of the Plans, Special Provisions and the Standard Specifications for the SMP.

The Contractor's role shall be that of the Operator having day-to-day responsibilities for implementation of the SMP for the Project. The Contractor shall be responsible for initiating any modification to the original permit connected with the location of his/her storage yard, plant sites and borrow areas located on or off the State right-of-ways. Modifications to the original permits may require modification of an existing SMP or development of an additional SMP.

The Contractor shall be responsible for submitting the Contractor's copy of the Notice of Intent (NOI) to the Office Engineer with the Contractor-executed Contract.

When the permanent erosion control measures have stabilized the project to not less than 70 percent, the Contractor shall submit to the Resident Engineer a Notice of Termination (NOT). The Resident Engineer shall assemble and submit NOTs to the DEQ. This action transfers the operational responsibility for Stormwater Management to the Department or the local government entity, as applicable.

SECTION 108 PROSECUTION AND PROGRESS

108.01. SUBLETTING OF CONTRACT.

The Contractor shall not sublet, sell, transfer, assign, or otherwise dispose of the Contract or Contracts or any portion thereof, or any of his/her rights, title, or any interests therein, without written consent of the Director or his/her authorized representative. In case such consent to Subcontract is given, the Contractor will be permitted to sublet a portion of the work as specified, but shall perform with his/her own organization, work amounting to not less than fifty (50) percent of the Contract amount, unless the Contract shall allow a greater percentage to be subcontracted. Any items designated in the Contract as "specialty items" may be performed by subcontract and the cost of any such specialty items so performed by subcontract may be deducted from the total cost before computing the amount of work required to be performed by the Contractor with his/her own organization.

Requests for permission to sublet, or otherwise dispose of any portion of the Contract work shall be in writing to the Resident Engineer. Requests shall be accompanied by a statement showing that the organization which will perform the work is particularly experienced and equipped for such work. All subcontracts shall incorporate and include all federally imposed requirements pertaining to equal opportunity, disadvantage business opportunity, Title VI of the Civil Rights Act of 1964 of the Davis-Bacon Act, and such other requirements as may be contractually imposed. The Contractor shall give assurance that the minimum wage for labor as stated in his/her Proposal shall apply to labor performed on all work sublet. No subcontracts, or transfer of Contract, shall in any case release the Contractor of his/her liability under the Contract and bonds.

Should the Contractor assign any of his/her right, title or interest in the Contract, said assignment shall be made only with the full knowledge and written consent of the Surety. It is specifically understood that a violation of the Subsection will constitute an act of default on the part of the Contractor.

108.02. NOTICE TO PROCEED.

The Notice to Proceed will stipulate the date on which it is expected the Contractor will begin the construction. In no case shall work, other than mobilization, start prior to issuance of the Notice to Proceed. When work starts prior to the effective date of the Notice to Proceed, time will be charged from time work actually starts, but not later than the effective date of the Notice to Proceed.

108.03. PROSECUTION AND PROGRESS.

Sufficient materials, equipment, and labor shall be provided by the Contractor to guarantee the completion of the project within the Contract time.

The Contractor shall submit a Progress Schedule to the Resident Engineer for review and acceptance prior to commencement of project work. The Progress Schedule shall be used to establish the Contractor's planned construction operations and to monitor the progress of the work.

The Progress Schedule chart may be in the form specified in 108.03.a. or 108.03.b., unless the Contract requires a critical path method schedule. The critical path method schedule must be in the form specified in 108.03.b.

- (a) **Activities Schedule Chart (ASC) and Written Narrative (WN)** The ASC and WN prepared shall break down into detail the time (working days or completion date) involved in performing major construction activities for the duration of the Project. The ASC shall be used for the coordination and Department monitoring of major work under the Contract including the activities of subcontractors, vendors, and suppliers.

1. Schedule Requirements:

All Activity Schedule Charts provided by the Contractor shall include:

- a) A bar chart chronologically sequenced and to time scale with a number of activities appropriate to the Project showing construction prosecution or preparation activities.
- b) Activity descriptions for each bar on the chart.
- c) Activity durations by calendar days.

2. All Written Narratives provided by the Contractor shall provide:

- a) The proposed work process sequence that will show major work activities required for the complete performance of all items of work under Contract, including major shop drawing submittals, permits, fabrication and delivery activities, etc.
- b) A description of activities so that work is readily identifiable.
- c) A description for each bar identifying the trade or entity performing the work, the duration of the activity in work days, and the location of the work.
- d) A description indicating work days per week, holidays, number of shifts per day, number of hours per shift, and major equipment to be used.

- 3. Preparation of Initial Schedule.** The Contractor shall complete development of the initial ASC and WN and present two (2) copies of each to the Resident Engineer at the prework conference.

The construction time indicated by the ASC and WN, for the entire Project or any milestone, shall not exceed the specified Contract time. Following a review of the initial ASC and WN by the Department, the Resident Engineer, and Contractor shall meet for a joint review, correction, and adjustment of the schedule if required.

If necessary this process will be repeated, however, the schedule must be finalized by the Contractor within thirty (30) calendar days after the prework conference. Failure to provide a complete final ASC and WN by that date will result in withholding all Contract payments until an acceptable schedule is received.

- 4. Progress Meetings.** Progress meetings between Contractor and the Department shall be held to coincide with submission of progressive estimates so as to verify actual agreed progress. In addition, job site progress meetings may be required by the Department to accommodate change orders, time extensions (whenever such time extensions total twenty-one (21) or more calendar days), or other circumstances as the Resident Engineer may deem appropriate. Copies of revised ASC shall be furnished to the Department.

- (b) **Critical Path Progress Schedule.** The Contractor's progress schedule prepared pursuant to this Subsection shall employ a network analysis system as described below when specified on the Plans or in the Contract. Implementing this system for the planning and scheduling of construction shall be the responsibility of the Contractor. As a minimum, the network analysis system shall be prepared in a form acceptable to the Department. Scheduling methods, other than CPM, will be considered on an individual basis.

The system shall consist of logic diagrams, computer mathematical analysis, calendar, and narration.

The logic diagram shall show the order and interdependence of activities and the sequence in which the work is to be accomplished as planned by the Contractor in coordination with all Sub-contractors and other prime Contractors. The basic concept of the logic diagram shall be followed to show how the start of a given activity is dependent on the completion of preceding activities and its completion restricts the start of following activities.

The detailed network activities shall include, in addition to construction activities, the submittal, approval of materials and shop drawings, procurement, installation and testing of materials and equipment that are significant as determined by the Resident Engineer. The system shall show early completion of certain portions of the Project as specified herein.

No activity duration shall be longer than thirty (30) work days without the Department's approval. The Department reserves the right to limit the number of activities on the schedule to between 50-500 activities. Detailed networks shall show a continuous flow from left to right and be drafted on paper 24 inches (610 mm) in width and 36 inches (914 mm) in length. The drafted network diagram alphanumeric characters (numbers and letters) shall be large enough to be easily read. The network diagram arrangement shall allow sufficient room between diagram paths for "red line" modification of existing activity and/or diagram arrangement. The following information shall be shown on diagrams for each activity: Activity identification number, description of the

activity, and activity duration in calendar days. The critical path shall be highlighted in order to be distinguished from other diagram paths.

The application software used shall be capable of compiling all completed and partially completed activities. The program shall be capable of accepting revised completion dates as modified by approved time adjustments and recomputations of all tabulation dates and total float accordingly.

The program shall list the activities in sorts or schedules as follows:

1. In order of activity numbers.
2. Total float sort, by the amount of total float order of least to highest.

The mathematical analysis of the network diagram shall be updated monthly unless waived by the Resident Engineer in writing.

The cover sheet for each monthly update shall list the following: State job number, Project number and description, Contractor, reporting period, scheduled completion date and actual completion date and variation from schedule.

A preliminary network analysis system defining the Contractor's planned operation during the first sixty (60) calendar days after the date of the notice to proceed shall be submitted at the prework conference. The Contractor's general approach for the balance of the Project shall be indicated.

The complete network analysis system consisting of the computer mathematical analysis and diagram shall be submitted within thirty (30) calendar days after the date of the prework conference unless extended in writing by the Resident Engineer.

The initial submittal of the diagram, calendar, and computer analysis shall be in four (4) copies. The monthly updated computer analysis shall be submitted in four (4) copies.

The detailed network analysis system will be reviewed by the Resident Engineer for logic and conformance to the requirements as set forth herein, and for conformance to any special notations in the Plans pertaining to sequence of operations. Within fifteen (15) calendar days after the receipt of the detailed network analysis system, the Contractor and the Resident Engineer shall meet for joint review, correction and adjustment of the schedule, if required. The construction time, as determined by the schedule, for the entire Project or any milestone for the Project shall not exceed the specified Contract time. In the event that any milestone date or Contract completion date is exceeded in the schedule, logic and/or time estimates will be revised. After this meeting but within fifteen (15) calendar days after any changes in the logic and/or time estimates have been agreed upon, another submission of the schedule, including four (4) copies of the diagram, an activity number order sort, and a total float sort, will be transmitted to the Resident Engineer. If necessary, this process will be repeated; however, the schedule must be finalized within thirty (30) days after the prework conference. Failure to finalize the schedule by that date will result in withholding all Contract payments until the schedule is approved. Time charges shall begin no later than the date specified in the Notice to Proceed.

Job site progress meetings will be held monthly by the Department and the Contractor for the purpose of updating the Project work schedule. Progress will be reviewed to verify start and finish dates of completed activities, remaining duration of uncompleted activities, and any proposed logic and/or time estimate revisions. It is the Contractor's responsibility to provide the Department with the

status of activities at this progress meeting and with the progress schedule updates based on this information once it has been verified.

The Contractor will create new CPM activities to reflect any precise period of delays which will affect the completion date of the Contract. The Contractor and the Department will agree on the start date and the finish date of the delay activities and the logic-dependent relationship to the activities of the affected predecessor and successor activities.

Not later than the fifth day of each month of the Project, the Contractor will submit four (4) copies of an updated activity number and total float sort illustrating verified progress. Included shall be a written narrative describing the critical path and logic revisions or modifications to the schedule, including, but not limited to, changes in the method or manner of the work, changes in Specifications, extra work, changes in duration, reasons for delay, etc. No logic revisions or modifications shall be made without prior approval of the Department. Failure to submit the required monthly network analysis system updates will cause the Department to withhold the monthly progressive pay estimate until such time as the update is received by the Department.

The Contractor will further submit two (2) copies of revised diagrams for the following: delay in completion of any critical activity; actual prosecution of the work which is, as determined by the Department, significantly different than that represented on the schedule; the addition, deletion, or revision of activities required by Contract modification; or any logic revisions or calendar revisions. The Contract completion time will be adjusted only for causes specified in the Contract.

As determined by computer analysis, only delays in activities which affect milestone dates, critical path, or Contract completion dates will be considered for a time extension under this Subsection.

If the Contractor does seek a time extension of any milestone or Contract completion date, he/she shall furnish documentation as required by the Department to enable the Department to determine whether a time extension is appropriate under the terms of the Contract.

It is understood by the Department and the Contractor that float is a shared commodity.

108.04. LIMITATION OF OPERATIONS.

Construction operations shall be conducted to assure the least interference with traffic with due regard to the location of detours and to the provisions for handling traffic. The Resident Engineer may require the Contractor to finish a section before work is started on any additional sections if the opening of the section is essential to public convenience.

108.05. CHARACTER OF WORKERS.

The Contractor shall employ sufficient resources for prosecuting all classes of work in the manner and time required by the Contract.

Workers shall have sufficient skill and experience to properly perform their assigned work. Workers engaged in work requiring special skills shall be sufficiently experienced in work and in the operation of the equipment required to perform the work satisfactorily.

Any person employed by the Contractor or by any subcontractor who does not perform the work in a proper and skillful manner or is intemperate or disorderly shall, at the written request of the

Resident Engineer, be removed from the work, and shall not be reemployed without the approval of the Resident Engineer.

Should the Contractor or subcontractor fail to remove the person or persons or fail to furnish suitable and sufficient personnel for the proper prosecution of the work, the work may be suspended by written notice as provided in Section 104.05. until the Resident Engineer's orders are followed.

The Contractor shall comply with all Federal and State requirements for nondiscrimination and equal employment opportunity. On all Projects, Special Provisions which set forth minimum wage rates and required reports, shall be included in the Contract.

108.06. METHODS AND EQUIPMENT.

All equipment used on the Project shall be of sufficient size and mechanical condition to meet the requirements of the work and to produce a satisfactory quality of work. Equipment used shall not cause injury to the roadway, adjacent property, or other highways.

When the methods and equipment to be used are specified, other methods and equipment shall not be used unless requested in writing and approved by the Resident Engineer. The request shall include a description of the methods and equipment proposed and the reasons for making the change. If approval is given, the Contractor shall be responsible for producing work meeting the Contract requirements. If the Resident Engineer determines that the work produced does not meet Contract requirements, the use of the substitute methods or equipment shall be discontinued and the remaining work shall be completed with the specified methods and equipment. Deficient work shall be removed and replaced or repaired to the specified quality by and at the Contractor's expense. No change will be made in the basis of payment for the construction items involved nor in Contract time as a result of approving a change in methods or equipment.

108.07. DETERMINATION AND EXTENSION OF CONTRACT TIME.

The time allowed for the completion of the work will be stated in the Proposal and Contract, and will be known as the "Contract Time." The Resident Engineer will furnish the Contractor a semi-monthly statement showing the number of days charged to the Contract for the preceding period and the number of days specified for completion of the Contract. The Contractor will be allowed ten (10) days in which to file a separate written protest setting forth in what respect said statement is incorrect. If the Contractor fails to file separate written protest within the time specified, the Contractor waives all rights to protest that time charge. If the Contractor should fail, refuse, or neglect to sign the semi-monthly statement of time charge and further should fail, refuse, or neglect to file a separate written protest of the time charges within the specified time, the Contractor waives all rights to protest the charges. It is hereby agreed and understood that a separate written protest of the time charges filed within ten (10) days as set forth herein is in all cases a condition precedent for the correction of the time charge.

When the Contract time is on a calendar day basis, it shall consist of the number of calendar days stated in the Contract counting from the effective date of the Notice to Proceed or from the date the Contractor begins work whichever is earlier, including all Sundays, holidays, and non-work days.

All calendar days elapsing between effective dates of any orders of the Resident Engineer to suspend work and to resume work for suspensions, not the fault of the Contractor, shall be excluded.

When the Contract completion time is a fixed calendar date, that date shall be the date on which all work on the Project shall be satisfactorily completed in accordance with Subsection 105.17.

All requests for adjustment to Contract time must identify delays actually encountered which interfered with Project work critical to timely completion of the Project work at a point in time when such work was scheduled to be in progress. Only a Contractor's Progress Schedule provided to the Department pursuant to Subsection 108.03.a. or 108.03.b. prior to commencement of Project work may be used to support the Contractor's request for additional Contract time or delay damages. No schedule prepared subsequent to commencement of Project work is acceptable for this purpose.

- (a) **Excusable (Noncompensable Delay).** Contract time allowed for the performance of the work may be extended for delays caused by acts of God, acts of the public enemy, fires, floods, epidemics, quarantine restrictions, strikes, freight embargoes, documented national, or regional material shortages which are industry wide, unusually severe weather, or delays not caused by the Contractor's fault or negligence. Delays necessitated by compliance with certain federally mandated programs which occur after the Contract is let may provide a basis for an excusable delay. No additional compensation shall be due to the Contractor for such delays.
- (b) **Unusually Severe Weather.** The occurrence of unusually severe weather during the life of the Contract will be considered a basis for extending Contract time when work is not already suspended for other reasons. Unusually severe weather means weather which, at the time of year it occurs, is unusual for the place in which it occurs.

Extension of time for unusually severe weather will be determined on a monthly basis and will include only those actual adverse weather days in excess of the normal adverse weather days included in the Contract time. Normal adverse weather means adverse weather which, regardless of its severity, is to be reasonably expected for that particular place at that particular time of year. The normal adverse weather days included in the Contract time are based on historical records of temperature and precipitation for the eight Department Field Divisions as shown in Table A.

Actual adverse weather days are those days meeting one or more of the criteria in "1", "2", "3" and "4" below. Time extensions for days meeting more than one criteria will take into consideration only that criteria having the greatest impact. Those actual adverse weather days covered by criteria "1", "2" or "3" that are in excess of the days in Table A will be allowed without regard to when they occur (except prior to mobilization or during suspension for other reasons) or their impact on Contract completion. However, those days covered by criterion "4" will be subject to the limitations as noted.

1. Days with Maximum temperature of +32 degrees Fahrenheit (0 degrees Celsius) or less - one full day allowed.
2. Days with Minimum temperature of +32 degrees Fahrenheit (0 degrees Celsius) or less, but whose Maximum temperature is over +32 degrees Fahrenheit (0 degrees Celsius) - one-half day allowed.

3. Days when ½ inch (12.7 mm) or more precipitation (rain or snow equivalent) occurs - one full day allowed.
4. Days when weather related conditions exist which prohibit proper performance of work as specified - one full day allowed. Allowance of such days will be subject to the work which is being delayed, being critical to timely Contract completion and the Contractor making every reasonable effort to minimize the adverse impact of the conditions.

TABLE A
NORMAL ADVERSE WEATHER DAYS
BY
ODOT DIVISION

MONTH	DIVISIONS							
	1	2	3	4	5	6	7	8
JANUARY	8	7	8	8	7	9	8	9
FEBRUARY	6	6	6	7	6	7	6	7
MARCH	6	5	5	5	4	6	3	6
APRIL	4	4	4	3	2	3	3	3
MAY	4	4	4	3	3	3	3	3
JUNE	3	2	3	3	2	2	2	3
JULY	2	2	2	2	2	2	2	2
AUGUST	2	2	2	2	1	2	2	2
SEPTEMBER	3	3	2	2	2	1	2	3
OCTOBER	3	3	3	3	2	2	3	3
NOVEMBER	5	4	4	4	4	5	4	5
DECEMBER	7	7	6	7	7	8	6	7

The number of days for performance allowed in the Contract as awarded is based on the original quantities as defined in Subsection 102.05. If satisfactory fulfillment of the Contract requires performance of work in greater quantities than those set forth in the Proposal, the Contract time allowed for performance may be increased on a basis commensurate with the amount and difficulty of the added work. If the Contractor finds it impossible, for reasons beyond his/her control, to complete the work within the Contract time as specified or as extended in accordance with the provisions of this Subsection, he/she may at any time prior to the expiration of the Contract time, as extended, make a written request to the Resident Engineer for an extension of time, setting forth therein the reasons which he/she believes will justify the granting of his/her request. To evaluate additional time, a Contractor may use scheduling methods described in 108.03.a., unless scheduling methodology prescribed in 108.03.b. is required by the Contract. Only additional work or delays beyond the

Contractor's control which affect milestone dates, incentive/disincentive dates, or Contractor completion will be considered for time extensions. If the Resident Engineer determines that a time extension is justified, the Contract shall be modified by Change Order. The Contractor's plea that insufficient time was specified in the Proposal and the Contract or that previously unprotested time charges were incorrect shall not be grounds for an extension of time. The extended time for completion shall be in full force and effect the same as though it were the original time for completion. Daily time charges will cease when the Project is completed in accordance with Subsection 105.17.

- (c) **Compensable Delay.** Contract time allowed for performance of the work may be extended for delays caused by the Department. Compensation may be paid only when completion of the delayed work element prevents the start of work on a successive work element and will adversely impact on Project completion. Float time in the scheduling of successive work elements is a shared commodity and no compensation will be paid to the Contractor by the Department for the use of float time. The Contractor may be granted an extension of time and additional compensation under Subsection 109.10.
- (d) **Notification of Delay.** Within five (5) calendar days of the occurrence of a delay to the prosecution of the work, the Contractor shall notify the Resident Engineer in writing of such a delay and indicate that a request for delay consideration will be filed with the Department.
- (e) **Procedures Following Notification of Delay.** After notifying the Resident Engineer of the request for delay consideration, the Contractor shall keep daily records of all non-salaried labor, material costs, and equipment expenses for all operations that are affected by the delay.

The Contractor shall maintain a daily record of each operation affected by the delay and the station location of the operations affected. Daily records of the affected operations' stations will also be maintained by the Department. Each Monday, Contractor shall compare the previous week's daily records with the records kept by the Department. The Contractor shall also prepare and submit written reports to the Resident Engineer containing the following information each Monday:

1. Number of days behind schedule.
2. A summary of all operations that have been delayed, or will be delayed.
3. In the case of a compensable delay, the Contractor shall explain how the Department's act or omission delayed each operation, and estimate the amount of time required to complete the Project.
4. Contractor may request compensation for extra costs incurred as such costs are identified in Section 109.04.

The Contractor shall provide written notice to the Resident Engineer within ten (10) calendar days of the results of the comparison of the detailed reports performed each Monday and define any disagreements between specific records.

Failure to meet to review the Department's records or to report disagreements between the records will be considered conclusive evidence that the Department's records are accurate. Delay costs allegedly incurred prior to notifying the Resident Engineer that operations have been delayed will not be allowed.

- (f) **Procedures Following Completion of Work Alleged to be Delayed.** Within fifteen (15) calendar days of Project completion, or phase of work allegedly delayed, the Contractor shall submit a report to the Resident Engineer containing the following information:
1. A description of the operations that were delayed and the documentation and explanation of the reason for the delay, including all reports prepared for the Contractor by consultants, if utilized, and;
 2. An as-built chart, or other graphic depiction of how the operations were delayed, and;
 3. An item by item measurement and explanation of extra costs requested for reimbursement due to the delay.

The Resident Engineer will review the data contained in the Contractor's report and the inspection diaries and records and reports available to him/her. A written decision will be provided to the Contractor within sixty (60) calendar days of the receipt of the Contractor's report which will contain notification of any additional time which may have been granted.

In the case of compensable delays, if the Resident Engineer determines that the Department is responsible for delays to the Contractor's operation, the Resident Engineer's written decision will identify the nature and extent of any delay and the compensation which may be due to the Contractor under the provisions of Subsection 109.10.

108.08. INCENTIVE/DISINCENTIVE FOR EARLY/LATE COMPLETION.

If it is in the public's interest to complete the Project at the earliest possible date, an incentive/disincentive provision will be included in the Contract detailing applicable dates and work stages covered by the provision.

For each calendar day the project or phase is opened to unrestricted continuous traffic before or after the date established in the Contract, payment will be increased or decreased by the amount established.

The statement "unrestricted continuous traffic" means no lane closures will be granted for any of the Contractor's operations necessary to complete the Project, and that traffic will be following the final lane arrangement as proposed for the finished surface for the roadway with lane striping and permanent safety features completed.

The Resident Engineer will determine when the work stage or Project is complete to open the roadway to unrestricted continuous traffic.

Subsection 108.09. relating to liquidated damages remains in effect and is applicable to the total Contract time; however, there will not be concurrent assessment of liquidated damages with disincentive assessments.

The Contractor shall be paid the amount of incentive, as it is earned, in the progress payment schedule. The Resident Engineer shall deduct the amount of disincentive, as it occurs, in the progress payment schedule.

Should the amount of disincentive or liquidated damages exceed the amount due for work performed in a specific pay period, the Contractor shall submit a check to the Department in the amount of the difference within forty-five (45) calendar days of notice that payment is due.

Under an incentive/disincentive plan, no time extension will be granted for labor disputes or delays in material deliveries unless it can be shown that such delays are industry wide. No time extension will be granted for quantity overruns or adverse weather conditions. No time extensions will be granted for obtaining permits to cross or perform construction on or over railroad property or for railroad approval of plans or drawings.

108.09. FAILURE TO COMPLETE ON TIME.

For each calendar day or work day that work remains uncompleted after the Contract time, the sum specified in the Contract will be deducted from any money due the Contractor. This sum shall not be considered and treated as a penalty but as liquidated damages due the Department by reason of inconvenience to the public, added cost of engineering and supervision, and other extra expenditures of public funds due to the Contractor's failure to complete the work on time. Any adjustment of the Contract time for completion of the work granted under the provisions of Subsection 108.07. will be considered in the assessment of liquidated damages.

Permission for the Contractor or Surety to continue and finish work after the Contract time and approved extensions have elapsed shall not waive the Department's rights under the Contract.

The assessment of all or any portion of the liquidated damages that accrue may be terminated if the Department has determined the work is substantially complete and is in a condition for safe and convenient use by the traveling public, except when the Contract time is a fixed calendar date.

The work will be considered substantially complete when all necessary signing, striping, guardrail, and other safety appurtenances have been installed. For Projects that will not be opened to the traveling public, the Contract will be considered substantially complete when it is ready for a subsequent Project or its designed usage. This shall not be construed as a contractual right and its application will be contingent upon the Contractor's diligence in completing the remaining items of work.

108.10. DEFAULT OF CONTRACT.

- (a) The Engineer may declare the Contract in default to the Contractor and the Surety advising them of the actions required for remedy if the Contractor:
1. Fails to begin the work under the Contract within the time specified to begin work, or
 2. Fails to perform the work with sufficient resources to assure the timely completion of the work, or
 3. Fails to perform the work in accordance with the Contract requirements or neglects or refuses to remove and replace rejected materials or unacceptable work, or
 4. Discontinues the prosecution of the work, or
 5. Fails to resume work that has been discontinued within a reasonable time after notice to do so, or
 6. Becomes insolvent, is declared bankrupt, or commits any act of bankruptcy or insolvency, allows any final judgement to remain unsatisfied for a period of ten (10) calendar days, makes an assignment for the benefit of creditors, or

7. Fails to comply with Contract requirements regarding minimum wage payments or EEO requirements, or
8. Is a party to fraud.

The Engineer will give notice in writing to the Contractor and the Surety of such delay, neglect, or default.

- (b) If the Contractor or Surety does not proceed in accordance with the notice within ten (10) calendar days of receipt, the Department has full power and authority, without violating the Contract, to take the prosecution of the work from the Contractor. The Department may appropriate or use materials at the project site and enter into an agreement with another Contractor for the completion of the work remaining. Acceptable materials obtained by the Contractor for use on the project and not yet included in the work, may be purchased by the Department from the Contractor at actual cost.
- (c) The methods used for completion of the Contract will be determined by the Department. All costs and charges incurred by the Department, as a result of the default, including the cost of completing the work under Contract, and any applicable liquidated damages or disincentives will be deducted from monies due the Contractor for completed work. If such costs exceed the sum that would have been payable under the Contract, the Contractor and Surety shall be liable and shall pay the Department the balance of such costs in excess of the Contract price.
- (d) If it is determined, after termination of the Contractor's right to proceed, that the Contractor was not in default, the rights and obligations of the parties will be the same as if the termination had been issued for the convenience of the Department under Subsection 108.11. Thus damages to which a Contractor may be entitled as a result of the improper default termination will be limited to appropriate amounts for the items listed in Subsection 108.11.

108.11. TERMINATION OF CONTRACT FOR CONVENIENCE OF THE DEPARTMENT.

The Department may terminate the entire Contract or any portion thereof, if the Resident Engineer determines that a termination is in the Department's interest. The Resident Engineer will deliver to the Contractor a notice of termination specifying the extent of termination and the effective date.

- (a) **Submittals and Procedures.** After receipt of a notice of termination, the Contractor shall immediately proceed with the following obligations:
 1. Stop work as specified in the notice.
 2. Place no further subcontracts or orders for materials, services, or facilities, except as necessary to complete the continued portion of the Contract.
 3. Terminate all subcontracts to the extent they relate to the work terminated.
 4. Settle all outstanding liabilities and termination settlement proposals arising from the termination of the Contract.
 5. Transfer title and deliver to the Department (1) for the fabricated, partially fabricated, or unfabricated parts, work in progress, completed work, supplies, and other material produced or acquired for the work terminated, and (2) the completed or partially completed plans,

drawings, information, and other property that, if the Contract had been completed, would be required to be furnished to the Department.

6. Complete performance of the work not terminated.
 7. Acceptable materials obtained by the Contractor for the Project that have not been incorporated in the work shall be inventoried in conjunction with the Resident Engineer at a date identified by the Resident Engineer.
 8. Take any action necessary, or that the Resident Engineer may direct, for the protection and preservation of the property related to the Contract that is in the possession of the Contractor and in which the Department has or may acquire an interest.
- (b) **Settlement Provisions.** When the Department orders termination of all or part of the Contract effective on a certain date, completed items of work as of that date will be paid for at the Contract bid price. Payment for partially completed work will be made either at agreed prices or under the provisions below. Items that are eliminated in the entirety by such termination shall be paid for as provided in Subsection 109.05.

1. **Additional Costs.** Within sixty (60) calendar days of the effective termination date, the Contractor shall submit a claim for additional damages or costs not covered above or elsewhere in the Contract. Such claim may include such cost items as reasonable idle equipment time, mobilization efforts, bidding and project investigative costs, overhead expenses attributable to the project terminated, subcontractor costs not otherwise paid for, actual idle labor cost if work is stopped in advance of termination date, guaranteed payments for private land usage as part of the original Contract, and any other cost or damage for which the Contractor feels reimbursement should be made. Anticipated profits will not be considered as part of any settlement.

The Contractor and the Department may agree upon the whole or any part of the amount to be paid because of the termination. The amount may include a reasonable allowance for profit on work done. The agreed amount may not exceed the total Contract price as reduced by the amount of payments previously made, and the Contract price of work not terminated. The Contract shall be amended, and the Contractor paid the agreed amount.

2. **Additional Cost Review.** If the Contractor and the Department fail to agree on the whole amount to be paid the Contractor because of the termination of work, the Department will pay the amounts determined as follows, but without duplication of any amounts agreed upon above:
 - a) For Contract work performed before the effective date of termination, the total (without duplication of any items) of:
 - (1) The cost of work performed;
 - (2) The cost of settling and paying termination settlement proposals under terminated subcontracts that are properly chargeable to the termination portion of the Contract if not included in subparagraph 1 above; and
 - (3) A sum, as profit on (1) above determined by the Department to be fair and reasonable. The Department shall allow no profit under this subdivision if the Contractor's costs incurred on work performed exceed the bid item payments made.

- b) The reasonable costs of settlement of the work terminated, including:
 - (1) Accounting, legal, clerical, and other expenses reasonably necessary for the preparation of termination settlement proposals and support data;
 - (2) The termination and settlement of subcontracts (excluding the amounts of such settlements); and
 - (3) Storage, transportation, and other costs incurred, reasonably necessary for the preservation, protection, or disposition of the termination inventory.
- c) Except for normal spoilage, and to the extent that the Department expressly accepts the risk of loss, Department will exclude from the fair value, as that is destroyed, lost, stolen, or damaged so as to become undeliverable to the Department or to the buyer.
- d) In arriving at the amount due the Contractor under this clause, there will be deducted
 - (1) All unliquidated advance or other payments to the Contractor under the Contract; and
 - (2) Any claim that the Department has against the Contractor under the Contract; and
 - (3) The agreed price for, or the proceeds from the sale of materials, supplies, or other things acquired and sold by the Contractor not recovered by or credited to the Department.

If the termination is partial, the Contractor may file a proposal with the Department for and request review of the unit price(s) on the continued portion of the Contract. The Department will review unit prices for the continued portion of the Contract and will revise such prices when appropriate. Any proposal for a review of unit prices under this clause shall be requested within ninety (90) calendar days from the effective date of termination unless extended in writing by the Engineer.

The Department may, under the terms and conditions it prescribes, make partial payments and payments against costs incurred by the Contractor for the terminated portion of the Contract, if these payments will not exceed the amount to which the Contractor is entitled.

The Contractor shall maintain and make available all project cost records to the Department for audit to the extent necessary to determine the validity and amount of each item claimed. This includes all books and other evidence bearing on the Contractor's costs and expenses under the Contract. These records and documents shall be made available to the Department at the Contractor's office, at all reasonable times, without any direct charge. If approved by the Department, photographs, microphotographs, or other authentic reproductions may be maintained instead of original records and documents.

Termination of the Contract or portion thereof shall not relieve the Contractor of contractual responsibilities for the work completed, nor shall it relieve the Surety of its obligation for and concerning any just claim arising out of the work performed.

SECTION 109 MEASUREMENT AND PAYMENT

109.01. MEASUREMENT OF QUANTITIES.

- (a) **General.** All work completed under the Contract will be measured by the Resident Engineer according to the United States standard measure or the modernized metric International System of Units (SI).

A station, when used as a definition or term of measurement, will be 100 linear feet (1 kilometer).

The methods of measurements and computations to be used in determination of quantities of material furnished and of work performed under the Contract will be those methods generally recognized as conforming to good engineering practice.

Unless otherwise specified, longitudinal measurements for area computations will be made horizontally, and no deductions will be made for individual fixtures having an area of 9 square feet (1.0 square meters) or less. Unless otherwise specified, transverse measurements for area computations will be the neat dimensions shown on the Plans or as modified by the Resident Engineer.

Where the area unit for measurement and payment is on an acre (hectare) basis, the measurements will be taken on the slope of the ground to compute the actual surface area in acres (hectares) for payment.

Structures will be measured according to neat lines shown on the Plans or as altered to fit field conditions.

All items which are measured by the linear foot (meter), such as pipe culverts, guardrail, underdrains, etc., will be measured as specified under the Method of Measurement for the item in the Specifications, unless otherwise shown on the Plans.

The thickness of plates and galvanized sheet used in the manufacture of corrugated metal pipe, metal plate, pipe culvert and arches, and metal cribbing will be specified and measured in decimal fractions in inches (millimeters). The measurement of wire will be by Size Number in accordance with AASHTO M 32 unless otherwise specified.

The term "ton" will mean the short ton consisting of 2000 pounds, avoirdupois. The term "metric ton" will mean 1000 kilograms. All materials which are measured or proportioned by weight shall be weighed on accurate approved scales by competent, qualified personnel at locations designated by the Resident Engineer. If material is shipped by rail, the car weight may be accepted, provided that only the actual weight of material will be paid for. However, car weights will not be acceptable for material to be passed through mixing plants. Trucks used to haul material being paid for by weight shall be weighed empty daily at such times as the Resident Engineer directs, and each truck shall bear a plainly legible identification mark.

All scales for weighing truck loads of materials to be paid for by weight measurements shall be of adequate size and capacity to weigh the entire gross load at one weighing on a single set of scales.

Scales shall be inspected and certified at least every six (6) months or more often as the Resident Engineer may deem necessary to assure their continued accuracy. The Contractor shall have on hand not less than ten 50 pound (22.7 kilogram) weights for testing scales. Approved commercial scales may be used.

Instead of weighing truck loads of materials on single sets of scales measuring the gross load as provided above, the Contractor may use an approved automatic batch weight and printer system.

The approved automatic batch weight and printer system shall be electronically controlled and capable of determining the net batch weight of material being delivered to the transporting truck. Such weights shall be evidenced by a weigh ticket containing all the required identifying information for each load.

The printed batch weights may be used in lieu of truck scales in making this weight determination.

The automatic batch weight and printer system shall be subject to calibration, inspection, and certification requirements as provided above for scales.

Materials to be measured by volume in the hauling vehicle shall be hauled in approved vehicles and measured therein at the point of delivery. Vehicles for this purpose may be of any size or type acceptable to the Resident Engineer, provided that the body is of such shape that the actual contents may be readily and accurately determined. All vehicles shall be loaded to at least their strike-off level or approved established capacity when materials are delivered to the Project.

The Resident Engineer may require leveling of the loads as deemed necessary to assure receiving at least the established capacity.

The capacity of all vehicles shall be established by the Resident Engineer and plainly marked on said vehicle and the capacity or marking shall not be changed without permission of the Resident Engineer.

When requested by the Contractor in writing, and approved by the Resident Engineer, material specified to be measured by the cubic yard or ton (cubic meter or metric ton) may be converted to the other measure as appropriate. Factors for conversion from weight measurement to volume measurement will be determined by the Resident Engineer and shall be agreed to by the Contractor before such method of measurement of the pay quantity is used.

Bituminous materials will be measured by the gallon (liter) or ton (metric ton).

Volumes will be measured at 60° Fahrenheit (15.6° Celsius) or will be corrected to the volume at 60° Fahrenheit (15.6° Celsius) using ASTM D 1250 for asphalts or ASTM D 633 for tars.

Net certified scale weights or weights based on certified volumes in the case of rail shipments will be used as a basis of measurement, subject to correction when bituminous material has been lost from the car or the distributor, wasted, or otherwise not incorporated in the work.

Wherever in the Plans or the Contract, or in the Proposal, it is provided that liquid asphalts be measured by the gallon (liter), and the liquid asphalt is delivered to the project with certified weight billing, the weight of the liquid asphalt used in the completed and accepted work shall be converted to gallons (liters) by the application of a conversion factor approved by the Department's Central Laboratory. Any portion of a load delivered to the work and not used shall be determined by

measurement or weighing, in the vicinity of the project, and making the necessary deduction to arrive at the weight or volume of liquid asphalt used in the work.

Liquid asphalt, when measured by weight and converted to gallons (liters), as provided herein, shall be paid for by the gallon (liter).

The Contractor shall provide all necessary means and assistance for measuring and calibrating distributors and tanks for determining the quantity of material in distributors and tanks at any time. The Resident Engineer may require that the distributor be calibrated before its use on the work and any other time deemed necessary. The Contractor shall furnish a calibrated gauge (strapping stick) for each distributor so that the volume can be determined at any level of the contents. The Contractor shall place the distributor on a level area for these measurements.

Portland cement will be measured by the pound (kilogram), ton (metric ton) or hundred weight [abbreviated "cwt"], as appropriate.

The term "lump sum" when used as an item of payment will mean complete payment for the work described in the Contract.

When a complete structure or structural unit (in effect, "lump sum" work) is specified as the unit of measurement, the unit will be construed to include all necessary fittings and accessories.

When standard manufactured items are specified such as fence, wire, plates, rolled shapes, pipe conduit, etc., and these items are identified by gauge, unit weight, section dimensions, etc., such identification will be considered to be nominal weights or dimensions. Unless more stringently controlled by tolerances in cited Specifications, manufacturing tolerances established by the industries involved will be accepted.

- (b) **Plan Quantities.** When the contract specifies payment of an item or of a portion of an item on a plan quantity basis, the quantities for payment will be those shown on the Plans with deductions from or additions to such quantities resulting from authorized deviations from the Plans.

When disagreement develops between the Contractor and the Resident Engineer as to the accuracy of the plan quantities, either party shall, before any work is started which would affect the measurement, have the right to request in writing that the quantities involved be measured. If the plan quantity is found to be in error, acceptance and payment will be made in accordance with the corrected plan quantity.

109.02. SCOPE OF PAYMENT.

The Contractor shall accept the compensation, as herein provided in the Contract, in full payment for furnishing all materials, equipment, labor, tools and incidentals necessary to complete the work and for performing all work contemplated and embraced under the Contract; also for loss or damage arising from the nature of the work, or from the action of the elements, or from any unforeseen difficulties, except as provided in Subsection 104.14., which may be encountered during the prosecution of the work until the final acceptance by the Resident Engineer, and for all risks of every description connected with the prosecution of the work, for all expenses incurred in consequence of the suspension or discontinuance of the work as herein specified, and for any infringement of patent, trademark, or copyright; and for completing the work according to the Plans and the Contract. The payment of any estimate shall not relieve the Contractor of any obligation to make good any defective work or material.

109.03. PAYMENT FOR INCREASED OR DECREASED QUANTITIES.

Payment for changes of quantities are to be paid for as set forth in Subsection 104.04.

Increase in quantities covered in Subsection 104.04., regardless of magnitude will be paid for at the Contract unit price bid for each item of work involved.

No adjustment of payments to the Contractor will be made for increases or decreases in cost. Sales tax reimbursements will be available in accordance with the applicable rules and regulations of the Oklahoma Tax Commission.

109.04. DIFFERING SITE CONDITIONS, CHANGES & EXTRA WORK.

- (a) When notification has been made as provided in Subsection 104.06. and the Resident Engineer and the Contractor agree that differing site conditions exist, significant changes in the character of work will be required or extra work will be performed which was not included with the scope of the Contract, such changes, conditions, and work will be paid for using the following methods as appropriate:
1. Contract unit prices.
 2. Unit prices agreed-upon in the order authorizing the work.
 3. Lump sum amount agreed upon in the order authorizing work.
- (b) When the Contractor and the Resident Engineer cannot agree as to a method for evaluation and compensation for differing site conditions, significant changes in the character of work, or for extra work, the Contractor shall submit a fully documented itemized claim as required by Section 105.18. listing of costs incurred by the Contractor in the completion of the disputed work. All cost listings for disputed work and documentation in support thereof shall be segregated from non-disputed work and shall be clearly attributable to the disputed work by date, stationing and type of work. Only the following cost items may be included in the Contractor's request for compensation.
1. **LABOR.** The Contractor may submit the actual costs incurred by the Contractor for labor which is directly attributable to the disputed work. In the support of this cost the Contractor shall submit certified time sheets detailing the name of each laborer or supervisor, the classification, the date of the work, the daily hours, the total hours, the wage rates, and extensions thereof. An additional amount equal to twenty percent (20%) of the labor costs attributable to the disputed work may be added for Contractor's overhead and profit.
 2. **MATERIALS.** For materials approved by the Resident Engineer and used in performance of the disputed work, the Contractor may receive the actual cost of such materials including transportation costs paid by the Contractor. The materials shall be documented by means of itemized invoices as prepared by the materials supplier. An amount equal to fifteen percent (15%) of the costs incurred by the Contractor for materials and transportation costs attributable to this disputed work may be added for Contractor's overhead and profit.
 3. **EQUIPMENT.** For any machinery or special equipment (other than small tools) the use of which as been authorized by the Resident Engineer, the Contractor may be compensated at a rate equal to seventy percent (70%) of the hourly combined ownership and repair expense found in the Contractor's Equipment Costs Guide as published by K III Directory Corporation

on January 1st of the year in which the work was performed. Compensation will be only for those pieces of equipment necessary for completion of the disputed work and for the period of time during which such disputed work was actually in progress. In addition to equipment actually in use for the prosecution of disputed work, the Contractor may be compensated whenever equipment is ordered by the Resident Engineer to be held on the job on a standby basis at a rate equal to fourteen percent (14%) of the hourly combined ownership and repair expense as provided on the Costs Guide. In support of the Contractor's request for compensation for equipment, the Contractor shall submit a listing showing all equipment used in completion of the disputed work or held by direction of the Resident Engineer in the standby condition by type, manufacturer, date of manufacturer, daily hours, total hours, and extension thereof. An amount equal to fifteen percent (15%) with the total cost of equipment used in disputed work or held in standby condition may be added for overhead and profit.

4. **BONDS, INSURANCE TAXES AND BENEFITS.** For increase in bond costs in premiums for property damage and liability insurance, for workers' compensation insurance as well as unemployment insurance contributions, and social security taxes attributable to the disputed work the Contractor may be compensated in accordance with the following schedule:
- (a) **Bonds.** The Contractor may add a sum equal to one percent (1%) of the total of (1), (2), and (3) (less overhead and profits) above for additional costs for bonding requirements.
 - (b) **Insurance.** For property damage and liability, the Contractor may be compensated at a sum equal to eight percent (8%) of the actual labor costs (less overhead and profits) listed in items (1) above.
 - (c) **Workers' Compensation.** For additional costs for Workers' Compensation during the time when the disputed work was in progress, the Contractor may be reimbursed for costs incurred for each worker actually performing disputed work at the rate prescribed for such worker's job classification in the Scope of Basic Manual Classifications as published by the National Council on Compensation Insurance for the period in which the disputed work was performed.
 - (d) **Unemployment Insurance Contribution.** For the Contractor's unemployment insurance contribution during the period that disputed work was in progress, the Contractor may be compensated the sum equal to three and eight tenths percent (3.8%) of actual labor costs (less overhead and profit) listed in item (1) above.
 - (e) **Social Security Taxes.** For social security taxes for labor attributable to the disputed work, the Contractor may be compensated at a rate equal to seven and sixty-five hundredths percent (7.65%) of actual labor costs (less overhead and profit) listed in item (1) above.
 - (f) **Employee Fringe Benefits.** For employee fringe benefits incurred by the Contractor for labor during the period that the disputed work was in progress the contractor may be compensated at a rate equal to twenty percent (20%) of actual labor costs (less overhead and profit) listed in item (1) above.

5. **SUBCONTRACTED WORK.** When the disputed work is of a nature that it is normally performed by a subcontractor in the highway industry, and it is, in fact, sublet by the Contractor, the documentation as indicated for items (1) through (4) above will be furnished by the subcontractor and the Contractor may request additional compensation of an amount equal to five percent (5%) for overhead expense incurred by the Contractor.
6. **WORK OF A NON-HIGHWAY CONSTRUCTION NATURE.** When the disputed work has in fact been performed by a contractor or a subcontractor not in the highway industry and was performed by workers of a specialized trade or business, the Contractor may submit invoices for costs incurred for such services and may add for the Contractor's overhead an amount to be determined as follows:

<u>When the Dollar Amount of the Work Is</u>	<u>Add on for Overhead</u>
\$0.00 to \$2,000.00	15%
\$2,000.00 to \$5,000.00	\$300.00 + 10% over \$2,000.00
Over \$5,000.00	\$600.00+ 5% over \$5,000.00

7. **MISCELLANEOUS.** No additional allowance shall be made for other overhead and general expense costs of any kind and the cost of any item not specifically and expressly included in Subsection 109.04.b.

109.05. PAYMENT FOR CANCELED ITEMS.

Payment for canceled items are to be paid for as set forth in Subsection 104.04. and as provided below.

Acceptable materials ordered by the Contractor or delivered on the work subsequent to the award of the Contract and prior to the date of cancellation, alteration, or suspension of the work by order of the Resident Engineer will be paid for at the actual cost to the Contractor and shall thereupon become the property of the State. The Contractor shall submit immediately certified statements covering all money expended in preparation for work on any canceled item when such preparation has no value to the remaining items of the Contract for a proportionate amount based on the total Contract price over which such preparation would ordinarily be distributed when other items are included in such a preparation.

109.06. PROGRESS PAYMENTS.

The Resident Engineer will make written estimates of the materials complete in place and amount of acceptable work performed in accordance with the Contract during the current period of time since the preceding estimate and the value thereof calculated at the Contract unit prices.

Estimates will be made monthly except that whenever the value of the work completed in one-half month amounts to fifteen thousand dollars (\$15,000) or more, estimates may be made semi-monthly. No estimates except final estimates will be made for a sum less than five hundred dollars (\$500). The estimates will be approximate only and all progressive estimates and payments will be subject to correction in any progressive estimate rendered following discovery of an error.

In computing progressive estimates, concrete piles will be considered fifty percent completed as soon as they are cast satisfactorily. This item will be paid on the progressive estimate at fifty percent of the contract unit price or prices, based on the total linear measurement cast.

Should any defective work or material be discovered, or should a reasonable doubt arise as to the integrity of any part of the work completed prior to the final acceptance and payment, there will be deducted from the first progressive estimate rendered after the discovery of such defect, an amount equal in value to the suspect or defective work, and this amount will not be included in a subsequent progressive estimate until the defects have been remedied or the cause for doubt removed.

109.07. PAYMENT FOR MATERIAL ON HAND.

Payment to the Contractor may be made for materials conforming to the Plans and the Contract which are stockpiled at the project site or other approved or designated locations, or at a plant site required for Contractor's operations as approved by the Department. This payment will be made in accordance with the Department's procedure on the following basis:

- (a) Payment for materials which alone or when blended with other materials conform to the Plans and the Contract and which are purchased and delivered to a location as covered above will be made on the basis of one hundred (100) percent of the value of the materials not to exceed ninety (90) percent of the Contract unit price. The value of the materials will be established from acceptable invoices prepared by the supplier, furnished by the Contractor, and kept on file by the Resident Engineer.
- (b) Payment for materials which alone or when blended with other materials conform to the Plans and the Contract, and which are produced by the Contractor's own operations will be made on the basis of one hundred (100) percent of the Contractor's cost of production and stockpiling, not to exceed ninety (90) percent of the Contract unit price. The Contractor's cost of production and stockpiling shall be evidenced by a detailed cost break down approved by the Resident Engineer.
- (c) The quantity of each particular stockpiled material to be considered will be limited to that required for the Project and the payment shall not exceed their pro rata part of the Contract item or items in which such materials are to be incorporated in conformity to the Contract.
- (d) Payment for stockpiled materials which are blended with other materials shall be limited to bulky materials which are durable in nature. Payment will be made for such materials when the total value exceeds ten thousand dollars (\$10,000.00).
- (e) Payment for material on hand will be withheld until issuance of Notice to Proceed, unless otherwise authorized.
- (f) Payment for individual items which are Contract specific shall be limited to items of not less than five thousand dollars (\$5,000) gross value.

109.08. ACCEPTANCE AND FINAL PAYMENT.

When the Project has been accepted under Subsection 105.17., the Resident Engineer will prepare the final estimate of work performed. If the Contractor approves the final estimate or files no claim or objection to the quantities therein within thirty (30) calendar days of receiving the final estimate, the

Department will process the estimate for final payment. With approval of the final estimate by the Contractor, payment will be made for the entire sum found to be due after deducting all previous payments and all amounts to be deducted under the provisions of the Contract.

If the Contractor files a claim under the Contract requirements, the Department must be timely notified of the conditions which the Contractor believes may warrant such claim as provided in Subsection 104.06. and the claim, if subsequently filed, must be in accordance with Subsection 105.18. No other procedures shall be authorized. Upon review or final adjudication of the claim, any additional payment determined to be due the Contractor will be placed on a supplemental estimate and processed for payment.

All prior progress payments will be subject to correction in the final estimate and payment.

Acceptance shall be final and conclusive except as otherwise provided in the Contract or as regards latent defects or frauds, or such gross mistakes as may amount to fraud, or as regards to the Department's rights under any warranty or guaranty or bond.

109.10. COMPENSATION FOR PROJECT DELAYS.

Strict compliance with the provisions of this Subsection will be an essential condition precedent for the Contractor to receive compensation for delays.

- (a) Only the additional costs associated with the following items will be recoverable by the Contractor as compensation for delays:
 - 1. Direct labor costs as allowed in Section 109.04.b.1. and 109.04.b.4.(c) through (f);
 - 2. Costs for materials as allowed in Section 109.04.b.2. Materials;
 - 3. Equipment costs for equipment authorized by the Engineer to be held in a standby condition during the period of the delay at a rate equal to fourteen percent (14%) of the hourly combined ownership and repair expense found in the current edition of the Contractor's Equipment Cost Guide as published by the K III Directory Corporation for January 1 of the year in which the work was performed;
 - 4. Costs of extended job-site overhead;
 - 5. An additional 10 percent of the total of items 1, 2, 3, and 4 for extended home office overhead and to compensate for other expenses for which no specific allowance is provided.
- (b) The parties agree that, in any adjustment for delay costs, the Department will have no liability for the following items of damages or expense.
 - 1. Profits in excess of those provided herein;
 - 2. Loss of profit;
 - 3. Labor inefficiencies based on published manuals of productivity, measurement and inefficiencies;
 - 4. Home office overhead in excess of that provided herein;

5. Consequential damages, including but not limited to loss of bonding capacity, loss of bidding opportunities and insolvency;
6. Indirect costs or expenses of any nature;
7. Attorney's fees, claims preparation expenses, or costs of litigation.

109.11. PAYMENTS TO SUBCONTRACTORS.

Contractors shall pay subcontractors for work satisfactorily performed by the subcontractor within thirty (30) days of receipt from the Department of payment for subcontracted work. Retainage may be held by the Contractor during the pendency of subcontractor's work in accordance with the terms of the subcontract but must be released by the Contractor within thirty (30) days of satisfactory completion of the subcontractor's work and payment for the completed work by the Department. Acceptance of the subcontracted work by the Resident Engineer shall constitute satisfactory completion of subcontracted work. Delay or postponement of payment to subcontractor for work or release of retainage may be imposed by the Contractor for failure by the subcontractor to pay for labor, supplies or materials or to provide required documentation or for other good cause shown but delay or postponement of payment may only be effected after written approval by the Resident Engineer. Exceptions will be approved only as to individual subcontractors on a case by case basis for good cause shown. Failure to promptly pay subcontractors or to release subcontractor's retainage may result in disqualification of a Contractor as non-responsible or refusal by the Department to issue a Proposal Form to a Contractor for future Projects as provided in Subsection 102.04. All subcontracting agreements made by the Contractor as provided in Subsection 108.01. shall include the currently adopted payment to subcontractors provisions as incorporated in the Contract. All disputes between Contractors and subcontractors relating to payment for completed work or retainage shall be referred to a dispute resolution service, such as American Arbitration Association (AAA) for resolution through binding arbitration.

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SOILS

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SECTION 201 CLEARING AND GRUBBING

201.01. DESCRIPTION.

This work shall consist of clearing, grubbing, removing and disposing of all vegetation and debris which are within designated limits occurring inside the limits of the right-of-way and easement areas—except objects that 1) are designated to remain or 2) are to be removed in accordance with other Sections of these Specifications. Clearing and grubbing will be required through grading exceptions unless otherwise noted on the plans. This work shall also include protecting from injury or defacement all vegetation and objects designated to remain.

201.04. CONSTRUCTION METHODS.

Construction methods include (a) clearing, (b) grubbing, (c) preserving areas outside of construction, and (d) selective clearing.

- (a) **Clearing.** Cut only those trees outside the limits of construction which are within areas designated by the plans. Leave all trees standing within the limits of construction which are permissible, consistent with the Clear Zone Policy, and which are designed as such by the Engineer. Remove branches of trees overhanging the roadway to a vertical distance of 20 feet (6m) above the road surface. Use only experienced workers to perform tree trimming and pruning and in such that the best standards of horticultural practices are observed. Do not damage trees remaining in place by careless or negligent construction practices.

When clearing trees, logs, stumps, brush, and objectionable material, remove, bury, burn, or otherwise dispose of them in an approved manner. When burning perishable material, obey all applicable laws and ordinances, and provide constant care by competent workers to avoid jeopardizing the surrounding vegetation, other adjacent property, or anything designated to remain on the right-of-way.

If there are perishable materials and debris which cannot be burned, remove these materials from the right-of-way if the Engineer permits. Dispose of the material at locations off the project and outside the limits of view from the project; do so only with the written permission of the owner of the property on which you plan to place the materials and debris, and only after making all necessary arrangements with the property owner. Include the cost in the unit price bid (or consider it as incidental to excavation).

- (b) **Grubbing.** Within the right-of-way—including channel right-of-way except as defined in (c) below—grub out and satisfactorily dispose of stumps and roots—except for undisturbed stumps and roots and nonperishable solid objects that are a minimum of 3 feet (0.9 m) below the subgrade or slope of embankments. In fill or channel areas, leave stumps and nonperishable solid objects (when convenient) provided they do not extend more than 6 inches (150 mm) above the original ground line or water level.

- (c) **Preserving Areas Outside of Construction.** Preserve areas outside of construction slopes (except area necessary for constructing fences) in their natural state. Unless specifically required by the Plans, do not clear or grub in areas outside construction stakes except to remove debris, dead trees, and stumps. If a strip or area within the median lies outside of construction stakes, your equipment may cross the median only at points designated by the Engineer.

NOTE: Be careful not to disturb areas outside of construction stakes except as necessary to store reserved topsoil from storage areas within the right-of-way. If your clearing operations damage any areas within the right-of-way (except for storage areas for topsoil), you shall restore them to the satisfaction of the Engineer at your own expense.

- (d) **Selective Clearing.** This work includes three types of activity: (1) trimming selected trees and shrubs (except those designated to be preserved as shown on the plans); (2) removing logs, root pods, brush, refuse dumps, and other undesirable debris from the ground and disposing of them; and (3) cutting, removing, and disposing of all undergrowth, stumps, and standing trees.

Perform this work in such a way that, when you are finished, the designated areas will be in a park-like condition that can be maintained economically. Dispose of all material in conformance with the Clearing and Grubbing requirements. Normally, when selecting trees for removal, leave a spacing of 20 to 30 feet (6 to 9 m) between the remaining trees.

Sever all stumps, trees and shrubs (except those designated to be preserved) flush with or below the ground. For uprooted trees, completely remove the stumps and fill the resulting holes with material approved by the Engineer. Trim selected trees and shrubs in such a manner that they will not be otherwise damaged.

Restrict the movement and operation of equipment so that trunks, branches, and roots of trees and shrubs selected for retention will not be scarred, broken, or otherwise damaged to the extent that the life of the plant is endangered.

201.05. METHOD OF MEASUREMENT.

Clearing and Grubbing or Selective Clearing will be measured by the lump sum for the project.

201.06. BASIS OF PAYMENT.

Clearing and grubbing or selective clearing (measured as provided above) will be paid for at the contract unit price by the lump sum. Such payment shall be full compensation for all equipment, tools, labor, and incidentals necessary to complete the work as specified.

CLEARING AND GRUBBING	LUMP SUM
SELECTIVE CLEARING	LUMP SUM

SECTION 202 EXCAVATION AND EMBANKMENT

202.01. DESCRIPTION.

This work shall consist of excavating material and constructing embankments. This includes furnishing, hauling, stockpiling, placing, disposing, sloping, shaping, compacting, and finishing material as described below. All material used as embankment and/or borrow must be free of dispersive clay as well as any hazardous and/or industrial waste as defined by 40CFR Parts 240 through 281 and state regulations.

- (a) **Excavations.** This work consists of removing, disposing, or compacting all material (except that removed under some other category) as required to construct a roadway in conformity with these Specifications and in reasonably close conformity with the lines, grades, thicknesses, and typical cross-sections shown on the Plans or established by the Engineer. This work involves four types of activity:
 - (1) **Unclassified Excavation.** Removing and disposing of all materials encountered in the work *except* muck excavation and structural excavation covered in section 501;
 - (2) **Muck Excavation.** Removing and disposing of saturated or unsaturated mixtures of soils and organic matter or other materials not suitable for foundation material (regardless of moisture content or other characteristic);
 - (3) **Unclassified Borrow.** Removing and disposing of all borrow excavation obtained off of the right-of-way or easement areas by the contractor which is *not* classified as Select Borrow;
 - (4) **Select Borrow.** Removing and disposing of all borrow material that meets the requirements in Subsection 705.01, or that is specified on the Plan (e.g., specific soil groups, group characteristics, or material obtained from a sandstone formation).
- (b) **Embankments.** Embankment construction consists of (a) constructing roadway embankments, including preparation of the areas upon which they are to be placed within the right-of-way, and (b) placing and compacting approved material.
- (c) **Earthwork.** Earthwork construction consists of all excavation, embankment, or unclassified borrow necessary to complete the project.

202.04. CONSTRUCTION METHODS.

- (a) **Excavations.**
 - (1) **Unclassified excavation.** Unclassified excavation requires attention to general characteristics, topsoil, rocks (including pre-splitting), obliteration of old roadways, avoiding the establishment of off-site facilities in wetlands or archeological sites, and avoiding unsuitable materials.

Finish the excavation and embankments for the project to reasonably smooth and uniform surfaces. Compact the top 6 inches (150 mm) of the subgrade in accordance with Section 202.02(b)(2) (earth embankment). The top of finished subgrade shall be within the tolerances shown in Subsection 202.02(f).

NOTE: Do not waste materials without permission of the Engineer.

Conduct excavation operations so that the material outside of the limits of the slopes will not be disturbed. Construct embankments that are incidental to unclassified excavation in accordance with Section 202.02(b).

When Plans require that topsoil be salvaged, remove and stockpile it before unclassified excavation begins. This will be paid for as a separate item in accordance with Section 205.

Rock Excavation: Unless otherwise provided for on the Plans, excavate rocks or other solid, unyielding material in the finished grade of roadbed cut sections to a depth of at least 12 inches (300 mm) below subgrade.

Backfill with approved material meeting the requirements of Select Borrow Subsections 705.01 or as specified on the Plans in accordance with Subsection 202.02(d)1-Materials. All approved material for backfill shall pass a 3 inches (75 mm) sieve. If any material does not reduce to less than 75 millimeters, remove it. Cut to drain all depressions or pockets in the undercut or overbreak areas. In cuts, compaction shall meet the moisture and density requirements described in Subsection 202.02(b)(2) (Earth Embankment), or as shown on the Plans.

NOTE: Neither an excavation below subgrade nor a backfill will be paid for unless it is verified by the Engineer before backfill is placed.

When pre-splitting is shown on the plans, the pre-splitting line will be established by the Engineer. Drill bore holes along the slope line, maintaining the drill holes at the angle designated on the plans, and ensuring that all drill holes are in the same plane. The diameter, spacing, and loading of pre-split holes must result in a neat break. Drill the pre-splitting holes for the full depth of the ledge. For the initial pre-splitting of a geological formation, use a 100 foot (30-m) test section. After drilling, loading, and shooting this test section, remove the material to determine if the diameter, spacing, and loading of the pre-split holes are adequate to give an acceptable backslope. If the pre-splitting is determined to be *unsatisfactory*, make adjustments in the spacing, diameter, and loading of the pre-split holes by using another 100 foot (30-m) test section. If the results are determined *acceptable*, however, continue the pre-splitting throughout the geological formation using these methods and procedures. When loading the pre-splitting holes with explosives, follow the manufacturer's recommendations. When the formation is of such character that no apparent advantage is gained by pre-splitting, the Engineer may order its discontinuance. Pre-splitting will be measured and paid as a separate item. Removal of pre-split material shall be measured and paid as unclassified excavation.

Old Roadways: Obliterate old roadways with any grading operations necessary to incorporate the old roadway into the new roadway and surroundings, thereby providing a pleasing appearance from the new roadway. Roadway obliteration will be paid for as unclassified excavation, unless it is included as a separate item under Section 210.

Archeological and Wetland Sites: Obey all laws and regulations when establishing off-site facilities, including plant sites, borrow pits, waste areas, haul roads, storage sites, parking areas, and similar areas associated with the acquisition, production, and delivery of borrow material and related road building materials.

Do not construct or locate off-site facilities in areas designated as wetlands by the U.S. Army Corps of Engineers (USACE) without written approval of the USACE. Contact the

Regulatory Branch of the USACE (phone, 918-669-7400) to determine the status of wetlands and to get approval for intended locations of off-site facilities. Present the entire plan for off-site facilities and site restoration to the USACE for approval. Forward a copy of the approval to the Engineer prior to the beginning of off-site excavation. When the project lies in an area designated as wetlands, do not disturb the area between the limits of construction and the right-of-way line without approval of the Engineer. Adhere to the requirements of permits which are included as a part of the contract.

Whether in wetlands or not, examine all intended locations of off-site facilities for archeological significance. Identify the intended location (legal description of the 1/4 section) to the Engineer, who will examine the site and confer with the proper authorities for this determination. Allow up to 10 days for the archeological investigation. If a site is determined to be of potential or established archeological significance requiring further investigation, you may either postpone the excavation until the artifacts have been removed or obtain an alternate location for the source of Borrow Material.

Whenever encountering archeological remains during the excavation of a previously approved off-site facility (or on the project itself), immediately cease the operation and notify the Engineer, who will contact the proper authorities for an evaluation. Depending on the significance of the archeological find, there may be only a short delay; but if the delay will be long, you should consider an alternate source of material. In such cases, with approval of the archeological authorities, it may be possible to cover over (rebury) the archeological materials and move to another location. If you remove archeological materials from a site, conform with the National Historic Preservation Act and the Archaeological Resources Protection Act of 1979, the Oklahoma State Register of Historic Places Act, and the Oklahoma Violating Sepulchre and the Remains of the Dead Act (refer to Oklahoma Statute 21, Sec. 1168, and 53, Sec. 361, OS 21, Chapter 47 Section 1168). If the construction operation is delayed due to archeological finds in an off-site facility, the Department will compensate a Contractor only with an extension of time commensurate with the amount of delay involving items on the critical path. Monetary compensation will not be allowed for these purposes.

Unsuitable Materials: If excavation to the finished graded section results in a subgrade or slopes of unsuitable soil, the Engineer may require (a) removal of the unsuitable materials and (b) backfill to the finished graded section with an approved material. Do not place the backfill before the Engineer can take the necessary cross-sectional measurements. To be suitable, material for backfilling must be equal to or better than approved materials close to or adjoining those materials removed, as determined by AASHTO M 145, Method of Classification. When shown on the Plans, backfill material shall meet the requirements of Subsection 202.02(d)1-Materials. The Engineer may designate as unsuitable those soils that cannot be properly compacted in embankments. Unsuitable material may also include trash, metal, glass, and other man-made items. Dispose of all unsuitable materials in a manner approved by the Engineer.

When the location of unstable soil is shown on the Plans, remove and replace the soil as shown on the Plans. If excavation requires more than one handling prior to the final placement, it will be paid for at the Contract unit price for unclassified excavation for each handling approved by the Engineer; or it may be paid for as another item of work for the second

handling. More than one handling is defined as an operation requiring a second loading and transporting of the material.

- (2) **Muck Excavation.** Locations and extent of muck excavation will be shown on the plans. Conduct excavation operations so that necessary measurements can be taken before replacing unsuitable material with an approved backfill, which will be either Unclassified Excavation or Unclassified Borrow pay items. Excavated materials that are not suitable for use as Topsoil can be hauled off and disposed of as waste.

Use an approved granular material below the water table level to prevent unsuitable material from becoming mixed with the backfill. Compact the backfill material according to Section 202.02(b) Embankments. Within the roadway fill limits, Muck Excavation may require coffer dams and dewatering, which will be incidental to the Muck Excavation. Quantities of Muck Excavation will be computed according to Section 202.05.

- (3) **Borrow Excavation.** Unless otherwise designated on the Plans or in the proposal, make your own arrangements for obtaining borrow and paying all costs involved. When procurement of borrow from a designated area is mandatory, it will be so shown on the Plans, and the right-of-way for mandatory borrow areas will be furnished by the State or other Agency purchasing right-of-way for the project.

In advance of opening any borrow areas, notify the Engineer far enough ahead of time to take cross-section elevations and measurements of the ground surface (after clearing) and to make any required tests.

NOTE: Do not excavate for borrow until the Engineer has determined that additional material will be needed. If you place more borrow than is required without written approval of the Engineer and thereby cause a waste of excavation, the amount of such waste will be determined and deducted from the borrow volume as originally measured, and payment will likewise be adjusted.

Do not place borrow pits and haul roads in a wetland. Once a potential borrow site has been identified, contact the U.S. Army Corps of Engineers regulatory branch for wetland determinations in accordance with "archeological and wetland sites" described in Subsection 202.02(a)(1).

Do not widen roadway cuts and special ditches except when shown on the Plans or authorized by the Engineer. Measure material removed from these as Unclassified Excavation.

Do not excavate borrow from pits closer than 500 feet (152 m) to the near right-of-way on a designated State or Federal highway system, except with written approval of the Engineer. Submit a plan detailing the excavation for borrow pits located in the upstream flood plain of a stream crossing any roadway or bridge project; in evaluating this plan for possible acceptance, the Bridge Engineer will consider possible detrimental effects to the bridge or roadway.

Provide and maintain all necessary haul roads from the borrow pits to the work site at your own expense. Unless otherwise provided, clearing, grubbing, stripping, and replacement of top soil of borrow areas and material not used in the embankment will not be measured for payment. Excavate all borrow pits with uniform slopes, and leave them in a neat, workmanlike condition and in full compliance with all applicable State and Federal laws. Upon completion of borrow excavation, shape the pit for cross-sectioning.

(b) **Embankments.**

Embankments require attention to (1) the preparation of the foundation and (2) construction practices.

- (1) **Preparation of Foundation.** Embankment less than 4 feet (1.2 m) high. Grub the trees and remove the topsoil and organic matter. Completely break up the cleared ground surface to a depth of 6 inches (150 mm) by plowing or scarifying. Compact the ground surface to not less than 95 percent of the Standard Density when tested in accordance to Subsection 106.03. Remove existing pavement or reduce pavement to a maximum size of 6 inches (150 mm).

Embankment more than 4 feet (1.2 m) high. Cut the trees 6 inches (150 mm) above the foundation. Break up the foundation to a depth of 6 inches (150 mm) by plowing or scarifying, where feasible. Place embankment directly on the scarified foundation.

Embankment across ground not capable of supporting equipment. The Engineer will determine whether the unstable material shall be removed or bridged. If bridged, limit the layer thickness to the minimum depth necessary to support equipment. Dump material on top of the layer and push it over the end. In those areas where roadway fills are to be placed which cannot be satisfactorily compacted to a stable and durable condition, the Engineer may designate removal and backfill with suitable material.

Embankment on an existing slope steeper than 1:4. Cut horizontal benches to a sufficient width to accommodate placing and compacting operations and necessary equipment. Begin each bench at the intersection of the original ground and the vertical cut of the previous bench.

- (2) **Construction Practices.** Start embankments at the low point and place in layers approximately parallel to the finished grade. Crown the roadbed to provide drainage at all times. Use effective spreading and disking equipment on each lift to obtain uniform moisture and thickness prior to compacting. If necessary, add or remove water in order to obtain the required density and moisture content.

During all stages of construction, route and distribute hauling and leveling equipment over the width and length of each layer of material.

Do not construct embankments on frozen material or place frozen material in embankments. Do not place rocks, broken concrete, or other solid materials in embankment areas where piling is to be placed or driven.

If an embankment is to be placed on one side only of abutments, wing walls, piers, retaining walls, or culvert headwalls, take care that the area immediately adjacent the structure is not compacted to the extent that it will cause overturning of the structure (or excessive pressure against it). When embankment is to be placed on both sides of a concrete wall, abutment, end bent, or box type structure, conduct operations so that the embankment is always at approximately the same elevation on both sides of the structure.

If rocks or boulders are larger than 6 inches (150 mm) in the largest dimension, do not use them in the embankment nearer than 5 feet (1.5 m) to the structure.

NOTE: If roadway excavation does not meet these requirements, other imported material will be measured and paid for as unclassified excavation or unclassified borrow.

Rock Embankment. If a large portion of the embankment material is rock, construct the embankment in layers no deeper than the maximum size of the rock present in the material; in no case shall the thickness of the layer exceed 2 feet (600 mm). Material with sizes up to 2 feet (600 mm) may be placed in lifts up to 3 feet (914 mm) in maximum thickness. The larger sizes should be placed near the outer slopes and the very large boulders, greater than 1 yd³ (0.76 m³), shall be embedded in the slopes, broken down to smaller sizes or wasted. End dumping is required: dump the rock onto the lift under construction; then push it with a crawler dozer (minimum 70,000 pounds (31,750kg)) over the leading edge of the lift, thoroughly wetted and compacted with heavy equipment. Level and smooth each layer with suitable leveling equipment and by distribution of spalls and finer fragments of earth. Construct the top 12 inches (300 mm) with approved material—placed in layers not exceeding 8 inches (200 mm) in loose thickness, and compacted as specified for earth embankments (see following paragraph). When specified on the Plans, approved materials will be classified for acceptance in accordance with Subsection 202.02(d)1.- Materials.

NOTE: No rock larger than 3 inches (75 mm) in any dimension shall be placed in the top 1 foot (0.3m) of compacted embankment.

Earth Embankment. If the roadway embankment is to be made of earth, including backfill, place it in layers not exceeding 8 inches (200 mm) (loose measurement). Compact all embankment material (including the top 6 inches (150 mm) of the subgrade in cuts) to not less than 95 percent of Standard Density when tested in accordance with AASHTO T99 methods C or D, unless otherwise stipulated by the Plans and the Contract or designated by the Engineer. Determine in-place density by AASHTO 205 (Rubber Balloon), AASHTO T 238 (Nuclear), or another approved test method for determining in-place density.

The moisture content of the embankment material at the time of compaction shall be within 2 points of the optimum moisture content as determined by AASHTO T-99, unless otherwise specified on the Plans or approved by the Engineer in writing. If specific or unusual conditions are encountered in the work, the Engineer may designate an adjusted moisture range for compaction of embankment. If desired, request in writing a lower moisture range for compaction of A-4 or A-5 soil groups to within 4 points below optimum moisture. If you successfully demonstrate to the Engineer's satisfaction that the lower moisture range is more practicable, your request may be so approved, provided embankment compaction meets the 95-percent minimum requirement.

Place and roll all material in layers except that which is inaccessible to the roller—for example, material adjacent to culverts or bridge abutments. In such cases, place the material in layers not to exceed 4 inches (100 mm) deep (measured loose), and compact it to the density and moisture content of the adjacent embankment with mechanical tampers.

NOTE: No additional compensation will be allowed for mechanical tamping. When the completed embankment section is greater than the typical section or greater than the section authorized by the engineer, the excess will be determined (with due allowance for shrinkage) and deducted from the appropriate quantity.

- (c) **Earthwork.** Construct earthwork on a project using excavation or embankment as defined in subsection 202.02(a) or 202.02(b).

(d) **Selective Subgrade Topping.** When designated on the Plans, construct the upper portion of the roadbed with selective subgrade topping materials; construct the base of the selected subgrade zone within plus or minus 0.20 feet (60mm) of the required elevation shown on the Plans.

(1) **Materials.** Selective subgrade topping materials shall meet the requirements specified for the various classes of topping shown below, or as may be otherwise specified by classification or characteristics referenced in AASHTO M 145.

<u>Selective Subgrade Topping</u>	<u>Specification Requirement</u>
Class I	AASHTO M 145 Granular Materials: A-1, A-2-4, A-2-5 or A-3 Groups
Class II	Subsection 705.01
Class III	5 to 15 P.I.
Class V (Restrictive)	AASHTO M 145 Silt-Clay Materials: <u>1/</u> A-7-5 and A-7-6 Groups A-4 and A-5 Groups

NOTE: 1/ these materials will be restricted from use in Class V Topping.

(2) **Selective subgrade topping.**

NOTE: Selective subgrade topping shall pass a 3 inch (75 mm) sieve unless otherwise specified.

2.1 *Testing.* Selective subgrade topping materials shall be tested in accordance with Subsection 705.01(b).

2.2 *Classification.* The classification of selective subgrade topping materials for acceptance by group and subgroup classifications will be in accordance with AASHTO M 145. The determination of group index values (numbers) specified for acceptance of group and subgroup classifications will be determined in accordance with the procedures prescribed in AASHTO M 145.

(3) **Sources of Selective Subgrade Topping Materials.**

3.1 *Contractor's Option.* The Contractor shall develop a plan which demonstrates to the Engineer that an adequate quantity of material will be salvaged or reserved for selective subgrade topping. During the movement of excavation, it will be the Contractor's responsibility to follow the approved grading plan to the extent that the available quantity of material needed for selective subgrade topping will be reserved for use.

3.2 *Mandatory Sources Designated on the Plans.* When selective subgrade topping material sources are designated on the Plans as mandatory sources, the Contractor shall excavate such materials within the limits designated, and haul and place the materials at the locations shown on the Plans.

(e) **Sloping, Shaping, Dressing, and Finishing.** Construct and dress the slopes of all cuts, ditches, and embankments in a neat and workmanlike manner, as indicated on the Plans or as directed by the Engineer.

NOTE: When rock extending to the top of cuts makes rounding impractical, it will not be required.

Slope, shape, and round old existing banks as specified for new work. The quantities of excavation in rounding tops of cut slopes will be paid for at the price for unclassified excavation and no other compensation will be allowed for this work.

NOTE: Where a neat, uniform face cannot be obtained using standard equipment, hand trim the slopes.

Trim the slopes in all cuts and banks of borrow pits from top to bottom in firm material.

Dressing shall include all the necessary clearing of the right-of-way of stumps, brush, weeds, and other rubbish, and disposing of same in accordance with Subsection 201.02.

- (f) **Tolerances.** Finish the roadbed to profile and cross-section within the following tolerances: bring the roadbed to a uniform cross-section with a maximum tolerance of ± 0.1 foot (30 mm) from the cross-section as given on Plans.

NOTE: The algebraic difference of the variations from grade of any points in the roadbed not more than 50 feet (15 m) apart shall not exceed 0.1 foot (30 mm).

When grading and surfacing are in the same contract, finish the roadbed profile and cross-section to within the tolerances specified under Section 301.04.

202.05. METHOD OF MEASUREMENT.

- (a) **Measured Quantities.** When payment is specified on a volume basis, measure all accepted excavation and borrow in both its original position and final position. Such measurements will include overbreakage or slides in unclassified excavation, not attributable to carelessness of the Contractor, and authorized excavation of rock, shale, muck or other unsuitable material.

NOTE: Volumes of structures and obstructions removed, measured and paid for under Section 619 will not be measured and paid for under this Section.

Authorized excavation of rock, shale, muck or unsuitable material below grade shall consist of that excavation necessary as authorized by the Engineer. If the plane of the designated grade line falls within a layer or stratum of rock, the below-grade excavation to the bottom of the layer, not exceeding 12 inches (300 mm) below the designated bottom of excavation, will be considered as authorized and will be paid as theoretical measurement.

NOTE: Rock excavation more than 12 inches (300 mm) below the designated grade line will not be paid for unless authorized by the Engineer. If the nature of the material, the thickness of the layers or strata and method of operations are such that it is practical to excavate only to the depth shown on the Plans, no measurement will be made of any material removed below the line designated. The measurements will include overbreakage in rock excavation from the backslopes to an amount not to exceed in any half station of 50 feet (15 m), 10 percent of the actual quantity required for that half station.

Measurements will be made for unsuitable materials actually excavated and removed to obtain proper compaction in cut sections and in foundations for fill sections.

Measurements will not be made of the suitable material temporarily removed and replaced to facilitate compaction of the material for the full depth shown on the Plans.

Where it is impractical to measure material by the cross-section method due to the erratic

location of isolated deposits, acceptable methods involving three-dimensional measurements may be used.

NOTE: Where the Contract does not specifically provide for payment for excavation, the work of excavation construction will not be paid for as such but will be considered incidental to the various classifications of embankment.

- (b) **Measurement of Embankments.** When embankment is specified in the Contract for payment as a separate bid item, accepted quantities for payment will be measured in its original and final position. The Engineer will compute the volume in cubic yards (cubic meters) from the dimensions of the embankment and the depths below the completed grade to which this method of construction applies. It will be the Contractor's responsibility to furnish the number of cubic yards (cubic meters) of material actually required to meet the Plan typical cross-sections.

NOTE: No allowances will be made for surplus material outside the limits of the typical cross-sections or for any materials or work required to correct settlement, shrinkage, or swell of the embankments. No deductions for the volume of culverts, manholes, and the like will be made. Where the Contract does not specifically provide for payment for embankment, the work of embankment construction will not be paid for as such but will be considered incidental to the various classifications of excavation.

- (c) **Earthwork.** When shown on the plans, earthwork will not be measured but will be paid for as lump sum. Estimated quantities will be shown on plans.
- (d) **Presplitting of Rock.** When specified in the Contract, presplitting of rock will be measured by the linear foot (meter) of drilling completed and approved.
- (e) **Selective Subgrade Topping.** Selective subgrade topping will not be measured for separate payment but measured as excavation or embankment. Any extra cost will be included.

202.06. BASIS OF PAYMENT.

Accepted quantities of excavation and embankment will be measured in accordance with accepted industry practices, such as the following:

Average End Area From Cross Sections. This method of volume computing is an average of the cross sectional end areas times the distance between them.

Average end area (using finite elements) from cross sections. This method of volume computing uses cross sectional end areas. The end area model is broken into finite elements (sections) and then sums the volumes of the elements. This method accounts for curvature in the alignment and any daylight (no cut/ no fill) points within each element.

Original surface vs. final surface (Digital Terrain Model). This method of volume computing creates a three dimensional surface of the original and final survey data. Triangulation is then used between the data points to determine the volume.

Three Dimensional Measurements. This method of volume computing may be used for erratic locations of isolated volumes by acceptable measuring practices.

Weight or Truck Measurement. This method of volume computing may be used if specified. It shall be done in accordance with Section 109.

Accepted quantities as measured above will be paid for at the contract unit price for the following:

- (A) UNCLASSIFIED EXCAVATION CUBIC YARD (CUBIC METER)
- (B) MUCK EXCAVATION CUBIC YARD (CUBIC METER)
- (C) UNCLASSIFIED BORROW CUBIC YARD (CUBIC METER)
- (D) SELECT BORROW CUBIC YARD (CUBIC METER)
- (E) EMBANKMENTS CUBIC YARD (CUBIC METER)
- (F) PRESPLITTING OF ROCK LINEAR FEET OF DRILLING
(METER OF DRILLING)
- (G) EARTHWORK LUMP SUM

Such payment shall be full compensation for furnishing all materials, equipment, labor and incidentals to complete the work as specified.

NOTE: When water is not specified as a pay item for use in embankment or excavation items in the contract, the water used will not be measured or paid for as a separate item but will be considered incidental to the work.

SECTION 203 TEST ROLLING

203.01. DESCRIPTION.

This work shall consist of the test rolling with heavy pneumatic tired rollers when shown on the Plans or required by the Specifications.

203.02. MATERIALS.

In the event test rolling discloses soft, yielding, or otherwise unstable areas, correct such areas by removing all unsuitable material and replacing it with suitable material. Demonstrate the satisfactory correction of any area by test rolling the corrected area.

203.03. EQUIPMENT.

Heavy pneumatic-tired rollers shall have a minimum of 7 wheels abreast. The tires must be of such size and ply that tire pressures shall not be less than 50 psi (350kPa) for rolling operations. The roller wheels and axles shall be so designed that each wheel will carry an approximately equal load. The roller shall have a loading platform suitable for loading with ballast sufficient to obtain a load of not less than 7,870 pounds (3,570 kg) per wheel. The Contractor shall furnish the Engineer with certified weights of the empty roller and weights of the ballast.

The rolling equipment shall be capable of operation within the limits of the Specification, and must be able to turn without damage to the work being tested. Rolling equipment shall be approved by the Engineer.

203.04. CONSTRUCTION METHODS.

Roll the area to be tested with at least 2 passes or 1 complete coverages. Operate the roller at speeds between 2 and 10 miles (3 and 16 kilometers) per hour as directed by the Engineer.

In every case when test rolling is called for on an embankment, test the embankment 2 feet (0.6m) below finish subgrade elevation also test the subgrade at the finished subgrade elevation in both embankments and cut sections.

203.05. METHOD OF MEASUREMENT.

Test rolling will be measured by the lump sum.

203.06. METHOD OF PAYMENT.

Test rolling will be paid for at the Contract unit price as follows:

TEST ROLLING.....LUMP SUM

Such payment will provide full compensation for furnishing all equipment, labor, water, and incidentals as may be required to achieve test rolling and meet the requirements of these specifications.

**SECTION 205
SALVAGING TOPSOIL**

205.01. DESCRIPTION.

This work shall consist of salvaging available natural topsoil from areas of excavation and embankment, then stockpiling and/or placing material on the completed areas as shown on the Plans or designated by the Engineer.

205.02. MATERIALS.

Soils exhibiting vegetative matter, grass roots, or other characteristics common to surface soils shall be deemed topsoil material. Areas where topsoil is to be salvaged shall be shown on the plans or designated by the Engineer.

205.03. EQUIPMENT.

The equipment for salvaging, stockpiling, and spreading the soil shall be approved by the Engineer.

205.04. CONSTRUCTION METHODS.

Where soil is to be salvaged, clear all of brush or other objectionable material, such as rock or shale. Incorporate weeds and tall grasses over 1 foot (0.3m) into the topsoil after they have been mowed. Excavate the soil to be salvaged to a depth that removes all material described in subsection 205.02. The depth shown on the plans is approximate and should be used only as a guide for determining the quantity on the project. Stockpile the topsoil in a manner approved by the Engineer in those areas shown on the Plans or determined by the Engineer.

- **Type A-Salvaged Topsoil.** Type A salvaged topsoil is the existing soil used as is. Finish the roadway excavation and embankment areas in reasonably close conformity to the lines and grades shown on the Plans or established by the Engineer. Prior to placing the salvaged soil, apply the specified fertilizer at the rate shown on the Plans. Spread the salvaged soil approximately 5 inches (130 mm) thick unless otherwise directed by the Engineer.

- **Type B-Salvaged Topsoil.** Type B salvaged topsoil is existing soil used in accordance with method B broadcast sprigging operations in Subsection 230.04(e). Prior to placing the salvaged topsoil, apply the specified fertilizer at the rate shown on the Plans. Stockpile the topsoil in a manner approved by the Engineer in those areas shown on the Plans or determined by the Engineer.

205.05. METHOD OF MEASUREMENT.

Measure both *type A and type B salvaged topsoil* in a stockpile by the cubic yard (cubic meter) in accordance with Subsection 109.01(a). This measurement will not be subtracted from excavation or embankment quantities. When designated on the plans and estimated quantities do not exceed 5000 cubic yards (3820 cubic meters), type A salvaged topsoil may be paid as a lump sum and will not be measured.

NOTE: Lump sum will not be used if estimated quantities exceed 5000 cubic yards (3820 cubic meters). Additional or second handling as defined in Subsection 202.02(a) will not be measured for payment. Type A salvaged topsoil will be measured as fifty-percent complete when the material has been removed from areas of excavation and embankment. Type B salvaged topsoil will be measured as 100-percent complete when stockpiled.

205.06. BASIS OF PAYMENT.

Accepted salvaged topsoil type A or B, measured as provided above, will be paid for at the contract unit price for as follows:

TYPE A-SALVAGED TOPSOIL.....LUMP SUM OR CUBIC YARD (CUBIC METER)
TYPE B-SALVAGED TOPSOIL.....CUBIC YARD (CUBIC METER)

Such payment shall be full compensation for furnishing all materials, equipment, labor and incidentals to salvage, stockpile and otherwise handle the materials as shown on the Plans and meet the requirements of these Specifications.

SECTION 209 MACHINE GRADING

209.01. DESCRIPTION.

This work shall consist of that class of grading in which the material to be excavated will approximately make the fills, and which can be completed principally by heavy machine blading supplemented with sufficient equipment to accomplish the necessary drifting and hauling. The work shall apply only to those sections of road where excavation does not exceed 5000 cubic yards (3820 cubic meters) balanced throughout each mile (1.6 kilometer) of road as specifically designated on the Plans.

209.04. CONSTRUCTION METHODS.

Machine grading shall include all necessary drifting or hauling of excavated material, plowing, scarifying, blading, removing stone and boulders from the roadway, compacting, and shaping to bring the roadbed to a uniform grade, and the typical cross section and approximate grade elevation shown on the Plans.

Grade and shape all side slopes and ditches to conform approximately with the typical cross section designated on the Plans. Unless otherwise shown on the Plans, excavate and backfill rock, hard sandstone, shale, or other solid unyielding material in the roadbed with acceptable material in accordance with Subsection 202.02(a). Construct excavation and embankment in accordance with Subsections 202.02 (a) and (b) of these Specifications. Unless otherwise noted on the Plans, clean all normal inlet and outlet channels to the right-of-way line; this work shall be included in the price bid for machine grading.

NOTE: Any damage to adjacent structures shall be repaired at the Contractor's expense, as directed by the Engineer.

As soon as any portion of the work is graded, blade and shape it to secure a smooth surface of uniform cross-section approximately true to line and grade. Maintain the roadway in a satisfactory condition at all times until final acceptance.

NOTE: All work performed under this item shall be done in a neat and workmanlike manner acceptable to the Engineer.

209.05. METHOD OF MEASUREMENT.

Measure machine grading by 100 foot (1.0 kilometer) stations to the nearest 0.01 (0.001) station along the centerline of the roadbed.

209.06. BASIS OF PAYMENT.

Machine grading, measured as provided above, will be paid for at the contact price for as follows:

MACHINE GRADING.....STATION

Such payment shall be full compensation for drifting, or hauling of excavated material, plowing, scarifying, blading, removal of stone and boulders from the roadway, compacting, shaping, cleaning all normal inlet and outlet channels to right-of-way lines, and for all labor, tools, equipment and incidentals necessary to complete the work as specified.

**SECTION 210
OBLITERATING ABANDONED ROAD**

210.01. DESCRIPTION.

This work shall consist of obliterating designated sections of old road by removing and disposing of surfacing, structures, and other items, in reasonably close conformity with the Plans and these Specifications.

210.04. CONSTRUCTION METHODS.

Complete this work only after the sections of the old road to be obliterated are no longer needed for traffic. Break and remove pavement and base courses in accordance with Section 619. Remove items with salvage value—such as steel bridges, culvert pipe, guard rail, posts, bridge timber, and all other items—without damage and stockpile or store them within the limits of the project as shown on the Plans.

NOTE: When salvage or use in the work is not shown on the Plans for any items, they shall become the property of the Contractor.

If concrete structures need to be removed, break them out to the ground level or to an elevation to be covered with earth. Then either spread out the broken concrete and at locations designated by the Engineer and cover it with earth to a depth of at least 1 foot (0.3 m), or remove it from the site of the work.

After removing the surfacing, structures, and other items, scarify or plow the old roadbed—rounding and smoothing by blading or other suitable methods; except in rock, grade, slope, and round the ends of embankments and the top of cuts within the existing right-of-way. Fill all ditches and grade the entire roadway.

210.05. METHOD OF MEASUREMENT.

When *obliterating abandoned road*, measure by the station of 100 foot (1.0 kilometers) or fraction thereof measured along the center line of the obliterated roadway.

210.06. BASIS OF PAYMENT.

Obliterating abandoned road, measured as provided above, will be paid for at the contract unit price for as follows:

OBLITERATING ABANDONED ROAD STATION

Such payment shall be full compensation for

- (1) removal, disposal, and storing of all materials with salvage value and for the satisfactory disposal and obliteration of other materials and debris,
- (2) regrading and shaping the roadway; and
- (3) for all equipment, tools, labor and incidentals necessary to complete the work as specified.

SECTION 220 TEMPORARY EROSION, SEDIMENTATION, AND STORMWATER POLLUTION PREVENTION AND CONTROL

220.01. DESCRIPTION.

This work shall consist of temporary measures and devices to control erosion and sediment within the project limits and to minimize the pollution of rivers, streams, impoundments and private properties. Such measures may include berms, dikes, slope drains, bale barriers, siltation screens, fabrics, sediment filters, sediment basins, fiber mats, netting, gravel, riprap, mulches, grasses and other erosion and sediment control devices and methods.

The temporary erosion and sediment controls shall be coordinated with the permanent erosion controls specified on the Plans, to assure economical, effective and continuous control of erosion and sediment throughout the construction and post-construction period.

220.02. MATERIALS.

The items, estimated quantities, and locations of the control measures will be shown on the Plans; however, the Engineer may increase or decrease the quantity of these items as the need arises. The Engineer also may allow other materials and work as the need arises and as approved in writing.

220.04. CONSTRUCTION METHODS.

- (a) **General.** Prior to the start of the construction, submit to the Engineer, for approval, schedules for accomplishment of the pollution control measures in accordance with the Storm Water Pollution Prevention Plan. Also submit, for approval, proposed methods of pollution control in areas which may be outside the construction limits, such as construction and haul roads, field offices, equipment and supply areas, and material sources; also submit a plan for disposal of waste materials.

NOTE: Work on the project shall not begin until the schedules for implementation of the controls and methods of operations have been reviewed and approved by the Engineer in writing.

- (b) **Requirements.**

(1) Limitation of disturbed surface area.

NOTE: The maximum disturbed surface area exposed by construction operations may be limited as mandated by soil conditions. Provide control measures to prevent or minimize impact to receiving waters as required by the Plans and/or in a manner approved by the Engineer in writing.

For areas of the State which have an average annual rainfall less than 20 inches (500 mm) and where stabilization is precluded by seasonal arid conditions, implement stabilization measures as soon as practicable. For all areas of the State with an average annual rainfall greater than 20 inches (500 mm), in any disturbed area where construction activities have ceased, permanently or temporarily, stabilize the area by the use of seeding, mulching, soil retention blankets, or other appropriate measures within 14 days, unless construction activities are scheduled to resume within 21 days.

Effectively prevent and control erosion and sedimentation on the site at the earliest practicable time as outlined in the approved schedule. Implement control measures, where applicable, prior to the commencement of each construction operation or immediately after the area has been disturbed.

Limit the amount of disturbed earth to the areas shown on the Plans in a manner approved by the Engineer. In areas where it is not possible to effectively control soil erosion and sedimentation resulting from construction operations, make every effort to limit the amount of disturbed area at any given time.

Should the control measures fail to function effectively, act immediately to bring the erosion and sedimentation under control by maintaining existing controls or by providing additional controls as directed by the Engineer. When in the opinion of the Engineer the site is adequately stabilized, remove and properly dispose of control measures.

**TEMP. EROS., SEDIMENTATION, AND STORMWATER
POLLUTION PREVENTION AND CONTROL**

220.04

(2) Conservation practices and controls.

NOTE: All labor, tools, equipment, and incidentals to complete the work will not be paid for directly but shall be considered as subsidiary work to the various items included in the contract.

- a. Construct disposal areas, stockpiles, and haul roads in a manner that will minimize and control the amount of sediment that may enter receiving waters. Do not locate disposal areas in any wetland, waterbody, or streambed. Do not locate construction roads in, or cross through, any waterbody or streambed without prior approval of the Engineer. With this approval, these areas must be crossed in compliance with applicable rules and regulations.
 - b. Restrict construction operations in rivers, streams, lakes, wetlands and other waterbodies to only those areas where it is necessary to perform the work shown on the Plans. Wherever streams are crossed, use temporary bridges, timber mats, or other structures, as directed by the Engineer. Minimize the use of a work road within a stream channel to the greatest extent practicable.
 - c. Provide protected storage for paints, chemicals, solvents, fertilizers, and other potentially toxic materials on the location approved by the Engineer.
 - d. Construct construction staging and vehicle maintenance areas in a manner to minimize the runoff of pollutants and have their location approved by the Engineer. Prevent pollution of receiving waters with petroleum products or other hazardous or regulated substances. When work areas of material sources are located adjacent to a waterbody, use control measures such as dikes, gabions, or rock berms to keep sediment and other contaminants from entering the adjacent waterbody. Take care during the construction and removal of such barriers to minimize down-gradient sedimentation.
 - e. As soon as practicable, clear all waterways of temporary embankment, temporary bridges, matting, falsework, piling, debris, or other obstructions placed during construction operations that are not a part of the finished work.
 - f. Minimize disturbance of existing vegetation, and limit such disturbances to only those areas approved by the Engineer.
 - g. Stabilize construction entrances by the use of rock, timber matting, or other acceptable techniques to minimize the off-site vehicle tracking of sediment.
- (3) Qualifications for project acceptance.** The project will not be accepted until, in the opinion of the Engineer, the Contractor has established a uniform perennial vegetative cover with a density of 70 percent in all areas not covered by permanent structures, or that equivalent permanent or temporary stabilization measures (such as riprap, gabions, soil retention blankets, mulching, or geotextiles) have been employed.

220.05. MEASUREMENT AND PAYMENT.

If the Contractor is required to install temporary erosion, sediment and water pollution control measures due to negligence, carelessness, lack of maintenance, or failure to install permanent controls as a part of the work as scheduled and ordered in writing by the Engineer, such work shall not be measured for payment but shall be performed at the Contractor's expense.

When the need for control measures can not be attributed to the Contractor's negligence, carelessness, lack of maintenance, or failure to install permanent water pollution control measures, and these measures are shown on the Plans and/or directed by the Engineer, these measures shall be calculated and paid for in accordance with applicable contract bid items. Removal of all control measures not incorporated as permanent control measures shall be performed subsidiary to the various bid items.

In case of failure on the part of the Contractor to prevent and control soil erosion, sedimentation, and water pollution which may degrade receiving water, the Engineer reserves the right to employ outside assistance or to use State forces to provide the necessary corrective measures.

NOTE: Such incurred direct costs plus project engineering costs will be deducted from any monies due or to become due to the Contractor.

Pollution control measures may be applicable to construction work outside the right of way where such work is necessary as a result of roadway-related construction such as material-source operations, haul roads, and equipment-storage sites. Pollution control measures outside the right-of-way will not be measured for payment but shall be performed at the Contractor's expense.

Temporary erosion, sedimentation and stormwater pollution prevention and control will not be measured for payment under Section 220 because they are included in other pay items.

SECTION 221 TEMPORARY SEDIMENT CONTROL SLOPE DRAINS

221.01. DESCRIPTION.

This work shall consist of the construction, maintenance, and removal of temporary slope drains and diversion dikes at locations shown on the Plans or determined by the Engineer.

221.02. MATERIALS.

For construction of slope drains, use flexible tubing, plastic sheeting, plastic screen, burlap, asphalt, pipe, or such materials as shown on the Plans. For inlets, use wood, pipe end sections, or other solid material. Construct outlets of loose rock, brush, straw, waste concrete, or pipe end sections.

221.04. CONSTRUCTION METHODS.

Construct diversion dikes in fill sections at the end of each day's operation. At points along the diversion dikes as specified on the Plans or by the Engineer, construct or extend slope drains at the end of each day's operations. Construct slope drains from the toe of the slope in order that they may be extended as additional fill is completed. Provide inlets with each slope drain. The type of outlet control will be determined by existing conditions, materials available, and in a manner approved by the Engineer.

Place slope drains on backslopes as the excavation of the cut area progresses, until the final grade is obtained and permanent controls are in place.

Maintain the slope drains and diversion dikes in such a manner as to be free from debris and open to the flow of water. Remove slope drains or leave them in place as determined by the Engineer and the permanent controls are completed and functioning.

221.05. METHOD OF MEASUREMENT.

Measure *temporary slope drains* by the linear foot (meter) in place. Measurements may be taken on each section of cut or fill slope when slope drains are installed.

NOTE: Inlets, outlets, and diversion dikes will be considered as an integral part of the drain.

221.06. BASIS OF PAYMENT

Accepted slope drains, measured as provided above, will be paid for at the contract unit price bid for as follows:

TEMPORARY SLOPE DRAINS.....LINEAR FOOT (METER)

Such payment shall be full compensation for furnishing all materials, equipment, labor, and incidentals to complete the work as specified.

SECTION 222 TEMPORARY SEDIMENT CONTROL BALE BARRIERS

222.01. DESCRIPTION.

This work shall consist of the construction, maintenance, and removal of temporary bale barriers at locations shown on the Plans or determined by the Engineer. Use bale barriers to trap sediment at the toes of slopes, or across ditches and defined waterways.

222.02. MATERIAL.

For vegetative material, use standard-sized rectangular bales of straw or hay—approximately 18x20x36 inches (450 x 500 x 900 mm) in size; securely bind them with wire or plastic twine. Anchor the bales with stakes of hardwood lumber, timber, or metal approximately 3 feet (0.9 m) long, and of sufficient strength to be driven firmly in the ground.

222.04. CONSTRUCTION METHODS.

As slope barriers, place the bales end to end and stake them down—a maximum distance of 4 feet (1.2 m) out from the toe of the slope. At locations determined on the site, leave out a bale and place a pile of loose rock or other acceptable filtering material in the opening—approximately 2/3 of the height of the bale—to act as a spillway type outlet.

As ditch checks, the bales shall be placed in a staggered position across the defined waterways and staked in place. The bales shall be placed up the slope on either side of the flow line, higher than the elevation of the bale in the center of the waterway.

All bale barriers shall be trenched 6 inches (150mm) into the soil.

Keep the barrier in good condition by replacing broken or damaged bales immediately after damage occurs. Removal of silt when specified by the Engineer shall be measured and paid for in accordance with Section 226. If at the direction of the Engineer the barriers are placed prior to final grade, the

contractor will be paid for each additional placement as “remove and reset temporary bale barrier.” This will involve using the existing barrier if possible.

Bale barriers may be removed or left in place at the discretion of the Engineer. All bale barriers replaced, due to natural causes and not the fault of the contractor, will be measured for payment at the direction of the Engineer.

222.05. METHOD OF MEASUREMENT.

Measure *temporary bale barriers* in place—along the length of the bale—by the linear foot (meter). Include the areas of the spillways, but the spillway material will not be measured as a separate item for payment.

222.06. BASIS OF PAYMENT.

Accepted bale barriers, measured as provided above, will be paid for at the contract unit price bid for as follows:

- (A) TEMPORARY BALE BARRIER LINEAR FOOT (METER)
- (B) REMOVED AND RESET TEMPORARY BALE BARRIER LINEAR FOOT (METER)

Such payment shall be full compensation for furnishing all materials, labor, equipment, and incidentals to complete the work as specified.

**SECTION 223
TEMPORARY SILT FENCE**

223.01. DESCRIPTION.

This work shall consist of the furnishing, installation, maintenance, and removal of geotextile barrier fence designed to remove suspended soil particles from water passing through the fence. It shall be installed as soon as practical around the toe of fill slopes to prevent siltation off right-of-way. The locations for temporary silt fence shown on the Plans are approximate and may be changed by the Engineer.

223.02. MATERIALS.

For a temporary silt fence, use a woven, polypropylene, polyester, or polyamide material that is resistant to ultraviolet degradation, mildew, and rot. Seal or selvege the edges of woven fabrics shall be sealed to prevent raveling. Use fabric at least 3 feet (0.9 m) wide.

NOTE: The material shall meet the requirements specified in subsection 712.06

223.04. CONSTRUCTION METHODS.

Install a temporary silt fence as shown on the plans and/or as directed by the Engineer. Construct it adequately to handle the stress from hydraulic and sediment loading. Six inches (150mm) of the fabric width shall be buried in a trench to prevent undercutting. Backfill the trench and the soil compacted over the geotextile. Splice fabric ends together with hog rings, locking plastic ties, or other approved methods.

Use posts of wood, steel, or synthetic material with a minimum length of 4 feet (1.1 m), and of sufficient strength to resist damage during installation and to support applied loads. Space posts no more than 5 feet (1.5 m) apart, and embed them into the ground at least 1 foot (300 mm). Securely fasten the geotextile to the posts in a manner that will withstand pressure during storm events.

Maintain the integrity of silt fences as long as they are necessary to contain sediment runoff, inspecting all temporary silt fences immediately after each rainfall and at least daily during prolonged rainfall. Correct any deficiencies immediately. In addition, make a daily review of the location of temporary silt fences in areas where construction activities have changed the natural contour and drainage runoff, to ensure that they are properly located for effectiveness.

When the accumulated silt reaches a depth of 6 inches (150 mm), remove the sediment and deposit it at approved sites in a manner that will not contribute to additional siltation. Removal of silt when specified by the Engineer shall be measured and paid for in accordance with Section 226. The fences shall remain in place until the Engineer approves removal. After removal of the fences, grade and dress the effected area to the satisfaction of the Engineer.

223.05. METHOD OF MEASUREMENT.

Measure *temporary silt fence* by the linear foot (meter) in place as directed by the Engineer.

223.06. BASIS OF PAYMENT.

Accepted fence, measured as provided above, will be paid for at the contract unit price bid for the following:

TEMPORARY SILT FENCE LINEAR FOOT (METER)

Such payment shall be full compensation for furnishing all materials, labor, equipment, and incidentals for installation, maintenance, and removal of silt fence along with the dressing of disturbed areas.

SECTION 224 TEMPORARY SEDIMENT CONTROL FILTERS

224.01. DESCRIPTION.

This work shall consist of the construction, maintenance, and removal of temporary sediment filters. Sediment filters shall be constructed to trap silt and debris prior to its entry into any drainage inlet or other similar structure which empties into a waterway or its subsidiary.

224.02. MATERIALS.

The bales of straw and stakes shall conform to the requirements of Section 222. Materials for type II sediment filter may be any type of nonerodible material available, such as loose rock, broken concrete, or other salvageable materials.

224.04. CONSTRUCTION METHODS.

Construct sediment filters in accordance with standard designs as soon as the inlets are completed sufficiently to receive runoff water; place these at locations shown on the Plans or determined by the Engineer.

Place bales for types 1-A and 1-B—staked tightly together—in such a manner as to cause the waterflow to be slowed and go over the bales, prior to entering the inlet.

Place nonerodible filter material shown for type II around the inlet—between the inlet and the flow of water. Place this material in such a manner that the water will be slowed and then flow over and through the material prior to entering the inlet.

Keep the filters (bales or other materials) in good condition by repairing any damage or break in the filters immediately. Removal of silt, when specified by the Engineer, shall be measured and paid for in accordance with Section 226.

Sediment filters may be removed as determined by the Engineer.

224.05. METHOD OF MEASUREMENT.

Temporary sediment filters will be measured by the number of units in place.

224.06. BASIS OF PAYMENT.

Accepted sediment filters, measured as provided above, will be paid for at the contract unit price bid for as follows:

TEMPORARY SEDIMENT FILTER..... ..EACH

Such payment shall be full compensation for furnishing all materials, labor, equipment, and incidentals to complete the work as specified.

**SECTION 225
TEMPORARY SEDIMENT CONTROL BASINS**

225.01. DESCRIPTION.

This work shall consist of the construction, maintenance, and removal of temporary sediment basins at locations shown on the Plans or determined by the Engineer. The approximate size, shape, and type shown on the Plans may vary depending on the soil type, the drainage area, and available right-of-way at the exact construction locations selected by the Engineer.

225.02. MATERIALS.

For both the inlet and outlet flows of the sediment basins, use (a) loose rock of sufficient size to withstand anticipated water velocity displacement or (b) other nonerodible materials approved by the Engineer. When type I sediment basins are specified, the outflow pipe shall be at least a 300 millimeter pipe installed in a manner approved by the Engineer.

225.04. CONSTRUCTION METHODS.

Shape inlets to confine the water to the defined channel as it enters the basin. Construct outlets to slow the velocity of water so sediment will be retained in the sediment basin. Use excavated material on the sediment basin dikes, or stockpile it, as directed by the Engineer.

Maintain sediment basins until permanent erosion control has been completed and is effectively operational. Sediment removal, when specified by the Engineer, will be measured for payment in accordance with Section 226.

225.05. METHOD OF MEASUREMENT.

Temporary sediment basins will be measured by the number of units constructed as specified above. Inlets and outlets will be considered an integral part of the basin.

225.06. BASIS OF PAYMENT.

Accepted sediment basins, measured as provided above, will be paid for at the contract unit price for the following:

TEMPORARY SEDIMENT BASIN EACH

Such payment shall be full compensation for furnishing all materials, labor, equipment and incidentals to complete the work as specified.

**SECTION 226
TEMPORARY SEDIMENT REMOVAL**

226.01. DESCRIPTION

This work shall consist of removing sediment which has become trapped by the various temporary or permanent erosion and sediment control devices.

226.04. CONSTRUCTION METHODS.

Sediment shall be removed at the direction of the Engineer from the control devices. After sediment removal has been completed, the control device shall be left in the operable condition for which it was designed. Any damage to the control devices shall be replaced at no cost to the Department. Materials removed shall be disposed of at locations and in a manner approved by the Engineer.

226.05. METHOD OF MEASUREMENT.

The number of times that the sediment needs to be removed will be determined by the Engineer. Measure sediment removal by the cubic yards (cubic meters) of material removed and disposed of in an approved manner.

226.06. BASIS OF PAYMENT.

Accepted sediment removal, measured as provided above, will be paid for at the contract unit price bid for as follows:

TEMPORARY SEDIMENT REMOVAL CUBIC YARD (CUBIC METER)

Such payment shall be full compensation for furnishing all materials, labor, equipment and incidentals to complete the work as specified.

**SECTION 227
TEMPORARY SILT DIKE**

227.01. DESCRIPTION.

This work shall consist of furnishing, installation, maintenance and removal of a geotextile and urethane foam barrier designed to remove suspended soil particles from water passing through the barrier. It shall be placed as soon as practical to prevent siltation off right-of-way. The locations shown on the Plans are approximate and may be changed by the Engineer.

227.02. MATERIALS.

Materials shall meet the requirements specified in Subsection 735.08. of the Section 700 MATERIALS.

Temporary Silt Dike 735.08

227.04. CONSTRUCTION.

All dikes shall be placed on the contour and in a row with ends tightly abutting the adjacent dike. Filter material shall lap over ends 6 inches (150mm) to cover dike to dike junctions; each junction shall be secured with wire staples. The staples shall be No. 11 gauge wire and be at least 6-8 inches (150-200 mm) in length.

The approach apron shall be followed by the sewn seam and front side of the dike section. The exiting apron will lie underneath the dike section and extend out beyond the discharge side.

When dikes are installed across surface drainage ditches, the highest point of the dike in the center of the ditch must be lower than the lowest point of the dike at the end. This will direct the water over the center of the dike and not around the end.

When installing as diversion dikes, silt dikes shall be placed along the contour or a 1-2 percent gradient to a planned discharge point.

Inspect all dikes after each rainfall event and/or each seven day period. Any deficiencies or damage shall be repaired at no cost to the Department. Accumulated silt or debris shall be removed and relocated as directed by the Engineer. If the dikes are damaged or inadvertently moved during the silt removal process, immediately reinstall or replace with functional material.

227.05. METHOD OF MEASUREMENT.

Temporary silt dike shall be measured by the linear foot (meter) in place, as directed by the Engineer.

227.06. BASIS OF PAYMENT.

Accepted silt dike, measured as provided above, will be paid for at the contract unit price bid for:

TEMPORARY SILT DIKE LINEAR FOOT (METER)

which shall be full compensation for furnishing all materials, labor, equipment and incidentals for installation, maintenance and removal of temporary silt dike along with the dressing of disturbed areas.

SECTION 228 NYLON EROSION CONTROL MAT

228.01. DESCRIPTION.

This work shall consist of furnishing and installing a nylon erosion control mat for ditch lining and slope protection in accordance with these Specifications and within reasonably close conformity with the lines and dimensions shown on the Plans or established by the Engineer.

228.02. MATERIALS.

Materials shall meet the requirements specified in the following Subsections of Section 700 Materials:

Nylon Erosion Control Mat	735.05(g)
Seed	735.04
Mat Fasteners	735.06 (b)

228.03. EQUIPMENT.

Furnish equipment required for satisfactory progress and completion of acceptable work in accordance with Subsection 108.06.

228.04. CONSTRUCTION METHODS

(a) Placing Mat.

- (1) **General.** Before protecting surfaces with nylon erosion control mat, grade, shape, and finish them so that the surfaces are stable, firm, and free of rocks or obstructions which would prevent the mat from lying in direct contact with the soil surface.
- (2) **Ditches.**
 - 2.1 Use three widths of mat for the standard ditch placement. Place the center width first, then the two side widths, using lap joints of 3 inches (75 mm).
 - 2.2 At the terminal ends of the ditch, bury the mat at least 12 inches (300 mm) vertically in an anchor slot dug into the soil. Secure the mat in the anchor slot by fasteners before backfilling the slot. Then compact the backfilled soil firmly in the anchor slot.
 - 2.3 On ditches with grades exceeding 6 percent, install a 6 inch (150 mm) deep check slot every 25 feet (7.6 m) and secure the mat in the check slots by fasteners.
 - 2.4 Seeding, Ditches Only. When mats are to be installed and approved during the normal "out of planting season," uniformly seed common Bermuda grass seed at the rate of 6 pounds per acre (6.7 kg per hectare) on the exposed areas of soil beneath the mat. During the "planting season," complete application of the specified plant material (sodding, sprigging, or seeding) prior to placing the mat in the ditches.
- (3) **Slopes.**
 - 3.1 When placing mat on slopes, bury the top end at least 12 inches (300 mm) vertically in an upper anchor slot and the bottom end at least 6 inches (150 mm) in the lower anchor slot. Secure the mat in the anchor slots by fasteners before backfilling the slot. Firmly compact the backfill soil in the anchor slots.

NOTE: Lower anchor slots cannot be secured when the ditch is lined with concrete or other types of materials.

- 3.2 Install the mat in a manner that will allow the downgrade edge to overlap the previously laid strip. Use lap joints of 3 inches (75 mm).
- 3.3 On slopes exceeding 60 feet (18 m) in slope length, install a 6 inch (150 mm) deep check slot every 40 feet (12 m), and secure the mat in the check slot by fasteners.
- 3.4 During the “planting season,” complete application of the specified plant material before placing the mat on the slopes. During the “out of planting season,” place the mat as temporary protection until the specified plant material can be applied during the proper season.

(4) End of Roll. Overlap the ends of the roll of the mat 3 feet (0.9 m) with the upslope end on top.

- (b) **Fastening the Mat.** The mat must be held firmly in place with fasteners, which must be pressed firmly against the mat and securely driven into the underlying soil. The normal spacing for fastening the mat shall be 3 feet (0.9 m) along the edge lap joint and down the center of each width of mat. The mat shall also be fastened across the width in anchor slots, check slots, and end overlaps on 18 inches (450 mm) centers. Offset the center fasteners 18 inches (450 mm) from the edge fasteners.
- (c) **Seeding.** When seeding is required in ditches due to work being done during the “out of planting season,” use either seeding method ‘A’ to apply it, as specified in Subsection 232.04(b), or use hand broadcasting.
- (d) **Maintenance.** Maintain the area properly until the entire project has been completed—including the refilling of washed out areas, reseeding, and replacing mat.

228.05. METHOD OF MEASUREMENT.

Nylon erosion control mat installed in place, including the seeding, shall be measured by the square yard (square meter) of the area covered.

228.06. BASIS OF PAYMENT.

Accepted quantities, measured as provided above, will be paid for at the contract unit price as follows:

NYLON EROSION CONTROL MAT SQUARE YARD (SQUARE METER)

Such payment shall be full compensation for furnishing all materials, equipment, labor, and incidentals to complete the work as specified.

**SECTION 229
DITCH LINER PROTECTION**

229.01. DESCRIPTION.

This work shall consist of furnishing and installing excelsior mat or solid slab sod as ditch liner protection in accordance with these Specifications and in reasonably close conformity with the areas and locations shown on the Plans or established by the Engineer.

229.02. MATERIALS.

Excelsior Mat: This material shall meet the requirements for Subsection 735.05(c).

Solid Slab Sod: This material shall meet the requirements for Subsection 735.02(b)1.

Mat Fasteners: Mat fasteners used for anchoring the excelsior mat shall meet the requirements for the type specified on the Standard Drawings.

229.04. CONSTRUCTION METHODS

- (a) **Placing Excelsior Mat.** Place the mat as shown on the Plans so that the fibers are in contact with the soil and the netting is on the top. Place a single strip of mat parallel to each side of the ditch liner.
- (b) **Placing Solid Slab Sod.** Place the sod as shown on the Plans and in accordance with Subsection 230.04(a). Apply 185 gallon (700 liters) of water and 5 pounds (2.25 kg) of 10-20-10 fertilizer per 100 linear feet (30 m) of ditch liner.
- (c) **Fastening the Mat.** After placing the excelsior mat, make sure it's held firmly in place with fasteners, as shown on the Plans, pressing them firmly against the mat and securely driving them into the underlying soil.
- (d) **Repairs.** If the ditch liner protection material becomes damaged, promptly replace it in kind. If the soil beneath or surrounding the ditch liner becomes eroded, restore the area to the original condition and grade it prior to placement of the protection material.

229.05. METHOD OF MEASUREMENT.

Ditch liner protection will be measured by the linear foot (meter) of ditch liner in place.

NOTE: Materials and work necessary for repairs will not be measured for payment.

229.06. BASIS OF PAYMENT.

Ditch liner protection, completed and accepted in place and measured as provided above, will be paid for at the contract unit price as follows:

DITCH LINER PROTECTION LINEAR FOOT (METER)

Such payment shall be full compensation for furnishing all materials, equipment, labor, and incidentals to complete the work as specified.

SECTION 230 SODDING AND SPRIGGING

230.01. DESCRIPTION.

This work shall consist of furnishing and planting viable Bermuda grass sod or sprigs in accordance with these Specifications and in reasonable close conformity with the areas and locations shown on the Plans or as established by the Engineer.

230.02. MATERIALS.

Materials shall meet the requirements specified in the following Subsections of Section 700 Materials:

Bermuda Grass Solid Slab Sod	735.02
Bermuda Grass Mulch Sod	735.02
Bermuda Grass Row Sprigging	735.02
Bermuda Grass Broadcast Sprigging	735.02

Make certain that the water is free from harmful quantities of toxic salts or other substances that might interfere with the establishment or future subsistence of turf or plants.

230.03. EQUIPMENT.

The Contractor shall furnish equipment in accordance with Subsection 108.06 and as prescribed herein.

- (a) **Rolling Equipment.** Unless otherwise approved by the Engineer, the machine for compacting mulch sodding shall be equipped with a single or tandem axle corrugated roller. It shall weigh not less than 125 or more than 300 pounds per foot (186 or more than 446 kilograms per meter) of rolling width for each axle. It shall be operated approximately parallel to the contour of slopes.
- (b) **Watering Equipment.** Equipment shall apply water as specified on plans without operating on the slopes. Provide a calibrated meter to measure water.
- (c) **Fertilizer Equipment.** Equipment shall conform to Subsection 234.03(b).
- (d) **Sprigging Equipment.** The equipment for row planting of sprigs shall automatically open the furrows, place the sprigs in the furrow, then cover the sprigs and furrow with soil—all in one continuous operation.

230.04. CONSTRUCTION METHODS.

- (a) **Solid Slab Sodding Operations.**
 - (1) To prepare areas to be sodded, fill, reshape eroded areas, clean ditches, and refinish slopes and medians to the established typical grading section.
 - (2) Clear the area of all litter and debris.
 - (3) The location, placement, and seasonal requirements for areas to be solid slab sodded will be as shown on the Plans.
 - (4) Place the slabs of sod soil side down in rows, which on slopes shall run parallel to the roadway. Fit each slab tightly against the edge of adjoining slabs, and place them so that the

vertical joints are not continuous across adjoining horizontal rows. Fill voids with additional sod. Thoroughly press all slabs into firm contact with the soil underneath.

- (5) After the slabs have been placed, thoroughly water the sodded area. When the area is sufficiently dry, fill additional voids with good soil and water again. Water the area daily for a period of at least seven days after placement. Watering operations shall conform to Subsection 230.04(g).
 - (6) Apply fertilizer in accordance with Subsection 230.04(h).
- (b) **Mulch Sodding Operations.**
- (1) To prepare areas to be mulch sodded, fill, reshape eroded areas, clean ditches, and refinish slopes and medians to the established typical grading section.
 - (2) Prior to placing the mulch sod, scarify the cut and fill slopes.
 - (3) Place the sod on the prepared areas and spread it uniformly to such a depth that when thoroughly compacted, with a roller conforming to Subsection 230.03, it is 3 inches (75 mm) thick. Roll slopes along approximate contour lines unless otherwise directed.
 - (4) Water the mulch areas within 24 hours after placement. The remaining watering operation shall conform to Subsection 230.04(g).
 - (5) Apply fertilizer in accordance with Subsection 230.04(h).
- (c) **Row Sprigging Operations.**
- (1) To prepare areas to be row sprigged, till the specified areas to a depth of at least 4 inches (100 mm) with an offset disk plow or a tandem disk plow.
 - (2) Apply fertilizer in accordance with Subsection 230.04(h).
 - (3) Plant the sprigs with an automatic sprig planter conforming to Subsection 230.03 (you may hand plant in areas where the sprig planter cannot operate). Plant the sprigs in furrows parallel to the approximate contour lines of the slopes. The distance between furrows shall not exceed 20 inches (500 mm) on centers. Place the sprigs approximately 3 inches (75 mm) deep at the rate of approximately 30 bushels per acre (6.9 cubic meters per hectare) with the ends of sprigs meeting or overlapping.
 - (4) Do not operate the sprig planter in excess of 4 miles (6.4 kilometers) per hour.
 - (5) Roll all sprigged areas the same day they are planted; roll slopes along approximate contour lines.
 - (6) Water the row sprigged areas within 24 hours after placement. The remaining watering operation shall conform to Subsection 230.04(g).
- (d) **Broadcast Sprigging Operations.**
- (1) • **Broadcast Sprigging Method A.** Prepare areas for broadcast sprigging method A by tillage with either a tandem disk plow or an offset disk plow until the areas are suitable for sprig planting. The depth of tillage shall be approximately 4 inches (100 mm). If rains or other conditions should pack the soil before planting can be completed, repeat the tillage. Plant at least 80 bushels per acre (8.70 cubic meters per hectare) of sprigs unless otherwise shown on the Plans. Broadcast the sprigs evenly and uniformly on the soil surface. Within two hours after the sprigs have been planted, disk the areas to a depth of approximately 3 inches (75 mm) with either a tandem or offset disk plow.

- (2) • **Broadcast Sprigging Method B.** Thoroughly incorporate at least 12 bushels (0.42 cubic meters) of sprigs into 100 cubic yard (76 cubic meters) of stockpiled method B salvaged topsoil. Use a method approved by the Engineer to meter and distribute the sprigs into the stockpiled topsoil. During the mixing operation, keep both the soil and sprigs moist. Prepare areas for broadcast sprigging method B shall consist by scarifying on the contour, with approved equipment, the designated areas shown on the Plans prior to placing the soil-sprig mixture. Spread the soil-sprig mixture on the designated areas 5 inches (125 mm) thick, within 4 hours of manipulation.
- (3) • **Fertilizing, Rolling, and Watering.** Use the following procedures for both method A and method B of broadcast sprigging:
- 3.1 • Apply fertilizer in accordance with Subsection 230.04(h).
 - 3.2 • Roll and compact the planted areas with equipment conforming to Subsection 230.03(a). Rolling of slopes shall be along approximate contour lines and in a manner approved by the Engineer.
 - 3.3 • Water the sprigged areas 24 hours after placement. Watering operations shall conform to Subsection 230.04(g).
- (e) **Planting Season and Weather Restrictions.**
- (1) Perform erosion control operations during the seasonal periods shown on the Plans. With written approval of the engineer, you may perform permanent erosion control operations out of season if you guarantee at least 70% cover at the beginning of the next planting season. As cut and fill sections are brought to grade and constructed to the lines and dimensions shown on the typical sections, promptly place and finish the salvaged topsoil, and construct the specific erosion control item or items, if in accordance with seasonal limitations, as shown on the Plans. Regardless of the dates specified, suspend the work during excessively wet or dry weather conditions that would cause unsatisfactory results.
 - (2) Planting shall begin promptly and shall proceed without undue delay until completed or until interrupted by the “out-of-season period.” When construction of an operation is interrupted by the “out-of-season period,” resume construction immediately with the beginning of the “in season period” for that operation.
- NOTE: If the contractor elects to place permanent erosion control out of season, the responsibility for repair and maintenance as specified in Subsection 230.04(i) shall be at the contractor’s expense.*
- (3) Apply temporary erosion control operations on all cuts, fills, and other disturbed erodible areas where the permanent operation was interrupted by seasonal limitations. Begin this work immediately after placement of topsoil or as otherwise directed by the Engineer and continue without undue delay.
- (f) **Soil Moisture Requirements.**
- (1) Soil moisture shall exist throughout the zone from 1 inch (25 mm) below the surface to at least 5 inches (125 mm) below the surface at the time of planting. The required moisture content of the soil may be estimated and judged closely by the hand-squeeze test. The soil should readily form a tight cast when squeezed in the hand. The cast should break into two pieces without crumbling and without leaving excess water on the hand after casting.

- (2) Sodded or sprigged areas shall be watered for 30 days after planting unless otherwise directed. The depth of watering with moving equipment shall be carried out on short sections until the soil is moist throughout the top 1 inch (25 mm).
 - (3) The application rate and fineness of the spray shall be adjusted according to wind velocity to provide uniform infiltration without appreciable erosion or excessive runoff.
- (g) **Fertilizer Operations.**
- (1) Apply fertilizer at the rates shown on the Plans.
- NOTE: Do not place fertilizer on hard or glazed surfaces.*
- (2) When satisfactory results can be obtained, you may disk for soil preparation, remove weeds, and incorporate fertilizer in one operation.
 - (3) If a fertilizer containing phosphorous is specified, apply it *before* placement of solid slab sod, mulch sod, row sprigging, or broadcast sprigging, and then incorporate it into the soil by disking.
 - (4) If a fertilizer contains nitrogen only, apply it *after* the sodding and sprigging operations have been completed.
- (h) **Repair and Maintenance.** The Contractor shall be responsible for repairs and maintenance of areas designated for sodding or sprigging until all work on the Contract or designated portion thereof has been completed and approved for final acceptance.
- (1) **Repair.** This includes the following: recovery, replacement, and compaction of soil that has been removed by erosion; filling and reshaping eroded areas; cleaning ditches; and refinishing slopes and medians to the approximate typical grading section shown on the Plans or as determined by the Engineer. Repair shall include resodding or sprigging, refertilizing, and watering damaged areas, which shall be performed during the specified planting season.
 - (2) **Maintenance.** This consists of weed control by mowing, hand cutting, herbicides, or other approved methods. Remove weed growth on sodded areas as often as determined by the Engineer. If herbicides are used, use them in accordance with label instructions and after getting approval from the Engineer. Mowing shall be in accordance with Section 241.

230.05. METHOD OF MEASUREMENT.

Solid slab sodding, mulch sodding, row sprigging, and broadcast sprigging Method A and Method B will be measured by the square yard (square meter) of sodded area.

Watering will be measured by the 1000 gallon (kiloliter) of water. The water will be measured by the use of a calibrated meter.

Fertilizer will be measured and paid for in accordance with Section 234.

Mowing when directed by the Engineer, shall be measured and paid for in accordance with Section 241.

230.06. BASIS OF PAYMENT.

Accepted sodding, measured as provided above, shall be paid for at the contract unit price as follows:

- (A) SOLID SLAB SODDING SQUARE YARD (SQUARE METER)
- (B) MULCH SODDING SQUARE YARD (SQUARE METER)
- (C) ROW SPRIGGING SQUARE YARD (SQUARE METER)
- (D) BROADCAST SPRIGGING (METHOD A) SQUARE YARD (SQUARE METER)
- (E) BROADCAST SPRIGGING (METHOD B) SQUARE YARD (SQUARE METER)
- (F) WATERING M-GAL (KILOLITER)

Such payment shall be full compensation for furnishing all materials, equipment, labor, and incidentals to complete the work as specified.

**SECTION 231
PLANTING**

231.01. DESCRIPTION.

This work shall consist of furnishing, handling, planting, and establishing plant materials in accordance with these Specifications and in reasonably close conformity with the areas and locations shown on the Plans or established by the Engineer.

231.02 . MATERIALS.

Materials shall meet the requirements specified in the following Subsections of Section 700 Materials.

Plant Materials	735.03
Plant Soil Mix	735.03
Vegetable Compost	735.03

Water shall be free from harmful quantities of toxic salts or other substances that might interfere with the establishment and growth of plants.

231.03. EQUIPMENT.

You must furnish equipment meeting the requirements of Subsection 108.06 and as prescribed herein. When machine planting trees, the equipment must have all the accessories necessary to dig, lift, carry, and deposit a plant intact into an excavation (previously dug by the same or identical type machine) without damage to the ball of soil or the plant.

231.04. CONSTRUCTION METHODS.

- (a) **General.**
 - (1) Perform all work under the supervision of a competent and experienced nurseryman.
 - (2) Protect all new plants and existing trees, shrubs, and turf from damage or injury before, during and after construction and plant establishment operations.
 - (3) Bare-rooted plants will be designated BR, and balled and burlapped plants will be designated B&B.

(b) Care and Handling of Plants.

- (1) While BR or B&B plants are being transported to the project site, moved to and from the heeling-in beds, being distributed in planting beds, or awaiting planting after distribution, protect the roots and balls from drying out.
- (2) If BR plants are not planted within 2 hours after delivery to the project site or planting location, you must see that they are heeled-in in moist soil or sawdust in accordance with acceptable horticultural practices.
- (3) If B&B plants are not planted within 24 hours after delivery to the project location, protect the balls adequately with moist soil or sawdust until they are removed for planting.
- (4) Protect containerized plants in the same manner as B&B plants.
- (5) Maintain all heeled-in plants properly until planted.

NOTE: Plants remaining heeled-in during the summer will not be acceptable.

- (6) In digging, loading, unloading, planting, and other handling operations, exercise utmost care to prevent injuries to the roots, stems, or branches of the plants. Carefully preserve the solidity of the ball of the B&B plants, which you must handle by the rootball, not by the stems or trunk.

NOTE: You must replace, at your own expense, any plants that are rendered unfit for planting.

- (7) Dig collected plants with extreme care in a manner satisfactory to the Engineer. Digging, transporting and replanting of collected plants shall be performed in accordance with acceptable horticultural practices. An approved tree digging machine may be used to dig, transport, and plant collected plants.
- (8) Unless plants are dug, transported, and planted by approved tree-digging machines, all evergreens shall be balled and burlapped (B&B) except when they are container grown and are still in the container. Deciduous plants may be either B&B, BR, or containerized, as specified on the Plans.

(c) Seasonal Planting Restrictions.

- (1) Planting operations for deciduous plants shall be restricted to the period from November 25th to the following March 31st, and the planting operations for Evergreen plants shall be restricted to the period from October 1st to the following May 15th.
- (2) Regardless of the specified planting dates, the work shall be suspended when the temperature is below 25°F(-3.8°C), the wind velocity over 25 miles (40 kilometers) per hour, the natural ground or topsoil is frozen or too wet, or the continuation of prevailing weather would likely cause unsatisfactory results.
- (3) The Contractor shall complete his planting operations as early in the specified season as practicable.
- (4) Plants that do not meet specifications for any reason after planting shall be removed immediately, and if within the current planting season, be replanted immediately, or if out of planting season, be replanted the following season all in accordance with these Specifications.

- (d) **Plant Locations.** The plant locations shown on the Plans are approximate and may be adjusted to suit actual field conditions as determined by the Engineer.
- (e) **Plant-Hole Excavation.**
- (1) Unless plant holes are dug with an approved tree digging machine, make all plant holes cylindrical with approximately vertical sides. When excavations are in rocky subsoil (or in any impervious material that would hamper proper drainage and would likely retard normal root development and growth), loosen the soil by methods approved by the Engineer. Caliper determinations shall be in accordance with current USA Standard for Nursery Stock USAS Z60.1.
 - (2) Excavate holes sufficiently deep to provide space for at least 4 inches (100 mm) of the existing excavated soil to be replaced below the roots or balls and to let the plant stand slightly higher than it stood in the nursery or collecting field. Regardless of the minimum size, for holes shown in the following Table for BR plants, make the diameters large enough to allow at least 8 inches (200 mm) of backfill between the outside tip of fully spread roots and the sides of the hole.
 - (3) Make plant holes for potted or containerized plants 3 times the diameter of the container and 150 millimeters deeper than the height of the container, unless otherwise specified on the Plans.
 - (4) When plants are to be grouped together in a plant bed, loosen the entire area of the plant bed, and break up all clods, to a depth of at least 6 inch (150 mm) prior to excavating plant holes.
 - (5) Thinly spread excess material from plant-hole excavations over the surrounding area, making a neat appearance. If material is not appropriate for spreading, dispose of it in a manner approved by the Engineer.
- (f) **Pruning.**
- (1) Before planting, examine the root systems of all BR plants and cut off smoothly any bruised or broken parts.
 - (2) Prune the tops of all plants in accordance with acceptable horticultural practices, as determined by the type, shape, size, and condition of the plant.
- (g) **Planting Procedures.**
- (1) Loosen the subsoil in the bottom of the plant hole 6 inch (150 mm) deep. Then place and firm a layer of soil 4 inch (100 mm) or more in depth in the bottom of the hole, to provide correct final planting elevation, before the plant is placed.
 - (2) Then place the plant in the prepared hole at the proper position with regard to depth, alignment, final grade of surrounding ground level, and vertical placement of the trunk or stems—and this position shall be maintained during all subsequent backfilling and watering operations. The plants shall stand, at the time of completion of the planting operation, slightly deeper than they stood in the nursery or collecting field, except that spreading evergreen plants shall stand slightly higher than they stood in the nursery.
 - (3) After BR plants are placed in the proper position, backfill the hole with friable soil, placing it in thin layers and carefully working and firming around the roots in such a manner as to avoid bruising or breaking the roots.

- (4) When 1/2 to 2/3 of the backfilling has been completed, apply sufficient water to settle the soil. Do not saturate the soil to the extent of filling voids and excluding all oxygen from around the roots. After sufficient water absorption has occurred, fill the remainder of the hole as previously specified.
 - (5) Handle B&B plants the ball and place them in the hole in such a manner that the soil of the ball shall not be loosened from the roots. Backfilling, firming, and settling shall be carefully done in the same manner as specified for BR plants. Just before the final backfilling above the top of the ball, loosen the burlap or cut it away from around the stem, the edges laid back and the plant thoroughly watered.
 - (6) On relatively flat areas, make a shallow saucer-like depression that extends from around the plant to 18 inches (450 mm) outside the plant hole. On steeper slopes, construct a ridge of firmly compacted soil, of sufficient plasticity to withstand washing and approximately 6 inches (150 mm) high, 18 inches (450 mm) outside and around the lower half of the plant hole.
- (h) **Vegetable Compost.** A 2 inch (50 mm) covering of approved vegetable compost, conforming to Subsection 735.03, shall be placed over the entire spaded area around each plant. When plants are placed in beds, the entire bed shall receive a covering of the compost. This compost shall be maintained as a fine textured mulch around the plants until acceptance of the project.
- (i) **Mulch.**
- (1) Following the application of nitrogen fertilizer, place a 4 inch (100 mm) covering of vegetable compost approved by the Engineer over the entire plant pit and saucer-shaped area around each plant as detailed on the Plans.
 - (2) When plants are placed in beds, fertilize the entire bed and cover it with mulch 4 inch (100 mm) deep. Maintain this mulch around the plants until final acceptance of the project.
 - (3) Place a slow release 38-0-0 Nitrogen fertilizer prior to placement of bark mulch, and spread it at the rate of 22 pounds per 100 square yards (12 kg per 100 square meters) of plant pit or plant bed area.
- (j) **Water.** Furnish and apply water in sufficient quantity whenever necessary to keep the plants in alive and healthy condition, from the time of delivery to the final acceptance at the end of the plant establishment period. If plants are replanted the following season, water them sufficiently for them to become established.
- (k) **Staking.** Immediately following the application of vegetable compost, stake all trees as shown on the Plans so that they present a neat appearance. Take precautions during staking operations to prevent damage or injury to the plants and roots.
- (l) **Plant Establishment Period and Replacements.** Maintain plant material for an establishment period of twenty-four months. When specified on the plans, the Contractor will warrant the trees for the entire twenty-four months period. The establishment period will begin upon completion of the entire planting operation and after a field inspection of the completed plantings. Employ all possible methods to keep the trees in a healthy growing condition for the duration of the establishment period. Good horticultural practices during the establishment period will include spraying for insects and disease control, watering, pruning, cultivating, adjustment of support guys and stakes and other tree maintenance activities as directed by the Engineer.

Water the trees to supplement rainfall amounts, with the amount of water needed dependent upon weather conditions. The use of a soil moisture probe is recommended for evaluation of watering needs.

Take care not to over water the trees. Maintain the mulch layer around the base of the trees at a minimum depth of 4 inches (100 mm) during the establishment period. Replace trees which are dead, dying, or otherwise unhealthy with trees of the same size and variety as the original planting. Alternate or substitute varieties of plants shall be used only if approved by the Engineer. Nursery stock of a similar variety with minimum diameter of 3 inches (75 mm) could be considered for a replacement item, if acceptable transplant trees are not available. Replacement shall occur as soon as weather conditions allow.

- (m) **Method of Determining Progress Percentages.**
- (1) Upon completion of the entire planting and a semi-final inspection and acceptance by the Engineer, the Contractor will have completed 75 percent of the contract work for machine planted trees.
 - (2) After the first 12 months of the establishment period, the trees shall be inspected and if the Engineer agrees that the Contractor has performed the specified establishment activities, the remaining 25 percent of the contract work for machine planted trees shall be considered complete.
 - (3) Payment for work specified during the establishment period will occur on a monthly basis for the duration of the 24 month period.
- (n) **Carry-Over of Work not Completed During Specified Season.**
- (1) If any of the proposed planting items are not completed at expiration of the initial planting season, planting work on the uncompleted items shall stop immediately, and the period during which the planting may be performed, regardless of the reason for failure to complete work, will not be extended. The work shall be carried over and completed the following planting season in accordance with these Specifications and the Plans.
 - (2) During the carry-over period, the Contractor shall be responsible for maintenance of planted areas and plant material. This work shall be as described in Subsection 231.04(l).
 - (3) Time will be charged from the beginning of the following planting season until all carry-over work is planted. Time will not be charged during the period from October 1st to November 25th for deciduous plants, or when replanting only is involved.
- (o) **Machine Planting of Trees.** For machine planting of trees the following additional requirements shall apply.
- (1) **Digging.** Excavated plants shall have a ball of soil encompassing their root systems. The size of the balls of all plants shall conform to the recommended specifications of ANSI-Z-60.1, Nursery Stock.
 - (2) **Transporting.** The plants shall be transported from the nursery to their new locations on the project by the same machine that dug them.
 - (3) **Transplanting.** Trees to be transplanted shall be placed in holes previously dug by the same or identical type machine. The top of the ball shall be placed in its final position at a slightly

lower elevation than the existing surrounding ground. After the machine is removed, and any necessary backfill is applied, the plant shall be thoroughly watered and mulched, then staked as shown on the Plans.

231.05. METHOD OF MEASUREMENT.

Live and healthy plants in satisfactory condition will be measured by each category, and the quantities to be paid for under this item will be the number of each kind of (A) *Trees*, (B) *Shrubs*, (C) *Vines* or *ground covers*, and (D) *Trees machine planted*.

231.06. BASIS OF PAYMENT.

Accepted planting, measured as provided above, will be paid for at the contract unit price as follows:

- (A) TREES (KIND) EACH
- (B) SHRUBS (KIND) EACH
- (C) VINES OR GROUND COVERS (KIND) EACH
- (D) TREES MACHINE PLANTED (KIND) EACH
- (E) ESTABLISHMENT PERIOD EACH

Such payment shall be full compensation for furnishing replacement trees, material, equipment, labor and all incidentals to complete the work as specified.

**SECTION 232
SEEDING**

232.01. DESCRIPTION.

This work shall consist of seedbed preparation, and furnishing and planting seeds in accordance with these Specifications and in reasonably close conformity with the areas and locations shown on the Plans or established by the Engineer. It includes seeding for permanent erosion control and seeding for the temporary erosion control.

232.02. MATERIALS.

Materials shall meet the requirements specified in the following Subsections of Section 700 Materials.

Seed	735.04
Fertilizer	735.07

Water shall be free from harmful quantities of toxic salts or other substances that might interfere with the establishment and growth of turf.

232.03. EQUIPMENT.

Furnish equipment in satisfactory working condition, and in sufficient quantity to perform the work as specified. Have the equipment on the project site and approved by the Engineer before beginning work on the corresponding item.

- (a) **Hydraulic Seeder.**
 - (1) This equipment shall be factory designed and built with sufficient pump capacity to apply specified quantities. The tank shall hold a minimum of 1000 gallons (4 kiloliters) and be equipped with a mechanical agitation system with an operating capacity sufficient to suspend and homogeneously mix the seed and water. The distribution hoses shall be large enough to prevent clogging and be equipped with spray nozzles that will provide even distribution on designated areas.
 - (2) The equipment shall be mounted on a traveling unit which may be either self-propelled or pulled, capable of getting the tank and nozzles within sufficient proximity of the area to be seeded without the wheels operating on the areas to be seeded.
- (b) **Grass Seed Drill.** The drill shall be an approved native grass seed drill, which shall be equipped with two separate planter boxes and planting mechanisms which will plant large chaffy seed and fine clean seed simultaneously. The drill shall be equipped with a mechanism for accurately adjusting the rate of seed flow, and with double-disk openers designed to open furrows on 8 inch (200 mm) or-less centers, with each disk having a depth regulating band 1 inch (25 mm) from the disk edge. Each furrow opener shall be equipped with heavy press wheels to firm the soil behind the opener and leave the seed covered to an average depth of 1/2 to 3/4 inches (12 to 19 mm).
- (c) **Corrugated Roller Seeder.** The seeder shall be equipped with corrugated roller wheels mounted on tandem axles. The roller wheels shall be spaced on approximately 2 inches (50 mm) centers and shall place the seed at a depth of 1/4 to 1/2 inch (6 to 12 mm). The seeder shall be equipped with two separate planter boxes and planting mechanisms, which will plant clean, fine seed and large, chaffy seed simultaneously. The seeder shall also be equipped with a mechanism for accurately adjusting the rate of seed flow and weigh approximately 125 to 250 pounds per linear foot (186 to 372 kg. per meter) of rolling width.
- (d) **General.** Rolling, fertilizing, and watering equipment shall meet the requirements of Subsection 108.06.

232.04. CONSTRUCTION METHODS.

- (a) **Seedbed Preparation.**
 - (1) To prepare areas to be seeded, fill, reshape eroded areas, clean ditches, and refinish slopes and medians to the established typical grading sections. Mow all live plants.
 - (2) Completely incorporate thick layers of previously applied mulching materials or residues of vegetation into the soil by disking, unless otherwise directed. Till soil on the contour to a depth of 4 inch (100 mm). Crush and pack all clods larger than 1 inch (25 mm) in diameter. The tillage consists of disking, harrowing, and rolling. Where necessary, apply water.
 - (3) When hydraulic seeding is specified, leave or make the seedbed surface sufficiently rough before seeding.
- (b) **Planting Methods.** Plant all seed uniformly at the specified rate. When several species are specified and cannot be combined due to different characteristics—such as size, weight, or being hulled or unhulled—plant the seed separately to obtain the specified seeding rate.

- (1) **Seeding Method A - Hydraulic Seeder Method.** Place the seed in water in the spray tank of a hydraulic seeder conforming to Subsection 232.03(a). Distribute the seed uniformly by power spraying through a suitable nozzle. If specified, place inoculant for legumes in the spray tank with the seed in accordance with approved methods. When seed is loaded into 1000 gallons (3.8 kiloliters) of water in the spray tank, do not exceed the quantity specified for 2 acres (0.80 hectares). If less than 1000 gallons (3.8 kiloliters) of water is used, reduce (1) the amount of seed, (2) other specified materials, and (3) the area seeded per load in proportion to the water. When seed and fertilizer are to be distributed as a water slurry, apply the mixture to the area to be seeded within 30 minutes after all components have been placed in the equipment.
 - (2) **Seeding Method B - Grass Seed Drill Method.** Plant seed with a grass seed drill conforming to Subsection 232.03(b). Carry out all drilling on the approximate contour lines.
 - (3) **Seeding Method C - Corrugated Roller Seeder Method.** Distribute the seed with a corrugated roller seeder conforming to Subsection 232.03(c) that has been adjusted to accurately apply the specified quantities. On slope, planting shall be along the approximate contour lines.
 - (4) **Hand Broadcasting Method.** Use hand broadcasting only in areas that are too small or inaccessible to accommodate the specified equipment.
- (c) **Planting Season and Weather Restrictions.** Erosion control operations shall be in accordance with Subsection 230.04(f).
- (d) **Soil Moisture and Watering Requirements.**
- (1) Soil moisture shall exist throughout the zone from 1 inch (25 mm) to at least 5 inches (125 mm) below the surface at the time of planting. The required moisture content of the soil may be estimated and judged closely by the hand squeeze test. The soil should readily form a tight cast when squeezed in the hand. The cast should break into two pieces without crumbling and without leaving excess water on the hand after casting.
 - (2) Water the areas to be seeded if called for on the Plans or determined by the Engineer.
- (e) **Fertilizer Application.** Fertilizer application shall be in accordance with Section 234.
- (f) **Repairs and Maintenance.** The Contractor shall be responsible for repairs and maintenance of areas designated for seeding until all work on the Contract or designated portion thereof has been completed and approved for final acceptance.
- (1) **Repair.** This work shall include the restoration of all eroded areas to the approximate typical grading section shown on the Plans or as determined by the Engineer. Repair includes seeding, fertilizing, and watering damaged areas, which shall be performed during the specified planting season.
 - (2) **Maintenance.** This work shall consist of weed control by mowing, hand cutting, herbicides, or other approved methods. Weed growth on sodded areas shall be removed as often as determined by the Engineer. If herbicides are necessary, use them in accordance with label instructions and only with prior approval from the Engineer. Mowing shall be in accordance with Section 241.

232.05. METHOD OF MEASUREMENT.

Seeding will be measured by the acre (hectare).

NOTE: Work and material used in repair of seeding will not be measured for payment.

Watering will be measured by the kiloliters of water. The method of measurement is in accordance with section 230.05. Water used as a carrier for seed in hydraulic seeding operations is considered subsidiary to "seeding" and will not be measured for payment.

Fertilizer will be measured and paid for in accordance with Section 234.

Mowing will be measured and paid for in accordance with Section 241.

232.06. BASIS OF PAYMENT.

Accepted seeding, measured as provided above, will be paid for at the contract unit price bid for as follows:

(A)	SEEDING METHOD A	ACRE (HECTARE)
(B)	SEEDING METHOD B	ACRE (HECTARE)
(C)	SEEDING METHOD C	ACRE (HECTARE)
(D)	WATERING	M-GAL (KILOLITER)

Such payment shall be full compensation for furnishing all materials, equipment, labor, and incidentals to complete the work as specified.

SECTION 233 MULCHING

233.01. DESCRIPTION.

This work shall consist of furnishing, applying, and fastening mulching materials on the soil surface in accordance with these Specifications and in reasonably close conformity with the areas and locations shown on the Plans or established by the Engineer.

233.02. MATERIALS.

Materials shall meet the requirements specified in the following Subsections of Section 700 Materials. These materials can be used either as a temporary protective item or as a protective mulch for seeded, sodded, or planted areas.

Vegetative Mulch	735.05(a)
Asphalt Mulch	735.05(b)
Excelsior Mat	735.05(c)
Jute Mesh	735.05(d)
Excelsior Mulch	735.05(e)
Wood Cellulose Fiber	735.05(f)
Nylon Erosion Control Mat	735.05(g)
Mulch Fasteners	735.06

233.03. EQUIPMENT.

The Contractor shall furnish equipment in accordance with Subsection 108.06.

(a) Equipment for Vegetative & Excelsior Mulch.

- (1) Adhesive Spray Method.** The machine for applying and fastening Vegetative and Excelsior Mulch shall have a blower mechanism for distributing the vegetative material, and a pump for distributing the liquid adhesive. The discharge pipe of the blower and the discharge nozzles of the liquid adhesive hoses shall be arranged so that the liquid adhesive is evenly distributed into the mulch as it emerges from the blower discharge spout. The liquid adhesive hoses shall have suitable valves and nozzles to provide distribution of the liquid-adhesive at the prescribed rate. Sufficient power shall be provided on the machine to operate the liquid adhesive pump and the mulch blower and distribute the liquid adhesive-bound mulch over the designated areas at the required rate with a single pass of the machine. The beater mechanism shall be adjusted so that the stem lengths are not materially shortened.
- (2) Mulching Tiller Method.** The machine for applying vegetative or excelsior mulch shall be the same as specified for the "Adhesive Spray Method," except that the liquid adhesive pump and accessories may be omitted. The mulching tiller shall be a heavy disk-type roller, having flat disks about 6 millimeters thick and spaced not more than 12 inches (300 mm) apart.

(b) Equipment for Wood Cellulose Fiber Mulch.

- (1)** The hydraulic equipment used to apply wood cellulose fiber mulch shall be factory designed and built with sufficient pump capacity to apply specified quantities. The slurry tank shall hold a minimum of 1000 gallons (3.8 kiloliters) and be equipped with a mechanical agitation system with operating capacity sufficient to suspend and homogeneously mix the mulch and water. The slurry distribution hoses shall be large enough to prevent clogging and be equipped with spray nozzles that will provide even distribution of the slurry on designated areas.
- (2)** The equipment shall be mounted on a traveling unit which may be either self-propelled or pulled, and is capable of getting the tank and nozzles within sufficient proximity of the area without tracking into the mulching area.

- (c) Equipment for Asphalt Mulch.** The distributor equipment shall be equipped with a pressure gauge and accurate volume-measuring device or a calibrated tank. Also, the distributor shall be equipped with a power unit for the pump, and a full circulation, adjustable, spray bar and hand-operated spray bar.

NOTE: A check of distribution rate and uniformity of application shall be made when directed by the Engineer.

- (d) Equipment for Jute Mesh.** A lightweight, smooth roller (lawn type) shall be used to press the mesh into direct contact with the soil.

233.04. CONSTRUCTION METHODS.**(a) Mulching Operation.**

- (1)** When the mulch material is used as a temporary protective item, repair eroded areas and clear the ground of all debris that would hinder the even application of the mulching material.

- (2) When the mulch material is used as a protective mulch over seeding or sodding, apply it within 24 hours after an area is seeded or sodded. If mulched areas become damaged, reshape the area and then sod or seed and mulch again as originally specified.

NOTE: Mulching operations shall not be performed during weather that would result in non-uniform application or waste of material.

(b) **Type of Application.**

- (1) **Adhesive Spray Method for Excelsior and Vegetative Mulch.** Broadcast the vegetative or excelsior mulch into a continuous, unbroken cover of approximate uniform thickness. Apply the mulch at the rate of 2 tons per acre (4.5 metric tons per hectare). During the spreading operation, the adhesive material must be ejected simultaneously into the mulch at the mulch blower discharge spout, giving a uniform distribution on the mulching material. Unless otherwise specified on the Plans, use emulsified asphalt, SS-1, at the rate of 2000 gallons per acre (1870 liters per hectare). If other types of fasteners are to be used, the type and quantity will be shown on the Plans. To avoid displacement of mulch by wind, place a bank of soil or a complete coverage of asphalt along the edge of the mulched area. Remove clumps of excess material promptly.
- (2) **Mulching Tiller Method for Excelsior and Vegetative Mulch.** Spread the mulching materials uniformly as specified in the Adhesive-Spray Method. The rates of application shall be 2.5 tons per acre (5.6 metric tons per hectare) of vegetative mulch or 2 ton per acre (4.48 metric tons per hectare) of excelsior mulch. Following closely behind the mulch spreading operation, roll a tiller over the mulched area, pressing the material into the soil approximately 3 inch (75 mm). Till dry, impermeable soil with a disk plow to the degree necessary to permit the 3 inch (75 mm) incorporation. When mulching loose sandy soil, take precautions not to incorporate an excess amount of the mulch into the soil. When mulching slopes, operate the tiller along the contour of the slope.
- (3) **Asphalt Mulching.** Dilute the mulching asphalt with 3 parts water to one part emulsified asphalt. Apply 1.25 gallon per square yard (5.66 liters per square meter) of the mixture of ground surface, unless otherwise specified. If soils to be mulched are impervious and cause appreciable mixture runoff, reduce the water so that the specified quantity 0.3125 gallon per yard (1.415 liters per square meter) of emulsified asphalt can be applied. When asphalt mulch is to be applied over sodded areas, water the sod immediately before applying the asphalt mulch.
- (4) **Wood Cellulose Fiber Mulch.** Apply wood cellulose fiber mulch at the rate of not less than 1200 pounds per acre (1345 kg per hectare) of air dry material . The quantity of water used in dispersing, suspending and applying the material shall be at the rate 3.3 gallons of water to one pound (27.5 liters of water to one kilogram) of material. Apply the cellulose fiber to form an evenly distributed layer over the area.

NOTE: Complete seed, fertilizer, lime, and other erosion control items before applying cellulose material.

- (5) **Excelsior Mat.** Place the mat as shown on the Plans so that the fibers are in contact with the soil and the netting is on the top. Place each strip of mat parallel to the direction of the flow of water.
- (6) **Jute Mesh.** When jute mesh is used over sodded or sprigged areas, place it prior to watering operations. Unless the hydro-seeding method is called for on the Plans, place the jute mesh after the seed or sod has been planted, and secure it as shown on the Plans. Maintain the jute mesh-covered areas until all work on the project is completed and accepted. Reshape damaged slopes to their original slope lines, then fertilize, seed, or sod, and cover with jute mesh again as originally specified.

233.05. METHOD OF MEASUREMENT.

The mulching items will be measured as follows:

Vegetative mulching, excelsior mulching, and wood cellulose fiber will be measured by the acre (hectare).

Asphalt mulching will be measured by the gallon (liter) of undiluted emulsified asphalt.

Excelsior mat and jute mesh will be measured by the square yard (square meter) of area covered.

233.06. BASIS OF PAYMENT.

Accepted mulches, measured as provided above will be paid for at the contract unit price as follows:

- (A) VEGETATIVE MULCHING ACRE (HECTARE)
- (B) EXCELSIOR MULCHING ACRE (HECTARE)
- (C) ASPHALT MULCHING GALLON (LITER)
- (D) WOOD CELLULOSE FIBER ACRE (HECTARE)
- (E) EXCELSIOR MAT SQUARE YARD (SQUARE METER)
- (F) JUTE MESH SQUARE YARD (SQUARE METER)

Such payment shall be full compensation for furnishing all materials, equipment, labor, and incidentals to complete the work as specified.

**SECTION 234
FERTILIZING AND AGRICULTURAL LIMING**

234.01. DESCRIPTION.

This work shall consist of furnishing and applying fertilizer or agricultural liming materials in accordance with these Specifications and in reasonably close conformity with the areas and locations shown on the Plans or established by the Engineer.

234.02. MATERIALS.

Materials shall meet the requirements specified in the following Subsections of Section 700 Materials.

Fertilizer	735.07
Agricultural Limestone	706.04
Hydrated Lime	706.01

234.03. EQUIPMENT.

- (a) **General.** Furnish equipment in satisfactory working condition and in sufficient quantity to perform the work as specified, and have the equipment on the project site and approved by the Engineer before beginning work on the corresponding item.
- (b) **Fertilizer and Lime Spreaders.**
 - (1) **Vertical Drop and Broadcast Type.** The machine for applying dry fertilizer or lime shall be an approved agricultural type spreader. It shall be capable of distributing the specified material uniformly on the designated area at specified rates of application without damaging the fertilizer granules or lime.
 - (2) **Power Spray.** The equipment for distributing fertilizer or lime in water shall comply with the specifications for Hydraulic Seeding, Subsection 232.03(a).

234.04. CONSTRUCTION METHODS.

- (a) **General.** Unless otherwise indicated on the Plans, apply the lime or fertilizer with the vertical drop or broadcast spreader. Do not apply the lime or fertilizer during weather that would result in waste or poor distribution. When lime and/or fertilizer is specified, apply it prior to or during the ground preparation for permanent seeding or sodding.
- (b) **Methods of Applying Fertilizer or Lime.**
 - (1) **Vertical Drop or Broadcast Method.** Apply the fertilizer or lime uniformly at the specified rate with a spreader conforming to the requirements of Subsection 234.03. The equipment shall not rut or otherwise damage the prepared surface.
 - (2) **Power Spray Method.** Apply the fertilizer or lime in water at the rate shown on the Plans, and distribute the material without appreciable runoff. The maximum quantity of fertilizer placed in the spray tank with 1000 gallons (3785 liters) of water shall not exceed the quantity specified for 2 acres (0.8 hectares) of seeding or sodding. The maximum amount of lime placed in the spray tank with 1000 gallons (3785 liters) of water shall not exceed the quantity specified for 1 acre (0.4 hectare) of seeding or sodding. If less than 1000 gallons (3785 liters) of water is loaded into the spray tank, the quantity of fertilizer or lime loaded and the area treated per load shall be reduced in proportion to the water.
 - (3) **Hand Broadcast Method.** On areas inaccessible to large spreaders or power sprayers, apply the lime or fertilizer with hand-operated equipment.

234.05. METHOD OF MEASUREMENT.

Fertilizing will be measured by the ton (metric ton) of specified material, as determined by approved scales or guaranteed weights of sacks shown by the manufacturer. If a substitute grade of fertilizer is furnished, the amount of material measured for payment will be adjusted to the equivalent number of pounds (kilograms) of fertilizer element per unit of area as would have been applied with specified grade.

NOTE: Fertilizer used in repair of unacceptable work will not be measured for payment.

Agricultural limestone or agricultural hydrated lime will be measured by the ton (metric ton), as determined by approved scales or by guaranteed weights of sacks shown by the manufacturer.

234.06. BASIS OF PAYMENT.

Accepted fertilizing and agricultural liming, measured as provided above, will be paid for at the contract unit price as follows:

- | | | |
|-----|----------------------------------|------------------|
| (A) | FERTILIZING | TON (METRIC TON) |
| (B) | AGRICULTURAL LIMESTONE | TON (METRIC TON) |
| (C) | AGRICULTURAL HYDRATED LIME | TON (METRIC TON) |

Such payment shall be full compensation for furnishing all materials, equipment, labor, and incidentals to complete the work as specified.

SECTION 241 MOWING

241.01. DESCRIPTION.

This work shall consist of mowing designated areas to a height not less than 4 inches (100 mm) when and as directed by the Engineer until acceptance of the Contract.

241.03. EQUIPMENT.

Use mechanical equipment for mowing operations.

241.04. CONSTRUCTION METHODS.

Mow only when the ground is sufficiently firm to prevent rutting.

NOTE: Any damage to the surface shall be repaired by the Contractor at no additional cost to the Department.

Remove litter, debris, and excessive amounts of grass clippings of sufficient magnitude to smother or retard grass growth from the areas as necessary to restore the sightliness of the areas.

In areas inaccessible to mechanical mowers, use hand-cutting methods-so the entire designated areas shall be uniform in appearance.

241.05. METHOD OF MEASUREMENT.

Mowing, when directed by the Engineer, will be measured by the acre (hectare) of mowing the designated areas in a manner approved by and accepted by the Engineer.

241.06. BASIS OF PAYMENT.

Mowing, measured as provided above, will be paid for at the contract unit price as follows:

- | | |
|--------------|----------------|
| MOWING | ACRE (HECTARE) |
|--------------|----------------|

Such payment shall be full compensation for furnishing all materials, equipment, labor and incidentals to complete the work as specified.

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SECTION 300

BASES

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SECTION 301 GENERAL REQUIREMENTS FOR BASES

301.01. DESCRIPTION.

This Section covers requirements common to all types of base construction, unless otherwise designated.

301.02. MATERIALS.

- (a) **General.** Unless otherwise shown on the Plans, furnish all materials meeting the requirements of Section 300 Bases. Make any necessary preliminary investigations to locate the proposed source of acceptable material.

NOTE: Information obtained by the Department in its preliminary investigations will be available to prospective bidders at the Materials Laboratory.

- (b) **Density.** Standard density and field density of soils and aggregates shall be determined in accordance with Subsection 202.02(b)(2), Earth Embankment, unless otherwise specified.

301.03. EQUIPMENT.

- (a) **General.** All equipment necessary for base construction shall meet the requirements of Subsection 108.06. The general requirements for equipment for base construction shall be those accepted by the industry which produce the quality of work specified.

- (b) **Mixing Equipment.**

- (1) **Traveling Plants.** Traveling plants may be approved types of either the single- or multiple-pass type; they must thoroughly pulverize and mix the materials of the job-mix formula to the required size and uniformity for each type of material, as described in this Section and in Section 700. The plant shall be mounted on wheels or tread equipment of such type that when loaded to capacity will not rut or damage the subgrade.

The plant shall have provisions for introducing water or other liquids at the time of mixing through a metering device or other approved methods. Leakage of liquids from the equipment shall be corrected immediately. The single-pass machine shall be designed to pick up the material to be mixed from a windrow or blanket and shall be equipped so that during at least 50 percent of the mixing cycle all the material is picked up and mixed while separated from the mixing table.

- (2) **Stationary Plants.** Stationary plants shall be either

- The batch type using revolving blade or rotary drum mixers
- or
- Continuous type mixing.

The aggregates and other ingredients of the job-mix formula may be proportioned either by weight or by volume. You must provide means by which the Engineer can readily verify the proportions in each batch or the rate of flow for continuous mixing. The charge and mixing time in a batch mixer or the rate of feed to a continuous mixer shall be sufficient to obtain complete mixing of all the material. Correct any dead areas in the mixer in which the material does not move or is not sufficiently agitated and ensure that the plant delivers a uniform mixture, meeting all specification requirements.

- (c) **Compactors.**
- (1) **Nonvibratory Steel-Wheeled Roller.** Unless otherwise provided, non-vibratory steel-wheel rollers shall be of the tandem or 3-wheel self-propelled type or steel-wheel trailer type weighing not less than 5 tons (4.5 metric tons). When drive rolls or trailer type rolls produce a compressive force of not less than 200 pounds per linear inch (3.6 kg/mm) of contact area, you may use a roller weighing less than 5 tons (4.5 metric tons). When the weight of the roller is specified in tons, do not weight the roller above the manufacturer's maximum rating. Operate the roller within the manufacturer's speed range.
 - (2) **Vibratory Compactors.** Vibratory compactors may be of the roller or pan type. The compactor shall be equipped with amplitude and frequency controls and specifically designed for the compaction of the material on which it is to be used.
 - (3) **Pneumatic-Tired Roller.** This shall be an approved type with pneumatic tired wheels mounted on two or more axles and spaced so that all tires have uniform load and contact with the surface; in addition, the rear group of tires will cover the gap between adjacent tires of the forward group. The roller shall be of the self-propelled or trailer type so constructed as to provide for the addition of weights. It shall weigh, under operating conditions, not less than 5 tons (4.5 metric tons) for a rolling width of 5 feet (1.5 m). The pressure of the tires shall be such that the tire is riding square on the tread. The roller shall be operated at a speed not less than 3 mph (5 km/h) nor more than 8 mph (13 km/h) per hour.
 - (4) **Tamping-Type Roller.** The tamping type roller, under working conditions, shall have a minimum weight of 90 pounds per linear inch (1.6 kg/mm) of length of drum and a minimum load on each sheeps-foot of 100 pounds per square inch (0.07 kg per mm²) of cross sectional area of the sheeps-foot in contact with the ground. Maximum area of the face of each sheeps-foot shall not be more than 12 square inches (7742 mm²). The feet on the sheeps-foot roller shall project not less than 7 inches (178 mm) from the face of the drum, and the roller shall be equipped with teeth-cleaning devices. The feet in adjacent rows shall be spaced so that the distance from center to center of adjacent parallel rows is not less than 6 inches (150 mm) nor more than 11 inches (279 mm). Individual drums of the roller shall not exceed 5 feet (1.5 m) in width and shall oscillate independently. Roller and tractor for pulling shall travel at a speed of approximately 3 mph (5 km/h) to 6 mph (10 km/h) per hour.
- (d) **Sprinklers** Sprinklers shall be equipped with positive and rapidly working cut off valves and approved spray bars which will insure uniform and continuous discharge for their full length.
- (e) **Distributors and Supply Tanks.** Distributors and supply tanks shall meet the requirements of Subsection 401.03.

301.04. CONSTRUCTION METHODS.

- (a) **General.** In order to provide the required subgrade, subbase and pavement structure of acceptable smoothness and thickness, maintain reasonably accurate control in the compaction of the subgrade, smoothness of the subgrade, and smoothness and thickness of the component parts of the pavement structure.

Use equipment adequate for providing acceptable construction within the prescribed tolerances, using construction methods and equipment that meet the requirements of Subsection

GENERAL REQUIREMENTS FOR BASES

301.04

108.06. Unless otherwise provided, tolerances for finished subgrade, subbase, and various bases and surfaces of bases are as follows:

BASES	SECTION	TOLERANCES	
		<u>SURFACE</u>	<u>THICKNESS</u>
Subgrade	310	1/2 inch (13 mm) in 10 feet (3 m)	
Subbase	306	1/2 inch (13 mm) in 10 feet (3 m)	Job average within 1/4 inch (6mm) of Plans. Not more than 1/2 inch (13 mm) deficient at any point except as provided in Subsection 301.04(b)
Aggregate Base	303	1/2 inch (13 mm) in 10 feet (3 m)	Same as above
Caliche Base	305	1/2 inch (13 mm) in 10 feet (3 m)	Same as above
Fly Ash Modified			
Subgrade	317	1/2 inch (13 mm) in 10 feet (3 m)	Same as above
Econocrete Base	318	1/4 inch (6 mm) in 10 feet (3 m)	Same as above
Open Graded			
Bituminous Base	319	1/4 inch (6 mm) in 10 feet (3 m)	Same as above
Open Graded Portland			
Cement Concrete Base	320	1/4 inch (6 mm) in 10 feet (3 m)	Same as above
Lime Treated Subgrade	307	1/2 inch (13 mm) in 10 feet (3 m)	Same as above

(b) **Checking for Compliance with Tolerances.**

- (1) **Surface.** At selected locations, the Engineer—using a 10 feet (3 m) straightedge or other approved device—will test for compliance with specified surface tolerances. The variation of the surface from the testing edge of the straightedge between any two contacts with the surface shall at no point exceed the specified tolerance. Correct any/all humps or depressions exceeding the specified tolerance in an acceptable manner as approved by the Engineer.
- (2) **Width and Thickness.** Width and thickness tolerances for bases and subbases paid for on the compacted volume in place (the theoretical cross section shown on the Plans or established by the Engineer, multiplied by the length) will be determined as follows: The minimum width shall be in reasonably close conformity with the dimensions shown on the Plans or established by the Engineer. The completed thickness of the base or subbase shall be the nominal thickness shown on the Plans, and shall be measured at intervals of not more than 500 feet (150 m) for each dual lane width. Where the measured thickness of the base or subbase is more than 1/2 inch (13 mm) deficient in the thickness, correct the deficiency in an acceptable manner—with no additional compensation.

Where the measured thickness of the base or subbase is more than 1/2 inch (13 mm) thicker than shown on the Plans, it shall be considered as conforming with the specified

thickness plus 1/2 inch (13 mm). In determining the average job thickness, not more than 1/2 inch (13 mm) in excess of the Plan thickness will be considered. The average job thickness shall be the average of the job measurements determined as specified above, but shall be within 1/4 inch (6 mm) of the typical section thickness shown on the Plans. In the event you construct the base in excess of the required width and thickness, including tolerances, the additional material and labor required for the additional thickness will be at your expense.

SECTION 303 AGGREGATE BASE

303.01. DESCRIPTION.

This work shall consist of furnishing and placing one or more courses of aggregates and any specified additives on a prepared subgrade or subbase in accordance with these Specifications and in reasonably close conformity with the lines, grades, thicknesses, and typical cross sections shown on the Plans or established by the Engineer. Aggregate base may be mixed off the roadbed and may be blended by plant mixing or other approved methods. Aggregate base may be mixed on the roadbed with approved methods that will produce a uniformly blended material.

NOTE: Aggregate base shall not be mixed on any completed base or surface course.

303.02. MATERIALS.

Materials shall conform to the requirements specified in the following Subsection of Section 700 - Materials, for the type gradation specified.

Aggregate Base 703.01

The gradation may be Type A, Type B, or Type C, unless otherwise specified on the Plans or in the Proposal, except as follows:

For base courses over 6 inches (150 mm) in specified thickness, the top 3 inches (75 mm) shall be Type A or Type C.

For base courses in which the specified thickness is 6 inches (150mm) or less, the total thickness shall be Type A or Type C.

After work starts, the same gradation type and source as specified or selected shall be used throughout the project unless otherwise permitted in writing by the Engineer.

303.04. CONSTRUCTION METHODS

- (a) **Preparation of Subgrade.** Prior to placing any new base material or subbase and base course material on the roadbed, complete the subgrade according to the requirements of method B of Section 310, Subgrade, of these Specifications, or according to the method specified on the Plans or in the Proposal.

If there is an existing aggregate course in place, prepare it in accordance with the requirements of the method of Section 311, Processing Existing Base and Surface, of these Specifications or as indicated on the Plans and in the Proposal.

(b) **Mixing Aggregate Base.**

(1) **Offsite Mixing.** When the mixing or blending of materials for aggregate base is done at an approved location off the roadbed, use one of the following procedures.

1.1 *Stationary Plant - Mixing Method:* Mix the aggregate and water in an approved central mixing plant of the pugmill type, rotary drum type, or in a continuous type of mixer. Add water during the mixing operation in the amount necessary to provide the proper moisture content for satisfactory compaction.

If a pugmill type or rotary drum type of mixer is used, proportion the materials by batch weights; if a continuous type of mixer is used, proportion the materials by either volume or weight.

If you elect to proportion the materials by volumetric methods and perform the mixing in a continuous type mixer, make sure the completed mixture is uniform in character and of the same consistency with respect to aggregates and water as that obtained by weight proportioning and batch mixing.

If a continuous type mixer is used, draw the correct proportions of each aggregate size to be introduced into the mixer from storage by an approved type of continuous feeder through adjustable calibrated gates; this feeder shall supply the correct amount of coarse aggregate and fine aggregate required to meet the specified gradation, and it shall allow the proportion of each aggregate size to be separately adjusted. Store sufficient materials to supply the mixer when it is in operation at full capacity.

NOTE: The weight of charge in a batch mixer or the rate of feed to a continuous type mixer shall not exceed that which will permit complete mixing of the material, and mixing of materials shall be continued until a uniform mixture is obtained.

1.2 *Travel Plant-Mixing Method.* Perform this method of producing aggregate base at an approved location off the roadbed. Clean the area selected to do this work of vegetation or other deleterious substance, overlaying it with a minimum of 3 inches (75 mm) of base material and compacting it to provide a satisfactory working table for mixing operations.

When the aggregates required to produce the specified mixture are to be combined and blended on the working area, deliver and place the weighed material in measured windrows, each in the proper proportions before blending. In the event a machine for mixing requires a blanket of material, spread the windrow to a reasonably uniform depth and width which the machine is capable of handling. Apply the water by means of controls which will supply a uniform rate of water in the proper amount for satisfactory compaction. Avoid application of excess water, during both mixing and compaction, so that undue softening of the subgrade will not develop.

The device by which the mixing machine picks up the material shall be subject to control, and it shall be so controlled and operated on each pass of the mixer as to pick up the material to be treated without cutting into the working area.

Mixing may be accomplished in one or more passes of the mixer through the material, but in any event shall be continued until the aggregate and water are evenly distributed through the mass and a uniform mixture meeting Specification requirements is obtained.

In the process of mixing, make adjustments for any tendency of the mixing equipment to shift material in a longitudinal direction.

- (2) **Onsite Mixing.** When the materials required to produce the specified mixture are to be combined and blended on the roadbed, deliver and place the weighed material in measured windrows, each in the proper proportions before blending. Pulverize fine aggregate to be added to the mixture to 100 percent passing the 1 inch (25 mm) sieve and not less than 80 percent passing the No. 4 (4.75 mm) sieve.

The total quantities for blending at one operation shall not be in excess of the amount that can be readily handled and thoroughly and uniformly mixed and blended to these requirements.

During the latter stages of the mixing—and before the final mixing is completed—moisten the mixture as deemed necessary to provide a suitable working condition during the final stages of mixing. Apply the water accurately and uniformly throughout the length of the section being treated so that no excess wet or dry spots exist in the finished blend. Avoid application of excess water, during both mixing and compaction, so that undue softening of the subgrade will not develop.

- (c) **Spreading.** Transport aggregate base materials mixed at locations off the roadbed to the roadbed by means of suitable vehicles and deposit them by means of approved spreading equipment. Place the layers so that when compacted they will be true to the grades or levels required with the least possible surface disturbance. Make such adjustments in placing procedures or equipment to obtain true grades, to minimize segregation and degradation, to reduce or increase moisture content and to assure an acceptable base.

Spread and compact the aggregate base material to the required density in one or more layers, as specified below, and of such width and thickness that, after compacting, the finished base will conform to the required grade and cross section. Spread the aggregate base material for each separate course for the full width of the roadbed before placing the succeeding courses. Stagger longitudinal and transverse joints a minimum of 1 foot (0.3 m) in each succeeding course.

Lay aggregate base material in courses of a minimum of 3 inches (75 mm) compacted thickness, and do not exceed a maximum of 6 inches (150 mm) compacted thickness, except when shoulders are shown on a typical section to be constructed as a separate operation; then they may be constructed in one course providing they do not exceed 8 inches (200 mm) in thickness, and in two approximately equal courses where they exceed 8 inches (200 mm). In either case, the compacted shoulders shall meet specified density requirements.

After the blended and flattened windrow of aggregate base material mixed on the roadbed has been tested and approved by the Engineer, spread it uniformly as specified above over the full length and width of the section to be compacted. Do this spreading in such a manner as to prevent segregation of the mixture.

- (d) **Shaping and Compaction.** Compact each layer until a density of not less than 98 percent of standard density—as determined by AASHTO T-180, method D—has been achieved. Maintain the surface of each layer during the compaction operations so that a uniform texture is produced

and the aggregates remain firmly keyed. Apply water uniformly over the base materials during compaction in the amount necessary for proper consolidation.

Before applying the prime coat , cure or season the aggregate base material sufficiently to permit the prime coat to be properly applied.

- (e) **Tolerances.** Tolerances for surface, width, and thickness shall conform with Section 301.

303.05. METHOD OF MEASUREMENT.

Aggregate base will be measured by the ton or by the cubic yard (metric ton or by the cubic meter), and compacted in place to the specified density. Measurement by the cubic yard (cubic meter) will be based on the actual length multiplied by the theoretical cross section shown on the Plans. All moisture in excess of 5 percent oven-dry weight will be deducted when measured by the ton (metric ton).

303.06. BASIS OF PAYMENT.

Accepted aggregate base, measured as provided above, will be paid for at the contract unit price as follows:

AGGREGATE BASE	CUBIC YARD (CUBIC METER)
AGGREGATE BASE	TON (METRIC TON)

Such payment shall be full compensation for furnishing all materials, equipment, labor, and incidentals to complete the work as specified.

NOTE: Rolling and water as required to obtain a specified density will not be a separate pay item, but the cost shall be included in the price of other bid items.

**SECTION 305
CALICHE BASE**

305.01. DESCRIPTION.

This work shall consist of constructing a base of approved deposits of calcareous and siliceous material constructed on the prepared subgrade in accordance with these Specifications and in reasonably close conformity with the lines, grades, thickness, and typical cross sections shown on the Plans or established by the Engineer.

305.02. MATERIALS.

Materials shall meet the requirements specified in Subsection 704.03.

305.04. CONSTRUCTION METHODS.

- (a) **Preparation of Subgrade.** Prior to placing the new base course material or subbase and base course material on the roadbed, prepare the subgrade according to the requirements of method B of Section 310, Subgrade, of these Specifications or as specified on the Plans.

Break up or pulverize the old base and/or surfacing in place and incorporate it in the top portion of new subgrade in accordance with the requirements of Section 311, Processing Existing Base and Surface of these Specification as indicated on the Plans and in the Proposal.

- (b) **Mixing and Placing.** When the materials required to produce the specified mixture are to be combined and blended on the roadbed, deliver weighed material and place it in measured windrows, each in the proper proportions before blending. The total quantities for blending at one operation shall not be in excess of the amount that can be readily handled and thoroughly and uniformly mixed and blended to these requirements by the equipment available on the project.

During the latter stages of the mixing—and before final mixing is completed—moisten the mixture as necessary to provide a suitable working condition during the final stages of mixing. Such application of water shall be accurate and uniform throughout the length of the section being treated so that there will be no excess wet or dry spots in the finished blend. Avoid application of excess water, during both mixing and compaction, so that undue softening of the subgrade will not develop.

- (c) **Spreading.** After the blended and flattened windrow has been tested and approved by the Engineer, spread the base course material uniformly over the full length and width of the section to be compacted. Do this spreading in such a manner as to prevent segregation of the mixture. The thickness or depth of the layers shall not be in excess of that which the equipment on the project is capable of compacting to the density required herein for the completed base course.
- (d) **Compaction-Density.** Wet the course or courses being compacted as necessary to obtain suitable uniform moisture. Continue rolling as required to produce a minimum density of 100 percent of standard density as determined by AASHTO T-99.
- (e) **Tolerances.** Tolerances for surface, width, and thickness shall be in conformity with Section 301.

305.05. METHOD OF MEASUREMENT.

Caliche base will be measured by the cubic yard (cubic meter) compacted in place, to the specified density. Measurement will be based on the actual length multiplied by the theoretical cross section shown on the Plans.

305.06. BASIS OF PAYMENT.

Accepted caliche base, measured as provided above, will be paid for at the contract unit price as follows:

CALICHE BASE CUBIC YARD (CUBIC METER)

Such payment shall be full compensation for furnishing all materials, equipment, labor, and incidentals to complete the work as specified.

SECTION 306 SUBBASE

306.01. DESCRIPTION.

This work shall consist of furnishing and placing subbase of the type shown on the Plans in reasonably close conformity with the lines, grades, and typical cross sections shown on the Plans or established by the Engineer.

306.02. MATERIALS.

Materials shall meet the requirements specified in Section 704 for the type and gradation specified. Subbase material shall meet the specified requirements prior to final incorporation in the work. After work starts, use the same type, gradation, and source throughout the project unless otherwise permitted in writing by the Engineer.

306.04. CONSTRUCTION METHODS.

- (a) **Preparation of Subgrade.** Construct the subgrade as specified for method B of Section 310 of these Specifications, or follow the method indicated on the Plans and in the Proposal.
- (b) **Compaction-Density.** Place the subbase material on the roadbed in sufficient quantities and uniformly spread to such thickness and width that the completed subbase will conform to the Plan width, thickness, and grade within the specified tolerances.
 Compact the subbase material to not less than 100 percent of standard density as determined by AASHTO T-99.
- (c) **Tolerances.** Tolerances for surface, width, and thickness shall be in conformity with Section 301.

306.05. METHOD OF MEASUREMENT.

Subbase will be measured by the cubic yard (cubic meter), compacted in place, to the specified density. Measurement will be based on the actual length multiplied by the theoretical cross section shown on the Plans.

306.06. BASIS OF PAYMENT.

Accepted subbase, measured as provided above, will be paid for at the contract unit price as follows:

SUBBASE CUBIC YARD (CUBIC METER)

Such payment shall be full compensation for furnishing all materials, equipment, labor, and incidentals to complete the work as specified.

SECTION 307 LIME-TREATED SUBGRADE

307.01. DESCRIPTION.

This work shall consist of furnishing and placing one or more courses of a mixture of soil, lime, and water in accordance with these Specifications and in reasonably close conformity with the lines, grades, thickness, and typical cross sections shown on the Plans or established by the Engineer.

In subgrade extents designated on the Plans or by the Engineer as having excessive rock—the dimensions or quantities of which 25 percent or more is greater than 2 1/2 inches (63 mm), which makes full compliance impractical—the Engineer may waive certain portions of the Standard Specifications as described below. The Engineer may require exploratory scarifying by the Contractor before designation of extents for which the full compliance of Specifications is waived.

307.02. MATERIALS.

Materials shall meet the requirements specified in the following Subsections of Section 700 - Materials.

Water	701.04
Hydrated Lime	706.01
Quick Lime	706.02
By-Product Lime	706.03

Store lime in a suitable, weather-tight building or compartment which will (1) protect it from dampness and (2) permit easy access for proper inspection and identification of each shipment. Lime shall not be used if for any reason it has become partially set or if it contains hard lumps or cakes. Do not mix limes from different sources in storage, even though they have been tested. By-product lime from residual or waste piles *from approved sources* may be used in lieu of hydrated or quick lime.

307.03. EQUIPMENT.

Equipment meeting the requirements of Subsection 301.03 shall be used on the project.

307.04. CONSTRUCTION METHODS.

- (a) **General.** The primary requirement of these Specifications is to secure a completed course of treated material containing a uniform lime mixture
- (1) free from loose or segregated areas,
 - (2) of uniform density and moisture content,
 - (3) well bound for its full depth, and
 - (4) with a smooth surface suitable for placing subsequent courses.

It shall be the responsibility of the Contractor to regulate the sequence of his work, to use the proper amount of lime, to maintain the work, and to rework the courses as necessary to meet the above requirements.

- (b) **Weather Limitations.** Lime slurry or dry hydrated lime shall not be applied unless the air temperature is at least 40° (4°C) and rising. The air temperature shall be taken 4 feet (1.2 m) above the ground in the shade and away from artificial heat.

Dry-quick lime shall not be applied unless the air temperature is at least 30°F(-1°C) and rising. The Contractor shall be responsible for the protection and quality of the lime treated subgrade under any weather conditions.

- (c) **Preparation of Existing Roadbed.** Prior to beginning any lime treatment, compact and shape the roadbed to reasonably close conformity with the typical sections, lines, and grades as shown on the Plans or established by the Engineer. Roll the subgrade as directed by the Engineer, and correct any soft areas that this rolling may reveal.
- (d) **Scarifying and Loosening.** Scarifying and loosening may be required prior to the application of lime to achieve the desired results as determined by the Engineer. Take precautions to avoid forming furrows of loosened material below the depth specified for the bottom of the treated subgrade.

NOTE: The length of roadway scarified and loosened at any time shall not exceed the length in which the first mixing (paragraph 307.04(f)1) can be completed in two calendar days.

- (e) **Application of Lime.** The proportion of lime indicated on the Plans is approximate. Apply lime at the rate prescribed by the Engineer, based on tests of the subgrade soil. Provide equipment for proper control of application rate of the lime. Where tests indicate a significant change in the subgrade soil, the Engineer will establish a new rate as deemed necessary for the section of road affected, and at the time of placing and spreading the lime, will advise the Contractor of the final rate for the said section.

NOTE: Do not apply lime when wind conditions are such that blowing lime becomes objectionable to traffic and adjacent property owners; and do not use a motor grader to spread hydrated lime.

When lime is applied to the soil ahead of the mixing plant, place the lime only on that area where the first mixing operations can be completed during the same working day. During the interval of time between application and mixing, lime that has been exposed to the open air for a period of six hours or more may not be accepted for payment; in addition, payment will not be made for lime loss due to excessive washing or blowing.

(1) Dry Method.

- 1.1 *Quick Lime.* When quick lime is used, the equipment for spreading lime shall be an approved type which shall demonstrate its ability to distribute the lime at controlled amounts uniformly.
- 1.2 *Hydrated Lime.* Bagged hydrated lime may be used for dry-method application only under unusual circumstances, i.e., when it would be impossible or impracticable to use other methods and only upon written approval of the Engineer provided that all applicable Federal, State, and local laws are met. The bagged lime shall bear the manufacturer's certified weight.

(2) Slurry Method. Lime shall be mixed with water into a slurry by either of the following methods.

- 2.1 *Central Plant.* Mixing shall be accomplished through integral paddles, recirculating pumps, or other devices that will meet mixing requirements. The slurry distributor truck, hauling from the central plant, shall be equipped with a recirculating pump or agitator of sufficient size which will keep the lime and water in a uniform mixture until spread.
- 2.2 *Transit Mix.* The lime from the storage bin shall be metered or weighed by an approved method into the tank transit mix equipment. The tank truck shall be equipped with a

recirculating pump or agitator to maintain a uniform mixing of the lime and water while in transit.

The distributor truck shall be equipped with a pump, regardless of the type of mixing method used. The slurry will be applied through the spray bars under pressure to assure a uniform flow and distribution. The slurry produced by either method shall consist of a minimum mixture of approximately 1 ton (0.9 metric ton) of lime to each 500 gallons (1893 L) of water and shall not contain more than 40 percent lime.

NOTE: Use of compressed air for mixing will not be permitted.

- (3) **By-product Lime.** When by-product lime is used, the equipment for spreading lime shall be an approved type which will demonstrate its ability to uniformly distribute the lime at controlled amounts.
- (f) **Mixing.** The mixing procedure shall be as described below:
- (1) **First Mixing.** Mix the soil, lime, and water until a uniform mixture is obtained in which all clods and nonaggregate lumps are reduced to a maximum of 2 1/2 inches (63 mm) diameter size. The quantity of water necessary for the first mixing operation will vary with the nature of the material, normally 3 to 5 percentage points above the optimum moisture content of the compacted treated soil. Add sufficient water in the first mixing process to insure proper chemical action between the lime and soil. When proper mixing has been accomplished, allow the mixture to cure. Curing time when hydrated lime is used shall be 72 hours at temperatures above 32°F (0°C). Curing time when quick lime is used shall be 48 hours at temperatures above 32°F (0°C). Curing time when by-product lime is used shall be 60 hours at temperatures above 32°F (0°C).

During the curing period, maintain the material in a moist condition. Seal the surface of the modified area by light rolling to the extent that the surface will repel water and contain the moisture. When deemed necessary by the Engineer, rescarify any portion of the area under modification for additional sprinkling to insure proper moisture for the curing.

- (2) **Final Mixing.** After the required curing time, mix the material uniformly by approved methods. Reduce all clods until the soil-lime mixture meets the following requirements when tested dry by laboratory sieves:

Minimum passing 1 1/2 inch (37.5 mm)	100%
Minimum passing No. 4 (4.75 mm) sieve	60%

- (3) **Depths of 8 inches (200 mm) or greater compacted thickness.** No course treated shall exceed 8 inches (200 mm) in depth. If the depth of material to be treated in cut sections is more than 8 inches (200mm), remove that portion above the lower 8 inches (200 mm) so that the bottom course can be treated in place. The upper portions of the cut section also shall be treated in courses not more than 8 inches (200 mm) in depth.

During normal fill construction, accomplish lime treatment by adding and mixing the amount of lime as required on the plans to each 8 inch (200 mm) lift, completing the depth of fill to the typical section shown on the plans.

On each properly compacted course (except the final course), the initial mixing shall be considered the final and only mixing necessary.

Variations to the mixing depths that may be properly performed by special equipment or methods may be used only after approved by the Engineer.

- (4) **Designated Excessive Rock Areas.** In areas designated by the Engineer as excessive rock areas, it is the intent that the completed course of treated material shall comply with the Standard Specifications as to uniformity of lime mixture, density, moisture content, and depth insofar as practicable. Mixing and pulverization shall be accomplished in two stages and shall be sufficient to accomplish the intent of the Specifications. The particle size requirement may be waived by the Engineer.
- (5) **Quick Lime Mixing.** Within two hours after spreading quick lime and before water is added, approved means shall be used to turn under a significant portion of the quick lime to reduce harmful exposure to the heat of hydration. Sufficient water shall be added within 6 hours after spreading to permit hydration of the quick lime.

CAUTION: Uncovered quick lime may be hazardous when in the presence of moisture.

- (g) **Compaction.** Compact the mixture during the same day as the final mixing unless approval is obtained from the Engineer to continue compaction on the following day. The target density shall be determined in the field by the soil-lime mixture obtained from the roadway when compaction is started. The test method for the target density will be as specified in Subsection 106.03—modified to provide one compacted specimen of the soil-lime mixture as obtained from the roadway and separate portions of the sample used for additional specimens with the moisture reduced or increased. Aerate or sprinkle the material as necessary to provide the optimum moisture within plus or minus 2 percentage points. Continue compaction until the entire depth of mixture is uniformly compacted to not less than 100 percent of the target density. Field density will be determined in accordance with Subsection 202.02(b)(2).

Compact depths of two or more lifts or courses in lifts or courses as specified in the mixing procedure. Sprinkle or dry the material as necessary to provide the moisture for proper compaction. Continue compaction until the entire depth of mixture is compacted to a satisfactory condition as demonstrated by test rolling (Section 203) with the further requirement that the top 6 inches (150 mm) of the uppermost course be compacted to not less than 100 percent of the target density established in accordance with the paragraph above.

Sprinkle and roll the material, immediately correcting any/all irregularities, depressions, or weak spots which develop by scarifying the areas affected, adding or removing material as required, and reshaping and recompacting by sprinkling and rolling.

In addition to the requirements specified for density, the full depth of the material shown on the Plans shall be uniformly compacted to the extent necessary to remain firm and stable under construction equipment. After each section is completed, tests, as necessary, will be made by the Engineer. If the material fails to meet the density requirements, rework it as necessary to meet these requirements. Throughout this entire operation, maintain the shape of the course; the surface upon completion shall be smooth and in conformity with the typical sections shown on the Plans and to the established lines and grades.

NOTE: Should the material, due to any reason or cause, lose the required stability, density, or finish before the next course is placed or the work is accepted, it shall be recompacted and refinished at the sole expense of the Contractor.

In areas designated by the Engineer as excessive rock areas, compaction must be in substantial compliance with the Standard Specifications. However, it is recognized that the soil-lime mixture may not be uniform and some variation is to be expected in both the target density and optimum moisture dependent on the lime content of a given sample. In the event that the in-place density tests are not practical because of rock in the soil-lime mixture, the Engineer may waive the density and moisture content requirements and approve compaction by visual observation in lieu of such tests.

- (h) **Finishing and Curing.** After the final layer of the lime-treated subgrade has been compacted, bring it within reasonable compliance to the lines, grades, and typical sections. Then, finish the completed section with a suitable roller sufficiently light to prevent hair cracking. Maintain the treated material at a moisture content satisfactory for proper curing by sprinkling until a prime, seal, or succeeding course is placed, whichever occurs first.
- (i) **Tolerance.** The finished surface tolerance shall be in conformity with Section 301.

307.05. METHOD OF MEASUREMENT.

Lime will be measured by the ton (metric ton).

Lime-treated subgrade will be measured by the square yard (square meter).

Prime coat will be measured and paid for in accordance with Section 408.

Water and rolling will not be measured for payment.

307.06. BASIS OF PAYMENT.

Accepted quantities, measured as provided above, will be paid for at the contract unit price as follows:

- (A) LIME TON (METRIC TON)
 (B) LIME TREATED SUBGRADE SQUARE YARD (SQUARE METER)

Such payment shall be full compensation for furnishing all materials, equipment, labor, and incidentals to complete the work as specified.

- Payment for quick lime *shall be based upon a 90 percent available lime index by rapid sugar method, calculated as percent CaO by weight.*
- Payment for hydrated lime *shall be based upon a 90 percent available lime index by rapid sugar method, calculated as percent Ca(OH)² by weight.*
- Payment for by-product lime *shall be based on a substitution ratio calculated on a 90 percent available lime index by rapid sugar method.*

When the available lime index percentage falls below 90 percent, payment will be made at an adjusted price—which shall be reduced at the rate of one percent of the Contract unit bid price for lime for each percent, or fraction thereof, from 90.0 percent down to—and including—an available lime index of 80.0 percent.

When the available lime index falls below 80.0 percent for the type of lime used, add a sufficient quantity of additional lime of the same type to bring the total amount to the required 90.0 percent of available lime index at no additional cost to the Department.

SECTION 309 ROLLING AND SPRINKLING

309.01. DESCRIPTION.

This work shall consist of authorized rolling of embankments, subgrades, subbases, bases, or surface courses. When specified, rolling and/or sprinkling shall be done as directed by the Engineer in accordance with the Specifications for the particular type of work under construction.

309.03. EQUIPMENT.

When end results only are specified, use whatever compaction methods will satisfactorily produce the end results. When specific equipment is designated, it shall meet the requirements of Subsection 301.03.

309.04. CONSTRUCTION METHODS.

Apply water in the amount required to place the course or layers in the most satisfactory condition for proper compaction. Roll the course adequately to obtain the required density for the type of material being compacted.

Begin rolling at the edges and continue until the outside portion and the edges of the course are thoroughly compacted. After the edges have been firmly rolled, progress gradually toward the center, parallel to the center line of the roadway, uniformly lapping each preceding track and covering the entire surface with the rear wheels for the full width of the course. Start subsequent rolling at the edges and proceed as before, covering the full width across the road, and continuing until all parts of the course are thoroughly keyed and compacted to the satisfaction of the Engineer. On superelevated curves, after the edges have been thoroughly rolled as specified above, continue the rolling from the inside edge to the outside edge instead of from the edges to the center. Operate the rollers at the speed previously specified. When operations are such that one roller unit cannot perform the required compaction satisfactorily, provide additional roller units and continue operations in a manner approved by the Engineer.

309.05. METHOD OF MEASUREMENT.

Rolling, when an item for rolling is shown on the Plans or in the Proposal as a pay item, will be measured by the hour and pay quantities will be as follows:

The number of hours that the roller actually works will be divided by 5 and the quotient thus obtained multiplied by the actual outside rolling width in feet (meters) of the roller tread. In case of sheeps-foot rollers, the width to be used will be the sum of the widths in meters of the individual drums composing the roller. No time will be allowed for moving the roller to and from the location of the work being rolled.

Sprinkling, when an item for sprinkling is shown on the Plans or in the Proposal as a pay item, will be measured by the 1000 gallon (kiloliter) increments, or fractional part thereof, of water used and will be measured as delivered in calibrated tank trucks; or if water is obtained by pipe line, the Contractor shall supply an accurate water meter for measuring the water.

309.06. BASIS OF PAYMENT.

When an item for rolling is shown on the Plans or in the Proposal as a pay item, rolling, measured as provided above, will be paid for at the contract unit price per hour for rolling and such payment shall be full compensation for furnishing the roller, operator, all equipment, fuel, and incidentals necessary to complete the work as specified.

When an item for sprinkling is shown on the Plans or in the Proposal as a pay item, sprinkling, measured as provided above, will be paid for at the contract price per 1000 gallon (kiloliter) for sprinkling, and such payment shall be full compensation for the cost of the water, for hauling, applying and furnishing all equipment, tools, labor and incidentals necessary to complete the work as specified.

- (A) ROLLING HOUR
 (B) SPRINKLING M-GAL (KILOLITER)

SECTION 310 SUBGRADE

310.01. DESCRIPTION.

This work shall consist of preparing the subgrade for the immediate construction of subbase, base, pavement, or surface.

The subgrade shall be constructed in accordance with one of the methods specified herein or by the method indicated on the Plans or in the Proposal for the work.

310.04. CONSTRUCTION METHODS.

- **Method A-Traffic-Bound Surface Course.** *Shape and crown the full width of the existing roadbed with a blade grader to the approximate grade and section required. Unless otherwise indicated, the completed section shall have a crown of at least 2.00%. Remove all exposed rock larger than 3 inches (75 mm) and any unstable soil, and replace it with acceptable material. Finish the roadbed so that it is smooth and uniform, and maintain it in this condition until the next specified course is placed.*
- **Method B - All Other Subbases, Bases, Pavement, or Surface.** *Scarify or otherwise process the subgrade to permit uniform dispersion of moisture to a depth of approximately 6 inches (150 mm).*

NOTE: In areas with subgrade through rock cuts that cannot be scarified or otherwise processed, shape the areas with soil meeting the requirements of select borrow Subsection 202.02(f), unless otherwise specified, to conform to the planned profile and cross section.

When the loosened soil has been pulverized, compact it thoroughly and uniformly with suitable equipment for a depth of approximately 6 inches (150 mm) and to at least 95 percent of standard density in accordance with Subsection 202.02(b)(2). Moisture content of the subgrade material at the time of compaction shall be within two points of the optimum moisture content as determined by AASHTO T 99 unless otherwise specified. In areas of the subgrade which are not accessible to rolling equipment, compact them to the required density with approved mechanical tampers.

The surface of the finished subgrade will be tested by the Engineer at selected locations. The variation of the surface shall meet the tolerance requirements of Subsection 301.04. Unless otherwise provided, points closer than 50 feet (15 m) shall not vary more than 1/2 inch (13 mm) from the approved grade in place.

Tests of the subgrade in place shall be made immediately in advance of placing the subsequent course and shall not vary more than the tolerances heretofore specified; any deficiency shall be corrected before material is placed for the subsequent course.

In the correction of the profile grade to conform to established elevations, excavation which cannot be wasted on inside slopes or ditch lines by lateral drifting with a motor grader will be measured and paid for as unclassified excavation in accordance with Section 202. Material required in excess of roadway excavation to raise the existing roadbed to established elevations will be measured and paid for as unclassified or select borrow as specified or directed in accordance with Section 202.

When the condition of the subsurface materials in excess of 12 inches (300 mm) below subgrade elevation prevents the satisfactory construction of the subgrade, excavation to remove the unstable material and backfill with acceptable material to subgrade elevation—within the area and depth designated by the Engineer—shall be done in accordance with Subsection 202.02.

NOTE: Material unsuitable for backfill shall be wasted as directed by the Engineer and the backfill made with acceptable material obtained from borrow in accordance with Subsection 202.02.

When grading and surfacing operations are let in one contract, removal and replacement of unstable material will not be measured or paid for in fill areas.

Instability due to excess moisture in the top 12 inches (300 mm) will not be recognized as justification for removal of unstable material, and payment will not be made for manipulation and aeration of materials in place necessary to establish a satisfactory subgrade.

Measurement of the excavation required for removal of unstable material and excavation for borrow required for backfill (with acceptable material, as provided above) will be made in accordance with Subsection 202.05.

Excavation required for removal of unstable material and excavation for borrow for backfill with acceptable material measured as provided above will be paid for at the contract unit price per cubic yard (cubic meter) for unclassified excavation.

310.05. METHOD OF MEASUREMENT.

Subgrade will be measured by the square yard (square meter).

310.06. BASIS OF PAYMENT.

Accepted subgrade quantities, measured as provided above, will be paid for at the contract unit price as follows:

- (A) SUBGRADE METHOD A SQUARE YARD (SQUARE METER)
- (B) SUBGRADE METHOD B SQUARE YARD (SQUARE METER)

Such payment shall be full compensation for furnishing all materials, equipment, tools, labor, and incidentals to complete the work as specified.

It is the intent of this Specification that payment for this item will be made only one time for work performed on the subgrade as defined in Subsection 101.52 regardless of the number of subbase or base courses placed on the subgrade.

SECTION 311

PROCESSING EXISTING BASE AND SURFACE

311.01. DESCRIPTION.

This work shall consist of the removal, processing, reuse, or disposal of existing aggregate surface course or base course and asphalt surface. This work shall be done in accordance with one of the following methods as specified herein and shown on the Plans or as indicated by a pay item on the Plans and in the Proposal.

311.04. CONSTRUCTION METHODS.

Loosen or scarify the aggregate or other materials in place (or use other suitable methods) to its full depth and width. Process all loosened aggregate or asphalt and break it into pieces which will pass a 3 inch (75 mm) sieve. Windrow the materials on the subgrade or shoulder as the case may require. Exercise care in loosening, removing, processing, and storing aggregate to avoid the addition of excess amounts of soil or other foreign material which would render it unsuitable for use hereafter specified.

NOTE: Damaged material resulting from improper workmanship of the Contractor will not be measured for payment.

- **Method A - For Salvage and Stockpiling.** The processed materials shall not contain detrimental amounts of subgrade or soil or other foreign material. The processed material shall be loaded and hauled to storage locations indicated on the Plans. All materials shall be stored in a neat and workmanlike manner. All grass, weeds, and other rubbish shall be removed from the storage area prior to stockpiling material.
- **Method B - For Use in Subgrade.** The processed materials shall be windrowed on the shoulders during the shaping and conditioning of the subgrade. The materials shall then be spread uniformly over the full width of the section and compacted and completed with the subgrade in accordance with the method specified.
- **Method C - For Use as Subbase.** The processed materials shall be spread evenly on the previously completed and compacted subgrade and then compacted to the requirements specified for the method of subgrade preparation.
- **Method D - For Use in New Base Courses, Shoulders, or Ramps.** The processed materials may be placed on the completed subgrade as a base course, shoulders, or ramps, or they may be blended uniformly with new material for any course. The suitability of the removed materials shall be determined by the Engineer, and the *materials used as authorized.*

NOTE: Materials used in method B, C, and D shall be compacted to not less than 95 percent of standard density for shoulders, ramps, and base courses.

311.05. METHOD OF MEASUREMENT.

Processing existing base and surface will be measured by the station or fraction thereof measured along the center line of the roadbed.

311.06. BASIS OF PAYMENT.

Accepted quantities for processing existing base and surface, measured as provided above, will be paid for at the contract unit price as follows:

- (A) PROCESSING EXISTING BASE AND SURFACE, METHOD A STATION
- (B) PROCESSING EXISTING BASE AND SURFACE, METHOD B STATION
- (C) PROCESSING EXISTING BASE AND SURFACE, METHOD C STATION
- (D) PROCESSING EXISTING BASE AND SURFACE, METHOD D STATION

Such payment shall be full compensation for furnishing all equipment, tools, labor, and incidentals necessary to complete the work as specified.

SECTION 317 FLY ASH MODIFIED SUBGRADE

317.01. DESCRIPTION.

This work shall consist of constructing one or more courses of a mixture of soil, fly ash, and water, in accordance with these Specifications and in reasonably close conformity with the lines, grades, and typical cross sections shown on the Plans or established by the Engineer.

317.02. MATERIALS.

Materials shall meet the requirements specified in the following Sections and Subsections of Section 700 - Materials:

Fly Ash	702
Water	701.04

317.03. EQUIPMENT.

- (a) **General.** All equipment necessary for construction of fly ash modified subgrade shall be furnished in accordance with the requirements of Subsection 108.06 and the following:
- (b) **Traveling Plants.** Traveling plants used for soil pulverization and mixing shall be approved in accordance with the requirements of Subsection 301.03(b).
- (c) **Compactors.** Equipment for compaction shall meet the requirements of Subsection 301.03(c).
- (d) **Sprinklers.** Sprinklers shall meet the requirements of Subsection 301.03(d).

317.04. CONSTRUCTION METHODS.

- (a) **General.** It is the primary requirement of these Specifications to secure a completed course or courses of subgrade material containing a fly ash mixture of uniform density and moisture content; it should be free from loose or segregated areas, and well bound for its full depth with

a smooth surface suitable for placing subsequent courses. It shall be the responsibility of the Contractor to regulate the sequence of this work, to use the prescribed amount of fly ash, and to maintain the work as necessary to meet the above requirements.

- (b) **Weather Limitations.** Do not perform fly ash mixing operations when the subgrade is frozen or when the air temperature in the shade is less than 40°F (4°C). Under any weather conditions, protect the quality of the fly-ash-modified subgrade mixture.
- (c) **Preparation of Existing Roadbed.** Prior to the application of fly ash, compact and shape the roadbed to reasonably close conformity with the typical sections, lines, and grades as shown on the Plans or established by the Engineer.

Roll the subgrade, and correct any soft areas that this rolling may reveal.

- (d) **Scarifying and Loosening.** Scarifying and loosening may be required prior to the application of fly ash to achieve the desired results as determined by the Engineer. Take precautions to avoid forming furrows of loosened material below the depth specified for the bottom of the fly-ash-modified subgrade. Except by special permission from the Engineer, the length of roadway scarified and loosened at any time shall not exceed the length in which mixing and compaction can be completed in two calendar days.

In subgrade extents designated on the Plans or by the Engineer as having excessive rock—the dimensions or quantities of which 25 percent or more are greater than 2 1/2 inches (63 mm) in size, making compliance with these Specifications impractical—the Engineer may waive certain portions of the work as described below. The Engineer may require exploratory scarifying by the Contractor before designation of extents for which full compliance of these Specifications is waived.

- (e) **Application of Fly Ash.** The proportion of fly ash indicated on the Plans is approximate. Apply fly ash at the rate prescribed by the Engineer based on tests of the subgrade soil. Provide equipment necessary for proper control of the application rate of fly ash. Where tests indicate a significant change in the subgrade soil, the Engineer will establish a new rate as deemed necessary for the section of road affected, and at the time of placing and spreading the fly ash will advise the Contractor of the final application rate.

NOTE: Fly ash shall not be applied by the slurry method; fly ash shall not be placed on wet subgrade or otherwise allowed to become wet during application; and fly ash shall not be applied when wind conditions are such that blowing fly ash becomes objectionable to traffic or adjacent property owners.

Use dry methods of application for placement of the fly ash onto the subgrade. Equipment for spreading shall be approved types which demonstrate the ability to distribute fly ash uniformly.

Fly ash shall be placed only on that area of roadway where mixing, compaction, and finishing can be completed in the same day.

NOTE: During the interval of time between application and completion of the first mixing operations, fly ash that has been exposed to weather conditions resulting in wetting or excessive loss by blowing will not be accepted for payment, and fly ash unacceptable as the result of wetting shall be removed from the roadway.

(f) **Mixing.**

(1) **General.** Mixing of the fly ash with the subgrade soil shall follow application and spreading as a continuous construction operation. Work areas for mixing shall not exceed 5,000 square yards (4000 m²) unless otherwise authorized by the Engineer. The mixing procedure shall be as hereinafter described:

1.1 *First Mixing.* At the time of first mixing, the moisture content of the subgrade soil shall not exceed 80 percent of optimum as determined by AASHTO T 99. Mix the soil and fly ash until a uniform mixture is obtained in which all clods and non-aggregate lumps are reduced to a maximum of 2 1/2 inches (63 mm) diameter size.

NOTE: The addition of water will not be permitted during the first mixing, which shall begin no later than four hours after application of the fly ash.

When deemed necessary by the Engineer, rescarify any portion of the work area and add fly ash as needed to ensure adequate soil modification.

Thoroughly mix the fly ash and soil prior to the beginning of final mixing operations.

1.2 *Final Mixing.* After the dry soil and fly ash have been satisfactorily mixed, add water to initiate soil-fly ash reaction. The method of mixing shall be an approved procedure using a traveling mixing plant which demonstrates uniform dispersion of fly ash and water throughout the soil materials. The quantity of water necessary for the final mixing operations will vary with the nature of the materials—normally 2 to 5 percentage points above the optimum moisture content of the compacted modified soil. In any case, add sufficient water in the final mixing process to insure chemical action between the fly ash and soil.

Reduce all clods in size by mixing until the soil-fly ash mixture meets the following size requirements when tested with laboratory sieves:

SIEVE SIZE	PERCENT PASSING
1 1/2 inch (37.5 mm)	100
3/4 inch (19.0 mm)	50 minimum

(2) **Lime Alternative.** Alternately, specific extents of the subgrade may require a pretreatment with lime—at a depth and rate of application as shown on the plans or as directed by the Engineer—to lower the plasticity index of the subgrade soils (to below 20) prior to the application of fly ash.

Blend the lime thoroughly into the soil with a pulvi-mixer at the proper moisture content—tight bladed, but not compacted. Sprinkle the lime with water daily during the mellowing stage (typically a minimum of four days) or a period of time as determined by the Engineer; this is needed to allow the lime to chemically react with the clay soils.

Thereafter, the mixing of subgrade soils with fly ash, compaction, finishing and curing shall be as described in (g) and (h) below.

(g) **Compaction.** Perform compaction of the soil-fly ash mixture immediately after final mixing, so that the compaction operation is a continuation of the final mixing operation. The target density shall be determined in the field by moisture density tests on representative samples of the soil-fly ash mixture obtained from the roadway when compaction is started. The test method for

the target density will be as specified in Subsection 202.02(b)(2), modified to provide one compacted specimen of the soil-fly ash mixture as obtained from the roadway; separate portions of the sample will be used for additional specimens with the moisture reduced or increased.

Compact the soil-fly ash mixture without delay and before any appreciable loss of mixing moisture occurs. Perform mixing and compaction operations so that the mixture will be compacted within plus or minus 2 percentage points of optimum moisture content. However, during the course of construction, changes or adjustments in the specified moisture requirements to meet field conditions may be authorized by the Engineer.

Continue compaction until the entire depth of the mixture is uniformly compacted to not less than 95 percent of target density. Field density will be determined in accordance with Subsection of 202.02(b)(2). The rate of operation and the number of rollers shall be sufficient to uniformly compact the section of roadway being processed within two hours of the final mixing.

Sprinkle and roll the material, and immediately correct any/all irregularities, depressions, or weak spots which develop by scarifying the areas affected, adding or removing material as required, and reshaping and recompacting by sprinkling and rolling.

In addition to complying with the requirements specified for density, uniformly compact the full depth of the material shown on the Plans to the extent necessary for it to remain firm and stable under construction equipment. After each section is completed, density tests, as necessary, will be made by the Engineer for acceptance. Throughout this entire operation maintain the shape of the course; upon completion, make the surface smooth and in conformity with the typical section shown on the Plans and to the established lines and grades.

NOTE: Should the material, due to any reason or cause, lose the required stability, density, or finish before the next course is placed or the work is accepted, it shall be replaced and refinished at the sole expense of the Contractor.

In areas designated by the Engineer as excessive rock areas, it is the intent that compaction be in substantial compliance with these Specifications. However, it is recognized that the soil-fly ash mixture may not be uniform and some variation is to be expected in both the target density and optimum moisture, depending on the fly ash content of a given sample. In the event the in-place density tests are not practical because of rock in the soil-fly ash mixture, the Engineer may waive the density and moisture content requirements and approve compacting by visual observation in lieu of such tests.

- (h) **Finishing and Curing.** After the final layer of the fly-ash-modified subgrade has been compacted, bring it within reasonable compliance to the lines, grades, and typical sections. Then, finish the completed section with a suitable roller sufficiently light to prevent hair cracking. The modified material shall be maintained at a moisture content satisfactory for proper curing by sprinkling or until a prime, seal, or succeeding course is placed, whichever occurs first.
- (i) **Surface Tolerance.** The finished surface tolerance shall be in conformity with Section 301.

317.05. METHOD OF MEASUREMENT.

Fly ash will be measured by the ton (metric ton).

Fly ash modified subgrade will be measured by the square yards (square meters) of subgrade modification completed in place.

Lime will be measured by the ton (metric ton).

Scarifying, mixing, and blading of the subgrade with lime pretreatment will be measured by the square yards (square meters) of subgrade modification completed in place.

Prime coat will be measured and paid for in accordance with Section 408.

Water will *not* be measured for payment.

317.06. BASIS OF PAYMENT.

Accepted quantities for fly-ash-modified subgrade, measured as provided above, will be paid for at the contract unit price as follows:

- (A) FLY ASH..... TON (METRIC TON)
- (B) SUBGRADE MODIFICATION SQUARE YARD (SQUARE METER)
- (C) LIME TON (METRIC TON)
- (D) SCARIFYING, MIXING BLADE OF SUBGRADE
WITH LIME TREATMENT SQUARE YARD (SQUARE METER)

Such payment shall be full compensation for furnishing all materials, equipment, labor, and incidentals to complete the work as specified.

**SECTION 318
ECONOCRETE BASE**

318.01. DESCRIPTION.

The work covered by this Section consists of the construction of an Econocrete Base in accordance with these Specifications and with the lines, grades, and dimensions shown on the Plans.

318.02. MATERIALS.

- (a) **General.** All materials shall meet the requirements specified in the following Subsections of Section 700 of the Standard Specifications for Highway Construction shown below:

Aggregate	701.15
Portland Cement	701.02
Water	701.04
Air Entraining Agent	701.03
Fly Ash	702
Chemical Admixtures	701.03
Curing Agents	701.07(d)

- (b) **Mix Design and Proportioning.** Design the mix proportions for the econocrete base, basing them on the absolute volume method for a cubic yard (cubic meter). At least 40 days prior to placement of the Econocrete Base, submit the design mix to the Engineer for approval. The design shall identify the source of materials proposed for use, the proportions of the materials,

the properties of the mixture, and the compressive strength of the mix at 28 days. In designing the mix, meet the following criteria:

- (1) The mix shall have a *minimum cement content* of 200 pounds per cubic yard (118 kg/m³). Fly ash may be substituted for up to 25 percent cement in the ratio of 1 pound (1.0 kg) of fly ash for each 1 pound (1.0 kg) of cement. Fly ash shall not be used November 1st through April 1st.
- (2) The mix shall be designed to produce a *maximum slump* of 3 inches (75 mm) at the roadway prior to placing.
- (3) The mix shall have an *air content* of four to twelve percent.
- (4) The mix shall have a *compressive strength* at 28 days of approximately 1200 psi (8300 kPa). Compressive strength shall be determined based upon results of six cylinders prepared and tested in accordance with Subsection 701.01(d).

The review and approval of the proposed mix by the Engineer will be to determine that the mix has met the design criteria.

318.03. EQUIPMENT.

All equipment used in the production and placement of the Econocrete Base shall comply with Subsection 414.03.

318.04. CONSTRUCTION METHODS.

Construction methods shall comply with the requirements of Subsection 414.04 except as noted herein. After strike off and consolidation, no additional finishing will be required except as needed to provide the required elevation, cross section, and smooth surface finish.

Place no longitudinal or transverse joints in the Econocrete Base except for construction joints, which shall be butt joints.

Accomplish the curing by applying a curing agent at the rate of one gallon (one liter) to not more than 150 square feet (3.75 m²). The curing period will be seven curing days; a curing day will be considered to be any consecutive 24-hour period during which the air temperature adjacent to the base does not fall below 40°F (4°C). Begin recording the curing days as soon as the placement of econocrete during a day's operation has reached the point where no more manipulation of the econocrete mix is being done.

No construction traffic will be allowed on the Econocrete Base-and no overlying pavement may be placed on the base-until unconfined compressive strengths of test cylinders (made during the placement of the base) all achieve 500 psi (3500 kPa), minimum. After the base strength reaches 500 psi (3500 kPa) keep construction traffic on the base to an absolute minimum-which includes not using it as a haul road. Repair any damage to the base caused by unacceptable traffic without additional charge to the Department.

At least 12 hours but not more than 48 hours prior to beginning the placement of the reinforcing steel for the overlying pavement, sweep the base clean and apply a second application of liquid membrane curing compound to the Econocrete Base. The rate of application shall be one gallon (one liter) to not more than 200 square feet (5 m²).

NOTE: After the second application of curing agent (bond breaker) has been applied, no haul traffic will be allowed on the Econocrete Base.

The tolerance for surface, width and thickness shall be in conformity with Section 301.

318.05. METHOD OF MEASUREMENT.

Econocrete Base will be measured in accordance with the requirements of Subsection 414.05.

318.06. BASIS OF PAYMENT.

The accepted quantities of Econocrete Base, measured as provided above, will be paid for at the Contract unit price as follows:

ECONOCRETE BASE SQUARE YARD (SQUARE METER)

Such payment shall be full compensation for furnishing all materials, equipment, labor, and incidentals to complete the work as specified.

SECTION 319 OPEN-GRADED BITUMINOUS BASE

319.01. DESCRIPTION.

This work shall consist of the construction of a permeable base course of aggregate and bituminous material mixed in a central plant and spread and compacted on a prepared surface in accordance with these Specifications. It shall be in reasonably close conformity with the lines, grades, thickness, and typical cross sections shown on the Plans or established by the Engineer.

319.02 . MATERIALS.

Materials shall meet the requirements specified in Section 708.

319.03. EQUIPMENT.

The equipment used for producing, heating, mixing, hauling, spreading, compacting, and finishing the bituminous base shall meet the requirements of Subsection 411.03.

319.04. CONSTRUCTION METHODS.

The construction methods shall comply with Subsection 406.04, except as follows:

- (a) **Prime Coat.** Prime Coat, if required, shall be in accordance with Section 408.
- (b) **Tolerances.** Surface, width and thickness tolerances of the base shall be in conformity with Section 301.
- (c) **Weather Limitations.** Weather limitations shall be the same as for asphalt concrete as specified in 411.04(g).
- (d) **Construction Traffic.** Construction traffic shall not be allowed on the Open Graded Bituminous Base (OGBB) until the OGBB has cooled to ambient temperature. Additional curing time may be required in some instances to facilitate compaction of the subsequent lift of paving material. Any additional time required will be determined by the Engineer. No overlying pavement shall

be placed on the base until the curing period has been completed. After completion of the curing period, construction traffic on the OGBB shall be held to a minimum; the OGBB shall not be used as a haul road, unless the Engineer has approved the Contractor's written plan. Any damages to the base as a result of the Contractor's operation shall be repaired at his expense to the satisfaction of the Engineer. The contractor shall be responsible to see that soil, mud, or other materials are not tracked or spilled on the base that would compromise its hydraulic efficiency.

- (e) **Hydraulic efficiency.** The hydraulic efficiency of any segment of the base will be measured by the flow of water through it. Approximately one quart (one liter) of water will be doused on the surface of the open-graded base. The water shall be totally absorbed into the base within 15 seconds with no water remaining on the surface. Failure to achieve this performance standard will indicate a contaminated base whose hydraulic efficiency has been severely impaired.

NOTE: Such contaminated OGBB whose hydraulic efficiency has been severely impaired shall be removed by the contractor and replaced at no cost to the Department. The extents of the replacement will be determined by the Engineer. Hauling equipment shall not be operated on the OGBB during the placement of the overlying pavement.

319.05. METHOD OF MEASUREMENT.

Open-graded bituminous base, including the aggregate, liquid asphalt, and other ingredients as specified in the job mix formula, will be measured by the ton (metric ton) of combined mixture.

Tack coat will be measured and paid for in accordance with Section 407.

319.06. BASIS OF PAYMENT.

The accepted quantities, measured as provided above, will be paid for at the Contract unit price as follows:

OPEN GRADED BITUMINOUS BASE TON (METRIC TON)

Such payment shall be full compensation for furnishing all materials, equipment, labor, and incidentals to complete the work as specified.

SECTION 320

OPEN-GRADED PORTLAND CEMENT CONCRETE BASE

320.01. DESCRIPTION.

This work shall consist of the construction of a permeable base course of aggregate, Portland Cement concrete, and water mixed in a central plant and spread and compacted on a prepared surface in accordance with the lines, grades, thicknesses, and typical cross section shown on the Plans or established by the Engineer.

320.02. MATERIALS.

Material shall meet the requirements specified in the following Subsections of Section 700 - Materials:

Aggregate	701.16
Water	701.04
Fly Ash	702
Portland cement	701.02

NOTE: The water actually used shall be determined by the water measured into the batch plus the free water on wet aggregate minus the water absorbed by dry aggregate. The exact water-cement ratio shall be as approved by the Engineer.

320.03. EQUIPMENT.

The equipment used for producing, mixing, hauling spreading, compacting, and finishing the Open-Graded Portland Cement Concrete Base (OGPCCB) shall meet the requirements of Subsections 301.03 and 414.03.

320.04. CONSTRUCTION METHODS.

The construction methods shall comply with the following requirements:

- The mix shall have a minimum cement content of 200 pounds per cubic yard (118 kg/m³).
 - Fly ash may be substituted for up to 25 percent of the required cement, with this substitution in the ratio of 1 pound (1.0 Kg) of fly ash for each 1 pound (1.0 Kg) of cement. Flyash shall not be used November 1st through April 1st.
 - The water-cement ratio shall be a maximum of 0.45 and shall be calculated as follows:

$$W/C = (\text{weight of water})/(\text{weight of cement} + \text{weight of fly ash})$$
- (a) **Mixing and Placing.** The mixing and placing of the OGPCCB will conform to the requirements for mixing and placing concrete pavement, Subsections 414.04(e), (f) and (g).
- (b) **Weather Limitations and Maintenance Quality.** Do not mix OGPCCB when either the aggregate or subgrade is frozen. The air temperature shall be at least 40°F (5°C) in the shade and rising.
 From the time work starts until it is completed and approved, protect the quality of the base and maintain it within limits of the Contract so that it is in good condition to the satisfaction of the Engineer. This maintenance shall be done at no additional charge and repeated as often as necessary to keep the area continuously intact. Make repairs in a manner that insures a uniform surface and the durability of the part repaired. Replace faulty work for the full depth of the base. Remedy low areas by replacing the material for the full depth of the treatment rather than by adding a thin layer of base to complete the work.
- (c) **Base.** The surface below the OGPCCB shall be uniformly moist at the time the base is placed.
- (d) **Consolidation of Mixture.** Consolidation of the mixture shall be performed by vibratory equipment during laydown operations, resulting in a minimum of 95% of AASHTO T121. Roadway consolidation of the finished base shall be determined on the fresh mixture fifteen to thirty minutes after laydown using nuclear gauge testing devices prescribed in AASHTO T238.
- (e) **Water Curing.** The completed OGPCCB shall be cured by sprinkling the surface with a fine spray of water every two hours for a period of eight hours. Curing shall start the morning after the base has been placed.

- (f) **Construction Joint.** At the start of the day-or in the case of an unavoidable interruption of operations that would form a joint in the base-cut back the edge of the base to leave a vertical face as is necessary to secure a satisfactory surface. Replace all removed base without additional charge to the Department.
- (g) **Traffic Restrictions and Curing Period.** Construction traffic shall not be allowed on the OGPCCB for at least three days after it has been placed. No overlying pavement shall be placed on the base until this curing period has been completed. After completion of the curing period, construction traffic on the OGPCCB shall be held to a minimum; the OGPCCB shall not be used as a haul road, unless the Engineer has approved the Contractor's written plan. Any damages to the base as a result of the Contractor's operations shall be repaired to the satisfaction of the Engineer at the Contractor's expense. The contractor shall be responsible to see that soil, mud, or other materials are not tracked or spilled on the base that would compromise its hydraulic efficiency.
- (h) **Hydraulic Efficiency.** The hydraulic efficiency of any segment of the base will be measured by the flow of water through it. Approximately one quart (one liter) of water will be doused on the surface of the open-graded base. The water shall be totally absorbed into the base with 15 seconds with no water remaining of the surface. Failure to achieve this standard will indicate a contaminated base whose hydraulic efficiency has been severely impaired.
- NOTE: Such contaminated OGPCCB whose hydraulic efficiency has been severely impaired shall be removed by the contractor and replaced at no cost to the Department. The extents of the replacement will be determined by the Engineer. Hauling equipment shall not be operated on the OGPCCB during the placement of the overlying pavement.*
- (i) **Tolerances.** Tolerances for surface, width, and thickness shall be in conformity with Subsection 301.04.

320.05. METHOD OF MEASUREMENT.

Open-graded portland cement concrete base will be measured by the square yard (square meter) of completed and accepted base.

320.06. BASIS OF PAYMENT.

The accepted quantities, measured as provided above, will be paid for at the Contract unit price as follows:

OPEN GRADED PORTLAND CEMENT CONCRETE BASE

(4 inch (100 mm) thick) SQUARE YARD (SQUARE METER)

Such payment shall be full compensation for furnishing all materials, equipment, labor, and incidentals to complete the work as specified.

SECTION 325 SEPARATOR FABRIC FOR BASES

325.01. DESCRIPTION.

This work shall consist of the installation of a separator fabric as shown on the plans. The installation shall be performed in accordance with these Specifications and as directed by the Engineer.

325.02. MATERIALS.

The separator fabric shall conform to Subsection 712.05.

325.04. CONSTRUCTION METHODS.

Furnish the separator fabric in a protective wrapping which shall protect the fabric from ultraviolet radiation and from abrasion due to shipping and handling. Label each roll to provide product identification for inventory and quality control. In the field, store the fabric rolls in a manner that protects them from the elements.

Place the fabric in the manner and at the locations shown on the Plans. The geotextile at the overlap shall be either lapped a minimum of 17 inches (430 mm) or sewn.

If lapped, place the fabric so that the preceding roll overlaps the following roll in the direction the base material is being spread.

If sewn, the seam strength shall not be less than 70 percent of the required tensile strength of the unaged fabric. Prepare the surface to receive the fabric to a smooth condition, free of obstructions and debris that may damage the fabric during installation.

Cover the fabric with the base material within two weeks of its placement. Should the fabric be damaged during construction, repair the torn or punctured section using a piece of fabric that is large enough to cover the damaged areas and to meet the overlap requirement as described above.

Apply cover material by back dumping. The cover shall be a minimum of 3 inches (75 mm). Bituminous mix material may be laid by a tracked laydown machine. Fill and compact any rutting that occurs in the base material with appropriate material.

NOTE: If windy conditions disturb the fabric, stabilize it by pinning with large nails with washers, or weighting with cover material.

325.05. METHOD OF MEASUREMENT.

Separator fabric shall be measured by the square yard (square meter) in place with no allowance for laps.

325.06. BASIS OF PAYMENT.

The accepted quantities, measured as provided above, will be paid for at the contract unit price as follows:

SEPARATOR FABRIC SQUARE YARD (SQUARE METER)

Such payment shall be full compensation for furnishing all material, equipment, labor, and incidentals to complete the work as specified.

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SECTION 401 GENERAL REQUIREMENTS FOR SURFACES

401.01. DESCRIPTION.

This Section covers requirements common to all types of surface construction.

401.02. MATERIALS.

Materials as required for construction of the various surface types shall meet the requirements set forth in the appropriate Subsections of Section 700 - Materials, where a Subsection is designated for each surface type.

401.03. EQUIPMENT.

Maintain and operate all equipment in accordance with the manufacturers' recommendations.

- (a) **Distributors and Supply Tanks.** Apply bituminous material, at uniform heat, uniformly on variable widths of surface up to 26 feet (7.8 m) at readily determined and controlled rates from 0.1 to 1.0 gallons per square yard (0.45 to 4.5 L/m²) with uniform pressure.

NOTE: Allowable variation from any specified rate must not exceed 0.03 gallon per square yard (0.14 L/m²).

Distributor equipment shall include a tachometer, pressure gauges, accurate volume metering devices or a calibrated tank, and a thermometer for measuring temperatures of tank contents. Distributors shall be equipped with a power unit for the pump and with full circulation spray bars adjustable laterally and vertically.

The distributor shall also be equipped with a positive shut-off valve and fittings as needed to prevent the spray bar or other mechanisms from dripping bituminous material; make sure that there will be sufficient material left in the distributor at the end of each application to insure uniform distribution.

NOTE: In no case should you allow the distributor to "blow."

Check the angle of the spray nozzles and the height of the spray bar frequently, and adjust them to insure uniform distribution of the bituminous material. Drilling, clogging, or streaking of the bituminous material is not an acceptable application; in the event these problems occur, take necessary corrective measures before resuming distribution.

Make a check of the distribution rate and the uniformity of the distribution when directed by the Engineer.

Supply tanks shall meet the requirements of AASHTO M-156 Section 3.

- (b) **Compactors.** Rollers shall be steel wheel, pneumatic tire, vibratory, or a combination of these types. They shall be in good condition, capable of reversing without backlash, and operable at speeds slow enough to avoid displacement of the bituminous mixture. Vibratory rollers shall be equipped with amplitude and/or frequency controls specifically designed for compaction of

the material on which it is to be used. The type, number, and weight of rollers shall be sufficient to compact the mixture to the required density while it is still in a workable condition.

NOTE: The use of equipment which crushes the aggregate will not be permitted.

401.04. CONSTRUCTION METHODS.

- (a) **Tolerances.** In order to provide acceptable smoothness, width, and thickness, maintain accurate control in placing, spreading, finishing, and compacting surface courses. Use equipment as may be required to provide acceptable construction within the prescribed tolerances.

<u>SURFACE TYPE</u>	<u>SECTION</u>	<u>TOLERANCES</u>	
		<u>SURFACE</u>	<u>THICKNESS</u>
Open Graded Friction Course	406	1/8 inch in 10 feet (3 mm in 3 m)	Reasonable Conformity with the Plans
Plant Mix Asphalt Concrete Pavement	411	1/8 inch in 10 feet (3 mm in 3 m)	same as above
P.C. Concrete Pavement	414	1/8 inch in 10 feet (3 mm in 3 m)	See Section 414

All pavement will be subject to straightedge inspection during construction operations. The Engineer will make tests with a 10 foot (3m) straightedge or other approved device for compliance with specified surface tolerances at selected locations. The variation of the surface from the testing edge of the straightedge between any two contacts with the surface shall at no point exceed the specified tolerance. Correct humps or depressions exceeding the specified tolerance in an acceptable manner.

- (b) **Traffic.** Prior to construction equipment being placed on new or existing pavement, provide the Engineer with a procedure that contains all of the measures and methods to be used to protect the pavement from damage. If any spalling, cracking, chipping, rutting, or other defacing of the pavement is caused by construction operations, repair the surface(s) to new-pavement condition at no additional cost to the Department of Transportation. Refer to Section 105.07 of the Standard Specifications for projects with multiple Contractors in the same project limits.

SECTION 402 BITUMINOUS SURFACE TREATMENT

402.01. DESCRIPTION.

This work shall consist of the construction of an acceptable single- or double-surface treatment of aggregates and bituminous materials; this means that the surface is free from bleeding, loose chips, loss of imbedded aggregates, or other defects in accordance with these Specifications, and is in reasonably close conformity with the lines shown on the Plans or established by the Engineer.

402.02. MATERIALS.

Materials shall meet the requirements specified in the following Subsections of Section 700 - Materials:

Cover Aggregates No. 1, No. 2, No. 3, and No. 3C	703.02
Bituminous Prime	708.03
Bituminous Binder	708.03

Use cover aggregates No. 2, No. 3, or No. 3C for Single Bituminous surface treatments, unless otherwise specified. Cover Aggregates No. 1 and No. 2 will be used for Double Bituminous treatments, unless otherwise specified.

402.03. EQUIPMENT

Distributors, Supply Tanks, and Compactors shall meet the requirements of Subsection 401.03.

The spreader shall operate independently of supply trucks, receiving the aggregate directly from the supply trucks into a hopper which feeds the aggregate into a spreader box. The spreader shall be equipped with controls which permit the spreading of aggregate at various controlled rates from 10 to 45 pounds per square yard (5 to 25 kg/m²) and in width from 3 feet to 12 feet (0.9 to 3.6 m) up to 24 feet (7.2 m) if full width cover is desired.

402.04. CONSTRUCTION METHODS

(a) **Weather and Seasonal Limitations.** Limit the construction of bituminous surface treatment to the following weather and seasonal limitations.

- (1) **General.** Weather and seasonal conditions set forth herein for construction of bituminous surface treatment will not preclude the provisions of Subsections 105.14 and 105.17 for acceptance of the work.
- (2) **Seasonal Limitations.** The target calendar dates between which bituminous surface treatment may be applied for the various types of bituminous materials that may be used are given in Table I.

TABLE I: CONSTRUCTION SEASONAL LIMITATIONS

Cutback Asphalt	April 1 through Nov. 15
Asphalt Cement	May 1 through Sept. 30
Emulsified Asphalt	May 15 thruSept. 15

Limit the construction of bituminous surface treatment to the above calendar day periods. When a request is made in writing and so approved by the Engineer, the beginning and/or ending dates may be modified; however, the temperature and weather limitations specified in Subsection 3 under Table II shall apply to the work at all times.

- (3) **Temperature and Weather Limitations.** The temperature and weather limitations for applying the various materials for bituminous surface treatment will be restricted under the conditions listed in Table II and as herein specified. Measure ambient temperatures in the shade 4 feet (1.2 m) above the ground away from artificial heat.

When construction of bituminous surface treatment is permitted outside the seasonal limitation dates specified in Table I, it is the intent of these Specifications that temperature and weather conditions will be favorable for completion of the work planned. This means that the

minimum temperatures set forth for application of the materials in Table II have also occurred on the previous calendar day.

Work shall be suspended at any time the temperature falls below the specified minimum temperatures or does not comply with restricted application conditions. Work shall also be suspended at any time due to adverse weather, such as wind chilling the bituminous binder, rain, foggy conditions, or when in the opinion of the Engineer an abnormally high relative humidity exists.

TABLE II: TEMPERATURE AND WEATHER LIMITATIONS

BITUMINOUS MATERIALS	AMBIENT TEMP. (MIN.)	SURFACE TEMP. (MIN.)	AGGREGATE TEMP. (MIN.)	BASE OR PAVEMENT SURFACE CONDITION DUE TO WEATHER
Cutback Asphalt	50°F (10°C)	60°F (15°C)	40°F (4°C)	Dry
Emulsified Asphalt	60°F (15°C)	70°F (20°C)	50°F (10°C)	No visual free moisture present
Asphalt Cement	60° (15°C)	70° (20°C)	50° (10°C)	Dry

- (4) **Detours and Shoo-Flys.** At the discretion of the Engineer, the minimum temperatures specified for application of bituminous surface treatment may be waived for temporary construction on detours and shoo-flys or other incidental construction.
- (b) **Traffic.** Provide traffic control so that (1) no vehicles are permitted to pass over the surface treatment until the cover material has been applied and properly stabilized and (2) no unnecessary risk to the health, safety, property, or delay to the traveling public is incurred.
- (c) **Preparation of Base.** Prior to the construction of the bituminous surface treatment, bring the base reasonably true to the lines, grades, and typical cross sections shown on the Plans. Where the existing base has been previously sealed or patched with bituminous materials, completely remove any excess or fatty areas of such patches or sealing from the surface of the base course before applying bituminous binder for surface treatment. Preparation of the base will be measured for payment under Subsection 402.05.

Prior to placing the prime coat, thoroughly clean the base of dust, clay, or other foreign matter.

- (d) **Protection of Structures.** When applying bituminous materials, protect the surfaces of all structures to prevent them from being discolored.

- (e) **Heating Bituminous Material.** Heat bituminous materials in such a manner as to insure the even heating of the entire mass with an effective and positive control at all times. Heat it to a degree consistent with the type of material used as specified under Subsection 708.03 and only to such temperatures as will insure the necessary fluidity.

NOTE: Introduction of steam into bituminous materials for heating will not be permitted, and no flame shall come into contact with the bituminous material or container. Any bituminous material which has been overheated or otherwise damaged will be rejected.

- (f) **Application of Prime.** Apply, measure, and be paid for the prime coat in accordance with the provisions of Section 408, when specified.
- (g) **Application of Tack Coat.** Apply, measure, and be paid for the tack coat in accordance with the provisions of Section 407, when specified.
- (h) **Application of Bituminous Binder and Cover Aggregate.** Application of bituminous binder will be permitted only when aggregate is immediately available for spreading over the freshly applied bituminous binder. Prior to applying the bituminous binder, thoroughly clean the primed base of dirt and loose material. Do not apply the first application of bituminous binder until sufficient time has elapsed to allow both proper penetration and hardening of the prime coat.
- (1) **Bituminous binder.** Uniformly apply the binder to the surface to be treated and delineate one edge of the bituminous surfacing in advance of the first application of bituminous binder. In order to prevent overlapping or missing of bituminous binder at transverse joints, spread building paper over the treated surface for a sufficient distance back, so as to allow the distributor nozzles to operate at full force when the uncovered surface is reached. Afterwards, remove and dispose of the paper.

NOTE: When the road is closed to traffic and the surface width does not exceed 24 feet(7.3 m), you may apply materials to the full surface width in one pass for each individual application. When the road is not closed to traffic, apply prime and bituminous material one-half width at a time. When the second half of the roadbed is "shot," the distributor nozzle nearest the center of the road shall overlap the previous application by at least one-half the width of the nozzle spray but shall not exceed the full width.

- (2) **Cover aggregate.** Immediately after applying the bituminous binder, apply cover aggregates at the approximate rates specified below by means of approved, self-propelled mechanical spreaders mounted on pneumatic tired traction wheels which will accurately and uniformly spread the cover material in the required amount. In areas inaccessible to the mechanical spreaders, hand spreading will be permitted.
- (3) **General application requirements.** Throughout the application process, make any/all necessary adjustments to obtain a satisfactory surface. If deemed necessary, the Engineer may terminate the surfacing operation until such time as satisfactory performance can be obtained.

There must be no overlaps (except as otherwise provided), streaks, or gaps in the application of bituminous binder and cover aggregate.

The distribution and coverage rate of the bituminous material and cover aggregate shall be determined for individual projects. The following table is included for estimating quantities and is based on midpoint requirements of bituminous binder and aggregate based on the Asphalt Institute's formula for bituminous surface treatments.

**APPROXIMATE RATES PER SQUAE YARD
(SQUARE METER) OF SURFACE:
PRIME COAT - 0.1 to 0.4 gallon (0.45 L to 1.8 L).**

	No. 1	No. 2	No. 3	No. 3C
	<u>Aggregate</u>	<u>Aggregate</u>	<u>Aggregate</u>	<u>Aggregate</u>
Single Treatment:				
Aggregate		25 pounds (14 kg)	28 pounds (15 kg)	35 pounds (19kg)
Bituminous Binder*		0.25 to 0.3 gallons (1.1-1.4 L)	0.25 to 0.3 gallons (1.1-1.4L)	0.3to3.5gallons (1.1-1.6 L)
Double Treatment:		<u>1st Increment</u>	<u>2nd Increment</u>	
Aggregate	40 pounds (22 kg)	20 pounds (11 kg)	15 pounds (8 kg)	
Bituminous Binder*	0.4 gallons (1.8 L)	0.2 gallons (0.9 L)	0.15 gallons (0.7 L)	

* *The amounts of bituminous binder are amounts of residual asphalt. Temperature application of bituminous binder shall be in accordance with Section 708 for the type of material being used.*

The sequence for applications of bituminous binder and cover aggregate shall be as follows:

Single Treatment. Apply bituminous binder, and spread No. 2, or No. 3, or No. 3C cover aggregate over the surface at the determined rates.

Double Treatment. For the first application, apply bituminous binder, and spread No. 1 cover aggregate over the surface at determined rates.

For the second application, apply bituminous binder on the surface of the No. 1 cover material; then spread the first application of No. 2 cover aggregate (1st increment) over the surface at the determined rates.

For the third application, apply bituminous binder on the surface of the No. 2 cover material, and spread the second application of No. 2 cover aggregate (2nd increment) over the surface at the determined rates.

- (i) **Rolling.** Thoroughly roll the entire surface after each application of cover aggregate, which must be firmly imbedded into the bituminous binder.

While the rolling is in progress, spread additional aggregate by hand in whatever quantities are required to fill irregularities and to cover bare spots to prevent the picking up of bituminous binder.

The final rolling of the entire surface of the cover material shall consist of at least four coverages with a pneumatic-type roller meeting the requirements of Subsection 401.03 and operated at a speed of not more than 7 miles per hour (10 km/h).

- (j) **Maintenance.** Remove unsatisfactory material and make repairs with additional bituminous binder and aggregate so that a uniformly dense treatment with maximum retention of the cover aggregate is maintained until final acceptance of the job. Correct any irregularities with additional wearing course materials, and do not measure such materials for payment.

For excessive bleeding, apply blotting materials which are free from clay, silt, loam, or other foreign matter in the manner and amounts acceptable to the Engineer.

402.05. METHOD OF MEASUREMENT.

Bituminous binder will be measured by the ton (metric ton) of residual asphalt.

Cover aggregate will be measured by the ton (metric ton). All weight of moisture in excess of 3 percent of oven dry weight will be deducted from the pay quantity. Sand or other approved aggregate, as may be required for blotting, will be measured for payment and included in cover aggregate No. 2, No. 3, or No. 3C.

Preparation of base when indicated on the Plans will be measured by the station (kilometer).

402.06. BASIS OF PAYMENT.

Accepted quantities, measured as provided above, will be paid for at the contract unit price as follows:

(A)	BITUMINOUS BINDER	TON (METRIC TON)
(B-1)	NO. 1 COVER AGGREGATE	TON (METRIC TON)
(B-2)	NO. 2 COVER AGGREGATE	TON (METRIC TON)
(B-3)	NO. 3 COVER AGGREGATE	TON (METRIC TON)
(B-4)	NO. 3C COVER AGGREGATE	TON (METRIC TON)
(B-2P)	PRECOATED NO. 2 COVER AGGREGATE	TON (METRIC TON)
(B-3P)	PRECOATED NO. 3 COVER AGGREGATE	TON (METRIC TON)
(B-4P)	PRECOATED NO. 3C COVER AGGREGATE	TON (METRIC TON)
(C)	PREPARATION OF BASE	STATION (KM)

Such payment shall be full compensation for furnishing all materials, equipment, labor and incidentals to complete the work as specified.

SECTION 403 TRAFFIC-BOUND SURFACE COURSE

403.01. DESCRIPTION.

This work shall consist of constructing a surface course composed of hard, durable particles of sand, gravel, mine chats, crushed stone, or disintegrated granite of the type shown on the Plans or in the Proposal; it shall be constructed on the prepared subgrade in accordance with these Specifications and in reasonably close conformity with the lines, grades, and typical cross sections shown on the Plans or established by the Engineer.

403.02. MATERIALS.

Materials shall meet the requirements specified in Subsection 703.03.

403.04. CONSTRUCTION METHODS.

- (a) **Preparation of Subgrade.** Prior to placing the surfacing material on the roadbed, complete the subgrade using these requirements:

- Method A of Section 310 (Subgrade) of these Specifications for types A, B, and D.
- Method B of Section 310 (Subgrade) for type C.

- (b) **Hauling and Placing.** Transport and deliver the surfacing material in approved vehicles, depositing the material in windrows on the shoulders on the same day the material is hauled. Maintain uniform distribution throughout the length of each station, unless other methods are approved by the Engineer.

- (c) **Shaping and Maintenance.** When material is placed in driveways and incidental areas adjacent to the roadway, properly shape and compact it in a manner approved by the Engineer.

Correct any holes, waves, and undulations by blading them and then adding more material from the windrow. Continue the shaping of the surface material until it is well compacted, free from ruts, waves, and undulations, conforms to the cross section shown on the Plans, and receives final acceptance.

Remove excess material not required for maintenance, and stockpile it at a place approved by the Engineer.

- (d) **Traffic Control.** The road shall not be closed to traffic during this construction work; therefore, carry on the operations so as to interfere as little as possible with the movement of traffic. Maintain sufficient warning signs and lights as required to safeguard against accidents. Do not leave windrows or piles of material on the traveled roadway overnight; instead, place the material on the shoulders.

403.05. METHOD OF MEASUREMENT.

Traffic-bound surface course will be measured by the ton (metric ton). All weight of moisture in excess of 5 percent oven-dry weight will be deducted from the pay quantity.

403.06. BASIS OF PAYMENT.

Accepted quantities of traffic-bound surface course, measured as provided above, will be paid for at the contract unit price as follows:

- | | | | | |
|-----|------------------------------|--------|-------|------------------|
| (A) | TRAFFIC BOUND SURFACE COURSE | TYPE A | ..... | TON (METRIC TON) |
| (B) | TRAFFIC BOUND SURFACE COURSE | TYPE B | ..... | TON (METRIC TON) |
| (C) | TRAFFIC BOUND SURFACE COURSE | TYPE C | ..... | TON (METRIC TON) |
| (D) | TRAFFIC BOUND SURFACE COURSE | TYPE D | ..... | TON (METRIC TON) |
| (E) | TRAFFIC BOUND SURFACE COURSE | TYPE E | ..... | TON (METRIC TON) |
| (F) | TRAFFIC BOUND SURFACE COURSE | TYPE F | ..... | TON (METRIC TON) |

Such payment shall be full compensation for furnishing all materials, equipment, labor, and incidentals to complete the work as specified.

SECTION 406 OPEN-GRADED FRICTION SURFACE COURSE

406.01. DESCRIPTION.

This work shall consist of mixing, in a central plant, aggregate and bituminous materials, and then spreading and compacting the mixed material on a prepared roadbed, all in substantial compliance with the Specifications and dimensions shown on the Plans.

406.02. MATERIALS.

Materials shall meet the requirements of Section 708.

406.03 . EQUIPMENT.

Equipment shall conform to the requirements of Subsection 411.03.

406.04. CONSTRUCTION METHODS.

- (a) **Stockpiling Materials.** Aggregate stockpiles shall meet the requirements of Subsection 106.09.
- (b) **Preparation of Materials.** Dry and heat the mineral aggregate to a temperature not to exceed 260°F (127°C); however, when Polymer Modified Asphalt Cement (PMAC) is specified, dry and heat the mineral aggregate to a temperature not to exceed 350°F (177°C). Collect dust resulting from this operation and either waste it or return it to the mixture as deemed necessary.

The mineral aggregate shall be free of oily or carbonaceous coatings prior to entering the mixer.

Bituminous materials shall not exceed 280°F (138° C) when introduced into the mixer; however, when PMAC is specified, the temperature of the PMAC shall not exceed 350°F (177° C) when it is introduced into the mixer.

- (c) **Mixing.** Mix the aggregate and bituminous material as specified in Subsection 411.04.
- (d) **Loading and Hauling.** Coordinate loading and hauling of the mixture with the laydown operations so that the mixture shall be placed within the temperature range established in Subsection 406.04(g) and so that there will not be separation of the asphalt and aggregate.

- (e) **Tack Coat.** Apply a tack coat in accordance with Section 407, except that the rate of application shall be approximately 0.1 gallon per square yard (0.45 L/m²) of the surface area unless otherwise shown on the Plans or directed by the Engineer.
- (f) **Weather and Seasonal Limitations.** Construction of Open Graded Friction Surface Courses (OGFSC) will be permitted only under the following conditions:

When the surface is dry; when the mat surface on which it is to be placed is 60°F (15° C) or above when measured away from artificial heat; when the weather is not foggy, rainy or stormy; and when the wind or other conditions prevent proper leveling and consolidation.

OGFSC shall only be placed between April 1 and October 31 of each calendar year.

- (g) **Spreading and Finishing.** Prior to placing the OGFSC, clean all foreign matter from the surface of the existing roadbed. The temperature of the mixture for placement on the road shall be established by the Engineer, and it shall not vary more than 25°F (14° C) above or below the target temperature for placement.

The forward movement of the paving machine shall be continuous. If the paver has to stop, pick up the machine and clean it out, and then start anew.

- (h) **Joints.** The location of the longitudinal joint shall be on the lane lines, and offset from the underlying joint a minimum of 3 inches (75mm). All construction joints shall be tight, smooth, butt-type joints.

- (i) **Compaction.** Immediately following placement of the OGFSC material, roll the surface with 2-3 passes of a static (non-vibratory) steel-wheeled, self-propelled roller of such weight as approved by the Engineer.

Finish the surface so that it is smooth and true to the dimensions shown on the Plans. Immediately correct any low or defective areas by removing them, replacing them with new material, and compacting them to conform to the remainder of the pavement. Such corrective work shall be done at the expense of the Contractor.

Trucks and all other traffic shall not be permitted on the finished OGFSC pavement until the surface temperature is within 10°F (6° C) of ambient temperature or two hours time has elapsed from final rolling.

406.05. METHOD OF MEASUREMENT.

Open-graded friction surface course, including the aggregate, liquid asphalt, and other ingredients as specified in the job-mix formula—will be measured by the ton (metric ton) of combined mixture.

Tack coat will be measured and paid for in accordance with Section 407.

406.06. BASIS OF PAYMENT.

Accepted quantities of open-graded friction surface course measured, as provided above, will be paid for at the contract unit price as follows:

OPEN-GRADED FRICTION SURFACE COURSE	TON (METRIC TON)
OPEN-GRADED FRICTION SURFACE COURSE (MOD.AC)	TON (METRIC TON)

Such payment shall be full compensation for furnishing all materials, equipment, labor and incidentals to complete the work as specified.

**SECTION 407
TACK COAT**

407.01. DESCRIPTION.

This work shall consist of preparing and treating an existing bituminous or concrete surface with bituminous material in accordance with these Specifications and in reasonably close conformity with the lines shown on the Plans or established by the Engineer.

407.02. MATERIALS.

Materials shall meet the requirements specified in the following Subsection of Section 700-Materials:

Emulsified Asphalt 708.03

The emulsified asphalt may be diluted as specified or approved by the Engineer.

407.03. EQUIPMENT.

Distributors, heating equipment, and supply tanks shall meet the requirements of Subsection 401.03

407.04. CONSTRUCTION METHODS.

Clean the existing surface or course to the satisfaction of the Engineer before tack coat is placed. Apply the tack coat, as directed by the Engineer, at the rate of—and not to exceed—0.1 gallon per square yard (0.45 L/m²) of surface. Paint all contact surfaces of curbs and gutters, manholes, and other structures with a thin, uniform coat of asphalt material used for the tack coat.

Apply the tack coat in such manner as to minimize damage, offer the least inconvenience to traffic, and permit one-way traffic without pickup or tracking of the bituminous material.

NOTE: Do not apply tack coat during wet or cold weather, when wind drift presents a potential problem to the traveling public or adjacent property, after sunset, or to a wet surface; however, the surface may be damp. Tack coat that is not "covered" the same day may be reapplied at a rate that insures proper adhesion as directed by the Engineer.

The quantity, rate of application, temperature, and areas to be treated shall be approved prior to application.

407.05. METHOD OF MEASUREMENT.

Tack coat will be measured by the gallon (liter) before dilution.

NOTE: Water used in dilution of emulsified asphalt will not be measured for payment.

407.06. BASIS OF PAYMENT.

The accepted quantities, measured as provided above, will be paid for at the contract unit price as follows:

TACK COAT..... GALLON (LITER)

Such payment shall be full compensation for furnishing all materials, equipment, labor, and incidentals to complete the work as specified.

SECTION 408 PRIME COAT

408.01. DESCRIPTION.

This work shall consist of preparing and treating an existing surface with bituminous material, and blotter material if required, in accordance with these Specifications and in reasonably close conformity with the lines shown on the Plans or established by the Engineer.

408.02. MATERIALS.

Materials shall meet the requirements specified in the following Subsections of Section 700-Materials:

Prime Material MC-30 or MC-70	708.03
Blotter material, (if required)	402.04(j)

408.03. EQUIPMENT.

Distributors, heating equipment, and supply tanks shall meet the requirements of Subsection 401.03.

408.04. CONSTRUCTION METHODS.

- (a) **Weather Limitations.** Do not apply bituminous material when the ambient temperature is below 50°F (10° C) or when weather conditions would otherwise prevent the proper construction of the prime coat. Ambient temperatures shall be measured in the shade, 4 feet (1.2m) above the ground, and away from artificial heat source.
- (b) **Preparation of Surface.** Before priming, clean the subgrade, subbase, or base of loose material, making certain that it is in satisfactory condition to obtain maximum penetration of the prime.
- (c) **Priming Subgrades, Subbases, or Bases That Are Non-Cohesive.** Subject to the acceptance by the Engineer, when friable or non-cohesive materials are encountered in the surface to be primed, the bituminous material shown on the Plans may be changed to an asphalt emulsion. The bituminous materials shown on the Plans may also be changed to an asphalt emulsion in those areas of the State in which the use of cutback asphalt is prohibited. Sprinkling water with asphalt emulsion added may be used in the final operations of sprinkling, manipulation, shaping, and rolling of the subgrade, subbase, or base. Additional applications may be made if necessary to form a firm, bonded working table.
- (d) **Application of Bituminous Material.** Apply bituminous material to the width of the section to be primed by means of a pressure distributor and in a uniform, continuous spread at the approximate rate of 0.1 to 0.4 gallons per square yard (0.45 to 1.8 L/m²) as directed by the Engineer. When traffic is maintained, do not treat more than 1/2 of the width of the sections in one application. Take care that the application of bituminous material at the junctions of spreads is not in excess of the specified amount. Remove any excess bituminous material from the surface.

NOTE: Skipped areas or deficiencies shall be corrected at the Contractor's expense.

When traffic is to be maintained, permit one-way traffic on the untreated portion of the roadbed. As soon as the bituminous material has been absorbed by the surface and will not pick up, transfer traffic to the treated portion, and prime the remaining width of the section.

Do not apply succeeding applications of bituminous materials or other courses until after sufficient time has elapsed to allow both proper penetration and hardening of the prime coat.

- (e) **Application of Blotter Material.** If, after the application of the prime coat, the bituminous material fails to penetrate within the time specified and the roadway must be used by traffic, blotter material shall be spread in the amounts required to absorb any excess bituminous material.

408.05. METHOD OF MEASUREMENT.

Prime coat will be measured by the gallon (liter) of residual asphalt. Blotter material will not be measured for payment.

408.06. BASIS OF PAYMENT.

The accepted quantities, measured as provided above, will be paid for at the contract unit price as follows:

PRIME COAT GALLON (LITER)

Such payment shall be full compensation for furnishing all materials, equipment, labor, and incidentals to complete the work as specified.

**SECTION 410
MICRO SURFACING**

410.01. DESCRIPTION.

This work shall consist of the application of micro surfacing material to an existing pavement surface in lifts 1 inch (25 mm) thick or less. The micro surfacing shall be a mixture of polymer-modified emulsified asphalt, mineral aggregate, mineral filler, water, and other additives—all properly proportioned, mixed, and spread on the surface in accordance with the plans and specifications.

410.02. MATERIALS.

Materials shall meet the requirements of Section 707.

410.03. EQUIPMENT.

The material shall be mixed by a self-propelled Micro Surfacing machine which shall be a continuous-flow mixing unit; this unit shall accurately deliver and proportion the aggregate, emulsified asphalt, mineral filler, and water to a revolving multi-blade mixer, and then discharge the thoroughly-mixed product on a continuous-flow basis. The machine shall have sufficient storage capacity for aggregate, emulsified asphalt, mineral filler, and water to maintain an adequate supply to the proportioning devices. The machine shall also be equipped with self-loading devices which provide for the loading of all materials while continuing to lay Micro Surfacing, thereby eliminating unnecessary construction joints. The machine shall be equipped with opposite side driving stations to optimize longitudinal alignment. The machine shall be equipped to allow the mix operator to have full hydrostatic control of the forward

and reverse speed during application of the micro surfacing material. The self-loading devices, opposite side driving stations, and forward and reverse speed controls shall be the original, manufacturer-designed equipment.

Provide individual volume or weight controls for proportioning each material to be added to the mix. Calibrate and properly mark each material control device.

The aggregate feed to the mixer shall be equipped with a revolution counter or similar device so the amount of aggregate used may be determined at any time.

The emulsion pump shall be the positive displacement type and shall be equipped with a revolution counter or similar device so that the amount of emulsion used may be determined at any time.

The mixing machine shall be equipped with a water pressure system and nozzle type spray bar to provide a water spray immediately ahead of and outside the spreader box. It shall also be equipped with an approved feeder that will provide a uniform, positive, accurately metered, predetermined amount of the specified mineral filler at the same time and location that the aggregate is fed.

When construction is being performed under traffic, all equipment, including loading vehicles and supply trucks, will be required to operate in a single lane on which micro surfacing is being applied. The Contractor's equipment for Micro Surfacing shall be operated in such a manner which will permit traffic to move safely and expeditiously through and around the work area.

If the mineral aggregates are stored or stockpiled, handle them in such a manner as to prevent segregation, mixing of the various materials or sizes, and contamination with foreign materials. The grading of aggregates proposed for use and as supplied to the mixing plant shall be uniform. Furnish suitable equipment of acceptable size to work the stockpiles and prevent segregation of the aggregates. Screen and weigh the mineral aggregate at the stockpile prior to jobsite delivery. Screens and scales shall be approved by the Engineer.

Keep all equipment used in the storage and handling of asphaltic material in a clean condition at all times, and operate it in such a manner that there will be no contamination with foreign matter.

410.04. CONSTRUCTION METHODS.

- (a) **Weather Limitations.** Spread the material only when the atmospheric temperature is at least 50°F (10°C) or above in the shade and 4 feet (1.2 m) above the ground away from any artificial heat source, and the weather is not foggy or rainy.
- (b) **Surface Preparation.** Thoroughly clean area to be Micro Surfaced of all vegetation, loose aggregate, and soil. Apply water used in pre-wetting the surface at a rate to dampen the entire surface without any free-flowing water ahead of the spreader box.
- (c) **Test Panel.** Prior to the application of the micro surfacing mixture, place a test panel, at a location established by the Engineer, to demonstrate the compatibility of the modified emulsion and the mineral aggregate under field conditions. This test panel shall also be used to demonstrate the following:

Mix uniformity; compliance of the mix to the requirements for proportioning the asphalt, mineral filler, and mineral aggregate; and adequate compliance with performance requirements for set, cure, stability, and conformance to the typical section. From this test panel, it will be determined by the Engineer whether or not the mix is acceptable.

- (d) **Leveling Course.** When designated on the Plans or in the Contract or deemed necessary by the Engineer, apply a leveling course. Adequately cure the leveling course as approved by the Engineer before the final surface course is placed.

At the direction of the Engineer, before the final surface course is placed, preliminary micro surfacing material may be required to fill ruts, utility cuts, depressions in the existing surface, etc. Ruts may be filled independently with a rut filling spreader box either 5 or 6 feet (1.5 or 1.8 m) in width to fill the rut or with a full-width scratch coat pass as directed by the Engineer.

- (e) **Spreading.** Spread the Micro Surfacing mixture uniformly by means of a mechanical-type squeegee box, equipped with augers to spread the materials uniformly throughout the box. Flexible seals shall be in contact with the road to prevent loss of mixture from the box. The rear flexible seal shall act as a strike-off and shall be adjustable. The spreader shall be maintained to prevent the loss of the Micro Surfacing product in surfacing super-elevated curves. The mixture shall be spread to fill all cracks and minor surface irregularities and leave a uniform application of fine aggregate and asphalt on the surface.

The seam, where two spreads join, shall be neat appearing and uniform.

NOTE: If, in the opinion of the Engineer, the seam is rough enough to cause a noticeable effect on the steering of an automobile, the seam shall be removed and a new Micro Surfacing patch applied. Patching shall be machine-applied patches with a full-width spreader box.

Operate the self-loading devices in such a manner as to eliminate unnecessary construction joints, and avoid overruns into the gutter. Remove all excess material from ends of each job site immediately.

- (f) **Curing and Maintaining Traffic.** Provide adequate means to protect the Micro Surfacing from damage by traffic until the mixture has cured sufficiently so that it will not adhere to or be picked up by the tires of vehicles.

NOTE: Any damage done by traffic to the Micro Surfacing shall be repaired by the Contractor and not measured for payment.

Suspend application of the surfacing materials early enough each day to permit traffic to safely travel over the completed work before dark. Work required or materials used in maintaining of traffic will not be paid for directly but shall be considered subsidiary to other items of work and shall be the responsibility of the Contractor.

410.05. METHOD OF MEASUREMENT.

Mineral aggregate will be measured by the dry weight ton (metric ton) including mineral filler.

Polymer-Modified Emulsified asphalt will be measured by the gallon (liter) or ton (metric ton) of residual asphalt cement.

410.06. BASIS OF PAYMENT.

The accepted quantities, measured as provided above, shall be paid for at the contract unit price as follows:

- (A) EMULSIFIED ASPHALT GALLON OR TON (LITER OR METRIC TON)
- (B) TYPE I AGGREGATE TON (METRIC TON)
- (C) TYPE II AGGREGATE TON (METRIC TON)
- (D) TYPE III AGGREGATE TON (METRIC TON)

Such payment shall be full compensation for furnishing all materials, equipment, labor and incidentals to complete the work as specified.

**SECTION 411
PLANT MIX ASPHALT CONCRETE PAVEMENT**

411.01. DESCRIPTION.

This work shall consist of the construction of one or more courses of bituminous mixture on the prepared foundation in accordance with these Specifications and the specific requirements of the type under contract, and in reasonably close conformity with the lines, grades, thicknesses, and typical cross sections shown on the Plans or established by the Engineer.

411.02. MATERIALS.

Materials shall meet the requirements of Section 708. Have ample material in the stockpiles at the plant site at the beginning of each day's operation to supply and be used for that day's operation as well as provide to the Department's representative results of quality control tests on a daily basis.

411.03. EQUIPMENT.

- (a) **Mixing Plants.** At all times, have available at the plant site 1) a legible copy of the manufacturer's specifications for the mixing plant and 2) any modifications made to the plant including the manufacturer's tolerances for points of wear affecting the production of bituminous mixtures. Mixing plants shall be inspected and shall be within the manufacturer's tolerances and in good working order; in addition, they shall be so coordinated and of sufficient capacity to adequately produce the required bituminous mixture. All plants used for preparation of bituminous concrete mixtures shall conform to the requirements of AASHTO M 156 for plants and meet the Department's certification requirements. Batch plants shall be equipped with a mechanical batch counter.

Develop and maintain calibration charts for each cold feed for the job aggregates or maintain other suitable evidence of compliance with the paving mixture Specifications.

Mixing plants used for the production of asphaltic concrete composed of reclaimed asphalt paving materials shall operate in a manner that the reclaimed asphalt material is not directly exposed to the burner flame and the very high temperature combustion gases. Plants that have been modified for production of asphalt concrete containing reclaimed asphalt materials shall meet the requirements of the plant manufacturer for the specific modifications.

- (b) **Scales.** The bituminous mixture shall be weighed on approved scales furnished by the Contractor or on public scales at the Contractor's expense. When an approved automatic printer system is used in conjunction with an automatic batching and mixing control system, the printed batch weights may be used in lieu of truck scales. Such weights shall be evidenced by a weigh ticket for each load. Scales shall be inspected and certified as often as the Engineer deems necessary to assure their accuracy but not less than once every six months.
- (c) **Bituminous Pavers.** Bituminous pavers shall be self-contained, power-propelled units, in good working order and provided with an activated heated screed; they shall also be equipped with an approved automatic control device for laying the mixture to the specified slope and grade, and be capable of spreading and finishing courses of bituminous plant mix material in lane widths applicable to the specified typical section and thicknesses shown on the Plans. Pavers used for shoulders and similar construction shall be capable of spreading and finishing courses of bituminous plant mix material in widths shown on the Plans.

The paver shall be equipped with a receiving hopper having sufficient capacity for a uniform spreading operation and also with a distribution system to place the mixture uniformly in front of the screed.

The screed shall effectively produce a finished surface of the required evenness and texture without tearing, shoving, or gouging the mixture.

When laying mixtures, the paver shall be capable of being operated at forward speeds consistent with satisfactory laying of the mixture.

The Contractor may use an approved strike-off assembly, heated if necessary, provided the finished surface produces the required evenness and uniform texture without tearing, shoving, or gouging the mixture.

The paver shall be equipped with hoppers and distributing screws of the reversing type adequate to place the mixture evenly ahead of the screed for the full width being laid.

- (d) **Trucks and Transports** Trucks used for hauling bituminous mixtures shall comply with legal load limits and have tight, clean, smooth metal beds which have been thinly coated with a minimum amount of soap solution, lime solution, or other approved material to prevent the mixture from adhering to the beds. Antiadhesive solutions shall not be allowed to pond in the truck beds.

NOTE: The use of solutions which contain diesel fuel or other contaminating solvents will not be allowed between daily truck deliveries.

Each truck shall have a cover of canvas or other suitable material of such size as to protect the mixture from the weather. When necessary, so that the mixture will be delivered on the road at the specified temperature, truck beds shall be insulated and covers shall be securely fastened.

Transports used for hauling liquid asphalt materials shall comply with Subsection 708.03(b). Keep a log or diary containing the delivery date, asphalt grade, source, quantity, invoice number, and the material hauled in the previous load. This information shall be furnished to the Engineer upon request.

- (e) **Sampling Device.** Provide an aggregate sampling device that can be safely operated by the Inspector and is capable of obtaining a representative sample of the combined aggregate from a flowing aggregate stream (belt or bin discharge)—in accordance with the requirements of AASHTO T-2—prior to entering the dryer drum or drum mixer and without stopping plant production. The sampling device shall be approved by the Engineer.
- (f) **Material Transfer Equipment.** Equipment to transfer mixture from the hauling units or the roadbed to the spreading and finishing machine will be allowed unless otherwise shown on the plans. A specific type of material transfer equipment shall be required when shown on the plans.

411.04. CONSTRUCTION METHODS.

- (a) **Stockpiling Materials.** Deliver and stockpile aggregates in accordance with Subsection 106.09.
- (b) **Preparation of Materials**
 - (1) **Bituminous material and aggregate.** Heat bituminous material and aggregate to the temperature specified in Subsection 708.03 and in a manner that will avoid local overheating and provide a continuous supply of the bituminous material to the mixer at a uniform temperature at all times.
 - (2) **Dried and heated aggregate.** Properly adjust flames used for drying and heating the aggregate to avoid damage to the aggregate and avoid soot on the aggregate.
 - (3) **Hot dry aggregates.** For plants controlling gradation of hot dry aggregates, screen the aggregate and store it in separate bins as follows: Mineral aggregate for use in Type C, D, or E mixtures shall be stored in not less than two bins and all other mixtures shall be stored in not fewer than three bins.
 - Bin No. 1 shall contain approved aggregate, 85 to 100 percent of which will pass a No. 10 (2.0 mm) sieve.
 - Bin No. 2 shall contain approved aggregate, 80 to 100 percent of which will be retained on a No. 10 (2.0 mm) sieve.
 - Other bins shall contain approved aggregate, 90 percent of which will be retained on the No. 4 (4.75 mm) sieve.

Correct continued variations in excess of these limitations by increasing the amount of screening area or reducing the rate of plant production.

- (c) **Plant Startup Requirements for New Construction and All Overlays.** Prior to placing any asphalt concrete, produce a sufficient amount of asphalt mix to properly calibrate the plant and procedures using the mix design approved for mainline construction. The asphalt concrete thus produced will be sampled and tested by the Engineer for the following:

VMA; asphalt cement content; gradation; air voids (Lab Molded); and Hveem stability.

No asphalt concrete from the startup operation that fails to meet specification requirements shall be placed on the mainline or the compaction test strips. Instead, continue to make adjustments until all of the requirements are met. Asphalt concrete not meeting the requirements may be used in the construction of temporary facilities, or if no temporary facilities are available, it shall become the property of the Contractor.

Costs of plant startup operations, including both labor and materials, will be included in the price bid for the mixture in place.

- (d) **Mixing.** Combine aggregates in the mixer in the amount of each fraction of aggregates required to meet the approved job-mix formula. Measure or gauge the bituminous material and introduce it into the mixer in the amount specified by the job-mix formula. The moisture content of the bituminous mixture at the point of discharge shall not exceed 0.75 percent. Uncoated or nonuniform mixtures will not be accepted.

During daily start-up or shutdown of plant operations, waste sufficient material to assure that all deliveries to the storage silo or roadway are in compliance with the Specification requirements for the type mixture specified. Do not change from one type of mixture to another until the plant has been emptied and the cold feed bins charged with the proper aggregates.

- (e) **Mat Irregularities.** The mat shall be free from segregation, nonuniform texture, bleeding or fat spots, and cracking.
- (f) **Tack Coat.** Tack coat, if required, shall be in accordance with Section 407.
- (g) **Weather Limitations.** The minimum surface temperature of the foundation course on which asphalt concrete may be laid shall be as shown in the following table:

COMPACTED LIFT THICKNESS	SURFACE TEMPERATURE (Minimum)
More than 3 inches (80mm)	40°F(4°C)
1 1/2 inches (40mm) to 3 inches (80mm)	45°F (7°C)
Less than 1 1/2 inches (40mm)	50°F (10°C)

Do not lay asphalt concrete when there is frost in the foundation course; and when conditions are such that the material becomes so chilled that it can't be properly leveled and thoroughly consolidated, stop operations. When rain begins, cease plant production; any material already in transit may be placed at the Contractor's risk, subject to all density and other requirements.

- (h) **Spreading and Finishing.** Lay the asphalt mixture with a paver that meets the requirements of Subsection 411.03(c) and upon an approved surface which is dry. Deliver the mixture on the job at an optimum workable temperature which will produce the density herein specified after final compaction. After the optimum workable temperature is determined, it shall not vary more than 25°F (14°C) above or below this temperature.

Establish the alignment of one edge of the asphalt mixture with a string or wire line in advance of the placing of the asphalt mixture.

On areas where irregularities or unavoidable obstacles make the use of mechanical spreading and finishing equipment impracticable, use hand tools to dump, spread, rake, and lute the mixture to the required compacted thickness.

Operate the spreading and finishing machine at a uniform forward speed consistent with the plant production rate, hauling capability, and roller train capacity to result in a continuous operation. The speed shall be slow enough that stopping between trucks is not ordinarily required. If, in the opinion of the Engineer, sporadic delivery of material is adversely affecting the mat, the Engineer may require paving operations to cease until acceptable methods are provided to minimize starting and stopping of the paver.

Spread the wearing course mixture uniformly high immediately adjacent to curbs, gutters, manholes, and other structures so that after compaction it will be approximately 1/4 inch (6 mm) above the edges of such structures. Before placing the mixture against contact surfaces of curbs, gutters, headers, manholes, etc., clean and paint them with a thin, uniform tack coat of a type specified herein.

When an unsatisfactory asphalt course is being produced, immediately make the necessary corrections to obtain a satisfactory surface. If deemed necessary, the Engineer may terminate the laydown operation until such time as satisfactory performance can be obtained and require that the unsatisfactory material be removed as unacceptable work.

- (i) **Joints.** Stagger longitudinal and transverse joints on succeeding lifts approximately 6 inches (150 mm), and make them carefully.

Construct all longitudinal joints within 1 foot (300 mm) of the lane lines. The longitudinal joints in the top layer or in the layer upon which an open-graded friction course is to be placed shall be at lane lines.

Well bonded and sealed joints are required. When making joints between old and new pavements or between successive days' work, take care to make them in such a manner as to insure a thorough and continuous bond between the old and new surfaces. Cut back the transverse edge of the previously laid course to its full depth so as to expose a fresh surface; then paint the edge with a tack coat, and place the hot mixture in contact with it, raking it to a proper depth and grade.

- (j) **Compaction.**

(1) **General.** To compact and smooth, use self-propelled steel wheel and pneumatic tired compactors. Steel wheeled compactors shall weigh at least 10 tons (nine metric tons). Pneumatic tired compactors shall have at least seven pneumatic tires of equal size and diameter. They shall be constructed so that their total weights shall be varied to produce an operating weight of at least 3500 pounds (1588 kg) per tire. The tires shall be capable of being inflated to at least 110 psi (758 kPa) and be spaced so that the gaps between adjacent tires shall be covered by the following tires. Operating tire pressure (after one hour of operation) shall be maintained at 90 to 110 psi (620 to 758 kPa) with the range in pressure between tires not to exceed 10 psi (68 kPa).

Compactors shall be of adequate number, size, and weight and designed and properly maintained so that they are capable of accomplishing the required compaction. Operate them in accordance with the manufacturer's recommendations.

Use self-propelled pneumatic tired rollers on all lifts following the initial rolling with a steel wheel roller and before finishing with a steel wheel roller. A minimum of two coverages with the pneumatic tired roller is required on each lift.

During compaction, if there is any displacement as a result of the reversing of direction of compactor, or other causes, correct the surface at once by the use of rakes and addition of fresh mixture when required. Be careful in compacting not to displace the line and grade of the edges of the bituminous mixture. Take care that there is no damage caused by adhesion of the mixture to the compactors.

Use hot hand tampers, smoothing irons, or mechanical tampers to thoroughly compact the mixture along forms, curbs, headers, walls, and other places not accessible to the compaction equipment. To transmit compression to a depressed area, a trench compactor may be used when approved by the Engineer.

Remove any mixture that becomes loose and broken, mixed with dirt, or is in any way defective, and replace it with fresh, hot mixture, compacting it to conform with the surrounding area.

NOTE: Any area showing segregation or an excess or deficiency of bituminous material shall be removed and replaced at the expense of the Contractor as unacceptable work.

Asphaltic concrete immediately behind the laydown machine shall be a minimum of 250°F (121°C). The target density of thicker lifts and optimum densities of thinner lifts shall be obtained before the mat temperature of the lifts under compaction drops below 180°F (82°C).

- (2) **Acceptance.** All lifts 1 1/2 inch (40 mm) or greater in nominal (Plan) thickness including both new construction and overlays will be accepted on the basis of density as specified in Subsection 2.1.

All lifts less than 1 1/2 inch (40 mm) in nominal thickness will be accepted on the basis of compactive effort as specified in Subsection 2.2.

Both new construction and overlays (all thicknesses) will be accepted on a lot-by-lot basis. Normally, a lot shall be considered to be 1000 tons (1000 metric tons); however, the Engineer may terminate a lot at any point and designate a new one when a materials or workmanship adjustment has been made which results in the desired correction.

- 2.1 *All lifts 1 1/2 inch (40 mm) or greater in nominal (Plan) thickness.* The target density of each lot shall be 94 percent of the Maximum Theoretical Specific Gravity at the Job Mix Formula (JMF) asphalt content determined by the most recent specific gravity of the bituminous paving mixture in accordance with AASHTO T 209.

The roadway density for each lot will be the average of tests of three separate specimens taken randomly within the limits of the area represented by the lot. Cut test specimens for each lot from the pavement by sawing or coring a specimen a minimum size of 6 inches (150 mm) on the cut side or diameter, at locations and times established by the Engineer. The cost of cutting specimens and satisfactorily placing and finishing new materials in areas where specimens have been taken will be included in the price bid for mixture in place. The tests may be on the specimens or through use of nuclear density gauges.

Acceptance and pay adjustments will be based on tests by the Department and in accordance with the following schedule:

AVERAGE LOT DENSITY % OF MAXIMUM THEORETICAL DENSITY (ALD)	PAY ADJUSTMENT FACTOR (PAF)
Above 97	Unacceptable *
92 - 97	1.00
91 - 92	1.00-(0.07) (92-ALD)
88.1-91	0.93-(0.15) (91-ALD)
Below 88.1	Unacceptable *
Adjustment Payment = PAF x Contract Unit Price	

* Unless otherwise directed by the Engineer, products testing in this range are unacceptable and shall be removed and replaced at no additional cost to the Department.

2.2 *All lifts less than 1 1/2 inch (40 mm) in Nominal (Plan) Thickness.* Through the use of test strips and daily monitoring of asphalt placement, the Engineer will approve the rolling patterns necessary to obtain optimum compaction. While 94 percent of Maximum Theoretical Density shall be considered the target, acceptance will be based on the Contractor performing as approved by the Engineer to obtain optimum compaction.

Compaction test strips shall consist of approximately 500 square yards (500 m²) of pavement area and shall reasonably conform to the production that they are intended to represent as regards to asphaltic concrete characteristic, rate of production, temperatures, mat width, and thickness.

Construct a sufficient number of strips to determine the number, sizes, and weights of compactors to be used and the number of coverages in which the compactors shall be operated in order to obtain the acceptable density. The density of the test strip will be determined using nuclear density measurements.

A new compaction test strip shall be constructed either when ordered by the Engineer or requested by the Contractor under one or more of the following conditions:

- (a) There is a change in the material or mix design.
- (b) There is reason to believe that a compaction test strip density is not representative of the material being placed or that the underlying material has changed significantly.

Compaction shall be in accordance with the rolling pattern approved by the Engineer. The rolling sequence, the type of compactor to be used, and the maximum roller speed shall be as follows:

ROLLING SEQUENCE	TYPE OF COMPACTOR	MAX. ROLLER SPEED (MPH)
Initial or Pneumatic Tired	Steel Wheel	2 1/2 (4 km/h)
Intermediate	Pneumatic Tired	3 (5km/h)
Finish	Static Steel	3 (5km/h)

- (3) **Documentation.** Fully document all work performed under Subsection 2.2. Documentation shall include, but not be limited to, records of all directions given by the Engineer and the resulting actions by the Contractor. The records of the Contractor's actions shall, as a minimum, include detailed descriptions of the equipment used (including weight and tire pressure), the speed, and the number of coverages. Such records shall be signed daily by the roller operators and the Contractor's superintendent, or other responsible official, and shall be instantly available for inspection by the Engineer. They shall be furnished in total to the Engineer at the conclusion of work under Subsection 2.2.
- (k) **Tolerances.**
- (1) **Surface.** The surface tolerance shall be in conformity with Section 401.
- (2) **Width and Thickness.** The width shall be in reasonably close conformity with the dimensions shown on the Plans or established by the Engineer. The thickness of individual courses and the total thickness of the asphalt concrete pavement shall be in reasonably close conformity with the thicknesses shown on the Plans or established by the Engineer.
- (l) **Opening to Traffic.** Do not permit traffic on the asphalt concrete pavement until it has received its final rolling and has cooled to a temperature such that traffic will not mar the surface or alter the surface texture. Water or other artificial means may be used to assist in cooling.

411.05. METHOD OF MEASUREMENT.

Plant mix asphalt concrete pavement including the aggregate, liquid asphalt and other ingredients as specified in the job-mix formula—shall be measured by the ton (metric ton) of combined mixture.

Tack coat will be measured and paid for in accordance with Section 407.

411.06. BASIS OF PAYMENT.

Accepted quantities for plant mix asphalt concrete pavement, measured as provided above, shall be paid for at the contract unit price as follows:

(A)	ASPHALT CONCRETE, TYPE A	TON (METRIC TON)
(B)	ASPHALT CONCRETE, TYPE B	TON (METRIC TON)
(C)	ASPHALT CONCRETE, TYPE C	TON (METRIC TON)
(D)	ASPHALT CONCRETE, TYPE D	TON (METRIC TON)
(E)	ASPHALT CONCRETE, TYPE E	TON (METRIC TON)
(A1)	ASPHALT CONCRETE, TYPE A (POL. MOD.)	TON (METRIC TON)
(B1)	ASPHALT CONCRETE, TYPE B (POL. MOD.)	TON (METRIC TON)
(C1)	ASPHALT CONCRETE, TYPE C (POL. MOD.)	TON (METRIC TON)
(D1)	ASPHALT CONCRETE, TYPE D (POL. MOD.)	TON (METRIC TON)
(E1)	ASPHALT CONCRETE, TYPE E (POL. MOD.)	TON (METRIC TON)

Such payment shall be full compensation for furnishing all materials, equipment, labor and incidentals to complete the work as specified.

SECTION 413 RUMBLE STRIP

413.01. DESCRIPTION.

The work under this item shall consist of the production of noise generating (rumble) strips in the asphalt concrete or portland cement concrete pavement on driving lanes or the roadway shoulders. These shall be at the locations specified on the project Plans, in accordance with the details shown in the Plans or on Standard Drawings and the requirements of these Specifications.

The rumble strips shall fall into the following categories:

- **Method AC-CON** designates rumble strips formed or cut in asphalt concrete shoulders continuously as shown in the Plans.
- **Method AC-CYC** designates rumble strips formed or cut in asphalt concrete shoulders in a cyclic pattern as shown in the Plans.
- **Method PCC-CYC** designates rumble strips formed or cut in portland cement concrete shoulders in a cyclic pattern and section as shown in the Plans.

413.03. EQUIPMENT.

- (a) **Method AC-CON or Method AC-CYC.** A roller may be modified to produce the desired rumble strip and pattern acceptable to the Engineer. With the Engineer's approval, the strips may also be machine cut or routed after final finishing is complete.

- (1) **Roller formed.** The roller to be used shall be of the self-propelled vibratory type and shall weigh at least 6 tons (5.4 metric tons). If the rear tires are pneumatic, they shall have a smooth or slick-head design. The roller shall be equipped with an approved water system which will moisten the drums and tires so that the bituminous material will not be picked up. The roller shall also be equipped with an approved guide that extends in front of the roller and is clearly visible to the operator so that proper alignment of the strips will be obtained.
- (2) **Machine cut or routed.** The machine approved by the Engineer will produce clearly incised grooves within the pattern and dimensional tolerances as shown on the details or Standard Drawing. Grooving may be accomplished with a single pass multi-cutter machine or multiple passes of a single cutter machine as long as the intended grooving is produced.

- (b) **Method PCC-CYC**

The plastic portland cement concrete may be formed to produce the desired rumble strip and pattern acceptable to the Engineer. With the Engineer's approval, the strips may also be machine cut or routed after final finishing is complete.

- (1) **Formed.** Form the rumble strips in the plastic portland cement concrete by hand floating or by blocking out the area and grouting a precast patterned block in place.
- (2) **Machine cut or routed.** Form strips as specified in Subsection 413.03(a)(2).

413.04. CONSTRUCTION METHODS.

- (a) **Asphalt Concrete Shoulders Or Mainline Pavement.** When forming or machine cutting (routing) in asphalt, produce indentations in accordance with the details shown in the Plans or the Standard Drawing(s). Position the roller by using planking or by other approved means so that the asphalt concrete is indented only at those locations specified on the project plans. Form the rumble strips in one or more repeating passes of the roller while it is in the vibratory mode and the asphalt concrete is hot.
- (b) **Portland Cement Concrete Shoulders Or Mainline Pavement.** When forming rumble strips by any method—hand forming, blockouts for precast blocks, or machine cutting (routing)—produce strips meeting all detail requirements for spacing, length, depth, and rumble section as shown in the Plans or on the Standard Drawing(s).

413.05. METHOD OF MEASUREMENT.

Rumble strips of the various classifications shall be measured as follows:

- **Method AC-CON:** *Asphalt concrete continuous* will be measured by the linear foot (meter) along the longitudinal centerline or lane baseline rounded to the nearest foot (meter).
- **Method AC-CYC:** *Asphalt concrete cyclical* will be measured by each group of recurring grooves, as shown on the plans. Only those groups meeting dimensional tolerances as shown on the plans will be measured for payment.
- **Method PCC-CYC:** *Portland cement concrete cyclical* will be measured by each group of recurring grooves, as shown on the plans. Only those groups meeting dimensional tolerances as shown on the plans will be measured for payment.

413.06. BASIS OF PAYMENT.

Accepted quantities of shoulder or mainline pavement rumble strips shall be paid for at the contract unit price as follows:

(A) RUMBLE STRIP-METHOD AC-CON.....	LINEAR FOOT (METER)
(B) RUMBLE STRIP-METHOD AC-CYC(GROUP).....	EACH
(C) RUMBLE STRIP-METHOD PCC-CYC(GROUP).....	EACH

Such payment amount shall be full compensation for furnishing all equipment, labor, and incidentals necessary to complete the production of mainline pavement or shoulder rumble strips (grooves) as shown in the plans or on the Standard Drawing(s).

SECTION 414 PORTLAND CEMENT CONCRETE PAVEMENT

414.01. DESCRIPTION.

This work shall consist of constructing a jointed pavement composed of portland cement concrete (P.C.C.), with or without reinforcement or continuously reinforced pavement, as specified, on a prepared base course in accordance with these Specifications and in reasonably close conformity with the lines, grades, thicknesses, and typical cross sections shown on the Plans or established by the Engineer.

414.02. MATERIALS.

Materials shall meet the requirements specified in the following Subsections of Section 700 - Materials:

Portland Cement Concrete	701
Fly Ash	702
Steel Reinforcement, Dowel Bars & Tie Bars	723

Tie bars which are bent and later straightened to facilitate construction shall conform to the following:

Deformed Billet-Steel Bars for Concrete Reinforcement	AASHTO M 31 Grade 300
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Approved reclaimed portland cement concrete materials may be used provided that the Department is notified in writing of the intention to use reclaimed materials, and provided that the requirements of Section 701 for portland cement concrete are met.

Furnish the Department with copies of the daily quality control tests.

414.03. EQUIPMENT.

Equipment and tools necessary for handling materials and performing all parts of the work shall be the responsibility of the Contractor as to design, capacity, and mechanical condition. The equipment shall be at the job site sufficiently ahead of the start of construction operations.

(a) **Plants and Equipment.**

- (1) **General.** The batching plant shall include bins, weighing hoppers, and scales for the fine aggregate and for each size of coarse aggregate. If cement is used in bulk, a bin, hopper, and separate scale for cement shall be included. The weighing hoppers shall be properly sealed and vented to preclude dusting during operation. All controls, gauges, revolution counters, etc. shall be properly functioning.

Provide documented evidence to the Department that the batching plant is producing quality concrete, and that the plant is functioning in proper working order at all times. See AASHTO M 157 Annex "Concrete Uniformity Requirements." The mixing plant shall conform to requirements of AASHTO M 157 as appropriate.

Clean the mixers at suitable intervals. Repair or replace the pickup and throw-over blades in the drum or drums when they are worn down 1/6 or more of the original width of blade. Either have available at the job site a copy of the manufacturer's design, showing dimensions and arrangements of blades in reference to original height and depth, or provide permanent marks on blades to show points of wear 1/6 of the width from new conditions. The Department recommends drilled holes of 1/4 inch (6 mm) diameter near each end and at the midpoint of each blade.

Storage silos for cement and fly ash shall be properly vented during filling or use. If a pressurized air system is used for discharge of cement or fly ash, this system shall provide for moisture traps so as to reduce caking of materials during storage.

Plants and scales shall be inspected and certified as often as the Engineer may deem necessary to assure their accuracy, but not less than every six months.

(b) **Placing And Finishing Equipment.**

(1) **Slip Form Paver.** The concrete shall be placed with an approved slipform paver designed to spread, consolidate, screed, and float-finish the freshly placed concrete in one complete pass of the machine in such manner that a minimum of hand finish will be necessary to provide a dense and homogeneous pavement in conformance with the Plans and Specifications. The machine shall vibrate the concrete for the full width and depth of the strip of pavement being placed. Such vibrations shall be accomplished with vibrating tubes or arms working in the concrete or with a vibrating screed or pan operating on the surface of the concrete.

The rated frequency of the surface vibrators shall not be less than 3,500 impulses per minute and the frequency of the internal type shall not be less than 5,000 impulses per minute for tube vibrators and not less than 7,000 impulses per minute for spud vibrators. When spud-type internal vibrators, either hand operated or attached to spreaders or finishing machines, are used adjacent to forms, they shall have a frequency of not less than 3,500 impulses per minute. They shall not come into contact with the joint, load transfer devices, subgrade, or side forms.

The sliding forms shall be rigidly held together laterally to prevent spreading of the forms.

(2) **Stationary Side-Form Method.**

2.1 *The finishing machine* shall be equipped with at least two oscillating-type transverse screeds capable of finishing the surface to the tolerance specified.

Vibrators for full width consolidation of the concrete may be the surface pan type (limited to pavements no thicker than 8 inches (203 mm)) or the internal type with either immersed tube or multiple spuds. Vibrators may be attached to the spreader or the finishing machine, or mounted on a separate carriage, and shall not contact the joint, load transfer device, subgrade, or side forms. The rated frequencies shall be not less than 3,500 impulses per minute for surface vibrators, 5000 impulses per minute for tube vibrators, and 7000 impulses per minute for spud vibrators.

When spud-type internal vibrators are used next to the forms, the frequency shall not be less than 3,500 impulses per minute.

2.2 *Use forms and vibrating or rotary strike off screeds* to construct radii, inlet basins, gore areas, lane tapers, intersection quadrants, and other areas inaccessible to mainline paving machinery. Be careful to achieve thorough consolidation and uniformity of the product. Segregation and excessive grout buildup will not be accepted. The tolerances specified shall be met.

(3) **Transverse Texturing Machine.** The transverse texturing machine shall be either a vibrating roller or a comb equipped with steel tines. The machine shall be self-propelled and shall automatically lift the roller or tine comb bar near the edge of the pavement to minimize edge damage. Hand texturing methods will be permitted in a manner accepted by the Engineer in those areas where the mechanical equipment cannot be used.

(c) **Concrete Saw.** Provide sawing equipment in good working condition, adequate in number of units and power, to complete the sawing to the required dimensions and at the required rate. As back up, also provide at least one standby saw in good working order. In addition, maintain an

ample supply of saw blades at the site of the work at all times during sawing operations. Also provide adequate artificial lighting facilities for night sawing. All of this equipment shall be on the job both before and continuously during concrete placement.

- (d) **Forms.** Make straight side forms of a metal having a thickness of not less than 7/32 inch (5 mm), and furnish them in sections not less than 10 feet (3 m) in length. Forms shall have a depth at least equal to the prescribed thickness of the concrete and a base width that will provide adequate support for all equipment operating on the forms.

Use flexible or curved forms of proper radius for curves of 100 feet (30 m) radius or less. Provide flexible or curved forms with adequate devices for secure setting so that when in place they will withstand, without visible spring or settlement, the impact and vibration of the consolidating and finishing equipment.

Flange braces shall extend outward on the base not less than 2/3 height of the form. Remove forms with battered top surfaces and bent, twisted, or broken forms from the work, and do not use repaired forms until they have been inspected and approved. The top face of the form shall not vary from a true plane more than 1/8 inch (3 mm) in 10 feet (3 m), and the upstanding leg shall not vary more than 1/4 inch (6 mm). Clean the forms of old accumulated concrete, grout, or other materials. Also, spray the forms or cover them with a form-release agent prior to their use.

- (e) **Header Boards.** When paving operations are stopped, use header boards of 2 inch (50 mm) material, cut to the exact cross section of the paving slab and set to a line parallel to the transverse joint. Design the boards so as to insure accurate installation of dowels or tie boards as called for on the Plans.
- (f) **Longitudinal Float.** The longitudinal float may either be a mechanical float or screed mechanism acceptable to the Engineer or a manually-operated float. The hand-operated float shall be a rigid straightedge float not less than 12 feet (3.6 m) nor more than 18 feet (5.4 m) in length, with a troweling or smoothing surface not less than 8 inches (200 mm) nor more than 12 inches (300 mm) in width, and shall be worked from bridges spanning the pavement.

Maintain longitudinal floats in good repair and working order at all times. In the event satisfactory results are not being obtained by use of a mechanical float, have a manually operated float available on the job for immediate use.

Adjust and operate the mechanical float so that the screed will have a small quantity of concrete in front of it at all times. Do not lower or raise the screed solely for the purpose of maintaining the proper amount of concrete in front of the screed.

In lieu of the mechanical or hand-operated longitudinal float, the use of a finishing machine with the float pan type finisher will be permitted provided that satisfactory performance and specified surface smoothness and tolerances are obtained.

- (g) **Small Tools, Belt, and Burlap Drag.** Furnish a sufficient number of work bridges, hand floats, 10 feet (3 m) straightedges, and small tools to satisfactorily complete the pavement as specified herein. Any float or straightedge which becomes warped or distorted and any belts or finishing tools which are defective shall be promptly replaced with acceptable appliances.

The burlap drag shall consist of a seamless strip of burlap or cotton fabric, which shall

produce a uniform surface of gritty texture after dragging it longitudinally along the full width of pavement. The dimensions of the drag shall be such that a strip of burlap or fabric at least 3 feet (1 m) wide is in contact with the full width of the pavement surface while the drag is used. The drag shall consist of not less than 2 layers of burlap with the bottom layer approximately 6 inches (150 mm) wider than the upper layer.

- (h) **Spraying Equipment.** The equipment for applying the white pigmented curing membrane shall be the fully atomizing type equipped with a tank agitator which will keep the compound thoroughly mixed during application. Hand sprayers of the pressure tank type accepted by the Engineer may be used to apply curing membrane to vertical surfaces, irregular areas, or edges after form removal.
- (i) **Joint Sealing Equipment.** Joint Sealing Equipment shall meet the requirements of Subsection 419.03.

414.04. CONSTRUCTION METHODS.

- (a) **Preparation of Grade.** After the roadbed has been graded and compacted, trim the grade approximately to correct elevation, extending the work at least 2 feet (0.6 m) beyond each edge of the proposed concrete pavement. When the foundation is stabilized with an admixture, it shall be within the tolerances provided for the foundation type.

Check and correct the alignment and grade elevations of the forms immediately before placing the concrete. When any form has been disturbed or any grade has become unstable, reset and recheck the form.

- (b) **Conditioning of Subgrade or Base Course.** The subgrade or base course shall be brought to proper cross section.

When cementitious bases are used, remove material trimmed from high areas and low areas and fill them with concrete integral with the pavement. Maintain the finished grade in a smooth and compacted condition until the pavement is placed.

Unless waterproof subgrade or base course cover material is specified, make sure the subgrade or base course is uniformly moist when the concrete is placed.

- (c) **Handling, Measuring, and Batching Materials.** The batch plant site, layout, equipment and provisions for transporting material shall be such as to assure a continuous supply of material to the work. Deliver both fine and coarse aggregate to the plant far enough in advance to allow time for proper sampling and testing. The quantities of materials available at the concrete plant at no time shall be less than that required for a normal day's paving operation. Delivering and stockpiling materials shall be in accordance with Subsection 106.09.

Measure and batch materials for concrete in accordance with AASHTO M 157, except as otherwise specified. Weigh the fine aggregate and each size of coarse aggregate separately in hoppers, in the respective amounts set by the approved job mix. Measure cement by weight, using separate scales and hoppers with a device to indicate positively the complete discharge of the batch of cement into the batch box or container.

- (d) **Mixing Concrete.** Mix and deliver concrete in accordance with AASHTO M 157 except as otherwise specified. The concrete may be mixed at the site of the work, in a central-mix plant, or in truck mixers. The mixer shall be of an approved type and capacity. Measure mixing time from the time all materials, except water, are in the drum. There shall be a maximum time limit of one hour from the time that the water, cement, and aggregate are combined until the mixed concrete is deposited in its final position.

When mixed at the work site or in a central mixing plant, the mixing time shall not be less than 50 seconds nor more than 90 seconds. Mixing time ends when the discharge chute opens. Transfer time in multiple drum mixers is included in mixing time. Remove the contents of an individual mixer drum before a succeeding batch is emptied therein.

Operate the mixer at a drum speed as shown on the manufacturer's name plate.

NOTE: Any concrete mixed less than the specified time shall be discarded and disposed of at the Contractor's expense.

The volume of concrete mixed per batch shall not exceed the mixer's nominal capacity in cubic yards (cubic meters), as shown on the manufacturer's standard rating plate on the mixer; however, an overload up to 10 percent above the mixer's nominal capacity may be permitted provided concrete test data for strength, segregation, and uniform consistency are satisfactory, and provided no spillage of concrete takes place.

The batch shall be so charged into the drum that a portion of the mixing water shall enter in advance of the cement and aggregates. The flow of water shall be uniform, and all water shall be in the drum by the end of the first 15 seconds of the mixing period. The throat of the drum shall be kept free of such accumulations as may restrict the free flow of materials into the drum.

Retempering concrete by adding water or by other means will not be permitted, except in the following circumstances:

When concrete is delivered in transit mixers or agitators, additional water may be added to the batch materials, and additional mixing performed at 20 revolutions at mixing speed, provided the design maximum water-cement ratio is not exceeded.

- (e) **Limitations of Mixing.** No concretes shall be mixed, placed, or finished when the natural light is insufficient, unless an adequate and approved artificial lighting system is operated. Unless otherwise authorized, the temperature of the mixed concrete shall be not less than 50° (10°C) and not more than 90°(32°C) at the time of placement.

When concreting is authorized during cold weather, heat the aggregates by either steam or dry heat prior to placing them in the mixer. The apparatus used shall heat the mass uniformly and shall be so arranged as to preclude the possible occurrence of overheated areas which might injure the materials. During concrete mixing, delivery, and placement in hot weather, use proper practices and procedures to insure that the maximum temperature of the concrete is not exceeded, pending acceptance by the Engineer. The Contractor shall be responsible for the protection and quality of concrete placed during any weather conditions.

- (f) **Setting Forms.** When formed paving equipment is used, set forms to line and grade by shimming or other approved methods. Correct imperfections or variations in the base or foundation which prohibit the placement of forms to the specified lines or grades in a manner accepted by the Engineer. Stake forms into place with not less than three pins for each 10 feet (3 m) section. Place a pin at each side of every joint. Form sections shall be tightly locked, free from play or movement in any direction. The forms shall not deviate from true line by more than 1/4 inch (6 mm) at any point. No excessive settlement or springing of forms under the finishing machine will be tolerated. Clean and oil forms prior to the placing of concrete.
- (g) **Placing Concrete.** Placing of concrete will not be allowed when there is frost in the foundation course.

Deposit the concrete on the grade in such a manner as to require as little rehandling as possible. Unless truck mixers, truck agitators, or nonagitating hauling equipment are equipped with means for discharge of concrete without segregation of the materials, unload the concrete into an approved spreading device and mechanically spread it on the grade in such manner as to prevent segregation of the materials. Placing shall be continuous between transverse joints without the use of intermediate bulkheads. Do any necessary hand spreading with shovels. Workers shall not be allowed to walk in the freshly mixed concrete with boots or shoes coated with earth or foreign substances.

Where concrete is to be placed adjoining a previously constructed lane of pavement—and mechanical equipment will be operated upon the existing lane—it shall have attained the strength specified for opening to traffic in Subsection 414.04(q). If only finishing equipment is carried on the existing lane, paving in adjoining lanes may be permitted after three days.

Operate the slip-form paver with a continuous forward movement, and coordinate all operations of mixing, delivering, and spreading concrete to provide a uniform progress with stopping and starting of the paver held to a minimum. If, for any reason, it is necessary to stop the forward movement of the paver, immediately stop the vibratory and tamping elements also.

Thoroughly consolidate concrete against the supporting grade and against the face of all forms and joint assemblies throughout their full length. Do not operate the vibrator in any one location longer than necessary to complete the consolidation.

Deposit concrete as near to expansion and contraction joints as possible without disturbing them, but do not dump it from the discharge bucket or hopper onto a joint assembly unless the hopper is well centered on the joint assembly.

Should any concrete materials fall on or be worked into the surface of a completed slab, remove them immediately by approved methods.

Do not place concrete unless an inspector is present.

- (h) **Test Specimens.** Furnish the concrete necessary for performing acceptance testing.
- (i) **Steel Reinforcement.** Reinforcing steel shall be free from dirt, oil, paint, grease, mill scale, and loose or thick rust which could impair bond of the steel with the concrete. Thin powdery rust and tight rust that does not reduce the effective cross section is not considered detrimental and need not be removed.

(1) **Placement of Reinforcement for Continuously Reinforced Concrete Pavement.** Reinforcement may be installed by one of the following methods:

- Preset on chairs or high chair bars or
- Placed by mechanical means.

Regardless of the method of placement used, the horizontal spacing tolerances shall be within 1/2 inch (12 mm) of Plan dimensions for longitudinal steel and within 2 inches (50 mm) of Plan dimensions for transverse steel. These tolerances notwithstanding, the number of longitudinal members for a given width of pavement and the number of transverse members per station shall be that shown on the Plans.

The position of the longitudinal and transverse steel in the vertical direction shall be that shown on the Plans.

At the time concrete is placed, handle the reinforcement with such care that the bars will remain reasonably flat and free from distortions. Bars shall be free from such kinks or bends as may prevent them from being properly assembled or installed. If forms are used, oil them prior to placement of reinforcement.

1.1 *Reinforcement Preset on Chairs or High Chair Bars.* The reinforcement shall be supported on chairs or continuous high chairs meeting the requirements of the Specifications and the approval of the Engineer.

Make the chairs of high chair bars high enough to allow steel placement within dimensioned tolerances.

Arrange and space the chairs so that the reinforcement will be supported in proper position without permanent deflection or displacement occurring during placing and consolidation of concrete.

Provide sufficient bearing at their base to prevent overturning and penetration into the base.

Design so as not to impede the placing and consolidation of concrete.

Do not set high chair bars so close to other transverse members as to make placing concrete through the space difficult. This is particularly important in lapped areas where there is a concentration of reinforcement.

NOTE: Welding of chairs to transverse bars will be permitted.

If requested by the Engineer, submit a sample of the chair or high chair bar to be furnished. Show chairs and the layout in the plans. If the support system does not maintain the reinforcement in the position required by these Specifications during placing and finishing of the concrete, increase the number of chairs or take such other steps as may be required to assure proper final position of the steel.

When the reinforcement consists of loose bars fabricated on the grade, secure the longitudinal bars to the transverse bars by wire ties or clips at sufficient intersections to maintain the horizontal and vertical tolerances specified herein.

1.2 *Reinforcement Placed by Mechanical Means.* The method of placement used shall be capable of maintaining the approved lap pattern and controlling the length of the lap of

longitudinal steel so as to assure that the specified minimum lap dimension will be obtained.

Place the reinforcement at the proper depth in the concrete by means of a machine approved by the Engineer. Perform placement of the reinforcing steel in such a manner that the concrete, after final finishing, shall show no segregation attributable to the placing operation. Operate the machine in such a manner that it does not drag the reinforcement.

If the machine shows any tendency to displace the reinforcement, seek the approval of the Engineer to halt paving operations until the machine is properly adjusted or until another machine may be provided that will operate in a satisfactory manner. Alternatively, install the reinforcement in accordance with the provisions of Subsection 1.1 above.

Operate the machine in such a manner that the concrete will not be excessively vibrated or otherwise manipulated.

Longitudinal reinforcement may be fabricated on the grade and raised into position by use of rollers, tube sleds, or other devices capable of supporting the reinforcement in the specified vertical and horizontal position while the concrete is being placed and consolidated. Place transverse steel as shown on the plans.

- (2) **Lap Splices in Reinforcing Steel.** Lap the reinforcing bars used as continuous reinforcement in the longitudinal direction in a staggered pattern as shown on the Plans. Laps in the longitudinal reinforcement shall be tied, fastened with clips, or otherwise securely fastened regardless of the method of placement.
- (j) **Joints.** Construct joints perpendicular to the surface of the slab and of the type, dimensions, and at locations shown on the Plans. Use suitable guidelines or devices to assure satisfactory alignment of joints.

All sawed joints shall be reasonably straight and true to line; if any are not, repair or correct them to the satisfaction of the Engineer. Seal the sawed joints in accordance with Subsection 419.04.

- (1) **Longitudinal Joints.** Saw and seal longitudinal contraction joints. Do not saw and seal longitudinal construction joints. Place deformed steel tie bars of specified length, size, spacing, and material perpendicular to the longitudinal joint. Place tie bars, by approved mechanical equipment or rigidly secured by chairs or other approved supports, to prevent displacement. Do not paint or coat bars with asphalt or other materials or enclose them in tubes or sleeves.

Saw the longitudinal contraction joint as soon as possible to the depth shown on the Plans without causing damage to the pavement or joint. Thoroughly clean the sawed area, leaving it free from dust, chalk, and contaminants and fill it with an approved joint-sealing material.

Do not allow construction equipment and other vehicles which may cause damage to the pavement joints on the pavement before the end of the curing period.

When tested with a straightedge, the surface across any joint shall not vary from the straightedge by more than 1/8 inch (3 mm).

(2) Transverse Joints.

- 2.1 *Expansion or Isolation Joint.* Make the expansion joint filler continuous from form to form, shaping it to the base and to the keyway along the form. Furnish preformed joint filler in lengths equal to the pavement width or equal to the width of one lane.

NOTE: Do not use damaged or repaired joint filler unless approved by the Engineer.

Appropriately punch premolded joint filler to the exact diameter and location of any dowels. Unless otherwise provided, furnish it in lengths equal to the pavement width. However, in cases where pavement two or more traffic lanes wide is being placed, the premolded filler may be furnished in sections, provided the length of each section is equal to the width of one lane. Where more than one section is used in a joint, securely lace or clip the sections together. The bottom edge of the filler shall project to or slightly below the bottom of the slab; and unless otherwise prescribed, the top edge shall be 1 inch (25 mm) below the surface of the pavement. While the concrete is being placed, protect the top edge of the filler by a metal channel cap of at least 10 gauge material, having flanges not less than 1 1/2 inch (40 mm) in depth.

After the concrete has been placed on both sides of the joint and struck off, slowly and carefully withdraw the installing bar, leaving the premolded filler in place. Before the installing bar and channel cap are completely withdrawn, carefully vibrate the concrete and work additional freshly mixed concrete into any depression left by the removal of the installing bar. The filler must be exposed for the full width of the slab. Clean and reoil the installing bar prior to each installation of a joint. After the removal of the side forms, the ends of the transverse joints at the edges of the pavement shall be carefully opened for the entire depth of the slab. Before the pavement is opened to traffic, seal or top out premolded joints with the joint-sealing filler specified, leaving a neat uniform strip of joint-sealing filler slightly below the surface of the pavement.

For joints in concrete curbing that cannot be satisfactorily sawed, form them by means of steel templates or other approved joint-forming dividers installed at the time the concrete is poured and at the location of the joint to be sawed.

- 2.2 *Contraction Joints.* Form transverse contraction joints by sawing them as soon as possible to the depth shown on the Plans without causing damage to the pavement or joint. Saw succeeding joints consecutively from the beginning to the end of the day's run, and saw all transverse joints soon enough to prevent uncontrolled transverse cracking.

Maintain the sawed area to the following standards:

Thoroughly clean and dry it; keep it free from dust, chalk, contaminates, and spalling; and fill it with an approved joint sealing material.

Do not allow construction equipment and other vehicles which may cause damage to the pavement joints to drive on the pavement before the end of the curing period.

- 2.3 *Transverse Construction Joints For Jointed Pavement.* Unless otherwise directed, construct transverse construction joints when there is an interruption of more than 30 minutes or as field conditions dictate in the concreting operations. No transverse joint

shall be constructed within 10 feet (3 m) of an expansion joint, contraction joint, or plane of weakness. If sufficient concrete has not been mixed at the time of interruption to form a slab at least 10 feet (3 m) long, the excess concrete back to the last preceding joint shall be removed and disposed of as directed by the Engineer.

Provide a rigid header with holes or slots for dowel bars that shall be of the spacing and dimensions as for expansion joints. Submit any alternate methods for header construction to the Engineer for approval.

NOTE: In no case shall the load transfer bar vary more than 3/8 inch (9 mm) from the planned horizontal or vertical position.

2.4 *Transverse Construction Joints for Continuously Reinforced Concrete Pavement.* Install a transverse construction joint at the end of each day's work or whenever paving operations must be interrupted for more than 30 minutes. Form the joint by placing the concrete against a headerboard approved by the Engineer. The longitudinal reinforcing steel shall extend through the headerboard and be properly supported from the base beyond the headerboard to prevent undue deflections during paving operations.

Cover the reinforcement which extends beyond the headerboard with sheets of plywood or other material to permit workers to walk on the steel without displacing it and to prevent concrete spilling on the base during screeding operations.

Construct construction joints and lap splices as shown on the current Design Standard.

Provide additional consolidation to the pavement areas adjacent to both sides of transverse construction joints using hand vibrators inserted into the concrete, and refinish the surface. These areas shall extend at least 10 feet (3 m) from the joint. When tested with a 10 feet (3 m) straightedge, the surface across the joint shall not vary more than 1/8 inch (3 mm).

(3) **Load Transfer Devices.** The placement method of load transfer devices is optional. Firmly hold or mechanically place approved load transfer devices in the position indicated on the Plans. In all cases, dowels shall be parallel to the surface and centerline of the slab and shall vary no more than 3/8 inch (9 mm) from the planned horizontal or vertical position. Cap dowels for expansion joints as shown on the plans.

(k) **Final Strike off, Consolidation, and Finishing.**

(1) **General.** The sequence of operations shall be as follows:

- Strike off and consolidation
- Floating and removal of laitance
- Straightedging
- and Final surface finish

In general, the addition of superficial water to the surface of the concrete to assist in finishing operations will not be permitted. If the application of water to the surface is permitted, it shall be applied as a fog spray by means of approved spray equipment.

- (2) **Finishing at Joints.** The concrete adjacent to joints shall be compacted or firmly placed without voids or segregation against the joint material, also under and around all load transfer devices, joint assembly units, and other features designed to extend into the pavement. Concrete adjacent to joints shall be mechanically vibrated.
- (3) **Slip-form Paving.** The strike-off, consolidation, and initial finishing shall be performed by the slip-form paver. At the beginning of the day's run, straight-edge the construction joint and the initial slab both longitudinally and transversely until the machine produces a satisfactory slab within the tolerances specified in 401.04 (a).

NOTE: For the outer 6 inches (150 mm) along the edge of the pavement, a maximum deviation of 1/4 inch (6 mm) from a 10 foot (3 m) straight-edge placed perpendicular to the centerline of the roadway will be permitted.

Perform occasional additional straight-edging throughout the day's run to insure the machine continues to produce a satisfactory slab. When constructing auxiliary parallel lanes, there shall be no appreciable slump along the edges of adjoining lanes.

NOTE: Any valleys or depressions that will not drain properly shall be corrected by the Contractor at his expense.

It is the intent of this Specification that modern slip-form machinery in good working order be used; therefore, keep hand-finishing to a minimum, using it only to correct surface defects or irregularities.

(4) Formed Paving.

- 4.1 *Machine Finishing.* As soon as the concrete has been placed, strike it off and screed it with an approved finishing machine. The machine shall go over each area of pavement as many times and at such intervals as necessary to give the proper compaction and to leave a surface of uniform texture. Avoid excessive operation over a given area. Keep the tops of the forms clean with an effective device attached to the machine, and maintain the travel of the machine on the forms true without lift, wobbling, or other variation tending to affect the precision finish.

During the first pass of the finishing machine, maintain a uniform ridge of concrete ahead of the front screed for its entire length.

Vibrators for full width vibration of concrete paving slabs shall meet the requirements in Subsection 414.03(b).

NOTE: If uniform and satisfactory density of the concrete is not obtained by the vibratory method at joints, along forms, at structures, and throughout the pavement, the Contractor will be required to furnish equipment and methods which will produce pavement conforming to the Specifications.

- 4.2 *Hand Finishing.* Hand finishing methods will not be permitted except under the following two conditions:
 - (1) In the event of breakdown of the mechanical equipment, to finish the concrete already deposited on the grade or in transit when the breakdown occurs.
 - (2) With narrow widths or areas of irregular dimensions where operation of the mechanical equipment is impractical.

As soon as the concrete has been placed, strike it off and screed it. Use an approved portable screed. If reinforcement is used, provide a second screed for striking off the bottom layer of concrete.

The screed for the surface shall be at least 2 feet (0.6 m) longer than the maximum width of the slab to be struck off.

Attain consolidation by the use of a suitable vibrator or other approved equipment.

In operation, move the screed forward on the forms with a combined longitudinal and transverse shearing motion—moving always in the direction in which the work is progressing; manipulate it so that neither end is raised from the side forms during the striking off process. If necessary, repeat this until the surface is of uniform texture reasonably true to grade and cross section, and free from porous areas.

- 4.3 *Floating.* After the concrete has been struck off and consolidated, further smooth, true, and consolidate it by means of a longitudinal float.

If necessary, use long-handled floats having blades not less than 5 feet (1.5 m) in length and 6 inches (150 mm) in width to smooth and fill in open textured areas in the pavement. Do not use long-handled floats to float the entire surface of the pavement. Be careful not to work the crown out of the pavement during the operation. After floating, remove any excess water and laitance from the surface of the pavement by a straightedge 3 feet (3 m) or more in length. Lap successive drags one-half the length of the blade.

- 4.4 *Straightedge Testing and Surface Correction.* After the floating has been completed and the excess water removed, but while the concrete is still plastic, test the surface of the concrete for trueness with a 10 feet (3 m) straightedge. For this purpose, furnish and use an accurate 10 feet (3 m) straightedge. Hold the straightedge in contact with the surface in successive positions parallel to the road centerline, going over the whole area from one side of the slab to the other as necessary. Advance along the road in successive stages of not more than one-half the length of the straightedge. If any depressions are found, immediately fill them with freshly mixed concrete, strike them off, consolidate, and refinish. Cut down high areas and refinish. Pay special attention to assure that the surface across joints meets the requirements for smoothness. Continue straightedge testing and surface corrections until the entire surface is found to be free from observable departures from the straightedge and the slab conforms to the required grade and cross section.

(5) Texturing.

- 5.1 *Burlap Drag.* Use the burlap drag prior to final finish of the pavement surface. The burlap or cotton fabric drag shall produce a uniform surface of gritty texture after it has been dragged longitudinally along the full width of pavement. For pavement 16 feet (4.9 m) or more in width, mount the drag on a bridge which travels on the forms. Maintain the drag clean and free from encrusted mortar. When drags cannot be cleaned, discard them and replace them with new drags.

- 5.2 *Transverse Groove Final Finish.* When final longitudinal texturing with the burlap drag is completed, mechanically transverse groove and texture the plastic pavement surface of the driving lanes and ramps in a manner accepted by the Engineer, using equipment meeting the requirements of Subsection 414.03(b)3. You have the option of tining the shoulder surface.

The grooves shall be perpendicular to the centerline of the pavement, 1/16 to 1/8 inch (2 to 3 mm) wide, 1/8 to 1/4 inch (3 to 6 mm) deep, and approximately spaced at 1/2 to 1 inch (12 to 25 mm). The machine shall automatically lift the roller or tines near the edge of pavement so that edge damage shall be held to a minimum. The overlap between grooving passes shall be less than 3 inches (75 mm).

In those areas where mechanical grooving equipment cannot be operated, hand grooving methods will be permitted in a manner approved by the Engineer.

- 5.3 *Edging at Forms and Joints.* After the final finish, but before the concrete has taken its initial set, work the following with an approved tool and round them to the radius required by the Plans:

The edges of the pavement along each side of each slab; and each side of transverse expansion joints, formed joints, transverse construction joints, and emergency construction joints shall be worked with an approved tool and rounded to the radius required on the plans to produce a well-defined and continuous radius and obtain a smooth, dense mortar finish. The surface of the slab shall not be unduly disturbed by tilting of the tool during use.

At all joints, eliminate any tool marks appearing on the slab adjacent to the joints by brooming the surface. In doing this, do not disturb the rounding of the corner of the slab. Completely remove all concrete on top of the joint filler.

Test all joints with a straightedge before the concrete has set, and make corrections if one side of the joint is higher than the other or if they are higher or lower than the adjacent slabs.

- (l) **Surface Test.** As soon as the concrete has hardened sufficiently, test the pavement surface with a 10 foot (3 m) straightedge or other specified device. Mark areas showing high spots of more than 1/8 inch (3 mm) but not exceeding 1/2 inch (12 mm) in 10 feet (3 m). Immediately grind them down with an approved grinding tool to an elevation where the area or spot will not show surface deviations in excess of 1/8 inch (3 mm) when tested with a 10 foot (3 m) straightedge. Retexture the surface of ground areas to match the surface of the surrounding areas.

NOTE: Where the departure from correct cross section exceeds 1/2 inch (12mm), the pavement shall be removed and replaced by and at the expense of the Contractor. Any area or section so removed shall be not less than 10 feet (3 m) in length nor less than the full width of the lane involved. When it is necessary to remove and replace a section of pavement, any remaining portion of the slab adjacent to the joints that is less than 10 feet (3 m) in length shall also be removed and replaced.

- (m) **Curing.** Immediately after the texturing operations have been completed and as soon as marring of the concrete will not occur, cover and cure the entire surface of the newly placed concrete in accordance with one of the following methods. In all cases in which curing requires the use of water, the curing shall have prior right to all water supply or supplies.

NOTE: Failure to provide sufficient cover material, or lack of water to adequately take care of both curing and other requirements, shall be cause for immediate suspension of concreting operations. The concrete shall not be left exposed for more than one-half hour between stages of curing or during the curing period.

- (1) **Cotton or Burlap Mats.** The surface of the pavement shall be entirely covered with mats. Use mats of such length (or width) that when laid they will extend at least twice the thickness of the pavement beyond the edges of the slab. Place the mat so that the entire surface and both edges of the slab are completely covered. Prior to their being placed, thoroughly saturate the mats with water. Place and weigh down the mats to keep them in intimate contact with the surface covered, and maintain a fully wetted covering for 72 hours after the concrete has been placed unless otherwise specified.
- (2) **Impervious Membrane Method.** Spray the entire surface of the pavement uniformly with white pigmented curing compound meeting the requirements of Subsection 701.07(d)— immediately after the texturing of the surface and before the set of the concrete has taken place; or if the pavement is cured initially with jute or cotton mats, the white pigmented curing compound may be applied upon removal of the mats. Do not apply the curing compound during rainfall.

Under normal conditions, apply curing compound—by mechanical sprayers meeting the requirements of Subsection 414.03(h)—under pressure at the rate of one gallon (one liter) to not more than 200 square feet (5 m²). However, when the temperature on the roadway is 100°F (38°C) or above, apply the curing compound at the rate of one gallon (one liter) to not more than 150 square feet (3.75 m²).

At the time of use, the compound shall be in a thoroughly mixed condition with the pigment uniformly dispersed throughout the vehicle. Hand spraying of odd widths or shapes and concrete surfaces exposed by the removal of forms will be permitted. Do not apply curing compound to the inside faces of joints to be sealed.

The curing compound shall be of such character that the film will harden within four hours after the application. Should the film become damaged from any cause within the required curing period, immediately repair the damaged portions with additional compound.

Upon removal of side forms, immediately protect the sides of the slabs exposed to provide a curing treatment equal to that provided for the surface.

- (3) **White Polyethylene Sheeting.** The top surface and sides of the pavement shall be entirely covered with polyethylene sheeting. Lap the units used at least 18 inches (450 mm). Place and weigh down the sheeting to keep it in intimate contact with the surface being covered. The sheeting as prepared for use shall have such dimensions that each unit as laid will extend beyond the edges of the slab at least twice the thickness of the pavement. Unless otherwise specified, maintain the covering in place for 72 hours after the concrete has been placed.

(4) Curing for Cold Weather.

NOTE: The Contractor shall be responsible for the quality and strength of the concrete placed during cold weather, and any concrete injured by frost action shall be removed and replaced at the Contractor's expense.

- (n) **Removing Forms.** Remove forms carefully so as to avoid damage to the pavement. After the forms have been removed, cure the sides of the slab as outlined in one of the methods indicated above. Repair any/all honeycombed areas.
- (o) **Sealing Joints.** The joints shall be of the type shown on the Plans. All joints shall be reasonably true to the line width and depth shown on the Plans. Joints in portland cement concrete pavement shall be thoroughly clean and dry prior to placement of backer rod and/or joint sealant.
- (p) **Protection of Pavement.** Erect and maintain suitable barricades and employ watchmen as may be required to exclude traffic from newly constructed pavement for the period herein prescribed.

NOTE: Provisions for traffic moving across the pavement shall be made at the Contractor's expense: construct suitable and substantial crossings to bridge over the concrete, which will be adequate for the traffic; protect the pavement against both public traffic and the traffic caused by employees and agents; keep all ditches and drains in such condition as to provide effective drainage; when berms of earth are placed along the shoulders, make proper provisions for the surface drainage; if any part of the pavement is damaged by traffic or other causes, occurring prior to opening to traffic, repair or replace it in a manner satisfactory to the Engineer.

- (q) **Opening to Traffic.** Exclude traffic from the newly constructed pavement for a period of 14 days after the concrete is placed or longer if weather conditions make it advisable to extend this time. However, at the discretion of the Engineer, the pavement may be opened to traffic when specimen beams or cylinders made, cured, and tested meet the strength requirements specified in Subsection 701.01(d)
- (r) **High-Early-Strength Concrete Pavement.**
 - (1) **General Requirements.** When high-early-strength concrete pavement is specified, it shall meet the requirements of Section 701.
 - (2) **Opening to Traffic.** Traffic shall be excluded from the newly constructed pavement until the strength specified in Subsection 701.01(d) is obtained.
 - (3) **Joints.** All joints shall be constructed in accordance with Subsection 414.04(j).
- (s) **Protection Against Rain.** Until the concrete is sufficiently hardened, have available materials for the protection of the edges and surface to protect them against rain. Such protective materials shall consist of the following:

Standard metal forms or wood plank having a nominal thickness of not less than 2 inches (50 mm) and a nominal width of not less than the thickness of the pavement at its edge for the protection of the pavement edges; and covering material such as burlap or cotton mats, curing paper, or plastic sheeting material for the protection of the surface of the pavement. When rain

appears imminent, stop all paving operations and have all available personnel place forms against the sides of the pavement and cover the surface of the unhardened concrete with the protective covering.

(t) **Tolerances.**

- (1) **Surface.** The surface tolerance shall be in conformity with Section 401.04.
- (2) **Width.** The width shall be in reasonably close conformity with the dimensions shown on the Plans or established by the Engineer.
- (3) **Thickness.** After any and all grinding operations have been performed, the thickness of the pavement will be determined by the average caliper measurement of cores tested in accordance with AASHTO T 148.

3.1 *Unit Identification.* For the purpose of establishing an adjusted unit price for pavement, units to be considered separately are defined as 1000 feet (300 m) of pavement in each traffic lane starting at the end, bearing the smaller station number. The last unit in each lane shall be the fractional part of 1000 feet (300 m) remaining. Units less than 250 feet (75 m) in length shall be combined with the previous unit. For entrances, crossovers, ramps, and other such areas, units to be considered separately are defined as 1000 square yards (1000 m²) of pavement or fraction thereof. Small, irregular areas may be included as part of another unit.

3.2 *Core Locations.* One core will be taken at random by the Department in each unit. If the core is deficient in thickness by more than 0.2 inch (5 mm), two additional cores will be taken by the Department from the unit. The unit will be divided into three equal subunits. One additional core will be taken at random from each of the two subunits not represented by the original core. If the measurement of any core is less than the specified thickness by more than 1 inch (25 mm), the actual thickness of the pavement in this area will be determined by taking exploratory cores at not less than 10 feet (3 m) intervals parallel to the centerline in each direction from the affected location until in each direction a core is found which is not deficient by more than 1 inch (25 mm).

3.3 *Average Thickness Determination.* When determining the average thickness for a unit, measurements which are in excess of the specified thickness by more than 0.2 inches (5 mm) will be considered as the specified thickness plus 0.2 inch (5 mm); measurements which are less than the specified thickness by more than 1 inch (25 mm) will not be included, and exploratory cores for deficient thickness *will not* be included.

3.4 *Adjustment Payment.* Payment for the unit will be made according to the following table:

CONCRETE PAVEMENT DEFICIENCY			
<u>AVERAGE THICKNESS DEFICIENCY (ATD) AS DETERMINED FROM CORES</u>		<u>PROPORTIONAL PART OF CONTRACT PRICE, PERCENT</u>	
<u>INCHES</u>	<u>(MM)</u>	<u>INCHES</u>	<u>(MM)</u>
0 to 0.2	[0 to 5]	100	[100]
0.2 to 0.3	[5 to 7.5]	100-(200)(ATD-0.2)	[100-(8)(ATD-5)]
0.3 to 1.0	[7.5 to 25]	92-(40)(ATD)	[92-(1.6)(ATD)]
ATD = Plan Thickness-Average Thickness			

Areas found deficient in thickness by more than 1 inch (25 mm) shall be evaluated by the Engineer, and if the deficient areas warrant removal, they shall be removed and replaced with concrete of the thickness shown on the Plans at the expense of the Contractor. When in the judgment of the Engineer the deficient areas do not warrant removal, there will be no payment for the area retained.

Core holes shall be filled with concrete by the Contractor in a manner approved by the Engineer. The cost of filling core holes will not be a separate pay item but will be included in other bid items.

- (u) **Acceptance of Pavement.** Pavement slabs may be rejected because of unsound concrete, uncontrolled cracking, malfunctioning of the sawed joints, spalling, honeycombing, surface irregularities, insufficient thickness, or for any deficiencies commonly associated with poor quality pavements. Rejected slabs shall be removed and replaced with new pavement conforming to these requirements. The removal and replacement shall be at least one lane in width and 10 feet (3 m) in length. Where the linear extent of removal falls within 10 feet (3 m) of a transverse joint, the removal limits shall be extended to the joint.

414.05. METHOD OF MEASUREMENT.

- (a) *Portland Cement Concrete Pavement*, shall be paid for by the number of square yards (square meters) of concrete pavement, of the type shown on the Plans or in the Proposal, completed and accepted, and measured complete in place. The width for measurement will be the width from outside to outside of the completed pavement, but not to exceed the width as shown on the Plans or as directed by the Engineer. The length will be the actual length measured along the riding surface on the centerline of the road, and shall exclude the length occupied by bridges, approach slabs, and all other exceptions.

NOTE: Reinforcing steel, load transfer devices, joint fillers and joint sealers will not be measured for payment.

- (b) *Terminal joint*, will be measured by each unit installed and shall include all steel, concrete, and other materials needed to construct the joint.
- (c) *Approach slabs*, will be measured and paid for as provided above for portland cement concrete pavement.

(d) *Terminal joint sleeper slabs*, will be measured by the square yard (square meter) and shall include all steel, concrete and other materials needed to construct the slab.

414.06. BASIS OF PAYMENT.

The accepted quantities of concrete pavement, terminal joint, and approach slabs, measured as provided above, will be paid for at the contract unit price as follows:

- (A) PORTLAND CEMENT CONCRETE PAVEMENT..... SQUARE YARD
..... (SQ. METER)
- (A1) P.C. DOWEL-JOINTED CONCRETE PAVEMENT..... SQUARE YARD
..... (SQ. METER)
- (B) HIGH-EARLY-STRENGTH CONCRETE PAVEMENT..... SQUAREYARD
..... (SQ.METER)
- (B1) H.E.S. DOWEL-JOINTED CONCRETE PAVEMENT..... SQUARE YARD
..... (SQ. METER)
- (C) APPROACH SLABS..... SQUARE YARD
..... (SQ. METER)
- (D) PORTLAND CEMENT CONCRETE PAVEMENT
(CONTINUOUSLY REINFORCED) SQUARE YARD
..... (SQ. METER)
- (E) HIGH-EARLY-STRENGTH CONCRETE PAVEMENT
(CONTINUOUSLY REINFORCED)..... SQUARE YARD
..... (SQ. METER)
- (F) TERMINAL JOINT.....EACH
- (G) TERMINAL JOINT SLEEPER SLAB..... SQUARE YARD (SQ. METER)

Such payment shall be full compensation for furnishing all materials, equipment, labor and incidentals to complete the work as specified.

No additional compensation will be allowed when the Contractor, at his option, uses high-early-strength portland cement in lieu of standard portland cement.

Where the average thickness of pavement is deficient in thickness by more than 0.2 inch (5 mm), but not more than 1 inch (25 mm), payment will be made at an adjusted price as specified in Subsection 414.04(t).

SECTION 417 COLD MILLING PAVEMENT

417.01. DESCRIPTION.

This work shall consist of cold milling and removing existing pavement surfaces below the present grade to a depth shown on the plans, and removing ridges, ruts, and other imperfections as determined by the Engineer. The milling operation shall produce a plane surface that will provide a smooth riding surface for traffic.

417.03. EQUIPMENT.

Provide a power-operated milling machine capable of planing a minimum depth of 1 1/2 inch (40 mm) in a single pass. The equipment shall be self-propelled with sufficient power, traction, and stability to maintain accurate depth of cut and slope. The equipment shall be capable of accurately and automatically establishing profile grades along each edge of the machine by referencing the existing pavement by means of a ski or matching shoe, or from an independent grade control; in addition, it shall have an automatic system for controlling cross slope at a given rate. The machine shall be equipped with an integral loading means to remove the material being cut from the pavement surface and to discharge the cuttings into a truck—all in a single operation.

417.04. CONSTRUCTION METHODS.

Mill the existing pavement uniformly to provide a uniform texture, true to line, grade, and cross section; it shall have no deviations in excess of 3/16 inch (5 mm) in 10 feet (m). Any portion of the planed surface not meeting this requirement shall be corrected in a manner approved by the Engineer.

Make as many passes as necessary to remove irregularities and to profile the surface to the depth and cross slope shown on the Plans.

Perform cold milling in a manner that will not create undue traffic hazards.

At the end of each day's operation, make sure that the milled lanes areas are as even as possible; this is to eliminate the hazard of an exposed vertical edge when traffic is carried through construction.

NOTE: The contractor shall take possession of all materials removed and dispose of them in accordance with Section 104.09 unless otherwise specified on the Plans.

417.05. METHOD OF MEASUREMENT.

Cold milling pavement will be measured by the square meter of surface area.

417.06. BASIS OF PAYMENT.

Accepted quantities of cold milling pavement, measured as provided above, will be paid for at the contract unit price as follows:

COLD MILLING PAVEMENT.....SQUARE YARD (SQUARE METER)

Such payment shall be full compensation for furnishing all materials, equipment, labor and incidentals to complete the work as specified.

SECTION 419 CONCRETE JOINT REHABILITATION

419.01. DESCRIPTION.

This work shall consist of sawing, cleaning, and sealing joints in existing portland cement concrete pavement in reasonably close conformity with the details shown on the Plans or as approved by the Engineer.

419.02. MATERIALS.

Materials shall meet the requirements of Subsection 701.08 for the type joint filler or sealer shown on the Plans or designated in the Proposal.

419.03. EQUIPMENT.

Furnish all necessary equipment in accordance with the requirements of Subsection 108.06. The minimum requirements for construction equipment as required to complete the work are specified herein:

Concrete Saw. Sawing equipment adequate in size and power to complete the sawing of concrete joints to the required dimensions.

High Pressure Water Pumping System. High pressure water pumping system capable of delivering sufficient pressure and volume of water to thoroughly flush concrete slurry from sawed joints.

Sand Blasting Unit. Compressed air pressure type sand blasting equipment of proper size and capacity to clean joint surfaces as specified. The unit shall be equipped with suitable traps for removal of all free water and oil from the compressed air.

Air Compressors. Air compressors capable of delivering compressed air having a pressure in excess of 90 psi (620 kPa) and equipped with suitable traps for removal of all free water and oil from the compressed air.

Extrusion Pump. Air-powered extrusion pumps as required for applying joint sealer with an output capable of delivering a sufficient volume of material to the joint.

Injection Tool. A mechanical injection device as required for applying the sealer into the joint.

Joint Sealer Kettle. When the joint sealant requires heating, the kettle shall be a double bottom oil bath indirect flame type, adequate in size and power to mix, heat, deliver and maintain the desired temperature.

419.04. CONSTRUCTION METHODS.

- (a) **Sawing Joints.** Cut the joints to the width and depth shown on the Plans. Perform sawing in such a manner as to produce a new joint that has a cut face on both sides and is uniform in width along its full length.
- (b) **Flushing Joints.** After sawing, remove the resulting slurry from the joint area by flushing with a high-pressure water system and any other equipment necessary to thoroughly remove the slurry.

(c) **Cleaning Joint Faces**

- (1) **General.** Thoroughly clean the cut faces of the joints of all foreign materials—including old sealant or any residue from water flushing operations by sandblasting—as required for proper installation and bonding of the joint sealer or filler.

NOTE: The use of portable hand saws will not be permitted for cleaning joint faces.

Thoroughly air dry the cut faces of the joint for a minimum of 48 hours after flushing them with water.

NOTE: Blow drying of the joints with compressed air will not be permitted.

- (2) **Sandblasting.** After the joint is completely dry, sandblast both joint faces. Attach the sandblaster nozzle to a mechanical aiming device so as to direct the sandblast at approximately a 45-degree angle and at a maximum of 2 inches (50 mm) from the faces of the joint.

After sandblasting, blow out the joints using filtered oil-free and moisture-free air at a minimum of 90 psi (620 kPa) and 120 cfm (3.4 m³/min). Use a blow tube which will fit into the joint. After blowing, check the joint for any residual dust or coating. If any is found repeat the sandblasting and blowing operations until the joint is cleaned.

Seal the cleaned joints the same day as they are cleaned. If joints are left open overnight, reclean them prior to sealing.

- (3) **Joint Contamination.** In the event the open joints prepared for installation of joint-sealing materials become contaminated by traffic or as result of weather conditions, reclean them as specified above or as approved by the Engineer.
- (d) **Backer Rod.** When shown on the plans or recommended by the sealant manufacturer, install a backer rod prior to applying the joint sealant. Use a backer rod of the type recommended by the manufacturer of the sealant material, and install it in a manner that will produce the dimensions (width and depth) described on the Plans.
- (e) **Sealing Joints.**
- (1) **Approval of Joints for Sealing.** The Department's inspectors will examine joints prepared for sealing just prior to installation of the joint filler or sealer. Joints will not be approved for sealing if contaminated or not adequately dry as required for bonding of sealing materials.
- (2) **Installation of Joint Sealers and Fillers.** A representative of the joint filler and/or joint sealer manufacturer shall be on the job site at the beginning of the joint-sealing operation to demonstrate to the Contractor and to the Department's inspectors the manufacturer's acceptable standards for installation of the joint sealant materials.
- (3) **Application of Joint Sealers.** Apply the joint sealer using a mechanical injection tool approved by the Engineer.

NOTE: Application of the joint sealer will not be permitted when the joint temperature is less than 40°F (4° C), and joints shall not be sealed unless they are thoroughly clean and dry.

Sealers to fill the joint shall be injected into the joint and applied in a manner which causes it to bond to the joint face surfaces. For surfaces of sealers that require tooling, use an approved mechanical device to produce a slightly concave surface approximately 1/4 to 1/2

inch (6mm to 12 mm) below the pavement surface. Complete the tooling before a skin forms on the surface of the sealer. Do not use soap or oil as a tooling aid.

NOTE: Tooling will not be required if the sealer is self-leveling.

- (4) **Bonding Failures.** Failure of the sealant to bond to sawed surfaces of the concrete joint will be cause for rejection, and repair shall be at the Contractor's expense.
- (f) **Traffic.** Do not allow traffic on the freshly applied sealant until it becomes tack free.

419.05. METHOD OF MEASUREMENT.

Concrete joint rehabilitation will be measured by the linear foot (meter) after the joint sealant is in place.

419.06. BASIS OF PAYMENT.

The accepted quantities, measured as provided above, will be paid for at the contract unit price as follows:

CONCRETE JOINT REHABILITATION LINEAR FOOT (METER)

Such payment shall be full compensation for furnishing all materials, equipment, labor and incidentals to complete the work as specified.

SECTION 420 FABRIC REINFORCEMENT FOR ASPHALT CONCRETE PAVEMENT

420.01. DESCRIPTION.

This work shall consist of the application of reinforcement fabric for plant mix asphalt concrete pavement in accordance with these Specifications and in reasonably close conformity with the locations and dimensions shown on the Plans or established by the Engineer.

420.02. MATERIALS.

Materials shall meet the requirements specified in the following Subsections of Section 700 - Materials:

Reinforcement Fabric	712.01
Asphalt Cement	708.03

420.03. EQUIPMENT.

- (a) **General.** Furnish equipment and tools necessary for performing all parts of the work in conformance with Subsection 108.06.
- (b) **Distributors.** Distributors shall meet the requirements of Subsection 401.03 and be equipped with a hand spray with a single nozzle and positive shut off valve.

- (c) **Fabric Laydown Equipment.** Mechanical laydown equipment shall be capable of handling full or partial rolls of fabric and shall be capable of laying the fabric smoothly without excessive wrinkles and/or folds. When manual laydown is required, a length of standard 1 inch (25 mm) pipe—together with suitable roll tension devices—shall be used for proper roll handling.
- (d) **Miscellaneous Equipment.** Miscellaneous equipment shall include stiff bristle brooms to smooth the fabric, scissors or blades to cut the fabric, and brushes as required for use in applying asphalt binder to fabric overlap at spliced joints.
- (e) **Pneumatic Tired Rollers.** Pneumatic tired rollers shall meet the requirements of Subsection 401.03.

420.04. CONSTRUCTION METHODS.

- (a) **Surface Preparation.** The surface on which the fabric is to be placed shall be free of dirt, dust, water, oil, or other foreign matter.
- (b) **Application of Bituminous Binder.** Heat the bituminous binder material, and, using an asphalt distributor, apply uniform spray over the area to be fabric covered. Mop the laps between layers of fabric. The longitudinal lap may be sprayed with the distributor. Hand spray areas not accessible to the distributor. When starting or stopping the distributor, use paper or roofing felt to provide neat cutoff lines.

The minimum application temperature of the bituminous binder shall not be less than 290°F (143°C), and if the fabric is oversprayed, the maximum application temperature shall not exceed 325°F (163°C) to avoid damage to the fabric. Apply the bituminous binder at the approximate rate of 0.2 gallons per square yard (0.9 L/m²). The *actual* application rates will be established by the Engineer.

The width of binder application shall be 2 to 6 inches (50 to 150 mm) wider than the fabric width. Be careful in the application of the binder to avoid spills or excessive application which would cause flushing of the bituminous material.

- (c) **Placement of Reinforcement Fabric.** Place the fabric after the bituminous binder has been applied and before the binder has cooled and lost tackiness. Unroll the fabric and place it into the binder with the unfused (fuzzy) side down and with a minimum of wrinkles, making every effort to lay the fabric as smoothly as possible. Broom the fabric to remove air bubbles and maximize fabric contact with the pavement surface. Cut wrinkles and lay them out flat. If misalignment of the fabric occurs, cut, realign, and joint the fabric as directed by the Engineer.

Overlap fabric at joints between 4 to 6 inches (100 to 150 mm). Shingle transverse joints in the direction of paving to prevent edge pick up by the paver. Apply additional binder to joints at the rate specified by the Engineer. Mop, brush, or hand spray transverse joints. Spray the longitudinal joints with the distributor. Embed the reinforcement fabric into the bituminous binder, and bond it to the pavement. Self-propelled pneumatic tired rollers may be used if deemed necessary by the Engineer.

If fabric is not overlaid the same day, blot it with clean, dry sand before traffic is restored. Sand for blotting will be included in other items for payment. In the event excess binder bleeds

through the fabric before the overlay is placed, blot the excess material by spreading sand on the affected area as directed by the Engineer.

- (d) **Weather Limitations.** Do not apply asphalt binder for installation of the fabric when the ambient air temperature is less than 50°F (10°C) unless otherwise approved by the Engineer.
- (e) **Tack Coat.** If tack coat is required for the pavement overlay, apply it in accordance with Section 407. The bituminous material type, grade, rate of application and temperature shall be approved by the Engineer. Do not use cut-back asphalt or emulsified asphalt containing petroleum distillate.
- (f) **Pavement Overlay.** Placement of the asphalt concrete pavement overlay should closely follow fabric lay down unless otherwise permitted by the Engineer.

NOTE: Any damage or disbonding of the fabric reinforcement membrane caused by traffic or wet weather conditions shall be repaired at the Contractors expense.

The temperature of the paving mix at time of placement on the reinforcement fabric membrane shall not exceed 325°F (163° C) to prevent damage to the fabric. The turning of pavers or other vehicles should be gradual and kept to a minimum to avoid damage to the fabric. Should equipment tires pick up the fabric or the paver cause movement of the membrane during paving operations, asphalt paving mix may be broadcast ahead of trucks and the paver to prevent damage.

NOTE: Any damage to the reinforcement membrane due to equipment shall be repaired at the Contractor's expense.

420.05. METHOD OF MEASUREMENT.

Fabric reinforcement will be measured by the square yard (square meter) in place.

Bituminous binder will be measured by the gallon (liter) in accordance with Subsection 109.01(a).

420.06. BASIS OF PAYMENT.

The accepted quantities of fabric reinforcement and bituminous binder, measured as provided above, will be paid for at the contract unit price as follows:

- (A) FABRIC REINFORCEMENT SQUARE YARD (SQUARE METER)
- (B) BITUMINOUS BINDER. GALLON (LITER)

Such payment shall be full compensation for furnishing all materials, equipment, labor and incidentals to complete the work as specified.

SECTION 425 DIAMOND GRINDING CONCRETE PAVEMENT

425.01. DESCRIPTION.

This work shall consist of grinding portland cement concrete pavement to restore drainage and riding characteristics to the pavement surface. This work shall be accomplished in accordance with these Specifications and in reasonably close conformity to the details shown on the Plans.

425.03. EQUIPMENT.

The grinding equipment shall be a power driven, self-propelled machine that is specifically designed to smooth and texture portland cement concrete pavement with diamond blades. The effective wheel base of the machine shall not be less than 12 feet (3.6 m). It shall have a set of pivoting tandem bogey wheels at the front of the machine and the rear wheels shall be arranged to travel in the track of the fresh cut pavement. The center of the grinding head shall be no further than 3 feet (0.9 m) forward from the center of the back wheels.

The equipment shall be of a size that will cut or plane at least 3 feet (0.9 m) wide. It shall also be of a shape and dimension that does not encroach on traffic movement outside of the work area. Equipment that causes excessive ravels, aggregate fractures, spalls, or disturbance of the transverse and longitudinal joints or cracks will not be permitted.

Other equipment may be considered in accordance with Subsection 108.06.

425.04. CONSTRUCTION METHODS.

- (a) **Grinding Pavement.** The Plans will designate the areas of pavement surfaces to be ground. Grinding shall be performed in the longitudinal direction so that grinding begins and ends at lines normal to the pavement centerline. The entire area designated on the Plans shall be ground until the pavement surfaces of adjacent sides of transverse joints and cracks are in the same plane. Extra depth grinding to eliminate minor depressions in the pavement to obtain 100% texturing will not be required.

Schedule the construction operation in a manner that produces a uniform finished surface. Grind in a manner that eliminates joint or crack faults, and provides positive lateral drainage by maintaining a constant cross-slope between the edges of grinding operations. Auxiliary or ramp lane grinding shall transition as required from the mainline edge to provide positive drainage and an acceptable riding surface.

- (1) **Surface Texture and Grooving.** The grinding process shall produce a pavement surface that is uniform in appearance with a longitudinal line type texture. The surface shall have grooves between 0.09 to 0.15 inches (2 to 4 mm) wide, spaced up to 1/8 inch (3 mm) apart. The peaks of the ridges shall be a minimum of 1/16 inch (1.5 mm) higher than the bottom of the grooves.
- (2) **Slurry Removal.** Provide positive means for removal of grinding slurry or residue by vacuum or other continuous methods. In no case shall slurry be allowed to flow across lanes being used by traffic.

(3) Pavement Smoothness.

- 3.1 *Profiling Pavement Surface.* Profile all ground surfaces in accordance with ASTM E 1274. The profilograph shall have non-uniformly spaced wheels. Pavement so tested shall have a profile index of 5 inches (125 mm) or less using a 0.2 inch (5 mm) blanking width. Reduce by grinding individual high points in excess of 0.3 inch (8 mm), as determined by measurements of the profilograph, until they no longer exceed 0.3 inch (8 mm).

After individual high points have been reduced, perform additional grinding as necessary to reduce the profile index to values specified above in any 0.1 mile (0.16 km) section along any line parallel with the pavement edge. All ground areas shall be neat rectangular areas of uniform surface appearance.

- 3.2 *Straight Edge Tolerance.* At locations to be determined by the Engineer, straightedge the surface with a straightedge 10 foot (3 meters) long. When the straightedge is laid on finished pavement parallel to centerline or normal to the centerline, the maximum distance to the roadway surface from the bottom edge of the straightedge shall not exceed 1/8 inch (3 mm) at any point. Additional grinding will be required at the locations found in excess of the 1/8 inch (3 mm) tolerance.

- (b) **Traffic Control.** Traffic control shall be in accordance with the Manual on Uniform Traffic Control Devices.

NOTE: Overnight closure of traffic lanes for the sole purpose of grinding pavement will not be permitted.

425.05. METHOD OF MEASUREMENT.

Diamond grinding concrete pavement will be measured by the square yard (square meter). The square yards (square meters) measured will be the final textured surface area regardless of the number of passes required to achieve acceptable results. Minor areas of untextured pavement within the designated areas to be textured will be included in the measurement.

425.06 BASIS OF PAYMENT.

The accepted quantities, measured as provided above, will be paid for at the contract unit price as follows:

DIAMOND GRINDING
CONCRETE PAVEMENT SQUARE YARD (SQUARE METER)

Such payment shall be full compensation for furnishing all materials, equipment, labor and incidentals necessary to complete the work as specified.

SECTION 426 PRESSURE GROUTING PORTLAND CEMENT CONCRETE PAVEMENT

426.01. DESCRIPTION.

This work shall consist of pumping a fly ash cement grout under portland cement concrete pavement. The grout shall fill the voids beneath the pavement with a mixture that will form a hard, insoluble mass. The grout shall be pumped through injection holes cored through the pavement slabs.

426.02. MATERIALS.

Materials shall meet the requirements specified in Subsection 733.09.

426.03. EQUIPMENT.

- (a) **Grouting Equipment.** The equipment used for pressure grouting shall consist of at least the following:
- (1) **Measuring and Proportioning Equipment.** Furnish measuring and proportioning equipment to accurately measure and proportion by weight the materials composing the grout. Prepackaged materials may be used as approved by the Engineer.
 - (2) **Batch Mixing Tank.** The batch mixing tank shall be watertight, containing a high speed mixer capable of blending the materials into a homogenous mixture. The mixer shall be equipped with a rotor operating in close proximity to a stator, creating a high shearing action. The mixing pump shall have a circulation capacity greater than 250 gallons per minute (950 L/min.) providing recirculation of the materials through the mixer and the mixing tank.
 - (3) **Holding Tank.** Furnish a holding tank with a paddle-type agitator to be used between the batch mixing tank and the grout pump for continuous operation. The agitator shall ensure complete circulation to keep the grout in suspension and remove air bubbles from the mix.
 - (4) **Grout Pump.** Furnish a grout pump consisting of a single acting plunger pump with a high-speed back stroke. The pump shall be equipped with precise pressure and capacity control valves which allow the presetting of both maximum pressure and flow independently. Whenever the preset pressure is reached, the pump shall automatically stop and maintain that pressure without fluctuation. The pump shall facilitate a capacity range of 0 to 30 gallons per minute (110 L/min.) and a pressure range of 0 to 100 psi (690 kPa).
 - (5) **Discharge Line.** The discharge line shall be furnished with a positive cutoff valve at the nozzle end, which will have a nozzle or device that will remain secure in the cored holes and be free of leaks.
 - (6) **Lift Measuring Device.** Equipment to measure slab lift shall be capable of determining movement at the outside slab corner adjacent to a joint. The device shall be a standard Benkelman Beam or other approved equipment and have the capability of making such measurement of 0.001 inch (0.025 mm).
- (b) **Coring Equipment.** Furnish coring equipment capable of cutting 2 inch (50 mm)diameter holes through the concrete pavement, and operate it so as to prevent damage to the pavement from excessive down pressure.

NOTE: Air driven or hydraulic impact drills will not be allowed.

426.04. CONSTRUCTION METHODS.

- (a) **General.** Exercise sufficient precautions during all operations to ensure that slabs are not broken or cracked.

NOTE: Any slabs cracked or broken during this operation shall be replaced at the Contractor's expense.

- (b) **Weather Limitations.** Do not start pressure grouting unless the ambient temperature is at least 35°F (2°C) and rising; and stop if the temperature is 45°F (7°C) and falling. The temperature of the pavement while pressure grouting shall not be less than 35°F (2°C).
- (c) **Coring Holes.** Core 2 inch (50 mm) diameter injection holes through the pavement at locations and depths shown on the Plans. The hole pattern and spacing may be modified by the Engineer. If there are irregular or unsatisfactory holes which cannot be satisfactorily used in pressure grouting, temporarily plug them or fill them with grout, and do not measure them for payment. Instead, core new holes. Do not core more holes than can be grouted during the same day, unless specific approval is given by the Engineer.
- (d) **Clearing Holes.** After the holes are cored to the depths shown on the Plans, and within 10 minutes of pumping the grout, clean the holes of debris to provide a passage for the grout. Do this by inserting a pipe nozzle into the holes and applying sufficient water pressure to clean the holes.
- (e) **Grouting.** The grout flow rate while pumping shall be a maximum of 7 gallons per minute (26.5 L/min.) at the pump head. The nozzle of the grout discharge hose shall be secured in the hole in a manner that provides a seal adequate to maintain the grout pressure underneath the slab. The nozzle end shall not extend below the bottom of the concrete. Pumping shall continue in a hole until the slab corner is lifted 0.032 to 0.036 inches (0.825 to 0.925 mm), or until the pressure gauge in the discharge line indicates a pressure exceeding 60 psi (414 kPa). If the slab does not lift and there is no pressure buildup, then pumping shall continue until the amount of clear grout flowing up through joints or cracks equals the amount of grout injected. Repeat this procedure in other holes until it is clear that all voids have been filled.

During pumping, pay close attention to the lift measuring device to prevent rapid lift of the slabs or substantial raising of the adjacent shoulders. Provide personnel and equipment to satisfactorily control the lift on every slab that is pressure grouted. Temporary plugging of adjacent holes may be required during pumping operations.

- (f) **Permanently Sealing Holes.** Remove all grout from the holes and fill them with a stiff sand-cement mortar composed of one part portland cement to three parts fine aggregate, by volume, or a commercial quality premixed rapid set mixture.

NOTE: Filled holes that ravel out or become damaged shall be repaired at the Contractor's expense.

- (g) **Regrouting.** If, in the judgment of the Engineer, a slab may benefit from additional grouting, regrout any such slab. Core new holes for regrouting as specified by the Engineer.

- (h) **Clean Up.** Remove deposits of grout on the pavement or shoulders, and clean the surface before traffic is permitted on the completed sections. Remove other debris, bags, spillage, etc., from the right-of-way each day.
- (i) **Opening to Traffic.** Restrict traffic from the grouted slabs for three days.

426.05. METHOD OF MEASUREMENT.

Core holes shall be measured by each.

Portland cement incorporated into the grouting mix will be measured by the ton (metric ton).

Fly ash incorporated into the grouting mix will be measured by the ton (metric ton).

Water used in the grout mix will not be measured for payment.

426.06. BASIS OF PAYMENT.

The accepted quantities of cored holes, portland cement and fly ash, measured as provided above, will be paid for at the contract unit price as follows:

- (A) CORED HOLES EACH
- (B) PORTLAND CEMENT TON (METRIC TON)
- (C) FLY ASH TON (METRIC TON)

Such payment shall be full compensation for furnishing all materials, equipment, labor and incidentals to complete the work as specified.

SECTION 433

RUBBLIZING PORTLAND CEMENT CONCRETE PAVEMENT

433.01. DESCRIPTION.

This work shall consist of rubblizing and seating existing portland cement concrete (PCC) pavement.

433.03. EQUIPMENT.

- (a) **Pavement Breaker.** Rubblizing shall be accomplished with a self-contained, self-propelled, resonant frequency pavement rubblizing unit capable of producing low amplitude 2000 pound (9 kN) force blows at a rate of not less than 44 cycles per second. The unit shall also be equipped with a water mist system to suppress dust generated by the operation. The rubblizing unit shall be capable of delivering such energy as may be necessary to satisfactorily fracture the pavement. A screen satisfactory to the Engineer shall be provided to protect vehicles in the adjacent lane from flying chips during the fracturing process when necessary.
- (b) **Roller.** Use a vibratory, steel wheel roller weighing a minimum of 10 tons (9 metric tons) to compact the rubblized pavement. The self-propelled unit shall be capable of varying both the vibration amplitude and frequency.

433.04. CONSTRUCTION METHODS.

- (a) **General.** Rubblize and seat portland cement concrete pavement across the full depth and panel width of the pavement. A joint shall either be saw cut full depth or load transfer devices shall be severed at an existing joint on ramps or mainline where rubblizing abuts PCC pavement which is to remain in place.

Except at restricted crossover and ramp crossings, have the full overlay in place prior to opening to traffic.

Exercise care during rubblizing and seating by operating the resonant breaker at a maximum amplitude of 1 inch (25 mm) for the protection and prevention of damage to underground utilities and drainage facilities.

Any asphalt pavement patch with a surface area of one square meter or larger shall be removed full depth and replaced with traffic-bound surface course Type E meeting the requirements of Subsection 703.03 and/or material as specified on the Plans. Measurement and payment will be in accordance with Section 403.

Remove any asphalt pavement overlay down to the concrete pavement.

- (b) **Rubblizing of Portland Cement Concrete Pavement.** Break the existing portland cement concrete pavement so that the majority of the pavement material shall be generally of 6 inch (150 mm) size or smaller, with no more than 20 percent of the material larger than 6 inches (150 mm), and no individual fragments larger than 8 inches (200 mm). The extent of the breakage will be based on cracks visible to unaided normal vision when the pavement surface is dry.

NOTE: The use of water to detect additional cracks will not be permitted.

Begin rubblizing at the edge of pavement and proceed toward the longitudinal centerline of the road. In areas where the roadway must be overlaid one lane at a time, extend initial rubblizing a minimum of 6 inches (150 mm) beyond the width of the pavement to be overlaid.

In areas where the pavement cannot be rubblized as specified, remove the pavement, undercut by 2 feet (600 mm), and replace with compacted aggregate base.

Debond steel reinforcement from the pavement, and leave it in place. Cut any exposed steel below the surface.

Continuously monitor the rubblizing operation, and make adjustments in the striking pattern, striking energy, number of passes, or other factors as necessary to continually achieve acceptable fracturing throughout the project.

- (c) **Test Section.** Before rubblizing operations begin, the Engineer will designate a test section. Rubblize the test section using varying energy and striking patterns and, if necessary, repeated passes of the equipment over the pavement until the test section is acceptably fractured as specified in Subsection (b) above. The extent of breakage of the test section shall be used as a guide for breaking the pavement on the remainder of the project. The Engineer may require additional test sections at any time during the course of the work that the size requirements are not being met.

- (d) **Seating of Rubblized Portland Cement Concrete Pavement.** After rubblizing, seat the broken concrete by rolling it with the steel wheel roller with at least three passes in the vibratory mode at a maximum speed of 4 mph(6 km/H). Additional passes may be required by The Engineer for sufficient compaction.
- (e) **Leveling Course.** The placement of an asphalt concrete pavement leveling or base course as may be designated on the Plans, for the type specified under other items of work, shall follow the pavement rubblizing and seating operation as closely as is practical.

433.05. METHOD OF MEASUREMENT.

Rubblizing pavement will be measured in square yards (square meters). The width will be the actual width of the existing portland cement concrete pavement, and the length will be measured horizontally along the centerline of each roadway or ramp.

433.06. BASIS OF PAYMENT.

Accepted quantities of rubblizing and seating portland cement concrete pavement, measured as provided above, will be paid for at the contract unit price as follows:

RUBBLIZING PAVEMENT SQUARE YARD (SQUARE METER)

Such payment shall be full compensation for furnishing all labor, equipment, materials, and incidentals necessary to acceptably rubblize and seat the existing portland cement concrete pavement and suppress dust until the initial leveling course or base is placed.

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SECTION 501

EXCAVATION AND BACKFILL FOR STRUCTURES

501.01. DESCRIPTION.

- (a) **General.** Excavation consists of the removal of all material, of whatever nature, necessary for the construction of bridges, retaining walls, and other major structures as specified in the contract documents. This work also includes the disposal of excess excavated material.

If not otherwise provided for in the contract documents, excavation work shall include the furnishing of all necessary equipment and the construction of and subsequent removal of all cofferdams, shoring, and water control systems which may be necessary for the execution of the work. If the contract does not include a separate pay item, or items, for such work, excavation work shall include all necessary clearing and grubbing and the removal of existing structures within the area to be excavated.

Backfill consists of placing of all necessary backfill material including any necessary stockpiling of excavated material which is to be used in the backfill and the disposing of excess excavated material which is not required for use in the project, if not otherwise specified in the contract documents.

Excavation and backfill shall be done in reasonably close conformity with the lines, grades and typical cross sections shown on the contract drawings or established by the Engineer.

Comply with all environmental regulations including the requirements of the United States Army Corp of Engineers 404 Permit when applicable.

- (b) **Classification.** Excavation and backfill for structures will be classified as follows:
1. *Unclassified Excavation.* Unclassified Excavation, as provided in Section 202, consists of the removal of all material, of whatever nature, for the construction of box culverts, channels, ditches at culvert inlets and outlets, and any other ditches as shown on the contract drawings or directed by the Engineer.
 2. *Structural Excavation, Unclassified.* Structural Excavation, Unclassified consists of the removal of all material, of whatever nature, below the level of Unclassified Excavation for the construction of box culverts, at the specified locations and elevations.
 3. *Substructure Excavation, Common.* Substructure Excavation, Common consists of the removal of all materials for the construction of substructures, piers and abutments, except those classified as substructure excavation, rock.
 4. *Substructure Excavation, Rock.* Substructure excavation, Rock consists of the removal of solid rock, redbed, shale, slate, or other hard material that cannot be excavated without first being loosened or broken by blasting, sledging or drilling for the construction of substructures, piers and abutments. Rock ledges encountered above the foundation material and, boulders or pieces of concrete having a volume of 0.5 cubic yards (0.5 cubic meter) or more, will be classified under this item.

The amount of substructure excavation, rock will be determined by the Engineer and agreed to by the Contractor while the excavation is open for inspection. Claims for additional

quantities under this classification over the amount determined during the progress of the work will not be recognized.

5. *Unclassified Backfill, Select Backfill, and Granular Backfill.* Unclassified Backfill, Select Backfill, Granular Backfill consists of supplying, placing, and compacting unclassified borrow, select borrow, granular backfill material, respectively, according to the requirements of Section 202, these specifications, and the contract documents.
 6. *Controlled Low-Strength Material (CLSM) Backfill.* CLSM Backfill consists of supplying and placing of controlled low strength material in excavations or other confined or formed spaces.
- (c) **Obstructions.** The removal and disposal of buried natural or man-made objects are to be included in the class of excavation in which they are located, unless specifically included in other items of work. The removal and disposal of man-made objects will be paid for as extra work and its volume not included in the measured quantity of excavation if:
- the removal of the man-made object requires the use of methods or equipment not used for other excavation on the project, and
 - its presence was not indicated in the contract drawings, and
 - its presence could not have been ascertained by site investigation, including contact with identified utilities within the area, and
 - the Contractor so requests in writing before its removal.

501.02. MATERIALS.

- (a) **Backfill - General Requirements.** Materials used for backfill shall be free of frozen lumps or other degradable or hazardous matter, and shall have a gradation such that the required compaction can be consistently obtained using the compaction methods selected.

Unclassified backfill shall comply with the requirements for Unclassified Borrow as specified in Section 202. Select backfill shall comply with the requirements for Select Borrow as specified in Section 705. Granular backfill shall comply with Subsection 703.05. Granular backfill for MSE walls shall comply with Section 510.

- (b) **Controlled Low-Strength Material (CLSM).**

1. *General.* Make CLSM from materials conforming to the following sections and subsections.

Portland Cement	701.02
Fly Ash	702
Fine Aggregate	701.05
Water	701.04
Air Entraining Agent (optional)	701.03

2. *Mix Design.* Use the sample mix proportions given in Table 501-1 as a guide to proportioning CLSM. Adjust the mix design to account for differences in specific gravities and bleeding rate, and to comply with the testing requirements. Use the absolute volume method to design the mix.

Table 501-1
Sample CLSM Mix Design

<u>Ingredient</u>	<u>Pounds per Cubic Yard</u>	<u>(Kilograms per Cubic Meter)</u>
Cement	20-50	12-30
Fly Ash	150-250	90-150
Sand (saturated- surface-dry condition)	2800-3000	1700-1800
Water	200-500	120-300

Submit for approval the proposed mix design with trial batch testing data before use. Include the weight, specific gravity, material source and other material requirements for each ingredient, and the results of the flowability, unit weight, and strength tests from the trial batch. Use the methods described in Subsection 501.02(b) 3. Previously used and successful mix designs may be submitted without retesting if the material sources have not changed.

If bleed water does not appear on the surface immediately after the CLSM levels off, replace 50 lb/C.Y. (30 kg/cubic meter) approximately 60 lb/C.Y. (35 kg/cubic meter) replacement rate depends upon the actual specific gravities of the fly ash and sand.) Continue this process incrementally until the mixture bleeds freely.

3. *Sampling and Testing.* Provide ample CLSM for field testing. The testing methods are as follows:
 - 3.1 *Flow Test.* Flow tests shall be conducted in accordance with ASTM D 6103, "Standard Test Method for Flow Consistency of Controlled Low Strength Material." To be acceptable, the diameter of the CLSM spread must equal or exceed 8 inches (200mm).
 - 3.2 *Unit weight.* Unit weight tests shall be conducted in accordance with ASTM D 6023, "Standard Test Method for Unit Weight, Yield, Cement Content, and Air Content (Gravimetric) of Controlled Low Strength Material." A deviation of 5% in measured unit weight from the approved mix design value will be cause for rejection of a CLSM batch.
 - 3.3 *Strength Test.* Compressive strength tests shall be conducted in accordance with ASTM D 4832, "Standard Test Method for Preparation and Testing of Controlled Low Strength Material." Strength shall be measured at 28 days. The Contractor may test CLSM strength earlier than 28 days to confirm the material placed has reached the minimum required strength. Report all cylinder breaks. To be acceptable, the compressive strength must be more than 100 psi (700kPa) and less than 1200 psi (8000kPa). If 28 day strengths exceed 1200 psi (8000kPa), adjust the mix design to reduce strength.

501.04. CONSTRUCTION METHODS.

(a) Excavation.

1. *Depth of Footings.* Consider planned elevations for the bottom of footings to be approximate. The Engineer may order in writing changes in dimensions or elevations of footings as may be necessary to secure a satisfactory foundation. Boring logs shown on the Plans were made

for the purpose of designing the foundation. Interpret and confirm the boring information for construction as needed.

2. *Foundation Preparation and Control of Water.*

- 2.1 *General.* Construct all substructures, where practical, in open excavation and, where necessary, shore, brace, or protect by cofferdams, the excavation in accordance with the requirements of Subsection 502.04(d).

When footings can be placed in the dry without the use of cofferdams, backforms may be omitted with the approval of the Engineer, and the entire excavation filled with concrete to the required elevation of the top of the footing. The additional concrete required shall be furnished and placed at the expense of the Contractor. Construct temporary water control systems according to Subsection 502.04(e).

Make excavations adjacent to abutments, wings, and retaining walls vertical or broken by “stepping” before backfilling.

Remove existing structures as shown on the contract drawings according to Subsection 619.04(b).

- 2.2 *Excavation within Channels.* Clear the right-of-way according to Section 201 for the full length of the bridge unless otherwise specified.

Keep creek and river banks in their natural state as much as possible. Do not excavate or cut banks up or downstream except as specified or directed. Submit proposed work road location for approval. Construct work roads in approved locations only. Restore all bank cuts and work roads to their original shape, density and condition in an approved manner.

Obtain approval before excavating or dredging outside of caissons, cribs, cofferdams, steel piling or sheeting, and before disturbing the natural stream bed adjacent to the structure. Backfill and compact excavation outside these structures according to Subsection 501.04(b) to the original ground surface without extra charge. Remove excess excavated material within the stream area, and restore the stream area to its natural condition.

- 2.3 *Foundations on Rock.* Excavate solid rock or other hard foundation material to the depth shown on the Plans or as directed. Remove all loose and disintegrated material from the excavation. Make the final surface entirely level or in level steps as shown on the contract drawings, or as directed. Do not disturb solid rock outside the neat lines of the footing. Clean out all seams and fill with concrete or CLSM before the footing is placed.

Where blasting is required to reach footing level, remove and replace any loose, fractured rock caused by overbreak below the bearing level with concrete at no additional cost to the Department.

- 2.4 *Foundations not on Rock.* When a foundation is to rest on an excavated surface other than rock, take special care not to disturb the bottom of the excavation. Do not make the final removal of foundation material to grade until just before the footing is to be placed.

Where the material below the bottom of the footings not supported by piles has been disturbed, remove the disturbed material and fill the entire disturbed volume with concrete or CLSM at no additional cost to the Department. Under footings supported on piles, replace and compact disturbed volumes as directed.

For box culvert excavation, remove poor foundation material below the normal designed elevation as directed. Replace material removed below designed elevation with approved bedding material. Open outlets for the effective width of the structure before constructing footings of box culverts.

- 2.5 *Approval of Foundation.* After each excavation is completed, notify the Engineer that the excavation is ready for inspection and evaluation, and, after the Engineer has approved the depth of the excavation and the character of the foundation material, place the footing concrete. Do not place concrete through water unless approved by the Engineer.

(b) **Backfilling.**

1. *General.* Place and compact backfill and embankment according to Section 202, except as modified in this subsection. If sufficient material of suitable quality is not available from excavation within the project limits, import such material as directed. Supply the type of backfill materials specified.

Unless otherwise specified in the contract documents, refill all spaces excavated and not occupied by abutments, piers, or other permanent work, with earth up to the surface of the surrounding ground, allowing for settlement. Except as otherwise provided, thoroughly compact all backfill to the density of the surrounding ground, and neatly grade its top surface. Deposit fill around piers on both sides to approximately the same elevation at the same time. Do not place rocks larger than 3 inches (75mm), maximum dimension, against concrete surfaces.

Place fill for retaining walls, abutments, wingwalls, and bridge bents in well-compacted layers not exceeding 6 inches (150 mm) in thickness and bring up uniformly on all sides of the structure or facility. Place fill behind abutments to subgrade elevation. Compact backfill within or beneath embankments, within roadways in excavated areas, or in front of abutments and retaining walls or wingwalls, to the same density required for the embankments. Unless otherwise specified in the Plans or Special Provisions, compact fill in embankments to not less than 95% of Standard Density in accordance with AASHTO T-99.

Allow concrete in structures against which backfill is to be placed, to mature according to the requirements of Subsection 509.04(i)2, "Earth Loads."

To prevent the possibility of forward movement, place the backfill in front of abutments and wingwall before placing backfill behind these structures. Do not jet the backfill behind abutments or wingwalls. Operate rollers, vibrators, or other approved compactors parallel to the outside lines of barrels and wing walls of cross drains. Compact areas inaccessible to rolling equipment with mechanical tampers.

2. *Placing CLSM.* Discharge CLSM into the work after the completion the required testing and acceptance of the material. Bring up the fill material uniformly to the elevation specified in

the contract documents. Placing of material over CLSM may commence as soon as the surface water is gone or as directed.

3. *Disposal of Surplus.* Clean up areas affected by the construction according to Subsection 104.10. Do not place excess material in the stream bed. Remove obstructions that may collect drift, induce scour, or endanger the work as directed. Dispose of excavated and removed materials not used in the project. (These unused, waste materials will be the property of the Contractor.)

501.05. METHOD OF MEASUREMENT.

- (a) **General.** Excavation for structures will be measured by volume in units of cubic yards (cubic meter). The volume will be computed based upon the material actually removed from its original position within the limits specified below, or as shown on the contract drawings. Additional volume caused by slips, slides, cave-ins, silting or filling due to the action of the elements or carelessness will not be measured for payment. Water will not be classified as excavated material. The disposal of excess material will not be measured and paid for separately, but will be considered incidental to the various classes of excavation and removal. Additional concrete required to fill any excavation outside the neat lines shown on the contract drawings will not be measured for payment.

Backfill for structures will be measured as specified in Subsection 501.05(f).

- (b) **Excavation for Box Culverts.**

1. *Unclassified Excavation.* For concrete boxes, the difference in elevation between the existing ground surface and the design flow line will be used to measure excavation depth. Unless otherwise specified, the base width of the excavation will be 8 feet (2.4m) wider (4 feet (1.2m) on each side) than the outside limits of the barrel of the structure. Side slopes will be 2:1 from the design flow line to the existing ground line. The length of the channel excavation will be measured along the center line to a point on the imaginary line connecting the outer ends of the wingwalls plus 15 feet (5m), to a similar point at the other end of the box. The volume of excavation as specified will be computed on a theoretical basis and will be paid for as unclassified excavation in accordance with Section 202. Except as otherwise directed, do not excavate the channel below the flow line elevation outside the neat lines of the concrete base.
2. *Structural Excavation, Unclassified.* Excavation for the base slab will be measured for payment as structural excavation, unclassified. The volume will be computed on a theoretical basis with the height and width dimension to the neat lines of the base slab of the box shown on the contract drawings. The length will be measured along the centerline to a point on the imaginary line connecting the outer ends of the wingwalls to a similar point at the other end of the box. Additional measurement and payment outside the theoretical dimensions defined above will not be made for curtain walls, wingwall footings, and aprons. Sheeting and shoring or extra excavation beyond the limits defined above will be considered as Contractor convenience and will not be measured for payment.

Soft and yielding material encountered at the bottom of the footing of boxes shall be removed and replaced with stable bedding material as directed. The materials removed and

replaced will be paid for as structural excavation, unclassified based upon double the volume of soft and yielding material removed.

- (c) **Excavation for Substructures Supported on Piling.** Excavation for substructures, piers and abutments, supported on piling will be measured as Substructure Excavation, Common. The excavation volume for each substructure will be bounded by the existing ground surface, the bottom of the footing, and vertical planes 3 feet (1m) outside the neat lines of the footing for the entire depth of the excavation. The existing ground surface will be the bottom of channel excavation when channel excavation is specified in the contract documents or directed by the Engineer.
- (d) **Excavation for Substructures Supported on Natural Foundation Materials.** Excavation for substructures, piers and abutments, supported on natural foundation materials will be measured as either Substructure Excavation, Common or Substructure Excavation, Rock. The excavation volumes will be computed as described above in Subsection 501.05(c), except the quantity below the top of the approved foundation material, will be computed within the neat lines of footings as shown on the contract drawings or as directed by the Engineer. Measurement of abutment excavation volumes will be based on contract drawings quantities.
- (e) **Excavation for Bracing.** Excavation necessary to place sway bracing, sash bracing and bulkheads on timber substructures will not be paid for as a separate item, but will be included in the price bid for such construction items.
- (f) **Backfilling.** Backfill for each type of specified backfill material, will be measured by volume within the neat lines shown on the contract drawings or as directed by the Engineer.

501.06. BASIS OF PAYMENT.

The accepted quantities of excavation measured as provided above, shall be paid for at the contract unit price for:

- (A) STRUCTURAL EXCAVATION, UNCLASSIFIED CUBIC YARD (CUBIC METER)
- (B) SUBSTRUCTURE EXCAVATION, COMMON CUBIC YARD (CUBIC METER)
- (C) SUBSTRUCTURE EXCAVATION, ROCK CUBIC YARD (CUBIC METER)

which will be full compensation for the respective work prescribed in this Section. Backfilling to existing ground line around structures will not be paid for as a separate item, but will be included in the cost of excavation for the various types of structures.

Accepted quantities of backfill, measured as provided above, shall be paid for at the contract unit price for:

- (D) UNCLASSIFIED BACKFILL CUBIC YARD (CUBIC METER)
- (E) SELECT BACKFILL CUBIC YARD (CUBIC METER)
- (F) GRANULAR BACKFILL CUBIC YARD (CUBIC METER)
- (G) CLSM BACKFILL CUBIC YARD (CUBIC METER)

which will be full compensation for the respective work prescribed in this Section.

SECTION 502

TEMPORARY STRUCTURES

502.01. DESCRIPTION.

This work consists of designing, constructing, and removing temporary structures used in the construction of highway bridge structures. Temporary structures include falsework, formwork, temporary retaining structures, temporary water control systems, and detour bridges.

Falsework is any temporary construction used to support the permanent structure until it becomes self-supporting. Formwork is the temporary structure or mold used to retain plastic or fluid concrete in its designated shape until it hardens. A temporary retaining structure is used to temporarily hold the surrounding earth and water out of an excavation and to protect adjacent property and facilities during construction of the permanent work. A temporary water control system is used to divert surface water or ground water to prevent such water from entering an excavation. A detour bridge conveys public or construction traffic during construction of the permanent work.

502.02. MATERIALS.

(a) Falsework.

1. *General.* Use materials, new or used, manufactured components, or a combination of these materials in falsework construction. Use concrete, reinforcing steel, and structural steel conforming to the following Sections.

Structural Steel	506
Structural Concrete (<i>Class A</i>)	509
Reinforcing Steel for Structures	511

Supply material certifications for new materials, if directed. Perform concrete tests described in Subsection 701. All salvaged and used material and manufactured components are subject to approval.

2. *Salvaged Steel.* Used structural steel satisfying ASTM A6 criteria for surface imperfections may be used in falsework construction at the allowable working stresses for new material if the grade of steel can be identified. If the steel cannot be identified, use the allowable stresses specified in this Section.
3. *Timber.* All wood species assigned allowable stresses in the *National Design Specification for Wood Construction* (NDS) Supplement, 1991 edition, as published by the National Forest Products Association are acceptable for use in falsework construction.
4. *Used lumber.* Used lumber of known species may be used in falsework construction under the following conditions:
 - If the grade is known and the lumber is in good condition, use the allowable stresses not exceeding those for new lumber of the same grade.
 - If the grade is unknown, use the lowest NDS allowable stresses for the species with appropriate reductions for condition.

5. *Manufactured components.* Manufactured components of the following proprietary product classes may be used:
 - Vertical shoring systems including tubular welded frame shoring, tube and coupler shoring, and components thereof.
 - Manufactured assemblies including single-post shores, brackets, jacks, joists, clamps, and similar devices manufactured for commercial use.

(b) **Forms.**

1. *General.* Use concrete forms that are mortar-tight, true to the dimensions, lines, and grades of the structure, and of sufficient strength to prevent appreciable deflection during concrete placement.
2. *Sheathing.* For exposed concrete surfaces, use U.S. Product Standard PS 1 for Exterior B-B (Concrete Form) Class I Plywood or other approved material that will produce a smooth and uniform concrete surface. Use only form panels in good condition free of defects on exposed surfaces. If form panel material other than plywood is used, it shall have flexural strength, modulus of elasticity, and other physical properties equal to or greater than the physical properties for the type of plywood specified.
3. *Structural Support.* Use materials for structural support of forms complying with the materials requirements for falsework. Vertical side forms, wall forms and column forms and related studs, walers, etc. are considered formwork or structural support for formwork.
4. *Prefabricated Formwork.* If prefabricated formwork is to be used, furnish shop drawings under Subsection 105.02 and technical data substantiating load-carrying capacity and detailing application instructions and limitations of use. Use prefabricated products according to manufacturer's recommendations.
5. *Stay-in-Place Steel Deck Forms.* Stay-in-place steel deck forms may be used only when permitted in the contract documents or approved by the Engineer.

If used, meet the requirements for prefabricated formwork. Furnish design calculations with shop drawings. Fabricate stay-in-place steel deck forms and supports from steel conforming to ASTM A 653, Grades 40(275) and 50(340), having a coating class of G165 according to ASTM A 525.

6. *Stay-in-Place Prestressed Concrete Deck Forms.* Stay-in-place prestressed concrete deck forms may be used only when permitted in the contract documents or approved by the Engineer.

If used, meet the requirements for prefabricated formwork. Furnish complete deck design calculations with the shop drawings. Fabricate stay-in-place deck forms according to Section 503.

502.04. CONSTRUCTION METHODS.

- (a) **Falsework.** Employ a professional engineer registered in Oklahoma to design falsework if the falsework is to be more than 14 feet (4.3 m) tall, or traffic, other than workmen involved in constructing the bridge, will travel under the falsework.
 1. *Working Drawings.* Prepare and submit drawings of the required falsework design according to Subsection 105.02. Include the following, as applicable:

- *General.* Design and show the details for constructing falsework that provides the necessary rigidity, supports the loads imposed, and produces the required lines and grades in the finished structure. Use a registered professional engineer proficient in structural design to design, sign, and seal the drawings. The design calculations shall show the stresses and deflections in load supporting members.
 - *Submission Sets.* Submit three sets of falsework drawings and one set of design calculations for approval.
 - *Design Details.* Include the information and details necessary to enable falsework construction without reference to any supplemental drawing, calculation sheet, design standard, or other source document. Show all design-controlling dimensions, including beam length, beam spacing, post location and spacing, vertical distance between connections in diagonal bracing, height of falsework bents, and similar dimensions controlling falsework design and erection.
 - *Foundation Loads.* Show the maximum applied structural load on the foundation material. Include a drainage plan or description of how foundations will be protected from saturation, erosion, and/or scour.
 - *Materials Specifications.* Precisely describe all proposed falsework material. Describe the material that is not describable by standard nomenclature (such as AASHTO or ASTM specifications) based on manufacturer's tests and recommended working loads. Evaluate falsework material and ascertain whether the physical properties and conditions of the material are such that it can support the loads assumed in the design.
 - *Concrete Placement.* Provide an outline of the proposed concrete placement operation listing the equipment, labor, and procedures to be used for the duration of each operation. Include proposed placement rates and design pressures for each pour. Include a superstructure placing diagram showing the concrete placing sequence and construction joint locations.
 - *Settlements.* Show anticipated total settlements of falsework and forms. Include falsework footing settlement and joint take-up. Design for anticipated settlements not to exceed 1 inch (25mm). Design and construct the falsework to elevations that include anticipated settlement during concrete placement and required camber to compensate for member deflections during construction.
 - *Traffic.* Where openings through the falsework are required to permit the passage of public traffic, show the location of all such openings, including horizontal and vertical clearances and the location of temporary railing. For falsework over traffic, show the sequence of falsework erection and removal.

Submit separate falsework drawings for each structure, except for identical structures with identical falsework design and details. Do not start construction of any unit of falsework until the drawings for that unit are reviewed and approved.
2. *Design Limitations.* The allowable maximum design stresses and loads listed in this section are based on the use of undamaged, high-quality material. If lesser quality material is used, reduce the allowable stresses and loads.

Limit the vertical deflection of falsework members to 1/500 of their span under the dead load of concrete. When computing deflection, neglect the deflection-reducing effect of camber strips and use 1700 ksi (11.7GPa) and 30,000 ksi (210GPa) for the modulus of elasticity (E) of wood and steel, respectively.

Do not exceed the following maximum stresses, loads, and deflections in the falsework design:

2.1 *Timber.* For designing timber members, comply with allowable stresses, for the wood species to be used, as assigned by the *National Design Specification for Wood Construction* or the following.

- Compression, perpendicular to the grain = 450 psi. (3.1 MPa)
- Compression, parallel to the grain = $\frac{480,000}{(L/d)^2}$ psi $\left(\frac{3309}{(L/d)^2} \text{ (MPa)} \right)$

or 1600 psi (11 MPa) maximum,

where: L = the unsupported length,
 d = the least dimension of a square or rectangular column or the width of a square of equivalent cross-sectional area for round columns.

- Flexural stress = 1800 psi (12.4MPa) (reduce to 1450 psi (10.0 MPa) for members with a depth of 8 inches (200 mm) or less.)
- Horizontal shear = 190 psi (1.3MPa).
- Axial tension = 1200 psi (8.3MPa).
- Axial loading on timber piles = 45 tons (400KN).

Design timber connections according to the stresses and loads allowed in the *National Design Specification for Wood Construction*, except:

- Reductions in allowable loads required therein for high moisture condition of the lumber and service conditions do not apply.
- Use 75% of the tabulated design value as the design value of bolts in two member connections (single shear).

2.2 *Steel.* For identified grades of steel, do not exceed the allowable design stresses specified in the AISC Manual of Steel Construction except as noted. For all grades of steel, do not exceed the following design stresses:

- Compression, flexural = $\frac{12,000}{Ld/bt}$ ksi $\left(\frac{82,750}{(Ld/bt)} \text{ (MPa)} \right)$

Note: Do not exceed 21.6 ksi (150 MPa) for unidentified steel or steel conforming to ASTM A 36. Do not exceed 0.6 F_y for other identified steel.

where: L = the unsupported length,
 d = the least dimension of a square or rectangular column or the width of a square of equivalent cross-sectional area for round columns or the depth of beams,

- b = the width of the compression flange,
 t = the thickness of the compression flange,
 r = the radius of gyration of the member,
 F_y = the specified minimum yield stress for the grade of steel used.

When the grade of steel cannot be positively identified, do not exceed the allowable design stresses either specified in the AISC Manual for ASTM A 36 steel or the following:

- Tension, axial and flexural = 21.6 ksi (150 MPa)
- Compression, axial = $16 - 0.00038(L/r)^2$ ksi ($110 - 0.00262(4r)^2$ MPa), except L/r shall not exceed 120.
- Shear on the web gross section of rolled shapes = 14.4 ksi (100 MPa)
- Web crippling for rolled shapes = 27.0 ksi (190 MPa)

2.3 *Other requirements.* Limit falsework spans supporting cast-in-place reinforced concrete T-beam girder bridges or slab-span bridges to 13 feet (4m) plus 8.5 times the overall depth of T-beam girder or minimum depth of the slab-span, respectively. This requirement does not apply to either pan girder bridges or prestressed double tee bridges.

2.4 *Manufactured assemblies.* For jacks, brackets, columns, joists and other manufactured devices, do not exceed the manufacturer's recommendations or 40% of the ultimate load carrying capacity of the assembly based on the manufacturer's tests or additional tests ordered. Limit the maximum allowable dead load deflection of joists to 1/500 of their spans.

Furnish catalog or equivalent data showing the manufacturer's recommendations or perform tests, as necessary, to demonstrate the adequacy of any manufactured device proposed for use. Do not substitute other manufacturer's components unless the manufacturer's data encompasses such substitutions or field tests reaffirm the integrity of the system.

If a component of the falsework system consists of a steel frame tower exceeding two or more tiers high, the differential leg loading within the steel tower unit shall not exceed 4 to 1. An exception may be approved if the manufacturer of the steel frame certifies, based on manufacturer's tests, that the proposed differential loadings are not detrimental to the safe load carrying capacity of the steel frame.

3. *Design Loads.* Design falsework for the specified combinations of vertical loads and horizontal loads.

3.1 *Vertical Loads.* Vertical loads consist of the following:

- *Dead Load.* Dead loads include the weight of concrete, reinforcing steel, forms, and falsework. Assume the density of concrete, reinforcing steel, and forms to be not less than 160 lb/ft³ (2600 kg/m³) for normal concrete and not less than 130 lb/ft³ (2100 kg/m³) for lightweight concrete. Consider the entire superstructure, or any concrete weight being supported by falsework to be a fluid dead load with no ability to support itself.

- *Live Load.* Consider live loads to be the actual weight of equipment to be supported by falsework applied as concentrated loads at the point of contact plus a uniform load of not less than 20 lb/ft² applied over the area supported, plus 75 lb/ft (1100 N/m) applied at the outside edge of deck falsework overhangs.
 - *Redistributed Prestress Load.* If the concrete is to be prestressed, design the falsework to support any increased or readjusted loads caused by the prestressing forces.
 - *Impact.* When impact can occur, increase by at least 30% the design load causing the impact on steel members and manufactured components.
 - *Minimum Vertical Load.* Use a minimum total vertical design load of not less than 100 lb/ft² (4800 Pa). The total vertical design load for falsework is the sum of dead and live vertical loads.
- 3.2 *Horizontal Loads.* Horizontal design loads consist of the sum of the actual horizontal loads due to equipment, construction sequence, or other causes and an allowance for wind and stream flow.

Use an assumed horizontal design load on falsework towers, bents, frames, and other falsework structures to verify lateral stability. Design the falsework so the falsework has sufficient rigidity to resist the assumed horizontal load without vertical dead load. Neglect the effects of frictional resistance. Use an additional safety factor against overturning of at least 1.2.

- *Wind Load.* The minimum wind allowance for each heavy-duty steel shoring having a vertical load carrying capacity exceeding 30 kips (130 kn) per leg is the sum of the products of the wind impact area, shape factor, and the applicable wind pressure value for each height zone. The wind impact area is the total projected area of all the elements in the tower face normal to the applied wind. Assume the shape factor for heavy-duty shoring to be 2.2. Determine wind pressure values from Table 502-1.

Table 502-1		
Design Wind Pressure - Heavy Duty Steel Shoring		
Height Zone Above Ground ft (m)	<u>Wind Pressure Value, psf (Pa)</u>	
	<u>Adjacent to Traffic</u>	<u>At Other Locations</u>
0 - 30 (0-9)	20 (960)	15 (720)
30 - 50 (9-15)	25 (1200)	20 (960)
50 - 100 (15-30)	30 (1450)	25 (1200)
Over 100 (over 30)	35 (1675)	30 (1450)

The minimum wind allowance on all other types of falsework, including falsework supported on heavy-duty shoring, is the sum of the products of the wind impact area and the applicable

wind pressure value for each height zone. The wind impact area is the gross projected area of the falsework and unrestrained portion of the permanent structure, excluding the areas between falsework posts or towers where diagonal bracing is not used. Use design wind pressures from Table 502-2.

Table 502-2
Design Wind Pressure - Other Types of Falsework

Height Zone Above Ground ft (m)	Wind Pressure Value, psf (Pa)	
	For Members Over and Bents Adjacent to Traffic Openings	At Other Locations
0 - 30 (0-9)	2.0 Q (320 Qm)	1.5 Q (240 Qm)
30 - 50 (9-15)	2.5 Q (400 Qm)	2.0 Q (320 Qm)
50 - 100 (15-30)	3.0 Q (480 Qm)	2.5 Q (400 Qm)
Over 100 (over 30)	3.5 Q (560 Qm)	3.0 Q (480 Qm)

NOTE Determine the value of Q, if applicable, in the above tabulation as follows:

$Q = 1 + 0.2W$ ($Qm=0.3+0.2W$), but not more than 10 (3). W is the width of the falsework system in feet (meters) measured in the direction of the wind force being considered.

- *Stream Flow.* When falsework supports are placed in flowing water, determine water pressure by the following formula:

$$P_w = C_D V^2 \quad (P_w = 514 C_D V^2)$$

where P_w is the pressure of flowing water in lb/ft²(Pa), V is the water velocity in feet/sec (m/s), and C_D is the drag coefficient having the following values:

- 0.7 for a semicircular nosed pier,
- 1.4 for a square ended pier,
- 1.4 for debris lodged against a pier,
- 0.8 for a wedged nosed pier with nose angle 90° or less.

Investigate scour depths as necessary.

- *Lateral fluid pressure.* For concrete with retarding admixture, fly ash, or other pozzolan replacement for cement, design forms, form ties, and bracing for a lateral fluid pressure based on concrete with a density of 150 lb/ft³ (2400 kg/m³). For concrete containing no pozzolans or admixtures, which affect the time to initial set, determine the lateral fluid pressure based on concrete temperature and rate of placement according to ACI Standard 347R, “*Guide for Formwork for Concrete.*”
- *Minimum Horizontal Load.* Use a minimum horizontal load of at least 2% of the total supported dead load at the location under consideration.

4. *Load Combinations.* Design falsework for the load combinations shown in Table 502-3.

Table 502-3
Load Combination

<u>Load Combination</u>	<u>Percentage of Basic Allowable Stress or Load</u>
DL+DP+LL+I+H	100%
DL+DP+PS+H	100%
DL+DP+LL+I+W+SF	133%
DL+DP+LL+PS+W+SF	133%

where: DL = design dead load,
 DP = dead load of supported permanent structure,
 LL = construction live load,
 I = impact load,
 H = minimum horizontal design load,
 PS = redistributed prestress load,
 W = wind load,
 SF = stream flow load.

5. *Slenderness.* For compression members, limit the slenderness ratio, Kl/r , to the following:

- Main load-carrying members:
 180 for steel,
 100 for aluminum.
- Bracing members:
 200 for steel,
 150 for aluminum.

Limit the slenderness ratio of tension members other than guy lines, cables, and rods, to a maximum of 240 for main members and 300 for bracing members.

6. *Falsework Foundations.* Field verify all ground elevations at proposed foundation locations before design.

Where spread footing type foundations are used, determine the bearing capacity of the soil. The maximum allowable bearing capacity for foundation material, other than rock, is 2 tons/ft² (200 kPa).

Do not locate the edge of footings closer than 12 inches (300 mm) from the intersection of the bench and the top of the slope. Unless the excavation for footings is adequately supported by shoring, do not locate the edge of the footings closer than 4 feet (1.2m) or the depth of excavation, whichever is greater, from the edge of the excavation.

When a pile type foundation is used, construct according to Section 514. When falsework is supported by footings placed on paved, well-compacted slopes of berm fills, do not strut the falsework to columns unless the column is founded on rock or supported by piling.

Size spread footings to support the footing design load at the assumed bearing capacity of the soil without exceeding anticipated settlements. Provide steel reinforcement in concrete footings.

When individual steel towers have maximum leg loads exceeding 30 kips (130kN), provide for uniform settlement under all legs or each tower under all loading conditions.

Protect the foundation from adverse effects for the duration of its use. Advise the Engineer of actions that will be taken to protect the foundation.

7. *Proprietary shoring systems.* If proprietary shoring systems are to be used, furnish a letter of certification from the shoring manufacturer stating that the shoring system is being used in accordance with the manufacturer's recommendations for loads and conditions of use.
8. *Falsework Over or Adjacent to Roadways and Railroads.* Design and construct the falsework to be protected from vehicle impact. Provide protection for:
 - falsework supports for members crossing over a roadway or railroad,
 - other falsework supports if the horizontal distance from the traffic side of the falsework to either the edge of pavement or a point 10 feet (3m) from the centerline of track is less than the total height of the falsework.

Provide additional features to ensure that this falsework will remain stable if subjected to impact by vehicles. Increase vertical design loads by 150% for these falsework supports, including posts, columns, and towers, but not footings.

Install temporary concrete traffic barriers before erecting falsework towers or columns adjacent to an open public roadway. Locate barriers so that falsework footings or pile caps are at least 3 inches (75mm) clear of concrete traffic barriers and all other falsework members are at least 12 inches (300 mm) clear. Do not remove barriers until approved.

Use falsework columns that are steel with a minimum section modulus about each axis of 10 in^3 ($150,000 \text{ mm}^3$) or sound timbers with a minimum section modulus about each axis of 250 in^3 ($4,000,000 \text{ mm}^3$).

Mechanically connect the base of each column or tower frame supporting falsework over or immediately adjacent to an open public road to its supporting footing or provide other lateral restraint to withstand a force of not less than 2000 pounds (9kN) applied to the base of the column in any direction. Mechanically connect such columns or frames to the falsework cap or stringer to resist a horizontal force of not less than 1000 pounds (4.5kN) in any direction. Neglect the effects of frictional resistance.

Mechanically connect all exterior falsework stringers and stringers adjacent to the end of discontinuous caps, the stringer or stringers over points of minimum vertical clearance and every fifth remaining stringer, to the falsework cap or framing. Provide mechanical connections capable of resisting a load in any direction, including uplift on the stringer, of not less than 500 pounds (2.2kN). Install connections before traffic is allowed to pass beneath the span.

Use $\frac{5}{8}$ inch (16mm) diameter or larger bolts to connect timber members used to brace falsework bents located adjacent to roadways or railroads.

Sheath falsework bents within 20 feet (6m) of the centerline of a railroad track solid in the area between 3 feet (1m) and 16 feet (5m) above the track on the side facing

the track. Construct sheathing of plywood not less than $\frac{5}{8}$ inch (16mm) thick or lumber not less than 1 inch (25mm) nominal thickness. Provide adequate bracing on such bents so that the bent resists the required assumed horizontal load or 5000 pounds (22kN), whichever is greater, without the aid of sheathing.

Provide at least the minimum required vertical and horizontal clearances through falsework for roadways, railroads, pedestrians, and boats.

9. *Falsework for Permanent Steel Structures.*

- *General.* Use falsework design loads consisting of the weight of structural steel, the load of supported erection equipment, and all other loads supported by the falsework. Do not apply loads to existing, new, or partially completed structures that exceed the load carrying capacity of any part of the structure according to the AASHTO Bridge Design Specifications.

Build supporting falsework that will accommodate the proposed method of erection without overstressing the structural steel, as required, and will produce the required final structural geometry, intended continuity, and structural action.

- *Overhanging Forms for Bridge Deck Placement.* Brace or tie exterior girders, upon which overhanging bridge deck falsework brackets are hung, to the adjacent interior girders as necessary to prevent rotation of the exterior girders or overstressing the exterior girder web. Strut and tie exterior girders supporting overhanging deck falsework brackets to adjacent interior girders, or use needle beams clamped to the bottom flanges of the exterior girder and the adjacent interior girder. Do not weld to structural steel to attach forms or falsework.

Design falsework and forms for concrete supported on steel structures so that loads are applied to girder webs within 6 inches (150mm) of a flange or stiffener. Distribute the loads in a manner that does not produce local distortion of the web. Space bracing and supports as needed, not exceeding 8 feet (2.5m).

10. *Falsework Construction.* Construct falsework to conform to the approved drawings.

Build camber into the falsework to compensate for falsework deflection and anticipated structure deflection. Camber shown on the plans or specified by the Engineer is for anticipated structure deflection only.

Attach tell-tales to the soffit of concrete forms in enough systematically placed locations to be able to determine from the ground the total settlement of the structure while concrete is placed.

Do not apply dead loads, other than forms and reinforcing steel, to any falsework until authorized.

Discontinue concrete placement and take corrective action, if unanticipated events occur, including settlements that cause a deviation of more than $\frac{3}{8}$ inch (10mm) from those shown on the falsework drawings. If satisfactory corrective action is not taken before initial set, remove all unacceptable concrete.

11. *Inspection and Certification.* When the falsework installation is complete and before concrete placement or removal begins, have the falsework inspected by a registered professional engineer proficient in structural design. Certify in writing that the installation conforms to

the contract, the approved falsework drawings (including approved changes), and acceptable engineering practices. Provide a copy of the certification before concrete placement.

(b) **Forms.**

1. *General.* Construct concrete forms mortar-tight, true to the dimensions, lines, and grades of the structure, and of sufficient strength to prevent appreciable deflection during placement of concrete. Unless otherwise specified, comply with the tolerance requirements (permissible variation from plan) of Table 502-4.

Table 502-4

Maximum Dimensional Tolerances for Cast-in-Place Formed Concrete¹

<u>Item</u>	<u>Tolerance, inch (mm)</u>
Deviation from plan line ²	±1 (25)
Cross-sectional dimensions of columns, piers and beams, slabs, and walls	+1 (25) - ¹ / ₂ (12)
Bridge deck thickness	+ ¹ / ₂ (12) - ¹ / ₄ (6)

1. Variations are to be compared with dimensions shown on the Plans or directed by the Engineer.
2. Tolerance measurement is perpendicular to the plan line or surface. This tolerance includes measurement of alignment, plumb, grade and level. Plumb (or batter) of retaining walls will be inspected both before and after backfilling.

Place all material required to be embedded in the concrete before concrete placement. Clean inside surfaces of forms of all dirt, mortar and foreign material. Remove all loose material before the completion of forming for the roadway deck slab of cast-in-place box girders or cells or voids of other members in which the forms are to either remain in place or be removed. Do not place concrete in forms until the forms have been inspected and approved.

2. *Removable Formwork.* Coat forms to be removed with form oil. Use commercial quality form oil or an equivalent coating that permits release of the forms and does not discolor the concrete.

Furnish and place form panels for exposed surfaces in uniform widths of not less than 3 feet (1m) and in uniform lengths of not less than 6 feet (2m), except where the width of the member formed is less than 3 feet (1m).

Arrange panels in symmetrical patterns conforming to the general lines of the structure. Place panels for vertical surfaces with the long dimension horizontal and with horizontal joints level and continuous. For walls with sloping footings which do not abut other walls, panels may be placed with the long dimension parallel to the footing.

Precisely align form panels on each side of the panel joint by means of supports or fasteners common to both panels. Provide ³/₄ inch (20mm) triangular fillets at all sharp edges of the concrete.

Devices may be cast into the concrete for later use in supporting forms or for lifting precast members. Do not use driven devices for fastening forms or form supports to concrete. Use form ties consisting of form bolts, clamps, or other devices necessary to prevent spreading of the forms during concrete placement.

Do not use form ties consisting of twisted wire loops. Use form ties and anchors that can be removed without damaging the concrete surface. Construct metal ties or anchorages within the forms to permit their removal to a depth of at least 1 inch (25mm) from the face without damage to the concrete. Fill cavities with cement mortar and finish to a sound, smooth, uniform colored surface.

Make forms sufficiently rigid so that the formed concrete surface does not undulate more than $\frac{3}{8}$ inch (9mm), when checked with a 5-foot (1500mm) straightedge or template, or $\frac{1}{360}$ of the center to center distance between studs, joists, form stiffeners, form fasteners, or wales. Interior surfaces of underground drainage structures are considered to be completely enclosed surfaces. Form all exposed surfaces for each element of a concrete structure with the same forming material or with material that produce similar surface textures, color, and appearance.

Support roadway slab forms of box girder type structures on wales or similar supports fastened, as nearly as possible, to the top of the web walls.

3. *Metal forms.* The specifications for forms relative to design, mortar tightness, filleted corners, beveled projections, bracing, alignment, removal, reuse, and oiling also apply to metal forms.
4. *Stay-in-place steel deck forms.*
 - 4.1 *General.* Install forms according to approved fabrication and erection drawings. Do not rest form sheets directly on the top of stringer or floor beam flanges. Securely fasten sheets to form supports with a minimum bearing length of 1 inch at each end. Place form supports in direct contact with the stringer or floor beam flange. Make all attachments with bolts, clips or other approved methods. Do not weld form supports to stringer or floor beam flanges or reinforcing steel.

Clean, wire brush, and paint with two coats of zinc dust zinc-oxide primer, Federal Specification TT-P-641 type II, with no color added, any permanently exposed form metal where the galvanized coating has been damaged. Minor heat discoloration in areas of welds need not be touched up. Discard and replace forms damaged by bending or crimping.

Locate transverse construction joints in slabs at the bottom of a flute. Field drill $\frac{1}{4}$ inch (6mm) weep holes at not less than 12 inches (300mm) on center along the line of the joint. Lap adjacent forms and connect, by means other than welding, form sheets at a maximum of 18 inch (450mm) centers along the lap. In the lap, place on top the panel which will be loaded first during concrete placement.

Use epoxy coated reinforcing steel in bridge floors using stay-in-place forms. If epoxy coated reinforcing steel is not specified by the plans, provide epoxy coated bars at no additional cost. Do not use reinforcing steel, placed directly on the forms, as support chairs.

Provide means for inspection of the underside of forms after concrete placement. After a minimum of 48 hours of curing, the concrete may be tested for soundness and bonding of the forms by sounding with a hammer. Where directed, remove the forms in areas of doubtful soundness. Do not use a cutting torch to remove forms. Do not replace removed forms. Repair or replace concrete as required.

4.2 *Design Requirements.* Design stay-in-place steel deck forms to meet the following criteria.

- *Design Load.* Use a design load consisting of the weight of the forms, reinforcement and plastic concrete plus 50 lb/ft² (2400 Pa) for construction loads.
- *Allowable Bending Stress.* Limit the unit working stress in the steel form sheet to a maximum of 0.725 times the specified minimum yield strength of the material furnished, not exceeding 36 ksi (250 MPa).
- *Allowable Deflection.* Limit the deflection of form sheets to a maximum of 1/240 of the form span, not exceeding $\frac{3}{4}$ inch (20 mm). Use either the calculated design load or 120 lb/ft², whichever is higher, to calculate deflection.
- *Maximum Camber.* Limit form camber to not exceed the deflection under actual load. Do not use camber to compensate for deflection in excess of specified limits.
- *Design span length.* Consider the span length of the form sheets to be the clear distance between the flanges of the supporting beams minus 2 inches (50mm), measured parallel to the form flutes.
- *Design Properties.* Compute physical design properties under the requirements of the "Specification for the Design of Cold Formed Steel Structural Members," published by the American Iron and Steel Institute.
- *Weight Limitation.* Limit the combined weight of the forms and any additional concrete necessitated by the use of stay-in-place forms to a maximum of 10 lb/ft² (0.5 kN/m²), in excess of the original plan weight of the bridge floor.
- *Deck Reinforcement.* Maintain the Plan dimensions of all deck reinforcement from the top surface of the concrete deck. Maintain all cover requirements shown on the Plans.
- *Flange Bracing.* Do not consider stay-in-place forms as lateral bracing for compression flanges of supporting structural members.

4.3 *Shop Drawings.* Prepare shop drawing for stay-in-place steel forms showing the following items as a minimum.

- The layout of the form sheets on the bridge floor identifying form sheets by piece marks.
- The steel grade, and dimensional and section properties for form sheets and supports.
- The type and spacing of chairs.
- Lap details and planned direction of concrete placement.
- Detail views of all connections.
- A complete bill of materials.
- Installation instructions.

- (c) **Removal of Forms and Falsework.** Remove all forms except stay-in-place forms.

The removal of forms that do not support the dead load of concrete members, other than railings and barriers, shall not begin until the concrete has sufficient strength to resist damage to the surface. Protect exposed concrete surfaces from damage.

Unless otherwise specified, do not begin the removal of forms and falsework until the requirements specified in Table 502-5 for minimum time in the forms have been met. Do not release falsework for cast-in-place post-tensioned portions of structures until the prestressing steel has been tensioned.

**Table 502-5
Form and Falsework Release Criteria**

<u>Forms and Falsework Supporting:</u>	
Spans more than 14 feet (4.3m) <u>(i.e., slab spans, pan girders, RCB decks, pier caps)</u>	<u>14 days</u>
Spans of 14 feet (4.3m) or less <u>(i.e., bridge decks on girders, RCB decks, diaphragms, pile bent pier caps)</u>	<u>10 days</u>
<u>Forms:</u>	
Not supporting the dead weight of concrete <u>(i.e., columns, walls, side forms for abutments & pier caps)</u>	<u>24 hours</u>
<u>For railings and barriers</u>	<u>12 hours</u>

1. Continue curing under Section 509 after removing the forms for the structure. Refer to Section 509 for sequence of placement and application of load requirements.
2. Time periods assume concrete curing temperatures more than 50°F (10°C). Add one day for every day having concrete temperatures below 50°F (10°C).
3. Time periods for falsework release may be shortened at the discretion of the Engineer if the concrete has attained 80 percent of the specified strength.

Completely remove falsework material. Remove falsework piling at least 2 feet (0.6 m) below the surface of the original ground or original stream bed. Where falsework piling is driven within the limits of ditch or channel excavation, remove the piling to at least 2 feet (0.6m) below the bottom and side slopes of the excavated areas.

Leave the forms for footings constructed within a cofferdam or crib in place when their removal would endanger the safety of the cofferdam or crib, and where the forms will not be exposed to view in the finished structure. Remove all other forms whether above or below ground line or water level.

(d) **Temporary Retaining Structures.**

1. *General.* Perform excavation under Section 501 and the OSHA Standard outlined in 29CFR 1926, Subpart P. When a temporary retaining structure is required by the Plans, these Specifications, or the OSHA Standard, meet the following requirements.

Sheet and brace vertical-sided excavations as necessary to retain the earth and water pressures and surcharges, and to protect adjacent property and facilities during construction of the permanent work. Use a registered geotechnical engineer to identify the soil type being excavated, if unknown. Use a registered structural engineer to design temporary retaining structures and prepare working drawings. Submit calculations and drawings for the temporary retaining structure before starting the work on the retaining structure.

2. *Cofferdams and Shoring.* Design and construct cofferdams and shoring for foundation construction to be as strong and watertight as necessary to properly perform the work. Size cofferdams to allow pumping outside the concrete forms and concrete placement in the dry.

When water cannot be controlled so that the footing concrete can be placed in the dry, use a cofferdam with a Class A-concrete seal placed underwater below the elevation of the footing. Control the water level within the cofferdam during concrete seal placement to prevent water flow through the seal.

Construct cofferdams so as to protect green concrete against damage from a sudden rising of the stream and to prevent damage from erosion. Do not leave bracing inside the permanent concrete structural members.

Obtain approval to substitute round pier bases of equal stability for square or rectangular bases specified on the Plans. Submit plans of proposed round bases for approval before constructing.

Unless otherwise specified, remove cofferdams and shoring with all sheeting and bracing after the completion of the footing, taking care to not damage the finished permanent work.

(e) **Temporary Water Control Systems.**

1. *General.* Temporary water control systems consist of dikes, bypass channels, flumes and other surface water diversion works, cutoff walls and pumping systems, including wellpoint and deep well systems, used to prevent water from entering excavations for structures.
2. *Working Drawings.* When required on the Plans, submit working drawings for temporary water control systems according to Subsection 105.02. Include details of the design and equipment, operating procedures to be employed, and the location of the point or points of discharge. Design and operate the system in compliance with all applicable water pollution control and environmental requirements.
3. *Operations.* Pump from the interior of any foundation excavation in such a manner as to preclude the possibility of the movement of water through any fresh concrete. Suspend pumping ground water from an excavation during concrete placement and for 12 hours (longer if directed) after concrete placement, unless using a sump separated from the concrete work by a watertight wall or other effective means. Before pumping to dewater a sealed cofferdam, allow the seal to set sufficiently to withstand the hydrostatic pressure.

Regulate pumping from wellpoints or deep wells to avoid damage by subsidence to adjacent property.

- (f) **Detour Bridges.** Construct and maintain the detour bridge according to the contract documents or an approved alternate design.

For alternate detour bridge designs, use a registered professional engineer to design and draw the detour bridge. Submit signed and sealed working drawings and calculations for approval of the alternate design according to Subsection 105.02. The alternate design must be equivalent in all respects to the design and details shown on the Plans. Use the same roadway width and traffic rail specified on the Plans. In the submittal, show clearances, alignment, load capacity, pay item quantities, and other design parameters specified. Design according to AASHTO *Standard Specifications for Highway Bridges*. Use an HS20-44 live load, unless otherwise specified in the contract documents.

To utilize used beams, verify that the beams satisfy the minimum section modulus required by the approved design. Account for section loss due to corrosion, or bent, cracked, or damaged flanges or webs, and fatigue life. Replace unsatisfactory beams as directed at no additional cost to the Department.

Remove detour bridges as specified or directed. Beams shall become the property of the Contractor at the conclusion of the project unless otherwise specified. Painting of beams that are to become the Contractor’s property shall not be required.

502.05. METHOD OF MEASUREMENT.

Forms, including stay-in-place forms, will not be measured for payment. Include the cost of forms in the unit price bid for the appropriate concrete pay items. When stay-in-place forms are used for bridge floors, concrete and reinforcing steel quantities will be computed based upon the conventionally formed design shown in the contract drawings.

Engineered falsework, not including engineering services, will be measured as a lump sum. *Falsework engineering services*, when required, to design, draw, inspect, and certify falsework will be measured as a lump sum.

Other falsework will not be measured for payment. Include the cost of this falsework in the unit price bid for the appropriate concrete pay items.

Temporary retaining structures and temporary water control systems will not be measured for payment. Include the cost of this work in the price bid for related excavation pay items.

Detour bridges, not including piling or drilled shafts, will be measured as a lump sum. Piling and drilled shafts will be measured as specified in the contract documents.

502.06. BASIS OF PAYMENT.

The accepted quantities, measured as specified in this Section, will be paid at the contract price per unit of measurement for the pay items listed below that are shown in the Plan bid schedule. Payment will be full compensation for the respective work prescribed in this Section.

- (A) ENGINEERED FALSEWORK LUMP SUM
- (B) FALSEWORK ENGINEERING SERVICES LUMP SUM
- (C) DETOUR BRIDGE LUMP SUM

SECTION 503

PRESTRESSED CONCRETE BRIDGE MEMBERS

503.01. DESCRIPTION.

This work consists of furnishing and placing in the bridge structure, precast prestressed beams and other precast concrete bridge components in accordance with these Specifications and in reasonably close conformity with the lines, grades, and dimensions shown on the contract drawings, approved shop drawings, or established by the Engineer.

Prestressing shall be by the pretensioning method in which the reinforcing tendons are tensioned, concrete is placed and cured, and, after the development of specified concrete strength, the tendons are released from anchorages, stressing the concrete. Refer to Section 517 for post-tensioning requirements.

503.02. MATERIALS.

- (a) **General.** Use materials conforming to this section and the following sections and subsections:

Structural Concrete	509
Joint Fillers and Sealers	701.08
Reinforcing Steel for Structures	511
Bearing Pads	733.06
Strands for Prestressing	723.04

- (b) **Concrete.** Unless otherwise specified, use Class P concrete satisfying strength requirements specified in the contract documents. Design concrete to have a minimum strength, at transfer of prestress (detensioning), of 75% of the 28-day specified strength, unless otherwise specified. Cast all members of the same specified strength from the same mix design.
- (c) **Strand and Structural Steel.** For a structure, use the same type, grade, and manufacturer of strand. For a member, limit the variation in modulus of elasticity to $\pm 1\%$.

Tension stress-relieved strand to 70% of its ultimate strength and low-relaxation strand to 75% of its ultimate strength. If low-relaxation strand is substituted for stress-relieved strand, tension to 70% of its ultimate strength and substitute strand for strand. Do not substitute stress-relieved strand for low-relaxation strand.

Use strand that is free of corrosion, rust, scale, pitting, flaking, dirt, grease, wax, oil, or other foreign material that may reduce bond between the strand and the concrete. Within members, do not use broken strand, strand that has been steamed, or strand that has been fully stressed and relaxed more than two times. Do not weld to, or near, strand.

Comply with Section 506 for structural steel items. Use weathering steel for anchor bolts and bearing assemblies. Unless otherwise specified in the contract documents, galvanize anchor bolt assemblies and paint bearing assemblies and embedded plates with the IZ-E-U paint system.

503.03. EQUIPMENT.

- (a) **Prestressing Equipment.** Perform prestressing with approved jacking equipment. Use hydraulic jacks capable of providing and sustaining the necessary forces and equipped with either a pressure gauge or a load cell for determining the jacking stress. Provide appropriate plumbing and gauges to prevent fluctuation in the gauge readings until the jacking load is released.

For measuring initial stress, use dynamometers or other devices graduated to be read within a tolerance of ± 100 lb (500N). For measuring final stress, use pressure gauges, load cells, or other devices graduated to be read within a tolerance of $\pm 2\%$ of the stress. Do not use load cells to measure stress less than 10% of the load cell capacity. Indicate the allowable operating range on or near the measuring device dial or display. Measure tendon elongation within a tolerance of ± 0.1 inch (2mm).

Use jacks and stress measuring gauges calibrated by approved testing laboratory. Calibrate each jack and gauge as a unit with the jack cylinder extended to the position approximately corresponding to final jacking force. Supply a certified calibration chart or curve for each jack/gauge combination. Repeat the calibration process annually and whenever stresses and elongations differ more than specified limits.

- (b) **Forms and Beds.** Comply with Section 502, "Temporary Structures," unless otherwise specified.

Use forms made of steel, except bulkheads may be made of either steel or wood. Use wooden bulkheads only once. Do not use forms or finishing tools made of aluminum. Make forms smooth, mortar-tight, and free of dings, dimples, or other surface irregularities. Provide a $\frac{3}{4}$ inch (19 mm) bevel on all exposed edges of prestressed concrete members.

Support forms on unyielding casting beds. Use abutments, beds, and forms designed by a registered professional engineer. Design beds to minimize differential settlement and movement.

The Engineer may reject the use of forms that do not produce satisfactory results.

- (c) **Calibration Records.** Keep calibration records for plant equipment such as prestressing equipment, batch plant scales, compression testing machine, and other necessary equipment available for use and inspection. Utilize **calibration records for tensioning.**

503.04. CONSTRUCTION METHODS.

- (a) **Shop Drawings.** Submit shop drawings for all prestressed concrete bridge members. Refer to Subsection 105.02 for general shop drawing requirements.

Include in all sets of shop drawings, a title sheet, erection sheets, and detail sheets of each fabricated member and component. On the title sheet, provide an index of shop drawing sheets and general notes. On the erection sheets, show the locations of all members, anchor bolts, and diaphragms. Include beam lengths and spacings, centerlines of bearings, span numbers, and construction phases.

On the detail sheets for fabricated members, show all member dimensions, pretensioned and mild reinforcement, plates, chair and tie requirements, inserts, diaphragm holes, dunnage and handling locations, piece mark locations, bills of materials, and design information. Design information includes casting length adjustment due to elastic shortening, strand specification, member weight, stressing data, detensioning procedure reference, mix design identification, and all compressive strength requirements. Include, as needed, detail sheets for fabricated components, such as bent rebar, embedded plates, anchor plates, and bearing pads. Show items, such as reinforcing steel, strand, anchors, inserts, and diaphragm holes, with sufficient detail so that conflicts in the placement of these items are avoided. Show, by way of sketch or note, lap lengths of reinforcing steel including steel mesh, maximum strand support (chair) spacings, and reinforcing added for support of other reinforcing.

- (b) **Contractor's Quality Control.** Provide quality control (QC) personnel, a production and QC manual, inspection, and testing to ensure that all prestressed concrete bridge members meet specifications.

Before fabricating, submit and obtain approval for a manual of production and quality control (QC) procedures detailing step-by-step the methods for fabricating each type of member and controlling quality. Resubmit after two years or whenever procedures change.

In the manual, describe stressing procedures, concrete mix design, batching and mixing, placement and finishing, curing, materials requirements, and other production practices. In the stressing procedure, describe initial strand tensioning for equalizing stresses and eliminating slack in the strands, uplift and holddown devices, methods for pretensioning and detensioning, and measurement of elongation and stress, and anchorage details. Describe QC procedures including all materials sampling and testing procedures, bed and product inspection methods, member identification, record keeping for bed and product inspection, stressing records, materials testing, and calibration records, and any other QC functions. Describe implementation of standard testing methods, such as those from ASTM or AASHTO. Make all QC records available to the Engineer.

- (c) **Preparation of Beds and Forms.** Thoroughly clean beds and forms before each use. Use commercial quality form oil or other approved form release agent that permits the ready release of the forms and does not discolor the concrete. Do not allow coatings of release agents to build up. Prevent contamination of any bonded reinforcement, prestressed or nonprestressed, by the form release agent. Replace contaminated reinforcement.

Make form joints smooth and tight enough to prevent significant leakage of paste. Inspect forms for dimensional conformance and maintain as needed. Check form alignment and grade before each casting according to the approved production/QC manual. Maintain form alignment during the casting operation.

- (d) **Tensioning Requirements.**

1. *General.* Notify the Engineer sufficiently in advance of tensioning to allow inspection by the Engineer.

Tension tendons, straight or draped, using either the single or multiple-strand stressing method. Design the stressing method to assure uniform stress both among the strands and along the length of the strands. Leave sufficient space between members to permit access for cutting the strands during release. Record all stressing measurements, and include the date, time, and ambient temperature during stressing.

Inspect the strands after the tensioning. Clean or replace any strand contaminated with form release agent. If more than 72 hours has elapsed since stressing, restress the strands before placing the concrete.

2. *Initial Tensioning.* Equally tension each tendon to eliminate slack before elongation readings are started. Use a tension intensity between 5% and 25% of the final jacking force. After initial tensioning, mark each strand before and after final tensioning to measure elongation and to monitor each anchor wedges for slippage.
3. *Target Stressing Values.* Compute the target force and elongation. The target force is the total jacking force needed for tensioning. The target elongation corresponds with the target force. Compute target values making appropriate allowances for all losses, such as, friction, slippage, and relaxation of anchors and splices. Adjust target values when the difference in temperature between the tendons and the concrete at the time of placement is more than 30°F (15°C). Limit overstressing of strand to 80% of its ultimate strength.
4. *Stress Measurement.* Measure tension in tendons using a pressure gauge or load cell. Mark tendons to measure elongations. Do not damage tendons when marking. For single and multiple-strand stressing, record force and elongation measurements for each tendon and tendon group, respectively. Monitor slippage of individual strands for multiple-strand stressing and restress individual strands as needed to meet specifications. Record heat numbers for all strand.

Tension until both force and elongation targets are reached. Stop tensioning before the targets are reached if either force or elongation exceeds the target value by more than 5%, or 7% for tendons less than 50 feet (15 m) long. If such a discrepancy occurs, check the entire stressing operation carefully, determine the source of error, and correct before proceeding. Use a third method of stress measurement if the problem cannot be determined.

5. *Draped Tendons.* Tension draped tendons by either partially jacking the tendons in a straight position from one end of the bed and finishing by vertically displacing the tendons into their draped positions, or jacking from both ends of the bed with the tendons held in the draped position by rollers, pins, or other approved low-friction devices.
6. *Strand Splicing.* Use no more than one splice per strand. Splice strands of similar physical properties, having the same source and “twist” or “lay.” When multiple-strand stressing is used, splice either less than 10% of the strands or all of the strands. Locate all splices outside of the prestressed members.

(e) **Concrete.**

1. *General.* Comply with the requirements of Section 509, except as modified in this Section. Vibrate the concrete internally, externally, or both. Avoid damaging or displacing reinforcement during vibrating. Replace honeycombed members.

Unless otherwise specified, finish the top surface of members with a rough float, followed by transverse finishing with a stiff broom.

2. *Curing.* Unless otherwise permitted, cure precast members by either the water method or the steam or radiant heat method as specified in Section 509. If needed, fog exposed concrete surfaces until regular curing starts.

During curing, if differential movement between forms and beds causes damage to members, either anchor the forms to prevent differential movement, or loosen the side forms so that movements do not cause damage. If side forms are to be loosened, wait until loosening does not cause damage to the members.

During curing, record the temperature surrounding the member using a minimum of three continuous temperature recorders per line.

3. *Testing.* Notify the Engineer in advance of casting so that the Engineer may be present for inspection. Conduct sampling and testing by the methods required in Section 509, except as modified in this Section.

For girders and piles, sample concrete for acceptance at the minimum rate of once per member. For PS stay-in-place form deck panels, sample concrete for acceptance at the minimum rate of once for each 10 cubic yards (10m³) or less of concrete placed in deck panels. Randomly select batches to be sampled, in advance. Vary sampling patterns for each casting operation. From each acceptance sample, determine slump, air content, temperature, yield, and compressive strength. Do additional sampling and testing for quality control purposes, as needed. Use the results of slump, air content, and yield tests to adjust the mix, as needed, within the limits established for the mix design.

Before detensioning, cure all cylinders in the same manner as the members they represent, as described by Subsection 9.4 of AASHTO T23. After detensioning, cure remaining cylinders by Subsection 9.3 of AASHTO T23. Make at least four cylinders from each sample, one for detensioning and three for 28-day testing. Make additional cylinders for detensioning and for early testing of 28 day requirements, as needed. Test the 28-day cylinders at 28 days, regardless of the results of any previous testing.

For detensioning, determine sample strength using the last cylinder tested from each concrete sample. Detension when all sample strengths in the line satisfy detensioning strength requirements.

For 28-day strength, determine sample strength using the average of three cylinders from the same concrete sample. The compressive strength of a member will be acceptable if all strength tests satisfy strength requirements.

- (f) **Detensioning.** Detensioning is the transfer of stress from the tendons into the concrete. Design detensioning procedures to:

- minimize shock to the members, and
- minimize movement against restrained items such as forms, inserts, and holddowns, and
- prevent overstressing or damaging members.

Determine the appropriate detensioning procedure for each member. List or reference on

the shop drawings the detensioning procedure for each member. List referenced procedures in full in the production and quality control manual.

Detension after the concrete has attained the required strength as specified in the previous subsection. If using steam or radiant heat curing, detension immediately after curing while the concrete is still warm and moist. Do not allow the temperature surrounding the members to drop below 45°F (7°C) before detensioning.

If jacking, limit tension force to 5% over the target stressing force or 80% of the ultimate strength of the strand, whichever is least. Cut or release strands in an order that minimizes lateral eccentricity of prestress. When cutting strand with an acetylene torch, minimize shock loading by first heating the strand to induce slow yielding and then cutting after the stress has been relieved through yielding. Correct the strand cutting procedure if indications of shock loading, such as brooming of strand, are evident.

Unless otherwise specified, cut all strands flush with the end of the member. Clean and paint flush-cut strand ends and adjoining concrete within 1 inch (25mm) of the strand. Use wire brushing or abrasive blast cleaning to remove all dirt and residue not firmly bonded to the metal or concrete surfaces. Coat with a minimum of 5 mils (150mm) zinc-rich paint conforming to the requirements of Federal Specification TT-P-641. Thoroughly mix the paint at the time of application and work the paint into voids.

- (g) **Storage, Inspection, and Transportation.** Maintain members in an upright position. Handle members using the lifting eyes. Support beams in storage and transit within 2 feet (0.5m) of the designed bearing locations. Support stay-in-place panels and piles as shown on the approved shop drawings. Note that improper handling or support of a member could result in collapse of the member.

Use care during storage, handling, and transportation to prevent cracking, excessive camber and sweep, overstressing, or other damage. Replace damaged members at no additional cost to the Department. Repair minor chipping, spalling, and scars as directed.

Mark each member with a clearly legible piece mark as shown on the shop drawings. Include the member mark number, piece number, job identification, and date cast.

At least two days before shipping a member to the project, provide sufficient access for the Engineer to inspect, approve, and stamp the member. Do not ship members that are not approved and stamped. Approval of the member before shipment will not relieve the Contractor of responsibility for defects found after shipment.

Allow members to age at least 7 days before shipment provided the specified 28-day compressive strength has been attained.

- (h) **Bearings and Anchor Bolts.** Provide bearing surfaces on both members and bridge seats with a true surface giving full and uniform bearing over the entire bearing area. Comply with the requirements of Section 509.04(k)1 for cast-in-place bearing surfaces. Except as modified in Subsection 503.02(c), comply with the requirements of Subsection 509.04(k)2 and 3 for anchor bolts and bearing assemblies. Bearing assemblies include anchor plates and elastomeric bearing pads. Apply inorganic zinc primer to all surfaces of sole plates before embedding in concrete.

Block and brace prestressed girders when set in place to assure lateral stability.

Construct anchors as specified. Position slotted anchor plates for expansion as specified for the temperature of the members at the time of erection. Field weld anchor plates to embedded sole plates of the members making, as needed, minor horizontal adjustments to the locations of elastomeric bearing pads and anchor plates. Weld according to Subsection 724.03. Do not weld until the bearings have been inspected. Repair the primer in welded areas and paint completed bearing assemblies with intermediate and top coats of the IZ-E-U paint system.

- (i) **Concrete Floors and Diaphragms.** Construct concrete floors and diaphragms by Section 504.

Add, in the haunch, stirrups matching the size and spacing of the member stirrups if the stirrups in the member do not extend at least 2 inches (50mm) above the haunch height into the bridge floor.

Do not drill or core members for diaphragm hole installation, compressive strength determination, or any other purpose.

- (j) **Tolerances.** Produce members that are well within the specified acceptable range. Correct the production process when members approach or equal a specified limit. Immediately notify the Engineer of any out-of-tolerance members. Check applicable dimensional tolerances before casting and after removal from the forms. Recheck time-dependent tolerances, such as, length, camber, and sweep, within 3 days before shipment. Check camber and sweep at a time when thermal effects of sunlight are negligible such as on a cloudy day or early morning. Sweep is defined as the horizontal deviation from a straight line parallel to the centerline of the member. Camber is defined as upward deflection of the member caused by prestress. Check local smoothness with a 5-foot (1.5m) straightedge.

Comply with the maximum dimensional tolerances in Table 503-1 for AASHTO girders and bulb-tees, Table 503-2 for double-tees, Table 503-3 for prestressed piling, and Table 503-4 for prestressed deck panels:

**Table 503-1
Maximum Dimensional Tolerances for AASHTO Girders and Bulb-tees**

Length	$\pm 1/4$ inch / 25 ft, ± 1 inch max.	(± 0.8 mm/m, ± 25 mm max.)
Width (overall)	$+3/8$ inch, $-1/4$ inch	(+10mm, -6mm)
Width (web)	$+3/8$ inch, $-1/4$ inch	(+10mm, -6mm)
Depth (overall)	$+1/2$ inch, $-1/4$ inch	(+13mm, -6mm)
Depth (flanges)	$\pm 1/4$ inch	(± 6 mm)
Sweep	$1/8$ inch / 10 ft	(1mm/m)
Variation from end squareness or skew	$\pm 3/16$ inch / ft, ± 1 inch max.	(± 16 mm/m, ± 25 mm max.)
Camber variation from design camber ¹	$\pm 1/8$ inch / 10 ft	(± 1 mm/m)
For spans of 80 ft or less	$\pm 1/2$ inch max.	(± 13 mm max.)
For spans more than 80 ft	± 1 inch max.	(± 25 mm max.)
Differential camber between adjacent members	$1/8$ inch / 10 ft	(1mm/m)
Position of Strands:		
Individual	$\pm 1/4$ inch	(± 6 mm)
Bundled	$\pm 1/2$ inch	(± 13 mm)
Draped strand holddown point	± 20 inches	(± 0.5 m)
Position of plates:		
Bearing plates	$\pm 5/8$ inch	(± 16 mm)
Other plates	± 1 inch	(± 25 mm)
Tipping and flushness of plates:		
Bearing plates	$\pm 0.5\%$, $\pm 1/8$ inch max.	($\pm 0.5\%$, ± 3 mm max.)
Other plates	$\pm 1/4$ inch	(± 6 mm)
Position of inserts including diaphragm holes	$\pm 1/2$ inch	(± 13 mm)
Position of handling devices:		
Parallel to length	± 6 inches	(± 150 mm)
Transverse to length	± 1 inch	(± 25 mm)
Position of stirrups:		
Longitudinal spacing	± 2 inches	(± 50 mm)
Projection above top	$\pm 3/4$ inch	(± 19 mm)
Local smoothness of any formed surface	$\pm 1/4$ inch / 10 ft	(± 3 mm/1500mm)

¹Use this camber tolerance when a design camber is specified.

Table 503-2
Maximum Dimensional Tolerances for Double-tees

Length	$\pm\frac{1}{4}$ inch / 25 ft, ± 1 inch max.	(± 0.8 mm/m, ± 25 mm max.)
Width (overall)	$\pm\frac{1}{4}$ inch	(± 6 mm)
Width (webs)	$\pm\frac{1}{8}$ inch	(± 3 mm)
Depth (overall)	$\pm\frac{1}{4}$ inch	(± 6 mm)
Thickness (flanges)	$+\frac{1}{4}$ inch, $-\frac{1}{8}$ inch	(± 6 mm, -3 mm)
Flange Overhang (flange edge to web edge)	$\pm\frac{1}{4}$ inch	(± 6 mm)
Distance between Webs	$\pm\frac{1}{4}$ inch	(± 6 mm)
Sweep	$\frac{1}{8}$ inch / 10 ft	(1mm/m)
Variation from end squareness or skew	$\pm\frac{3}{16}$ inch / ft, ± 1 inch max.	(± 10 mm/m, ± 25 mm max.)
Camber variation from design camber ¹	$\pm\frac{1}{8}$ inch / 10 ft, $\pm\frac{3}{4}$ inch max.	(± 1 mm/m, ± 19 mm max.)
Differential camber between adjacent members	$\frac{1}{8}$ inch / 10 ft, $\frac{3}{4}$ inch max.	(1mm/m, 19mm max.)
Position of Strands:		
Individual	$\pm\frac{1}{4}$ inch	(± 6 mm)
Bundled	$\pm\frac{1}{2}$ inch	(± 13 mm)
Draped strand holddown point	± 12 inches	(± 300 mm)
Position of plates:		
Bearing plates	$\pm\frac{1}{2}$ inch	(± 13 mm)
Other plates	± 1 inch	(± 25 mm)
Tipping and flushness of plates:		
Bearing plates	$\pm 0.5\%$, $\pm\frac{1}{8}$ inch max.	($\pm 0.5\%$, ± 3 mm max.)
Other plates	$\pm\frac{1}{4}$ inch	(± 6 mm)
Position of inserts including diaphragm holes	$\pm\frac{1}{2}$ inch	(± 13 mm)
Position of handling devices:		
Parallel to length	± 6 inches	(± 150 mm)
Transverse to length	± 1 inch	(± 25 mm)
Position of stirrups:		
Longitudinal spacing	± 2 inches	(± 50 mm)
Projection above top	$\pm\frac{3}{4}$ inch	(± 19 mm)
Local smoothness of any formed surface	$\pm\frac{1}{4}$ inch / 10 ft	(± 3 mm/1500mm)

¹Use this camber tolerance when a design camber is specified.

Table 503-3
Maximum Dimensional Tolerances for Prestressed Concrete Piling

Length	±1 inch (±25mm)
Width or Diameter	± ³ / ₈ inch (±10mm)
Variation from longitudinal axis (bow)	± ¹ / ₈ inch / 10 ft (1mm/m)
Variation from end squareness or skew	± ¹ / ₄ inch / 1 foot, ± ¹ / ₂ inch max. (±6mm/300mm, ±13mm max.)
Position of Individual Strands:	± ¹ / ₄ inch (±6mm)
Position of handling devices:	±6 inches (±150mm)
Longitudinal spacing of spiral reinforcement:	± ³ / ₄ inch (±19mm)
Local smoothness of any formed surface	± ¹ / ₄ inch / 10 ft (±3mm/1500mm)

Table 503-4
Maximum Dimensional Tolerances for Prestressed Concrete Stay-in-Place Forms

Length (in direction of panel strands)	+ ³ / ₄ inch, - ¹ / ₄ inch (+18mm, -6mm)
Width	+ ¹ / ₄ inch, - ¹ / ₂ inch (+6mm, -12mm)
Thickness	+ ¹ / ₄ inch, - ¹ / ₈ inch (+6mm, -3mm)
Variation from end squareness or skew	± ¹ / ₄ inch (±6mm)
Camber, sweep, and warping ¹	± ¹ / ₄ inch / 10 ft (±2mm per meter of length)
Position of individual strands:	
Vertically	+0, - ¹ / ₄ inch (+0mm, -6mm)
Horizontally	± ¹ / ₂ inch (±12mm)
Position of handling devices:	
Parallel to length	±3 inches (±75mm)
Transverse to length	±2 inches (±50mm)
Local smoothness of any formed surface	± ¹ / ₄ inch / 10 ft (±3mm/1500mm)

¹When measuring panel camber, account for dead load deflection of the panel. SIP form deck panels are designed to have no camber, only dead load deflection.

Remedy out-of-tolerance members in one of the following ways:

- Replace the member at no additional cost to the Department.
- Correct the member tolerance problem, if possible, using an approved correction procedure at no additional cost to the Department.
- If correction is not possible but the member is considered usable, submit the member for review and acceptance at a reduced price under Subsection 105.03. Include a description of the problem and any proposed corrective action. Provide structural and physical evaluation by a qualified professional engineer registered in Oklahoma, as required. Replace the member at no additional cost to the Department if the submittal is rejected.

503.05. METHOD OF MEASUREMENT.

Prestressed concrete beams and double tees will be measured by the linear foot (meter), complete in place, as shown on the plans. Concrete and reinforcing steel placed in haunches in excess of the plan quantity will not be measured for payment.

Prestressed concrete piling will be measured as specified in Section 514. Prestressed concrete stay-in-place forms will not be measured for payment; Refer to Section 502.

Anchor plates, anchor bolt assemblies, and diaphragm bolt assemblies for prestressed concrete members will be measured as structural steel under Section 506. Embedded plates will not be measured for payment.

503.06. BASIS OF PAYMENT.

The accepted quantities, measured as specified in this Section, will be paid at the contract price per unit of measurement for the pay items listed below that are shown in the Plan bid schedule. Payment will be full compensation for the respective work prescribed in this Section.

- (A) PRESTRESSED CONCRETE BEAMSLINEAR FOOT (METER)
 (B) PRESTRESSED CONCRETE DOUBLE TEESLINEAR FOOT (METER)

SECTION 504**BRIDGE DECKS, APPROACHES, RAILS AND PARAPETS****504.01. DESCRIPTION.**

This work consists of constructing concrete bridge decks and approach slabs according to these Specifications and in reasonably close conformity with the lines, grades and dimensions shown on the Plans or established by the Engineer.

This work also consists of the construction of railings and parapets for bridges, roadways, wing walls, retaining walls, and other structures, in accordance with these Specifications and in reasonably close conformity with the lines, grades and dimensions shown on the Plans or established by the Engineer.

Comply with the requirements of Section 414 for approach slabs, except as modified in this Section.

504.02. MATERIALS.

Use materials conforming to following Sections and Subsections.

Structural Concrete (<i>Class AA</i>)	509
Joint Fillers and Sealers	701.08
Reinforcing Steel for Structures	511
Curing Materials	701.07
Metal Beam Railing	732.01
Aluminum Alloy Tubes for Railings	732.03
Cast Aluminum Alloy Bridge Railing Posts	732.03
Pipe Railing	732.04

When using stay-in-place prestressed concrete deck forms, include an approved corrosion-inhibiting admixture in all cast-in-place bridge deck concrete and precast deck form concrete.

Limit the concrete temperature for bridge decks and approach slabs to a maximum of 85°F (30°C).

504.03. EQUIPMENT.

- (a) **Finishing Machine.** Use an approved self-propelled finishing machine to transversely finish the bridge deck and approach slabs. Before placing concrete, submit to the Engineer for approval, a description of the finishing machine, including make and model, a finishing plan, and a plan for equipment breakdown, listing spare equipment and parts, and estimated length of down time. Provide sufficient equipment and labor so that potential finishing machine down time is limited and concrete placement can be done within the time specified in Table 509-6 if a breakdown occurs.

Support the finishing machine on rails or steel-clad headers parallel to the centerline of the structure. Firmly fasten the rails and headers in place and set to correct line and grade with proper allowances for dead-load deflections. The rails, headers, and strike-off equipment shall be of sufficient strength and be adjusted so that the concrete surface after strike-off will conform to the planned profile and cross-section.

For bridge decks narrower than 30 feet (10m) wide, finishing templates or screeds may be used to longitudinally finish the bridge deck. Support the finishing template or screed on steel-clad header boards cut to the crown of the roadway. Use finishing templates or screeds of sufficient weight and rigidity (or trussed) to provide the specified longitudinal finish camber.

- (b) **Finned Float.** Unless saw-cut grooving is specified, use a finned float, having a single row of fins, to provide the final finish for the deck and approach concrete. The spacing of the fins shall correspond to the specified groove spacing. Do not use a tining rake, unless otherwise directed. If saw-cut grooving is specified, use a conventional float to finish the bridge deck and approach slabs.
- (c) **Fogging Equipment.** Provide a fogging system that will cover the entire area of fresh finished concrete. Provide a system that continuously keeps the air over this area cool and moist with a blanket of fog. Make fog using pressurized water and a series of fogging nozzles. Do not use common garden hose nozzles which can produce an excessive washing spray.

If the section of bridge deck or approach slab to be placed is less than 50 feet (15m) wide and less than 100 feet (30m) long, fogging may be made by mixing water and oil-free compressed air in a hand-held spray nozzle. Provide and use a minimum of two hand-held foggers with at least a third backup fogger. Use compressed air of sufficient pressure and flow to atomize the water into a fog.

Test the fogging equipment immediately before each placement to ensure the equipment is in good working order. Use approved fogging equipment only.

Other methods of controlling evaporation, such as, night placement, windbreaks, shades, or a combination of these may be used in lieu of fogging, if approved and proven effective.

- (d) **Grooving Machine.** If saw-cut grooving is specified or required, groove hardened concrete with a self-propelled grooving machine built for the purpose of grooving pavement or bridge decks. Use a grooving machine equipped with the following features:
- Diamond saw blades mounted on a multiblade arbor at the specified groove spacing.
 - A depth control device that detects variations in the surface of the bridge deck or pavement and adjusts the height of the cutting head to maintain the specified groove depth.
 - An alignment control device.
 - A vacuum attachment that removes and collects slurry or residue from grooving operation.
- (e) **Work Bridges.** Furnish at least two work bridges to enable workers to satisfactorily perform the floating, straightedging, fogging, curing and final finishing at the proper times.

504.04. CONSTRUCTION METHODS.

- (a) **Forming, Bracing, and Finishing Machine Rails.** See Subsections 502.02(b) and 502.04(b) for form requirements. Provide forms and bracing for the overhang part of the deck adequate to support the weight of the concrete, forms, finishing machine, and other construction loads. Brace exterior steel girders to prevent twisting or lateral displacement as specified in Subsection 502.04(a)9.

Set rails on non-yielding supports for the scheduled length of the concrete placement. Extend rails beyond both ends of the scheduled length of the concrete placement a sufficient distance that will permit the float of the finishing machine to fully clear the concrete to be placed. Use rails that are fully adjustable for elevation. Set rails to allow for settlement, camber, and deflection of falsework, as necessary to obtain a finished surface true to the required grade and cross-section. Adjust rails as necessary to correct for unanticipated settlement or deflection that may occur during the finishing operations. If rail supports are located within the area where concrete is being placed, as soon as they are no longer needed, remove them to at least 3 inches (75mm) below the finished surface and fill the void with fresh concrete.

- (b) **Construction Joints.** Build construction joints as specified in Subsection 509.04(d) or as directed. Where the deck is continuous over abutments or piers, place a construction joint at the end of simple spans. Wait at least 24 hours between placement of adjacent deck sections.

After concrete has been placed on both sides of the joint and has hardened, saw-cut the top of the joint 1 inch (25mm) deep and $\frac{1}{4}$ inch (6mm) wide and seal with an approved sealant unless otherwise specified. Use a rapid cure joint sealant as specified in Section 701.08(h) when sealing construction joints on bridges subjected to vibration from traffic.

Refer to Subsections 509.04(e)4 and 5 for requirements covering waterstops and compression joint seals, respectively.

- (c) **Expansion Joints.** Furnish and install the types of expansion devices specified in the contract documents.
1. *Metal Expansion Joints.* Fabricate metal expansion joints, such as, sealed expansion joints and finger type expansion joints, according to Section 506.

Carefully check the expansion devices for line, grade, and crown. Install expansion joint assemblies so that the top surface of the joint matches the plane of the adjacent finished concrete for the entire length of the assembly.

Employ positive methods of placing the assemblies to keep them in correct position during concrete placement. Cut all rigid connections between opposite halves of an expansion joint after initial set of the concrete has occurred to avoid damaging the concrete from joint movement due to thermal changes in the superstructure.

The traffic rail and concrete parapet opening dimension shall have the same opening dimension as the expansion joint.

Before installing the neoprene gland in sealed expansion joints, clean steel surfaces that will contact the neoprene.

2. *Joints Made of Elastomeric Mortar and Rapid Cure Joint Sealant.* Furnish elastomeric mortar and rapid cure joint sealant complying with Subsection 701.08(h). Install these materials as specified in the contract documents.

For new concrete surfaces, form concrete to comply with the shape shown on the plans. Strip forms and clean the concrete surfaces to assure proper bond of the elastomeric mortar. For existing concrete surfaces, saw, flush and clean joints according to Subsections 419.04(a), (b), and (c) of the Standard Specifications and as recommended by the manufacturer. Blast-clean steel surfaces according to SSPC-SP10, Near-White Blast Cleaning. After completing surface preparation, notify the Engineer so that the joint may be inspected and approved, before installing the elastomeric mortar (nosing).

Install the elastomeric mortar when the joint surface temperature is 45°F (70°C) or higher. The application of heat, when recommended by the manufacturer, may be used to improve the curing time of the elastomeric mortar. Allow the mortar to cure at least two hours (four hours for joint surface temperatures below 70°F (21°C)) before loading with traffic.

After the elastomeric mortar has been successfully installed, install the rapid cure joint sealant when the joint surface temperature is 60°F (15°C) or higher. The best time for installing the sealant in expansion joints is when the openings are at a minimum width. Do not install the sealant if the expansion joint opening is less than 3/4 inches (19mm) or more than 2 1/2 inches (63mm); notify the Engineer.

Provide a qualified representative of the elastomeric mortar and sealant manufacturers at the beginning of the work to ensure adequate workmanship and for inspection of the sealing operation.

- (d) **Reinforcing Steel Placement.** Comply with Section 511. Place the ends of transverse reinforcing steel bars 2 inches (50mm) from the edge of the deck or slab. Place the ends of longitudinal reinforcing steel bars, including parapet bars, 1 inch (25mm) from the end of the concrete or expansion device. Use approved wire supports to support the reinforcing steel. Extend longitudinal reinforcing steel bars through construction joints unless otherwise specified in the contract documents.

(e) **Concrete.** Comply with the requirements of Section 509.

1. *Prepour Check.* Before concrete placement begins, make a dry run with the finishing machine to check the following:
 - cover on reinforcing steel,
 - rail deflection,
 - proper deck thickness, and
 - operation of all equipment.

Make all necessary corrections before concrete placement has begun.

2. *Placement.* Deposit the concrete ahead of the finishing machine, slightly higher than the finished surface. Keep a slight excess of concrete in front of the cutting edge of the screed at all times. Carry the excess all the way to the edge of the pour or form and waste it.

Place concrete at a rate that completely covers 25 feet (8m) or more per hour, measured longitudinally along the length of the bridge.

During hot weather, place concrete during the cooler times of the day or at night, if necessary, to comply with temperature requirements of Subsection 509.04(b). The Engineer may require placing concrete during the nighttime hours during hot weather. The Engineer will inform the Contractor, in writing, if night placing becomes necessary.

3. *Lighting.* If requested to place concrete during nighttime hours, conform to the requirements of Subsection 509.04(c)3.3.
4. *Finishing.* Immediately after consolidating the concrete, use the finishing machine to transversely strike off the concrete to the proper profile. Use a float to finish the concrete to a smooth, even surface throughout the entire bridge length. Finish transversely unless longitudinal finishing is permitted.

Do not spray water onto the surface of concrete to assist in finishing operations, unless otherwise permitted. If the application of water is permitted, apply a fine mist that does not disturb the surface of the fresh concrete.

While the concrete is still plastic, test the trueness of the concrete surface with a 10-foot (3m) straightedge. Fill depressions with fresh concrete, and cut down high areas. Consolidate, strike off, and refinish the repaired areas. Check the surface across joints to meet all smoothness requirements.

When grooving fresh concrete, use the finned float at such time and in such a manner that the desired texture will be achieved while minimizing displacement of the larger aggregate particles in the fresh concrete. When saw-cut grooving is to be used, floating shall be the last step in finishing. Refer to Subsection 504.04(g) for grooving requirements.

Apply the same final finish to the approach slabs that is applied to the bridge decks or, if overlaid, bridge deck overlays.

If the concrete bridge deck is to receive a concrete overlay, use a machine or float finish. Do not use a broom finish or drag finish.

5. *Fogging and Curing.* Limit moisture loss from fresh concrete by first, fogging and then, curing. Begin fogging immediately after concrete strike-off, and continue until the concrete is protected from moisture loss by curing.

Fog according to the requirements of Subsection 504.03(c). Control evaporation adequately to prevent premature crusting of the surface or an increase in drying cracking. Limit the application of moisture to avoid either disturbing the finish or collecting water in puddles. Do not use water from fogging as an aid to finishing the concrete.

Cure bridge deck and approach slab concrete using both the liquid membrane curing compound method and the water method described in Subsection 509.04(f). Immediately after final finishing, apply liquid membrane curing compound. When the surface has hardened sufficiently that no damage to the finish will result, apply covering material and begin curing in accordance with the water method.

Cure bridge deck and approach slab concrete uninterrupted during the curing period. Do not prematurely remove covering material to form the rail or parapet, unless the exposed area is kept continuously wet.

6. *Removing Forms.* Comply with Subsection 502.04(c).

- (f) **Surface Correction through Grinding.** Test the hardened driving surfaces after curing for trueness using a 10-foot (3m) straightedge or other specified device before final acceptance. Mark and grind areas having high spots of 1/8 inch (3mm) or more, or areas requiring grinding to meet smoothness specifications. Grind after the concrete curing period is completed, and according to Section 425. Discontinue grinding when the out-of-tolerance areas are within specified tolerances. Do not reduce the concrete cover of reinforcing steel to less than 2 inches (50mm). Restore the skid-resistant surface in ground areas using saw-cut grooving.

Remove and replace, at no additional cost, bridge decks and approach slabs which cannot be corrected to specification tolerances.

- (g) **Transverse Grooving.**

1. *Groove Geometry.* Make grooves by finned floating, tining, or saw cutting to the dimensions and tolerances given in Table 504-1. Make the cross-section of grooves rectangular for saw-cut grooves, or approximately rectangular for finned-float grooves. Measure the width tolerance at mid-depth of the groove. Begin grooves within 2 feet (0.6m) of the face of the parapet, guardrail, or curb, and run continuously across the width of the bridge to within 2 feet (0.6m) of the face of the opposite parapet, guardrail, or curb. Do not groove within 6 inches (150mm) of a construction joint. Do not overlap parallel grooving patterns. For curved bridges, make grooves transverse to the cord of the curve within each span. Provide means to accurately measure grooves.

Table 504-1
Groove Dimensions

Groove Dimension	Allowable Size, inches (mm)	
	<u>Finned-Float</u>	<u>Saw-Cut</u>
Width	$\frac{1}{16}$ to $\frac{1}{4}$ (1.5 to 6)	$\frac{1}{8}$ to $\frac{1}{4}$ (3 to 6)
Depth	$\frac{1}{8}$ to $\frac{1}{4}$ (3 to 6)	$\frac{1}{8}$ to $\frac{3}{16}$ (3 to 5)
Spacing (c/c)	$\frac{1}{2}$ to $\frac{3}{4}$ (6 to 19)	$\frac{1}{2}$ to 1 (6 to 12)

**Randomly vary the groove spacing between $\frac{3}{4}$ inch (19mm) to $1\frac{1}{2}$ inch (38mm) for saw-cut grooving for bridges more than 1000 feet (300 m) long.*

2. **Grooving Hardened Concrete.** Provide saw-cut transverse grooving for bridge decks and approach slabs under the following conditions:
 - Saw-cut transverse grooving is specified in the contract documents as a pay item.
 - Transverse grooving must be replaced after grinding.
 - Out-of-tolerance transverse grooving must be corrected.

Begin saw-cut grooving after the concrete curing period is complete and grinding repairs are complete. If significant spalling occurs, discontinue grooving until the cause of the spalling is identified and corrected. If during the course of the grooving work a single blade on any individual multiple blade grooving machine becomes incapable of cutting a groove, the work may continue for the remainder of the work shift before repairing the damaged blade. Repair of the omitted groove will not be required. If more than one blade is damaged or the machine is producing otherwise unacceptable work, discontinue work with the machine in question and repair the unacceptable areas.

3. **Slurry Removal.** While grooving, continuously vacuum the slurry and residue caused by the grooving operation. Prevent the flow of slurry across the bridge deck and lanes open to traffic, or into gutters or other drainage facilities. Immediately after grooving, clean the pavement or bridge deck such that the surface is not slippery from slurry residue. Dispose of slurry in an approved manner.

(h) Load on Decks and Approach Slabs.

1. **Construction Loads.** Light materials and equipment may be carried on bridge decks and approach slabs only after the concrete has been in place at least 24 hours, providing curing is not interfered with and the surface texture is not damaged. Allow the last placed concrete on a span or approach slab to attain a compressive strength of at least 2500 psi (17MPa) before loading it with construction vehicles having a weight between 1000 pounds (450kg) and 4000 pounds (1800kg) and comparable materials and equipment loads. Allow the concrete to attain its full specified strength before placing loads in excess of the above. In addition, for post-tensioned structures, complete the tensioning of a span before loading that span with vehicles weighing more than 4500 pounds (2000kg) and comparable material and equipment loads.

Do not place equipment or other loads which exceed the bridge design load. Do not operate a mixer on concrete bridge decks without approval. Only rubber-tire construction vehicles will be allowed on bridge decks or approach slabs.

2. *Traffic Loads.* Unless otherwise specified in the contract documents, do not permit traffic loads on concrete decks or approach slabs until at least 14 days after the last placement of deck concrete and until all concrete in the structure has attained its specified strength.
- (i) **Rails, Parapets, and Curbs.** For concrete rails, parapets, and curbs, comply with Sections 509 and 511. For cast-in-place superstructures, such as, slab spans, pan girders, and post tensioned spans, do not place railing, parapets, and curbs until the falsework for the span has been released and the span swung.
1. *Forming.* Comply with Section 502. The slip form method may be permitted for the construction of parapets provided that:
 - the results are equal in all respects to those obtained by the use of fixed forms, and
 - adequate arrangement is provided for curing, finishing, and protecting the concrete.
 2. *Curing.* Cure all rail and parapet concrete according to the methods described in Subsection 509.04(f). Either the forms-in-place method or the water method may be used. Use the water method for exposed surfaces. If forms are removed and the finish applied before completing the specified curing period, resume curing for the balance of the curing period.
 3. *Finish.* Provide a Class 2, rubbed finish for all exposed concrete surfaces of rails and parapets, and sides of curbs as specified in Subsection 509.04(g). Finish the tops of curbs with a wooden float.
 4. *Line and Grade.* Build the line and grade of the parapet or rail as specified in the contract documents. Unless otherwise specified, make parapets vertical. Make handrailing parallel to the curbs.

504.05. METHOD OF MEASUREMENT.

Concrete bridge decks will be measured as specified in Section 509 for Class AA Concrete and Section 511 for Reinforcing Steel. Quantities of concrete and reinforcing steel resulting from larger than planned haunches, will not be measured for payment.

Approach slabs will be measured by the square yard (square meter) of completed approach slab according to the top surface dimensions specified by the contract documents or the Engineer.

Saw-cut grooving will be measured by the square yard (square meter) of surface bounded by the ends of the approach slabs and the edges of the clear roadway. Grinding will not be measured for payment.

Expansion joints shall be measured by the linear foot (meter) along the centerline of the joint (at the top of the joint cross section) from end to end of the joint.

Rapid cure joint sealant will be measured by the linear foot (meter) as shown on the plans. Measurement will be along the centerline of the joint at the surface of the roadway. *Elastomeric mortar* will be measured by the cubic foot (cubic meter) as shown on the plans or as directed by the Engineer. Other joint fillers and joint sealers will not be a separate pay item, but the cost of the same shall be included in the price of other bid items.

Authorized *floodlighting* will be measured for payment by the day. A day is defined as the period of time included in one continuous period of darkness. Each day of floodlighting will include the cost of furnishing, installing, maintaining, and servicing the lights, including the electric current required and any other additional costs incurred for concrete placement at night. Consider floodlighting authorized for the same period the Engineer requires nighttime concrete placement in writing.

Concrete rail, parapet or metal handrail with concrete posts will be measured by the linear foot (meter) from outside to outside of end posts with no deduction for expansion joint gaps. *Metal posts* will be measured by the linear foot (meter) from end to end of railing in place.

Unless otherwise provided, incidental items will be paid for as provided under the following sections:

Metal Drains	506
Reinforcing Steel for Structures	511

504.06. BASIS OF PAYMENT.

The accepted quantities, measured as specified in this Section, will be paid at the contract price per unit of measurement for the pay items listed below that are shown in the Plan bid schedule. Payment will be full compensation for the respective work prescribed in this Section. Payment will be made under:

- (A) APPROACH SLAB SQUARE YARD(SQUARE METER)
- (B) SAW-CUT GROOVING SQUARE YARD (SQUARE METER)
- (C) EXPANSION JOINTS LINEAR FOOT (METER)
- (D) FLOODLIGHTING DAY
- (E) CONCRETE RAIL LINEAR FOOT (METER)
- (F) CONCRETE PARAPET LINEAR FOOT (METER)
- (G) HANDRAILING LINEAR FOOT (METER)
- (H) RAPID CURE JOINT SEALANT LINEAR FOOT (METER)
- (I) ELASTOMERIC MORTAR CUBIC FOOT (CUBIC METER)

**SECTION 505
REPAIR AND OVERLAY OF CONCRETE BRIDGE DECKS**

505.01. DESCRIPTION.

- (a) **Repair.** Repair of bridge decks consists of removing loose, delaminated, spalled, or deteriorated concrete from the existing surface, replacing with new high density concrete, or latex modified concrete and other necessary work as specified in the contract documents. When the bridge deck is to be overlaid, the replacement material for Class A and Class B repair shall be the same as the overlay material.

The Engineer will make a field inspection of all bridge decks and determine the areas of concrete deck to be repaired. These areas will be marked by the Engineer and repaired by the Contractor. The lower limit for Class A and Class B bridge deck repair shall be to suitable

existing concrete, as determined by the Engineer. Bridge deck repair shall be classified as follows:

1. *Class A Bridge Deck Repair.* Class A bridge deck repair consists of:
 - Removing unsound concrete down to the top mat of reinforcing steel;
 - Disposing of concrete removed;
 - Replacing the excavated volume of concrete with high density concrete or latex modified concrete.
 2. *Class B Bridge Deck Repair.* Class B bridge deck repair consists of:
 - Removing unsound concrete below the top mat of reinforcing steel;
 - Cleaning existing concrete from the top mat of reinforcing steel in the repair area;
 - Disposing of concrete removed;
 - Replacing the excavated volume of concrete with high density concrete or latex modified concrete.
 3. *Class C Bridge Deck Repair.* Class C bridge deck repair consists of:
 - Removing all unsound concrete for the full depth of the deck;
 - Cleaning existing concrete from both mats of reinforcing steel in the repair area;
 - Disposing of concrete removed;
 - Replacing the excavated volume of concrete with Class AA concrete.
- (b) **Overlays.** Overlay of bridge decks consists of deck preparation and overlaying with either high density concrete or latex modified concrete, and other necessary work as specified in the contract documents. Unless otherwise specified, the overlay shall raise the roadway surface and shall cover the entire concrete deck. Deck preparation and overlaying consist of:
- Sandblasting and/or chipping the concrete to a depth as necessary to remove rust, oil, and other foreign matter leaving a clean etched concrete surface free of any laitance; (Where the original deck concrete was cured by linseed oil emulsion, the entire deck shall be scarified to a depth of $\frac{1}{4}$ inch (6mm) below the original surface.)
 - Disposing of concrete removed;
 - Overlaying with the specified overlay concrete to the depth designated in the contract documents.

Thickness of the concrete overlay shall be measured from the level of the original surface to the specified final raised surface as shown on the Plans. When the deck is to receive Class A or Class B repairs, the replacement material may be placed monolithically with the overlay course or separately prior to the overlay.

505.02. MATERIALS.

Use materials conforming to the following subsections:

High Density Concrete	701.10
Latex Modified Concrete	701.11

For repairs and overlays, use either high density concrete or latex modified concrete as specified in the contract documents. Limit the maximum concrete temperature to 85°F (30°C).

505.03. EQUIPMENT.

Provide all equipment with suitable traps, filters, drip-pans, or other devices to prevent oil or other deleterious matter from being deposited on the deck.

- (a) **Surface Preparation Equipment.** Use the following types of surface preparation equipment:
1. *Sawing Equipment.* Use sawing equipment capable of sawing concrete to the specified depth.
 2. *Sandblasting Equipment.* Use sandblasting equipment capable of removing rust and old concrete from the exposed reinforcement.
 3. *Power Driven Hand Tools.* Power driven hand tools for removal of concrete will be permitted with the following restrictions:
 - Limit the nominal size class of jack hammers to a maximum of 30 pounds (125n).
 - Operate jack hammers or mechanical chipping tools at an angle less than 45° measured from the surface of the slab.
 - For removing concrete from beneath any reinforcing bar, limit the nominal size class of chipping hammers to a maximum of 15 pounds (65N).
 4. *Scarifying equipment.* Use a scarifier for preparing an existing deck for an overlay. Use a power-operated mechanical scarifier capable of uniformly scarifying or removing the old surface to the depths required.
- (b) **Proportioning and Mixing Equipment.**
1. *For High Density Concrete.* Use proportioning and mixing equipment meeting the requirements of Subsection 414.03 for high density concrete. Use a construction or stationary concrete mixer of the rotating-paddle type, or a continuous mixer used in conjunction with volumetric proportioning.
 2. *For Latex Modified Concrete.* Use proportioning and mixing equipment of a self-contained, mobile, continuous-mixing type meeting the following requirements:
 - The mixer shall be self-propelled and shall be capable of carrying sufficient unmixed, dry, bulk cement, sand, coarse aggregate, latex modifier, and water to produce on the site not less than 5 cubic yards (5m³) of concrete.
 - The mixer shall be capable of positive measurement of cement being introduced into the mix. The recording meter visible at all times and equipped with a ticket printout shall indicate this quantity.
 - The mixer shall provide positive control of the flow of water and latex emulsion into the mixing chamber. Water flow shall be indicated by a flowmeter and shall be readily adjustable to provide for minor variations in aggregate moisture.
 - The mixer shall be capable of being calibrated to automatically proportion and blend all components of indicated composition on a continuous or intermittent basis as required by the finishing operation, and shall discharge mixed material through a conventional chute directly in front of the finishing machine. Sufficient mixing capacity of mixers shall be provided to permit the intended placement of the mixed material without interruption.

(c) **Placing and Finishing Equipment.**

1. *Placing Equipment.* For placing and rough finishing, use adequate hand tools for placement of stiff plastic concrete to approximately the strike off level of the screed.
2. *Finishing Machines.*
 - *Repairs.* For deck repairs, use a vibrating screed to finish the deck surface.
 - *Overlays.* Place and finish overlays with an approved finishing machine meeting the following requirements.

Use a finishing machine capable of screeding concrete within 12 inches (300mm) of the face of the existing curb or parapet wall. Make the screed sufficiently long to extend at least 6 inches (150mm) beyond the sides of the placement section, overlapping previously placed courses, overlay forms, and existing and planned sawcut edges. Provide each screed with positive control of the vertical position, the angle of tilt, and the shape of the crown.

Power and gear the finishing machine to maintain smooth finishing operations under all conditions in forward and reverse. Make provisions for raising the screeds to clear the screeded surface for traveling in reverse.

Use a finishing machine capable of final screeding within 10 minutes of depositing the concrete on the deck under normal operating conditions. See Table 505-1 for other production rate requirements.

Support the finishing machine on rails that are fully adjustable, not shimmed, to obtain the correct profile.

When placing concrete in a lane abutting a previously completed lane, equip the finishing machine to travel on the completed lane without marring or damaging its surface.

For high density concrete overlays, use a mechanical strike-off to provide a uniform thickness of concrete in front of the oscillating screed. Equip the oscillating screed(s) to consolidate the concrete to 98% of the unit weight determined by AASHTO T 121. Install identical vibrators along the screed length on 5 foot (1.5m) maximum centers. Make the bottom face of this screed at least 5 inches (125mm) wide with a turned up or rounded leading edge to minimize tearing of the surface of the plastic high density concrete.

For latex modified overlays, use a finishing machine equipped with not less than two finishing devices:

- A vibrating screed designed to consolidate the modified composition to 98% of the rodded unit weight, and one of the following,
- A vibrating oscillating screed, or
- A finishing device consisting of one or more rotating cylindrical drums not exceeding 4 feet (1.2m) in length.

Equip the vibrating screed(s) for latex modified concrete with positive control of vibration so that vibration frequency can be varied between 3000 and 6000 vibrations per minute. Make the bottom face of the screed at least 4 inches (100mm) wide.

505.04. CONSTRUCTION METHODS.

- (a) **General.** Comply the requirements of Section 509 unless otherwise specified.
- (b) **Work Plan.** Before starting the work, submit a work plan to the Engineer and obtain approval. Allow 14 days for the Engineer's review. Include descriptions of the material, equipment, and forms to be used, and the labor requirements.

For overlays, show that the proposed labor and equipment for proportioning, mixing, placing, and finishing new concrete can meet the production requirements of Table 505-1.

Table 505-1
Overlay Production Rates

Total Overlay Area per Bridge, per Bridgesquare yards (m ²)	Minimum Production Rate, Cub.Yd./hr. (m ³ /hr.)
0-298 (0-249)	1.0 (0.75)
299-477 (250-399)	1.5 (1.15)
478-658 (400-550)	2.0 (1.50)
More than 658 (More than 550)	2.5 (1.90)

(c) Preparation of Surfaces.

1. *General Requirement for Repairs.* Remove all unsound deck concrete as specified. Repair areas will be enlarged, reduced, or reclassified as directed by the Engineer, based upon inspection. Do not revise the size of a repair area without permission.

Provide a saw-cut vertical edge around the perimeter of the repair areas. Make the saw cut at least 1 inch (25mm) deep measured from the original surface of the deck.

Avoid cutting, stretching, or damaging any exposed reinforcing steel. Blast clean reinforcing steel to remove all concrete. Replace damaged reinforcing steel, lapping new and old reinforcing as directed.

After removing all unsound concrete, clean and dry the repair area using sandblasting and filtered air blast. Remove all rust, oil, and other foreign matter to provide a clean, dry, etched concrete surface.

2. *Class A Bridge Deck Repair.* For Class A repair, remove unsound concrete by chipping with power hand tools specified in 505.03. In Class A repair areas, notify the Engineer before removal below the top mat. Where removal of material beneath the top mat of reinforcing steel is directed, the repair will be classified as Class B repair.
3. *Class B Bridge Deck Repair.* For most Class B repair, remove unsound concrete by the methods used for Class A repair. If removing unsound concrete deeper than 50% of the original deck thickness, use 15 pound (65N) chipping hammers or hand tools to prevent damage to remaining concrete. In Class B repair areas, notify the Engineer before removing concrete below the mid-depth level. Remove concrete at least 1 inch (25mm) below the top mat. If the depth of the bottom mat is reached, remove the full depth of the deck. Full depth removal will be classified as Class C repair.

4. *Class C Bridge Deck Repair.* For Class C repair, remove the concrete for full depth of the deck, leaving the reinforcing steel intact.

Provide forms meeting the requirements of Section 502 to enable placement of new concrete in the full-depth opening. For areas of one square yard or greater, support forms from the existing superstructure. For smaller areas, the forms may be suspended from existing reinforcing bars by wire ties. Remove all forms when completed. Show typical forming details in the work plan submittal.

5. *Overlays.* Clean the entire existing concrete deck area uniformly using sandblasting alone or chipping followed by sandblasting. Sandblast that portion of the curb or parapet wall against which new concrete is to be placed. Remove all rust, oil, and other foreign matter to provide a clean, etched concrete surface free of laitance. If the original deck concrete was cured with linseed oil emulsion, scarify to a depth of $\frac{1}{4}$ inch (6mm) below the original deck before cleaning.

Place expansion joints as shown on the contract drawings. The longitudinal and transverse profile and the elevation of all expansion joints will be established by the Engineer.

(d) **Mixing.**

1. *High Density Concrete.* Mix high density concrete at the project site in accordance with Section 414.
2. *Latex Modified Concrete.* Comply with the following requirements for the proportioning and mixing latex modified concrete materials:
 - *Measurement of Materials.* Accurately proportion all materials for the specified mixture using a mobile continuous mixer. Calibrate the proportioning equipment for each material in the presence of the inspector. Operate the proportioning equipment at the manufacturer recommended speed during calibration, checks, and normal operation. Make yield checks as needed.
 - *Mixing of Materials.* Mix materials in accordance with the specified requirements for the equipment used. The mixture, as discharged from the mixer, shall be uniform in composition and consistency. Mixing capability shall be such that finishing operations can proceed at a steady pace with final finishing completed before the formation of the plastic surface film.
3. *Class AA Concrete.* Comply with Section 414.

(e) **Placing and Finishing Concrete for Repairs.**

1. *General.* Concrete for repairs may be placed either monolithically with overlays or separately. In addition to the surface screed vibration, vibrate the fresh concrete internally if the concrete thickness is 3 inches (75mm) or more.

If to be overlaid, leave the repair rough textured. If not to be overlaid, match the surface texture of the repair with the existing deck. Unless part of an overlay, place concrete to the level to the existing deck.
2. *Surface Preparation Immediately before Concreting.*
 - *Grouting for High Density Concrete.* Before placing high density concrete, scrub a thin coating of bonding grout into the dry, prepared surface. Exercise care to insure

that all parts receive a thorough, even coating and excessive grout does not collect in pockets. Limit the application rate of grout to insure the grout does not dry before concrete placement. Since grout will dry on a vertical surface more rapidly than the flat deck surface, give special attention to maintaining the grout in the required condition.

- *Surface Wetting for Latex Modified Concrete.* Before placing latex modified concrete, clean the repair areas with air blast followed by flushing with water. Keep the surfaces wet for an hour or more before placing latex modified concrete. Remove puddles of free water before concrete placement.

(f) **Placing and Finishing Concrete for Overlays.**

1. *Dimensions.* Make high density overlays 2 inches (50mm) $\pm 1/4$ inch (6mm) thick and latex modified overlays $1\frac{1}{2}$ inches (38mm) $\pm 1/4$ inch (6mm) thick. Limit the width of each overlay pass to a maximum of 26 feet (8m).
2. *Joints.*
 - *High Density Concrete.* Saw the previously placed high density concrete overlay course to have straight and vertical edges at transverse and longitudinal joints, before placing the adjacent overlay course. Remove all slurry produced by wet sawing of concrete joints from prepared areas before placing new concrete.
 - *Latex Modified Concrete.* Install transverse bulkheads, equal in depth to the thickness of the latex modified concrete, to the required grade and profile before placing concrete.
3. *Finishing Machine Setup.* Adjust the finishing machine to provide the required overlay profile. Place finishing machine rails outside the area to be concreted. Positively anchor the rails to provide horizontal and vertical stability for the rails. Do not use a hold-down device shot into the concrete unless the concrete is to be subsequently resurfaced. Submit working drawings for anchoring support rails for approval.

Before concrete is placed, make a dry run with the finishing machine to check anticipated overlay thickness. Attach a filler block having a thickness $1/8$ inch (3mm) less than overlay thickness to the bottom of the screed. With screed guides in place, pass the screed over the area to be concreted. Correct, in an approved manner, those areas not having the required clearance.

4. *Surface Preparation Immediately before Concreting.* Prepare the surface to be overlaid in the manner specified for repairs using like concrete type (refer to Subsection 505.04(e)2).
5. *Placement.* Place concrete in a continuous operation throughout the pour. In case of a long delay in latex modified concrete placement, install a transverse bulkhead. During shorter delays of less than one hour, protect the end of the placement from drying with several layers of wet burlap.

Place and mechanically strike off the new concrete overlay slightly above the final grade. Mechanically consolidate to 98% of the unit weight, determined by AASHTO T 121, and screed to final grade. In addition to the surface screed vibration, vibrate fresh concrete internally if 3 inches (75mm) or more in thickness. Hand finish with a wood float as required to produce a tight, uniform surface.

6. *Work Bridges.* Keep a minimum of two movable work bridges on hand at all times during concrete placement. Use one of the work bridges for nuclear density measurements and surface finishing and texturing. Use the other work bridge to apply the curing.
7. *Evaporation Control and Curing.* Control evaporation of moisture from the fresh overlay concrete and cure as specified in Subsection 504.04(e)5. Cracking or other damage caused by improper curing will be cause for rejection of the work.
8. *Ambient Temperature Limitations.* Do not place concrete when the air or deck temperature is cooler than 45°F (70°C) or the deck temperature is hotter than 85°F (30°C).

The Engineer may require placing concrete during the nighttime hours during hot weather. The Engineer will inform the Contractor, in writing, if night placing becomes necessary. Comply with floodlighting requirements of Subsection 504.04(e)3.

- (g) **Straightedge Testing and Surface Tolerance.** Immediately after completing the surface of either a repair or overlay and before final finishing, test the surface for trueness with a 10-foot (3m) straightedge. Comply with Subsection 414.04(k)4.4.

When the straightedge is laid on the repaired pavement or overlay in a direction parallel to the centerline, the surface shall not vary more than $\frac{1}{8}$ inch (3mm) from the lower edge of the straightedge. The transverse slope of the pavement shall be uniform to a degree such that no depression greater than $\frac{1}{8}$ inch (3mm) is present when tested with the 10-foot (3m) straight edge laid in a direction transverse to the centerline and extending from edge to edge in a traffic lane.

After completing curing, retest the surface and grind any high areas in excess of the specified tolerances. Groove the ground surfaces to have a texture equal to the surrounding surfaces.

- (h) **Transverse Groove Final Finish for Overlays.** Do not tine finish overlays within 2 inches (50mm) of a construction joint.

1. *High Density Concrete.* After completing the finishing and before applying the transverse groove final finish, seal all vertical joints with adjacent concrete by painting with thinned grout.

After joint painting, apply the transverse groove final finish. Comply with Subsection 414.04(k)5.2, except the grooving passes shall not be overlapped but shall be within 1 inch (25mm) of the preceding pass.

2. *Latex Modified Concrete.* After completing the finishing, apply the transverse groove final finish. Comply with Subsection 414.04(k)5.2, except the grooving passes shall not be overlapped but shall be within 1 inch (25mm) of the preceding pass. This must be done before the plastic film forms on the surface, approximately 25 minutes in hot, dry weather.

Separate screed rails and construction dams from the newly placed material by passing a point trowel along their inside face. Exercise care to insure that this trowel cut is made for the entire depth and length of rails or dams after the concrete has stiffened sufficiently to not flow back.

(i) **Limitation of Operations.**

1. *Traffic Control.* During the construction period of the project, provide such traffic controls as required by the contract documents.
2. *Loading.* After removing old concrete and before placing new concrete, restrict loading on bridge decks to approved construction equipment. Limit the wheel and axle loads of construction vehicles to 8000 pounds (35kN) and 16,000 pounds (70kN) respectively. Any combination of axles spaced closer than 4 feet (1.2m) center-to-center of axles will be considered as one axle.

Unless otherwise specified, keep traffic off the finished surface during the specified curing period. Do not perform preparation work in the adjacent lane on areas adjoining new concrete during the specified curing period.

505.05. METHOD OF MEASUREMENT.

Class A bridge deck repair, Class B bridge deck repair, and Class C bridge deck repair will be computed in square yards (square meters) from measurements of the areas so repaired. All classes of bridge deck repair will be measured prior to the actual placement of the concrete.

Bridge deck overlay will be measured in square yards (square meters) from measurements of the areas so overlaid.

Authorized floodlighting will be measured and paid for as specified in Section 504 for floodlighting.

Grinding and grooving will not be measured for payment. Include the cost of these items in the cost of related items of work.

505.06. BASIS OF PAYMENT.

The accepted quantities, measured as specified in this Section, will be paid at the contract price per unit of measurement for the pay items listed below that are shown in the Plan bid schedule. Payment will be full compensation for the respective work prescribed in this Section. Payment will be made under:

- (A) CLASS A BRIDGE DECK REPAIR SQUARE YARD (SQUARE METER)
- (B) CLASS B BRIDGE DECK REPAIR SQUARE YARD (SQUARE METER)
- (C) CLASS C BRIDGE DECK REPAIR SQUARE YARD (SQUARE METER)
- (D) BRIDGE DECK OVERLAY SQUARE YARD (SQUARE METER)

SECTION 506 STRUCTURAL STEEL

506.01. DESCRIPTION.

This work consists of furnishing, fabricating, and erecting steel structures and structural steel portions of other structures in accordance with these Specifications and the contract documents.

506.02. MATERIALS.

Conform to the requirements of the following Subsections.

Structural Steel	724.01
High-Strength Fasteners	724.02
Welding	724.03
Welded Stud Shear Connectors	724.04
Galvanizing	724.06
Cold Rolled Shafting for Pins and Rollers	725.02
Steel Castings	725.03
Iron Castings	725.04
Phosphor Bronze	725.06
Paint	730.02
Elastomeric Bearings Pads	733.06

506.04. CONSTRUCTION METHOD.

- (a) **General.** For the fabrication of main-load carrying members such as trusses, arches, continuous beams, plate girders, bents, towers, and rigid frames, use a structural steel fabricating plant certified under the AISC Quality Certification Programs in the Major Steel Bridges Category. Use a fabricator who currently has an unrestricted certification under the AISC Quality Certification Programs in the Major Steel Bridges Category with endorsement “F,” for the fabrication of “*fracture critical*” members. Fabricate “*fracture critical*” elements according to the AASHTO Guide Specifications for Fracture Critical Non-Redundant Steel Bridge Members.

Details of design which are permitted to be selected by the Contractor shall conform to the AASHTO *Standard Specification for Highway Bridges*.

Conform to the requirements of Section 512, “Painting,” to paint structural steel. Paint all exposed surfaces of non-weathering grades of steel unless galvanized or otherwise specified; apply the inorganic zinc primer to the top flange of girders. Do not paint weathering steel unless otherwise specified in the contract documents. For superstructures made of weathering steel, blast-clean to the requirements of SSPC-SP6, “Commercial Blast Cleaning.”

Before cutting or welding painted steel, remove all paint to bare metal within 3 inches (75mm) of the work. Comply with the requirements of Section 512. Repaint when finished.

Conform to the requirements of Section 502, “Temporary Structures,” for falsework used to erect structural steel and for temporary bracing.

- (b) **Notice of Beginning of Work.** Give written notice 21 calendar days before the beginning of work at the shop, so that inspection may be provided. Do not manufacture any material or perform any work in the shop before notification and before inspection is provided.
- (c) **Inspection.** Structural steel will be inspected at the fabrication site according to Subsection 106.05.

Furnish a copy of all mill orders and certified mill test reports (Type A certificates). Show on the mill test reports the chemical analyses and physical test results for each heat of steel used in the work.

If approved, furnish Type D certificates from the fabricator, in lieu of mill test reports for material that normally is not supplied with mill test reports and for items such as fills, minor gusset plates, and similar material when quantities are small and the material is taken from stock.

Include in the certified mill test reports for steels with specified impact values, in addition to other test results, the results of Charpy V-notch impact tests. When fine-grain practice is specified, confirm on the test report that the material was so produced. Furnish copies of mill orders at the time orders are placed with the manufacturer. Furnish certified mill test reports and Type D certificates before the start of fabrication using material covered by these reports. Furnish, from the fabricator, a Type D Certificate for the fabrication.

Make material to be used available to the Engineer so that each piece can be examined. Provide the Engineer free access at all times to any portion of the fabrication site where material is stored or where work on the material is being performed.

The inspector will have the authority to reject materials or quality-of-work which does not fulfill the requirements of these Specifications. In cases of disputes, the Contractor may appeal to the Engineer, whose decision will be final.

Inspection at the mill or shop is intended as a means of facilitating the work and avoiding errors, and it is expressly understood that it shall not relieve the Contractor of any responsibility in regard to defective material or quality-of-work and the necessity for replacing the same at the Contractor's expense.

The inspector will stamp each piece accepted with a private mark. Any piece not so marked may be rejected. The acceptance of any material or finished members by the inspector shall not be a bar to subsequent rejection. Promptly replace or correct rejected materials and quality-of-work.

- (d) **Working Drawings.** Prepare and submit drawings according to Subsection 105.02. Approval of the drawings covers the requirements for "*strength and detail*" only. The Department assumes no responsibility for errors in dimensions.

1. *Shop drawings.* Show full detailed dimensions and sizes of component parts of the structure and details of all miscellaneous parts (such as pins, nuts, bolts, drains, weld symbols, etc.) on shop drawings for steel structures.

Adjust girder dimensions on the shop drawings to account for vertical curve, camber, dead load deflection, and grade since the girder detail on the plans is drawn and dimensioned as if the top flange of the girder were horizontal, with no accounting for these items.

Where specific orientation of plates is required, show the direction of rolling of plates. Cut flanges and webs of plate girders from plates so the long dimension of the girder parallels the rolling direction.

Identify on the shop drawings the type and grade of each piece that is to be made of steel.

Show on the shop drawings assembly marks that are cross-referenced to the original pieces of mill steel and their certified mill test reports.

The location of all shop welded splices shown on the shop drawings are subject to approval. Locate all shop welded splices to avoid points of maximum tensile or fatigue stress. Locate splices in webs at least 12 inches (300mm) from shop splices, butt joints in flanges, or stiffeners. Additional nondestructive tests may be required on shop welded splices.

Show on the shop drawings a complete set of bills of materials including pay weights.

2. *Erection drawings.* For all structural steel bridge members, provide erection drawings showing where the members are located in the structure. Identify members by erection mark.

For steel superstructures that require engineered falsework support during erection under Section 502, submit drawings fully illustrating the proposed method of erection. Show details of all falsework bents and attachments to the bridge members. Show the sequence of erection and locations of lifting points. Calculations may be required to demonstrate that factored resistances are not exceeded and that member capacities and final geometry will be correct.

3. *Camber diagram.* Furnish a camber diagram with the shop drawings that shows the camber at each panel point of trusses or arch ribs and at the location of field splices and fractions of span length (tenth points minimum) of continuous beams and girders or rigid frames. When shown on the Plans, show camber at the locations shown on the Plans. On the camber diagram, show calculated cambers to be used in preassembly of the structure as required in Subsection 506.04(f)3.
4. *Transportation drawings.* If required, furnish transportation drawings for approval.

Show all support points, tie-downs, temporary stiffening trusses or beams, and any other details needed to support and brace the member. Provide calculation sheets showing the dead load plus impact stresses induced by the loading and transportation procedure. Use impact stresses of at least 200% of the dead load stress. Use a total load, including impact, of not less than 300% of the dead load.

Ship and store all members, both straight and curved, in their upright position.

(e) **Fabrication.**

1. *Identification of steels.* Use a system of assembly-marking individual pieces and cutting instructions to the shop (generally by cross referencing of the assembly-marks shown on the shop drawings with the corresponding item covered on the mill purchase order) that maintains the identity of the original piece.

Material may be furnished from stock which can be identified by heat number and mill test report.

During fabrication, up to the point of assembling members, show clearly and legibly the specification of each piece of steel (other than Grade 36 (250) steel) by writing the material specification on the piece or using the identification color code shown in AASHTO M 160.

For other steels not included in AASHTO M 160, provide information on the color code used. Comply with the material identification requirements of AASHTO M 160.

Mark for grade by steel die stamping, or by a substantial, firmly attached tag, pieces of steel, other than Grade 36 (250) steel, that before assembling into members will be subject to fabricating operations, such as blast-cleaning, galvanizing, heating for forming, or painting, which might obliterate paint color code marking. Where the steel stamping method is used, place the impressions on the thicker tension-joint member in transition joints.

2. *Storage of Material.* Store structural material, either plain or fabricated, above the ground on platforms, skids, or other supports. Keep material free from dirt, grease, and other foreign matter and provide appropriate protection from corrosion. Store high-strength fasteners in accordance with Subsection 506.04(f)6.4.
3. *Plates.*
 - 3.1 *Direction of rolling.* Unless otherwise shown in the contract documents, cut and fabricate steel plates for main members and splice plates for flanges and main tension members, not secondary members, so that the primary direction of rolling is parallel to the direction of the principal tensile and/or compressive stresses.
 - 3.2 *Plate cut edges.*
 - 3.2.1 *Edge planing.* Remove sheared edges on plates thicker than $\frac{5}{8}$ inch (16mm) to a depth of $\frac{1}{4}$ inch (6mm) beyond the original sheared edge, or beyond any re-entrant cut produced by shearing. Fillet re-entrant cuts before cutting to a minimum radius of $\frac{3}{4}$ inch (20mm).
 - 3.2.2 *Oxygen Cutting.* Oxygen cut structural steel according to ANSI/AASHTO/AWS Bridge Welding Code D1.5.
 - 3.2.3 *Visual Inspection and Repair of Plate Cut Edges.* Visually inspect and repair plate cut edges. The cut edges shall conform to ANSI/AASHTO/AWS Bridge Welding Code D1.5.
 - 3.3 *Bent plates.*
 - 3.3.1 *General.* Furnish unwelded, load-carrying, rolled-steel plates to be bent as specified herein.

Take material from the stock plates such that the bend line will be at right angles to the direction of rolling, except that cold-bent ribs for orthotopic-deck bridges may be bent with bend lines in the direction of rolling.

Before bending, round the corners of the plates to a radius of $\frac{1}{16}$ inch (2mm) throughout the portion of the plate where the bending occurs.
 - 3.3.2 *Cold bending.* Cold bend so that no cracking of the plate occurs. Use the minimum bend radii shown in Table 506-1 measured to the concave face of the metal.

Table 506-1
Minimum Bending Radii

Plate Thickness - t, inches (mm)	Bending Radius*
Less than 1/2 (12)	2(t)
Over 1/2 to 1 (12 to 25)	2.5(t)
Over 1 to 1 1/2 (25 to 38)	3(t)
Over 1 1/2 to 2 1/2 (38 to 60)	3.5(t)
Over 2 1/2 to 4 (60 to 100)	4(t)

*Bend radii for all grades of structural steel.

Allow for springback of Grades 100 (690) and 100W (690W) steels equal to about three times that for Grade 36 (250) steel. Use a lower die span of at least 16 times the plate thickness for break press forming. Make multiple hits.

3.3.3 *Hot bending.* If a radius shorter than the minimum specified for cold bending is essential, hotbend the plates at a temperature not greater than 1200°F (650°C), except for Grades 70W (485W, 100 (690), and 100W (690W). If Grades 100 (690) and 100W (690W) steel plates are heated to a temperature greater than 1100°F (595°C) or, Grade 70W (grade 485W) steel plates are heated to a temperature greater than 1050°F (565°C), re-quench and temper according to the producing mill's standard practice and, when directed, tested to verify restoration of specified properties.

4. *Stiffeners.* Provide bearing stiffeners in pairs, one on each side of the web. Mill to bear at the bottom flange and tight fit at the top flange. Provide fillet welds ($\frac{5}{16}$ inch (8mm), unless otherwise specified) on both sides of the bearing stiffener, at the web and top and bottom flanges. Allow the fit of the bearing stiffener to the flanges to be inspected before covering with weld. Install bearing stiffeners to be vertical in the finished structure.

Fabricate intermediate stiffeners not intended to support concentrated loads to provide a tight fit against both flanges. Provide fillet welds ($\frac{1}{4}$ inch (6mm), unless otherwise specified) on both sides of the stiffener at the web and compression flange. On exterior girders, place all intermediate stiffeners on the outside of the web. On interior girders, alternate sides of the web when placing intermediate stiffeners.

Provide diaphragm stiffeners in pairs, one on each side of the web. Fabricate diaphragm stiffeners to provide a tight fit against both flanges. Provide fillet welds ($\frac{1}{4}$ inch (6mm), unless otherwise specified) on both sides of the stiffener, at the web and top and bottom flanges.

Clip the corners of stiffeners at flange-web intersections. If clip dimensions are not shown on the plans, use the following clip dimensions:

- along the flange: 1 1/2 inches (38mm),
- along the web: 4 to 6 times the web thickness, but not less than 1 1/2 inches (38mm), nor more than 3 inches (75mm).

5. *Abutting joints.* Mill or saw-cut abutting joints in compression members of trusses and columns to give a square joint and uniform bearing. The maximum allowed opening at other joints, not required to be faced, is $\frac{3}{8}$ inch (10mm).
6. *Facing of bearing surfaces.* Finish bearing and base plates and other bearing surfaces that will come in contact with each other or with concrete to the ANSI surface roughness defined in ANSI B46.1, *Surface Roughness, Waviness and Lay, Part I*, as shown in Table 506-2.

Table 506-2
ANSI Surface Roughness Values

<u>Bearing Surface</u>	<u>Surface Roughness Value</u> <u>μ-inch (μm)</u>
Steel slabs	2000 (50)
Heavy plates in contact in shoes to be welded	1000 (25)
Milled ends of compression members, milled or ground ends of stiffeners and fillers	500 (13)
Bridge rollers and rockers	250 (6)
Pins and pin holes	125 (3)
Sliding bearings	125 (3)

Machine sliding bearings that have a surface roughness greater than ANSI 60 (2μm) so the lay of the cut is parallel to the direction of movement.

Fabricate parts in bearing to provide a uniform even contact with the adjacent bearing surface when assembled. Limit the maximum gap between bearing surfaces to 0.040 inch (1mm). Base and sole plates that are plane and true and have a surface roughness not exceeding the above tabulated values need not be machined, except machine sliding surfaces of base plates.

Do not machine surfaces of fabricated members until all fabrication on that particular assembly or subassembly is complete. Machine metal components that are to be heat treated after heat treatment.

7. *Straightening material.* If approved, straighten plates, angles, other shapes, and built-up members by methods that will not produce fracture or other damage to the metal. Straighten distorted members by mechanical means or, if approved, by carefully planned procedures and supervised application of a limited amount of localized heat. Use rigidly controlled procedures and do not exceed the temperatures specified in Table 506-3 when heat straightening Grades 70W, 100 and 100W (grades 485W, 690, and 690W) steel members.

Table 506-3
Heat Straightening Temperatures

<u>Material to be Straightened</u>	<u>Maximum Temperature</u>
Grade 70W(485W) > 6 inches(150mm) from weld	1050°F (565°C)
Grade 70W(485W) < 6 inches (150mm)from weld	900°F (480°C)
Grade 100(690) or 100W(690W) > 6 inches (150mm)from weld	1100°F (595°C)
Grade 100(690) or 100W(690W) < 6 inches (150mm)from weld	950°F (510°C)

In all other steels, do not exceed 1200°F (650°C) in the heated area. Control the application by temperature-indicating crayons, liquids, or bimetal thermometers. Heating in excess of the limits shown shall be cause for rejection, unless the Engineer allows testing to verify material integrity.

Keep parts to be heat straightened substantially free of external forces and stress, except stresses resulting from mechanical means used in conjunction with the application of heat.

Evidence of fracture following straightening of a bend or buckle will be cause for rejection of the damaged piece.

8. Bolt Holes.

8.1 Holes for High-Strength Bolts and Unfinished Bolts.

8.1.1 General. Make bolt holes to the dimensions given in Table 506-4 for standard, oversize, short slotted, and long slotted holes. Provide oversize, short slotted, and long slotted holes only when specified in the contract documents.

**Table 506-4 (English)
Bolt Hole Sizes (inches)**

Bolt Diameter (d)	Standard (Diameter)	Oversize (Diameter)	Short Slot (Width x Length)	Long Slot (Width x Length)
5/8	11/16	13/16	11/16 x 7/8	11/16 x 1 9/16
3/4	13/16	15/16	13/16 x 1	13/16 x 1 7/8
7/8	15/16	1 1/16	15/16 x 1 1/8	15/16 x 2 3/16
1	1 1/16	1 1/4	1 1/16 x 1 5/16	1 1/16 x 2 1/2
1 1/8	d+1/16	d+5/16	d+1/16 x d+3/8	d+1/16 x 2.5d

**Table 506-4 (Metric)
Bolt Hole Sizes (mm)**

Bolt Dia. (d)	Standard (Dia.)	Oversize (Dia.)	Short Slot (Wid. X Len.)	Long Slot (Wid. X Len.)
16	18.0	20.0	18.0 x 22.0	18.0 x 40.0
20	22.0	24.0	22.0 x 26.0	22.0 x 50.0
22	24.0	28.0	24.0 x 30.0	24.0 x 55.0
24	27.0	30.0	27.0 x 32.0	27.0 x 60.0
27	30.0	35.0	30.0 x 37.0	30.0 x 67.0
30	33.0	38.0	33.0 x 40.0	33.0 x 75.0

Punch or drill all bolt holes, except as noted herein. Material forming the parts of a member composed of not more than 5 thicknesses of metal may be punched full-size whenever the thickness of the material is not greater than 3/4 inch (20mm) for structural steel, 5/8 inch (16mm) for high-strength steel, or 1/2

inch (12mm) for quenched and tempered alloy steel, unless subpunching and reaming is required under Subsection 506.04(e)8.5, the preparation of field connections.

When material is thicker than $\frac{3}{4}$ inch (20mm) for structural steel, $\frac{5}{8}$ inch (16mm) for high-strength steel, or $\frac{1}{2}$ inch (12mm) for quenched and tempered alloy steel, either subdrill and ream or drill full-size all holes. If required, either subpunch or subdrill (subdrill if thickness limitation governs) $\frac{1}{4}$ inch (6mm) smaller and, after assembling, ream $\frac{1}{16}$ inch (2mm) larger or drill full size.

8.1.2 *Punched holes.* Use a die diameter that is not more than $\frac{1}{16}$ inch (2mm) larger than the punch diameter. Ream holes that require enlarging to admit bolts. Clean cut the holes without torn or ragged edges. The slightly conical hole that naturally results from punching operations shall be considered acceptable.

8.1.3 *Reamed or drilled holes.* Ream or drill holes so they are cylindrical and perpendicular to the member. Where practical, direct reamers by mechanical means. Remove burrs on the outside surfaces. Ream and drill with twist drills, twist reamers, or roto-broach cutters. Assemble and securely hold together connecting parts that are being reamed or drilled and match-mark before disassembling.

8.1.4 *Accuracy of holes.* Holes not more than $\frac{1}{32}$ inch (1mm) larger in diameter than the true decimal equivalent of the nominal diameter of the drill or reamer are acceptable. The slightly conical hole resulting from punching operations is acceptable. The width of slotted holes produced by flame cutting or a combination of drilling or punching and flame cutting shall be no more than $\frac{1}{32}$ inch (1mm) greater than the nominal width. Grind flame cut surfaces smooth.

8.2 *Accuracy of Hole Group.*

8.2.1 *Accuracy before reaming.* Accurately punch full size, subpunched, or subdrilled holes so that after assembling (before any reaming is done) a cylindrical pin $\frac{1}{8}$ inch (3mm) smaller in diameter than the nominal size of the punched hole may be entered perpendicular to the face of the member, without drifting, in at least 75% of the contiguous holes in the same plane. Punched pieces not meeting this requirement will be rejected. Holes, through which a pin $\frac{3}{16}$ inch (5mm) smaller in diameter than the nominal size of the punched hole cannot be inserted, will be rejected.

8.2.2 *Accuracy after reaming.* After reaming, the maximum allowed offset of 85% of any contiguous group of holes through adjacent thicknesses of metal is $\frac{1}{32}$ inch (3mm).

Use steel templates having hardened steel bushings in holes accurately dimensioned from the centerlines of the connection as inscribed on the template. Use connection centerlines when locating templates from the milled or scribed ends of members.

- 8.3 *Numerically-controlled drilled field connections.* In lieu of drilling undersized holes and reaming while assembled, or drilling holes full-size while assembled, drilling or punching bolt holes full-size in unassembled pieces and/or connections, including templates for use with matching undersized and reamed holes by means of suitable numerically-controlled (N/C) drilling or punching equipment is allowed.
- 8.4 *Holes for ribbed bolts, turned bolts, or other approved bearing-type bolts.* Subpunch or subdrill holes for ribbed bolts, turned bolts, or other approved bearing-type bolts, $\frac{3}{16}$ inch (5mm) smaller than the nominal diameter of the bolt and ream when assembled, or drill from the solid. Provide finished holes with a driving fit.
- 8.5 *Preparation of field connections.* Subpunch or subdrill and ream while assembled, or drill full size to a steel template, holes in all field connections and field splices of main members of trusses, arches, continuous beam spans, bents, towers (each face), plate girders, and rigid frames.

Holes for field splices of rolled beam stringers continuous over floor beams or cross frames may be drilled full-size unassembled to a steel template. Holes for floor beams or cross frames may be drilled full size unassembled to a steel template. Subpunch and ream while assembled, or drill full size to a steel template, all holes for floor beam and stringer field end connections.

When reaming or drilling full size field connection holes through a steel template, carefully locate and position the template and firmly bolt in place, before drilling. Use exact duplicates of templates used for reaming matching members, or the opposite faces of a single member. Accurately locate templates used for connections on like parts or members so that the parts or members are duplicates and require no match-marking.

For any connection, in lieu of subpunching and reaming or subdrilling and reaming, holes drilled full-size through all thicknesses or material assembled in proper position may be used.

9. *Pins and Rollers.*

- 9.1 *General.* Accurately fabricate pins and rollers that are straight, smooth, and free from flaws. Forge and anneal pins and rollers more than 9 inches (230mm) in diameter. Pins and rollers 9 inches (230mm) or less in diameter may be either forged and annealed or cold-finished carbon-steel shafting.

In pins larger than 9 inches (230mm) in diameter, bore a hole not less than 2 inches (50mm) in diameter full length along the pin axis after the forging has been allowed to cool to a temperature below the critical range (under suitable conditions to prevent damage by too rapid cooling and before being annealed).

- 9.2 *Boring pin holes.* Bore pin holes true to the specified diameter, smooth and straight, at right angles with the axis of the member and parallel with each other. Produce the final surface using a finishing cut.

Produce a pin hole diameter that does not exceed that of the pin by more than 0.020 inches (0.5mm) for pins 5 inches (125mm) or less in diameter, or by $\frac{1}{32}$ inch (1mm) for larger pins.

The maximum allowed variation of the outside-to-outside distance of end holes in tension members and the inside-to-inside distance of end holes in compression members is $\frac{1}{32}$ inch (1mm) from that specified. Bore pin holes in built-up members after the member has been assembled.

- 9.3 *Threads for bolts and pins.* Provide threads on all bolts and pins for structural steel construction that conform to screw threads Profile ANSI B1.13 (B1.13M) with a tolerance Class 6G for external threads and Class 6H for internal threads.
10. *Eyebars.* Pin holes may be flame cut at least 2 inches (50mm) smaller in diameter than the finished pin diameter. Securely fasten together (in the order to be placed on the pin) all eyebars that are to be placed side by side in the structure and bore at both ends while clamped. Pack and match-mark eyebars for shipment and erection. Stamp with steel stencils, so as to be visible when the bars are nested in place on the structure, all identifying marks on the edge of one head of each member after fabrication is completed. Use low-stress type steel die stamps. Do not weld on eyebars.

Provide eyebars, straight and free from twists, with pin holes accurately located on the centerline of the bar. Do not allow the inclination of any bar to the plane of the truss to exceed a slope of 0.5 percent.

Simultaneously cut the edges of eyebars that lie between the transverse centerline of their pin holes with two mechanically operated torches abreast of each other, guided by a substantial template to prevent distortion of the plates.

11. *Annealing and Stress Relieving.* When structural members are indicated in the contract documents to be annealed or normalized, machine, finish bore, and straighten annealed or normalized these members subsequent to heat treatment. Normalize and anneal (full annealing) according to ASTM A919. Maintain uniform temperatures throughout the furnace during the heating and cooling so that the temperature at no two points on the member will differ by more than 100°F at any time.

Do not anneal or normalize members of Grades 100/100W (690/690W) or Grade 70W(485W) steels. Stress relieve these grades only with approval.

Record each furnace charge, identify the pieces in the charge and show the temperatures and schedule actually used. Provide proper instruments, including recording pyrometers, for determining at any time the temperatures of members in the furnace. Make records of the treatment operation available for approval. The maximum allowed holding temperature for stress relieving Grades 100/100W (690/690W) and Grade 70W (485W) steels is 1100°F (595°C) and 1050°F (565°C), respectively.

Stress relieve members, such as bridge shoes, pedestals, or other parts that are built up by welding sections of plate together, according to Subsection 4.4 of ANSI/AASHTO/AWS Bridge Welding Code D1.5.

12. *Curved Girders.*
- 12.1 *General.* Flanges of curved, welded girders may be cut to the radii specified in the contract documents or curved by applying heat as required by these Specifications providing the radii is not less than allowed the AASHTO Standard Specifications for Highway Bridges.

12.2 Heat Curved Rolled Beams and Girders.

12.2.1 *Materials.* Do not heat curve steels that are manufactured to a specified minimum yield point greater than 50 ksi (345MPa).

12.2.2 *Type of Heating.* Beams and girders may be curved either continuous or V-type heatings as approved by the Engineer.

For the continuous method, heat a strip along the edge of the top and bottom flange simultaneously. Make the strip of sufficient width and temperature to obtain the required curvature.

For the V-type heating, heat the top and bottom flanges in truncated triangular or wedge-shaped areas having their base along the flange edge and spaced at regular intervals along each flange. Use the spacing and temperature as required to obtain the required curvature, heating along the top and bottom flange at approximately the same rate. Terminate the apex of the truncated triangular area applied to the inside flange surface just before the juncture of the web and the flange is reached. To avoid unnecessary web distortion, take special care when heating the inside flange surfaces (the surfaces that intersect the web) so that heat is not applied directly to the web. When the radius of curvature is 1000 feet (300m) or more, extend the apex of the truncated triangular heating pattern applied to the outside flange surface to the juncture of the flange and web. When the radius of curvature is less than 1000 feet (300m), extend the apex of the truncated triangular heating pattern applied to the outside flange surface past the web for a distance equal to $\frac{1}{8}$ of the flange width or 3 inches (75mm), whichever is less. The truncated triangular pattern shall have an included angle of approximately 15 to 30 degrees but the base of the triangle shall not exceed 10 inches (250mm). Variations in the patterns prescribed above may be made with the approval of the Engineer.

For both types of heating, the flange edges to be heated are those that will be on the inside of the horizontal curve after cooling. Heating both inside and outside flange surfaces is only mandatory when the flange thickness is $1\frac{1}{4}$ inch (32mm) or greater, in which case, heat the two surfaces concurrently. The maximum temperature shall be as prescribed below.

12.2.3 *Temperature.* Conduct the heating-curving operation in such a manner that the temperature of the steel does not exceed 1150°F (620°C) as measured by temperature-indicating crayons or other suitable means. Do not artificially cool the girder until after naturally cooling to 600°F (315°C). The method of artificial cooling shall be subject to the approval of the Engineer.

12.2.4 *Position for Heating.* The girder may be heat-curved with the web in either a vertical or horizontal position. When curved in the vertical position, brace or support the girder in such a manner that the tendency of the girder to deflect laterally during the heat-curving process will not cause the girder to overturn.

When curved in the horizontal position, support the girder near its ends and at the intermediate points, if required, to obtain a uniform curvature; the

bending stress in the flanges due to the dead load of the girder must not exceed the usual allowable design stress. When the girder is positioned horizontally for heating, maintain intermediate safety catch blocks at the midlength of the girder within 2 inches (50mm) of the flanges at all times during the heating process to guard against a sudden sag due to plastic flange buckling.

12.2.5 *Sequence of Operations.* Heat-curve the girder in the fabrication shop before it is painted. The heat-curving operation may be conducted either before or after all the required welding of transverse intermediate stiffeners are completed. However, unless provisions are made for girder shrinkage, locate and attach connection plates and bearing stiffeners after heat curving. If longitudinal stiffeners are required, heat-curve or oxygen-cut the stiffeners separately and then weld to the curved girder. When cover plates are to be attached to rolled beams, they may be attached before curving if the total thickness of one flange and cover plate is less than $2\frac{1}{2}$ inches (65mm) and the radius of curvature is greater than 1000 feet (300m). For other rolled beams with cover plates, heat-curve the beams before the cover plates are attached; either heat-curve or oxygen-cut cover plates separately and then weld to the curved beam.

12.2.6 *Camber.* Perform cambering of girders before heat curving. Camber for rolled beams may be obtained by heat-cambering methods approved by the Engineer. For plate girders, cut the web to the prescribed camber with suitable allowance for shrinkage due to cutting, welding, and heat curving. The heat-curving process may tend to change the vertical camber present before heating. This effect will be most pronounced when the top and bottom flanges are of unequal widths on a given transverse cross section. However, subject to the approval of the Engineer, moderate deviations from specified camber may be corrected by a carefully supervised application of heat.

12.2.7 *Measurement of Curvature of Camber.* Horizontal curvature and vertical camber shall be measured for final acceptance after all welding and heating operations are completed and the flanges have cooled to a uniform temperature. Check horizontal curvature with the girder in the vertical position.

13. *Full-Size Tests.* When full-size tests of fabricated structural members or eyebars are required in the contract documents, provide suitable facilities, material, supervision, and labor necessary for making and recording the required tests.

14. *Marking and Shipping.* Paint and mark each member with an erection mark for identification. Use the corresponding marks from the approved working drawings.

Furnish as many copies of material orders, shipping statements, and erection drawings, as the Engineer directs. Show the weight of the individual members on the statements. Mark thereon the weight of members over 6000 pounds (3000kg).

Load structural members on trucks or cars in such a manner that they may be transported and unloaded at their destination without being excessively stressed, deformed, or otherwise damaged.

Ship bolts, nuts, washers, and other fastener components from each rotational-capacity lot in the same container. If there is only one production lot number for each size of nut and washer, the nuts and washers may be shipped in separate containers. Ship pins, small parts, and packages of bolts, nuts, and washers in boxes, crates, kegs, or barrels, not exceeding 300 pounds (140kg) gross weight per package. Plainly mark a list and description of the contained materials on the outside of each shipping container.

(f) **Assembly.**

1. *Bolting.* Clean surfaces of metal in contact before assembling. Assemble parts of a member. Securely pin and firmly draw together before drilling, reaming, or bolting is commenced. Take assembled pieces apart for the removal of burrs and shavings produced by the operation. Assemble members to be free from twists, bends, and other deformation.

Drift during assembling only enough to bring the parts into position without enlarging holes or distorting the metal.

Place a washer under the element of the bolted assembly that is turned during installation.

2. *Welded Connections.* Fabricate surfaces and edges to be welded smooth, uniform, clean, and free of defects that would adversely affect the quality of the weld. Prepare edges according to ANSI/AASHTO/AWS *Bridge Welding Code D1.5*.
3. *Preassembly of Field Connections.*

- 3.1 *General.* Preassemble field connections of main members of trusses, arches, continuous beams, plate girders, bents, towers, and rigid frames before erection to verify the geometry of the completed structure or unit and to verify or prepare field splices. Submit the method and details of preassembly for approval. Use methods and details of preassembly that are consistent with the procedure shown on the approved erection drawings and camber diagrams.

Preassemble at least 3 contiguous panels or sections that are accurately adjusted for line and camber. For successive assemblies include at least one panel or section of the previous assembly (repositioned if necessary and adequately pinned to assure accurate alignment) plus 2 or more sections or panels added at the advancing end. For structures longer than 150 feet (50m), make each assembly not less than 150 feet (50m) long regardless of the length of individual continuous panels or sections. Assembly may start from any location in the structure and proceed in one or both directions as long as preceding requirements are satisfied.

- 3.2 *Bolted connections.* Prepare bolted connections holes as specified in Subsection 506.04(e)8. Where applicable, assemble major components with milled ends of compression members in full bearing and then ream subsized holes to the specified size while the connections are assembled.
- 3.3 *Check assembly/numerically-controlled drilling.* When using numerically controlled drilling or punching, make a check assembly for each major structural type of each project. Fabricate the check assembly of at least 3 contiguous shop sections or, for a truss, all members in at least 3 contiguous panels but not less than the number of panels associated with 3 contiguous chord lengths (such as the length between field splices). Base check assemblies on the proposed order of erection, joints in bearings, special

complex points, and similar considerations. Shop assemblies other than the check assemblies are not required.

If the check assembly fails in some specific manner to demonstrate that the required accuracy is being obtained, further check assemblies may be required for which there shall be no additional cost to the Department.

Receive approval of each assembly (including camber, alignment, accuracy of holes, and fit of milled joints) before reaming is commenced or before any N/C drilled check assembly is dismantled.

- 3.4 *Field welded connections.* Field welded connections are prohibited unless specifically specified in the contract documents. Verify the fit of members (including the proper space between abutting flanges) with the segment preassembled in accordance with Subsection 506.04(f)3.1.
4. *Match Marking.* Match mark connecting parts preassembled in the shop to assure proper fit in the field. Provide a diagram showing such match-marks.
5. *Connections Using Unfinished, Turned, or Ribbed Bolts.*
 - 5.1 *General.* Use unfinished, turned, or ribbed bolts, where specified, conforming to the requirements for carbon and alloy steel externally threaded fasteners, ASTM A 568, Property Class 4.6, 60 ksi (400MPa) tensile strength. Use bolts with single self-locking nuts or double nuts. Use beveled washers where bearing faces have a slope of more than 1:20 with respect to a plane normal to the bolt axis. Note that the specifications of this Subsection 506.04(f)5.1 do not pertain to the use of high-strength bolted connections, which are covered in Subsection 506.04(f)6.
 - 5.2 *Turned bolts.* Furnish turned bolts with a body surface ANSI roughness not exceeding 125 (3.2mm). Furnish hex headed bolts and nuts of the nominal size specified. Carefully ream holes for turned bolts and furnish bolts to provide for a light driving fit. Keep bolt threads entirely outside of the holes. Provide a washer under the nut.
 - 5.3 *Ribbed bolts.* Use approved form of ribbed body with continuous longitudinal ribs. Provide a body diameter measured on a circle through the points of the ribs $\frac{1}{16}$ inch (2mm) greater than the nominal diameter specified for the bolts.

Furnish ribbed bolts with round heads conforming to ANSI B18.5.2.2M or B18.5.2.3M as specified. Furnish hexagonal nuts that are either recessed or have a washer of suitable thickness. Ribbed bolts shall have a driving fit when installed in holes. Provide sufficiently hard ribs such that the ribs do not compress or deform and allow the bolts to turn in the holes during tightening. If the bolt twists before drawing tight, ream the hole and provide an oversized replacement bolt.
6. *Connections Using High-Strength Bolts.*
 - 6.1 *General.* This subsection covers the assembly of structural joints using AASHTO M 164 or AASHTO M 253 high-strength bolts, or equivalent fasteners, tightened to a high tension. Install bolts in holes conforming to Subsection 506.04(e)8. Use direct tension indicators (DTIs) on all connections using high-strength bolts, unless otherwise specified in the contract documents.

- 6.2 *Bolted parts.* Use steel material within the grip of the bolt with no compressible material such as gaskets or insulation. Fabricate bolted steel parts to fit solidly together after the bolts are tightened. Limit the maximum slope of the surfaces of parts in contact with the bolt head or nut to 1:20 with respect to a plane normal to the bolt axis.
- 6.3 *Surface conditions.* In painted joints including slip-critical joints, paint the faying surfaces with inorganic zinc primer of the Inorganic Zinc/Epoxy/Urethane (IZ-E-U) paint system specified in Subsection 730.02. Before blast-cleaning and painting, remove burrs that would prevent solid seating of the connected parts in the snug-tight condition. At the time of assembly, clean all joint surfaces (including surfaces adjacent to the bolt head and nut) of dirt or foreign material. Repair damage that would prevent solid seating of the connected parts in the snug-tight condition

If a paint system other than the IZ-E-U system is specified, paint the faying surfaces only if the primer is a Class B classification, minimum slip coefficient of 0.50, as tested by the “Test Method to Determine the Slip Coefficient for Coatings Used in Bolted Joints” from the Research Council on Structural Connections. Otherwise, treat the joint as a non-painted joint. Do not assemble painted joints before the primer has cured for the minimum time used in the qualifying test.

In non-painted joints, exclude paint (including any inadvertent overspray) from areas closer than one bolt diameter, but not less than 1 inch (25mm), from the edge of any hole and all areas within the bolt pattern. At the time of assembly, clean all joint surfaces (including surfaces adjacent to the bolt head and nut) of dirt or foreign material and scale, except tight mill scale. Remove burrs that would prevent solid seating of the connected parts in the snug-tight condition.

For faying surfaces to be galvanized, hot-dip galvanize in accordance with AASHTO M 111 and hand roughen by means of hand wire brushing. Do not use a power wire brush.

6.4 *Installation.*

- 6.4.1 *General.* Install fasteners of the same lot number together. Protect fasteners from dirt and moisture. Take from protected storage only as many fasteners as are anticipated to be installed and tightened during a work shift. Return to protected storage fasteners not used at the end of the shift. Do not clean lubricant from fasteners that is required to be present in the as-delivered condition. Clean, re-lubricate, and test for rotational capacity before installation, fasteners for slip-critical connections which accumulate rust or dirt. Lubricate all galvanized nuts with a lubricant containing a visible dye. Provide plain bolts that are “oily” to the touch when delivered and installed. Remove lubricant before painting.

Provide a tension measuring device (a Skidmore-Wilhelm calibrator or other acceptable bolt tension indicating device) at all job sites where high-strength fasteners are being installed and tightened. Use the tension measuring device to perform the rotational-capacity test and to confirm:

- the requirements of Table 506-5 of the complete fastener assembly,
- the calibration of the wrenches, if applicable, and
- the understanding and proper use by the bolting crew of the tightening method.

For short grip bolts, direct tension indicators (DTI) with solid plates may be used to perform this test. First check the DTI with a longer grip bolt in the Skidmore-Wilhelm calibrator. The frequency of confirmation testing, number of tests to be performed, and test procedure shall conform to the requirements for turn-of-nut tightening and direct tension indicator tightening methods as applicable (see Subsection 506.04(f)6.4.4, *Turn-of-nut tightening* and Subsection 506.04(f)6.4.6, *Direct tension indicator tightening*). Confirm the accuracy of the tension measuring device by an approved testing agency at least annually.

Install fasteners together with washers of size and quality specified, located as required below, in properly aligned holes and tightened by the methods described in this specification inclusive to at least the minimum tension specified in Table 506-5 after all the fasteners are tight. Where the use of direct tension indicators is specified, use the direct tension indicator method of tightening.

TABLE 506-5
Minimum Required Bolt Tension¹

<u>Bolt Size-inches</u>	AASHTO M 164 ASTM A 325 <u>(pounds)</u>	AASHTO M 253 ASTM A 490 <u>(pounds)</u>
$\frac{5}{8}$	19,000	24,000
$\frac{3}{4}$	28,000	35,000
$\frac{7}{8}$	39,000	49,000
1	51,000	64,000
$1\frac{1}{8}$	56,000	80,000
$1\frac{1}{4}$	71,000	102,000

¹ Equal to 70% of the specified minimum tensile strength of bolts (as specified in ASTM Specifications for tests of full size ASTM A 325 and ASTM A 490 bolts with coarse thread series, ANSI B1.13, loaded in axial tension) rounded to the nearest 1000 pounds.

**TABLE 506-5 (Metric)
Minimum Required Bolt Tension ²**

<u>Bolt Size-mm</u>	<u>AASHTO M 164 ASTM A 325M (kN)</u>	<u>AASHTO M 253 ASTM A 490M (kN)</u>
16	91.2	114
20	142	179
22	176	221
24	205	257
27	267	334
30	326	408
36	476	595

² Equal to 70% of the specified minimum tensile strength of bolts (as specified in ASTM Specifications for tests of full size ASTM A 325M and ASTM A 490M bolts with metric coarse thread series, ANSI B1.13M, loaded in axial tension) rounded to the nearest 0.1 kN.

If approved, tightening may be performed by turning the bolt while the nut is prevented from rotating when it is impractical to turn the nut. If impact wrenches are used, provide adequate capacity and sufficient air to tighten each bolt in approximately 10 seconds.

Do not reuse AASHTO M 253 fasteners and AASHTO M 164 fasteners. Touching up or re-tightening previously tightened bolts that may have been loosened by the tightening of adjacent bolts will not be considered as re-use, provided the snugging up continues from the initial position and does not require greater rotation, including the tolerance, than that required by Table 506-6.

TABLE 506-6 ^(a)
Nut Rotation from the Snug-Tight Condition ^{(b)(d)}
Geometry of Outer Faces of Bolted Parts

Bolt length measured from underside of head to end of bolt	Both faces normal to bolt axis	One face normal to bolt axis and other face sloped not more than 1:20. <u>(Bevel washers not used)</u>	Both faces normal to bolt axis and other face sloped not more than 1:20. <u>(Bevel washers not used)</u>
Up to and including 4 diameters	1/3 turn	1/2 turn	2/3 turn
Over 4 diameters but not exceeding 8 diameters	1/2 turn	2/3 turn	5/6 turn
Over 8 diameters but not exceeding 12 diameters ^(c)	2/3 turn	5/6 turn	1 turn

- (a) Applicable only to connections where all material within the grip of the bolt is steel.
- (b) Nut rotation is relative to bolt, regardless of the element (nut or bolt) being turned. The tolerance is $\pm 30^\circ$ for bolts installed by $\frac{1}{2}$ turn or less. The tolerance is $\pm 45^\circ$ for bolts installed by $\frac{2}{3}$ turn or more.
- (c) For bolt lengths greater than 12 diameters, determine the required rotation by actual tests in a suitable tension device simulating the actual conditions.
- (d) *Snug-tight* is defined as the tightness that exists when the plies of the joint are in firm contact. This may be attained by a few impacts of an impact wrench or the full effort of a worker using an ordinary spud wrench.

Install bolts in all holes of the connection and bring to a snug-tight condition. Systematically progress with snug-tightening from the most rigid part of the connection to the free edges. Retighten the bolts of the connection in a similar systematic manner as necessary until all bolts are simultaneously snug-tight and the connection is fully compacted.

6.4.2 *Rotational-capacity tests.* Subject high-strength fasteners, black and galvanized, to job-site rotational-capacity tests performed according to AASHTO M 164 and the following.

- a. Include washers as part of the test even if they may not be required as part of the installation procedure.
- b. Test each combination of bolt production lot, nut lot, and washer lot as an assembly. Where washers are not required by an installation procedures, they need not be included in the lot identification.

- c. Assign a rotational-capacity lot number to each combination of lots tested.
- d. Test at a minimum frequency of 2 assemblies per rotational-capacity lot.
- e. For bolts that are long enough to test in a Skidmore-Wilhelm Calibrator, assemble and test the bolt, nut, and washer assembly in a Skidmore-Wilhelm Calibrator or approved equivalent device.
- f. For bolts that are too short to test in a Skidmore-Wilhelm Calibrator, test the assembly in a steel joint. The tension requirement in Subsection 506.04(f)6.4.2*h*, need not apply. Compute the maximum torque requirement,

$$\text{Torque} \leq 0.25 PD,$$

using a value of P equal to the turn test tension (1.15 times the fastener tension in Table 506-5).

- g. After tightening to a snug-tight condition, tighten the fastener 2 times the required number of turns indicated in Table 506-5, in a Skidmore-Wilhelm Calibrator or equivalent tension measuring device, without stripping or failure.
- h. During this test, the maximum recorded tension must be equal to or greater than the turn test tension which is 1.15 times the required fastener tension indicated in Table 506-5.
- i. After exceeding the turn test tension required above, take and record one reading of tension and torque. The measured torque at a tension "P" shall conform to the following equation:

$$\text{Torque} \leq 0.25 PD$$

where: Torque = Measured torque (foot-pounds) [Newton ° meter]
 P = Measured bolt tension (pounds) [kilo Newtons]
 D = Bolt diameter (feet) [millimeters]

- 6.4.3 Washers. Where the outer face of the bolted parts has a slope greater than 1:20 with respect to a plane normal to the bolt axis, use a hardened beveled washer to compensate for the lack of parallelism.

Use hardened square or rectangular beveled washers for American Standard Beams and Channels conforming to AASHTO M 293.

Where necessary, washers may be clipped on one side not closer than 7/8 of the bolt diameter from the center of the washer.

Hardened washers not required for connections using AASHTO M 164 and AASHTO M 253 bolts except under the following conditions.

- Use hardened washers under both the head and the nut when AASHTO M 253 bolts are installed in material having a specified yield point less than 40 ksi (275MPa) regardless of the tightening method.
- Use a hardened washer conforming to AASHTO M 293 where AASHTO M 164 bolts of any diameter or AASHTO M 253 bolts equal to or less than

1 inch (24mm) in diameter are to be installed in oversize or short-slotted holes in an outer ply.

- Use hardened washers conforming to AASHTO M 293, except with $\frac{5}{16}$ inch (8mm) minimum thickness, under both the head and the nut in lieu of standard thickness hardened washers where AASHTO M 253 bolts more than 1 inch (24mm) in diameter are to be installed in an oversize or short-slotted hole in an outer ply. Multiple hardened washers with combined thickness equal to or greater than $\frac{5}{16}$ inch (8mm) do not satisfy this requirement.
- Where AASHTO M 164 bolts of any diameter or AASHTO M 253 bolts equal to or less than 1 inch (24mm) in diameter are installed in a long-slotted hole in an outer ply, provide a plate washer or continuous bar of at least $\frac{5}{16}$ inch (8mm) thickness with standard holes with sufficient size to cover the slot after installation and is structural grade material that need not be hardened. When AASHTO M 253 bolts over 1 inch (24mm) in diameter are used in long-slotted holes in external plies, use a single hardened washer conforming to AASHTO M 293 with a $\frac{5}{16}$ inch (8mm) minimum thickness in lieu of washers or bars of structural grade material. Multiple hardened washers with combined thickness equal to or greater than $\frac{5}{16}$ inch (8mm) do not satisfy this requirement.

Alternative design fasteners, meeting the requirements of Subsection 724.02 with geometry which provides a bearing circle on the head or nut with a diameter equal to or greater than the diameter of hardened washers meeting the requirements of AASHTO M 293, satisfy the requirements specified herein and may be used without washers.

- 6.4.4 *Turn-of-nut tightening.* When turn-of-nut tightening is used, hardened washers are not required, except as specified in Subsection 506.04(f)6.4.3, *Washers*.

At the start of the work, test nut tightening using a device capable of indicating bolt tension a sample of not less than 3 bolt-and-nut assemblies of each diameter, length, and grade to be used in the work. Demonstrate with the test that the method for estimating the snug-tight condition and controlling the turns from snug tight to be used develops a tension not less than 5% greater than the tension required by Table 506-5. Perform periodic re-testing when required.

Following the snug-tightening operation, tighten all bolts in the connection by the applicable amount of rotation specified in Table 506-5. During all tightening operations, do not allow rotation of the fastener part not turned by the wrench. Tighten systematically from the most rigid part of the joint to its free edges.

- 6.4.5 *Installation of alternative design bolts.* When fasteners that incorporate a design feature intended to indirectly indicate the bolt tension or to automatically provide the tension required by Table 506-5 and conform to Subsection 724.02 are to be

installed, test a representative sample of not less than 3 bolt and nut assemblies of each diameter, length, and grade at the job site with a device capable of indicating bolt tension. Include in the test assembly flat-hardened washers, if required in the actual connection, arranged as in the actual connections to be tensioned. The calibration test must demonstrate that each bolt develops a tension not less than 5% greater than the tension required by Table 506-5. Follow manufacturer's installation procedure. Perform periodic re-testing when required.

When alternative design fasteners that are intended to control or indicate bolt tension of the fasteners are used, install bolts in all holes of the connection and initially tighten sufficiently to bring all plies of the joint into firm contact, but without yielding or fracturing the control or indicator element of the fasteners. Continue to tighten systematically from the most rigid part of the connection to the free edges in a manner that will minimize relaxation of previously tightened fasteners. Proper tensioning of the bolts may require more than a single cycle of systematic partial tightening before final twist-off of the control or indicator element of individual fasteners.

- 6.4.6 *Direct tension indicator tightening.* When direct tension indicators (DTIs) meeting the requirements of Subsection 724.02 are to be used with high-strength bolts to indicate bolt tension, subject assemblies (bolts, nuts, washers, and DTIs) to verification testing as described in Subsection 506.04(f)6.4.6.1 and install assemblies as specified in Subsection 506.04(f)6.4.6.2.

Unless otherwise approved, install DTIs with the protrusions against the head of the bolt and turn the nut to tighten the fastener. Prevent the element against the DTI from turning during installation and final tensioning. Give special attention to proper installation of flat-hardened washers when direct tension indicator devices are used with bolts installed in oversize or slotted holes.

During verification, do not exceed the maximum allowed number of refusals after snugging.

- 6.4.6.1 *Verification.* Perform verification testing in a calibrated bolt tension measuring device. Use a special flat insert in place of the normal bolt head holding insert.

Perform three verification tests for each combination of fastener rotational-capacity lot, DTI lot, and DTI position relative to the turned element (bolt head or nut) to be used on the project. Tighten the fastener by turning the element not against the DTI. Prevent the element against the DTI from turning. Conduct verification tests in two stages. Install the bolt, nut and DTI assembly in a manner so that 3 to 5 threads are located between the bearing face of the nut and the bolt head. Tighten the fastener first to the load required in Table 506-7 under verification tension for the grade and diameter of the fastener.

If an impact wrench is used, it shall be deemed acceptable to tighten to a load slightly below the required load and subsequently tighten using a manual

wrench to attain the required tension. Determine and record the number of refusals of a 0.005 inch (0.125mm) tapered feeler gauge in the spaces between the protrusions. The required number of spaces is specified in Table 506-7. Do not exceed the number of refusals listed in Table 506-7 under Maximum Verification Refusals for the grade and diameter of bolt for uncoated DTIs. The maximum number of refusals for coated (galvanized, painted, or epoxy-coated) DTIs shall be no more than the number of spaces on the DTI less one. The DTI lot shall be rejected if the number of refusals exceeds the values in Table 506-7, or, for coated DTIs, if the gauge is refused in all spaces.

Table 506-7
Direct Tension Indicator Requirements

Bolt Size	Verification Tension		Maximum				Minimum	
	(kips)		Verification Refusals		DTI Spaces		Installation Refusals	
	M 164	M 253	M 164	M 253	M 164	M 253	M 164	M 253
	<u>A325</u>	<u>A490</u>	<u>A325</u>	<u>A490</u>	<u>A325</u>	<u>A490</u>	<u>A325</u>	<u>A490</u>
$\frac{5}{8}$	20	25	1	2	4	5	2	3
$\frac{3}{4}$	29	37	2	2	5	6	3	3
$\frac{7}{8}$	41	51	2	2	5	6	3	3
1	54	67	2	3	6	7	3	4
$1\frac{1}{8}$	59	84	2	3	6	7	3	4
$1\frac{1}{4}$	75	107	3	3	7	8	4	4

Table 506-7
Direct Tension Indicator Requirements (Metric)

Bolt Size	Verification Tension		Maximum				Minimum	
	(kips)		Verification Refusals		DTI Spaces		Installation Refusals	
	M 164	M 253	M 164	M 253	M 164	M 253	M 164	M 253
	<u>A325M</u>	<u>A490M</u>	<u>A325M</u>	<u>A490M</u>	<u>A325M</u>	<u>A490M</u>	<u>A325M</u>	<u>A490M</u>
16	88.96	111.2	1	2	4	5	2	3
20	129.0	164.6	2	2	5	6	3	3
22	182.4	226.9	2	2	5	6	3	3
24	240.2	298.0	2	3	6	7	3	4
27	262.4	373.6	2	3	6	7	3	4
30	333.6	475.9	3	3	7	8	4	4
36	395.9	564.9	3	3	7	8	4	4

After the number of refusals is recorded at the Verification Tension, further tighten the fastener until the 0.005 inch (0.125mm) feeler gauge is refused at all the spaces and a visible gap exists in at least one space. Record the load at this condition and remove the fastener from the tension measuring device. The nut shall be able to be reassembled by hand for the complete thread length of the bolt

excluding thread runout. Reject the DTI lot if the nut cannot be assembled for this length, unless the load recorded is less than 95% of the average load measured in the rotational-capacity test of the fastener lot as specified in the subsection, *Rotational-Capacity Tests*.

If the bolt is too short to be tested in the calibration device, test the DTI as described above on a long bolt in a calibrator to determine the number of refusals at the Verification Tension listed in Table 506-7. Test another DTI from the same lot with a short bolt in a convenient hole in the work. Tighten the fastener assembly until the 0.005 inch (0.125mm) feeler gauge is refused in all spaces and a visible gap exists in at least one space. Then disassemble the fastener, remove it from the hole, and reassemble it by hand for the complete thread length of the bolt excluding thread runout. Reject the DTI lot if the nut cannot be run down this thread length.

- 6.4.6.2 *Installation.* Perform the installation of fasteners using DTIs in two stages. Prevent the fastener element against the DTI from rotating during each stage of installation. Snug the connection with bolts installed in all the connection holes and sufficiently tighten to bring all the plies of the connection into firm contact. The number of spaces in which a 0.005 inch (0.125mm) feeler gauge is refused in the DTI after snugging shall not exceed those listed under Maximum Verification Refusals in Table 506-7. If the number exceeds the values in the table, remove the complete assembly (bolt, nuts, washers, and DTI) and install another complete assembly followed by resnugging.

Further tighten the connection until the number of refusals of the 0.005 inch (0.125mm) feeler gauge shall be equal to or greater than the number listed under Minimum Installation Refusals in Table 506-7. Tighten all fasteners systematically from the most rigid part of the connection to the free edges in a manner that will minimize relaxation of previously tightened fasteners. If the fastener is tightened so that no visible gap in any space remains, remove and replace the complete assembly.

- 6.4.7 *Inspection.* Inspect, in the presence of the Engineer, the tightened bolts using an inspection torque wrench, unless alternative fasteners or DTIs are used, allowing verification by other means. Inspect within 24 hours of bolt tightening to prevent possible loss of lubrication or corrosion on tightening torque.

Individually place three bolts of the same grade, size, and condition as those under inspection in a device calibrated to measure bolt tension. Perform this calibration operation at least once each inspection day.

Use a washer under the part turned in tightening each bolt if washers are used on the structure. If washers are not used on the structure, use the same specification material which abuts the part turned in the tension measuring device as used on the structure. In the calibrated device, tighten each bolt by any convenient means to the specified tension. Apply the inspecting wrench to the tightened bolt to determine the torque required to turn the nut or head 5°,

approximately 1 inch (25mm) at a 12-inch (300mm) radius, in the tightening direction. Use the average of the torque required for all three bolts as the job-inspection torque.

Select at random in each connection 10% (at least two) of the tightened bolts on the structure represented by the test bolts, and apply the job-inspection torque to each selected bolt with the inspecting wrench turned in the tightening direction. If this torque turns no bolt head or nut, the bolts in the connection will be considered to be properly tightened. If the torque turns one or more bolt heads or nuts, apply the job-inspection torque to all bolts in the connection. Tighten and reinspect any bolt whose head or nut turns at this stage. As an option retighten all bolts in the connection and re-submit for inspection.

7. *Welding.* Welding, welder qualifications, prequalification of weld details, and inspection of welds shall conform to ANSI/AASHTO/AWS Bridge Welding Code D1.5.

Do not weld or tack brackets, clips, shipping devices, or other material not required to any member unless shown on the approved drawings.

(g) **Erection.**

1. *General.* Provide all tools, machinery, and equipment necessary to erect the structure. Falsework and forms shall conform to Section 502.
2. *Handling and storing material.* Place material stored at the job site on skids above the ground. Keep material clean and properly drained. Place and shore girders and beams upright. Support long members, such as columns and chords, on skids placed near enough together to prevent damage due to deflection.

If the contract documents are for erection only, check the material received against shipping lists and report promptly in writing any shortage or injury discovered. After material is received, the Contractor is responsible for any damage to or loss of material.

3. *Bearings and anchorages.* Furnish and install bridge bearings and anchors according to Section 509. If the steel superstructure is to be placed on a substructure that was built under a separate contract, verify that the concrete pedestals have been correctly constructed before ordering material.

If actual centerline bearing of the assembly does not line up horizontally within ± 2 inches (50mm) of the vertical bearing stiffener plates, weld additional vertical bearing stiffeners to the beam or girder.

4. *Erection procedures.*
 - 4.1 *Conformance to drawings.* Erect according to approved erection drawings and contract documents. Modifications to or deviations from the approved erection procedure will require revised drawings and verification of stresses and geometry.
 - 4.2 *Erection stresses.* Allow for erection stresses induced in the structure as a result of the use of a method of erection or equipment that differs from that previously approved, and that will remain in the finished structure as locked-in stresses. Provide additional material, as needed, to keep both temporary and final stresses within the allowable limits used in the design.

Provide temporary bracing or stiffening devices to accommodate handling stresses in individual members or segments of the structure during erection.

- 4.3 *Maintaining alignment and camber.* During erection, support segments of the structure in a manner that will produce the proper alignment and camber in the completed structure. Install cross frames and diagonal bracing as necessary during erection to provide stability and assure correct geometry. As necessary, provide temporary bracing at any stage of erection.

5. *Field assembly.* Accurately assemble as shown on the erection drawings and required by match-marks. Carefully handle the material. Do not hammer, damage, or distort the members. Clean bearing surfaces and permanent contact surfaces before assembly.

Assemble splices and field connections with at least two cylindrical erection pins per part (four minimum per splice or connection). A plate girder splice requires for example, at least four cylindrical erection pins for the top flange splice, four pins for the web splice, and four pins for the bottom flange splice. These provide two pins for each part. Place the pins in the corner holes of the splice plates. Where field bolted diaphragms are shown, erect at least every other diaphragm at the time the beams are set in place with bolts or driftpins placed in 50% of the connection holes. Where field welded diaphragms are shown, erect all diaphragms as the beams are set in place by one $\frac{3}{4}$ inch (20mm) make up bolt at each connection point.

Install more cylindrical erection pins, if necessary, to accurately align the parts. Fill the remaining holes in the connection with bolts and tighten systematically from the most rigid part of the connection to the free edges. Remove cylindrical erection pins and replace with tightened bolts.

Release temporary erection supports at a splice or connection only after all bolts are installed and tightened. Show special assembly and support situations on the erection and falsework drawings.

Fitting-up bolts may be the same high-strength bolts used in the installation. If other fitting-up bolts are required, use the same nominal diameter as the high-strength bolts. Use cylindrical erection pins $\frac{1}{32}$ inch (0.75mm) larger than the bolts.

6. *Pin connections.* Use pilot and driving nuts in driving pins. Furnish these items without charge. Drive the pins so that the members will fully bear on the pins. Screw pin nuts tight and burr the threads at the face of the nut with a pointed tool.
7. *Misfits.* Correction of minor misfits involving minor amounts of reaming, cutting, and chipping may be done, if approved. Any error in the shop fabrication or deformation resulting from handling and transporting will be cause for rejection.

The Contractor shall be responsible for all misfits, errors, and damage and shall make the necessary corrections and replacements.

- (h) **Expansion Joints.** Fabricate expansion joints in accordance with the requirements of this section. Install expansion joints in accordance with the requirements of Section 504.

Submit complete working drawings for fabrication and installation of expansion joints. Include the joint manufacturer's instructions for proper installation of the joint on the drawings.

Show the joint opening dimension for an ambient temperature of 60°F (15°C) and adjustments to that dimension due to temperature variations.

Accurately fabricate expansion joints to conform to the specified concrete floor section, matching cross slopes and break points. Assemble expansion joints in the shop and check for fit, then match mark for shipment.

For sealed expansion joints, fabricate the steel receptors to be continuous the full length of joint including 6 inch (150mm) extensions. Minimize the number of splices in the steel receptor. To splice, use a partial penetration weld, ground smooth. Do not weld in the areas in contact with the neoprene.

Provide and install a neoprene gland continuous the full length of joint including 6 inch (150mm) extensions. At locations where joints are shown to be mitered for skew of 35° and greater, splice the neoprene by vulcanizing or other approved method that provides strength and durability equal to unspliced neoprene. Make splices permanently watertight.

506.05. METHOD OF MEASUREMENT.

Pay quantities for each type of *structural steel* and iron will be measured by the pound (kilogram), computed from the dimensions shown on the approved shop drawings using the following rules.

Weight shall be computed on the basis of the net finished dimensions of the parts as specified in the contract documents and using the unit weights given in Table 506-8. Approved substituted sections that are larger than those specified, shall be measured by the weight of the originally specified sections. Deductions shall not be made for cuts, clips, copes, bolt holes, pin holes, or weld joint preparation. Waste necessitated by girder camber or curve shall not be measured. Changes in quantities resulting from alternative details proposed by the Contractor and approved as part of the drawings shall not be considered changes ordered by the Engineer.

Table 506-8
Unit Weights of Steel and Iron Density, lb/ft³ (kg/m³)

Steel, Rolled or Cast	490 (7850)
Cast Iron	445 (7130)
Malleable Iron	470 (7530)
Wrought Iron	487 (7800)

The weight of rolled shapes shall be computed on the basis of their nominal weight per foot as specified in the contract documents. If weight is not specified in the contract documents, use AASHTO M160, or an approved handbook.

The weight of plates shall be computed on the basis of the nominal weight for their width and thickness as specified in the contract documents with no allowance for overruns.

The weight of castings shall be computed from the dimensions shown on the approved shop drawings, deducting for open holes. To this weight shall be added 5 percent allowance for fillets and overrun. The weight shall include, steel and iron castings, steel or cast iron pipe for drains and all minor items necessary to complete the work satisfactorily according to the Plans. If approved, scale

weight may be substituted for computed weight in the case of castings or small complex parts for which accurate computations of weight would be difficult.

The weight of heads, nuts, single washers, DTIs, and threaded stick-through of all high tensile strength bolts, both shop and field, shall be included as specified in Table 506-9.

**Table 506-9
Weight Per 100 Bolts**

Bolt Size, <u>inches</u>	Weight per 100 bolts <u>pounds</u>
5/8	31.7
3/4	52.4
7/8	80.4
1	116.7
1 1/8	165.1
1 1/4	212.0

**Table 506-9
Mass Per 100 Bolts (Metric)**

Bolt Size, <u>mm</u>	Weight per 100 bolts <u>kg</u>
16	14.4
20	23.8
22	36.5
24	53.0
27	75.0
30	96.4
36	127.3

The weight of anchor bolt assemblies (threaded bars, nuts, and washers), anchor plates not embedded in concrete, and diaphragm bolt assemblies (threaded-end bars, couplers, nuts, plates, and washers) for diaphragms between prestressed concrete girders shall be measured as structural steel. The weight of threaded bars shall be computed on the basis of smooth bar of the specified diameter. The weight of nuts and washers shall be determined from approved handbooks.

The weight of weld metal, temporary erection bolts, drift pins, driving caps, shop and field paint, galvanized coating, boxes, crates, and other containers used for shipping, and materials used for supporting members during transportation and erection, will not be included.

The weight of any additional material required under Subsection 506.04(g)4.2 to accommodate erection stresses resulting from the Contractor's choice of erection methods will not be included. The weight of additional bearing stiffeners required under Subsection 506.04(g)3 will not be included.

Metal expansion joints shall be measured as specified in Section 504.

506.06. BASIS OF PAYMENT.

The accepted quantities, measured as provided above, will be paid at the contract price per unit of measurement for the pay item listed below that is shown in the bid schedule. Payment will be full compensation for the work prescribed in this section.

(A) STRUCTURAL STEEL POUND (KILOGRAMS)

SECTION 507 TIMBER STRUCTURES

507.01. DESCRIPTION.

This work shall consist of constructing timber structures and the timber portions of composite structures, in accordance with these specifications and in reasonably close conformity with the details specified in the contract documents or established by the Engineer.

It shall include furnishing, preparing, fabricating, erecting, treating, and painting of timber. All timber, treated or untreated, shall be of the specified species, grades and dimensions. Also included shall be any required yard lumber of the sizes and grades specified and all hardware required for timber connections and ties.

507.02. MATERIALS.

- (a) Lumber and Timber (Solid Sawn or Glued Laminated). Use sawn lumber and timber conforming to the Specifications for Wood Products, AASHTO M168.

Structural glued laminated timber shall conform to the American National Standard ANSI/AITC A-190.1, Specification for Structural Glued Laminated Timber. The separate laminations shall not exceed 2 inches in net thickness. They may be comprised of pieces end-joined to form any length, of pieces placed or glued edge to edge to make wider ones, or of pieces bent to curved form during gluing. On glued-laminated structural members that are not to be preservative treated, apply an approved end sealer after end trimming of each completed member.

The grades of timber used for various structural purposes shall be as specified in the contract documents.

Furnish the following certificates of compliance to the Engineer, as appropriate, upon delivery of the materials to the job site:

- For timber and lumber, a Type B certification by an agency certified by the American Lumber Standards Committee that the timber or lumber conforms to the grade, species and any other specified requirements.
- For glued-laminated timber, a Type B certification by a qualified inspection and testing agency that the glued-laminated timber complies with the grade, species and other requirements outlined in ANSI/AITC A 190. 1.
- If the wood is to be treated with a preservative, furnish a Type B certification for the preservation treatment.

- (b) Steel Components. Rods, plates, eyebars, and shapes shall conform to the requirements of AASHTO M270, Grade 36 (Grade 250) unless otherwise specified.
- (c) Castings. Castings shall be cast steel or gray-iron, as specified, conforming to the requirements of Sections 725.03 and 725.04.
- (d) Hardware. Bolts, nuts, drift-bolts, and dowels shall be of mild steel. Washers shall be cast iron ogee or malleable iron castings, or they may be cut from mild steel plate, as specified in the contract documents.

Bolts shall have either standard square, hex or dome heads, or economy type (washer) heads. Nails shall be cut or round wire of standard form. Spikes shall be cut or wire spikes, or boat spikes, as specified. Unless otherwise specified, bolts shall comply with ASTM A307, and shall have coarse threads, Class 2 tolerance conforming to ANSI Standard Specifications.

All fasteners, including nails, spikes, bolts, dowels, washers, and lag screws shall be galvanized, unless otherwise specified in the contract documents or permitted.

- (e) Galvanizing. Unless otherwise specified in the contract documents, all hardware for timber structures shall be galvanized in accordance with AASHTO M232 or cadmium plated in accordance with AASHTO M299. All steel components, timber connectors, and castings, other than malleable iron, shall be galvanized in accordance with AASHTO M111.
- (f) Timber Connectors.
 1. *Dimensions.* The various types of timber connectors shall generally conform to the dimensions shown in Tables 507-1 and 507-2 and to the dimensions specified in this Subsection 507.02(f).
 2. *Split Ring Connectors.* Split rings of 2½ inches (65mm) and 4 inches (100mm) inside diameter shall be manufactured from hot-rolled carbon steel conforming to the Society of Automotive Engineers Specification SAE-1010. Each ring shall form a closed true circle with the principal axis of the cross section of the ring metal parallel to the geometric axis of the ring. The metal section shall be beveled from the central portion toward the edges to a thickness less than the midsection. It shall be cut through in one place in its circumference to form a tongue and slot.
 3. *Shear-Plate Connectors.* Pressed steel shear-plates of 2⁵/₈ inch (67mm) in diameter shall be manufactured from hot-rolled carbon steel conforming to the Society of Automotive Engineers Specification SAE-1010. Each plate shall be a true circle with a flange around the edge, extending at right angles to the face of the plate and extending from one face only, the plate portion having a central bolt hole and two small perforations on opposite sides of the hole and midway from the center and circumference.

Malleable iron shear-plates of 4 inches (100mm) diameter shall be manufactured according to ASTM A 47 (47m), Grade 32510 (Grade 22010), for malleable iron casting. Each casting shall consist of a perforated round plate with a flange around the edge extending at right angles to the face of the plate and projecting from one face only, the plate portion having a central bolt hole reamed to size with an integral hub concentric to the bolt hole and extending from the same face as the flange.

4. *Spike-Grid Connectors.* Spike-grid timber connectors shall be manufactured according to ASTM A 47 (47m), Grade 32510 (Grade 22010), for malleable iron casting.

Square grids shall consist of four rows of opposing spikes forming a $4\frac{1}{8}$ inch (105mm) square grid with 16 teeth that are held in place by fillets. Fillets for the flat grid in cross section shall be diamond shaped. Fillets for the single curve grids shall be increased in depth to allow for curvature and shall maintain a thickness between the sloping faces of the fillets equal to the width of the fillet.

Circular grids of $3\frac{1}{4}$ inch (83mm) diameter shall consist of eight opposing spikes equally spaced around the outer circumference and held in place by connecting fillets joint around the outer diameter and radial fillets projecting to a central circular fillet which forms a bolt hole opening of $1\frac{1}{4}$ inches (32mm). Fillets in cross section shall be diamond shaped except that the inner circular fillet may be flattened on one side to provide for manufacturer identification.

Table 507-1
Typical Dimensions of Timber Connectors, inches (mm)

	<u>Split Rings</u>	
	$2\frac{1}{2}$ (65)	4(100)
Split Ring:		
Inside diameter at center when closed	2.500(63.50)	4.00(101.60)
Thickness of metal at center	0.163(4.14)	0.193(4.90)(4.90)
Depth of metal (width of ring)	0.750(19.05)	1.00(25.40)
Groove:		
Inside Diameter	2.56(65.02)	4.08(103.63)
Width	0.18(4.57)	0.21(5.33)
Depth	0.375(9.52)	0.50(12.70)
Bolt Diameter:	$\frac{1}{2}$ (12.70)	$\frac{3}{4}$ (14.28)
Hole Diameter	$\frac{9}{16}$ (14.3)	$\frac{13}{16}$ (20.6)
Washers, Standard:		
Round, cast, or malleable iron:		
Diameter	$2\frac{5}{8}$ (66.67)	3(76.20)
Round, mild steel		
Diameter	$1\frac{3}{8}$ (34.92)	2(50.80)
Thickness	$\frac{3}{32}$ (2.38)	$\frac{5}{32}$ (3.97)
Square Plate, mild steel		
Length of side	2(50.80)	3(76.20)
Thickness	$\frac{1}{8}$ (3.17)	$\frac{3}{16}$ (4.76)

Table 507-2 (English)
Typical Dimensions of Timber Connectors (inches)

<u>Shear Plates</u>				
Shear Plate:	$2\frac{5}{8}$	$2\frac{5}{8}$	4	4
Material	Pressed steel		Light gage	Malleable
Malleable				
Diameter of plate	2.62	2.62	4.03	4.03
Dia. of bolt hole	0.81	0.81	0.81	0.94
Thickness of plate	0.172	0.12	0.20	0.20
Depth of flange	0.42	0.35	0.64	0.64
Design steel straps or shapes for use with shear plates in accordance with accepted engineering practices.				
Hole Diameter in Straps or Shapes for Bolts	$\frac{13}{16}$	$\frac{13}{16}$	$\frac{13}{16}$	$\frac{15}{16}$
Circular Dap - Dimensions				
A	2.63	2.63	4.03	4.03
B		1.07	1.55	1.55
C	0.81	0.81	0.81	0.94
D		0.65	0.97	0.97
E	0.19	0.13	0.27	0.27
F	0.45	0.38	0.64	0.64
G	0.25	0.14	0.22	0.22
H		0.34	0.50	0.50
I	2.25	2.37	3.49	3.49
Bolt Hole-diameter in timber Washers, Standard:	$\frac{13}{16}$	$\frac{13}{16}$	$\frac{13}{16}$	$\frac{15}{16}$
Round, cast or malleable iron diameter	3	3	3	3
Round, medium steel minimum:				
Diameter	2	2	2	$2\frac{1}{4}$
Thickness	$\frac{5}{32}$	$\frac{5}{32}$	$\frac{5}{32}$	$\frac{11}{64}$
Square Plate:				
Length of Side	3	3	3	3
Thickness	$\frac{1}{4}$	$\frac{1}{4}$	$\frac{1}{4}$	$\frac{1}{4}$

**Table 507-2 (Metric)
Typical Dimensions of Timber Connectors (mm)**

<u>Shear Plates</u>				
	66.675	66.675	101.6	101.6
Shear Plate:				
Material	Pressed steel	Light gage	Malleable	Malleable
Diameter of plate	66.55	66.55	102.36	102.36
Dia. of bolt hole	20.57	20.57	20.57	23.88
Thickness of plate	4.37	3.05	5.08	5.08
Depth of flange	10.67	8.89	16.26	16.26
Design steel straps or shapes for use with shear plates in accordance with accepted engineering practices.				
Hole Diameter in Straps or Shapes for Bolts	20.64	20.64	20.64	23.81
Circular Dap - Dimensions				
A	66.80	66.80	102.36	102.36
B		27.18	39.37	39.37
C	20.57	20.57	20.57	23.88
D		16.51	24.64	24.64
E	4.83	3.30	6.86	6.86
F	11.43	9.65	16.26	16.26
G	6.35	3.56	5.59	5.59
H		8.64	12.70	12.70
I	57.15	60.20	88.65	88.65
Bolt Hole-diameter in timber	20.64	20.64	20.64	23.81
Washers, Standard:				
Round, cast or malleable iron diameter	76.20	76.20	76.20	88.90
Round, medium steel minimum:				
Diameter	50.80	50.80	50.80	57.81
Thickness	3.97	3.97	3.97	4.36
Square Plate:				
Length of Side	76.2	76.2	76.2	76.2
Thickness	6.35	6.35	6.35	6.35

507.04. CONSTRUCTION METHOD.

- (a) **Quality.** Provide first class quality-of-work throughout. Frame true and exact. Unless otherwise specified, drive nails and spikes with just sufficient force to set the heads flush with the surface of the wood. Deep hammer marks in wood surfaces shall be considered evidence of poor quality and sufficient cause for removal of the workman causing them.
- (b) **Storage of Material.** At the construction site, store lumber and timber in orderly piles or stacks. Store untreated material open-stacked on supports at least 12 inches (300mm) above the ground surface to avoid absorption of ground moisture and permit air circulation. Stack and sticker untreated material to permit free circulation of air between the tiers and courses. Provide protection from the weather by a suitable covering. Clear the ground underneath and near the timber of weeds and rubbish. Construct the storage area where water will not collect under or near the stored timber.
- (c) **Treated Timber.**
1. *Handling.* Carefully handle treated timber without sudden dropping, breaking of outer fibers, bruising, or penetrating the surface with tools. Use web slings. Do not use cant hooks, peaveys, pikes, or hooks. When using metal bands to bundle members, provide corner protectors to prevent damage to the treated timber.
 2. *Framing and Boring.* Perform all cutting, framing, and boring of treated timbers before treatment insofar as is practicable. When treated timbers are to be placed in waters infested by marine borers, avoid untreated cuts, borings, or other framings below high water elevation.
 3. *Cuts and Abrasions.* Field treat all cuts and all recesses formed by countersinking in creosote treated piles or timbers, and all abrasions, after having been carefully trimmed, as specified either in this Subsection 507.04(c)3, *Cuts and Abrasions*, or the following Subsection 507.04(c)4, *Bored Holes*. Cover all cuts and recesses with two applications of a mixture of 60% creosote oil and 40% roofing pitch, or brush coat cuts and recesses with at least three applications of hot creosote oil covered with hot roofing pitch. Fill recesses likely to collect injurious materials with hot roofing pitch. Unless specified otherwise, heat hot preservatives to a temperature between 150°F (66°C) and 200°F (93°C) Where particularly heavy coatings are required, a suitable plastic compound can be prepared by mixing 10% to 20% of creosote and 80% to 90% of coal-tar roofing pitch.

For timbers originally treated with pentachlorophenol, creosote, creosote solutions or water-borne preservatives, field treat all cuts, abrasions and recesses which occur after treatment with two liberal applications of a compatible preservative in accordance with the requirements of the American Wood Preservers Association Standard M 4 entitled, "Standard for the Care of Pressure Treated Wood Products."
 4. *Bored Holes.* Treat all holes bored after treatment by filling the holes with the preservative used for field treatment. After treatment, plug any holes not filled with bolts or other items with preservative treated plugs.
 5. *Temporary Attachment.* When removing forms or temporary braces attached to treated timber with nails or spikes, treat the resulting holes as required for bored holes and fill by driving galvanized nails, spikes or preservative treated plugs flush with the surface.

- (d) **Installation of Connectors.** Use one of the following types of timber connectors, as specified in the contract documents: the split ring, the shear plate, or the spike grid. Install the split ring and the shear plate types in precut grooves of dimensions as given herein or as recommended by the manufacturer. Force spike grids into the wood so that timbers will be in firm contact. Use pressure equipment that does not damage the wood. One acceptable method is to use high-strength bolts or rods fitted with low friction ball-bearing washers made for this purpose. Replace the high-strength bolt with specified bolts for the final installation. Embed all connectors of this type at a joint simultaneously and uniformly.

Cut connector grooves in timber concentric with the bolt hole. Make the grooves conform to the cross-sectional shape of the rings, and provide a snug fit. Make the inside groove diameter larger than nominal ring diameter in order that the ring will expand slightly during installation. (See Tables 507-1 and 507-2.)

Fabricate all structural members using connectors before preservative treatment. When prefabricated from templates or shop details, bolt holes shall not be more than $\frac{1}{16}$ inch (1.5mm) from required placement. Bolt holes shall be $\frac{1}{16}$ inch (1.5mm) larger than the finished bolt diameter. Bore bolt holes perpendicular to the face of the timber.

Store timber after fabrication in a manner that will prevent changes in the dimensions of the members before assembly. Cure timber before fabrication so that it will remain stable in its dimensions. Timber that shrinks during storage causing predrilled grooves for split rings or plates to become elliptical or causing bolt hole spacing to change will be sufficient reason for rejection.

- (e) **Holes for Bolts, Dowels, Rods, and Lag Screws.** Bore holes for round drift-bolts and dowels with a bit $\frac{1}{16}$ inch (1.5mm) less in diameter than the bolt or dowel to be used. The diameter of holes for square drift-bolts or dowels shall be equal to the least dimension of the bolt or dowel.

Bore holes for machine bolts with a bit the same diameter as the finished bolt, except as otherwise provided for bolts in connectors.

Bore holes for rods with a bit $\frac{1}{16}$ inch (1.5mm) greater in diameter than the finished rod.

Bore holes for lag screws with a bit not larger than the body of the screw at the base of the thread. To prevent splitting or stripping the threads, bore the hole for the shank the same diameter and to the same depth as the shank. The depth of holes for lag screws shall be approximately 1 inch less than the length under the head.

- (f) **Bolts and Washers.** Use a washer, of the size and type specified, under all bolt heads (except for timber bolts with economy type heads) and nuts which would otherwise come in contact with wood. Effectually lock the nuts of all bolts after they have been finally tightened.
- (g) **Countersinking.** Countersink where smooth or flush surfaces are required. Treat all recesses in treated timber, formed for countersinking, as specified in Subsection 507.04(c)3. Fill recesses likely to collect injurious materials with hot roofing pitch.

- (h) **Framing.** Accurately cut and frame all lumber and timber to a close fit in such manner that the joints will have even bearing over the entire contact surfaces. Mortises shall be true to size for their full depth and tenons shall fit snugly. No shimming will be permitted in making joints, nor will open joints be accepted.
- (i) **Framed Bents.**
1. *Mud Sills.* Firmly and evenly bed mud sills to solid bearing and tamp in place. Mud sills shall be pressure preservative treated for ground contact. Where untreated timber is permitted for mud sills, it shall be of heart cedar, heart cypress, redwood, or other durable timber as approved by the Engineer.
 2. *Concrete Pedestals.* Carefully finish concrete pedestals for the support of framed bents so that the sills or posts will take even bearing. Dowels for anchoring sills or posts shall be not less than $\frac{3}{4}$ inch (20mm) in diameter and project at least 6 inches above the tops of the pedestals. Cast these dowels in the concrete pedestals. Concrete and reinforcing steel shall conform to the requirements of Sections 509, "Structural Concrete," and 511, "Reinforcing Steel," respectively
 3. *Sills.* Make sills to have true and even bearing on mud sills, piles, or pedestals. Drift-bolt sills to mud sills or piles with bolts of not less than $\frac{3}{4}$ inch (20mm) diameter and extending into the mud sills or piles at least 6 inches (150mm), or by other types of connectors as detailed in the contract documents. When possible, remove all earth from contact with sills so that there will be free air circulation around the sills.
 4. *Posts.* Fasten posts to pedestals with dowels of not less than $\frac{3}{4}$ inch (20mm) diameter, extending at least 6 inches (150mm) into the posts, or by other types of connectors as detailed on the plans. Fasten posts to sills by one of the following methods, as indicated on the plans
 - By dowels of not less than $\frac{3}{4}$ inch (20mm) diameter, extending at least 6 inches (150mm) into posts and sills.
 - By drift-bolts of not less than $\frac{3}{4}$ inch (20mm) diameter driven diagonally through the base of the post and extending at least 9 inches (225mm) into the sill. Drift bolts shall be driven in holes as required by Subsection 507.04(e) at a 45° angle and shall enter the post at least 6 inches (150mm) above the post base.
 - By other types of connectors as detailed in the contract documents.
 5. *Caps.* Place timber caps, with ends aligned, in a manner to secure an even and uniform bearing over the tops of the supporting posts or piles. Secure all caps by drift-bolts of not less than $\frac{3}{4}$ inch (20mm) diameter, extending at least 9 inches (225mm) into the posts or piles, or by other types of connectors as detailed in the contract documents. Install the drift-bolts approximately in the center of the post or pile.
 6. *Bracing.* Bolt bracing through the pile, post, or cap at the ends and at all intermediate intersections using a bolt of not less than $\frac{5}{8}$ inch (16mm) in diameter. Make bracing of sufficient length to provide a minimum distance of 8 inches (200mm) between the outside bolt and the end of the brace.

- (j) **Stringers.** Size and position stringers at bearings so that knots near edges will be in the top portions of the stringers. Outside stringers may have butt joints with the ends cut on a taper, but lap interior stringers to take bearing over the full width of the floor beam or cap at each end. Separate the lapped ends of untreated stringers at least $\frac{1}{2}$ inch (12mm) for the circulation of air and securely fasten by drift-bolting where specified in the contract documents. When stringers are two panels in length, stagger the joints.

Unless otherwise specified in the contract, place cross-bridging or blocking at the center of each span. Neatly and accurately frame cross-bridging between stringers and securely toenail with at least two nails in each end. All cross-bridging members shall have full bearing at each end against the sides of stringers. Blocking shall be snug-fit and held in place by either prefabricated galvanized steel beam hangers or by tie-rods as detailed on the plans.

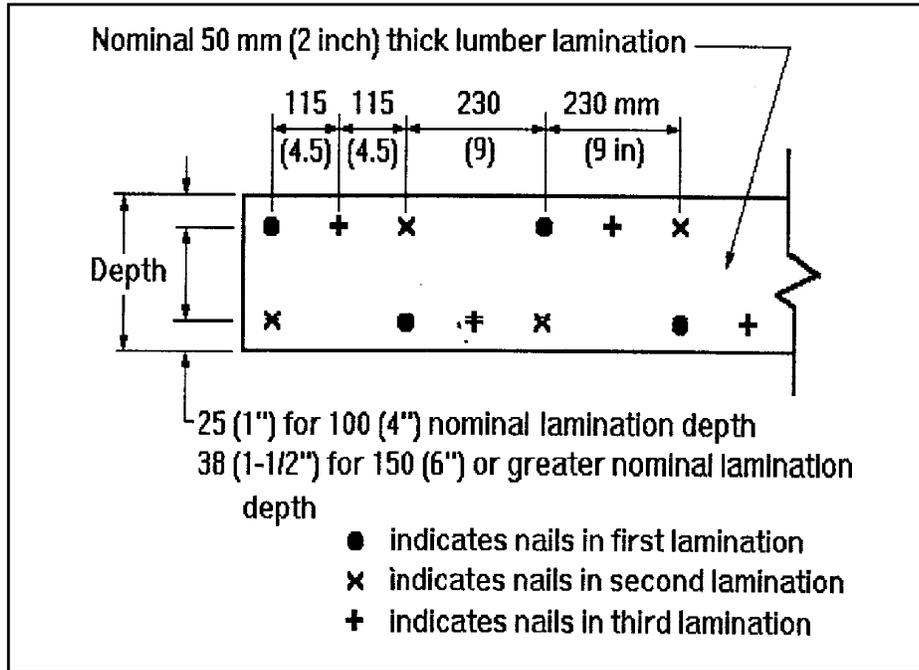
- (k) **Plank Floors.** Unless otherwise specified in the contract documents, provide planks for flooring surfaced four sides (S 4 S).

For single plank floors, provide a single thickness of plank supported by stringers or joists. Lay the planks heart side down, with $\frac{1}{4}$ inch (6mm) openings between them for seasoned material and with tight joints for unseasoned material. Securely spike each plank to each joist. Carefully grade the planks as to thickness and lay so that no two adjacent planks vary in thickness by more than $\frac{1}{8}$ inch (3mm).

For two-ply timber floors, provide two layers of flooring supported on stringers or joists. Lay the top course either diagonal or parallel to the centerline of roadway, as specified in the contract documents, and securely fasten each floor piece to the lower course. Stagger joints at least 3 feet (1000mm). If the top flooring is placed parallel to the centerline of the roadway, take special care to securely fasten the ends of the flooring. At each end of the bridge, bevel these members.

- (l) **Nail Laminated or Strip Floors.** Place the strips on edge, at right angles to the centerline of roadway. Nail each strip to the preceding strip as shown in Figure 507-1. The spikes shall be of sufficient length to pass through two strips and at least half-way through the third strip.

Figure 507-1
Nail Placement Pattern



If using timber supports, toe-nail every other strip to every other support. Use the size of the spikes specified in the contract documents. When specified in the contract documents, securely attach the strips to steel supports by the use of approved galvanized metal clips. Take care to have each strip vertical and tight against the preceding strip, and bearing evenly on all the supports.

- (m) **Glue Laminated Panel Decks.** Unless otherwise specified in the contract documents, provide deck panels pressure preservative treated with creosote or pentachlorophenol with Type A, C or D carrier. When it is not possible to complete the fabrication and drilling of glulam members for field connections before treating, apply a preservative treatment to cut or drilled areas in the field, in accordance with Subsections 507.04(c)3 and 4.

Do not drag or skid panels. Handle and transport glue-laminated deck panels in a way to prevent bending the panels, especially transverse to the laminated pieces. When lifted, support the panels at a sufficient number of points to avoid overstressing, and protect the edges from damage.

When dowels are shown on the drawings between deck panels, use a template or drilling jig to ensure that dowel holes are accurately spaced. Drill the holes to a depth $\frac{1}{4}$ inch (6mm) greater than one-half the dowel length and of the same diameter as the dowel unless otherwise shown in the contract documents. Use a temporary dowel as a check for snug fit prior to

production drilling. Use dowels of the size shown in the contract documents with the tips slightly tapered or rounded. A lubricant may be used to facilitate the connection process.

Start the tips of the dowels partially and equally into the holes of the two panels being joined. Draw the panels together keeping the edges parallel, until the panels abut tightly. Securely fastened each panel to each stringer or girder as shown in the contract documents.

- (n) **Composite Wood-Concrete Decks.** Furnish and install shear connectors, needed to resist shear and provide hold-down capacity between timber and concrete elements which are designed for composite action, in conformance with the details shown in the contract documents. If no such details are provided and the construction is described in the contract documents as being composite, submit working drawings for such details and devices for approval by the Engineer before the subject work is begun.
- (o) **Wheel Guards and Railing.** Accurately frame wheel guards and railing in accordance with the contract documents and erect true to line and grade. Unless otherwise specified in the contract documents, use wheel guards, rails, and rail posts surfaced four-sides (S 4 S). Lay wheel guards in sections not less than 12 feet (3700 mm) long, except where necessary to match expansion joints or end joints.
- (p) **Trusses.** Trusses, when completed, shall show no irregularities of line. Build chords to be straight and true from end to end in horizontal projection and, in vertical projection, show a smooth curve through panel points conforming to the correct camber. Fit all bearing surfaces accurately. Uneven or rough cuts at the points of bearing shall be cause for rejection of the piece containing the defect.
- (q) **Painting.** Paint rails and rail posts of timber and any other parts designated in the contract documents to be painted with three coats of white paint. Provide the type of paint specified in the contract documents. Do not apply paint to timber treated with creosote, or oil borne, pentachlorophenol preservatives, or timber having a moisture content exceeding 20%.

Give metal parts, except for hardware, galvanized or cadmium plated metal, and malleable iron, one coat of shop paint and, after erection, two coats of field paint as specified for IZ-E-U system in Section 512, "Painting."

507.05. METHOD OF MEASUREMENT.

Timber and *lumber* shall be measured by the thousand board feet (cubic meter) of each species and grade of lumber and timber listed in the schedule of bid items, complete in place and accepted. Measurements of lumber and timber shall be computed from the nominal dimensions and actual lengths. The cross-sectional dimensions on the plans shall be interpreted as standard sizes. The standard cross-sectional dimensions shall be used in the computations even though the actual size is less in the dimension specified.

Timber in wheel guards shall be included. Timber in piling, railing and other items for which separate payment is provided will not be included.

Measurements for *glued laminated girders* and beams shall be computed from the applicable finished dimensions and actual lengths. Quantities for glue laminated girders and beams shall be paid for by the linear foot (meter) for each size and stress combination.

The measurement of lumber and timber and of glued laminated girders and beams shall include only such material as is a part of the completed and accepted work, and shall not include materials used for erection purposes, such as falsework, bracing, sheeting, etc.

507.06. BASIS OF PAYMENT.

The accepted quantities, measured as provided above, will be paid for at the contract price per unit of measurement for the pay items listed below that are shown in the bid schedule.

- (A) LUMBER M.F.B.M. (CUBIC METER)
- (B) GLUE LAMINATED GIRDER (*DESCRIPTION*) LINEAR FOOT (METER)

Payment for timber, lumber and glued-laminated girders and beams shall be considered to be full compensation for all costs of furnishing of materials, including hardware and timber connectors, preservative treatment, equipment, tools, and labor for the fabrication, erection, and painting necessary to complete all of the work in compliance with the plans and specifications in a satisfactory manner. Metal parts, other than hardware and timber connectors, will be measured and paid for as provided in Section 506. Concrete will be measured and paid for as provided in Sections 509.

**SECTION 508
CONCRETE CULVERTS**

508.01. DESCRIPTION.

This work shall consist of constructing concrete culverts in accordance with these Specifications and in reasonably close conformity with the lines and grades specified in the contract documents or established by the Engineer. Precast concrete box culverts may be used in lieu of cast-in-place concrete box culverts only if approved by the Engineer or permitted by the contract documents and, when used, comply with the contract documents.

508.02. MATERIALS.

Materials shall meet the requirements specified in the following Subsections of Section 700 - Materials.

Structural Concrete (<i>Class A</i>)	509
Reinforcing Steel for Structures	511

Precast concrete box sections for culverts shall meet the requirements of AASHTO M 259 or M 273. Joint materials shall meet the requirements specified under Subsection 726.02(a).

508.04. CONSTRUCTION METHODS.

- (a) **General.** Comply with the applicable requirements of Sections 501, 502, 509 and 511. Construct curtain walls as directed by the Engineer to insure protection against undermining.

When the barrel length of cast-in-place culverts exceeds 60 feet (18m) , a construction joint may be placed in the culvert. When the barrel length of cast-in-place culverts exceeds 100 feet (30m) , place a construction joint in the culvert. Construct the joint according to the

requirements of Section 509.04(d) and the details shown on the plans. Extend longitudinal reinforcing steel through the joint a minimum of 18 inches (0.5m) and lap 18 inches (0.5m) with the longitudinal reinforcing steel in the adjoining section.

- (b) **Finish.** Give the exposed surface of all wings, curbs, rails and retaining walls a Class 2 - Rubbed Finish as specified in Subsection 509.04(g)2.
- (c) **Bedding.** Provide bedding for precast concrete box culverts a minimum depth of 4 inches below the precast box sections unless otherwise specified on the Plans. Bedding material shall meet the requirements for Class "B" Bedding in accordance with Subsection 613.04(c).
- (d) **Laying Precast Sections.** Lay precast concrete box sections after the Engineer has approved the condition of the bedding material. Slowly lower and place the precast section into final position by hoisting equipment adequate to handle the section without damage to the section or the bedding material. Replace damaged sections at no additional cost to the Department. The inside of the barrel shall be clean and free of debris when the sections are lowered into place.

Start laying the conduit at the downstream end of the culvert. Lay the sections reasonably true to the established line and grade. After the precast culvert has been inspected and approved, backfill carefully to prevent displacement or damage of the sections. Join precast sections as required in Subsection 613.04(e).

- (e) **Box Culvert End Sections.** Cast in place end sections for all concrete box culverts. End sections include wingwalls, curbs, end of barrels, curtain walls, and aprons. When precast sections are used in skewed structures, build the wings in the same skewed relationship to the culvert walls as shown on the Plans for the cast-in-place culvert. Build curbs and curtain walls perpendicular to the barrels of precast sections for skews between 90° and 60°.
- (f) **Working Drawings for Precast Box Sections.** Before constructing precast concrete box culverts, furnish fully engineered and sealed working drawings of the proposed construction to the Engineer for approval. Comply with Subsection 105.02. Show on these drawings complete details of reinforcing steel and concrete dimensions.
- (g) **Extension of Existing Cast-in-Place Culvert.** When the contract documents require extension of an existing cast-in-place culvert, perform the following work:

Remove and dispose of the existing wing walls. Remove and dispose of existing curbs, handrails, aprons, etc., as required by the plans. Repair damaged areas of the remaining culvert, caused by the removal process.

Provide dowel bars of the same diameter and grade as the longitudinal reinforcing steel in the new adjoining section of culvert. Lap each dowel bar 18 inches with each longitudinal bar in the new section. Comply with Subsection 509.04(d)3.

508.05. METHOD OF MEASUREMENT.

The work described in Subsection 508.04(g) will be measured per each culvert end extended under the pay item, *removal of culvert end*. Dowel bars will be measured as reinforcing steel.

508.06. BASIS OF PAYMENT.

When shown on the Plan bid schedule, accepted quantities of "Removal of Culvert End" will be paid at the contract price per unit of measurement for the pay item listed below. Payment will be full compensation for the respective work prescribed in this section:

- (A) REMOVAL OF CULVERT END EACH

The quantities which constitute the completed and accepted structure will be measured for payment according to the contract documents for the several pay items as provided under Sections 501, 509, and 511 of these Specifications, which will be full compensation for all materials, falsework, labor, equipment, and incidentals necessary to complete the work as specified.

Payment for precast concrete box culverts will be made based on unit prices bid for the items and quantities of a cast-in-place box of the length required as determined by field measurements for the construction.

**SECTION 509
STRUCTURAL CONCRETE**

509.01. DESCRIPTION.

- (a) **General.** This work consists of furnishing, placing, finishing, and curing concrete in bridges, culverts, and miscellaneous structures in accordance with these specifications and in reasonably close conformity with the lines, grades, and dimensions specified in the contract documents. The work may include elements of structures constructed by cast-in-place and precast methods using either plain (unreinforced), reinforced, or prestressed concrete or any combination thereof.
- (b) **Related Work.** Other work involved in the construction of concrete structures shall be as specified in the applicable sections of this specification, especially Section 502, "Temporary Works," Section 503, "Prestressed Concrete Bridge Members," Section 504, "Concrete Bridge Decks," Section 511, "Reinforcing Steel for Structures," and Section 517, "Post-tensioning."

509.02. MATERIALS.

Conform to the requirements of following Sections and Subsections, except as otherwise specified:

Portland Cement Concrete	701
Fly Ash	702
Anchor Bolts for Bridge Structures	724.05
Elastomeric Bearing Pads	733.06
Waterstops	733.08
Concrete Surface Finish for Structures	737

509.04. CONSTRUCTION METHODS.

- (a) **General.** For handling and measuring materials, batching, and mixing, comply with the requirements of Subsections 414.04(c), (d), and (e) except as otherwise specified.

Whenever the contract documents the selection of the method or equipment to be used for any operation, employ methods and equipment which will produce satisfactory work under the conditions encountered and which will not damage any partially completed portions of the work.

Use falsework and forms conforming to Section 502, "Temporary Works." Fully support all concrete until the required strength and age has been reached.

(b) **Protection of Concrete from Environmental Conditions.**

1. *General.* Take precautions to protect concrete from damage due to weather or other environmental conditions during the placing and curing operations. Remove and replace, or repair to an acceptable condition, concrete that has been frozen or otherwise damaged by weather conditions.

Except as otherwise specified, place concrete only when the concrete temperature is between 50°F (10°C) and 90°F (32°C). Measure concrete temperature immediately before placement. Do not place concrete against any form (including the ground) or reinforcement colder than 35°F (2°C) or hotter than 100°F (38°C).

To determine ambient temperature, measure the temperature of the air in the shade 5 feet (1.5m) above the ground on the project.

Have available on the project site at least two maximum-minimum thermometers that are accurate within $\pm 5^\circ\text{F}$ (3°C). Maintain these devices in good working order. Install and provide temperature data from these devices as directed by the Engineer. Report readings and reset daily.

2. *Rain Protection.* Under conditions of rain, do not place concrete unless adequate protection is provided to prevent damage to the surface mortar or damaging flow or wash of the concrete surface.
3. *Hot Weather Protection.* Use a water spray or other approved methods to cool surfaces, hotter than 100°F (38°C), which will come in contact with the mix. Such surfaces include forms, reinforcing steel, steel beam flanges, etc.

Maintain the concrete temperature within the specified range by any combination of the following methods:

- Shade the materials storage areas and the production equipment.
- Cool the coarse aggregates by sprinkling with water conforming to the requirements of Subsection 701.04.
- Cool the aggregates or water by refrigeration or replace a portion or all of the mix water with flaked or crushed ice that will melt completely during mixing.
- Use liquid nitrogen injection.

4. *Cold Weather Protection.* Cold weather is defined as any time during the concrete placement or curing period the ambient temperature at the work site drops below 35°F (2°C). Before commencing cold weather concreting, have all material and equipment required for protection available at or near the project.

Remove all snow, ice, and frost from the surfaces, including reinforcement and subgrade, against which the concrete is to be placed. The temperature of any surface that will come

into contact with fresh concrete shall be at least 35°F (2°C) and shall be maintained at a temperature of 35°F (2°C) or above during the placement of the concrete.

If using heaters, place heaters and direct ducts so as not to cause concrete drying or fire hazards. Vent exhaust flue gases from combustion heating units to the outside of any enclosures. Heat the concrete components in a manner that is not detrimental to the concrete. Apply and withdraw the heat gradually and uniformly so that no part of the concrete surface is heated to more than 90°F (32°C) before set or caused to change temperature by more than 20°F (11°C) in 8 hours when removing protection.

Do not heat cement or permit the cement to come into contact with aggregates that are hotter than 100°F (38°C). Concrete at the time of placement shall be of uniform temperature and free of frost lumps. Do not heat aggregates with a direct flame or on sheet metal over fire. Do not heat fine aggregate by direct steam. The addition of salts to prevent freezing is not permitted.

During cold weather, protect the concrete for at least 7 calendar days so that the concrete surface temperature does not drop below 50°F (10°C) . Extend the protection period to 10 days if fly ash, slag or silica fume is used in the concrete.

(c) **Handling and Placing Concrete.**

1. *General.* Handle, place, and consolidate concrete by methods that will not cause segregation of the mix and will result in a dense homogeneous concrete which is free of voids and rock pockets. Use methods that will not cause displacement of reinforcing steel or other materials to be embedded in the concrete.

Place and consolidate concrete before initial set and in no case before the time allowed under Table 509-1 has elapsed. Do not retemper concrete.

Table 509-1
Time Limits for Completion of Concrete Placement/Consolidation

Cement Type With and Without Admixtures	Time Limit ¹ (hour)
Type I or II	1.00
Type I or II with Retarding Admixture	1.50
Type III	0.75
Type III with Retarding Admixture	1.25

¹Begin time measurement when the cement is added to the mix.

Place concrete only after the Engineer has inspected and approved the forms, all materials to be embedded, and, for footings, the adequacy of the foundation material. Remove all mortar from previous placements, debris, and foreign material from the forms and steel before placement. Thoroughly moisten the forms and subgrade with water immediately before concrete is placed against them. Leave in place temporary form spreader devices until concrete placement precludes their need, then remove them.

Place concrete continuously without interruption between planned construction or expansion joints. The delivery rate, placing sequence and methods shall be such that fresh concrete is always placed and consolidated against previously placed concrete before initial

set has occurred in the previously placed concrete. Do not allow the time between the placement of successive batches to exceed 20 minutes. This period may be increased to 30 minutes when the ambient temperature during placement is less than 60°F (15°C). If a delay occurs causing the permissible time between successive batches to be exceeded and initial set has occurred before placement can be completed, make an emergency construction joint as specified in 509.04(d).

During and after placement of concrete, take care not to injure the concrete or break the bond with reinforcing steel. Keep workers off placed, fresh concrete. Do not support platforms for workers and equipment on any reinforcing steel. Once the concrete is set, do not apply forces to the forms or reinforcing steel which project from the concrete until the concrete is of sufficient strength to resist damage.

2. *Sequence of placement.* Comply with the form and falsework release requirements in Subsection 502.04(a)8.
 - 2.1 *Substructures.* Do not place loads on finished bents, piers, or abutments until concrete cylinder tests from the same concrete cured under the same conditions as the substructure element indicate that all concrete has at least 80% of its required 28-day compressive strength and has aged at least 7 days.
 - 2.2 *Vertical members.* For vertical members, such as columns, substructures, cast-in-place retaining walls, and culvert walls more than 16 feet (5m) in height, allow the concrete to set and settle (due to bleeding) for at least 12 hours before placing concrete for integral horizontal members, such as caps, slabs, or footings. For vertical members less than 16 feet (5m) in height, allow the concrete to settle for at least 30 minutes. When friction collars or falsework brackets are mounted on such vertical members, do not place concrete for horizontal members until the vertical member has been in place at least seven days or attained its required 28-day strength.
 - 2.3 *Superstructures.* Do not place concrete in the superstructure until substructure forms have been stripped sufficiently to determine the acceptability of the supporting substructure concrete. Do not place concrete in the superstructure until the substructure has attained the required strength.

Concrete for cast-in-place T-beams or pan girders may be placed in one continuous operation or two separate operations; first, to the top of the girder stems and second, to completion. If the section is more than 4 feet (1200mm) deep, place in two separate operations. Wait at least 5 calendar days after stem placement before placing the top deck slab concrete.

Concrete for box girders may be placed in two or three separate operations consisting of bottom slab, girder webs, and top slab or as shown on the plans. However, place the bottom slab first and do not place the top slab until the girder webs have been in place for at least 5 calendar days.

- 2.4 *Arches.* Place concrete in arch rings so that the centering is loaded uniformly and symmetrically.
- 2.5 *Box culverts.* Place the base slab of box culverts and allow to set 24 hours before placing the culvert wall concrete. For wall heights of 5 feet (1.5m) or less, the walls

and top slab may be placed in one continuous operation. For walls greater than 5 feet (1.5m) , the requirements for vertical members shall apply.

2.6 *Precast elements.* Place and consolidate concrete so that shrinkage cracks are not produced in the member.

3. *Placing methods.*

3.1 *General.* Place concrete as near as possible to its final position. Do not use vibrators for extensive shifting of the mass of fresh concrete.

Do not place concrete in horizontal layers greater than 18 inches (0.5m) thick. Do not exceed the vibrator capacity to consolidate and merge the new layer with the previous layer. Do not place concrete at a rate that, when corrected for temperature, exceeds the design loading of the forms.

Do not drop unconfined concrete more than 6 feet (2m) . Concrete may be confined by using a tube fitted with a hopper head or other approved device that prevents mix segregation and mortar spattering. This does not apply to cast-in-place piling or drilled shafts when concrete placement is completed before initial set occurs in the concrete placed first.

3.2 *Equipment.* Use equipment of sufficient capacity that is designed and operated to prevent mix segregation and mortar loss. Do not use equipment that causes vibrations that could damage the freshly placed concrete. Do not use equipment with aluminum parts that come in contact with the concrete. Remove set or dried mortar from inside surfaces of placing equipment.

Use chutes that are lined with smooth watertight material and, when steep slopes are involved, that are equipped with baffles or reverses.

Operate concrete pumps so that a continuous stream of concrete without air pockets is delivered at the tube discharge.

Do not use conveyor belt systems longer than 550 feet (170m) when measured from end to end of the total belt assembly. Arrange the belt assembly so that each section discharges into a vertical hopper to the next section without mortar adhering to the belt. Use a hopper, chute, and deflectors at the discharge end of the conveyor belt system to cause the concrete to drop vertically.

3.3 *Lighting.* If placing concrete during nighttime hours, provide sufficient lighting as necessary to make quality workmanship and adequate inspection possible. Exercise reasonable care to avoid interruptions during the hours of darkness, repair promptly any damage to the lighting system, and replace all burned out lamps as soon as possible.

4. *Consolidation.* Consolidate all concrete, except concrete placed underwater and as specified for drilled shafts, by mechanical vibration immediately after placement.

Except as noted herein, use internal vibration. External form vibrators may be used for thin sections when the forms have been designed for external vibration.

Vibrators shall be of approved type and design and of a size appropriate for the work. They shall be capable of transmitting vibration to the concrete at frequencies of not less than 75 hertz.

Provide a sufficient number of vibrators to properly compact each batch of concrete immediately after it is placed in the forms. Provide at least one spare vibrator immediately available in case of breakdown.

Manipulate vibrators to thoroughly work the concrete around reinforcement, embedded fixtures, corners, and angles in the forms. Vibrate the concrete at the point of deposit and at uniformly spaced points not farther apart than 1.5 times the radius over which the vibration is visibly effective. Insert vibrators so that the affected vibrated areas overlap. Do not use vibrators to move concrete. Insert vibrators vertically and slowly withdraw from the concrete. The vibration shall be of sufficient duration and intensity to thoroughly consolidate the concrete, but not to cause segregation. Do not vibrate at any point long enough to cause localized areas of grout to form. Do not vibrate reinforcement or through the reinforcement to sections or layers of concrete which have hardened to the degree that the concrete ceases to be plastic under vibration.

Supplement vibration with spading, as necessary, to ensure smooth surfaces and dense concrete along form surfaces, in corners, and at locations impossible to reach with the vibrators.

5. *Underwater placement.*

- 5.1 *General.* Underwater placement of concrete is permitted only for seal concrete and drilled shafts. Seal concrete is concrete used to seal out water in structures, such as cofferdams. For concrete placed underwater, increase the minimum cement content by 10% to compensate for loss due to wash. Refer to Section 516 for additional placement requirements for drilled shafts.

To prevent segregation of seal concrete, carefully place concrete under water in a compact mass, in its final position, using a tremie, concrete pump, or other approved method for placement. Maintain still water at the point of deposit. Forms under water shall be watertight. Vent cofferdams during placement and curing to equalize the hydrostatic pressure and thus prevent flow of water through the seal concrete.

Place seal concrete under water in a continuous manner from start to finish. Keep the concrete surface as level as practicable. To ensure thorough bonding, place each succeeding layer of seal concrete before the preceding layer has taken initial set. For large pours, use more than one tremie or pump to ensure compliance with this requirement.

5.2 *Equipment.*

- *Tremies.* Use watertight tremies, with a diameter of 10 inches (250mm) or more. Fit the top with a hopper. Use multiple tremies as required. Make tremies capable of being rapidly lowered to retard or stop the flow of concrete.

At the start of concrete placement, seal the discharge end and fill the tremie tube with concrete. Keep the tremie tube full of concrete to the bottom during placement. If water enters the tube, withdraw the tremie and reseal the discharge end. Maintain continuous concrete flow until the placement is completed.

- *Concrete pumps.* Use pumps with a device at the end of the discharge tube to seal out water while the tube is first being filled with concrete. When concrete

flow is started, keep the end of the discharge tube full of concrete and below the surface of the deposited concrete until placement has been completed.

- 5.3 *Cleanup.* Dewatering may proceed after test specimens cured under similar conditions indicate that the seal concrete has sufficient strength to resist the expected loads. Remove all laitance or other unsatisfactory materials from the exposed surface by scraping, chipping, or other means which will not injure the surface of the seal concrete before placing the foundation concrete.

(d) **Construction Joints.**

1. *General.* Make construction joints only where specified in the contract documents, unless otherwise approved. Extend all planned reinforced steel uninterrupted through joints. In the case of emergency, place construction joints as directed and, if directed, add steel dowels across the joint at no additional cost to the Department.
2. *Bonding.* Unless otherwise specified in the contract documents, horizontal joints may be made without shear keys and vertical joints shall be constructed with shear keys. Sufficiently rough float the surface of fresh concrete at a horizontal joint to thoroughly consolidate the surface. Leave the joint roughened. Shear keys shall consist of formed depressions in the surface of covering approximately one-third of the contact surface. Bevel the forms for keys so that removal will not damage the concrete.

Clean all construction joints of surface laitance, curing compound, and other foreign materials before fresh concrete is placed against the surface of the joint. Use abrasive blast or other approved methods to clean joints without shear keys to the extent that clean aggregate is exposed (full amplitude of approximately $\frac{1}{4}$ inch (6mm)). Use a stiff wire brush or other approved method for joints with shear keys. Flush all construction joints with water and allow to dry to a surface dry condition immediately before placing concrete.

3. *Doweling into Existing Concrete.* When the contract documents specify that new concrete be bonded to existing concrete structures, clean and flush the existing concrete as specified in Subsection 509.04(d)2. When the contract documents show reinforcing dowels grouted into holes drilled in the existing concrete at such construction joints, drill the holes by methods that will not shatter or damage the concrete adjacent to the holes. Drill holes to the depth specified in the contract documents or as approved. In no case shall the hole depth be less than either 15-bar diameters or the epoxy manufacturer's recommended depth for full development of the dowel, whichever is deepest. Make hole diameter just large enough to easily fit the dowel into the hole, but no larger than $\frac{1}{4}$ -inch (6mm) more than the dowel diameter.

Use Type IV epoxy meeting the requirements of Subsection 701.13. Before use, submit information on the proposed epoxy including its brand name, specification, type, class, and grade for approval. Use equipment and techniques that will ensure the epoxy components are properly proportioned, mixed, and placed.

Inject epoxy into the hole through a tube or hose of sufficient length to reach the closed end of the hole being filled. Fill the hole with epoxy starting from the closed end and fill to a depth such that when the dowel is inserted into the hole, excess epoxy runs out. Twist the dowel when inserting to insure a uniform coating of epoxy around the steel. In horizontal or

overhead applications, prevent the epoxy from running out of the hole after the dowel has been inserted. Wipe clean excess epoxy around the hole while the epoxy is still fluid.

If the approved epoxy product used is not consistent with this procedure, use the manufacturer's recommended procedure.

4. *Forms at Construction Joints.* When forms at construction joints overlap previously placed concrete, retighten the forms before depositing new concrete. Neatly form the face edges of all joints exposed to view with straight bulkheads or grade strips, or otherwise finish true to line and elevation.
- (e) **Installing Expansion and Contraction Joints.** Construct expansion and contraction joints at the locations, and in accordance with the details, specified in the contract documents. Such joints include open joints, filled joints, joints reinforced with steel armor, waterstops, compression seals, elastomeric expansion joint seals, and joints with combinations of these features.
1. *Open joints.* Form open joints with a wooden strip, metal plate, or other approved material. Remove the joint forming material without chipping or breaking the corners of the concrete. Do not extend reinforcement across an open joint. Finish the edge of non-armored joint using a $\frac{1}{2}$ inch (12mm) radius edging tool.
 2. *Filled joints.* Cut premolded expansion joint filler to the shape and size of the surface being jointed. Secure the joint filler on one surface of the joint using galvanized nails, waterproof adhesive, or other acceptable means. Make as few splices in the filler material as possible. Splice according to the manufacturer's recommendations. After form removal, remove and neatly cut all concrete or mortar that has sealed across the joint. Fill all joint gaps $\frac{1}{8}$ inch (3mm) or wider with hot asphalt or other approved filler. Place all necessary dowels, load transfer devices, and other devices as shown on the plans or as directed.
 3. *Steel Joints.* Refer to Section 504 for requirements for Metal Expansion Joints in bridge decks.
 4. *Water stops.* Place adequate waterstops of rubber or plastic as specified in the contract documents. Where movement of the joint is specified, use waterstops that permit such movement without injury.
 - 4.1 *Rubber Waterstops.* Before installation, submit for approval the following.
 - Performance test data.
 - One yard sample of each type of waterstop required.
 - If splices are used, at least one preliminary field splice.Form waterstops with a cross-section that is uniform in width and web thickness. Do not splice straight strips. Full-mold all junctions in the special connection pieces. Provide well cured, dense, homogeneous special connection pieces that are nonporous and are free from other defects.

Fabricate splices that are dense and homogeneous throughout the cross-section. Fabricate splices watertight by vulcanizing or by mechanical means. Fabricate splices so they have a tensile strength of at least 50% of the reported tensile strength of the unspliced rubber waterstop.

- 4.2 *Plastic Waterstops.* Before installation, submit for approval at least one preliminary field splice sample.

Heat splices according to the manufacturer's instructions to make them watertight. Fabricate splices so they have a tensile strength of at least 80% of the reported tensile strength of the unspliced plastic waterstop.

- 4.3 *Placing Waterstops.* Carefully place and support waterstops. Prevent waterstops from being displaced or damaged by construction operations or other activities. Keep all surfaces of waterstops free from oil, grease, dried mortar, or any other deleterious material until embedded in concrete. Ensure that embedded portions of the waterstop are completely enclosed in dense concrete.

5. *Compression joint seals.* Use one piece compression joint seals for transverse joints and the longest practicable length for longitudinal joints. Clean and dry joints and remove spalls and irregularities. Apply a lubricant-adhesive as a covering film to both sides of the seal immediately before installation. Compress the seal and place it in the joint as recommended by the manufacturer. Make sure the seal is in full contact with the joint walls throughout its length.

Remove and discard all seals twisted, curled, nicked or improperly formed. Remove and reinstall joint seals that elongate more than 5% of their original length when compressed. Remove all excess lubricant-adhesive before it dries.

6. *Elastomeric expansion joint seal.* Install the joint according to the manufacturer's recommendations and in conformance with the contract documents.

(f) **Concrete Curing.**

1. *General.* Cure all newly placed concrete by use of one or more of the methods specified herein. Except as otherwise specified, begin curing immediately after the free surface water has evaporated and the finishing is complete. Do not damage the concrete surface with the application of the curing material. If the surface of the concrete begins to dry before the selected cure method can be started, keep concrete surface moist using a fog spray without damaging the surface.

Keep surfaces to be rubbed moist after forms are removed. Cure immediately following the first rub.

Unless using either the steam or radiant heat curing method, cure all concrete uninterrupted for at least 7 calendar days. If pozzolans, such as fly ash, in excess of 10 percent by weight of the Portland cement are used in the mix, cure uninterrupted for at least 10 calendar days. Except for concrete used in bridge floors and pavements, the above curing periods may be reduced and curing terminated if cylinders cured under the same conditions as the structure indicate that concrete strengths of at least 70% of that specified have been reached.

Refer to Subsection 701.07 for curing material requirements.

2. *Forms-in-place method.* For formed surfaces, leave the forms in place without loosening. If forms are removed during the curing period to facilitate rubbing, strip forms only from those areas able to be rubbed during the same shift. During rubbing, keep the surface of the exposed concrete moist. After the rubbing is complete, immediately continue curing process using

the water method or by applying a clear curing compound (Type 1-D) for the remainder of the curing period.

3. *Water method.* Keep the concrete surface continuously wet by ponding, spraying, or covering with material that is kept continuously and thoroughly wet. Covering material may consist of cotton mats, multiple layers of burlap, or other approved material that does not discolor or otherwise damage the concrete.
4. *Liquid membrane curing compound method.* Use Type 2, white pigmented, liquid membrane on the top surfaces of bridge decks and approach slabs or on surfaces not exposed to view in the completed work. Use Type 1-D clear curing compounds on other surfaces.

Mix membrane curing solutions containing pigments before use. Continue to agitate during application. Use equipment capable of producing a fine spray. Apply the curing compound at a minimum rate of 1 gallon per 160 square feet (1 liter per 4 square meters) in one or two uniform applications. If the solution is applied in 2 applications, follow the first application with the second application within 30 minutes and apply at right angles to the first application.

If the membrane is damaged by rain or other means during the curing period, immediately apply a new coat over the damaged areas.

Do not use the liquid membrane method on surfaces to receive a rubbed finish. Usage of curing compound on construction joint surfaces is permitted only if the compound is removed by sandblasting before placement of concrete against the joint.

5. *Waterproof cover method.* Cover the wet concrete surface with a waterproof sheet material that prevents moisture loss from the concrete.

Use widest sheets practical. Lap adjacent sheets at least 6 inches (150mm) and tightly seal all seams with pressure sensitive tape, mastic, glue, or other approved methods. Secure all material so that wind will not displace it. Immediately repair sheets that are broken or damaged.

6. *Steam or Radiant Heat Method.* Use this method only for precast concrete members manufactured in established plants.

Conduct steam curing or radiant heat curing under a suitable enclosure to contain the live steam or radiant heat and exclude outside air. Provide uniform temperature within the enclosure. Place the required temperature recorder inside the enclosure.

Apply steam or radiant heat after the initial set of all concrete in a line, or from 2 to 4 hours after final placement for normal set concrete and 4 to 6 hours after final placement for retarded set concrete. To measure time of initial set, use AASHTO T197 (ASTM C403), "Time of Setting of Concrete Mixtures by Penetration Resistance." After placement and before the application of steam or radiant heat, use steam or radiant heat as needed to maintain the temperature within the curing chamber between 50°F (10°C) and 90°F (32°C).

Prevent localized high temperatures on the members caused by live steam or radiant heat applied directly to the concrete, forms, or test cylinders. Limit the rate of ambient temperature change within the curing enclosure to 40°F (22°C) per hour. Do not exceed 160°F (70°C) within the enclosure. Hold the curing temperature near its peak until the required concrete detensioning strength has been reached. When discontinuing steam or

radiant heat, allow the ambient air temperature within the enclosure to cool to 20°F (10°C) above the temperature of the outside air. Do not reapply steam or radiant heat after cooling.

Use low pressure, saturated steam having 100 percent relative humidity for the steam method. Use pipes circulating steam, hot oil or hot water, or electric heating elements to apply radiant heat. When using the radiant heat method, also cover all exposed concrete surfaces with plastic sheeting or an approved liquid membrane curing compound. After the completion of curing, completely remove all residue of curing compound from surfaces to receive cast-in-place concrete or other materials requiring surface bonding.

Unless the ambient temperature is maintained above 60°F (16°C), transfer the stressing force for prestressed members immediately after discontinuing the steam or radiant heat curing.

- (g) **Finishing Formed Concrete Surfaces.** Remove and replace or repair, as approved, all rock pockets or honeycombed concrete. Provide a durable, tightly-bonded surface finish that is uniform in texture and color. Finish sound formed concrete surfaces as follows.

1. *Class 1 - Ordinary Surface Finish.* Finish all formed concrete surfaces with a Class 1, ordinary surface finish. If another class of surface finish is specified, apply the specified class of surface finish after the Class 1 finish is complete.

Begin finishing when the forms are removed. Remove fins and irregular projections from all surfaces that are exposed or will be waterproofed. Remove bulges and offsets with carborundum stones or discs. Remove localized poorly bonded rock pockets or honeycombed concrete and replace with sound concrete or packed mortar in an approved manner and as specified in Subsection 509.04(h). If, in the opinion of the Engineer, rock pockets or honeycombed concrete are of such an extent or character as to effect the strength of the structure materially or to endanger the life of the steel reinforcement, the Engineer may declare the concrete defective and require removal and replacement of the portions of the structure affected.

Clean and point all form tie cavities, holes, broken corners and edges, and other defects. Saturate the area with water. Finish the area with mortar that is less than 1 hour old. Use mortar complying with Subsection 509.04(h). After the mortar is set, rub it (if required) and continue curing. Match exposed surfaces to surrounding concrete.

Carefully tool and remove free mortar and concrete from construction and expansion joints. Leave joint filler exposed for its full length with clean, true edges.

Rub or grind bearing surfaces on piers and abutments to the specified elevation and slope.

If the final finished surface is not true and uniform, provide a Class 2, rubbed finish.

2. *Class 2 - Rubbed Finish.* If not otherwise specified in the contract documents, finish exposed concrete surfaces with a Class 2, rubbed finish, except the soffits of superstructures, the interior faces and bottoms of concrete girders, and the interior faces of reinforced concrete boxes.

Complete the Class 1 finish. Immediately before rubbing, saturate the concrete surface with water. Rub the surface with a medium coarse carborundum stone using a small amount of mortar on its face. Use mortar composed of cement and fine sand mixed in the same

proportions as the concrete being finished. Continue rubbing until form marks, projections, and irregularities are removed and a uniform surface is obtained. Leave the paste produced by this rubbing in place.

After other work that could affect the surface is complete, rub with a fine carborundum stone and water until the entire surface has a smooth texture and uniform color. After the surface has dried, rub it with burlap to remove loose powder. Leave it free from all unsound patches, paste, powder, and objectionable marks.

For slip formed surfaces, use appropriate tools and methods to achieve a rubbed finish appearance.

3. *Class 3 - Tooled Finish.* Provide a Class 3 surface finish only when specified. Let the concrete set for at least 14 calendar days or longer if necessary to prevent the aggregate particles from being “picked” out of the surface. Use air tools such as a bush hammer, pick, or crandall. Chip away the surface mortar and break the aggregate particles to expose a grouping of broken aggregate particles in a matrix of mortar.
4. *Class 4 - Sandblasted Finish.* Provide a Class 4 surface finish only when specified. Let the concrete set for at least 14 calendar days. Protect adjacent surfaces that are not to be sandblasted. Sandblast the surface with hard, sharp sand to produce an even fine-grained surface in which the mortar is cut away leaving the aggregate exposed.
5. *Class 5 - Wire Brushed or Scrubbed Finish.* Provide a Class 5 surface finish only when specified. Begin when the forms are removed. Scrub the surface with stiff wire or fiber brushes using a solution of muriatic acid. Mix the solution in the proportion of 1 part acid to 4 parts water by volume. Scrub until the cement film or surface is completely removed and the aggregate particles are exposed. Leave an even pebbled texture having the appearance of fine granite to coarse conglomerate depending upon the size and grading of aggregate. Wash the entire surface with water containing a small amount of ammonia.
6. *Class 6 - Mortar Finish.* Unless otherwise specified in the contract documents, a Class 6 surface finish may be provided instead of Class 2 surface finish except for bearing surfaces. Use cement mortar complying with Section 737 as a surface finish coating. Provide a color slightly lighter than the natural color of concrete, unless otherwise specified.

Build a sufficient number of 18 inch (0.5m) by 36 inch (1m) concrete finish sample panels to obtain a color acceptable to the Engineer. Protect the approved sample panel at all times during the work. Finish all designated surfaces to match the color of the approved sample.

Do not apply the mortar finish until all other work that might mar or deface the surface finish is complete. After completing the Class 1 surface finish, remove all dust, foreign matter, form oil, grease, curing compound, or other deleterious material by lightly abrasive cleaning the surface. Wash the surface with a jet spray of clean water.

Use paper, cloth, or other means to protect surfaces not to be color finished. Apply the finish to a dry concrete surface when the surface temperature is 50°F (10°C) or higher and the air temperature in the shade is anticipated to be 50°F (10°C) or higher during the 24 hours following application.

Apply the finish according to the manufacturer's recommendations. Apply the coating with an approved plaster type spray gun or by the brush and float method. Cure cement-based mortar coatings in the same manner as required for curing concrete.

Clean concrete areas not intended to be covered by the finish using an approved method. Clean and recoat defective areas at no additional cost.

7. *Class 7 - Paint Finish.* Paint concrete only when specified in the contract documents. When painting concrete, comply with Sections 512 and 737.

For all classes of surface finishes except Class 7 - Paint Finish, apply penetrating water repellent treatment after completion of the surface finish. Apply water repellent before painting. Refer to Section 515 for water repellent requirements.

(h) **Mortar and Grout.**

1. *General.* This work consists of making and placing of mortar and grout for use in concrete structures other than in prestressed ducts. Such uses include mortar to fill voids and repair surface defects and grout used to fill sleeves for anchor bolts.
2. *Materials and Mixing.* Use materials for mortar and grout conforming to the requirements of Section 701. Modify the grading of sand for use in grout or for use in mortar when the width or depth of the void to be filled is less than $\frac{3}{4}$ inch (20mm), so that all material passes the No. 8 (2.36mm) sieve. Use Type I Portland Cement and air entraining admixture. Unless otherwise specified or directed, use one part cement to two parts sand for mortar and one part cement to one part sand for grout. Proportion by loose volume.

When non-shrink mortar or grout is specified, use either a non-shrink admixture or an expansive hydraulic cement conforming to ASTM C 845 of an approved type.

Use only sufficient water to permit placing and packing. For mortar, use only enough water so that the mortar will form a ball when squeezed gently in the hand.

Do mixing by either by hand methods or with rotating paddle-type mixing machines. Continue mixing until all ingredients are thoroughly mixed. Do not retemper mortar or grout. Place within one hour.

3. *Placing and Curing.* Clean all loose and foreign material that would in any way prevent bond, from areas to be in contact with mortar or grout. Flush with water and allow to dry to a surface dry condition immediately before placement.

Completely fill and tightly pack with mortar or grout recesses and holes and other locations specified. Cure all surfaces of mortar and grout using the water method for at least three days. Do not load mortar or grout before the end of curing.

Remove and replace defective mortar and grout.

(i) **Application of Loads.**

1. *General.* Do not apply load to concrete structures until the concrete has attained sufficient strength and, when applicable, sufficient prestressing has been completed, so that damage will not occur. Determine strengths from test cylinders cured at the work site under similar conditions as the structure as specified in Section 701.
2. *Earth Loads.* Whenever possible, use a sequence of placing backfill around structures such that overturning or sliding forces are minimized. When the placement of backfill will cause

flexural stresses in the concrete, and unless otherwise permitted by the Engineer, allow concrete to reach at least 80 percent of its specified strength and age at least 7 days before placing backfill.

For a rigid frame bridge or a bridge where the abutments are designed to be integral with the superstructure, do not backfill the abutments until the superstructure is in place and forms supporting girders and deck are removed. Do not place embankment around any supporting form.

3. *Construction Loads.* Allow the concrete in substructure elements, such as drilled shafts, piers, pier caps, and abutments, to reach at least 80 percent of its specified strength and age at least 7 days before loading these elements with girders, precast concrete or steel.

Refer to Section 504 for requirements regarding construction loads on bridge decks.

In general, limit construction loads on existing, new, or partially completed portions of structures to the load carrying capacity of the structure as determined by the current AASHTO *Standard Specifications for Highway Bridges*. Use the lowest measured, actual strength of the structure in computing capacities.

- (j) **Concrete Anchorage Devices.** Use chemical, grouted, or cast-in-place concrete anchorage devices for attaching equipment or fixtures to concrete. Furnish the following:

- Concrete anchorage device sample.
- Manufacturer's installation instructions.
- Material data and certifications.

Fabricate all metal parts of the anchorage devices from stainless steel or from steel protected with a corrosion resistant metallic coating that does not react chemically with concrete. Supply anchorage devices complete with all hardware.

For chemical or grouted anchors, conduct a system approval test on one anchor at the job site, not to be incorporated in the work. Conduct a static load test according to ASTM E 488. Demonstrate that the anchorage device will withstand a sustained direct tension test load not less than the values shown in Table 509-2 for at least 48 hours with movement not to exceed 0.035 inch. Also demonstrate that when loaded to failure, the anchor device displays a ductile failure of the anchor steel, not a failure of the chemical, grout, or concrete.

Table 509-2
Sustained Load Test Values

Anchorage Device Stud Size (inches)	Tension Test Load (lb)
1/4	1000
3/8	2100
1/2	3200
5/8	4100
3/4	5100

Table 509-2 (Metric)
Sustained Load Test Values

Anchorage Device Stud Size	Tension Test Load (kN)
M20	24.0
M16	18.3
M12	12.7
M8	7.1

Install concrete anchorage devices as recommended by the device manufacturer and so that the attached equipment or fixtures will bear firmly against the concrete. Torque installed nuts to the values specified in Table 509-3 unless otherwise specified in the manufacturer’s instructions.

**Table 509-3
Torque for Anchorage Devices**

<u>Anchorage Device Stud Size (inches)</u>	<u>Torque (ft-lbs)</u>
1/4	10
3/8	35
1/2	60
5/8	90
3/4	125

**Table 509-3 (Metric)
Torque for Anchorage Devices**

<u>Anchorage Device Stud Size</u>	<u>Torque (N-m)</u>
M20	180
M16	130
M12	80
M8	30

In the presence of the Engineer, proof load a random sample of at least 10 percent of the anchors to 90 percent of the yield stress of the steel. If any anchor fails, reset the failed anchor and proof torque the reset anchor and 100 percent of all remaining anchors. The proof load may be applied by torquing against load indicator washers, applying direct tension load to the anchor, or another method approved by the Engineer. After proof loading, release the load on the anchor and retighten to the load specified in Table 509-3 or according to the manufacture’s instructions.

(k) **Girder Bearings.**

1. *Concrete Bearing Surfaces.* Finish concrete bearing surfaces to meet the requirements for Class 2, rubbed surface finish, and to provide full and even bearing.

Check concrete bearing surfaces, in the presence of the Engineer, for smoothness, levelness, and elevation before erecting girders. Build the concrete bearing surface to be within 1/4 inch (6mm) of the specified elevation and sloping no more than 0.5 percent from horizontal, measured at all locations and directions on the bearing surface. If bearing surfaces are at improper elevations, not level, or if bearings cannot otherwise be set properly, notify the Engineer and submit a written proposal to modify the installation for approval.

2. *Anchor Bolts.* Furnish threaded, galvanized anchor bolts conforming to Subsection 724.05 or as specified in the contract documents.

Install anchor bolts in the same manner as specified in Subsection 509.04(d)3 for construction joint dowels or preset them before placing the concrete. Do not restrict free movement of the superstructure at movable bearings by anchor bolts or nuts.

3. *Bearing Assemblies.*
 - 3.1 *Drawings.* Prepare and submit drawings for the bearings according to Subsections 105.02 and 733.06, and Section 506 as applicable. Show all details of the bearings including the material proposed for use. Obtain approval before beginning fabrication.
 - 3.2 *Fabrication.* Preassemble bearing assemblies in the shop and check for proper completeness and geometry.

- 3.3 *Packaging, handling, and storage.* Before shipping from the manufacturer, clearly identify each bearing component and mark on its top the location and orientation in the structure. Securely bolt, strap, or otherwise fasten the bearings to prevent any relative movement.

Package bearings so they are protected from damage due to shipping, handling, weather, or other hazards. Do not dismantle bearing assemblies at the site except for inspection or installation. Store all bearing devices and components at the work site in a location that provides protection from environmental and physical damage.

- 3.4 *Construction and Installation.* Clean the bearings of all deleterious substances. Install the bearings to the positions shown on the drawings. Set bearings and bearing components to the dimensions shown on the drawings or as prescribed by the manufacturer. Adjust according to the manufacturer's instructions to compensate for installation temperature and future movements of the bridge.

Bed metallic bearing assemblies, not embedded in concrete, on concrete with an approved filler or fabric material. Set elastomeric bearing pads directly on properly prepared concrete surfaces without bedding material. Machine bearing surfaces seated directly on steel to provide a level and planar surface upon which to place the bearing.

- 3.5 *Elastomeric Bearing Pads.* Provide elastomeric bearing pads conforming to Subsection 733.06 unless otherwise specified.

Place bearings on a level surface. Correct any misalignment in the support to form a level surface. Do not weld steel girders or base plates to the exterior plates of the bearing unless there is more than 1½ inch (38mm) of steel between the weld and elastomer. Do not expose the elastomer or elastomer bond to instantaneous temperatures greater than 400°F (200°C).

- 3.6 *Other Bearing Types.* Provide and install other types of bearing devices conforming to the requirements of the AASHTO Standard Specification for Highway Bridges.

(l) **Miscellaneous Construction.**

1. *Waterproofing.* Waterproof reinforced concrete retaining walls, abutments, earthfilled arches, etc., when specified in the contract documents. Conform to the requirements of Sections 606 or 607, depending upon the type specified.
2. *Drainage and Weep Holes.* Construct drainage and weep holes in the location and manner specified in the contract documents or as directed.
3. *Pipes and Conduits.* Install pipes and conduits for utility service lines to be embedded in concrete or attached to the concrete surface. Provide the pipes, conduits, and support hardware if so specified in the contract documents.

- (m) **Testing.** Randomly selected batches of fresh structural concrete will be tested for slump, air content, and temperature, and cylinders for compressive strength tests will be made from these batches. Compressive strength will be evaluated under Subsection 701.01.

Make compressive strength cylinders for controlling construction operations as required and needed. Perform other testing as required and needed to assure compliance with these specifications.

509.05. METHOD OF MEASUREMENT.

Structural concrete will be measured by the cubic yard (cubic meter) . Measurement will be according to the neat lines of the structure as shown on the plans except as altered by the Engineer to fit field conditions. No deduction will be made for the volume occupied by reinforcing steel, anchors, weep holes, piling, or pipes/ducts less than 8 inches (200 mm) in diameter.

For volumes of concrete having strengths less than the specified requirements but accepted under Subsection 105.03, the pay reduction factor for the represented volume of concrete will be computed by the following equation:

$$\text{Pay Reduction Factor} = (\text{Actual Strength/Specified Strength})^2$$

The contract price will be multiplied by pay reduction factor for the represented volume of concrete.

When *Class A concrete, small structures* is shown as a bid item in the contract documents, Class A concrete used in structures having less than 20 cubic yards (15 cubic meters) of total concrete volume per structure will be measured by the cubic yard under this item.

Anchor bolt assemblies (threaded bars, nuts, and washers), anchor plates not embedded in concrete, and diaphragm bolt assemblies (threaded-end bars, couplers, nuts, plates, and washers) will be measured as structural steel under Section 506.

Bearing assemblies and components, such as, elastomeric bearing pads, pot bearings, TFE bearings, fillers, etc., will not be measured for payment. Include the cost of these items in the price bid for related superstructure items of work.

509.06. BASIS OF PAYMENT.

The accepted quantities, measured as specified in this Section, will be paid at the contract price per unit of measurement for the pay items listed below that are shown in the Plan bid schedule. Payment will be full compensation for the respective work prescribed in this Section.

- (A) CLASS AA CONCRETE CUBIC YARD (CUBIC METER)
- (B) CLASS A CONCRETE CUBIC YARD (CUBIC METER)
- (C) CLASS A CONCRETE, SMALL STRUCTURES .. CUBIC YARD (CUBIC METER)
- (D) CLASS C CONCRETE CUBIC YARD (CUBIC METER)
- (E) CLASS P CONCRETE CUBIC YARD (CUBIC METER)

SECTION 510

EARTH RETAINING SYSTEMS AND SOUND BARRIER WALLS

510.01. DESCRIPTION.

This work consists of constructing earth retaining systems, cast-in-place concrete sound barrier walls, and sloped walls in accordance with these Specifications and in close conformity with the lines and grades shown on the Plans or established by the Engineer.

510.02. MATERIALS.

- (a) **General.** Materials shall conform to the following sections and subsections:

Structural Concrete	509
Reinforcing Steel for Structures	511
Portland Cement Concrete	701
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For sloped walls, use Class A concrete with coarse aggregate for thin section concrete.

- (b) **Precast Elements.** Precast elements shall meet the applicable requirements of Section 503 except that Class AA concrete shall be used instead of Class P concrete.
- (c) **Steel Sheet Piles.** Steel sheet piling shall conform to AASHTO M 202 or AASHTO M 270, Grade 50W (Grade 345W).
- (d) **Filter Fabric.** Filter fabric shall conform to Subsection 620 of the AASHTO Guide Specifications for Highway Construction, GSH-7, 1993. Filter fabric shall prevent clogging of the drain and transmission of fines from the backfill.
- (e) Granular Backfill for Mechanically Stabilized Earth (MSE) Walls. Granular backfill for MSE walls shall comply with Subsection 703.05 and the following.

The backfill material shall have an angle of internal friction of not less than 34°. Determine the angle of internal friction by the standard Direct Shear Test, AASHTO T 236, on the portion finer than the No. 10 (2mm) sieve, using a sample of material compacted to 95% of AASHTO T 99, Methods C or D (with oversized correction) at optimum moisture content. No testing is required for backfills where 80% of sizes are greater than $\frac{3}{4}$ inch (20mm).

If the backfill material is to be used with steel soil reinforcement, use backfill material meeting the following electrochemical requirements:

- pH of 5 to 10,
- Resistivity 30 ohm meters,
- Chlorides 100 parts per million,
- Sulfates 200 parts per million.

510.04. CONSTRUCTION METHODS.

- (a) **General.** For earth retaining systems and noise barrier walls, use construction methods conforming to Sections 501, 502, 509, 510, 511, and 613.

Alternative designs for earth retaining systems and noise barrier walls may be used if permitted in the contract documents. Obtain the working drawing approval before using an alternative design.

- (b) **Working Drawings.** Provide working drawings and design calculations for alternative earth retaining systems and alternative design noise barrier walls, or when required by the contract documents. Comply with Subsection 105.02. Include the following items in the working drawings and design calculations:

- Verification of existing ground elevations for each structure involving construction in original ground,
- The layout of the wall that will effectively retain the earth (for retaining walls) or block noise (for noise barrier walls) but not less in height or length than the wall system shown in the contract documents,
- Complete design calculations substantiating that the proposed design satisfies the design parameters in the contract documents,
- Complete details of all elements required for the proper construction of the system, including complete material specifications,
- Earthwork requirements including specifications for material and compaction of backfill (for retaining walls),
- Details of revision or additions to drainage systems or other facilities required to accommodate the system,
- Other information required in the contract documents or requested by the Engineer.

Provide working drawings for concrete walls that have an architectural finish required. Show the layout for the form liners. Identify each piece of form liner. Show the sequence of construction.

- (c) **Backfill.** Place backfill material within the neat lines shown on the plans. For retaining walls, use granular backfill of the type specified.

- (d) **Drainage.** Construct drainage facilities in accordance with the details shown on the approved working drawings or in the contract documents and these specifications.

1. *Concrete Gutters.* Construct concrete gutters to the profile indicated in the contract documents or on the approved working drawings. Provide outlet works at sags in the profile, at the low of the gutter, and at other indicated locations.
2. *Weep Holes.* Construct weep holes at the locations shown in the contract documents or on the approved working drawings. Place a minimum of 2 ft³ (0.06m³) of coarse cover material for pipe underdrains encapsulated with filter fabric at each weep hole.

Cover the joints between precast concrete retaining wall face panels that function as weep holes with filter fabric. Bond the filter fabric to the face panels with adhesive conforming

to Federal Specification MMM-A-121. The face panels that are to receive the filter fabric shall be dry and thoroughly cleaned of dust and loose materials.

3. *Drainage Blankets.* Construct drainage blankets consisting of coarse cover material for pipe underdrains encapsulated in approved filter fabric or filter sand, collector pipes, outlet pipes, and cleanout pipes as specified in the contract documents or on the approved working drawings.

Prepare the subgrade for filter fabric installation by compacting to the specified density and grading to the specified elevation. Remove any extraneous material and sharp objects that may damage the fabric during installation. Stretch and align the fabric, and place in a wrinkle-free manner. Overlap adjacent borders from 12 inches (300mm) to 18 inches (450mm). Repair torn or punctured fabric by placing a piece of fabric that is large enough to cover the damaged area and meet the overlap requirement.

Place the coarse cover material in horizontal layers and thoroughly compact. Do not pond or jet the coarse cover material or adjacent backfill. During spreading and compacting of the cover material, maintain a minimum of 6 inches (150mm) of cover material between the fabric and the construction equipment.

Place the perforated collector pipe within the cover material to the elevations shown. Place outlet pipes at sags in the flow line, at the low of the collector pipe, and at other indicated locations. Place cleanout pipes at the high ends of collector pipes and at other indicated locations.

4. *Geocomposite Drainage Systems.* Install geocomposite drainage systems at the locations shown in the contract documents or on the approved working drawings. Place and tightly secure the geocomposite drainage material against the excavated face, lagging, or back of wall as specified in the contract documents. When concrete is to be placed against geocomposite drainage material, protect the drainage material against physical damage and grout leakage.

(e) **Wall Systems.**

1. *Cast-in-place Concrete Walls.*

- 1.1 *Architectural Finish.* When the plans specify an architectural finish on the exposed surface(s) of the wall, comply with the following requirements:

- Submit a sample of the form liner for approval (with working drawings).
- Use as few joints in the form liner as possible.
- Discard and replace damaged form liner.

- 1.2 *Retaining Wall Placement.* Unless otherwise specified, cast retaining walls with a 1% batter (leaning toward the backfill side) to compensate for wall deflection caused by the backfill material. Do not backfill until all sections within a continuous section of wall have been cast and cured by Subsection 509.

- 1.3 *Vertical Precast Concrete Wall Elements with Cast-in-Place Concrete Footings.* Adequately support and brace wall elements to prevent vertical or horizontal displacement until footing concrete has been placed, completely cured, and has sufficient strength to support the wall elements. Comply with Section 502.

2. *Mechanical Stabilized Earth (MSE) Walls.* The construction of MSE retaining walls shall consist of constructing a facing system to which steel or polymeric soil reinforcement is connected and the placing of structure backfill material surrounding the soil reinforcement.
 - 2.1 *Facing.* Provide facing consisting of precast concrete panels that conforms to the details and materials specified in the contract documents or on the approved working drawings.

Provide a Class 2, Rubbed finish or the architectural treatment specified in the contract documents. The face not exposed to view shall have a uniform surface finish free of open pockets of aggregate or surface distortion in excess of $\frac{1}{4}$ inch (6mm). Accurately locate and secure soil reinforcement connection hardware during concrete placement. Do not allow contact of hardware with the facing reinforcing steel.
 - 2.2 *Soil Reinforcement.* Provide galvanizing according to AASHTO M 111 for all steel soil reinforcement and steel connection hardware. Steel strip reinforcement shall be hot rolled to the required shape and dimensions. The steel shall conform to AASHTO M 223, Grade 65 (Grade 450) , unless otherwise specified in the contract documents.

Welded wire fabric reinforcement shall be shop fabricated from cold-drawn wire of the sizes and spacings specified in the contract documents or on the approved working drawings. The wire shall conform to AASHTO M 32. The fabricated fabric shall conform to AASHTO M 55.

Polymeric reinforcement shall be of the type and size specified in the contract documents or on the approved working drawings.

Connection hardware shall conform to the contract documents or the approved working drawings.
 - 2.3 *Construction.* When required, provide a cast-in-place concrete leveling pad for entire length of wall. Prepare foundation material under level pad according to Section 501.

Place and support panels as necessary so that their final position is vertical or battered as shown in the contract documents or on the approved working drawings within a tolerance of +0%, -1%. (The minus direction leans toward the backfill.)

Install joint filler, bearing pads, and joint covering material concurrently with face panel placement.

Place and compact granular backfill for MSE walls simultaneously with the placement of facing and soil reinforcement. Place and compact without distorting or displacing the facing panels or soil reinforcement. Do not use sheeps foot or grid-type rollers for compacting granular backfill. Roughly level the backfill material at each level of soil reinforcement to an elevation approximately 1 inch (25mm) above the connection at the facing before placing the soil reinforcement. Uniformly tension all soil reinforcement to remove any slack in the connection or soil reinforcement.
- (f) **Slopedwalls.** Construct slopedwalls according to requirements for concrete sidewalks in Section 610. Do not place horizontal construction joints in the slopedwalls. Space vertical construction joints less than 10 feet (3m) measured along the top of slopedwall. The final number and location of construction joints will be determined in the field by the Engineer.

510.05. METHOD OF MEASUREMENT.

The *retaining walls* and *sound barrier walls* will be measured for payment by the accepted area of wall as measured from the top of the footing to the top of the wall.

Items used in wall construction including, but not limited to, excavation, backfill, backfill material, concrete, reinforcing steel, form liners, perforated pipe underdrain, geocomposites, filter fabric, pipe underdrain cover material, concrete surface finish, and sheeting and shoring, will not be measured for payment. Include the cost of these unmeasured items in the price bid for wall construction.

Drilled shafts and piling will be measured and paid for as specified for drilled shaft and piling pay items.

Sloped wall will be measured by the surface area of completed sloped wall, according to the dimensions shown on the plans or required by the Engineer.

510.06. BASIS OF PAYMENT.

Accepted quantities of retaining wall, sound barrier wall, and sloped wall will be paid for at the contract unit price for:

- (A) RETAINING WALL SQUARE YARD (SQUARE METER)
- (B) SOUND BARRIER WALL SQUARE YARD (SQUARE METER)
- (C) SLOPEWALL SQUARE YARD (SQUARE METER)

which will be full compensation for all labor, material, equipment, and incidentals necessary to complete the respective work.

SECTION 511 REINFORCING STEEL FOR STRUCTURES

511.01. DESCRIPTION.

This work consists of furnishing and placing reinforcing steel in accordance with the contract documents. Reinforcing steel consists of deformed bars, epoxy coated deformed bars, and cold drawn wire mesh as specified.

511.02. MATERIALS.

- (a) **General.** Reinforcing steel shall meet the requirements of Section 723, except the strength requirement shall conform to grade 60 (420) unless otherwise specified in the special provisions or plans. Furnish cold drawn wire for spiral ties and other reinforcing designated in W (wire) sizes.
- (b) **Bar Lists and Bending Diagrams.** The bar list and bending diagrams shown in the contract documents are provided for estimating quantities. Bent bars are dimensioned out-to-out. Verify the quantity, size and shape of the bar reinforcement against the structure drawings and make necessary corrections before ordering.

If detailed bar lists and bending diagrams are not provided, submit such lists and diagrams for approval according to Subsection 105.02. Do not fabricate before the lists and diagrams

are approved. Do not fabricate vertical reinforcement in columns, walls, and piers until footing elevations are established in the field.

(c) **Fabrication.**

1. *Bending.* Fabricate reinforcing bars according to ACI 318 (318M) “*Building Code Requirements for Structural Concrete.*” Cold bend all reinforcing bars that require bending, unless otherwise permitted. If the Engineer allows heating for field bending reinforcing bars, take precautions to assure that the physical properties of the steel will not be materially altered. Do not bend bars partially embedded in concrete except as shown on the contract drawings or otherwise permitted.
2. *Hook and Bend Dimensions.* When the dimensions of hooks or the diameter of bends are not shown, provide standard hooks conforming to ACI 318 (ACI 318 M) .
3. *Identification.* Ship bar reinforcement in standard bundles, tagged and marked according to CRSI “*Manual of Standard Practice.*”

511.04. CONSTRUCTION METHODS.

(a) **Protection of Material.**

1. *General.* Store reinforcing steel above the ground on platforms, skids, or other supports. Protect from physical damage, rust, and other surface deterioration.

Use reinforcing steel only when the surface is clean and the minimum dimensions, cross-sectional area, and tensile properties conform to the physical requirements for the size and grade of steel specified. Do not use reinforcing steel that is cracked, laminated, or is covered with dirt, rust, loose scale, paint, grease, oil, or other deleterious material. Thin powdery rust and tight rust that does not reduce the effective cross section is not considered detrimental and need not be removed.

2. *Epoxy Coated Reinforcing.* Support coated bars on padded contact areas. Pad all bundled bands. Lift with a strong back, multiple supports, or a platform bridge. Prevent bar to bar abrasion. Do not drop or drag bundles.

Before placement, inspect coated bars for damage to the coating. Patch all defects in the coating that are discernable to the unaided eye with a prequalified patching/repair material according to AASHTO M 284. Clean areas to be patched by removing all surface contaminants and damaged coating. Roughen the area to be patched before applying the patching material. Where rust is present, remove the rust by blast cleaning or power tool cleaning immediately before applying the patching material.

Promptly treat the bar according to the resin manufacturer’s recommendations and before detrimental oxidation occurs. Overlap the patching material onto the original coating for 2 inches (50mm) or as recommended by the manufacturer. Provide a minimum 8 mil (200mm) dry film thickness on the patched areas.

Take necessary steps to minimize damage to the epoxy coating of installed bars. Clean and patch any damage to the coating noted after installation as described above.

Field repairs will not be allowed on bars that have severely damaged coatings. Replace bars with severely damaged coatings. A severely damaged coating is defined as a coating with a total damaged area in any 18-inch (450mm)length of bar that exceeds 5% of the

surface area of that portion of the bar. Coat mechanical splices after splice installation according to AASHTO M 284 for patching damaged epoxy coatings.

(b) **Placing and Fastening.**

1. *General.* Accurately place reinforcing steel in the position specified by the contract documents. Keep the reinforcing steel firmly held in place using approved supports while placing of concrete. Do not spot weld reinforcing steel.

Measure the spacing of parallel bars from center to center. For circular cages, measure on the curve where applicable. Measure the distance from face of concrete to reinforcing steel as clear distance.

Space parallel bars, center to center, at least $2\frac{1}{2}$ times the bar diameter apart, but not closer than $1\frac{1}{2}$ times the maximum nominal size of the concrete coarse aggregate plus one bar diameter.

Measuring perpendicular to the nearest concrete surface, place reinforcing steel within $\frac{1}{4}$ inch (6mm) of the plan location for bridge decks, and for slabs and walls less than 12 inches (300mm) thick; place reinforcing steel within $\frac{1}{2}$ inch (12mm) of plan location for all other structures. Provide 2 inches (50mm) clear cover for all reinforcement except as otherwise specified. For structure elements in direct contact with the ground, such as footings, abutments, retaining walls, and piers, provide 3 inches (75mm) clear cover.

Space parallel bars within $1\frac{1}{2}$ inches (40mm) of the required location. Do not cumulate spacing variations. The average of any two adjacent spaces shall not exceed the required spacing.

For mats and cages, tie reinforcing bars at all intersections except where spacing is less than 12 inches (300mm) in both directions, in which case alternate intersections may be tied. Tie all intersections around the perimeter of a mat. Tie all intersections of the last stirrup, hoop, or complete turn of a spiral at both ends of a cage.

Tie bundle bars together at intervals not exceeding 6 feet (2m). Do not bundle bars unless the location and splice details are specified. Use plastic-coated ties for tying epoxy coated bars.

Do not place concrete until the placement of the reinforcement is approved.

2. *Support System.* Support reinforcing steel in its proper position by use of mortar blocks, wire bar supports, supplementary bars or other approved devices. Use supports of such size and placed at sufficiently frequent intervals to maintain bar position within tolerances. Space slab bar supports no more than 4 feet (1.2m) apart transversely or longitudinally. Do not use reinforcing steel or bar supports to carry platforms for workers and equipment.

Use approved supports only.

3. *Mortar Blocks.* When using mortar blocks, use mortar blocks having compressive strength not less than that of the concrete in which they are to be embedded. Make the face of the blocks in contact with the forms no more than 2 inches (50mm) by 2 inches (50mm) in size. Use blocks having the same color and texture to match the concrete to be cast. Attach concrete block supports to the supported bar with 14 gage (2mm) wire cast in the center of each block. Use plastic or epoxy-coated wire when supporting epoxy coated reinforcing.

4. *Wire Supports.* When using wire supports, use ferrous metal chairs and bolsters complying with industry practice described in the “*Manual of Standard Practice of the Concrete Reinforcing Steel Institute.*” Use Class 1 (plastic protected), Class 1A (epoxy-coated), or Class 2, Type B (stainless steel protected) metal supports in contact with exposed concrete surfaces. Use stainless steel conforming to ASTM A 493, Type 430. Coat chairs, tie wires, and other devices used to support, position, or fasten epoxy coated reinforcement with a dielectric material. Do not use plastic supports.

(c) **Splices.**

1. *General.* Furnish all reinforcement in the full lengths specified. Except splices specified in the contract documents and splices of No. 4 (No. 13) or smaller bars, splicing will not be permitted without written approval.
2. *Lapped Splices.* Provide lap lengths shown on the plans. Splice reinforcing bars only where shown on the contract drawings or approved drawings. Stagger splices when possible. Do not place slab bar mechanical splices next to each other. Make lapped splices by placing the reinforcing bars in contact and wiring them together to maintain the alignment and position of the bars. Do not lap splice bars larger than No. 11 (No. 36) bars; use approved welded or mechanical splices.
3. *Welded Splices.* Use welded splices only if welding of reinforcing steel is detailed in the contract documents, or authorized. If welding is allowed, conform to AWS D 1.4.
Use welders that are currently certified. When required in the contract documents, test each weld using magnetic particle, radiography, or other nondestructive inspection techniques.
4. *Mechanical Splices.* Mechanical couplers may be used if specified or approved. Use approved couplers with a strength that is at least 125% of the required yield strength of the reinforcing steel.
When requested, remove and test two coupler splices out of each 100 installed, to verify coupler splice capacity. The Engineer will randomly select the splices to be tested.
5. *Splicing of Mesh.* If welded wire fabric is shipped in rolls, straighten into flat sheets before placing. Splice sheets of mesh or bar mat reinforcement by overlapping not less than one mesh width plus 2 inches (50mm) . Securely fasten at the ends and edges.

511.05. METHOD OF MEASUREMENT.

Reinforcing steel incorporated in the concrete will be measured in pounds (kilograms) based on the total computed weight (mass) for the sizes and lengths of bars, wire or welded wire fabric shown on the contract drawings or authorized for use in the work.

The weight (mass) of reinforcing bars, plain or epoxy-coated, will be computed using Table 511-1. The weight (mass) of reinforcing wire, welded wire fabric, and plain bar of sizes other than those listed in Table 511-1, will be computed from tables of weights (masses) published in the AASHTO material specifications for those items.

The weight (mass) of reinforcement used in items, such as railings or precast members, where payment for the reinforcement is included in the contract price for the item, will not be included. Threaded bars or dowels placed after the installation of precast members in the work and used to attach such members to cast-in-place concrete will be included, if not included in structural steel. No

allowance will be made for clips, wire, separators, wire chairs, and other material used in fastening the reinforcement in place. If bars are substituted upon the Contractor's request and as a result more steel is used than specified, only the amount specified will be included.

The additional steel required for splices that are not shown on the contract drawings but are authorized, will not be included.

No allowance will be made for the weight of epoxy coating in computing the weight (mass) of epoxy-coated reinforcing steel.

**Table 511-1
Reinforcing Bar Weights**

Bar Designation, No.	Nominal Weight, lb/ft
3	0.376
4	0.668
5	1.043
6	1.502
7	2.044
8	2.670
9	3.400
10	4.303
11	5.313
14	7.650
18	13.600

**Table 511-1
Reinforcing Bar Masses (Metric)**

Bar Designation, No.	Nominal Mass, kg/m
10	0.560
13	0.994
16	1.552
19	2.235
22	3.042
25	3.973
29	5.060
32	6.404
36	7.907
43	11.380
57	20.240

511.06. BASIS OF PAYMENT.

The accepted quantities of each class of reinforcement, measured as specified in this Section, will be paid at the contract price per unit of measurement for the pay items listed below that are shown in the Plan bid schedule. Payment will be full compensation for the respective work prescribed in this Section.

- (A) REINFORCING STEEL POUND (KILOGRAM)
- (B) EPOXY COATED REINFORCING STEEL POUND (KILOGRAM)

SECTION 512 PAINTING

512.01. DESCRIPTION.

- (a) **General.** This work consists of the painting of surfaces specified in the contract documents to be painted. The work shall be taken to include, but is not limited to, the preparation of surfaces to be painted, application and curing of paint, protection of the work, protection of existing facilities, vehicles, the public and the environment from damage due to this work, and furnishing of all labor, equipment, and materials needed to perform the work. Note that some testing limits are given in metric units.
- (b) **References, Definitions and Abbreviations.**
- *CERCLA.* Comprehensive Environmental Response, Compensation, and Liability Act. (Commonly called "SUPERFUND.")
 - *CFR.* Code of Federal Regulations. To obtain a copy, contact:
 Superintendent of Documents
 General Printing Office
 Washington, D.C. 20402
 Telephone (202) 783-3238.

List of CFR Titles Specified

CFR Number	Title
29 CFR 1926.62	Lead
40 CFR 50, App. J	Reference Method for Determination of Particulate Matter as PM in the Atmosphere
40 CFR 50.6	National Primary and Secondary Ambient Air Quality Standards for Particulate Matter
40 CFR 50.12	National Primary and Secondary Ambient Air Quality Standards for Lead
40 CFR 261	Identification and Listing of Hazardous Waste
40 CFR 263	Standards Applicable to Transporters of Hazardous Waste
40 CFR 268.7	Waste Analysis and Recordkeeping
40 CFR 300	National Oil and Hazardous Substances Pollution
40 CFR 302	Designation, Reportable Quantities, and Notification

Note: Absence of a CFR title does not relieve the Contractor of responsibility to comply with federal regulations.

- *Chain of Custody Form.* A form used for maintaining identification of waste samples, by signature and date, from the time the sample is taken, through transportation, receipt at the laboratory, and testing.
- *Deleading.* Deleading is the removal and elimination lead-based paint or lead-based paint contaminated materials.
- *DEQ.* Oklahoma Department of Environmental Quality.

- *EPA*. Environmental Protection Agency.
- *Hazardous Material*. Material is considered as hazardous if, when TCLP tested, any of the elements listed in the following table are extracted in concentrations equaling or exceeding those listed. Note that other materials, such as chemical strippers, can cause a material to be hazardous as defined in 40 CFR 261 and must be taken into consideration.

Hazardous Materials	
Hazardous Elements	Concentration (ppm)
Arsenic	5
Barium*	100
Cadmium*	1
Chromium*	5
Lead*	5
Mercury	0.2
Selenium	1
Silver	5

*Typical Elements found in ODOT paints.

- *HEPA Filters*. A HEPA (High Efficiency Particulate Air) filter removes at least 99.97% of particles that are 0.3 microns in diameter or larger.
- *Manifest*. The shipping document U.S. EPA Form 870022 and, if necessary, U.S. EPA Form 8700-22A.
- *Manifest Document Number*. The U.S. EPA twelve digit identification number assigned to the generator plus a unique five digit document number assigned to the manifest by the generator for recording and reporting purposes.
- *MSDS*. Material Safety Data Sheet.
- *OSHA*. Occupational Safety and Health Administration.
- *PEL*. Permissible Exposure Limit. The 29 CFR 1926.62 standard requires that the Contractor assure that no one on the project is exposed to lead at concentrations greater than 50 $\mu\text{g}/\text{m}^3$ averaged over an eight hour period.
- *PM 10*. Particulate matter with an aerodynamic diameter less than or equal to a nominal 10 μm . PM 10 is determined from samples collected using high-volume air monitors. The analysis conducted according to 40 CFR 50, Appendix J.
- *RCRA*. Resource Conservation and Recovery Act.
- *Reportable Release of Lead*. A discharge of 10 pounds or more of lead into the atmosphere, water, or soil within a 24-hour period is considered a reportable release under 40 CFR 300 and 40 CFR 302 or CERCLA.
- *Representative Sample*. A sample that can be expected to exhibit the average properties of the collected debris.
- *SSPC*. Society for Protective Coatings, formerly Steel Structures Painting Council.

SSPC
 40 24th Street
 Pittsburgh, PA 15222-4643
 Telephone (412) 281-2331

- *SSPC Guide 6*. “Guide for Containing Debris Generated During Paint Removal Operations.” This guide describes methods of paint removal, containment systems and procedures for minimizing or preventing emissions from escaping the work area, and procedures for assessing the adequacy of the control over emissions. The following class definitions are from SSPC Guide 6 and are used in this specification:

SSPC Guide 6 Classes

<u>Class</u>	<u>Definition</u>
2A	For abrasive blast cleaning, Class 2A requires air impenetrable walls with rigid or flexible framing, fully sealed joints, partially sealed entryways, forced air flow (verified visually), and exhaust air filtration.
2W	For wet methods of preparation, Class 2W requires water impermeable walls and floors, rigid or flexible framing, fully sealed joints, overlapping entryways, and natural air flow.
2C	For chemical stripping, Class 2C requires water impermeable and chemical resistant walls and floors with rigid or flexible framing, fully sealed joints, overlapping entryways, and natural air flow.
3W	For wet methods of preparation, Class 3W requires water impermeable walls and floors, minimal framing, partially sealed joints, open seam entryways, and natural air flow.
3C	For chemical stripping, Class 3C requires water impermeable and chemical resistant walls and floors with minimal framing, partially sealed joints, open seam entryways, and natural air flow.
3P	For hand or power tool cleaning, Class 3P requires air penetrable walls with minimal framing, partially sealed joints, overlapping or open seam entryways, and natural air flow.
4A	For abrasive blast cleaning, Class 4A requires air penetrable walls with flexible framing, open seams and entryways, and natural air flow.

- *Subtitle C Landfill*. A landfill permitted according to Subtitle C of the Resource Conservation and Recovery Act for the disposal of hazardous waste.
- *Subtitle D Landfill*. A landfill permitted according to Subtitle D of the Resource Conservation and Recovery Act for the disposal of nonhazardous waste.
- *TCLP Test*. Toxicity Characteristic Leaching Procedure Test (EPA Method 1311 in SW 846, Test Methods for Evaluating Solid Wastes).
- *Treatment*. A process designed to change the physical, chemical, or biological characteristics or composition of any hazardous waste to neutralize or to render such waste nonhazardous.
- *WAP*. Waste Analysis Plan.

- *Waste Generator.* The Contractor and the Department are considered waste generators or co-generators when existing paint, which is classified as hazardous waste, is removed from the surfaces it covered. Under co-generator status, both parties remain permanently responsible for the waste and RCRA compliance.
- *Water Booms.* Water booms are long, narrow tubes (less than one foot in diameter) linked together to create a floating containment wall on water.

512.02. MATERIALS. Paint shall conform to the Section 730.

512.04. CONSTRUCTION METHODS.

(a) **General Requirements.**

1. *Contractor Qualifications.* When the contract documents specify SSPC-QP 2 certification, submit a current SSPC-QP 2 certificate showing qualifications to remove hazardous paints in accordance with SSPC-QP 2, “*Standard Procedure for Evaluating Qualifications of Contractors to Remove Hazardous Paint from Industrial Structures,*” for the applicable category. Submit SSPC certificates at the time of submission of the Proposal. Perform the work with personnel qualified under the applicable SSPC procedures. Perform the work according to these SSPC procedures, unless otherwise specified.

SSPC certifications will not be required for projects having only Category R paint applications (see Subsection 512.04(b)2 for paint category definitions).

2. *Protection of Public, Property, and Workers.*

- 2.1 *Work Plan.* At least 14 calendar days before beginning surface preparation, submit a written plan for approval that details the measures to be used for the protection of the environment, public, adjacent property, and the workers while doing the work. Make the plan available to state and federal agencies on request. Include the following in the work plan as applicable:
 - *MSDS.* Provide the material safety data sheets for the cleaning and painting products.
 - *Paint Removal Plan.* Describe the proposed methods and procedures for the removal of the existing paint and for the containment and the disposal of removed materials, cleaning products, and paint debris.
 - *Waste Management Plan.* Describe the types of waste generated by the cleaning and painting processes. Describe waste sampling and testing; collecting, handling, treating, and storing of wastes; transporting and disposing of wastes generated; documentation; and clearance testing after a project has been completed.
 - *Worker Protection Plan.* The proposed safety measures to be used to protect workers from site hazards, including protection from falls, fumes, fire, explosion, or other dangers. Use safety practices according to the SSPC-PA Guide No. 3, “*A Guide to Safety in Paint Application,*” and according to OSHA. Describe hygiene facilities; employee training; design, operation, and maintenance of

engineering controls; demarcation of hazardous material work areas; medical surveillance; and planned measures to reduce the hazardous material danger.

- *Environmental Compliance Plan.* Describe establishment of a regulated area; ensuring ambient air quality; ensuring soil quality; ensuring water/sediment quality; and reporting a release of hazardous materials into the environment.
- *Certification.* Provide a written certification stating that proposed methods of containment and disposal conform to all applicable federal, state, and local regulations, and the contract documents. Provide copies of all permits and approvals.

Do work according to the approved plan. When the measures fail to perform as intended, immediately stop work and take corrective actions.

2.2 *Protection Requirements for Cleaning Existing Steel Bridges.* Comply with the following requirements for projects involving cleaning of existing steel bridges.

- *Soil Testing.* Before cleaning structures having existing paint, test the soil at a minimum of four sites for the presence of lead. For bridges exceeding 1000 feet (300m) in length, add a test site for each 250 feet (76m) in excess of 1000 feet (300m). Locate two sites under the bridge and two sites from 10 feet (3m) to 100 feet (30m) away from the bridge. The Engineer will designate the location of additional test sites. At each test site, align a 12 inch (300mm) x 12 inch (300mm) template parallel to the structure. Within the template, take five 3/4-inch (20mm) diameter by 1/2-inch (12mm) deep soil samples, one at the center of the square and one at each corner. Combine the five soil plugs in a single bag to represent the sample at the given location. Split the sample into three equal parts. Supply the testing laboratory and the Engineer with two of the three parts. Retain one part of the split sample until the end of the project. At the completion of cleaning operations, return to the same locations and repeat the sampling and testing.

Test the samples for total lead content using EPA Method 3050, "Acid Digestion of Sediments, Sludges, and Soils". Provide the DEQ, Waste Management Division and the Engineer a copy of the soil test results. Notify the Engineer and the testing laboratory before sampling to allow inspection of the sampling process. Provide a chain of custody form for all soil test samples. Use a testing lab accredited by the DEQ. Provide cleanup of the soils if the geometric mean of the post-job soil test results is more than 100 ppm or two standard deviations (whichever is greater) higher than the geometric mean of the pre-job soil test results. The geometric mean is the n th root of the product n number of test results. Calculate standard deviation using pre-job test results. Cleanup is accordance with DEQ guidelines.

- *Airborne Emissions Monitoring.* During the paint removal process, provide air monitoring complying with SSPC Guide 6 methods specified in the following table.

Airborne Emissions Monitoring

Project Situation	Method(s) Required
Project located within 300 feet (100m) or two times the height of the bridge, whichever is greater, of inhabited buildings	Method A: Visible Emissions, Level 1 and Method B: Ambient Air Monitoring for PM-10
Projects involving hazardous materials.	Method A: Visible Emissions, Level 2
Projects involving nonhazardous materials.	Method A: Visible Emissions, Level 3

For Method A monitoring, the boundary of the emissions will be defined as the edge the containment system. Discontinue operations if emissions exceed the specified cumulative duration limits over an 8-hour period until the problem is corrected. For Method B monitoring, discontinue operations if emissions exceed $150 \mu\text{g}/\text{m}^3$ of PM 10 over a 24-hour period until the problem is corrected.

Provide, in the work plan, a detailed description of the monitoring methods, including testing frequency and data recording methods. Use a cleaning method or containment system that minimizes dust according to 40 CFR 50.6 and 40 CFR 50.12.

- *Containment Requirements.* During cleaning operations, contain all waste, hazardous and nonhazardous, solid or liquid, within the work area to prevent pollution of the environment. Prevent waste from reaching the ground or, if the project is over a lake or waterway, the water.

Design and implement a containment system for the work area complying with SSPC class 2A, 2W, 2C, or 3P for hazardous waste materials and SSPC class 4A, 3W, 3C, or 3P for nonhazardous waste materials. UNLESS OTHERWISE STATED IN THE CONTRACT DOCUMENTS, CONSIDER THE WASTE FROM CLEANING EXISTING PAINT TO BE HAZARDOUS. If the project is situated so that PM 10 air monitoring is required, use SSPC class 2 containment or better. For vacuum blasting and cleaning with power tools equipped with HEPA filters, comply with SSPC class 3P containment for hazardous waste.

For vacuum blasting, maintain continuous contact between the blasting head and the blast surface. If dust is visible from vacuum blasting, discontinue vacuum blasting until the problem is corrected. Equip cleaning power tools with HEPA filters. For vacuum blasting and power tool cleaning, use an equipment manufacturer representative at the start of work to ensure the equipment is being used correctly.

Obtain permission of the Engineer and the DEQ to use chemical stripping. Submit the MSDS for the chemical stripper to both agencies

When the projected wind area of the proposed enclosure exceeds 30% of the projected bridge superstructure area and the enclosure is attached to the bridge, submit structural analysis of the bridge performed by a professional engineer and shop drawings showing the enclosure/bridge attachment details. Determine wind areas on a span-by-span basis.

- *Reportable Release of Hazardous Materials.* When a reportable release of hazardous materials occurs, notify the Engineer and the DEQ. Provide testing and cleanup as directed by the DEQ.
- *Permits from Other Governmental Entities.* Obtain written approval of the DEQ, Waste Management Division, for all solid waste collection/containment, storage, treatment, and disposal methods. Obtain approval from the DEQ, Water Quality Division, for the treatment of all liquid waste. Provide copies of submissions and approvals to the Engineer.

If blast cleaning methods are to be used, obtain all required blast-cleaning permits. Notify the Engineer and state, county, and municipal air and water pollution agencies, including the DEQ, 10 days before commencement of cleaning operations.

- *Worker Safety and Health.* Refer to Subsections 107.07 and 107.12 of the Standard Specifications. Comply with 29 CFR 1926.62. Provide each worker on the project site with a copy of the publication "Working with Lead in the Construction Industry," OSHA 3126. Require each worker to become familiar with the publication contents. Submit to the Engineer blood lead level test results of each worker on the project site. Test blood lead levels before and after the entire deleading process. Additionally, establish a testing schedule to monitor blood lead levels during the project. Use an OSHA Certified Laboratory for all blood testing. Report blood lead levels over 40 µg/dl to the Epidemiology Service of the Oklahoma State Department of Health.

Supply each worker within the enclosure with personal air monitors to verify that worker exposure to lead paint dust within the permissible exposure limit (50 µg/m³).

- *Work Area Signs.* During surface cleaning where hazardous materials are involved, post signs in the work area that read as follows:

<p style="text-align: center;">WARNING Lead Work Area POISON From This Point On No Smoking or Eating Authorized Personnel Only</p>
--

- *Waste Storage.* Store waste in closed containers (drums) that do not leak and comply with EPA requirements. Label the drums as shown in the following two examples. For waste from dust collectors, add the label "From Dust Collectors."

HAZARDOUS WASTE		
FEDERAL LAW PROHIBITS IMPROPER DISPOSAL		
IF FOUND, CONTACT THE NEAREST POLICE, OR PUBLIC SAFETY AUTHORITY, OR THE U. S. ENVIRONMENTAL PROTECTION AGENCY		
PROPER D.O.T.		
SHIPPING NAME _____	UM OR NA# _____	
GENERATOR INFORMATION:		
NAME _____		
ADDRESS _____		
CITY _____	STATE _____	ZIP _____
EPA	EPA	
ID NO. _____	WASTE NO. _____	
ACCUMULATION _____	MANIFEST _____	
START DATE _____	DOCUMENT NO. _____	
HANDLE WITH CARE!		
CONTAINS HAZARDOUS OR TOXIC WASTES		

WARNING	
CONTENTS - LEAD PAINT RESIDUE	
TARE WT. _____	_____
DATE COLLECTED _____	_____
LOCATION _____	_____
CONTAINER NO. _____	_____

Store waste drums on the project site, in a storage area secured by a chain link fence with a gate and lock. Lay down impermeable tarpaulin to protect drums from rusting and to facilitate any required cleanup. Place drums on pallets. Store drums no more than two drums deep or two drums high. Place the storage area within the right-of-way as approved by the Engineer and the DEQ, Waste Management Division. Do not place the storage area within a flood plain, drainage area, or where water may pond.

- *Waste Sampling and Testing.* Test waste in the same manner described in Subsection 512.04(b)1.6, *Soil Testing*, with the following exceptions. Conduct at least one TCLP test for every 4000 pounds (1800 kg) of collected debris, liquid or solid, and one TCLP test for every 1000 pounds (450kg) of debris taken from dust collectors. Provide a minimum of four tests. Take a representative sample containing portions from the top, middle, and bottom of each drum. Test for all hazardous elements as defined in Subsection 512.01.
- *Waste Treatment.* Submit a WAP and a “Nonhazardous Industrial Waste Form” to the Engineer and DEQ, Waste Management Division according to 40 CFR 268.7. Include with the WAP, the proposed location of the disposal site. Treat waste by either incineration or stabilization, as described below.

Waste Treatment

<u>Method</u>	<u>Treatment Procedure</u>
Incineration.	Incinerate all solid waste, hazardous or nonhazardous, in a lead blast furnace or recycle the nonhazardous blast debris as feedstock for cement kilns. Obtain approval of the treatment process in writing from the DEQ and provide a copy of the approval to the Engineer 10 days before treating.
Stabilization.	Stabilize hazardous waste. Also stabilize nonhazardous waste containing steel shot or grit. Unless another method is approved, combine waste with Portland cement and water to stabilize. Add sufficient amounts of cement and water to lower leachable hazardous element concentrations, as determined by TCLP testing, below the specified limits. Provide a minimum of four TCLP tests to characterize the treated waste as nonhazardous. Prevent dust from escaping and provide worker protection during the stabilization process. For waste containing steel shot or grit, conduct back-to-back TCLP tests and the Multiple Extraction Procedure (MEP), EPA Method 1320, to demonstrate the long-term stability of the stabilized waste, simulating 500 years in a landfill.

- *Transportation.* Transport the hazardous collected debris according to 40 CFR 263. Provide manifests to the Engineer for both hazardous and nonhazardous waste to verify that the handling, disposal, and notifications are done as specified and that the names of approved disposal facility and licensed transporter are included.
- *Disposal.* Dispose of waste at the permitted landfill, Subtitle C or D in 90 days as approved by the DEQ and the Engineer.

2.3 *Traffic Control.* When construction affects highway traffic by encroaching on traffic lanes, shoulders, or reducing sight distances, provide traffic control. Design and construct traffic control under Chapter VI of the Manual of Uniform Traffic Control Devices for Streets and Highways and the Oklahoma Department of Transportation Standards.

3. *Protection of the Work.* Provide protective devices such as tarps, screens, covers, etc. as necessary to prevent damage to the work. Prevent contamination of freshly painted surfaces by dust, oil, grease, or other harmful and deleterious material. Protect all parts of the work against disfigurement by spatters, splashes, and smirches of paint materials. Repair painted surfaces that are marred or damaged, at no additional cost to the Department, with materials and to a condition equal to that of the coating specified herein.

If traffic causes an objectionable amount of dust, sprinkle the adjacent roadbed and shoulders, when directed, with water or dust palliative for a sufficient distance on each side of the location where painting is being done.

Upon completion of all painting operations and of other work that would cause dust, grease, or other foreign materials to be deposited on the painted surfaces, thoroughly clean, without damaging, the painted surface of dust, grease, or other foreign materials.

4. *Color.* Furnish paint so each coat of paint will be a contrasting color to ensure complete coverage and such that the previous coat can be hidden by a single coat of the next application. If requested, provide appropriate color chips. Obtain approval of the color for the top coat before application.
 5. *Quality Control.* Establish quality control (QC) procedures to assure surface preparation and paint application is done according to these specifications, the contract documents and the paint manufacturer's guidelines. Submit the written QC procedures for approval with the work plan.
- (b) **Painting Steel Structures.** Clean all surfaces to be painted. Provide written notice at least one week before beginning field cleaning and painting operations.
1. *Surface Preparation.*
 - 1.1 *New steel or existing steel to be completely stripped of existing paint.*

Clean new steel or existing steel to be completely stripped of existing paint as follows.

Begin cleaning steel, new or existing, by removing gross contaminants by hand, broom, compressed air, or other approved methods.

For new steel, unless otherwise prohibited by the contract documents, use solvents to remove oil, grease, and other soluble contaminants from new steel according to SSPC-SP 1, Solvent Cleaning.

When the steam cleaning method of solvent cleaning is used, clean according to SSPC-SP 1 except:

- Do not steam clean more than 14 calendar days before performing other phases of cleaning.
- Use a biodegradable detergent in the feed water of the steam generator or apply the detergent directly to the surface to be cleaned.
- Use a detergent and steam cleaning apparatus that will remove all dirt, grease, loose chalky paint, or other foreign material from previously painted or galvanized surfaces.
- After cleaning and flushing, wait a minimum of 24 hours to apply paint.

For existing steel, begin cleaning by removing dirt and salt deposits. Wash with either a water spray, pressurized from 800 psi (5.5 MPa) to 1500 psi (10.4 MPa), or an approved chemical solution, applied according to the manufacturer's recommendations. Keep the nozzle within 12 inches (300mm) of the surface during washing. Do not wash if wet abrasive blasting is used or testing proves that chloride content is less than 50 $\mu\text{g}/\text{cm}^2$. Submit, to the DEQ, Water Quality Division, and the Engineer, the MSDS for any chemical solutions to be used as cleaning agents and obtain approval before using. Collect all water, paint chips, and solids used for washing or cleaning including solvents and store as hazardous waste unless the DEQ determines the waste is nonhazardous.

After the initial cleaning of new and existing steel, remove all remaining dirt, mill scale, rust, paint, and other foreign material from exposed surfaces according to SSPC-SP 10, Near-White Blast Cleaning. Obtain a written statement from the paint manufacturer approving the cleaning method, abrasive, and abrasive additives. Include a copy of the statement in the work plan, along with a description of the cleaning method. Blast-clean with clean dry sand, mineral grit, steel shot, or steel grit having a suitable gradation to produce a dense, uniform anchor pattern. Unless otherwise specified, produce an anchor profile height of 1 mil (25 μm) to 2 mils (50 μm), but not less than that recommended by the manufacturer's product data sheet for the paint system specified. Measure anchor profile height using the tape method according to ASTM D 4417. Check the anchor profile at least twice for each 8-hour shift. Increase frequency if needed. Do not apply primer before the anchor profile has been verified and is correct.

Provide compressed air (for abrasive blast-cleaning and roughening) that is free from oil or moisture and does not show black or wet spots when tested according to ASTM D 4285. When blast-cleaning near machinery, seal all bearings, journals, motors, and moving parts against entry of abrasive dust before beginning.

The same day cleaning is performed, remove dirt, dust, and other debris from the surface by brushing, blowing with clean dry air, or vacuuming and apply the first coat of paint to the blast-cleaned surfaces. If the cleaned surfaces rust or become contaminated before painting, repeat blast-cleaning.

- 1.2 *Preparing existing steel surfaces when sound existing paint is to remain.* Clean existing steel surfaces when sound existing paint is to remain as follows.

Prepare surface according to SSPC-SP 2, SP 3, SP 10 and SP 11, as described below to 2 inches (50mm) beyond damaged area. Feather edges of remaining old paint to achieve a reasonably smooth surface.

Use hand or power tool cleaning methods according to SSPC-SP 2 and SP 3 to remove dirt, loose mill scale, loose rust, or paint that is not firmly bonded to the underlying surfaces. In addition, clean small areas that show pinhole corrosion, stone damage from traffic, or minor scratches. Clean small areas of deteriorated topcoat (less than 10% rust) according to SSPC-SP 2 and 3. Also, remove rust and rust bubbles.

Use the SSPC SP 10 blast-cleaning methods described in the preceding subsection to remove all visible oil, grease, dirt, dust, mill scale, rust, paint, oxides, corrosion products, and other foreign matter in areas showing severe deterioration (greater than 10% rust). Cleaning according to SSPC-SP 11, Power Tool Cleaning to Bare Metal, may also be done in these areas. Use SSPC SP 10 methods for new structural steel to be used in repair applications.

The same day cleaning is done, remove dirt, dust, and other contaminants from the surface with methods permitted by SSPC-SP 1 and spot paint with the first coat of paint all areas cleaned. If the cleaned surfaces rust before painting, repeat blast cleaning. If the cleaned surfaces are contaminated with foreign material, including any surface treatment, before painting, clean according to SSPC-SP 1.

- 1.3 *Abrasives and Pretreatments.* Use abrasives free of oil, moisture, hazardous substances, and corrosive constituents, such as, chlorides, sulfates, and salts. Use additives or coatings, such as, inhibitors and proprietary cementitious materials, according to the manufacturers instructions. Do not use abrasives with more than 1% "free" silica. In vacuum blasters, use No. 24 aluminum oxide grit or as approved by the Engineer.
2. *Paint Systems.* See Section 730 for paint system requirements. Unless otherwise specified in the contract documents, supply a paint system appropriate for the application. Applications are categorized as follows:

<i>Category</i>	<i>Application</i>	<i>Paint System</i>
N	New structure. Shop-applied primer. Field-applied intermediate and top coats.	IZ-E-U
E	Existing structure with all existing paint removed. All coats field-applied.	IZ-E-U or SC-MC-U
O	Existing structure with existing sound paint (Overcoating). All coats field-applied.	SC-MC-U
R	Repair of existing structure. All coats field-applied. Application area limited to repair area as specified.	SC-MC-U or an approved Performance Class 2 paint system

For Category O and R applications, verify the compatibility of the paint system with the existing system as follows:

- Apply the proposed system to the existing topcoat and to the existing primer. Observe for lifting, bleeding, blistering, wrinkling, cracking, flaking, or other evidence of incompatibility. Verify that no indication of incompatibility exists after at least 48 hours after the application of each product.
- Perform adhesion tests according to ASTM D 3359, Method A or ASTM D 4541. For ASTM D 3359, scale results 5A are acceptable. For ASTM D 4541, adhesion strengths exceeding the larger of 150 psi (1000 kPa) or the paint manufacturer's specified adhesion strength, are acceptable. Notify the Engineer immediately if adhesion testing fails at the interface of the existing system and substrate or between the existing top coat and primer.

Perform compatibility testing at least two weeks before ordering paint. Furnish a written certification and supporting test results verifying compatibility.

3. *Weather Conditions.* Unless otherwise specified by the manufacturer and approved by the Engineer, apply paint when the following conditions are met:

- The surface to be painted is thoroughly dry.
- The ambient air temperature and the surface temperature are between 40°F (5°C) and 100°F (38°C) .
- The surface temperature is 5°F (3°C) or more above the dew point.
- The humidity is 85% or less.
- Rain, fog, or ambient air temperature below 40°F (5°C) is not predicted during the drying period.

Do not paint when metal surfaces are hot enough to cause the paint to blister, to produce a porous film, or to cause the vehicle to separate from the pigment.

Suitable enclosures may be used to provide the conditions required above. Control the atmospheric conditions within the enclosure within limits suitable for painting throughout the painting operation and curing. The cost of providing and maintaining such an enclosure shall be considered as included in the prices bid for contract items involving painting and, therefore, no additional compensation will be allowed.

4. *Film Thickness.* Limit the thickness of each application to that which will result in uniform drying throughout the paint film. Verify the application rate of each coat with an approved wet film paint thickness gage, adjusted for volatile content, immediately after applying paint to the surface.

An example is as follows: If 3 mils (75µm) of dry thickness is needed and the volatile content of the paint is 50%, the wet film paint thickness gage must read at least 6 mils (150µm) immediately after application of the paint to achieve the desired dry coat thickness of 3 mils (75µm) .

Provide the dry film thickness of each coat and total thickness of the finished product according to the contract documents. Measure dry coating thickness after each application of paint according to SSPC-PA2, "*Measurement of Dry Paint Thickness with magnetic Gages.*"

5. *Application of paints.*

- 5.1 *General.* Mixing and application procedures shall conform to the product manufacturer's instruction data sheet. Mix paint with mechanical mixers. Before application, mix paint a sufficient length of time to blend the pigment and vehicle thoroughly. Continue the mixing during application. Do not thin paints formulated ready for application.

Paint in a neat and workmanlike manner that does not produce excessive paint buildup, runs, sags, skips and holidays, or thin areas in the paint film. Apply paint by brush, spray, roller, or any combination thereof as necessary for the paint being applied, unless otherwise specified.

Use brushes that have sufficient bristle body and length to spread the paint in a uniform film. Use round, oval shaped brushes, or flat brushes no wider than 4¹/₂ inches (115mm). Evenly spread and thoroughly brush out the paint as it is applied.

Use airless or conventional spray equipment with suitable traps, filters, or separators to exclude oil and water from the compressed air. Use rollers only on flat, even surfaces. Do not use rollers that leave a stippled texture in the paint film.

Paint surfaces that are inaccessible for painting by regular means, using sheepskin daubers, bottle brushes, or other acceptable methods. When spot painting, remove old paint that lifts after the first application by scraping. Repaint the area before the next application.

Cure each application of paint, and correct any skips, holidays, thin areas, or other deficiencies before the next application of paint. Tint succeeding applications of paint to contrast with the paint being covered.

Coat structures with the primer before erection. After erection and before applying the field coats, thoroughly clean all areas where coating has been damaged, has deteriorated, or where there are exposed unpainted surfaces, and spot coat with the primer to the specified thickness.

- 5.2 *Application of Zinc-Rich Primers.* Apply zinc-rich primers, which include inorganic and organic zinc primers, by spray methods. On areas inaccessible to spray application, the primer may be applied by brush or daubers.

Mix paint with mechanical mixers. After mixing, strain the primer through a metal 30-60 mesh screen or a double layer of cheesecloth immediately before or during pouring into the spray pot.

Use an agitating spray pot to apply the primer. The agitator or stirring rod shall reach to within 2 inches (50mm) of the bottom of the spray pot and shall be in motion at all times during primer application. Stir sufficiently to keep the primer well mixed.

Use spray equipment that provides the proper pot pressure and atomization pressure to produce a coating the composition of which shall comply in all respects to the specification for zinc paint. The hose from the pot to the nozzle shall not be more than 75 feet (23m) long, nor be used more than 15 feet (4.5m) above or below the pot.

Cured, zinc-rich primer shall be free from dust, dirt, salt, or other deleterious deposits and thoroughly dry before applying the intermediate coat.

Comply with the following additional requirements for *inorganic* zinc primers:

- Apply succeeding coats of inorganic zinc primer within 24 hours of the preceding application, but not earlier than 30 minutes after the preceding application.
 - In areas where mud-cracking occurs in the inorganic zinc primer, blast-clean these areas back to soundly bonded primer, and recoat to the same thickness by the same methods specified for the original coat.
 - Cure inorganic zinc primer for 48 hours at a relative humidity of at least 45 percent before applying intermediate coat. Before applying intermediate coat, wash the cured primer with water to remove any evidence of dust, dirt, salt, or other deleterious deposits if present, and to allow time to dry completely.
6. *Painting Galvanized Surfaces.* Clean and prepare the surface to be painted by washing with a mineral spirit solvent to remove all oil, grease, or other contaminants on the surface according to SSPC-SP 1. Apply the intermediate and final coats of the specified paint system.
 7. *Labeling.* Stencil the paint types (all coats), manufacturer name, contractor name, and date of completion inside the exterior girder on the southwest corner.

512.05. METHOD OF MEASUREMENT.

For new structural steel, include the cost of cleaning, painting and related work described in this section in the price bid for the appropriate structural steel pay items.

For existing steel structures, painting will be measured under the *painting existing structures* pay item by the lump sum unless otherwise specified in the contract documents. The painting pay item shall include the cost of painting and the painting related work. Cleaning, containment, stabilization, incineration, transportation and disposal of waste, sampling and testing of soil, air, and waste materials, permits and related items, other than painting, will be measured under the *collection and handling of waste* pay item as a lump sum unless otherwise specified in the contract documents.

512.06. BASIS OF PAYMENT.

The accepted quantities, measured as provided above, will be paid at the contract price per unit of measurement for the pay items listed below that are shown in the bid schedule. Payment will be full compensation for the work prescribed in this Section.

- (A) PAINTING EXISTING STRUCTURES LUMP SUM
- (B) COLLECTION AND HANDLING OF WASTE LUMP SUM

SECTION 514

DRIVEN FOUNDATION PILES

514.01. DESCRIPTION.

This work consists of furnishing and driving piles of the type and dimensions designated in the contract documents, including cutting off or building up foundation piles when required. This work also includes providing test piles and performing loading tests, and furnishing and placing reinforcing steel and concrete in concrete filled steel shell and concrete filled pipe piles. Piling shall conform to and be installed according to these specifications, at the location, and to the elevation, penetration, and bearing capacity shown in the contract documents or as directed by the Engineer.

Piles are designated as steel H-piles, concrete filled steel shell piles, concrete filled pipe piles, precast concrete piles, prestressed concrete piles, or timber piles. Pile load tests are designated as static or dynamic.

Unless test piles are required, furnish the piles according to the dimensions shown in the contract documents. When test piles are required, the piling lengths shown on the plans are for estimating purposes only and actual length to be furnished for production piles shall be determined by the Engineer after the test piles have been driven. The lengths given in the order list provided by the Engineer shall include only the lengths anticipated for use in the completed structure. Increase the lengths shown or ordered to provide for heading and such additional length as may be necessary to suit the method of operation without added compensation.

514.02. MATERIALS.

- (a) **General.** Material shall conform to the following Sections and Subsections:

Structural Concrete	509
Reinforcing Steel for Structures	511
Structural Steel	724
Steel Castings	725.03
Timber Piles	728
Paint	730
Timber Preservative and Treatment	731

- (b) **Steel Piles.** Provide structural steel conforming to AASHTO M 270, Grade 36 (250) for steel piling.

When steel piles or steel pile shells extend above the ground surface or water surface and are left exposed in the finished structure (i.e., pile bents), prime each pile as shown on the Plans before driving. If the required remaining coat surface is accessible, remaining coats may be applied after driving. Recoat splices; recoat damaged areas above the water or ground surface. Comply with paint curing requirements before driving.

- (c) **Cast-in-Place Concrete Piles.** Provide Class AA concrete for cast-in-place concrete piles cast in steel shells.

Provide steel shells for cast-in-place concrete piles of the thickness shown in the contract documents or thicker. Furnish shells of greater thickness if necessary to provide sufficient strength and rigidity to permit driving with the equipment selected for use without damage, and to prevent distortion caused by soil pressures or the driving of adjacent piles. Use watertight shells to exclude water during the placing of concrete. Alternate designs for shells must be approved before any driving is done. The shells may be cylindrical or tapered, step-tapered, or a combination of either, with cylindrical sections.

- (d) **Precast Concrete Piles.** Provide Class AA concrete for precast concrete piles and Class P concrete for precast prestressed concrete piles.

514.03. EQUIPMENT.

- (a) **Approval of Pile Driving Equipment.** Furnish pile driving equipment of such size that the permanent piles can be driven with reasonable effort to the required depths without damage. The Engineer will evaluate the suitability of the equipment and will accept or reject the driving system within 14 calendar days of receipt of the pile and driving equipment information. Approval of pile driving equipment will be based on a wave equation analysis when:

- dynamic load testing is required, or
- ultimate pile capacities exceeding 270 tons (2400kN) , or
- precast or prestressed concrete piles are used, or
- specified in the contract documents.

When the wave equation analysis is not used, approval of the pile driving equipment will be based on minimum hammer energy in Table 514-2. Approval of a pile hammer relative to driving stress damage does not relieve the Contractor of responsibility to drive piles, free of damage, to the bearing and tip elevation shown in the contract documents.

Approval of the pile driving system is specific to the equipment submitted. If the proposed equipment is modified or replaced, resubmit the revised data for approval before using. The revised driving system will be accepted or rejected within 14 calendar days of receipt of the revised pile, equipment, and wave equation analysis (if required) information. The time required for submission, review, and approval of a revised pile driving system shall not constitute the basis for a contract time extension. Use the approved equipment during pile driving operations.

1. *Equipment submittal.* Submit the following pile driving equipment information at least 30 calendar days before driving piles. When either dynamic load testing or wave equation analysis are required by the contract documents, submit a wave equation analysis performed by a pile specialty consultant meeting the requirements of this section. If both dynamic load testing and wave equation analysis are not specified by the contract documents, the Engineer will perform the wave equation analysis, when needed.

- 1.1 *General.* Project and structure identification, pile driving contractor or subcontractor, and auxiliary methods of installation such as jetting or preboring and the type and use of the equipment.

- 1.2 *Hammer*. Manufacturer, model, type, serial number, rated energy (_____ at _____ length of stroke), and modifications. Include charts required in Subsection 514.03(b)1 for diesel hammers.
- 1.3 *Capblock (hammer cushion)*. Material, thickness, area, modulus of elasticity (E), and coefficient of restitution (e).
- 1.4 *Pile cap*. Helmet weight, bonnet weight, anvil block weight, and drivehead weight.
- 1.5 *Pile cushion*. Cushion material, thickness, area, modulus of elasticity (E), and coefficient of restitution (e).
- 1.6 *Pile*. Pile type, length (in leads), weight/foot (mass/meter) , wall thickness, taper, cross-sectional area, ultimate pile capacity, description of splice, and tip treatment description.
Capblock, pile cap, and pile cushion information are required for wave equation analysis only.
2. *Wave equation*. Use the hammer efficiencies shown in Table 514-1 for wave equation analyses.

Table 514-1
Hammer Efficiencies

<u>Hammer Type</u>	<u>Efficiency (%)</u>
Diesel Hammer	72
Air or Steam Hammer (Single Acting)	67
Air or Steam Hammer (Double Acting)	50
Gravity Hammer	95

The required number of hammer blows indicated by the wave equation at the ultimate pile capacity shall be between 3 and 10 per inch (25mm) . In addition, the pile stresses resulting from the wave equation analysis shall not exceed the values at which pile damage is impending. The point of impending damage is defined for steel, concrete, and timber piles as follows.

- *Steel piles*. Limit the compressive driving stress to 90% of the yield stress of the pile material.

- *Concrete piles.* Limit both the tensile and compressive driving stresses as follows:

$$TS \leq EPV + a f'_c \quad (TS \leq EPV + a f'_c)$$

$$CS \leq 85f'_c - EPV \quad (CS \leq 0.85f'_c - EPV)$$

- where:
- TS= Tensile Driving Stress, psi (MPa)
 - CS= Compressive Driving Stress, psi (MPa)
 - EPV= Effective prestress value, psi (MPa)
 - f'_c = Specified 28-day compressive strength of concrete, psi (MPa)
 - a = 3.0 (0.25)

- *Timber piles.* Limit the compressive driving stress to three times the allowable static design strength.

3. *Minimum hammer energy.* The energy of the driving equipment submitted for approval, as rated by the manufacturer, shall be sufficient to drive piles at a penetration rate of 120 blows per foot (300mm) at the required ultimate pile capacity. When the wave equation is not used, use Table 514-2 to determine the minimum hammer energy needed for the required ultimate pile capacity.

Table 514-2
Pile Hammer Minimums

<u>Pile Hammer Type</u>	<u>Minimum Rated Hammer Energy, ft-lb (J)</u>
Diesel Hammers	255 P (39P)
Air or Steam Hammers (Single or Double Acting)	195 P (30P)
Gravity Hammers	1080 P (165P)

1. "P" is the ultimate pile capacity (tons) (kN) required by the contract documents.
2. The table values are based upon the ENR formula for an average penetration rate of 120 blows per foot (300 mm).

(b) **Pile hammers.**

1. *Diesel Hammers.*
 - 1.1 *Open-end diesel hammers.* Equip open-end (single acting) diesel hammers with a device, such as rings on the ram or a scale (jump stick) extending above the ram cylinder, to permit visual determination of hammer stroke. Submit a chart from the hammer manufacturer equating stroke and blows per minute for the hammer to be used. A speed versus stroke calibration may be used if approved.
 - 1.2 *Closed-end diesel hammers.* Submit a chart, calibrated to actual hammer performance within 90 calendar days of use, equating bounce chamber pressure to either equivalent energy or stroke for the hammer to be used. Equip hammers with a dial gage for measuring pressure in the bounce chamber. Make the gage readable at ground level.

Calibrate the dial gage to allow for losses in the gage hose. Verify the accuracy of the calibrated dial gage during driving operations by ensuring that cylinder lift occurs when bounce chamber pressure is consistent with the maximum energy given in the hammer specifications. Do not use closed-end diesel hammers that do not attain cylinder lift at the maximum energy-bounce chamber pressure relationship given in the hammer specification.

2. *Air or steam hammers.* Furnish plant and equipment for steam and air hammers with sufficient capacity to maintain the volume and pressure specified by the hammer manufacturer. Equip the hammer with accurate pressure gages that are easily accessible. Use a hammer with the weight of the striking parts equal to or greater than 1/3 the combined weight of the driving head and pile. The combined weight shall be at least 2750 pounds (1250 kg).
3. *Gravity hammers.* Do not use a gravity hammer to drive concrete piles or piles having a required ultimate capacity greater than 30 tons (267kN) . Furnish a hammer with a ram weighing between 2000 pounds (900kg) and 3500 pounds (1600kg) and limit the drop height to 13 feet (4m) . The ram weight shall be greater than the combined weight of the drive head and pile. Provide hammer guides to ensure concentric impact on the drive head.
4. *Non-impact hammers.* Do not use non-impact hammers, such as vibratory hammers, unless permitted in writing or specified in the contract. If permitted, use such equipment for installing production piles only after the pile tip elevation for safe support of the pile load is established by static or dynamic load testing. Control the installation of production piles when using vibratory hammers with power consumption, rate of penetration, specified tip elevation, or other acceptable methods that will ensure the pile load capacity equals or exceeds the load test pile capacity. On one out of every 10 piles driven, re-tap with an impact hammer of suitable energy to verify the required pile capacity is obtained.
5. *Additional Equipment or Methods.* If the required penetration is not obtained using a hammer complying with the minimum requirements above, the Contractor may be required to provide a hammer of greater energy or, when permitted, resort to supplemental methods such as jetting or preboring.

(c) **Driving appurtenances.**

1. *Hammer cushion.* Equip all impact pile driving equipment, except gravity hammers, with a suitable thickness of hammer cushion material to prevent damage to the hammer or pile and to ensure uniform driving behavior. Fabricate hammer cushions from durable, manufactured material according to the hammer manufacturer's recommendations. Do not use wood, wire rope, or asbestos hammer cushions. Place a striker plate, as recommended by the hammer manufacturer, on the hammer cushion to ensure uniform compression of the cushion material. Inspect the hammer cushion in the presence of the Engineer when beginning pile driving at each structure or after each 100 hours of pile driving, whichever is less. Replace the cushion when its thickness is reduced by more than 25% of its original thickness.
2. *Pile drive head.* Provide adequate drive heads for impact hammers to distribute the hammer blow to the pile head. Align the drive head axially with the hammer and pile. The drive head shall be guided by the leads and not be free-swinging. Fit the drive head around the pile head so that it will prevent transfer of torsional forces during driving while maintaining proper alignment of hammer and pile.

For steel and timber piling, cut the pile heads squarely and provide a drive head to hold the longitudinal axis of the pile in line with the axis of the hammer.

For precast concrete and prestressed concrete piles, the pile head shall be plane and perpendicular to the longitudinal axis of the pile to prevent eccentric impacts from the drive head.

For special types of piles, provide appropriate driving heads, mandrels or other devices according to the manufacturer's recommendations so that the piles may be driven without damage.

3. *Pile Cushion.* Protect the heads of concrete piles using a pile cushion when the nature of the driving is such as to unduly injure the piles. When plywood is used, place at least 4 inches (100mm) of plywood before driving. Provide a new pile cushion if, during driving, the cushion is either compressed more than one-half the original thickness or begins to burn. Provide a new pile cushion for each concrete pile. The pile cushion dimensions shall be such as to distribute the blow of the hammer throughout the cross-section of the pile.
4. *Leads.* Support piles in line and position with leads while driving. Construct pile driver leads to allow freedom of movement of the hammer while maintaining axial alignment of the hammer and the pile to insure concentric impact for each blow. Provide leads of sufficient length that do not require a follower but will permit proper alignment of battered piles.
5. *Followers.* Followers are not permitted unless approved in writing. When followers are permitted, drive the first pile in each bent or substructure unit and every tenth pile driven thereafter, full length without a follower, to verify that adequate pile length is being attained to develop the required ultimate pile capacity. Provide a follower of such material and dimensions that will permit the piles to be driven to the required penetration. Hold and maintain the follower and pile in proper alignment during driving.

The follower shall be of such material and dimensions to permit the piles to be driven to the length determined to be necessary from the driving of the full length piles. In each substructure unit, check the final position and alignment of the first two piles installed with followers. Verify that these piles are within location tolerances before additional piles are installed.

6. *Jetting.* Do not use jetting unless specified or approved in writing.

When jetting is not specified, but approved by the Engineer, determine the number of jets and the volume and pressure of water at the jet nozzles necessary to freely erode the material adjacent to the pile without affecting the lateral stability of the final in-place pile. The Contractor shall be responsible for all damage to the site caused by jetting operations.

When jetting is specified, provide jetting equipment with sufficient capacity to deliver a consistent pressure equivalent to at least 100 psi (0.7MPa) at two $\frac{3}{4}$ inch (20mm) jet nozzles. Jet so as not to affect the lateral stability of the final in-place pile.

In either case, remove jet pipes when the pile tip is at least 5 feet (1.5m) above the prescribed tip elevation and drive the pile to the required ultimate pile capacity with an impact hammer. Control, treat, if necessary, and dispose of all jet water in an approved manner.

514.04 CONSTRUCTION METHODS.**(a) Manufacture of Piles.**1. *Precast Concrete Piles.*

1.1 *Forms.* Conform to the requirements for formwork in Section 502, "Temporary Works," and, where applicable, Section 503, "Prestressed Concrete Bridge Members." Provide access in the forms for vibration and consolidation of the concrete.

1.2 *Casting.* Conform to the requirements for handling and placing of concrete in Section 509, "Structural Concrete." Conform to Section 511, "Reinforcing Steel." Take special care placing the concrete to produce a satisfactory bond with the reinforcement and to avoid the formation of "stone pockets," honeycomb, or other defects.

To secure uniformity, place the concrete in each pile continuously and compact by vibrating or other means acceptable to the Engineer. Overfill the forms, screed off surplus concrete, and finish the top surfaces to a uniform, even texture similar to that produced by the forms.

1.3 *Finish.* Finish portions of piling exposed to view according to the provisions governing the finishing of concrete columns. Do not finish other piling, except as set forth above.

1.4 *Curing and Protection.* Cure concrete piles as provided in Section 509, "Structural Concrete." When the piles have set sufficiently to avoid damage, remove the piles from the forms and stack in a curing pile separated from each other by wood spacing blocks. Note handling requirements below.

Before driving, allow each pile to age at least 21 days, and, in cold weather, for a longer period as determined by the Engineer. Cure concrete piles for use in high chloride or sulfate soils for at least 30 days before driving. Protect concrete from freezing until the compressive strength reaches at least 80 percent of the specified 28-day compressive strength.

1.5 *Prestressing.* Conform to the requirements of Section 503, "Prestressed Concrete Bridge Members," for prestressing of concrete piles. Use an approved corrosion-inhibiting admixture in precast prestressed concrete piles.

1.6 *Storage and Handling.* Perform the removal of forms, curing, storing, transporting, and handling of precast concrete piles in a manner to avoid excessive bending stresses, cracking, spalling, or other injurious results. Comply with the AASHTO *Standard Specifications for Highway Bridges* and Subsection 503.04(g) for transporting and handling concrete piles. Cracks or other damage will be cause for rejection.

2. *Cast-in-Place Concrete Piles.*

2.1 *Inspection of Metal Shells.* At all times before placing of concrete in the driven shells, provide a suitable light for the inspection of each shell throughout its length.

2.2 *Placing Concrete.* Do not place concrete until all driving within a radius of 16 feet (5m) has been completed, or discontinue all driving until the pile concrete within this radius has set for at least five days.

Provide concrete for cast-in-place piles that is dense and homogeneous. Place concrete for each pile in continuous operation with the flow of concrete directed down

the center of the pile to consolidate the concrete by impact. Vibrate all concrete from at least 5 feet (1.5 m) below the ground surface to the top of the cast-in-place pile. Remove accumulations of water before concrete is placed.

After the concrete has hardened, cut back the top surface to remove laitance and to expose aggregate as specified for construction joints in Subsection 509.04(d)2.

(b) **Preparation for Driving.**

1. *Site Work.*

1.1 *Excavation.* In general, drive piles only after excavation is complete. Remove any material forced up between the pile to the correct elevation before concrete for the foundation is placed.

1.2 *Preboring to Facilitate Driving.* When required by the contract documents, prebore holes at pile locations to the depths specified in the contract documents or by the Engineer. If the depth of preboring is not specified in the contract documents, stop preboring for skin friction piles at least 5 feet (1.5m) above the pile tip elevation and drive the pile with an impact hammer to a specified blow count. Preboring for end bearing piles may extend to the surface of the rock or hardpan where piles are to be end-bearing on rock or hardpan. Seat installed piles into the end-bearing strata.

Use auguring, wet rotary drilling, or other approved methods of preboring. Make prebored holes smaller than the diameter or diagonal of the pile cross-section and sufficient to allow penetration of the pile to the specified depth. If subsurface obstructions, such as boulders or rock layers are encountered, increase the hole diameter to the least dimension that is adequate for pile installation. Fill any void space remaining around the pile after the completion of driving with sand or other approved material. Do not use a spud or punch unless otherwise permitted or specified. (A spud is a short, strong driven member that is removed to make a hole for inserting a pile.) Dispose of material from drilling in a manner approved by the Engineer.

Do not impair the carrying capacity of existing piles or the safety of adjacent structures. If preboring disturbs the load carrying capacities of previously installed piles or structures, restore the required ultimate capacity of piles and structures by approved methods.

1.3 *Predrilled Holes in Embankments.* When the depth of a new embankment is more than 6 feet (2 m) , prebore or spud through the embankment where piles are to be driven. Make the hole diameter not less than the greatest dimension of the pile cross-section plus 6 inches (150 mm) . After driving the pile, fill the space around the pile with dry sand or pea gravel. Dispose of material from drilling in a manner approved by the Engineer.

2. *Preparation of Piling.* In addition to squaring up pile heads before driving, further prepare piles as described below.

2.1 *Collars.* When timber piles are required to be driven to more than 35 tons (310 kN) bearing or when driving condition required it, provide collars, bands, or other devices to protect piles against splitting and brooming.

- 2.2 *Pointing.* Point timber piles where required by soil conditions. When necessary, shod the piles with metal shoes of a design satisfactory to the Engineer. The points of the piles shall be carefully shaped to secure an even and uniform bearing on the shoes.

Point steel piles as specified in the contract documents. Perform welding according to Section 724. If approved by the Engineer, pile shoes may be either substituted for pointing steel piles or used at the option of the Contractor when hard driving is expected.

- 2.3 *Pile Shoes.* Use pile shoes, for all types of piles, at the locations specified. Provide pile shoes of the type specified. Fabricate pile shoes from cast steel conforming to Subsection 725.03.

(c) **Driving.**

1. *General.* Drive piles to the minimum tip elevations and required ultimate capacity shown in the contract documents or approved by the Engineer. Do not drive piles after practical refusal has been obtained. Splice piles not obtaining the required ultimate capacity at the ordered length and drive with an impact hammer until the required ultimate pile capacity is achieved. Monitor the performance of the hammer and other driving equipment to ensure the expected driving energy is used for each pile throughout driving.

When using the wave equation to determine bearing resistance, adequate penetration will be considered obtained when the specified wave equation resistance criterion is achieved within 5 feet (1.5m) of the designated tip elevation. Drive piles that do not achieve the specified resistance within these limits to a penetration determined by the Engineer.

Place individual piles in pile groups either starting from the center of the group and proceeding outward in both directions or starting at the outside row and proceeding progressively across the group. Redrive piles that heave more than 1/4 inch upward during the driving of adjacent piles.

Make the heads of all piles plane and perpendicular to the longitudinal axis of the pile. Coordinate pile driving so not to damage other parts of the completed work.

2. *Test Piles.* When specified in the contract documents, furnish test piles to the lengths specified and drive test piles at the locations and to the depths specified or directed. Usually, test piles will be longer than the estimated length of permanent piles to provide for variation in soil conditions. Prepare for driving as specified in Subsection 514.04(b). Drive test piles with the same equipment as the permanent piles.

Drive test piles to the required ultimate capacity at the estimated tip elevation. Allow test piles that do not attain the required ultimate capacity at 12 inches (300mm) above the estimated tip elevation to “set up” for 24 hours before re-driving. If possible, warm the hammer before re-driving begins by applying at least 20 blows to another pile. If the required ultimate capacity is not attained on re-driving, drive a portion or all of the remaining test pile length and repeat the “set up” and re-drive procedure as directed. Splice and continue driving until the required ultimate pile capacity is obtained.

Test piles to be used in the completed structure shall conform to the requirements for permanent piles. Remove test piles not incorporated in the completed structure to at least 2 feet (0.5m) below finished grade.

3. *Accuracy of Driving.* Drive piles so that the axial alignment is within 1:50 from the vertical or the batter shown in the contract documents. Horizontally, keep the top of the pile within 2 inches (50mm) of plan location for bent caps and within 6 inches (150 mm) of plan location for piles capped below finished ground. The pile shall not be closer than 4 inches (100mm) to any cap face. The Department will not pay for additional costs of increased footing dimensions due to out-of-position piles.

The Engineer may stop driving to check the pile alignment. Check the alignment of piles that cannot be internally inspected after installation before the last 6 feet (2m) are driven. Do not pull laterally on piles or splice to correct misalignment. Do not splice a properly aligned section on a misaligned pile.

Correct all piles driven improperly, driven out of proper location, misaligned, or driven below the designated cutoff elevation in an approved manner. Replace piles damaged during handling or driving. Obtain approval for the proposed method(s) of correcting or repairing deficiencies.

4. *Timber piles.* Do not use piles with checks wider than 1/2 inch (12mm) . Drive treated timber piles within six months after treatment. Handle and care for pressure-treated piles according to AWPA Standard M 4.
5. *Steel piles.* Furnish steel piles with as few splices as practicable, not exceeding the limits defined in Table 514-3.

Table 514-3
Steel Pile Splices

<u>Plan Length, ft(m)</u>	<u>Maximum Number of Splices Allowed to Make Plan Length (per pile)</u>
0 to 40 (0 to 12)	1
40 to 80 (12 to 24)	2
80 or more (24 or more)	3

The number of splices in extensions beyond plan length shall not be limited by Table 514-3. Use cutoff lengths of steel piles for extensions where practicable.

Load, transport, unload, store, and handle steel piles so that the metal is kept clean and free from damage. Do not use piles that exceed the camber and sweep permitted by allowable mill tolerance. Steel piles damaged during installation are considered unsatisfactory unless the bearing capacity is 100% of the required ultimate capacity by load tests. Load tests performed will be at no cost to the Department.

6. *Precast and prestressed concrete piles.* Support concrete piles during lifting or moving at the points shown on the plans or, if not so shown, provide support at the quarter points. Provide slings or other equipment when raising or transporting concrete piles to avoid bending the pile or breaking edges.

Protect the heads of concrete piles with a pile cushion as specified for pile cushions in Subsection 514.03(c)3.

A concrete pile is defective if any defect is observed that will affect the strength or long term performance of the pile.

7. *Concrete filled pipe or steel shell piles.* Furnish and handle the steel shells or pipes as specified for steel piles in Subsection 514.04(c)5. Cutting shoes for shells or pipes may be inside or outside the shell. Use high-carbon structural steel with a machined ledge for shell bearing or cast steel with a ledge designed for attachment with a simple weld.

Provide for inspection and concrete placement as specified for cast-in-place concrete piles in Subsection 514.04(a)2. Do not drive any pile shell or pipe after it is filled with concrete.

Remove and replace all shells with breaks, bends, or kinks determined to be unacceptable for use.

(d) **Determination of Bearing Capacity.**

1. *General.* Use the appropriate form of the Engineering News-Record (ENR) formula in Table 514-4 to determine bearing resistance of the in-place pile unless the wave equation is required for this purpose. When specified, use dynamic or static load tests to verify bearing resistance of piles.
2. *Practical Refusal.* Practical Refusal is defined as four consecutive sets of 10 blows having no more than $\frac{1}{2}$ inch (12mm) of penetration per each 10-blow set. Discontinue driving before practical refusal is reached if driving is causing damage to the pile.
3. *Engineering News-Record (ENR) Formula Method.* Use Table 514-4 to determine bearing resistance by the ENR formula method.

Table 514-4
Engineering News-Record (ENR) Formulas

<u>Pile Hammer Type</u>	<u>Bearing Resistance, P, pounds</u>	<u>Metric Bearing Resistance, J, Joules</u>
Diesel Hammers	$2E / (S + 0.15)$	$E / (6S + 24)$
Air or Steam Hammers (Single or Double Acting)	$2E / (S + 0.1)$	$E / (6S + 15)$
Gravity Hammers	$2E / (S + 1.0)$	$E / (6S + 150)$

where: E= Energy produced by the hammer per blow in foot-pounds (joules, J) . Value based on actual hammer stroke or bounce chamber pressure observed (double acting diesel hammer).
S= Average penetration in inches (mm) per blow for the last 5 to 10 blows for gravity hammers and the last 10 to 20 blows for all other hammers.

The formulas in Table 514-4 are applicable only when:

- the hammer has a free fall (gravity and single acting hammers only),
- the head of the pile is not broomed, crushed, or otherwise damaged,
- the penetration is quick and uniform,

- there is no appreciable rebound of the hammer, and
- a follower is not used.

The penetration per blow may be measured either during initial driving or by re-driving with a warm hammer operated at full energy after a pile set period, as determined by the Engineer.

If water jets are used in connection with the driving, determine the bearing resistance by the formulas in Table 514-4 after the jets have been withdrawn.

4. *Wave Equation Method.* When wave equation analysis is required, use the soil, pile, and drive equipment properties as shown in the contract document and as approved to determine bearing resistance. Reduce bearing resistance to 80 percent of its calculated value unless the wave equation analysis was calibrated to the results of a dynamic pile test. Apply any additional factors of safety specified in the contract documents to all bearing resistances calculated by the wave equation.
5. *Dynamic load tests.* Comply with the following requirements when dynamic load tests are specified in the contract documents.

Use a qualified pile specialty consultant with at least 3 years experience in dynamic load testing and analysis to perform the dynamic load test, the case pile wave analysis program (CAPWAP), and the wave equation analysis including the initial wave analysis specified for the equipment submittal. Submit a resume of the specialty consultant for approval.

Furnish a shelter to protect the dynamic test equipment from the elements. Locate the shelter within 50 feet (14m) of the test location. Provide a shelter with a minimum floor size of 65 ft² (6m²) and minimum ceiling height of 6½ feet (2m). Maintain the inside temperature between 50°F (10°C) and 100°F (40°C).

Furnish equipment and perform dynamic load tests according to ASTM D 4945 under the supervision of the Engineer.

Place the piles designated as dynamic load test piles in a horizontal position and not in contact with other piles. Drill holes for mounting instruments near the head of the pile. Mount the instruments and take wave speed measurements. Place the designated pile in the leads. Provide at least a 4 foot (1.2m) by 4 foot (1.2m) rigid platform with a 42-inch (1.1m) safety rail that can be raised to the top of the pile.

Provide a suitable electrical power supply for the test equipment. If field generators are used as the power source, provide functioning meters for monitoring power voltage and frequency.

Drive the pile to the depth at which the dynamic test equipment indicates that the required ultimate pile capacity is achieved. If necessary to maintain stresses in the pile below the values in Subsection 514.03(a)2, reduce the driving energy transmitted to the pile by using additional cushions or reducing the energy output of the hammer. If nonaxial driving is indicated, immediately realign the driving system.

At least 24 hours after the initial driving, re-drive each dynamic load test pile with instrumentation attached. Warm the hammer before re-driving by applying at least 20 blows

to another pile. Redrive the dynamic load test pile for a maximum penetration of 6 inches (150 mm) or a maximum of 50 blows, whichever occurs first.

Verify the assumptions used in the initial wave equation analysis submitted according to Subsection 514.03(a) using CAPWAP. Analyze one blow from the original driving and one blow from the re-driving for each pile tested.

Perform additional wave equation analyses with adjustments based on the CAPWAP results. Provide a graph showing blow count versus ultimate capacity. For open-ended diesel hammers, provide a blow count versus stroke graph for the ultimate capacity. Provide the driving stresses, transferred energy, and pile capacity as a function of depth for each dynamic load test.

Based on the results of the dynamic load testing, CAPWAP analyses, and wave equation analysis, the order list and production driving criteria may be approved and the required cut-off elevations provided, or additional pile penetration and testing specified. This information will be provided within seven calendar days after receipt of the order list and all required test data for the test piles driven.

6. *Static load tests.* When specified in the contract documents, perform static load tests according to ASTM D 1143 using the quick load compression test method except as modified herein. Submit drawings of the proposed loading apparatus for approval according to the following:

- Have a licensed professional engineer prepare the drawings.
- Furnish a loading system capable of applying 150% of the ultimate pile capacity or 1000 tons (9000kN) , whichever is less.
- Construct the apparatus to allow increments of load to be placed gradually without causing vibration to the test pile.

When tension (anchor) piles are required, drive tension piles at the location of permanent piles when feasible. Do not use timber or tapered piles installed in permanent locations as tension piles. Take the test to plunging failure or the capacity of the loading system.

The safe axial pile load is defined as 50% of the failure load. The failure pile load is defined as follows:

- For piles 24 inches (600mm) or less in diameter or diagonal width, the load that produces a settlement at failure of the pile head equal to:

$$S_f = S + (a + 0.008D)$$

- For piles greater than 24 inches (600 mm) in diameter or diagonal width:

$$S_f = S + D/30$$

where:

- S_f = Settlement at failure in inches (millimeters) ,
- D = Pile diameter or diagonal width in inches (millimeters) ,
- S = Elastic deformation of total unsupported pile length in inches (mm),
- a = 0.15 (3.8)

Determine top elevation of the test pile immediately after driving and again just before load testing to check for heave. Wait a minimum of 3 calendar days between the driving of any anchor or the load test piles and the commencement of the load test. Before testing, redrive or jack to the original elevation any pile that heaves more than 1/4 inch (6 mm) .

After completion of static testing, remove or cut off any test or anchor piling not a part of the finished structure at least 2 feet (0.5 m) below either the bottom of the footing or the finished ground elevation.

Based on the results of the static load testing, the order list and production driving equipment may be approved and the required cut-off elevations provided or additional tests may be specified. This information will be provided within seven calendar days after receipt of the order list and all required test data for the test piles driven.

- (e) **Splices.** Align and connect pile sections so the axis of the spliced pile is straight.
1. *Steel piles.* Submit a welder certification for each welder. Use welders certified for structural welding under Section 724.

Make surfaces to be welded smooth, uniform and free from loose scale, slag, grease, or other material that prevents proper welding. Steel may be oxygen cut. Carbon-arc gouging, chipping, or grinding may be used for joint preparation.

Weld according to AASHTO/AWS D 1.5 Bridge Welding Code except inspection requirements. Weld the entire pile cross-section using prequalified AWS groove weld butt joints. The arc method of welding is preferred for splicing. Weld so there is no visual evidence of cracks, lack of fusion, undercutting, excessive piping, porosity, or inadequate size. Manufactured splices may be used in place of full penetration groove butt welds. When in conflict, comply with the welding requirements shown on the plans.
 2. *Concrete pile splices and extensions.* Do not splice concrete piles. Extend concrete piles after driving is completed; do not drive extended concrete piles.
 - 2.1 *Precast concrete piles.* Extend precast concrete piles by removing the concrete at the end of the pile and leaving 40 diameters of reinforcement steel exposed. Remove the concrete to produce a face perpendicular to the axis of the pile. Securely fasten reinforcement of the same size as that used in the pile to the projecting reinforcing steel. Form the extension to prevent leakage along the pile. Place concrete of the same mix design and quality as that used in the pile. Keep forms in place for not less than seven calendar days after the concrete has been placed. Cure and finish according to Section 509.
 - 2.2 *Prestressed piles.* Submit drawings of proposed extensions for approval. Use dowels or other acceptable mechanical means to splice precast concrete or precast prestressed concrete piles. The splice shall develop strengths in compression, tension, and bending

equal to or exceeding the strength of the pile being spliced. Include reinforcement bars in the pile head for splicing to the extension bars.

3. *Timber piles.* Do not splice timber piles.

- (f) **Pile Cutoffs.** Cut off the tops of all permanent piles and pile casings at the required elevation. Cut off the piles clean and straight parallel to the bottom face of the structural member in which they are embedded. All cutoff lengths of piling shall remain the property of the Contractor and shall be properly disposed of.

Saw timber piles which support timber caps or grillage to conform to the plane of the bottom of the superimposed structure. The length of the pile above the elevation of cutoff shall be sufficient to permit the complete removal of all material injured by driving.

Immediately after making final cutoff on treated timber foundation piles, give the cut area two liberal application of preservative followed by a heavy application of coal-tar roofing cement or other approved sealer. Treat the heads of all treated timber piles that are not embedded in concrete with three coats of a compatible preservative material meeting the requirements of American Wood Preservers Association Standard M4. Allow a minimum of two hours between applications.

- (g) **Defective Piles.** Correct, by an approved method, piles driven out-of-position (beyond specified limits), or having crushed, cracked, or spalled concrete, splintered or broomed wood, excessively deformed steel, or otherwise deemed defective. Methods of correcting unsatisfactory piles may include one or more of the following:
- Use pile at a reduced capacity,
 - Install additional piles,
 - Repair damaged piles,
 - Replace damaged piles.

Do not force out-of-position piles into the proper position. All remedial materials and work shall be furnished at the Contractor's expense. Piles used at a reduced capacity with no other remedial work shall be accepted at a reduced price under Subsection 105.03.

514.05. METHOD OF MEASUREMENT.

- (a) **General.** For pay items, *piles, furnished and piles, driven*, individual pile lengths will be measured and summed to the nearest hundredth of a foot (meter) and the overall total for each pile type will be rounded to the nearest hundredth of a foot (meter). Remedial piling work will not be measured for payment. Only work accepted by the Engineer will be measured for payment.
- (b) **Piles, Furnished.** For each pile type indicated in the contract documents, pile lengths furnished and stockpiled at the site of the work will be measured under the corresponding *piles, furnished* pay item. The *piles, furnished* quantity will be limited by the total plan length with increases for approved extensions as follows. (The total plan length is defined as the sum of all planned pile lengths for a pile type, where planned pile lengths are either shown on the plans or determined by the Engineer after driving test piles.) For concrete piles, furnished extensions,

not exceeding the length ordered in writing by the Engineer, will be added to the total pile length. For steel piles, the *piles, furnished* quantity will equal the *piles, driven* quantity when the as-built *piles, driven* quantity exceeds the total plan length.

- (c) **Piles, Driven.** For each pile type indicated in the contract documents, pile lengths driven will be measured under a corresponding pay item, *piles, driven*. The *piles, driven* quantity will be determined by measuring the actual pile lengths in place. Preboring, jetting or other methods used for facilitating pile driving procedures when either required or permitted will not be measured, and payment shall be considered included in the unit price bid for the piles driven.
- (d) **Splices for Steel Piling.** Each splice made in a steel pile will be measured for payment except as limited by Table 514-5.

Table 514-5
Maximum Number of Splices Measured for Payment

<u>Plan Length, ft (m)</u>	Actual Pile Length is:	
	<u>Plan Length or less</u>	<u>Over Plan Length</u>
0 to 40 (0 to 12)	1	2
40 to 80 (12 to 24)	2	3
80 or more (24 or more)	3	4

Each accepted steel pile splice, measured as provided above, will be paid for at the contract price for three feet (one meter) of *piles, driven*.

- (e) **Test Piles.** Test piles, furnished and driven, will be measured using the same method of measurement as specified above for piles.
- (f) **Load Tests.** The number of each type of load test listed in the bid schedule that is completed and accepted will be measured for payment.
- (g) **Metal Pile Shoes.** When metal pile shoes are listed in the bid schedule, the number of metal pile shoes furnished and accepted will be measured for payment.

514.06. BASIS OF PAYMENT.

The accepted quantities, measured as provided above, will be paid for at the contract price per unit of measurement for the pay items listed below that are shown in the bid schedule.

- (A) PILES, FURNISHED LINEAR FOOT (METER)
- (B) PILES, DRIVEN LINEAR FOOT (METER)
- (C) TEST PILES, FURNISHED LINEAR FOOT (METER)
- (D) TEST PILES, DRIVEN LINEAR FOOT (METER)
- (E) PILE LOAD TEST (STATIC) EACH
- (F) PILE LOAD TEST (DYNAMIC) EACH
- (G) METAL PILE SHOES EACH

Payment for furnishing piles includes full compensation for all costs involved in the furnishing and delivery of all piles, including steel shells for cast-in-place driven piles, to the project site and all costs involved in the furnishing and placing of concrete and reinforcing steel for cast-in-place

concrete piles. For each size of steel pile listed in the bid schedule, the price bid for furnishing may not exceed 70% of the combined price bid for furnishing and driving.

Payment for driving piles includes full compensation for all costs involved in the actual driving and cutting off piles and pile shells, and for all costs for which compensation is not provided for under other pay items involved with the furnishing of labor, equipment, and materials used to construct the piles as shown in the contract documents.

Payment for load tests includes full compensation for providing labor, equipment, and materials needed to perform the load tests as specified.

Payment for metal pile shoes includes full compensation for all costs involved with furnishing all materials and performing the work involved with installing metal pile shoes.

SECTION 515

PENETRATING WATER REPELLENT TREATMENT

515.01. DESCRIPTION.

This work consists of furnishing necessary labor, materials, and equipment to treat concrete surfaces with a penetrating water repellent treatment solution according to the contract documents.

515.02. MATERIALS.

Penetrating water repellent treatment solution shall meet the requirements of Subsection 701.12.

515.03. EQUIPMENT.

- (a) **General.** Furnish equipment meeting the requirements of Subsection 108.06 and the treatment solution manufacturer's recommendations.
- (b) **Surface Preparation.** Use one or more of the following types of equipment for surface preparation.
 1. *Sand Blasting.* A compressed air pressure type sand blasting equipment of proper size and capacity to clean concrete surfaces as specified.
 2. *Shot Blasting.* A portable type machine designed especially for cleaning horizontal concrete surfaces utilizing recyclable steel shot blast techniques.
 3. *Hot Water Pressure Washers.* A hot water pressure system for cleaning concrete surfaces as specified, utilizing 160°F (70°C) minimum water temperature at 2500 psi (17 MPa) nozzle pressure.
 4. *Hydroblast Washer.* A high pressure cold water washer unit for cleaning concrete surfaces as specified, using 7000 psi (48 MPa) nozzle pressures.
 5. *Steam Cleaning.* A steam jet cleaning equipment for preparing concrete surfaces as specified, utilizing 320°F (160°C) water temperature under 300 psi (2 MPa) operating pressure.

- (c) **Application.** Use low pressure airless type spray equipment with 15 psi (100 kPa) to 40 psi (275 kPa) application pressure.

515.04. CONSTRUCTION METHODS.

(a) **Treatment.**

1. *General.* Employ personnel certified by the treatment solution manufacturer to clean the concrete surface and apply the penetrating water repellent solution. Follow the manufacturer's explicit procedures for surface preparation and application. Before starting work, provide the Engineer with the following information:
 - The identification of the treatment solution to be used by brand name, the name of the manufacturer and a copy of the manufacturer's unabridged application procedures;
 - A description of the surface preparation methods and equipment to be used;
 - A description of the application methods and equipment to be used;
 - Weather limitations;
 - A list of treatment solution manufacturer certified personnel to be used.
2. *Surface Preparation.* Clean all concrete surfaces to be treated before applying the penetrating water repellent treatment solution. Remove all traces of curing compound, laitance, dirt, dust, salt, oil, asphalt or other foreign materials.

Surface preparation may include the application of pretreatment cleaning agents before the use of water washing cleansing methods.

If necessary, use solvents and hand tools as required to remove bonded materials detrimental to treatment of the concrete surface.

Water washing methods of cleaning may use the addition of detergents to reduce surface tension of the cleaning water. The addition of such detergents may be used in proportions of 2% or less by weight.

During cleaning, do not damage concrete surface, remove or alter the existing concrete surface finish, or expose the coarse aggregate of the concrete. Clean in a manner to provide a uniform appearing surface color.

After cleaning with water washing methods, remove any standing water or excess moisture, which may delay surface drying or restrain surface penetration of the repellent treatment solution.

3. *Application.*
 - *Preapplication Requirements.* Allow the concrete to age a minimum of 28 days before surface treatment. Allow concrete surfaces to dry a minimum of eight hours after cleaning with water or after rain, before applying penetrating water repellent treatment solution. For formed surfaces, apply penetrating water repellent treatment after applying classes 1 through 6 concrete surface finishes, and before applying a class 7 - paint finish. Refer to Subsection 509.04(g) for definitions of surface finish classes.

Reclean previously cleaned concrete surfaces that become contaminated, before applying the penetrating water repellent treatment.

- *Inspection.* Notify the Engineer at least one day before the application of penetrating water repellent treatment so that the Engineer may inspect the work. The Engineer will use the fugitive dye in the solution to gauge the uniformity of application. Retreatment will be required in areas where coverage is inadequate.
- *Application Rate.* Use the penetrating water repellent treatment solution as supplied by the manufacturer; do not dilute or alter in any way.

Spray a flood coat of the solution onto concrete surfaces at the approved rate of coverage. Adjust the application rate as required for vertical surfaces and surfaces tined, grooved or roughened.
- *Weather Limitations.* Apply the penetrating water repellent treatment solution when the weather conditions comply with Table 515-1. Comply with the manufacturer’s recommendations for weather limitations.

Table 515-1
Acceptable Weather Conditions During Application.

<u>Weather Condition</u>	<u>Acceptable Range</u>
Temperature: Air or Concrete Surface	Above 40°F (4°C) and within the manufacturer’s recommended application temperature range.
Wind Speed	Below 25 mph (40 km/hr)
Precipitation	None

- *Seasonal Limitations.* Comply with the manufacturer’s seasonal limitations when applicable.
 - *Traffic.* Keep traffic off treated surfaces until the applied solution has completely dried.
- (b) **Control of Materials.** Use penetrating water repellent treatment solution that is in unopened, sealed containers with the manufacturer’s label identifying the product and with numbered seals intact. Each container shall be clearly marked by the manufacturer with the following information:
- Manufacturer’s name and address
 - Product name
 - Date of manufacture
 - Expiration date
 - Lot identification number

Store materials delivered to the job site in original unopened containers within an appropriate storage facility. The storage facility shall provide protection from the elements and safe and secure storage of the materials.

- (c) **Sampling and Testing of Bridge Decks and Approaches.** After the treatment has been completed, the Engineer will divide the bridge deck and approach slab surface area into equal size lots for sampling, testing, and acceptance. The number of lots for a bridge will be determined by dividing the area of bridge deck and approach slabs in square feet by 20,000 ft² (2000 m²) and rounding to the nearest whole number. The minimum number of lots per bridge will be two. The area of each lot will be the area of bridge deck and approach slabs divided by the number of lots. The width of the lot shall equal the width of the deck or slab; the length will be determined by dividing lot area by lot width.

Take two core samples of treated concrete for testing from each lot of treated surface locations within the lot area selected randomly by the Engineer. The Engineer may select additional sample locations if either the coverage or water repellency of the treatment within a test area is in question. All samples taken within a lot area will be considered representative of the lot.

Before coring, find rebar in the bridge deck and approach slabs so that during coring rebar can be avoided. Make the cores 4 inches (100mm) in diameter by 4 inches (100 mm) in depth. Core the concrete in the presence of the Engineer and give the cores to the Engineer immediately after making.

Cores will be tested by the Engineer for moisture absorption and depth of treatment penetration by the requirements of Table 515-2. Bridge deck and approach slab treatment will be evaluated for acceptance and payment based on core testing results.

Table 515-2
Core Testing Requirements

<u>Test</u>	<u>Method</u>	<u>Limit</u>
Absorption	OHD L 39 (48 hour water immersion)	1% maximum by weight
Penetration	OHD L 40	0.15 inch (3.8 mm) minimum depth

The Contractor may independently test the surface treatment to determine the adequacy of the work. A maximum of one core per lot will be permitted for this purpose. The Contractor's results will not be used for acceptance or payment.

- (d) **Acceptance.**
 1. *Concrete Surfaces Other Than Bridge Deck and Approach Slabs.* Acceptance of penetrating sealer application for concrete surfaces other than bridge decks and approach slabs shall be based upon two inspections by the Engineer. The Engineer will visually examine the treatment surfaces after cleaning and, again, after treatment. If all treatment surface areas have been properly cleaned according to these specifications, and by visual inspection of the fugitive dye, the penetrant sealer has been adequately applied within the approved rates of application, the work will be accepted.

2. *Bridge Decks and Approach Slab Surfaces.* Acceptance of bridge deck and approach slab treatment will be based upon the absorption and penetration test results for each lot. Payment will be adjusted by the pay factors for absorption and penetration.

The pay factor for absorption shall be determined by the following equations:

$$\begin{array}{ll} PF_a = 1.00 & \text{for A of 1.000 or less,} \\ PF_a = 1.00 - (A - 1.0) & \text{for A between 1.000 and 1.500,} \\ PF_a = 0.00 & \text{for A of 1.500 or more,} \end{array}$$

where:

PF_a is the pay factor for absorption,
A is the percentage of absorption from OHD L39 test.

The pay factor for penetration shall be determined by the following equations:

$$\begin{array}{ll} PF_p = 1.05 & \text{for D of 0.25 (6.3 mm) or more,} \\ PF_p = 1.00 + 0.05(D - 0.15)/0.1 & \text{for D between 0.15 and 0.25,} \\ & (PF_p = 1.00 + 0.05(D - 3.8)/2.5) \quad \text{(for D between 3.8 and 6.3 mm)} \\ PF_p = (D - 0.05)/0.1 & \text{for D between 0.05 and 0.15,} \\ & (PF_p = (D - 1.3)/2.5) \quad \text{(for D between 1.3 and 3.8 mm)} \\ PF_p = 0.00 & \text{for D of 0.05 (1.3 mm) or less} \end{array}$$

where:

PF_p is the pay factor for penetration,
D is the depth in inches (mm) of penetration from OHD L40 test.

The overall pay factor for each lot shall be:

$$PF = PF_a \times PF_p$$

where:

PF is the overall pay factor.

Payment for a lot will be determined by multiplying the Contract Unit Price by the overall pay factor, PF, for that lot. If a pay factor for any lot on a structure is less than 1.00, then the incentive portion (that in excess of 1.00) of the overall pay factors for all lots on the structure will be reduced by 50 percent.

- (e) **Core Hole Repair.** Repair core holes with a cement mortar consisting of Portland Cement, concrete sand, water and acrylic polymer binder. Proportion the cement mortar as recommended by the manufacturer of the acrylic polymer binder. Submit mix design for approval. Place mortar the same day the cores are taken. Treat the patch surface with treatment solution after curing.

515.05. METHOD OF MEASUREMENT.

The penetrating *water repellent* treatment will be measured by the square yard (square meter) of treated concrete surface area.

515.06. BASIS OF PAYMENT.

Accepted quantities of penetrating water repellent treatment of concrete surfaces other than bridge decks and approach slabs, accepted according to Subsection 515.04(d)1, will be paid for at the contract unit price for:

(A) WATER REPELLENT (VISUALLY INSPECTED)....SQUARE YARD (SQUARE METER)

Accepted quantities of penetrating water repellent treatment of bridge decks and approach slabs, accepted for payment according to Subsection 515.04(d)2, will be paid for at the adjusted contract unit price for:

(B) WATER REPELLENT (PERFORMANCE TESTED).SQUARE YARD (SQUARE METER)

Payment for the above pay items shall be full compensation for furnishing all materials, equipment, labor and incidentals to complete the work as specified.

SECTION 516

DRILLED SHAFT FOUNDATIONS

516.01. DESCRIPTION.

This work consists of constructing drilled shafts including the furnishing and placing of reinforcing steel and concrete, all in accordance with the contract documents.

516.02. MATERIALS.

- (a) **General.** Materials shall conform to the requirements specified herein and the following sections:

Structural Concrete	509
Reinforcing Steel for Structures	511

- (b) **Concrete.** Furnish Class AA concrete modified as follows. Limit the maximum nominal aggregate size to 3/4 inch (19mm) . Increase minimum cement content 10% for concrete placed under water or slurry.

Adjust approved admixtures for site conditions to ensure that the concrete has at least 6 inches (150 mm) of slump at the start of placement and at least 4 inches (100mm) of slump at the completion of placement and casing/reinforcement alignment. Maintain the concrete temperature under 85°F (30°C) during placement.

- (c) **Casings.** For all exterior casings, use smooth, clean, watertight, steel casings of ample strength to withstand handling and driving stresses, and the concrete and surrounding earth pressures. The dimensions of a permanent casing is subject to American Pipe Institute tolerances applicable to regular steel pipe. If only a single casing is used in a shaft, the casing is considered an exterior casing.

For permanent exterior casings, use steel conforming to AASHTO M270 Grade 36 (ASTM A709M Grade250) unless otherwise specified. Perform welding of permanent exterior casings by Section 506. Permanent exterior casing diameters shown on the plans are outside diameters.

For permanent interior casings, use round corrugated galvanized steel pipe with 3 inch (75 mm) x 1 inch (25 mm) corrugations meeting AASHTO M36, and of sufficient gauge to maintain a round shape and withstand the pressure of the concrete.

516.04. CONSTRUCTION METHODS.

- (a) **Contractor Qualifications.** Use personnel with appropriate experience for the construction of drilled shafts.

Submit an installation plan for informational purposes before constructing drilled shafts. Include the following information in the plan for all drilled shafts.

- Details of reinforcement placement including support and centering methods.
- Details of concrete placement including proposed operational procedures for tremie and pumping methods.
- Details of the concrete mix design including results of concrete trial mix and slump loss tests.

Include the following additional information in the plan for slurry displacement drilled shafts.

- List of proposed equipment to be used including cranes, drills, augers, bailing buckets, final cleaning equipment, desanding equipment, slurry pumps, core sampling equipment, tremies, concrete pumps, casings, etc. (Analyze the capacity of the equipment to drill the size, depth, and hardness of the planned excavations.)
- Details of overall construction operation sequence and the sequence of shaft construction in bents or groups.
- Details of shaft excavation methods and procedures for maintaining correct horizontal and vertical alignment of the excavation.
- Details of excavated materials use or disposal.
- Details of the methods to mix, circulate, desand, dispose of the slurry.
- Details of methods to clean the shaft excavation.
- Personnel resumes of project experiences and appropriate documentation including names, addresses, and telephone numbers of organizations or associations that verify the information.

Revise and resubmit if the installation plan does not provide satisfactory results. Submit any request for changing the top of shaft elevations, as needed, with the installation plan.

- (b) **Trial Drilled Shafts.** If trial drilled shafts are required by the contract, demonstrate that the methods and equipment described by proposed installation plan are capable of constructing the required drilled shafts by constructing a trial drilled shaft adjacent to the permanent shafts at an approved location, before constructing the permanent drilled shafts.

Construct the trial shaft to the same size and to the tip elevation of the deepest shaft shown on the plans. Leave completed excavation open for a minimum of four hours before concreting to monitor excavation stability and groundwater seepage. Clean the excavation and place the approved mix design concrete, filling the hole completely. Remove the concrete down to 2 feet (0.6 m) below the finished grade. Reinforcing steel is not required in trial drilled shafts.

If the trial drilled shaft is determined to be unsatisfactory, modify the installation plan appropriately, resubmit the new installation plan, and drill a new trial drilled shaft.

Once approval is given to construct the permanent drilled shafts, no changes are permitted in the installation plan without resubmission.

(c) **Drilled Shafts.**

1. *Hole Excavation.* Excavate holes according to the installation plan.

Before drilling, excavate for structure footings supported on drilled shafts and construct embankments and fills.

Position the drilled shaft within 3 inches (75 mm) of the required position in a horizontal plane at the top of the shaft elevation. Do not allow the alignment of a vertical shaft to vary from the required alignment by more than 1% of shaft depth. Do not allow the alignment of a battered shaft to vary from the required battered alignment by more than 2% of shaft depth.

Use excavation equipment and methods that provide a bottom to the completed shaft that is normal to the axis of the shaft within 5% of the shaft diameter. Measurement of this shaft bottom tolerance will be left to the discretion of the Engineer. Use excavation equipment that provides a shaft diameter not more than one inch smaller than the required diameter.

Excavate to the plan elevation, extending the excavation below the plan elevation only when it is determined that the load bearing material encountered during excavation does not satisfy plan requirements. Take soil samples or rock cores as shown on the plans or directed by the Engineer to determine the character of the material directly below the shaft excavation. Immediately notify the Engineer of any significant deviation from the plans in subsurface conditions that may result in a shaft depth change.

Check dimensions and alignment of each shaft excavation in the presence of the Engineer before concrete placement. Final shaft depth shall be measured after final cleaning.

When it is determined that the hole sidewall has softened due to excavation methods, swelled due to delays in concreting, or degraded as a result of slurry cake buildup, overream the sidewall a minimum of $\frac{1}{2}$ inch (12mm) and maximum of 3 inches (75 mm) to sound material.

Immediately before concrete placement, clean the hole so not more than 50% of the bottom of each hole has more than $\frac{1}{2}$ inch (12 mm) of sediment and the maximum depth of sediment or debris at any place on the bottom of the hole does not exceed $1\frac{1}{2}$ inches (38 mm). For dry holes, reduce the depth of water to 6 inches (150 mm) or less before placing concrete.

Use one or more of the following methods for excavation. Do not use methods prohibited by the plans or special provisions.

- 1.1 *Dry Method.* Use the dry construction method at sites where the groundwater level and soil conditions are suitable to permit construction of the shaft in a relatively dry

excavation and where the sides and bottom of the shaft may be visually inspected before placing concrete. The dry method consists of drilling the shaft, removing accumulated water, removing loose material from the excavation, placing the reinforcing cage, and concreting the shaft in a relatively dry condition. When caving, sloughing, or swelling conditions exist or when groundwater seepage exceeds the described limits, discontinue and use an approved alternative method.

1.2 *Wet Method.* Use the wet construction method or a casing construction method for shafts that do not meet the above requirements for dry construction method. The wet method consists of using water or slurry to maintain stability of the hole perimeter while advancing the excavation to final depth, placing the reinforcing cage, and concreting the shaft. The wet method may involve the following work.

- Desanding and cleaning the slurry.
- Final cleaning of the excavation using a bailing bucket, air lift, submersible pump, or other approved devices.
- Placing the shaft concrete with a tremie or concrete pump beginning at the shaft bottom.
- Providing temporary surface casings to aid shaft alignment and positioning.
- Providing temporary surface casings to prevent sloughing of the top of the shaft excavation unless it can be satisfactorily demonstrated that the surface casing is not required.

Refer to Subsection 516.04(c)2 for slurry requirements.

1.3 *Casing Methods.*

1.3.1 *General.* For all casing methods, do not case to the bottom of the shaft. Discontinue the casing at the top of the founding stratum as shown on the Plans. Continue excavating below the casing using either the dry or wet method. To provide design frictional load capacity, excavate into the founding stratum the length shown on the Plans or to Plan depth, whichever is deepest. Refer to Subsection 516.04(c)3, *Exterior Casings*, for casing installation requirements.

1.3.2 *Temporary Casing Method.* Use the temporary casing construction method at sites where the dry or wet methods are inappropriate. This method consists of advancing the excavation through caving material into a nearly impervious formation by the wet method, setting a casing, completing excavation, placing the reinforcing cage, and concreting the shaft while removing the casing. As an alternate process for excavating through the caving material and setting the casing, drive or drill the casing into the nearly impervious formation, then proceed with excavation.

1.3.3 *Permanent Casing Method.* Use the permanent casing construction method when required by plans or where drilled shafts are located in open water areas. This method consists of advancing the excavation through caving material by driving or drilling a permanent casing to a prescribed depth or a nearly impervious formation whichever is deepest, excavating to the final depth, placing the

reinforcing cage, and concreting the shaft.

If during casing installation full penetration cannot be attained, excavate within the embedded portion of the casing. Drill a pilot hole if necessary. Casing shall be continuous from the top of the shaft to the elevation shown on the plans.

Where drilled shafts are located in open water areas, extend casings from above the water elevation into the ground to protect the shaft concrete from the water action during placement and curing of the concrete.

- 1.3.4 *Double Casing Method.* Use the double casing construction method when specified in the contract documents or as an alternate for the temporary casing method when groundwater or unstable soil conditions are severe. This method is similar to the temporary casing method except that the temporary exterior casing is larger than the specified shaft diameter and a permanent interior casing (corrugated galvanized steel pipe) is set into the top of the founding stratum after the excavation is complete.

Supply the interior casing with a permanent inner diameter equal to the plan shaft diameter, and use a temporary exterior casing having an inner diameter at least 6 inches (150mm) larger than the interior casing. After the exterior casing is in place, complete the excavation to the plan shaft diameter and set the interior casing into the top of the founding stratum, bracing the interior casing at the top. Remove the temporary casing after filling interior casing with concrete, adding concrete as needed to maintain top of shaft elevation during removal. Do not adjust the interior casing position after the concrete has taken initial set.

- 1.4 *Obstructions.* When excavation through unexpected manmade materials cannot be advanced, the removal of the manmade materials is considered an obstruction. Removal of naturally-occurring material, regardless of difficulty or removal method, is not considered an obstruction. **Removal of tools lost in the excavation by the Contractor is not considered an obstruction.**

Remove obstructions when encountered. Inform the Engineer, in advance, of the proposed method for obstruction removal. If additional compensation for obstruction removal is sought, include a cost estimate for excess costs under Subsection 104.03. Do not use blasting methods unless approved by the Engineer.

2. *Slurry.* Premix the slurry material with clean fresh water according to the slurry manufacturer to allow for hydration before introduction into the shaft excavation. Use slurry tanks of adequate capacity for slurry circulation, storage, and treatment. Do not use excavated slurry pits. Use either mineral (bentonite or attapulgate) or polymer slurry.

Provide desanding equipment to limit slurry sand content at any point in the bore hole to less than 4 percent by volume for mineral slurry and less than 1 percent by volume for polymer slurry. Desanding is not required for setting temporary casings.

During drilling, maintain a slurry surface in the shaft at least 4 feet (1.2 m) above the highest expected water table elevation and at a level sufficient to prevent caving of the hole.

When there is a sudden significant loss of slurry from the hole, stop drilling and take corrective action to prevent slurry loss. Prevent the slurry from “setting up” in the shaft. If at any time the slurry construction method fails to produce the desired results, stop and use an approved alternative method.

When the excavation is to the required elevation and clean, allow at least 30 minutes for polymer slurry to stand undisturbed and then clean the base of the excavation with either a submersible pump or air lift.

Maintain the density, viscosity, and pH of the slurry during shaft excavation within the acceptable ranges shown in Table 516-1 for mineral slurry and Table 516-2 for polymer slurry.

Table 516-1
Acceptable Range of Values for Mineral Slurry

<u>Property</u>	<u>At the time of Slurry Introduction</u>	<u>In Hole at Time of Concreting</u>	<u>Method</u>
Density (lb/ft ³)	64.3 - 69.1	64.3 - 75.0	Density Balance
Viscosity (sec/qt)	28 - 45	28 - 45	Marsh Cone
pH	8 - 11	8 - 11	pH paper or meter

Table 516-2
Acceptable Range of Values for Polymer Slurry

<u>Property</u>	<u>At the time of Slurry Introduction</u>	<u>In Hole at Time of Concreting</u>	<u>Method</u>
Density (lb/ft ³)	62.4 - 63.0	62.4 - 63.5	Density Balance
Viscosity (sec/qt)	30 - 40	30 - 40	Marsh Cone
pH	9 - 11	9 - 11	pH paper or meter

Notes for Tables 516-1 and 516-2: Density values shown are for fresh water. Increase density values 2.0 lb/ft³ 32 kg/m³) for salt water. Perform tests when slurry temperature is above 40°F.

Table 516-1 (Metric)
Acceptable Range of Values for Mineral Slurry

<u>Property</u>	<u>At the time of Slurry Introduction</u>	<u>In Hole at Time of Concreting</u>	<u>Method</u>
Density (kg/m ³)	1030-1107	1030-1200	Density Balance
Viscosity (sec/l)	30-48	30-48	Marsh Cone
pH	8-11	8-11	pH paper or meter

Table 516-2 (Metric)
Acceptable Range of Values for Polymer Slurry

Property	At the time of Slurry Introduction	In Hole at Time of Introduction	Method
Density (kg/m ³)	1000-1010	1000-1017	Density Balance
Viscosity (sec/l)	32-42	32-42	Marsh Cone
pH	9-11	9 - 11	pH paper or meter

Notes for Tables 516-1 and 516-2: Density values shown are for fresh water. Increase density values 32 kg/m³ for salt water. Perform tests when slurry temperature is above 4°C.

Take slurry samples using an approved sampling tool. Extract slurry samples from the base of the shaft and 10 feet (3 m) above the base of the shaft. Perform four sets of tests during the first eight hours of slurry use. When the results are acceptable and consistent, the testing frequency may be decreased to one test set for every four hours of slurry use.

When a slurry sample is unacceptable, make necessary corrections to bring the slurry within specifications. Do not place concrete until the results of the resampling and retesting indicate acceptable values.

Furnish reports of all tests, signed by an authorized representative, after completion of each drilled shaft. Dispose of slurry at approved locations.

3. *Exterior Casings.* Install all casings to produce a positive seal that prevents piping of water or other material into or from the hole. If it becomes necessary to remove a casing and substitute a longer or larger diameter casing through caving soils, stabilize the excavation with slurry or backfill before the new casing is installed. Other approved methods may be used to control the stability of the excavation and protect the integrity of the foundation soils.

All subsurface exterior casings are to be considered temporary unless designated in the contract as permanent casing. Remove temporary casing before completing placement of concrete in any cased drilled shaft. During casing removal from the hole, maintain a level of fresh concrete in the casing that is a minimum of 5 feet (1.5 m) above the surrounding level of water or slurry. Exercise care during casing removal to maintain an adequate level of concrete within the casing so fluid trapped behind the casing is displaced upward and discharged at the ground surface without contaminating or displacing the shaft concrete.

Temporary casings that have become bound or fouled during shaft construction and cannot be practically removed are considered a defect in the drilled shaft.

Extend casings above the ground surface to keep the excavation clean through concrete placement. When a casing is designated as permanent, cut the casing off at the required elevation and leave in place after concrete placement.

4. *Reinforcing Steel Cages for Drilled Shafts.*
 - 4.1 *General.* Place the reinforcing steel cage as a unit immediately after the shaft excavation is inspected and accepted and before concrete placement. Securely wire together contact

reinforcing steel lap splices. If the concrete is not placed immediately after the cage is installed, the cage may have to be removed before placing the concrete to verify the integrity of the excavated area and to ensure loose material is removed from the bottom of the hole.

Tie and support the reinforcing steel so it remains within the required tolerances. Securely tie concrete spacers or other approved spacing devices at fifth points around the cage perimeter and space at intervals not to exceed 10 feet (3 m) along the length of the cage. Use spacers of approved material equal in quality and durability to the shaft concrete.

During concrete placement, provide positive support from the top for the reinforcing steel cage. Support the cage concentrically to prevent racking and distortion of the cage. Maintain the top of the reinforcing steel cage no more than 6 inches (150 mm) above and no more than 3 inches (75 mm) below the required position. If the reinforcing steel cage is not maintained within tolerances, make acceptable corrections and do not construct additional shafts until the method of reinforcing steel cage support has been approved.

If it is determined in the field that the shaft must be longer than planned, provide reinforcing steel for the extended length.

- 4.2 *Access Tubes for Crosshole Sonic Logging (CSL).* When CSL access tubes are specified in the contract documents, i.e., shown in the bid schedule, provide CSL testing access tubes for all drilled shafts including trial shafts.

Use access tubes made of schedule 40 steel pipe and having an inside diameter of 2.0 inches (50 mm). The tubes, including pipe joints, shall have a round, regular internal diameter free of defects or obstructions to permit the free, unobstructed passage of a 1.3 inches (33 mm) diameter source and receiver probes. The tubes and joints shall be watertight and free from corrosion with clean internal and external surfaces to ensure passage of the probes and a good bond between the concrete and the tubes.

Install each access tube the full depth of each shaft to permit access of CSL testing equipment. Using the planned shaft diameter, determine and install the number of access tubes in each drilled shaft as specified in Table 516-3, unless otherwise specified in the contract documents.

Table 516-3

Minimum Number of Access Tubes per Drilled Shaft

Planned Shaft Diameter, ft.(m)	Minimum Number of Access Tubes
$D \leq 3.0$ (0.9)	3
3.0 (0.9) < $D \leq 4.0$ (1.2)	4
4.0 (1.2) < $D \leq 5.0$ (1.5)	5
5.0 (1.5) < $D \leq 6.0$ (1.8)	6
6.0 (1.8) < $D \leq 8.0$ (2.4)	7
8.0 (2.4) < $D \leq 10.0$ (3.0)	8
10.0 (3.0) < $D \leq 12.0$ (3.7)	9

Fit each tube with a watertight shoe on the bottom and a removable cap on the top. Securely attach the tubes to the interior of the reinforcement cage in a regular, symmetric pattern such that each tube is equally spaced from the others around the perimeter of the cage. Install the tubes as near to parallel and vertical as possible. Start the tubes at the shaft bottom and end at least 3 feet (0.9 m) above the shaft top. If the shaft top is subsurface, extend the tubes at least 3 feet (0.9 m) above the ground and/or water surface.

Take care during reinforcement installation operations in the drilled shaft hole so as not to damage the tubes. Before placement of concrete, fill the access tubes with clean water and cap the tube tops to keep out debris. After concrete placement, exercise care when removing caps to avoid applying excess torque, hammering, or other stresses that could break the bond between the access tubes and the concrete.

5. *Concrete for Drilled Shafts.* Place concrete immediately, except as otherwise specified, after all excavation is complete and the reinforcing steel cage is in place. Complete concreting in a shaft, including the removal of temporary casing, within two hours of starting concrete placement. Do not retemper concrete that has developed initial set.

Before placement in a wet hole, allow water in the hole to seek its natural hydraulic head.

Place concrete in one continuous operation from bottom to top of the shaft using either a tremie or concrete pump. Continue placing concrete after the shaft excavation is full and until acceptance quality concrete is evident at the top of the shaft. Before initial concrete set, consolidate the top 10 feet (3.0 m) of the shaft concrete using acceptable vibratory equipment. Finish the top of the shaft within 1 inch (25 mm) higher to 3 inches (75 mm) lower than the required elevation. For wet holes, do not consolidate until all water above the concrete surface has been removed.

Place the discharge end of either a tremie or concrete pump at the shaft base elevation. Keep the discharge end immersed at least 5 feet (1.5 m) below the surface of the fluid concrete. Maintain a positive head of concrete in the tremie or pump during concrete placement. If anytime during the concrete placement, the discharge end is removed from the fluid concrete column and discharges concrete above the rising concrete surface into displaced water, remove the reinforcing cage and concrete, complete any necessary sidewall removal as directed, and reconstruct the shaft.

When the top of the shaft is above ground, use a removable form or other approved means to form the shaft from the top to a minimum of 2 feet (0.6 m) below finished ground. When the top of the shaft is below ground, use a temporary oversize surface casing to control caving of soil, etcetera, into the freshly placed concrete.

Concrete will be sampled for acceptance at the point of discharge into the tremie or concrete pump hopper. Cure exposed concrete surfaces by Section 509.

- 5.1 *Tremies.* Use watertight tremies for concrete placement in either wet or dry holes. A tremie consists of a tube of sufficient length, weight, and diameter to discharge concrete at the shaft base. Make the tremie so that the bottom can be sealed and charged with concrete in the dry, and then opened when in place at the bottom of the shaft. Do not

use tremies that contain aluminum parts that will contact the concrete. Make the tremie capable of being rapidly lowered to retard or stop the flow of concrete.

Make the tremie inside diameter at least 10 inches (250 mm) and not more than 14 inches (350 mm). Make the inside and outside surfaces of the tremie clean and smooth. Make the wall thick enough to prevent crimping or sharp bends. Fit the top with a hopper. Construct the discharge end of the tremie to permit free radial flow of the concrete during placement.

- 5.2 *Concrete Pumps.* Use pumped concrete placement in either wet or dry holes. Use 4-inch (100 mm) minimum diameter discharge tubes with watertight joints. Place the discharge tube at the shaft base elevation.

For wet holes, use pumps with a device at the end of the discharge tube to seal out water while the tube is first being filled with concrete. If a plug is used, remove it from the hole or use a plug made from approved material that will prevent a defect in the shaft if not removed.

6. *Nondestructive Testing of Drilled Shafts.*

- 6.1 *General.* Provide Crosshole Sonic Logging (CSL) testing to check the integrity of concrete drilled shafts when CSL testing is required by the contract documents, i.e., shown in the bid schedule. If CSL access tubes are required by the contract document but CSL testing was not required by the contract documents and, in the opinion of the Engineer, a construction problem was observed during shaft construction, the Department will conduct CSL testing. If access tubes were not specified or installed, the Engineer may require full depth coring to determine the soundness of a questionable drilled shaft (see 514.04(c)6.7).
- 6.2 *NDT Consultant.* When CSL testing is required by the contract documents, provide a Nondestructive Testing (NDT) consultant experienced in CSL testing. Submit resumes of the consulting personnel for approval before testing. Perform all CSL testing and analyses under the supervision of an Oklahoma registered Professional Engineer. The consultant shall have a minimum of one year experience in field testing and analyzing CSL testing.
- 6.3 *Testing Schedule.* Wait at least 24 hours after the placement of all concrete in a shaft before CSL testing. After placement of concrete, finish CSL testing within 30 calendar days for steel access tubes.
- 6.4 *CSL Test Equipment.* Use CSL test equipment capable of performing the following functions:
- Displaying individual CSL records, recording CSL data, and analyzing receiver responses.
 - Printing of CSL logs.
 - Testing in 2 inches (50 mm) I.D. access tubes.
 - Generating an ultrasonic voltage pulse to excite the source with a synchronized triggering system to start the recording system.

- Measuring and recording the depths of CSL probes at the time signals are recorded.
 - Filtering/amplifying signals.
- 6.5 *CSL Logging Procedures.* Test all perimeter tube pairs and major diagonal tube pairs. If a possible defect is indicated, conduct CSL testing between additional pairs of tubes as determined by the NDT consultant.
- Perform CSL tests with the source and receiver probes in the same horizontal plane unless test results indicate potential defects. Angled tests consisting of the source and receiver vertically offset in the access tubes may be made to further evaluate a questionable zone. Make CSL measurements at depth intervals of 2 inches (50mm) . Pull the probes, starting from the bottom of the tubes, over a depth-measuring device. Remove any slack from the cables before pulling to provide accurate depth measurements. Report to the Engineer any indicated defects and conduct further tests as required to evaluate the extent of such defects.
- 6.6 *CSL Testing Results.* Provide a preliminary report to the Engineer within 72 hours of CSL testing. Furnish, within 10 working days of testing, two copies of the final CSL testing report sealed by the Professional Engineer supervising the testing. Include in the final report the CSL logs with analyses of the initial pulse arrival time versus depth and pulse energy/amplitude versus depth. Present a CSL log for each tube pair tested with any defect zones indicated on the logs and discussed in the test report as appropriate. Include in the report a summary of the CSL test results which covers drilled shaft identification, test date, shaft age at time of CSL testing (days from concrete placement to CSL testing), drilled shaft diameter, number of CSL tubes tested, test length, average compression velocity, and a description of defects detected. In each defect description, include the CSL tube number, depth below top of concrete, percent concrete wave speed reduction, and recommended concrete condition rating. The Engineer will evaluate the CSL test results and determine whether the drilled shaft construction is acceptable.
- 6.7 *Core Drilling of Drilled Shaft Concrete.* If a drilled shaft is believed to be unacceptable, the Engineer may require continuous coring of the shaft using an “NW” size core barrel as specified in ASTM D 2113. The number, depth, and location of cores will be determined by the Engineer. Submit the methods and equipment used to core the drilled shaft and grout the cored hole to the Engineer for approval before coring.
- Place the cores in a crate and properly mark showing the shaft depth at each interval of core recovery. Submit the cores and an accurate log for each core recovered. Do not proceed with construction above the drilled shaft in question until the quality of the concrete in the shaft, as represented by the core samples, is determined to be acceptable and notification to continue construction is given by the Engineer. If the quality of the concrete in a drilled shaft is determined to be unacceptable, then the drilled shaft will be considered defective.
- 6.8 *Abandoning CSL Access Tubes.* After completing CSL testing and the Engineer has approved continuing construction above the shafts, dewater and Portland cement grout the access tubes in the drilled shafts. Submit the grout mix design and grouting method for approval.

7. *Defective Shafts.* Correct defective shafts using approved methods. Submit for approval a plan for corrective work. Corrective action may consist of, but not limited to, the following.
- Removing the shaft concrete and extending the shaft deeper to compensate for loss of frictional capacity in the cased zone when temporary casing cannot be removed.
 - Providing straddle shafts to compensate for capacity loss.
 - Providing a replacement shaft.

516.05. METHOD OF MEASUREMENT.

Accepted lengths of *drilled shafts* and *trial drilled shafts* shall be measured by the linear foot (meter) from the shaft base elevation to the top of shaft elevation. Measurements shall be based upon the planned elevations or the elevations approved by the Engineer. Additional work for the correction of defective shafts shall not be measured for payment. Miscellaneous items, such as, soil samples or rock cores specified in the contract documents, rebar splices, permanent casings, tools and equipment lost, overreamed excavation, surface excavation or backfill needed for construction, and concrete placed outside the neat lines of the shaft shall not be measured for payment.

Accepted lengths of *Crosshole Sonic Logging (CSL) access tubes* shall be measured by the linear foot (meter) of tubing when shown in the bid schedule. Tube lengths measured for payment shall not exceed the actual length of tubing in place or the limits of tubing required by these specifications. CSL testing shall be measured for payment per drilled shaft tested when shown in the bid schedule. Additional testing (CSL and coring) to determine extent of defects shall not be measured for payment.

Approved obstructions shall be measured by lump sum. No reduction shall be made in drilled shaft measurements due to obstructions.

516.06. BASIS OF PAYMENT.

Accepted quantities of drilled shafts, measured as provided above, will be paid for at the contract price per unit of measurement for the pay items listed below that are shown in the bid schedule. Payment will be made under:

- (A) DRILLED SHAFTS LINEAR FOOT (METER)
- (B) TRIAL DRILLED SHAFTS LINEAR FOOT (METER)
- (C) CROSSHOLE SONIC LOGGING EACH
- (D) CSL ACCESS TUBES LINEAR FOOT (METER)

which will be full compensation for all material, labor, equipment and incidentals necessary to complete the work described in this section. Approved obstructions will be paid for by Supplemental Agreement. Either soil samples or rock cores not specified by the Plans will be paid for by Supplemental Agreement. Nondestructive testing by the Department, revealing structural defects requiring corrective action, shall be paid for by the Contractor. Contractor coring, required by the Engineer and not revealing structural defects, shall be paid for by Supplemental Agreement. Contractor coring, required by the Engineer and revealing structural defects, shall be paid for by the Contractor.

SECTION 517

POST-TENSIONING

517.01. DESCRIPTION.

Post-tensioning work consists of prestressing cast-in-place concrete by furnishing, placing, and tensioning of prestressing steel in accordance with details shown in the contract documents and as specified in these specifications.

This work shall include the furnishing and installation of any appurtenant items necessary for the particular prestressing system to be used, including but not limited to ducts, anchorage assemblies and grout used for pressure grouting ducts.

517.02. MATERIALS.

- (a) **Concrete.** Use Class P concrete meeting the requirements of Section 509.
- (b) **Reinforcing Steel.** Use reinforcing steel meeting the requirements of Section 511.
- (c) **Prestressing Steel.** Use prestressing steel of the type specified in the contract documents and meeting the requirements of the following Subsections as applicable for the type:

Strands for Prestressing	723.04
Bars for Post-tensioning	723.05
Parallel Wire Assemblies for Post-tensioning	723.06

Assign a lot number to all wire, strand, or bars shipped to the project site and tag for identification purposes. Each lot of wire or bars and each reel of strand reinforcement shall be accompanied by a manufacturer's certificate of compliance, a mill certificate, and a test report. The mill certificate and test report shall include:

- the chemical composition (not required for strand),
- cross-sectional area,
- elongation at rupture,
- modulus of elasticity, and
- the stress-strain curve for actual prestressing steel intended for use.

All values certified shall be based on test values and nominal cross-sectional areas of the material being certified.

- (d) **Corrosion Inhibitor.** Corrosion inhibitor for prestressing steel shall consist of a vapor phase inhibitor (VPI) powder conforming to the provisions of Federal Specification MIL-P-3420F-87 or as otherwise approved.
- (e) **Grout.** In making grout for pressure grouting the post-tensioning ducts, use materials conforming to the following requirements:
1. *Portland Cement.* Portland Cement shall conform to one of the following: Specifications for Portland Cement - AASHTO M 85, Type I, II, or III.

Cement used for grouting shall be fresh and shall not contain any lumps or other indication of hydration or "pack set."

2. *Water.* The water used in the grout shall conform to the requirements of Subsection 701.04.
3. *Admixtures.* Admixtures, if used, shall impart the properties of low-water content, good flowability, minimum bleed, and expansion if desired. They shall contain no chemicals in quantities that may have harmful effect on the prestressing steel or cement. Do not use admixtures that, at the dosage used, contain chlorides in excess of 0.005% of the density of the cement used or contain any fluorides, sulphites, and nitrates.

When a grout expanding admixture is required, or is used at the Contractor's option, it shall be well dispersed through the other admixtures and shall produce a 2 to 6% unrestrained expansion of the grout. Determine by tests the amount of admixture needed to obtain a desired amount of expansion. If the source of manufacture or brand of either the admixture or cement changes after testing, conduct new tests to determine proper proportions.

Use all admixtures in accordance with the manufacturers' instructions.

- (f) **Ducts.** Ducts used to provide holes or voids in the concrete for the placement of post-tensioned tendons may be either formed with removable cores or may consist of rigid or semi-rigid ducts that are cast into the concrete.

When using removable cores to form ducts, form the ducts with no constrictions that would block the passage of grout. Remove all coring materials.

Ducts formed by sheath left in place shall be a type that will not permit the intrusion of cement paste. They shall transfer bond stresses as required and retain shape under the weight of the concrete and shall have sufficient strength to maintain their correct alignment without visible wobble during placement of concrete.

1. *Metal ducts.* Sheathing for ducts shall be metal, except as otherwise specified in the contract documents. Such ducts shall be galvanized ferrous metal and shall be fabricated with either welded or interlocked seams. Galvanizing of welded seams will not be required. Rigid ducts shall have smooth inner walls and shall be capable of being curved to the proper configuration without crimping or flattening. Semi-rigid ducts shall be corrugated and, when the tendons are to be inserted after the concrete has been placed, their minimum wall thickness shall be 26 gage (0.45 mm) for ducts less than or equal to $2\frac{5}{8}$ inch (67 mm) diameter and 24 gage (0.60 mm) for ducts greater than $2\frac{5}{8}$ inch (67 mm) diameter. When bar tendons are preassembled with such ducts, the duct thickness shall not be less than 31 gage (0.25 mm).
2. *Polyethylene Ducts.* As an alternative to metal ducts, ducts for transverse tendons in deck slabs and at other locations shown on the contract drawings, may be made of high density polyethylene conforming to material requirements of ASTM D 3350.

Do not use polyethylene ducts when the radius or curvature of the tendon is less than 30 feet (9.1 m).

Semi-rigid polyethylene ducts for use where completely embedded in concrete shall be corrugated with minimum material thickness of 0.050 inch (1.25 mm) \pm 0.010 inch (0.25 mm). Such ducts shall have a white coating on the outside, or shall be of white material with ultraviolet stabilizers added.

Rigid polyethylene ducts for use where the tendon is not embedded in concrete shall be rigid pipe manufactured in accordance with ASTM D2447, ASTM F714, ASTM D2239, or AASHTO T 85. For external applications, such ducts shall have an external diameter to wall thickness ratio of 21 or less.

For applications where a polyethylene duct is exposed to sunlight or ultraviolet light, carbon black shall be incorporated into the polyethylene pipe resin in such amount to provide resistance to ultraviolet degradation in accordance with ASTM D 1248.

3. *Size of Ducts.* The inside diameter of ducts shall be at least $\frac{1}{4}$ inch (6 mm) larger than the nominal diameter of single bar or strand tendons. For multiple bar or strand tendons, the inside cross-sectional area of the duct shall be at least 2.0 times the net area of the prestressing steel, except, where the tendons are to be placed by the pull-through method, the duct area shall be at least 2.5 times the net area of the prestressing steel.

The size of ducts shall not exceed 0.4 times the least gross concrete thickness at the duct.

4. *Duct Fittings.* Couplings and transition fittings for ducts formed by sheathing shall be of either ferrous metal or polyethylene, and shall be cement paste intrusion proof and sufficient strength to prevent distortion or displacement of the ducts during concrete placement.

Provide all ducts or anchorage assemblies with pipes or other suitable connections at each end of the duct for the injection of grout after prestressing. Provide ducts with ports for venting or grouting at the high points and for draining at intermediate low points.

Vent and drain pipes shall be $\frac{1}{2}$ inch (12 mm) minimum diameter standard pipe or suitable plastic pipe. Connections to ducts shall be made with metallic or plastic structural fasteners. The vents and drains shall be mortar tight, taped as necessary, and shall provide means for injection of grout through the vents and for sealing to prevent leakage of grout.

- (g) **Post-tensioning Anchorages and Couplers.** Comply with Subsection 723.07 and the following.

All anchorages and couplers shall develop at least 96% of the actual ultimate strength of the prestressing steel, when tested in an unbonded state, without exceeding anticipated set. The coupling of tendons shall not reduce the elongation at rupture below the requirements of the tendon itself. Couplers and coupler components shall be enclosed in housings long enough to permit the necessary movements. Couplers for tendons shall be used only at locations specifically indicated in the contract documents or approved by the Engineer. Couplers shall not be used at points of sharp tendon curvature.

1. *Bonded Systems.* Bond transfer lengths between anchorages and the zone where full prestressing force is required under service and ultimate loads shall normally be sufficient to develop the minimum specified ultimate strength of the prestressing steel. When anchorages or couplers are located at critical section under ultimate load, the ultimate strength required of the bonded tendons shall not exceed the ultimate capacity of the tendon assembly, including the anchorage or coupler, tested in an unbonded state.

Use housings designed so that complete grouting of all coupler components will be accomplished during grouting of tendons.

Refer to the following subsection, *Unbonded Systems*, for dynamic testing requirements for bonded systems.

2. *Unbonded Systems.* For unbonded tendons, perform two dynamic tests on a representative anchorage and coupler specimen. In the first test, the tendon shall withstand, without failure, 500,000 cycles from 60% to 66% of its minimum specified ultimate strength, and, in the second test, 50 cycles from 40% to 80% of its minimum specified ultimate strength. Take each cycle to be the change from lower stress level to the upper stress level and back to the lower. Different specimens may be used for each of the two tests. Systems utilizing multiple strands, wires, or bars may be tested utilizing a test tendon of smaller capacity than the full-size tendon.

Dynamic tests shall be required on bonded tendons where the anchorage is located or used in such manner that repeated load applications can be expected on the anchorage.

When dynamic testing is required, perform the testing and furnish certified copies of test results that indicate conformance with the specified requirements before installation of anchorages or couplers.

Anchorages for unbonded tendons shall not cause a reduction in the total elongation under ultimate load of the tendon to less than 2% measured in a minimum gauge length of 10 feet (3m).

Protect all the coupling components completely with a coating material before encasement in concrete.

3. *Anchorage Device Acceptance Test.* Use anchorage devices tested by the following test procedure and meeting the requirements specified.
- 3.1 *Test Block Requirements.* Provide a rectangular prism test block containing those anchorage components that will also be embedded in the concrete of the post-tensioned structure. Comply with the practical application and anchor supplier specifications in arranging the anchorage components. Place in the test block an empty duct of a size appropriate for the maximum tendon size that can be accommodated by the anchorage device.
- 3.2 *Test Block Dimensions.* Make the dimensions of the test block perpendicular to the tendon in each direction:
- $1.1F_{pu}$ for specimens tested under cyclic or sustained loading,
 - $1.2F_{pu}$ for specimens tested under monotonic loading.
- The maximum crack width shall not exceed:
- 0.010 inch (0.12 mm) at $0.8F_{pu}$ after the completion of cyclic or sustained loading, or at $0.9F_{pu}$ after the completion of the one hour monotonic loading period.
 - 0.016 inch (0.20 mm) at $0.9F_{pu}$ for cyclic or sustained loading, or at $1.0F_{pu}$ for monotonic loading.
- 3.8 *Test Series Requirements.* Test three specimens to make a test series. Each test in the series shall meet the anchorage zone requirements. If one of the three specimens fails to meet these requirements, a supplementary test of three additional specimens is allowed.
- 3.9 *Records of the Anchorage Device.* Record the following information for each anchorage device acceptance test:
- Dimensions of the test specimens,

- Drawings and dimensions of the anchorage device, including all confining reinforcing steel,
- Amount and arrangement of supplementary skin reinforcement,
- Type and yield strength of reinforcing steel,
- Type and compressive strength at time of testing of concrete,
- Type of testing procedure and all measurements specified for the procedure.

517.03. EQUIPMENT.

- (a) **Jacking Equipment.** For stressing the tendons, furnish hydraulic jacks that can provide and sustain the necessary forces and are equipped with a gauge, either a pressure gauge or a load cell, for determining the jacking stress. Use a jacking system that provides an independent means of measuring tendon elongation.

Equip the jack with a gauge that can be read within 1% of the final jacking force. The gauge shall be either a dial at least 6 inches (150 mm) in diameter or a digital display. The range of a load cell shall be such that the lower 10% of the manufacturer's rated capacity will not be used to measure stress. Calibrate each jack and its gauge as a unit with the cylinder extension in the approximate position that it will be at final jacking force. Provide a certified calibration chart or curve with each jack and gauge combination. Recalibrate the gauges at least once a year and whenever gauge pressures and elongations indicate materially different stresses.

Use a jack capable of slow release of stress to allow relaxation from overstress to the proper seating force.

- (b) **Grouting Equipment.** Furnish grouting equipment that includes a mixer capable of continuous mechanical mixing that will produce a grout free of lumps and undispersed cement, a grout pump of sufficient capacity to properly place grout in quantities and pressures required, and standby flushing equipment with water supply.

Accessory equipment that will provide for accurate solid and liquid measures shall be provided to batch all materials.

The pump shall be a positive displacement type and be able to produce an outlet pressure gauge reading of at least 150 psi (1.0 MPa). The pump shall have seals adequate to prevent introduction of oil, air or other foreign substance into the grout and to prevent loss of grout or water.

A pressure gauge having a full scale reading of no greater than 300 psi (2 MPa) shall be placed at some point in the grout line between the pump outlet and the duct inlet. Standby flushing equipment capable of developing a pumping pressure of 250 psi (1.7 MPa) and of sufficient capacity to flush out with water any partially grouted ducts shall be provided.

The grouting equipment shall contain a screen having clear openings of $\frac{1}{8}$ inch (3 mm) maximum size to screen the grout before its introduction into the grout pump. If a grout with a thixotropic additive is used, a screen opening of $\frac{3}{16}$ inch (4.75 mm) will be satisfactory. This screen shall be easily accessible for inspection and cleaning.

The grouting equipment shall utilize gravity feed to the pump inlet from a hopper attached to and directly over it. The hopper shall be kept at least partially full of grout at all times during the pumping operation to prevent air from being drawn into the post-tensioning duct.

Under normal conditions, the grouting equipment shall be capable of continuously grouting the largest tendon on the project in no more than 20 minutes.

Grout pipes and vents shall be fitted with positive mechanical shutoff valves capable of withstanding the pumping pressures. These valves shall not be removed or opened until the grout has set. Leakage of grout through the anchorage assembly shall be prevented by positive mechanical means.

517.04. CONSTRUCTION METHODS.

- (a) **General.** Conform to the applicable requirements of Sections 502, 504, 509 and 511 and the following requirements.

When the design for the prestressing work is not fully detailed in the contract documents, determine the details or type of prestressing system for use and select materials and details conforming to these specifications as needed to satisfy the prestressing requirements. The system selected shall provide the magnitude and distribution of prestressing force and ultimate strength required by the contract documents without exceeding allowable temporary stresses. Unless otherwise shown in the contract documents, all design procedures, coefficients and allowable stresses, friction and prestress losses, as well as tendon spacing and clearances, shall be in accordance with the AASHTO *Standard Specifications for Highway Bridges* and the *Guide Specifications for Design and Construction of Segmental Concrete Bridges*, as applicable.

When the effective working force or stress is specified in the contract documents, consider it to be the force or stress remaining in the prestressing steel after all losses, including creep and shrinkage of concrete, elastic shortening of concrete, relaxation of steel, friction and take up or seating of anchorages, and all other losses peculiar to the method or system of prestressing have taken place or have been provided for. When the jacking force is specified in the contract documents, consider it to be the force applied to the tendon before anchorage and the occurrence of any losses, including the anchor set loss.

- (b) **Working Drawings.** When the contract documents do not include complete details for a prestressing system and its method of installation, or when proposing any change in these items, submit working drawings of the prestressing system proposed for use. Comply with Subsection 105.03. Submit falsework drawings with prestressing drawings.

Show in the working drawings complete details and substantiating calculations of the method, materials, and equipment proposed for use in the prestressing including any additions or rearrangement of reinforcing steel and any revision in concrete dimensions from that specified in the contract documents. Outline the method and sequence of stressing and complete specifications and details of the prestressing steel and anchorage devices, working stresses,

anchoring stresses, tendon elongations, type of ducts, and all other data pertaining to the prestressing operation, including the proposed arrangement of the prestressing steel in the members.

Show on these drawings details of type, size, and number of strands, bars, wires per duct, anchorage devices, duct profiles, grouting and venting ports, marking used to identify unlike ducts and their location, total force per duct with proper conversion to the units expressed on the jack gauge, total elongation, temporary overstress and other information necessary to properly complete the work.

Include a complete numbered layout showing the steel and step-by-step stressing sequence on the drawings. Include details of prestressing steel slack removal, overstress, gauge reading for seating, elongation measurement and wedge seating.

Also include the details of the method of support for and dimensions to properly locate the ducts so steel will be at its proper location. List and describe the pressure grouting materials and equipment including backup equipment.

(c) **Ducts.**

1. *Placement.* Rigidly support ducts at the proper locations in the forms by ties to reinforcing steel. Use ties that are adequate to prevent displacement during concrete placement. Use supplementary support bars where needed to maintain proper alignment of the duct. Use hold-down ties to the forms when the buoyancy of the ducts in the fluid concrete would lift the ducts. Maintain a tolerance $\pm 1/4$ inch (6 mm) for duct position.

Couple joints between sections of duct with positive connections that do not result in angle changes at the joints and will prevent the intrusion of cement paste.

After placing ducts and completing reinforcement and forming, inspect the ducts to locate possible damage. Repair all unintentional holes or openings in the duct before placing concrete.

Secure grout openings and vents to the duct and to either the forms or to reinforcing steel to prevent displacement during concrete placing operations. Cover the ends of ducts to prevent the entry of water or debris.

2. *Vents and Drains.* For continuous structures, vent all ducts at high points of the duct profile, except where the curvature is small, as in continuous slabs, and at additional locations as specified in the contract documents. Where freezing conditions can be anticipated before grouting, install drains at low points in ducts where needed to prevent the accumulation of water. Leave low-point drains open until grouting is started.

Remove the end of vents and drains 1 inch below the surface of the concrete after grouting has been completed, and fill the void with mortar. Comply with Subsection 509.04(h).

(d) **Prestressing Steel.**

1. *Packaging, Storing and Handling.* Protect all prestressing steel against physical damage and rust or other results of corrosion at all times from manufacture to grouting. Prestressing steel that has sustained physical damage at any time shall be rejected. The development of pitting or other results of corrosion, other than rust stain, shall be cause for rejection.

Keep prestressing steel packaged in containers or shipping forms for the protection of the steel against physical damage and corrosion during shipping and storage. Place a corrosion inhibitor in the package or form, or when permitted, apply directly to the steel. Use a corrosion inhibitor meeting these specifications and having no deleterious effects on steel, concrete, or grout, or the bond strength between each of these. Repair or replace damaged packaging or forms.

Clearly mark the shipping package or form with a statement that the package contains high strength prestressing and the type of corrosion inhibitor used, including the date packaged.

2. *Placement.* Before installing prestressing steel in the ducts, demonstrate that the ducts are free of water and debris immediately before installing the prestressing steel. Pull the total number of strands in an individual tendon through the duct as a unit, or pull or push individual strands through the duct.

If prestressing steel is preinstalled in the ducts before concrete placement, accurately place the assembly of prestressing steel and ducts and hold in position while placing concrete.

Set and hold anchorage devices or block-out templates for anchorages so that their axis coincides with the axis of the tendon and anchor plates are normal in all directions to the tendon.

Distribute the prestressed steel so that the force in each girder stem is equal or as required by the contract documents. For box girders with more than two girder stems, the prestressing force may vary up to 5% from the theoretical required force per girder stem provided the required total force in the superstructure is obtained and the force is distributed symmetrically about the centerline of the typical section.

3. *Protection of Steel after Installation.* Continuously protect prestressing steel against rust or other corrosion by using a corrosion inhibitor placed in the ducts or directly applied to the steel, unless the prestressed steel is grouted within 10 days after installation in the duct.

After placing tendons in ducts, seal the ends of the ducts to prevent entry of moisture.

When steam curing is used, do not install prestressing steel until steam curing is completed.

Whenever electric welding on or near member containing prestressing steel, directly attach the ground to the steel being welded. Protect prestressing steel and hardware from weld spatter or other damage.

- (e) **Anchorage Hardware.** Properly place all anchorage materials according to the approved working drawings and the requirements of the anchorage device supplier. Exercise care and attention in placing anchorage hardware, reinforcement, concrete, and consolidation of concrete in anchorage zones. Do not modify the local zone details without approval.

Maintain a tolerance of $\pm 1/4$ inch (6 mm) for the position of tendon anchorage bearing plates.

- (f) **Tensioning.**

1. *General.* Tension prestressing steel using approved jacking equipment to produce the forces shown in the contract documents or on the approved working drawings, with appropriate allowance for all losses. Determine losses in accordance with the AASHTO “*Standard Specifications for Highway Bridges*” and include the anchor set loss appropriate for the

anchorage system employed. Limit stressing values, both before and after seating, to the values permitted by AASHTO.

Before post-tensioning any member, demonstrate to the satisfaction of the Engineer that the prestressing steel is free and unbonded in the duct.

During stressing of strand, individual wire failures may be accepted if not more than one wire in any strand is broken and the area of broken wires does not exceed 2% of the total area of the prestressing steel in the duct.

2. *Concrete Strength and Age Requirements.* Apply prestressing forces only after all concrete in the member to be post-tensioned has attained the specified strength for initial stressing and has aged at least 10 days.
3. *Sequence of Stressing.* When the sequence of stressing individual tendon is not otherwise specified in the contract documents or on the approved working drawings, stress tendons in a sequence that produce a minimum of eccentric force in the member.

Stress simultaneously all strand in each tendon with a multiple strand jack. Stress tendons from both ends unless otherwise specified in the contract documents or in the approved working drawings.

4. *Measurement of Stress.* Provide a record of gauge pressures and tendon elongations for each tendon for approval. Measure elongation to an accuracy of $1/16$ inch (1.5 mm). Do not cut off stressing tails until the stressing records have been approved.

Determine the stress in tendons during tensioning by gauge or load cell readings and verify with measured elongations. For the calculations of anticipated elongations, utilize the nominal area and modulus of elasticity as furnished by the manufacturer for the lot of steel being tensioned, or as determined by a bench test of strands used in the work.

Tension all tendons to a preliminary force as necessary to eliminate any take-up in the tensioning system before starting elongation readings. Make this preliminary force between 5% and 25% of the final jacking force. Measure the initial force using a dynamometer or other approved method, so that its amount can be used as a check against elongation as computed and as measured. Mark each strand before final stressing to permit measurement of elongation and insure that all anchor wedges set properly.

It is anticipated that there may be a possible difference in indicated stress between jack pressure and elongation of about 5%. In such event, the error shall be so placed that the discrepancy shall be on the side of a slight overstress rather than understress. In the event of an apparent discrepancy between gauge pressure and elongation of more than 5% in tendons over 50 feet (15 m) long and 7% in tendons 50 feet (15 m) or less in length, carefully check the entire operation and determine the source of error before proceeding further.

(g) **Grouting.**

1. *General.* Permanently protect and bond prestressing steel to the concrete by completely filling the void space between the duct and the tendon with grout.
2. *Preparation of Ducts.* Clean all ducts of deleterious materials that would impair bonding of the grout or interfere with grouting.

Flush ducts with clean, potable water. The water may contain slack lime (calcium hydroxide) or quicklime (calcium oxide) in the amount of 1.7 pounds per gallon (0.2 kg per liter) . After flushing, blow out all water in the duct with oil-free compressed air.

3. *Mixing of Grout.* Add water to the mixer first, followed by the Portland Cement and admixture, or as required by the admixture manufacturer.

Mix long enough to obtain a uniform, thoroughly blended grout, without excessive temperature increase or loss of expansive properties of the admixture. Continuously agitate the grout until it is pumped.

Do not add water to increase grout flowability that has decreased by delayed use of the grout.

Determine proportions of materials based on tests made on the grout before grouting is begun, based on prior documented experience with similar materials and equipment and under comparable field conditions (weather, temperature, etc.). Use the minimum amount of water in the grout mixture as is necessary for proper placement. When Type I or II cement is used, limit the water cement ratio to a maximum of 0.45.

Determine the pumpability of grout in accordance with the U. S. Corps of Engineers Method CRD-C79. When this method is used, the efflux time of the grout sample immediately after mixing shall not be less than 11 seconds. The flow cone test does not apply to grout which incorporates a thixotropic additive.

4. *Injection of Grout.* Open all grout and highpoint vent openings when starting to grout. Pump the grout through the duct and continuously waste at the outlet until no visible slugs of water or air are ejected and the efflux time of ejected grout, as measured by a flow cone test, if used, is not less than that of the injected grout. Allow grout to flow from the first vent after the inlet pipe until any residual flushing water or entrapped air has been removed, and then cap or otherwise close the vent. Close the remaining vents in sequence in the same manner.

To ensure that the tendon remains filled with grout, close the outlet and allow the pumping pressure to be raised to not less than 70 psi (0.5 MPa) and held for at least 15 seconds. Close the valve at the inlet while maintaining this pressure. Do not remove plugs, caps, or valves until the grout has set.

Limit the pumping pressure at the tendon inlet to a maximum of 250 psi (1.7 MPa) . If the actual grouting pressure exceeds the maximum recommended pumping pressure, inject the grout at any vent that has been, or is ready to be capped as long as a one way flow of the grout is maintained. If this method is used, fit the vent to be used for injection with a positive shutoff. When one-way flow of the grout cannot be maintained, immediately flush out the duct with clean, potable water.

5. *Temperature and Grout Strength.* When temperatures are below 32°F (0°C) , keep ducts free of water to avoid damage due to freezing.

Maintain the temperature of the concrete above 35°F (2°C) from the time of grouting until the job site cured 2 inch cubes of grout reach a minimum required compressive strength of 800 psi (5.5 MPa) .

Limit the temperature of the grout to a maximum of 90°F (32°C) during mixing and pumping. If necessary, cool the grout mixing water.

517.05. METHOD OF MEASUREMENT.

Post-tensioning (*prestressing*) will be measured by the lump sum. The concrete for post-tensioned cast-in-place concrete structures will be measured under Section 509. The reinforcing steel for post-tensioned cast-in-place concrete structures will be measured under Section 511.

517.06. BASIS OF PAYMENT.

The accepted quantities, measured as provided above, will be paid for at the contract price per unit of measurement for the pay item listed below if shown in the bid schedule. Payment will be full compensation for the work prescribed in this Section. Payment will be made under:

- (A) PRESTRESSING LUMP SUM

SECTION 520
STRUCTURAL CONCRETE REPAIR BY SEALING
AND INJECTION

520.01. DESCRIPTION.

This work shall consist of structurally rebonding cracks, delaminations and hollow planes in Portland cement concrete structures and restoring the structural integrity of the concrete by injecting and sealing the cracks in the structure with an epoxy resin system as shown on the contract documents or as directed by the Engineer.

520.02. MATERIALS.

- (a) **Injection Ports.** Injection ports shall be tubes, fittings, pressure plates or other suitable devices to serve as an entry port for accepting the epoxy resin system under injection pressures of 60 psi (0.4 MPa) . Provide suitable means for sealing each port after completing injection of the port.
- (b) **Crack Sealer.** Provide a sealing compound as recommended by the epoxy resin manufacturer that is suitable for sealing cracks in concrete members and anchoring the injection ports during the injection and curing of the epoxy resin system.
- (c) **Pressure Plates.** Pressure plates may be used instead of sealing compound. The pressure plates must be made of clear plastic and shall be cut to appropriate lengths, widths and shapes to cover the cracks adequately.
- (d) **Epoxy Resin System.** The epoxy resin system shall be a non-shrink, 100% solid, two-component, moisture-insensitive material formulated for pressure injection. The mixed epoxy system shall meet the requirements in Table 520-1.

- (e) **Packaging and Labeling.** Each container shall be clearly labeled with the product name, component designation (“A” and “B”), manufacturer’s name, batch number ratio of component mixture, complete instructions for storing, mixing, using and all applicable safety requirements. Component “A” and “B” shall be packaged in suitable separate containers of a size that when mixed, a specified quantity of properly proportioned material will be produced.

Table 520-1
Epoxy Requirements

<u>Characteristic</u>	<u>Required Value</u>
Slant Shear Strength.....	3000 psi minimum , when bonded to saturated, dry surface at 40°F and 90-100% humidity. Test Method: AASHTO T-237 Note: Joint width of 1/8 inch will be used for testing purposes.
Set Time.....	18 hours maximum Test Method: AASHTO T-237
Pot Life.....	10 minutes minimum Test Method: AASHTO T-237
Viscosity.....	250-900CPS Brookfield #3 Spindle 60 RPM at 77°F after mixing for 3 minutes at slow speed Test Method: ASTM D-2196
Specific Gravity.....	1.1 minimum at 77°F

Table 520-1 (Metric)
Epoxy Requirements

<u>Characteristic</u>	<u>Required Value</u>
Slant Shear Strength	20 MPa minimum , when bonded to saturated, dry surface at 4°C and 90-100% humidity. Test Method: AASHTO T-237 Note: Joint width of 3mm will be used for testing purposes.
Set Time	18 hours maximum Test Method: AASHTO T-237
Pot Life	10 minutes minimum Test Method: AASHTO T-237
Viscosity	250-900CPS Brookfield #3 Spindle 60 RPM at 25°C after mixing for 3 minutes at slow speed Test Method: ASTM D-2196
Specific Gravity	1.1 minimum at 25°C

- (f) **Sampling and Testing.** Submit samples of each batch of material proposed for use to the Engineer at least 30 days before date of usage to allow for completion of testing.

520.03. EQUIPMENT.

To inject epoxy, use a pressure pot, hand pump, caulking device, injection machine or other special device that is compatible with the material used.

Where pressure plates have been used to seal the cracks, use a special pressure fitting on the injection device to prevent leakage when injecting the epoxy resin through the $\frac{1}{4}$ inch (6 mm) holes in the pressure plates.

Use drilling equipment (for drilling the injection ports) equipped with a vacuum system to prevent drilling dust from compacting into the cracks or laminations and blocking the injection and sealing effort.

520.04. CONSTRUCTION METHODS.

- (a) **Preparation.** Clean the surfaces adjacent to cracks of existing efflorescence, deteriorated concrete and other surface debris. Wherever feasible, clean the interior surfaces of the crack to enhance adhesive bond. Clean by vacuuming, flushing, sawing or other approved means.

Widen all cracks to be repaired to $\frac{1}{4}$ inch (6 mm) at the concrete surface. Seal with a quick-setting material to bond the injection ports and prevent loss of the injected resin. Sealing with a clear plastic plate to prevent loss of the injected resin may be permitted. Apply the seal so the concrete surface will not be defaced and the seal can contain the pumped resins.

- (b) **Epoxy Resin Injection.** Space the entry ports for the resin so that travel of material between ports is assured. Begin injection at the lower port and continue until siting the resin at the entry port directly above or adjacent to the port being pumped. When material travel is indicated, move the nozzle to the port showing resin and seal the previously pumped port. Continue this procedure until the crack is completely filled. On wide cracks, where travel of the resin between ports will be rapid, two or more ports may be pumped simultaneously.
- (c) **Leveling of Surface Seal.** After completing injection of the cracks and allowing necessary curing time for the resin, grind all surface areas until flush with the concrete surface.
- (d) **Clean Up.** Clean the areas repaired on a daily basis.

520.05. METHOD OF MEASUREMENT.

Repair of structural concrete by the sealing and injection of the cracks will be measured on the surface by the linear foot (meter) *preparation of cracks* above and below water and by the gallon (liter) of *epoxy resin* injected into the cracks above and below water.

520.06. BASIS OF PAYMENT.

The accepted quantities, measured as provided above, will be paid for at the contract price per unit of measurement for the pay item listed below if shown in the bid schedule. Payment will be full compensation for the work prescribed in this Section. Payment will be made under:

- (A) PREPARATION OF CRACKS, ABOVE WATER LINEAR FOOT (METER)
- (B) PREPARATION OF CRACKS, BELOW WATER LINEAR FOOT (METER)
- (C) EPOXY RESIN, ABOVE WATER GALLON (LITER)
- (D) EPOXY RESIN, BELOW WATER GALLON (LITER)

SECTION 521 PNEUMATICALLY APPLIED MORTAR

521.01. DESCRIPTION.

This work consists of furnishing and placing of pneumatically applied mortar for the construction of portions of structures, repairing concrete structures, texturing concrete surfaces, encasement of structural steel members, lining ditches and channels, paving slopes and for other miscellaneous work, all as specified in the contract documents.

This work shall also include the preparation of surfaces to receive the mortar and the furnishing and placing of any reinforcing steel and the anchors for reinforcement.

Pneumatically placed mortar shall consist of either dry mixed fine aggregate and Portland Cement pneumatically applied by a suitable mechanism, to which mixture the water is added immediately before its expulsion from the nozzle, or mortar premixed by mechanical methods and pneumatically applied through a nozzle onto the prepared surface.

521.02. MATERIALS.

- (a) **General.** Provide materials conforming to the following subsections, except as otherwise specified:

Fine Aggregate	701.05
Coarse Aggregate	701.06
Water	701.04
Portland Cement	701.02
Reinforcing Steel for Structures	723.01
Wire Mesh	723.03

Use fine aggregate only, or a combination of fine and coarse aggregates with the percentage of coarse aggregate to total aggregate not exceeding 30%. Coarse aggregate, if used, shall conform to AASHTO M43, No. 8 or 89 gradation. Recovered rebound which is clean and free of foreign material may be reused as fine aggregate in quantities not to exceed 20% of the total fine aggregate requirements.

- (b) **Anchor Bolts or Studs.** Anchor studs used to support reinforcing wire fabric or bars when placing mortar against existing concrete or rock shall consist of $\frac{1}{4}$ inch (6 mm) minimum diameter expansion hook bolts placed in drilled holes. Each bolt shall have sufficient engagement in sound masonry to resist a pullout force of 150 pounds (670N) .

When permitted by the Engineer, driven steel studs of not less than $\frac{1}{8}$ inch (3 mm) diameter and a minimum length of 2 inches (50 mm) may be used. The equipment used for driving such studs shall be of the type that uses an explosive for the driving force, and shall be capable of inserting the stud or pin to the required depth without damage to the surrounding concrete.

521.04. CONSTRUCTION METHODS.

- (a) **Proportioning.** Submit the proposed mix design to the Engineer for approval before the start of the work. Unless otherwise specified in the contract documents, provide in the mix design a cement to aggregate ratio, based on dry loose volumes, of not less than 1:3.5 for the construction and repair of concrete structures and for encasing steel members, or not less than 1:5 for lining ditches and channels and for paving slopes. The water content shall be as low as practical. Adjust the water content so that the mix is sufficiently wet to adhere properly and sufficiently dry so that it will not sag or fall from vertical or inclined surfaces or separate in horizontal work.
- (b) **Mixing.** Perform mixing either by the dry mix or wet mix process. Before being charged into the placing equipment, thoroughly and uniformly mix the materials using a paddle-type or drum-type mixer designed for use with pneumatic application. Transit mix equipment and methods may be used for the wet process.
- (c) **Surface Preparation.**
1. *Earth.* When placing pneumatically applied mortar against earth, accurately grade the area to the elevation and dimensions specified in the contract documents. Thoroughly compact the area using sufficient moisture to provide a firm foundation and to prevent absorption of water from the mortar. Limit the application of moisture so that free surface water is not present after compacting.
When shown in the contract documents, provide joints, side forms, headers, and shooting strips for backing or paneling. Use ground or gaging wires where necessary to establish thicknesses, surface planes and finish lines.
 2. *Forms.* When placing mortar against forms, provide forms conforming to the requirements of Section 502.
 3. *Concrete or Rock.* When placing mortar against concrete or rock, remove all deteriorated or loose material by chipping with pneumatic or hand tools. Cut square or slightly undercut shoulders approximately 1 inch (25 mm) deep along the perimeter of repair areas. Sandblast the surface as necessary to clean all rust from exposed steel and to produce a clean rough textured surface on the concrete or rock. Keep the surface, against which mortar is to be placed, wet for at least one hour and then allow to dry to a surface dry condition just before applying the mortar.

(d) **Installation.**

1. *Placement of Reinforcing.* Install reinforcing steel in conformance to Section 511. Place reinforcement in new construction as specified in the contract documents. Secure to insure no displacement from impact of the pneumatically placed mortar during application.

For repair work support reinforcing steel by anchor studs installed in the existing masonry except where existing reinforcing steel in the repair area is considered by the Engineer to be satisfactory for support. Space anchors no more than 12 inches (300 mm) center-to-center on overhead surfaces, 18 inches (450 mm) center-to-center on vertical surfaces, and 36 inches (920 mm) center-to-center on top horizontal surfaces. Use at least three anchors in each individual patch area.

Notify the Engineer before starting the installation of anchor studs. Locate stud such that damage will not occur to the prestressing tendons or conduits embedded in the concrete.

Unless otherwise specified in the contract documents, for repair work, reinforce all areas where the mortar exceeds 1½ inch (38 mm) with a single layer of either 2 x 2 (50 mm x 50 mm) - W1.2 x W1.2 or 3 x 3 (75 mm x 75 mm) - W1.4 x W1.4 welded wire fabric. For areas where the thickness of the mortar exceeds 4 inches (100 mm), reinforce each 4 inch (100 mm) thickness of patch or fractional part thereof with a single layer of wire fabric. Place all fabric parallel to the proposed finish surface. Before installing the succeeding layer of fabric, completely encase in mortar each layer of fabric and allow the mortar to set. Place fabric no closer than ½ inch (12 mm) to the prepared masonry surface. Carefully prebend fabric before installing to fit around corners and into re-entrant angles. Do not bend in place.

Place all steel items, including anchors, reinforcing bars, and wire fabric, no closer than 1 inch (25 mm) to the finished surface of the mortar.

2. *Placement of Mortar.* Employ only experienced personnel. Furnish satisfactory evidence of such experience when requested by the Engineer.

Apply the mortar by pneumatic equipment that sprays the mix onto the prepared surface at a high velocity as needed to produce a compacted dense homogeneous mass. Use an air compressor and delivery hose lines of adequate capacity and size to provide a minimum pressure of 35 psi (240 kPa) at the nozzle for 1 inch (25 mm) nozzles and proportionally greater for larger nozzles. Maintain the velocity of the material as it leaves the nozzle at a uniform rate determined for the given job conditions to produce minimum rebound.

Supply water added at the nozzle at a uniform pressure of not less than 15 psi (100 kPa) greater than the air pressure at the nozzle.

Apply the mortar as dry as practicable to prevent shrinkage cracking. Employ shooting strips to insure square corners, straight lines and a plane surface of mortar, except as otherwise specified in the contract documents or approved by the Engineer. Place the strips so as to keep the trapping of rebound at a minimum. At the end of each day's work, or similar stopping periods requiring construction joints, slope off the mortar to a thin edge. Before placing an adjacent section, thoroughly clean and wet the construction joint as required under Subsection 521.04(c). In shooting all surfaces, direct the stream of material flowing from the nozzle to impinge as nearly as possible at right angles to the surface being covered, and hold the nozzle between 2 feet (0.6 m) and 4 feet (1.2 m) from the working surface.

Apply a sufficient number of mortar coats to obtain the required thickness. On vertical and overhead surfaces, limit the thickness of each coat to a maximum of 1 inch (25 mm), except as approved by the Engineer. Place each coat so that it will neither sag nor decrease the bond of the preceding coat. Allow sufficient time between successive layers in sloping, vertical, or overhanging work for initial but not final set to develop. When initial set is developing, clean the surface to remove the thin film of laitance to provide for a bond with succeeding applications.

Remove rebound or accumulated loose sand from the surface to be covered before placing any layer of mortar. Do not embed such material in the work. Apply materials within 45 minutes of mixing unless otherwise permitted by the Engineer.

After curing and before final acceptance, sound all repaired areas. Remove and replace all unsound and cracked areas.

- 2.1 *Weather Limitations.* Do not place pneumatically placed mortar on a frozen or hot surface (less than 32°F (0°C) or more than 100°F (35°C)) or if the ambient temperature is anticipated to drop below 35°F (2°C) within 24 hours after placement.

Suspend the application of mortar if high winds prevent proper application or if rain occurs which would wash out the mortar.

- 2.2 *Protection of Adjacent Work.* During the progress of the work, protect adjacent facilities that may be permanently discolored, stained, or otherwise damaged by overspray, dust, or rebound. Clean contacted areas by early scraping, brushing, or washing, as the surroundings permit.

3. *Finishing.* After placing mortar to the required thickness, cut off all high spots with a sharp trowel, or screed to a true plane as determined by shooting strips or by the original masonry surface, or as directed. When using cutting screeds, lightly apply the screed to all surfaces so as not to disturb the mortar for an appreciable depth and work the screed in an upward direction on vertical surfaces. Unless otherwise specified in the contract documents, give the finished mortar surface a final flash coat of about 1/4 inch (3 mm) of mortar. Take special care to obtain a uniform appearance on all exposed surfaces.
4. *Curing and Protecting.* Cure pneumatically placed mortar in conformance with the requirements of either "Water Method," or "Waterproof Cover Method" in Subsection 509.04(f). Cure for a minimum duration of 96 hours. Protect the mortar from freezing during the curing period. Comply with Subsection 509.04(b).

521.05. METHOD OF MEASUREMENT.

Pneumatically placed mortar shall be measured by the square yard (square meter) of finished surface area of acceptable mortar placed in the work along the plane or curve of each surface.

521.06. BASIS OF PAYMENT.

The accepted quantities, measured as provided above, will be paid for at the contract price per unit of measurement for the pay item listed below if shown in the bid schedule. Payment will be full compensation for the work prescribed in this Section. Payment will be made under:

- (A) PNEUMATICALLY PLACED MORTAR.....SQUARE YARD (SQUARE METER)

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SECTION 601 RIPRAP

601.01. DESCRIPTION.

This work shall consist of furnishing and placing Riprap protection of the type specified at the locations and in reasonably close conformity with the lines and dimensions shown on the Plans or established by the Engineer. The types of Riprap are as follows:

Type I	Plain Riprap
Type I-A	Plain Riprap with Filter Blanket
Type II	Special Plain Riprap
Type II-A	Special Plain Riprap with Filter Blanket
Type III	Laid Up Riprap
Type IV	Grouted Riprap

601.02. MATERIALS.

Materials shall meet the requirements specified in the following Subsections of Section 700 - Materials:

Portland Cement	701.02
Fine Aggregate	701.05
Filter Fabric	712.04
Stone for Riprap	713.02
Filter Blanket	713.03

601.04. CONSTRUCTION METHODS.

- (a) **General.** Shape and dress slopes, ditches, and areas to be protected to the lines and grades shown on the Plans. Where Type III or Type IV construction is specified, compact the base in accordance with Subsection 501.04 before placing the Riprap .
- (b) **Filter Blanket.** When specified, place filter blanket in one or two layers as indicated on the Plans. When material is stockpiled at the job site, follow guidelines in Subsection 106.09.

Spread each layer uniformly on the prepared base, in a satisfactory manner, to the neat lines indicated. Repair any damage to the surface of the filter blanket during placing of the blanket before proceeding with the work. Compaction of the filter blanket will not be required, but finish it to present a reasonably even surface free from mounds or windrows.

- (c) **Filter Fabric.** When filter fabric is specified, place it to conform to Plan details. Areas on which filter fabric is to be placed shall have a uniform slope and be reasonably smooth, free from mounds and windrows, and free of any debris or projections which could damage the filter fabric to be placed on it.

Loosely lay the material (do not stretch it). Overlap adjacent strips by a minimum of 2 feet (0.6 m). Support the fabric at all times to maintain its intended position. All methods of fabric support and all methods of holding the fabric in place shall be approved by the Engineer. Laps in filter fabric shall be made in conformance with Section 602.04(d).

If there is any filter fabric damage or displacement before fabric placement, during fabric placement, or during Riprap placement, replace or repair it to the satisfaction of the Engineer at the your own expense.

During periods of shipment and storage, protect the filter fabric from direct sunlight, ultraviolet rays, temperature greater than 140°F (60°C), mud, dirt, dust and debris. To the extent possible, keep the fabric wrapped in a heavy-duty protective covering.

Schedule the work so that the filter fabric is covered or otherwise protected within 30 days after it's placed. Failure to comply with this requirement shall require replacement of the fabric.

- (d) **Types I, I-A, II and II-A.** The areas to be protected shall be dressed approximately to the lines and grades shown on the Plans prior to placing Riprap or the filter blanket, when a filter blanket is specified.

Dump plain Riprap and special plain Riprap, graded so that the smaller stone is uniformly distributed throughout the mass, dumped over the area designated until the required depth is attained. Hand or machine placing will be required as is necessary to deposit the stones to the general lines and to the thickness shown on the Plans.

- (e) **Type III.** Excavate the foundation for Riprap below probable scour or the elevation shown on the Plans, and do not lay stone or place concrete until the footing is approved by the Engineer.

Fill spaces between stones with spalls which have been securely rammed into place. he finished wall shall present an even, tight, and reasonably plain surface of the contour required. If points of stones project beyond the surface of the wall, break them off.

- (f) **Type IV.** Excavate the foundation for Riprap below probable scour or to the elevation shown on the Plans, and do not lay stone or place concrete until the footing is approved by the Engineer.

Place the stones with their beds at the approximate angle to the slopes as indicated on the Plans. Lay them in close contact and so as to break joints; thoroughly key the individual stones into the wall. Take care during this procedure to keep earth or sand from filling the spaces between the stones.

Immediately after the stones are in place, wet them thoroughly; then place the grout, completely filling the spaces between the stones from bottom to top. Sweep the surface swept with a stiff broom.

NOTE: No Riprap shall be grouted in freezing weather and in hot, dry weather the work shall be protected from the sun and kept moist for at least 3 days after grouting.

Grout for grouted Riprap shall consist of one part of portland cement and 3 parts fine aggregate by volume, thoroughly mixed with water, to produce grout having the proper consistency.

NOTE: Retempering of grout will not be permitted.

601.05. METHOD OF MEASUREMENT.

Type I and Type I-A. Measure plain Riprap or plain Riprap and filter blanket separately by the ton (metric ton).

Type II and Type II-A. Measure special plain Riprap or special plain Riprap and filter blanket separately by the ton (metric ton).

Type III. Measure laid up Riprap by the square yard (square meter). This measurement covers the whole face area, regardless of thickness, and including additional thickness at base of walls.

Type IV. Measure grouted Riprap by the square yard (square meter). This measurement covers the whole face area, regardless of thickness, including additional thickness at the base of walls. Scales for weighing shall meet the requirement of Subsection 109.01.

Filter Fabric. Measure filter fabric complete in place by the square yard (square meter) of area covered. Laps will not be measured for payment.

601.06. BASIS OF PAYMENT.

Accepted Riprap, measured as provided above, will be paid for at the contract unit price as follows:

(A)	TYPE I	PLAIN RIPRAP	TON (METRIC TON)
(A-1)	TYPE I-A	PLAIN RIPRAP	TON (METRIC TON)
(A-2)	TYPE I-A	FILTER BLANKET	TON (METRIC TON)
(B)	TYPE II	SPECIAL PLAIN RIPRAP	TON (METRIC TON)
(B-1)	TYPE II-A	SPECIAL PLAIN RIPRAP	TON (METRIC TON)
(B-2)	TYPE II-A	FILTER BLANKET CUBIC	TON (METRIC TON)
(C)	TYPE III	LAID UP RIPRAP	SQUARE YARD (SQUARE METER)
(D)	TYPE IV	GROUTED RIPRAP	SQUARE YARD (SQUARE METER)
(E)		FILTER FABRIC (RIPRAP)	SQUARE YARD (SQUARE METER)

Such payment shall be full compensation for furnishing all materials, equipment, labor, and incidentals to complete the work as specified.

**SECTION 602
GABIONS AND REVEMENT MATTRESSES**

602.01. DESCRIPTION.

This work shall consist of furnishing and placing both stone-filled wire-mesh baskets and plastic filter fabric in close conformity with the line, grades, dimensions, and details shown on the plans or established by the Engineer. Gabions and revetment mattresses are used to retain embankments and control erosion.

Gabions are wire-mesh baskets—box or rectangular shaped—filled in-place with hard, durable stone. Gabions have a minimum thickness of 1 foot (0.3 m).

Revetment Mattresses are similar to gabions except they have a maximum thickness of 1 foot (0.3 m) and are always rectangular baskets.

602.02. MATERIALS.

- (a) **Material Requirements.** Provide materials as specified under the following subsections:

Filter Sand	703.04
Filter Fabric	712.02
Stone	713.04(a)2
Wire Baskets	732.09
Cubical stone for gabions and Revetment mattresses	713.02

- (b) **Basket Requirements.** For twisted-wire mesh, supply gabion baskets maximum nominal mesh openings of 3x4 inches (75x100mm) and revetment mattresses and maximum nominal mesh openings of 2 1/2x3 inch (63x75mm) (unless otherwise specified on the plans).

For welded-wire mesh, supply gabion baskets maximum nominal mesh openings of 1 1/2x3 inches (38x75mm) and revetment mattresses and maximum nominal mesh openings of 1 1/2x3 inches (38x75mm).

NOTE: Unless otherwise specified on the plans, provide twisted-wire mesh baskets.

For each individual basket, use the same mesh style for the base, front, ends, back, diaphragms, and lid. Assemble successive baskets so that the strength and flexibility are in accordance with requirements of Subsection 732.09 to a single panel. Fabricate baskets to the dimensions shown on the plans, keeping the height, width, and length of each basket to within 5 percent of the specified dimensions. Install diaphragms that equally divide each gabion basket or revetment mattress into cells, the length of which does not exceed 1.5 times the base width of the gabion basket or 1.0 times the horizontal width of the revetment mattress, respectively. Fabricate diaphragms from the same type of mesh used for the basket body. Secure diaphragms in proper position on the base.

602.04. CONSTRUCTION METHODS.

- (a) **Technical Supervision.** At the start of construction, provide on-site a technical representative from the basket manufacturer who is knowledgeable and experienced in construction of gabions and revetment mattresses. Make the representative available for consultation as needed during construction of the gabions or revetment mattresses.
- (b) **Foundation Preparation.** Place baskets on a smooth excavation extending to the limits on the plans or as directed by the Engineer. Remove all loose or otherwise unsuitable materials. Fill all depressions to grade with suitable materials from adjacent required excavation, or other approved sources, and compact to a density at least equal to that of the adjacent foundation. Allow the Engineer to inspect the prepared surface before proceeding with subsequent construction.
- (c) **Filter Sand Placement.** When required on the plans, uniformly spread filter sand on the prepared foundation surface as specified, making certain not to cause segregation of the filter sand. Repair any damage to the foundation surface during filter placement. Compact and finish filter sand as needed to make the surface even and free of mounds or windrows.
- (d) **Filter Fabric Placement.** Place filter fabric as shown on the plans. Loosely lay the fabric so that it is free of tension, but has no folds, wrinkles or creases. Do not stretch the fabric.

Overlap adjacent strips by a minimum of 2 feet (0.6 m). Stagger vertical fabric laps at least 5 feet (1.5 m). Use full rolls whenever possible to reduce the number of vertical laps. Place the uphill or upstream layer of a lap on top.

Secure the fabric at the top to prevent displacement from its intended position. If securing pins are used to hold the fabric, place the pins in the lapped longitudinal joints, spaced on 10 feet (3 m) centers. Place securing pins through both fabric strips near the overlap midpoint.

Any defects, rips, holes, flaws or damage to the material will be cause for rejection. Torn or punctured fabric may be repaired by placing a layer of fabric over the damaged area, which overlaps a minimum of 2 feet (0.6 m) beyond the damaged area in all directions.

Cover filter fabric within 3 days of installation. Protect the fabric during shipment and storage from direct sunlight, temperature of 140°F (60° C) or more, dirt, dust, and debris. Keep fabric wrapped in a heavy duty protective covering until use.

- (e) **Connections.** Use any of the following methods for connecting individual gabions or revetment mattresses, or groups of gabions or revetment mattresses. When Polyvinyl Chloride (PVC) coating is specified, use either PVC-coated connections or stainless steel connections.
- (1) **3/32 inch (2.2 mm) Tie Wire.** When 3/32 inch (2.2 mm) tie wire is used as the joint material, assemble all vertical edges of each gabion panel first to form groups of empty gabions.
 - 1.1 For twisted-wire mesh, construct the joint using single loop-double loop lacing pattern (locked loops) of 3/32 inch (2.2 mm) tie wire at 6 inch (150 mm) nominal spacing. Do not use simple spiraling (looping without locking) of tie wire.
 - 1.2 For welded-wire mesh, construct the joint using alternating single and double half hitches (locked loops) in every mesh opening along the joint. Securely fasten all lacing wire terminals.
 - (2) **Spiral Binders.** When spiral binders are used with 7/32 inch (2.7 mm) wire or larger, rotate the spiral into position so that it passes through each mesh opening along the joint. Wrap both ends of all spiral binders at least two times around the mesh, to secure the spiral in place. Separate spiral binders 3 inch (75 mm) between continuous, successive loops.

NOTE: Do not use spiral binders after the stone has been placed in the baskets.

- (3) **Interlocking Rings (tiger tites).** For gabions, use one interlocking ring in each mesh opening. For Revetment Mattress, use one interlocking ring in every mesh opening. Securely lock all rings.
- (4) **Overlapping Rings (spenax fasteners).** Use overlapping rings only if a 1 inch (25 mm) lap can be consistently obtained. Install one ring in each mesh opening. Verify the gun used to close the overlapping rings is functioning properly and has the minimum required air pressure.
- (5) **Alternate Fasteners.** Provide alternate fasteners having a minimum strength of 1400 pounds/foot (20 kN/m) for galvanized gabions, 1250 pound/foot (18 kN/M) for PVC Gabions, and 800 pound/foot (12 kN/m) for revetment mattresses. Space connections to prevent separation between baskets from exceeding 2 inch (50 mm) during a connection tensile strength test. Use fasteners that do not damage the protective coating on the wire.

(f) **Assembly and Installation.**

(1) **General.** Assemble and place the empty baskets on the prepared surface. Place the front row of baskets first and successively construct toward the top of the slope. Check that all creases are in the correct position and the top of each side is level. Install the baskets so that when finished no gaps exist between adjoining basket units. Connect adjoining baskets in the same row before filling a basket with stone. Do not move baskets after filling with stone. Connect the next row of baskets to the previous row along all contacting edges.

(2) **Connections.** Make all connections by joining through selvage wire to selvage wire, selvage wire to edge wire, or selvage wire to mesh. If the connections cannot be made by one of the previous methods, mesh to mesh connections may be made.

For closing stone-filled basket lids, do not use alternate fasteners such as spirals, interlocking rings, or overlapping rings, unless otherwise approved. To gain approval, demonstrate that the fasteners can be properly installed on a stone-filled basket without excessively stretching the basket or damaging its protective coating.

(3) **Stone-filling.**

3.1 Fill baskets with stone by hand or machine with hand work to assure a minimum of voids between the stones. Do not damage wire coating. Maintain alignment throughout the filling process. Correct any excessive deformation and bulging of the mesh before continuing with the stone filling. Fill using courses of 1 foot (0.3 m) or less.

NOTE: During stone placement, do not fill any cell more than 1 foot (0.3 m) higher than the adjacent cell; also do not drop stone into the baskets from higher than 3 feet (1 m).

3.2 Along exposed faces, arrange the stone by hand to ensure a neat and compact appearance. Uniformly overfill gabions and revetment mattresses by approximately 1 1/2 inches (38 mm). Allow for the proper closing of the lid and provide an even, uniformly-appearing surface.

NOTE: Do not underfill.

(4) **Connecting Wires.** For gabion baskets greater than 2 feet (0.6 m) in height having exposed faces, place two uniformly-spaced internal connecting wires between each stone course connecting the back and the front faces of each cell. Loop connecting wires around two mesh openings or a single welded-wire joint on each basket face. Securely twist the wire terminals.

(5) **Basket Lids.** Stretch lids tightly over the stone fill using an approved lid-closing tool, until the lid meets the perimeter edges of the front and end panels. Do not use crowbars or other single-point leverage bars for lid closing. Close the lid with lacing wire or approved wire fasteners, along the edges, ends, and internal-cell diaphragms. Turn projections or wire ends into the baskets.

(6) **Partial Baskets.** For partial baskets, cut, fold, and wire together the basket to suit existing site conditions. Fold the mesh back and neatly wire to the adjacent basket face. Perform the assembly, installation, filling, lid closing, and lacing of the reshaped partial basket as specified above.

- (7) **PVC Coated Baskets.** Do not install PVC coated materials until the ambient air temperature and the temperature of the PVC materials are at least 15°F (8°C) above the brittleness temperature of the PVC materials.
- (g) **Backfilling.** Backfill behind gabions according to Subsection 202.02(b) of the Specifications.
- (h) **Retaining Walls.** Construct retaining walls on a 6 to 10% batter (when indicated on the plans). Offset vertical joints in a layer from the previous layer.

602.05. METHOD OF MEASUREMENT.

Measure acceptable *gabions and revetment mattresses*, complete in place, by the cubic yard (cubic meter) as constructed to the dimensions shown on the plans or approved by the Engineer. Measure acceptable *filter fabric*, complete in place, by the square yard (square meter) as constructed to the dimensions shown on plans or approved by the Engineer.

Include stone fill and filter sand for gabions and revetment mattresses in the price bid for the respective bid item. Unless otherwise shown on the Plans, include backfill for gabions in the price bid for gabions.

602.06. BASIS OF PAYMENT.

Accepted quantities of gabions, revetment mattresses, filter fabric measured as provided above, will be paid for at the contract unit price as follows:

- (A) GABIONS CUBIC YARD (CUBIC METER)
- (B) REVETMENT MATTRESSES SQUARE YARD (SQUARE METER)
- (C) FILTER FABRIC SQUARE YARD (SQUARE METER)

Such payment shall be full compensation for furnishing all materials, equipment, labor, tools, and incidentals to complete the work as specified

**SECTION 603
STEEL JETTY BANK PROTECTION**

603.01. DESCRIPTION.

This work shall consist of furnishing materials and placing steel jetty bank protection; this consists of a main line jetty with or without back up jetties as shown on the Plans. The jetties shall consist of steel jacks connected by steel cable or reinforcing bars to a deadman at the anchoring end.

The length of main line and back up jetties and the distance between lines of jetties shall be substantially as shown on the Plans; however, if erosive conditions develop after preparation and approval of Plans, it may be desirable to increase or decrease the length or alter the position of the jetties.

603.02. MATERIALS.

- (a) **Steel Jack.** Each jack shall consist of the following:
 - Three new structural steel angles size 4x4 inch x 1/4 inch x 16 feet (100x100mm x 6mm x 4.8m)
 - Six 1/2 inch (13mm) x 1 1/2 inch (38 mm) high strength bolts with hexagon heads and nuts

- No. 6 double annealed smooth wire lacing
- (b) **Steel Cable.** The steel cable shall consist of good, used oil field cable—inspected, respooled, and oil treated—having a diameter of not less than 7/8 inch (22.2 mm) or reinforcing steel bars having a diameter of not less than 3/4 inch (19 mm) and cable clamps of the proper size for fastening.
- (c) **Deadman.** The deadman shall be either concrete or timber. The concrete deadman shall be made from Class A Concrete and shall have minimum dimensions of 3 feet x 2 feet x 1 1/2 feet (1 meter x 0.60 meter x 0.5 meter). The timber deadman shall be either new creosoted railroad ties 6 inch x 8 inch x 8 feet (152 mm x 203 mm x 2.40 meters) minimum or approved creosoted pile cutoffs minimum 7 inch (178 mm) diameter at the smallest end by 8 feet (2.40 meters) in length.

603.04. CONSTRUCTION METHODS.

- (a) **Constructing Jacks.** For each jack, use three steel angles bolted securely together so that each angle is perpendicular to the other two angles. Each jack shall have a minimum height of 9 feet (2.80 meters) and be laced with a minimum of four lines of wire:
 - The **outside line** of lacing shall be tied at each angle.
 - The **second line** of lacing shall pass through each angle approximately 2 feet (0.60 meters) from each end.
 - The **third line** of lacing shall pass through each angle approximately 4 feet (1.2 meters) from each end.
 - The **inside line** of lacing shall pass through each angle approximately 6 feet (1.8 meters) from each end.
- (b) **Anchoring Jacks.** Use double runs of steel cable or reinforcing bars for anchoring the jacks. Pass one cable or bar on each side of the jack, and apply a cable clamp on each side of the jack to hold the cables together and the jack in its original position. Anchor the cables or bars for main line jetty at each end by a deadman. Fasten the cables or bars for backup jetties to the main line at a steel jack and anchor them to a deadman at the opposite end.

Avoid splices as much as possible; where necessary, place them at a jack. To make (1) splices, (2) end connections to timber deadmen, and (3) connection of backup jetties to mainline, wrap each line around the jack or deadman a minimum of 2 times and fasten it with double cable clamps. Connection to concrete deadmen shall be as shown on the Plans. Splice reinforcing bars with a double-flare-v groove weld, minimum, 3 inch (75 mm) length of weld. For details, refer to the current edition of the AWS “Reinforcing Steel Welding Code.”

- (c) **Placing the Deadman.** Place each deadman in a trench so that the pull will be at right angles to the deadman, which shall bear on undisturbed earth. Bury each deadman a minimum of 6 feet (1.8 meters) to the bottom of the deadman. Backfill the trenches with soil compacted to the density of the adjacent undisturbed material.

603.05. METHOD OF MEASUREMENT.

Measure the *steel jacks* by the number of jacks constructed, placed, and anchored as specified. Measure the *steel cable* by the linear foot (meter) of cable as specified. Measure cable length from center to center of deadman for mainline jetty and from its tie to the main line jetty to center of deadman

for backup jetties. Excavation and backfill necessary to place deadmen shall be included in the unit price bid for each *deadman*.

Unless otherwise shown on the plans, excavation necessary to place steel jacks on the slopes shown on the plans shall be included in the unit price bid for each steel jack and meter of steel cable.

603.06. BASIS OF PAYMENT.

The accepted quantities of steel jetty bank protection, measured as provided above, will be paid for at the contract unit price as follows:

- (A) STEEL JACK EACH
- (B) STEEL CABLE LINEAR FOOT (METER)
- (C) DEADMAN EACH

Such price shall include all cost of materials, labor and equipment necessary for installation of the steel jetty bank protection in place.

**SECTION 605
DAMPPROOFING**

605.01. DESCRIPTION.

Dampproofing shall consist of furnishing materials and placing a prime coat of asphalt and two coats of hot asphalt as shown on the Plans or established by the Engineer.

605.02. MATERIALS.

Materials shall meet the requirements specified in the following Subsections of Section 700 - Materials:

Priming Coat	716.01
Asphalt Coats	716.03

605.04. CONSTRUCTION METHODS.

- (a) **Preparation of Surface.** On surfaces to be dampproofed, dress off all projections and point up all holes with mortar. Remove the outside film of cement by brushing with wire brushes and washing with clean water. Before applying the prime coat, thoroughly clean the surface of dust and loose materials, and make certain the surface is completely dry

NOTE: Priming coat shall not be applied in wet weather nor when the temperature is below 35°F (2°C) without special authorization from the Engineer.

- (b) **Priming Surface.** Immediately after the surface is prepared and in proper condition, apply a prime coat to all concrete surfaces requiring dampproofing, as directed above. Completely cover the surface to be dampproofed with a uniform continuous film of the priming coat applied at the rate of 1.25 gallon per 100 square feet (0.5 liters per square meters).

- (c) **Dampproofing.** After the surface has been primed, cover the entire surface shall with two coats of hot asphalt as specified above.

NOTE: Asphalt shall not be heated above a temperature of 350°F (177°C) and shall be stirred frequently while being heated. Kettles shall be equipped with armored thermometers.

Mop each coat completely and cover it with a continuous heavy film applied at the rate of 25 pounds per 100 square feet (1.2 kilograms per square meter). Where any breaks or thin spots show in the dampproofed surface after drying, retouch them to secure an even, impervious coating.

After the first coat is thoroughly set—and not less than one hour after its application—apply a second coat.

605.05. METHOD OF MEASUREMENT.

Dampproofing will be measured by area in square yards (square meters) within the lines shown on the Plans or where specified.

605.06. BASIS OF PAYMENT.

Accepted dampproofing, measured as provided above, will be paid for at the contract unit price as follows:

DAMPPROOFING SQUARE YARD (SQUARE METER)

Such payment shall be full compensation for furnishing all materials, equipment, labor, and incidentals to complete the work as specified.

**SECTION 606
WATERPROOFING**

606.01. DESCRIPTION.

This work shall consist of furnishing materials and placing membrane waterproofing in reasonably close conformity with the dimension as shown on the Plans or established by the Engineer.

The membrane shall be of the type shown on the Plans or as specified and shall be one of the following:

Type A. Two layers of bitumen-treated cotton fabric and four moppings of hot asphalt or coal-tar pitch.

Type B. Three layers of bitumen-treated cotton fabric and four moppings of hot asphalt or coal-tar pitch.

Type C. Two layers of bitumen-treated felt, one middle layer of bitumen-treated cotton fabric, and four moppings of hot asphalt or coal-tar pitch.

Type D. Four layers of bitumen-treated felt, one middle layer of bitumen-treated cotton fabric, and six moppings of hot asphalt or coal-tar pitch.

606.02. MATERIALS.

Materials shall meet the requirements specified in the following Subsections of Section 700 - Materials:

Priming Coat	716.01 & 716.02
Mop Coats	716.03 & 716.04
Asphalt Felt	717.01
Treated Fabric	717.02
Plastic Cement	717.03
Insulating Paper	717.04
Butyl Rubber Membrane	717.05

606.04. CONSTRUCTION METHODS.

- (a) **Preparation of Surface.** On surfaces to be waterproofed, dress off all projections and point up all holes with mortar. Remove the outside film of cement by brushing it with wire brushes and washing it with clean water. Before applying the prime coat, thoroughly clean the surface of dust and loose materials, and make certain the surface is completely dry.

NOTE: Do not apply a priming coat in wet weather or when the temperature is below 35°F (2°C).

- (b) **Priming Surface.** Immediately after the surface is prepared and in proper condition, cover all concrete surfaces requiring waterproofing with a priming coat of asphalt or creosote meeting the requirement of Section 716. Completely cover the surface to be waterproofed with a uniform continuous film of the priming coat.

- (c) **Application.**

NOTE: Do not apply membrane waterproofing when the atmospheric temperature is below 50°F (10°C). Surfaces to be waterproofed shall be dry and clean, and concrete shall be well cured before waterproofing is applied. Before starting, remove any projections that might injure the membrane.

Make sure the waterproofing is free from punctures, pockets, or folds, and that there are no depressions or pockets in the horizontal surfaces of finished waterproofing, which shall be turned into the drainage castings without a break in the membrane. Take special care to make the waterproofing effective along the sides and ends of girders and at stiffeners, gussets, etc. Fill grooves with plastic cement meeting the requirements of these Specifications.

On the surfaces that are vertical or nearly so, lay the strips of cotton fabric or felt vertically, or with the slope. On other surfaces, lay the strips shingle fashion, beginning at the lowest part of the surface to be waterproofed. Allow sufficient cotton fabric or felt for a 6 inch (150 mm) lap or anchorage at the upper edge of the surface to be waterproofed.

If surfaces of concrete or steel come into contact with asphalt waterproofing, give them one coat of asphalt primer before the first mopping of asphalt, or one coat of creosote primer before the first mopping of coal-tar pitch—except where insulation is to be used at expansion joints. Work the primer in well to give a uniform coating. Apply the priming coat approximately 24 hours before applying the waterproofing membrane, and dry it before the first mopping is applied.

Surfaces to be waterproofed are to be mopped in sections. While the first mopping of bitumen is still hot, lay a strip of cotton fabric or felt on the mopping and press it into place.

Apply each mopping thereafter so that it will completely cover and seal the cotton fabric or felt. The amount of bitumen used for each mopping shall be not less than 4 1/2 gallon per 100 square feet (1.8 liters per square meter) of surface.

NOTE: Do not heat asphalt above 350°F (177°C) or coal-tar pitch above 250°F (121°C). Kettles shall be equipped with armored thermometers. Stir the bitumen frequently while heating it.

Start two-ply work by mopping a section of the surface 2 inches (50 mm) wider than half the width of the cotton fabric or felt. On this hot mopping, lay a half width of the cotton fabric or felt. Then mop the top surface of this cotton fabric or felt plus an adjacent section of the surface 2 inches (50 mm) wider than a half width of the cotton or felt. On this mopping, lay a full width of the cotton fabric or felt, completely covering the first strip. Thereafter, lay full widths of the cotton fabric or felt in hot moppings, and in such manner that each strip will lap the second preceding strip by 2 inches (50 mm) and end laps not less than 12 inches (300 mm).

The procedure for three-ply work is the same as for two-ply work, except make the first strip a one-third width of the cotton fabric or felt; make the second strip a two-thirds width; and make the third and succeeding strips full width. Make the second full strip lap the first strip at least 2 inches (50 mm).

Build up membrane waterproofing consisting of more than three-ply in shingle fashion similar to three-ply work by addition of as many ply as required.

Regulate the work so that at the end of the day all fabric or felt that has been laid will have received the final coat of bitumen.

NOTE: Do not patch the work without permission from the Engineer. Where patching is permitted for defective waterproofing, it shall extend at least 12 inches (300 mm) beyond the outermost edge of the defective portion. The second and each succeeding ply of the patch shall extend at least 3 inches (75 mm) beyond the preceding ply.

At construction joints, omit the primer for a width of 18 inches (450 mm) of the surface and lay a strip of insulating paper before applying waterproofing.

Fill expansion joints with plastic cement conforming to these Specifications. Dry and clean joints immediately before they are filled, overfilling them slightly to allow for shrinkage in drying.

606.05. METHOD OF MEASUREMENT.

Measure *waterproofing* of the type specified by the area in square feet (square meters) within the lines shown on the Plans or specified.

606.06. BASIS OF PAYMENT.

Accepted waterproofing, measured as provided above, will be paid for at the contract unit price as follows:

- (A) WATERPROOFING TYPE A SQUARE FEET (SQUARE METERS)
- (B) WATERPROOFING TYPE B SQUARE FEET (SQUARE METERS)
- (C) WATERPROOFING TYPE C SQUARE FEET (SQUARE METERS)
- (D) WATERPROOFING TYPE D SQUARE FEET (SQUARE METERS)

Such payment shall be full compensation for furnishing all materials, equipment, labor, and incidentals to complete the work as specified.

**SECTION 607
ASPHALT PLANKING**

607.01. DESCRIPTION.

This work shall consist of furnishing materials and placing asphalt plank in reasonably close conformity with the dimensions as shown on the Plans or established by the Engineer.

607.02. MATERIALS.

Materials shall meet the requirements specified in the following Subsections of Section 700 - Materials:

Asphalt	708.03
Asphalt Plank	718.01

607.04. CONSTRUCTION METHODS.

First, protect the surface by coating it with hot asphalt.

NOTE: Not less than 50 pounds of asphalt per 100 square feet (2.4 kilograms of asphalt per square meters) shall be used. Place the planks while this asphalt coating is still hot. Heavily coat the edges of the planks with hot asphalt as they are set. Set the planks as closely together as possible, pushing each one tightly against the previously laid plank in such a manner as to completely fill the joints between the planks with hot asphalt—until you squeeze a small amount of asphalt out of the joints. If any joints are not completely closed after all the planks have been placed, fill them with hot asphalt.

When necessary to cut plank lengthwise or at ends, make the cuts in a professional manner.

607.05. METHOD OF MEASUREMENT.

Measure *asphalt planking* by the area in square feet (square meters).

607.06. BASIS OF PAYMENT.

Accepted asphalt planking, measured as provided above, will be paid for at the Contract unit price as follows:

- ASPHALT PLANKING SQUARE FEET (SQUARE METERS)

Such payment shall be full compensation for furnishing all materials, equipment, labor, and incidentals to complete the work as specified.

SECTION 609

INTEGRAL CURB, COMBINED CURB AND GUTTER BITUMINOUS CURBING AND HEADER CURBING

609.01. DESCRIPTION.

This work shall consist of the construction of integral curb, combined curb and gutter, header curbing, or bituminous curbing, in accordance with these Specifications and in reasonably close conformity with the lines, grades, and dimensions shown on the Plans or established by the Engineer.

609.02 . MATERIALS.

Concrete for integral curb, combined curb and gutter, or header curbing shall be Class A concrete meeting the requirement of Section 701.

Asphalt concrete used for asphalt curbing shall meet the requirements of Subsection 708.04 Type B or C mix, except that the asphalt content shall be approximately 1.15 times the content required by the job-mix formula in the basic mix.

Sealing materials for concrete curbs shall conform to Subsection 701.08. Materials for sealing new concrete pavements and for most joint rehabilitation applications shall be in accordance with Subsection 701.08(f); materials for sealing joints in integral concrete curb and combined curb and gutter shall be in accordance with Subsection 701.08(d), unless otherwise approved by the Engineer.

609.03. EQUIPMENT.

If a curb machine is used, it shall be capable of extruding a uniformly textured material to the shape and density specified and placing it in reasonably close conformity to the established line and grade.

609.04. CONSTRUCTION METHODS.

- (a) **Excavation.** Excavate to the required depth, and compact the base upon which the curb is to be set to a firm, even surface. Remove all soft and unsuitable material, and replace it with suitable material which is then thoroughly compacted.
- (b) **Forms.** Make forms from wood, metal, or other suitable material, taking care that they are straight, free from warp, and of such construction that there will be no misalignment of grade. All forms shall extend for the entire depth of the curb or curb and gutter and shall be braced and secured sufficiently so that no deflection from alignment or grade will occur during the placing of the concrete or asphalt.

Shimming to the bottom of the forms is not to exceed 2 inches (50 mm) in built-up thickness for special curb sections to provide the specified thickness. The material and method of fastening the built-up section to the form shall be approved by the Engineer prior to use.

Clean and oil or wet forms before placing the concrete. Make them sufficiently tight to prevent leakage.
- (c) **Placing Concrete.** Check forms, and place and vibrate concrete in accordance with Subsection 414.04.

- (d) **Surface Finish.** As soon as the curb concrete has set sufficiently to retain its shape without support, obtain the final surface finish by uniformly brushing the surface in a manner approved by the Engineer.

Neatly edge all formed concrete joints—including edges at expansion and contraction joints or planes of weakness joints—to the required radius.

- (e) **Joints.** Make all joints in curbs perpendicular to the subgrade at right angles to the longitudinal axis of the curb. Construct expansion and contraction joints at the same location as similar joints in the paving slab.

For expansion joints, use premolded expansion joint filler of the thickness—and placed at the locations—shown on the Plans or as approved by the Engineer. Place curb and gutter joints opposite the joints in the pavement meeting requirements of section 701.08.

When contraction joints in curb and gutter are used in conjunction with asphalt surfacing, saw them as specified in Subsection 609.04(h) and seal them with the same material specified for sealing expansion joints.

- (f) **Curb Openings.** Where curb is to be omitted for driveways, or other cause, either all or only the top portion of the separate curb may be omitted as shown on the Plans or approved. In general, only the curb will be left off of combined curb and gutter. Where the bottom portion of separate curb or the gutter of combined curb and gutter is left in place, make the concrete slightly higher at the back of the curb line than at the front, as shown on the Plans or as approved. Such curb shall be considered as regular curb for measurement and payment.

- (g) **Curing.** Cure concrete curbs or combined curb and gutter in accordance with Section 414.

- (h) **Extruded Method.** When the extruded method is used to construct combined curb and gutter, operate the extrusion machine on a string or wire line, with the rails or forms set at a uniform depth below the predetermined finished top of curb grade.

Feed concrete to the machine uniformly, and make it of such consistency that after extrusion the concrete will maintain the shape of the section without support. The finished curb or curb and gutter shall present a well-compacted mass; its surface shall be free from voids and honeycomb and reasonably true to established shape, line, and grade. When additional surface finishing is required, perform it immediately after extrusion. Tolerances shall meet the requirements of Subsection 414.04(t).

Construct joints at the same locations as required when form construction is being used. Make weakened joints, spaced at 20 foot (6 meter) intervals, by sawing, unless other methods are approved by the Engineer.

- (i) **Bituminous Curbing.** The Engineer may permit the construction of curbing by means other than the automatic curber or machine when short sections or sections with short radii are required, or for such other reasons as approved by the Engineer. The resulting curbing shall conform in all respects to the curbing produced by the use of the machine.

Construction methods shall be in accordance with Subsection 411.04, paragraphs (a) to (g) inclusive, except as amended by the next two paragraphs.

**INTEGRAL CURB, COMBINED CURB AND GUTTER BITUMINOUS CURBING
AND HEADER CURBING**

609.04

Before placing the bituminous mixture, establish one edge of the bituminous curb by a string or wire line. Lay the bituminous mixture within the lowest practical temperature range which is found to give the best results with the particular mix and machine being used for the job. Once the optimum temperature is established for a given job, do not vary that temperature by more than 20°F (11°C).

- (j) **Backfill.** Backfill the back side of the curbs with approved earth, and thoroughly compact it in layers not exceeding 6 inches (150 mm) in depth and neatly graded as shown on the Plans or as approved by the Engineer. Take care not to damage the concrete in placing or compacting the backfill; any damage will be repaired at no additional charge.

609.05. METHOD OF MEASUREMENT.

Curbing will be measured by the linear foot (meter) along the front face of the curb for (A) concrete curb, (B) combined curb and gutter, (C) concrete header curbing, and (D) bituminous curbing.

609.06. BASIS OF PAYMENT.

The accepted quantities, measured as provided above, will be paid for at the contract unit price as follows:

- (A) CONCRETE CURB LINEAR FOOT (METER)
- (B) COMBINED CURB AND GUTTER LINEAR FOOT (METER)
- (C) CONCRETE HEADER CURBING LINEAR FOOT (METER)
- (D) BITUMINOUS CURBING LINEAR FOOT (METER)

Such payment shall be full compensation for furnishing all materials, equipment, labor, and incidentals to complete the work as specified.

SECTION 610

**CONCRETE OR BITUMINOUS SIDEWALKS, DRIVEWAYS,
AND DIVIDING STRIP**

610.01. DESCRIPTION.

This work shall consist of the construction of bituminous or concrete sidewalks, driveways, and dividing strips in accordance with these Specifications and in reasonably close conformity with the lines, grades, and typical cross sections shown on the Plans or established by the Engineer.

610.02. MATERIALS.

Material shall meet the requirements specified in the following Subsections of Section 700 - Materials:

Bituminous Mixture	708.04
Portland Cement Concrete, Class A	701.01

610.04. CONSTRUCTION METHODS.

- (a) **Concrete Construction.** All forming, placing, and finishing shall be in accordance with Subsection 414.04 except that the final surface finish of concrete sidewalks, driveways, and divider strips shall be broom finished, burlap drag, or completed as directed by the Engineer. Make a sawed joint to connect the old and new pavements.

Expansion Joints. Make expansion joints of the dimensions specified, and fill them with the type of premolded expansion joint filler noted in the plans.

Dummy Joints. Divide the sidewalk into sections with dummy joints formed by a jointing tool or other acceptable means as approved by the Engineer. These dummy joints shall extend into the concrete for at least 1/3 of the depth and shall be approximately 1/8 inch (3 mm) wide.

Construction Joints. Form construction joints around all appurtenances such as manholes, utility poles, etc., extending them into and through the sidewalk, driveway, or dividing strip. Into these joints install premolded expansion joint filler 1/4 inch (6 mm) thick. Also install expansion joint filler, of the thickness indicated, between the concrete and any fixed structure, such as a building or bridge, extending it for the full depth of the concrete.

Curing. In accordance with Section 414.04(m), cure concrete for at least 72 hours by means of moist burlap or mats or by other approved methods. During the curing period, exclude all traffic—both pedestrian and vehicular; in addition, vehicular traffic may also be excluded for such additional time as the Engineer directs.

- (b) **Bituminous Construction.** Excavation and forms shall meet the requirements of Subsection 609.04(a) and (b). Construction methods shall be in accordance with Subsection 411.04.

Place the material on the compacted subgrade in one or more courses as indicated so as to give the required depth when rolled.

To compact the material, use a hand-operated or power roller of a type and weight acceptable to the Engineer. In areas inaccessible to the roller, hand tamping will be permitted. In any case, compact the bituminous sidewalk material so that it's uniform.

- (c) **Backfill.** Backfill the sides of sidewalks and driveways as soon as the forms have been removed and the required pointing up of honeycombed areas completed. The backfill shall be of approved earth, thoroughly compacted in layers not exceeding 6 inches (150 mm) in depth as shown on the Plans or in a manner approved by the Engineer. Take care not to damage the concrete or bituminous material in placing or compacting the backfill.

Where the general elevation of the adjacent ground surface is lower than the top of the sidewalk or driveway, the minimum width of the backfill shall be 2 feet (0.6 meters).

- (d) **Protection from Traffic.** Protect sidewalks, driveways, and dividing strip from traffic—using substantial barricades—for a period of seven days for concrete and one day for bituminous construction, unless otherwise permitted or ordered by the Engineer.

- (e) **Remove Relay or Extend Brick or Stone Sidewalks.** Where existing brick or stone sidewalks are to be relaid or extended, prepare the subgrade as specified for concrete sidewalks, providing a sand cushion 1 1/2 inches (38mm) in depth that has a uniform flat surface at the proper subgrade elevation. Satisfactorily clean all old bricks before relaying them. Lay the brick or

610.04 CONCRETE OR BITUMINOUS SIDEWALKS, DRIVEWAYS, AND DIVIDING STRIP

stone close together in a manner to match the existing walk, and uniformly tamp it firmly into the sand cushion. Make the top surface of the walk shall be smooth and at the proper grade. Fill all joints with 1:2 mortar grout by spreading an excess over the surface and sweeping it into the joints. Then clean the top surface of the brick. Backfill the sides of the walk as specified for concrete walks.

610.05. METHOD OF MEASUREMENT.

Concrete sidewalks, driveways, and dividing strip will be measured by the square yard (square meter). *Bituminous sidewalks, driveways and dividing strip* will be measured by the ton (metric ton) or by the square yard (square meter) of bituminous material. *Removing, relaying, or extending of brick or stone sidewalks* will be measured by the square yard (square meter).

610.06. BASIS OF PAYMENT.

The accepted quantities, measured as provided above, will be paid for at the contract unit price as follows:

- (A) CONCRETE SIDEWALK SQUARE YARD (SQ. METER)
- (B) CONCRETE DRIVEWAY SQUARE YARD (SQ. METER)
(HIGH EARLY STRENGTH)..... SQUARE YARD (SQ. METER)
- (C) CONCRETE DIVIDING STRIP SQUARE YARD (SQ. METER)
- (D) REMOVE AND RELAY BRICK OR
STONE SIDEWALK.. SQUARE YARD (SQ. METER)
- (E) BRICK OR STONE SIDEWALK SQUARE YARD (SQ. METER)
- (F) BITUMINOUS SIDEWALK SQUARE YARD OR TON
..... (SQUARE METER OR METRIC TON)
- (G) BITUMINOUS DRIVEWAY SQUARE YARD OR TON
..... (SQUARE METER OR METRIC TON)
- (H) BITUMINOUS DIVIDING STRIP SQUARE YARD OR TON
..... (SQUARE METER OR METRIC TON)

Such payment shall be full compensation for furnishing all materials, equipment, labor, and incidentals to complete the work as specified.

Reinforcement, if used, excavation, backfill, expansion joint material, rolled curb on driveways, and other related miscellaneous items will not be paid for separately, but the cost thereof shall be included in the cost of other items.

SECTION 611
MANHOLES, DROP OR CURB INLETS,
AND JUNCTION BOXES

611.01. DESCRIPTION.

This work shall consist of the construction of manholes, drop or curb inlets—Including special curbs—junction boxes, or similar structures in accordance with the Plans and these Specifications, and in reasonably close conformity with the lines, grades, and elevations shown on the Plans or established by the Engineer.

The Contractor shall have the option of furnishing precast concrete units in lieu of brick masonry or cast-in-place concrete structures unless otherwise shown on the Plans.

611.02. MATERIALS.

- (a) **General.** Materials shall meet the requirements specified in the following Subsections of Section 700 - Materials:

Portland Cement	701.02
Mortar Sand	701.05
Clay or Concrete Brick	714.01 & 714.02
Reinforcing Steel	723.01 & 723.02
Structural Steel	724
Steel Castings	725.03
Iron Castings	725.04
Precast Manholes	726.02

Portland cement concrete shall be Class A and shall meet the requirements of Subsection 701.01.

Concrete brick or precast concrete block units shall not be used in the construction or rebuilding of sanitary sewer manholes.

Construct manholes, inlets, and junction boxes of approved design with precast concrete units. All precast structures with slab tops which may be subject to traffic shall meet H-20 loading requirements.

Use Class A concrete for precast units. The coarse aggregate shall conform to Subsection 701.06. Coarse aggregate for thin section concrete shall be Size No. 7. Alternate material shall be concrete referenced in AASHTO M 199 (ASTM C 478).

Reinforcing steel for precast concrete units shall conform to the requirement of Subsections 723.01, 723.02 and 723.03. Alternate material shall be steel referenced in AASHTO M 199 (ASTM C 478).

- (b) **Portland Cement Mortar.** With brick masonry, use mortar composed of one part portland cement and two parts mortar sand by volume, mixed with sufficient water to form a plastic consistency. You may use hydrated lime not to exceed 10 percent by volume of the amount of cement, but when used, it must added to the cement first and in such proportions that the mortar will be considered as cement.
- (c) **Accessories.** Accessories—such as bolts, rivets, spacers, small I-beams, channels, and plates used for assembling or supporting frames, gratings, or covers—shall be of first quality standard commercial material free from defects which may affect their value for the service intended.

611.03. EQUIPMENT.

Specialized equipment required for off-loading, handling, and placement must be capable of safely handling the largest single unit and/or subassemblies. Provide lift holes or lift rings in each unit at the manufacturer's discretion; all lift devices and/or connection points shall be safe for handling above ground and in the inlet excavation.

611.04. CONSTRUCTION METHODS.

- (a) **Concrete.** In the construction of concrete bottoms for manholes and inlets, round the concrete to the dimensions and shape, and trowl and retrowel the surface until a uniform, smooth, and impervious hard fanned finish is obtained.

All exposed concrete edges shall have a minimum 1/2 inch (13 mm) chamfer, or an approved rounded edging. All exposed concrete surfaces shall be finished in accordance with Subsection 509.04(g).

- (b) **Clay Brick or Concrete Brick.** Brick masonry in circular or curved walls which have a radius of less than 2 feet (0.6 meters) shall have every fifth course stretchers, and the remainder shall have headers; and the thickness of joints shall not exceed 1/4 inch (6 mm) vertical on the inside face or 3/8 inch (10 mm) horizontal. Brick masonry in straight walls—and in walls where the radius of curvature is 2 feet (0.6 meters) or greater—shall have every fifth course headers, and the remainder shall be stretchers; and all joints shall have a thickness not exceeding 3/8 inch (10 mm). Vertical joints in adjacent courses shall be broken approximately half the length or width of the brick, as the case may be.

Lay all brick in a full bed of mortar, and make all joints shoved joints, completely filled with mortar.

NOTE: Buttered joints will not be permitted.

The joints on the inside face or exposed face of the masonry shall be rubbed full and cut as the brick work is built up. Build up the masonry in level courses that are reasonably true to line, grade, and dimension. Use bats only when necessary to close joints, or around irregular openings. Thoroughly wet down all brick immediately before placing it. Complete all work—and finish it—in a careful, professional manner. Thoroughly clean and wet old brick masonry before joining new masonry to it. Where a mortar coating is required, it shall have the minimum thickness shown on the Plans; apply it while the brick masonry is clean and damp, then trowl and retrowel until a uniform, smooth, and relatively impervious surface is obtained.

- (c) **Pipe Connections.** Use inlet and outlet pipe of the size indicated on the Plans or as required by the Engineer. Make the end of the pipe flush with the inside of the wall, and tightly seal it in the wall with mortar throughout the circumference of the pipe. Remove the lip of the female end of the pipe and press in and trowel off the mortar flush with the face of the wall.
- (d) **Special Curb.** Curbs adjacent to sewer inlets shall be the same kind of concrete as that used in the regular curb, or where no regular curb is being built, shall be Class A concrete. Accurately shape the forms for the curb opening to the dimensions specified on the Plans and secure them in true position. They shall remain in place not less than three days under favorable curing conditions and as much longer as approved by the Engineer under unfavorable conditions.
- (e) **Reinforcing Steel.** Place all reinforcing steel in accordance with Section 511.
- (f) **Castings, Grating and Drop Inlet Gratings and Special Frames.** With all castings, gratings, or special frames or supports, accurately and rigidly assemble them and place them carefully as shown on the Plans. Bed the frames of all manhole frames and covers as well as inlet frames and gratings in a substantial layer of mortar, with a full bearing, and set these to the exact grade required. Unless otherwise shown on the Plans, make the top of such casting flush with the surrounding surface.

Finish exposed surfaces of special structural steel frames and supports as provided in Section 506.

- (g) **Excavation and Backfill.** Excavate to the required depth, and compact the base upon which the manhole, inlet, or junction box is to be set to a firm, even surface. Remove all soft and unsuitable material, and replace it with suitable material, thoroughly compacting it.
- (h) **Precast Units.** Bed precast concrete units on a 2 inch (50 mm) minimum thick solid foundation of reasonably clean uniformly graded material capable of being mechanically leveled or leveled by flooding, or floated on a lean grout.

NOTE: No clay balls or cement clumps will be allowed. Anchor the units securely to prevent lateral or vertical movement if any type of sand flooding or grout pouring is used for bedding and/or backfilling. As soon after placement as is practicable, backfill inlet excavation and thoroughly compact it in incremental lifts or by sand flooding.

Place entrance and exit conduits (round, oval, elliptical, arch pipe, or concrete boxes) with their flowlines as shown on the Plans.

NOTE: Under no circumstances will the elevation or angle be altered to facilitate ease of installation or to make use of an existing blockout.

Set precast concrete inlet units (main boxes and additional opening boxes) flush or slightly below the subgrade to allow free travel of the paving equipment. If precast concrete inlet assemblies are set at subgrade elevation, use a bedded brick (fired clay or concrete) leveling course to bring the inlet assembly to final working grade. A formed and poured concrete collar may also be used. Pin it to the inlet box and additional opening boxes in a manner approved by the Engineer.

All precast concrete units shall provide a soil-tight connection between subassemblies and at each entrance or exit conduit blockout. If a unit is delivered with a blockout placed in

error, or if the Plans are altered to render a blockout unnecessary, clean the hole and fill it with an approved concrete patch. The patch may be from a previous blockout hole securely grouted in place or poured and/or placed using a dry-mix high-strength concrete.

Gasket material used between subassemblies, or between the inlet unit and entrance or exit conduits, shall be chosen from the list of approved adhesive materials maintained by the Department's Materials Division.

When precast manholes are used, properly seal all joints and the base to prevent the passage of water, in accordance with Subsection 613.04(e,) with the following exception: joints shall be made with a single natural rubber or neoprene gasket or 'O' ring, in accordance with the manufacturer's recommendations.

611.05. METHOD OF MEASUREMENT.

The accepted items of this Section will be measured for payment in the following manner:

- (a) **Manholes.** Measure manholes—except special manholes, that do not exceed 5 feet (1.5 meters) in depth, as measured from the bottom of the frame cover casting to the flow line of the outlet lead—for payment as manhole and include the walls and the concrete bottom.
- (b) **Additional Depth in Manholes.** Measure manholes—except special manholes, exceeding 5 feet (1.5 meters) in depth—as set out above; and measure the depth in excess of 5 feet (1.5 meters) by the vertical foot (meter) of wall and classified for payment as additional depth in manhole.
- (c) **Special Manholes.** Measure special manholes by the cubic foot (cubic meters) of wall constructed based on an 8 inch (200 mm) thick wall with deductions made for all openings. Measure concrete used in the base for payment in accordance with Section 509.
- (d) **Frames, Covers and Grates.** Measure frames, covers, and grates for manholes and junction boxes by each manhole frame and cover, manhole frame, manhole cover, or manhole cover grate.

Include the cost of support beams for installation in junction boxes in above measured items, instead of measuring them separately.

Include the cost of 'T' handles for locking manhole covers in measurement for the above items. Two handles will be furnished for up to and including 20 locking manhole covers and one for every 20 thereafter.

- (e) **Inlets.** Measure inlets by each unit. Measure units for inlet boxes (single or double) and additional curb opening boxes complete in place by inlet per each unit specified by configuration and based upon a specified maximum depth (see current standard drawing for dimensioning).
- (f) **Additional Depth in Inlets.** Measure additional depth in inlet for inlet boxes (single or double) and additional curb opening boxes by the vertical foot (meter) for each unit specified by configuration for that portion greater or deeper than the specified maximum depth, as shown on the current standard drawing.
- (g) **Frames and Grates for Inlets.** Measure frames and grates for inlets by each inlet frame and grate, inlet frame, or inlet grate, complete in place and accepted.

Do not measure separately (1) the cost of support beams and/or support beams with riser plates and (2) bolts and nuts necessary for installation as shown on the Plans; instead, include them in the above measured items.

- (h) **Cast Steel Grate.** With special frames, measure cast steel grates for payment without the cast iron frame for each grate.
- (i) **Special Structural Steel Frames.** Measure special structural steel frames by each such frame, complete in place, or by the pound (kilogram) of structural steel frames if so provided on the Plans or in the proposal. Painting will not be measured as a separate item, but the cost of painting shall be included in the price bid for the structural steel frame.
- (j) **Junction Boxes.** Measure junction boxes by the cubic foot (cubic meter) of wall constructed, based on an 8 inch (200 mm) thick wall. Deductions will not be made for openings made by pipes having an 18 inch (450 mm) nominal diameter or less.
- (k) **Cast Iron Curb Inlets.** Measure cast iron curb inlets by the unit, complete in place.
- (l) **Drop Inlet Grates.** Measure drop inlet grates by the unit, complete in place.
- (m) **Special Inlet Curb.** Measure special inlet curb for payment by the linear foot (meter), complete in place and accepted.
- (n) **Welded Steel Grate.** Welded steel grate will be measured by the unit, complete in place.

611.06. BASIS OF PAYMENT.

Accepted quantities, measured as provided above, will be paid for at the contract unit price as follows:

(A)	MANHOLE	EACH
(B)	ADDITIONAL DEPTH IN MANHOLE VERTICAL FOOT (VERTICAL METERS)	
(C)	SPECIAL MANHOLE	CUBIC FOOT (CUBIC METERS)
(D)	MANHOLE FRAME AND COVER	EACH
(D)	MANHOLE FRAME	EACH
(D)	MANHOLE COVER	EACH
(D)	MANHOLE COVER GRATE.....	EACH
(E)	INLET	EACH
(F)	ADDITIONAL DEPTH IN INLET	VERTICAL FOOT (VERTICAL METERS)
(G)	INLET FRAME AND GRATE	EACH
(G)	INLET FRAME	EACH
(G)	INLET GRATE	EACH
(H)	CAST STEEL GRATE	EACH
(I)	SPECIAL STRUCTURAL STEEL FRAMES	EACH
(J)	JUNCTION BOXES	CUBIC FEET (CUBIC METERS)
(K)	CAST IRON CURB INLETS	EACH
(L)	DROP INLET GRATES	EACH
(M)	SPECIAL INLET CURB	LINEAR FOOT (METERS)
(N)	WELDED STEEL GRATE	EACH

Such payment shall be full compensation for furnishing all materials, equipment, labor, and incidentals to complete the work as specified.

Excavation and backfill will not be measured for payment; instead these costs will be included in the unit price or prices bid for various pay items.

Reinforcing steel will be included as part of the cost of the structure, complete, and will not be measured as a pay item.

SECTION 612

ADJUSTMENT OF EXISTING STRUCTURES

612.01. DESCRIPTION.

This work shall consist of adjusting, altering, relocating, or resetting to the required grade and aligning existing structures, equipment, or appurtenances; this applies to only those structures which are not to be removed or abandoned and which are not the property of a private company, firm, or corporation which would be required to move its own property. All work shall be in accordance with these Specifications and in reasonably close conformity with the lines, grades, elevations, and dimensions shown on the Plans or approved by the Engineer.

When specified on the Plans or shown in the Proposal, this work shall include refurbishing and resetting existing electrical equipment taken from storage.

612.02. MATERIALS.

Materials for use in this work—including the existing item to be adjusted or reset and any new material necessary—shall be specified on the Plans, or if not specified, shall be of the same grade of material as specified elsewhere in these Specifications or for a similar type work, or of a material equivalent to that in the structure being adjusted.

612.04. CONSTRUCTION METHODS.

- (a) **General.** The materials and workmanship necessary in raising, lowering, or otherwise adjusting or resetting existing structures shall conform to the requirements of the Plans and Specifications for the class of work involved, or as approved by the Engineer. Rebuild existing structures in accordance with the Plans and Specifications. If the structure is in the pavement, complete the final adjustment to grade after the final surface course has been placed.

Guard against damage or breakage to any portion of the structure or appurtenance to be altered, removed, or reset. Any damage or breakage due to failure to properly protect such structure or appurtenances shall be repaired or replaced at the Contractor's expense.

At the Contractor's expense, transport items to be reset from the storage site, and reset them as shown on the Plans. Repair or replace any items damaged as a result of failure to properly transport, adjust, or reset the structure or appurtenance. If the Plans specify an existing item to be modified, cleaned, repaired, or otherwise made ready for reuse, do this work in accordance with the Plan requirements, prior to resetting them at the planned location.

- (b) **Manholes.** Where the tops of the manholes are to be lowered to a new grade, remove the walls and rebuild them to an elevation far enough below the new grade so that the maximum batter of the walls does not exceed 4 inches per foot (330 mm per meter).

Where manholes are to be built up a distance of 1 foot (300 mm) or less to a new grade, the walls may be carried up vertically. Where the walls are to be built up a distance exceeding 1 foot (300 mm), first remove the existing walls to the bottom of the batter section, or to such elevation that the inside diameter of the manhole is not less than 3 feet (one meter). After that, rebuild the manhole in conformity with the size and shape requirements for new manholes.

- (c) **Catch Basins, Inlets, Manholes.** Where inlets, catch basins, manholes or similar structures are to be revised to grade or rebuilt, do the work in conformity with the requirements for new construction of this class of work as provided in 611 of these Specifications.
- (d) **Valve Boxes, Meter Boxes, Lampholes.** Take care in removing valve boxes, meter boxes, etc., and resetting them to grade, to avoid breaking; any damage must be replaced at the Contractor's expense.
- (e) **Fire Hydrants, Valves, Water Meters, Waterlines, Manholes, Etc.** Where adjustment or relocation of waterlines and appurtenances is to be done by the owner, the Contractor shall be responsible for coordinating the arrangements with the owner for lowering or relocating of all waterlines and the resetting of water valves, meters, manholes, and fire hydrants. When the alteration is part of the work to be performed by the Contractor as a part of the contract, perform such work in conformity with the requirements of the owner as well as in accordance with the requirements of these Specifications for new work of this type.
- (f) **Traffic Signal or Highway Lighting Systems.** When the adjustment or relocation of traffic signals or highway lighting systems requires new concrete footing or other concrete appurtenances, construct these concrete structures in accordance with the details shown on the Plans and arrange for them to be paid for in other items of work, unless otherwise specified.

If items are to be reused—such as signal heads, luminaries, etc.—inspect them for damage and repair if necessary; then clean them thoroughly, and relamp them with a new lamp of the original size and type before reinstalling the items.

Dispose of materials that are not reusable—such as wiring, connectors, fuses, conduit, etc.—in a manner approved by the Engineer. Furnish all additional new materials necessary to complete the installation as specified and to make the system operational; they shall be paid for in other items of work.

After adjusting and/or resetting the items specified in this work and after the electrical connections have been completed, energize and test the traffic signal or highway lighting system in a manner approved by the Engineer. Correct any item that fails to function as specified to the satisfaction of the Engineer.

- (g) **Pipe Sewers.** If pipe sewers and appurtenances are to be removed and relaid, perform this work in conformity with the requirements for new sewers.
- (h) **Waterlines.** If waterlines and appurtenances are to be removed and relaid or lowered, perform this work in conformity with the requirements for new waterlines.

612.05. METHOD OF MEASUREMENT.

Structure to be adjusted and/or reset, or relaid, will be measured by each unit of the type and size specified or on the lump sum basis, if stipulated, complete with all necessary accessories, and will be operationally tested.

612.06. BASIS OF PAYMENT.

The accepted quantities of items, measured as provided above, will be paid for at the contract unit price as follows:

(A)	MANHOLES ADJUST TO GRADE	EACH
(B)	MANHOLES REBUILT	EACH
(C)	CATCH BASINS ADJUST TO GRADE	EACH
(D)	CATCH BASINS REBUILT	EACH
(E)	INLETS ADJUST TO GRADE	EACH
(F)	INLETS REBUILT	EACH
(G)	VALVE BOXES ADJUST TO GRADE	EACH
(H)	METER BOXES ADJUST TO GRADE	EACH
(I)	LAMPHOLES ADJUST TO GRADE	EACH
(J)	FIRE HYDRANT RESET	EACH
(K)	VALVES RESET	EACH
(L)	WATER METERS RESET	EACH
(M)	WATERLINE LOWERED	LINEAR FOOT (METERS)
(N)	WATERLINE REMOVED AND RELAID	LINEAR FOOT (METERS)
(O)	REMOVE & RELOCATE TRAFFIC SIGNAL	
	(Specific Item)	LUMP SUM
(P)	RESET LIGHT POLES	EACH
	(Specific Item)	
(Q)	ELECTRIC CABLE RELAID	LINEAR FOOT (METERS)
(R)	ELECTRIC CABLE CONDUIT RELAID	LINEAR FOOT (METERS)
(S)	PIPE SEWER REMOVED AND RELAID	LINEAR FOOT (METERS)
(T)	REMOVE AND RESET MANHOLE	
	FRAME AND COVER	EACH

Such payment shall be full compensation for furnishing all materials, equipment, labor, and incidentals to complete the work as specified.

Valve boxes, meter boxes, etc., in connection with valves or meters to be reset, will be considered as part of the valve or meter and will not be paid for as a separate item.

Valves in waterlines or fire hydrant leads will not be considered as a separate pay item, but the cost of resetting same shall be included in the contract unit price for the waterline or lead.

When the valve is under pavement, adjustment of the valve box will be a separate pay item.

Extensions to fire hydrant leads, when separately classified for payment, will be paid for as set out for the new waterlines under Section 616; otherwise cost of pipe for extending the lead shall be included in the contract unit price for fire hydrants reset.

SECTION 613 DRAINAGE CONDUITS

613.01. DESCRIPTION.

This work shall consist of the construction of pipe conduits of the type shown on the Plans in accordance with these Specifications and in reasonably close conformity with the lines and grades shown on the Plans or established by the Engineer. Included are the following:

- pipe underdrains 4 inches (100 mm) in diameter or greater
- all other pipe with an inside diameter of 12 inches (300 mm) or greater which is used in storm drains and culverts, or in drainage conduits not defined as bridges.

613.02. MATERIALS.

Drainage conduit shall be of the kind specified on the Plans and shall meet the requirements of Section 726. The class of reinforced concrete pipe—and the sheet thicknesses of the corrugated steel and corrugated aluminum pipe for various diameters and heights of fill above the top of pipes—shall be as shown on the standard drawings. When the class of reinforced concrete culvert pipe is not specified, it shall be Class III.

When not specified on the Plans, the kind of pipe will be optional, but the same kind of pipe shall be used throughout any one project, unless otherwise approved in writing by the Engineer.

Joint filler and cover materials shall meet the requirements specified in the following Subsections of Section 700 - Materials:

Joint Filler	726.02(a)
Cover Material For Pipe Underdrains	703.04

The type, size, class and quantity of pipe to be installed by jacking shall be as specified on the Plans.

613.04. CONSTRUCTION METHODS.

- (a) **General.** Begin construction of all pipe conduit at the outlet or the low point in the line. When the construction involves the building of main or submain drainage conduit having one or more laterals or tributaries, do not start the construction of tributary lines until the main or submain drainage conduit has been completed to the point where the tributary or laterals discharge into it.

Adhere to the installation practices shown on the Plans. Any conduit cracked or deformed prior to final acceptance shall be replaced at the Contractor's expense.

During the construction, make adequate provisions for drainage of the system.

Make the connection of storm drain appurtenances to other storm drain appurtenances in accordance with the Plans or in a manner approved by the Engineer. Do the work in a workmanlike manner in such a way as not to damage any of the structures involved. Do not have storm drain conduit project beyond the inside wall line of other sewers or of sewer appurtenances. The grade line shown on the Plans or established by the Engineer is the

elevation of the invert or flow line of the drain. As a rule, accurately establish the center and grade lines in the trench at intervals of not more than 25 feet (10 meters); however, when using a laser device to establish line and grade, you may increase the interval to 50 feet (15 meters)—with the exception that when laying out a manhole or appurtenance the first interval shall be set at 25 feet (10 meters).

Close dead ends of all conduits or drains, wyes, tees, etc. with approved stoppers securely cemented in place. The cost of stoppers (plugs) shall be included in cost of other items. When work is stopped temporarily on storm drains 24 inches (600 mm) in diameter and smaller, use a non-watertight stopper to close the end of the pipe to prevent trash or debris from entering it.

- (b) **Excavation.** Except by special permission from the Engineer, the amount of trench excavated at any time shall not exceed the amount in which pipe conduit can be set and the trench backfilled in two calendar days. Where conduits are to be placed in embankment fill, make the trench excavation after the embankment has been completed to a height specified on the Plans above the design flowline grade for those conduits.

The width of trench excavation at the bottom of the trench shall conform to the dimensions shown on the standard pipe and/or box installation drawings. Trench excavation shall be of the width specified thereon for at least 2 feet (0.6 meters) above the top of the conduit.

Excavate bell holes, or recesses for bells of the pipe, at every joint, and make them of sufficient size and depth to relieve the bell of all load; this is to permit the barrel to be firmly bedded throughout its length and to provide ample space for forming the joint.

NOTE: Filling and ramming earth or other material beneath the pipe to raise it to grade will not be permitted.

Where a concrete cradle or refill is shown on the Plans or required by the Engineer, place it in conformity with the Plans and Specifications; it shall consist of Class A concrete meeting the requirements of Section 701.

Make the completed trench bottom firm for its full length and width. Remove any soft and yielding material encountered in the trench bottom and replace it with suitable material, as directed by the Engineer; it is to be paid for as trench excavation for removal and standard bedding material for backfilling. Where required, in the case of cross drains, the trench shall have a longitudinal camber of the magnitude specified.

Unless otherwise specified, all excavation and removed materials not used in the project embankment or as backfill around structures shall become the property of the Contractor, who will dispose of them. This disposal of excess material will not be measured and paid for separately, but will be considered incidental to the various classes of excavation and removal.

All trench excavation will be considered unclassified excavation as defined in Section 202.

- (c) **Bedding.** When bedding is not specified on the Plans, use Class B for rigid conduits and Class C for flexible conduits. Classes of bedding are as follows:
- (1) **Class A.** Consists of a continuous concrete cradle conforming to the Plan details.
 - (2) **Class B.** Meets the requirements of Subsection 27.5.2 of the current AASHTO Standard Specifications for Highway Bridges and conforms to the requirements of Section 703.06.

- (3) **Class C.** Consists of bedding the conduit to a depth of not less than 10 percent of its total height, the bed shaped to fit the conduit and having recesses shaped to receive the bell, and meets the requirements of Subsection 703.06.
- (4) **Underdrain Bedding.** Consists of a bedding layer of granular backfill material meeting the requirement of Subsection 703.04 compacted in the bottom of the trench for its full width and length as shown on standard drawings for pipe underdrain.
- (d) **Laying Pipe.** Place pipe on an approved foundation to true line and grade, with the bell facing upstream, in a manner that will not change the conduit.

NOTE: No buckling in or laying pipe downgrade will be permitted. Do not drop pipe to the bottom of the trench; instead, lower it and place it in its final position using hoisting equipment adequate to handle the pipe without damage to the pipe or trench. Replace any damaged pipe at no additional cost. Clean the inside of the barrel before the pipes are lowered into the trench.

Begin laying conduit at the downstream end of the conduit line. The lower segment of the conduit shall be in contact with the shaped bedding throughout its full length. Place bell or groove ends of rigid conduits and outside circumferential laps of flexible conduits facing upstream.

Lay paved or partially-lined conduit so that the longitudinal center line of the paved segment coincides with the flow line. Place elliptical and elliptically-reinforced conduits with the major axis within five degrees of a vertical plane through the longitudinal axis of the conduit.

Firmly embed underdrain pipe in the bedding material, and lay it reasonably true to the established line and grade. Lay perforated (round holes or elongated slots) pipe with perforations down. Lay pipe underdrain with a top of pipe indentation with the marker up in all installations.

Form and securely fasten metal screens to the outlet end of the subdrain pipe. They will have 1/2 inch (12 mm) mesh size openings composed of either 0.04 inch (1 mm) or 0.08 inch (2 mm) diameter steel wire (after galvanization) meeting the requirements of ASTM A 740. Permanently seal the dead end of the pipe with end caps.

After the pipe has been inspected and approved, carefully cover it with cover material and/or backfill material as shown on current standard drawings, taking care in placing cover materials to prevent displacement or damage to the pipe.

Furnish and set a marker post at the outlet of all pipe underdrains. (See details as shown on standard drawings.) Included costs in the contract unit price per meter of pipe underdrain.

- (e) **Joining Pipe Conduit.** Rigid conduits may be of bell, spigot, or tongue-and-groove design unless one type is specified. The method of joining conduit sections shall be such that the ends are fully entered and the inner surfaces are reasonably flush and even.

Make joints with mortar, cold applied mastic, rubber gaskets, or plastic joint material—in accordance with the appropriate Specifications for the type of pipe being used. Take care that the joints are concentric, reasonably watertight, and free from superfluous joint material on the inside of the pipe. Join flexible conduit by an approved external or internal coupling device (separate item), or by an approved twist-lock coupling system integrated into the wall of the

conduit. To prevent separation during installation, handling, and backfilling operations, join the coupling system firmly and solidly to the conduit.

The performance of the coupling system under field conditions will determine its acceptability; repeated releases of any system will be cause for rejection.

NOTE: The Engineer has the right of approval or rejection of any coupling system, regardless of its presence or absence on an approval list elsewhere.

- (f) **Backfilling.** Before any backfill is placed, the conduit shall be inspected by the Engineer. Inside joints shall be smooth and barrels clean. If pipe is found to be out of alignment, unduly settled, or damaged, take it up and relay or replace it before backfilling. Place standard bedding material over all pipe except pipe underdrain to the depth shown on the Plans. Place and uniformly compact backfilling in accordance with Subsection 202.02(b).
- (g) **Jacking Pipe Conduit.** Only when shown on the plans, designated in the Contract, or approved by the Engineer shall conduit of any nature be placed by jacking, boring, or pushing. Where jacking or boring has been designated, place the conduit to a true line and grade. Unless otherwise specified, the methods and equipment used in jacking and boring conduit shall be optional, provided that the proposed method is approved by the Engineer. Investigate the area of placement, being careful not to interfere with existing underground utilities under the roadway or adjacent to the jacking operation. Take care also to keep the disturbed area of construction to a minimum.

Unless otherwise shown, install bored, pushed, or jacked conduits a minimum depth of 18 inches (460 mm) below the top of ground line or subgrade, as applicable. Where conduit passes under a surfaced area, cut an "X" in the curb or surfacing above the conduit crossings for future relocating purposes.

The use of water or other fluids in connection with the boring or jacking operation will be permitted only under unusual conditions as determined by the Engineer and only on his written approval. The water or other lubricant used as the circulation medium authorized under these conditions must be applied without the use of undue pressure and retained within the casing as the boring or jacking progresses.

Where conduit is required to be installed under railroad embankments or under highways, streets, or other facilities by jacking methods, do not allow the work to interfere with the operation of the railroad, street, highway, or other facility, and do not weaken or damage any embankment or structure.

Conduit to be placed by jacking shall be of the size, type, and class specified on the Plans, except that the strength of the conduit designated in the Contract is determined for not less than final loading, complete in place under the embankment. Additional reinforcement or strength of conduit required to withstand jacking pressure shall be the responsibility of the Contractor, and any such extra-strength conduit required shall be at the Contractor's expense.

Conduit larger than 2 inches (50 mm) inside diameter shall not be pushed or jacked under the highway, railroad, or street without boring or otherwise removing the soil as the conduit is advanced. Conduit up to 36 inch (915 mm) inside diameter shall be constructed by a combined

method of boring and jacking. The boring auger or bit shall have a smaller diameter than the specified diameter of the conduit to be jacked.

The conduit shall be jacked as the boring auger drills out the material, with excavation ahead of the conduit not exceeding 1 foot (0.3 meter).

If the grade of the conduit at the jacking end is below the ground surface, excavate suitable pits or trenches for the purpose of conducting the jacking so as to prevent earth caving. Dewatering, if necessary, shall be continuous until the backfill is made. All costs involved in the performance of the work of constructing pilot tunnels shall be included in the contract unit price for jacking conduit.

Provide heavy-duty jacks suitable for forcing the conduit through the embankment. When operating jacks, apply even pressure to all jacks used. Provide a suitable jacking head, usually of timber, and suitable bracing between jacks and jacking head, so that pressure will be applied to the conduit uniformly around its ring. Also provide a jacking frame or back stop. Set the conduit to be jacked on guides, properly braced together, to support the section(s) of conduit and to direct it in the proper line and grade. When sections of conduit are less than 6 feet (2 meters) in length, carefully place two sections in the guide frame with joints so lubricated as to minimize the possibility of breakage. Place the whole jacking assembly so as to line with the direction and grade of the conduit. In general, excavate earth material just ahead of the conduit and remove the material through the conduit; then the conduit can be forced through the embankment with jacks into the space thus provided.

The excavation for the underside of the conduit, for at least 1/3 of the circumference of the pipe, shall conform to the contour and grade of the conduit. Except as provided herein below, a clearance of not more than 2 inches (50 mm) may be provided for the upper half of the conduit. The clearance is to be tapered off to zero at the point where the excavation conforms to the contour of the conduit.

The Contractor may provide a steel cutting edge around the head and for not less than the upper 2/3 of the conduit and extending a short distance beyond the end of the conduit. Construct the steel cutting edge, and mount and use it so as to insure that clearance between the outside of the conduit and the undisturbed earth will be not more than 1/2 inch (12 mm). Excavation inside the pipe shall not exceed the outside diameter of the conduit, nor extend more than 12 inches (300 mm) beyond the lead edge of the cutting head; this provides for final trimming by the cutting edge and eliminates any void space except that clearance permitted above regarding the steel cutting head.

When jacking of the conduit is begun, carry out the operation without interruption, as far as practicable, to prevent the conduit from becoming firmly set in the embankment.

NOTE: Any evidence at any time of caving shall require that the operation be discontinued until provisions are made for eliminating such caving and the location of any cavity identified.

Fill all cavities formed by caving or any voids resulting from excavation larger than the pipe diameter with grout in a manner approved by the Engineer.

Remove any conduit damaged in jacking operations, and replace it at the Contractor's expense.

- (h) **Removing and Replacing Railway Track.** When the area has been cleared, immediately proceed with the trench excavation, Class B bedding, and laying the pipe, as shown on the Plans and in accordance with the Specifications.

Backfill in accordance with Subsection 613.04(f) except that the standard bedding material and approved backfill material shall be placed in 4 inch (100 mm) layers (loose measurement) and compacted with approved mechanical tampers in accordance with Subsection 202.02(b).

NOTE: Flooding the trench will not be permitted.

Upon satisfactory completion of the backfill, the railway company shall restore its ballast, ties, and tracks.

The railway company will be reimbursed for removing and replacing the necessary trackage, ballast, and ties in accordance with a force account agreement with the Department.

613.05. METHOD OF MEASUREMENT.

No deductions will be made for wye branches; and on conduits 12 inches (300 mm) or less in diameter, no deductions will be made for standard manholes. On the other hand, deductions will be made for special structures, unless otherwise shown on the Plans; and on conduits larger than 12 inches (300 mm) in diameter, deductions will be made for all manholes and for all structures. Conduits which extend only through the wall of the structure will be measured to the actual end of the pipe—except as provided above for measuring conduits 12 inches (300 mm) or less in diameter through standard manholes.

- (a) **Items Measured:**

Drainage conduit will be measured by the linear foot (meter) along the center line of the conduit actually laid. Conduit with sloped or skewed ends will be measured along the invert or as shown on the Plans.

End sections will be measured by the number of units installed.

Standard bedding material will be measured by the cubic yard (cubic meter) calculated on a theoretical basis with the height as shown on the Plans above and below the design flowline, the width inside the vertical neat lines of the trench as defined in Subsection 613.04(b), the length as that measured for the drainage conduit and deducting the volume displaced by the conduit calculated from the nominal designated outside diameter of the pipe, pipe arch or elliptical pipe, or precast box conduit.

Pipe underdrain cover material, other than earth, will be measured by the cubic yard (cubic meter) of pipe underdrain cover material placed and accepted and based on Plan width and established depth of the trench with no deduction for the volume of the underdrain pipe.

Trench excavation will be measured by the cubic yard (cubic meter) calculated on a theoretical basis of the volume of material defined as follows:

The depth in cut areas will be the average depth measured from the lower excavation line specified (below the conduit flowline as shown on the pipe or box installation standard drawings) to the finished subgrade. The depth in fill areas will be measured from the lower excavation line to a distance 2 feet (0.6 meter) above the top of conduit. The Engineer shall establish an equitable measurement elevation in areas requiring both excavation and embankment in adjacent

areas. Thickness of rigid conduit will be the actual measured thickness, while thickness of flexible conduit will be the height of corrugation or wall thickness of the type of conduit used when calculating the dimension below the flow line for establishing the datum plane.

The length will be that measured for the drainage conduit.

The width will be measured inside the vertical neat lines of the trench defined in Subsection 613.04(b).

The conduit of the size and type as shown on the Plans and constructed by jacking as specified above will be measured by the linear foot (linear meter) along the center line of the conduit actually jacked in place and accepted. The cost of the conduit shall be included in the cost of jacking.

(b) Items Usually Not Measured:

Joint filler for pipe will not be measured for payment, but the cost will be included in other bid items.

Earth backfill, sheeting, and shoring will not be measured for payment.

Concrete cradles, if specified, will not be a separate pay item unless otherwise provided.

613.06. BASIS OF PAYMENT.

The accepted quantities of drainage conduit of the types and sizes specified, measured as provided above, will be paid for at the contract unit price as follows:

- (A) NON-REINFORCED CONCRETE PIPE LINEAR FOOT (METER)
- (B) REINFORCED CONCRETE PIPE,
ROUND, ELLIPTICAL OR ARCH LINEAR FOOT (METER)
- (C) SPECIAL END SECTIONS OF REINFORCED CONCRETE EACH
- (CC) CULVERT END TREATMENT EACH
- (D) CORRUGATED GALVANIZED STEEL PIPE,
ROUND OR ARCH LINEAR FOOT (METER)
- (E) CORRUGATED GALVANIZED STRUCTURAL
PLATE PIPE, ROUND OR ARCH LINEAR FOOT (METER)
- (F) PRECOATED CORRUGATED STEEL PIPE,
ROUND OR ARCH LINEAR FOOT (METER)
- (G) GALVANIZED STEEL CULVERT END
SECTIONS, ROUND OR ARCH EACH
- (H) CORRUGATED ALUMINUM PIPE,
ROUND OR ARCH LINEAR FOOT (METER)
- (I) ALUMINUM STRUCTURAL PLATE PIPE,
PIPE ARCHES AND ARCHES LINEAR FOOT (METER)
- (J) ALUMINUM END SECTIONS, ROUND OR ARCH EACH
- (K) PIPE FOR CROSS DRAIN**, ROUND OR ARCH LINEAR FOOT (METER)
- (L) PIPE FOR SIDE DRAIN*, ROUND OR ARCH LINEAR FOOT (METER)
- (M) PREFAB. CULV. END SEC., ROUND OR ARCH EACH
- (MM) SLOPED CONCRETE END SECTION EACH
- (N) VITRIFIED CLAY PIPE LINEAR FOOT (METER)

(O)	PVC PIPE	LINEAR FOOT (METER)
(P)	PERFORATED PIPE UNDERDRAIN	LINEAR FOOT (METER)
(Q)	NON-PERFORATED PIPE UNDERDRAIN	LINEAR FOOT (METER)
(R)	PIPE UNDERDRAIN COVER MATERIAL	CUBIC YARD (CUBIC METER)
(S)	TRENCH EXCAVATION	CUBIC YARD (CUBIC METER)
(T)	STANDARD BEDDING MATERIAL	CUBIC YARD (CUBIC METER)
(U)	JACKED CONDUIT	LINEAR FOOT (METER)
(V)	CAST IRON PIPE	LINEAR FOOT (METER)
(W)	CORRUGATED POLYETHYLENE PIPE	LINEAR FOOT (METER)

Such payment shall be full compensation for furnishing all materials, equipment, labor, and incidentals to complete the work as specified.

** Height of fill to be specified.

* Conduit for this use shall be minimum class or sheet thickness as shown in Fill Height Table (for metal and concrete conduits) on standard drawings.

SECTION 614 RELAYING CULVERT PIPE

614.01. DESCRIPTION.

This work shall consist of relaying culvert pipe of the type specified on the Plans, at the location, and to the lines and grades shown on the Plans or established by the Engineer.

614.04. CONSTRUCTION METHODS

Relay pipe in accordance with the requirements of Section 613. Clean pipe of objectionable material before relaying it.

614.05. METHOD OF MEASUREMENT.

Measure the *relaying culvert pipe* by the linear foot (meter) in place. Different sizes and types of pipe shall constitute separate pay items.

614.06. BASIS OF PAYMENT.

Accepted quantities for relaying culvert pipe, measured as provided above, will be paid for at the contract unit price as follows:

RELAYING CULVERT PIPE	LINEAR FOOT (METER)
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Such payment shall be full compensation for furnishing equipment, labor, and incidentals to complete the work as specified.

SECTION 615 SANITARY SEWER PIPE CONDUITS

615.01. DESCRIPTION.

This work shall consist of the construction of sanitary sewer pipe conduits of the type shown on the Plans in accordance with these and other applicable Specifications and in reasonably close conformity with the lines and grades shown on the Plans or established by the Engineer.

This Specification sets forth the general requirements for this type of work and provides a basis of payment for the required work. Additional specifications will be found in the Oklahoma State Department of Health (OSDH) Regulations, Manufacturers' recommendations, ASTM, ANSI, AWWA, and the Public Utility for whom the work is to be performed. The Special Provisions, Plans, Public Utility Specifications, Supplemental, or Standard Specification shall govern over the OSDH minimum regulations.

615.02 . MATERIALS.

Materials shall be in accordance with Section 726, with the following exceptions: all pipe shall be marked with the appropriate Specification number, such as AASHTO, ASTM, ANSI, NSF, AWWA, etc.

- (a) **Pipe.** Concrete pipe shall be subjected to an in-plant hydrostatic test of 10 psi (70kPa) in accordance with ANSI/ASTM C 497, prior to delivery to the jobsite. All concrete pipe used for sanitary sewer pipe shall be coated inside with two coats, minimum of 16 mils (0.40 mm), of a coal tar base paint, Koppers Super Service Black, or equal, with a 24-hour drying period between coats.

Plastic pipe shall bear the seal of the National Sanitation Foundation (NSF), and have a Standard Dimension Ratio (SDR) not exceeding 35.

Cast-in-place reinforced concrete boxes may be used in sanitary sewer installations. If precast concrete boxes are used, they must be capable of passing the hydrostatic test covered above.

- (b) **Joints.** Joints shall be in accordance with Section 726, with the following exceptions: joints shall be made with a single natural rubber or neoprene gasket or 'O' ring, in accordance with the manufacturer's recommendations.
- Reinforced concrete pipe joints shall be in accordance with ANSI/ASTM C443, with a 1:1 cement mortar collar formed by a diaper.
 - Vitrified clay pipe joints shall be in accordance with ANSI/ASTM C 425.
 - PVC pipe, fittings, and in-line tees shall dimensionally conform to ASTM D 3034, with an SDR of 35.

615.03. SUPPLEMENTAL DRAWINGS.

Supplemental drawings shall be furnished in accordance with Subsection 105.02.

615.04. CONSTRUCTION METHODS.

- (a) **General.** Begin the construction of all pipe conduits at the outlet or the low point of the line. When the construction involves the building of main or submain pipe conduit having one or more laterals or tributaries, do not start the construction of tributary lines until the main or submain pipe conduit has been completed to the point where the tributary or laterals discharge into it.

During construction, make adequate provision for the sewerage of the system.

Connect sanitary sewers or sewer appurtenances to other sanitary sewers or to sewer appurtenances in accordance with the Plans or with the approval of the Engineer. Do the work in such a way as not to damage any of the structures involved. Do not allow sewer pipe to project beyond the inside wall line of other sewers or of sewer appurtenances.

Setting Grade Lines. The grade line shown on the Plans or supplemental drawings or as established by the Engineer is the elevation of the invert or flow line of the sewer. Accurately establish the grade line and alignment through the use of batterboards and a top line. Maintain a top line over a span of three-grade stakes when laying pipe. As each batterboard is erected, sight the top line to assure the accuracy of the grade stakes and the batterboards setting. Any error, discrepancies, or displacement of grade stakes shall be called to the attention of the Inspector for correction.

Using a Laser Device. As a rule, accurately establish the batterboards at intervals of not more than 25 feet (10 meters). However, a laser device may be used to establish line and grade, in which case the batterboard interval may be increased to 50 feet (15 meters), except that the first batterboard shall be set at 25 feet (10 meters) when laying out a manhole or appurtenance.

Accommodating Water Mains. Maintain horizontal and vertical separation of sanitary sewers and water mains as specified in the OSDH regulations. Whenever possible, locate a sewer at least 10 feet (3 meters) horizontally from any existing or proposed water main and 50 feet (15 meters) horizontally from any potable water well.

When sewers cross water mains, lay them so as to provide a minimum vertical distance of 2 feet (0.60 meters) between the outside of the water main and the outside of the sewer. This shall be the case where the water main is either above or below the sewer. Where a water main crosses under a sewer, provide adequate structural support for the sewer to prevent damage to the water main. Whenever possible, locate sewer pipe joints at least 10 feet (3 meters) from any water line. When it is impossible to obtain proper horizontal and vertical separation as stipulated above, design and construct the sewer equal to water pipe, and pressure test it to assure watertightness prior to backfilling.

Closing Dead Ends. When construction is stopped at the end of each day's work or for any other cause, close dead ends of all sewers, wyes, tees, etc. with approved stoppers securely cemented in place. Securely place tight-fitting watertight stoppers or bulkheads in or across the end of all sanitary sewer lines.

- (b) **Excavation.** Excavate in accordance with Subsection 613.04(b).
(c) **Bedding.** Construct bedding in accordance with Subsection 613.04(c).

- (d) **Laying Pipe.** Lay pipe in accordance with Subsection 613.04(d).
- (e) **Joining Pipe Conduit.** Construct joints in accordance with the Manufacturer's recommendations.

Prior to making pipe joints, clean and dry all surfaces of the portion of the pipe to be jointed. Keep trenches water free during jointing and for a sufficient period thereafter to allow the joint to become fully set and completely resistant to water penetration.

NOTE: There shall be no realignment of the pipe after the joint is completed unless the pipe is removed and a completely new joint constructed.

- (f) **Backfilling.** Backfill in accordance with Subsection 613.04(f).
- (g) **Field Testing.** Leakage tests may include appropriate water or low pressure air testing. The leakage outward or inward (exfiltration or infiltration) shall not exceed 200 gallons per inch of pipe diameter per mile (1860 liters per 100 mm of pipe diameter per kilometer) per day for any section of the system. An exfiltration or infiltration test shall be performed with a minimum positive head of 2 feet (0.60 meters).

Perform deflection tests performed on all flexible pipe, conducting the test after the final backfill has been in place at least 30 days. No pipe shall exceed a deflection of 5 percent. Make the deflection test with a rigid ball or mandrel that has a diameter equal to 95 percent of the inside diameter of the pipe, and without the use of mechanical pulling devices.

Perform lamping in the presence of the Inspector. Provide a mechanical method of exchanging the air within the sewer line, and use explosion-proof devices as required by applicable OSHA regulations. If in the opinion of the Engineer any deviation in grade or alignment is excessive, then correct the pipe alignment for no additional charge. In general, a full 3/4 of the barrel of the pipe shall be visible from manhole to manhole or appurtenance.

NOTE: All of the before-mentioned testing shall be conducted by the Contractor, and all cost shall be included in the price bid for other items of work. The Contractor shall inform the Engineer, in writing, 24 hours in advance of any testing.

- (h) **Inspection.** The public utility for whom the work is to be performed will assign a utilities representative to the project, for the purpose of coordinating compliance with the Specifications during construction. The utilities representative will be directly responsible to the Oklahoma Department of Transportation's Engineer. All negotiations, decisions, instructions, interpretations of applicable Specifications, and other matters influencing the work shall be directed to the ODOT Engineer.

615.05. METHOD OF MEASUREMENT.

Pipe conduit will be measured by the linear foot (meter) along the centerline of the conduit actually laid. Conduit with sloped or skewed ends will be measured along the invert. Standard bedding material will be measured by the cubic yard (cubic meter) in accordance with Subsection 613.05. Trench excavation will be measured by the cubic yard (cubic meter) in accordance with Subsection 613.05. The following will not be measured for payment:

- That length of line within manholes and special structures.
- Vertical pipe or fittings required for drop manholes.

- Earth backfill, sheeting, and shoring.
- Concrete cradles, unless otherwise provided.

615.06. BASIS OF PAYMENT.

Accepted quantities of pipe conduit of the types and sizes specified, measured as provided above, will be paid for at the contract unit price as follows:

(A)	REINFORCED CONCRETE PIPE, ROUND	LINEAR FOOT (METER)
(B)	VITRIFIED CLAY PIPE	LINEAR FOOT (METER)
(C)	POLYVINYL CHLORIDE (PVC) PIPE	LINEAR FOOT (METER)
(D)	SANITARY SEWER SERVICE CONNECTION*	EACH
(E)	SANITARY SEWER SERVICE LINE**	LINEAR FOOT (METER)
(F)	TRENCH EXCAVATION	CUBIC YARD (CUBIC METER)
(G)	STANDARD BEDDING MATERIAL	CUBIC YARD (CUBIC METER)

Such payment shall be full compensation for furnishing all materials, equipment, labor, and incidentals to complete the work as specified.

* *Includes the cost of installing an in-line tee and bracing for riser pipe.*

** *Riser pipe will be measured for payment; cost includes all fittings and adaptors to connect service to the existing line.*

SECTION 616 WATER PIPE AND FITTINGS

616.01. DESCRIPTION.

This work shall consist of the construction of waterlines and service lines of the type shown on the Plans in accordance with these and other applicable Specifications and in reasonably close conformity with the lines and grades shown on the Plans or established by the Engineer.

These Specifications set forth the general requirement for this type of work and provide a basis of payment for the required work. Additional specifications will be found in the Oklahoma State Department of Health (OSDH) Regulations, Manufacturers' recommendations, AASHTO, ASTM, ANSI, AWWA and the Public Utility for whom the work is to be performed. The Special Provisions, Plans, Public Utility Specifications, Supplemental or Standard Specifications shall govern over the OSDH minimum regulations.

616.02. MATERIALS.

Materials shall be in accordance with Section 733.

- (a) **Pipe.** Pipe shall be of the kind specified on the Plans and shall be identified in the project specifications with appropriate AASHTO, ASTM, ANSI or AWWA specifications numbers for both quality control (dimensions, tolerances, etc.) and installation (bedding, backfill, etc.).

In no case shall pipe or fittings with a pressure rating of less than 200 psi (1.4MPa) be used. Whenever plastic pipe is used, it shall bear the seal of the National Sanitation Foundation (NSF), have a Standard Dimension Ratio (SDR) not exceeding 14, and shall have an outside

diameter (OD) equal to the OD of the equivalent size ductile iron pipe. The minimum thickness class of cast or ductile iron pipe shall be 4 inch (100 mm) through 8 inch (200 mm), Class 51; 10 inch (250 mm) and larger shall be Class 50. All ductile iron pipe shall be wrapped with a loose fitting, slip-on polyethylene film. The film shall cover all portions of the water line and shall be used on all cast or ductile iron fittings.

- (b) **Joints.** Packing and jointing materials used in the joints of pipe and fittings shall meet the standards of the AWWA and the public utility.
- (c) **Fittings.** Use cast or ductile fittings for water lines—with the exception of copper water lines, which shall use all copper fittings. Use bronze service clamps for standard water service connections. The couplings shall be provided with factory installed brass bushing which conform to ASTM B 62 and AWWA C 800 for standard corporation stop threads.

616.03. SUPPLEMENTAL DRAWINGS.

The drawings on which the Proposal and Contract are based shall be supplemented by installation drawings. When shown in the Proposal they will be furnished at the contract unit price. When not shown in the Proposal, the drawings will be furnished in accordance with Subsection 105.02. These installation drawings shall include but are not limited to the following:

Profiles having a horizontal scale of not more than 100 feet to the inch (12 meters to 10 mm) and a vertical scale of not more than 10 feet to the inch (1.2 meters to 10 mm) with both scales clearly indicated

Brand name and model number of all materials

Installation instructions, thrust block sizes and locations; location of all fittings, method of disinfection and methods and/or materials required to make connections to the existing lines.

All drawings are to be identified with the plans by station number and distances left or right.

The public utility for whom the work is to be performed may have its own Specifications which are more stringent than the minimum OSDH Regulations. All pipe installation drawings after approval by the Engineer will become a part of the Contract documents and will govern the installation of all materials indicated thereon insofar as they apply.

NOTE: The approval of the Engineer shall not relieve the Contractor of sole responsibility for correctness of details, dimensions, and quantities, and shall in no way waive or modify any requirements of the Specifications or Plans.

616.04. CONSTRUCTION METHODS.

- (a) **General.** The work to be constructed as specified under the pipe bid item shall also be understood to mean bends, tees, crosses, sleeves, outlet assemblies, plugs and other specified fittings.

In general, the depth of trench shall be such that it will provide a covering of at least 30 inches (760 mm) below the surface of the natural ground or established subgrade.

During construction, make adequate provisions for drainage of the trench. Suspend pipe-laying operations during rains or whenever the trench cannot be kept dewatered. Place a watertight plug shall be placed in the open end of the main when construction is stopped at the end of each day's work or for any other cause.

Locate—or have located before excavation of the water line trench is begun—all intersecting sewer lines, house sewer lines, and sewers within 10 feet (3 meters) of the proposed water line location; these locations will have been mapped. Take measures to prevent the discharge of waste into the trench.

NOTE: If any sewer is disturbed, it must be carefully restored immediately to a tight operating condition at the Contractor's expense.

Horizontal and vertical separation of sanitary sewers and water mains must be maintained as specified in the OSHD Regulations. Whenever possible, locate a water main at least three meters horizontally from any existing or proposed sanitary sewer line. When water mains cross sanitary sewers, lay them to provide a minimum of vertical distance of 24 inches (600 mm) between the outside of the water main and the outside of the sewer. This shall be the case where the water main is either above or below the sewer. Where a water main crosses under a sewer, adequate structural support shall be provided for the sewer to prevent damage to the water main. Whenever possible, sewer pipe joints will be located at least 10 feet (3 m) from any water line. When it is impossible to obtain proper horizontal and vertical separation as stipulated above, construct the sewer equal to water pipe and test it to assure it is watertight prior to backfilling.

Block all bends, tees, crosses, outlet assemblies, valves and plugs with concrete except where the fittings have flanged, welded or harnessed joints. Place concrete blocking so that joints are accessible for repair.

- (b) **Excavation.** Excavate in accordance with Subsection 613.04 (b).
- (c) **Bedding.** Provide bedding in accordance with Subsection 613.04(c).
- (d) **Laying Pipe.** Lay pipe in accordance with Subsection 613.04(d).
- (e) **Joining Pipe Conduit.** Make joints in accordance with the Manufacturers' recommendations and requirements of the AWWA. Prior to making pipe joints, clean and dry all surfaces of the portion of the pipe to be jointed. Keep trenches waterfree during jointing and for a sufficient period thereafter to allow the joint to become fully set and completely resistant to water penetration.

NOTE: There shall be no realignment of the pipe after the joint is completed unless the pipe is removed and a completely new joint constructed.

- (f) **Connecting to Existing Lines.** Where it's indicated on the Plans or required by the Engineer, make connections to existing lines, furnishing the materials required. No additional compensation will be allowed for this; instead, include the cost for these connections in the price bid for other items of the work.
- (g) **Removal of Existing Lines.** In general, if there is no further use for existing lines, abandon them (instead of removing them). When it is necessary to remove existing line or lines to provide for new installation, no additional compensation will be paid for that removal; instead include the cost for that work in the total price bid for the new line.

- (h) **Setting Valves.** Locate valves where shown on the Plans or as directed by the Engineer. Set them with the valve stem up unless otherwise specified, and caulk the joints as specified for other joints in the pipeline. Take care to see that all parts are in first-class working condition and that the valve is entirely free from foreign material before it's placed.
- (i) **Setting Fire Hydrants.** Locate fire hydrants where shown on the Plans or designated by the Engineer. Before placing any hydrant, take care to see that all foreign matter is removed from within the body or barrel. Tighten the stuffing boxes, and open and close the hydrant valve to see that all parts are in a first class working condition.

NOTE: Hydrant leads shall be cast or ductile iron pipe. Block the back side of the hydrant opposite the pipe with concrete between the hydrant and the vertical face of the end of the trench to prevent the hydrant from blowing off the line. Place each hydrant on a slab of stone or concrete not less than 4 inches (100 mm) thick and 16 inches (400 mm) square. Around the drain of the hydrant, place not less than 7 cubic feet (0.20 cubic m) of broken stone, gravel, or brick bats so the hydrant will properly drain. Firmly tamp backfill around the hydrant to the surface of the ground and to a distance of 5 feet (1.5 m) in front of the hydrant.

- (j) **Dead Ends.** Close dead ends with the required cap or plug depending on whether the dead end is a spigot end or bell end. Caps and plugs shall meet the same requirements as other cast iron fittings. In addition to caulking caps or plugs, securely brace them by casting a concrete block against the cap or plug. On pipes up to 4 inches (100 mm in diameter) place a 2 inch (50 mm) blowoff.
- (k) **Backfilling. Backfill in accordance with Subsection 613.04 (f).**
- (l) **Field Testing.** Inform the Engineer in writing 24 hours in advance of any testing. Test the installed pipe for pressure and leakage in accordance with AWWA Standard C 600. Working pressure of the pipe should not exceed 2/3 of the rated pressure of the pipe. Leakage shall not exceed 10 gallons per inch of diameter of pipe per mile (93 liters per 100 mm of diameter of pipe per kilometer) per 24 hours at 150 psi (1034 kPa) testing pressure.

Disinfect all new, cleaned, or repaired water mains in accordance with Rules and Regulations Governing Operation of Public Water Supply Systems. Water with 50 to 100 parts per million of chlorine shall be allowed to stand 24 hours and develop a residual of at least 10 parts per million of chlorine. Drain the spent solution in an acceptable manner and replace it with potable water prior to use of the line. As an alternate, either of the methods listed in the latest AWWA Specifications may be used. Obtain safe bacteriological samples on two consecutive days before that portion of the line is used.

Include all of the before-mentioned testing in the price bid for other items of work.

- (m) **Inspection.** The public utility for whom the work is to be performed will assign a utilities representative to the project for the purpose of coordinating compliance with Specifications during construction. The utilities representative will be directly responsible to the ODOT Engineer. All negotiations, decisions, instructions, interpretations of applicable Specifications, and other matters influencing the work shall be directed to the ODOT Engineer.

616.05. METHOD OF MEASUREMENT.

Water pipe will be measured for payment by the linear foot (meter), including such fittings as crosses, tees, sleeves, outlet assemblies, plugs, and other specified fittings, complete in place and accepted. Each separate size of pipe shall constitute a separate item for payment, and will be measured along the center line of the completed line, with no deductions made for the space occupied by fittings, valves, etc.

Valves will be measured for payment by each valve installed. Valves of different sizes shall constitute separate pay items. The price bid for these items shall include all the costs of work required to install them, such as tapping, tapping sleeves, valve boxes, meter boxes, etc.

Fire hydrants will be measured for payment by each such fire hydrant set, complete in place and approved, including drainage stone, blocking, and fire hydrant extensions.

Excavations, bedding material, blocking, testing, and fittings will not be measured for payment as a separate item, but the cost of same will be included in the contract unit price for water pipe.

When stipulated in the contract, *supplemental drawings* will be measured for payment on a lump sum basis.

616.06. BASIS OF PAYMENT.

Accepted quantities of water pipe and appurtenances of the types and sizes specified and supplemental drawings, measured as provided above, will be paid for as the contract unit price as follows:

(A)	DUCTILE IRON PIPE (LINED).....	LINEAR FOOT (METER)
(B)	POLYVINYL CHLORIDE (PVC) PIPE	LINEAR FOOT (METER)
(C)	COPPER WATER SERVICE PIPE	LINEAR FOOT (METER)
(D)	VALVES	EACH
(E)	CORPORATION STOP INSTALLATION*	EACH
(F)	METER INSTALLATION**	EACH
(G)	FIRE HYDRANTS	EACH
(H)	SUPPLEMENTAL DRAWINGS	LUMP SUM

Such payment shall be full compensation for furnishing all materials, equipment, labor, and incidentals to complete the work as specified.

* Corporation stop includes tapping, service clamp, and coupling for a complete installation; all materials will be as specified by the public utility.

** *Meter installation includes meter can, meter setter with ground key angle stop, crushed stone, and fittings for a complete installation; all materials will be as specified by the public utility.*

SECTION 619

REMOVAL OF STRUCTURES AND OBSTRUCTIONS

619.01. DESCRIPTION.

This work shall consist of the removal—wholly or in part—and satisfactory disposal of all buildings, bridges, culverts, fences, structures, old pavements, abandoned pipe lines, and any other obstructions which are designated for removal. It shall also include the salvaging of designated materials and backfilling the resulting trenches, holes, and pits.

This work, when specified, shall also consist of removing designated traffic signal and highway lighting items, such as pole assemblies, luminaries, pull boxes, power supplies, signal heads, controllers, and other related electrical equipment; these shall be delivered to a location specified on the Plans and in a manner approved by the Engineer. This work shall also consist of removing abandoned items and restoring the site to match the surrounding conditions.

When the proposal does not include pay items for removal of structures and obstructions as set out in this Section, the cost of such work shall be included in other items.

619.04. CONSTRUCTION METHODS.

- (a) **General.** Raze, remove, and dispose of all buildings and foundations, structures, fences, and other obstructions, any portions of which are on the right-of-way—except utilities and those for which other provisions have been made for removal.

NOTE: When one part of or portion of a system or configuration is removed, the removal of that one part or portion shall be performed in such a manner that the remaining parts or portions shall continue to operate or function as previously intended.

Remove all designated salvable material without unnecessary damage in sections or pieces which may be readily transported, and store them at specified places within the project limits. Destroy unusable perishable material. Dispose of nonperishable material outside the limits of view from the project with written permission of the property owner on whose property the material is placed. Furnish the Engineer with copies of all agreements with property owners. Fill basements or cavities left by structure removal to the level of the surrounding ground, and if within the prism of construction, compact them in accordance with Subsection 202.02(b) and (d). Break up basement floors in a manner acceptable to the Engineer to provide adequate drainage from the basement.

When the work includes or involves traffic signals or highway lighting, carefully disconnect the item to be removed from the existing footing, conduit, and wiring system, and carefully remove the item or assembly so that it may be stored for future use or reset.

NOTE: The Contractor shall be responsible for damage to the removed item as a result of negligence and shall repair or replace the damaged item to the satisfaction of the Engineer.

- (b) **Removal of Bridges, Culverts and other Existing Structures.** Do not remove bridges and culverts in use by traffic until satisfactory arrangements have been made to accommodate traffic.

Removal of existing structures when shown on the Plans shall be in accordance with Subsection 104.09.

- (1) When structures are to remain the property of the State, the method of dismantling steel superstructure and wood bridges shall insure the material against unnecessary damage. Before dismantling, match mark steel members for reerection purposes by painting them and by using steel stencils in a manner approved by the Bridge Engineer. Dismantle steel members at the original field splices and support them on falsework during the operation of dismantling, or otherwise dismantle them in a manner and method approved by the Bridge Engineer.

NOTE: Any steel damaged shall be replaced or satisfactorily repaired by the Contractor without compensation.

Cut piers, abutments, and piling at the ground line, or in case of channel change, at the elevation of the channel excavation shown on the Plans.

Stack salvaged lumber, structural steel, etc. on the right-of-way outside of the ditch line in a neat and workmanlike manner.

Break up old concrete and other similar materials and place them in the fill as specified for placing solid rock in fills, or otherwise dispose of them as directed by the Engineer.

Unless otherwise directed, remove the substructures of existing structures down to the natural stream bottom; remove those parts outside of the stream down 1 foot (0.3 meter) below natural ground surface. Where such portions of existing structures lie wholly or in part within the limits for a new structure, remove them as necessary to accommodate the construction of the proposed structure.

NOTE: In no case shall material be left in the channel.

When blasting or other operations necessary for the removal of an existing structure or obstruction which may damage new construction are necessary, complete them prior to placing the new work.

- (2) When structures or material in structures are to become the property of the Contractor, remove and dispose of the material in accordance with Subsection 104.10. Remove piers, abutments, piling, and substructures as specified in (1) above.
- (c) **Removal of Culvert and Sewer Pipe.** Unless otherwise provided, carefully remove all salvable culvert and sewer pipe, taking every precaution to avoid breaking and damaging the pipe. If pipes are to be relaid, remove and store them so that there will be no loss or damage before relaying.

NOTE: The Contractor will be required to replace sections lost from storage or damaged by negligence or by use of improper methods.

- (d) **Removal of Pavement, Sidewalks, Curbs, Etc.** All concrete pavement, base course, sidewalks, curbs, gutters, etc. designated for removal shall be broken into pieces weighing not more than 150 pounds (68 kilograms); stockpile them at designated locations shown on the Plans for use by the Department or in a manner approved by the Engineer.

NOTE: There will be no separate payment for excavating, removal of structures and obstructions, or for backfilling and compacting the remaining cavity.

When the removal of asphalt concrete or portland cement concrete pavement is specified, saw the joint in a manner approved by the Engineer. Sawing shall be reasonably true to line and the depth of sawing shall be such that when removing the material there will be no undue underbreakage or shattering of the adjacent area.

- (e) **Structures Abandoned.** Break off existing structures which are to be abandoned, removing them to a depth of not less than 6 inches (150 mm) below the foundation grade of new structure.

When sewer lines, water lines, etc. are to be abandoned, tightly plug them at each end with concrete in a manner approved by the Engineer.

Remove manholes and similar structures to be abandoned to the depth specified, fill the with suitable material, and compact them in accordance with Subsection 202.02. If the structure abandoned and so backfilled is to be under paving or another structure, the backfill material shall be tamped in uniform layers not exceeding 6 inches (150 mm) in depth and compacted as specified in Subsection 202.02.

If the structure is not under paving or other structures, settlements may be obtained by thoroughly flushing with water during backfill operations.

- (f) **Disposal of Materials.** Any abandoned concrete footing, concrete apron, conduit, and other miscellaneous material shall become the property of the Contractor and shall be removed and disposed of in a manner approved by the Engineer. Materials such as drop inlet grates and frames, manhole covers and frames, concrete or clay pipe, water pipe, goosenecks, valves, stops, valve boxes, or any material of value shall become the property of the Contractor, unless the Plans or Special Provisions provide otherwise for their disposal.

619.05. METHOD OF MEASUREMENT.

When the Contract stipulates that payment will be made for removal of *structures and obstruction* on a lump sum basis, the pay item—removal of obstructions—will include all structures and obstructions encountered within the right-of-way in accordance with the provisions of this Section. Where the proposal stipulates that payment will be made for the *removal of (specific items)* on a unit basis, measurement will be made by the unit stipulated in the Contract.

When such work is not separately classified for payment on the Plans or in the Proposal, it will be considered as incidental work and will not be paid for directly, but the cost will be included in the contract unit price for other items of work.

When stipulated as a pay item, the length of pipe removed will be measured in linear feet (meters) computed by (1) multiplying the number of commercial lengths removed by the nominal laying length or by (2) measuring the pipe in place prior to removal if practicable.

When *sawing pavement* is shown on the Plans as a pay item, it will be measured by the linear foot (meter).

619.06. BASIS OF PAYMENT.

The accepted quantities of items, measured as provided above, will be paid for at the contract unit price bid as follows:

- | | | |
|-----|--|-----------------------------|
| (A) | REMOVAL OF STRUCTURES AND OBSTRUCTIONS | LUMP SUM |
| (B) | REMOVAL OF (SPECIFIC ITEM) | LINEAR FOOT (METER) |
|  | ..... | SQUARE YARDS (SQUARE METER) |
|  | ..... | CUBIC YARDS(CUBIC METER) |
|  | ..... | LUMP SUM, EACH |
| (C) | SAWING PAVEMENT | LINEAR FOOT (METER) |
| (D) | REMOVAL OF EXISTING BRIDGE STRUCTURE.. .. | LUMP SUM |

Such payment shall be full compensation for furnishing all materials, equipment, labor, and incidentals to complete the work as specified. The price shall also include salvage of materials removed, their custody, preservation, storage on the right-of-way, and disposal as provided herein. There will be no separate payment for the excavation, removal, disposal, backfilling, and compacting of the cavity created by the removal of these items.

SECTION 622**PIPE RAILING AND MISCELLANEOUS PIPE WORK****622.01. DESCRIPTION.**

This work shall consist of furnishing and erecting pipe railing with pipe posts, pipe railing with concrete posts, or miscellaneous work in accordance with these Specifications and in reasonably close conformity with the design, lines, grades, and dimensions shown on the Plans or established by the Engineer.

622.02. MATERIALS.

Materials shall meet the requirements of Subsection 732.02.

When standard black steel pipe is used, it shall be painted with two coats of aluminum paint (finish field coat) in accordance with Subsection 730.02.

Concrete posts, when specified, shall be in accordance with Section 504. Reinforcement shall be in accordance with Subsection 723.01 or 723.02.

622.04. CONSTRUCTION METHODS.

- (a) **Pipe Railing.** Submit shop drawings of the Railing details. Allow ten days for approval.

Join the rail pipe to the post with fittings as shown on the Plans. Make splices in the rail as male/female connections so that no dimension will exceed the nominal outside dimension of the rail. Approved methods of welding will be permitted.

Secure each railing post in position by means of such fittings as specified on the Plans.

- (b) **Miscellaneous Pipe.** Set pipe used in miscellaneous work—such as conduits or drains through concrete curb, sidewalks, or retaining walls—as shown on the Plans or as directed by the Engineer. When pipe is embedded in concrete, take care to work the concrete in well around the pipe.

622.05. METHOD OF MEASUREMENT.

Pipe railing will be measured by the linear foot (meter) of pipe railing complete in place, measured center to center of the end posts. Posts of steel or concrete will not be measured for payment.

When classified for payment, *miscellaneous pipe work* will be paid for by the linear foot (meter) of pipe. When this class of work is not specifically classified on the Plans or in the Proposal for payment, it will be considered as incidental work and will not be paid for as a separate item, but the cost will be included in other contract prices.

622.06. BASIS OF PAYMENT.

Accepted quantities of pipe railing and miscellaneous pipe work, measured as provided above, will be paid for at the contract unit price as follows:

- (A) PIPE RAILING LINEAR FOOT (METER)
- (B) MISCELLANEOUS PIPE WORK LINEAR FOOT (METER)

Such payment shall be full compensation for furnishing all materials, equipment, labor, and incidentals to complete the work as specified.

**SECTION 623
GUARD RAIL AND GUIDE POSTS**

623.01. DESCRIPTION.

This work shall consist of the construction of guard rail and guide posts in accordance with these Specifications and in reasonably close conformity with the lines and grades shown on the Plans or established by the Engineer.

The types of guard rail are designated as follows:

- Beam Guard Rail-Steel-W-Beam-Single
- Beam Guard Rail-Steel-W-Beam-Double
- Beam Guard Rail-Steel-Thrie Beam-Single
- Beam Guard Rail-Steel-Thrie Beam-Double
- Beam Guard Rail-Steel-Transition Section
- Guard Rail Anchor Unit
- Guard Rail Extruder Terminal
- The Trend (Transition End Treatment)
- The Centre (Safety Barrier End Treatment)

Guide Post with Reflective Bands shall be wood as specified.

623.02 . MATERIALS.

Materials shall meet the requirements specified in the following Subsections of Section 700 - Materials:

Portland Cement Concrete, Class A	701.
Epoxy Resin Adhesive	701.13
Reinforcing Steel	723.
Zinc Rich Paint	730.02
Guard Rail Posts	732.01
Guide Posts (Wood)	732.02
Spacer Blocks	732.01
Beam Guard Rail Elements	732.01
Fittings (Steel) Hardware	732.01
Wire Cable and Fittings	732.05
Reflective Sheeting	733.05
Nonshrink Grout	733.07

623.04. CONSTRUCTION METHODS.**(a) Setting Posts for Guard Rail, Guide Posts, or Barrier Posts**

- Set posts for guard rail in accordance with the Plans.
- When posts are to be set in the ground, set them in holes that have been dug in thoroughly compacted soil.
- Keep the bottom of the holes free of loose material so that the post will have a stable foundation.
- Space the posts as shown on the Plans, setting them plumb and with the front faces in a straight line, or if on a curve, at a uniform distance from the edge of the pavement.
- Set the top of the post to the elevation shown on the Plans or as approved by the Engineer.
- After the posts are placed, backfill the holes with approved material, thoroughly compacted in layers not to exceed 6 inches (150 mm) in depth and in such manner as not to shift the posts from the correct alignment.

NOTE: Posts for guard rail may also be machine driven. Promptly fill any depression in the surface resulting from driving the posts, and tamp with like material.

All other requirements shall be as shown on the current guard rail standard drawings.

- (b) Rail Elements.** Erect rail elements in a manner resulting in a smooth, continuous installation. All bolts, except adjustment bolts, shall be drawn tight. Bolts shall be of sufficient length to extend beyond the nuts.

Where painting of railing components is specified, correct any damage to the shop coat of paint by applying an approved rust-inhibitive primer prior to other painting. If any surfaces will be inaccessible to paint after erection, field paint them before they're erected. Give the railing components the specified number of coats of paint, uniformly applying them by thorough brushing or by approved pressure spray as specified.

Protect the following with two coats of an approved zinc rich paint: (1) galvanized surfaces which have been abraded so that the base metal is exposed; (2) threaded portions of all fittings; (3) and fasteners and cut ends of bolts.

Where double-faced guard rail is specified, install it in accordance with the Plans.

- (c) **Placing Metal Plate Rails and Fittings.** Where metal plate rails are specified or used, fasten them to the posts in the manner shown on the Plans. The plate shall be at the elevation shown on the Plans. All laps in the rail shall conform to the direction of traffic on the roadway.

When the type of metal plate guard rail to be used is not specifically set out on the Plans, no more than one type will be permitted on any one Project.

- (d) **Placing Reflective Sheeting on Guide Posts.** After the posts are set, provide them with reflective sheeting when specified, fixed to the post with four 8d box nails as shown on the Plans.

- (e) **Guard Rail Anchor Units.** Construct guard rail anchor units as shown on the Plans. When rock harder than medium sandstone (outcropping on surface, massive boulders, and ledge rock under overburden) is encountered during construction of the concrete anchor, the following steps should be followed.

- (1) For surface outcropping, drill four properly spaced and patterned 2 inches (50 mm) diameter holes to receive the full depth anchor bolts as shown on the Plans. Half fill the rock holes with pourable epoxy grout, insert the bolts, and stabilize them to their final position; then fill the remainder of the hole. Air bubbles and voids shall be expelled from the holes to guarantee full bearing of the bolts.

- (2) For rock with a soil overburden up to 18 inches (450 mm) deep, following these steps:

- Drill the four, properly-spaced holes to receive the anchor bolts.
- Drill four additional holes at 2 1/2 inch (64 mm) diameter, spaced at 90° and 12 inches (300 mm) from center of concrete anchor.
- Half fill the outer holes with pourable epoxy grout; then insert and stabilize plumb one number 9 reinforcing steel bar per hole, cut to the proper length.
- Fill the remaining hole and expel any bubbles. Length should enable insertion of full 12 inches (300 mm) into the rock and clear the top of the concrete anchor by 2 inches (50 mm).
- Tie the 6x6-W1.5xW1.5 wire mesh to the bars after grout is dry.
- Spread pourable epoxy grout on the mating surface between the rock and concrete for positive bond.
- Construct the upper portion with the same details as shown on the Plans.

- (3) For encountered rock at depths greater than 18 inches (450 mm), omit the holes for the four anchor bolts and construct the anchor as covered in 623.04(e) above.

623.05. METHOD OF MEASUREMENT.

Beam guard rail single and double, and thrie beam single and double will be measured by the linear foot (meter) using the nominal distance from center to center of the supporting posts. *Beam guard rail transition sections, guard rail anchor units, and guide posts* will be measured by each unit.

623.06. BASIS OF PAYMENT.

The accepted quantities of the various items, measured as provided above, will be paid for at the contract unit price as follows:

- (A) BEAM GUARD RAIL-W-BEAM-SINGLELINEAR FOOT (METER)
- (B) BEAM GUARD RAIL-W-BEAM DOUBLE LINEAR FOOT (METER)
- (C) BEAM GUARD RAIL-THRIE BEAM-SINGLE..... LINEAR FOOT (METER)
- (D) BEAM GUARD RAIL-THRIE BEAM-DOUBLE LINEAR FOOT (METER)
- (E) BEAM GUARD RAIL-TRANSITION SECTION EACH
- (F) GUARD RAILANCHOR UNIT EACH
- (G) GUIDE POSTS EACH

Such payment shall be full compensation for furnishing all materials, equipment, labor, and incidentals to complete the work as specified.

SECTION 624 FENCES

624.01. DESCRIPTION.

This work shall consist of the construction of fence and gates in accordance with these Specifications and in reasonably close conformity with the lines and grades shown on the Plans or established by the Engineer.

The style, type, and/or class of fence will be as shown on the Plans. The styles are designated as follows:

- (a) Fence, Style WWF (Woven Wire Fence)
- (b) Fence, Style SWF (Strand Wire Fence)
- (c) Fence, Style CLF (Chain Link Fence)
- (d) Fence, Style GDF (Glare Deflector Fence)
- (e) Fence, Metal Panel

Fence gates shall be installed at locations shown on the Plans or as directed by the Engineer, and in accordance with the Plans.

624.02. MATERIALS.

Materials shall meet the requirements specified in the following Subsections of Section 700 - Materials:

Portland Cement Concrete, Class A	701.
Zinc Rich Paint	730.02
Fence, Style WWF	732.06
Fence, Style SWF	732.06
Fence, Style CLF	732.07
Fence, Style GDF	732.08

When not specified on the Plans or in the Proposal, the kind of post, hardware, and fittings meeting the requirements of Section 732 shall be optional, but the kind selected shall be used throughout the project unless otherwise approved in writing by the Engineer.

624.04. CONSTRUCTION METHODS.

- (a) **General.** Perform such clearing and grubbing as may be necessary to construct the fence to the required grade and alignment.

NOTE: Existing fencing on permanent right-of-way when the work order is issued will become the responsibility of the Contractor.

At locations where breaks in a run of fencing are required, or at intersections with existing fences, make appropriate adjustment in post spacing. Cross fencing connections shall include an end post approximately perpendicular to the right-of-way fence, or at an angle dictated by the route of the cross fence.

Concrete. When the Plans require that posts, braces, or anchors be embedded in concrete, install temporary guys, or braces, as may be required, to hold the posts in proper position until such time as the concrete has set sufficiently to hold the posts. Unless otherwise permitted, do not install materials on posts or place strain on guys and bracing that are set in concrete until five days after the placing of the concrete.

Driving Option. Instead of being set in concrete footings or tamped in earth holes, line posts may be driven with the approval of the Engineer. For the driving option, wooden line posts shall be sharpened by the supplier prior to preservative treatment, and the top shall be protected.

NOTE: Splitting or damage to the post top as a result of the driving operation will be cause for rejection. Field sharpening or taper dressing will not be allowed.

Metal posts shall also have a fitted impact head to minimize deformation or damage to the galvanized or painted finish. After driving the metal posts, clean any deformed and/or damaged tops and paint them with a zinc-rich paint.

NOTE: Severely deformed or poorly painted tops will be cause for rejection.

Offset Control. Exercise adequate plumb and offset (alignment) control to assure a smooth profile and alignment. In shallow depressions, use extra length posts and barbed wire fans to maintain a smooth top-of-fence profile. Strengthened fence construction and the use of movable water gates may be necessary in installations over deep ravines.

NOTE: Under no circumstances shall swales or ravines subject to periodic water flow be filled to facilitate fence construction. Adequate provision for drainage must be maintained.

Installations in Rock. For installations in earth and soft rock (softer than medium sandstone), the following criteria shall be adhered to: driven posts shall reach the minimum embedment as shown on the Plans unless refusal of the post is reached. Refusal is defined as 1 inch (25 mm) or less entry per minute of driving with a 60 pound (27 kilograms) hammer using mechanical or pneumatic means, delivering a minimum of 60 blows per minute. If refusal is encountered at 24 inches (610 mm) or deeper, the post may remain and be top cut for profile control. If refusal is encountered at less than 24 inches (610 mm) depth, the post shall be pulled and a concrete

footing, of the dimensions as shown on the Plans for earth installations, shall be installed.

For installations in *medium to hard rock* (medium sandstone or harder) when encountered at the surface, the following criteria shall be adhered to: A hole of the diameter and depth for footings in rock, as shown on the Plans for the type of post being used, shall be drilled. The post shall then be inserted, plumbed, and braced, and the hole filled with lean grout.

The procedure for installations when *medium to hard rock is encountered under a layer of earth* is as follows: At any depth less than the minimum driven embedment (as shown on the Plans) at which rock is encountered, the earth shall be augered and treated like a regular concrete-embedded earth footing. Drill a hole of the diameter for footings in rock (as shown on the Plans for the type of post being used) shall to a depth which will yield the total minimum earth embedment, or the minimum rock embedment, whichever occurs first. Then half fill the rock hole with an approved type of lean grout (thin hydraulic cement); insert, plumb, and brace the post; and fill the remainder of the rock hole with lean grout. Concrete for earth footing may be immediately placed above the grouted hole.

NOTE: The intent is for all driven posts to be firmly in the earth a minimum of 24 inches (610 mm) where driving has been refused, or the minimum earth embedment as shown on the Plans, unless rock is encountered. The minimum rock embedment shall be required unless the total minimum earth embedment is reached prior to the rock embedment being reached. When these conditions have been fully satisfied, the post may be top cut for profile control.

Aligning Posts. Set the tops of all posts approximately to the required grade and alignment.

NOTE: Cutting of the tops of the posts will be allowed only with the approval of the Engineer or under the conditions specified herein or on the Plans.

After cutting wood posts (no flame cuts allowed), paint the tops with a preservative solution. Clean cut areas on metal posts and paint them with a single coat of zinc-rich paint. Attach wire or fencing of the size and type required to the posts and braces in the manner indicated.

Stretch all wire taut and install it to the required elevations.

Grounding the Fence. At each location where an electric transmission, distribution, or secondary line crosses any of the types of fences covered by the Specifications, ground the fencing in accordance with the following: Install a galvanized or copper-coated steel ground rod 8 feet (2.4 m) long having a minimum diameter of 1/2 inch (13 mm) directly below the point of crossing. Drive the rod vertically until the top is 6 inches (150 mm) below the ground surface. Use a No. 6 solid copper conductor or equivalent to connect each fence element to the grounding rod. Either braze or fasten the connections with approved non-corrosive clamps.

When a powerline runs parallel or nearly parallel to and above the fence, ground the fence at each end and gate post and at intervals not to exceed 1500 feet (450 meters).

Provide the abutting property owners with the equivalent property protection given by the existing fences.

NOTE: The Contractor shall be responsible for the maintenance of all fences and gates that he constructs during his construction operations.

(b) **Fence, Style WWF (Woven Wire Fence).** This item shall consist of woven wire fabric with smooth, barbless, or barbed wire strands on a steel and/or wood post system.

(1) **Alignment.** The Plan sheets show the general alignment, angles, corners and attachment types at culverts. In general, construct fence on the permanent right-of-way line and attach wire to the private property side of the fence posts. On curves, place wire fabric on that side of the post which will maintain the wire in a taut condition. Where the right of-way fence is to be constructed, clear the area of obstructions and level the ground of minor irregularities.

(2) **Setting Posts.** Line posts shall be of the size indicated on the Plans and shall be set on the permanent right-of-way line, or to a line shown on the Plans or approved by the Engineer, and in a reasonably true line on the property owner's side to which wire generally is to be attached. Embed them in the ground to the depth shown on the Plans, tamping and firmly setting them. Spacing between line posts shall not exceed the dimensions shown on the Plans. Set additional posts at each abrupt change in grade, alignment, and/or at locations approved by the Engineer.

Extra-length posts (fan posts) shall be required at small depressions where it is not practicable for the fence to follow closely to the contour of the ground. At such small ground depressions, close the space below the bottom of the fence fabric with wire, stretched taut between posts, either on horizontal lines or fanned at 6 inches (150 mm) maximum spacing, as shown on the Plans or as approved by the Engineer. Stretch the wires taut, and securely fasten them to the posts to prevent vertical movement of the wires.

Concrete for encasing posts as indicated on the Plans may be poured without forming if the excavation is of sufficient stability to receive the concrete without caving or sliding in. However, if specified by the Engineer, footings shall be formed.

(3) **Placing Fencing.** Fasten barbed wire, barbless wire, or smooth wire to all fan, end, corner, gate and/or stretcher posts, and to all line posts by substantial and approved means. Use tools designed for the purpose in accordance with the manufacturer's recommendations. Apply the tension for stretching by using mechanical fence stretchers or single-wire stretchers designed for the purpose. Stretch all strands taut to a tensile force of approximately 300 pounds (136 kilograms) as shown on the Plans, or as recommended by the manufacturer.

Splice strand wire and wire fabric using a mechanical device of an approved type, or make a wire splice in the following manner: carry the ends of wires 2 inches (50 mm) past the splicing tools and wrap them around both wires backward from the tool for at least five turns.

Stretch woven wire fabric uniformly tight by means of an approved mechanical tensioning device and in conformity to the location on the posts designated on the Plans. Parallel stays shall be straight, and uniformly spaced, as shown on the Plans. Staple each woven fabric wire and strand wire to wood posts or fasten it with approved fittings to steel posts. Cut or splice woven wire at stretcher or wood posts as required to prevent buckling or undue stretching.

Build attachment assemblies according to the Plans. When it is necessary to make attachments to culvert or bridge endwalls after the culvert is constructed, drill the hole with a drill of the same size as the expansion device, making the holes neat, without chipping or breaking the concrete.

- (c) **Fence, Style SWF (Strand Wire Fence).** This item shall consist of smooth, barbless, or barbed wire strands on a steel and/or wood post system; it shall be constructed in the same manner as fence-style WWF, except the fencing fabric shall consist of strands of an approved smooth wire, barbless wire, or barbed wire. Fence-style SWF shall have the number of strands of wire as shown on the Plans or as approved by the Engineer. The fence shall be set on the permanent right-of-way line.

- (d) **Fence, Style CLF (Chain Link Fence).**

This item shall consist of chain link type fabric fencing on galvanized steel or aluminum alloy post system—with or without barbed wire, smooth tension wire, or climb barrier systems.

- (1) **Alignment.** The provisions of Subsection 624.04(a) General and 624.04(b)1 fence-style WWF shall govern.
- (2) **Setting Posts and Placing Fencing** See Subsection 624.04(a) General for alternate driving criteria for line posts. Dig post holes to the minimum size and spacing as shown on the Plans. Set posts plumb, centering them in the hole and to the lines shown on the Plans. Place posts in the concrete before initial set; take care they're thoroughly puddled and supported plumb until the concrete has set. Do not stretch the wire until concrete in the post holes is at least five days old. Set all post braces before placing any wire.

Stretch the wire slightly above the tension recommended by the manufacturer for the season of the year in which the construction takes place, and allow it to slack away slightly when pullers are released. Attach pullers to the wire full width, and make ties in at least seven places on each post before releasing them. If desired, pulls may be made from two ways and jointed by inserting one picket. Place tension and barb wire after proper size of fabric has been placed. Place wire on the outside of the posts, with respect to the road, except on curves where wire shall be placed on the outside of the post with respect to the center of the curve.

- (3) **Concrete Wall for Fence.** Across ravines where it would not be practical to set posts and follow the ground line with the fence, set posts in a concrete wall as shown on the Plans and at locations directed by the Engineer. When a wall is constructed across any dry wash or periodically wet ravine, make provision for drainage. A partial wall on each bank with a water gate or fan in the center, or culverts through any solid wall will satisfy the drainage requirements.

3.1. *Concrete.* All concrete shall be Class "A" and meet the requirements of Section 701.

3.2. *Reinforcing Steel.* Reinforcing steel shall meet the requirements of Section 511.

- (e) **Fence, Style GDF (Glare Deflector Fence)**

This item shall consist of an approved mesh fence on ground-embedded posts, guard rail posts, parapet wall, or concrete median barrier.

- (1) **Alignment.** In general, this fence shall be constructed in the median, between opposing lanes of traffic. The Plan sheets shall show the general alignment, angles, and corners. On curves, place the wire fabric on the side of the post which will maintain the wire in a taut condition.
- (2) **Setting Post and Placing Fencing.** The provisions of Subsection 624.04(d)2 shall govern. For fence mounted on guard rail, bolt the fence post to the guardrail post shown on the Plans using the specified bolts. For fence mounted on parapet wall or median barrier, cast or drill

holes of the specified dimensions in the wall and fit them with pipe sleeves as shown on the Plans. Alternate attachment methods will be threaded pipe flanges firmly attached to the top surface of the barrier wall.

Space terminal posts at maximum 100 feet (30-meter) intervals or as shown on the Plans.

Truss diagonal braces from the brace end of the line post back to the terminal post, and fasten them to it by a brace band.

Install glare deflector fence fabric as shown on the Plans and securely fasten it to the line posts with wire ties spaced at approximately 14 inch (350 mm) intervals, and to the top and bottom tension wire with wire ties or hog rings, at a maximum of 12 inches (300 mm) intervals. Tighten the chain link glare deflector fence to provide a smooth, uniform appearance.

Install stretcher bar-bands at a maximum of 11 inches (280 mm) intervals.

624.05. METHODS OF MEASUREMENT.

Fence will be measured by the linear foot (meter). Measurement will be along the ground line of the fence from outside to outside of end posts for each continuous run of fence. Connections to cross fences will not be measured separately, but costs shall be included in price bid for fence.

Gates will be measured as complete units of the size, type, and class specified.

Concrete wall for fence, when specified, will be measured in accordance with the dimensions shown on the Plans and will be paid for under Section 509, Class A Concrete or Class A Concrete for Small Structures and Section 511, Reinforcing Steel.

624.06. BASIS OF PAYMENT.

The accepted quantities of fence, measured as provided above, will be paid for at the contract unit price per meter of fence and per each for gates of the types and sizes as follows:

- (A) FENCE, STYLE WWF LINEAR FOOT (METER)
- (B) GATES, STYLE WWF EACH
- (C) FENCE, STYLE SWF LINEAR FOOT (METER)
- (D) FENCE, STYLE CLF LINEAR FOOT (METER)
- (E) GATES, STYLE CLF EACH
- (F) FENCE, STYLE GDF LINEAR FOOT (METER)

Such payment shall be full compensation for furnishing all materials, equipment, labor, and incidentals to complete the work as specified.

SECTION 625
REMOVAL AND STORAGE OR RECONSTRUCTION OF
FENCING, GUARD RAIL, AND GUIDE POSTS**625.01. DESCRIPTION.**

This work shall consist of the removal and storage or reconstruction of fencing, guard rail, and guide posts in accordance with these Specifications and in reasonably close conformity with the lines and grades shown on the Plans or established by the Engineer.

625.02. MATERIALS.

When reconstruction is called for, materials salvaged from the existing installation may be used if in good condition. All other material shall be replaced with approved materials. Paint shall meet the requirements of Subsection 730.02. Unless otherwise specified, the paint for refurbishing shall be aluminum. Zinc rich paint shall meet the requirements of Subsection 730.02.

625.04. CONSTRUCTION METHODS.

- (a) **Removal and Storage.** Store removed material, unless otherwise provided, at a designated location.

Take care when removing material to prevent damage to posts, cable, fence, plates, or fittings. Coil cable or fence and tie tightly before storing. Tie fittings together in bundles or box them. Neatly stack such items as metal plates and posts on blocks, to prevent contact with the ground.

- (b) **Reconstruction**

- (1) **Guard Rail or Fence.** When reconstruction of guard rail or fence is provided in the Contract, remove the guard rail or fence and store it as required above until such time as it is to be reset. Construct guard rail or fence in the same manner as provided for new work.

NOTE: The Contractor will be required to replace at his own expense any material damaged or lost.

Cut all fresh or new-cut holes, etc., with zinc-rich paint. After erection of metal plate rail, thoroughly clean all abrasions of the existing paint and apply one coat of aluminum paint. After this paint coat is thoroughly dry, give the plate rail and all fittings one coat of aluminum paint as required for new metal plate guard rail. Setting of guard rail furnished by the State, when such work is provided for in the Contract, shall be done in the same manner as provided for new work.

- (2) **Guide Post.** To reconstruct guide posts, remove, store, and reset guide posts in place, or set guide posts furnished by the Department when such work is provided for in the Contract. All reconstruction of guide posts or setting guide posts shall be done in the manner as provided for new work.

NOTE: The Contractor will be required to replace at his own expense any guide posts damaged during removal or storage or any posts that may be lost.

**REMOVAL AND STORAGE OR RECONSTRUCTION OF FENCING,
GUARD RAIL, AND GUIDE POSTS**

625.06

After the posts are set, provide them with reflective sheeting fixed to the post with four 2 1/2 inch (64 mm) long box galvanized nails. Reflective sheeting shall be of the type shown on the Standard Drawings.

625.05. METHOD OF MEASUREMENT.

Remove and store guard rail or fence not to be replaced will be measured by the length in linear feet (meters) from center of end posts as measured before removal.

Remove and reconstruct guard rail or fence to be reset will be measured by the length in linear feet (meters) from center to center of end posts as measured after reconstruction and approval.

Remove and store guide posts not to be replaced will be measured by the number of such guide posts actually removed and stored as directed.

Remove and reconstruct guide posts to be reset will be measured by the number of such posts removed and reset as measured after reconstruction and approved.

625.06. BASIS OF PAYMENT.

Accepted quantities of the various items, measured as provided above, will be paid for at the contract unit price as follows:

- (A) REMOVE AND STORE FENCE LINEAR FOOT (METER)
- (B) REMOVE AND RECONSTRUCT FENCE LINEAR FOOT (METER)
- (C) REMOVE AND STORE GUARD RAIL LINEAR FOOT (METER)
- (D) REMOVE AND RECONSTRUCT GUARD RAIL LINEAR FOOT (METER)
- (E) REMOVE AND STORE GUIDE POSTS EACH
- (F) REMOVE AND RECONSTRUCT GUIDE POSTS EACH

Such payment shall be full compensation for furnishing all materials, equipment, labor, and incidentals to complete the work as specified.

**SECTION 626
MONUMENTS**

626.01. DESCRIPTION.

This work shall consist of concrete monuments or markers constructed in accordance with the Plans and these Specifications, and erected at the locations designated on the Plans or where established by the Engineer.

626.02. MATERIALS.

Materials shall meet the requirements specified in the following Subsections of Section 700 - Materials:

Portland Cement Concrete, Class A	701
Reinforcing Steel	723
Bronze Plates	The bronze plates to be used shall be furnished by the Department.

626.04. CONSTRUCTION METHODS.

Construct monuments and right-of-way markers of reinforced concrete complying with the requirements of Section 509 of these Specifications, and conforming in all respects to the requirements of the Plans. They shall have a carborundum finish.

NOTE: Any monument or right-of-way marker that is damaged at any time previous to the final acceptance of the work shall be removed and replaced by the Contractor at his own expense.

Set monuments and markers to the depth shown on the Plans and make them plumb. The backfilling shall be of selected material and shall be carefully tamped in place so that the monument or marker, when completed, shall be stable and secure.

626.05. METHOD OF MEASUREMENT.

The unit of measurement for *monuments, right-of-way markers, or right-of-way markers removed and reset* will be for each such monument or marker.

626.06. BASIS OF PAYMENT.

Accepted monuments and right-of-way markers, measured as provided above, will be paid for at the contract unit price as follows:

- (A) MONUMENTS EACH
- (B) RIGHT-OF-WAY MARKERS EACH
- (C) RIGHT-OF-WAY MARKERS REMOVED AND RESET EACH

Such payment shall be full compensation for furnishing all materials, equipment, labor, and incidentals to complete the work as specified.

When placing of bronze plate only is specified on the Plans, such as in the end posts of bridges or face of curb on paved streets, the item will not be measured or paid for directly; instead, the cost of placing such bronze plate will be included in contract unit price of other items.

SECTION 627.

CONCRETE MEDIAN BARRIER

627.01. DESCRIPTION.

- PRECAST CONCRETE MEDIAN BARRIER

This work shall consist of furnishing and placing the precast concrete median barrier in its first functional location on the project site.

The Contractor may submit for approval, prior to manufacture, designs other than those detailed in the Plans. The only alternate and special design features that will be considered are changes that will influence the casting of a section, and attachments or holes to facilitate the handling and lifting of a section. Alternate designs must meet all of the test and performance requirements specified on the Plans or by the Specifications.

- DELIVERY AND RELOCATION OF CONCRETE MEDIAN BARRIER

This work consists of the delivery of portable concrete median barrier from a storage area to the project site, relocation of the barrier along with any new barrier purchased for the project, as needed, and delivery of all barrier to the storage area.

- CAST-IN-PLACE CONCRETE MEDIAN BARRIER (DESIGN 1,1A)

This work shall consist of furnishing and placing concrete and reinforcing steel for cast-in-place concrete median barrier as shown on the Plans and in accordance with these Specifications.

The Contractor may submit for approval designs other than those detailed on the Plans. Alternate designs must meet exterior dimensions, as well as all of the test and performance requirements specified on the plans or by the Specifications.

- MOVABLE CONCRETE MEDIAN BARRIER

This work shall consist of the construction, placement, maintenance, and all handling including realignment, resetting, removal, and transportation of movable concrete median barriers at the locations designated on the Plans or as required by the construction sequence for work zone protection. Movable concrete median barriers furnished by the Contractor shall be in accordance with the details shown on the Plans and applicable Specifications herein. Movable concrete median barriers to be furnished by the Department will be available at sites designated on the Plans.

627.02 . MATERIALS.

Materials for A-Precast concrete Median Barrier, C-Cast-in-Place Concrete Median Barrier, and D-Movable Concrete Median Barrier shall meet the requirements specified in the following Subsections of Section 700 - Materials:

Portland Cement Concrete, Class A	701
White Concrete	701
Reinforcing Steel	723

627.03. EQUIPMENT.

The transfer and transport vehicle for placing, resetting, and removing the Movable Concrete Median Barriers at the project site shall be furnished in accordance with Special Provisions.

627.04. CONSTRUCTION METHODS.

- (a) **Construction methods for Precast Concrete Median Barrier and Cast-in-Place Concrete Median Barrier.** Construction methods for Precast Concrete Median Barrier and Cast-in-Place Concrete Median Barrier are as follows:

Concrete. Handle, measure, batch, and mix concrete for the precast concrete median barriers in accordance with Subsection 414.04.

Forms. Forms for the precast members shall meet the requirements of Subsection 509.04(d).

Reinforcing Steel. Reinforcing steel construction shall meet the requirements of Section 511.

Placing Concrete. Place the concrete in accordance with Subsection 509.04(e).

Finishing. The finish on all exposed surfaces of the concrete median barrier shall be smooth and dense concrete. As soon as the forms are removed, fill all rough places, holes, and porous spots, and cut all bolts, wires, or other appliances used to hold the forms 1/4 inch (6 mm) below the surface. Fill the depression with cement mortar at once. All exposed surfaces of each unit shall have a concrete surface finish as provided under Subsection 509.04(g).

Curing. The precast units may be water cured in accordance with Subsection 509.04(f) by the Forms-w-place, Water Method, or the Steam Heat Method.

Handling of Units. Take care during storage, hoisting, and handling of the precast units to prevent cracking, side bow, excessive camber, or other damage.

NOTE: Units damaged by improper storing or handling shall be replaced by the Contractor at no additional cost to the Department. Minor chipping, spalling, and scars may be repaired if approved by the Engineer.

Erection. All surfaces on which the precast units are to be placed shall be finished to a true surface to give full and uniform bearing over the entire bearing area. In case such a uniform bearing is not obtained, the defect shall be corrected in a manner approved by the Engineer. Units shall be connected or joined as shown on the Plans and shall be horizontally and vertically aligned to present a uniform and pleasing appearance.

- (b) **Construction methods for Movable Concrete Median Barriers.** Prior to beginning casting of the Movable Concrete Median Barriers, advise the Engineer of the casting site and the date casting will begin.

The mixing, placement, finishing, and curing of concrete median barriers shall be in accordance with Section 627.

Before furnishing movable concrete median barriers that have been previously constructed, provide written certification that the barrier sections conform to the requirements specified herein.

NOTE: Barrier sections, including the required hinges and hinge pins, which are damaged or lost during the process of fabrication, curling, handling, or placement shall be repaired or replaced at the Contractor's expense.

Once the movable concrete median barriers are no longer required for protection of the work site or motoring public on the project, the barriers and all hardware become the property of the Department. Remove them to storage areas designated on the Plans. At the storage area, neatly stockpile the barrier sections, and store all hardware in sturdy containers marked for future identification.

627.05. METHOD OF MEASUREMENT.

The completed and accepted quantities for all *concrete median barrier* except *concrete median barrier design IA* will be measured by the linear foot (meter).

The completed and accepted quantities for all *concrete median barrier end sections* except *median barrier design IA* end sections and transitions will be measured by each end section provided.

The quantities which constitute completed and accepted *concrete median barrier design IA*, end sections, and transition sections will be measured for payment as provided under Section 509, Class A Concrete, or Class A Concrete (small structures) and Section 511, Reinforcing Steel, which shall include full compensation for all materials, falsework, labor, equipment and incidentals necessary to complete the work as specified.

When *precast concrete median barrier, portable type* is specified, the price bid shall include the purchase of the new barrier, the delivery of the new barrier to the project site and the installation of the new barrier to the project site and the installation of the new barrier in its first functional location—i.e., the first location where the barrier is used, not where it may have been stored temporarily. The only exception is when such storage is specified in the plans, or when the Engineer directs in writing that such storage is authorized. When precast concrete median barrier, portable type is installed in its first functional location, its status becomes the same as Department owned median barrier. Any subsequent payment for the new barrier will be made in accordance with *relocation of portable type precast concrete median barrier* or *deliver portable type precast concrete median barrier*.

When relocation of portable type precast concrete median barrier is specified, the price bid shall be paid when the barrier is moved from one functional location to another functional location on the project site (when required). The last payment for this item will be made when the barrier is moved to its last functional location.

The price bid for *deliver portable type precast concrete median barrier* shall be paid when all of the barrier remaining on the project, including new barrier purchased for the project, is loaded, delivered, and stored. This payment shall include the cost of loading all of the barrier at its last functional location, delivery of the barrier to the ODOT storage yard, unloading of the barrier at the ODOT storage yard and placement as directed by the ODOT yard manager.

Movable concrete median barriers will be measured for payment as follows:

The work performed and materials required to construct the *movable concrete median barriers*, transport them, and install the barriers at the initial locations shown on the plans will be measured for payment by the linear foot (meter) at the contract unit price for movable concrete median barrier.

The work performed in realignment and resetting of the barriers in a new location, as required by the construction sequence, will be measured for payment by the linear foot (meter) at the contract unit price for *movable concrete median barrier (realign/reset)*.

The work performed in moving movable concrete median barriers furnished by the Department from storage sites and installing the barriers in place on the project site—or the work performed in removing and transporting the barriers from the project site to a designated storage area—will be measured for payment by the linear foot (meter) at the contract unit price for *movable concrete median barrier (remove/install)*.

The work performed to move concrete median barriers within the project limits a distance which exceeds the capability of the transfer and transport equipment will be measured for payment by the meter at the contract unit price for *movable concrete median barrier (relocate)*.

The work performed to load, transfer, and transport the machinery and equipment to a project or other location so designated will be paid for at the contract unit price for *movable concrete median barrier (transfer and transport vehicle)* lump sum.

627.06. BASIS OF PAYMENT.

Concrete median barrier, measured as provided above, shall be paid for at the contract unit price as follows:

- (A) PRECAST CONCRETE MEDIAN BARRIER, TYPE I LINEAR FOOT (METER)
- (B) PRECAST END SECTION CONCRETE
MEDIAN BARRIER, TYPE I EACH
- (C) PRECAST CONCRETE MEDIAN BARRIER, TYPE II LINEAR FOOT (METER)
- (D) PRECAST END SECTION CONCRETE
MEDIAN BARRIER, TYPE II EACH
- (E) PRECAST CONCRETE MEDIAN BARRIER,
PORTABLE TYPE LINEAR FOOT (METER)
- (F) PRECAST END SECTION CONCRETE MEDIAN
BARRIER, PORTABLE TYPE EACH
- (G) RELOCATION OF PORTABLE TYPE PRECAST
CONCRETE MEDIAN BARRIER LINEAR FOOT (METER)
- (H) DELIVER PORTABLE TYPE PRECAST CONCRETE
MEDIAN BARRIER LINEAR FOOT (METER)
- (I) CONCRETE MEDIAN BARRIER DESIGN 1 LINEAR FOOT (METER)
- (J) MOVABLE CONCRETE MEDIAN BARRIER LINEAR FOOT (METER)
- (K) MOVABLE CONCRETE MEDIAN BARRIER
(REALIGN/RESET) LINEAR FOOT (METER)
- (L) MOVABLE CONCRETE MEDIAN BARRIER
(REMOVE/INSTALL) LINEAR FOOT (METER)
- (M) MOVABLE CONCRETE MEDIAN BARRIER
(RELOCATE) LINEAR FOOT (METER)
- (N) MOVABLE CONCRETE MEDIAN BARRIERS
(TRANSFER & TRANSPORT VEHICLE) LUMP SUM

Such payment shall be full compensation for furnishing all materials, equipment, labor, and incidentals to complete the work as specified.

SECTION 629 MAILBOXES

629.01. DESCRIPTION.

- (a) **General.** The purpose of this Subsection is to specify the placement of mailboxes on public rights-of-way of the road system, with due regard for the safety of the traveling public and safe access for both the delivery and retrieval of items delivered by the United States Postal Service.

629.02. MATERIALS.

- (a) **Mailboxes.** Mailboxes shall be of light metal construction or formed thermoplastic conforming to the requirements of the United States Postal Service (USPS). Requirements covering dimensions, nomenclature, and required marking is contained in "A Guide for Erecting Mailboxes on Highways (Appendix C)," 1984, AASHTO. Newspaper receiver tubes or boxes shall be of the same type materials, but do not need to adhere to any other requirements of the USPS. Dimensions for the newspaper receiver tube or box shall be the minimum necessary to receive the largest item normally delivered to the box. The property owner is responsible for providing newspaper tubes and placing names on mailboxes.
- (b) **Post Systems.**
- (1) **Wood Post.** The support post system shall consist of a single 4 inch x 4 inch (100mm x 100mm) wood post, treated or untreated, durable to the elements and soil borne attack. The post dimensions are nominal, and the post may be furnished smooth and square on four sides or rough sawn. The possible splintering surfaces shall not present a hazard to the delivery person or the owner. The post may be finished natural, oiled, or painted. Alternate posts may be a nominal 4 1/2 inch (114 mm) diameter wood post, treated or untreated, durable to the elements and soil borne attack. The post must be furnished with bark removed, and may be natural, oiled, or painted in finish.
 - (2) **Metal Posts.** A metal post system may be used provided the steel pipe posts, cold rolled shape, or hot rolled member has an equal or less strength in bending as a nominal 2 inch (50 mm) diameter standard weight steel pipe (Schedule 40). The test criteria which must be met is Section Modulus (Schedule 40-2 inch (50 mm) nominal pipe) multiplied by 36000 psi (250MPa) (yield strength of Schedule 40 pipe) must be greater than or equal to section modulus of new post system multiplied by the tested yield strength. Example: The product (0.561 inches cubed (9.14 centimeter cubed) (Section Modulus of Schedule 40-2 inch (50 mm) Pipe) x 36000 psi (250MPa) (Yield Strength of Schedule 40-50 mm Pipe) shall be greater than or equal to the product (Section Modulus of New Shape) x (Tested Yield Strength of New Shape). Aluminum tubing (round or square) or aluminized steel tubing (round or square) may also be used if the section affords sufficient strength to support the box array and withstand lateral loads caused by mail and paper delivery and/or retrieval.

Metal post systems integrating a mailbox support arm for single or multiple (not to exceed 5 mailboxes) are commercially available. The automatically accepted designs are those having favorably passed a Department-approved crash test to ensure safety to occupants of an impacting vehicle.

See Subsection 107.03 of the Standard Specifications for guidance in use of patented materials, systems, and devices.

- (3) **Post-to-box attachment.** Post-to-box attachment fittings shall be of sufficient strength to prevent the mailbox from separating from the post top when the completed installation is struck by an automobile or light truck.
- (4) **Basis of acceptance.** Basis of acceptance will be a Type D certification for materials and visual inspection by Department project personnel.

629.04. CONSTRUCTION METHODS.

- (a) **General.** All mailboxes designs—single post-single box, single post-multiple box, or multiple single post-single box array—must be only strong enough to withstand wind loading and/or lateral loading associated with delivery and retrieval of box contents. In no case shall a concrete footing be used without approval of the Resident Engineer. In those cases, a concrete footing or a footing of native soil mixed with a cementitious media must be necessary to guarantee the post will remain upright in the native soil. The post cannot exceed the dimensions or strength criteria given in Subsection 629.02, and in certain cases must be weakened at the soil surface plane to guarantee bending or failure in the event of impact by a vehicle. Accepted designs having passed an approved crash test with a concrete footing may be constructed with a concrete footing or installed through an asphalt or portland cement concrete surface. Embedment is 2 feet (0.6 m) maximum depth for all post types, or as recommended by the manufacturer or supplier.

The metal post system may have an anti-twist device, but it cannot extend more than 10 inches (250mm) into the ground.

Although placed on public right-of-way, mailboxes are privately owned. Coordinate with the box owner and the USPS to ensure the owners receive mail deliveries at all times, and the owner has ample opportunity to claim salvable items in the existing mailbox installation, not to exceed the lesser of 60 days or the duration of the Contract.

Not more than two mailboxes may be mounted on a single post support system, unless the support system has been shown to be safe for more than two mailboxes by an approved crash test. Lightweight newspaper receiver boxes (tubes) may be mounted below the mailbox or on the post below the mailbox.

Mailbox support system designs not covered in this specification or on standard drawings will be acceptable if approved by the Chief Engineer (or designee) of the Department.

NOTE: Mailbox support systems and/or housings which are rigid, massive, and/or unyielding, or which could cause heavy damage to impacting vehicles or severe injury and deaths to the occupants, are strictly prohibited and will not be approved under any circumstance.

Support systems using a cantilever arm to maximize the post offset are encouraged where terrain and circumstance permit.

- (b) **Placement.** No mailbox will be permitted where access is obtained from the through lanes of a freeway, or where access is otherwise prohibited by law, regulation, ordinance, or policy. Horizontal spacing between multiple single post support system members must not be closer than $3/4$ the exposed height of the post (including the box and/or excess post higher than the box) above the ground line.

Locate mailboxes on the right-hand side of the roadway in the direction of the delivery route except on one-way streets where they may be placed on the left-hand side. Set the bottom of the box at an elevation established by the USPS route carrier, usually between 3 feet (1 m) and 4 feet (1.22 m) above the roadway surface. Offset the roadside face of the box from the edge of the traveled way a minimum distance, as shown on standard drawings.

Exceptions to the lateral placement criteria above will exist on residential streets and certain designated rural roads where the Department deems it in the public interest to permit lesser clearances or to require greater clearances. Place mailbox(es) located at driveway entrances on the near side of the driveway in the direction of the delivery route.

When mailbox(es) are located at an intersecting road, place them a minimum distance in advance or beyond the center of the through road in the direction of the delivery route. See Standard Drawing for placement criteria on through roadways and cross roads.

629.05. METHOD OF MEASUREMENT.

Removal of mailbox installation on the project will be measured separately for each in-place mailbox installation. *Remove and reset mailbox* will be measured separately by each item to be removed and reset. Each existing mailbox within the project limits affected by the construction and/or construction slopes will be measured by either the removal of mailbox installation or the remove and reset mailbox unit.

To remove and reset a mailbox shall include the removal, storage, and reconstruction of the complete mailbox installation, which includes the serviceable, crash-worthy support system and the conforming mailbox unit.

Construction of mailbox installations (support systems) will be measured by each *mailbox installation—single or multiple*. One mailbox supported by any approved support system will be measured by each mailbox installation-single. Two or more mailboxes supported by any approved support system will be measured by each mailbox installation-multiple.

Mailbox will be measured by each mailbox regardless of the type of installation; this includes every mailbox installed. The various approved sizes should be summarized or subnoted within the plans to indicate the number required and the station/locations where erection is suggested.

Base and surfacing quantities for the all-weather turnout as shown on the Standard Drawing will not be measured as part of the mailbox installation or removal items. Turnout quantities will be measured for payment in items of surfacing included in the Plans.

Owner-generated items will not be measured for payment, such as newspaper tubes and/or their installation and names painted on the mailboxes or appurtenant identification items.

629.06. BASIS OF PAYMENT.

Mailbox(es), mailbox installation(s), removal of mailbox installations, and the removal resetting of mailboxes will be paid for at the contract unit price as follows:

- (A) MAILBOX INSTALLATION-SINGLE EACH
 (B) MAILBOX INSTALLATION-MULTIPLE EACH
 (C) MAILBOX EACH
 (D) REMOVAL OF MAILBOX INSTALLATION EACH
 (E) REMOVE AND RESET MAILBOX EACH

Such payment shall be full compensation for furnishing all materials, equipment, labor, and incidentals to complete the work as specified.

SECTION 640 FIELD OFFICE OR LABORATORY

640.01. DESCRIPTION.

This item covers the furnishing of a field office when shown on the Plans, and a laboratory building at all asphalt or ready-mixed concrete plants, when shown on the plans, for the independent and exclusive use of the Highway Department personnel for the duration of the project. The building may be either a mobile unit or a permanent structure.

640.02. MATERIALS.

The building used for field office or laboratory shall be weatherproof and maintained at all times in a manner approved by the Engineer, who will designate an acceptable site. This field office or laboratory shall be installed within the time frame established by the Engineer.

Minimum outside dimensions of the building shall be 8 feet (2.4 m) wide and 16 feet (4.9 m) long. The inside ceiling height shall be not less than 7 feet (2 m). The building shall be floored, and have at least four windows which can be opened, closed, and locked. It shall have two doors near opposite ends of the building which can be secured and locked.

The building shall contain an office desk and at least one acceptable chair, be properly wired for electricity with at least three double wall plugs conveniently located and three overhead ceiling lights, and be heated and cooled so the inside room temperature can be maintained at $75^{\circ}\text{F} \pm 5^{\circ}\text{F}$ ($24^{\circ}\text{C} \pm 3^{\circ}\text{C}$) at all times.

Furnish all required utility service; the cost of utility connections or site preparation shall be included in other items.

A building unit used as the laboratory shall meet the following additional requirements:

It shall be located at the plant site at a location acceptable to the Engineer that is convenient to the physical control center of the plant and where all delivery, loading, and unloading operations can be observed conveniently from the building.

It shall be equipped with a work bench approximately 3 feet (0.9 m) wide and 6 feet (1.8 m) long and an adequate gas or electric oven and hot plate in good working condition.

It shall contain an inside cold water supply line plumbed to an adequate potable water supply.

Furnish a pressurized, dry-chemical ABC-rated fire extinguisher of at least 20 pound (9 kg) rated capacity and hang it on the wall at a place selected by the Engineer. The fire extinguisher shall be maintained in a completely charged condition and shall be inspected, approved, and tagged for serviceability at least every 12 months.

In building units used as the laboratory for asphalt extractions, provide a fume hood for removal of flammable organic vapors generated by routine laboratory testing , and adhere to the following requirements:

the fume hood shall be fireproof and shall have an explosion-proof motor, blower, and light.

Vent the exhaust from the fume hood to the outside atmosphere

The minimum interior dimensions shall be 3 feet (0.9 m) wide, 1 3/4 feet (0.53 m) deep and 2 1/2 feet (0.76 m) high.

The fume hood shall have a tempered safety glass front panel which slides up a minimum of 2 feet (0.61 m) to provide access to the fume hood and slides down to fully enclose the fume hood.

The fume hood shall be equipped with an air bypass which prevents “jet-stream” effects as the front panel is closed.

The fume hood shall produce a volume of air flow per minute equivalent to a minimum of 14 times the nominal external volume of the fume hood.

Catalog cut sheets, brochures, and/or Specifications shall be provided with the fume hood.

640.05. METHOD OF MEASUREMENT.

Measurement of the *field office or laboratory* will be by the number of units furnished. On all optional tied projects, when bid as a tie, one or more field offices and laboratories will be deleted from the tied portion of the Proposal. It will be mandatory that the remaining field offices will remain on the job site and the remaining laboratories will remain at the plant sites until all projects are completed.

640.06. BASIS OF PAYMENT.

The furnishing of a building for a field office and laboratory, as specified will be paid for at the contract unit price as follows:

FIELD OFFICE	EACH
LABORATORY	EACH

Ownership and use of the building or mobile unit with appurtenances will revert to the Contractor when it is no longer needed for the project field office or laboratory as determined by the Engineer.

**SECTION 641
MOBILIZATION**

641.01. DESCRIPTION.

This work shall consist of the performance of construction preparatory operations, including the movement of personnel and equipment to the project site and for the establishment of the Contractor’s offices, buildings, and other facilities necessary to begin work on a substantial phase of the Contract. The Engineer’s field office and laboratory is a separate pay item and is not included in this work.

641.05. METHOD OF MEASUREMENT.

Measurement for *mobilization* will be made on a lump sum basis.

641.06. BASIS OF PAYMENT.

Mobilization, measured as provided above, will be paid for at the contract price as follows:

MOBILIZATION LUMP SUM

Such payment shall be full compensation for performing the work specified and the furnishing of all materials, labor, tools, equipment, and incidentals necessary to mobilize and subsequently demobilize the construction preparatory operations.

Payment for this item will be made in two installments unless the first estimate submitted is also the final estimate, in which case the total lump sum bid will be paid. The first payment of 50 percent of the lump sum Contract price—up to and including the amount defined in Table A below as the maximum amount payable for mobilization item—will be made on the first estimate following partial mobilization and the initiation of construction work.

The second and final payment will be made on the next estimate following the completion of substantial mobilization. The determination of when an estimate is due shall be in accordance with Subsection 109.06 of the Standard Specifications. Mobilization will not be considered in this determination. The completion of the erection of materials processing plants, if any, will not be required as a condition to the release of the final payment.

The lump sum price paid for mobilization shall be subject to the following limitations:

TABLE A

TOTAL ORIGINAL CONTRACT AMOUNT INCLUDING MOBILIZATION**		MAXIMUM AMOUNT PAYABLE FOR MOBILIZATION ITEM*
More Than 0	To and Including \$100,000	10% of total contract amount
100,000	500,000	\$10,000 plus 4 percent of (total contract minus \$100,000)
500,000	more	\$26,000 plus 3 percent of (total contract minus \$500,000)

- * In the event the lump sum bid for mobilization exceeds the amount stated herein, the difference (remainder) will not be paid until the project is complete in accordance with Subsection 105.17.a.
No additional payment will be made for demobilization and remobilization due to shutdowns, suspensions of the work, or for other mobilization activities.
- ** On all tied projects, the total original contract amount including mobilization established in Table A will be the sum of the original contract amounts of the separate tied projects.

SECTION 642 CONTRACTOR CONSTRUCTION STAKING

642.01. DESCRIPTION.

When specified in the Contract, this work shall consist of furnishing, placing, and maintaining construction layout stakes necessary for the proper prosecution and inspection of the work under the contract in accordance with these Specifications.

642.04. CONSTRUCTION METHODS.

Unless specified elsewhere, the Department of Transportation will be responsible for measurement of volumes of pay quantities and survey control of permanent facilities. The Contractor shall be responsible for staking line and grade of all construction features.

- (a) **Department Responsibilities.** The Department will locate and reference the centerline of permanent construction, stake the right-of-way lines, identify and verify bench marks, and take original and final cross sections for the roadway, borrow pits, channels, and all other earthwork construction features. The Engineer will set stakes to mark centerline/control line and establish bench marks for bridges and special structures as needed. When the centerline of survey and the construction reference line are not the same, the Engineer will set major control points on target and at the beginning and ending of curves on the construction reference line.
- (b) **Contractor Responsibilities.** Exercise care in the preservation of stakes and bench marks and have them reset when they are damaged, lost, displaced, or removed. Use competent personnel and suitable equipment for the layout work required. Do not engage the services of any person or persons in the employment of the Department or use Department-owned equipment for the performance of any work covered by this item.

Set all additional stakes needed, such as offset stakes, reference point stakes, slope stakes, pavement, curb line and grade stakes, stakes for bridges, sewers, roadway drainage, pipe underdrains, paved gutter, fence, culverts, or other structures—and any other horizontal or vertical controls necessary to secure a correct layout of the work. Stake centerline/control line of temporary features, such as shoo-fly detours. When earthwork quantities are specified to be measured by photogrammetry methods, clear and grub the entire project prior to the taking of the original photos or beginning the excavation work. Make stakes for line and grade adequate to maintain the specified tolerances for the operation being performed. Mark the station number and the distance from the centerline of construction on all grade stakes.

- (c) **Error Correction/Engineer Notification.** Furnish platforms and equipment necessary for the proper and safe access for checking the staking, and when significant errors occur, resurvey to the satisfaction of the Department.

NOTE: Any inspection or checking of the layout by the Engineer and the acceptance of all or any part of it shall not relieve the Contractor of the responsibility to secure the proper dimensions, grades, and elevation of the several parts of the work. Deviations resulting from plan errors will be resolved by the Department.

Advise the Engineer immediately of plan errors. Special surveys required to determine corrective action due to plan errors are the responsibility of the Department. Measure the profile of highway features to which the project will be connected—such as bridges, bridge approach slabs, and the surface of abutting projects—for approximately 30 meters. If the profile of the project and the profile of the existing feature will not connect in true tangency, yielding a smooth ride, immediately notify the Engineer. It is the intent that the finished surface have a smooth ride for the length of the project, including connections.

NOTE: Failure to make the referenced notification may result in a partial deduction of monies earned for contractor staking.

Perform all survey work, compilation of field notes, and documentation in accordance with the Oklahoma Department of Transportation “Guide for Construction Staking.”

642.05. METHOD OF MEASUREMENT.

Measurement for contractor construction *staking* will be made on a lump sum basis. Refer to Engineer Notification above.

642.06. BASIS OF PAYMENT.

Contractor construction staking, measured as provided above, will be paid for at the contract price as follows:

STAKING LUMP SUM

Such payment shall be full compensation for furnishing all materials, equipment, labor, and incidentals to complete the work as specified, including profile measurements of connecting features.

Payment for this item of work shall be on the following schedule:

- 25 percent** on first estimate
- 25 percent** when 10 percent of the contract work is completed
- 25 percent** when 50 percent of the contract work is completed
- 20 percent** when 75 percent of the contract work is completed
- 5 percent** when all construction features have been verified as properly placed and completed

SECTION 653

EDGE DRAIN CONDUIT

653.01 . DESCRIPTION.

This work shall consist of the construction of a perforated underdrain conduit at the edge of the pavement and installing edge drain outlet laterals. The pavement edge drain conduit shall be installed in accordance with these Specifications and in reasonable close conformity with the locations and dimensions as shown on the Plans or approved by the Engineer.

653.02. MATERIALS.

Materials shall meet the requirements specified in the following Sections:

Edge Drain Conduit - Perforated	726
Edge Drain Lateral - Nonperforated	726
Outlet Lateral Headwall	509

653.04. CONSTRUCTION METHODS.

- (a) **General.** Place the edge drain conduit in an excavated trench lined with separator fabric as shown on the Plans. Backfill of the trench shall be either open graded base or pipe underdrain cover material, as shown on the Plans. All surfacing above the backfill shall be so shown on the Plans. All necessary splices shall be neat and professional and made in accordance with the manufacturer's directions. Elbow outlet fittings of hi-impact polyethylene or equivalent material shall be used to make the transition between the edge drain conduit and the edge drain outlet laterals as shown on the Plans.

Place the outlet laterals and headwalls on a smooth and proper grade according to the Engineer or as shown on the Plans. Backfill trenches for outlet laterals with native material and compact them as directed by the Engineer.

Install outlet lateral and properly connect it to the edge drain within 48 hours after the edge drain is placed.

If edge drain conduit is damaged, replace or repair that portion by splicing it with an undamaged section of conduit at no additional charge to the Department.

At the time of acceptance, adequately cover all lateral outlets and clear the head walls of earth materials, vegetation, and other debris.

- (b) **Excavation.** The amount of trench excavated from the existing paved area at any time shall not exceed the amount of edge drain that can be set and backfill completed in one working day.

Do not damage the existing pavement during the excavation and placement operations. Any damage done to the pavement shall be repaired, at no additional charge, in a manner approved by the Engineer.

Disposal of excess trench excavation shall be the responsibility of the Contractor.

- (c) **Separator Fabric.** Construct separator fabric in accordance with Section 325 and the details shown on the Plans.

- (d) **Outlet Headwalls.** Construct outlet headwalls and place at each outlet lateral as shown on the Plans or approved by the Engineer.
- (e) **Rodent Screen.** Install rodent screens in each outlet lateral line and securely fasten them to the outlet end of the edge drain lateral pipe.

653.05. METHOD OF MEASUREMENT.

Completed and accepted pavement *edge drain conduit* will be measured by the linear foot (meter) along the centerline of the edge drain actually placed. *Edge drain outlet laterals* for the edge drain conduit will be measured by the linear foot (meter) actually installed. *Outlet lateral headwalls* will be measured for each headwall actually constructed.

Separator fabric will be measured in accordance with Section 325.

653.06. BASIS OF PAYMENT.

Accepted quantities of pavement edge drain conduit, measured as provided above, shall be paid for at the contract unit price as follows:

- (A) EDGE DRAIN CONDUIT-PERFORATED LINEAR FOOT (METER)
- (B) EDGE DRAIN OUTLET LATERAL-NONPERFORATED . LINEAR FOOT (METER)
- (C) OUTLET LATERAL HEADWALL EACH

Such payment shall be full compensation for furnishing all materials, equipment, labor, and incidentals to complete the work as specified.

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SECTION 701
PORTLAND CEMENT CONCRETE

This Specification covers all materials, classification, mix designs, proportioning, and testing of portland cement concrete. All concrete shall be air entrained unless otherwise shown on the Plans.

The equipment and tools necessary for the mixing of concrete shall meet the requirements of Subsection 414.03.

701.01. MIX DESIGN AND PROPORTIONING.

(a) **Classes of Concrete.** The classes of concrete are shown in the following table:

CLASSES OF CONCRETE

Class of Concrete	Minimum Cement Content ^a , lb/y ³ (kg/m ³)	Air Content, Percent	Maximum Water/Cement Ratio ^b , lb/lb (kg/kg)	Slump ^c , inches (mm)	Minimum 28-day Compressive Strength ^d , psi (kPa)
AA	611 (363)	6.5±1.5	.44	2±1 (50±25)	4000 (27,580)
A	564 (335)	6±1.5	.48	2±1 (50±25)	3000 (20,685)
AP	470 (279)	6±1.5	.48	2±1 (50±25)	3000 (20,685)
C	395 (234)	6±1.5	.62	3±1 (75±25)	2400 (16,550)
P	611 (363)	5±1.5	.44	3±1 (75±25)	As specified

^a Cement Substitution. Fly ash meeting the requirements of Section 702 may be substituted for up to 15% (20% from April through October) of the required cement. Ground granulated blast furnace slag meeting the requirements of AASHTO M 302 Grade 100 or Grade 120 may be substituted for up to 25% of the required cement. A combination of up to 25% ground granulated blast furnace slag and up to 15% fly ash may be substituted for up to 40% of the required cement. From April through October, a combination of up to 25% ground granulated blast furnace slag and up to 20% fly ash may be substituted for up to 45% of the required cement. Substitution shall be by weight: 1.0 pound (1 kg) for each 1.0 pound (1 kg) of cement. The concrete mix design shall be appropriately adjusted. These substitutions will not be allowed for high early strength concrete, Class P concrete or concrete containing Type IP, Type I (PM), or Type I (SM) cement. If the specified minimum cement content is satisfied, additional fly ash or ground granulated blast furnace slag, or silica fume complying with ASTM C 1240, may be added to the mix when approved as part of the mix design.

^b Water Cement Ratio. Using the weight in pounds of each material, calculate the water-cement ratio (W/C) by the following equation:

$$W/C = \text{Water} / (\text{Cement} + \text{Fly Ash} + \text{Blast Furnace Slag} + \text{Silica Fume})$$

- The water actually used is determined by the water measured into the batch plus the free water on wet aggregate minus the water absorbed by dry aggregate plus water in any admixture solutions and shall not exceed the limit specified.
- ^c **Slump.** The slump shall be as shown, or as specified in the contract documents, or as approved by the Engineer, and the consistency required shall be that which will provide satisfactory workability for the type work being done. Slump tests will be made during the progress of the work as a measure of uniformity of the consistency of the concrete. If using a high-range water reducing admixture, limit the slump to a maximum of 9 inches (230 mm).
- ^d **Compressive Strength.** Compressive strength is based on the average of three test cylinders. The compressive strength requirements of Class P concrete will be specified in the contract documents. When the class of concrete is not expressly indicated on the Plans, the following requirements shall govern:
- *Class AA.* Use Class AA concrete in superstructure items, such as bridge floors, approach slabs, reinforced concrete piles, drilled shaft foundations, parapet walls, concrete rail and handrails.
 - *Class A.* Use Class A concrete for pavements and in substructures items, such as pier caps, columns, abutments, retaining walls, box culverts, and all reinforced concrete not requiring Class AA concrete.
 - *Class AP.* Use Class AP concrete in shoulders, merge areas and gore areas for PCC pavements, unless otherwise directed by plan notes.
 - *Class C.* Use Class C concrete for soil erosion control structures.
 - *Class P.* Use Class P concrete for precast prestressed concrete members, such as PC beams, double tees, prestressed concrete piling, and stay-in-place precast concrete deck panels, and cast-in-place post-tensioned structures.
- (b) **Proportioning.** Base the mix design on absolute volume for the class of concrete specified and the consistency suitable for satisfactory placement of the concrete. Design and produce concrete mixtures that conform to the Class of Concrete table in this section and base the mix design on absolute volume. Proportion the coarse and fine aggregate in accordance with ACI 211.1. Use the least amount of sand and mixing water which will ensure concrete of the required workability for placement conditions. Meet the minimum strength within 72 hours of placement for high early strength concrete. Submit the mix design at least 14 days before production to the Engineer. Include at least the following information with each mix design:
- a. Project identification
 - b. Name and address of contractor and producer
 - c. Mix design designation
 - d. Intended use of the mix design
 - e. Expected travel time from batch to placement
 - f. If the concrete will be pumped or not

- g. Aggregate sources, gradation, moisture content, saturated surface dry batch mass, LA abrasion (AASHTO T 96-92), and freeze thaw durability (AASHTO T 103-91).
- h. Fineness modulus of fine aggregate
- i. Cement type and source
- j. Type of cement replacement, if used, and source
- k. Type of admixtures and sources
- l. Material proportions
- m. Air content
- n. Slump
- o. Water / cement ratio
- p. Strengths at 7 and 28 days
- q. Strengths at 72 hours for high early strength concrete.

NOTE: Do not place any concrete until the mix design is approved.

Submit new mix designs if:

1. The mix design is rejected by the Engineer
2. The source of any material changes
3. The mix design produces unacceptable workability or production test results.

- (c) **Tests and Samples.** Conduct fresh concrete sampling using AASHTO T141. If pumped, sample concrete after discharge from the pump. Determine the slump using AASHTO T119, and the air content using AASHTO T121, AASHTO T152 or AASHTO T196 as appropriate. Make and cure test specimens in accordance with AASHTO T23, except, after initial curing, specimens for acceptance testing will be cured in a medium maintained at 40°F (4°C) to 85°F (29°C) until tested. Test specimens for acceptance according to AASHTO T22 for cylinders.

701.02. PORTLAND CEMENT.

Portland cement shall conform to the requirements of AASHTO M 85 or AASHTO M 240.

Type I, Type I(SM), Type I(PM), and Type IP shall be used in concrete for general concrete construction. When white portland cement is required, it shall meet the requirements of Type I.

Type II shall be used in concrete exposed to moderate sulphate action or moderate heat of hydration, when specified on the Plans or in the Proposal.

Type III may be used when high early strength concrete is required.

Unless otherwise approved by the Engineer, the product of only one mill of any one brand and type of portland cement shall be used on any structure or adjacent structures.

Provide suitable means of storing and protecting the cement against dampness.

NOTE: Cement which for any reason has become partially set or which contains lumps of caked cement will be rejected. Cement salvaged from discarded or used bags shall not be used.

All methods of sampling and testing shall be in accordance with the requirements of AASHTO M 85 or AASHTO M 240, except as modified by the Department's acceptance policy: "Procedure for Sampling, Testing and Acceptance of Portland Cement." Copies of the procedure are available at the office of the Materials Engineer.

701.03. ADMIXTURES.

Use admixtures included in the approved mix design only, unless otherwise specified in the contract documents. This subsection does not specify requirements covering fly ash, ground granulated blast furnace slag, or silica fume. In addition, admixtures shall not be used to replace cement, and admixtures containing chlorides such as Cl⁻ in excess of ten thousand ppm shall not be used in prestressed or reinforced concrete.

- Accurately measure admixtures into each batch by methods approved by the Engineer.
- Dispense admixtures in liquid form. Dispensers for liquid admixtures shall have sufficient capacity to measure at one time the full quantity required for each batch. Unless liquid admixtures are added to pre-measured water for the batch, their discharge into the batch shall be arranged to flow uniformly into the stream of water. Do not allow the dosage to vary more than 5 percent from the dosage established by the mix design for the mix requirements. Make sure the measuring equipment allows for easy confirmation of the accuracy of measurement of the admixture dosage.
- Store admixtures in a manner to prevent freezing and agitate them to prevent separation or sedimentation of solids. Do not use air agitation.
- If more than one liquid admixture is used, be certain that they are compatible, and dispense each one by separate equipment.

NOTE: Any type of admixture shall be uniform in properties throughout its use in the work; if the furnished admixture is not uniform in properties, discontinue using it. Use only those admixtures which have been approved by the Materials Engineer. A list of approved commercial admixtures is maintained by the Materials Division.

NOTE: Admixtures not on the approved list may be accepted if the manufacturer presents a type A certification defined in Subsection 106.04 that the admixture meets all the requirements of AASHTO M 154 or AASHTO M 194 as appropriate.

Furnish the Engineer a type C certification from the manufacturer with each lot or shipment to the effect that the admixture supplied for use in the work is identical in all essential respects, including concentration, to the admixture tested and approved under these Specifications.

- (a) **Air Entraining Admixtures.** Air entraining admixtures shall conform to AASHTO M 154. An exception to the above requirement may be granted in the case of admixtures manufactured by neutralizing vinsol resin with caustic soda provided the manufacturer furnishes certification that the product is neutralized vinsol resin and contains no other additive. Air entraining admixture shall be ADDED DURING BATCHING ONLY.
- (b) **Chemical Admixtures.** Chemical admixtures shall conform to AASHTO M 194 for the particular type specified.
- (c) **High Range Water Reducer (HRWR) Concrete Mixture.** The use of a Type F and G HRWR in concrete mixes will require written approval of the Engineer and meet the additional requirements of this Subsection for each specific project. If a high range water reducing chemical admixture is to be used, the concrete mixture shall meet the requirements of Subsection 701.01 or 509.01 prior to the addition of the admixture.

When proposing the use of high range water reducer, provide a work plan with the mix design. Include the following in the work plan:

- *Purpose.* Describe the purpose for using a high range water reducing admixture.

- *Sequence.* Specify the batching sequence detailing when, where, and how HRWR is to be added to the mix.
 - *Mixing Data.* Specify the mixer capacity and the mixing time and revolutions before and after the addition of the HRWR.
 - *Redose.* Specify any condition that may require a redose include the redose dosage, permissible slump range for the redose, and the mixing time after redosing. Check air content after each redose.
 - *Slump Loss.* Provide an estimate of slump immediately before and after the addition of the HRWR, slump during placement and finishing, and the total length of time the HRWR is effective. Base the estimate upon trial batches or data from previous work using a similar mix design and consider the time required for delivery, placement, finishing, and temperature.
 - *Air Content.* For each slump estimate required above, provide a corresponding estimate of air content.
- (d) **Corrosion-Inhibiting Admixtures.** When an approved corrosion-inhibiting admixture is required by the contract documents, the admixture shall meet the following requirements.
 The admixture shall comply with the following characteristics when tested using the procedures described in AASHTO M194.

Physical Requirements for Corrosion-Inhibiting Admixture

<u>Characteristic</u>	<u>Value</u>
Calcium Nitrite Content	30%±2% (by weight)
Time of Setting, allowable deviation from control, (h:min)	
Initial, not more than:	1:00 earlier nor 3:30 later
Final, not more than:	1:00 earlier nor 3:30 later
Compressive Strength, minimum percent of the control, any time:	90
Flexural Strength, minimum percent of the control, any time:	90
Length Change, maximum shrinkage, percent of the control:	135
Relative Durability Factor, minimum:	80

The average corrosion current of the corrosion inhibitor-protected specimens shall be less than two microamps when tested according to ASTM G109 “Standard Test Method for Determining the Effects of Chemical Admixtures on the Corrosion of Embedded Steel Reinforcement in Concrete Exposed to Chloride Environments.” The test shall be run for three complete cycles after the control specimens have failed according to Section 8, Period of Testing.

Protection potentials (Ep) shall be more positive than -280 mV versus SCE when tested according to ASTM G61 “Standard Test Method for Conducting Cyclic Potentiodynamic Polarization Measurements for Localized Corrosion Susceptibility of Iron, Nickel, or Cobalt-Based Alloys.” The test medium shall be modified to contain a calcium hydroxide solution with a pH similar to concrete of 12.5, and sodium chloride content equivalent to approximately 5 lb/yd³ (3kg/m³) of concrete.

After five years of testing, the corrosion inhibitor-protected test specimens shall have a corrosion current in microamps of less than 10% of the control when tested according to ASTM G109. The test specimens shall have a minimum 1 inch (25mm) of concrete cover over the reinforcement and a maximum water-to-cement ratio of 0.40.

Unless otherwise specified, the concrete shall contain 4.0 gallons of corrosion inhibiting admixture per cubic yard (19.8 l/m³). Account for possible set acceleration effects from the use of calcium nitrite based admixture. Set retarding admixtures may be required.

701.04. WATER.

All water used in mixing or curing Portland cement concrete or cement treated base shall be clean and practically free from oil, salt, acid, alkali, organic matter, or other substances injurious to the finished product.

Water from city water supply may be accepted without being tested.

Water from doubtful sources shall not be used until tested and approved. When required by the Engineer, the quality of the mixing water shall be determined in accordance with AASHTO T 26.

When tests are made comparing the water with water of known satisfactory quality, any indication of unsoundness, marked change in time of set, or reduction in mortar strength shall be sufficient cause for rejection of the water under test.

701.05. FINE AGGREGATE.

(a) **Materials Covered.** These Specifications cover the quality and size of fine aggregates for portland cement concrete pavements or bases, highway bridges, and incidental structures. Mortar sand shall meet the requirements of AASHTO M 45.

(b) **General Requirements.** Fine aggregate shall consist of natural sand, or -subject to approval- combinations of manufactured sand and natural sand, having hard, strong, durable particles, and it shall conform to these Specifications.

Mix and store fine aggregate from different sources in separate stockpiles; in addition, do not use them alternately in the same class of construction or mix without permission from the Engineer or as provided herein for manufactured sand.

Stockpile fine aggregate in accordance with Subsection 106.09.

When manufactured sand is approved for use in combination with natural sand, at least 50 percent of the total fine aggregate by mass shall be natural sand. Store and batch the two materials separately. Each of the materials shall conform to the requirements of these Specifications, except that the mortar strength test shall be made on the blend of materials proposed for use.

(c) **Deleterious Substances.** The amount of deleterious substances shall not exceed the following limits:

<u>ITEM</u>	<u>LIMITS</u>
Clay lumps and friable particles, %, maximum	3.0
Coal and Lignite, %, maximum	0.25

(d) **Organic Impurities.** All fine aggregate shall be free from injurious amounts of organic impurities. Aggregates subjected to the colorimetric test for organic impurities and producing a color darker than the standard shall be rejected unless they pass the mortar strength test as specified below. Should the aggregate show a darker color than that of samples originally approved for the work, its use shall

be withheld until tests satisfactory to the Engineer have been made to determine whether the increased color is indicative of an injurious amount of deleterious substances.

NOTE: A fine aggregate failing in the test may be used provided that, when tested for the effect of organic impurities on strength of mortar, the relative strength at 7 and 28 days calculated in accordance with Section 10 of AASHTO T 71 is not less than 95 percent.

- (e) **Gradation.** Fine aggregate shall be well graded from coarse to fine, and when tested by means of laboratory sieves, it shall conform to the following requirements:

<u>SIEVE SIZE</u>	<u>PERCENT PASSING</u>
3/8 inch (9.5 mm)	100
No. 4 (4.75 mm)	95-100
No. 8 (2.36 mm)	80-100
No. 16 (1.18 mm)	50-85
No. 30 (600 μm)	25-60
No. 50 (300 μm)	5-30
No. 100 (150 μm)	0-10
No. 200 (75 μm)	0-3

The gradation requirements given above represent the extreme limits which shall determine suitability for use from all sources of supply. The gradation from any one source shall be reasonably uniform and not subject to the extreme percentages of gradation specified above. For the purpose of determining the degree of uniformity, determine a fineness modulus (See Note). Determination shall be made from a representative sample obtained by the Engineer from the Contractor's proposed source. Reject fine aggregate from any one source having a variation in fineness modulus greater than 0.20 either way from the fineness modulus of the representative sample.

NOTE: The fineness modulus of an aggregate is determined by adding the total percentages of material in the sample that are coarser than each of the following sieves (cumulative percentages retained), and dividing the sum by 100; No. 100 (150 μm), No. 50 (300 μm), No. 30 (600 μm), No. 16 (1.18 mm), No. 8 (2.36 mm), No. 4 (4.75 mm), 3/8 inch (9.5 mm), 3/4 inch (19.0 mm), 1 1/2 inch (37.5 mm), and larger increasing at the ratio of 2 to 1.

- (f) **Methods of Sampling and Testing.**

Sampling and testing of fine aggregate shall be in accordance with the following methods of the American Association of State Highway and Transportation Officials:

Sampling	T 2
Friable particles	T 112
Coal and lignite	T 113
Amount of passing a No. 200 (75 μm) sieve	T 11
Organic impurities	T 21
Mortar-making properties	T 71
Sieve analysis	T 27

701.06. COARSE AGGREGATE.

- (a) **Materials Covered.** These Specifications cover the quality and size of coarse aggregate for use in portland cement concrete pavements or bases, highway bridges, and incidental structures.
- (b) **General Requirements.** Stockpile coarse aggregate in accordance with Subsection 106.09.

Coarse aggregate shall be a gravel or crushed stone which shall conform to the requirements of AASHTO M 80, Class A, except as modified by these Specifications. Coarse aggregate shall produce Class A concrete with a durability factor of 50 or more. The durability factor will be determined after 350 cycles of alternate freezing and thawing in accordance with AASHTO T 161, Procedure A. The Los Angeles Abrasion percent wear shall be limited to a maximum of 40 percent after 500 revolutions when tested in accordance with AASHTO T 96. The sodium sulfate soundness requirement shall not apply.

Use only coarse aggregate shall consisting of clean, tough, durable particles, practically free from clay, shale, coatings of any character, disintegrated or soft pieces, conglomerates, mud balls, sticks, salt, alkali, or vegetable matter.

Crushed stone or crushed gravel from different sources may be combined in the mix when stored and batched separately in recommended proportions, upon written permission of the Engineer.

At least 70 percent of all aggregate retained on the No. 4 (4.75 mm) sieve in the combined mix shall be crushed stone or mechanically crushed gravel having two or more fractured faces and shall contain not more than 15 percent of flat and elongated pieces. (A flat and elongated piece is one in which the length is greater than five times the average thickness).

- (c) **Gradation.** The coarse aggregate shall be well graded within the limits of the following table:

<u>SIEVE SIZE</u>	<u>Processed Aggregate Size Number</u>				
	<u>357</u>	<u>57</u>	<u>67</u>	<u>7</u>	<u>8</u>
	<u>PERCENT PASSING</u>				
2 1/2 inch (63 mm)	100				
2 inch (50 mm)	95-100				
1 1/2 inch (37.5 mm)		100			
1 inch (25.0 mm)	35-70	95-100	100		
3/4 inch (19.0 mm)			90-100	100	
1/2 inch (12.5 mm)	10-30	25-60		90-100	100
3/8 inch (9.5 mm)			20-55	40-70	85-100
No. 4 (4.75 mm)	0-5	0-10	0-10	0-15	10-30
No. 8 (2.36 mm)		0-5	0-5	0-5	0-10
No. 16 (1.18mm)					0-5
No. 200 (75mm)	0-1.5	0-2.0	0-2.0	0-2.0	0-2.0

1. Furnish coarse aggregate for Class A concrete in the No. 57 size only except as noted below.
2. Furnish coarse aggregate for massive Class A concrete in the No. 357 size. Coarse aggregate for Class C concrete may be either No. 57 or No. 357.
3. Furnish coarse aggregate for thin section concrete in the No. 7 size.

4. Coarse aggregate for Class AA or P concrete shall be furnished in the No. 67 size. No. 7 or No. 8 coarse aggregate may be used in Class P concrete if either the specified 28-day compressive strength is in excess of 6000 psi (41.4 MPa) or permeability limits are specified.

701.07. CURING AGENTS.

Concrete curing agents shall consist of burlap, cotton mats, earth, white or red pigmented membrane curing compound, waterproof paper, polyethylene film, linseed oil emulsion, or water for ponding. Keep the curing agents reasonably free from ingredients which may damage or be detrimental to the surface of the concrete.

- (a) **Burlap.** Burlap cloth shall conform to AASHTO M 182, Class 3 or better.

Burlap shall be new burlap or burlap which has been used for no purpose other than the curing of concrete. New burlap, not previously used for curing concrete, shall be reasonably free from starch, filler, or other substances added during the process of manufacturing, or shall be washed by repeated rinsing in clear water until reasonably free from such substances. Worn burlap or burlap with holes will not be permitted. Burlap shall be at least 2 feet (600 mm) longer than the width of the pavement slab.
- (b) **Cotton Mats.** Cotton mats shall be either new, or they shall not have been used for any other purpose than curing concrete. Do not use mats with holes.
- (c) **Earth.** Earth used in curing concrete pavement shall be reasonably free of roots, sticks, stones, or other ingredients which may be detrimental to the surface of the concrete, and shall be of such nature as to retain moisture.
- (d) **Liquid Membrane Curing Compounds.** Liquid membrane curing compounds shall conform to AASHTO M 148 with these exceptions:

The type 2, white pigmented compound hiding power shall have an apparent daylight reflectance of not less than 65 percent compared to magnesium oxide as determined by ASTM E 97.

The type 1-D compound shall be colored by a red fugitive dye so that inspection may indicate complete coverage. The color must be maintained at least 4 hours, after which it should gradually disappear.

When tested in accordance with OHD L-17, the curing compound shall provide a water retention of at least 90 percent.
- (e) **Sheet Materials.** Sheet Materials shall conform to AASHTO M 171. Sheet material not specifically defined in AASHTO M 171 may be approved providing all other requirements of AASHTO M 171 are met.

The sheeting material shall be fabricated into sheets of such width as to provide a complete cover for the entire concrete surface. All joints in the sheets shall be securely cemented together in such a manner as to provide a waterproof joint.

Do not use sections of membrane which have lost their moisture-retaining qualities.
- (f) **Linseed Oil Emulsion.** Linseed oil emulsion shall comply with the following table of composition:

<u>Composition</u>	<u>Mass Percent</u>
Oil Phase (50% min. by volume)	
Boiled linseed oil	97.0 ± 0.1
Saturated Tallow Alcohols	<u>3.0 ± 0.1</u>
	100.0
Water Phase (50% Max. by volume)	
Water	99.60 ± 0.01
Sodium hydroxide	0.37 ± 0.01
Dipicolinic acid	<u>0.03 ± 0.001</u>
	100.00

The emulsion shall be stable at the time of application.

Fugitive Dye. Linseed oil emulsion shall be colored by a red fugitive dye so that inspection may indicate complete coverage. The color must be maintained at least four (4) hours, after which it should gradually disappear within a couple of weeks.

Moisture Retention. When tested in accordance with OHD L-17, the curing compound shall provide a water retention of at least 90 percent when applied at the rate of 1 gallon per 175 square feet (4.3 m²/l).

Containers. All linseed oil emulsion furnished under this Specification shall be in plastic containers. Each container shall be marked or labeled with the manufacturer's name, contents "Linseed Oil Emulsion", lot number, and date of manufacture.

- (g) **Water for Ponding and Material for Dikes.** Water for ponding shall be reasonably free from salt, acid, alkali, oil, or any substance that would injure or discolor the surface. Water suitable for use in mixing portland cement concrete will be satisfactory to use for ponding. Material for dikes shall be loam, sand, clay, or any combination of the above, free from rocks, sticks, or any objects that would prevent formation of a watertight dike.

701.08. JOINT FILLERS AND SEALERS.

This Subsection establishes the requirements for joint fillers and sealers for portland cement concrete.

- (a) **Preformed Expansion Joint Filler (Bituminous Type).** This joint filler shall conform to the requirements of AASHTO M 33. Do not use this type filler in joints for which the Plan detail requires a sealer. Submit a type A certification from the manufacturer for each lot or shipment of materials.
- (b) **Preformed Expansion Joint Fillers. (Nonextruding and Resilient Types).**
1. *Nonbituminous Joint Filler.* The nonbituminous joint filler shall conform to AASHTO M 153.
 2. *Bituminous Joint Filler.* The bituminous joint filler shall conform to the requirements of AASHTO M 213, except that the maximum permissible load to compress the test specimen to 50 percent of its thickness before testing shall be 1500 psi (10.34 MPa). Compliance with the asphalt content requirement is waived providing the material meets all other physical requirements as specified. Submit a type A certification from the manufacturer for each lot or shipment of materials.

(c) **Preformed Elastomeric Compression Joint Sealer.**

1. *Description.* These Specifications cover preformed elastomeric compression joint sealers for use in portland cement concrete pavements and concrete bridge floors.

2. *Materials.*

2.1. *Preformed Joint Seals.* The joint seals shall be manufactured from an elastomeric material that is resistant to heat, oil, jet fuel and ozone. The material shall be compatible with concrete and shall conform to the physical requirements of AASHTO M 220. All tests will be made on samples taken from the preformed joint sealer.

2.2. *Shape and Dimensions.* The molded joint seals shall be of cross sectional dimensions, lengths and tolerances shown on the Plans. The sealer shall be one piece for the full length of the transverse joint and in practical lengths for longitudinal joints.

Elongation of the joint material of more than 2 percent during placement will require the preformed elastomeric compression joint sealer to be removed and replaced.

2.3. *Samples.* Two 2 foot (600 mm) long pieces of each size of sealer to be used shall be submitted to the Materials Division for tests as warranted.

2.4. *Inspection.* Representative sections of each lot shall be subject to surface and dimensional inspection by the Engineer to determine visual compliance with applicable requirements of this Specification which do not require physical tests.

2.5. *Lubrication Adhesive.* Any lubricant adhesive used shall be compatible with the sealer and the concrete and relatively unaffected by the normal moisture in the concrete. The lubricant adhesive shall be a compound consisting of the same base polymer as the sealer, blended with a suitable volatile solvent. It shall maintain a suitable consistency at the temperature at which the seal is installed.

2.6. *Certification.* A type A certification shall be submitted by the manufacturer for each lot or shipment of materials.

Any cracking visible after recovery testing is basis for rejection.

(d) **Polymer Type, Two Component Cold Applied Machine Extruded and Pourable Joint Sealer.**

1. *Description.* These Specifications cover two- component, polymer- type, rubberlike, cold- applied joint sealing compounds for use in portland cement concrete pavements and bridge floors.

When recommended by the manufacturer, use a primer in accordance with the manufacturer's recommendation.

The shape of the joint and joint sealer shall be as shown on the Plans.

2. *Materials.* Materials meeting Federal Specifications SS-S-200 may be used. Use the bond breaker recommended by the materials manufacturer as shown on the ODOT standard drawings.

2.1. *Acceptance.* Furnish a type A certification with each shipment or lot.

2.2. *Packaging.* Package the joint sealer in sealed containers identified by the name of the manufacturer, the manufacturer's lot number, and the date of manufacture, and bearing instructions for mixing and application. Containers including the curing agent shall be marked A, and the container including the polymer shall be marked B. If a primer is required by the manufacturer, it must be so stated on containers A and B. Give proper instructions for use of the primer on its container.

2.3. *Tests.* Tests shall be made in accordance with OHD L-21.

3. *Machine Extruded Joint Sealer.*

3.1. *General.* The joint sealer shall be a modified polysulfide or polyurethane polymer consisting of 2 components to be machine mixed and machine extruded directly into the joints.

The polysulfide components shall be mixed at a 1:1 ratio by volume and the polyurethane components shall be mixed in accordance with the manufacturer's recommendations.

Upon being opened, component B shall not exhibit more than a slight degree of skinning.

3.2. *Properties of Laboratory Mixed Material.*

<u>Determination</u>	<u>Requirements</u>
Penetration, 77°F, 0.1 mm (25°C)	50 to 120
Penetration, 158°F (70°C)	1.5 x Pen. at 25°C
Cold Flow, 3 minutes, mm, minimum	19.1
Cold Flow, 40 minutes, mm, maximum	12.7
Resilience, 77°F (25°C), %, minimum	70 60 ^a
Resilience of oven aged sample, 7 days, %, minimum	70 60 ^a
Resilience, 158°F (70°C), %, minimum	60 50 ^a
Bond to concrete ^b , 100% extension, dry, -20°F (-29°C)	No failure
Bond to concrete ^b , 100% extension, wet, -20°F (-29°C)	No failure
Nonvolatile content, %, minimum	88

^aApplies if penetration at 77°F is 90 to 120(0.1mm) (25°C is 90 to 120)

^b Cure Sample for 24 hours at 77°F (25°C); then oven age for 7 days at 158°F±2°F (70 ± 1°C).

4. *Pourable Joint Sealer.*

4.1. *General.* The joint sealer shall be a polymeric material consisting of two components to be uniformly mixed and poured directly into the joints. The mass of component A in the mixture shall be not less than 10 percent of the mass used of component B.

Upon being opened, neither component shall exhibit more than a slight degree of skinning.

4.2. *Properties of Laboratory Mixed Material*

<u>Determination</u>	<u>Requirements</u>
Viscosity, 5 minutes after mixing, Pa-s	2.00 to 3.50
Application time (Pot life or time to reach 20.00 Pa-s), 77°F (25°C), hr, minimum	1
Penetration, 77°F (25°C), 24 hours aging, maximum	150
Penetration ^a , 77°F (25°C)	50 to 120
Penetration ^a , 158°F (70°C)	1.5 x Pen @ 25°C
Resilience ^a , 77°F (25°C), %, minimum	70
	60 ^b
Resilience ^a , 158°F (70°C), %, minimum	60
	50 ^b
Resilience ^a , oven aged sample, 7 days, %, minimum	70
	60 ^b
Bond to Concrete ^c , 100% extension, dry, -20°F (-29°C)	No failure
Bond to Concrete ^c , 100% extension, wet, -20°F (-29°C)	No failure
Nonvolatile content, %, minimum	88

^a After 96 hours aging at 77°F (25°C)

^b This requirement applies if penetration at 77°F (25°C) after 96 hours at 77°F is 90 to 120(0.1mm) (25°C is 90 to 120).

^c Cure sample for 24 hours at 77°F (25°C), then oven age at 158°F±2°F (70°C ± 1°C) for 7 days before testing.

(e) **Hot Poured Joint Sealer.**

1. *Description.* Joint sealers furnished shall be of the hot poured type which readily bonds to concrete surfaces.

2. *Materials.*

2.1. *Sealer.* Joint sealers used under these Specifications shall meet the requirements of Federal Specification SS-S-1401. The sealant material shall be heated for application to the temperature within the range recommended by the manufacturer unless otherwise established by the Engineer.

2.1.1. *Safe Heating Temperature.* The safe heating temperature shall be set forth by the manufacturer and furnished with samples for approval. The safe heating temperature shall also be shown on all containers and packages in each shipment received at the job site.

2.1.2. *Acceptance.* Hot poured joint sealer furnished under these Specifications will be accepted for use upon receipt of a type C certification in accordance with Subsection 106.04.

Sealer materials damaged by excessive or prolonged heating will be rejected.

2.2. *Backer Rod.* When shown on the Plans, the use of a backer rod of the size and dimensions shown shall be required. The backer rod shall be compatible with the joint sealant. The backer rod shall be an approved product listed for use by the Materials Division.

(f) **Low Modulus Silicone Joint Sealant.**

1. *Description.* These Specifications cover low modulus silicone joint sealant and expanded polyethylene backer rod for use in sealing portland cement concrete pavement joints. The silicone sealant shall be furnished in a one part silicone formulation. Acetic acid cure sealants are not acceptable.
2. *Materials.*
 - 2.1. *Silicone Sealant.* The silicone sealant shall meet the color, toxicity, stability, and durability requirements of the current Federal Specification TT-S-001543 for Class A sealants and the following test requirements:

<u>Test</u>	<u>Limit</u>	<u>Test Method</u>
Flow, inches (mm), maximum	0.3 (7.6)	MIL S 8802
Extrusion Rate, g/minute	75-250	MIL S 8802
Tack Free Time, 77°F (25°C), 45-55% relative humidity, minutes	20-75	MIL S 8802
Specific Gravity	1.01 - 1.515	ASTM D 792 Method A ^a
Durometer, Shore A, 0°F (-17.8°C)	10-27	ASTM D 2240 ^a
Tensile Stress, 100% Elongation, psi (kPa), maximum	75 (517)	ASTM D 412 Die C ^a
Elongation, %, minimum	500	ASTM D 412 Die C ^a

^a Cured 7 days at 77°F±4°F (25 ± 2°C) and 50 ± 5 percent relative humidity.

Concrete primer may be used if specified by the sealant manufacturer.

2.1.1. *Acceptance.* The sealant shall be accepted on the basis of manufacturer's certification and approval by the Materials Engineer in accordance with Subsection 106.04.

A type A certification shall be furnished for the above listed test requirements.

A type D certification shall be required for compliance with current Federal Specification TT-S-001543 in accordance with Subsection 2.1 of these Specifications.

Samples of the joint sealant shall be submitted by the manufacturer to the Materials Division for tests and approval prior to use.

2.1.2. *Storage and Shelf Life.* Storage and use of the joint sealant shall be in accordance with the manufacturer's recommended practices.

2.2. *Backer Rod.* The backer rod shall be of the size and dimensions shown on the Plans. The backer rod shall be compatible with the joint sealant and no bond or reaction shall

occur between the rod and sealant. The backer rod shall be an approved product listed for use by the Materials Division.

(g) Low Modulus Silicone Joint Sealant (Self-Leveling).

1. *Description.* These Specifications cover self-leveling, low modulus silicone joint sealants and polyethylene backer rod for use in sealing portland cement concrete pavement joints and/or portland cement concrete to asphalt concrete pavement joints. The self-leveling silicone sealant shall be furnished in a one part silicone formulation. Acetic acid cure sealants are not acceptable.
2. *Materials.*
 - 2.1 *Silicone Sealant.* The silicone sealant shall meet the color, toxicity, stability, and durability requirements of the current Federal Specification TT-S-001543 for Class A sealants and the following test requirements:

<u>Test</u>	<u>Limit</u>	<u>Test Method</u>
Appearance	Smooth, non-grainy, homogeneous mixture	MIL S 8802
Extrusion Rate, g/minute, minimum	200	MIL S 8802
Tack Free Time, 77°F (25°C), 45-55% relative humidity, hr	5	MIL S 8802
Specific Gravity	1.26-1.34	ASTM D 792, Method A
Elongation, %, minimum	500	ASTM D 3583-85 Section 13, Modified ^a
Modulus @ 50%, psi (kPa), maximum	10(69)	ASTM D 3583-85 Section 13, Modified ^a
Modulus @ 100%, psi (kPa), maximum	15(103)	ASTM D 3583-85 Section 14, Modified ^a
Modulus @ 150%, psi (kPa), maximum	20(138)	ASTM D 3583-85 Section 14, Modified ^a

^a Clean two 1x1x3 inch (25.4 x 25.4 x 76.2 mm) concrete test blocks, hold under running tap water, and scrub with a brush for approximately 30 seconds. Allow blocks to dry for 24 hours at room temperature. Assemble blocks with 1x3 inch surface facing (with 25.4 x 76.2 mm surfaces facing) with 1/2 x 1/2 x 1 inch (12.7 x 12.7 x 25.4mm) Teflon spacers. Hold in place with a clamp. Without touching the surface with your fingers, insert backer rod closed cell 1/2 inch diameter x 1 inch (closed cell 12.7 mm diameter x 25.4 mm). Inject sealant to fill the cavity with no air entrapment. Allow the sealant to flow to a smooth surface, and do not strike off. Allow it to cure at 77°F (25°C) and 45-55% relative humidity. After 21 days, remove the clamp and Teflon spacers and pull the test specimens at 2 inches (50.8 mm) per minute.

2.1.1. *Acceptance.* The sealant shall be accepted on the basis of the manufacturer's certification and approval by the Materials Engineer in accordance with Subsection 106.04.

Furnish a type A certification for the above listed test requirements.

Furnish a type D certification to comply with current Federal Specification TT-S-001543 in accordance with Subsection 2 of these Specifications.

Submit samples of the joint sealant to the Materials Division for tests and approval prior to use.

2.1.2. *Storage and Shelf Life.* Storage and use of the joint sealant shall be in accordance with the manufacturer's recommended practices.

- 2.2. *Backer Rod.* The backer rod shall be of the size and dimensions shown on the Plans. The backer rod shall be compatible with the joint sealant, and no bond or reaction shall occur between the rod and the sealant. The backer rod shall be an approved product listed for use by the Materials Division.

(h) **Rapid Cure Joint Sealant and Elastomeric Mortar.**

1. *Description.* These Specifications cover rapid cure joint sealant and elastomeric mortar for use in expansion joints in bridge decks.

2. *Materials.*

- 2.1. *Joint Sealant.* Joint sealer shall be a self-leveling, rapid cure silicone joint sealant that cures to a low-modulus rubber upon exposure to atmospheric moisture. Rapid cure is defined as the development of sufficient integrity within the silicone in 8 hours or less to accommodate highway traffic and movements associated with bridges. Deliver each lot or batch of sealing compound to the job site in the manufacturer's original sealed container. Each container shall be marked with the manufacturer's name, and batch or lot number, and shall be accompanied by the manufacturer's certification. Petroleum products shall not be deleterious to the sealant. Joint sealant shall meet the following requirements:

<u>Test</u>	<u>Limit</u>	<u>Test Method</u>
AS SUPPLIED:		
Extrusion Rate, g/minute, minimum	200	MIL S 8802
Specific Gravity	1.25 - 1.35	ASTM D 1475

AS INSTALLED - AT 77°F (25°C) AND 46-54% RH:		
Accelerated Weathering, 5,000 hours	No cracks, blisters or bond loss	ASTM C 793-75
Skin-over time, minutes, maximum	20	OHD L-3
Non-volatile content, %, minimum	93	OHD L-4
Joint Elongation, %, minimum	600	ASTM D 3583-85
Joint Modulus at 100%, psi (kPa)	3-12 (20.7 - 82.7)	ASTM D 3583-85 ^a

^a Section 14, Modified: Clean six 1x1x3 inch (25.4 x 25.4 x 76.2 mm) concrete blocks; hold under running tap water and scrub with a brush for approximately 30 seconds. Allow blocks to dry for 24 hours at room temperature. Assemble blocks with 1x3 inch (25.4 x 76.2 mm) surfaces facing with

1/2 x 1/2 x 1 inch (12.7 x 12.7 x 25.4 mm) Teflon spacers; hold in place with a clamp. Insert backer rod, closed cell, 1/2 inch diameter by 2 inches (12.7 mm diameter by 50.8 mm); do not touch surface with fingers. Inject sealant to fill the cavity, with no air entrapment. Allow the sealant to flow to a smooth surface, do not strike off. Allow to cure at 77°F (25°C) and 46-54% relative humidity. Cure for 160 hours, remove clamp and Teflon spacers, and pull the test specimens at 2 inches (50.8 mm) per minute.

2.2. *Elastomeric Mortar.* The binder material shall be a two-component, rapid curing liquid polymer that cures to a dense, semi-flexible polymer resistant to chemicals, weather, abrasion and impact. The binder material shall be compatible with the sealant, as determined by the sealant manufacturer. The binder shall be cured in the “neat” to form the primer between the elastomeric mortar and the existing surfaces and shall be mixed with aggregate to form the polymer based mortar. Aggregate for the elastomeric mortar shall be compatible with the liquid polymer (binder material), as determined by the manufacturer. Properties for the binder material shall conform to the following requirements:

COMBINED LIQUID COMPONENTS (The mixing ratio shall be 1:1 by volume)		
<u>Test</u>	<u>Limit</u>	<u>Test Method</u>
Viscosity, Pa-s, 75°F±2°F (23.9°C ± 1.1°C) (Brookfield Model LVT) (Spindle No. 2, 30 RPM)	0.9 - 2.0	ASTM D 2393
Gel Time, minutes	25 - 60	AASHTO M-200
Elongation, %	40 - 55	ASTM D 638 ^a
Tensile Strength, psi (MPa), minimum	900 (6.21)	ASTM D 638 ^a
Shore D Hardness, 77°F (25°C), 7 day cure	45 - 75	ASTM D 2240

^a Test Method Type 1, Molded Specimens, 1/4 inch (6.4 mm) thickness; speed of testing shall be 0.2±0.05 inch (5.1 ± 1.3 mm).

Properties for the elastic mortar shall conform to the following:

<u>Test</u>	<u>Limit</u>	<u>Test Method</u>
Absorption, %, maximum	1.0	ASTM D 570
Compressive Strength, 24 hr, psi (MPa), Method B, minimum	2500 (17.24)	ASTM C 579
Bond Shear Strength, psi (MPa), minimum	750 (5.17)	ASTM C 882
Abrasion Resistance Wear Index, Taber H-22, maximum	1.5	ASTM C 501
Compressive Stress, psi (MPa), minimum	350 (2.41)	OHD L-6
Resilience, %, minimum	70	OHD L-6
Thermal Compatibility	Pass	ASTM C 884

- 2.3. *General Use Procedure.* Mixing and application time shall be as recommended by the manufacturer. No modification of the elastomeric mortar should be attempted without first consulting the manufacturer.
- 2.4. *Acceptance and Sampling.* The sealant and elastomeric mortar shall be accepted on the basis of the manufacturer's certification in accordance with Subsection 106.04 and acceptable performance on the project. A type A certification shall be furnished for the joint sealant, except a type B certification shall be furnished for the Accelerated Weathering test. A type B certification will be furnished for elastomeric mortar, except a type A certification will be furnished for the binder material. Samples of the rapid cure joint sealant, and the binder material and aggregate for the elastomeric mortar, shall be submitted by the manufacturers to the Materials Division for testing and evaluation.
- 2.5. *Backer Rod.* Backer rod shall be in accordance with Subsection 419.04(d) of the Standard Specifications.
- 2.6. *Primer.* Primer shall be applied as detailed in the plans prior to installation of the sealant or as specified by the sealant manufacturer.
- 2.7. *Alternate Joint Products.* When alternate expansion joint systems are specified on the plans, the Contractor may use the alternate joint system in place of the nosing and sealant specified above. Sealants and nosing material may be considered as an equal alternate to the above specified materials provided that they successfully complete a 3-year trial installation and evaluation in the State of Oklahoma as determined by the Bridge Engineer.

701.09. METAL PARTING STRIPS.

These Specifications cover metal parting strips for use in forming longitudinal joints in concrete pavement or concrete base course.

Metal parting strips shall be shaped from metal of the sheet thickness shown on the Plans and shall be free from bends and kinks. They shall conform to the dimensions and be punched for pins and tie bars as shown on the Plans. Punching for pins may not be farther apart than 3 feet (915 mm) center to center. Sections of metal parting strips shall be not less than 10 feet (3.0 m) in length and so designed

that adjoining sections may be securely fastened together by lapping and pinning, by means of a slip joint or other approved method.

701.10. HIGH DENSITY CONCRETE FOR BRIDGE DECK REPAIR AND OVERLAY.

This Subsection covers the material requirements for high density concrete used for bridge deck repairs and/or overlays.

(a) **Aggregate.**

1. *Fine Aggregate.* The fine aggregate shall meet all requirements of Subsection 701.05 except for gradation.
2. *Coarse Aggregate.* The coarse aggregate shall be a crushed stone containing no chert or shale and having a minimum durability of 50 as determined by AASHTO T 210. The coarse aggregate shall meet all other requirements of Subsection 701.06 and shall have an absorption of not more than 3 percent by mass.
3. *Gradation.* The combined aggregate shall meet the following gradation requirements:

<u>SIEVE SIZE</u>	<u>PERCENT PASSING</u>
3/4 inch (19.0 mm)	100
1/2 inch (12.5 mm)	75 - 90
3/8 inch (9.5 mm)	62 - 80
No. 4 (4.75 mm)	38 - 54
No. 16 (1.18 mm)	16 - 32
No. 30 (600 μm)	10 - 20
No. 50 (300 μm)	4 - 12
No. 100 (150 μm)	2 - 8
No. 200 (75 μm)	0 - 4

(b) **Concrete.** The concrete shall meet the following requirements:

Basic Absolute Volumes per Unit Volume of Concrete.

Combined Aggregate	0.6194
Air Content	0.0650
Water	0.1601
Cement	<u>0.1555</u>
	1.0000

A water-reducing admixture meeting the requirements of Subsection 701.03 shall be used. The slump, measured in accordance with AASHTO T 119, shall be 3/4 inch ± 1/4 inch (20 ± 5 mm). The air content of the freshly mixed concrete shall be 6.5 ± 1.0 percent when tested in accordance with AASHTO T 152 or T 196.

- (c) **Grout.** Grout for bonding new concrete to existing concrete shall consist of equal parts by mass of portland cement and sand, mixed with sufficient water to form a stiff slurry. The consistency of this slurry shall be such that it can be applied with a stiff brush or broom to the old concrete in a thin, even coating that will not run or puddle in low spots. For sealing vertical joints around repair or between adjacent lanes of overlay and at curbs, this grout shall be thinned to paint consistency.

701.11. LATEX MODIFIED CONCRETE FOR BRIDGE DECK OVERLAYS.

Description. This Subsection covers the material requirements for latex modified concrete for bridge deck overlays.

(a) **Aggregate.**

1. *Fine Aggregate.* The fine aggregate shall meet all requirements of Subsection 701.05 except for gradation.
2. *Coarse Aggregate.* The coarse aggregate shall be a crushed stone containing no chert or shale and having a minimum durability factor of 50 as determined by AASHTO T 210 and have an absorption of not more than 3 percent. The coarse aggregate shall meet all other requirements of Subsection 701.06.
3. *Gradation.* The combined aggregate shall meet the following gradation requirements:

<u>SIEVE SIZE</u>	<u>PERCENT PASSING</u>
3/4 inch (19.0 mm)	100
1/2 inch (12.5 mm)	68 - 83
3/8 inch (9.5 mm)	56 - 70
No. 4 (4.75 mm)	36 - 46
No. 16 (1.18 mm)	12 - 24
No. 30 (600 μm)	7 - 17
No. 50 (300 μm)	4 - 12
No. 100 (150 μm)	2 - 8
No. 200 (75 μm)	0 - 4

- (b) **Latex Emulsion Admixture.** Formulated latex admixture shall be nontoxic, film forming, polymeric emulsion in water to which all stabilizers have been added at the point of manufacture and shall be homogenous and uniform in composition. Physical properties of the latex modifier shall conform to the following requirements:

Polymer Type Stabilizers	Styrene Butadiene
(1) Latex	Nonionic Surfactant
(2) Portland Cement Composition	Poly-dimethyl Siloxane
Percent Solids	46.0 - 49.0
Mass per Unit Volume, lbs/gallon, 77°F (kg/l, 25°C)	8.4 (1.007)
Color	White

A type D certification of materials will be required and shall be furnished to the Materials Engineer before acceptance of the product.

Latex admixture to be stored shall be kept in suitable enclosures which will protect it from freezing and from prolonged exposure to temperatures in excess of 29°C. Containers of latex admix-

ture may be stored at the bridge site for a period not to exceed 10 days. Such stored containers shall be covered completely with suitable insulating blanket material to avoid excessive temperatures.

- (c) **Latex Modified Concrete.** The latex modified concrete for use in overlay shall be a workable mixture having the following properties or limits:

<u>Material or Property</u>	<u>Concrete</u>
Cement (Parts by Mass)	1
Fine Aggregate (Parts by Mass)	2.5
Coarse Aggregate (Parts by Mass)	2.0
Latex Emulsion Admixture, gallon/bag (mL/Kg) cement	3.5 (311)
Air Content, %	3-6
Slump ^{a,b} , inches (mm)	4-6 (100-150)

- ^a Following sampling of the discharged, normally mixed material, the commencement of the slump test shall be delayed from 4 to 4-1/2 minutes.
- ^b Water may be added to obtain slump within the prescribed limits, but the water-cement ratio produced should be between 0.35-0.40 by mass. All of the nonsolids in the latex admixture should be considered as a part of the water.

701.12. PENETRATING WATER REPELLENT FOR TREATMENT OF CONCRETE SURFACES.

Description. This Subsection covers the material requirements for penetrating water repellents for use on concrete surfaces.

- (a) **General.** The penetrating water repellent treatment solution shall be an organo silicon compound dissolved in a suitable solvent carrier that, when applied, will produce a hydrophobic surface covalently bonded to the concrete. The organo silicon compound shall be one of the following:

ALKYL-ALKOXY-SILANE
OLIGOMEROUS ALKYL-ALKOXY-SILOXANE

The solvent shall leave less than one percent residue by mass upon evaporation. The penetrating water-repellant treatment solution shall not permanently stain, discolor, or darken the concrete. Application of the solution shall not alter the surface texture or form a coating on concrete surfaces and shall be compatible with the use of special surface finish texture coatings specified in Subsection 509.04(g). Treated concrete shall be surface dry within 30 minutes after application.

The penetrating water repellent treatment solution shall be tinted with a fugitive dye to enable the solution to be visible on the treated concrete surface for at least four hours after the application. The fugitive dye shall not be conspicuous more than seven days after application when exposed to direct sunlight.

- (b) **Certification.** A type D certification shall be submitted for each lot or shipment of materials prior to use. The manufacturer's recommended rate of coverage for the treatment solution as approved for use under these Specifications shall be included with the type D certification.

701.13. EPOXY RESIN ADHESIVES FOR GENERAL USE WITH CONCRETE.

Description. This Subsection covers two component, epoxy-resin bonding systems for application to portland cement concrete.

- (a) **General.** Epoxy-resin adhesives for general use with concrete shall comply with AASHTO M 235. If the type, grade and class of epoxy-resin is not specified on the Plans or in the Proposal, the Contractor shall furnish an epoxy-resin system that is appropriate for its intended use in accordance with AASHTO M 235.
Epoxy-resin adhesives for bonding pavement markers to pavement surfaces shall meet the requirements of Subsection 736.04 of these Specifications.
- (b) **Acceptance.** The Contractor shall furnish a type A certification for each batch or lot of each component.

701.14. WHITE CONCRETE.

Description. This Subsection covers the requirements for furnishing white Portland Cement concrete for median barriers specified under Section 627.

- (a) **Materials.** When white Portland Cement concrete is specified on the Plans, the following requirements shall supplement the general provision for Portland Cement concrete.
1. *Cement.* Cement shall be white Portland Cement and meet the requirements of ASTM C150 and AASHTO M-85 for Type 1 Portland Cement, except that the cement shall contain not more than 0.50% by mass of ferric oxide (Fe_2O_3).
 2. *Fine Aggregate.* Fine aggregate shall be light in color. The fine aggregate to be used in white concrete shall meet the requirements of Subsection 701.05 of the Standard Specifications.
 3. *Coarse Aggregate.* Coarse aggregate shall be light colored. The coarse aggregate shall be either No. 57 or 67, be free of discoloring and shall meet the requirements of Subsection 701.06 of the Standard Specifications.
 4. *Water.* Potable water, free from iron or other impurities which may cause staining, shall be used as mixing water.
 5. *Proportioning.* White concrete mixes shall be proportioned using ACI 211.1, "Standard Practice for Selecting Proportions for Normal Heavyweight and Mass Concrete." A white concrete mix for use in barrier construction will contain 660 lb/cy (392 Kg/m³) of white Type 1 cement, air content of $6 \pm 1\%$ and a slump of 3 ± 1 inch (75 ± 25 mm). Maximum water cement ratio shall be 0.53, and minimum compression strength shall be 3000 psi (20.68 MPa) in 28 days.
- (b) **Batching and Mixing.** Equipment for batching and mixing of white concrete shall be clean to prevent contamination by material which may contribute to discoloration. Cement bins and weigh hoppers shall be free of loose gray Portland Cement and truck mixers shall be cleaned to remove all loose gray concrete from the mixer drum.

- (c) **Surface Finish.** When white concrete median barriers are constructed in metal forms, take care to select a form oil which will not stain the surface of the white concrete. The surface shall be treated with penetrating water repellent solution in accordance with Section 515 at the rate recommended by the manufacturer.
- (d) **Acceptance.** The white concrete barrier or parapet shall be as white or whiter than a 10Y91 when compared to the Munsell Book of Color. Before production of the white concrete barrier or parapet, the Contractor will prepare and submit to the Engineer for approval a 1 square foot (300x300 mm) test panel using the materials proposed for use in the construction. The approved test panel shall be used as a standard for the remainder of the work.

701.15. AGGREGATES FOR ECONOCRETE BASE.

- (a) **Materials Covered.** These Specifications cover the requirements for aggregate used in econocrete bases.
- (b) **General Requirements.**
 1. **Alternate One.** Fine aggregate shall comprise 40 to 60 percent of the aggregate and shall meet the requirements of Subsection 701.05. Coarse aggregate shall be size no. 57 and shall meet the requirements of Subsection 701.06.
 2. **Alternate Two.** Fine aggregate shall meet the requirements of Subsection 701.05, except the gradation requirements do not apply. Coarse aggregate shall meet the requirement of Subsection 701.06, except the gradation requirements do not apply. The combined aggregate for econocrete base shall have a minimum sand equivalent of 45 when tested in accordance with AASHTO T176 and shall conform to the following gradation requirements:

<u>SIEVE SIZE</u>	<u>PERCENT PASSING</u>
1 1/2 inch (37.5 mm)	100
1 inch (25.0 mm)	70-100
1/2 inch (12.5mm)	55-85
No. 4 (4.75mm)	30-60
No. 40 (425µm)	10-30
No. 200 (75µm)	1-15

Recycled portland cement concrete pavement may be used under this subsection. When recycled portland cement concrete pavement is used as the sole source of coarse aggregate, the durability factor determined by AASHTO T161, Procedure A shall be waived and the Los Angeles Abrasion percent wear determined by AASHTO T96 shall be limited to a maximum of 50 percent wear after 500 revolutions.

3. **Notification.** The Contractor shall notify the Engineer in writing at the time of his design mix submittal as to which alternate he will use.
- (c) **Sampling and Testing.** Sampling and testing shall be in accordance with the applicable methods of Subsections 701.05 and 701.06.

701.16. AGGREGATE FOR OPEN GRADED PORTLAND CEMENT CONCRETE BASE.

(a) **Materials Covered.** These Specifications cover the requirements for aggregate used in open graded portland cement concrete bases.

(b) **General Requirements.** Aggregate shall be stockpiled in accordance with Subsection 106.09.

Aggregate shall be a gravel or crushed stone which shall conform to the requirements of AASHTO M 80, Class A, except as modified by these Specifications.

Aggregate shall consist of clean, tough, durable particles, practically free from clay, shale, coatings of any character, disintegrated or soft pieces, conglomerates, mud balls, sticks, salt, alkali, or vegetable matter, and shall meet the requirements as follows:

<u>PHYSICAL PROPERTIES OF AGGREGATES</u>	
L. A. Abrasion (max. % wear)	40
Mechanically Fractured Faces (min. %) ^a	70 w/2
Aggregate Durability Index, (min.)	40
Flat or Elongated Pieces ^{a,b} (max. %)	15
Clay Balls and Friable Particles (max. %)	0
Soft Particles (max. %)	5
Sticks or Roots (max. %)	0

^a Applies to the aggregate retained on the No. 4 (4.75 mm) sieve.

^b A flat or elongated piece is one in which the length is greater than five times the average thickness.

(c) **Gradation.** The aggregate shall conform to the following gradation requirements:

<u>SIEVE SIZE</u>	<u>PERCENT PASSING</u>
1 1/2 inch (37.5 mm)	100
1 inch (25.0 mm)	95 - 100
1/2 inch (12.5 mm)	25 - 60
No. 4 (4.75 mm)	0 - 10
No. 8 (2.36 mm)	0 - 5
No. 200 (75 μm)	0 - 2

(d) **Sampling and Testing.** Sampling and testing shall be in accordance with the applicable methods of Subsection 701.06.

SECTION 702 FLY ASH AND GROUND GRANULATED BLAST FURNACE SLAG

Description. This section covers fly ash to be used to modify or stabilize soils and ground granulated blast furnace slag and fly ash to be used as an admixture for concrete.

702.01. FLY ASH.

Fly ash shall meet the requirements of ASTM C 618, Class C or Class F.

The product of only one plant shall be used on the project, unless otherwise approved by the Engineer. The Contractor shall provide suitable means of storing and protecting the fly ash against contamination and dampness. Fly ash which has become partially set, contains lumps of caked fly ash, or has been contaminated will be rejected.

All methods of sampling and testing shall be in accordance with the above requirements except as modified by the Department's acceptance policy published as: "Procedure for Sampling, Testing and Acceptance of Fly Ash." Copies of the procedure are available at the office of the Materials Engineer.

702.02. GROUND GRANULATED BLAST FURNACE SLAG.

Ground granulated blast furnace slag shall meet the requirements of AASHTO M302, Grade 100 or 120.

The product of only one plant shall be used on the project, unless otherwise approved by the Engineer. The Contractor shall provide suitable means of storing and protecting the ground granulated blast furnace slag against contamination and dampness. Ground granulated blast furnace slag which has become partially set, contains lumps of caked ground granulated blast furnace slag or has been contaminated will be rejected. All methods of sampling and testing shall be in accordance with the above requirements except as modified by the Department's acceptance policy published as: "Procedure for Sampling, Testing and Acceptance of Ground Granulated Blast Furnace Slag." Copies of the procedure are available at the office of the Materials Engineer.

SECTION 703 MINERAL AGGREGATE, MISCELLANEOUS USES

Description. This Specification covers the requirements for mineral aggregate intended for various uses not specifically covered in other sections of these Specifications.

703.01. AGGREGATE FOR AGGREGATE BASE.

- (a) **Materials Covered.** These Specifications cover the aggregate for use in the construction of aggregate base courses (Section 303).
- (b) **General Requirements.** The aggregate base course material shall consist of an intimate mixture of graded aggregate, coarse and fine, and shall be practically free from vegetation or other deleterious substances. Coarse aggregate (material retained on a No. 10 (2.00 mm) sieve) shall consist of sound, tough, durable particles or fragments of gravel, stone, mine chats, disintegrated granite, crushed

concrete, or a combination thereof. Fine aggregate shall be sand, stone dust, or other inert, finely-divided mineral matter.

At least 40 percent of that portion of the completed mixture retained on the No. 4 (4.75 mm) sieve shall be composed of uniformly graded crushed particles (pieces of aggregate with one or more fractured faces resulting from the artificial crushing).

One hundred percent (100%) of the completed type C mixture retained on the No. 4 sieve shall be composed of uniformly graded particles with two or more fractured faces resulting from artificial crushing. The complete type C mixture may not contain more than fifteen percent (15%) natural (uncrushed) sand.

- (c) **Physical Properties.** The coarse aggregate retained on the 3/8 inch (9.5 mm) sieve of the finished mixture shall have a percent of wear, Los Angeles Abrasion Test, of not more than 45. No source of material used in the blend shall have a percent of wear of more than 45. The aggregate shall have an aggregate durability index of 40 or more.
- (d) **Gradation.** The graded aggregate, when uniformly blended and sampled from trucks or windrows, shall conform to the following requirements depending on the type being used. Materials for base courses which contain oversize particles of rock, gravel, lumps of clay, or conglomerated material shall not be loaded into vehicles for delivery to the road. Such oversize particles of aggregate must be screened, crushed, or otherwise processed to meet the Specifications before delivery to the road. The samples taken from trucks or windrows after the graded aggregate has been uniformly blended shall conform to the gradation limits for the type being constructed, as follows:

<u>SIEVE SIZE</u>	<u>TYPE A</u>	<u>TYPE B</u> <u>PERCENT PASSING</u>	<u>TYPE C</u>
3 inch (75 mm)		100	
2 inch (50mm)			100
1 1/2 inch (37.5 mm)	100	40-100	90-100
1 inch (25.4mm)			80-100
3/4 inch (19.0 mm)	40-100	30-75	
1/2 inch (12.5mm)			60-80
3/8 inch (9.5 mm)	30-75	25-60	
No. 4 (4.75 mm)	25-60	20-50	40-60
No. 10 (2.0 mm)	20-43	15-35	25-45
No. 40 (425 μm)	8-26	7-22	15-30
No. 200(75 μm) ^a	4-12	3-10	0-5
Plasticity Index ^b , %, maximum	6	6	6
Liquid Limit ^b , %, maximum	25	25	25

^a The material passing the No. 200 (75 μm) sieve shall not be greater than 2/3 of the amount of material passing the No.40 (425 μm) sieve.

^b The blending of separate aggregates will be permitted to produce an aggregate mixture meeting these requirements providing no individual aggregate has a plasticity index in excess of 8.

- (e) **Sampling and Testing.** Tests shall be conducted in accordance with the latest revision of the following AASHTO Methods except as noted:

Los Angeles Abrasion	T 96
Sieve Analysis	T 27
Sampling	T 2
Determining Plastic Limit & Plasticity Index	T 90
Fractured Faces	OHD L-18
Method of Preparation of Samples	T 87
Determining Liquid Limit	T 89
Standard Density	T 180 Method D
Aggregate Durability Index	T 210
Material Passing No.200 (75 µm) Sieve	T 11
Dust Coating (Plus No.8 (2.36 mm) material after dry sieving)	T 11
Soft Particles	OHD L-38

703.02. COVER AGGREGATES FOR BITUMINOUS SURFACE TREATMENTS.

- (a) **Materials Covered.** This Section establishes the requirements for aggregate to be used in construction of bituminous surface treatment (Section 402).
- (b) **General Requirements.** The aggregate for cover material shall consist of clean, sound and durable particles of mine chats, crushed gravel, or crushed stone. The cover material shall be of uniform quality throughout with not more than 5 percent of slate, shale, or soft stone particles and shall be substantially free from organic matter, clay, loam, or objectionable coating. A minimum of 75 percent of the aggregate retained on the No. 4 (4.75 mm) sieve shall have 2 or more mechanically fractured faces.
 The cover aggregate shall be reasonably dry when placed on the bituminous binder except when cationic emulsified asphalt is used.
 After the work starts, the same kind of cover material shall be used throughout the project unless otherwise permitted in writing by the Engineer.
- (c) **Physical Properties.** The cover aggregate shall conform to the following requirements:

<u>PROPERTY</u>	<u>LIMITS</u>
Los Angeles Abrasion, % wear, maximum	40
Durability, Dc Factor, minimum	40
Flat or elongated pieces ^a , %, maximum	15

^a A flat and elongated piece is one in which the length is greater than 5 times the average thickness.

- (d) **Gradation.** The gradation requirements for cover aggregates shall be as follows:

<u>Sieve Size</u>	<u>No. 1 Aggregate</u>	<u>No. 2 Aggregate Percent Passing</u>	<u>No. 3 Aggregate</u>	<u>No. 3C Aggregate</u>
3/4 inch (19.0 mm)	100			
5/8 inch (16.0 mm)			100	100
1/2 inch (12.5 mm)	25-60	100	90-100	70-100
3/8 inch (9.5 mm)	0-15	90-100	40-75	20-55
No. 4 (4.75 mm)	0-5	0-25	0-15	0-15
No. 8 (2.36 mm)		0-5	0-5	0-5
No. 200 (75 µm)	0-2	0-2	0-2	0-2
Dust Coating ^a	0-1	0-1	0-1	0-1

- ^a Dust coating on aggregates retained on No. 8 (2.36 mm) sieve shall be determined by ash loss (AASHTO T 11) after dry sieving.

The specific gradation or gradations shall be as shown on the Plans or in the Proposal. Use the same kind of specified aggregates throughout the project unless otherwise permitted in writing by the Engineer.

- (e) **Precoated Cover Aggregates.** When precoated material is specified, treat cover aggregate meeting the above Specification requirements with bituminous material meeting the requirements of Subsection 708.03. The application of bituminous material is to be within the range of 0.30 to 1.75 percent by mass of the untreated aggregate, depending on the type and grade of bituminous material applied. Apply sufficient quantity to satisfy the particular needs of surface absorption, dust dissipation, and film coating--durable and free of scales and blisters-- of the aggregate to be treated. When applied to the road, it shall be free of excess binder or moisture which might hinder the handling, spreading, or rolling operations.

NOTE: The producer shall obtain the approval of the Materials Engineer pertaining to the type, grade, and amount of asphalt treatment prior to starting production.

The producer shall consistently ascertain that the aggregate is free of surface or absorbed moisture which will interfere with binder absorption and adhesion, or cause blisters or subsequent scaling of the treatment. However, when it is advisable or necessary to facilitate uniform coating of the aggregate with the bituminous material, water may be added at the pugmill in an amount not to exceed 2 percent by mass of the aggregate. When heating is required, or elected by the producer, he shall maintain the bituminous materials at temperatures below the flash points or damaging temperatures. The temperatures of asphalt materials shall be within the mixing range for the particular type and grade as shown in Subsection 708.03(c) during application of the asphalt material to the aggregate.

Flow characteristics of the treated aggregate shall be such that it may be satisfactorily spread by approved mechanical spreading devices.

The required percent of asphalt for precoating the aggregate shall be determined by inspection of the type and grade of bituminous material and aggregate used.

- (f) **Sampling and Testing.** Sampling and testing shall be in accordance with the applicable methods of subsection 703.01(e).

703.03. AGGREGATES FOR TRAFFIC BOUND SURFACE COURSE.

- (a) **Materials Covered.** This Subsection covers the requirements and test methods for aggregates to be used in the construction of traffic bound surface course in Section 403.
- (b) **General Requirements.** Traffic bound surface course material shall consist of an intimate mixture of graded aggregate-- coarse and fine-- and shall be practically free from vegetation or other deleterious substances. Coarse aggregate, material retained on a No. 10 (2.00 mm) sieve, shall consist of sound, tough, durable particles or fragments of gravel, stone, mine chats, disintegrated granite, or combination thereof, crushed to size if necessary. Fine aggregate shall consist of sand, stone dust, or other inert finely divided mineral matter.
- (c) **Physical Properties.** The coarse aggregate retained on the 3/8 inch (9.5 mm) sieve of the finished mixture for Types A, B, C, D, and E shall have a percent wear not more than 45 when tested in accordance with the Los Angeles Abrasion Test.
- (d) **Gradation.** This Specification permits the selection and use of one of 6 gradations or types of surface course. The type required on the project may be specified in the bid item of the Proposal. When the type is not so specified, the Contractor may select the gradation or type in advance of construction. The material produced or processed shall conform in gradation for the type specified or selected. After work starts, the same type of material as specified or selected shall be used throughout the project unless otherwise permitted in writing by the Engineer.

Oversized particles of rock, gravel, lumps of clay, or conglomerate materials delivered to the road shall be crushed to meet the Specification sizes and shall then be incorporated in the surfacing material.

<u>SIEVE SIZE</u>	<u>TYPE A^a</u>	<u>TYPE B^b</u>	<u>TYPE C^c</u>	<u>TYPE D^d</u>	<u>TYPE E^e</u>	<u>TYPE F^f</u>
	<u>PERCENT PASSING</u>					
1 1/2 inch (37.5 mm)				100	100	100
1 inch (25.4 mm)	100	100	100	90-100		
3/4 inch (19.0 mm)	95-100	95-100			40-100	
1/2 inch (12.5 mm)				25-60		
3/8 inch (9.5 mm)					30-75	
No. 4 (4.75 mm)	5-75	0-85	40-75	0-5	25-60	35-80
No. 10 (2.5 mm)					20-43	
No. 20 (850 μm)	0-30					
No. 40 (425 μm)			20-40		8-26	
No. 200 (75 μm)	0-10	0-20	8-25		4-12	0-20
Plasticity Index, %			8-18		6 max.	
Liquid Limit, %, maximum			Not more than 35		25 max.	

- a Type A material shall consist of hard durable particles of sand, gravel, mine chats, crushed rock, or a combination of any of these materials.
 - b Type B material shall consist of hard, durable particle of disintegrated granite with natural binder.
 - c Type C material shall produce a bonded traffic bound surface course and shall consist of an intimate mixture of graded aggregate, coarse and fine. Coarse aggregate (material retained on a No. 10 (2.00 mm) sieve shall consist of sound, tough, durable particles or fragments of gravel, stone, disintegrated granite, or combination thereof, crushed to size if necessary. Fine aggregate shall consist of sand, stone dust, or other inert finely divided mineral matter.
 - d Type D material shall consist of hard durable particles of gravel or crushed stone.
 - e Type E material shall meet the requirements for Aggregate Base Type A in Subsection 703.01.
 - f Type F material shall consist of crusher run ledge rock, gyp rock or caliche and shall be used for temporary purposes only, in light traffic situations. The Los Angeles Abrasion Test requirement is not applicable to this material.
- (e) **Sampling and Testing.** Sampling and testing shall be in accordance with the applicable methods of Subsection 703.01(e).

703.04. COVER MATERIAL FOR PIPE UNDERDRAINS.

- (a) **Materials Covered.** These Specifications cover the materials used for coarse cover aggregate and filter sand for use with underdrain pipes in Section 613.
- (b) **General Requirements.** Coarse cover material shall be gravel or crushed stone. Filter sand shall be well graded and free from organic or other deleterious materials.
- (c) **Physical Properties.** The coarse cover material shall have a maximum abrasion loss of 50 and a minimum aggregate durability index of 40.
- (d) **Gradation.**
 1. *Coarse Cover Aggregate.*

<u>Sieve Size</u>	<u>Percent Passing</u>
1/2 inch (12.5 mm)	100
3/8 inch (9.5 mm)	90-100
No. 4 (4.75 mm)	20-55
No. 8 (2.36 mm)	0-25
No. 16 (1.18 mm)	0-5
No. 50 (300 μm)	0-2

2. *Filter Sand.*

<u>Sieve Size</u>	<u>Percent Passing</u>
3/8 inch (9.5 mm)	100
No. 4 (4.75 mm)	95-100
No. 16 (1.18 mm)	50-85
No. 50 (300 μ m)	15-33
No. 100 (150 μ m)	0-10

- (e) **Sampling and Testing.** Sampling and testing shall be in accordance with the applicable methods of Subsection 703.01(e).

703.05. GRANULAR BACKFILL.

- (a) **Materials Covered.** These Specifications cover granular backfill for use in excavation for structures (Section 501).
- (b) **General Requirements.** All granular backfill material shall be free from organic or other deleterious materials.
- (c) **Physical Properties.** The granular backfill material shall be substantially free of shale or other soft, poor durability particles, and the granular backfill shall have an aggregate durability index greater than or equal to 30.
- (d) **Gradation.** The granular backfill material shall be well graded and conform to the following gradation requirements.

<u>Sieve Size</u>	<u>Percent Passing</u>
3 inch (75 mm)	100
1 inch (25.0 mm)	90-100
No. 40 (425 μ m)	0-45
No. 200 (75 μ m)	0-10
Plasticity Index	Non-Plastic

- (e) **Sampling and Testing.** Sampling and testing shall be in accordance with the applicable methods of Subsection 703.01(e).

703.06. STANDARD BEDDING MATERIAL.

- (a) **Materials Covered.** These Specifications cover standard bedding material used in the construction of drainage conduits in Section 613.
- (b) **General Requirements.** Standard bedding material shall be sand, stone, screenings, or select sandy soil, and it shall be free of the following: organic material, stones larger than 3 inches (76.2 mm) in greatest dimension, frozen lumps, or moisture in excess of that permitting the specified compaction.
- (c) **Gradation.**
1. **Class B Bedding Material.** Class B bedding material shall conform to the following gradation requirements.

<u>Sieve Size</u>	<u>Percent Passing</u>
3/8 inch (9.5 mm)	100
No. 200 (75 μ m)	0-10

2. **Class C Bedding Material.** Class C bedding material shall be 1 inch (25 mm) maximum size granular material meeting the requirements of AASHTO M145 A-1 or A-3.
- (d) **Sampling and Testing.** Sampling and testing shall be in accordance with the applicable methods of Subsection 703.01(e).

SECTION 704 SOIL AGGREGATES

704.01. SOIL AGGREGATES FOR SUBBASES.

Description. These Specifications cover the material for use in the construction of a subbase foundation course in Section 306.

- (a) **Materials.** Subbase material shall conform to the requirements listed herein for the type of material designated on the Plans or in the Proposal. Unless otherwise shown on the Plans, furnish soil aggregate for subbases, and make such preliminary investigations as may be necessary to locate the proposed source of acceptable material. Information obtained by the Department in its preliminary investigations will be available to prospective bidders at the Materials Laboratory. Subbase materials shall meet the specified requirements before incorporation in the work.

NOTE: No material shall be delivered to the roadbed when the plasticity index exceeds the specified requirements by more than 2 points.

Type I. Subbase material to be used in Type I work shall pass a 3 inch (75 mm) sieve. If any material hauled on the project does not reduce to 3 inch (75 mm) or less, remove it from the right-of-way limits.

The material passing the 3 inch (75 mm) sieve and retained on the No. 10 (2.00 mm) sieve shall be composed of sound, durable particles. Lumps or clods will be broken down for testing. Material produced from a rock or rocklike formation shall have a slake durability index of 80 or more.

The fraction passing the No.10 (2.00 mm) sieve shall conform to the following:

<u>Sieve Size</u>	<u>Percent Passing</u>
No. 200 (75 μ m)	5 - 45
Liquid Limit, %, maximum	30
Plasticity Index, %, maximum	10

Type II. Subbase material to be used in Type II work shall be a soil aggregate obtained from an approved source. Material retained on the No.10 (2.00 mm) sieve shall be composed of sound, durable particles or fragments of sand, gravel, crushed stone, crushed concrete, mine chat, disintegrated granite,

stone screening— or a blend of these materials. Material produced from a rock or rocklike formation shall have a slake durability index of 80 or more. The gradation and soil constants shall conform to the requirements of the table for Grading A, B, C, and D. The Grading for Type II subbase shall be as specified on the Plans or in the Proposal.

Processing, including blending, may be necessary to comply with the grading or soil constants requirements for the grading specified.

TABLE REQUIREMENTS FOR GRADING AND SOIL CONSTANTS

<u>Sieve Size</u>	<u>Grading A</u>	<u>Grading B</u>	<u>Grading C</u>	<u>Grading D</u>
		<u>Percent Passing</u>		
2 1/2 inch (63 mm)	100			
2 inch (50 mm)	90-100	100	100	100
1 1/2 inch (37.5 mm)	60-100	95-100	95-100	95-100
3/8 inch (9.5 mm)	30-75			
No. 4 (4.75 mm)		45-100		45-100
No. 10 (2.00 mm)	15-50	25-100	55-100	25-100
No. 40 (425 μm)	8-35	10-50	30-70	10-50
No. 200 (75 μm) ^a	3-20	3-20	3-20	8-25
Liquid Limit, %, maximum	35	35	30	25
Plasticity Index, %, maximum	15	12	10	6

^a The fraction passing the No.200 (75 μm) sieve shall not be greater than 2/3 of the fraction passing the No.40 (425 μm) sieve.

(b) **Sampling and Testing.** Sampling and testing shall be done in accordance with the following AASHTO methods:

Sampling	T 2
Sieve Analysis	T 88
	(omitting Hydrometer Test)
Preparing Samples	T 87
Liquid Limit	T 89
Plastic Limit and Plasticity Index	T 90
Slake Durability	ASTM D4644
Standard Density	T 99

704.02. SOIL AGGREGATE FOR SAND CUSHION.

Description. These Specifications cover the material for use as sand cushion for concrete pavement.

- (a) **Materials.** Sand cushion shall all pass a 1 inch (25.0 mm) sieve and shall contain 5 to 35 percent of material passing the No. 200 (75 μ m) sieve. The final material shall have a liquid limit not exceeding 35 and a plasticity index not to exceed 8.

The material shall consist of natural sand-or, subject to approval, combinations of manufactured and natural sand- having hard, strong, durable particles, and it shall conform to these Specifications.

When manufactured sand is approved for use in combination with natural sand, at least 50 percent of the total material shall be natural sand.

- (b) **Sampling and Testing.** Sampling and testing shall be in accordance with AASHTO methods except where otherwise specified.

Sampling	T 2
Sieve Analysis	T 27
Liquid Limit	T 89
Plastic Limit & Plasticity Index	T 90
Standard Density	T 99

704.03. SOIL AGGREGATE FOR CALICHE BASE.

Description. This Subsection covers the material for use in the construction of caliche base in Section 305.

- (a) **Materials Covered.** The caliche base course material shall consist of an intimate mixture of graded aggregate, coarse and fine, together with a calcareous binder, and it shall be practically free from vegetation or other deleterious substances. Material retained on the No. 4 (4.75 mm) sieve shall be composed of gravel, stone, caliche type material or a combination of these materials.

The material passing the No. 4 (4.75 mm) sieve shall be a caliche type material and may contain sand, stone dust, or other inert finely divided matter, provided that not less than 1/2 shall be a calcareous material.

- (b) **Gradation.** The graded aggregate with calcareous binder, when uniformly blended and sampled from windrows, shall conform to the limits as follows:

<u>Sieve Size</u>	<u>Percent Passing</u>
2 inch (50 mm)	100
No.4 (4.75 mm)	0-60
No.40 (425 μ m)	0-40
Liquid Limit, %, maximum	35
Plasticity Index, %, maximum	10

- (c) **Crushed Particles.** At least 25 percent of that portion of the completed mixture retained on the No. 4 (4.75 mm) sieve shall be composed of uniformly graded crushed particles (pieces of aggregate with one or more fractured faces resulting from artificial crushing).
- (d) **Sampling and Testing.** Sampling and testing shall be done in accordance with AASHTO methods except where otherwise specified.

Sampling	T 2
Preparation of Sample for Test & Sieve Analysis	OHD L-20
Determination of Crushed Particles	OHD L-18
Liquid Limits	T 89
Plastic Limit & Plasticity Index	T 90
Standard Density	T 99 Method C or D

704.04. SOIL AGGREGATE FOR FLY ASH TREATED BASE.

Description. This Subsection covers the requirements and test methods for soil aggregate for fly ash treated base in Section 322.

- (a) **Source of Materials.** Suitable soils meeting these requirements shall be obtained from sources furnished by the Contractor and approved by the Engineer. The Contractor will be responsible for both the suitability and adequacy of the source proposed for use.

Make such preliminary investigations as may be necessary to locate the proposed source of suitable material. Information obtained by the Department in its preliminary investigations will be available to prospective bidders at the Materials Division.

Open the proposed source of suitable soil for the Engineer to inspect and obtain samples. Make such explorations as are necessary for the Engineer to obtain sufficient samples that are fully representative of the deposit. Each sample shall be representative of the full depth proposed for use. Tests of these samples, which must be obtained by the Engineer, will be made to determine if the material is suitable, the extent of the suitable material, and the proportioning of fly ash required. Allow a minimum of 30 days for sampling and testing the proposed source in advance of construction operations.

Excavation and production of the suitable material shall be done in a manner to deliver to the mixer a homogenous mixture represented by the samples which were used to determine the fly ash requirement.

- (b) **Soil.** The soil aggregate to be used in the fly ash treated base shall be sand, sand-gravel, silty sand, sand-clay, silt clay soil, limestone screenings, sandstone, or jig sand obtained from approved sources and shall be free of roots, sticks and sod tufts and reasonably free of deleterious concentrations of other organic matters, acids and minerals. It shall meet the following requirements prior to addition of fly ash:

<u>SIEVE SIZE</u>	<u>PERCENT PASSING</u>
2 inch (50 mm)	100
1 inch (25.0 mm)	95-100
No. 4 (4.75 mm)	55-100
Silt and clay fraction, maximum (smaller than 50 μ m)	50
Clay and colloid fraction, maximum (smaller than 5 μ m)	20
Liquid Limit, %, maximum	35
Plasticity Index, %, maximum	9

- (c) **Mixtures.** The proportions of soil-fly ash and water for each soil shall be determined by laboratory tests.
- (d) **Sampling and Testing.** Sampling and testing shall be done in accordance with the following AASHTO methods:

Sampling	T 2
Water	T 26
Preparation of Samples	T 87
Mechanical Analysis	T 88
Liquid Limits	T 89
Plastic Limit and Plasticity Index	T 90
Target Density	T 134

The target density shall be determined in the field by moisture density tests on representative samples of fly ash treated mixture obtained from the roadway. The test method for the target density is AASHTO T 134 modified to provide one compacted specimen of the soil-fly ash mixture as obtained from the roadway, with separate portions of the sample used for additional specimens with the moisture reduced or increased. The soil-fly ash mixture shall be mixed and compacted within ± 2 percentage points of optimum moisture content specified by the Engineer before there is any appreciable moisture loss.

SECTION 705 SELECT BORROW

Description. These Specifications cover the requirements and test methods for select borrow in Section 202.

705.01. MATERIALS.

- (a) **General Requirements.** Select borrow for use under these Specifications shall be a material meeting the following group classifications and group index values as defined in AASHTO M-145.

<u>Group Classification</u>	<u>Group Index (Maximum Value)</u>
A-1	(0)
A-2-4	(0)
A-3	(0)

Material to be used in this work shall pass a 3 inch (75 mm) sieve. Any material hauled to the project which does not reduce to 3 inch (75 mm) or less shall be removed from the right-of-way limits. Material produced from a rock or rocklike formation shall have a slake durability index of 80 or more.

When a lens, layer, or stratum of material is found in a borrow pit or roadway cut and is intended for use by the Contractor which does not comply with the specified requirements, it may be included in the mixture if a uniform blend of acceptable material will result from the blending and mixing accomplished in the production, loading, handling, and placement operations, in the normal course of construction.

The material shall be uniform in gradation and plastic properties throughout the entire plan depth.

Unless otherwise provided, furnish all materials for select borrow. Make such preliminary investigations as may be necessary to locate and verify the proposed source of acceptable material. Information obtained by the Department in its preliminary investigations will be available to prospective bidders at the Materials Division.

- (b) **Testing.** Testing shall be in accordance with the following AASHTO Methods except as noted:

Sieve Analysis	T 88 (Omitting Hydrometer Test)
Preparing Samples	T 87
Liquid Limit	T 89
Plastic Limit & Plasticity Index	T 90
Slake Durability	ASTM D4644

SECTION 706 LIME

Description. These Specifications cover lime requirements for lime treatment of soils in Section 307.

706.01. HYDRATED LIME.

- (a) **Definition.** Hydrated lime for stabilization shall consist essentially of a calcium hydroxide (with a lesser amount of calcium oxide, magnesium oxide, and magnesium hydroxide) made from a dry powder obtained by treating quick-lime with enough water to satisfy its chemical affinity for water under the conditions of its hydration.
- (b) **Chemical Composition.** When tested under the appropriate sections of ASTM C 25, the lime shall conform to the following requirements:
Available calcium hydroxide.
Available lime index (as is basis) expressed as Ca(OH)_2 - Not less than 90 percent.
- (c) **Fineness.** When tested under the appropriate sections of ASTM C 110, the lime shall conform to the following requirements:

<u>SIEVE SIZE</u>	<u>PERCENT PASSING</u>
No. 20 (850 μm)	99 - 100
No. 200 (75 μm)	80 - 100

706.02. QUICK LIME.

- (a) **Definition.** Quick lime for stabilization purposes shall consist of a calcined material, the major part of which is calcium oxide or calcium oxide in natural association with a lesser amount of magnesium oxide capable of slaking with water.
- (b) **Chemical Composition.** When tested under the appropriate sections of ASTM C 25, the lime shall conform to the following requirements:
Available calcium hydroxide expressed as calcium oxide.
Available lime index (as is basis) expressed as CaO - not less than 90 percent.
- (c) **Fineness.** When tested under the appropriate sections of ASTM C 110, the lime shall conform to the following requirements:

<u>PROPERTY</u>	<u>LIMITS</u>
Slaking Temperature Rise, $^{\circ}\text{C}$, minimum	40
Total active Slaking Time, minutes, maximum	20

When tested in accordance with method OHD L-28 the lime shall conform to the following requirements:

<u>SIEVE SIZE</u>	<u>PERCENT PASSING</u>
5/8 inch (16.0 mm)	95-100
No. 200 (75 µm)	0-15

706.03. BY-PRODUCT LIME.

By-product lime will be tested under the appropriate sections of ASTM C 25 to determine the available lime index (by rapid sugar method) expressed as available calcium hydroxide $\text{Ca}(\text{OH})_2$.

Calculations will be based on the dry mass of the material. Sufficient by-product lime shall be required to provide an equivalent amount of available lime based on 90 percent availability per ton (metric ton) (dry mass) of hydrated lime.

706.04. AGRICULTURAL LIMESTONE.

Agricultural limestone shall be a high calcic or dolomitic limestone having a neutralization value of at least 80 percent of calcium carbonate. The neutralization value and sieve analysis shall be in accordance with ASTM C 602. The material shall be free from harmful quantities of toxic salts and other objectionable matter.

The fineness shall conform to the following requirements:

<u>SIEVE SIZE</u>	<u>PERCENT PASSING</u>
No. 4 (4.75 mm)	100
No. 8 (2.36 mm)	90-100
No. 60 (250 µm)	30-100

SECTION 707 MICRO SURFACING

707.01. DESCRIPTION.

These Specifications cover the materials for use in the construction of micro surfacing.

707.02. MATERIALS.

- (a) **Approval of Materials.** Prior to use, samples of all materials proposed to be used under these Specifications shall be submitted to the Materials Division for tests. The mix design will be prepared by the contractor and submitted to the Materials Division, with applicable worksheets and data, for approval. The mix design shall comply with these Specification requirements and establish the job-

mix formula for the mixture. The job-mix formula shall establish a single percentage of residual asphalt for the mixture. Previous mix designs from the current calendar year may be used.

To substantiate the design, trial mixtures may be produced and tested using all of the proposed project materials and equipment prior to placement. The Engineer may waive trial mixtures if the same design has been proven to be in conformance with these requirements.

If a change in sources of materials is made, a new mix design will be established before the new material is used. When unsatisfactory results or other conditions make it necessary, the Engineer may request a new mix design.

The aggregate will be conditionally approved in the stockpile at the plant. The asphalt will be conditionally approved at the source. The mixture will be conditionally approved after blending and mixing at the micro surfacing machine, pending the results of all applicable final acceptance tests.

- (b) **Mineral Aggregate.** The mineral aggregate shall be composed of clean and durable particles of 100% crushed traprock, granite, sandstone or other approved aggregates and shall meet the requirements as follows:

<u>PHYSICAL PROPERTIES OF AGGREGATES</u>	
<u>PROPERTY</u>	<u>LIMITS</u>
L. A. Abrasion, % wear, maximum	40
Sand Equivalent, %, minimum	65
Mechanically Fractured Faces ^a , %, minimum	100 w/2
Aggregate Durability Index, minimum	40
Insoluble Residue, %, minimum	65
Flat or Elongated Pieces ^{a,b} , %, maximum	15
Natural Sand and Gravel, %, maximum	0
Clay Balls and Friable Particles, %, maximum	0
Soft Particles, %, maximum	5
Sticks or Roots, %, maximum	0

^a Applies to the aggregate retained on the No. 4 (4.75 mm) sieve.

^b A flat or elongated piece is one in which the length is greater than five times the average thickness.

- (c) **Emulsified Asphalt.** The asphalt shall be a polymer modified PMCSS-1h (cationic) emulsified asphalt conforming to the provisions of Subsection 708.03, Table 5c.
- (d) **Mineral Filler.** The mineral filler shall be a recognized brand of Portland cement that is free from lumps. It may be accepted upon visual inspection.
- (e) **Water.** The water will be potable and will be free of harmful soluble salts. Water may be added as recommended by the emulsion manufacturer.
- (f) **Other Additives.** Additives supplied and approved by the emulsion manufacturer may be added to the emulsion mix to provide control of the material in the field.

707.03. COMPOSITION OF MIXTURES.

The mixture system will be so formulated that it will cure sufficiently one (1) hour after mixing, at job site conditions, to allow traffic without damage to the mat. Additional curing may be required at locations such as driveways, intersections, or other areas where sharp turns, sudden accelerations or decelerations take place.

<u>SIEVE SIZE</u>	<u>TYPE I</u>	<u>TYPE II</u>	<u>TYPE III</u>
	<u>PERCENT PASSING</u>		
3/8 inch (9.5 mm)	100	99-100	98-100
No. 4 (4.75 mm)	98-100	80-94	75-85
No. 10 (2.00 mm)	68-86	40-60	45-55
No. 40 (425 µm)	22-41	12-30	15-25
No. 80 (180 µm)	10-25	8-20	8-15
No. 200 (75 µm)	5-15	5-15	2-8

Residual asphalt, by dry mass of aggregate: 6 - 9%

Mineral filler, by dry mass of aggregate: 1.0 - 3.0%

Water: as required to provide the specified properties.

Additives: as required to provide the specified properties.

707.04. TOLERANCES.

The limits in Subsection 707.03 establish the Specification ranges, except that the residual asphalt content of the mixture shall not vary more than ± 0.5 percent from the job-mix formula when measured by the tank-strap method.

707.05. SAMPLING AND TESTING.

Sampling and testing shall be done in accordance with Subsection 708.06.

SECTION 708**PLANT MIX BITUMINOUS BASES AND SURFACES**

Description. This Section covers the materials requirements, mix designs, proportioning, mix tolerances, and sampling and testing methods for plant- mixed bituminous bases and surfaces.

708.01. APPROVAL OF MATERIALS.

Prior to use, aggregate sources and percentage of blends must be approved on a project basis by the Materials Engineer.

The aggregate shall be stockpiled in accordance with Subsection 106.07 and may be accepted in stockpile at the plant site. The plant mixed materials may be accepted after blending and mixing at the plant. Asphalt must be obtained from an approved source and may be conditionally accepted in accordance with Subsection 708.06(b).

708.02. MINERAL AGGREGATE.

The mineral aggregate shall be composed of coarse aggregate, fine aggregate, and mineral filler as required to meet these Specifications. If natural gravel is to be crushed for use in any of the mixes, a washing operation may be required to provide complete separation of all fines which may be stuck to the gravel.

NOTE: In no case will the blending of different material in the same storage or feeder be permitted. The aggregates shall meet the requirements set forth in Table 1.

**TABLE 1
PHYSICAL PROPERTIES OF AGGREGATES**

<u>Aggregates to be used in:</u>				
Test	Asphalt Concrete	Open Graded Friction Course	Open Graded Bituminous Base	Hot Mix Cold Lay
L. A. Abrasion ^a % wear, maximum	40	30 ^b	40	40
Sand Equivalent ^b , %, minimum				
Wearing Course	45	NA	NA	45
Base or Binder	40	NA	NA	40
Mechanically Fractured Faces ^{b,c} , %, minimum	75w/2	75w/2 ^a	75w/2	75w/2
Aggregate Durability Index ^a , minimum	40	40	40	40
Insoluble Residue ^{d,e} , %, minimum				
3000 Million ESAL's or More	40	40	NA	NA
Less Than 3000 Million ESAL's	30	30	NA	NA
Flat or Elongated Pieces ^{b,c,f} , %, maximum	15	15	15	15
Natural Sand and Gravel ^b , %, maximum				
1000 ADT or more	15 ^h	0	0	NA
Less Than 1000 ADT	25 ^h	0	0	NA
Clay Balls and Friable Particles ^g , %, maximum	1.0	0	0	1.0
Soft Particles ^a , %, maximum	5	5	5	5
Sticks or Roots ^a , %, maximum	0.5	0	0	0.5

- ^a Applies to each source except as noted.
- ^b Applies to the combined aggregate except as noted.
- ^c Applies to the aggregate retained on the No. 4 (4.75 mm) sieve.
- ^d Applies to the combined coarse aggregate.
- ^e Applies to the coarse aggregate used in the surface course. Does not apply to shoulders and temporary detours.
- ^f A flat or elongated piece is one in which the length is greater than five times the average thickness.
- ^g Applies to the combined aggregate. Provided the maximum for the combined aggregate is not exceeded, a maximum 1.5 percent will be allowed for any one source.
- ^h Limited to 10 percent for Type E.

The use of a crusher run or similarly graded aggregate shall not be the sole source of crushed coarse aggregate in asphalt concrete, types A, B, C, and E.

- (a) **Coarse Aggregate.** The coarse aggregate shall be that part of the aggregate retained on the No. 10 (2.00 mm) sieve and shall consist of clean, tough, durable particles. It shall be practically free from soft and disintegrated pieces, shale, clay, organic or other injurious matter occurring either free or as a coating on the aggregate.

Natural gravel shall not be used as a source of insoluble material unless it has been crushed so that at least 75 percent of the material retained on the No. 4 (4.75 mm) sieve has two or more mechanically fractured faces. The natural gravel used as a source of insoluble materials shall have not more than 30 percent passing the No. 4 (4.75 mm) sieve after crushing except when used in asphalt concrete, type D.

- (b) **Fine Aggregate.** Fine aggregate shall be that part of the aggregate passing the No. 10 (2.00 mm) sieve and shall consist of hard, durable grains of natural sand, crushed stone, stone dust, crushed gravel, mine chat or jig-sand or any combination of these materials. Crushed materials shall be produced from material conforming to the requirements of coarse aggregate.

When used in the wearing course, the material in the natural sand passing the No. 200 (75 μ m) sieve shall be less than 50 percent of that contained in the combined aggregate including mineral filler.

- (c) **Mineral Filler.** Mineral filler, when required in addition to that naturally contained in the aggregate, shall conform to AASHTO M 17.

708.03. ASPHALT MATERIALS.

- (a) **General.** Asphalt cement shall meet the requirements of AASHTO MP1 for the grade specified. All other bituminous materials shall meet the requirements shown in Tables 2 through 3C for the type and grade of asphalt material specified.

**TABLE 2
REQUIREMENTS FOR CUT-BACK ASPHALT (MEDIUM CURING TYPE)**

Cut-back asphalt shall be produced by fluxing an asphalt base with suitable petroleum distillates, shall show no separation or curdling prior to use, and shall not foam when heated to application temperature.

GRADE TEST	MC-30		MC-70		MC-250		MC-800		MC-3000	
	MIN	MAX	MIN	MAX	MIN	MAX	MIN	MAX	MIN	MAX
Kinematic Viscosity, 140°F (60°C), mm ² /s	30	60	70	140	250	500	800	1600	3000	6000
Flash Point (Tag, open-cup), °F (°C)	100 (38)	...	100 (38)	...	150 (66)	...	150 (66)	...	150 (66)	...
Water, %	...	0.2	...	0.2	...	0.2	...	0.2	...	0.2
Distillation Test:										
Distillate percentage by volume										
of total distillate to 680°F (360°C);										
to 440°F (225°C)	...	25	0	20	0	10	...	...	...	...
to 500°F (260°C)	40	70	20	60	15	55	0	35	0	15
to 600°F (315°C)	75	93	65	90	60	87	45	80	15	75
Residue from distillation to 680°F (360°C)										
volume percentage of sample by										
difference										
	50	...	55	...	67	...	75	...	80	...
Tests on residue from distillation:										
Absolute Viscosity, 140°F (60°C), Pa·s	40	120	40	120	40	120	40	120	40	120
Ductility ^a , 77°F (25°C), 5 cm/min., cm	100	...	100	...	100	...	100	...	100	...
Solubility in Trichloroethylene, %	99.0	...	99.0	...	99.0	...	99.0	...	99.0	...
Spot test with Standard Naphtha Solvent	Neg		Neg		Neg		Neg		Neg	

^a If the ductility is less than 100, the material will be accepted if its ductility at 60°F (15.6°C) is 100 or greater.

TABLE 3A

REQUIREMENTS AND TYPICAL APPLICATIONS FOR EMULSIFIED ASPHALT

The emulsified asphalt shall be homogeneous. Within 30 days after delivery and provided separation has not been caused by freezing, the emulsified asphalt shall be homogeneous after thorough mixing.

TYPE GRADE	RAPID-SETTING				MEDIUM-SETTING					
	RS-1		RS-2		MS-1		MS-2		MS-2h	
	MIN	MAX	MIN	MAX	MIN	MAX	MIN	MAX	MIN	MAX
TEST										
Tests on emulsion:										
Viscosity, Saybolt Furol, 77°F (25°C), s	20	100	...	...	20	100	100	...	100	...
Viscosity, Saybolt Furol, 122°F (50°C), s	...	...	150	400	...	...	...	...	...	...
Storage stability test, 24-h, %	...	1	...	1	...	1	...	1	...	1
Demulsibility ^a , 35 ml, 0.02 N CaCl ₂ , %	60	...	60	...	...	...	...	...	...	...
Coating ability and water resistance:										
Coating	...	...	...	...	...	good	...	good	...	good
Coating retention	...	...	...	...	...	fair	...	fair	...	fair
Sieve test, %	...	0.10	...	0.10	...	0.10	...	0.10	...	0.10
Residue by distillation, %	55	...	63	...	55	...	65	...	65	...
Tests on residue from distillation test:										
Viscosity, 140°F (60°C), Pa-s	40	120	40	120	40	120	40	120	160	480 ^b
Penetration, 77°F (25°C), 100g, 5s	100	200	100	200	100	200	100	200	40	90
Ductility, 77°F (25°C), 5 cm/min., cm	40	...	40	...	40	...	40	...	40	...
Solubility in Trichloroethylene, %	97.5	...	97.5	...	97.5	...	97.5	...	97.5	...

Typical applications:

For RS-1: Surface treatment, penetration macadam, sand seal coat, tack coat, mulch.

For RS-2: Surface treatment, penetration macadam, coarse aggregate seal coat (single and multiple).

For MS-1: Cold plant mix, road mix, sand seal coat, crack treatment, tack coat.

For MS-2: Cold plant mix, coarse aggregate seal coat (single and multiple), crack treatment, road mix, tack coat, sand seal coat.

For MS-2h: Cold plant mix, hot mix, coarse aggregate seal coat (single and multiple), crack treatment, road mix, tack coat.

TABLE 3A (continued)

TYPE GRADE TEST	HIGH FLOAT				S LOW SETTING							
	HFMS-1		HFMS-2		HFMS-2h		HFMS-2s		SS-1		SS-1h	
	MIN	MAX	MIN	MAX	MIN	MAX	MIN	MAX	MIN	MAX	MIN	MAX
Tests on emulsion:												
Viscosity, Saybolt Furol, 77°F (25°C), s	20	100	100	...	100	...	50	...	20	100	20	100
Viscosity, Saybolt Furol, 122°F (50°C), s	...	...	...	...	...	...	...	...	...	...	...	...
Storage stability test, 24-h, %	...	1	...	1	...	1	...	1	...	1	...	1
Coating ability and water resistance:												
Coating	good		good		good		good		good		good	
Coating retention	fair		fair		fair		fair		fair		fair	
Cement mixing test, %	...	...	...	...	...	...	...	...	2.0	...	2.0	...
Sieve test, %	...	0.10	...	0.10	...	0.10	...	0.10	...	0.10	...	0.10
Residue by distillation, %	55	...	65	...	65	...	65	...	57	...	57	...
Tests on residue from distillation test:												
Viscosity, 140°F (60°C), Pa-s	40	120	40	120	160	480 ^b	20	60	40	120	160	480 ^b
Penetration, 77°F (25°C), 100g, 5s	100	200	100	200	40	90	200	...	100	200	40	90
Ductility, 25°C, 5 cm/min., cm	40	...	40	...	40	...	40	...	40	...	40	...
Solubility in Trichloroethylene, %	97.5	...	97.5	...	97.5	...	97.5	...	97.5	...	97.5	...
Float test, 140°F (60°C), s	1200	...	1200	...	1200	...	1200	...	...	...	...	...

Typical applications^c:

- HFMS-1: Cold plant mix, road mix, sand seal coat, crack treatment, tack coat.
- HFMS-2: Cold plant mix, coarse aggregate seal coat (single and multiple), crack treatment, road mix, tack coat, and seal.
- HFMS-2h: Cold plant mix, hot plant mix, coarse aggregate seal (single and multiple), crack treatment, road mix, tack coat.
- HFMS-2s: Dense-graded cold plant mix and road mix, stockpile mix, crack treatment, patching mix.
- SS-1&SS-1h: Cold plant mix, road mix, slurry seal coat, tack coat, fog seal, dust layer, mulch.

^a The demulsibility test shall be made within 30 days from date of shipment.

^b Variability will be limited to ± 60 Pa-s from the target value established by the manufacturer.

^c These typical applications are for use only as a guide for selecting and using emulsion for pavement construction and maintenance.

**TABLE 3B
REQUIREMENTS AND TYPICAL APPLICATIONS FOR CATIONIC EMULSIFIED ASPHALT**

The emulsified asphalt shall be homogeneous. Within 30 days after delivery and provided separation has not been caused by freezing, the emulsified asphalt shall be homogeneous after thorough mixing.

TYPE GRADE TEST	RAPID-SETTING				MEDIUM-SETTING				
	CRS-1		CRS-2		CMS-1		CMS-2		
	MIN	MAX	MIN	MAX	MIN	MAX	MIN	MAX	
Tests on emulsions:									
Viscosity, Saybolt Furol, 77°F (25°C), s	...	...	...	...	...	...	...	...	...
Viscosity, Saybolt Furol, 122°F (50°C), s	20	100	150	400	50	500	50	450	
Storage stability test ^a , 24-h, %	...	1	...	1	...	1	...	1	
Demulsibility ^a , 35ml 0.8%									
Sodium dioctyl sulfosuccinate %	40	...	40	...	...	...	...	...
Classification test	Passes		Passes						
Coating ability and water resistance:									
Coating	...	...	...	...	Good		Good		
Coating retention	...	...	...	...	Fair		Fair		
Particle charge test	Positive		Positive		Positive		Positive		
Sieve test, %	...	0.10	...	0.10	...	0.10	...	0.10	
Cement mixing test, %	...	...	...	...	...	...	...	...
Distillation:									
Oil distillate, by volume of emulsion, %	...	0.1	...	0.1	...	8	...	12	
Residue, %	60	...	65	...	65	...	65	...	
Tests on residue from distillation test:									
Viscosity, 140°F (60°C), Pa-s	40	120	40	120	°	...	40	120	
Penetration, 77°F (25°C), 100 g, 5s	100	250	100	250	300	...	100	250	
Ductility, 77°F (25°C), 5cm/min., cm	40	...	40	...	40	...	40	...	
Solubility in Trichloroethylene, %	97.5	...	97.5	...	97.5	...	97.5	...	

**TABLE 3B (continued)
REQUIREMENTS AND TYPICAL APPLICATIONS FOR CATIONIC EMULSIFIED ASPHALT**

The emulsified asphalt shall be homogeneous. Within 30 days after delivery and provided separation has not been caused by freezing, the emulsified asphalt shall be homogeneous after thorough mixing.

TYPE GRADE TEST	SLOW-SETTING			
	CSS-1		CSS-1h	
	MIN	MAX	MIN	MAX
Tests on emulsions:				
Viscosity, Saybolt Furol, 77°F (25°C), s	20	100	20	100
Viscosity, Saybolt Furol, 122°F (50°C), s	...	...	...	...
Storage stability test ^a , 24-h, %	...	1	...	1
Demulsibility ^a , 35ml 0.8%				
Sodium dioctyl sulfosuccinate, %	...	...	...	...
Classification test				
Coating ability and water resistance:				
Coating	Good		Good	
Coating retention	Fair		Fair	
Particle charge test	Positive ^b		Positive ^b	
Sieve test, %	...	0.10	...	0.10
Cement mixing test, %	...	2.0	...	2.0
Distillation:				
Oil distillate, by volume of emulsion, %	...	...	...	...
Residue, %	57	...	57	...
Tests on residue from distillation test:				
Viscosity, 140°F (60°C), Pa-s	40	120	160	480 ^d
Penetration, 77°F (25°C), 100 g, 5s	100	250	40	90
Ductility, 77°F (25°C), 5cm/min., cm	40	...	40	...
Solubility in Trichloroethylene, %	97.5	...	97.5	...

FOOTNOTES FOR TABLE 3B

Typical applications^e:

CRS-1: Surface treatment, penetration macadam, sand seal coat, tack coat, mulch.

CRS-2: Surface treatment, penetration macadam, coarse aggregate seal coat (single and multiple).

CMS-1: Cold plant mix, road mix, hot mix-cold lay.

CMS-2: Cold plant mix, coarse aggregate seal coat (single and multiple), crack treatment, road mix, tack coat, sand seal coat.

CSS-1 & CSS-1h: Cold plant mix, road mix, slurry seal coat, tack coat, fog seal, dust layer, mulch.

- ^a The 24 hour storage stability test results do not necessarily predict satisfactory 5 - day settlement test results.
- ^b If the particle charge test result is inconclusive, material having a maximum pH value of 6.7 will be acceptable.
- ^c The Saybolt Furol viscosity of the residue shall be 200-600 seconds when tested at 180°F (82°C).
- ^d Variability will be limited to ± 60 Pa-s from the target value established by the manufacturer.
- ^e These typical applications are for use only as a guide for selecting and using the emulsion for pavement construction and maintenance.

**TABLE 3C
REQUIREMENTS AND TYPICAL APPLICATIONS FOR
POLYMER MODIFIED CATIONIC EMULSIFIED ASPHALT**

The emulsified asphalt shall be homogeneous. Within 30 days after delivery and provided separation has not been caused by freezing, the emulsified asphalt shall be homogeneous after thorough mixing.

TYPE GRADE TEST	RAPID-SETTING PMCRS-2s ^a		SLOW-SETTING PMCSS-1h	
	MIN.	MAX.	MIN.	MAX.
Tests on emulsions:				
Viscosity, Saybolt Furol, 77°F (25°C), s	...	...	20	100
Viscosity, Saybolt Furol, 122°F (50°C), s	125	400	...	...
Storage stability test ^b , 24-h, %	...	...	...	1
Storage stability test ^c , 5 day, %	...	5	...	...
Classification test	Passes			
Particle charge test	Positive		Positive	
Sieve test, %	...	0.1	...	0.1
Demulsibility	60	...	...	...
Distillation: ^{d,e}				
Oil distillate, by volume of emulsion, %	...	2	...	0.5
Residue, %	65	...	62	...
Tests on residue from distillation test:				
Viscosity, 140°F (60°C), Pa·s	110	...	8000	...
Penetration, 77°F (25°C), 100 g, 5s	100	200	40	90
Ductility, 77°F (25°C), 5cm/min., cm	...	...	70	...
Ductility, 40°F (4°C), 5cm/min., cm	30	...	...	...
Softening point, ring & ball, °F (°C)	112 (44)	...	135 (57)	...
Elastic recovery, 50°F (10°C), %	58	...	...	...
Tensile stress @ 800% elongation, 40°F (4°C), 50 cm/min., kPa	196	...	...	...
Solubility in Trichloroethylene, %	...	...	97	...
Ash Content, %	...	1.0	...	...

Typical applications ^f:

PMCRS-2s: Bituminous binder in bituminous surface treatments in Section 402.

PMCSS-1h: Bituminous binder in micro-surfacing in Section 707.

FOOTNOTES:

- ^a A Type B certification shall be furnished for each lot for polymer modified asphalt in accordance with Subsection 106.04.
- ^b The 24 hour storage stability test results do not necessarily predict satisfactory 5 day settlement test results.
- ^c Upon examination of the test cylinder after standing undisturbed for 5 days, there shall be no milky colored substance anywhere within the test cylinder but a homogenous brown color throughout.
- ^d The standard distillation procedure will be modified as follows:
1. Temperature of 350°F±5°F (177°C ± 3°C) will be maintained on lower thermometer for the last 20 minutes of test.
 2. Test duration of 60 ± 10 minutes from the first application of heat.
- ^e The distillation residue of the modified emulsion shall contain a minimum of 3% polymer solids by mass of asphalt, as determined by an analytical method approved by the Department.
- ^f These typical applications are for use only as a guide for selecting and using the emulsion for pavement construction and maintenance.

TABLE 4 (English)
TEMPERATURE RANGES FOR USE OF ASPHALT MATERIALS

<u>Type or Grade of Asphalt</u>	<u>Mixture At Discharge Max.°F</u>	<u>Asphalt Temperature</u>	
		<u>For Mixing °F</u>	<u>For Spraying °F</u>
PG76	350	275-350	285-350
PG70	350	275- 350	285-350
PG64	350	275-350	285-350
PG58	350	275-350	285-350
PG52	325	275-350	285-350
MC-30		50-120	50-120
MC-70		80-150	80-150
MC-250	200	100-200	100-200
MC-800	210	160-210	185-260
MC-3000	250	200-250	225-275
ALL EMULSIONS		70-185	70-185

TABLE 4 (Metric)
TEMPERATURE RANGES FOR USE OF ASPHALT MATERIALS

<u>Type or Grade of Asphalt</u>	<u>Mixture At Discharge Max. °C</u>	<u>Asphalt Temperature</u>	
		<u>For Mixing °C</u>	<u>For Spraying °C</u>
PG76	177	135-177	141-177
PG70	177	135-177	141-177
PG64	177	135-177	141-177
PG58	177	135-177	141-177
PG52	163	135-177	141-177
AC-3.5	163	116-143	127-163
MC-30		10-49	10-49
MC-70		27-66	27-66
MC-250	93	38-93	38-93
MC-800	99	71-99	85-127
MC-3000	121	93-121	107-135
ALL EMULSIONS		21-85	21-85

- (b) **Handling.** The handling, loading, hauling, transfer pumping or similar operations connected with the movement of bituminous materials shall be in compliance with the requirements of the Oklahoma Department of Transportation, Materials Division. Copies of these requirements may be obtained at the office of the Materials Engineer. If at any time materials furnished for use under these Specifications fail to produce satisfactory results, further shipments will be rejected. The material will not be accepted for further work until the producer satisfies the Engineer that the material has been so corrected as to produce satisfactory results.
- (c) **Application Temperature.** The temperature to which asphalt materials shall be heated at the time of use shall be as shown in Table 4, unless otherwise specified.
- (d) **Additional requirements for Asphalt Cement.** PG 64-22 OK, PG 70-28 OK, PG 76-28 OK shall meet the requirements for PG 64-22, PG 70-28, and PG 76-28 as shown in AASHTO MP1. Additionally, they must meet the requirements as shown below.
1. Elastic recovery, ASTM D6048, 25°C, run on RTFO residue.
 - a. 65% Minimum for PG 70-28 OK
 - b. 75% Minimum for PG 76-28 OK
 2. Separation, AST D5976, except test as original binder for G* value according to AASHTO TP5. (Separation is defined as 10% or greater difference in G* between top and bottom samples.)
 3. AASHTO TP5 - Test Method for Determining the Rheological Properties of Asphalt Binder Using a Dynamic Shear Rheometer (DSR)
 - a. Original DSR G*/sin (d) limits 1.00 - 2.50.

- b. RTFO DSR $G^*/\sin(d)$ limits 2.20 - 5.50
- c. PAV DSR $(G^*)*(\sin(d))$ -Run at 25°C for PG 64-22OK, PG 70-28 OK and PG 76-28 OK
- 4. Spot test with standard Naphtha Solvent, AASHTO T102, Negative, PG 64-22 OK
- 5. Flash Point, AASHTO T48, increase from 230°C to 288°C
- 6. Solubility in Trichloroethylene, AASHTO T44 and AASHTO MP1 (99% Soluble Required)
- 7. Asphalt Binder Suppliers shall furnish recommended mixing and compaction temperatures for their product to the hot-mix producer. They shall also supply handling requirements.

708.04. COMPOSITION OF MIXTURES.

- (a) **Asphalt Mix Design and Initial Job-Mix Formula.** The asphalt mix design and initial job-mix formula are the responsibility of the Contractor and shall be submitted to the Materials Engineer for review.

The review of the proposed mix design will be to determine that the mix meets the design criteria. The Contractor shall furnish one mix design for each specific asphalt concrete mixture listed on the plans or in the Contract. The mix design shall be prepared in an approved laboratory of the Contractor's choice. A request for laboratory approval may be made either by a Contractor or a Laboratory. Approval will be according to the Materials Division Policy for Asphalt Mix Design Laboratories.

The initial job-mix formula shall meet the requirements of Tables 5A or 5B and Tables 6A and 6B for the type mix specified on the Plans or in the Proposal.

Prepare a trial mixture in accordance with Subsection 414.04(c).

If the trial mixture, prepared at the initial job-mix formula proportions, fails to meet the requirements of Tables 6A and 6B, propose changes to the job-mix formula. If these changes do not result in a mixture meeting the requirements of Tables 5A or 5B and Tables 6A and 6B, the Engineer will require a new mix design.

If the changes do result in a mixture meeting these Specifications, the job-mix formula will be adjusted accordingly.

The job-mix formula shall establish a single percentage of aggregate passing each required sieve, a single percentage of asphalt to be contained in the mixture, and a single temperature of the mixture at point of discharge from the plant.

The job-mix formula with the allowable tolerances shown in Table 7 shall establish the Specification limits for each mixture. These limits may be outside the broad range in Tables 5A or 5B except for the following conditions:

1. *Absolute maximum sieve size.* Example, 1/2 inch (12.5 mm) sieve for type C.
 2. *Open graded friction surface.* The job-mix formula with allowable tolerances shall be within the broad range given in Table 5A.
 3. *No tolerances are shown.* The broad ranges in Table 5A are the Specification limits.
- (b) **Plant Produced Mixtures.** The plant produced mixture shall be a uniform mixture of the combined aggregate and asphalt and shall conform to the requirements of Tables 6A and 6B and the Specification limits established by the job-mix formula with allowable tolerances.

After the plant is in operation, the Contractor may propose adjustments to the job-mix formula within the limits shown in Tables 5A or 5B. If test results indicate these adjustments will result in a mixture meeting the requirements of Tables 6A and 6B, the job-mix formula will be adjusted accordingly.

Should a change in sources of materials be made, a new job-mix formula shall be established before the new material is used. When unsatisfactory results or other conditions make it necessary, the Engineer will require a new job-mix formula.

The job-mix formula for asphalt is the target value. Every effort shall be made by the Contractor to incorporate that amount of asphalt into the mixture regardless of the allowable tolerances.

For temporary construction, such as crossovers and detours, the requirements given in Table 5A for minimum percent asphalt and Tables 6A and 6B for retained strength and V.M.A. will be waived.

- (c) **Recycled Bituminous Pavements.** Unless otherwise noted on the Plans, bituminous mixtures containing up to 25 percent reclaimed asphalt concrete pavement will be accepted provided that the mixture meets all the requirements of these Specifications. For roadways with 0.3 million ESALS or more, bituminous mixtures containing reclaimed asphalt concrete pavement will not be accepted in the wearing course.

The reclaimed asphalt concrete pavement shall be crushed, screened or otherwise sized such that at least 95 percent passes the 2 inch (50 mm) sieve. The insoluble residue content for reclaimed asphalt concrete pavement will be considered to be zero unless it is from a known source and documentation of insoluble residue content is available. The total amount of natural sand and gravel permitted in the combined aggregate will be reduced by the amount of natural sand and gravel contained in the reclaimed asphalt concrete pavement.

TABLE 5A - TABLE OF MIXTURES (HOT MIX - HOT LAY)

MIXTURE TYPE:	ASPHALT CONCRETE					OPEN GRADED BITUM. BASE	OPEN GRADED FRICTION SURFACE^a
	A	B	C	D	E		
Sieve Size	Percent Passing						
1 1/2 inch(37.5 mm)	100					100	
1 inch(25.0 mm)	90-100					95-100	
3/4 inch(19.0 mm)		100					
1/2 inch(12.5 mm)	70-90	90-100	100		100	25-60	100
3/8 inch(9.5 mm)		70-90	90-100	100	85-95		90-100
No. 4(4.75 mm)	40-65	45-70	60-80	80-100	45-60	0-10	25-45
No. 10(2.0 mm)	25-45	25-50	35-60	50-90	20-35	0-5	0-10
No. 40(425 µm)	10-26 ^b	12-30 ^b	15-35 ^b	20-50	9-19		
No. 80(180 µm)	6-18	7-20	8-22	10-30	6-14		
No. 200(75 µm)	- ^c	- ^c	- ^c	5-15	- ^c	0-3	0-5
Asphalt Cement ^d , % of mix mass	3.8-6.5	4.7-7.5	5.1-7.5	5.5-7.5	4.8-7.5	- ^e	- ^f
Viscosity Grade Asphalt Cement	- ^g	- ^g	- ^g	- ^g	- ^g	- ^g	- ^g

TABLE 5B - TABLE OF MIXTURES (HOT MIX - COLD LAY)

<u>TYPE:</u>	<u>HC1</u>	<u>HC2</u>	<u>HC3</u>	<u>HC4</u>
<u>Sieve Size</u>	<u>Percent Passing^{h,i,j}</u>			
1 1/2 inch(37.5 mm)	100			
1 inch(25.0 mm)	90-100			
3/4 inch(19.0 mm)	--	100		
1/2 inch(12.5 mm)	70-90	90-100	100	
3/8 inch(9.5 mm)	--	70-90	90-100	100
No. 4(4.75 mm)	40-65	45-70	60-80	80-100
No. 10(2.0 mm)	25-45	25-50	35-60	50-90
No. 40(425 µm)	10-26	12-30	15-35	20-50
No. 80(180 µm)	6-18	7-20	8-22	10-30
No. 200(75 µm)	3-6	4-7	4-8	5-15
Asphalt Type ^k	MC-800	MC-800	MC-800 or PG 52-22	MC-800 or CMS-1

FOOTNOTES FOR TABLES 5A AND 5B

- ^a A minimum of 55 percent of the aggregate shall be retained between the 3/8 inch (9.5 mm) and the No. 4 (4.75 mm). An approved anti-stripping agent shall be used at the rate of 5 gallon per 1000 gallons (5 liter per 1,000 lSiter) of asphalt cement.
- ^b The upper limit for the No. 40 (425 µm) sieve shall be controlled by the gradation of the No. 10 (2.00 mm) sieve as follows:

<u>TYPE A</u>		<u>TYPE B</u>		<u>TYPE C</u>	
No.10 (2.00 mm)	No.40 (425µm) maximum	No.10 (2.00 mm)	No.40 (425µm) maximum	No.10 (2.00 mm)	No.40 (425µm) maximum
25-32	19	25-43	24	35-49	27
33	20	44	25	50	28
34	21	45	26	51	29
35	22	46	27	52	30
36	23	47	28	53	31
37	24	48	29	54	32
38	25	49-50	30	55	33
39-45	26	--	--	56	34
--	--	--	--	57-60	35

- c The ratio of the percent passing the No. 200 (75 μm) sieve to the percent asphalt cement shall be a minimum of 0.6 to a maximum of the 1.2. This ratio will establish the master range for the job-mix formula on the No. 200 (75 μm) sieve.
- d The lower limit may be adjusted if the effective specific gravity of the combined aggregates is greater than 2.65. This adjustment will be allowed if a theoretical lab molded specimen at the JMF asphalt content meets the VMA requirement at 4 percent air voids.
- e The amount of binder shall be 2.5 ± 0.3 percent by mass of the mix. The amount of asphalt binder may be adjusted if the effective specific gravity of the combined aggregate is greater than 2.833 or less than 2.495.
- f The job-mix formula for percent AC in the open graded friction course is calculated by the following equation:

$$\% \text{ AC} = (16.5) / (\text{Effective Specific Gravity} + 0.165).$$
- g Three grades of asphalt cement will be used as shown below unless otherwise specified on the plans. Use PG 64-22 OK in roadways with <3M ESALs and with all mixes more than 5 inches (125 mm) below the surface of the pavements in roadways with ≥3M ESALs and with all mixes used for shoulders and temporary detours. Use PG 70-28 OK with all mixes in the top 5 inches (125 mm) of pavements in roadways with ≥3M ESALs. Use PG 76-28 OK with all mixes in the top 5 inches (125mm) of pavements in roadway ≥30M ESALs or in roadways with slow, standing, or turning traffic such as urban intersections with ≥3M ESALs.
- h If emulsion or MC grade asphalt is used, the aggregate shall be surface dry and heated to a temperature above 160°F (71.1°C).
- i AC Type Mixtures. The aggregate shall be thoroughly dried and delivered to the mixer at a temperature above 200°F (93.3°C) and not higher than the temperature of the asphalt binder. Water, not exceeding 3 percent and primer not exceeding 1.2 percent of the aggregate by mass, shall be added as necessary to assure the required workability of the mixture. The quantity of water and primer added to the aggregate shall be accurately controlled by a meter or other suitable measuring device. Except as otherwise requested by the Engineer, the workability of the mixture shall be suitable for stockpiling and use at ambient temperatures.
- j The temperature of the aggregate shall not be heated in excess of the temperature of the liquid asphalt at time of mixing.
- k MC-3000 may be substituted for MC-800 when specified or approved by the Engineer.

TABLE 6A - PROPERTIES OF LABORATORY MOLDED SPECIMENS

<u>Asphalt Mixture Property</u>	<u>Hot Mix-Concrete</u>	<u>Hot Mix-Cold Lay</u>
Density, % of max. theo.sp.gr.		
3 million ESALs or more	94-96	93-97
0.3 million to 3.0 million ESALs	95-97	93-97
0.3 million ESALs or less	96-98	93-97
Hveem Stability, min,		
0.3 million ESALs or more ^a	40	35
Less than 0.3 million ESALs	35	35
% Retained Strength, min.	75	NA

TABLE 6B - PROPERTIES OF LABORATORY MOLDED SPECIMENS

	ASPHALT CONCRETE						
	<u>Type A</u>	<u>Type AH</u>	<u>Type B</u>	<u>Type BH</u>	<u>Type C</u>	<u>Type D</u>	<u>Type E</u>
V.M.A. min % ^b	13	13	15	15	16	17	16

^a Includes all city streets regardless of ESALs.

^b V.M.A. (Voids in the Mineral Aggregate) is based on the effective specific gravity of the aggregates. V.M.A. shall be applicable when establishing the initial job-mix formula, when evaluating a proposed adjustment to the job-mix formula, and when transferring the mix design to another project. *NOTE: V.M.A. is an important mixture property and shall be calculated and reported for all asphalt concrete mixtures.*

(d) **Acceptance of Combined Cold Feed Aggregate Gradation.** Combined aggregate samples obtained by an approved sampling device may be tested for gradation in accordance with Subsection 708.06 (AASHTO T 27 & T 11) in lieu of testing extracted aggregate for gradation, provided the asphalt mixture does not contain reclaimed bituminous materials and the aggregate does not degrade appreciably during the drying and mixing process. The use of combined aggregate samples taken prior to asphalt coating for gradation acceptance of the mixture will be at the Engineer's discretion.

When approved or directed by the Engineer, acceptance of bituminous plant mix gradation results based on cold feed combined aggregate samples under this Contract will be contingent on the following conditions.

1. When the aggregate gradation test on extracted aggregates per AASHTO T 30 compares favorably with the results of cold feed aggregate gradation results.
2. When the Independent Assurance Samples test results of extracted gradation analysis compare favorably with Job Control Acceptance Samples.
3. When the results do not compare favorably, acceptance will be based on results of gradation tests performed in accordance with AASHTO T 30 on extracted aggregate.

(e) **Acceptance of Bitumen Content.** Determination of the bitumen content of plant produced mixtures shall be determined by OHD L-26 method of test.

708.05. TOLERANCES.

The tolerances shown in Table 7 shall be applied to the job-mix formula (JMF) as described in Subsection 708.04.

The job average for gradation shall meet the stated tolerances. An individual sample will be allowed 1-1/2 times the tolerance shown for gradation, providing adjustments are made and the subsequent sample is within the stated tolerance.

TABLE 7 - RANGE OF TOLERANCES

<u>Sieve Size</u>	Asphalt Concrete	Hot Mix Cold Lay	Open Graded Friction Course	Open Graded Bituminous Base
	<u>Percent Passing</u>			
No. 4 (4.75 mm) & larger	±7	±7	±7	--
No. 10 (2.00 mm)	±4	±5	±4	--
No. 40 (425 µm)	±4	±4	--	--
No. 80 (180 µm)	±4	±4	--	--
No. 200 (75 µm)	±2	±2	±2	--
Asphalt Cement	±0.4 ^a	±0.5 ^a	±0.3 ^b	±0.3 ^b
Temp. of mix as discharged from mixer °C	±10	±10	±10	±10

^a The tolerances shown for asphalt content are for individual samples. The average asphalt content by OHD L-26 shall be within ±0.2 percent of the job-mix formula.

^b The percent asphalt may be determined by the tank strap method of measurement or the printed batch weights from an approved automatic printer system or the counter on a drum-mix plant.

708.06. SAMPLING AND TESTING.

(a) **Methods.** Sampling and testing shall be done in accordance with AASHTO methods, except as noted below:

1. **Sampling and Testing Aggregates:**

Sampling	T 2
Sieve Analysis	T 27
Material Passing No. 200 (75 µm) Sieve	T 11
Los Angeles Abrasion	T 96
Mud, Clay Balls, Sand Clusters, Sticks and Root	
Retained on No. 4 (4.75 mm) Sieve	OHD L-9
Fractured Faces	OHD L-18
Sand Equivalent	T 176
Aggregate Durability Index	T 210
Insoluble Residue	OHD L-25
Soft Particles	OHD L-38

2. **Sampling and Testing Bituminous Mixtures:**

Mechanical Analysis of Extracted Aggregate	T 30
Sampling ^a	T 168
Bitumen Content	OHD L-26
Recovery of Asphalt from Solution by Abson Method	T 170
Maximum Specific Gravity of Bituminous Paving Mixtures	T 209

Bulk Impregnated Specific Gravity of Aggregates ^b	OHD L-7
Compacting Materials for Stabilometer Value	OHD L-8
Specific Gravity and Wt.per ft ³ (m ³)	
Compressed Bituminous Mixture	OHD L-14
Test for Stabilometer Value (Hveem)	OHD L-16
Retained Strength	OHD L-36

^a The sample size of compacted bituminous pavement shall be in accordance with T 166

^b OHD L-7 shall only be used when the results obtained from AASHTO T 209 are suspect.

3. **Testing Asphalt Materials:**

Absolute Viscosity	T 202
Kinematic Viscosity	T 201
Saybolt Furol Viscosity	T 72
Penetration	T 49
Flash Point	T 48
Solubility in Trichloroethylene	T 44
Thin Film Oven Test	T 179
Ductility	T 51
Spot Test	T 102
Water	T 55
Rolling Thin Film Oven Test	T 240
Distillation	T 78
Flash Point	T 79
Testing Emulsified Asphalt	
pH of Aqueous Solutions with the Glass Electrode	T 200
Coating & Retention Testing for Mixing Grade Emulsions	T 59 Modified
Specific Gravity by Pycnometer	T 228
Specific Gravity by Hydrometer	ASTM D3142
Elastic Recovery	OHD L-42
Ash in Bituminous Material	T 111
Creep Stiffness by Bending Beam Rheometer	TP1
Rheological Properties by Dynamic Shear Rheometer	TP5
Grading or Verifying Asphalt Binder	PP6
Accelerated Aging of Asphalt Binder by Pressure Aging Vessel	PP1

(b) **Method and Procedure for Sampling Bituminous Materials.** Sampling of bituminous materials shall be in accordance with AASHTO T 40, except that the method at the project site or mixing plant shall be in accordance with OHD L-5.

The methods of sampling, testing and acceptance as specified may be modified for the bituminous materials under the Department's acceptance policy. Copies of the procedure are available at the office of the Materials Engineer.

Sampling will be done at the point of manufacture whenever the quantity shipped will warrant such procedure, and samples may also be taken at the point of destination. Bituminous materials shall not be used until conditionally approved at the source by the Materials Division.

SECTION 709 ELECTRICAL CONDUIT

Description. This Section covers the requirement of materials for electrical conduit of the size, type, and at the locations shown on the Plans or established by the Engineer in Section 802.

709.01. METALLIC CONDUITS.

- (a) **Rigid Steel.** Rigid galvanized steel conduit, intermediate metallic tubing, electrical metallic tubing and rigid aluminum conduit shall meet the requirements shown on the Plans.
- (b) **Flexible Steel.** Liquid-tight flexible steel conduit and fittings shall comply with the requirements of UL-360.

709.02. NON-METALLIC CONDUITS.

- (a) **Rigid Plastic.** Rigid plastic conduit shall meet the requirements shown on the Plans.
- (b) **Flexible Plastic.** Flexible plastic conduit shall comply with the requirements of NEMA TC7 and shall be smooth wall coilable duct of high density polyethylene (HDPE) meeting the requirements of ASTM D 1248, Type III Class C, Grade P33, Category 5, Schedule 40, unless otherwise specified in the Plans.
- (c) **Cable-in-Duct.** Cable-in-duct conduit shall be factory assembled. The duct shall be HDPE and comply with paragraph (b) above and be the size shown on the Plans. The conductors shall be of the type, size and number shown on the Plans. Identification of the conductor shall be accomplished by color coding the insulation by means of a continuous longitudinal colored stripe or various solid colors of continuous longitudinal colored stripe or various solid colors of insulation, in addition to the standard conductor markings.

709.03. OUTLET BOXES, FITTING AND ENTRANCE CAPS.

- (a) **General.** Outlet boxes, fittings, and entrance caps shall comply with current industry standards and be compatible with the conduit material used.
- (b) **Fittings.** Fittings and cement used with plastic conduit shall be compatible with conduit material.

709.04. TESTING.

Conduit may be accepted on the project without testing provided it is visually inspected and all pieces are clearly labeled with the UL label or a type D certification is furnished by the manufacturer. *In lieu of the above procedure, the following may be forwarded to the Materials Division for testing: a 2 foot (600 mm) length representing either each 1000 feet (300 m) or each 100 pieces of conduit, whichever is greater, of each size and type of conduit to be used.*

SECTION 710

DELINEATORS

Description. This Section establishes the requirements for materials and tests for delineators in Section 853.

710.01. REFLECTORS.

- (a) **General.** Reflectors that are mounted on a post to form a delineator unit shall be circular and provided with a single mounting hole through the center. The mounting hole shall have an inside diameter of 0.188 to 0.203 inch (4.78 to 5.16 mm). The reflector shall have the capacity of accommodating a 3/16 inch (4.76 mm) nominal diameter blind rivet expanded to 0.196 inch (4.98 mm) without fracturing. The center mount reflectors may or may not be fabricated with an aluminum housing.
- (b) **Delineators.** Delineators shall consist of reflectors as specified herein, mounted on galvanized steel posts when installed on roadway shoulders, galvanized steel posts installed on guard rail posts, or galvanized steel posts and brackets installed on bridges.
- (c) **Acrylic Plastic Reflector.** The reflector shall be acrylic plastic methyl methacrylate, meeting requirements of Federal Specifications L-M-5002, Type 1, Class 3.

Reflectors shall consist of a crystal (colorless), amber, or red transparent plastic face with a minimum dimension of 3 inches (76.2 mm) and not less than 7 square inches (4516 mm²) of reflective area, herein referred to as the lens, with a heat sealable acrylic plastic or heat sealable metal foil back fused to the lens under heat and pressure around the entire perimeter of the lens and the central mounting hole to form a unit permanently sealed against water and water vapor. The embossed aluminum housing shall have a thickness of 0.02 ± 0.002 inches (0.51 ± 0.051 mm). The center mount reflectors without aluminum housing shall be backed by a vapor-tight, hermetically- sealed plastic backing to prevent vapor and dust from reaching the reflex surface.

The lens shall consist of a smooth front surface free from projection or indentation other than a central mounting hole and identification with a rear surface bearing a prismatic configuration such that it will effect total internal reflection of light. The manufacturer's name or trade mark shall be molded legibly into the face of the lens.

- (d) **Definitions.**
 - 1. **Incidence angle** shall mean the angle at reflector between direction of light incident on it and direction of reflector's axis.
 - 2. **Divergence angle** shall mean the angle at reflector between observer's line of sight and direction of light incident on the reflector.
 - 3. **Specific intensity** shall mean candela returned at the chosen divergence angle by a reflector for each Lux illumination at the reflector.
- (e) **Specific Intensity.** The specific intensity of each reflex reflector intended for use as delineators or markers shall be equal to or exceed the following minimum values regardless of reflector orientation:

Divergence Angle, <u>Degrees</u>	Incidence Angle, <u>Degrees</u>	<u>Crystal</u>	Specific Intensity, Candela Per Lux	
			<u>Amber</u>	<u>Red</u>
1/10	0	11.1	6.6	2.7
1/10	20	4.4	2.6	1.0
1/3	0	1.9	1.1	0.46
1/3	20	0.7	0.46	0.19

- (f) **Specific Intensity Test.** Specific intensity will be determined in accordance with Federal test method Standard 370.

Failure to meet the specific intensity minimum shall constitute failure of the reflector being tested. Failure of more than 4 percent of the reflectors subjected to testing shall constitute failure of the lot or shipment-- except that when 25 or fewer samples are submitted, failure of more than one reflector subjected to testing shall constitute failure of the lot or shipment.

- (g) **Seal Test.** The following test shall be used to determine whether a reflector is completely sealed against dust and water: Submerge the samples in a water bath at room temperature. Subject the submerged samples to a vacuum of 2.45 psi (16.9 kPa) for 5 minutes. Restore atmospheric pressure and leave sample submerged for 5 minutes, then examine the samples for water intake. Failure of more than 4 percent of the number tested is cause for rejection.
- (h) **Sampling.** The sample reflectors required for optical and seal tests will be selected at random by the Engineer. The number of reflectors required for a sample are as indicated in the schedule below:

<u>Quantity in Shipment or Lot</u>	<u>Reflectors Reflectors Required for Sample</u>
100 or less	3
100 to 800	3%
800 to 5000	25 to 50
5000 and over	1%

710.02. POSTS.

- (a) **Galvanized Steel Delineator Posts.** This item shall consist of furnishing, cutting, drilling, punching, fabricating, and galvanizing a finished channel-type or hat-type delineator post, according to these requirements and the Plans.

The galvanized channel-type post shall be fabricated from 1 1/2 x 1/2 x 1/8 inch (38 x 12 x 3 mm) steel bar channel, cut to the specified length, and drilled, or punched, as required; it shall be suitable for mounting the approved type delineator and installed on guard rail posts when so intended. The basic steel channel employed in the fabrication shall meet dimensional tolerances for the specified size above according to Table 28 of ASTM A 6 for bar- size shapes less than 3 inches (75 mm).

An alternate galvanized steel hat section type post may be used. It shall be rolled from sheet

steel to the dimensions and shape shown on current Department standard drawings. The alternate post shall have a mass of 1.12 pounds \pm 3.5% per linear foot (1.67 kg \pm 3.5 percent per meter) before galvanizing.

Furnish the correct size fasteners required for the type post used, unless otherwise shown on the Plans.

Perform all cutting and hole drilling or punching prior to galvanizing.

The posts shall receive a 2 ounce per square foot (610 g/m²) zinc coating according to ASTM A 123.

- (b) **Testing.** One or more samples will be required for determination of zinc coating, according to ASTM A 123, and compliance with dimensional requirements of ASTM A 6 and these Specifications.

710.03. FLEXIBLE DELINEATOR POSTS.

- (a) **Flexible Delineator Posts.** The flexible delineator post shall consist of a delineator post with Type III retroreflective sheeting material.

The side or sides of the post facing traffic may be either flat or curved in design and shall have a minimum of 3 inches (76.2 mm) wide flat surface suitable for adherence of the reflective sheeting. The minimum length of the post shall be 62 inches (1575 mm). The lower end of the post shall be designed so as to facilitate installation and replacement by field personnel.

The reflective sheeting material attached to the post shall be 9 inches long x 3 inches wide (228.6 mm x 76.2 mm) with 1 inch (25.4 mm) gaps (beginning 1 inch (25.4 mm) below the top of the post) and shall be provided in white, yellow or red colors as specified. The delineator posts shall be designated as (a) Mono-direction-sheeting material on one side or (b) Bi-directional-reflective sheeting material on both sides or with one, two or three reflective sheeting strips applied around the delineator post.

- (b) **Materials.**

1. *Posts.* The posts may be manufactured from any combination of thermosetting resins, plasticizers, coloring pigments, and inert fillers as long as the other requirements are satisfied.
2. *Reflective Sheeting.* Type III retroreflective sheeting material shall be in accordance with AASHTO M 268.

- (c) **Performance.** The posts shall be capable of remaining in service after sustaining ten vehicle impacts from front, side, or back of the posts at any temperature between -0°F and 100°F (-17°C and 37°C). The impacting vehicle shall be a typical medium size, American-made sedan traveling at a speed of 55 mph (88 km/h). The posts shall demonstrate the ability to remain in place and in an upright position after 10 vehicle impacts.

- (d) **Testing and Sampling.**

1. *Temperature Resistance.* A post, after remaining a minimum of two hours in a conditioning chamber at a temperature in a range from 0°F to 140°F (-17°C to 60°C), and tested as described below, shall straighten itself out, showing no adverse effects 60 seconds after testing. A segment of post, 36 inches (914.4 mm) in length, shall be secured in any suitable device and bent 90 degrees and then released. The procedure shall be repeated for a total of four bends. Cracking or permanent deformation shall be cause for rejection.
2. *Weathering.* A post shall show no significant change in color, flexibility or integrity when subject to 300 hours of exposure in an Atlas-Sunshine Weather-o-Meter fitted with a 19-102 cyclic gear. Random samples shall be selected from any shipment for testing in accordance

with the above testing procedures. The manufacturer shall provide a type D certification for the reflective sheeting with each shipment of delineator units.

- (e) **Prequalification.** Prior to the installation of flexible delineator posts, the Contractor shall have demonstrated to the satisfaction of the Department of Transportation that the posts to be provided shall meet the physical and performance requirements of this Specification.

SECTION 711

TRAFFIC STRIPE

Description. This Section establishes the requirements for materials and tests for thermoplastic compounds, preformed plastic tapes, traffic stripe paint, and glass beads.

711.01. THERMOPLASTIC COMPOUNDS.

Hot Applied Thermoplastic Compound Materials. The hot applied thermoplastic compound shall meet the requirements of AASHTO M 249. The binder component shown in Section 4.2, Table 1 Composition, shall be made of hydrocarbon material unless otherwise specified on the Plans. Each shipment of the product shall be accompanied by a type A certification as specified in Subsection 106.04.

711.02. PERMANENT PAVEMENT MARKING TAPE.

General. The plastic striping tape as supplied shall be of good appearance, free from cracks, and have edges that are true, straight and unbroken. The material shall be available in rolls with no more than 3 splices per 150 feet (45.7 m) of length.

Preformed words and symbols shall conform to the applicable shapes and sizes as outlined in the current "Manual on Uniform Traffic Control Devices for Streets and Highways."

The plastic striping tape shall be packaged in standard commercial containers constructed so as to insure acceptance by the carrier and prevent damage during shipment and storage.

The plastic striping tape as supplied shall be capable of retaining required properties when stored at temperatures up to 100°F (38°C) for periods up to one year.

A Type A certification shall be furnished in accordance with Subsection 106.04.

The plastic striping tape shall conform to the following requirements:

1. *Composition.* The retroreflective, preformed pavement marking film shall consist of high-quality plastic materials, pigments, and glass beads uniformly distributed throughout its cross-sectional area and with a retroreflective layer of glass beads firmly bonded on the top surface. The preformed plastic film shall be precoated with a pressure-sensitive adhesive which is compatible with bituminous concrete and portland cement concrete road surfaces.
2. *Skid Resistance.* The surface of the retroreflective preformed film shall provide a minimum skid resistance value of 35 British Pendulum Number when tested in accordance with ASTM E 303.
3. *Thickness.* The thickness of the preformed plastic film without adhesive for lane and edge lines shall be not less than 0.060 inch (1.52 mm) and not more than 0.090 inch (2.29 mm).
4. *Tensile Strength and Elongation.* The film shall have a minimum tensile strength of 40 psi (275.8 kPa) of cross section when tested according to ASTM D 638, except that a sample 6 x 1

inch (152.4 x 25.4 mm) shall be tested at a temperature between 70°F and 80°F (21.1°C and 26.7°C) using a jaw speed of 10 to 12 inches (254 to 304.8 mm) per minute. The sample shall have a minimum elongation of 75 percent at break when tested by this method.

5. *Conformability.* The preformed film shall be capable of conforming to pavement contours, breaks and faults through the action of traffic at normal pavement temperatures. The preformed plastic film shall have characteristics such that it is capable of fusing with itself and previously applied marking film of the same composition under normal conditions of use.
6. *Removability.* The plastic striping tape shall be designed so as not to be easily removed after application.
7. *Adhesive.* The plastic striping tape for longitudinal and transverse markings shall have pressure-sensitive backing without liner. Word and symbol tape shall have pressure-sensitive backing with protective liner.
8. *Application Properties.* The material shall adhere to asphalt and concrete surfaces when applied according to manufacturer's recommendations at surface temperature of 65°F (18.3°C) and rising. If the markings must be applied when the surface temperature is below 65°F (18.3°C), but not below 50°F (10°C), the markings are to be applied in strict accordance with the manufacturer's recommended procedures and/or other special instructions.
9. *Glass Beads.* Glass beads shall be incorporated by the manufacturer to provide immediate and continuing retroreflection. The size, quality and refractive index of the glass beads shall be such that the performance requirements for the markings shall be met. The bead adhesion shall be such that beads are not easily removed when the material surface is scratched with a thumbnail.
10. *Pigmentation.* Color pigments shall be thoroughly blended to provide a pavement marking film that maintains uniform color under both daylight and night lighting conditions throughout the expected life of the film. White pavement marking film shall be similar to Federal Standard Color No. 595-17886. Yellow pavement marking film shall be similar to Federal Standard Color No. 595-13538.
11. *Reflectance.* The white and yellow films shall have the following initial minimum reflectance values at 0.2° and 0.5° observation angles and 86.0° entrance angle as measured in accordance with the testing procedures of Federal Test Method Standard 370. The photometric quantity to be measured shall be specific luminance and shall be expressed as millicandelas per square foot per foot-candle [mcd/ft²/fc] (mcd/m²/lux). The test distance shall be 50 feet (15.2 m), and the sample size shall be a 24 inch x 30 inch (610 x 762 mm) rectangle.

The angular aperture of both the photoreceptor and light projector shall be 6 minutes of arc. The reference center shall be the geometric center of the sample and reference center shall be taken perpendicular to the test sample.

	<u>White</u>		<u>Yellow</u>	
Observation Angle, degree	0.2	0.5	0.2	0.5
Specific Luminance, mcd/ft ² /fc (mcd/m ² /lux)	550	380	410	250

12. *Effective Performance Life.* The film, when applied according to the recommendations of the manufacturer, shall provide a neat, durable marking that will not flow or distort due to temperature if the pavement surface remains stable. The tape must be qualified by a satisfactory performance test of at least 12 months conducted by the Department or an equivalent performance test

conducted by another State Highway or Transportation Department. Although reflectivity is reduced by wear, the pliant polymer shall provide a cushioned, resilient substrate that reduces bead crushing and loss. The film shall be weather resistant and, through normal traffic wear, shall show no appreciable fading, lifting, or shrinkage throughout the useful life of the marking, and shall show no significant tearing, roll back, or other signs of poor adhesion.

711.03. NON-REMOVABLE TEMPORARY PAVEMENT MARKING TAPE.

- (a) **General.** The traffic striping material shall consist of a white or yellow weather and traffic resistant reflective film on a conformable backing precoated with a pressure-sensitive adhesive. A satisfactory performance test of not less than 12 months conducted by the Department or an equivalent performance test by another State Highway or Transportation Department shall qualify the material.

The striping tape shall be white or yellow as specified. The white and yellow striping tape shall be retroreflective, reflecting white or yellow respectively, and shall be readily visible when viewed with automobile headlights at night.

The striping tape shall have a precoated pressure-sensitive adhesive which shall not require a liner for protection from contamination, preadhesion, or blocking within the roll, nor require activation procedures.

The material shall adhere to asphalt and concrete surfaces when applied according to manufacturer's recommendations at surface temperatures down to 35°F (1.7°C) and shall require no protective devices such as traffic cones or barricades.

- (b) **Conformability.** The striping material shall be thin, flexible, and formable, and following application shall remain conformed to the texture of the pavement surface.

The average thickness of the material, as determined by five micrometer readings, will not be less than 15 mils (381 µm) nor more than 45 mils (1143 µm).

- (c) **Durability and Wear Resistance.** The striping material applied in accordance with manufacturer's recommended procedures shall be weather resistant and show no appreciable fading, lifting or shrinkage during the useful life of the line.
- (d) **Packaging.** The striping material shall be packaged in standard commercial containers so constructed as to insure acceptance by the carrier and prevent damage during shipment and storage.
- (e) **Storage.** The striping material as supplied shall be capable of being stored at temperatures up to 100°F (37.8°C) for periods up to one year without deterioration.
- (f) **Certification.** A type D certification shall be required for the non-removable temporary pavement marking tape in accordance with Subsection 106.04.

711.04. REMOVABLE PAVEMENT MARKING TAPE.

- (a) **General.** Removable pavement marking tape shall consist of a white or yellow all-weather traffic-resistant film on a reinforced conformable backing, precoated with a pressure-sensitive adhesive. Glass beads shall be uniformly distributed throughout the film for retroreflectivity.
- (b) **Adhesive.** The removable, preformed pavement marking film shall be precoated with a pressure-sensitive adhesive capable of being adhered to asphalt concrete and portland cement concrete pavement surfaces without the use of heat, solvents, additional adhesives, or activators, and shall be immediately ready for traffic after application. The adhesive shall be capable of bonding to pavement surfaces when applied at temperatures of 50°F (10°C) and above without pickup or distortion by vehicular traffic.

- (c) **Color.** The material shall be white or yellow, as specified, conforming to the standard highway color requirements of the Manual on Uniform Traffic Control Devices.
- (d) **Glass Beads.** The glass beads shall be colorless and shall have a minimum refraction index of 1.50 when tested using the liquid immersion method. The size and quantity of beads shall be such that retroreflectivity of the preformed film is maintained as the film wears through the surface course.
- (e) **Removability.** The preformed pavement marking film shall be removable from asphalt concrete and portland cement concrete pavement intact or in substantially large strips, either manually or by a mechanical roll-up device, at temperatures above 50°F (10°C), and without the use of heat, solvents, grinding or sandblasting.
- (f) **Durability.** The film, when applied according to the recommendations of the manufacturer, shall provide a neat, durable marking that will not flow or distort due to temperature. The tape must be prequalified by a satisfactory performance test of at least 6 months conducted by the Department or by an equivalent performance test conducted by another State Highway or Transportation Department. The removability characteristics must also be demonstrated to meet the requirements of this section through the above described performance test. The film shall be weather resistant and through normal traffic wear shall show no appreciable fading, lifting or shrinkage throughout the useful life of the marking.
- (g) **Certification.** A type D certification shall be required for the removable pavement marking tape in accordance with Subsection 106.04.

711.05. TRAFFIC STRIPE PAINT - TYPE I.

The white and yellow traffic paint shall be suitable for spray application and use as a reflecting traffic guide on concrete and bituminous highway pavements. It is the intent of these Specifications to provide both general and composition requirements in sufficient detail to assure a quality paint capable of providing satisfactory reflectorized traffic lines.

The paint shall be of a type in which the glass beads are dropped on the pigmented binder during application (hereinafter designated as binder type) so that, upon drying, the paint line is capable of retroreflection of the headlight beams from vehicles. The term "paint" is herein construed as pigmented binder.

- (a) **Condition and Stability.** The paint shall be homogeneous, shall be well ground to a uniform and smooth consistency, and shall not skin or settle badly, or cake, liver, thicken, curdle, or gel in the container. The paint shall be capable of being broken up and mixed without difficulty by use of a paddle and shall show the desired characteristics at any time within a period of 6 months from date of delivery.
- (b) **Drying Time.** The paint, when applied to either portland cement concrete or bituminous surfacing at a rate of 15 mil (0.38 mm) thickness (wet film), shall be sufficiently dry within 1/2 hour after application so that there will be no pickup under traffic and shall be thoroughly dry and free from tackiness within 40 minutes after application when the atmospheric temperature is a minimum of 77°F (25°C) and the relative humidity is between 25 and 50 percent.
- (c) **Viscosity.** The paint as received shall have a consistency as determined by the Stormer Viscosimeter at 77°F (25°C) of 68 to 80 Krebs Units (KU). Any paint which changes consistency within 6 months after receipt so that the consistency falls outside the viscosity limits stated above shall be considered to have failed this test.

- (d) **Colors.** The white and yellow colors for traffic marking paint shall conform to the standard highway color code requirements of the Manual on Uniform Traffic Control Devices for Streets and Highways.
- (e) **Bleeding.** The paint shall not show bleeding sufficient to impair the color and visibility of the paint when applied to a suitably prepared and cured bituminous surface. The pigmented binder shall be tested in accordance with Federal Specification TT-P-85b and shall have a minimum bleeding ratio of 0.95 when tested.
- (f) **Foreign Matter.** The paint shall be free from skins, dirt and other foreign matter, and shall contain not more than one percent water. (Methods 4081, 4091, and 4902.1, Federal Specification TT-P-141a).
- (g) **Composition Requirements and Proportioning.** The various components shall be proportioned by mass as set forth below:

<u>PIGMENTED BINDER</u>	<u>WHITE</u>	<u>YELLOW</u>
	<u>PERCENT</u>	
Pigment, minimum	59.0	55.5
Titanium Dioxide (ASTM D 476 Type III), minimum	18.0	3.2
Medium Chrome Yellow, minimum		14.7
Talc (ASTM D 605), maximum	25.5	42.3
Mica, Water Ground (ASTM D 607), maximum	7.0	
Calcium Carbonate, maximum (Particle size range 0.5-10.0 μm)	49.7	40.7
Vehicle, maximum	41.0	44.5
Medium Oil Alkyd Resin Solids ^a , minimum	37.8	37.9
VM&P Naphtha (IBP 200°F (93.3°C) minimum; DP 290°F (143.3°C), maximum	60.0	59.9
Driers and Additives, maximum	2.8	3.5
Binder Constants:		
Viscosity, 77°F (25°C), KU	68-80	68-80
Fineness, Nominal Size, minimum	2.5	2.5
Dry Time, ASTM D 711, No pick-up, minutes, maximum	40	40
Mass/Unit Volume, 77°F, lb/gal (25°C, kg/l), minimum	12.25 (1.468)	11.80 (1.414)
Skinning, 48 hours, 3/4 full, tightly capped container	None	None
^a Alkyd Resin		
Linseed Oil or Soya Oil, minimum		50
Phthalic Anhydride, minimum		33
Acid Number, minimum		10
Color (G-H), maximum		9
Resin, Phenolic, Petroleum Resins		Negative
Solvent		VM&P Naphtha

- (h) **Containers.** The paint shall be furnished in container size and type as specified in the Contract. Containers shall meet Federal requirements. All containers shall be labeled with the following information:
1. Oklahoma Department of Transportation.
 2. Specification Type.
 3. Purchase Order Number (If applicable).
 4. Manufacturer's Name.
 5. Date of Manufacture.
 6. Manufacturer's Batch Number.
- Labels must be sufficiently weather resistant to withstand outside storage for a minimum of one year.
- (i) **Inspection, Sampling and Testing.** All sampling shall be in accordance with Section 730.
- (j) **Sealed Shipments.** Shipments shall be sealed in accordance with Section 730.

711.06. TRAFFIC STRIPE PAINT - TYPE II.

The high heat white and yellow traffic paint shall be suitable for application by spray equipment when heated from 130°F to 150°F (55°C to 65°C) and applied to bituminous or Portland cement concrete pavements. It shall be capable of receiving and holding glass beads for producing reflectorized traffic markings. High heat traffic paint, as specified herein, shall dry to no pick-up in three (3) minutes.

All materials used in manufacture shall meet the requirements herein specified. Any materials not specifically covered shall meet the approval of the Materials Engineer. The manufacturer shall furnish to the Department the batch formula used to produce the paint.

- (a) **Condition and Stability.** The vehicle and pigment shall be so prepared and blended that the resulting paint shall be uniform in composition and of the required consistency. After storage for periods up to 12 months from the date of packaging, the pigment shall not settle badly or cake in the container, nor shall the paint skin or thicken in storage sufficiently to cause an undesirable change in consistency. The paint, at the time of use, shall comply with all the provisions of these Specifications and be capable of being re-dispersed with a paddle to a smooth uniform condition. Any paint which cannot be remixed to a smooth uniform suspension of useable consistency shall be removed and replaced immediately by the contractor at his expense without additional compensation (including handling and transportation charges).
- (b) **Pigment.**
1. *Medium Chrome Yellow.* This pigment shall comply with ASTM D 211 Type III.
 2. *Titanium Dioxide.* This pigment shall comply with ASTM D 476, Type I, Anatase or Type II, Rutile.
 3. *Aluminum Silicate.* A white pigment that shall consist substantially of anhydrous (calcined) natural aluminum silicate which has been processed to paint pigment quality.
 4. *Magnesium Silicate.* This pigment shall consist substantially of natural hydrous magnesium silicate that is white, fibrous, finely ground, and is commercially known as paint pigment quality.
 5. *Calcium Carbonate.* This pigment shall comply with ASTM Specification D 1199, Type GC, Grade I.
 6. *Anti-Settling (Organo-montmorillonite).* This pigment shall be a finely divided hydrous magnesium aluminum silicate mineral activated with 95% methyl alcohol.

7. *Formulation.*

<u>Pigment Portion</u>	<u>White</u>	<u>Yellow</u>
	<u>PERCENT</u>	
Titanium Dioxide	20-25	--
Medium Chrome Yellow	--	18-23
Aluminum Silicate	28-33	28-33
Magnesium Silicate	16-21	16-21
Calcium Carbonate	20-30	20-30
Bentone 34, Claytone 40 or Tixogel VP	1-2	1-2

No silicas, amorphous or crystalline, shall be permitted.

(c) **Vehicle.**

1. *Alkyd Resin.* The alkyd resin solution shall be a short oil alkyd reduced in toluene to a 59-61% solids content. The solution shall contain a minimum of 41% phthalic anhydride based on the alkyd solids.
2. *Methyl Ethyl Ketone.* This material shall comply with ASTM Specification D 740.
3. *Aliphatic Naphtha.* This material shall meet Federal Specification TT-N-95B.
4. *Toluene.* This material shall comply with ASTM Specification D 362.
5. *Methyl Alcohol.* This material shall be commercial Methyl Alcohol suitable for use in paints.
6. *Drier.* This material shall be lead drier suitable for use in paints.
7. *Anti-Skinning Agent.* This material shall be an anti-skinning agent suitable for use in paints.
8. *Wetting Agent.* Soya lecithin is suitable for use in paint.
9. *Formulation.* This is the Vehicle portion of white and yellow paint.

Alkyd Resin,	63-69%
Solvents, Drier, Wetting Agents,	
Anti-Skinning Agent,	31-37%

(d) **Composition Requirements.**

Pigment by mass, %	50-55
Vehicle by mass, %	45-50
Total non-volatile, %, minimum	70
Vehicle solids/non-volatile vehicle, %, minimum	37
Mass/Unit Volume, lb/gal (Kg/L), minimum	11.90 (1.426)
Viscosity, 77°F (25°C), KU	90-110
Grind (Hegman Gage), minimum	3
Laboratory dry time, ASTM D 711, minutes, maximum	8
Field drying time, minutes	3

- (e) **Field Drying Time.** The reflectorized line, when applied at 15 ± 1 mil (0.38 ± 0.03 mm) wet film thickness and 6 pounds of beads per gallon (0.72 kg of beads per liter) of paint, shall dry to no tracking in 3 minutes or less. The line for the test will be applied with the Department's equipment so as to have the paint at a temperature of 130°F to 150°F (55°C - 65°C) at the spray gun. The 3 minute time shall not be exceeded under any humidity conditions provided that the pavement is dry and the pavement temperature is between 60°F to 120°F (15°C and 50°C). "No tracking in 3 minutes" shall be the time, not to exceed 3 minutes, required for the line to withstand the running of a standard automobile over the line at a speed of approximately 40 mph (65 km/h) simulating a passing procedure without tracking of the reflectorized line when viewed from a distance of 50 feet (15 m).

No allowance for mixing losses will be made in determining percentages of pigment. The mixed paint shall contain the required percentage of pigment upon analysis. Pigments and vehicles extracted from these paints will be subjected to testing by appropriate methods including wet chemical, atomic absorption, X-ray, flame emission, infrared, liquid chromatography, or other available means as may be deemed necessary by the Department to assure compliance with these Specifications.

If outside testing labs are used, the manufacturer will pay the cost of these tests on any batches the Department finds not to be in compliance with these Specifications.

- (f) **Skimming Test.** No skinning shall be present on the surface when the paint is allowed to stand in a partly filled, closed container for 72 hours. The paint shall be free of lumps and skins when strained through a No. 100 (150 μ m) mesh sieve.
- (g) **Bleeding.** The white and yellow pigmented binders shall have a minimum bleeding ratio of 0.95 when tested in accordance with Federal Specification TT-P-85 E (or applicable revision). The asphalt saturated felt shall conform to ASTM Specification D 226 for Type I.
- (h) **Color.** For white, the color after drying shall be a pure flat white, free from tint, furnishing the maximum amount of opacity and visibility under both daylight and artificial light. For yellow, the color after drying shall closely match Chip 33538 of Federal Standard 595. The fixed drying oils used shall be of such character as will not darken under service or impair the color and visibility of the reflectorized line.
- (i) **Contrast Ratio.** The paint shall have a minimum ratio of 0.96 when applied at a wet film thickness of 15 mils (0.38 mm). Apply the wet film, as determined by an Interchemical Wet Film Thickness Gage, to a 2A Leneta Chart or equal. After air drying the paint for 24 hours, measure the luminous reflectance of white and black sections. Contrast Ratio = Black/White.
- (j) **Luminous Reflectance.** The daylight directional reflectance of a dry film white paint (without glass spheres) shall not be less than 80%. The daylight directional reflectance of a dry film of yellow paint (without glass spheres) shall not be less than 54%. A 15 mil (0.38 mm), wet film of paint, as determined by an Interchemical Wet Film Thickness Gage, shall be applied to a form 2A Leneta Chart or equal. After air drying for 24 hours, measure the luminous reflectance of the dry film over a black square using a Hunter or Gardner Tristimulus Colorimeter. Use test method ASTM E-97.
- (k) **Settling.** The pigmented binder in full pint, triple-sealed, friction top, unlined tin cans shall show no dense or hard settling when stored free of vibration at 120°F (50°C) air temperature for five days. At the end of that period, the pigmented binder shall be cooled at room temperature for four hours before making examination. The degree of settling shall have a rating of six or better, when evaluated in accordance with ASTM D 869. In making the tests, place the filled (filled to bottom of the

lip), triple-sealed, friction top, unlined tin can in an inverted position for one hour to insure a complete seal between the cover and body of the can. At the end of one hour, place the filled can in an upright position for at least one hour before placing it in an air temperature of 120°F (50°C). Place the can or cans in a single tier.

- (l) **Containers.** Containers shall meet the requirements of Subsection 711.05(h).
- (m) **Inspection, Sampling, and Testing.** All sampling shall be in accordance with Section 730.
- (n) **Sealed Shipments.** Shipments shall be sealed in accordance with Section 730.

711.07. TRAFFIC STRIPE PAINT - TYPE III (DROP ON).

The white and yellow traffic paints shall conform on a mass basis to the composition of the standard formula as closely as accepted good paint practice will permit. No variation from the standard formula will be permitted, except for replacements of volatiles lost in processing or those approved by the Materials Engineer.

- (a) **Substitutions.** The exact brands and types of raw materials are listed for the purpose of facilitating the selection of parallel material equal not only in quality and composition, but also in physical and chemical behavior after aging in the finished product. Since evaluation of questionable materials may require 60 days after receipt of request from a paint manufacturer, the Contractor is reminded that he should schedule material procurement to permit him to meet delivery commitments. The final decision as to quality of materials shall be made by the Department of Transportation. After the Department of Transportation has approved the brand names of raw materials proposed by paint manufacturer, no substitution will be allowed during manufacture without prior approval of the Department of Transportation.

- (b) **Pigment.**

1. *Pure Titanium Dioxide Rutile, Type II*, shall meet ASTM Specification D 476.
2. *Lead Free Zinc Oxide: American Process, Acicular*, shall meet Federal Specifications TT-P-463a, Type I.
3. *Talc, Paint Grade Magnesium Silicate*, shall meet Federal Specification MIL-M15173, Type B.
4. *Calcium Carbonate:*

CaCo_3	Min. 97 percent
H ₂ O Max.	0.4 percent
Specific Gravity	2.63 - 2.73
Fineness Requirements	80 percent less than 5 μm
5. *Medium Chrome Yellow ASTM D 211, Type III*.
6. Feldspar, water washed alkali aluminum silicate, Lawson-United LU-340.

Color: Equal to material listed in standard formula. Substitution in a standard formula shall not result in a viscosity greater than 5 KU.

(c) **Resins.**1. *Traffic Paint Alkyd Resin Solution:*1.1 *General:*

- Type: Pure, drying alkyd
 Length: Medium
 Type Oil: Soya, linseed or tall. No mixture of two or more oils will be permitted.
 Solvent: Toluol, ASTM Specification D 362
 Compatibility: A solution of one part 75 percent traffic alkyd and five parts toluol shall be clear.

A solution containing the equivalent of 120 grams of 20 cps chlorinated rubber, 130 grams of 75% traffic alkyd, 200 grams of methyl ethyl ketone shall be clear transparent, and show no separation after 24 hours of storage in a 3/4 full test tube at 80°F±5°F (26.7 ± 2.8°C). This rubber-alkyd solvent solution shall produce a clear film upon drying.

1.2 *Solid Resin Basis:*

Phthalic Anhydrides, %	33 to 37
Percent Oil Acids, %	48 to 55
Acid Number, %, Maximum	8.0
Ash Residue, %, Maximum	0.10
Unsaponifiable, %, Maximum	2.0
Iodine Number of Fatty Acids, Minimum	115
Refractive Index of Fatty Acids, Minimum	1.4660
Rosin based on Fatty Acids, %, Maximum (Tall Oil Alkyds)	1.0

1.3 *45% Solid Basis:*

- Color: Gardner 1953 Standard-9 Maximum
 Drying Time: A wet film 3 mils (76 µm) thick shall set to touch in not more than 90 minutes.
 Dryers: Based on the resin solids present, add the equivalent of 0.06% Cobalt (metal) and 1.0% Lead (metal).
 Toluol shall be used to reduce the resin solution to 45% solids, and shall meet ASTM Specification D 362.

2. *Chlorinated Paraffin:* Shall meet Federal Specification MIL-C-429A, Type I.

3. *Chlorinated Rubber:*

Appearance	Free flowing white powder
Viscosity, 20 % W/W in Toluene (ASTM D 115) 77°F (25°C), Pa-s	0.018 - 0.022
Chlorine, %, minimum (TT-P-115c 4.3.6)	64.5
Ash, %, maximum	0.20

Solubility: Soluble in aromatic hydrocarbons, eg., toluene, xylene, and alkylated benzenes.

(d) **Thinners:**

1. *Methyl Ethyl Ketone* Federal Specification TT-M-26

(e) **Additives:**

1. *Antisettling agent* Bentone 34 or Claytone 40
2. *Stabilizer* Thermolite 813.

(f) **Composition Requirements.** The various components shall be proportioned by weight (mass) as set forth below:

1. *Paint, Traffic:*

	<u>WHITE</u> <u>pounds or kg</u>	<u>YELLOW</u> <u>pounds or kg</u>
Medium Chrome Yellow		85
Titanium Dioxide, Rutile Type II	100	25
Lead Free Zinc Oxide	25	50
Talc	250	100
Feldspar - LU390		125
Calcium Carbonate	275	250
Anti-settling Agent	5	5
Traffic Alkyd 75% solids	130	130
Chlorinated Rubber 20CPS	105	120
Chlorinated Paraffin	85	75
36% Lead Drier	1.5	1.5
12% Cobalt Drier	0.5	0.5
Anti Skinning Agent	2	2
Thermolite 813	0.5	0.5
Methyl Alcohol	5	6
Methyl Ethyl Ketone	207	270
Toluene	53	
Xylene	10	
<hr/>		
Total weight, pounds or kg	1254.5	1245.5
Volume, gallons (l)	99.272 (828.46)	98.592 (822.79)
Weight (Mass)/Unit Volume, lb/gal (kg/l)	12.637 (1.5142)	12.633 (1.5138)

2. **Properties of Finished Paint:**

2.1. Weight (Mass)/Unit Volume	±0.25 lb/gal (± 0.030 kg/l) of theoretical
2.2. Consistency (Krebs-Stormer), KU, 77°F (25°C)	75-85
2.3. Drying Time (ASTM D711), maximum, minutes	5
2.4. Bleeding (Fed. Spec TT-P-85d 4.3.11), minimum	0.95
2.5. Dry Opacity (Fed. Test Std. No. 141a Method 4121 using wet film of approximately 4 mils (101.6 µm)), minimum	0.91
2.6. Daylight Reflectance (Fed. Test Std. No. 141 Method 6121), %	White, 80 Yellow, 50
2.7. Fineness of grind (Hegman), minimum	3
2.8. Skinning, 48 hours, 3/4 filled tightly closed can	None
2.9. Color: Yellow dry film shall be in compliance with "Highway Yellow Color Chart" U.S. Dept. of Transportation, Federal Highway Administration.	

(g) **Composition Requirements:**

	<u>WHITE</u>	<u>YELLOW</u>
Total Solids, %	75.0 ± 2	74.5 ± 2
Pigment, %	52.2 ± 2	51.4 ± 2
Vehicle, %	47.8 ± 2	48.6 ± 2
Non-volatile Material (Vehicle), %, minimum	45.5	45.5

Upon chemical analysis of pigments and vehicle solids, the percentages must be within reasonable manufacturing tolerances as determined by the Department of Transportation.

- (h) **Containers.** Containers shall meet the requirements of Subsection 711.05(h).
 (i) **Inspection, Sampling, and Testing.** All sampling shall be in accordance with Section 730.
 (j) **Sealed Shipments.** Shipments shall be sealed in accordance with Section 730.

711.08. TRAFFIC STRIPE PAINT - TYPE IV (DROP-ON).

The white and yellow traffic paints shall conform on a mass basis to the composition of the standard formula as closely as accepted good paint practice will permit. No variations from the standard formula will be permitted, except for replacement of volatiles lost in processing, or those approved by the Materials Engineer.

- (a) **Substitutions.** The exact brands and types of raw materials are listed for the purpose of facilitating the selection of parallel materials equal not only in quality and composition, but also in physical and chemical behavior after aging in the finished product. Since evaluation of substituted materials may require up to sixty days, the Contractor is reminded to schedule material procurement to permit him to meet delivery commitments. The final decision as to quality of materials shall be made by the Department of Transportation. After the Department of Transportation has approved the brand names

of raw materials proposed by paint manufacturer, no substitution will be allowed during manufacturing without prior approval of the Department of Transportation.

(b) **Pigment.**

1. **Pure Titanium Dioxide Rutile, Type II;** shall meet ASTM Specification D 476-73.
2. **Lead Free Zinc Oxide:** American Process, Acicular, shall meet Federal Specification TT-P-463a, Type I.
3. **Talc, Paint Grade Magnesium Silicate;** shall meet Federal Specification MIL-M15173, Type B.
4. **Calcium Carbonate:**

CaCO ₃	Min. 97 percent
H ₂ O	Max. 0.4 percent
Specific Gravity	2.63 - 2.73
Fineness Requirements:	80% less than 5 μm

Color: Equal to material listed in Standard Formula. Substitution in a Standard Formula shall not result in viscosity variation greater than 5 KU.

5. **Medium Chrome Yellow ASTM D 211, Type III.**
6. **Feldspar,** water washed alkali aluminum silicate, Lawson-United LU-340.

(c) **Resins.**

1. **Traffic Paint Alkyd Resin Solution:**

1.1 **General:**

- Type: Pure, drying alkyd
- Length: Medium
- Type Oil: Soya, linseed or tall. No mixture of two or more oils will be permitted.
- Solvent: Toluol, ASTM Specification D 362

Compatibility: A solution of one part 75% traffic alkyd and five parts toluol shall be clear.

A solution containing the equivalent of 125 grams hypalon, 144 grams of 75% traffic alkyd, 200 grams of methyl ethyl ketone shall be clear, transparent, and show no separation after 24 hours of storage in a 3/4-full test tube at 80°F ± 5°F (26.7°C ± 2.8°C). This rubber-alkyd-solvent solution shall produce a clear film upon drying.

1.2 **Solid Resin Basis:**

Phthalic Anhydrides, %	33 to 37
Oil Acids, %	48 to 55
Acid Number, %, Maximum	8.0
Ash Residue, %, Maximum	0.10
Unsaponifiable, %, Maximum	2.0
Iodine Number of Fatty Acids, Minimum	115
Refractive Index of Fatty Acids, Minimum	1.4660
Rosin based on Fatty Acids (Tall Oil Alkyds), %, Maximum	1.0

1.3 **45% Solids Basis:**

- Color: Gardner 1953 Standard - 9 max.
- Drying Time: A wet film 3 mil (0.076 mm) thick shall set to touch in not more than 90 minutes.
- Driers: Based on the resin solids present, add the equivalent of 0.06% Cobalt (metal) and 1.0% Lead (metal).

Toluol shall be used to reduce the resin solution to 45% solids, and shall meet ASTM Specification D 362.

2. **Chlorinated Paraffin:** Shall meet Federal Specification MIL-C-429A, Type I.

3. **Hypalon Resin:**

Appearance: Free flowing white powder

Viscosity (20% W/W in Toluene

ASTM-D-115), 25°C, Pa·s 0.018 - 0.022

Chlorine, (TT-P-115c4.3.6), %, minimum 64.5

Ash, %, maximum 0.20

Solubility: Soluble in aromatic hydrocarbons eg., toluene, xylene, and alkylated benzenes

(d) **Thinners.**

1. Methyl Ethyl Ketone Federal Specification TT-M-26

(e) **Additives.**

1. Antisettling agent Bentone 34 or Claytone 40

2. Stabilizer Thermolite 813

(f) **Composition Requirements.** The various components shall be proportioned by weight (mass) as set forth below:

1. **Paint, Traffic**

	WHITE	YELLOW
	<u>pounds or kg</u>	<u>pounds or kg</u>
Medium Chrome Yellow		85
Titanium Dioxide, Rutile Type II	100	25
Lead Free Zinc Oxide	25	50
Talc	350	300
Feldspar - LU390		175
Calcium Carbonate	175	
Anti-settling Agent	5	5
Traffic Alkyd 75% solids	144	144
Hypalon	125	125
Chlorinated Paraffin	25	25
36% Lead Drier	2.0	2.0
12% Cobalt Drier	1.0	1.0
Anti-skinning Agent	2.0	2.0
Thermolite 813	0.5	0.5
Methyl Alcohol	5	6
Methyl Ethyl Ketone	200	200
Aliphatic Naphtha (TTN-95)	83	83
Soya Lecithin	<u>8</u>	<u>8</u>
Total weight, pounds (Mass, Kg)	1250.5	1236.5
Volume, gallons (L)	102.46 (855.1)	101.44 (846.56)
Mass/Unit Volume, 16/gal (Kg/L)	12.204 (1.4624)	12.189 (1.4606)

2. Properties of Finished Paint:

- 2.1. Weight (Mass)/Unit Volume ±0.25 lb/gal (± 0.030 Kg/L)
of theoretical
- 2.2. Consistency (Krebs-Stormer), KU, 77°F (25°C) 80-90
- 2.3. Drying Time (ASTM D711), maximum, minutes 7
- 2.4. Bleeding (Fed. Spec TT-P-85d 4.3.11), minimum 0.95
- 2.5. Dry Opacity (Fed. Test Std. No. 141a
Method 4121 using wet film of approximately
4 mils (101.6 µm)), minimum 0.91
- 2.6. Daylight Reflectance
(Fed. Test Std. No. 141a Method 6121), % White, 80 Yellow, 50
- 2.7. Fineness of grind (Hegman), minimum 3
- 2.8. Skinning, 48 hours, 3/4 filled tightly closed container None
- 2.9. Color: Yellow dry film shall be in compliance with “Highway Yellow Color Chart”
U.S. Dept. of Transportation, Federal Highway Administration.

3. Composition Requirements:

	<u>WHITE</u>	<u>YELLOW</u>
Total Solids, %	73.5 ± 2	73.5 ± 2
Pigment, %	52.2 ± 2	51.4 ± 2
Vehicle, %	47.8 ± 2	48.6 ± 2
Non-volatile Material(Vehicle), %, minimum	43.5	43.5

Upon chemical analysis of pigments and vehicle solids, the percentages must be within reasonable manufacturing tolerances as determined by the Department of Transportation.

- (g) **Containers.** Containers shall meet the requirements of Subsection 711.05(h).
- (h) **Inspection, Sampling, and Testing.** All sampling shall be in accordance with Section 730.
- (i) **Sealed Shipments.** Shipments shall be sealed in accordance with Section 730.

711.09. GLASS BEADS FOR TRAFFIC PAINT.

Glass beads used for thermoplastic compound and traffic stripe paint shall meet the requirements of AASHTO M 247, Type I. Beads shall be supplied with a moisture- resistant coating.

711.10. TRAFFIC STRIPE PAINT - ACRYLIC WATERBORNE.

These Specifications cover waterborne white and yellow traffic paint for application directly onto bituminous or Portland cement concrete pavements or existing traffic stripe composed of solvent based paint, waterborne paint, or thermoplastic compounds. Application will be made by spray equipment at application temperatures of 50°F to 150°F (10°C to 66°C). The paint shall be capable of receiving and holding glass beads for producing reflectorized traffic markings.

- (a) **Materials.** The paint shall contain no lead and/or chromium and shall have limited Volatile Organic Content (VOC), as noted herein.
- (b) **General.** The finished paint shall be formulated and manufactured from first-grade material. The materials shall be as listed in the Standard Formula, unless otherwise authorized in advance of manufacture by the Engineer. Any proposed equivalent materials shall equal or exceed the quality and composition and the physical and chemical behavior of the specified material after aging in the finished product.
- (c) **Pigment.**
1. **Titanium Dioxide.** This material shall comply with the latest revision of the Specification for Titanium Dioxide Pigments, ASTM D 476, type II, Rutile. Hiding power of the titanium dioxide shall be greater than or equal to the standard sample when tested in the standard formula.
 2. **Pigment Yellow 65.** This material will only be allowed from the following sources unless otherwise approved by the Materials Engineer: Hoechst Celanese, Engelhard, and Sun Chemical.
 3. **Calcium Carbonate.** This material shall comply with the latest revision of the Specification for Calcium Carbonate Pigments, ASTM D 1199, Type GC, Grade I, with minimum of 95% Calcium Carbonate and Type PC, minimum 98% Calcium Carbonate.
- (d) **Vehicle.**
1. **Acrylic Emulsion Polymer.** The nonvolatile portion of the vehicle shall be composed of a 100% acrylic polymer and shall not be less than 44% by mass. Acrylic emulsion polymer shall be Rohm and Haas E-3427 or equal as determined by the Materials Engineer.
 2. **Methyl Alcohol.** ASTM D 1152 Specific Gravity, 20/20° C, 0.791 to 0.794.
 3. **Water.** Potable.
 4. **Miscellaneous Materials.**
 - 4.1. **Dispersant.** Tamol 850, Colloids 226-35.
 - 4.2. **Surfactant.** Triton CF-10, Colloids CTA 639.
 - 4.3. **Defoamer.** Foamaster 111, Drew 493 Colloids 654.
 - 4.4. **Hydroxy Ethyl Cellulose.** Natrasol 250 HBR, Bermocoll E431FQ.
 - 4.5. **Coalescent.** Texanol.
 - 4.6. **Preservative.** Troy 192, Dowicil 75, Nuosept 101.
- (e) **Manufacture.**
1. All ingredient materials shall be delivered in the original containers and shall be used without adulteration.
 2. The manufacturer shall furnish to the Department the exact batch formula which will be used in manufacturing the paint. No change shall be made in this formula without prior approval by the Department, and no change will be approved that adversely affects the quality or serviceability of the paint.
 3. The following Standard Formulas shall be the basis for the paint. No variations will be permitted except for the replacement of volatiles lost in processing, or those approved by the Engineer. Amounts are shown in pounds (kilograms) of material.

	<u>WHITE</u>	<u>YELLOW</u>
C.I. Pigment, Yellow 65 (Engelhard 1244)	-	32 (14.5)
Titanium Dioxide, Rutile, Type II (Kerr McGee CR800)	100 (45.4)	21 (9.5)
Calcium Carbonate, Type PC (Miss. M-60)	150 (68.0)	150 (68.0)
Calcium Carbonate, Type GC (Hubercarb Q6)	430 (195.0)	465 (210.9)
Hydroxy Ethyl Cellulose (Natrasol 250HBR)	0.5 ^a (0.2 ^a)	0.5 ^a (0.2 ^a)
Acrylic Emulsion, 50% Solids (E2706)	541 (245.4)	535 (242.7)
Texanol (Eastman)	24 (10.9)	23 (10.4)
Defoamer (Colloids 654)	5 (2.3)	5 (2.3)
Dispersant (Tamol 850)	8 (3.6)	9 (4.1)
Surfactant (Triton CF10)	2 (0.9)	2 (0.9)
Methyl Alcohol	29 (13.2)	28 (12.7)
Preservative (Troy 192)	1.5 (0.7)	1.5 (0.7)
Water	<u>10. (4.5)</u>	<u>10. (4.5)</u>
TOTAL POUNDS (KILOGRAMS)	1301 (590.1)	1282 (581.8)

^a Hydroxy Ethyl Cellulose amount may be varied by up to 1 pound (0.05 kg) to adjust viscosity to desired range.

(f) **Mixed Paint.** The mixed paint shall conform to the following requirements. Furthermore, if any variations in materials are allowed from the Standard Formula, the mixed paint shall equal or exceed all test results on a standard prepared from the Standard Formula and tested by the manufacturer under parallel conditions for all the listed requirements.

1. The paint shall be strained before filling, using a screen not coarser than No. 40 mesh (425µm) or a suitable sieve meeting the approval of the Engineer.
2. The volatile content of the finished paint shall contain less than 1.25 pounds (150 grams) of volatile organic matter per gallon (liter) of total non-volatile paint material in accordance with ASTM D 3960.
3. The paint shall have the following properties:
 - 3.1. **Pigment Composition.** Analysis of the extracted pigment shall conform to the following requirements:

	<u>WHITE</u>	<u>YELLOW</u>
Organic Yellow (65%)	-	Min. 4.8 ^a
Titanium Dioxide (%)	Min. 13.4	Min. 2.6
Calcium Carbonate (%)	Max. 86	Max. 93

^a To be determined by x-ray florescence, color spectrophotometry, or any other method the Department may choose. This may be sent to an outside agency or organic pigment manufacturer. It also may include audit of the manufacturer's invoices, batch tickets, inventory or any other means determined by the Department.

3.2. **Physical Properties.**

% Total Solids by mass, minimum	73
% Volume Solids, minimum	58
% Pigment by mass	49-54
% Vehicle by mass	46-51
% Non-volatile in Vehicle by mass, minimum	44
Theoretical weight (mass) per unit volume	±0.3 lb/gal (± 36 g/liter)
Viscosity, 77°F (25°C), Krebs Unit	83-98
Grind (Hegman Gage), minimum	3
Laboratory Dry Time, ASTM D 711, minutes, maximum	10
Dry Through	Not greater than 15 minutes of Standard Formula

3.3. **Color.** The color of the white paint after drying shall be a flat white, free from tint, furnishing good opacity and visibility under both daylight and artificial light.

For yellow, the color shall closely match Color Chip 33538 of Federal Standard 595 and be ± 6% from the PR 1 chart central color when read over the black portion of a 2A Leneta Chart.

3.4. **Flexibility.** The paint shall show no cracking or flaking when tested in accordance with Federal Specification TT-P-1952B.

3.5. **Water Resistance.** The paint shall conform to Federal Specification TT-P-1952B. There shall be no blistering or appreciable loss of adhesion, softening, or other deterioration after examination.

3.6. **Freeze-Thaw Stability.** The paint shall show no coagulation, discoloration, or change in consistency greater than 10 Krebs Units, when tested in accordance with Federal Specification TT-P-1952B.

3.7. **Heat Stability.** The paint shall show no coagulation, discoloration, or change in consistency greater than 10 Krebs Units, when tested in accordance with Federal Specification TT-P-1952B.

3.8. **Dilution Test.** The paint shall be capable of dilution with water at levels without curdling or precipitation such that the wet paint can be readily cleaned up with water only.

3.9. **Storage Stability.** After thirty (30) days of storage in a three-quarters (¾) filled, closed container, the paint shall show no caking that cannot be readily remixed to a smooth, homogeneous state, no skinning, livering, curdling or hard settling. The viscosity shall not change more than 5 Krebs Units from the viscosity of the original sample. After storage for periods of up to nine (9) months from the date of packaging, the pigment shall not settle badly or cake in the container, nor shall the paint skin or thicken in storage sufficiently to cause an undesirable change in consistency, nor show spoilage. The paint shall comply with all the provisions of these Specifications and be capable of

being re-dispersed with a paddle to a smooth, homogeneous condition of useable consistency.

- 3.10. **Contrast Ratio.** The minimum contrast ratio shall be 0.98 when applied at a wet film thickness of 15 mil (381 μm) on a 2A Leneta Chart or equal and air dried for 24 hours. Contrast Ratio = Black/ White.
- 3.11. **Reflectance.** The daylight directional reflectance of the white paint shall not be less than 84% and not less than 50% for yellow paint of a 15 mil (381 μm) wet film applied to a 2A Leneta Chart or equal. After it has dried for 24 hours, measure the reflectance of the paint over the black portion of the chart using a Colorimeter and test method ASTM E 97.
- 3.12. **Bleeding.** The paint shall have a minimum bleeding ratio of 0.97 when tested in accordance with Federal Specifications TT-P-1952B. The asphalt- saturated felt shall conform to ASTM D 226 for Type I.
- 3.13. **Abrasion Resistance.** No less than 50 gallons (190 liters) of sand shall be required for removal of the paint film when tested in accordance with Federal Specification TT-P-1952B.
- 3.14. **No-Tracking Time Field Test.** The paint shall dry to a no-tracking condition under traffic in three minutes maximum when applied at 17 mils \pm 1 mil (432 \pm 25 μm) wet film thickness plus 45 pounds of glass beads per cubic foot (719 kilogram of glass beads per cubic meter) of paint under conditions specified in these Specifications. "No tracking" shall mean the line has dried to the point where a standard automobile can run over the line at 40 mph (64 km/hr) while making a passing movement and not track the reflectorized line when viewed from a distance of 50 feet (15 meter).
- 3.15. **Dry Through Time.** The paint shall be applied to a non-absorbent substrate at a wet film thickness of 17 mils \pm 1 mil (432 μm \pm 25 μm) and placed in a humidity chamber controlled at 90 \pm 5% R.H. and 72.5°F to 2.5°F (22.5°C \pm 1.4°C).

The dry through time shall be determined according to ASTM D 1640, except that the pressure exerted shall be the minimum needed to maintain contact with the thumb and film.

- (g) **Containers.** Containers shall meet the requirements of Subsection 711.05(h).
- (h) **Inspection, Sampling and Testing.** All sampling shall be in accordance with Section 730.
- (i) **Sealed Shipments.** Shipments shall be sealed in accordance with Section 730.

SECTION 712

CONSTRUCTION FABRICS

Description. This Section covers fabrics to be used for reinforcement of asphalt pavements and filter fabric for various uses.

712.01. FABRIC REINFORCEMENT FOR ASPHALT CONCRETE PAVEMENT.

- (a) **General.** The fabric shall meet the requirements for paving in AASHTO M 288.
- (b) **Packaging and Storing.** The fabric shall be supplied by the manufacturer in rolls of standard widths and lengths uniformly wound onto suitable cylinder forms or cores to aid in handling and unrolling by the use of mechanical laydown equipment. The rolls that are supplied shall provide full coverage of the pavement with a minimal number of joint splices.

Wrap the rolls of fabric for protection against sunlight and moisture. When stored outdoors, elevate the rolls and cover them with a tarpaulin.

- (c) **Sampling and Testing.** Furnish a type A materials certification for the reinforcement fabric in accordance with Subsection 106.04. Also, furnish a 3 square yard (2.5 square meter) sample of the fabric for testing to the Materials Engineer from each lot or shipment by the Engineer.

712.02. FILTER FABRIC FOR GABIONS.

- (a) **General.** The fabric shall meet the requirements for separation in AASHTO M 288. A non-woven fabric is required.
- (b) **Acceptance.** Furnish a type D material certification for the fabric in accordance with Subsection 106.04. Also, furnish a 3 square yard (2.5 square meter) sample of the fabric for testing to the Materials Engineer from each lot or shipment by the Engineer.

712.03. GEOTEXTILES FOR SUBSURFACE DRAINAGE PURPOSES.

- (a) **General.** This Subsection covers geotextiles to be used in conjunction with pipe underdrain and other drainage systems. The fabric shall meet the requirements of AASHTO M 288. In addition, use AASHTO M288 Subsurface Drainage, Table 2 with 15% to 50% of in situ soil passing the No. 200 (75 μ m) sieve.
- (b) **Acceptance.** Furnish a type D material certification for the fabric in accordance with Subsection 106.04. Also, furnish a 3 square yard (2.5 square meter) sample of the fabric for testing to the Materials Engineer from each lot or shipment by the Engineer.

712.04. FILTER FABRIC FOR USE WITH RIPRAP.

- (a) **General.** This Subsection describes a pervious fabric to be used under riprap for slope protection. The fabric shall meet the requirements for separation in AASHTO M 288. A non-woven fabric is required.
- (b) **Acceptance.** Furnish a type D material certification for the fabric in accordance with Subsection 106.04. Also, furnish a 3 square yard (2.5 square meter) sample of the fabric for testing to the Materials Engineer from each lot or shipment by the Engineer.

712.05. SEPARATOR FABRIC FOR BASES.

- (a) **General.** This Subsection describes a pervious fabric to be used under base courses for separation. The fabric shall meet the requirements for separation in AASHTO M 288. A non-woven fabric is required.
- (b) **Acceptance.** Furnish a type A certification for the fabric in accordance with Subsection 106.04. Also, furnish a 3 square yard (2.5 square meter) sample of the fabric for testing to the Materials Engineer from each lot or shipment by the Engineer.

712.06. FILTER FABRIC FOR SILT FENCE.

- (a) **General.** This Subsection describes fabric to be used for the removal of soil particles from water flowing through the fence. The fabric shall meet the requirements for temporary silt fence in AASHTO M 288. In addition, use AASHTO M288, Table 6, Unsupported Silt Fence with an elongation less than 50%.
- (b) **Acceptance.** Furnish a type D material certification for the fabric in accordance with Subsection 106.04. Also, furnish a 3 square yard (2.5 square meter) sample of the fabric for testing to the Materials Engineer from each lot or shipment by the Engineer.

SECTION 713**STONE FOR RIPRAP, FILTER BLANKET, AND GABIONS****713.01. MATERIALS COVERED.**

This Section covers stone for plain riprap, laid up riprap or grouted riprap, stone for special plain riprap, and materials for filter blanket and gabions.

713.02. RIPRAP STONE.

Stone for riprap shall be hard, sound, and durable, and shall be approved by the Engineer prior to use. Submit samples of the stone to be used to the Materials Engineer for approval before any stone is used.

Determine tests for mass/unit volume and absorption in accordance with ASTM C 97. The minimum mass/unit volume shall be 140 lbs/ft³ (2,243 kg/m³), and the maximum absorption shall be 6 percent.

Soundness (freeze and thaw test) loss of the stone after 20 cycles shall not exceed 15 percent when tested in accordance with the Corps of Engineers test method CRD-C 144.

The size of stone for the various kinds of riprap shall be as follows:

(a) Stone for Plain Riprap.

Riprap Thickness, <u>inches (mm)</u>	Maximum, <u>pounds (kg)</u>	Average Size, <u>pounds (kg)</u>	Not More than 20% Shall Have a Mass Less <u>Than, lb (kg)</u>
12 (300)	150 (70)	30-50 (13-23)	20 (9)
18 (450)	300 (150)	70-125 (30-60)	30 (14)
24 (600)	1000 (450)	225-400 (100-180)	40 (18)
30 (750)	1000 (450)	225-400 (100-180)	40 (18)
36 (900)	2000 (900)	450-800 (200-360)	80 (36)

When placed on the embankment, the smaller stones shall be well distributed throughout the mass. Neither the breadth or the thickness of any piece of riprap shall be less than 1/3 of its length.

(b) Stone for Laid up or Grouted Riprap.

Riprap Thickness, <u>inches (mm)</u>	Size Range, <u>pounds (kg)</u>	At Least 60% Shall Have a Mass More Than, lb (kg)
12 (300)	50-250 (23-113)	100 (45)
18 (450)	50-250 (23-113)	150 (68)

Slabs or slivers will be rejected. Spalls shall be well graded of a suitable size for the work.

(c) Stone for Special Plain Riprap.

<u>PERCENT</u>	<u>VOLUME</u> <u>Cubic Feet (Cubic Meter)</u>
40 to 60	5 to 12 (0.142 to 0.340)
20 to 30	2 to 5 (0.057 to 0.142)
10 to 20	0.25 to 2 (0.007 to 0.057)
5 to 15	may be less than 0.25 (0.007)

713.03. FILTER BLANKET MATERIAL.

Material for a filter blanket shall consist of sand, gravel, crushed stone, or other approved materials that have been processed, blended, or naturally combined. It shall be reasonably free from lumps or balls of clay, organic matter, objectionable coatings, or other foreign materials, and shall be durable and sound. Blanket material shall not contain flat and/or elongated particles in an amount exceeding 20 percent. A flat or elongated piece is one in which the length is greater than 5 times the minimum dimension. The backing material in place shall be reasonably well graded within the following limits:

SINGLE COURSE BACKING (FILTER BLANKET)	
<u>SIEVE SIZE</u>	<u>PERCENT PASSING</u>
4 inch (100 mm)	100
2 inch (50 mm)	60-90
1 inch (25.0 mm)	40-70
3/8 inch (9.5 mm)	15-40
No. 4 (4.75 mm)	0-15

TWO COURSE BACKING (FILTER BLANKET)		
	PERCENT PASSING	
<u>SIEVE SIZE</u>	<u>Lower Course of Two Layers</u>	<u>Upper Course of Two Layers</u>
6 inch (150 mm)	—	100
4 inch (100 mm)	—	90-100
2 inch (50 mm)	—	65-85
1 inch (25.0 mm)	—	40-70
3/8 inch (9.5 mm)	100	15-35
No. 4 (4.75 mm)	95-100	0-10
No. 8 (2.36 mm)	80-90	—
No. 16 (1.18 mm)	55-75	—
No. 30 (600 μm)	30-60	—
No. 50 (300 μm)	12-30	—
No. 100 (150 μm)	0-10	—

713.04. GABIONS AND REVETMENT MATTRESSES.

(a) **Materials.**

1. **Wire Baskets.** Gabion baskets shall meet the requirements of Subsection 732.09
2. **Stone Fill for Gabions and Revetment Mattresses.** Stone fill for gabions and revetment mattresses shall consist of hard, dense, sound, durable, rough-fractured stone as nearly cubical as practicable. The stone shall have a minimum specific gravity of 2.5 and meet the following dimensional requirements:

<u>Structure Type</u>	<u>Minimum Dimension</u>	<u>Maximum Dimension</u>
Gabions	4 inch (100 mm)	8 inch (200 mm) ^a
Revetment Mattresses	3 inch (75 mm)	5 inch (125 mm) ^b

- ^a When the gabion height exceeds 18 inches (450 mm), 5% of the stone may have a maximum dimension of 10 inches (250 mm).
- ^b For 12 inch (300 mm) revetment mattresses, the stone may have a maximum dimension of 6 inches (150 mm)

3. Soundness (freeze and thaw test) loss of the stone after 20 cycles shall not exceed 15 percent when tested in accordance with the Corps of Engineers test method CRD-C 144.
- (b) **Filter Fabric.** The filter fabric shall conform to the requirements of Subsection 712.02.
- (c) **Filter Sand.** Filter sand shall meet the requirements of Subsection 703.04.

SECTION 714

MASONRY BRICK

Description. This Specification pertains to masonry brick for various types of construction. The particular type required will be specified on the Plans or in the Proposal. Masonry brick may be made from clay, shale, or a satisfactory mixture of aggregates and cement.

714.01. MASONRY BRICK MADE FROM CLAY OR SHALE.

Brick of this type shall comply with the requirements of the “Standard Specification for Building Brick (Solid Masonry Units Made from Clay or Shale)”, AASHTO Designation M-114—except that the requirements for “Maximum Water Absorption by Five-hour Boiling” and “Maximum Saturation Coefficient” shall not apply.

Masonry Brick shall be Grade MW unless shown otherwise on the plans.

Brick for Sanitary Sewer Manholes shall be select, hard-burned, sewer brick which will not deteriorate under conditions encountered in sewer manholes. They shall comply with the requirements of AASHTO M-91, “Sewer and Manhole Brick (Made from Clay or Shale),” for either Grade MM or MS bricks.

714.02. CONCRETE BUILDING BRICK.

Brick of this type shall comply with the requirements of the “Standard Specifications for Concrete Building Brick,” ASTM Designation C55— except that the requirements for “Water Absorption”, “Moisture Content,” and “Linear Shrinkage” shall not apply. Concrete building brick shall be Type II, Grade N-II, unless shown otherwise on the Plans.

714.03. METHODS OF TEST.

These materials will be tested in accordance with the applicable AASHTO or ASTM methods as indicated in the Specifications for these items.

714.04. BASIS OF ACCEPTANCE.

Acceptance of masonry brick will be based on satisfactory results of tests conducted on samples submitted to the Materials Division.

SECTION 716 BITUMINOUS DAMPPROOFING AND WATERPROOFING MATERIALS

This Section covers bituminous primer and mop coats for use, when specified, in dampproofing and waterproofing below or at ground level, for application to concrete and masonry surfaces.

716.01. ASPHALT PRIMER.

Asphalt primer for use with asphalt for waterproofing or dampproofing shall meet the requirements of ASTM D 41. Furnish Type D certification for the asphalt primer in accordance with Subsection 106.04.

716.02. CREOSOTE PRIMER.

Creosote primer for use with tar for waterproofing shall meet the requirements of ASTM D 43. Furnish a Type D certification for the creosote primer in accordance with Subsection 106.04.

716.03. ASPHALT CEMENT.

Asphalt cement for waterproofing or dampproofing shall meet the requirements of ASTM D 449, type II. Furnish a Type D certification for the asphalt cement in accordance with Subsection 106.04.

716.04. COAL-TAR PITCH.

Coal-tar pitch for waterproofing shall meet the requirements of ASTM D 450. Furnish a Type D certification for the coal-tar pitch in accordance with Subsection 106.04.

SECTION 717 MISCELLANEOUS WATERPROOFING MATERIALS

717.01. ASPHALT FELT.

Asphalt felt for use in the membrane system of waterproofing shall meet the requirements of ASTM D 226. Furnish a Type D certification for the asphalt felt in accordance with Subsection 106.04.

717.02. BITUMINOUS TREATED FABRIC.

Bituminous treated fabric for use in the membrane system of waterproofing shall meet the requirements of ASTM D 173. Furnish a Type D certification for the bituminous treated fabric in accordance with Subsection 106.04.

717.03. PLASTIC CEMENT.

(a) **Description.** Plastic cement shall be composed of semi-solid asphalt dissolved in a suitable volatile solvent and stiffened with a mineral filler consisting essentially of short, incombustible, mineral fibers.

- (b) **General Requirements.** The asphalt forming the base of the plastic cement shall be refined petroleum asphalt with a penetration at 77°F (25°C) of 30-70. The mixture shall meet the following requirements:

Asphalt, %, minimum	38
Mineral Filler, %, minimum	25
Petroleum Solvent, %, maximum	25

Plastic cement shall be of such consistency that it can be spread readily with a trowel without drawing or pulling, or can be extruded through a suitable nozzle under a minimum pressure of 50 psi (345 kPa).

When applied in a layer 1/16 to 1/8 inch (1.6 to 3.2 mm) thick, plastic cement shall set within 24 hours to a tough plastic coating free from blisters.

After drying for 72 hours, a patch of plastic cement 1/16 to 1/8 inch (1.6 to 3.2 mm) thick, applied to the material upon which it is to be used, shall not blister or sag more than 1/4 inch (6.4 mm) upon exposure at a temperature of 140°F (60°C) for 5 hours.

After drying for 72 hours and exposure at a temperature of 140°F (60°C) for 5 hours, a patch of cement 1/16 to 1/8 inch (1.6 to 3.2 mm) thick shall be plastic and adhere well to fabric, saturated felt, metal, or concrete, upon exposure at a temperature of 32°F (0°C) for one hour.

After drying for 24 hours and exposure at a temperature of 140°F (60°C) for 24 hours, and then cooling to a temperature of 70°F to 77°F (21°C to 25°C), a patch of the cement 1/16 to 1/8 inch (1.6 to 3.2 mm) thick shall not crack or break from the saturated fabric, saturated felt, or metal, when bent over a mandrel 1 inch (25.4 mm) in diameter.

717.04. INSULATING PAPER.

Insulating paper shall be a waterproof paper 36 inches (914 mm) wide, having a weight (mass)/unit volume not less than 10 lb/100 ft² (488 g/m²). Furnish a Type D certification for the insulating paper in accordance with Subsection 106.04.

717.05. BUTYL RUBBER MEMBRANE.

- (a) **Description.** This Subsection covers type E butyl rubber membrane for use in waterproofing railroad bridges.
- (b) **Butyl Rubber.** The membrane shall be 1/16±1/64 inch (1.6 ± 0.4 mm) thick. It shall be single layer of compounded butyl elastomer of the IIR family (Iso butyl-Isoprene Rubber), complying with Chapter 29, part 2 of the current AREA Specifications.
- (c) **Adhesive.** The rubber-based bonding adhesive shall be compatible with the butyl membrane and with the material to which it is bonded and shall remain elastic at -40°F (-40°C) and above.
- (d) **Cement.** Cement for splicing shall be a butyl compound of self-vulcanizing butyl rubber with not less than 30-percent solids.
- (e) **Tape.** Butyl gum tape for splices shall be of black, unvulcanized butyl rubber with an 0.008 inch (0.20 mm) thick polyethylene backing. It shall be 0.030±0.004 inch (0.76 ± 0.10 mm) thick, including the backing.
- (f) **Shop Drawings.** Furnish 5 copies of shop drawings for the approval by the Engineer and railway company and obtain such approval before proceeding with the work. These drawings shall show

extent, sizes, and complete details of the membrane waterproofing, including detailed installation instructions.

- (g) **Certification.** Furnish a type D certification for the materials specified above in accordance with Subsection 106.04.

SECTION 718

PREMOLDED ASPHALT PLANK

718.01. ASPHALT PLANK.

- (a) **Description.** This Subsection covers asphalt plank for use on railroad bridges.
- (b) **General Requirements.** Premolded asphalt plank shall conform to the requirements of the current AREA Specifications, Chapter 29, Part 2, Section B, Article 4g.

SECTION 719

SIGNS

Description. This Section establishes the requirements for materials for signs in Section 850.

719.01. PANELS.

- (a) **Aluminum.**
 1. **Sheet Aluminum.** Sheet aluminum signs shall be ASTM B 209 alloy 6061-T6 or 5052-H38 with mill finish. Thickness, dimensions, hole sizes, and hole locations shall be shown on the Plans. All panels shall be flat and straight within commercial tolerances established by the aluminum industry.

Sheet aluminum signs shall be treated with a chromate type chemical conversion coating in accordance with ASTM B 449, Class II.
 2. **Extruded Aluminum.** Extruded aluminum panel signs shall be ASTM B 221 alloy 6063-T6. Thickness, dimensions, hole sizes and hole locations shall be as shown on the Plans. All panels shall be flat and straight within commercial tolerances established by the aluminum industry. The extruded aluminum shall be free of corrosion, white rust, and dirt.

Type A edge strip shall be aluminum ASTM B 221 alloy 6063-T6. Aluminum type B sheet metal screws with slotted pan heads shall be placed on 24 inch (609.6 mm) centers maximum to secure the edge strips to the sign panels. On signs with width of 36 inches (914.4 mm) or less, a minimum of three screws shall be used.
- (b) **Sign Faces.** All sign faces are to be made in accordance with the detailed drawings as shown in the latest revision of the Manual on Uniform Traffic Control Devices for Streets and Highways, and/or as shown on the Plans.
- (c) **Basis of Acceptance.** A type A or B certification is required for acceptance of sign panels, extrusions, and shapes covered in this Section.

719.02. SUPPORT ARMS AND FITTINGS.

- (a) **Materials.** Sign supports for sheet signs shall be structural steel conforming to AASHTO M 183 or aluminum alloy conforming to ASTM B 221 alloy 6063-T6.
- (b) **Fabrication.** Fabrication of all signs, bracket arms and fittings shall be accomplished in a uniform and workmanlike manner. All fabrication, including cuttings, shearing and punching, shall be completed prior to metal degreasing, etching, and application of reflective sheeting. All parts shall be cut to size and shape and shall be free of buckles, warp, dents, cockles, burrs, and all defects resulting from fabrication.
- (c) **Basis of Acceptance.** A type A or B certification is required for acceptance of material in this Section.

719.03. SHEET AND EXTRUDED ALUMINUM SIGN FASTENERS.

Bolts for fastening sheet aluminum signs to sign bracket arms shall be aluminum fasteners and collars of the size shown on the Plans.

Panel bolts, hex nuts, post clip bolts, stop nuts, and flat washers shall be aluminum ASTM B 209 alloy 2024-T4. Extruded aluminum signs shall be attached to posts on each side as shown on the Plans with post clip, post clip bolt, and nut and flat washer. Flat washers shall be used under each nut to prevent gouging.

719.04. RETROREFLECTIVE AND NONRETROREFLECTIVE SHEETING.

- (a) **Description.** Retroreflective sheeting used in the fabrication of reflectorized sign faces shall be of types as follows:

Type II - A medium-high intensity retroreflective sheeting, typically enclosed lens glass-bead sheeting.

Type III - A high-intensity retroreflective sheeting, typically encapsulated glass-bead reflective material.

Type IV - A high-intensity retroreflective sheeting, typically an unmetallized microprismatic retroreflective element material.

All retroreflective sheeting shall be of the Type II classification unless otherwise required by Plan details or the proposal.

All sheeting shall be weather resistant and have a precoated adhesive backing protected by a removable liner.

- (b) **Requirements.**

1. **Photometric.** Material requirements for all retroreflective sheeting shall be in accordance with the provisions of AASHTO M 268.
2. **Tests and Samples.** Furnish a certified test report confirming compliance with the requirements noted in these Specifications. In addition, furnish at least one set of four 12 x 12 inch (300 x 300 mm) samples of each color and each lot of material involved in the Contract for evaluation and verification tests by the Department.

Verify colors by comparing samples with color tolerance charts published by the FHWA. Noticeable variation of color in a production run shall be cause for ordering inspection of all sign faces and the rejection of any sign face outside of the tolerances provided by the color tolerance charts.

All testing shall be in accordance with AASHTO M 268.

All completed signs shall be inspected on the project by the Resident Engineer. Faulty application, blemishes or other faults that might impair the serviceability of the sign or any noticeable color mismatching, when viewed from a distance of 25 feet (7.6 m) under both daylight and night time conditions, shall be cause for rejection of any sign face.

719.05. SIGN COPY.

(a) **Screen Copy.**

1. **Direct Screening Process.** The direct screening process may be used for applying nonreflectorized copy on reflectorized or nonreflectorized backgrounds. This method is normally applicable to black copy.
2. **Reverse Screening Process.** The reverse screening process shall be used to provide reflectorized messages on colored backgrounds by the use of transparent color stencil paste applied to a sheeting background of silver white color. This method is normally applicable to a requirement for white copy, for example, the "STOP" sign.
3. **Material and Application.** Material for application by the silk screen method shall be a top quality exterior baking screen enamel or stencil paste manufactured especially for use on roadway signs and compatible with the type sign background material being used. Application of screened copy and curing thereof shall be in strict accordance with the manufacturer's recommendations of the background material.

Colors shall be durable and consistent with the requirements of the FHWA Standards Colors Charts for Signs. The color shall be uniform in acceptable hue when viewed in daylight or under normal headlights at night.

4. **Final Finish.** All of the above mentioned signs shall be treated after completion as prescribed in Subsection 850.04(d).
5. **Tests.** All screening enamel, stencil pastes, and process inks when applied in accordance with recommended procedure and exposed to accelerated weathering for 1000 hours in accordance with Federal Test Method 141/6151 shall show no appreciable discoloration, cracking, crazing, blistering, or lifting.

719.06. RETROREFLECTIVE AND NON-RETROREFLECTIVE CUTOUT LETTERS, NUMERALS, ARROWS, SYMBOLS AND BORDERS.

- (a) **General.** Letter design shall be in accordance with the 1966 FHWA standard alphabets (as revised). Retroreflective cutout letters shall be Type III or Type IV retroreflective sheeting as specified in the Plans and shall meet the requirements of Subsection 719.04.

SECTION 720 OVERHEAD SIGN STRUCTURES

This Section establishes the requirements for materials for overhead sign structures in Section 852.

720.01. ALUMINUM.

- (a) **Aluminum Alloy Extruded Tube.** Aluminum alloy extruded tube shall conform to ASTM B 221, alloy 6061 T6.
- (b) **Aluminum Alloy Permanent Mold Castings.** Aluminum alloy permanent mold castings shall conform to ASTM B 108, alloy SC 70A, F or T 71.
- (c) **Aluminum Alloy Sand Castings.** Aluminum alloy sand castings shall conform to ASTM B 26, alloy SC 70A, F or T7.
- (d) **Aluminum Alloy Plate.** Aluminum alloy plate shall conform to ASTM B 209, alloy 6061 T6.
- (e) **Aluminum Alloy Bolts.** Aluminum alloy bolts shall be made from rod conforming to ASTM B 211, alloy 2024 T4. Bolt heads shall conform to American Standard Regular Hexagon, ASA B18.2. Threads shall conform to standards of Class 2 or 2A. The finished bolt shall be given an anodic coating conforming to a no. 204 aluminite finish. Stainless steel bolts conforming to ASTM F 593 may be used.
- (f) **Nuts.** Nuts shall be of the self-locking type and shall conform to the requirements of the Air Force-Navy Aeronautical Specification; Nuts, Self-Locking, AN-N-5b, or approved equivalent. Stainless steel nuts conforming to ASTM F 593 may be used.
- (g) **Aluminum Alloy Washers.** Aluminum alloy washers shall be made from sheet conforming to the ASTM B 209, alloy, 2024 T4. Stainless steel washers conforming to ASTM F 593 may be used.
- (h) **Aluminum and Aluminum Alloy Welding Rods and Bare Electrodes.** Filler wire for welding shall conform to AWS A5.10.
- (i) **Aluminum Extruded Shapes.** Aluminum extruded structural shapes shall conform to ASTM B 221, alloy 6061 T6.
- (j) **Aluminum Alloy Pipe.** Aluminum alloy pipe for handrail shall conform to ASTM B 241, schedule 40, alloy 6063 T6.
- (k) **Anchor Bolts, Nuts and Washers.** Anchor bolts, nuts, and washers shall conform to the requirements of the current Specifications for steel machine bolts, nuts, and tap bolts, ASTM A 307. The exposed portion plus 6 inches (152 mm) of all steel anchor bolts, nuts, and washers shall be zinc plated. Stainless steel bolts, nuts, and washers conforming to ASTM F594 may be used.

720.02. STEEL.

- (a) **Tube or Pipe Members.** All round tube or pipe members shall be in conformance with ASTM A 53, Grade B. After all welding has been completed and all required holes have been punched or drilled on both the horizontal truss units and the vertical end support unit, they shall be galvanized in accordance with AASHTO M 111.
- (b) **Bolts, Nuts, and Plain Washers.** All bolts, nuts, and plain washers shall be of the size shown on the Plans and shall conform to AASHTO M 164 unless otherwise noted. All bolts, nuts, and plain washers shall be galvanized in accordance with AASHTO M 232.

720.03. WELDING REQUIREMENT.**(a) Welding Requirements for Aluminum.**

1. **Aluminum Alloy.** These Specifications apply to the welding of aluminum alloys used in sign structures, bridge rails, lamp posts, etc., when shown on the Plans or permitted by the Engineer.

The welding terms used in these Specifications shall be interpreted in accordance with the definitions given in the latest edition of AWS Definitions-Welding and Cutting (AWS A3.0) of the American Welding Society.

The welding symbols used on the Plans shall be those shown in the latest edition of Standard Welding Symbols (AWS A2.1) of the American Welding Society. Special conditions shall be fully explained by added notes or details.

- 1.1. **General.** All welding shall be in compliance with ANSI/AWS D1.2.

- 1.2. **Qualification of procedures, welders, and welding operators.**

- (a) Joint welding procedures shall be previously qualified by tests prescribed in ANSI/AWS D1.2 Aluminum Structural Welding Code. The Engineer may accept evidence of previous qualification of the joint welding procedures to be employed.
- (b) All welders and welding operators shall be previously qualified by tests as prescribed in ANSI/AWS D1.2 Aluminum Structural Welding Code. The Engineer may accept evidence of previous qualification of the operators to be employed. The same process and type of equipment required for execution of the work shall be used in qualifying welders and welding operators.

- 1.3. **Identification Marks.** All identification marks shall be made using low- stress stencils. The Fabricator's mark shall be on each structure adjacent to the item number. The welder shall place his permanent identification with steel dies having figures not less than 1/2 inch (12.5 mm) in height; the area to be placed shall be adjacent to all primary member welds and shall also be highlighted to facilitate the inspection.

- 1.4. **Weld Quality.** All welds shall meet the requirements set forth in ANSI/AWS D1.2. Defective welds may be repaired if permitted by the Engineer.

- 1.5. **Inspection.** To determine compliance for weld quality, all welds shall be visually inspected; in addition, all welds subjected to computed stress shall be inspected by the dye penetrant method except as specified herein.

For highway sign structures, the dye penetrant method shall be used on the following: fillet welds connecting columns to bases and main chord members, including the associated flanges, gussets, or main load- carrying brackets or members; and on fillet welds connecting flanges to the main truss chord members.

The dye penetrant tests shall be performed in accordance with the requirements of ASTM E 165, Standard Methods for Liquid Penetrant Inspection, Method B, Procedures B-2 or B-3.

Dye penetrant inspection may be omitted provided that the inspector examines each layer of weld metal with a magnifier of 3X minimum before the next successive layer is deposited.

1.6. **Corrections.** In lieu of rejection of an entire piece or member containing welding which is unacceptable, defective welds shall be corrected as required in ANSI/AWS D1.2.

(b) **Welding Requirements for Steel.** All welding material and methods, including qualification of welders, shall conform to the requirements of ANSI/AWS D1.1.

720.04. FABRICATION.

A type A certification covering all component parts of the structure shall be submitted prior to fabrication. The structure shall be free from all sharp edges and irregularities and shall be free from any misfits or structural deficiencies. All members must fit and make for any easy and quick erection. Prior to shipment, the completed structure will be inspected at the place of fabrication.

720.05. SHIPPING AND ERECTION.

The structures must be protected on all surfaces so that no injury or defacement takes place during transportation or handling to point of destination.

The structure will be visually inspected when delivered to the project. Any defects shall be repaired or replaced in a manner approved by the Engineer.

NOTE: The use of metal tie-downs in direct contact with the structure will not be permitted.

For galvanized steel structures, such injury or defacement shall be cause for rejection unless in the opinion of the Engineer such injury or defacement is so slight that it may be quickly and efficiently regalvanized or metalized in accordance with “American Welding Society Standard C2.2 Recommended Practices for Metalizing.”

720.06. ELECTRICAL REQUIREMENTS.

All electrical equipment, materials, and installation methods shall conform to the latest requirements of the National Electrical Code and to the Electrical Code in the area having jurisdiction.

In the event provision has not been made for furnishing electrical power at the site, then Contractor shall be responsible for furnishing temporary power to demonstrate that all fixtures and equipment are properly installed.

SECTION 721 GALVANIZED STEEL SIGN POSTS

Description. This Section establishes the requirements for galvanized steel sign posts in Section 851. A type A or type B certification will be required for posts greater than 2 inches (50mm) in diameter. Samples and a type D certification will be required for posts 2 inches (50 mm) or less in diameter. Galvanized specimens shall be submitted for testing in accordance with Section 8, ASHTO M 111.

721.01. PIPE POSTS.

Galvanized steel pipe posts shall be made from new galvanized steel pipe of the size shown on the Plans and shall conform to ASTM A 53 or F 1083. When the wall thickness or mass is not designated,

standard weight pipe, Schedule 40, shall be used. Galvanizing shall be done after fabrication and punching or drilling of holes that may be permitted on the Plans, except as provided herein. Cap plates shall be structural steel, AASHTO M 183 galvanized, in accordance with AASHTO M 111 or other materials when shown on the Plans.

Sign posts used for signs that are minor items or incidental construction, when approved by the Engineer, may have holes drilled or punched and one end cut to length after galvanizing— provided that the exposed metal surfaces shall be regalvanized, metalized, or painted with an approved zinc dust-zinc oxide paint.

721.02. WIDE FLANGE BEAM POSTS.

Galvanized steel wide flanged beams shall be new material of the size shown on the Plans and shall conform to the requirements of AASHTO M 183. Galvanizing shall be in accordance with AASHTO M 111 and shall be done after punching or drilling of any holes or cutting that may be permitted by the Plans or by the Engineer.

721.03. SQUARE TUBE POSTS.

Square tube posts shall be made from new hot- rolled carbon sheet steel, structural quality, ASTM A 570-79. The finish shall be in-line, hot- dip galvanized zinc coating per AASHTO M-120, followed by a chromate conversion coating and a clear organic exterior coating. The posts shall have 7/16 inch (11.1 mm) diameter holes or perforated holes spaced 1 inch (25.4 mm) on center along the center of each of the four sides. A type C certification from an approved manufacturer shall be provided with each lot or shipment and shall be completed by the supplier for each project quantity.

721.04. FLANGE CHANNEL POSTS.

Galvanized flange channel posts shall be new material of the size shown on the Plans and shall conform to the requirements of AASHTO M-183. Galvanizing shall be in accordance with ASTM A 123 and shall be done after punching or drilling of any holes or cutting that may be permitted by the Plans or by the Engineer.

**SECTION 723
REINFORCING STEEL****723.01. BAR STEEL REINFORCEMENT - (BILLET STEEL).**

This Specification covers plain and deformed billet steel bars for concrete reinforcement and dowels used in the work. The billet steel bars shall meet the Specification requirements of AASHTO M 31, grade 40 (300) or grade 60 (400). Furnish reinforcing steel bars of structural grade 60 (400) unless otherwise specified and shown on the Plans.

Sample two bars, not less than 24 inches (600 mm) in length, from each lot of bars in the shipment and furnish the chemical analysis report with each lot. The term “lot” used in this paragraph means all bars of one size up to 10 ton (10 metric ton) bearing one manufacturer’s roll mark.

723.02. AXLE STEEL.

This Specification covers deformed and plain axle steel bars for concrete reinforcement and dowels which may be used in lieu of those as specified in Subsection 723.01. Axle steel bars shall meet the Specification requirements of AASHTO M 53. Furnish reinforcing steel bars for structural grade 60 (400) unless otherwise specified and shown on the Plans.

Sampling shall conform to Subsection 723.01 above- except that the carbon range for each lot will be required in lieu of a full chemical analysis.

723.03. WELDED STEEL WIRE FABRIC.

These Specifications cover cold drawn steel wire to be used as such, or in fabricated form, for the reinforcement of concrete.

The fabric shall comply with the requirements of AASHTO M 55 or AASHTO M 221. The size and spacing of wires in the fabric shall be as shown on the Plans. Welds shall be of sufficient strength that they will not be broken during handling or placing.

Furnish reinforcing fabric in flat sheets or rolls. If any materials have become bent or distorted, straighten or otherwise put them in proper condition before using them. When placed in the work, the fabric shall be free from excessive rust, scale, or coating of any character which will impair its bond with the concrete.

Cut two samples at least 24 inches (600 mm) per side from the fabric and submit them for each different bar size in the fabric. Submit samples for each 10 tons (10 metric tons) or less of material.

723.04. STEEL WIRE STRAND FOR PRESTRESSING.

Steel wire strands for prestressing shall conform to the Specifications for "Uncoated Seven-Wire Stress-Relieved Strand for Prestressed Concrete," AASHTO M203, including Supplement I, "Low Relaxation Strand," except that a Type A certification shall be furnished for each reel or coil of strand included in the work.

NOTE: When stress-relieved strand is specified, conformance to Supplement I of AASHTO M203 is not mandatory.

All strand shall be Grade 270 unless otherwise specified.

723.05. BARS FOR POSTTENSIONING.

Bars shall be high strength alloy steel bars meeting the requirements of AASHTO M 275. Furnish a type A certification for each heat of material.

723.06. POSTTENSIONING STEEL WIRE.

Steel cable for posttensioning shall conform to the Specifications for Uncoated Stress-Relieved Wire for Prestressed Concrete, AASHTO M 204, Type BA or WA. Furnish a type A certification for each coil of wire.

When low-relaxation wire is specified, it shall meet the requirements of the supplement to AASHTO M 204.

723.07. ANCHORAGES FOR POSTTENSIONED TENDONS.

All anchorages shall be capable of detensioning or retensioning prestressing steel at any time prior to grouting. The load from the anchoring device shall be distributed to the concrete by means of approved devices.

Anchorage shall develop the specified ultimate strength of the tendons without exceeding anticipated set.

Bending stresses in the plates or assemblies induced by the pull of the prestressing steel shall not exceed the yield point of the material. All parts of the anchoring devices will be at least 2 inches (50 mm) inside the final end surfaces of the members. Furnish a type A certification for each heat of anchorage plates.

723.08. COLD DRAWN STEEL WIRE.

Cold drawn steel wire for concrete reinforcement for spiral ties and other reinforcing designated on the Plans in "W" (Wire) sizes shall comply with AASHTO M 32.

723.09. EPOXY COATED REINFORCING BARS.

These Specifications cover organic protective coatings electrostatically applied to steel bars to be used for concrete reinforcement.

- (a) **Materials.** Epoxy coated reinforcing bars and epoxy coating material shall meet the requirements of AASHTO M 284 Specifications, except as otherwise stipulated under these Specifications.
1. **Reinforcing Steel.** Reinforcing steel bars shall meet the requirements of Subsections 723.01 or 723.02.
 2. **Coating Materials.** Coating materials prequalified for use may be obtained from the Materials Engineer's list of approved materials.
Supply a representative 8 ounce (200g) sample of coating material from each batch to the Materials Division for testing as deemed necessary.
 3. **Color.** The finished epoxy coating shall be of a color and tone that will give easily apparent visual indications of holidays, damage, or corrosion staining.
- (b) **Certification.** A type D certification shall be submitted in accordance with Subsection 106.04.
- (c) **Fabricator's Quality Control.** Epoxy coating will be accepted only from fabricators who have an approved quality control program. Submit the quality control program and schedule to the Department for review and approval prior to any coating and/or fabrication.

**SECTION 724
STRUCTURAL STEEL**

Description. This Section covers the requirements for structural steel, bolts, nuts and washers, shear connector studs, and filler material for welds in Section 506.

724.01. STRUCTURAL STEEL.

- (a) **General.** Furnish steel according to the following specifications. The grade or grades of steel to be furnished shall be as specified in the contract documents. Unless otherwise specified in the contract

documents, all structural steel shall be high-strength low-alloy structural steel conforming to AASHTO M 270 (ASTM A 709), Grade 50W (345W).

All steel for use in main load-carrying member components shall conform to the Charpy V-Notch (CVN) Impact Test requirements of AASHTO M 270 for Zone 2.

Components subject to CVN requirements include, but are not limited to, all flanges and webs of welded plate girders, rolled beams, cover plates, stiffeners (longitudinal, intermediate, or bearing), diaphragm and cross-frame components in curved girder bridges, all connection plates for main load carrying components (i.e., splice plates and filler plates over 6 millimeter), and all steel welded to any of the above.

Steel components not subject to CVN requirements include shoes, diaphragm and cross-frame components in straight girder bridges, lateral bracing, diagonals, armor joints, finger joints, expansion devices, handrails, and guardrails.

Rolled steel plates, shapes, sheet piling, and bars for structural steel shall conform to AASHTO M 160.

Furnish mill test reports for each heat of material, unless greater frequency testing and reporting is required by the materials Specification; in that case, furnish mill test reports at the greater frequency specified by the materials Specification.

- (b) **Carbon Steel.** Structural carbon steel for bolted or welded construction shall conform to AASHTO M 270 (ASTM A 709), Grade 36 (250).
- (c) **High-Strength Low-Alloy Structural Steel.** High-strength low-alloy structural steel shall conform to AASHTO M 270 (ASTM A 709), Grades 50 or 50W (345 or 345W).
- (d) **High-Strength Low-Alloy, Quenched and Tempered Structural Steel Plate.** High-strength low-alloy, quenched and tempered structural steel plate shall conform to AASHTO M 270 (ASTM A 709), Grade 70W (485W).
- (e) **High-Yield-Strength, Quenched and Tempered Alloy Steel Plate.** High-yield-strength, quenched and tempered alloy steel plate shall conform to AASHTO M 270 (ASTM A 709), Grades 100 or 100W (690 or 690W). Quenched and tempered alloy steel structural shapes and seamless mechanical tubing, meeting all of the mechanical and chemical requirements of AASHTO M 270 (ASTM A 709), Grades 100 or 100W (690 or 690W) steel, except that the specified maximum tensile strength may be 140 ksi (965 MPa) for structural shapes and 145 ksi (1000 MPa) for seamless mechanical tubing, shall be considered as AASHTO M 270 (ASTM A 709), Grades 100 or 100W (690 and 690W) steel.
- (f) **Structural Tubing.** Structural tubing shall be either cold-formed welded or seamless tubing conforming to ASTM A 500, Grade B, or hot-formed welded or seamless tubing conforming to ASTM A 501.

724.02. HIGH-STRENGTH FASTENERS.

- (a) **Materials.** High-strength bolts for structural steel joints shall conform to either AASHTO M 164 (ASTM A 325) or AASHTO M 253 (ASTM A 490). When high-strength bolts are used with weathering grades of steel, the bolts shall be Type 3.

The supplier shall provide a lot number appearing on the shipping package and a certification noting when and where all testing was done, including the rotational-capacity tests indicated below, and include zinc thickness when galvanized bolts and nuts are used.

Proof load tests (ASTM F 606, Method 1) shall be required for the bolts. Wedge tests of full-

size bolts are required in accordance with Section 8.3 of AASHTO M 164 (ASTM A 325). Galvanized bolts shall be wedge tested after galvanizing. Proof load tests specified by AASHTO M 291 (ASTM A 563) are required for the nuts. The proof load tests for nuts to be used with galvanized bolts shall be performed after galvanizing, over tapping, and lubricating.

Except as noted below, nuts for AASHTO M 164 (ASTM A 325) bolts shall conform to AASHTO M 291 (ASTM A 563), Property Class 8S, 8S3, 10S or 10S3. Nuts for AASHTO M 253 (ASTM A 490) conform to AASHTO M 291 (ASTM A 563), Property Class 10S or 10S3. The exceptions are nuts to be galvanized (hot-dip or mechanically galvanized) shall be Property Class 10S, nuts to be used with AASHTO M 164 (ASTM A 325) Type 3 (weathering) bolts shall be Property Class 8S3 or 10S3 and nuts to be used with AASHTO M 253 (ASTM A 490) Type 3 (weathering) bolts shall be Property Class 10S3.

All galvanized nuts shall be lubricated with a lubricant containing a visible dye. Black bolts must be oily to touch when delivered and installed. Weathered or rusted bolts shall be cleaned and relubricated prior to installation

Washers shall be hardened steel washers conforming to the requirements of AASHTO M 293 (ASTM F 436) and washer requirements in Subsection 506.04(f)6.4. Washers to be used with Type 3 (weathering) bolts shall be Type 3.

- (b) **Identifying Marks.** AASHTO M 164 (ASTM A 325) for bolts and the specifications referenced therein for nuts require that bolts and nuts manufactured to the specification be identified by specific markings on the top of the bolt head and on one face of the nut. Head markings must identify the grade by the symbol “A325,” the manufacturer, and, if Type 3, the type. Nut markings must identify the property class, the manufacturer, and, if Type 3, the type. Markings on direct tension indicators (DTIs, ASTM F 959) must identify the manufacturer and type “8.8.” Other washer markings must identify the manufacturer and, if Type 3, the type.

AASHTO M 253 (ASTM A 490) for bolts and the specifications referenced therein for nuts require that bolts and nuts manufactured to the specification be identified by specific markings on the top of the bolt head and on one face of the nut. Head markings must identify the grade by the symbol “A490,” the manufacturer, and, if Type 2 or 3, the type. Nut markings must identify the property class, the manufacturer, and, if Type 3, the type. Markings on direct tension indicators must identify the manufacturer and type “10.9.” Other washer markings must identify the manufacturer and, if Type 3, the type.

- (c) **Dimensions.** Bolt and nut dimensions shall conform to the requirements for Metric Heavy Hexagon Structural Bolts and for Metric Heavy Semi-Finished Hexagon Nuts given in ANSI Standard B18.2.3.7M and B18.2.4.6M, respectively.
- (d) **Galvanized High-Strength Fasteners.** AASHTO M 253 (ASTM A 490) bolts shall not be galvanized.

When fasteners are to be galvanized, they shall be hot-dip galvanized in accordance with AASHTO M 232 (ASTM A 153), Class C, or mechanically galvanized in accordance with AASHTO M 298 (ASTM B 695) Class 50 (345). Bolts to be galvanized shall be either AASHTO M 164 (ASTM A 325) Type 1 or Type 2, except that Type 2 bolts shall only be mechanically galvanized. Direct tension indicators shall only be mechanically galvanized. Galvanized bolts shall be tension tested after galvanizing. Washers, nuts, and bolts of any assembly shall be galvanized by the same process. The nuts should be overtapped to the minimum amount required for the fastener assembly, and shall be

lubricated with a lubricant containing a visible dye so a visual check can be made for the lubricant at the time of installation.

- (e) **Alternative Fasteners.** Other fasteners which meet the materials, manufacturing, and chemical composition requirements of AASHTO M 164 (ASTM A 325) or AASHTO M 253 (ASTM A 490), and which meet the mechanical property requirements of the same Specification in full size tests and which have body diameter and bearing areas under the head and nut, or their equivalent, not less than those provided by a bolt and nut of the same nominal dimensions prescribed in article (c) above, may be used, subject to the approval of the Engineer. Such alternate fasteners may differ in other dimensions from those of the specified bolts and nuts.

Subject to the approval of the Engineer, high-strength steel lock-pin and collar fasteners may be used as an alternate for high-strength bolts as shown in the contract documents. The shank and head of the high-strength steel lock-pin and collar fasteners shall meet the requirements of article (c). Each fastener shall meet the following criteria: a solid shank body of sufficient diameter to provide tensile and shear strength equivalent to or greater than that of the bolt specified in the contract documents; a cold-forged head on one end, of type and dimensions as approved by the Engineer; a shank length suitable for material thickness when fastened; and locking grooves, breakneck groove and pull grooves (all annular grooves) on the opposite end. Each fastener shall provide a steel locking collar of proper size for the shank diameter used which, by means of suitable installation tools, is cold swaged into the locking grooves forming head for the grooved end of the fastener after the pull groove section has been removed. The steel locking collar shall be a standard product of an established manufacturer of lock-pin and collar fasteners, as approved by the Engineer.

- (f) **Load Indicator Devices.** Load indicating devices may be used in conjunction with bolts, nuts, and washers specified in article (a). Load indicating devices shall conform to the requirements of ASTM Specification for Compressible-Washer Type Direct Tension Indicators for Use with Structural Fasteners, ASTM F 959, except as provided in the following paragraph.

Subject to the approval of the Engineer, alternative design direct tension indicating devices may be used provided they satisfy the requirements of article 506.04(f)6.4 under *Installation of Alternative Design Fasteners*, or other requirements detailed in specifications provided by the manufacturer and subject to the approval of Engineer.

When used with weathering steel, direct tension indicators shall be galvanized and coated with "baked epoxy" as specified in ASTM F 959.

724.03. WELDING.

- (a) **General.** All shop and field welding shall be arc welding and shall be done in accordance with the current ANSI/AASHTO/AWS D1.5, Bridge Welding Code.

No welding will be allowed when the air temperature is lower than

20°F (-6°C), when surfaces are wet or exposed to rain, snow, or wind, or when operators are exposed to inclement conditions that will hamper good workmanship.

Any moisture present at the point of welding shall be driven off by heat before welding commences. Wind breaks shall be required for the protection of all welding operations.

The welder shall place a permanent identification mark with a low-stress stencil adjacent to all welds made as soon as they are completed.

If a fabricating shop prequalifies its welders, welding operators, and tackers in accordance with this Specification— and certifies to the Engineer that the welder, welding operator, or tacker has been

prequalified within 12 months previous to the beginning of work on the subject structure— the Engineer may consider the worker qualified.

The certificate shall state that the welder, welding operator, or tacker has been doing satisfactory welding of the required type within the three month period previous to the subject work. A certification shall be submitted for each welder, welding operator, or tacker and for each project, stating the following : (1) name of the welder, welding operator, or tacker, (2) the name and title of the person who conducted the examination, (3) the kind of specimens, (4) the position of welds, (5) the results of the tests, and (6) the date of the examination.

Such a certification of prequalification may also be accepted as proof that a welder, welding operator, and tacker on the field welding is qualified, if the Contractor who submits it is properly staffed and equipped to conduct such an examination, or if the examining and testing is done by a recognized agency which is staffed and equipped for such purpose.

(b) **Qualification of Welders.**

1. **Field Welders.** Field welders shall be qualified by the Department of Transportation , Materials Division, in accordance with the current ANSI/AASHTO/AWS D1.5, Bridge Welding Code, and in accordance with instructions provided by the Materials Engineer.

Test plates will be furnished by the Laboratory, but the applicant shall pay all expenses necessary for cutting and machining test specimens from the test weld plates.

Field welders will be issued a certificate of qualification on the basis of qualification tests given by the Department of Transportation. “Field welder” as used herein refers to a unit consisting of the welder, the welding machine, and a class or group of manual shielded electrodes suitable for welding structural grades of steel.

A certificate of qualification shall become void following any 12- month period after its issuance in which the field welder has not accomplished satisfactory welding on an Oklahoma Department of Transportation project. Submit the evidence of qualification of each field welder to be accepted by the Engineer before starting any welding operation.

2. **Shop Welders and Welding Operators.** Shop welders and welding operators shall be qualified by the official “Shop Inspection” Testing Laboratory of the Department in accordance with the Section on “Qualification” of the ANSI/AASHTO/AWS D1.5 Bridge Welding Code, and in accordance with instructions provided by the Materials Engineer. The shop shall provide base material test plates for the qualification tests.

(c) **Procedure.**

1. **General.** Beam and girder splices shall be made using the sequences shown in Figure 1, except that some members will require fewer or more passes than shown. Welds shall be alternated from side to side to prevent heat build-up on one flange edge. The progression for all passes in the vertical position shall be upwards.

2. **Welding Procedure for Splices.** Groove welds shall begin and terminate at the ends of a joint on extension bars. Edge preparation and thickness of extension bars shall be the same as that of the member being welded and shall extend a minimum of 3/4 inch (20 mm) beyond the joint. Extension bars shall be removed with a cutting torch upon completion and cooling of the weld; the flange edges shall be ground smooth.

All welded flange splices, both shop and field, shall be finished smooth and flush with the base metal on all surfaces by grinding in the direction of applied stress, along the longitudinal axis of the girder, leaving surfaces free from depression.

(d) **Filler Metal.** When shown on the Plans or in the Proposal that the structural steel is to be left bare and unpainted, the deposited weld metal must have a similar atmospheric corrosion resistance and coloring characteristics as the base metal used. Follow the steel producer's recommendation and ANSI/AASHTO/AWS D1.5, Bridge Welding Code, paragraph 4.1.

1. Shielded metal arc welding (SMAW) electrodes shall conform to the requirements of ANSI/AWS A5.1.
 2. Electrodes and fluxes for submerged arc welding shall conform to ANSI/AWS A5.17.
 3. Electrodes for gas metal arc welding shall conform to the requirements of ANSI/AWS A5.18.
 4. Electrodes for flux-cored arc welding shall conform to the requirements of ANSI/AWS A5.20.
- All electrodes and electrodes-flux combinations shall be compatible with the type and thickness of steel to be welded. Use them only with the type current, the polarity, and in the positions permitted by the applicable AWS Specification.

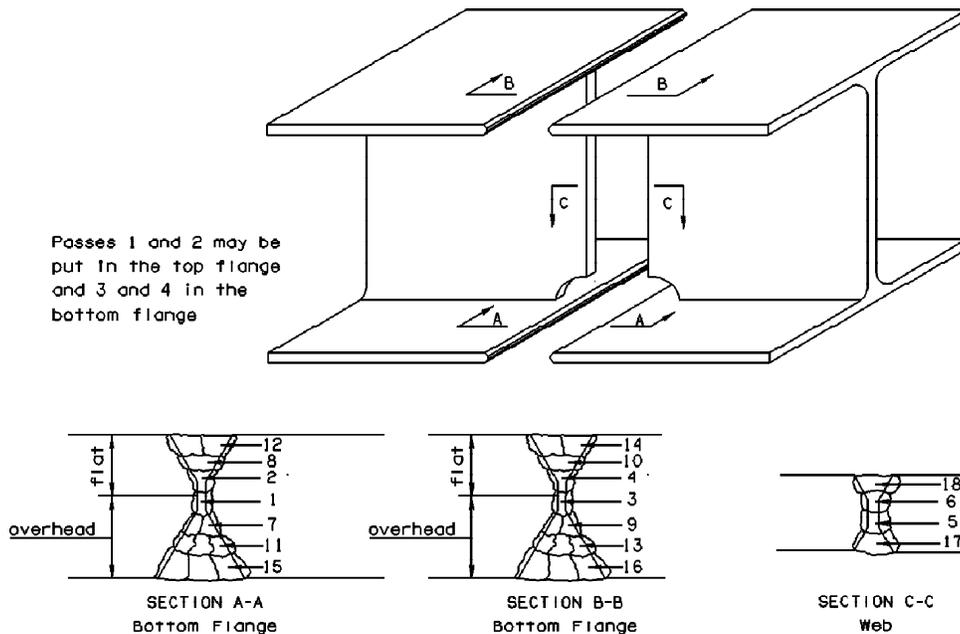


FIGURE 1
Welding Procedure for Splices

724.04. WELDED STUD SHEAR CONNECTORS.

- (a) **General.** The materials, installation, and inspection of end-welded stud shear connectors where welded to steel beams, girders, or plates to connect the members to concrete in composite steel-concrete construction shall be in accordance with the ANSI/AASHTO/AWS D1.5, Bridge Welding Code and as follows:

Before placing orders for studs, submit to the Engineer for approval the following information on the studs to be purchased:

1. The name of the manufacturer.
 2. A detailed description of the stud and arc shield to be furnished.
 3. A certification from the manufacturer that the stud base is qualified.
 4. A copy of the qualification test report as certified by the testing laboratory.
- (b) **Materials.** Shear connector studs shall conform to the requirements of Cold Finished-Carbon Steel Bars and Shafting, AASHTO M 169 (ASTM A 108), cold drawn bars, Grades 1015, 1018, or 1020, either semi-killed or fully killed deoxidation. If flux retaining caps are used, the steel for the caps shall be of a low carbon grade suitable for welding and shall comply with Cold-Rolled Carbon Steel Strip, ASTM A 109M.

Tensile properties, as determined by tests of bar stock after drawing or of finished studs, shall conform to the following requirements in Table 724-1 in which the yield strength is as determined by a 0.2% offset method:

TABLE 724-1

Tensile Properties of Shear Connectors	
Tensile Strength, minimum	60 ksi (415 MPa)
Yield Strength, minimum	50 ksi (345 MPa)
Elongation, minimum	20% in 2 inches (50 mm)
Reduction of area, minimum	50%

- (c) **Test Methods.** Tensile properties shall be determined in accordance with the applicable sections of AASHTO T 244 (ASTM A 370), Mechanical Testing of Steel Products. Make tensile tests of finished studs on studs welded to test plates using a test fixture similar to that shown in Figure 7.2 of ANSI/AASHTO/AWS D1.5 Bridge Welding Code. If fracture occurs outside of the middle half of the gage length, repeat the test.
- (d) **Finish.** Finished studs shall be of uniform quality and condition, free from injurious laps, fins, seams, cracks, twists, bends, or other injurious defects. Finish shall be as produced by cold drawing, cold rolling, or machining.
- (e) **Certification.** Furnish certification from the manufacturer that the studs as delivered are in accordance with the Specification. Furnish certified copies of in-plant quality control test reports to the Engineer.
- (f) **Installation Testing.** After the first two studs welded on each beam or girder have been allowed to cool, bend them 45 degrees by striking the stud with a hammer. If failure occurs in the weld of either stud, correct the procedure and successfully weld and test two successive studs before any more studs are welded to the beam or girder. Promptly inform the Engineer of any changes in the welding procedure at any time during construction.

When the temperature of the base metal is below 32°F (0°C), one stud in each 100 studs welded shall be bent 45 degrees in addition to the first two bent as specified above.

- (g) **Check Samples.** The Engineer may select, at the Contractor's expense, studs of each type and size used under the contract documents as necessary for checking the requirements of the subsection.

724.05. ANCHOR BOLTS FOR BRIDGE STRUCTURES.

Anchor bolts for bridge structures shall be continuously threaded steel bars conforming to AASHTO M 270, Grade 50W (345W) with metric coarse thread series, ANSI B1.13M for the bolt size specified in the contract documents.

Grade 50W (345W) anchor bolts shall be used with nuts and washers made of weathering steels as specified for high-strength bolts, AASHTO M 164 (ASTM A 325) in subsection 724.02.

Anchor assemblies shall be galvanized when used with painted or galvanized anchor plates.

724.06. GALVANIZING.

When galvanizing is specified in the contract documents, ferrous metal products, other than fasteners and hardware items, shall be galvanized in accordance with the Standard Specifications for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products, AASHTO M 111 (ASTM A 123). Fasteners and hardware items shall be galvanized in accordance with the Standard Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware, AASHTO M 232 (ASTM A 153), except as noted in subsection 724.02.

**SECTION 725
MISCELLANEOUS METALS****725.01. DESCRIPTION.**

This Section covers steel forging, cold-rolled shafting for pins and rollers, steel castings, iron castings (gray and ductile), and bronze castings.

725.02. STEEL FORGINGS AND STEEL STAFTING.

- (a) **Steel Forgings.** Steel forgings shall conform to the Specifications for Steel Forgings Carbon and Alloy for General Use, AASHTO M 102 (ASTM A 668), Classes C, D, F, or G.
- (b) **Cold Rolled Shafting for Pins and Rollers.** Pins and rollers up to 8 inches (200 mm) in diameter, unless marked as forging on the Plans, may be furnished from cold finished shafting meeting the requirements of the Standard Specifications for Commercial Cold Finished Carbon Steel Bars and Shafting, AASHTO M 169, Grade 1035 or 1045 (UNS Designations G10350 or G10450), providing that tensile tests made on specimens machined from the finished shafting shall develop a minimum tensile strength of 75 ksi (515 MPa).

725.03. STEEL CASTINGS.

- (a) **General.** Castings shall be true to pattern in form and dimensions, free from pouring faults, sponginess, cracks, blow holes, and other defects in positions affecting their strength and value for the service intended. All covers and gratings that fit into frames shall fit properly and seat uniformly and solidly.

Sandblast or otherwise effectively clean all castings of scale and sand so they present a smooth, clean, and uniform surface.

Castings will be accepted only from domestic foundries which have an approved quality control program. The quality control program and schedule shall be submitted to the Department for review and approval prior to casting production. See Subsection 725.04(a) General for lettering identification requirements.

- (b) **Mild Steel Castings.** Steel castings for use in highway bridge components shall conform to the Standard Specification for Steel Castings for Highway Bridges, AASHTO M 192 (ASTM A 486), Class 70 (485), or Standard Specification for Steel Castings, Carbon, for General Application, AASHTO M 103 (ASTM A 27), Grade 70-36 (485-250), unless otherwise specified.
- (c) **Chromium Alloy-Steel Castings.** Chromium alloy-steel castings shall conform to the Standard Specification for Corrosion-Resistant Iron-Chromium, Iron-Chromium-Nickel and Nickel Based Alloy Castings for General Application, AASHTO M 163 (ASTM A 743M). Furnish grade CA-15M unless otherwise specified.

725.04. IRON CASTINGS.

- (a) **General.** Iron Castings shall be true to pattern in form, within industry- acceptable dimensional tolerances for the size and/or shape of the unit, and free from pouring faults, sponginess, cracks, blow holes, and other defects in positions affecting their strength and value for the service intended. Castings shall be boldly filleted at angles and the arises shall be sharp and perfect.

All castings must be sandblasted or otherwise effectively cleaned of scale and sand so as to present a smooth, clean, and uniform surface. Remove runners, risers, fins, and other cast-on pieces. Where shown on the Plans, machine mating surfaces of cast assemblies to provide flat, true surfaces, and ensure well-mated, non-rocking and non-rattling components. All covers or grates that fit into frames shall fit tight and seat uniformly and solidly. They shall not rock nor rattle when installed.

Where mass is specified on the Plans, castings shall conform to such requirements. All castings shall be identified in an area as shown on the Plans or in an area visible when the unit is installed. The lettering shall be recessed 1/16 inch (1.6 mm) from the surrounding surface. In the case of a surface having a grid pattern, the lettering shall be recessed into a non-gridded area. Lettering content required shall be sufficient for identification, including manufacturer or distributor, heat and/or pour number, and date of casting. Castings will be accepted only from domestic foundries which have an approved quality- control program. Submit the quality- control program and schedule to the Department for review and approval prior to any casting production.

- (b) **Gray Iron Castings.** Gray iron castings shall meet the requirements of AASHTO M 105 (ASTM A 48) and shall be Class 35 B for manhole covers and inlet grates. All others shall be Class 30 B unless otherwise shown on the Plans or specified herein.
- (c) **Ductile Iron Castings.** Ductile iron castings shall conform to the Standard Specifications for Ductile Iron Castings, ASTM A 536, Grade 65-45-12 (414-276-18), unless otherwise specified. In addition to the specified test coupons, test specimens from parts integral with the castings, such as risers, shall be tested for castings with a mass more than 1000 pounds (450 kg) to determine that the required quality is obtained in the castings in the finished condition.
- (d) **Malleable Iron Castings.** Malleable iron castings shall meet the requirements of the Standard Specification for Ferritic Malleable Iron Castings, ASTM A 47, Grade 24118, unless otherwise specified.

725.05. ACCESSORIES FOR CASTINGS AND SPECIAL FABRICATED UNITS.

- (a) **General.** Bolts required for casting assemblies shall meet the requirements of AASHTO M 164. They shall be machine bolts furnished galvanized (zinc-coated), cadmium plated, or stainless steel. Support beams required for casting assemblies shall meet the requirements of AASHTO M 183. Furnish "T" handles as shown on standard drawings for locking manhole covers. The minimum shall be two handles for up to and including 20 locking manhole covers and one for every 20 thereafter.

- (b) **Special Fabricated Drainage Grates.** Welded steel drainage grates shall meet the material requirements of AASHTO M 183 for the load-bearing members. Stiffeners shall be specified by the manufacturer. Welding shall meet all applicable standards as covered in Section 724 and references.

Furnish grate units that have been galvanized after fabrication or painted with an inorganic zinc ethyl silicate base primer and vinyl finish coat. Galvanization shall be in accordance with the requirements of AASHTO M 111. Paint shall meet the materials requirements of Section 730.

Cleaning of grate units (for either procedure) and paint application shall be as covered in Subsection 506.04(d) Painting. Only those procedures which apply to grate sized units shall apply, and shop-applied paint shall be utilized for both coats.

Pipe for use in fabricated grates shall meet the requirements of ASTM A 53 and be furnished in standard mass, unthreaded mill finish unless otherwise stated. Hydrostatic pressure testing shall be waived. After welding, thoroughly clean the grate units, and for galvanized units only, punch or drill a pressure vent. See Plans for location of vent holes. See above for paint and painting requirements. Angle iron and strap iron used for end members or spacers shall meet the requirements of AASHTO M 183 mill-finish.

Butt welded pipe shall be acceptable for use as grate members with the approval of the Engineer.

725.06. BRONZE.

Bronze castings shall conform to the requirements of AASHTO M-107, Copper Alloy UNS No. C91100. Bronze bearings and expansion plates shall conform to the requirements of the Specifications for Rolled Phosphor Bronze Bearings and Expansion Plates for Bridges and Structures, AASHTO M 108 Copper Alloy UNS No. C51000. The class of metal shall be shown on the Plans.

SECTION 726 DRAINAGE CONDUITS

726.01. DESCRIPTION.

This section covers the materials requirements for surface and subsurface drainage conduits of the kind specified on the Plans and the requirements of Section 613.

726.02. MATERIALS.

- (a) **Rigid Conduits.** Materials covered in this Subsection are as follows: nonreinforced concrete pipe, drain tile porous and perforated pipe, reinforced concrete circular, elliptical, and arch pipe, cast (ductile) iron, precast reinforced concrete box sections, manhole sections, inlet boxes, and junction boxes, all meeting the following requirements:

1. **Concrete and Clay Culverts.**
 - 1.1. **Concrete Sewer, Storm Drain, and Culvert Pipe** shall conform to AASHTO M 86.
 - 1.2. **Reinforced Concrete Culvert, Storm Drain and Sewer Pipe** shall conform to AASHTO M 170.

In addition to the Pipe Classes shown in AASHTO M 170, a special design Class IV/V conforming to AASHTO M 170M may also be used. Design criteria for Class IV/V is a midline interpolation between the design criteria shown for Class IV (Table 4) and Class V (Table 5) of AASHTO M 170.
 - 1.3. **Reinforced Concrete Arch Culvert, Storm Drain, and Sewer Pipe** shall conform to AASHTO M 206.
 - 1.4. **Reinforced Concrete Elliptical Culvert, Storm Drain and Sewer Pipe** shall conform to AASHTO M 207.
 - 1.5. **Reinforced Concrete D-Load Culvert, Storm Drain, and Sewer Pipe** shall conform to AASHTO M 242.
 - 1.6. **Concrete Drain Tile** shall conform to AASHTO M 178.
 - 1.7. **Vitrified Clay Pipe, Extra Strength, Standard Strength, and Perforated** shall conform to AASHTO M 65.
 - 1.8. **Clay Drain Tile** shall conform to AASHTO M 179.
2. **Rigid Metallic Culverts.**
 - 2.1. **Ductile Iron Culvert Pipe** shall conform to AASHTO M 64.
3. **Precast Sewer Appurtenances and Box Sections for Culverts.**
 - 3.1. **Precast Reinforced Concrete Manhole Sections** shall conform to AASHTO M 199.
 - 3.2. **Precast Reinforced Concrete Curb Inlet Boxes** shall conform to ODOT approved Designs.
 - 3.3. **Precast Reinforced Concrete Junction Boxes** shall conform to ODOT approved Designs.
 - 3.4. **Precast Reinforced Concrete Box Sections for Culverts, Storm Drains, and Sewers** shall conform to AASHTO M 259.
 - 3.5. **Precast Reinforced Concrete Box Sections for Culverts, Storm Drains, and Sewers With Less Than 2 feet (600 mm) of Cover Subject to Highway Loadings** shall conform to AASHTO M 273.
4. **DELETED.**
5. **Inspection and Acceptance.** Inspection and acceptance criteria will be as specified unless the manufacturer has established an approved quality control program with the Department.
6. **Joint Filler.** Joint filler for joints in concrete pipe culverts shall meet the requirements of one of the following materials:

- 6.1. **Cold Applied Mastic Type.** This compound, when applied according to the manufacturer's directions, shall be resilient and adhesive and maintain an effective seal through repeated cycles of expansion and contraction. The material shall comply specifically with the following requirements:

	Minimum	Maximum
Soluble in Trichloroethylene, AASHTO T 44, %	45.0	—
Ash, AASHTO T 111, %	15.0	55.0
Penetration ^a , AASHTO T 49, 150 g., 5 sec., 77°F (25EC)	150	275

^a Penetration shall be in accordance with AASHTO T 49, except that a penetration cone shall be used in lieu of the standard penetration needle. The cone shall conform to the requirements given in the Standard Method of Test for Cone Penetration of Lubricating Grease (ASTM D 217), except that the interior construction may be modified as desired.

NOTE: This joint filler shall not be used for pipes larger than 60 inches (1524 mm) in diameter or for precast concrete boxes.

- 6.2. **Flexible Watertight Gaskets.** The joint materials shall meet the requirements of AASHTO M 198 and provide a proper fit for a satisfactory seal. When not on the approved list maintained by the Materials Engineer, a type A certification stating the material meets AASHTO M 198 shall be submitted.

NOTE: Butyl rubber sealant shall be used for all pipes in excess of 60 inches (1524 mm) in diameter.

- 6.3 **Flexible Cellular Seals.** The joint materials shall meet the requirements of ASTM D 1056 "Standard Specification for Flexible Cellular Materials - Sponge or Expanded Rubber, Type 2C1."

NOTE: This joint material shall be one continuous piece, shall be applied in accordance with the manufacturer's recommendation, and shall not be used for pipes larger than 60 inches (1524 mm).

- (b) **Flexible Conduits.** Materials covered in this Subsection are as follows: steel conduits, coated and clad steel conduits, structural plates, aluminum conduits, clad aluminum conduits, and nonmetallic conduits, all meeting the following requirements:

1. **Steel Conduits-Culverts.**

- 1.1. **Metallic (Zinc or Aluminum) Coated, Corrugated Steel Culverts** shall conform to AASHTO M 36.

- 1.1.1. **Sheets for Culverts.** Zinc coated (Galvanized) steel sheets for culverts shall conform to AASHTO M 218. Steel sheet, aluminum-coated (type 2) by the hot-dip process for sewer and drainage pipe shall conform to AASHTO M 274. Aluminum-zinc alloy coated sheet steel for corrugated steel pipe shall conform to AASHTO M 289.

- 1.1.2. **Types of Culverts.** Culverts shall be type I (Circular) or type II (Arch) shape unless otherwise specified on the Plans.
- 1.1.3. **Externally Coated or Clad Culverts.**
 - 1.1.3.1. **Bituminous Coated Corrugated Metal Culvert Pipe and Pipe Arches** shall conform to AASHTO M 190. Type A bituminous coating shall be used unless type B, type C, or type D is specified.
 - 1.1.3.2. **Precoated Corrugated Steel Culverts** shall conform to AASHTO M 245 constructed from polymer coated sheet conforming to AASHTO M 246.
2. **Aluminum Conduits-Culverts.**
 - 2.1. **Corrugated Aluminum Alloy Culverts** shall conform to AASHTO M 196. If bituminous coating is specified it shall be type A coating unless type B or type C coating is specified, meeting the requirements of AASHTO M 190.
 - 2.2. **Clad Aluminum Alloy Sheets for Culverts** shall conform to AASHTO M 197.
3. **Nonmetallic Conduits-Culverts.**
 - 3.1. **Class PS 50 Polyvinyl Chloride (PVC) Pipe** shall conform to AASHTO M 278.
 - 3.2. **Corrugated Polyethylene Pipe**, shall conform to AASHTO M 294.
4. **DELETED.**
5. **DELETED.**
6. **Nonmetallic Conduits-Underdrain.**
 - 6.1. **Polyvinyl Chloride (PVC) Pipe.** Class PS 50 polyvinyl chloride (PVC) pipe shall conform to AASHTO M 278, or highway underdrain conforming to the requirements of ASTM F 758, Standard Specifications for Smooth-Wall Polyvinyl Chloride (PVC) Plastic Underdrain Systems for Highway, Airport, and Similar Drainage with material Specification of ASTM D 1784. This underdrain shall be furnished with a minimum pipe stiffness of 45 psi (317 kPa) (Type PS-46). Corrugated polyvinyl chloride (PVC) pipe shall meet the requirements of ASTM F 949.
 - 6.2. **Polyethylene Drainage Tubing.**
 - 6.2.1. **Corrugated Polyethylene Drainage Tubing.** Corrugated polyethylene drainage tubing shall conform to AASHTO M 252 Type C or CP.
 - 6.2.2. **Smooth Interior Corrugated Polyethylene Drainage Tubing.** Smooth wall corrugated polyethylene drainage tubing shall conform to AASHTO M 252 Types S or SP or AASHTO M 294 Type S. The polyethylene pipe shall be manufactured from High Density Polyethylene (HDPE), virgin compounds in accordance with ASTM D 3350, cell class 324420 C.
 - 6.2.3. **Perforations.** When perforations are specified, they shall meet the requirements of Class 2 unless otherwise noted on the Plans.
 - 6.2.4. **Materials Certification, Testing, and Acceptance.** Materials certification, testing, and acceptance shall be in accordance with the requirements of AASHTO M 252, AASHTO M 294, and the Department's acceptance policy, published as: "Procedure for Inspection,

Sampling, Testing, and Acceptance of Corrugated Polyethylene Pipe.” Copies of the procedure are available at the office of the Materials Engineer.

6.2.5. **Inspection.** Inspection criteria will be specified by the manufacturer’s approved quality control program with the Oklahoma Department of Transportation.

7. **Structural Plate for Pipe, Pipe Arches, and Arches.**

7.1. **Corrugated Galvanized or Coated Steel.**

7.1.1. **Description.** This Subsection covers galvanized corrugated steel structural plate structures for use as culverts, drainage structures, underpasses, and special shapes for field assembly of sizes and dimensions as shown on the Plans.

7.1.2. **Materials.** The materials shall comply with the requirements of AASHTO M 167. The minimum thickness shall be as shown on the standard drawings for the design live load on the project, or on special detail sheets.

7.1.3. **Fabrication.** All structural plate structures shall conform to the requirements of applicable sections of AASHTO Standard Specifications for Highway Bridges. Plate sizes and shapes, forming and punching, radius of curvature, gauge, mass, tolerances, corrugation pitch and depth, and workmanship shall be as specified therein. The minimum plate thickness shall be as shown on the Plans.

7.1.4. **Sampling and Testing.** Sample and test all sheets or plates used in the fabrication of structural plate structures as provided in AASHTO M 167.

7.2. **Aluminum Alloy.**

7.2.1. **Description.** This Subsection covers aluminum alloy structural plate structures for use as culverts, drainage structures, underpasses, and special shapes for field assembly of sizes and dimensions as shown on the Plans.

7.2.2. **Materials.** The materials shall comply with the requirements of AASHTO M 219. The minimum plate thickness shall be as shown on the standard drawings for the design live load on the project, or on special detail sheets.

7.2.3. **Fabrication.** All structural plate structures shall conform to the requirements of applicable sections of AASHTO Standard Specifications for Highway Bridges. Plate sizes and shapes, forming punching, radius of curvature, gauge, mass, tolerances, corrugation pitch and depth, and workmanship shall be as specified therein. The minimum plate thickness shall be as shown on the Plans.

7.2.4. **Sampling and Testing.** Sample and test all sheets or plates used in the fabrication of structural plate structures as provided in AASHTO M 219.

7.3. **Steel End Sections.**

7.3.1. **Description.** This Subsection covers metal culvert end sections for attachment to the inlet and outlet of corrugated galvanized steel pipe and corrugated galvanized steel pipe arch culverts.

7.3.2. **Materials.** The materials shall comply with the requirements of AASHTO M 36 for base metal, spelter coatings, rivets, riveting and sampling, accepted brands of metal,

sheet manufacturer's certified analysis, sheet manufacturer's guarantee, and thickness determination and tolerance.

7.3.3. **Fabrication.**

7.3.3.1. **Shape, Dimensions, and Masses.** The units, to the shape and dimensions and number of pieces as shown in the standard drawing or special details in the Plans for steel culvert end sections, shall be manufactured as integral units so they can be readily assembled and erected in place.

7.3.3.2. **Bolts.** Galvanized bolts may be used for assembly of end sections where more than one piece is used to form the skirt, when sections have not been riveted together.

7.3.3.3. **Workmanship.** It is the intent of these Specifications that in addition to compliance with the details of construction, the completed unit show carefully finished workmanship in all particulars. This requirement applies not only to the individual unit, but to the shipment as a whole.

The following defects are specified as constituting poor workmanship, and the presence of any of them in an individual unit in any shipment shall constitute sufficient cause for rejection: not of the specified dimensions, not of the specified shape, uneven laps, ragged sheared edge, loose, unevenly lined or spaced rivets, poorly formed rivet heads, illegible brands, lack of rigidity, or dents or bends in the metal itself.

7.3.4. **Sampling and Testing.** All steel culvert end sections will be inspected for compliance with the provisions governing fabrication heretofore given. Sample and test all sheet stock going into such end sections as provided in AASHTO M 36M and T 65.

SECTION 727 TIMBER AND LUMBER

This Subsection covers treated or untreated timber and lumber for use in the construction of timber bridges.

727.01 TIMBER AND LUBMER.

- (a) **Species of Wood.** Timber and lumber furnished under these Specifications shall be Douglas Fir of the coast region only, or Southern Yellow Pine.
- (b) **Grades.** The grades of timber and lumber covered herein are as follows:

Stress Grades:

1700 F
1600 F
1450 F
1200 F
1100 F

The particular stress grade governing shall be that specified on the Plans.

- (c) **Classes.** The above named grades are further subdivided on the basis of use, size, and defects, into the following classes:
 Joist and Plank: For stress grades 1700 F to 1100 F
 Beams and Stringers: For stress grades 1700 F to 1450 F
- (d) **Sizes.** Nominal sizes included in the two classes area are as follows:

Class	Nominal Thickness, inches (mm)	Nominal Width, inches (mm)
Joist and Plank	2 to 4 (50.8 to 101.6)	\$4 (\$101.6)
Beams and Stringers	\$5(\$127)	\$8 (\$203.2)

- (e) **Dressing.** Dressing shall be in accordance with Section 507 or as modified on the Plans.
- (f) **Size Standards.** When surfaced S1E and S1S to S4S, timber shall not be smaller in any dimensions affected by surfacing than the nominal dimensions less 1/2 inch (12.7 mm) for dimensions of 7 inches (178 mm) or less and 3/4 inch (19.1 mm) for dimensions of 8 inches (203.2 mm) and greater.
 Rough timber shall be sawn full to nominal dimensions except that the following occasional variation in sawing is permissible:

Nominal Size, inches (mm)	Permissible Variations	
	Under, inches (mm)	Over, inches (mm)
2 to 7 (50.8 to 177.8)	1/16 (1.6)	1/4 (6.4)
\$8(\$203.2 mm)	1/8 (3.2)	1/2 (12.7)

No shipment shall contain more than 20 percent of pieces of minimum dimension due to such variation in sawing.

- (g) **Grading Requirements.** Methods of grading and general requirements shall be in accordance with the Southern Pine Inspection Bureau (SPIB) for Southern Pine and the West Coast Lumber Inspection Bureau (WCLIB) for Douglas Fir, grading rules, latest editions.
- (h) **Inspection.** If untreated, the timber shall be inspected at destination; if treated, it shall be inspected at the treating plant.

NOTE: No allowance shall be made for shrinkage or variation in manufacture other than outlined in these Specifications.

SECTION 728 TIMBER PILES

728.01. TIMBER PILES.

- (a) **Materials Covered.** This Section covers requirements for round timber piles to be used untreated, or treated by standard preservatives, as specified; timber piles shall meet the requirements of AASHTO M168, except as modified by these Specifications.

The diameter of the pile shall be determined by means of a circumference-diameter tape, and in the case of piles to be treated, such measurements shall be taken at the treating plant immediately prior to treatment, or in the case of untreated piles, it shall be measured on the job.

Piles after peeling shall have the minimum dimensions of the tip and at a section 4 feet (1.2 m) from the butt as shown in the following tabulations:

Length of Pile <u>feet (m)</u>	Tip Diameter inches <u>(mm)</u>	<u>Diameter, 4 feet (1.2 m) from Butt, inches (mm)</u>	
		Southern Yellow Pine Southern Cypress <u>Douglas Fir</u>	All Other <u>Species</u>
#21(6.3)	9(299)	11(279)	11(279)
21-40(6.4-12.4)	8(203)	12(305)	13(330)
41-60(12.5-18.3)	7(178)	13(330)	14(356)
>60(18.3)	6(152)	14(356)	14(356)

Diameter of the piles at the butt shall not exceed 18 inches (457 mm).

- (b) **Storing and Handling.** The method of storing and handling shall be such as to avoid injury to the piles. Special care shall be taken to avoid breaking the surface of treated piles, and cant dogs, hooks or pike poles shall not be used.

Cuts or breaks in the surface of treated piling shall be given 3 brush coats of hot creosote oil of approved quality, and hot creosote oil shall be poured into all bolt holes.

SECTION 730 PAINT FOR STRUCTURAL STEEL

730.01. GENERAL REQUIREMENTS.

- (a) **Scope.** This Section covers the various types of paint used to protect structural steel.
- (b) **Certification.** For each shipment of paint, furnish a Type C certification in accordance with Subsection 106.04, for each lot of each paint. Only paint systems included on the Materials Engineer's list of approved products shall be used on Department projects.

For a paint system to be considered for inclusion on the list of approved products, the paint manufacturer shall submit a Type A certification showing satisfactory test results from an approved testing laboratory. The certification shall include the manufacturer's name, system performance test results and dates; it will also show the following for each paint: test results and dates, brand name, lot number, and date of manufacture. New certification shall be required if any of the following conditions occur: the manufacturing process or paint formulation is changed, testing indicates nonconformance to the Specifications, or the certification is older than 5 years.

A 1 gallon (4 liter) sample of each component in a paint system may be required by the Engineer for testing purposes. In case of variance, the Department's test results will govern. Failure to meet Specification requirements will be grounds for removal from the list of approved products.

The Department reserves the right to suspend approval of products if paint system performance is unsatisfactory (i.e., the paint has poor durability or appearance).

- (c) **System Performance.** Paint shall be evaluated according to Performance Class. The performance of the coating system shall be measured using test panels. These test panels shall be coated with all required paint coats. Each coat shall be applied as specified.

1. **Performance Class 1.** Performance Class 1 coating systems shall be tested as follows: Three test panels shall be made for each of the specified tests; the test panels shall be prepared as described in AASHTO M300; and, where applicable, blistering shall be rated by ASTM D714.

- 1.1. **Fresh Water Resistance.** Fresh water resistance testing shall conform to the requirements of ASTM D870. Panels shall be scribed in accordance with AASHTO M300 for Salt Fog Resistance and then immersed in fresh tap water at $75\pm 5^{\circ}\text{F}$ ($24 \pm 3^{\circ}\text{C}$). After 30 days of immersion, the panels shall not show any rusting, nor shall the coating show any blistering, softening, or discoloration.
- 1.2. **Salt Water Resistance.** Salt water resistance testing shall conform to the requirements of ASTM D870. Panels shall be scribed in accordance with AASHTO M300 for Salt Fog Resistance and then immersed in a solution of water and 5% sodium chloride at $75\pm 5^{\circ}\text{F}$ ($24 \pm 3^{\circ}\text{C}$). After 30 days of immersion, the panels shall not show any rusting, nor shall the coating show any blistering, softening, or discoloration. Panels shall be rated at 7, 14, and 30 days. The saline solution shall be replaced with fresh saline solution after the 7 and 14 day examinations.
- 1.3. **Salt Fog Resistance.** Panels shall be tested as described in AASHTO M300 for Salt Fog Resistance except that the exposure will be 2,500 continuous hours.
- 1.4. **Weathering Resistance and Specular Gloss.** Weathering resistance testing shall conform to the requirements of ASTM D4587, Method D, utilizing UVA 340 bulbs. Testing of the panels shall start at the beginning of a wet cycle. After 3,000 hours continuous exposure, the coating shall not show any blistering or loss of adhesion, nor shall the panels show any rusting.

The 60° specular gloss measurements shall be performed on the sprayed panels utilized for the weathering resistance test. The initial specular gloss measurements (one from each panel) shall be averaged together. The final specular gloss measurements shall also be averaged together.

- 1.5. **Elcometer Adhesion Test.** Elcometer adhesion testing shall conform to the requirements of ASTM D4541. The panels shall be tested using an adhesion tester 1000 psi (6.9 MPa) in accordance with the following: the coating surface and aluminum dolly shall be lightly sanded and a quick-set adhesive applied; the adhesive is cured overnight; the coating and adhesive around the dolly is scribed before testing; and a minimum of three trials is made and reported.

For a paint to be acceptable, each trial must have adhesion of 400 psi (2.76 MPa) or more and show no evidence of fracture at the primer-blast interface.

2. **Performance Class 2.** Performance Class 2 coating systems shall be tested as follows: Three test panels shall be made for each of the specified tests; the test panels shall be prepared as described in AASHTO M300. Where applicable, blistering shall be rated by ASTM D714 and rusting in accordance with ASTM D610.

- 2.1. **Salt Fog Resistance.** Panels shall be tested as described in AASHTO M300 for Salt Fog Resistance except that the exposure will be 1,000 continuous hours.
- 2.2. **Prohesion.** Panels shall be tested for 2,000 hours in accordance with ASTM G 85, Appendix A5. The electrolyte solution for the cyclic fog/dry test shall consist of a

Timmins solution: 0.40 wt% (NH₄)₂SO₄ with 0.05 wt% NaCl. The temperature shall be maintained at 100°F (38°C) during the fog/dry cycles. Any test panels having rust spots, blisters, or undercutting at the scribe will be considered a failure.

- 2.3. **Fluorescent UV.** Test for 2,000 hours in accordance with ASTM G53 (8 hours UV at 160°F (71°C) followed by four hours condensation at 120°F(49°C)). Any test panels with rust spots, blisters, or undercutting at the scribe will be considered a failure.

Additionally, the paint system shall have at least three years of satisfactory performance (less than 1% of the painted surface shows visible rust, rust breakthrough, paint blistering, peeling, or scaling) in a bridge environment. Case histories from at least five bridge projects shall be included in the Type A certification data.

- (d) **Containers and Labeling.** All paint furnished under these Specifications shall be supplied in strong, tight, approved containers. Each container shall be labeled with the manufacturer’s name, paint type, Volatile Organic Compounds (VOC) content, date of manufacture, lot number, mixing instructions, and equipment cleanup instructions. Labels shall be sufficiently weather resistant to withstand one year of outdoor storage exposure without deterioration or fading.

If not affixed to the paint containers, Material Safety Data Sheets and Product Data Sheets shall be supplied with each paint shipment. Copies of both sheets shall be posted on the project site and submitted to the Resident Engineer prior to painting.

- (e) **Toxic Substance Restriction.** Lead paint, or similar coatings containing lead or lead compounds, in which the lead content (calculated as lead metal) is in excess of 0.19% by mass of the total nonvolatile content of the paint or the mass of the dried paint film shall not be used on Department projects.

Paints containing asbestos or containing leachable hazardous elements in the dry paint film exceeding the limits shown below when tested using the Toxicity Characteristic Leaching Procedure (TCLP), 40 CFR 261, “Identification and Listing of Hazardous Waste,” shall not be used on Department projects. The TCLP test shall be included in the Type A certification.

Arsenic, ppm	5.0
Barium, ppm	100.0
Cadmium, ppm	1.0
Chromium, ppm	5.0
Lead, ppm	5.0
Mercury, ppm	0.2
Selenium, ppm	1.0
Silver, ppm	5.0

- (f) **VOC Limitation.** The maximum permissible Volatile Organic Compound (VOC) level in any paint used for Department projects shall be 2.9 lb/gal (350 g/l) as thinned for application. VOC is defined as any organic compound which has a vapor pressure of .0019 psi (13 Pa) absolute or greater at standard condition. Lower VOC limits may be specified in the plans depending on project location. When shop painting is done, be aware that VOC regulations could be stricter than required by the Department. The Contractor shall comply with the most severe VOC regulations applicable.

- (g) **Color.** Unless otherwise specified on the plans, the color of the coatings shall be as follows: the topcoat shall be light gray, Federal Standard No. 595A-16440, except for weathering steel, in which

case the topcoat shall be dark brown, Federal Standard No. 595A-10075. The primer and intermediate coats shall be colored so that each layer is clearly distinguishable from the other.

730.02. REQUIREMENTS FOR PAINT SYSTEMS.

- (a) **Inorganic Zinc/Epoxy/Urethane (IZ-E-U) System.** The IZ-E-U system shall comply with the system performance requirements for Performance Class 1. This system shall produce a tough, durable film of minimum 9 mils (230 μm) dry film thickness, each coat well bonded to the previous layer. Prepare each surface and apply paint in such a manner to assure bonding of each coat. Cure each coat according to the manufacturer's recommendations prior to further coating. The dry film thickness of an individual coat shall be within $-0.5/+2.0$ mils ($-15/+50$ μm) of the specified coat thickness.

1. **Inorganic Zinc-Rich (IZ) Primer.** The first coat shall be an IZ primer conforming to the requirements of AASHTO M300, Type IA and the following: the primer shall have a Class B classification, with a minimum slip coefficient of 0.50, as tested by the "Test Method to Determine the Slip Coefficient for Coatings Used in Bolted Joints" from the Research Council on Structural Connections. (See Appendix A of Allowable Stress Design Specification for Structural Joints Using ASTM A325 or A490 Bolts, published by the Research Council on Structural Connections.)

Immediately prior to the application of the IZ primer, prepare the steel surface by the Steel Structure Painting Council's preparation specification SSPC-SP10, Near-White Blast Cleaning. For new steel, the surface profile shall be 1 to 3 mils (25 to 75 μm) as determined by ASTM D4417, Method A, B, or C. For new structural steel, the IZ primer shall be applied in the shop. The dry film thickness of the IZ primer shall be 3 mils (80 μm).

2. **Epoxy (E) Intermediate Coat.** The epoxy-polyamide paint intermediate coat shall be applied over IZ primer-coated steel in plan position on the project and shall conform to the following requirements:

<u>Epoxy (E) Intermediate Coat</u>		
Pot Life	4 hours, minimum	SSPC Paint 22, Para. 5.5
Dry Through Time, 75°F (24°C), 45%R.H.	24 hours, maximum	ASTM D 1640
Fineness of Grind, Hegman Units	3.0, minimum	ASTM D 1210
Solvent Resistance	(see test method)	SSPC Paint 22, Para. 5.6
Test Panels	(see test method)	SSPC Paint 22, Para. 5.7
Elcometer Adhesion Test	(see test method)	SSPC Paint 22, Para. 5.8
Salt Spray Resistance	(see test method)	SSPC Paint 22, Para. 5.9
Dry Film Thickness	4 mils(100 μm)	See Subsection 512.04(b)4

3. **Urethane (U) Topcoat.** The two-package, aliphatic urethane paint top coat shall conform to the requirements of the most recent edition of the Steel Structures Painting Council SSPC-PS Guide No. 17.00. The paint shall have a minimum 2-hour usable pot life at 77°F (25E C), and a maximum 4-hour dry-to-touch time at 77°F (25E C). The U topcoat shall be applied over E intermediate coat. The urethane topcoat also shall conform to the following requirements:

Urethane (U) Topcoat		
<u>Characteristic</u>	<u>Value</u>	<u>Test Method</u>
Solids by weight	67%, minimum	ASTM D 1644
Solids by volume	54%, minimum	ASTM D 1644
Specular Gloss, 60°	85% minimum after drying, 70% minimum after 3,000 hours of weathering resistance testing	ASTM D 4587, Method D
Dry Film Thickness	2 mils(50 μm)	See Subsection 512.04(b)4

(b) **Single-Component Moisture-Cured Urethane (SC-MC-U) System.** The SC-MC-U system shall comply with the system performance requirements for Performance Class I. This system shall produce a tough, durable film of minimum 10 mils (0.25 mm) film thickness, each coat well bonded to the previous layer. Prepare each surface and apply paint in such a manner to assure bonding of each coat. Cure each coat according to the manufacturer’s recommendations prior to further coating. The dry film thickness of each coat shall be within -0.5/+2.0 mils (-15/+50 μm) of the specified coat thickness.

The first coat shall be either a zinc-rich or zinc/MIO primer. The primer shall be formulated with other synthetic or natural MIO. If approved, the primer may be two component. The intermediate coat and topcoat shall be formulated with natural micaceous iron oxide (MIO). The MIO intermediate coat shall be a SC-MC-U paint. The topcoat shall be a MIO-based SC-MC-Aliphatic-U paint. The SC-MC-U paint coats shall be formulated as follows:

	<u>Zinc-Rich Primer</u>	<u>Zinc/MIO Primer</u>	<u>MIO Intermediate Coat</u>	<u>MIO Topcoat</u>
Minimum Zinc Powder (mixed paint)	78% by weight	--	--	--
Minimum MIO Content	--	--	4lb/gal (6.87kg/l)	--
Minimum Solids (mixed paint)	60% by volume	60% by volume	60% by volume	53% by volume
Pigment Type	zinc dust	zinc dust & MIO	--	--
Minimum Weight/Volume (mixed paint)	23 lb/gal (39.5 kg/l)	19 lb/gal (32.6 kg/l)	12 lb/gal (20.6 kg/l)	11 lb/gal (18.89 kg/l)
Minimum Zinc Content (dry film)	86% by weight	--	--	--
Dry Film Thickness	3.5 mils (89μm)	3.5 mils (89μm)	3.5 mils (89μm)	3 mils (76μm)

(c) **Repair Paint Systems.** The coating system for Category R applications as defined in Subsection 512.04(b)2 shall comply with Performance Class 2 requirements. The system may be comprised of one to three coats, but one coat systems may only be used when permitted in the plans.

SECTION 731 TIMBER PRESERVATIVES AND TREATMENT

This Section covers the preservative and treatment of timber where preservative treatment is specified.

731.01. TIMBER PRESERVATIVES AND TREATMENT.

- (a) **Materials.** Timber preservative treatment shall conform to the requirements of AASHTO M 133. Unless otherwise provided, the type of preservative used shall be as follows:
 - 1. *Creosote Oil and Creosote Solutions.* These preservatives shall be used for piling and structural grade timber.
 - 2. *Creosote Oil, Creosote Solutions, Oil-Borne Preservative and Water-Borne Chromated Copper Arsenate.* These preservatives shall be used for guard rail posts, spacer blocks, guide posts, fence posts, and post bracing.
- (b) **Preparation for Treatment.**
 - 1. *General Requirements.* All lumber, timber, piling, and posts shall be of the grade and size specified and shall be inspected for grade and size immediately prior to the treatment.
 - 2. *Inspection.* All materials and processes used in the treatment shall be subject to inspection at the manufacturer's plant, which shall be equipped with all necessary gauges, appliances, and facilities to enable the inspector to satisfy himself that the requirements of the Specifications are fulfilled. Inspection for conformity with the specified treatment shall be in accordance with the current AWWA Standard M2.
- (c) **Handling.** After treatment the lumber or timber shall be handled carefully, piled properly, and allowed to dry thoroughly.

SECTION 732 MATERIALS FOR GUARD RAIL, GUIDE POSTS, BRIDGE RAIL, MISCELLANEOUS RAILING AND FENCES

This Section covers the requirements for materials for guard rail, guide posts, bridge rail, miscellaneous railing, fences, and gabion wire baskets.

732.01. METAL BEAM RAIL.

- (a) **Beams.** Corrugated steel beams shall conform to the requirements of AASHTO M 180 for the gauge specified on the Plans.
- (b) **Guard Rail Posts and Spacer Blocks.**
 - 1. *Steel Posts.* Steel posts and spacer blocks shall be of the length and size shown on the Plans. Hot rolled (forged) steel shapes shall conform to the requirements of AASHTO M 183 and shall be furnished galvanized in accordance with AASHTO M 111. All punching, drilling, cutting, shearing, and grinding shall be performed prior to galvanization. Surface defects shall be repaired by grinding, cutting, welding, or other industry acceptable method, then coated with two coats of zinc-dust zinc-oxide primer meeting the requirements of Section 730. Alternate repair techniques shall be those shown in ASTM A 780, Repair of Hot-Dip Galvanized Coatings.

Steel posts and spacer blocks fabricated by the methods and requirements of ASTM A 769 are acceptable alternates. These fabricated posts shall not vary by more than 5 percent from the mass, dimensions and section properties shown for acceptable hot rolled (forged) shapes. Dimensions, mass, and section properties shall conform to the current edition of the American Institute of Steel Construction (AISC) Manual of Steel Construction, or from the supplier's technical publications endorsed by the AISC.

Sharp sheared edges on the fabricated posts and spacer blocks shall be dulled in the upper 18 inches (450 mm) of the post and all edges on the block. Any industry acceptable method to dull these edges may be used, such as grinding, secondary rolling, or sand or shot-blasting. This operation and all hole drilling, punching, cutting, shearing, butt welding, etc., shall be fully completed prior to galvanization. Galvanization shall comply with AASHTO M 111 and repair techniques as covered above.

Tests on either type of steel post and compatible spacer blocks shall follow test procedures in the appropriate Specifications. Each cut post or spacer block is one unit of a lot, which consists of a maximum of 200 units and/or the remainder thereof. One failure in any lot shall require testing on two other units. Failure of two of the three selected units from any lot shall be cause for rejection of the entire lot.

Testing may be done in the field for visual, mechanical, or electronic checks to ensure the units adhere to the requirements of AASHTO M 183, ASTM A 769, and/or AASHTO M 111. Suppliers of fabricated beams shall submit their quality control procedures to the Materials Division for approval prior to production of any material for use on Department Contracts. Suppliers of hot rolled (forged) or fabricated beams shall certify their product complies with all pertinent Sections of the appropriate Specifications for production and galvanization. Upon Department approval of the quality control procedures, written notice will be sent to suppliers.

Steel base plates and miscellaneous fabricated guard rail hardware shall be of the section and length as shown on the Plans. Connections to posts (cut to proper length) shall be as shown on the Plans. All cutting, welding, and drilling required shall be completed prior to galvanization. Steel plate shall conform to the requirements of AASHTO M 183 and the galvanization shall conform to requirements of AASHTO M 111.

2. **Wood Posts.** Wood posts and spacer blocks shall be of the length and size specified on the Plans. Both type posts (sawed and round) and sawed spacer blocks shall be cut from live trees and shall be close grained. Posts and blocks shall contain only sound wood.
 - 2.1. **Sawed Posts and Spacer Blocks.** Sawed posts and spacer blocks shall be of the size and length shown on the Plans. They shall meet the requirements of Section 727 for timber and lumber, furnished rough. Minimum stress grade shall be 1200 F unless otherwise shown on the Plans.
 - 2.2. **Post Weakening.** The leading posts in the approach anchor unit shall be weakened by drilling holes at the ground line as shown on the Plans.
 - 2.3. **Preservative Treatment and Inspection.** Wood posts and spacer blocks shall be preservative treated in accordance with Section 731.

The size of the post or block shall be determined at the preservative treatment plant immediately prior to treatment. The diameter of round posts shall be determined by a circumference-diameter tape. Minimum diameter at the bottom edge of the slabbed

face shall not exceed 3/4 inch (20 mm) less than the nominal diameter, and the actual diameter at any point shall not vary from the nominal diameter by more than 1 inch (25 mm), over or under.

All sawing, chamfering, boring, slabbing, or cutting shall be performed prior to preservation treatment. The only exceptions are the holes shown drilled at the ground line for weakening the leading posts in the approach anchor unit, or holes enlarged or drilled into new wood to facilitate guard rail attachment. These holes shall be thoroughly and uniformly treated by pulling or pushing a preservative solution saturated rag through or into the holes. Multiple passes of the saturated rag may be required to obtain the treatment level required.

- (c) **Guard Rail Hardware.** Unless otherwise specified, all fittings, bolts, washers, and other accessories shall be galvanized in accordance with the requirements of AASHTO M 111 or M 232, whichever may apply.

732.02. GUIDE POSTS.

Guide posts and underdrain marker posts shall be as shown on the Plans.

732.03. METAL BRIDGE RAILING MATERIALS.

1. **Structural Steel Shapes for Posts and Rails.** Structural steel shapes for posts and rail shall meet the requirements of Section 724.
2. **Metal Beams.** Metal beams shall meet the requirements of Subsection 732.01.
3. **Aluminum Alloy Tubes.** Aluminum alloy tubes for bridge railing shall meet ASTM B 221, alloy 6063 or 6061 T6.

Welding, when shown on the Plans or permitted, shall be in accordance with Subsection 720.03(a)1.

A certificate of analysis executed by the producer shall be furnished to the Department, setting forth the chemical analysis and test results for tubes.
4. **Cast Aluminum Alloy Bridge Railing Posts.** Cast aluminum alloy bridge railing posts shall meet the requirements of AASHTO M 193.

Welding, when shown on the Plans or permitted, shall be in accordance with Subsection 720.03(a)1.

 - 4.1. **Anchor Bolts.** Anchor bolts and anchoring methods for cast aluminum alloy bridge railing posts shall be as shown on the Plans.

732.04. PIPE RAILING.

- (a) **Galvanized Steel Pipe and Fittings.** Galvanized steel pipe and fittings shall meet the requirements of ASTM A 53, standard weight pipe. The requirement for hydrostatic testing shall be waived.
- (b) **Black Steel Pipe and Fittings.** Black steel pipe and fittings shall comply with the requirements of ASTM A 53, standard weight pipe. The requirement for hydrostatic testing shall be waived.

732.05. WIRE CABLE AND FITTINGS.

Materials shall meet the requirements of AASHTO M 30.

732.06. FENCE, STYLE WWF OR FENCE, STYLE SWF.

- (a) **Description.** This item covers the materials requirements for fabric, strand wire, and other wire items, frame work for fence and gates, and all fastening and bracing hardware necessary for the construction of woven wire or strand wire fence. The height of fence, or number of strands, the height and size of opening for gates, and the shape, size, and length of posts shall be as shown on the Plans or in the Proposal.
- (b) **Materials.**
1. **Wire Items.**
 - 1.1. **Woven Wire.** The woven wire shall be design number 832-6-12-1/2 with a Class 1 zinc coating meeting the requirements of AASHTO M 279 or wire of design number 832-6-12-1/2 with a Class 1 aluminum coating meeting the requirements of ASTM A 584.
 - 1.2. **Barbed Wire.** Zinc coated steel (galvanized) barbed wire shall consist of two strands of 12-1/2 gage (2.51 millimeter diameter) steel wire twisted in the same direction, or in alternate directions, with 14 gage (2.03 millimeter diameter) full or half-round 4 point barbs spaced 5 inches (127 mm) apart, with a Class 1 zinc coating on the 12-1/2 gage (2.51 millimeter diameter) wire. Also acceptable is wire consisting of two strands of 15-1/2 gage (1.70 millimeter diameter) steel wire twisted in alternate directions, with 16-1/2 gage (1.47 millimeter diameter) full round 4 point barbs spaced 5 inches (127 mm) apart. The coating shall be a Class 3 zinc coating on the 15-1/2 gage (1.70 millimeter diameter) wire. The wire described here shall meet all requirements of AASHTO M 280. Aluminum coated steel barbed wire shall consist of two strands of 12-1/2 gage (2.51 millimeter diameter) steel wire twisted in the same or in alternate directions, with 14 gage (2.03 millimeter diameter) full or half-round 4 point barbs spaced 5 inches (127 mm) apart. The wire may be furnished with aluminum coated steel wire barbs, or with aluminum alloy barbs. The strands (main wires) shall be aluminum coated steel barbed wire meeting the requirements of ASTM A 585. Any barbed wire furnished shall have a minimum assembly break strength of 950 pounds (4.23 kN).
 - 1.3. **Smooth Wire.** Smooth zinc coated (galvanized) carbon steel wire may be substituted for the top wire or any or all barbed wire shown on the Plans or in the Proposal, with the approval of the Engineer. The smooth wire shall meet the requirements of ASTM A 641, and be one of the following : 11 gage (3.05 millimeter diameter) medium or hard temper, minimum 85 ksi (586.1 MPa) tensile strength with a Class 1 coating, or 9 gage (3.76 millimeter diameter) soft temper, minimum 60 ksi (413.7 MPa) tensile strength with a Class 1 coating.
 - 1.4. **Barbless Wire.** Zinc coated steel (galvanized) barbless wire shall consist of two strands of 12-1/2 gage (2.51 millimeter diameter) steel wire twisted in the same direction, or in alternate directions, with a Class 1 zinc coating. Also acceptable is wire consisting of two strands of 15-1/2 gage (1.70 millimeter diameter) steel wire twisted in alternate directions with a Class 3 zinc coating. The wire described here shall meet all requirements of AASHTO M 280. Aluminum coated steel barbless wire shall consist of two strands or 12-1/2 gage (2.51 millimeter diameter) steel wire twisted in the same or alternate direction.

The wires shall have a minimum Class 1 aluminum coating. Aluminum coated steel barbless wire shall meet the requirements of ASTM A 585. All barbless wire furnished shall have a minimum assembly break strength of 950 pounds (4.23 kN).

- 1.5. **Tension Wire.** Diagonal steel tension wire may be either size listed in Subsection 732.06(b)1.3.
- 1.6. **Fan, Corner, End, Stretcher and Gate Posts.** These posts shall be treated wood of the length and nominal diameter as shown on the Plans. They shall be sound and reasonably straight and shall be treated in accordance with Section 731 of the Specifications. The minimum wood post quality standard grades are shown in ASTM F 537, Section 6.3.
- 1.7. **Line Posts.** Line posts shall be either preservative treated wood of the nominal diameter or steel of acceptable shape and mass, and the specified length shown on the Plans or in the Proposal. The kind of material selected shall be used throughout any one project except in cases where the Engineer approves a mixture of materials in writing. Wood line posts shall meet the post quality standards of ASTM F 537, Section 6.3, and shall be preservative treated as covered in Section 731 of the Specifications. Steel posts shall meet the requirements of AASHTO M 281. They shall be furnished galvanized or painted, and have an adequate number of deformable clip protrusions on the post, or be furnished with the same number of wire ties as the number of strands to be joined to the posts.
- 1.8. **Post Ties (Wire Ties).** Post ties shall meet the requirements of AASHTO M 281 and shall be furnished with a Class 1 zinc coating in minimum 11 gage (3.05 millimeter diameter).
- 1.9. **Gates.** Gates may be furnished with a pipe or tubular framework covered with the same type strand or woven wire as the fence. Pipe or tubing for the gate frames shall meet the requirements of ASTM A 53, standard weight steel pipe (Schedule 40) but the pressure testing (hydrostatic) requirement will be waived. The minimum size will be 1.66 inch (42.2 mm) outside diameter pipe with a wall thickness of 0.140 inch (3.56 mm). The frame shall be covered and braced as indicated on the plans. Fittings, latches, and hinges shall be a type approved by the Engineer. Pipe or tubing may be substituted for the pipe specified above. The substitution formulation will be as shown on the plans or in Subsection 732.07(c)2.2.

Commercially available ranch-type metal panel gates may be furnished as an alternate unless otherwise shown on the plans. Acceptance will be based on visual inspection by the Engineer. Aluminum coated steel, aluminum alloy or galvanized steel, mill finish or painted, are all acceptable materials for this item.

- 1.10. **Hardware.** Various hardware items, hinges, and gate latches shall be furnished as shown on the Plans or as recommended by the gate manufacturer. They shall be furnished galvanized in accordance with ASTM A 90 and AASHTO M 232, or with a protective coating compatible with the gate coating or alloy. Eye bolts for fastening fence to existing headwalls or wingwalls on culverts shall be furnished galvanized.
- 1.11. **Staples.** Staples used for fastening wire to wood shall be made of 9 gage (3.76 millimeter diameter) galvanized wire. They shall be minimum 1 1/2 inch (38.1 mm) long.

- 1.12. *Nails.* Nails shall be round or oval steel wire. They shall be 40 pwt. nails or 20 pwt. spikes, and furnished galvanized.

732.07. FENCE, STYLE CLF.

- (a) **Description.** This item covers the materials requirements for chain link fabric and other wire items, framework for the fence and gates, and all fastening and bracing hardware necessary for the construction of chain link type fence. The height of the fence fabric, the width and height of the gate openings, the size, shape and length of posts and the size and shape of framework members shall be as shown on the plans or in the proposal.
- (b) **Classifications.** The following classifications and combinations of acceptable materials will be used throughout this Specification:
1. *Fence, Style CLF, Type I* shall consist of zinc coated (galvanized) steel wire fabric on either a steel or aluminum mounting system.
 2. *Fence, Style CLF, Type II* shall consist of aluminum coated steel wire fabric on either a steel or aluminum mounting system.
 3. *Fence, Style CLF, Type III* shall consist of aluminum alloy fabric on either steel or aluminum mounting system.
 4. *Fence, Style CLF, Type IV* shall consist of vinyl coated or PVC plastic coated galvanized steel wire fabric on either zinc-coated steel or aluminum mounting system of the same color or a harmonizing color.
 5. *Fence, Style CLF, Type XX, NOBAR.* This nomenclature indicates any of the four combinations of acceptable materials and NOBAR indicates no barbed wire climb barriers above the fence fabric.
 6. *Fence, Style CLF, Type XX, BARR.* This nomenclature indicates any of the four combinations of acceptable materials and BARR indicates fence fabric topped by the number of strands of barbed wire climb barrier as shown on the plans.
 7. *Nomenclature.* The full nomenclature as shown in Subsection 732.07(b) 5 and 6 is for ordering information only. Unless otherwise specified on the plans, the "Type" is optional with the Contractor. The fence pay item may not contain the full nomenclature.
- (c) **Materials.**
1. *Wire Items.*
 - 1.1. *Fabric.* Unless otherwise specified, the fabric shall be 9 gage (3.76 millimeter diameter) wire woven in 2 inch (50.8 mm) mesh. Unless otherwise specified herein, or on the Plans and in the Proposal, all fabric shall meet the minimum requirements of AASHTO M 181 and references for the type fabric used.
 - 1.2. *Tension Wire.* The tension wire shall meet the requirements of AASHTO M 181, Class 1 with a minimum zinc coating mass/unit volume of 0.8 ounce/ft²(244.1 g/m²).
 - 1.3. *Barbed Wire.* Barbed wire shall meet the requirements of Subsection 732.06(b)1.2.
 - 1.4. *Post Ties.* Post ties shall comply with Subsection 732.07(c)3.4.
 - 1.5. *Wire Ties.* Wire ties shall comply with Subsection 732.07(c)3.4.

2. **Framework Items.**

- 2.1. **End (Terminal), Stretcher (Pull), Corner, and Gate Posts** shall be the size, shape, and length as shown on the plans or in the proposal. Fan posts shall be the same type of post, shape, and size and of a length necessary to provide a smooth top line on the fence. Pipe for round posts shall be Grade 1 steel posts or Grade 2 steel posts meeting the requirements of AASHTO M 181. Grade 1 steel posts shall be pipe meeting the requirements of ASTM A 53 or F1083 with a minimum 1.8 ounce/ft² (549.3 g/m²) zinc coating. The post shall have the dimensions shown on the plans for the height of fence specified. The hydrostatic tests will be waived on the pipe used for fence posts, and the pipe shall be furnished with plain ends.

Roll-formed shapes (other than round) shall be furnished in the size, shape, and length shown on the plans. Unless otherwise specified, they shall be furnished with a minimum 549.3 g/m² ft. zinc coating and be fabricated from steel sheet meeting the requirements of ASTM A 570, Grade 45. See Subsection 732.07(c)2.2 for round roll-formed post shapes, materials, and substitution formula.

- 2.2. **Line Posts.** Line posts shall be the size, shape, and length shown on the Plans or in the Proposal for the height of fence as specified, and as shown in Subsection 732.07(c)2.1.

Grade 2 steel posts shall be round pipe or tubing manufactured by cold rolling and electric resistance welding of steel strip. Exterior and interior corrosion resistance coating shall conform to the requirements of AASHTO M 181. This applies to material used in Subsections 732.07(c)2.3 and 732.07(c)2.4.

Properties (dimensions, mass, and section modulus) for the round pipe as shown in the schedule on the standard drawing are for Schedule 40 pipe, meeting the requirements of ASTM A53, (galvanized) zinc coated. Pipe meeting the requirements for grade 2 pipe of AASHTO M 181 are acceptable substitutes. The pipe (or tubing) shall be tested to determine the tensile and yield strengths, and the following criteria shall be met. The product of the section modulus (from the schedule on the standard drawing) multiplied by 25,800 (177.9) [minimum yield strength in psi (MPa) for Schedule 40 pipe] shall be equal to or be exceeded by the product of the section modulus of the grade 2 pipe multiplied by its tested yield strength in psi (MPa). Steel used in grade 2 pipe shall have a minimum 50,000 psi (344.7 MPa) yield strength. The outside diameters of the substituted pipes shall be within 0.1 inch (2.54 mm) of the Schedule 40 pipe and the section modulus of the grade 2 (cold-formed process) pipe shall be determined by the formula:

$$SM = B (OD^4 - ID^4)/(32 \times OD)$$

where: SM = Section Modulus
 OD = Outside Diameter
 ID = Inside Diameter
 B = 3.1416 (a constant)

Thickness measurement of the pipe shall be made with micrometers accurate to 0.0004 inch (0.01 mm).

- 2.3. **Rail (Braces and Top Rail).** Material for top rail and braces shall meet the requirements of ASTM A 501, ASTM A 53, or ASTM F 1083 and be furnished in the size and shape

shown on the Plans or in the Proposal. They shall be furnished galvanized to comply with ASTM A 53. See Subsection 732.07(c)2.2 for round roll-formed brace and rail materials and substitution formula. Dimensions, mass, and section properties shown on the Plans are those of ASTM A 501. When substituting for ASTM A 53 pipe, use the same outer diameter pipe. Hydrostatic testing on ASTM A 53 pipe shall be waived.

- 2.4. **Gate Frame.** Material for gate frames shall be the size and shape as shown on the Plans or in the Proposal. They shall meet the requirements of ASTM A 501, ASTM A 53, or ASTM F 1083 and be furnished galvanized to the requirements of ASTM A 53. See Subsection 732.07(c)2.2 for round roll-formed framework materials and substitution formula. Dimensions and section properties shown on the plans are those of ASTM A 501. When substituting for ASTM A 53 pipe, use the same outer diameter pipe. Hydrostatic testing on ASTM A 53 pipe shall be waived.
3. **Fence Fittings.** The materials requirements, coating Specifications, and inspection procedures of the following items necessary for chain link fence erection are covered in ASTM F 626, as amended herein:
 - 3.1. Post and line post caps.
 - 3.2. Rail and brace ends.
 - 3.3. Sleeves for top rail.
 - 3.4. Tie wire and clips, minimum 12 gage (2.69 millimeter diameter) with 0.8 ounce/ft² (244.1 g/m²) zinc coating, or aluminum wire as shown.
 - 3.5. Tension and brace bands.
 - 3.6. Tension bars.
 - 3.7. Truss rods.
 - 3.8. Barb arms.

732.08. FENCE, STYLE GDF.

- (a) **Description.** This item shall cover the materials requirements for fence fabric and other wire items, framework for the fence, and all fastening and bracing hardware necessary to construct glare deflector fence. The height of the fence fabric and the type of mounting system shall be as shown on the Plans or in the Proposal.
- (b) **Classifications.** The following classifications and combinations of acceptable materials will be used throughout this Specification:
 1. **Fence, Style GDF, Type I** shall comply with Subsection 732.07(b)1.
 2. **Fence, Style GDF, Type II** shall comply with Subsection 732.07(b)2.
 3. **Fence, Style GDF, Type III** shall comply with Subsection 732.07(b)3.
 4. **Fence, Style GDF, Type IV** shall comply with Subsection 732.07(b)4.
 5. **Fence, Style GDF, Type XX, RAILMTD.** This nomenclature indicates any of the four combinations of acceptable materials and RAILMTD indicates glare deflector fence mounted on guard rail.

6. **Fence, Style GDF, Type XX, POSTMTD.** This nomenclature indicates any of the four combinations of acceptable materials and POSTMTD indicates glare deflector fence mounted on ground mounted posts.
 7. **Fence, Style GDF, Type XX, WALLMTD.** This nomenclature indicates any of the four combinations of acceptable materials and WALLMTD indicates glare deflector fence mounted on parapet wall or median barrier.
 8. **Nomenclature.** The full nomenclature as shown in Subsection 732.08(b) 5 through 7 is for ordering information only. Unless otherwise specified on the Plans, the "Type" is optional with the Contractor. The fence pay item may not necessarily contain the full nomenclature.
- (c) **Materials.**
1. **Wire Items.**
 - 1.1. **Fabric.** Unless otherwise specified, the fabric shall be 9 gage (3.76 millimeter diameter) wire woven in 1 inch (25.4 mm) mesh. All other materials references shall be as covered in Subsection 732.07(c)1.1.
 - 1.2. **Tension Wire.** Tension wire shall be as shown in Subsection 732.07(c)1.2.
 - 1.3. **Post Ties.** Post ties shall be as shown in Subsection 732.07(c)3.4.
 - 1.4. **Wire Ties.** Wire ties shall be as shown in Subsection 732.07(c)3.4.
 2. **Framework Items.** All framework items, posts, line posts, top rail and brace rail shall be as shown in Subsection 732.07(c)2.1 through 2.3.
 3. **Fence Fittings.** All fittings shall be as shown in Subsection 732.07(c)3.1 through 3.8.

732.09. WIRE BASKETS FOR GABIONS AND REVETMENT MATTRESSES.

- (a) **General.** Wire baskets shall be constructed of double twisted hexagonal wire mesh or, when specified in the Plans, welded-wire mesh. The wire mesh shall be nonraveling mesh that will not separate at any of the twists or detach at any welded connections forming the mesh if a single wire in the mesh is cut.
- (b) **Wire Requirements.** The mesh, selvage, lacing, internal-connecting, and spiral wire shall meet the requirements of ASTM A 641, Class 3, Soft [Tensile Strength 55-75 ksi (380-520MPa)] and ASTM A 853. The wire shall have High Grade or Special High Grade zinc coating as described in ASTM B 6, Table 1. For welded-wire mesh, the coating uniformity shall equal or exceed four 1-minute dips by the Preece Test, as determined by ASTM A 239.
- (c) **Twisted-wire mesh baskets.**
 1. **General.** The mesh wires shall be wrapped around the selvage wire with the number of turns necessary to interconnect each of them with adjacent mesh wires. All wire shall be galvanized before fabrication of mesh.
 2. **Gabions.** Galvanized baskets shall be manufactured from 11-gage (3.0mm) mesh wires and 9-gage (3.9 mm) selvage wires. PVC-coated baskets shall be manufactured from 12-gage (2.7 mm) mesh wire and 10-gage (3.4 mm) selvage wire.
 3. **Revetment Mattresses.** For 12 inch (300 mm) thick revetment mattresses, the baskets shall be manufactured from 13.5-gage (2.2 mm) mesh wires and 12-gage (2.7 mm) selvage wire. For thinner revetment mattresses, the baskets shall be manufactured from 13.5-gage (2.2 mm) mesh wires.

(d) **Welded-Wire Mesh Baskets.**

1. **General.** Wire welds shall be made using resistance welding. The mesh shall conform to ASTM A 185, "Steel Welded Wire Fabric - Plain for Concrete."
2. **Gabions.** The baskets shall be manufactured from 11-gage (3.0 millimeter) wire. PVC-coated baskets shall be manufactured from 12-gage (2.7 millimeter) wire.
3. **Revetment Mattresses.** For 12 inch (300mm) thick revetment mattresses, the baskets shall be manufactured from 13.5-gage (2.2 mm) mesh wires. For thinner revetment mattresses, the baskets shall be manufactured from 14-gage (2.0 mm) mesh wires.

(e) **Connection Wires.** The following table shall be used for connection wire sizes:

<u>Wire Type</u>	<u>Minimum Wire Size</u>
Lacing Wire	13.5-gage (2.2 mm)
Spiral Wire	12-gage (2.7 mm)
Internal Connecting Wire	13.5-gage (2.2 mm)

A sufficient quantity of lacing wire and connection wire shall be supplied to securely fasten all edges of the Gabion baskets and diaphragms.

(f) **Basket Strength and Flexibility Requirements.**

1. **Elongation.** Elongation tests shall be made, before fabrication of the baskets, on a wire sample 12 inches (300 mm) long. Elongation shall not be less than 12% in accordance with the requirements of ASTM A370-92.
2. **Strength.** The following "punch" test and table of strengths shall be met when tested according to the Colorado Procedure for Methods of Conducting Strength Tests of Gabions (CP I-6130).
3. **Punch Test.** The 3 inch x 5 inch (75 mm x 125 mm) wire mesh shall not rupture when subjected to a load of 6000 lbs (26.7 kN) when applied as follows:
 - (a) Place in testing machine seats, without binding individual wires, a section 6 feet (1.83 m) long, not less than 3 feet (0.91 m) wide including the selvage bindings, for 3 feet (0.91 m) along the width, or in the middle for widths greater than 3 feet (0.91 m), with the excess falling free on each side.
 - (b) Apply tension to elongate the section 10%.
 - (c) Apply the load, 6000 pound (26.7 kN) as stated above, to 1 square foot (0.093 square meters) located approximately in the center of the sample between the clamps. The direction of the load should be perpendicular to the elongation tension force direction and be applied with a circular ram head with the edges beveled or rounded to prevent cutting the wires.

**MATERIALS FOR GUARD RAIL, GUIDE POSTS,
BRIDGE RAIL, MISCELLANEOUS RAILING AND FENCES**

	TABLE OF STRENGTHS		
	Gabions, <u>Galvanized</u>	Gabions, PVC <u>Coated</u>	Revetment <u>Mattresses</u>
Wire mesh-pulled parallel to wire twist	2300lb/ft (34 kN/m)	2000lb/ft (29 kN/m)	1800lb/ft (26 kN/m)
Wire mesh-pulled perpendicular to wire twist	1800 lb/ft (26 kN/m)	1400lb/ft (20 kN/m)	900lb/ft (13 kN/m)
Wire mesh connection to selvages	1400lb/ft (20 kN/m)	1200lb/ft (18 kN/m)	900lb/ft (13 kN/m)
Joint connection strength-lacing wire or ring wire fastener	1400lb/ft (20 kN/m)	1200lb/ft (18 kN/m)	900lb/ft (13kN/m)

- (g) **PVC Coating.** PVC coating shall be extruded onto the wire and the PVC-coated wire shall meet the following requirements:

Property	PVC COATING Tolerance Limits
Coating Thickness	Nominal 20 mils (500 μ m), Minimum 15 mils (380 μ m)
Specific Gravity ^a	1.20-1.40, ASTM D 2287, D 792
Tensile Strength ^a	Minimum 2900 psi (20 Mpa), ASTM D 412
Modulus of Elasticity ^a	Minimum 2600 psi (18 Mpa) @ 100% strain, ASTM D 412
Brittleness Temperature	Maximum -10EC, ASTM D 746
Abrasion Resistance ^a	12% max. Wt. Loss, Method D ASTM D 1242, Method B at 200 cycles, CSI-A Abrader _Tape, 80 Grit
Salt Spray Test ^b	Minimum 3,000 hours, ASTM B 117
Ultraviolet Light Exposure ^b	Minimum 3,000 hours, apparatus type E @ 145°F (63EC), ASTM D 1499, G 23

- ^a After the salt spray and ultraviolet light testing, reject the PVC coating if specific gravity, tensile strength, modulus of elasticity, or resistance to abrasion have changed more than 6%, 25%, 25%, or 10%, respectively, from initial values.
- ^b Reject the PVC coating if after the salt spray and ultraviolet light testing the coating is cracked, blistered, split, or shows noticeable change of color.
- (h) **Certification.** A type A certification shall be furnished for the wire and PVC coating in accordance with Subsection 106.04. A type D certification shall be furnished for gabion and revetment mattress baskets.

SECTION 733 MISCELLANEOUS MATERIALS

All materials for pipe, fittings, valves, valve boxes, hydrant risers, and other miscellaneous materials covered shall comply with the requirements of the individual materials set out in this Section.

733.01. CAST IRON WATER PIPE, FITTINGS, VALVES, ETC.

- (a) **Materials Covered.** This item covers cast iron water pipe, fittings, valves, valve boxes, fire hydrants, and jointing materials for use in the construction, extension, or repairs of cast iron water lines.
- (b) **Pipes.**
 - 1. **Cast Iron Water Pipe.** Cast iron pipe shall conform to, and be tested in accordance with, the American Standard for Cast Iron Pipe Centrifugally Cast in Metal Molds for Water or Other Liquids, AWWA C 106, or Cast Iron Pipe Centrifugally Cast in Sand-Lined Molds for Water, AWWA C 108. Length shall be either 18 feet (5.49 m) or 20 feet (6.10 m). Strength of iron shall be 18/40 with thickness class 22 for 3 inch (76.2 mm) to 12 inch (304.8 mm) diameters, and thickness class 24 for diameters over 12 inches (304.8 mm), unless otherwise specified.

Two inch (50.8 mm) cast iron pipe shall conform to, and be tested in accordance with, the American Standard for 2 inch and 2 1/4 inch (50.8 and 57.2 mm) Cast Iron Pipe, Centrifugally Cast, for Water and Other Liquids, AWWA C 112. Lengths shall be 12, 18, or 20 feet (3.66, 5.49, or 6.10 m).
 - 2. **Ductile Iron Water Pipe.** Ductile iron pipe shall conform to and be tested in accordance with the American Standard for Ductile--Iron Pipe, Centrifugally Cast in Metal Molds or Sand--Lined Molds, for Water or Other Liquids, AWWA Designation C 151.
- (c) **Fittings.** Cast iron fittings shall conform to, and be tested in accordance with, the American Standard for Cast Iron Fittings, 2 inch (50.8 mm) through 48 inch (1,219 mm) for Water and Other Liquids, AWWA C 110. Pressure rating shall be 250 psi (1.72 MPa). All sleeves shall be the longest of lengths allowed.
- (d) **Valves.**
 - 1. **Gate Valves.** Gate valves shall conform to, and be tested in accordance with, the AWWA Standard for Gate Valves for Ordinary Water Works Service, AWWA C 500. Valves shall have double disc parallel seats, nonrising stem, vertical mounting, "O" ring stem seal, counterclockwise opening, and ends to fit the pipe or fittings to which they are attached (push-on mechanical, bell and spigot, or flanged).

They shall be Crane, Darling, Ludlow-Rensselaer, M & H, Mueller, A.P. Smith, or an approved equal.
 - 2. **Ball Valves.** Ball valves shall be: double-seated with natural or synthetic rubber, bronze, or monel metal seats; designated for 150 psi (1.03 MPa) working pressure; flanged end; "O" ring rotor bearing seals; constructed of high-tensile strength cast iron; equipped with totally enclosed manual operators, with open-closed indicator, and hand wheel with standard size square wrench nut for one-man operation at 150 psi (1.03 MPa) unbalance across the valve. Valves shall be tested by, and shall withstand without leak, a hydrostatic pressure of: (1) 250 psi (1.72 MPa) on the valve body with the rotor in the open position; and (2) 150 psi (1.03 MPa) on each side of the

valve with the opposite side open to atmosphere. Four copies of the test results and manufacturer's drawings shall be submitted for approval prior to delivery of the valve.

They shall be Allis-Chalmers, Henry Pratt, Williamette Iron & Steel, or an approved equal.

3. **Air Relief Valves.** Air relief valves shall be heavy-duty combination air release and vacuum type for 300 psi (2.07 MPa) water working pressure, tested to 300 psi (2.07 MPa), 2 inch (50.8 mm) in size. Body, cover, and baffle shall be cast iron. All internal parts shall be either highest quality stainless steel or bronze, and the inside of the valve shall be coated with rust inhibitor. They shall be Apco No. 145C, Darling, Rensselaer, or an approved equal.

4. **Check Valves.** Check valves shall be horizontally mounted, single disc, swing type with a full diameter passage providing minimum pressure loss. Valves shall be of the non-slamming type designed for the future installation of outside lever and weight. Disc faces and seat rings shall be bronze. Ends shall fit the pipe or fitting to which they are attached (push-on, mechanical, bell and spigot, or flanged).

They shall be Crane, Darling, Ludlow-Rensselaer, M & H, Mueller, A.P. Smith, or an approved equal.

- (e) **Valve Boxes.** Unless otherwise specified on the Plans, valve boxes shall be of the screw type adjustable valve box, complete with drop cover.

- (f) **Fire Hydrants.** Fire hydrants shall conform to, and be tested in accordance with the AWWA Standard for Fire Hydrants for Ordinary Water Works Service, AWWA C 502. All hydrants shall have the following: breakable connection features and a breakable coupling on the stem immediately above the bury line, both of which have a lower breaking point than the rest of the unit; 4 1/2 inch (114.3 mm) compression main valve; 6 inch (152.4 mm) inlet connection; bell, flange, or mechanical joint inlet; 4 1/2 foot (1.37 m) bury length; two 2 1/2 inch (63.5 mm) hose nozzles with National Standard threads; one 4 inch (101.6 mm) pumper nozzle; "O" ring seal; drain valve, left (counterclockwise) opening; yellow finish paint above ground line; and National Standard pentagon operating nut.

Fire hydrant extensions shall be of the proper design to accommodate the make of fire hydrant installed.

Fire hydrants shall be Darling, Mueller Improved, M & H, or an approved equal.

- (g) **Joints.** Joint cast iron pipe and fittings with any of the end types as specified below, unless a particular end type is specified. Use flange ends only where specifically noted on the drawings, except that the valve connection end of all tapping sleeves shall be flanged.

Push-on joints shall conform to, and be tested in accordance with, the American Standard for Rubber Gasket Joints for Cast Iron Pressure Pipe and Fittings, AWWA C 111.

Mechanical joints shall conform to, and be tested in accordance with, the American Standard for Rubber Gasket Joints for Cast Iron Pressure Pipe and Fittings, AWWA C 111.

Bell-and-spigot joints shall consist of square, braided, sterilized hemp and 99.73 percent pure lead caulking.

Flange joints shall conform to the American Standard for Cast Iron Pipe Flanges and Flanged Fittings, ASA B 16.1.

- (h) **Lining.** When specified, cast iron pipe and fittings shall be lined in accordance with the American Standard for Cement Mortar Lining for Cast Iron Pipe and Fittings for Water, AWWA C 104.

- (i) **Certification.** Tests will not ordinarily be made by the Materials Division on the above materials, but the materials furnished shall be recognized standard products, and the manufacturer of such products shall furnish the Engineer a type C certification.

733.02. COPPER WATER SERVICE PIPE AND FITTINGS.

- (a) **Materials Covered.** This item covers copper water service pipe and fittings for use in construction of water service lines.
- (b) **Copper Service Pipe.** Copper service pipe shall be a seamless copper tubing cold drawn to size. It shall be type K soft annealed and shall meet the requirements of ASTM B 88.

Sampling and testing shall be done as provided in ASTM B 88, with the exception that making the chemical analysis shall be optional with the Engineer.
- (c) **Fittings.** All fittings, including corporation stops and curb stops, shall be of cast brass or bronze and shall be finished in a thoroughly workmanlike manner. They shall be sound, clean, and free from blow holes, porous places, cracks, or any other defects affecting their strength or appearance, which would indicate inferior quality of metal. All moving parts shall be accurately fitted up so as to work smoothly and freely without binding. They shall be of a standard type commonly used and shall be the product of a recognized manufacturer of such fittings. Each casting shall bear the name or trademark of the manufacturer, permanently cast in the metal.
- (d) **Certification.** Tests will not ordinarily be made by the Materials Division on the above materials, but the materials furnished shall be recognized standard products and the manufacturer of such products shall furnish the Engineer a type C certification.

733.03. GALVANIZED STEEL WATER PIPES AND FITTINGS.

- (a) **Materials Covered.** This item covers galvanized steel pipe for use in water service lines.
- (b) **Galvanized Steel Pipe.** Galvanized steel pipe shall meet the requirements of ASTM A 53, Standard Weight Pipe. All pipe shall be first class galvanized welded and seamless steel pipe of standard mass and standard dimensions, new stock, smoothly finished, and free from any defects which might affect its strength or durability, and shall be approved by the Engineer before using.
- (c) **Fittings.** Fittings shall be galvanized and may be either of wrought iron or steel. All connections shall be standard right-hand screw threads unless otherwise noted on the Plans.

733.04. NONMETALLIC WATERLINE PIPE AND FITTINGS.

- (a) **Materials Covered.** Each specific type of nonmetallic pressure waterline pipe and fittings shown below shall meet the following requirements unless otherwise shown on the Plans.
 1. Asbestos-Cement Waterline Pipe and Fittings - ASTM C296.
 2. Polyvinyl Chloride (PVC) Waterline Pipe and Fittings - ASTM D1785.
 3. Acrylonitrile-Butadiene-Styrene (ABS) Waterline Pipe and Fittings - ASTM D1527.
 4. Polyethylene (PE) Waterline Pipe and Fittings - ASTM D2104.
 5. Polybutylene (PB) Waterline Pipe - ASTM D2662.

733.05. REFLECTIVE SHEETING FOR GUIDE POSTS.

This item covers reflective sheeting to be used in reflectorized guide posts, or any other post or barrier which requires reflectivity, and shall be in accordance with the requirements for reflective sheeting as provided in Subsection 719.04., Type II. Reflective sheeting for use on the underdrain outlet post (guide post) shall meet the same requirements. Metal backing plates (sheet) for these posts shall conform to the requirements of ASTM A 526, in minimum 30 gage (399 μm thickness) for galvanized sheet, or ASTM B 209 Alloy 1060-H12 in minimum 406 μm thickness. Metal bands shall be prepared to receive

the reflective sheeting by degreasing and fully cleaning or caustic etching. Wording on the band shall be as shown on the current Standard Drawing.

733.06. ELASTOMERIC BEARING PADS.

- (a) **Description.** This item covers elastomeric bearing pads for bearings under structural members when so specified on the Plans. The dimensions and shapes of plain and laminated pads shall be as provided on the Plans. Plain pads shall consist of elastomers only (50, 60 or 70 Durometer Hardness) and laminated pads shall consist of layers of elastomers (50 or 60 Durometer Hardness) restrained at their interfaces by bonded laminates.
- (b) **Materials.** Materials, fabrication, fabrication tolerances, markings and certification, testing, and installation shall conform with the requirements of the latest revision of the AASHTO Standard Specifications for Highway Bridges.

Unless otherwise shown on the Plans, the shear modulus for the Durometer hardness indicated on the Plans shall be as follows:

Durometer Hardness	Shear Modulus, 73°F, psi (22.8EC, MPa)
50	110 (0.76)
60	150 (1.03)
70	235 (1.62)

Unless otherwise noted on the Plans, all elastomer compounds shall be classified as being of low temperature Grade 2.

The edge cover of embedded laminates or connection members for all steel reinforced bearing pads shall be 1/8 inch (3.2 mm).

If it is specified on the Plans that the anchor plate is to be bonded to the bearing pad, then it shall be a heat-bonded connection made by the pad manufacturer during the vulcanization process.

- (c) **Acceptance.** Acceptance of the bearing pads will be based on the following:
- Seven copies of the shop drawings shall be submitted to the Bridge Engineer for approval. Fabrication shall not begin until the pad manufacturer receives such approval.
 - A type A certification showing compliance with these Specifications shall be furnished by the Contractor.
 - A sample, consisting of one finished bearing pad per size or type, per project, shipment or lot, shall be submitted to the Materials Laboratory for dimensional and Durometer Hardness checks, and, whenever appropriate, and with the direction of the Materials Engineer, laboratory tests of the full-size bearing pad shall be conducted.

Testing of the bearing pads, conducted by the Department or others in its charge, shall be of a nondestructive nature. Upon completion of the required tests, sample bearing pads may be picked up from the Materials Laboratory by the pad manufacturer or their representative. Samples of plain bearing pads for slab bridges or other pads deemed cumbersome by the Bridge Engineer need not be submitted to the laboratory. The Engineer shall document the dimensional check of all bearing pads.

733.07. NONSHRINK GROUT.

- (a) **General.** Nonshrink grout shall consist of a mixture of portland cement, fine aggregate, water, and an approved nonshrink admixture.
- (b) **Materials.**
 - 1. **Portland Cement, Water and Aggregate.** Portland cement, mixing water, and aggregate shall conform to Section 701. The gradation requirements of the aggregate will conform to the following:

<u>Sieve Size</u>	<u>Percent Passing</u>
No. 16 (1.18 mm)	100
No. 50 (300 μm)	20-50
No. 200 (75 μm)	0-10

- 2. **Nonshrink Admixture.** Nonshrink admixture shall be the type manufactured under a trade name for use in nonshrink grout and approved by the Materials Engineer prior to use.
 - 3. **Premix.** Manufacturer’s premix formulations may be used when approved by the Materials Engineer prior to use.
- (c) **Nonshrink Mortar.**
 - 1. **Proportioning.** Unless otherwise specified by the manufacturer of the nonshrink admixture, the dry materials shall be proportioned on a 1:1:2 basis by mass, or as follows:

94 pounds (42.64 kg) Portland Cement
100 pounds (45.36 kg) sand
200 pounds (90.72 kg) nonshrink admixture

- 2. **Mixing.** The proportioned materials shall be combined and mixed until thoroughly blended. If the sand is noticeably wet, the quantity of free moisture shall be determined as a percentage of the dry mass and the mass of sand adjusted accordingly. Water shall be added in increments until the desired consistency has been obtained. The mixing water will be estimated as a percentage of the total mass of the dry materials. Mortar not used within 20 minutes after completion of mixing shall be discarded.
NOTE: Retempering the mortar will not be permitted.

733.08. WATERSTOPS.

- (a) **General.** This item covers the requirements for plastic waterstops and rubber waterstops to be used in construction joints of structural concrete, when shown on the Plans, in reasonably close conformity with the dimensions and location shown on the Plans or established by the Engineer.
 Waterstops shall have a dense, homogeneous cross section and shall be produced in continuous lengths not to exceed 100 feet (30.48 m). If any field splices are necessary, they shall be made in accordance with the manufacturer’s instructions.
- (b) **Materials.** When a particular type of material is not shown on the Plans, either plastic or rubber material is acceptable.
 Subject to visual inspection and approval by the Engineer, material from an approved source will be accepted on the basis of the manufacturer’s identification markings showing the appropriate

grade of material. To qualify as an approved source of material, the manufacturer shall submit to the Materials Engineer certification of tests of the name product showing compliance with these Specifications.

1. **Plastic Waterstops.** The waterstops shall be extruded from an elastomeric plastic compound, the basic resin of which shall be a polyvinyl chloride (PVC). The compound shall contain any additional resins, plasticizers, stabilizers, or other materials needed to insure that, when the material is compounded, it will meet the performance requirements given in this Specification.

Sampling shall be in accordance with ASTM Designation D 15 Methods of Sample Preparation for Physical Testing of Rubber Products and Federal Test Method Standard No. 601 Rubber; Sampling and Testing.

The material shall meet the following requirements:

<u>Property</u>	<u>Test Method</u>	<u>Property Requirement</u>
Tensile Strength (die III), psi (MPa), minimum	4111 ^a	1750 (12.07)
Ult. Elongation (die III), %, minimum	4121 ^a	350
Low Temp. Brittleness, no failure such as cracking or chipping at, °F (EC)	ASTM D 746	-35 (-37.2)
Stiffness in flexure, 1/2 inch (12.7 mm) Span, psi (MPa), minimum	ASTM D 747	400 (2.76)

^a Federal Test Method Standard No. 601.

2. **Rubber Waterstops.** The material for rubber waterstops may be a natural rubber, suitable synthetic rubber, or a blend of natural and suitable synthetic rubber.

Sampling shall be in accordance with ASTM Designation D 15 Methods of Sample Preparations for Physical Testing of Rubber Products and Federal Test Method Standard No. 601 Rubber; Sampling and Testing.

The material shall meet the following requirements:

<u>Property</u>	<u>Test Method^a</u>	<u>Physical Requirements</u>
Tensile Strength (die III), psi (MPa), minimum	4111	2500 (17.24)
Hardness, Shore Diameter, Type A	3021	60-70
Ult. Elong. (die III), %, minimum	4121	450
300% Modulus, psi (MPa), minimum	4131	900 (6.21)
Water Absorp., 7-day immersion, 73.4°F±2°F (23±1 EC), %, maximum	6631	5
Compression Set, %, maximum	3311	30
	or ASTM D 395, Method B	
Tensile Strength after aging Oxygen bomb method, %, minimum	7111	80

^a Federal Test Method Standard No. 601.

- (c) **Acceptance.** A type D certification in accordance with Subsection 106.04 shall be required.

733.09. SLURRY GROUT.

- (a) **Description.** This item covers a slurry type grout for stabilizing and undersealing portland cement concrete pavements by pressure grouting method.
- (b) **Materials.** The grout shall consist of a mixture of portland cement, fly ash and water proportioned as approved by the Engineer.

Portland cement, fly ash, water and approved admixtures shall meet the following requirements of the Subsections:

Portland Cement	701.02
Admixtures	701.03
Water	701.04
Fly Ash	702

- (c) **Mix Designs and Tests.** Submit in advance to the Materials Engineer a proposal for materials to be used in the grout mixture. Also submit job mix test results of the grout from an independent laboratory, showing the following: 7 day strengths (ASTM C 942); flow cone rate (Corps of Engineers Method) (ASTM C 939); shrinkage and expansion (ASTM C 940 or C 827); and time of initial set (ASTM C 403 or AASHTO T 197). The 7 day strength shall not be less than 800 psi (5.52 Mpa), and the flow cone rate shall be 10-16 seconds.

**SECTION 735
MATERIAL FOR ROADSIDE
DEVELOPMENT AND EROSION CONTROL**

735.01. DESCRIPTION.

These Specifications establish the material requirements for roadside development and erosion control.

735.02. SODDING AND SPRIGGING MATERIALS.

- (a) **General.** Bermudagrass sod or sprigs to be used as source material shall be a thick stand of common bermudagrass growing on fertile topsoil. Types of bermudagrass other than "Common" may not be used unless specified or approved by the Engineer. The vegetative parts (rhizomes, stolons, and roots) of bermudagrass shall be viable as indicated by a dense, deep-rooted stand.

The source for sod and sprigs shall be free of reproducing parts of weeds classified as "Prohibited Noxious" and shall be as free of other legally "Restricted Noxious" plant materials as required by the Oklahoma Department of Agriculture Seed Law. The proposed source of sod or sprigs will be approved by the Engineer before the beginning of sodding or sprigging operations. Prior to approval, the area shall not be tilled or mowed. After approval, all vegetative growth exceeding 3 inches (75 mm) in height shall be mowed and the residue removed prior to harvesting the sod or sprigs.

The sod or sprigs shall be moist when excavated from the source and shall be kept moist until planted. Watering of the sod source, if to be measured for payment, shall be performed when and as directed by the Engineer. Sod in storage which becomes dry, shall not be remoistened and used, but shall be discarded.

- (b) **Sodding.** This material shall consist of vegetative parts (rhizomes, stolons, and roots) of bermudagrass with an appreciable quantity of adhering soil.
1. **Solid Slab Sod** shall be rectangular slabs of bermudagrass having minimum dimensions designated on the standard detail. Bermudagrass vegetative parts shall exist throughout the slab and shall be obtained from soils with a minimum Plasticity Index of 3. The slab must have a dense vegetative growth and be capable of being transported in a condition closely resembling its original state.
 2. **Mulch Sod** shall consist of fertile topsoil that contains bermudagrass vegetative parts which have not been harvested within the previous 12 months. Before excavation, disk the sod in different directions to the depth of planned excavation. Each disking shall be at right angles to the preceding disking until the bermudagrass vegetative parts have been cut into small pieces. Limit the depth of excavation to 6 inches (150 mm) unless otherwise determined by the Engineer. Excavate immediately after disking. The sod may be windrowed or otherwise stored for short periods and shall be kept in a moist condition in a manner approved by the Engineer.
- (c) **Sprigging.** This material shall consist of vegetative parts (rhizomes, stolons, and roots) of the bermudagrass which has been separated from a majority of the adhering soil.
- The sprigs for row sprigging and broadcast sprigging shall be removed from the soil with an approved automatic sprig harvester which digs, cleans, and loads the sprigs in one continuous operation. The vehicle in which the sprigs are loaded for transportation shall not have open sides.
- As soon as the vehicle is loaded, the sprigs shall be wet thoroughly with water and covered with a heavy canvas or other approved cover to reduce moisture loss. They shall be kept moist and covered until planted, and they shall be planted within 48 hours after removal from the soil.

735.03. PLANTING MATERIALS.

- (a) **Plant Materials.** The grading tolerances, quality definitions, balling and burlapping Specifications, container and bare-root requirements of plant materials shall meet the requirements of ANSI Specification Z-60.1, Nursery Stock, except as modified by these Specifications, the Plans, or in the Proposal.
- All plant materials shall be nursery grown stock unless collected plant materials are specified or permitted by the Engineer.
- Plant material shall be well grown, healthy, representative samples of their normal species or variety, with a vigorous and well developed root system. Trees shall have reasonably straight stems and shall be well branched and symmetrical in accordance with their natural habits of growth. The branch system shall be free from disfiguring knots, sun scald injuries, abrasions of the bark, dead or dry wood, broken terminal growth, or other objectionable disfigurements.
- Nursery grown stock are those plants which have been grown by proper cultural treatment and have been transplanted or root pruned two or more times according to approved nursery practices. All evergreens shall be either balled and burlapped (B & B) or containerized. Deciduous plants may be bare-rooted (BR), B & B, or containerized. B & B plant materials shall have solid, firm balls, which have been dug from firm soil that contains a minimum amount of sand.
- When nursery- grown plants of the species, size, and grade specified are not available, collected plant material meeting the Specifications may be substituted if approved in writing by the Engineer. Collected plant material shall be dug by an approved nursery doing the collecting. Notify the Engineer in writing at least 2 weeks in advance of the time and place of digging collected plant materials so that an inspection of the work and material can be made.

NOTE: Any additional cost for materials, equipment, labor and incidentals required to acquire and use the substitute collected material shall be at the Contractor's expense.

The spread of roots and minimum ball size for collected plant material shall be at least 33 percent greater than that for nursery- grown plant material, as specified in ANSI Specification Z-60.1.

Plant materials shall be packed to insure adequate protection against climatic, seasonal, or other injuries during transit. Bare rooted (BR) plants shall have their roots kept in a moist healthy condition, with a suitable material.

Plant materials may be inspected for provisional approval, at any time during the life of the contract. Plant materials not meeting Specifications shall be rejected, and if on the project, removed immediately and replaced at the Contractor's expense.

At the time of delivery, all plant materials shall be accurately and legibly tagged with their names and sizes. Furnish the Engineer a written statement, giving the origin of each shipment, plus an invoice showing quantities, sizes, varieties, and inspection certificates, as required by Federal and State laws, certifying the plant materials to be free from plant diseases and insect pests.

- (b) **Planting Soil Mix.** The planting soil mix shall contain one part sand*, three parts sandy loam*, and one part peat moss by volume. These materials shall meet the following requirements:

Sand. Sand is defined as soil material that contains 85 percent or more of sand. The percentage of silt, plus 1-1/2 times the percentage of clay, shall not exceed 15 percent. Included are coarse sand, fine sand, and very fine sand.

Sandy Loam. Sandy loam shall meet one of the following definitions:

1. Soil material that contains 20 percent clay or less, and the percentage of silt plus twice the percentage of clay exceeds 30 and contains 52 percent or more sand.
2. Soil material that contains less than 7 percent clay, less than 50 percent silt, and between 43 and 50 percent sand.

Peat Moss. Peat moss shall consist of at least 75 percent of partially decomposed stems and leaves of sphagnum, hypnum, polytrichum, and other mosses in which the fibrous and cellular structure is still recognizable. It shall be brown to black in color. Humus peat shall not be acceptable. Peat moss shall have the following characteristics:

Moisture content shall not exceed 60 percent by mass.

Ash content shall not exceed 20 percent, based on the oven dry mass of the material.

The pH value shall be between 3.2 and 7.0 at 77°F (25°C).

Water holding capacity shall be not less than 400 percent, by mass, on an oven dry basis.

Furnish the Engineer with a certificate stating the type of peat moss, the brand name, and the place of origin. The certificate shall also contain the cubic feet (cubic meter) of compressed material, the compression ratio, and the approximate weight per cubic foot (mass per cubic meter). A certificate will not be required if this information is marked on the bales.

(*Textures as determined by U.S. Department of Agriculture Soil Classifications and defined in the OHD Manuals of Engineering Classification of Geological Material, R&D Division. The materials shall be well blended until homogenous in texture and composition).

The planting soil mix shall be free from subsoil roots, brush, refuse, and other offensive or deleterious materials that would interfere with proper planting procedures or with future maintenance. It shall be free from harmful quantities of toxic salts or other material that might retard establishment or interfere with the future growth of the specified plant. The mix shall be free from the seeds, roots, and other reproducing parts of weeds classified as "Prohibited Noxious" and shall

be free of other legally "Restricted Noxious" plant materials as required by Oklahoma Department of Agriculture regulations.

Stockpile and mix the planting soil materials at a predetermined location approved by the Engineer.

- (c) **Vegetable Compost.** The material shall consist of cotton seed hulls, peat moss, chopped peanut hulls, partially decayed and chopped cotton burrs, or any combination of these, and shall be free from seeds or other reproducing parts of noxious or objectionable weeds.

735.04. SEEDING MATERIALS.

The kind and quantity of seeds to be planted per acre will be indicated on the Plans or in the Proposal. A list of seeds and the Specifications for them are given in table of seed Specifications.

Furnish the seed in sealed bags, with each "lot" in separate bags, even though mixtures may be called for on the Plans. All labeling required by law shall be intact and legible.

Furnish the Engineer two (2) legible copies of the invoices and seed tags. The invoice shall describe each species by name, variety, if any, and treatment (hulled, scarified, etc.), if any.

Each "lot" of seed furnished shall have been officially sampled and tested by the Oklahoma State Board of Agriculture, and 2 copies of the report shall be supplied to the Engineer by the Contractor. Each seed test shall have been completed not more than 9 months prior to delivery of the seed.

The information furnished in the seed report for a particular "lot number" shall agree with information appearing on the seed tags having the same "lot number", or the seed of that "lot" will be rejected.

The seed and tags shall not be removed from the original tagged and sealed bag until approved by the Engineer. After approval, the seed may be mixed, sacked, and batched as required to facilitate planting, but it shall be tagged for identification and mass. The mixing or sacking into batches shall be performed under supervision of the Engineer.

TABLE OF SEED SPECIFICATIONS

Kind of Seed: Common and Botanical Name	P.L.S. Index ^a , Minimum	Purity, percent, minimum	Germination, percent, minimum	Weed Seeds ^d , percent, maximum
Bermudagrass, common (Cynodon dactylon)unhulled	80			0.2
Bermudagrass, common (Cynodon dactylon)hulled	82			0.2
Bermudagrass, Guymon variety (Cynodon dactylon)unhulled	80			2.0
Bermudagrass, Guymon variety (Cynodon dactylon) hulled	82			2.0
Bluestem ^b , big (Andropogon gerardi)	20			
Bluestem, Caucasian (Andropogon caucasicus)	15			

**MATERIAL FOR ROADSIDE
DEVELOPMENT AND EROSION CONTROL**

735.04

Kind of Seed: Common and Botanical Name	P.L.S. Index ^a , Minimum	Purity, percent, minimum	Germination, percent, minimum	Weed Seeds ^d , percent, maximum
Bluestem ^b , little (<i>Andropogon scoparius</i>)	15			
Bluestem, Plains (<i>Bothrichloa ischaemum</i>)	30			1.0
Bluestem ^c sand (<i>Andropogon halli</i>)	20			
Bluestem, yellow (<i>Andropogon ischaemum</i>)	18			
Brome, smooth (<i>Bromus inermis</i>)	70			2.0
Buffalograss ^{b,c} (<i>Buchloe dactyloides</i>)	55			
Burclover (<i>Medicago hispida, arabica or rigidula</i>)		98	85	1.0
Clover, crimson (<i>Trifolium incarnatum</i>)		95	85	0.5
Clover ^e , large hop (<i>Trifolium procumbens</i>)		95	85	0.5
Clover ^e , small hop (<i>Trifolium dubium</i>)		95	85	0.5
Dropseed, sand (<i>Sporobolus cryptandrus</i>)	70			2.0
Fescue,tall(<i>Festuca arundinacea</i>)	80			0.5
Gramma ^b , blue (<i>Bouteloua gracilis</i>)	25			
Gramma ^b , side-oats (<i>Bouteloua curtipendula</i>)	30			
Indiangrass ^b (<i>Sorghastrum nutans</i>)	35			2.0
Lespedeza, common (<i>Lespedeza striata</i>)		97	90	0.5
Lespedeza ^e , Korean (<i>Lespedeza stipulacea</i>)		97	90	0.5
Lespedeza, roundhead (<i>Lespedeza capitata</i>)		97	90	0.5
Lespedeza ^e , sericea (<i>Lespedeza cuneata</i>)		98	90	0.5
Lovegrass ^b , sand (<i>Eragrostis trichodes</i>)	65			0.5
Lovegrass, weeping (<i>Eragrostis curvula</i>)	80			0.3

Kind of Seed: Common and Botanical Name	P.L.S. Index ^a , Minimum	Purity, percent, minimum	Germination, percent, minimum	Weed Seeds ^d , percent, maximum
Millet, German foxtail (<i>Setaria italica</i>)		98	80	0.5
Native grasses ^b (Predominately little bluestem)	15			
Oats (<i>Avena sativa</i>)		95	80	0.5
Rye (<i>Secale cereale</i>)		90	70	0.3
Ryegrass, annual (<i>Lolium multiflorum</i>)	85			0.2
Ryegrass, perennial (<i>Lolium perenne</i>)	85			0.2
Sudangrass (<i>Sorghum vulgare sudanense</i>)		98	80	0.5
Switchgrass(<i>Panicum virgatum</i>)	60			2.0
Wheat (<i>Triticum aestivum</i>)		96	80	0.1
Wheatgrass ^b , western (<i>Agropyron smithii</i>)	56			1.0

^a The P.L.S. Index (Pure Live Seed Index) shall be calculated from information given on the seed tag, as follows:

$$\text{P.L.S. Index} = \% \text{Purity} \times (\% \text{Germination} + \% \text{Firm Seed}) / 100$$

The pounds (kg) of seed shown on the Plans are stated as pounds (kg) of bulk seed. If the P.L.S. index of any "seed lot" furnished exceeds the minimum P.L.S. index specified by 25 percent or more, the pounds (kg) of bulk seed to be planted will be adjusted by using the following formula:

$$P = (S \times C) / F$$

where:

P= pounds (kg) of bulk seed to be planted

S= P.L.S. Index specified

C= pounds (kg) of bulk seed specified

F= P.L.S. Index furnished

^b The seed source shall be Oklahoma, Texas, Kansas, or New Mexico.

^c The seed shall have been prechilled and treated with potassium nitrate in accordance with the Hays Treatment Technique.

^d The seed shall contain no Johnson grass seed. (This note applies to all seed).

^e The seed shall be treated with an approved nitrogen fixing inoculant, such as manufactured by commercial laboratories suitable for the particular legume. The inoculant shall be stored and handled in accordance with the manufacturer's directions.

735.05. MULCHING MATERIALS.

- (a) **Vegetative Mulch.** This material shall consist of straw or hay as specified below. It shall be free from mold or rot and shall be in a good state of preservation when used. It shall be primarily long, heavy- stemmed material. The material shall be delivered dry, in bales, and shall be kept dry until applied. The mulch shall contain no seeds which are classified as "Prohibited Noxious" and shall be as free of "Restricted Noxious" as is legally allowed by the Oklahoma Department of Agriculture.
1. Straw shall be the mature stems of barley, oats, rye, or wheat from which the grain has been harvested.
 2. Hay shall consist of mature weeping lovegrass, caucasian bluestem, K.R. bluestem or pure stands of the other bluestem hays. The hay shall be free from appreciable quantities of annual grass, short grass or immature tall grass.
- (b) **Asphalt Mulch.** Asphalt mulch shall be MS-2 emulsified asphalt conforming to Subsection 708.03. Before application, the mulching asphalt shall be diluted with water, in the proportion of one gallon (l) of emulsified asphalt to 3 gallons (l) of water.
- (c) **Excelsior Mat.** This material shall consist of a machine- produced mat of wood excelsior, with the excelsior fibers interlocking to form a continuous web. At least 80 percent of the fibers shall be 8 inches (200 mm) or longer in length. The web of fibers shall be distributed uniformly throughout the mat, resulting in uniform thickness and density. The mat shall be covered on one side with extruded plastic netting which shall not exceed a mesh size of 1 inch x 2 inch (25 x 50 mm). The dimension of the mat shall be as follows:
- Length: not less than 130 feet (45 m)
 - Width: 48 inches or 60 inches±1 inch (1220 or 1525 ± 25 mm)
 - Dry mass per unit area: 0.8 lb/yd² (0.43 kg/m²)
- The mat shall be smolder resistant. The smolder resistant treatment shall be nonleaching, and it shall be noninjurious to vegetation, as well as to animals and humans. The leaching resistance test shall be in accordance with Federal Test Method 191, Method 5830. The smolder resistance test shall be conducted after the leaching test and on the air-dried sample. Furnish a type D certification for excelsior mat material.
- Fasteners meeting the requirements of Subsection 735.06(b) shall be used for anchoring the mat.
- (d) **Jute Mesh.** This material shall be a uniform, open, plain weave of new and unused single jute yarn. The yarn shall be loosely twisted and shall not vary in thickness by more than one half its normal diameter. Jute mesh shall be furnished in strips as follows:
- Length: not less than 150 feet (45 m)
 - 78 Warp ends per width approximately.
 - 41 Weft ends per yard (m) approximately.
 - Mass per Unit Area: not less than 0.9 lb/yd² (0.49 kg/m²)
- Fasteners meeting the requirements of Subsection 735.06(b) shall be used for anchoring the mat.
- (e) **Excelsior Mulch.** The material shall consist of wood fibers cut from sound green timber. The cut shall be made at a slight angle to the natural grain of the wood, so as to cause splintering of the fiber when weathered.
- The excelsior mulch shall have the following properties:
 - Burred wood fibers; major portion shall be approximately 4 inches (100 mm) long. The fiber size shall be 0.024 x 0.031 inches (0.61 x 0.79 mm) ± 20 percent.

The total volatile content (moisture, etc.) at the time of manufacture shall not exceed 45 percent, as expressed by the following formula:

$$V = (a-b) \times 100/a$$

where: V = Percent volatile content
a = Mass of original sample
b = Mass of dry sample

The material shall be delivered in bales. Each bale shall be 80-90 pounds (36-41 kg) and shall be tagged with the mass at the time of manufacture. Density of the baled material shall be 11-15 lbs/ft³ (175 - 240 kg/m³)

- (f) **Wood Cellulose Fiber.** The material shall be composed of natural wood fiber produced from wood by-products. It shall contain no growth or germination inhibiting factors and shall contain a water soluble, nontoxic coloring agent.
- (g) **Nylon Erosion Control Mat.** Nylon erosion control mat shall consist of a bulky structure of entangled nylon monofilaments, melt-bonded at their intersections, forming a stable mat of suitable mass and configuration. The mat shall be resilient, permeable, and highly resistant to environmental deterioration and ultraviolet degradation. The color of the mat shall be black. The material shall comply with the following physical properties:

1. *Material Type.* Nylon 6 plus a minimum content of 0.5% by mass of carbon black.

- 1.1. *Dimensions:*

Filament diameter, inches (mm)	0.0157 (0.40)
Mass per Unit Area, lb/yd ² (Kg/m ²)	0.747 (0.41)
Thickness of mat, inches (mm)	0.71 (18)
Width, inches (mm)	38.2 (970)
Roll length, yard (m)	109±3.3 (100 ± 3)

- 1.2. *Tensile Properties:*

STRENGTH	
Length dimension, lb/yd (N/M), minimum	282 (1372)
Width dimension, lb/yd (N/M), minimum	161 (783)
ELONGATION	
Length direction, %, minimum	50
Width direction, %, minimum	50

NOTE: ASTM D 1682 strip test procedure modified to obtain filament bond strength used to indicate tensile properties.

- 1.3. *Resiliency:* Compression load cycling of 100 psi (689.4 kPa) on a 2 x 2 inches (50.8 x 50.8 mm) sample size, crosshead speed of 2 inch (50.8 mm) per minute.
30 minute recovery (3 cycles) 80% min.
2. *Certification.* The manufacturer shall furnish a type D certification with each shipment of the mat material.
3. *Mat Fasteners.* Mat fasteners meeting the requirements of Subsection 735.06(b) shall be used for anchoring the mat.
4. *Seed.* Common bermudagrass seed, unhulled, shall meet the Specification requirements of Section 735.04 of the Standard Specifications.

- (h) **Inspection of Materials.** Prior to delivery of mulching materials, notify the Engineer of the intended sources of materials and quantities to be obtained from each source. Also, furnish the Engineer with representative samples of the materials proposed for use. The Engineer may use the samples for provisional approval prior to delivery. Evidence of wetting, caking, or other deterioration at any time before use shall be cause for rejection.

If, during application or after placement, the character or action of any mulching material indicates that the material cannot be applied or fastened in accordance with Specifications, it will be rejected and shall be promptly removed from project.

735.06. MULCH FASTENING MATERIALS.

- (a) **Adhesive Fastener.** The adhesive fastener shall conform to Specifications for emulsified asphalt, SS-1, Section 708.
- (b) **Mat Fasteners.** The mat fasteners shall meet the requirements for the type specified on the standard drawings.

735.07. FERTILIZER AND AGRICULTURE LIMING MATERIALS.

- (a) **Fertilizer.** This material shall be a commercial fertilizer composed of the standard materials and conforming to the grade specified. The term "grade" shall mean the percentages of "total nitrogen," "available phosphoric acid," and "soluble potash," respectively, in accordance with the requirements of Oklahoma Department of Agriculture.

Fertilizer furnished in standard, factory-sealed containers shall have all labeling required by the Oklahoma Department of Agriculture. The label shall be intact and legible until the contents are used.

Each vehicle load of fertilizer furnished in bulk form shall be accompanied by two (2) legible copies of the purchase receipt, which shall be given to the Engineer upon delivery of the fertilizer. Each receipt shall show the mass, brand name, grade of the fertilizer, and the guaranteed analysis showing the minimum percentage of plant food in the fertilizer. The name and address of the person, firm, or corporation registering or guaranteeing the fertilizer with the Oklahoma Department of Agriculture shall also be shown.

The fertilizer to be broadcast dry shall be in a pelleted or other approved granular form, and the material to be applied by power spray shall be soluble in water and uniform in suspension.

A fertilizer with an identical NPK ratio but of a higher grade than specified may be furnished, provided the application rate is adjusted to the equivalent number of kilograms of each plant food element per unit of area as would have been applied with the specified grade.

In the event such a substitution is made, the following formula shall be used in determining the new application rate:

$$a = (bxc)/d$$

where:

- a=New application rate
- b=Grade of specified fertilizer (N.P.K.)
(converted from percent to decimal)
- c=Specified application rate.
- d=Grade of new fertilizer (N.P.K.)
(converted from percent to decimal)

- (b) **Agricultural Liming Material.** This material shall consist of either agricultural limestone or hydrated lime and shall meet the requirements of Section 706. When agricultural limestone is called for, 70 pounds (kg) of hydrated lime may be substituted for 100 pounds (kg) of agriculture limestone. Agriculture limestone shall not be substituted for hydrated lime.

Liming material furnished in standard factory-sealed containers shall have all labeling required by the Oklahoma Agricultural Liming Materials Act intact and legible until the contents are used.

Each vehicle load of liming material furnished in bulk form shall be accompanied by two legible copies of the purchase receipt. This receipt shall be given to the Engineer upon delivery of the liming material. Each receipt shall include the following: the name of the liming material, the brand or trade name, the net mass, the percent ECCE (Effective Calcium Carbonate Equivalent), and the name and address of the manufacturer, producer, or distributor.

The Engineer will obtain a one quart (liter) sample from each vehicle load of bulk material to be submitted to the Materials Laboratory for testing.

735.08. TEMPORARY SILT DIKE MATERIALS.

Temporary silt dike shall be triangular shaped, having a height of at least 8-10 inches (200-250 mm) in the center with equal sides and a 16-20 inch (400-500 mm) base. The outer cover shall be a woven geotextile fabric placed around the inner material and allowed to extend beyond both sides of the triangle 24-36 inches (600-900 mm). The geotextile fabric shall be mildew resistant, rot-proof and resistant and ultraviolet radiation meeting the requirements for temporary silt fence in AASHTO M288-97. The edges shall be treated to prevent unraveling. Seams and stress points shall be reinforced. The fabric cover and apron shall be a continuous wrapping of the fabric: the apron shall be a continuous extension of the upstream face. The urethane foam used as the inner layer of the silt dike shall meet the requirements for ASTM D3574.

SECTION 736 PAVEMENT MARKERS

736.01. CLASS A REFLECTIVE PAVEMENT MARKERS.

- (a) **Design and Shape.** The prismatic reflectorized marker shall conform to the shape and dimensions shown on the Plans and shall be so constructed that moisture and road grime will not penetrate or damage the element. Reflector units shall be smooth throughout and made of methylmethacrylate conforming to the requirements of Standard Specifications for Methacrylate Molding and Extrusion Compounds ASTM D 788. Grade 8 shall be used unless otherwise specified. The reflector shall show no change in shape or color when subjected to the requirements of Test Method OHD-L-24 at a temperature of 140°F (60°C) with the marker in the vertical position.

The marker shall be molded of methylmethacrylate conforming to Federal Specification L-P-380a, Type 1, Class 3. Filler shall be a potting compound selected for strength, resilience, and adhesion adequate to pass the necessary physical requirements. The marker shall withstand a load of 9000 pounds (40.0 kN) without breaking or being significantly deformed when tested according to Test Method OHD-L-23.

- (b) **Reflector.** Horizontal incidence angle means the angle, in a plane parallel to the base of the marker, between a line in the direction of the incident light and a line perpendicular to the leading edge of the reflective surface.

Divergence angle means the angle at the reflector between observer's line of sight and the direction of the light incident on the marker. Specific intensity shall mean candela of the returned light at the chosen divergence and incidence angle for each lux of incident light. Federal Test Method Standard 370 will be used to determine specific intensity.

The specific intensity of the reflector at 0.2° divergence angle shall not be less than the following when the incident light is parallel to the base of the marker:

<u>Horizontal Entrance Angle,</u> <u>degrees</u>	<u>Specific Intensity, mcd/lux</u>		
	<u>Crystal</u>	<u>Amber</u>	<u>Red</u>
0	232	139	56
20	93	56	19

- (c) **Sampling and Testing.** A minimum of five pavement markers of each type to be used on the project, selected at random by the Engineer, shall constitute a sample. Testing shall be in accordance with testing procedures indicated in this Specification.

736.02. CLASS B NONREFLECTIVE PAVEMENT MARKERS.

- (a) **Design and Shape.** Traffic Buttons shall be round and dome shaped with a uniform curvature. The top and sides of the buttons shall be smooth and free from surface irregularities, pits, cracks, checks, chipping, discoloration, and any other defects which adversely affect appearance and application. The bottom of the buttons shall be rough-textured, free from gloss, glaze or any other substances that may reduce its bond to the adhesive.

Each traffic button shall be $4 \pm 1/8$ inch (101.6 ± 3.2 mm) in diameter at the base. Height of the button shall be $11/16 \pm 1/16$ inch (17.5 ± 1.6 mm). The base of the button shall not deviate from a flat plane by more than $1/16$ inch (1.6 mm).

- (b) **Physical Requirements.** The water absorption of the button shall not exceed 1.0 percent of the original dry mass when tested in accordance with ASTM C 373.

The glazed surface of the button shall not craze, spall, or peel when subjected to one cycle of the autoclave test at 250 psi (1.72 MPa) in accordance with ASTM C 424.

A random sample of 5 buttons shall be subjected to the compressive load test. The average compressive strength of the 5 buttons shall not be less than 1500 pounds (6.67 kN), and no individual button shall have a compressive strength less than 1200 pounds (5.34 kN).

The button shall be centered, base down, over the open end of a vertically positioned hollow metal cylinder. The cylinder shall be 1 inch (25.4 mm) high with an internal diameter of 3 inches (76.2 mm) and a wall thickness of $1/4$ inch (6.4 mm). A load necessary to break the button shall be applied at a speed of 0.2 inch (5.1mm) per minute to the top of the button through a 1 inch (25.4 mm) diameter solid metal cylinder centered on the top of the button. Should any of the samples tested for strength fail to comply with this Specification, 10 additional samples will be tested. The

failure of any one of the resamples shall be cause for rejection of the entire lot or shipment represented by the samples.

The button shall not break, chip, or crack when subjected to the impact of a 1 pound (454 g) steel ball falling freely from a height of 24 inches (610 mm). Impact tests shall be performed at a temperature of 40°F to 45°F (4.4 to 7.2°C) with the button resting on but not bonded to a flat steel plate. Buttons shall be heat-aged a minimum of 10 days at 150°F (65.6°C) before testing for impact resistance.

- (c) **Color.** The color of the buttons shall be as designated on the Plans, shall be uniform, and shall be determined by visual comparison with calibrated standards having C.I.E. Chromaticity Coordinate limits determined in accordance with Federal Test Method TT-T-141, Method 4252 falling within an area having the following corner points:

	<u>1</u>		<u>2</u>		<u>3</u>		<u>4</u>		Brightness
	<u>X</u>	<u>Y</u>	<u>X</u>	<u>Y</u>	<u>X</u>	<u>Y</u>	<u>X</u>	<u>Y</u>	(% MgO)
White	.290	.316	.310	.296	.330	.321	.310	.342	80 min.
Yellow	.470	.460	.515	.485	.545	.455	.490	.425	40 min.

- (d) **Glaze Thickness.** The glazed surface shall have a mean thickness not less than 0.005 inch (125 µm) when measured not closer than 1/4 inch (6.4 mm) from the edge of the button. The glaze thickness shall be measured on a fractured edge of the button to the nearest 0.001 inch (25 µm) by a calibrated scale microscope.
- (e) **Sampling and Testing.** A minimum of ten traffic buttons selected at random by the Engineer will constitute a sample. Samples will be forwarded to the Materials Division for testing.

736.03. CLASS C REFLECTIVE ALL- WEATHER PAVEMENT MARKERS.

- (a) **Design and Shape.** Pavement markers shall consist of an iron casting to which are attached replaceable prismatic reflectors of the type shown on the Plans and as further described in these Specifications. The forward portion(s) of the casting shall be so shaped that the blade of a snowplow, maintainer, or other highway maintenance equipment will be deflected without snagging or damaging the marker. The bottom of the casting shall incorporate anchoring devices designed to fit into slots or grooves cut in the roadway surface. The marker shall be bonded to the roadway pavement with an approved adhesive. It shall be anchored so that the marker will not be dislodged by traffic, snowplows, or other highway maintenance equipment. Design the casting so that the reflector-mounting surface will be 30° to the horizontal and contain provisions for securely attaching replaceable reflectors. Make provisions for fast, easy replacement of reflectors with common handtools without disturbing the anchorage of the casting. The marker shall withstand a load of 9000 pounds (40.0 kN) without breaking or being significantly deformed when tested according to test method OHD L-23.
- (b) **Casting.** The casting of the marker shall conform to the shape and dimensions shown on the Plans and shall be a clean, substantial casting, free from sand or blow holes or other defects. The surface of the castings shall be free from burnt-on sand and shall be reasonably smooth. Runners, risers,

fins, and other cast-on pieces shall be removed from the casting and such areas ground smooth. All corners and edges exposed to traffic shall be rounded. Casting shall be made of ductile iron and shall conform to the requirements of ASTM A 536. Grade 65-45-12 shall be used unless otherwise specified. The top of the forward rails of the casting shall have a hardness of 50-55 RC when tested by ASTM E18.

- (c) **Reflector.** The reflectors of the marker shall conform to the shape and dimensions shown on the Plans and shall be so constructed that moisture and road grime will not penetrate or damage the element. Reflector units shall be smooth throughout and made of methylmethacrylate conforming to the requirements of ASTM D 788. Grade 8 shall be used unless otherwise specified.

The reflector shall show no change in shape or color when subjected to the requirements of test method OHD-L-24. The temperature shall be 140°F (60°C) with the marker in a vertical position.

The specific intensity of the reflector shall meet the requirements of Subsection 736.01(b).

- (d) **Sampling and Testing.** Sampling and testing shall be in accordance with Subsection 736.01(c).

736.04. ADHESIVES FOR USE WITH PAVEMENT MARKERS.

- (a) **Epoxy Resin Adhesives.** Epoxy resin adhesives used for securing Class A and Class B pavement markers to the roadway surface shall meet the requirements of AASHTO M 237. The epoxy resin adhesives used for securing Class C pavement markers shall meet the requirements of AASHTO M 237 except the viscosity may be lower in accordance with the pavement marker manufacturer’s recommendation.
- (b) **Bituminous Type Hot-Melt Adhesives.** This item establishes the requirements for Bituminous Type Hot-Melt Adhesive used for securing the Class A and Class B Construction Zone Pavement Markers and Tube Channelizers to the roadway surface:
 1. *Description.* The adhesive shall be suitable for bonding ceramic and plastic markers to Portland Cement Concrete, Asphaltic Concrete, and chip-sealed road surfaces—and applicable when road surface and marker temperatures are in the range of 40°F to 160°F (4°C to 70°C). The composition of the adhesive must be such that its properties will not deteriorate when heated to and applied at temperatures up to 430°F (220°C) using either air or oil-jacketed melters.
 2. *Materials.* The adhesive shall be an asphalt material with a homogeneously mixed mineral filler and shall comply with the following requirements:

ADHESIVE PROPERTIES:

<u>Property</u>	<u>Min</u>	<u>Max</u>	<u>Method</u>
Softening Point, °F (EC)	200 (93.3)	-	ASTM D 36
Penetration	10	20	ASTM D 5
Flow, inches (mm)	-	0.2 (5.1)	ASTM D 3407, As Modified in Test Methods
Heat Stability flow, inches (mm)	-	0.2 (5.1)	As in Test Methods
Viscosity, 400°F (204.4EC), Pa•s	-	7.5	ASTM D 2669, As Modified in Test Methods
Flash Point, C.O.C., °F (EC)	500 (260)	-	ASTM D 92

Asphalt properties determined on the filler-free-material derived from the extraction and Abson recovery process as explained in the test methods:

<u>Property</u>	<u>Min</u>	<u>Max</u>	<u>Method</u>
Penetration, 100 G. 5 Sec. 77°F (25EC)	25	-	ASTM D 5
Viscosity, 275°F (135EC), Pa•s	1.2	-	ASTM D 2171
Viscosity Ratio, 275°F (135EC)	-	2.2	As Explained in Test Methods

Filler properties determined using the filler separation technique described in test methods:

<u>Property</u>	<u>Min</u>	<u>Max</u>	<u>Method</u>
Filler Content, %	50	75	As in Test Methods
Filler Fineness, %			ASTM C 430, As
45 µm	75	-	Modified in Test
75 µm	95	-	Methods
150 µm	100	-	

3. *Test Methods.*

- 3.1. Flow shall be determined according to Section 6, Flow of ASTM D 3407 with the exception that the oven temperature shall be 158°F ± 2°F (70 ± 1°C) and sample preparation shall be according to Section 7.1 of ASTM D 5.
- 3.2. Heat stability flow shall be determined according to flow with the exception that 2 pounds (1000 g) of adhesive shall be placed in a covered liter can, heated to 430°F (220°C), and maintained at this temperature for four hours prior to preparing the sample panel.
- 3.3. Viscosity is to be determined according to ASTM D 2669 using a spindle speed of 1.88 rad/s. The adhesive shall be heated to approximately 210°C and allowed to cool. Viscosity shall be determined at 400°F ± 1°F (204.4 ± 0.6°C).
- 3.4. Properties of the base asphalt are to be determined on the material obtained from the following extraction and abson recovery methods. The asphalt shall be extracted by heating the adhesive just to the point where it will easily flow and then transferring 125 to 150 g into 400 ml of trichloroethylene with a temperature of 125°F to 150°F (52 to 66°C). This mixture shall be thoroughly stirred to dissolve the asphalt. The trichloroethylene-asphalt mixture shall be decanted and the asphalt shall be recovered using the abson recovery methods, ASTM D 1856 as modified by the following. The extraction methods of ASTM D 271s shall not apply and there shall be no filtration of the solvent-asphalt mixture. The extraction solution of the trichloroethylene and asphalt shall be centrifuged for at least 30 minutes at 770 times gravity in a batch centrifuge. Decant this solution into the distillation flask, taking care not to include any filler sediment. Apply heat and bubble carbon dioxide slowly to bring the solution temperature to 300°F (149°C). At this point, the carbon dioxide flow is increased to 800 to 900 ml per minute. The solution temperature is maintained at 320 to 335°F (160 to 168°C) with this carbon

dioxide flow rate for at least 20 minutes and until the trichloroethylene vapors have been completely removed from the distillation flask. Repeat the above extraction-recovery method as necessary to obtain the desired quantity of asphalt. Use the recovered asphalt to determine penetration, 275°F (135°C) viscosity, and 275°F (135°C) viscosity ratio.

- 3.5. The 275°F (135°C) viscosity ratio shall be determined by comparing the 275°F (135°C) viscosity on the base asphalt before and after the thin-film oven test. The thin-film oven test shall be performed as in ASTM D 1754. The specific gravity shall be determined by pycnometer as in ASTM D 70 for use in the thin-film oven test. The 275°F (135°C) viscosity ratio shall be calculated by dividing the viscosity after the thin-film oven test by the original 275°F (135°C) viscosity.
- 3.6. The filler material shall be separated from the asphalt to determine filler content and filler fineness. The portion by mass of the adhesive insoluble in trichloroethylene shall be considered the filler content. Filler content shall be determined by placing 10 ± 0.01 g of solid adhesive into centrifuge flask with approximately 100 ml volume such as that specified in ASTM D 1796. Add 50 ml of trichloroethylene to the adhesive, which should be broken up into small pieces in order to speed the dissolution process. Swirl or stir with a fine rod, taking care not to lose any solids, place the sample flask in a balanced centrifuge, and spin using a minimum relative centrifugal force of 150 (as determined in Section 6 of ASTM D 1796) for 10 minutes. Remove the sample flask, and decant the solvent, taking care not to lose any solids. Repeat the application of solvent and centrifuging until the solvent becomes clear and the filler is visually free of asphalt. Dry the filler at $160^\circ\text{F} \pm 5^\circ\text{F}$ ($71 \pm 3^\circ\text{C}$) to remove solvent and determine the mass the resulting filler. Filtration of the decanted solvent may be performed to verify there is no loss of filler, percent filler content is calculated as follows:

$$\text{Filler Content, \%} = \frac{\text{Filler, g}}{\text{Original Adhesive, g}} \times 100$$

- 3.7. Filler fineness shall be determined according to ASTM C 430 using numbers 325, 200 and 100 (45, 75, and 150 μm) sieves. This method is to be modified by the use of a water-soluble non-toxic wetting agent, such as Triton X-100, to aid the wetting action. Concentration of the surfactant solution shall be approximately one percent by mass. The one-gram dry sample shall be thoroughly wetted in the surfactant solution and allowed to soak for 30 minutes. The filler shall be transferred completely into the sieve cup and waterspray applied for two minutes. Surfactant solution may be added as needed, and physical means may be used to disperse any clumped particles. The sample shall then be dried and handled as directed in ASTM C 430.
4. *Packaging and Labeling.* The adhesive shall be packaged in self-releasing cardboard containers which will stack properly. Containers shall have a maximum net mass of 120 pound (54.4 kg). The label shall show the manufacturer, quantity and lot or batch number. Bituminous adhesive for traffic markers shall be printed in bold lettering on the label.
- (c) **Sampling and Testing.** Furnish a Type D certification for each batch or lot of the materials. In addition, submit a 1 gallon (4 liter) sample of each epoxy component and/or a minimum of 10 pounds (5 kg) of bituminous adhesive for each batch or lot to the Materials Engineer for testing.

SECTION 737

CONCRETE SURFACE FINISH FOR STRUCTURES

737.01. DESCRIPTION.

This Section covers materials and testing requirements for concrete surface finishing compounds for structures.

737.02. OPTION I - HEAVY CEMENT BASE MORTAR.

(a) **Materials.**

1. Heavy cement base packaged in dry powder form for mixing with water.
 - (a) Plaster mix for plaster gun application.
 - (b) Brush and float mix for brush and float application.
2. *Bonding Agent.* A formulation of acrylic polymers and modifiers in liquid form for use as an additive with portland cement mixes to assure adhesion.

- (b) **Proportioning and Consistency.** The bonding agent and water shall be proportioned in accordance with the manufacturer's recommendations. A copy of those recommendations shall be furnished to the Engineer.

737.03. OPTION II - PAINT TYPE SPRAY FINISH.

- (a) **Materials.** Material for paint type spray finish shall be a textured commercial product designed specifically for this purpose.
- (b) **Testing and Certification.** A list of approved products is kept by the Materials Division. Other brand products may be qualified by the submission of a type A certification and samples to the Materials Division for evaluation of durability and appearance. The Department reserves the right to discontinue approval of products that prove unsatisfactory when used in accordance with the manufacturer's instructions.

Each shipment of the satisfactorily tested product shall be accompanied by a type C certificate from the manufacturer.

Material to be furnished for spray finish (option II) shall conform to the following requirements.

1. *Freeze-Thaw Cycle.* Cast and cure three concrete specimens, not less than 4 inch x 6 inch x 6 inch (101.6 x 152.4 x 152.4 mm) of the mix designed for the structure. Apply the surface finish after moist curing the specimens for 14 days and dry curing them for 24 hours in room air at 60°F to 80°F (15.6 - 26.7°C). Caution shall be taken that there be no excessive oil on specimen forms. Coat sides of specimens (brush permitted) and cure at room temperature for 48 hours, after which:
 - 1.1. Immerse in water at room temperature 60°F to 80°F (15.6°C to 26.7°C) for three hours.
 - 1.2. Place in cold storage at -15°F (-26.1°C) for one hour.
 - 1.3. Thaw at room temperature -15°F (15.6°C to 26.7°C) for one hour minimum.
 - 1.4. Repeat steps 1.2 and 1.3 to complete a total of 50 cycles.

At the end of 50 cycles of freeze-thaw test, the specimens shall show no visible defects.

2. *Accelerated Weathering.* The material shall be subjected to a 5000 hour exposure test in a twin-arc-weatherometer at an operating temperature of 145°F (62.8°C). The test shall be made at 20 minute cycles consisting of 17 minutes of light and 3 minutes of water spray plus light. At the end of said exposure test, the exposed sample must not show any chipping, flaking or peeling.
3. *Flexibility.* The material, when applied to a thin metal plate at a spreading rate to 45 ± 5 ft²/gallon (1.10 ± 0.12 m²/L) shall bend without breaking the film at an angle of 180 degrees over a 25.4 mm mandrel.
4. *Fungus Growth Resistance.* The material to be used shall pass a fungus resistance test as described by Federal Specification TT-P-29b with a minimum incubation period of 21 days where no growth shall have been indicated after the test.
5. *Abrasion Test.* When tested for abrasion resistance in accordance with ASTM C418, the loss shall not be greater than 0.5 cm³/cm²
6. *Salt Spray Resistance.* The material, when applied to concrete at a rate of 50 ft²/gallon (1.23 m²/L) and tested in accordance with ASTM B117 with the coating exposed to a 5 percent sodium chloride (salt solution) for 300 hours and maintained at 90°F \pm 2°F (32.2 \pm 1.1°C) during the period of exposure, shall show no loss of adhesion or deterioration at the end of the 300 hours exposure to the salt spray.

SECTION 738 ELECTRICAL CONDUCTORS

DESCRIPTION. This section covers the requirements of materials for electrical conductors of the size, type and the locations shown on the Plans or established by the Engineer in Section 811 and 834.

738.01. TRAFFIC SIGNAL WIRE AND CABLE.

- (a) Traffic and Signal Electrical Cable shall comply with the requirements of the International Municipal Signal Association (IMSA) Specifications No. 19-1 or No. 20-1. The conductors shall be copper No. 14 AWG, unless otherwise shown on the Plans.
- (b) Shielded Loop Detector Lead-In Cable shall comply with the requirements of IMSA No. 50-2. The conductors shall be copper No. 14 AWG, unless otherwise shown on the Plans.
- (c) Loop Detector Wire shall comply with the requirements of IMSA No. 51-1 or IMSA No. 51-3 except, when specified on the Plans, IMSA No. 51-5 shall be used. The conductors shall be copper No. 14 AWG, unless otherwise shown on the Plans.

738.02. BUILDING AND SECONDARY DISTRIBUTION WIRE AND CABLE.

- (a) All conductors shall be copper and standard AWG sizes, unless otherwise shown on the Plans.
- (b) Building Wire and Cable shall comply with the applicable requirements of ASTM B 3, ASTM B 8, ASTM B 33, the National Electric Code (NEC) and be rated for 600 volts, unless otherwise specified on the Plans.

- (c) Underground Secondary Distribution Wire and Cable shall comply with the requirements of the Insulated Cable Engineers Association (ICEA)/National Electrical Manufacturers Association (NEMA) Standard Publication S-61-402/WC 5 or ICEA/NEMA Standard Pub. No. S-66-524/WC 7, unless otherwise shown on the Plans.
- (d) Outdoor Aerial Neutral-Supported Secondary Distribution Wire and Cable shall comply with the requirements of ICEA/NEMA Standard Publication S-66-524/WC 7, unless otherwise specified on the Plans.

SECTION 739

PULL BOXES

739.01. PRECAST CONCRETE PULL BOXES.

Concrete pull boxes shall conform reasonably closely to the dimensions shown on the Plans and to the following materials requirements:

Portland Cement. Portland cement shall meet the requirements of Subsection 701.02.

Aggregate. Aggregate shall meet the quality requirements of Section 701 or of ASTM C 330 for Lightweight Aggregate.

Reinforcement. Welded wire fabric shall comply with Subsection 723.03.

Gray Iron Casting Cover. Gray iron casting covers shall comply with Subsection 725.04. The cover shall have a nonslip surface and two 3/8 inch (9.5 mm) pent head brass bolts and nuts to secure it to the box.

Concrete. The concrete mixture shall be designed to produce 3000 psi (20.67 MPa) strength in accordance with AASHTO T 23 and AASHTO T 22.

739.02. PRECAST REINFORCED PLASTIC PULL BOXES.

- (a) **General.** Plastic pull boxes shall conform reasonably closely to the dimensions shown on the Plans and to the following materials requirements:

The reinforced plastic mortar shall be composed of a borosilicate type glass fiber in the form of woven fabric, chopped strand or mat, catalyzed polyester resin, and an aggregate.

Plastic pull boxes shall have the following design characteristics. The cover shall have an embossed nonskid surface and be equipped with two 3/8 inch (9.5 mm) pent head brass bolts and nuts to secure it to the box. The box and cover shall be concrete gray in color. The pull boxes shall be capable of withstanding the following loads.

1. *Cover:* 5000 pounds (2,268 Kg) distributed over a 10 x 10 inch (254 x 254 mm) area centered on the cover and shall withstand without puncture or splitting, a 75 ft •lb (101.6 NCm) impact load from a 12 pound (5.44 Kg) mass having a "C" tip in accordance with ASTM D 2444.
2. *Box walls:* 5000 pounds (2,268 Kg) vertical load distributed over a 10 x 10 inch (254 x 254 mm) area centered over an exposed edge of the box with the cover in place.
3. *Lateral Loads:* 5000 pounds (2,268 Kg) distributed over a 10 x 10 inch (254 x 254 mm) area of backfill immediately adjacent to the box with the box in the installed condition and without the cover in place.

Deflections resulting from loads imposed under the above mentioned tests shall in no case cause binding of the cover or displacement from the extension.

- (b) **Plastic Material.** Plastic materials shall be self-extinguishing when tested in accordance with ASTM D 635 and show no appreciable change in physical properties when exposed to the weather.
- (c) **Certification.** Submit a type A certification for each lot or shipment of precast reinforced plastic pull boxes.

SECTION 740

TRAFFIC SIGNAL BACKPLATES

740.01. DESCRIPTION.

This section covers the material requirements for traffic signal backplates.

- (a) **Materials.** Backplates shall be constructed from sheet material of polycarbonate or acrylonitrile-butadiene-styrene (ABS). Backplates shall be vacuum formed.
 - 1. Polycarbonate sheet material shall conform to the requirements of ASTM D 638, D 695, D 790 and D 1822.
 - 2. ABS sheet material shall conform to ASTM D 1788.
 - 3. The thickness of the backplates shall be as shown on the Plans.
- (b) **Finish.** The backplate shall be black in color with a haircell finish on the front side and smooth finish on the back side.
- (c) **Certification.** Submit a type A certification for each lot or shipment of backplates.

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TRAFFIC CONTROL FACILITIES

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SECTION 801 HIGHWAY LIGHTING, SIGNALS, AND SIGNING-ELECTRICAL

801.01. DESCRIPTION.

This work consists of furnishing all labor, equipment, appliances, and materials, and performing all operations in connection with the installation of

- highway lighting systems
- traffic signal systems, or
- *highway sign lighting systems*

in accordance with these Specifications and the Plans, or as established by the Engineer.

All electrical work shall conform to the requirements of the National Electric Code (NEC) except where superseded by these Specifications.

The highway lighting system shall be complete with all necessary accessories for proper operation. Transformers, disconnecting devices, protective devices, luminaires, and all other equipment shall be coordinated to secure the required result.

The traffic signal system shall be complete with all necessary accessories for proper operation. Controllers, signal heads, detectors, push buttons, synchronizing devices, time clocks, and all other equipment shall be coordinated to secure the required result.

The highway sign lighting system shall be complete with all accessories, including the sign lights either permanently connected to power or left in such condition as the Plans indicate ready for future connection to power.

801.02. MATERIALS.

Within 30 days after receiving notice to proceed, submit five copies of a complete schedule of materials and equipment proposed for installation to the Engineer for review and approval. Include catalog cuts, diagrams, drawings, and such other descriptive data as may be necessary to satisfy the Engineer that the requirements of the Specifications will be met.

Upon completion of the work on traffic signal systems, deliver the manufacturer's instruction manual for the maintenance, timing, and operation of all traffic control equipment to the Engineer.

Also furnish a complete wiring diagram of the signal system and components—and a parts list sufficient for the ordering of any part of the equipment furnished—with each controller.

NOTE: Where galvanizing on hardware is specified, it shall comply with AASHTO M 232, Class C coating.

The electrical and mechanical equipment furnished and used shall be new, standard, manufactured products. All units of the same class of equipment shall be products of a single manufacturer.

Supply guarantees and warranties as specified in Subsection 106.12.

801.04. CONSTRUCTION METHODS.

The locations of the electrical energy supply shown on the Plans are approximate only. Exact locations will be determined in the field.

- (a) **Connections.** Make the necessary arrangements with the serving utility to complete the service connections. The connection to the primary system will be made by others.

The highway lighting electrical energy supply and circuits will be as follows, unless otherwise specified: 60 cycle, 480 volt, single phase. Also, they must be multi-grounded neutral for multiple connection of luminaires, with automatic photoelectric control to turn the highway lights on at dusk and off at dawn. The 480-volt lighting circuits must each be supplied from a primary system through a distribution transformer and control equipment.

The traffic signal electrical energy supply and circuits will be 60-cycle, single-phase, 120-volt power, unless otherwise specified.

The highway sign lighting electrical energy supply and ballasts will be 60-cycle, single-phase, 480-volt power.

- (b) **Bonding and Grounding.** Secure conduit, poles, and cabinets mechanically and electrically to form a continuous system, and effectively ground them.

Bond and ground jumpers using at least No. 10 AWG copper wire or better for all systems.

Ground poles using at least No. 8 AWG copper wire or better, securely attached to the pole and the ground rod, as shown on the Plans.

At each service location, use grounding conductors of conduit and neutral that are at least No. 6 AWG copper wire.

- (c) **Existing Traffic Signal Equipment Removal.** Remove all existing traffic signal equipment and store it at a site designated by either the owner or the Engineer.

Remove such equipment with as little damage as possible.

Remove poles wholly; cut anchor bolts, protruding conduit, and the like flush with the final ground level.

Remove wiring from underground conduit.

Leave footings, pull boxes, and underground conduit in place.

Include labor and equipment costs necessary to complete such removal in the contract unit price for other items unless otherwise provided for on the Plans.

Do not remove normally existing signal equipment or make it wholly inoperative until the the 24-hour test period of the new equipment has been completed satisfactorily and the new system is approved for continued use.

- (d) **Covering of Signal Indications.** Before putting new signal equipment into operation, completely cover the new signal heads with an all-weather bag—with the exception of pedestrian WALK-DON'T WALK indications.

NOTE: At no time shall the new system and existing system be visible to traffic at the same time.

- (e) **Testing.** Test equipment in accordance with Section 805.

SECTION 802

ELECTRICAL CONDUIT

802.01. DESCRIPTION.

This work shall consist of furnishing and installing all the electrical conduit, junction boxes, fittings, expansion devices, and miscellaneous hardware necessary to complete the electrical conduit system in accordance with these Specifications and the Plans. The location of the conduit, junction boxes, etc., as shown on the Plans, is diagrammatic and may be subject to adjustment as the Engineer may direct in order to conform to existing field conditions.

802.02. MATERIALS.

- (a) **Conduits and Fittings.** Conduits and fittings shall meet the requirements of Section 709.
- (b) **Junction Boxes.** Junction boxes shall be of the size and type shown on the Plans and shall be furnished with gasket and cover.

Oversized condulets may be used in lieu of junction boxes when installed in conjunction with exposed conduit systems if an adequate splicing chamber can be provided and when approved by the Engineer.

Condulets may NOT be used when the branch circuit is shown to be fused.

All materials furnished shall be new and of approved quality and workmanship.

802.04. CONSTRUCTION METHODS.

- (a) **General.** Install conduit in accordance with the codes and regulations listed in Section 801 and these Specifications, unless they are in conflict; in that case, carry out the installation in compliance with 1) the requirements herein stated and 2) the details shown on the Plans. Make conduit runs as direct as possible, using conduit of the minimum sizes shown on the Plans.

NOTE: You may, at your option and expense, use conduit of a larger size provided the larger size is used for the entire length of the run from outlet to outlet. Do not use slip joints or running threads for coupling conduit. When a standard coupling cannot be used for coupling metal-type conduit, use an approved threaded union coupling.

Ream the ends of all conduits—whether shop or field cut—to remove burrs and rough edges. Make cuts square and true so that the ends will butt together for the full circumference.

For metal-type conduit, tighten couplings until the ends of the conduits are brought together. Do not leave exposed threads.

For nonmetallic-type conduit connections, use the solvent weld type.

When galvanized conduit surfaces have been damaged to the extent that bare metal is exposed, regalvanize, metalize, or paint them with an approved zinc dust-oxide paint.

Thread and cap all metal-type and nonmetallic-type conduit ends with standard pipe caps until wiring is started. When caps are removed, provide the threaded ends with conduit bushings. Also

cap all conduit installed for future use, unless it terminates in a junction box or other electrical enclosure.

Factory conduit bends shall be in accordance with requirements of the NEC. Where factory bends are not used, bend conduit, without crimping or flattening it, using the longest centerline radius practicable but not less than six times the inside diameter of the conduit.

Conduit installed in concrete pole bases, structures, or pedestals shall extend not more than 2 inches (50mm) vertically above the footing.

Conduit entering through the side of pull boxes shall extend not more than 2 inches (50 mm) inside the box wall and not be less than 4 inches (100 mm) above the bottom, and shall be sloped toward the top of the box to facilitate pulling of conductors.

Conduit entering through the bottom of a pull box shall extend a minimum of 4 inches (100 mm) above the bottom and shall be located near the end walls to leave the major portion of the box clear.

Use nipples to eliminate cutting and threading where short lengths of conduit are required.

NOTE: No conductor shall be installed in the conduit system until all other work that might damage the conductors has been completed.

When existing underground conduit is to be incorporated into a new system, clean it and blow it out with compressed air.

- (b) **Pushed or Bored Conduit.** Place the conduit under existing pavement by approved pushing or boring methods. Do not disturb the pavement without permission from the Engineer. Keep pushing or boring pits at least 2 feet (0.60 m) clear of the edge of any type of surfaced area whenever possible.

NOTE: Excessive use of water, such that the pavement might be undermined or the subgrade softened, will not be permitted. If pits are to be left overnight, cover them with substantial planking, and mark them in a manner approved by the Engineer.

All pushed conduits shall be rigid metal. Bored conduit may be rigid metal or nonmetallic. For rigid, nonmetallic type conduit, predrill a hole larger than the conduit and install it by hand.

Unless otherwise shown, install bored or pushed conduits a minimum depth of 30 inches (0.80 m) below top of ground line.

Where conduit passes under a surfaced area, cut an "X" in the curb and/or surfacing above the conduit crossings for future relocating purposes.

- (c) **Trenched Conduit and Backfilling.** Conduit installed in a trench shall be of the type specified on the Plans. Excavate trenches deep enough to provide for 30 inches (0.80 m) minimum cover over the conduit, unless otherwise specified. Do not use cinders, broken concrete, or other hard or abrasive materials in backfilling. Also, clear the trench of such materials before the conduit is placed.

NOTE: Conduit shall not be placed prior to inspection of the trench by the Engineer.

Excavate immediately before installing the conduit, placing the material in a position where there is the least damage and obstruction to vehicular and pedestrian traffic and the least interference with the surface drainage. Be careful not to excavate the trenches wider than necessary for the proper installation of the electrical conduits or cables.

Dispose of all surplus excavated material in a manner approved by the Engineer.

When rock is encountered during trenching and the required trench depth cannot be attained, alter the trench depth or location at the discretion of the Engineer. The minimum trench depth shall be 1 foot (0.30 m).

Backfill all trenches with acceptable material as soon as possible after installation of conduit; deposit the backfill material in the trench in layers not to exceed 6 inches (150 mm) in depth.

NOTE: The first layer shall be free of rocks and compacted, and each successive layer shall be compacted before the next layer is placed

Compact backfill to not less than 95 percent standard density in accordance with Subsection 106.03.

Reconstruct all disturbed surfaced areas, base materials, and sodded areas using replacement materials of equal or better quality; this is to be done at the expense of the Contractor and to the satisfaction of the Engineer.

Whenever a part of an existing concrete sidewalk or driveway is broken or damaged, remove the entire square or slab unless otherwise specified by the Engineer, and reconstruct the concrete as specified above. Remove pavement in accordance with Section 619.

- (d) **Exposed Conduit.** When conduit is to be installed on the surface of structures, poles, or other exposed locations, use rigid metal-type unless otherwise specified.

Run surface-mounted conduit straight and true, so that it's horizontal or vertical on the surface of the structure or pole. Support it at intervals of not more than 5 feet (1.50 m), unless otherwise specified, using galvanized malleable iron conduit clamps and bolts with expansion shield anchor devices approved by the Engineer.

NOTE: Lag or machine bolt shields and percussion driven anchors in concrete or masonry will not be accepted.

Use only approved supporting devices for conduit that's attached to structural steel members.

- (e) **Conduit in Concrete Structures.** For concrete structures, use rigid metal- type conduit, unless otherwise specified. When the conduit crosses an expansion joint in the structure, install an expansion device of the type and size shown on the Plans.

Junction boxes installed in or on structures shall be of the size and type shown on the Plans.

802.05. METHOD OF MEASUREMENT.

Electrical conduit of the size and type specified will be measured by the linear foot (meter) along the centerline of the installed conduit from end to end, and shall include all flexible steel conduit, fittings, outlets, entrance caps, pull wires, condulets, expansion devices, and other miscellaneous hardware necessary to complete the conduit system. Each size and type of conduit shall constitute a separate pay item, unless otherwise provided. Unless otherwise provided, trenching and backfilling will not be measured for payment. *Junction boxes* installed in structures shall be measured by each unit installed, if so specified in the Plans.

802.06. BASIS OF PAYMENT.

Accepted quantities of electrical conduit, measured as provided above, will be paid for at the contract unit price as follows:

- | | | |
|-----|---|---------------------|
| (A) | GALVANIZED STEEL ELECTRICAL CONDUIT | LINEAR FOOT (METER) |
| (B) | PLASTIC CONDUIT | LINEAR FOOT (METER) |
| (C) | ALUMINUM CONDUIT | LINEAR FOOT (METER) |
| (D) | JUNCTION BOX | EACH |

Such payment shall be full compensation for furnishing all materials, equipment, labor, and incidentals to complete the work as specified.

SECTION 803 PULL BOXES

803.01. DESCRIPTION.

This work shall consist of furnishing materials and installing the pull boxes in accordance with these Specifications and in reasonably close conformity with the locations and dimensions shown on the Plans or established by the Engineer.

803.02. MATERIALS.

Materials used shall meet the requirements specified in the following Subsections of Section 700 - Materials:

Concrete Pull Boxes	739.01
Plastic Pull Boxes	739.02

803.04. CONSTRUCTION METHODS.

Pull boxes shall be of the sizes shown on the Plans and as herein specified. The pull box locations may be revised to fit existing field conditions or to better facilitate the installation of the conduit system with approval of the Engineer.

- (a) **Installation.** Install all pull boxes on a bed of crushed rock as shown on the Plans.

When installing pull boxes in sidewalks or other surfaced areas, make the tops of pull boxes flush with the finished surface. When practical, place pull boxes shown in the vicinity of curbs adjacent to the back of the curb and flush with the top of the curb.

When installing pull boxes in the ground, make the tops of the pull boxes flush with the top of the ground or no greater than 1 inch (25 mm) above the ground. Provide all pull boxes not installed in surfaced areas with concrete aprons, unless otherwise specified by the Engineer. Include aprons in the cost of pull boxes.

Install conduits entering pull boxes as shown on the Plans and in accordance with Section 802. When called for on the Plans, provide pull box extensions of the same material as the pull box and attach it to the pull box so that it will maintain the required depth without separation of the assembly.

- (b) **Cover and Markings.** Mark pull box covers with the appropriate legend of “Highway Lighting” or “Street Lighting” when they’re used for lighting conductors only, or “Traffic Signal” when they’re used for traffic signal conductors with or without lighting conductors. Make the letters between 1 inch and 3 inches (25 and 75 mm) tall. Cast the legend with the cover so that it’s clearly defined, of uniform depth or height, and placed parallel to one side of the cover. When the conductor voltage is greater than 600 volts, add the words “High Voltage.”

Equip the cover, which shall have a non skid surface, with a recessed molded lifting eye and recess hold-down bolts.

- (c) **Ground Rod.** If specified, install a copperweld ground in accordance with the details and at the locations shown on the Plans.

803.05. METHOD OF MEASUREMENT.

The *pull boxes* of the size and type specified will be measured by each unit installed. Each pull box unit shall include cover, extension, ground rod, concrete apron, crushed rock, excavation, and backfilling, necessary to construct and install pull boxes as shown on the Plans.

803.06. BASIS OF PAYMENT.

Accepted pull boxes, measured as provided above, will be paid for at the contract unit price as follows:
 PULL BOX.....EACH

Such payment shall be full compensation for furnishing all materials, equipment, labor, and incidentals required to complete the work as specified.

**SECTION 804
 CONCRETE FOOTINGS**

804.01. DESCRIPTION.

This work shall consist of furnishing materials and installing concrete footings for traffic control devices in accordance with these Specifications and in reasonably close conformity with the locations and dimensions shown on the Plans or established by the Engineer.

804.02. MATERIALS.

Materials used shall meet the requirements specified in the following Sections of Section 700-Materials and AASHTO Specifications:

Portland Cement Concrete, Class A	701
Reinforcing Steel	723
Electrical Conduit	709
Anchor Bolts and Nuts	AASHTO M 183
Galvanizing (Bolts, Nuts & Washers)	AASHTO M 232

804.04. CONSTRUCTION METHODS.

- (a) **Footings.** Construct concrete footings in accordance with Section 509 so that they rest on firm ground with the top of the footing level, to minimize the amount of shimming required later. Construct them in place as required on the Plans and to the grade established by the Engineer. When an obstruction prevents the construction of a footing at the planned location, construct it at a location established by the Engineer.

NOTE: The footing shown on the Plans may be modified if conditions require. Such modification, if ordered by the Engineer, will be paid for according to Subsection 109.03 or by the adjusted quantities of materials required—i.e., concrete and reinforcing steel.

- (b) **Anchor Bolts.** Use anchor bolts of the size and quantity shown on the Plans. Locate them accurately and securely in the footing by means of a template. Anchor bolts shall have the top exposed portion plus 6 inches (150 mm) both galvanized and threaded, as shown on the Plans. Supply each anchor bolt with galvanized hex head nuts plus flat washers and lock washers as shown on the Plans.

NOTE: Do not weld on any portion of the body of the anchor bolt.

- (c) **Conduits.** When conduit must be installed as part of the footing, it shall be of the quantity, size and type as shown on the Plans. Locate conduit couplings at least 6 inches (150 mm) from the face of the footing. The conduit required in the footing will be paid for in the cost of other materials in the footing.
- (d) **Ground Rod** If copperweld ground rod is required, it shall be of size shown in the Plans.
- (e) **Poles, Posts, or Breakaway Bases.** Do not erect poles, posts, or breakaway bases until the foundation has set at least 72 hours unless they are required to be set directly into the footing.

After the footing has been completed, restore the surrounding area to an acceptable appearance.

804.05. METHOD OF MEASUREMENT.

Concrete footings of various sizes and shapes will be measured by the cubic yard (cubic meters) of concrete and pounds (kilograms) of *reinforcing steel* required. The footing unit shall also include anchor bolts, nuts, washers, ground rod, conduit, all labor, tools, equipment, excavation, backfilling, and incidental work necessary to construct the footing as shown on the Plans.

804.06. BASIS OF PAYMENT.

Accepted concrete footings, measured as provided above, will be paid for at the contract unit price as follows:

- (A) STRUCTURAL CONCRETE CUBIC YARD (CUBIC METER)
 (B) REINFORCING STEEL POUND (KILOGRAM)

Such payment shall be full compensation for furnishing all materials, equipment, labor, and incidentals to complete the work as specified.

SECTION 805 ELECTRICAL-MECHANICAL PERFORMANCE AND OPERATIONAL TESTS

805.01. DESCRIPTION.

This work shall consist of furnishing all the necessary equipment, tools, and labor required to perform the tests specified within this Specification or as directed by the Engineer.

805.03. EQUIPMENT.

Furnish all the necessary specialized test equipment, tools, electrical diagrams, and labor required to perform the tests specified.

805.04. CONSTRUCTION METHODS.

- (a) **General.** Notify the Engineer not less than 48 hours prior to the beginning of the testing procedures. The Engineer shall notify the city, county, or other agency responsible for supplying the electrical power for testing procedures.

- (b) **Electrical Field Testing.** Prior to the start of functional testing, perform the following tests on all traffic signal, sign lighting, and highway lighting circuits, in the presence of the Engineer; include the written results in the project file:

Tests each circuit for continuity.

Test each circuit for grounds.

Make an insulation resistance test at 50 volts DC on each circuit between the circuit and ground.

Make sure the insulation resistance is not be less than 10 megohms on all circuits.

NOTE: Ground rods, after installation, shall not have a resistance to ground in excess of 25 ohms. Do not perform the insulation resistance test on magnetometer detector devices. Also, do not make splices in the conduit or junction box adjacent to the magnetometer prior to performing the test on the lead-in conductors between the splices and the controller cabinet field terminals.

- (c) **Electrical Functional Tests.** Notify the appropriate governmental agency at least 24 hours in advance of commencing the functional tests of a traffic signal system, in order that adequate precautions may be taken with respect to traffic service on the street system. Where traffic is being maintained through the project, make every effort to insure the safe movement of vehicles during this testing period.

NOTE: At no time shall the new system and an existing system be in operation at the same time.

To determine that all parts of the system are functioning properly, operate highway lighting systems—both conventional and high mast—and traffic signal systems for a 24-hour continuous period. Put the electrical system into service and patrol it immediately to ascertain if there are any defects. During the test period, inspect the system at intervals established by the Engineer. In addition, at some time during this test, throw all safety switches to check their operation, and sometime during the night-time portion of the test, switch all photoelectric controllers from auto to manual and back to auto, to observe the action of the photoelectric controller.

At the end of the 24 hours of continuous operation, again inspect the complete electrical system to see that everything is operating normally and prove to the satisfaction of the Engineer that all fixtures and equipment have been properly installed and are in operating condition.

Test all sign lighting systems, flashing beacons, and electro-mechanical changeable message signs in accordance with the test above, if they are connected to either the highway lighting system or to independent power sources. If they are not permanently connected to power at the time of installation, provide temporary power to each device and demonstrate, to the satisfaction of the Engineer, that they are properly installed and functioning as intended.

- (d) **Mechanical Test.** Following the successful completion of the 24-hour functional test, allow all high-mast lighting systems to operate normally for six days. During these 6 days, observe the system at night time for any defects in the luminaire or lamps. Demonstrate to the Engineer that each lowering device assembly is functioning properly by completing one lower and raise cycle on each assembly.
- (e) **Defects.** The above tests are to show that the luminaires, lamps, wiring, controllers, and related equipment have been properly installed and are in a satisfactory operating condition. Correct any defects to the satisfaction of the Engineer.

805.05. METHOD OF MEASUREMENT.

The tests specified will not be measured for payment. Include all costs of performing these tests in other items of work.

SECTION 806 POLES AND MAST ARMS

806.01. DESCRIPTION.

This work shall consist of furnishing materials and installing poles, mast arms, and pedestal poles for traffic signals, as well as highway lighting luminaires, in accordance with these Specifications and in reasonably close conformity with the locations and dimensions shown on the Plans or established by the Engineer.

806.02. MATERIALS.

Materials shall meet the requirements specified in AASHTO Standard Specifications for Structural Supports of Highway Signs, Luminaires, and Traffic Signals, and Section 700 of these Specifications.

806.04. CONSTRUCTION METHODS.

- (a) **General.** The design of the poles and mast arms shall be the responsibility of the manufacturer. The poles and mast arms shall be designed for a minimum of 80 mph (128 km/hr) wind velocity and shall meet all other design requirements of AASHTO Standard Specifications for Structural Supports for Highway Signs, Luminaires and Traffic Signals.

Calculated stresses from design loading on poles and arms shall not exceed 50,000 psi (344.8 MPa) or 85 percent of ASTM yield strength, whichever is smaller. Certification shall be required that the material in poles meets the applicable ASTM specification for stress range the poles are designed to operate within. Minimum thickness of traffic signal steel poles and mast arms materials shall be 7 gauge.

The manufacturer shall submit shop and design drawings, and calculations in accordance with Subsection 105.02.

Mast arms may be mounted to the pole prior to erection of the pole. Take care not to damage the pole, mast arm, or finish during erection. If the finish is damaged, repair it at no additional cost in a manner approved by the Engineer.

Level anchor base poles with nuts or shims. If double nut leveling is used, fill the space between the concrete foundation and the pole base with a nonshrink grout.

Install all fasteners in accordance with the manufacturer’s specifications.

Cast all structural castings in permanent molds.

(b) **Poles.** The nominal mounting height of the luminaire or traffic signal shall be as shown on the Plans. All poles, with the exception of pedestal poles, shall be uniformly taper poles— either round or multisided— from bottom to top. Pedestal poles may be without taper. Make sure poles are straight and centered on the longitudinal axis. , Unless otherwise specified, furnish each pole with a reinforced handhole and weatherproof cover. Install a removable pole cap on each shaft (except pedestal poles). Provide all metallic poles with a grounding connection inside the base of the shaft, and ground them as shown on the Plans. Anchor bases may be either cast or structural plate.

(c) **Mast Arms.** The mast arm shall be of the length shown on the Plans.
Design luminaire mast arms to support the weight of a 75 pound (34 kg) luminaire with a projected area of 3.3 square feet (0.30 square meters), and provide a smooth raceway for the wiring, supplying each with a slip-fitter tenon. Design traffic signal mast arms to support the required signal heads, as shown on the Plans.

806.05. METHOD OF MEASUREMENT.

Poles and mast arms, pedestal and post top poles of various types, sizes, and lengths will be measured by each unit installed.

806.06. BASIS OF PAYMENT.

The accepted poles and mast arms, measured as provided above, will be paid for at the contract unit price as follows:

- (A) TRAFFIC SIGNAL POLE AND MAST ARM EACH
- (B) TRAFFIC SIGNAL PEDESTAL POLE EACH
- (C) HIGHWAY LIGHTING POLE AND MAST ARM EACH
- (D) HIGHWAY LIGHTING POST TOP POLE EACH

Such payment shall be full compensation for furnishing all materials, equipment, labor, and incidentals to complete the work as shown on the Plans and these Specifications.

SECTION 807 BREAKAWAY BASES - HIGHWAY LIGHTING

807.01. DESCRIPTION.

This work shall consist of furnishing materials and installing breakaway bases in accordance with these Specifications and in reasonably close conformity with the locations and dimensions shown on the Plans or established by the Engineer.

807.02. MATERIALS.

Materials used shall meet the requirements of the following Specifications:

Cast Aluminum	ASTM B 26 or ASTM B 108 Alloy SG 70A T6 or Alloy 356F
Bolts, Nuts and Washers	Subsection 724.02
Adapter Plates	AASHTO M 183
Galvanized Hardware	AASHTO M 232
Galvanized Plates	AASHTO M 111

Breakaway bases furnished shall comply with AASHTO Standard Specifications for Structural Supports for Highway Signs, Luminaires, and Traffic Signals, and be listed as approved by the FHWA.

807.04. CONSTRUCTION METHODS.

Cast all cast aluminum transformer bases in a permanent mold, providing each with an approved plastic door.

Provide a bolt circle at the bottom of each base to match the bolt circle of the concrete footing, and a bolt circle at the top of the base to fit the bolt circle at the base of the pole.

The pole base shall not be larger than the top flange of the transformer base. Furnish the transformer base with four galvanized anchor washers 1/2 inch (13 mm) thick minimum, and shape it to conform to the bottom flange of the base. The top and bottom flanges of the base may be supplied with slotted anchor bolt holes. Provide each base with four machine bolts, four nuts, eight flat washers, and four lock washers—all galvanized—for connecting to the pole. These bolts shall be nominal 1 inch (25 mm) diameter for poles 40 foot (12.2 m) mounting height and less, and 1 1/4 inch (32 mm) nominal diameter for poles longer than 40 foot (12.2 m), up to and including 50 foot (15.2 m) mounting height. Level breakaway base poles only by use of shims.

NOTE: Double nut leveling shall not be allowed.

807.05. METHOD OF MEASUREMENT.

The *breakaway base* of the size and type specified will be measured by each unit installed and shall include all nuts, bolts, washers, or adapter plates and other miscellaneous hardware.

807.06. BASIS OF PAYMENT.

Accepted quantities of breakaway bases, measured as provided above, will be paid for at the contract unit price as follows:

BREAKAWAY BASE EACH

Such payment shall be full compensation for furnishing all materials, equipment, labor and incidentals required to complete the work as specified.

**SECTION 808
PIER MOUNTED POLE BRACKETS**

808.01. DESCRIPTION.

This work shall consist of furnishing materials and installing pier mounted pole brackets in accordance with these Specifications and in reasonably close conformity with the locations and dimensions shown on the Plans or established by the Engineer.

808.02 . MATERIALS.

Materials shall meet the requirements of the following Specifications.

Structural Steel	Section 724
Galvanizing	AASHTO M 111
Conduit	Section 709
Bolts, Nuts and Washers	Subsection 724.02

808.04. CONSTRUCTION METHODS.

Construct the brackets and install them on bridge piers in accordance with the details shown on the Plans. After all fabrication—such as cutting, welding, drilling, or punching—has been completed, galvanize the brackets.

808.05. METHOD OF MEASUREMENT.

Pier mounted pole brackets of the size and type specified will be measured by each unit installed and shall include all materials and hardware.

808.06. BASIS OF PAYMENT.

Accepted quantities of pier mounted pole brackets, measured as provided above, will be paid for at the contract unit price as follows:

PIER MOUNTED POLE BRACKET EACH

Such payment shall be full compensation for furnishing all materials, equipment, labor, and incidentals required to complete the work as specified.

SECTION 809 LUMINAIRES

809.01. DESCRIPTION.

This work shall consist of furnishing materials and installing roadway and sign lighting luminaires of various sizes and types in accordance with these Specifications and in reasonably close conformity with the locations and dimensions shown on the Plans or established by the Engineer

809.02. MATERIALS.

All materials furnished, fabricated, assembled, or installed under these Specifications shall be in strict accordance with the details shown on the Plans. The luminaires shall consist of a housing, ballast, reflector, refractor, and lamp of the type and lumen rating specified on the Plans.

The luminaires furnished by the manufacturer shall meet IES standards for the size and type of luminaire specified on the Plans. The manufacturer shall provide photometric test data for each size and type of luminaire to be installed, certified to be conducted in accordance with testing procedures approved by IES.

809.04. CONSTRUCTION METHODS.

Carry out the installation of the luminaires in conformance with the details shown on the Plans.

If specified on the Plans, equip the luminaires with a cut-off visor.

809.05. METHOD OF MEASUREMENT.

Luminaires of the size and type specified will be measured by each unit installed and shall include all materials and hardware.

809.06. BASIS OF PAYMENT.

Accepted luminaires, measured as provided above, will be paid for at the contract unit price as follows:

- | | |
|-----------------------------------|------|
| (A) ROADWAY LUMINAIRE | EACH |
| (B) UNDERPASS LUMINAIRE | EACH |
| (C) POST TOP LUMINAIRE | EACH |
| (D) OVERHEAD SIGN LUMINAIRE | EACH |
| (E) HIGH MAST LUMINAIRES | EACH |
| (F) NAVIGATIONAL LIGHT | EACH |

Such payment shall be full compensation for furnishing all materials, equipment, labor and incidentals required to complete the work as specified.

SECTION 810 POWER SUPPLIES

810.01. DESCRIPTION.

This work shall consist of furnishing materials and installing power supply systems of the various types in accordance with these Specifications and in reasonably close conformity with the locations and dimensions shown on the Plans or established by the Engineer.

Temporary lighting service shall be used to provide electrical power to the existing highway lighting system and all temporary lighting installed as called for in the plans. All existing lighting circuits and temporary lighting shall operate from this temporary lighting service. The temporary lighting service shall be metered and the Contractor shall be reimbursed for the cost of electricity to power the temporary service pole(s).

810.02. MATERIALS.

Materials used shall meet the requirements specified in the following Subsections of these Specifications or as otherwise specified.

Wood Poles	American National Standards Institute 05.1
Electrical Conduit and Fittings	Section 709
Portland Cement Concrete, Class A	Section 701
Reinforcing Steel	Section 723
Conductors	Subsection 811.02

All miscellaneous pole line hardware required to complete the installation as planned shall be standard material manufactured for pole line construction. All metal parts shall be hot-dipped galvanized, or other noncorrosive metals.

Control equipment shall conform to NEMA Specifications, as applicable.

810.04. CONSTRUCTION METHODS.

The construction of power supplies shall be in accordance with National Bureau of Standards Handbook 81 Safety Rules for the Installation and Maintenance of Electric Supply and Communication Lines. When in conflict, these Specifications shall supersede. Cooperate with the local utility company in locating, installing, and connecting all power supplies. Also, contact local "excavator alert" organizations prior to trenching or boring operations.

- (a) **Voltage and Construction Specifications.** The voltage for the permanent or temporary service pole(s) shall be as shown on the plans.
- Concrete construction shall be in accordance with Section 509.
- Reinforcing steel construction shall be in accordance with Section 511.

- (b) **Temporary Power Supplies.** The temporary lighting service shall supply electricity for, but not be limited to, the following:
1. Temporary lighting on wood poles. Supply electrical service for the temporary lighting of traffic control crossovers, points of conflict, and /or other locations as determined and approved by the Engineer.
 2. Existing lighting circuits. Keep the existing lighting systems within the project in operation. In the event an existing lighting system is disrupted due to construction, use additional temporary lighting on wood poles to supplement the existing lighting at these locations.
 3. New permanent lighting circuits. Use the temporary lighting service and the temporary service pole(s) to supply electricity during the construction to both the temporary lighting poles and the new permanent lighting circuits. Upon completion of the project, connect the permanent service pole to the new permanent lighting circuits. Install the permanent electrical service for the new highway lighting systems as shown on the plans. These new permanent lighting circuits include conventional highway lighting poles, high-mast towers, underpass lighting, and overhead sign structure lights.

For the temporary service pole, arrange for all the electrical power connections for the temporary lighting to be made as soon as construction allows. Arrange power connections for the locations not identified on the traffic control plans through the local utility company, with the approval of the Engineer.

The temporary lighting system shall be erected and energized, as well as deactivated and removed, at various stages of the traffic control plans as specified on the plans, in these specifications, or as otherwise directed or approved by the Engineer.

The suggested spacing of the temporary lighting on wood poles is approximately 150 feet (50 m) or as specified in the plans. Protect these light poles from motorists in a manner approved by the Engineer.

NOTE: Do not use aerial conductors to connect power temporarily or permanently to light poles having breakaway bases.

Install the temporary light poles and temporary service pole(s) and repair any damage inflicted during the installation, relocation, and/or removal of these items. In addition, maintain the existing permanent, new permanent, and temporary lighting systems—including light bulbs—throughout the construction period. The Department of Transportation will not incur any additional cost for this maintenance in accordance with Subsection 105.14. After a semi-completion of any portion of the lighting system within the project limits, the following shall apply:

In the event a lighting pole assembly is damaged or knocked down, through no fault of the Contractor, the Contractor shall repair or replace the damaged lighting pole assembly to its original condition and be reimbursed by ODOT at the contract unit price bid for all pay items necessary to complete the repair or replacement, excluding any costs for concrete footing removal.

Upon the completion of the lighting system or the completion of the project, make connections from the temporary service pole(s) to the permanent service pole(s). Connect

the completed circuits to the permanent service pole(s) for final acceptance of the lighting system.

Handle with care the items that are to be removed and/or reset, taking responsibility for any damages occurring during these operations. Neatly store the removed items in an area designated by the Engineer.

All removed service poles, light poles, mast arms, luminaires and pertinent equipment that is used for temporary lighting shall become the property of the Oklahoma Department of Transportation and stockpiled at a location approved by the Engineer, unless otherwise noted on the plans.

Leave the temporary service pole(s) and the temporary lighting system items in place or remove these at the end of the project as directed by the Engineer. If any temporary service pole(s) or temporary lighting system is necessary to provide a safe driving environment, leave such items in place during the interim period between the project and the next construction project at this location, as approved by the Engineer.

Upon completion of the project, the Contractor shall be relieved of any payments or costs for the temporary lighting system. Payment shall become the responsibility of the Oklahoma Department of Transportation or local authority.

810.05. METHOD OF MEASUREMENT.

Power supplies of the various types will be measured by each unit installed.

Temporary service poles will be measured by each unit installed. The temporary lighting service will be metered, and measured in units of kilowatt-hour. Prior to payment, furnish the Engineer with copies of the utility company’s invoice and proof of payment.

Wood poles will be measured by each unit installed of the various sizes as specified on the plans.

810.06. BASIS OF PAYMENT.

The accepted power supply items, measured as provided above, will be paid for at the contract unit price as follows:

- (A) SERVICE POLE EACH
- (B) POLE-MOUNTED TRANSFORMER STATION EACH
- (C) PAD-MOUNTED TRANSFORMER STATION EACH
- (D) TEMPORARY SERVICE POLE EACH
- (E) TEMPORARY LIGHTING SERVICE KWH
- (F) WOOD POLE EACH

Such payment shall be full compensation for furnishing all materials, equipment, labor, and incidentals required to complete the work as specified.

SECTION 811 ELECTRICAL CONDUCTORS HIGHWAY LIGHTING

811.01. DESCRIPTION.

This work shall consist of furnishing materials and installing electrical conductors used in buildings and outdoors for the transmission and distribution of electrical energy shown on the Plans.

811.02. MATERIALS.

The electrical conductors shall meet the requirements specified in the following Subsections of Section 700 - Materials:

Building Wire and Cable	738.02(b)
Underground Secondary Distribution Wire and Cable	738.02(c)
Outdoor Aerial Neutral-Supported Secondary Distribution Wire and Cable	738.02(d)

811.04. CONSTRUCTION METHODS.

- (a) **General.** Take care to prevent damage to the conductor or insulation during installation. Replace any conductor damaged during the installation at no additional cost.
- (b) **Conductors in Conduit.** Complete the conduit system before installing the conductors. Provide slack in each conductor as follows: At least 2 feet (0.60 m) at all pole bases and at least 3 feet (0.9 m) at each pull box.
- (c) **Aerial Conductors.** Install aerial conductors in accordance with the National Electric Safety Code and the conductor manufacturer's recommended sag and tension charts. Require of the cable manufacturer a copy of these charts for each size and type of cable supplied, prior to installation and acceptance of the cable by the Engineer.
- (d) **Splices and Taps.** Splice or tap the underground and indoor conductors only at pull boxes, pole bases, control cabinets, junction boxes, or other appropriate weatherproof enclosures. Splice and tap outdoor aerial conductors as shown on the Plans. Do not pull splices into the conduit system. Provide the types of splices and taps shown on the Plans or provided for herein.

In insulated conductors, make splices or taps waterproof. There are two acceptable procedures for achieving this:

1. Make splices and taps using compression type of split bolt connectors, giving them a minimum of three layers of rubber tape applied in uniform half-lap wrapping, or covering the joint with at least a 1/8 inch (3 mm) layer of electrical insulating putty. The next covering shall be not less than three layers of high dielectric, high tensile strength cold weather type plastic tape in uniform half-lap wrapping over the rubber tape or putty, and then coated with insulating paint, or
2. use waterproof self-insulating connections made up of compression type connectors and epoxy type cast splice kits or heat shrinking type splice kits.

An alternative is to make waterproof self-insulating connections made up of compression type connectors and epoxy-type cast splice kits or heat shrinking type splice kits.

- (e) **Fuse Holders and Fuses.** Make fuse holders either in-line or Y-type connectors as shown on the Plans; make sure they are waterproof and self-insulating, and have a quick disconnect breakaway feature on the load side, if specified. Install a Y-type fuse holder at the base of each pole or overhead sign structure complete with the properly sized fuse. If specified on the Plans, branch circuits shall have an in-line fuse holder and fuse.
- (f) **Testing.** Test the installed electrical conductors in accordance with Section 805.

811.05. METHOD OF MEASUREMENT.

The electrical conductors will be measured by the linear foot (meter) for each of the various sizes and types specified, installed and shall include all connectors, fuses, splices, taps, and incidentals necessary to complete the electrical system as provided on the Plans.

811.06. BASIS OF PAYMENT.

The accepted *electrical conductors*, measured as provided above, will be paid for at the contract unit price as follows:

ELECTRICAL CONDUCTOR LINEAR FOOT (METER)

Such payment shall be full compensation for furnishing all materials, equipment, labor, and incidentals required to complete the work as specified.

**SECTION 812
HIGH MAST POLES**

812.01. DESCRIPTION.

This work shall consist of furnishing materials and installing of high mast poles in accordance with these specifications and details shown on the Plans or established by the Engineer.

812.02. MATERIALS.

Before the notice to proceed is issued, and before starting work, submit 8 copies, in brochure form, of a schedule of materials and equipment items proposed for the project. Include brand names, catalogue numbers, descriptions, cuts, shop and design drawings, and calculations as may serve to establish compliance with these specifications. (Materials normally used in highway construction and covered by the Standard Specifications, as to requirements, sampling and acceptance, need not be included in the schedules.)

NOTE: It is the Contractor's responsibility to hold the manufacturer responsible for the correctness of dimensions and details on the design drawings. Approval of such drawings will not relieve the manufacturer of this responsibility.

(a) Structural Design.

- 1. The design of the high mast poles covered by these specifications shall be the responsibility of the manufacturer. High mast poles shall be designed for a minimum of 80 mph (130 km/hr) wind velocity in accordance with the current edition of AASHTO "Standard Specifications for Structural Supports for Highway Signs, Luminaires and Traffic Signals." The wind loads,

allowable stresses, etc., shall be in compliance with the above specifications. The Oklahoma Department of Transportation reserves the right to check any pole design at random.

NOTE: Noncompliance with the above mentioned AASHTO Standard Specifications shall be cause for rejection.

2. The pole manufacturer shall certify in writing that he has coordinated his design with the manufacturer of the high mast lowering device and will accept the installation of the high mast lowering device and luminaire to insure the proper function of the total system mechanically, electrically, and in all other respects.
3. The high mast pole shall be designed for a maximum deflection not to exceed 10 percent of the pole height.

(b) Fabrication of Steel Shafts.

1. The shaft shall be fabricated from a high-strength steel conforming to Section C of this Specification. The shaft may be either circular many-sided construction of the lengths shown or in telescoping sections. The sections shall be cold formed. The shaft shall taper uniformly from top to bottom. All galvanized poles shall be telescoping sections.

If a single welded unit shaft is furnished and, because of hauling restrictions, the shaft cannot be shop fabricated in one piece, a field weld will be allowed. This field welding shall be done by AWS certified welders working for and under the direct supervision of the pole manufacturer. If the shaft is furnished in telescoping section, the number of sections shall not exceed 5 for shafts 120 feet (36m) or less, and shall not exceed 6 for shafts up to and including 150 feet (46m).

The telescoping section may be fabricated either as a one piece unit or as a multipiece unit of not more than 2 pieces. One piece or multipiece sections shall be fabricated of pieces with a minimum length of 10 feet (3m). All pieces shall be butt welded in accordance with Paragraph 2(b), "Welds."

Each shaft section shall be fabricated so that it may be telescoped over the next lower section a minimum of 1-1/2 times the diameter of the female end of the joint. Telescoping sections shall be prefitted and matchmarked by the manufacturer. Each telescoping joint shall be preassembled to insure a proper fit. Field assembly of the telescoping section shall be as recommended by the manufacturer and in a manner approved by the Engineer.

NOTE: No racking shall be allowed, and the manufacturer shall guarantee in writing that no settling of the joints shall occur.

Each shaft shall be fabricated with a hand hole, complete with a weatherproof cover bolted to a reinforced frame or to a laminated shaft section. A reinforced frame or laminated shaft section shall restore the strength lost by the removal of metal for the hand hole. The circuit breaker and winch bracket mounting plate shall be provided opposite the hand hole.

Each shaft shall be provided with a grounding connection inside near the base of the pole.

The pole manufacturer shall meet Standard Manufacturing Tolerance for straightness of the pole shaft.

The use of laminated or layered steel plates in fabricating the shaft section may be allowed, if it meets the structural requirements of this specification and has been approved by the Bridge Engineer prior to fabrication. The minimum thickness of the shaft sections may be either 3/16 inch (4.76mm) plate or 7 gauge sheet.

2. Welds.
 - (a) All welding shall conform to the latest edition of the AASHTO "Standard Specifications for Highway Signs, Luminaires and Traffic Signals," as modified herein.
 - (b) The shaft of single unit poles and multipiece telescoping sections shall be butt welded with backed up 100-percent penetration circumferential transverse welds and shall be ultrasonically inspected by the manufacturer. All circumferential transverse welds, except the base plate connection, shall be ground flush to + 1/8 inch, - 0 inch (+3.18mm, -0mm). Backup material must be contoured for full contact, continuous, and of the same material as the shaft.
 - (c) Each shaft may have a maximum of two longitudinal electric welds with 60 percent minimum penetration. The weld may be ground or rolled flush and smooth.
 - (d) The shaft shall be welded to the steel base by either two continuous welds, one at the top of the base and one at the bottom of the shaft, or by full penetration butt welds with a suitable backup strip, if necessary. The size and spacing of the welds shall be such as to develop the full resisting moment of the shaft.
 - (e) No field welds shall be permitted, except as noted in Paragraph (B) 1, "Fabrication of Steel Shafts."
 - (f) All welds shall be visually inspected and tested by one of the following methods: (1) ultrasonic method of AWS D1.1 including revisions, (2) magnetic particle method to ASTM E-709, or (3) radiographics method to ASTM E-94, E-390 or E-142-92, as applicable. Certified results shall be submitted for the Engineer's review. All field welds shall be tested 100 percent. All weld testing shall be at the expense of the manufacturer.
 - (g) All weld splatter shall be thoroughly removed before finishing.
 - (h) All welding shall be done before galvanizing.
 - (i) All weld metal shall meet the notch-toughness requirements as specified for bridge application in AWS D1.1 including revisions. Impact tests in accordance with Appendix C of AWS D1.1 are required for electroslag and electrogas weld metal.

(c) **Mechanical Properties.**

1. Any high-strength steel supplied for the shaft shall have a minimum yield strength of 48,000 psi (331 MPa) and shall meet the notch-toughness requirements of the Charpy "V" Notch Test for 15 ft•lbs at 40°F (2.08 kg•m at 4.4°C). Four copies of the manufacturer's certified mill test report (chemical and physical properties) covering each heat used on the project shall be submitted to the Engineer. A minimum of 3 coupons shall be tested for each heat after rolling by the steel manufacturer. Any sample showing less than the minimum yield strength shall be retested from the same heat. Failure to the second test is cause for rejection.
2. All base flanges, brackets, and miscellaneous hardware shall be fabricated from steel plate and shall have a minimum yield strength of 36,000 psi (248.2 Mpa).

3. Anchor Bolts.
 - (a) Each high mast pole shall be furnished with a minimum of 6 anchor bolts.
 - (b) Anchor bolts shall be shipped prior to the pole and shall be caged before installation in the excavated foundation hole.
 - (c) A template shall be provided to insure the proper fit of the pole base on the anchor bolts.
 - (d) Anchor bolts and nuts installed with galvanized poles shall be galvanized in accordance with ASTM A-153-82 (AASHTO M-232) a minimum of the threaded length plus 6 inches (75 mm) and comply with ASTM A-143-74 for prevention of embrittlement. Certification shall be provided at the request of the Engineer.
 - (e) Anchor bolts may not be welded to make the required lengths, nor shall they be tacked or welded to make up the anchor cage.
 - (f) Anchor bolts shall be torqued as specified by the pole manufacturer.
 - (g) Each anchor bolt shall be supplied with three hex nuts, one of which shall be a lock nut.
4. Finish.
 - (a) If specified on the Plans, the shaft, base and miscellaneous brackets shall be galvanized in accordance with ASTM A-123-89a (AASHTO M-111-94). Precautions shall be taken against embrittlement, warpage and distortion in accordance with ASTM A-143-74 and ASTM A-384-76. Certification shall be provided at the request of the Engineer.
 - (b) Care shall be taken not to scratch the pole finish prior to and during erection. However, if the finish is damaged, it shall be repaired in accordance with recommended materials and procedures established by the manufacturer of the finish and the pole and approved by the Engineer.

812.04. CONSTRUCTION METHODS.

1. Join together shafts made of telescoping sections before erection, in a manner recommended by the pole manufacturer and approved by the Engineer.
 2. Plumb and verify shafts in at least two directions, 90 degrees apart, with a transit. Plumb at the time of day approved by the Engineer and within a tolerance of one-half of the pole top diameter.
 3. Fill the void between the base plate and top of the foundation with an approved nonshrinking grout only after inspection and approval by the Engineer. Provide the grout with a drain hole of adequate size and location to drain any moisture accumulated inside the pole.
 4. As an alternative to grout, install a heavy gauge galvanized sheet steel formed to fit the hole inside the base plate and of sufficient width to enclose the void between the base plate and foundation.. In this case, fasten the sheet steel in place in such a manner as to prevent entry by either rodents or vandals.
 5. Install the high mast lowering device prior to erection of the pole. Take care to not damage the lowering device during installation.

812.05. METHOD OF MEASUREMENT.

High mast poles will be measured by each unit of the size and finish specified, installed in place, complete with all accessories and attachments.

812.06. BASIS OF PAYMENT.

The accepted high mast poles, measured as provided above, will be paid for at the contract unit price bid as follows:

HIGH MAST POLE EACH

Such payment shall be full compensation for furnishing all materials, equipment, labor, and incidentals required for completing the work as specified.

**SECTION 813
HIGH MAST LOWERING DEVICE**

813.01. DESCRIPTION.

This work shall consist of furnishing materials and installing of a raise and lower device in accordance with these Specifications and details shown on the Plans or established by the Engineer.

813.02. MATERIALS.

Prior to starting work, submit to the Engineer 5 copies, in brochure form of the bill of materials and equipment replacement parts list for items proposed for the project. Also include 5 copies of the service manual and operating manual. Include in the schedule part brand names, catalogue numbers, descriptions, cuts, diagrams and shop drawings, with all part numbers and materials finishes labeled, as may serve to establish compliance with these Specifications. (Materials normally used in highway construction and covered by the Standard Specifications as to requirements, sampling, and acceptance need not be included in the schedules.)

The lowering device manufacturer shall have manufactured and satisfactorily installed this a minimum of 5 years, unless otherwise approved by the Design Engineer. Final acceptance of any submitted lowering device design will rest solely with the Design Engineer.

(a) **Structural Design.**

1. The lowering device shall be of proven design, construction, and materials that will assure a long, reliable, safe, and low-maintenance life.
2. The lowering device shall lower a ring of luminaires to within approximately 3 feet (1m) of the pole base so that routine luminaire maintenance can be accomplished safely and efficiently.
3. There shall be facilities to energize the entire ring of luminaires while the lowering device is in the lowered position. Each pole shall be supplied with a power cable and connectors for this purpose. The service receptacle for this cable shall be weatherproof, twistlock, rated at 600 volts.

4. The hoisting cables shall be attached and equally spaced to the luminaire ring. A method shall be provided by which the tension on the hoisting cables will be equalized.
 5. In raised position, the luminaire ring shall have a minimum free movement and shall be rigidly suspended from equally spaced points by either purely mechanical latches or by cables in tension as specified in the Plans and approved by the Engineer.
 - (a) If Type I is specified, the automatic mechanical latching system shall be positive and require no manual or electrical tripping devices to either latch or unlatch the system. That portion of the latching system which is permanently attached to the top of the pole shall have no moving parts or contain any parts that require adjustment after the pole is erected. There shall be visual indication of positive latching. The latching system shall not be impaired by snow or ice accumulations. When latched, all tension will be removed from the hoisting and winch cables.
 - (b) If Type II is specified, the cables in tension system shall have a positive guide and positioning method to prevent rotational, horizontal, or vertical movement of the luminaire ring. The hoisting cables will be in tension all the time and a method shall be provided to equalize the stress on all three cables and remove all tension from the winch and cable assembly when the ring is in the raised position.
 6. Guide arms and/or rollers shall be installed on the luminaire ring. They shall prevent hang-up of the ring during raising and lowering, prevent damage to the finish of the tower shaft, and keep the luminaire ring equidistant from the pole at all times.
 7. The self-lubricating pulleys which are located at the top of the pole must be housed under a weather-tight cover similar in color to the support assembly.
 8. The suspension shall be highly stable and operable (raised or lowered) in 30 mph (48 km/hr) winds.
 9. The lowering device winch shall be powered by a lightweight remotely controlled portable motor. The motor shall be a heavy-duty reversible type, minimum of 3/4 horsepower (560 Watt) electric motor. The lowering device shall also have provisions for manual operation as a backup, in the event of a loss of power.
 10. The lowering device manufacturer shall certify in writing that he has coordinated his design to accept the installation of the pole and high mast luminaires to insure the proper function of the total system mechanically, electrically, and in all other respects.
 11. At the top of the pole there shall be no electromechanical disconnect installed in the circuit supplying power to the luminaires. The power cable shall be wired direct to the terminal blocks in the junction box on the luminaire ring.
 12. The power cable shall be attached to the luminaire ring in such a manner as to support the full weight of the cable while in the raised position, without pulling out or causing damage to the cable.
- (b) **Materials.**
1. Wire rope attachments, such as thimbles for eyes, clips, compression, and swedge-type fittings shall be approved by the Engineer and installed and torqued in accordance with the wire rope manufacturer's recommendations.

2. The luminaire ring and mast arms shall be constructed of weldable, structural steel with the mast arms of 2 inch (50 mm) diameter pipes for slip-fitter connections to the high mast luminaires; these arms shall be equally spaced around the ring, unless otherwise specified. The number of mast arms required shall be as shown on the Plans. The luminaire ring shall be prewired to distribute power from the main power cable and shall be weatherproof. The mast arms shall be easily attached or removed and one mast arm shall be provided for each high mast luminaire.
3. The high mast support assembly shall be fabricated from weldable structural steel and attached to the pole shaft. A positive method of pole attachment shall be devised in cooperation with the pole manufacturer to prevent any rotation of the support assembly on the pole top. The support assembly shall house all required pulleys and mechanical latching devices to support the luminaire ring and the luminaires.
4. The winch assembly shall be located at the base of the pole shaft adjacent to the hand hole and shall be a worm gear drive with a reduction ratio of 30:1, self-locking type and equipped with a take-up guide to prevent cable overlap. It shall be adequately sized to raise and lower the luminaire ring and luminaires at a minimum of 10 feet (3 m) per minute. The winch shall be supplied with an inboard and outboard support and be designed for hand and mechanical operation by means of a portable electric motor. The winch cable shall be securely attached to the winch drum and shall have at least three wraps on the drum when the luminaire ring is in the lowered position.
5. The luminaire ring shall be equipped, unless otherwise specified, with an double FAA approved red aircraft obstruction marker and dry type transformer, mounted on the ring assembly with a suitable bracket. Pipe with conduit lock rings are not considered satisfactory. The marker shall be located so as to be visible 360 degrees around the pole and shall be turned "on" and "off" with the luminaires. The lights shall be equipped with a multiple transfer relay to instantly change over to a reserve lamp when operating lamp fails. The transfer relay shall be installed in a weather tight enclosure and the relay should be a plug-in type.
6. All hardware shall be of noncorrosive materials or shall be plated with sufficient coatings to be compatible and comparable thickness as the structural parts of the lowering device.
7. All fasteners and pins shall be secured in a manner that will preclude their becoming loosened by vibration. Self-locking nuts, jam nuts and cotter pins shall be used for such purposes.
8. The pole shall be grounded as shown on the Plans.

(c) **Welding.**

1. All welding shall conform to the latest edition of the "Standard Specifications for Highway Construction" and Supplemental Specifications of the Oklahoma Department of Transportation and AWS D1.1 latest revisions.
2. No field welds shall be permitted.
3. All welds shall be visually inspected and may be tested by the ultrasonic method to AWS D1.1, latest revisions, magnetic particle method to ASTM E-709 or radiographic method to ASTM E-94, E-390 or E-142-92, as applicable and certified results submitted, if required by the Engineer.
4. All welding shall be completed and all weld splatter removed before finishing.

- (d) **Finish.** The high mast lowering device shall be galvanized after fabrication in accordance with ASTM A-123-89a (AASHTOM-111-94)

813.04. CONSTRUCTION METHODS.

Recruit the services of the manufacturer’s representative to assist in the proper installation of the lowering device. The manufacturer shall supply a written manual for installation and operation of the lowering device, with a minimum of 5 copies per project or one copy per device, whichever is greater.

Following the installation of the lowering device on the tower, but prior to its erection, request an inspection by the Traffic Engineer of the fully rigged device. Do not erect the tower without this inspection and/or approval by the Engineer. Take care not to damage the lowering device during the installation and erection of the tower.

813.05. METHOD OF MEASUREMENT.

The *high mast lowering device* will be measured by each unit of the size and type specified, installed in place, complete with all accessories, attachments, wiring, circuit breakers, etc., necessary to provide a complete mechanical and electrical system ready for connecting the high mast luminaires.

813.06. BASIS OF PAYMENT.

The accepted high mast lowering device, measured as provided above, will be paid for at the contract unit price bid as follows:

HIGH MAST LOWERING DEVICE EACH

Such payment shall be full compensation for furnishing all materials, equipment, labor, and incidentals required to complete the work, as specified.

**SECTION 825
TRAFFIC SIGNAL CONTROLLER ASSEMBLY**

825.01. DESCRIPTION.

This specification describes the minimum acceptable requirements for a full- traffic-actuated controller assembly with the options specified on the plans.

The controller assembly shall include a cabinet, a solid state full-actuated controller unit, load switches, flasher, conflict monitor, and pertinent documentation.

The controller assembly shall meet the requirements of NEMA (National Electrical Manufacturers Association) Standards Publication No. TS-1. In addition, all inputs and outputs to the controller unit shall conform to all interface and environmental standards in NEMA TS-1. Where a difference occurs, these requirements shall govern.

When called for on the plans, the controller assembly shall meet the requirements of NEMA Standards Publication No. TS-2.

Each controller unit shall have a unique serial number that is permanently and neatly displayed on the face of the unit.

825.02. MATERIALS.

(a) Full-Actuated Traffic Signal Controller.

1. Hardware Design Requirements. The controller unit shall be completely solid state and digitally timed. All timing shall be referenced to the 60 HZ power line. The dimensions of the controller unit shall not exceed 12 inch (0.33 m) height, 18 inch (0.44 m) width, 12 inch (0.33 m) depth.

Build the controller unit using one or more circuit boards. All printed circuit boards shall be designed to plug into or out of a mother board or harness within the unit.

NOTE: Power supply, transformers, capacitors, and heat-dissipating components are excepted from these requirements.

The controller unit design shall allow for removal or replacement of individual circuit boards without having to unplug or remove other circuit boards. Also, one side of each board needs to be completely accessible for trouble shooting and testing the unit while it is still operating. This may be accomplished with extender boards or cables to be used on one circuit board at a time. When required, one set of extender boards for every 10 controller units ordered shall be provided with the order.

A circuit assembly shall consist of two circuit boards attached to each other. The hardware used to attach them shall use captive nuts or another purchaser-acceptable method to secure the boards together. The boards shall be designed so that the purchaser can test and operate the controller unit with the boards separated. No circuit cuts shall be allowed on circuit boards in any of the equipment supplied. Any wire jumpers included on circuit boards shall be placed in plated through holes that are specifically designed to contain them.

NOTE: Jumpers that are tack soldered to circuit traces or are added to correct board layout errors are not acceptable.

All integrated circuits (IC's) with 14 or more pins shall be mounted in machine-tooled sockets. All sockets shall have two-piece, machined contacts and closed-end construction to eliminate solder wicking. The outer sleeve shall be brass with tin or gold plating and tapered to allow easy IC insertion. The inner contact shall be beryllium copper sub-plated with nickel and plated with gold. All sockets shall have thermoplastic bodies meeting UL Specification 94V-0. Other high quality sockets may be acceptable but must have prior approval of the Chief Traffic Engineer.

NOTE: Zero insertion force sockets will not be allowed.

Each of the following shall be displayed on the face of the unit:

1. Phase(s) in service (one per ring)
2. Phase(s) next to be serviced (one per ring)
3. Presence of vehicle call (one per Phase)
4. Presence of pedestrian call (one per phase)

5. Reason for green termination (one per ring)

Gap-out

Maximum time-out

Force-off

6. Pedestrian service (one per phase)

7. Max II in effect (one per ring)

Steady and flashing indications may be used for phase in service, phase next, and pedestrian service (walk, don't walk), or any other mutually exclusive indications.

Store and maintain user-programmed entries and timing settings in non-volatile memory.

NOTE: Battery power will not be allowed for this application.

All circuit components shall be of high quality and designed to withstand any of the environments and voltage conditions described in part 2 of NEMA Standard TS-1.

Design the controller unit to operate properly with the logic ground isolated from the AC Neutral (Common).

Provide a high quality keyboard with a rated lifetime of one million operations/key on the front panel of the controller unit. The keyboard shall be used for programming all user entered timings and settings. Provide a direct reading alphanumeric or graphic liquid crystal display with back lighting on the front panel of the controller unit.

The display shall have the following properties:

be clearly readable in ambient light including the cabinet light, in full sunlight, or in the absence of light from a distance of approximately 3 feet (1 m) at a 45 degree angle;

have an automatic time-out feature unless the display has an expected continuous life of 10 years or more;

have an operating temperature range of -30°F (-34°C) to 160°F (75° C);

blank out 10 minutes after the last keystroke is made;

have a minimum 40 character X 4 line display.

Demonstrate that all display requirements of this specification are met prior to acceptance. If an LCD contrast adjustment control is required for visibility at temperature extremes, then position the control, which must be adjustable without the use of tools, on the face of the controller unit.

Provide one spare set of all proprietary components including displays, IC's, and prom's for every ten controller units furnished or portions thereof, with a minimum of one set per project.

2. *External Download/upload Interface.* Have an RS 232 Serial port accessible through a DB-25S connector. The reserve connector pin assignments shall be as follows:

Pin	Designation
1	Frame Ground
2	Transmit Data
3	Receive Data

4	Request to Send
5	Clear to Send
6	Data Set Ready
7	Signal Ground
8	Data Carrier Detect
20	Data Terminal Ready
22	Ring Indicator

The minimum baud rate of the port shall be 2400 and shall be keyboard or jumper selectable. The port shall be configured for an 8 bit word, one (1) stop bit, no parity.

3. *Program Requirements.*

- 3.1 Programming/Data Entry. For programming of the controller unit, including TBC/BCT features, use a keyboard and display on the front of the controller unit. Programming shall require only simple keystrokes aided by full menu displays. For option start up programming, use internal dip switches.

NOTE: Ease of programming and ease in interpreting the display shall be required for acceptance.

The menu structure shall contain a main menu which contains options for all sections of the controller on one screen. Each option shall be selectable by a numeric entry. Each subsequent menu shall be a detailed breakdown of one of the previous menu options. Each menu option shall be a descriptive name to prompt the user to the desired section for programming. All entries shall be displayed and entered in plain English. Toggle type entries shall be set by entering yes/no or on/off responses. Non alphanumeric symbols used to display information shall be clear and unambiguous in their meaning. Numeric entries shall be in the base 10 (decimal) number system.

NOTE: Entries in other number bases such as hexadecimal or binary are not acceptable.

Each of the NEMA timing intervals shall be programmable for all eight phases from the same display screen in a spreadsheet format. The display may be rolled or paged down to display additional intervals or information.

A user selectable four digit (minimum) code shall be available to secure access to timing and configuration of the unit. Display features shall be available without the need to access the unit. Supply the controller units with the code preset to be all zeros (0000). Internal dip switches may be used to establish codes. Do not provide instructions for use of the access code on the face of the unit; instead, provide a keyboard-entered coded command (a series of commands or entries, not a single entry) which will set all controller and TBC timings and entries to a default or an inactive value. This coded command shall allow new values to be entered without first deleting prior entries.

The controller unit shall have a copying mode whereby the user, after having programmed all intervals of one phase, may copy this information into all or selected remaining phases. Other versions of the copying process that meet the functional intent are acceptable.

- 3.2 *Operational Features.* Provide volume density timing as specified in NEMA TS-1.

The controller unit shall be programmable for dual entry operations.

The following modes shall be available on a per phase basis:

1. Maximum Recall
2. Minimum Recall
3. Pedestrian Recall
4. Soft Recall
5. Detector Locking and Non-locking Memory
6. Phase Omit

The following configurations, as a minimum, shall be programmed within the controller unit and be user selectable:

1. 8 Phase NEMA
2. 8 Phase Sequential

The controller unit shall be designed to provide pedestrian phasing with any phase(s).

The controller shall be programmable for conditional servicing of left turns in the 8 phase NEMA configuration if the following conditions are true:

- A. The opposing through movement has gapped out.
- B. The compatible through movement green continues to extend.
- C. The compatible through movement has adequate time on the max timer to service the turn's minimum time and the terminating through movement's amber and red times.

If a left turn is reserviced, the controller shall terminate the phases when the through phase gap termination or max termination point is reached.

The controller shall have user programmable detector assignments. Each detector shall be assignable to any phase for the purpose of calling or extending the phase. The default detector assignments shall be as defined by NEMA TS-1.

- 3.3 *TBC/BCT*. The TBC/BCT shall select and coordinate reversible left turn sequence operations (dual leading, leading and lagging, or lagging and leading left turns). It shall be possible to transfer operation from one sequence to another at a preprogrammed time. Transfer shall take place at the barrier following phases 1, 2, 5 and 6 or at T (0) as defined in section 3.4 below.

There shall be a pedestrian override mode in addition to any modes of operation described in this specification that operates as follows:

1. When no pedestrian calls are present, the normal phase timings programmed for a particular coordination plan shall be effective for service of the intersection.
2. When a pedestrian call is present, the call will be serviced by timing the programmed pedestrian times for that phase and override the normal split times. The intersection may drop out of coordination when servicing the call in this mode. The controller shall return to coordination in the manner described in this specification after the call is serviced. The programmed phase sequence may not be altered in reestablishing coordination.

3. When the intersection is being operated under computer control, this mode shall be ignored.
4. All timing entries required to operate in this mode shall be user programmable. The timings shall be programmable on a per phase basis. Normal pedestrian timing entries may be used for the pedestrian override timings in this mode (Special pedestrian timings are not required).
5. This mode shall be selectable by individual plan.

A minimum of 36 patterns specifying cycle length, splits and offsets shall be required and consist of the following:

1. A minimum of 4 cycle length selections each changeable from 30 to 200 seconds in one second increments.
2. A minimum of three splits per cycle length selection.
3. A unique offset for every cycle / split combination adjustable from 0 to 200 seconds in 1 second increments.

The patterns not specified above can be achieved by additional cycle lengths, splits per cycle length selection, or offsets per cycle split combination.

- 3.4 *Coordinator Operation.* The coordinator shall reference a system wide reference cycle timer (system cycle timer). The term T (0) shall refer to the point in the local cycle timer when the coordinated phase (or leading coordinated phase if a pair of coordinated phases was selected by the user) is scheduled on for the first time. Note this may not be the beginning of green in the case of early return. In the event of early return to main street green, the pedestrian outputs shall not turn on until after a point when no other phases are allowed to be serviced before T (0). The offset shall be the amount the local cycle timer is behind the system cycle timer. Example: If the offset is +10 seconds, T (0) (the point at which the local cycle timer is at 0) will occur when the system cycle timer is at 10 seconds.

The following information shall be all that is required from the user to establish a pattern:

1. Basic NEMA controller timing.
2. Cycle length in seconds.
3. Phase sequence desired for the particular pattern.
4. Total seconds or percentage of the cycle that a phase is to be active including green, amber, and red times when there is a constant demand on all input detectors.
5. The offset of the first coordinated phase serviced in the sequence from the reference clock's T (0) in seconds.
6. Pedestrian override mode selection.

Using the above information, the coordinator must perform the following functions for each pattern:

1. Guarantee the coordinated phase(s) programmed time will be serviced in its entirety to achieve coordination between intersections. The programmed time of the first coordinated phase in the phase sequence shall start at T (0).

2. Calculate each phase's force off point (the point at which a phase's green must terminate in order to not violate the following phase's programmed times when calls exist).
3. Calculate the beginning of each phase's permissive window (the points in the cycle when each phase's preceding phase is allowed to yield to the phase).
4. Calculate the end of each phase's vehicle permissive window (the point preceding a phase's force off point by its minimum time and the prior phase's clearance time). Any phase receiving a vehicle call before the end of vehicle permissive window will be serviced during the current cycle.
5. Calculate the end of each phase's pedestrian permissive window (the point preceding a phase's force off point by pedestrian walk and pedestrian clearance times and the prior phase's clearance time). Any pedestrian call received by a phase before the end of pedestrian permissive window will be serviced during the current cycle.
6. Guarantee that each phase's programmed time be serviced in full if the call was received before the beginning of the permissive window and the phase does not terminate due to gap out.

No percentage inputs are allowable except for coordination phase times. Once the information for phase service is entered, the controller unit shall test the plan to insure that the plan does not violate any minimum times based on the specified numbers and cycle length. If a faulty plan is detected, the controller unit shall show an error code indicating the problem. If the error is not corrected, the controller shall run in the free mode of operation when the erroneous plan is selected. If pedestrian override has been selected, the coordinator shall ignore errors detected due to pedestrian times violating split times (see section (a) 3.3 for synchronization information).

The TBC/BCT shall be programmable to seek offsets by shortway (lengthening or shortening the cycle length up to 20%) and by dwell in the coordination phase awaiting the proper offset. The user shall determine which method and may program the longest permissible dwell times.

The TBC/BCT shall allow the following features and operations under time-of-day (T.O.D.) control:

- Max II Timing
- Gap/Ext II Timing
- Phase Omit
- Free Operation
- Flash Operation

Transfer into and out of flash shall take place in a safe manner from any point in the phasing sequence. It shall be possible to program each phase and overlap to flash either yellow or red via the front panel of the controller unit. The flashing operation shall be accomplished by flashing the loadswitch driver outputs simultaneously.

The controller unit coordination program shall be designed to be programmed from the front panel to emulate the operation of a pretimed controller by recall or BCT for applications where no vehicle detection is provided.

Pedestrian movements for the main street shall rest in green and don't walk at points in the cycle where servicing the walk would violate other phases' permissive period unless the call to non-actuated function is active.

The internal reference sync pulse, from which the local offset is calculated, shall resync at midnight, or the resync shall be user programmable with default to midnight. A pulse shall be generated whenever the time-of-day clock shows a time which is an exact multiple of the current cycle length after this resynchronization.. In case of a power failure, resync shall be calculated from the programmed resync time. The power failure recovery routine shall accommodate the case of a power failure at midnight. If the TBC is operating in the free mode, the current cycle length will still cause a sync pulse to be output. This output will not cease due to preempt input, stop timing , manual control enable or any other command other than external start in which case all coordination outputs shall be false.

For each configuration the coordinated phase or phase pair shall be selectable from one of the individual phases or phase pairs shown in the following table:

CONFIGURATION

Coordinated Phase(s)	8 phase NEMA	Quad Sequential	8 Phase Sequential
Individual Pairs	2, 4, 6, 8 2 & 6, 4 & 8	2, 4, 6, 8 2 & 6	2, 4, 6, 8 _____

NOTE: Compatible phase pairs shall not be forced to begin simultaneously.

When establishing its offset from the reference point, the coordinator shall reference only the leading edge of the sync pulse, regardless of its width. Pulse width shall be a minimum of 1 second.

The internal coordination and upload/download programs shall be simultaneously operable and mutually non-interfering. The implementation of revised timing parameters loaded into the timer shall be programmed to occur only at points in the controller coordination cycles which do not alter the selected phase sequence. The controller unit may temporarily drop out of synchronization during the upload/download, but must continue to operate. A complete description of the upload/download format and protocol shall be supplied with the order.

- 3.5 Communication. Internal settings, including coordination, shall be accessible via an external modem through the RS 232 interface. All functions including detector actuation, signal indications, gap-out, max-out, minimum green, extensions, preempt and coordination synchronization status shall be displayed on the modem connected download/upload unit, or other compatible unit, in approximate real time on a graphical display of the intersection.

All alarms provided shall be accessible through the RS 232 port by remote interrogation and by automatic dialing initiated by the controller unit.

- 3.6 System Software. All software required to perform the functions described in section (a) 3.5 shall be provided as part of the controller software and shall be provided as a set consisting of the software on 3 1/2 inch (89 mm) disks. One set of software shall be provided for every ten controller units ordered. The Department reserves the right to make additional copies of this software for its own use.
4. Clock/Calendar Programming Requirements.
- 4.1 Clock Programming. The clock shall be easily set to the year, month, day of month, day of week, hour, minute, and second. The clock shall store an entire yearly program including dates and times for starting and ending daylight savings time (DST).
- 4.2 Clock/Calendar Adjustment. The dates for beginning and end of DST shall be keyboard programmable by the user. Dates for fixed and floating holidays and special events shall be user programmable. Calendar adjustments for leap years shall be automatic.
- 4.3 Clock/Calendar Structure. The clock shall store sequences of operations in the form of one yearly program, 10 weekly programs, 15 day programs and 30 exception programs. The structure and interrelationships of each type of program shall be in accordance with the following paragraphs.

A day program shall consist of the following:

Event 1, Event 2, and Event 10

where each event is unique. There shall be a minimum of ten events per day program. and a total of 15 day programs.

Each event in a day program shall consist of the following:

Time of Day
 Cycle (1-4)
 Offset (1-3)
 Split (1-3)
 MUTCD Flash (on/off)
 Mode of Operation (a means of changing operating modes by TOD)
 Special Function 1 (on/off)
 Special Function 2 (on/off)
 Left Turn Sequence (lead-lead/lead-lag/lag-lead)
 Max II
 Gap/Ext II

Any or all of these may be selected within a single event.

A Weekly Program shall consist of the following entries:

Sunday	-	Day Program 1-15
Monday	-	Day Program 1-15
Tuesday	-	Day Program 1-15
Wednesday	-	Day Program 1-15
Thursday	-	Day Program 1-15

- Friday - Day Program 1-15
- Saturday - Day Program 1-15
- Monday through Friday - Day Program 1-15
- All Days of the Week - Day Program 1-15

There shall be a total of 10 Weekly Programs.

A Yearly Program shall consist of up to 52 entries, each consisting of the following:

Starting Month (1-12)

Starting Day of Month (1-31)

Weekly Program Number (1-10)

There shall be 30 user programmable exception programs. The first 10 programs shall be programmable for the following standard holidays:

- New Years Day
- Labor Day
- Martin Luther King Day
- Columbus Day
- Presidents Day
- Veterans Day
- Memorial Day
- Thanksgiving Day
- Independence Day
- Christmas Day

The 30 exception programs shall be user programmable for both fixed and floating exceptions. Fixed exception format shall consist of the structure of a day program defined above, but shall also have a date (month/day of month) assigned to it indicating when it should override the normally operating program.

Floating exception format shall consist of the structure of a day program defined above, but shall also have a date (month/week of month/day of week) assigned to it indicating when it should override the normally operating program.

There shall be a copy feature that allows the transfer of entries between programs within the same program level (weekly program to weekly program, day to day, exception to exception). Other programming schemes that meet the functional intent are acceptable but require approval by the Chief Traffic Engineer.

- 5. Coordination Control Hierarchy. In the absence of any on-line control by a central computer, the internal TBC shall control the coordinated, free, and flash operation of the intersection when no 120 VAC conventional interconnect line inputs are present or when the interconnect free input is not present.

When the interconnect free input signal is present and the intersection is not under computer control, the controller unit shall be under the control of the master controller TBC.

When the central computer brings the intersection on-line, via the computer on-line input, its control shall supersede that of the internal time base or external conventional interconnect inputs.

For non-computerized applications where conventional 120 VAC interconnect lines are present, it shall be possible to operate the TBC and cabinet interface as provided both as a master for the conventional wire system, and as a local which will accept conventional cycle, offset, split, free/flash, and on-line commands from the interconnect line.

6. Preemption Programming Requirements. The internal preemptor supplied shall be easily programmable from the front panel for either railroad or fire run preemption sequences.

Phases shall be selectable such that a limited signal sequence may be operational during preempt (P.E.). It shall be possible to add phases to this special limited sequence which are not in the intersection sequence. This shall be accomplished without adding external logic.

The following intervals shall be provided as a minimum. Terminology may vary but the meaning must be clear. Additional unspecified intervals which may lead to confusion shall be programmable to zero. If three letter abbreviations or interval numbers are used on the display, they shall be defined on the front panel. While in preemption, the display will clearly identify the intervals being timed as preempt intervals. Yellow and red clearance from the phase timings may be utilized in place of the clearance intervals shown, providing all other preemption requirements are met.

TIMING INTERVAL INCREMENTS	TIME	
	(Seconds)	(Seconds)
0. Preempt Delay (Emergency Vehicle Preempt)	0-99	1
1. P.E. Minimum Green	0-9	1
2. P.E. Yellow	3-9.9	0.1
3. P.E. Red Clearance	0-9.9	0.1
4. Track Green	0-99	1
5. Track Yellow	0-9.9	0.1
6. Track Red	0-9.9	0.1
7. Minimum P.E. Duration	0-99	1
(Flash or Limited Cycle)	0-99	1
8. Return Yellow (Solid Display)	0-9.9	0.1
(Yellow after Limited Cycle Green)	0-9.9	0.1
9. Return Red Clearance	0-9.9	0.1
(Red after Flash P.E.)		

The phases to be serviced following the preempt sequence shall be front panel keyboard programmable.

Preempt sequences shall be selectable using external inputs. Preempt priority shall be assigned with No. 1 being the highest. If a higher priority preempt input is received during a preempt sequence the controller unit shall immediately clear to the next all red interval before entering the new sequence. The transition shall take place in a safe manner from any point in the sequence.

Preempt 1 shall be reserved for a priority railroad preempt. If more than two preempts are provided it shall be possible to delete the priority override for all but the railroad preempt. If a non-priority preempt is activated during another preempt cycle, the one in progress shall continue through its entire cycle. If the second preempt input is still active when the first one is completed, the controller unit shall go to all red flash or to the appropriate point in the non-priority preempt. When all preempt inputs are removed, the controller unit shall proceed through the normal sequence to return red clearance (Interval 9).

Once the controller unit has entered the first timed interval following preempt delay (Interval 1), the sequence shall continue to the end even if the preempt call is dropped. If the call returns or remains through the minimum preempt (Interval 7) the controller unit shall remain in this interval until the call is dropped.

The controller unit shall be programmable to be in flash or in limited sequence during Interval 7. If flash is specified, the phases shall flash yellow or red as programmed from the front panel. Flash shall be implemented by simultaneously flashing the appropriate loadswitch driver outputs and not be setting the voltage monitor output false. If limited sequence is selected, all phases shall be programmable even if not normally used in the intersection sequence.

6.1 All Intervals Are Sequential.

0. *Preempt delay* - This time shall start immediately when the preempt command is received. It shall not affect the normal operation of the controller unit until the delay time out occurs. This interval may be used for emergency vehicle (Fire Lane) Preemption delay. If 0 (Zero) time is set the interval shall be omitted.
1. *P.E. Minimum Green* - Any vehicle signal that is green at the time this interval becomes active shall not terminate unless it has been displayed for at least the time programmed in this interval. Walk/Walk clearance indications shall immediately change to Don't Walk at the end of this interval. If 0 (Zero) time is set the interval shall be omitted.
2. *P. E. Yellow Clearance* - Green signals not programmed as track or fire lane signals shall change from green to yellow. Red signals shall not change. Signals displaying yellow at the start of this interval shall remain yellow. All yellows, including those already yellow at the start of this interval, shall display yellow for a minimum of 3 seconds before leaving this interval. Walk/Walk clearance indications shall immediately change to Don't Walk at the beginning of this interval. Signals programmed as track or fire lane signals which are yellow shall remain yellow. Green and red signals shall not change.
3. *P.E. Red Clearance* - All yellow signals shall change from yellow to red. Red signals shall not change. Green signals shall not change.
4. *Track Green* - Signals programmed as track (or fire lane) signals shall remain green or be changed to green. All other signals shall be red. Intervals 4, 5, and 6 shall be optionally programmable to zero during emergency vehicle P.E.
5. *Track Yellow* - This interval is the yellow interval for the track (or fire lane) signals. All other signals shall remain red.

6. *Track Red* - This interval provides all red time for clearance of the track or fire lane.
7. *Minimum P.E. Duration* - The preempt sequence shall not terminate until the preempt input signal is removed, and the minimum duration time has expired. Each signal shall be keyboard programmable for red, red flash, yellow flash or green. As an alternative, a limited cycle shall be programmable for use with railroad preempts.
8. *Return Yellow Clearance* - This interval shall provide a solid yellow clearance for indications that were green or flashing yellow. Red and flashing red displays shall display solid red. This interval shall be skipped if programmed to zero.
9. *Return Red Clearance* - This interval shall be an all red clearance in preparation for return to the normal cycle. Return phases shall be programmable from the keyboard.

In the event of a power interrupt as defined in NEMA Standard Publication TS-1, if the preempt command is present when power is restored, the controller unit shall power up in all red flash operation and remain there until the P.E. command is removed.

Overlap phases shall begin and terminate with the parent phases as described in NEMA TS-1. If the P.E. call occurs during yellow or red displays between parent phases, the overlap phase shall display a minimum of 3 seconds of yellow and a minimum of 1 second of red clearance.

Don't Walk shall be displayed throughout the preempt sequence unless a limited cycle is run during P.E. Duration (intervals 2 through 9). During a limited cycle (interval 7) the pedestrian heads may be programmed to be dark.

Preempt routines shall have priority over all functions except for emergency and conflict flash.

The signal from the conflict monitor shall stop time the preempt cycle until it is removed or reset.

(b) Cabinet Requirements.

1. *Design Requirements.* The cabinet shall be constructed using unpainted sheet aluminum with a minimum thickness of 1/8 inch (3 mm). No wood, wood fiber products, or other flammable material shall be used in the cabinet. All welds shall be neat and of uniform consistency. The cabinet shall be completely weatherproofed to prevent the entry of water. All unwelded seams shall be sealed with a clear or aluminum colored weather-seal compound.

Vertical shelf support channels shall be provided to permit adjustment of shelf location in the field. The channels shall have a single continuous slot to allow shelves to be placed at any height within the cabinet. Channels with fixed notches or holes are not acceptable. There shall be sufficient shelf space to accommodate a controller unit 12 inches (0.30 m) high, a 12-channel NEMA conflict monitor, and 12 NEMA type loop detector amplifiers. Additional shelf space a minimum of 12 inch (0.30 m) high, 12 inch (0.30 m) wide, and 12 inch (0.30 m) in depth shall be provided.

The cabinet shall be vented and cooled by a thermostatically controlled fan. The fan shall be a commercially available model with a capacity sufficient to meet NEMA requirements but shall be at least 2 CFS (0.05 CMS). The thermostat shall be an adjustable type with an adjustment range of 70°F to 110°F (20° C to 43° C) The intake for the vent system shall be

filtered with an air conditioning filter. The filter shall be securely mounted so that any air entering the cabinet must pass through the filter. The cabinet opening for intake of air shall be large enough to use the entire filter. The air intake and exhaust vent shall be screened to prevent entry of insects. The screen shall have openings no larger than 0.012 square inch (8 square mm). The total free air opening of the exhaust vent shall be large enough to prevent excessive back pressure on the fan. The minimum filter dimensions shall be 15 inch (0.40 m) wide by 12 inch (0.30 m) high by 1 inch (25 mm) thick, for base mounted cabinets.

The cabinet shall be provided with a unique serial number which shall be stamped directly on the cabinet or engraved on a metal or metalized Mylar plate, epoxied or riveted with aluminum rivets to the cabinet. The digits shall be at least 1/4 inch (6 mm) in height and located on the upper right sidewall of the cabinet near the front. A ground fault circuit interruption (GFCI) type duplex receptacle shall be mounted and wired in the lower front right side wall of the cabinet. This receptacle shall be wired on the load side of the 20 amp circuit breaker.

2. *Back Panel.* The back panel shall be designed to accept the minimum load switches as required on the plans. The back panel shall be hinged at the bottom and shall fold down and out from the top for maintenance with all components (load switches, relays, etc.) in place. It shall be possible to gain full access to the back of the back panel in less than two minutes, using simple tools. Wire termination points on the back of the back panel shall be numbered or identified to correspond to the labeling on the face of the panel. No printed circuit back panels shall be permitted. No components shall be mounted behind the back panel. Transient suppression devices for relay coils are excepted from this requirement.

The outputs from the controller to the load switches, and outputs from the detectors to the controller, shall be brought through posted binder head screw terminals with removable shorting bars installed. The load switches and flasher shall be supported by a bracket(s), designed to accept all NEMA type load switches and flashers, that will support the switch and prevent vibration from dislodging it from the socket in the back panel. The load switch outputs shall be brought out through posted binder head screw terminals. Field wiring for the signal heads shall be connected at this terminal strip. If the phasing on the plans require additional load switches, they shall be provided. The cost is to be included in the bid price of the controller.

3. *Detector Panel.* The cabinet shall have a loop detector panel mounted on the left side of the cabinet. This panel shall provide for all connections between loops at the street and the detector amplifiers, pedestrian call isolation, and connection between detector amplifiers and controller unit. Three position detector test switches shall be provided in the cabinet.

Inputs from the loops shall be brought through posted binder head screw terminals. The outputs from the detectors to the controller shall be brought through posted binder head

screw terminals with removable shorting bars installed. The detector harnesses shall be equipped with an MS3106A-18-1S connector and shall be wired as follows:

PIN NO.	FUNCTION
A	AC Common
B	Controller unit logic ground
C	120 Volts AC
D	Loop
E	Loop
F	Controller detector call input
G	Spare
H	Ground bus
I	Controller detector call input
J	120 Volts AC output from green load switch for this phase

An on-off-momentary toggle switch shall be provided for each vehicle and pedestrian phase to permit the user to disconnect the input from the detector for that phase from the controller unit, or permit the user to place a call to the controller. The momentary position shall place a call to the controller. The on position shall connect the detector to the controller unit. The center off position shall disconnect the detector from the controller unit.

If a detector rack is used, Section 828 shall be in effect for the detector panel, loop amplifiers, and all associated wiring.

4. *Cabinet Door.* The cabinet shall be provided with one door in front that will provide access to the cabinet. The door shall be provided with three hinges with nonremovable stainless steel pins, or a full length piano hinge with stainless steel pins spot welded at the top of the hinge. The stainless steel pin shall conform with ASTM A320 B8F. The hinges shall be mounted so that it is not possible to remove them from the door or cabinet without first opening the door. The bottom of the door opening shall extend at least to the bottom level of the back panel.

The cabinet door shall be fitted with a Number 2 Corbin type lock and a cast aluminum or chrome plated steel handle with a 3/4 inch (19 mm) minimum shaft and a three point latch. The lock and latch design shall be such that the handle cannot be released until the lock is released. One key shall be provided for each cabinet. The lock shall be located to be clear of the arc of the handle. The door handle shall be stainless steel to prevent rusting and shall be capable of being padlocked in the closed position.

A gasket shall be provided to act as a permanent dust and weather resistant seal at the controller cabinet door facing. The gasket material shall be of a nonabsorbent material and shall maintain its resiliency after long term exposure to the outdoor environment. The gasket shall have a minimum thickness of 3/8 inch (9 mm). The gasket shall be located in a channel provided for this purpose either on the cabinet or on the door(s). An "L" bracket is acceptable in lieu of this channel if the gasket is fitted snugly against the bracket to insure a uniform dust and weather resistant seal around the entire door facing.

A locking auxiliary police door shall be provided in the door of the cabinet to provide access to a panel that shall contain a signal shutdown switch, a signal flash switch, and a manual-automatic switch. A standard 1/4 inch (6 mm) 2-Conductor phone jack shall also be

provided to accept a manual push button. The police door shall be gasketed to prevent entry of moisture or dust and the lock shall be provided with one brass key.

A heavy gauge vinyl plastic pouch shall be riveted to the inside of the cabinet door. The pouch shall be approximately 12 inch x 17 inch (0.30 m x 0.43 m) and large enough to accommodate a copy of the cabinet wiring diagram, controller manual, and documentation for other accessories.

5. *Wiring.* All wiring within the cabinet shall be neat and routed such that opening and closing the door or raising and lowering the back panel will not twist or crimp the wiring. All wiring harnesses shall be either braided, sheathed in nylon mesh sleeving, or made of PVC or polyethylene insulated jacketed cable. Wiring leading to the cabinet door shall be of PVC jacketed cable only. Loop detector harnesses shall be made from jacketed cable only.

All conductors between the main power circuit breakers and the signal power bus shall be a minimum size 10 AWG stranded copper. All conductors carrying individual signal lamp current shall be a minimum size 16 AWG stranded copper. All AC service lines shall be of sufficient size to carry the maximum current of the circuit(s) they are provided for. Minimum cabinet conductor wire size shall be 22 AWG stranded copper. All wiring and insulation shall be rated for 600 volts or greater.

Conductors for AC common shall be white. Conductors for equipment grounding shall be green. All other conductors shall be a color different than the foregoing.

A barrier terminal block with a minimum of three terminals and one compression fitting designed to accept up to a 4 AWG stranded wire shall be provided for connection of the AC power lines. The block shall be rated at 50 amperes and shall have binder head screw terminals. All AC wiring in the path from the terminal block to the transient surge suppression device shall be isolated and bundled separately from all other wiring in the cabinet.

All terminals shall be permanently identified in accordance with the cabinet wiring diagram and as listed below. Where through-panel solder lugs or other suitable connectors are used, both sides of the panel shall have the terminals properly identified. Identification shall be permanently attached and as close to the terminal strip as possible and shall not be affixed to any part which is easily removable from the terminal block panel.

- A. Each controller input and output function shall be distinctly identified with no obstructions, at each terminal point in the cabinet, with both a number and the function designation. The same identification must be used consistently on the cabinet wiring diagrams.
- B. Each load switch socket shall be identified by number. No cabinet equipment, including the load switches themselves, may obstruct these identifications.
- C. Each flash transfer base and power relay base shall be properly identified with no possible obstructions.
- D. Each harness within the cabinet shall be distinctly identified by function on the connector end.
- E. The flasher socket shall be distinctly identified with no possible obstruction.
- F. All other sockets needed within the cabinet to fulfill the minimum requirements of the plans, or attachments thereof, shall be distinctly identified.

All NEMA controller unit and conflict monitor connector pinouts, except for the loadswitch inputs to the conflict monitor, shall be made available on binder head screw terminals on the back panel.

The controller unit harness (A, B, and/or C plugs) shall be long enough to reach any point 15 inches (0.40 m) above the timer shelf. The conflict monitor harness and any required auxiliary harness shall reach 24 inches (0.60 m) from the conflict monitor shelf.

Copper ground buses shall be provided for both the power supply neutral (common) and chassis ground. The AC neutral and chassis ground buses shall be jumpered together with a minimum 10 AWG wire. The logic ground shall be isolated from the AC neutral and terminated on a logic ground bus designed to accept 20 number 20 AWG stranded wires.

The circuit breakers shall be equipped with solderless connectors and installed on the right side wall (facing the cabinet) or lower right hand side of the back panel inside the cabinet. The breakers shall be easily accessible. The breakers shall be positioned so that the rating markings are visible.

The above breakers are in addition to any auxiliary fuses which may be furnished with the controller to protect component parts, such as transformers, etc.

The load side of the main circuit breaker shall be protected by a lightning surge suppressor, such as the EDCO ACP-340, or an approved equal. The suppressor ground connection shall be connected to the cabinet. The suppressor shall be connected to the line filter as recommended by the manufacturer. Number 10 AWG or larger wire shall be used for connections to the suppressor, line filter and load switch bus.

A relampable fluorescent light, with switch, shall be installed in the cabinet. This light shall turn on when the cabinet door is opened, and turn off when the cabinet door is closed.

Transient suppression devices shall be placed on the coil side of all relays in the cabinet. DC relay coils shall have, as a minimum, a reversed biased diode across the coil. AC relays shall have MOV's or equivalent suppression across their coils. RC networks are acceptable. One suppression device shall be supplied for each relay.

Except where soldered, all wires shall be provided with lugs or other approved fittings for attachment to binding posts. Insulation parts and wire insulation shall be insulated for a minimum of 600 volts.

The outgoing traffic control signal circuits shall be of the same polarity as the line side of the power source.

A switch shall be provided on the inside face of the cabinet door that shall be labeled "Auto-Flash." When the switch is in the "Flash" position, call for flashing operation shall not remove the power from the controller unit, in order to allow the controller to operate in a normal fashion, while the intersection is in flash. When the switch is in the "Auto" position, the operation shall be in a fully automatic mode with the signals on. A switch shall be provided near the "Auto-Flash" switch to cause the controller unit, and any auxiliary equipment, to stop timing. It shall be labeled "Stop Timing". This "Stop Timing" switch shall have three positions. The top position shall be labeled "Automatic Operation", the middle position shall be labeled "Stop Time Off", and the bottom position shall be labeled "Stop Time On." A controller power on/off switch shall also be provided.

The cabinet shall be wired so that activation of the conflict monitor will cause the controller unit, and any auxiliary equipment, to stop timing. Conflict and manual flash shall be wired for all red.

The red enable and remote reset from the conflict monitor shall be terminated on the face of the back panel.

- (c) **Conflict Monitor.** The conflict monitor shall meet the standards of NEMA Publication No. TS-1. The number of channels shall be as required on the plans. If the phasing on the plans calls for additional channels, they shall be provided and the cost shall be included in the price bid of the controller.
- (d) **Solid State Load Switch.** The solid state load switches shall meet the requirements set forth in Section 5 of the NEMA Specification No. TS-1, and shall be "Triple-Signal Load Switch" type. The load switches shall be all solid state and an indicator light for each circuit shall be provided in each load switch. The indicator light shall be on when a "true" input to the load switch is present.
- (e) **Two Circuit Solid State Flasher.** The flasher shall meet the electrical and physical characteristics described in Section 8 of the NEMA Standards Publication TS-1. The two circuit flasher shall be of solid state design and contain no electromechanical devices. The voltage range shall be 95 to 135 volts AC. The nominal voltage shall be 120 volts AC. The operating frequency range shall be 60 HZ +/- 3.0 HZ. The two circuit solid state flasher shall be designed to operate as specified at any ambient temperature range from -30°F to 160°F (-34° C to 74° C). The flasher shall be so constructed that each component may be readily replaced if needed. The flasher shall be a Type III (dual circuit rated at 15 amperes per circuit) unit.
- (f) **Documentation.** Each cabinet shall be provided with the following documentation:
 - 1. Three complete, accurate, and fully legible cabinet wiring diagrams.
 - 2. One manual for the controller, conflict monitor, load switch, flasher, and all detector units.

825.04. CONSTRUCTION METHODS.

Construction Methods Install the vehicle-actuated solid state traffic signal controller at the location shown on the Plans in accordance with the manufacturers requirements and Specifications.

825.05. METHOD OF MEASUREMENT.

Traffic vehicle actuated solid state digital traffic signal controller units with auxiliary equipment including cabinet and installation will be measured by the unit, complete in place.

825.06. BASIS OF PAYMENT.

Traffic vehicle actuated solid state digital traffic signal controller assemblies, measured as provided above, will be paid for at the contract unit price as follows:

TRAFFIC SIGNAL CONTROLLER ASSEMBLY..... EACH

Such payment shall be full compensation for furnishing all materials, equipment, labor and incidentals necessary to complete the work as specified.

SECTION 827 SOLID STATE FLASHING CONTROLLER

827.01. DESCRIPTION.

This work shall consist of furnishing materials and installing a solid state flashing controller in accordance with these Specifications.

827.02. MATERIALS.

The flashing controller shall be a solid state, NEMA two circuit Type III , 15 amp, flashing controller.

Enclose the flashing controller and associated equipment in an approved weatherproof or aluminum alloy cabinet of the type regularly supplied by the manufacturer. The minimum size of the cabinet shall be 14 inches (355 mm) x 10 inches (254 mm) x 5 inches (127 mm) (H x L x W), in order to provide ample space for housing the flashing controller unit and all of the associated electrical devices.

Provide a hinged door permitting complete access to the interior of the cabinet. Seal the door with neoprene gasketing material, making the cabinet weatherproof, and furnish the door with a standard police lock and two keys.

Terminals shall be identified, accessible without removal of equipment contained in the cabinet, and connected to terminal boards.

An EDCO SPA-100 surge protector, or an approved equal, shall be provided with each flashing controller.

The circuit breaker shall be in conformance with requirements of the NEC.

The following type of flashing controller shall be provided as called for in the plans:

Type I - A flashing controller as per this section of the Specifications.

Type II - A flashing controller as per this section of the Specifications and includes a solid state time clock.

This solid state time clock shall meet the requirements of Section 835.

827.04. CONSTRUCTION METHODS.

Place the solid state flashing controller unit as shown on the plans and wire it for operation.

827.05 METHOD OF MEASUREMENT.

The *solid state flashing controller* and associated equipment including a solid state time clock and cabinet as specified in the plans will be measured by the unit, complete in place not including post and footings.

827.06. BASIS OF PAYMENT.

The accepted solid state flashing controller, measured as provided above, will be paid for at the contract unit price as follows:

SOLID STATE FLASHING CONTROLLER EACH

Such payment shall be full compensation for furnishing all materials, equipment, labor and incidentals necessary to complete the work as specified.

SECTION 828 VEHICLE LOOP DETECTOR AND LOOP DETECTOR WIRE

828.01. DESCRIPTION.

This work shall consist of furnishing materials and installing a solid state digital inductive vehicle loop detector and loops in accordance with these Specifications, the latest NEMA TS-1 Specifications, and as shown on the Plans.

828.02. MATERIALS.

- (a) **Detector Loop Wire.** The detector loop wire that is embedded in the pavement for the detector loop shall be IMSA 51-1, IMSA 51-3 or IMSA 51-5 wire and shall meet the requirements of Subsection 738.01(c) of Section 700.
- (b) **Shelf Mounted Detector Unit.** The detector unit shall be self-contained, self-tuning solid state digital and shall compensate automatically for variations in temperature and environmental conditions.
 1. **Mechanical Requirements.** The complete detector unit, including power supply, shall be completely enclosed in a sheet metal housing with a protective paint finish. The case shall be so designed to provide convenient access to the entire interior assembly to permit easy testing and servicing of parts. Each detector unit shall be supplied with a connecting cable. Electrical connection from the detector to the incoming and outgoing circuits shall be made by inserting a multi-terminal plug into the plug receptacle located on the face panel of the detector. The detector shall be replaceable with a similar unit without the necessity of disconnecting and reconnecting the individual wires leading therefrom.
 2. **Output Delay and Extend.** The loop detector unit shall be supplied with programmable delay and extend output features.
 - 2.1. **Delay Output.** Furnish a variable delay circuit to provide a delayed output. This circuit shall be variable from zero to at least 20 seconds in one second increments. Detection of a vehicle shall be delayed for the amount of time selected, thereby providing no detector output until a vehicle has been present in the loop for this length of time. This timing shall reset each time the loop is vacated. However, the delay circuit shall be disabled immediately when 120 VAC is present on pin J of the MS 3106A-18 1P connector for this channel.
 - 2.2. **Extend Output.** Furnish a variable extend circuit to provide a carryover output. This circuit shall be variable from zero to at least 15 seconds in 0.25 second increments. Detector actuation shall be extended after the vehicle leaves the loop. The timing circuit shall reset after the extension has expired. However, the extend circuit shall not be disabled when 120 VAC is present at Pin J of the connector described again.

The timing shall be digital and all programming settings shall be accomplished by pins, thumbwheels or dip switches. The delay and extend features described herein shall not be required to function simultaneously unless otherwise specified on the Plans.

All programming (extend, delay, retention of presence, etc.) shall be external and located on the face of unit.

3. *Operating Requirements.* Design the detector so that environmental metal objects in the vicinity of the loop shall not affect its operation. The circuit design shall permit the lead-in cable described in Section 834 to be placed in a common conduit with signal and interconnect cable without any interference to the operation of the detector.

Also design the detector to operate satisfactorily in temperatures ranging from -30°F to 160°F (-34° C to 71° C) and to operate satisfactorily on line voltage of single phase 120 volts 60 cycle alternating current. This voltage may vary \pm 15 percent without any noticeable affect of the operation or life of the detector equipment. The detector unit shall have a tuning range of loop inductance from 40 to 700 microhenries. The detector shall also be capable of detecting vehicles traveling at speeds ranging from 0 to 160 km/hr, and shall detect only those vehicles that pass over any portion of the loop. Should power fail momentarily, the detector, when power is restored, shall return to its condition at the time of the power failure. If in the rest condition, it shall return to the rest condition, or if in detect condition, it shall return to the detect condition.

4. *Electrical Requirements.* Circuitry of the detector shall be all solid state. The printed circuit board shall be as described in Section 825. Facilities for adjusting the detector shall be an integral part of the detector on the front panel. Loop tuning shall be a simplified procedure which may be performed without traffic activity and without the need of test apparatus. There shall be two operating modes, pulse and presence. The operating mode shall be independently selected for each detector by means of switches located on the front of the detector unit. Each detector unit shall be furnished with an EDCO SRA-16C-1 surge protector, or an approved equal, in order to protect the detector unit from lightning or other like disturbance. The detector shall be provided with a multiconductor color coded harness and connector of the MS type. Provide each detector unit with a fuse replaceable without tools, located on the front panel. Permanently ground each detector unit internally. Visual indication of vehicle detection shall be provided by an indicator light located on the front panel.
- (c) **Card Rack Detector Unit.** The card rack detector units shall be 2-channel, self tuning, solid state, digital, and shall compensate automatically for variations in temperature and environmental conditions. They shall meet the requirements of NEMA TS-1 and the general requirements of Section 828.02 (b) of this specification.
 - (d) **Card Rack Assembly.** The card rack shall accommodate a minimum of eight (8) detector units. The card rack shall be crosswired for two-channel or four-channel operation.

The detector card rack frame shall be fabricated from aluminum and shall have slots set in a modular fashion such that the PCB edge connectors shall plug into the rear while sliding between top and bottom card guides for each module. Mounting flanges shall be provided and be turned outward for ease of access. The detector card rack shall be hinged on one side and fastened with thumb screw type connectors on the other in order for the unit to swing out for maintenance purposes. Enough slack shall be provided in the wiring to allow for the unit to swing out.

- (e) **Power Supply.** The power supply shall be a 24 VDC power supply capable of supplying a minimum of 3.6 amperes. For a shelf mounted power supply the front panel of the power supply shall provide a power on LED, a power on-off switch, an appropriate sized fuse for the 120 VAC input line, and a connector. The connector shall have a metallic shell which is connected to the chassis ground internally and shall mate with an MS-3106A-18-1SW cable connector.

Connector PIN terminations shall be as follows:

PIN	Function
A	AC Neutral
B	Reserved
C	120 VAC Line
D	Reserved
E	24 VDC Output
F	Reserved
G	Logic Ground
H	Chassis Ground
I	Reserved
J	Reserved

- (f) **Vehicle Loop Wire Sealant.** This section shall govern for furnishing and installing loop wire sealant for use in the installation of vehicle detector loops in asphaltic and concrete pavement as shown on the plans.
 - 1. *General Requirements.* The sealant shall be a one-part polyurethane material and shall be suitable for use in both asphaltic and concrete pavement. The sealant shall be designed to enable traffic to pass over the filled slot immediately after application without tracking or stringing. The sealant shall not shrink in volume during or after its curing process.
 - 2. *Physical Properties.* The sealant shall have a minimum shelf life to 12 months. The sealant shall have certain physical properties in its uncured and cured states. They are as follows:

2.1 *Uncured (wet) Sealant.* The physical properties of the uncured (wet) sealant are as follows:

Property	Requirement	Standard
Weight	717.87 lbs/cy +/- 1.0 lb. (1210 kg/cu. m. +/- 0.45 kg.)	ASTME201
Total Solids by Weight	75-86%	ASTMD1353 18 hours at 200°F (94°C)
Viscosity	0.00073-0.0123 psi-s (5-85 Pa-s)	Brookfield RVF No. 6 Spindle at 20 RPM, 77°F (25°C), 50% Rel. Hum.
Curing Time	Touch: 24 Hr. Max Complete: 36 Hr. Max 50% Rel. Hum.	ASTMD1640 4 mil (1000 µm) Film, 77°F (25°C), 50% Rel. Hum.

2.2 *Cured Sealant.* The physical properties of the cured sealant are as follows:

Property	Requirement	Standard
Hardness (Indentation)	65 - 85	ASTMD2240 Model 1700, 25C, 50% Rel. Hum.
Tensile Strength	125 lb/in (862 kPa) Minimum	ASTMD412 Die C Pulled at 20 IPM
Elongation	200% Minimum	ASTMD412 Die C Pulled at 20 IPM
Adhesion (Peel Strength)	15 lb/in (6.8 kg/25 mm) width	ASTMD903 Canvas to Concrete
Application Temp. Range	+41°F to 131°F (+5° C to 55° C)	
Service Temp. Range	-40°F to 150°F (-40° C to 65° C)	

Resistance: The cured sealant shall have the following chemical resistances:

Deicing	No Effect	ASTM D471*
Gasoline	Slight Swell	ASTM D471*
Hydraulic Brake Fluid	No Effect	ASTM D471*
Motor Oil	No Effect	ASTM D471*
Sodium Chloride (5%)	No Effect	ASTM D471*

* The ASTM Test shall be conducted at 70°F to 77°F (18° C to 25° C) for a period of 22 hours.

3. *Application of Sealant.* Unless otherwise shown on the plans, the Contractor shall apply the sealant using his own equipment. The Department reserves the right to perform any or all of the tests described in this Specification to insure compliance. Failure of a sample will require that the loops be removed and replaced with new sealant meeting this specification.

828.04. CONSTRUCTION METHODS.

Install the detection loop of the system so that it will perform reliably over a long period of time. Locate the loop detection system as shown on the Plans. Mark the exact location on the roadway with chalk string, spray paint, or some suitable marking device that can withstand weather and traffic until such time as the locations have been approved by the Engineer. Cut the induction loop slot, including corner cuts, to the exact width and depth as shown on the Plans. Clean and dry the slot with compressed air to remove all water and debris. Wind all loop wires in any given location in the same direction. All loop wire shall be one continuous length to the pull box where it shall be connected to the lead-in cable. Use a blunt wood instrument for placing the wire into the slot so that the insulation is not damaged in any way. All connections that are made from loop wire to the lead-in cable shall be made only in the pull box. Solder the connection with a 60/40 alloy, rosin core solder. Take care while soldering not to damage the insulation of the wire and cable. When the connection has been completed, place a water tight connector sealing pack over it. If no lead-in cable is required, connect the loop wire directly to the terminal block that is located in the base of the traffic signal pole. After carefully placing the loop wire and backer rod in the slot and checking the circuitry, seal the slot with a sealer that meets the requirements of this Specification.

828.05. METHOD OF MEASUREMENT.

The solid state digital inductive *vehicle loop detector* installed will be measured by the channel unit as specified in the plans, complete in place, wired and connected to the controller. The *loop detector wire* will be measured by the linear foot (meter) or each loop installed and connected to the loop detector.

828.06 . BASIS OF PAYMENT.

The accepted vehicle loop detector unit and loop detector wire, measured as provided above, will be paid for at the contract unit price as follows:

- (A) VEHICLE LOOP DETECTOR EACH
 (B) LOOP DETECTOR WIRE EACH OR LINEAR FOOT (METER)

Such payment shall be full compensation for furnishing materials, labor, equipment and incidentals necessary to complete the work as specified.

SECTION 830 PEDESTRIAN PUSH BUTTON

830.01. DESCRIPTION.

The work shall consist of furnishing materials and installing pedestrian push buttons and signs on traffic signal installations in accordance with these Specifications and as shown on the Plans.

830.02. MATERIALS.

The pedestrian push button switch shall meet the requirements of the "Americans with Disabilities Act", (ADA), Section 14.2.5 and be a phenolic enclosed precision snap-acting single-pole, single-throw unit with screw-type terminals rated at 5 amperes at 125 volts A. C. Materials for pedestrian information signs shall be as shown on the Plans.

830.04. CONSTRUCTION METHODS.

Install in accordance with ADA and construct the pedestrian push button so that it is tamper proof. Design it to prevent an electrical shock under any weather condition.

Attach the pedestrian push button and sign to a traffic signal pole or steel pipe as shown on the Plans. Shape the housing to fit the curvature of the pole or pipe and secure it to provide a rigid installation.

830.05. METHOD OF MEASUREMENT.

The *pedestrian push button* will be measured by the unit complete in place, connected, including signs and all hardware.

830.06. BASIS OF PAYMENT.

The accepted pedestrian push button, measured as provided above, will be paid for at the contract unit price as follows:

- PEDESTRIAN PUSH BUTTON EACH

Such payment shall be full compensation for furnishing materials, labor, equipment, and incidentals necessary to complete the work as specified.

SECTION 831 TRAFFIC SIGNAL HEADS

831.01. DESCRIPTION.

This item shall consist of providing and installing traffic signal heads and lamps on various types of supports at locations shown on the Plans and in conformance with these Specifications and the Institute of Traffic Engineers Standard Specifications.

831.02. MATERIALS.

The traffic signal head or pedestrian head and all component parts can be either polycarbonate or die cast aluminum and shall conform to the ITE Standard for Adjustable Face Vehicular Traffic Control Signal Heads. All pedestrian signal heads shall meet the requirements of the ITE Standard Adjustable Face Pedestrian Signal Head Standard.

Traffic signal lamps furnished shall conform to the ITE Standard for Traffic Signal Lamp.

A minimum of 60 watt, 590 lumens, 120 volt, clear, traffic signal lamps of 8000 hour minimum rated life shall be furnished with 8 inch (200 mm) signal heads and 12 inch (300 mm) pedestrian heads. A 150 watt, 1750 lumens, 120 volt, clear, traffic signal lamp of 6000 hour minimum rated life shall be furnished with 12 inch (300 mm) traffic signal heads. All reflectors shall be specular alzak aluminum.

If light emitting diode (LED) lamps are specified in the plans to be used in lieu of traffic signal lamps, the LED modules shall meet the requirements in the Institute of Traffic Engineering Standard titled "Vehicle Traffic Control Signal Heads" (VTCSH). The colors of the LED traffic signal modules shall conform to the chromaticity requirements of Section 8.04 and Figure 1 of the VTCSH standard. The LED modules should be of screw-in type as direct replacements for traffic signal lamps.

All die cast aluminum surfaces of the door, visors, and signal housing inside and outside shall be painted before assembly with three coats as follows:

First coat - Primer: Oxide Baking Primer, which meets or exceeds the performance specifications of Federal Specifications TT-P-636.

Second coat - Grey Enamel: Medium Grey Alkyd Urea Exterior Baking Enamel which complies with Federal Specifications TT-E-489.

Third coat - Yellow Enamel: Highway Yellow, best quality, synthetic resin enamel. The third coat on the inside and outside of the visors and the face of the signal doors shall be an Alkyd Urea Exterior Synthetic Baking Enamel, with minimum gloss reflectance meeting the performance requirements of TT-E-489, Enamel Heat Resisting Glyceryl Phthalate, Type 4, Instrument Black.

831.04. CONSTRUCTION METHODS.

Make each signal head weathertight.

NOTE: A signal head may consist of one or more signal sections of the adjustable, incandescent type, with multiple signal sections rigidly and securely fastened together. Each signal section shall be a self-contained assembly consisting of an optical unit with housing, housing door, visor, and glass lenses unless otherwise specified on the plans. Supply signal heads with all brackets and fittings necessary for proper mounting on the type of signal support designated on the Plans, and

make them capable of being positively positioned to control the movement of one direction of traffic.

831.05. METHOD OF MEASUREMENT.

The *traffic signal heads* and lamps will be measured by the unit, complete in place, including wiring and all hardware.

831.06. BASIS OF PAYMENT.

The accepted traffic signal heads and lamps, measured as provided above, will be paid for at the contract unit price as follows:

TRAFFIC SIGNAL HEADS EACH

Such payment shall be full compensation for furnishing materials, labor, equipment, and incidentals necessary to complete the work as specified.

**SECTION 832
OPTICALLY PROGRAMMED ADJUSTABLE
TRAFFIC SIGNAL HEADS**

832.01. DESCRIPTION.

This work shall consist of providing and installing optically programmed adjustable traffic signal heads and lamps on various types of supports at locations shown on the Plans in conformance with these Specifications.

832.02. MATERIALS.

The optically programmed adjustable traffic signal head shall permit the visibility zone of the indication to be determined optically and require no hoods or louvers. The projected indication(s) may be selectively visible or veiled anywhere within 15° of the optical axis and shall emanate from a single section. No indication shall result from external illumination nor shall one light unit illuminate a second unit.

(a) **Optical System.**

1. The lamp shall be nominal 75 watt, 120 volt AC, three prong, sealed beam having an integral reflector with stippled cover and an average rated life of at least 6,000 hours.
2. The lamp collar including specular inner surface shall couple the lamp to the diffusing element.
3. The diffusing element may be discrete or integral with the convex surface of the optical limiter. The optical limiter shall provide an accessible imaging surface at focus on the optical axis for objects 900 to 1200 feet (275 to 365 m) distance, and permit an effective veiling mask to be variously applied as determined by the desired visibility zone. The optical limiter shall be composed of heat resistant glass.
4. The objective lens shall be a high resolution planar incremental lens, hermetically sealed within a flat laminant of weather resistant acrylic or approved equal. The lens shall be

symmetrical in outline and may be rotated to any 90° orientation about the axis without displacing the primary image. The optical system shall accommodate projection from a single section of diverse selected indicia to separate portions of the roadway such that only one indication will be simultaneously apparent to any viewer.

5. The projected indication shall conform to ITE chromaticity standards.
- (b) **Electrical.** The lamp fixture shall comprise a separately accessible housing and integral lamp support, indexed ceramic socket and self-aligning, quick release lamp retainer. Electrical connection between case and lamp housing shall be accomplished with an interlock assembly which disconnects lamp holder when opened. Each signal section shall include a covered terminal block for clip or screw attachment of lead wires. Concealed copper #18 AWG, stranded and coded wires shall interconnect all sections to permit field connection within any section.
- (c) **Photo Controls.** Each signal section shall include integral means for regulating its intensity between limits as a function of individual background illumination. Lamp intensity shall not be less than 97 percent of uncontrolled intensity at 10,760 lux, and shall reduce to 15 percent \pm 2 percent of maximum at less than 11 lux. Response shall be proportional and essentially instantaneous to any detectable increase of illumination from darkness to 10,760 lux, and damped for any decrease from 10,760 lux.

The intensity controller shall comprise an integrated, directional light sensing and regulating device interposed between lamp and line wires. It shall be compatible with 60 HZ input and responsive within the range 105 to 135 volts. Output may be phase controlled, but the device shall provide a nominal terminal impedance of 1200 ohms open circuit and a corresponding holding current.

832.04. CONSTRUCTION METHODS.

Die cast aluminum parts shall conform to ITE alloy and tensile requirements and have a chromate preparatory treatment. Finish the exterior of the signal case, lamp housing and mounting flanges with a high quality prime baked enamel and finish paint. Make the lens holder and interior of the case optical flat black. Pre-drill the signal case and lens holder for backplates and visors. Hinges and latch pins shall be stainless steel. Seal all access openings with weather resistant rubber gaskets. Mount the signal to standard 1 1/2 inch (38 mm) fittings as a single section, as a multiple section face, or in combination with other signals. Provide the signal section with an adjustable connection that permits incremental tilting from 0-20 degrees below the horizontal while maintaining a common vertical axis through couplers and mounting. Mounting attachment shall permit external adjustment about the mounting axis in 5 degree increments. Make the signal mountable and capable of being serviced with ordinary tools. Attachments such as visors, backplates or adapters shall readily fasten to existing mounting surfaces without affecting water and light integrity of the signal. Install, direct, and veil the signal in accordance with manufacturer's instructions. Mask each section of the signal with prescribed materials in an acceptable and workmanlike manner.

832.05. METHOD OF MEASUREMENT.

Optically programmed adjustable traffic signal heads will be measured by the unit complete in place including masking, wiring, and all hardware.

832.06. BASIS OF PAYMENT.

Accept optically adjustable traffic signal heads, measured as provided above, will be paid for at the contract unit price as follows:

OPTICALLY PROGRAMMED ADJUSTABLE TRAFFIC SIGNAL HEADS EACH

Such payment shall be full compensation for furnishing materials, labor, equipment, and incidentals necessary to complete the work as specified.

**SECTION 833
TRAFFIC SIGNAL BACKPLATES**

833.01. DESCRIPTION.

This work shall consist of furnishing and installing backplates to traffic signal heads in accordance with these Specifications and as shown on the Plans.

833.02. MATERIALS.

Backplates shall meet the requirement of Section 740.

833.04. CONSTRUCTION METHODS.

The backplates shall consist of one piece construction. A two piece backplate may be used for the S-19 signal head. Secure the backplates to the traffic signal heads with noncorrosive machine screws and lock nuts as shown on standard drawings.

833.05. METHOD OF MEASUREMENT.

Backplates will be measured by the unit complete in place.

833.06. BASIS OF PAYMENT.

Accepted backplates, measured as provided above, will be paid for at the contract unit price as follows:

BACKPLATES EACH

Such payment shall be full compensation for furnishing materials, labor, equipment, and incidentals necessary to complete the work as specified.

**SECTION 834
ELECTRICAL CONDUCTORS TRAFFIC SIGNAL**

834.01. DESCRIPTION .

This item consists of furnishing materials and installing electrical conductors for traffic signal systems as shown on the Plans.

834.02. MATERIALS.

The electrical conductors shall meet the requirements specified in the following Subsections of Section 700.

Traffic Signal Wire and Cables:	738.01(a)
Traffic Signal Electrical Cable	
Shielded Loop Detector Lead-In Cable	738.01(b)

834.04. CONSTRUCTION METHODS.

- (a) **Traffic Signal Electrical Cable.** Install traffic signal electrical cable from the heads on each traffic signal pole to the traffic signal controller. Place the electrical cable from the traffic signal pole to the controller in conduit. Furnish electrical cable that has a sufficient number of conductors and at least one spare conductor as shown on the Plans.
- (b) **Shielded Loop Detector Lead-In Cables.** Place the shielded loop detector lead-in cables in conduit from each loop detector pull box location to the traffic signal controllers. At each of the loop detector pull box locations, splice the loop wire or the sensing element lead to the loop detector lead-in cable as shown on the Plans.

834.05. METHOD OF MEASUREMENT.

The *electrical conductors* will be measured by the foot (meter) for each of the various types specified and installed, and shall include all connectors, splices and incidentals necessary to complete the traffic signal system as provided on the Plans.

834.06. BASIS OF PAYMENT.

The accepted electrical conductors, measured as provided above, will be paid for at the contract unit price as follows:

- (A) TRAFFIC SIGNAL ELECTRICAL CABLE LINEAR FOOT (METER)
- (B) SHIELDED LOOP DETECTOR LEAD-IN CABLE LINEAR FOOT (METER)

Such payment shall be full compensation for furnishing materials, labor, equipment, and incidentals necessary to complete the work as specified.

SECTION 835 SOLID STATE TIME CLOCK

835.01. DESCRIPTION.

This work shall consist of furnishing materials and installing a solid state time clock in accordance with these Specifications.

835.02. MATERIALS.

This specification sets forth the minimum acceptable design requirements for a single circuit solid state time clock. It is intended for use in traffic control systems and shall be of all solid state construction except for the relay output. All components shall be made available to the purchaser for servicing for five years after expiration of the manufacturer's warranty, or the components shall each be so identified that they may be purchased from industrial electronics suppliers.

Time of day, day of week, date, year and the operation of the relay output shall be easily settable from the integral keyboard. The functions of the keys shall be clearly marked on the keypad. All data required to properly set and program the unit and review the stored program shall be clearly displayed without the use of auxiliary devices.

Changeover from standard time to daylight savings time or vice versa shall be accomplished automatically. This program shall be valid once the unit has been programmed with the time of day, month, date and year in which it is operating. From this entry, at the appropriate time each year, the change will be made automatically. This feature shall be defeatable by a simple hardware and/or software change.

When the user is programming the unit, the display shall provide for verification of each piece of data prior to its being entered. Provisions shall be made for correcting any incorrect data prior to entering it. It shall be possible to alter any individual program step without disturbing any other step in the program.

When an instruction is given to turn the output on or off, that instruction time shall be settable to one minute, and the change shall take place at the zero second of that minute.

The time switch shall be capable of initiating a minimum of six program steps. A program step is defined as the time of day and the day or days of the week at which the output shall be turned on or off.

A set of clear operating instructions shall be furnished with each time switch.

The time switch shall be capable of executing five separate skip plans programmable at least one year in advance.

Programming for the skip plans shall be accomplished through the integral keyboard. Each plan shall be programmed by entering the beginning date (month/day/year) and the ending date for which the output of the time switch will not be activated. The time switch shall be capable of skipping as short a duration as one day or as long as six months. It shall be possible to begin a skip plan in one calendar year and end that same plan in the next consecutive year.

It shall not be necessary to enter the skip plan program in chronological order.

A means shall be provided to review the skip plan program without affecting the normal operation of the time switch. The display shall include the skip plan number, the beginning date and the ending date.

In addition to the skip plan as described above, the time switch shall also be capable of providing a one day skip. The programming of this one day skip may be entered at any time during the six days prior to the day that is to be skipped. After the execution of the one day skip, the time switch will automatically reset and resume normal operation.

A means shall be provided to maintain timekeeping and the program when the line power source (115 volt AC) is temporarily interrupted. This backup system shall maintain timekeeping and all programmed steps intact for not less than 48 hours at 77°F (25°C) when fully charged and shall go on line automatically upon failure of the line power. Upon resumption of the line power, the unit shall automatically resume normal operation and begin recharging the backup system. The charging system shall be capacitive. Batteries will not be accepted.

Should the program of the time switch be erased during an AC power outage, the unit shall display an indication of the program loss. The display shall be a discrete LED indicator and shall be resettable from the integral keyboard.

When the time switch is operating on the backup system, the displays shall be blanked and the output disabled to conserve backup power.

Integral with the time switch shall be a clear display of the time of day, day of week, date and the condition of the output relay. If time is kept on a 12 hour format, provisions shall be made to display AM/PM. The unit shall have the ability to switch to an alternate display of time that includes seconds. A single keystroke shall be all that is necessary to switch to this display or to return to the normal display.

A means shall be provided to review the program on the clock memory and such means shall be integral with the input. Such program review shall not affect the current operation of the time switch.

The time switch backpanel shall be equipped with a means for mounting to a suitable backplate. Mounting holes that provide clearance for at least a No. 10 screw will be acceptable.

The time switch shall not exceed 4 inches (100 mm) x 7 3/8 inches (190 mm) x 3 1/8 inches (80 mm) (WxHxD). A cover shall be provided to protect the time switch from dust. The cover shall fasten securely to the unit and must be easily removable for access to the field wiring terminals. The cover need not be raintight since the time switch will be installed in an existing aluminum cabinet.

Interface to the power line and to the controlled device shall be provided by means of a terminal block capable of terminating wire sizes ranging from #20 to #12 AWG.

The time switch shall operate on a nominal 115 volt AC, 60 Hz power source and shall operate satisfactorily between 95 and 135 volt AC and from -30°F to 160°F (-1°C to 71°C).

Timing shall be synchronous with the power line when such power is available. When commercial power is lost, the timing shall be maintained by a backup power source. Timing accuracy during such backup operation shall be ± 3 seconds per 24 hour period throughout its full temperature range.

No time shall be gained or lost during changeover from 115 volt AC to the backup system and back to 115 volt AC.

All programming shall be accomplished via a keyboard which is an integral part of the unit.

The time of day shall be accurately settable to one second.

835.04. CONSTRUCTION METHODS.

Mount the solid state time clock in a controller cabinet and wire it for operation.

835.05. METHOD OF MEASUREMENT.

The *solid state time clock* will be measured by the unit complete in place.

835.06. BASIS OF PAYMENT.

The accepted solid state time clock, measured as provided above, will be paid for at the contract unit price as follows:

SOLID STATE TIME CLOCK EACH

Such payment shall be full compensation for furnishing materials, labor, equipment, and incidentals necessary to complete the work as specified.

SECTION 836 REGULATORY OR WARNING SIGN WITH FLASHERS

836.01. DESCRIPTION.

This work shall consist of furnishing and installing either regulatory or warning sign assembly with flashing beacons in accordance with these Specifications in reasonably close conformity with the location and dimensions as shown on the Plans or established by the Engineer.

836.02. MATERIALS.

The regulatory or warning sign assembly shall consist of the sheet aluminum sign with the message as specified, the traffic signal heads, solid state flashing controller with time clock, sign post, foundation, wiring and conduit as shown on Std. Drawing RWFS-1 (Latest Revision).

- (a) **Sign.** The sign material and fabrication shall be in accordance with Section 850 of these Specifications.
- (b) **Solid State Flashing Controller.** The solid state flasher controller shall be a Type 1 or 11 as shown on the Plans and in accordance with Section 827 and Section 835 of these Specifications.
- (c) **Flasher Beacons.** The flasher beacons shall consist of traffic signal heads and lamps, of the size specified on the Plans, in accordance with Section 831 of these Specifications.
- (d) **Sign Post, Footing and Mounting Hardware.** The sign post and foundation shall be of the size, length and type specified on the Plans, in accordance with Section 831 of these Specifications. Mounting hardware shall be either galvanized, aluminum or stainless steel.
- (e) **Aluminum Base.** The cast aluminum base shall be FHWA approved.

836.04. CONSTRUCTION METHODS.

The regulatory or warning sign assembly shall be installed and connected to a power supply in accordance with the Plans.

836.05. METHODS OF MEASUREMENT.

The *regulatory or warning sign assembly* will be measured by the unit, complete in place, wired and connected to power as shown on the Plans.

836.06. BASIS OF PAYMENT.

The accepted regulatory or warning sign assembly, measured as provided above, will be paid for at the contract unit price for:

REGULATORY OR WARNING SIGN WITH FLASHER EACH

which shall be full compensation for furnishing all materials, equipment, labor and incidentals necessary to complete the work as specified.

**SECTION 850
SIGNS**

850.01. DESCRIPTION.

This work shall consist of furnishing and erecting, complete in place, signs in accordance with these Specifications and in reasonably close conformity with the Plans or established by the Engineer. Included are signs of sheet aluminum and extruded aluminum panels, all with a retroreflective or nonretroreflective sheeting background, and with steel or aluminum sign bracket arms, bolts, and fittings.

850.02. MATERIALS.

Materials shall meet the requirements of Section 719. All panel signs, blue signs, warning signs, and R1-1, R1-2, R5-1 and R5-1A signs shall have Type III high intensity retroreflective sheeting. All other permanent signs shall have Type II-A medium-high intensity retroreflective sheeting. Shop drawings shall be required and shall be approved by the Department prior to fabrication for all special signs.

850.04. CONSTRUCTION METHODS.

- (a) **Cleaning.** To insure proper bond of the sheeting adhesive, thoroughly clean sheet aluminum and extruded aluminum panel signs to remove grease, oil, and other contaminants prior to the application of retroreflective and nonretroreflective sheeting.
- (b) **Application of Retroreflective or Nonretroreflective Sheeting.** Apply sheeting to properly treated base panels with mechanical equipment in a manner as specified below. Class 2 adhesive coated sheeting shall be pre-perforated.

1. *Vacuum Application.* Apply retroreflective or nonretroreflective sheeting to all sheet sign faces by an approved vacuum applicator. The precoated adhesive on the back of the sheeting shall be activated by a minimum temperature of 185°F (85° C), and the sheeting shall be evenly attached to the sign face by the diaphragm of the vacuum applicator which applies continuous even pressure, and evacuates, with a minimum vacuum pressure of 10 psi (84.4 kPa), all air between the sheeting and the sign face to insure that there are no air pockets or bubbles. This operation shall be in accordance with the recommendations of the manufacturer of the retroreflective sheeting. After aging for 48 hours at 75°F (24 ° C), the adhesive shall form a bond equal to or greater than the strength of the retroreflective sheeting.
2. *Continuous Roll Application.* Apply the sheeting with Class 1 adhesive coating in a continuous operation over the entire surface of the sign so that the surface is free of air pockets or bubbles. The retroreflective sheeting for extruded panel signs shall extend approximately 1/4 inch (6.35 mm) over each side of the panel and shall be adhered to each side. The sheeting on extruded panels shall not have more than one splice per panel.
3. *Color Match.* Sign faces comprising two or more pieces or panels of retroreflective sheeting shall be carefully matched for color at the time of sign fabrication to provide uniform appearance and brilliance, both day and night.

NOTE: Nonuniform shading and an undesirable contrast between adjacent widths of applied sheeting will not be acceptable.

4. *Splices.* At splices, Class 1 adhesive coated sheeting shall be overlapped not less than 3/16 inch (4.76 mm). Class 2 adhesive coated sheeting shall be butt spliced, gap not to exceed 1/64 inch (0.397 mm). Only butt splices shall be used on any sign face that is screen processed with transparent color.

Maximum allowable splices of retroreflective sheeting on sheet metal signs:

24 inch (0.61 m) height sign and under - no splices

36 inch (0.91 m) height sign and larger - one horizontal or one vertical splice

- (c) **Finishing Signs.** Following the application of the retroreflective sheeting background on sheet metal signs, apply the messages and border by the silk screen process; when specified, use a cutout legend.

Seal all sign face splices and edges with materials supplied and in a manner specified by the sheeting manufacturer.

Use stick-on copy for legend, symbols, and borders on extruded panel signs.

The finished signs shall show careful workmanship and have a smooth and uniform light surface. All letters and numbers shall be clear and sharp.

NOTE: Do not permit sheet signs to become wet during shipment or storage.

- (d) **Location and Positioning of Signs.** Erect signs so the sign face is vertical and at a horizontal angle away from the direction of travel, as shown on the Plans. Take care in the erection of all signs to eliminate or minimize specular reflection.

NOTE: If specular reflection is apparent on any sign, adjust its positioning at no additional cost to eliminate or minimize this condition.

Align the lower edge of extruded panel signs on overhead trusses along the centerline of the

lower horizontal chord member. After installation of the signs is completed, they shall be further inspected at night by the Engineer.

850.05. METHOD OF MEASUREMENT.

Signs will be measured by the square foot (square meter) of area of the vertical front face with no deduction for rounding off sign corners.

850.06. BASIS OF PAYMENT.

Accepted signs, measured as provided above, will be paid for at the contract unit price as follows:

- (A) SHEET ALUMINUM SIGNS SQUARE FOOT (SQUARE METER)
- (B) EXTRUDED ALUMINUM PANEL SIGNS SQUARE FOOT (SQUARE METER)
- (C) MAST ARM MOUNTED SIGNS SQUARE FOOT (SQUARE METER)
- (D) SPECIAL SIGNS.EACH OR SQUARE FOOT (SQUARE METER)

Such payment shall be full compensation for furnishing all materials, labor, equipment and incidentals necessary to complete the work as specified.

**SECTION 851
GALVANIZED STEEL SIGN POSTS**

851.01. DESCRIPTION.

This work shall consist of furnishing materials and constructing galvanized steel sign post footings in accordance with these Specifications and in reasonably close conformity with the dimensions and locations shown on the Plans or established by the Engineer.

851.02. MATERIALS.

Materials shall meet the requirements of Section 721.

851.04. CONSTRUCTION METHODS.

Should it be necessary to field cut a steel post, place the cut end in the concrete foundation. Any parts of steel posts from which galvanizing has been knocked or chipped off down to bare metal in transit, erection, or field alteration shall be regalvanized, metalized, or painted with an approved zinc dust-oxide paint.

851.05. METHOD OF MEASUREMENT.

Sign posts will be measured by the linear foot (meter) of the various sizes of galvanized steel posts erected in place as shown on the Plans or as directed by the Engineer.

On sign posts which require breakaway capabilities the breakaway design elements are considered a part of the sign post and are not measured separately.

Unless otherwise provided, footings will be measured and paid for in accordance with Section 804 and as shown on the Plans.

851.06. BASIS OF PAYMENT.

Accepted sign post, measured as provided above, will be paid for at the contract unit price as follows:

- (A) GALVANIZED STEEL WIDE FLANGE BEAM POSTS LINEAR FOOT (METER)
- (B) GALVANIZED STEEL PIPE POSTS LINEAR FOOT (METER)
- (C) SQUARE TUBE POST LINEAR FOOT (METER)
- (D) FLANGE CHANNEL POSTS LINEAR FOOT (METER)

Such payment shall be full compensation for furnishing all materials, equipment, labor, and incidentals necessary to complete the work as specified.

SECTION 852 OVERHEAD SIGN STRUCTURES

852.01. DESCRIPTION.

This work shall consist of furnishing materials and constructing overhead sign structures on prepared footings in accordance with these Specifications and in reasonably close conformity with the Plans or established by the Engineer.

852.02. MATERIALS.

Materials shall meet the requirements of Section 720. Materials and construction of concrete footings shall conform with Section 804 and as shown on the Plans.

852.04. CONSTRUCTION METHODS.

Requirements for aluminum or steel:

- (a) **Design.** General data for design of overhead sign structures shall be in accordance with the AASHTO Publication Standard Specifications for Structural Supports for Highway Signs, Luminaires, and Traffic Signals, or with Oklahoma Department of Transportation Standard drawings.
Shop drawings will be required and shall be approved by the Department prior to fabrication.
- (b) **Welding.** The welding of aluminum shall be in accordance with Subsection 720.03. Qualification of procedures, welders, and welding operations shall be in accordance with Subsection 720.03.
Welding of steel, including qualification of welders, shall conform with the requirements of AASHTO/ANSI/AWS D 1.1.
- (c) **Fabrication.** The structure shall be free from all sharp edges and irregularities and shall be free from any misfits or structural deficiencies. All members must fit and make for an easy and quick erection. Unless otherwise shown on the Plans, all overhead sign structures including bridge mounted structures shall be complete with walkways, handrails, sign lights, electrical conduits, and wiring.

- (d) **Shipping and Erection.** Upright supports and truss structure shall not be delivered to location until such date as the complete structure, including signs, can be erected (not including light fixtures or other components that may be added at a later date).

The structures shall be protected on all surfaces so that no injury or defacement takes place during transporting and erecting.

NOTE: Any structure having injury or defacement which can not be quickly and efficiently regalvanized or metalized in accordance with American Welding Society Standard C2.2-52T-Recommended Practices for Metalizing shall be cause for rejection.

- (e) **Electrical Requirements.** All electrical equipment, materials, and installation methods shall conform to NEC and Section 801.

In the event provisions have not been made for furnishing electrical power at the site, furnish temporary power to demonstrate that all fixtures and equipment are properly installed in accordance with Section 805.

852.05. METHOD OF MEASUREMENT.

Overhead sign structures will be measured by the unit, for the various span lengths, with all appropriate appendages paid for separately: internal walkway and hand rail, external walkway and hand rail, sign lights, electrical conduit, wiring, pull boxes, reinforcing steel in footings and concrete footings. These pay items will be measured and paid for in accordance with Sections 802, 803, 804, 805, and 809 and as shown on the plans.

852.06. BASIS OF PAYMENT.

Accepted overhead sign structures, measured as provided above, will be paid for at the contract unit price as follows:

- (A) ALUMINUM OVERHEAD SIGN STRUCTURES. EACH
- (B) GALVANIZED STEEL OVERHEAD SIGN STRUCTURES EACH
- (C) ALUMINUM OVERHEAD SIGN STRUCTURES-BRIDGE MOUNTED EACH
- (D) GALVANIZED STEEL OVERHEAD SIGN STRUCTURES-BRIDGE MOUNTED EACH
- (E) OVERHEAD SIGN STRUCTURES,
WALKWAY & HANDRAIL LINEAR FOOT (METER)
- (F) UPRIGHTS FOR OVERHEAD SIGN STRUCTURE EACH
- (G) TESTING OF ALUMINUM WELDS LUMP SUM
- (H) REPLACE ALUMINUM TUBING IN
OVERHEAD SIGN STRUCTURE POUND (KILOGRAM)
- (I) ALUMINUM OVERHEAD SIGN STRUCTURE LINEAR FOOT (METER)
- (J) GALVANIZED STEEL OVERHEAD SIGN STRUCTURE LINEAR FOOT (METER)
- (K) REPAIR OVERHEAD SIGN STRUCTURE EACH

Such payment shall be full compensation for furnishing all materials, equipment, labor and incidentals to complete the work as specified.

SECTION 853 DELINEATORS

853.01. DESCRIPTION.

This work shall consist of furnishing and installing delineators in accordance with these Specifications and in reasonably close conformity with the lines, dimensions, and grades shown on the Plans or established by the Engineer.

853.02. MATERIALS.

Materials shall meet the requirements of Section 710.

853.04. CONSTRUCTION METHODS.

Install posts so that the delineator units will be at the elevations specified on the Plans or established by the Engineer, and make them reasonably true to line and grade and plumb.

The posts may be either driven or set. If driven either by hand or mechanical devices, they shall be plumb and firm in the ground, spaced as specified, and driven to the required lines and grades. Use a suitable driving cap when posts are driven.

After they have been driven, the top of the posts shall have substantially the same cross sectional dimensions as the body of the post.

NOTE: Battered heads will not be permitted. Posts bent or otherwise damaged to the extent that they are unfit for use in the finished work shall be removed from the site and replaced by the Contractor at his own expense.

When posts are set, dig the post holes to the correct depth, and space them as shown on the Plans. Backfill post holes with approved material placed in layers not more than 6 inches (150 mm) in depth; thoroughly compact each layer, taking care to preserve the alignment of the posts.

All bolts and fasteners shall be of the type, length, diameter, and material as called for on the Plans, or approved equal.

At bridges, fasten the delineators to the bridge handrail posts or parapet wall using brackets and fasteners for the various types as shown on the Plans or approved equal.

853.05. METHOD OF MEASUREMENT.

Delineators will be measured by each delineator assembly, including post mounting brackets and hardware as specified in the plans. Each type of delineator will be measured separately.

Delineators shall be divided into types and coded for measurement and payment as follows:

Type 1 - Monodirectional

Code 1 - One single reflector

Code 2 - Two reflectors placed vertically

Code 3 - Three reflectors placed vertically

Type 2 - Bidirectional

Code 1 - Two single reflectors mounted back to back

Code 2 - Four reflectors with two on each side of the post mounted back to back and placed vertically

Code 3 - Six reflectors with three on each side of the post mounted back to back and placed vertically

The color of the reflectors will be as specified on the Plans or as established by the Engineer.

853.06. BASIS OF PAYMENT.

Accepted delineators, measured as provided above, will be paid for at the contract unit price as follows:

DELINEATORS EACH

Such payment shall be full compensation for furnishing all materials, equipment, labor, and incidentals to complete the work as specified.

**SECTION 854
TRAFFIC STRIPE (PAINT)**

854.01. DESCRIPTION.

This work shall consist of furnishing materials and placing a white or yellow paint stripe with glass beads applied by the drop-on method in accordance with these Specifications and in reasonably close conformity with the locations and dimensions shown on the Plans or established by the Engineer.

854.02. MATERIALS.

Materials shall meet the requirements of Section 711.05, 711.06, 711.07, 711.08, 711.09 or 711.10.

854.03. EQUIPMENT.

The paint machine shall be capable of applying an even clean-cut line without excessive drifting of paint. The cutoff mechanism on the paint machine shall be capable of making a clean cut end section without dripping or stringing fine lines of paint.

The bead dispenser shall be equipped with an automatic cutoff control synchronized with the cutoff of the striping material.

854.04. CONSTRUCTION METHODS.

In order to insure maximum adhesion, clean all dirt, glaze, grease, road film, and all other foreign materials from the pavement area to be striped.

Apply the material to the pavement at a wet film thickness of approximately 15 mils (0.381 mm).

Distribute the beads evenly over the wet paint at a reasonably accurate rate of 6 pounds per gallon (719 kg per cubic meter) of paint, unless a different rate is specified by the Engineer. Use an automatic

bead dispenser attached to the striping machine in such a manner that the beads are dispensed immediately upon the completed line.

The completed line shall be a uniform cross section.

NOTE: The paint traffic stripe shall not be applied when there is moisture on the pavement that would cause a poor bond between the paint and the pavement, and application shall not be permitted when atmospheric temperature is below 40°F (5° C) and falling.

854.05. METHOD OF MEASUREMENT.

Traffic stripe (paint) will be measured by the each unit or linear foot (meter) of 4 inches (100 mm) wide traffic stripe placed or the equivalent 4 inch (100 mm) stripe necessary when a narrower or wider stripe is specified on the Plans. Where arrows, words, and symbols are placed, they will be measured by each unit. Arrows shall be counted by each head.

854.06. BASIS OF PAYMENT.

Accepted traffic stripe (paint), measured as provided above, will be paid for at the contract unit price as follows:

- (A) TRAFFIC STRIPE (PAINT) LINEAR FOOT (METER)
- (B) TRAFFIC STRIPE (PAINT) EACH

Such payment shall be full compensation for furnishing all materials, equipment, labor, and incidentals to complete the work as specified.

**SECTION 855
TRAFFIC STRIPE (PLASTIC)**

855.01. DESCRIPTION.

This work shall consist of furnishing materials and placing thermoplastic compound or preformed plastic tape markings on the roadway in accordance with these Specifications and in reasonably close conformity with locations and dimensions shown on the Plans or established by the Engineer.

855.02. MATERIALS.

Materials shall meet the requirements of Section 711.

855.03. EQUIPMENT.

- (a) **Extruded Application (Thermoplastic).** Apply the material to the pavement by the extrusion method wherein one side of the shaping die is the pavement surface and the other three sides are contained by, or are part of, suitable equipment for heating and controlling the flow of material.

NOTE: Extrusion of the material above the pavement surface will not be permitted.

All parts of the equipment which come in contact with the material shall be easily accessible for cleaning and maintenance. Conveying parts between the main reservoir and the shaping die shall not be allowed to clog up. All mixing and conveying parts up to and including the shaping die shall

maintain the material at the plastic temperature, and assure the continuous uniformity in the dimensions of the stripe. The equipment shall be so designed to insure uniform film thickness in the range of 90 mils (2.38 mm) minimum to 188 mils (4.76 mm) maximum.

The shaping die shall include a cutoff device remotely controlled to provide clean, square stripe ends and to provide a method of applying skip lines.

NOTE: The use of pans, aprons, or similar appliances which the die overruns will not be permitted.

Apply the top dressing of glass spheres at the rate of approximately 1 pound per 100 feet (1.5 kg per 100 m) of 4 inch (100 mm) wide line and in a manner which will firmly imbed them into the line surface at least 1/2 the diameter of the larger gradation sizes.

- (b) **Mechanical Application (Preformed Plastic Tape).** Install preformed pavement line markings with a mechanical applicator which shall be capable of placing pavement lines in a neat, accurate, and uniform manner. The mechanical applicator shall be equipped with a film cut off device and with measuring devices which automatically and accumulatively measure the length of each line actually placed to within a tolerance of ± 2 percent.

855.04. CONSTRUCTION METHODS.

- (a) **Surface Preparation.** In order to insure maximum possible adhesion for both AC and PC surfaces, clean off all dirt, glaze, grease, curing compound, or other foreign materials from the surface where lines are to be applied. The pavement surface shall be dry.

On all AC and PC surfaces that have been in place over 12 months, or that have either existing pavement markings or have had the pavement markings removed, apply a two-part epoxy primer sealer (50/50 blend) to the area to be striped. The primer sealer shall be compatible with the plastic material to be used and the surface to which it is applied.

Pavement markings which fail to provide a uniform appearance or which fail to be clearly visible during the day or night shall be corrected in a manner acceptable to the Engineer and at no additional cost to the Department.

The removal of existing striping will be at the discretion of the Engineer and will be measured and paid for under Section 859.

To insure the satisfactory performance of plastic pavement markings, new portland cement concrete pavement shall be sandblasted to remove the curing compound from the surface on which pavement markings are to be applied. Sandblasting may be done seven days after placement of the concrete surface unless otherwise directed by the Engineer. Payment of this operation will be included in Subsection 855.06.

On all portland cement concrete surfaces and on asphalt surfaces in place over 12 months, apply a liquid seal coat to the area which is to be striped. The seal coat shall be the type that is compatible with the plastic material used and the surface to which it is applied.

Do not place plastic pavement markings over longitudinal joints unless special written authorization is given by the Engineer for necessary exceptions.

- (b) **Application of Markings.**
 - 1. **Hot Applied Plastic Pavement Markings.** Apply hot applied pavement markings straight and true by the extrusion die method. Give lines sharp edges, uniform thickness, good adhesion,

and uniform reflectance of a high level. To insure the best possible adhesion, install the compound in a melted state at temperature of 400°F to 450°F (204° C to 232° C) measured at the pavement surface, and in accordance with the manufacturer's recommendations.

Apply hot applied thermoplastic markings only on clean dry pavement having a road surface minimum temperature of 55°F (13° C) and rising with a windchill factor of 45°F or higher.

The drying time shall be defined as the minimum elapsed time after application when the stripe shall have and retain the characteristics required and after which time normal local traffic will leave no impression or imprint on the new stripe. The minimum drying time shall not exceed two minutes at 50°F (10° C) at a maximum relative humidity of 70 percent when applied at 188 mils (4.76 mm) thickness or one minute when applied at 90 mils (2.38 mm) thickness.

Thermoplastic material used under this Specification shall be so compounded and applied as to retain for the life of the stripe the original characteristics of the bond to the surface, ability to resist distortions by traffic impact or normal climate changes, and resistance to natural discoloration.

The thickness of the dry thermoplastic material shall comply with the table below:

<u>DESCRIPTION</u>	<u>STANDARD-LINE THICKNESS</u>		<u>THIN-LINE THICKNESS*</u>	
	<u>MIN.</u>	<u>MAX.</u>	<u>MIN.</u>	<u>MAX.</u>
LANE AND STOP LINES	120mils (3mm)	188 mils (4.8mm)	70 mils (1.8mm)	125 mils (3.2mm)
EDGE, GORE AND DIAGONAL LINES	90mils (2.4mm)	188 mils (4.8mm)	70 mils (1.8mm)	125 mils (3.2mm)
WORDS, ARROWS AND SYMBOLS	120mils (3mm)	188 mils (4.8mm)	70 mils (1.8mm)	125 mils (3.2mm)

* Usage: Roadways with less than 5000 ADT, 4 inch stripe only, no words or symbols.

2. *Cold Applied Plastic Pavement Markings.* For pavement markings which are preformed of reflectorized plastic material and applied cold to the surface, coat them with a factory-applied, pressure-sensitive adhesive.

The material shall adhere to asphalt and concrete surfaces when applied according to the manufacturer's recommendations at surface temperature of 65°F (18° C) and rising. If the markings must be applied when the surface temperature is below 65°F (18° C) but not below 50°F (10° C), the markings are to be applied in strict accordance with the manufacturer's recommended procedures and/or other special instructions.

NOTE: The application of the reflectorized plastic markings shall be without the use of heat, solvents, or extra adhesives of any nature except that a surface sealer is required on portland cement concrete surfaces as indicated in these Specifications.

3. *Inlaid Installation of Preformed Plastic Tape.* When the inlaid method is to be used, apply the markings after the newly-placed bituminous concrete pavement has been adequately

compacted and when the bituminous concrete pavement has attained a temperature range of 125°F to 155°F (68° C to 52° C).

Inlay the preformed pavement markings into the bituminous concrete surface by means of a mechanical roller. The mechanical roller shall be of sufficient weight capacity to inlay the preformed pavement marking to a minimum depth of 65 percent of the material thickness and to not more than 80 percent of the material thickness while the temperature range of the bituminous concrete is within 125°F to 155°F (68° C to 52° C). In the event the inlaid preformed pavement markings are distorted by these operations, fail to provide a uniform appearance, or are installed improperly, repair or replace the inlaid pavement markings at no additional charge in a manner approved by the Engineer. Install the inlaid preformed pavement markings in the finished surface of the bituminous concrete pavement work prior to conclusion of each day's work.

855.05. METHOD OF MEASUREMENT.

Traffic stripe (plastic) will be measured by the linear foot (meter) of 4 inch (100 mm) wide traffic stripe material actually placed or the equivalent 4 inch (100 mm) wide stripe when a narrower or wider stripe is specified in the Plans. Arrows, words, and symbols will be measured by each unit installed. Arrows shall be counted by each head.

855.06. BASIS OF PAYMENT.

Accepted traffic stripe (plastic), measured as provided above, will be paid for at the contract unit price as follows:

- (A) TRAFFIC STRIPE (PLASTIC) LINEAR FOOT (METER)
- (B) TRAFFIC STRIPE (PLASTIC) EACH

Such payment shall be full compensation for furnishing all materials, equipment, labor, and incidentals to complete the work as specified.

**SECTION 856
CONSTRUCTION ZONE PAVEMENT MARKINGS**

856.01. DESCRIPTION.

This work shall consist of furnishing materials and placing pavement markings on detours and roadways on which traffic is maintained during construction in accordance with these Specifications and in reasonably close conformity with the locations, lines, and dimensions shown on the Plans or established by the Engineer. The use of paint, removable pavement marking tape, or other construction zone pavement markings will be as specified on the Plans or as directed by the Engineer.

856.02. MATERIALS.

Traffic stripe materials shall meet the requirements of Section 711. Other construction zone pavement-marking materials shall meet the specifications noted on the plans.

856.03. EQUIPMENT.

The application of pavement markings shall be in accordance with the manufacturer's recommendations. When applying construction traffic stripe (paint), the paint machine and bead dispenser shall meet the requirements of Subsection 854.03. During the period of application, the pavement surface shall be dry and the atmospheric temperature shall be above 50°F (10° C) and wind chill factor above 40°F (4°C).

856.04. CONSTRUCTION METHODS.

- (a) **Detours.** Complete pavement markings on detours, including lane lines and edge lines, before the detour is opened to traffic. When maintenance or restoration of pavement markers or restriping of detours is necessary as determined by the Engineer, start the maintenance, restoration and/or restriping within 24 hours (weather permitting) after being notified by the Engineer.
- (b) **Stage Construction.** When roadways are being resurfaced in successive stages, have pavement markings in place prior to opening to traffic in a manner as shown on the Plans or as directed by the Engineer.

If any detour or permanent pavement markings could conflict with the permanent pavement markings of the next phase of traffic control, remove them in a manner acceptable to the Engineer prior to switching traffic to the next phase of traffic control. Before existing pavement markings are removed from any roadway open to traffic, have temporary pavement markings in place. Also, remove all temporary pavement markings prior to the installation of final striping.

When additional pavement marking is necessary due to overlays, redirection of traffic, or restoration due to wear—or other reasons as determined by the Engineer—start the striping within 24 hours after being notified by the Engineer.

Install removable pavement marking tape and pavement markers in accordance with the manufacturer's recommendations as approved by the Engineer. The pavement surface shall be dry at the time of pavement marking application. Remove all dirt, debris, loose particles, curing compound, and heavy oil residues from the road surface application areas immediately prior to the installation of pavement markings.

All removable pavement marking tape and pavement markers shall present a uniform appearance and be clearly visible during the day and night for traffic control. If pavement markings fail to provide a uniform appearance or to be clearly visible during the day or night, correct them in a manner acceptable to the Engineer and at no additional cost to the Department.

When removable pavement markings are no longer required, as approved or determined by the Engineer, neatly remove the pavement marking and adhesive. Additional pavement markings may be installed as necessitated by traffic conditions, as approved or determined by the Engineer. Dispose of removed pavement marking tape and pavement markers immediately.

The removal of painted stripe and plastic stripe will be accomplished and paid for in accordance with Section 859. The removal of removable pavement marking tape and construction zone pavement markers will not be paid for separately and will be included in the unit price for that item.

856.05. METHOD OF MEASUREMENT.

Traffic stripe will be measured by the linear foot (meter) of 4 inch (100mm) wide traffic stripe material actually placed or the equivalent 100 mm stripe when narrower or wider stripe is required. Where arrows and words are placed, they will be measured by each unit. *Pavement markers* will be measured by each unit installed on the project. Costs for restoration of pavement markers, restriping, and maintenance of pavement markings shall be included in the price bid for the initial installation.

856.06. BASIS OF PAYMENT.

Traffic stripe, measured as provided above, will be paid for at the contract unit price as follows:

- (A) CONSTRUCTION TRAFFIC STRIPE (PAINT) LINEAR FOOT (METER)
- (B) CONSTRUCTION TRAFFIC STRIPE (PAINT) EACH
- (C) REMOVABLE PAVEMENT MARKING TAPE LINEAR FOOT (METER)
- (D) REMOVABLE PAVEMENT MARKING TAPE EACH
- (E) NONREMOVABLE PAVEMENT MARKING TAPE LINEAR FOOT (METER)
- (F) NONREMOVABLE PAVEMENT MARKING TAPE EACH
- (G) CONSTRUCTION ZONE PAVEMENT MARKERS EACH

Such payment shall be full compensation for road surface preparation, disposal of waste materials, and for all materials, labor, tools, equipment and incidentals to complete the work as specified.

SECTION 857 PAVEMENT MARKERS

857.01. DESCRIPTION.

This work shall consist of furnishing and installing pavement markers of the class and type specified on the Plans as directed by the Engineer, and in conformity with these Specifications.

857.02. MATERIALS.

Materials shall meet the requirements of Section 736.

857.03. EQUIPMENT.

The equipment used for mixing and application of epoxy resin adhesive shall meet the requirements of AASHTO M 237.

857.04. CONSTRUCTION METHODS.

The portions of the highway surface to which the marker is to be attached shall be free from dirt, curing compound, grease, oil, moisture, loose or unsound pavement, or any other material which might affect the attachment of the marker to the pavement. On portland cement concrete pavement, prepare the area to which the marker is to be affixed by sand blasting or wire buffing immediately prior to placement of the marker.

Follow the installation procedure recommended by the manufacturer of the marker. Firmly affix the markers to the surface in such a manner that they will not be displaced under traffic.

When installing the markers, make the color of the marker housing compatible with the color of the traffic stripes they are to supplement or replace.

If any pavement markings fail to provide a uniform appearance or fail to be clearly visible during the day or night, correct them in a manner acceptable to the engineer and at no additional cost to the Department.

Place retroreflective pavement markers at the designated location in such a way that the color of the reflected light is in accordance with the Plans, details, or as directed by the Engineer.

If the road is open to public travel during the progress of work, operate the equipment and store materials and supplies in such a manner as to cause a minimum of hazard and inconvenience to the traveling public.

Any damage to the pavement or other facilities caused by the operation of the equipment shall be repaired at no additional expense to the Department.

857.05. METHOD OF MEASUREMENT.

Pavement markers installed as directed and accepted will be measured by counting separately the number of various classes and types of markers.

Pavement markers shall be divided into classes and types for measurement and payment as follows:

- Class A - Retroreflective
 - Type 1 - Monodirectional
 - Type 2 - Bi-directional
- Class B - Nonretroreflective ceramic
 - Yellow
 - White
- Class C - Retroreflective, all weather
 - Type 1 - Monodirectional
 - Type 2 - Bi-directional

On retroreflective markers, the color of the marker body other than the reflective face shall be neutral or match the reflector face. On bi-directional markers, the color of the marker body shall be neutral or split to match the reflective. Bi-directional markers shall comply with color code: A = Crystal/Crystal, B=Amber, C=Crystal/Red and D=Amber/Amber.

The reflector unit for the Class C markers shall be affixed to the casting with an adhesive material which is molded to and is an integral part of the reflector unit. The section of the casting where the reflector unit is to be attached shall be brushed with a coat of primer furnished by the manufacturer immediately prior to attaching the reflector unit. The manufacturer's recommendations shall be closely followed.

The surfaces of the casting shall be free of rust, scale, dirt, oil, grease, or other foreign material which might adversely affect the bond of the adhesive used to affix the marker to the pavement surface.

857.06. BASIS OF PAYMENT.

Accepted pavement markers, measured as provided above, will be paid for at the contract unit price as follows:

- (A) PAVEMENT MARKERS EACH
- (B) REMOVE & RESET PAVEMENT MARKERS EACH

Such payment shall be full compensation for furnishing all materials, preparation and installation and for all labor, equipment, tools and incidentals necessary to complete the work.

**SECTION 858
RAILWAY-HIGHWAY CROSSBUCK SIGNS**

858.01. DESCRIPTION.

This work shall consist of furnishing and erecting railway-highway crossbuck signs with posts constructed in accordance with the Plans and these Specifications at the locations shown on the Plans or as established by the Engineer.

858.02. MATERIALS.

The materials used in this work shall meet the requirements specified on the Plans. A type D certification shall be furnished in accordance with subsection 106.04.

858.04. CONSTRUCTION METHODS.

- (a) **Sign Fabrication.** Fabrication of the signs and posts shall be as specified on the Plans.
- (b) **Setting Signs.** Set the sign posts in holes dug in thoroughly compacted soil with the top of the sign set to the elevation shown on the Plans or as designated by the Engineer. The sign shall face oncoming traffic and shall be so adjusted as to provide maximum effectiveness under local conditions. Backfill the holes as shown on the Plans with Class A concrete which shall be thoroughly rodded to obtain density. Provide for the sign to be temporarily supported in a plumb position for a minimum of 24 hours before the supports are removed.
- (c) **Location of Signs.** Locate crossbuck signs with respect to the roadway pavement or shoulder in accordance with the Manual on Uniform Traffic Control Devices for Streets and Highways or as established by the Engineer.

858.05. METHOD OF MEASUREMENT.

Railway-highway crossbuck signs will be measured by the unit for each sign installed including post and footing.

858.06. BASIS OF PAYMENT.

Accepted railway-highway crossbuck signs, measured as provided above, will be paid for at the contract unit price as follows:

RAILWAY-HIGHWAY CROSSBUCK SIGNS. EACH

Such payment shall be full compensation for furnishing all materials, equipment, labor and incidentals to complete the work as specified.

SECTION 859 REMOVAL OF PAVEMENT MARKINGS

859.01. DESCRIPTION.

This work shall consist of the removal of traffic stripe or other pavement markings in accordance with these Specifications at the locations shown on the Plans or as designated by the Engineer.

859.03. EQUIPMENT.

Equipment used for this removal of the markings may be of any type that will not materially damage the surface or texture of the pavement material.

859.04. CONSTRUCTION METHODS.

Remove all pavement markings to the fullest extent possible without damage to pavement surface.

NOTE: Painting over or blotting out the existing pavement markings is not an acceptable method of removal and will not be considered for measurement as removal. When sand or other material is deposited on the pavement as a result of the removal operation, remove it as the work progresses. Where blast cleaning is used for the removal of the pavement markings and such removal operation is being performed within ten feet of a lane under use by the traveling public, immediately remove the residue, including dust, by a vacuum attachment operated concurrently with the blast cleaning operation or by other methods approved by the Engineer.

Repair any damage deemed appreciable by the Engineer at no additional expense and by methods acceptable to the Engineer.

NOTE: Nothing in these Specifications shall relieve the Contractor from public relations and responsibilities as set forth in Section 107.

859.05. METHOD OF MEASUREMENT.

Traffic stripe or *pavement marking removal* will be measured by the linear foot (meter) of 4 inch (100 mm) wide traffic stripe where a narrower or wider stripe is to be removed or by the each where an arrow, word, or symbol is to be removed.

859.06. BASIS OF PAYMENT.

Except where otherwise specified on the Plans, removal of pavement markings, measured as provided above, will be paid for at the contract unit price as follows:

- (A) PAVEMENT MARKING REMOVAL LINEAR FOOT (METER)
- (B) PAVEMENT MARKING REMOVAL EACH

Such payment shall be full compensation for furnishing all materials, equipment, labor and incidentals to complete the work as specified.

SECTION 870
SAND FILLED IMPACT ATTENUATION MODULES

870.01. DESCRIPTION.

This work shall consist of furnishing and placing sand filled impact attenuation modules in accordance with these Specifications and in reasonably close conformity with the design, line, grades, and dimensions shown on the Plans or established by the Engineer. A module as used in these Specifications is defined as one free standing, frangible unit within the impact attenuation system.

870.02. MATERIALS.

(a) **Module.**

- 1. *General.* Sand filled impact attenuation modules shall meet the current test requirements, procedures and results as prescribed in the latest “National Cooperative Highway Research Program” (NCHRP) report approved by the Federal Highway Administration (FHWA) and in accordance with ODOT Standard Drawings.

Each module shall consist of three basic components consisting of an outer container, an inner container system, and a lid. The module shall be made of high density thermoplastic materials as specified herein, designated and constructed to shatter under impact.

The module shall be designed to support a sand mass of 200, 400, 700, 1400 and 2100 pounds (90, 180, 320, 640, and 960 kg) as specified at a height to insure that the center of gravity of each module is at the proper elevation to control the attitude of impacting vehicles so as to prevent ramping.

Each module shall be specifically designed for proper distribution of the specified sand mass without spontaneous rupture of the outer container or collapse of the inner core.

The outer container, unless otherwise shown on the Plans, shall be yellow colored, conforming to the standard highway color code requirement of the Manual on Uniform Traffic Control Devices for Streets and Highways.

Modules furnished shall be one of the following types.

- 2. *Type A Module--Seamed Outer Container.* The outer container shall consist of two identical cylinder halves made of high density polypropylene with an ultraviolet stabilizer that is durable and weatherproof, each half having shear carrying tongue and groove joints and

assembled into one cylinder. The assembled outer container shall be cylindrical in shape 35 inches to 37 inches (885 to 945 mm) in diameter by 36 inches to 38 1/4 inches (910 to 975 mm) high and shall have a wall thickness of 7/32 to 9/32 inch (5 to 7 mm).

2.1. Inner Container. The inner container support system shall consist of an inner core, disc and seal. The inner core shall be of one piece design of molded expanded polystyrene. The disc shall be a die cut piece of plastic sheeting at least 100 mils (2.5 mm) thick. The seal shall be a die cut piece of plastic sheeting of surlyn ionomer, or equivalent, at least 35 mils (0.10 mm) thick. The inner core, disc and seal system shall be designed to prevent leakage of the sand mass contained therein.

2.2. Lid. The lid shall clamp or snap fit over the top of the outer container and securely seal the module. The lid shall be of molded plastic with an ultraviolet stabilizer, producing a finished part satisfying durability and shape retention characteristics and having a thickness of 9/32 to 11/32 inch (7 to 9 mm).

3. *Type B Module--Seamless Outer Container.* The outer container shall be made of high density polyethylene material with an ultraviolet stabilizer that is durable and weatherproof, manufactured in one piece with an integral bottom.

The outer container shall be cylindrical in shape 35 inches (885 to 945 mm) inch in diameter and may taper to not less than 30 1/2 inches (700 mm) at the bottom. The wall thickness shall be 3/16 to 5/16 inch (5 to 8 mm). The container shall be 35 3/4 to 45 1/4 inch (915 to 1150 mm) in height.

3.1. Inner Container. The inner container support system shall consist of an inner core manufactured of molded polyethylene material. The inner core shall be designed to prevent leakage of the sand mass contained therein.

The inner container support system will not be required for the 2100 pounds (960 kg) module or the 1400 pound (640 kg) module when the outer container is specifically designed for proper distribution of the sand mass.

3.2. Lid. The lid shall be manufactured from a polyethylene material. The lid shall clamp or pressfit over the outer container and securely seal the module. The lid shall be 1/8 inch to 3/8 inch (3 to 9 mm) thick.

4. *Certification.* A Type D certification shall be submitted in accordance with Subsection 106.04 for each lot or shipment of modules.

- (b) **Sand.** Sand mass and sieve analysis for the modules shall meet the manufacturer's specifications and shall contain not more than 2 percent moisture by dry weight of the aggregate at the time of placement.

870.04. CONSTRUCTION METHODS.

Place the modules in the configuration for each location as shown on the Plans. Paint the outline of the base of each module on the surface of the pavement or apron with the weight of the sand mixture to be placed in the module painted in approximately 4 inches (100 mm) high numbers within the outlined circle of the module.

If the modules are to be installed on sloping surfaces greater than 5%, attach a half-ring block or other leveling device to the pavement or apron surface to prevent “walking” or overturning of the module which might occur from vibration caused by passing vehicles.

As each module is placed in its final position, fill it to the proper weight of the sand mass ±10 pounds (4.50 kg).

When the module is filled, place the lid on the module and fit it securely. If the lid is not self-securing, drill four holes, 1/4 inch (7 mm) in diameter, through the lid and outer container at equidistant points around the perimeter of the lid. Then secure the lid with four pop rivets to prevent it from being lifted or removed.

As a replacement supply, furnish additional modules of each capacity. The required number of replacement modules will be as shown on the Plans. These unassembled modules will become the property of the Department and be delivered to the nearest Department warehouse designated by the Engineer.

870.05. METHOD OF MEASUREMENT.

- (a) **Permanent Installations.** The modules as defined above will be measured by the unit, including all component parts installed as shown on the Plans. Replacement modules will be measured by the unit and delivered to the designated warehouse in accordance with these Specifications. The sand and paint required to complete the work will not be measured for payment, and the cost of these items will be included in other items. As a replacement supply, furnish additional modules of each capacity. The required number of replacement modules will be as shown on the Plans. These unassembled modules will become the property of the Department and be delivered to the nearest Department warehouse designated by the Engineer.

- (b) **Temporary Installations.** When Sand Filled Attenuation Modules are used temporarily in construction work zones, replacement modules and their installation will not be measured for payment.

Maintain enough sand filled replacement modules to provide replacement of thirty-five percent of the total number of modules in use on the project. The cost of maintaining replacement modules in stock shall be included in the price bid for Sand Filled Impact Attenuation Module.

Retain the right to seek compensation from the person or persons causing damage to the attenuation modules.

Upon completion of the project, sand filled impact attenuation modules used for temporary installations shall remain property of the contractor, unless stated otherwise on the plans.

870.06. BASIS OF PAYMENT.

Accepted modules, measured as provided above, will be paid for at the contract unit price as follows:

- (A) SANDFILLED IMPACT ATTENUATION MODULE EACH
- (B) REPLACEMENT IMPACT ATTENUATION MODULE EACH

Such payment shall be full compensation for furnishing all materials, equipment, labor, and incidentals to complete the work as specified.

SECTION 876 TRUCK MOUNTED IMPACT ATTENUATORS

876.01. DESCRIPTION.

The work covered by this section consists of furnishing, installing, operating, maintaining, and relocating truck-mounted impact attenuators and furnishing, stockpiling, and emoving repair packages in accordance with the plans and specifications.

876.02. MATERIALS.

The truck mounted impact attenuator shall consist of the following four basic components:

- A crushable cartridge encased in a shell.

- A backup.

- A backup support assembly for attaching the backup to the truck.

- A truck with a gross vehicle weight between 15,000 and 35,000 lb. (6,800 and 15,800 kg)

The impact attenuator shall be mounted on a truck chassis to provide a clearance of 11 to 13 inches (280 to 330mm) between the bottom of the shell and the roadway.

Truck-mounted attenuators must pass NCHRP #350. All certified test results shall be submitted showing that the truck mounted attenuator cartridge assembly has met all test and performance criteria as called out by NCHRP #350. The report shall be in the format of and evaluated by NCHRP #350 guidelines.

The truck-mounted impact attenuator cartridge shall have a standard trailer lighting system, including brake lights, tail lights and turn signals.

Truck-mounted attenuators shall be equipped with a 90 degree tilt system. The unit shall have a mechanical locking device to secure the truck mounted attenuator cartridge in the 90 degree position.

876.04. CONSTRUCTION METHODS.

Truck-mounted impact attenuators shall not be parked against rigid objects such as bridge piers and portable concrete barrier except as a temporary safety measure until a stationary crash cushion is installed. This use of impact attenuators shall be 72 hours maximum, or as shown in the Plans.

The truck upon which the attenuator is to be mounted shall be fully operational. The attenuator shall be installed according to manufacturer's specifications.

The truck-mounted impact attenuator replacement packages required by the plans shall be stockpiled on the project at all times when a truck-mounted attenuator is in use. The stockpile area shall be on the project, or at a location near the project, approved by the Engineer.

During the process of repairing the truck-mounted impact attenuator, furnish adequate means, acceptable to the Engineer, to provide for the safe control of traffic through the construction area or suspend all construction activities requiring the use of the attenuator until the damaged impact attenuator is restored to operation.

Any truck-mounted attenuator that becomes crushed or damaged so that it will not perform its intended purpose shall be immediately removed and repaired or replaced.

Upon completion of the project, truck-mounted attenuators that are paid for by each unit shall become the property of the state unless otherwise noted on the plans. Truck -mounted attenuators paid for on a sign day basis shall remain the property of the contractor unless otherwise noted on the plans

Payment for one sign day will constitute payment for the furnishing, operating, and maintaining one acceptable truck mounted attenuator for one day.

876.05. METHOD OF MEASUREMENT.

The quantity of *truck mounted attenuators* to be paid for by each unit will be the maximum number of truck mounted attenuators placed and in use at any one time during the life of the project.

The quantity of *truck mounted impact attenuator replacement packages* to be paid for will be the actual number of replacement packages which have been utilized during the life of the project, unless otherwise stated in the plans.

876.06. BASIS OF PAYMENT.

Truck mounted impact attenuators will be paid for at the contract unit price for “Truck Mounted Impact Attenuators.”

Truck Mounted Impact Attenuator Replacement Packages will be paid for at the contract unit price for “Truck Mounted Replacement Package.”

Accepted truck mounted attenuators, measured as provided above, will be paid for at the contract unit price as follows:

- (A) TRUCK MOUNTED ATTENUATOR..... EACH
- (B) TRUCK MOUNTED ATTENUATOR REPLACEMENT PACKAGE EACH
- (C) TRUCK MOUNTED ATTENUATOR SIGN DAY

Such payment shall be full compensation for furnishing all material, equipment, labor and incidentals to complete the work as specified.

**SECTION 878
MODULAR GLARE SCREEN**

878.01. DESCRIPTION.

This work shall consist of (1) furnishing materials and (2) installing modular glare screen units on concrete median barrier—in accordance with these specifications and in reasonably close conformity with the lines, dimensions, and locations shown on the plans or established by the Engineer.

878.02. MATERIALS.

The modular glare screen, as described herein, shall be 10 feet (3.05 m) in length and shall consist of glare screen blades, a flexible base rail, mounting brackets with hardware, and an anchor bolt system.

The modular glare screen blade and base rail shall be manufactured from frangible or flexible light weight material to prevent the possibility of penetration through the windshield of vehicles traveling at high speeds in the event that blades and/or base rail should inadvertently detach from the barrier wall. Modular glare screen shall meet the following physical requirements.

(a) **Modular Glare Screen Blades.**

	<u>Minimum</u>	<u>Maximum</u>
weight	_____	0.9pounds/foot (1.30 kg/m)
width	4 1/2 inch (115 mm)	6 inch (150 mm)
specific gravity	0.90	1.70
tensile strength	2900 psi (20,000 kPa)	_____

The modular glare screen blades shall be green in color similar in appearance to Federal Standard Number 595-34227.

(b) **Base Rail.**

	<u>Minimum</u>	<u>Maximum</u>
weight	_____	1.4 pounds/ft (2.00kg/m)
width	4 1/2 inch (115 mm)	6 inch (150 mm)
rail tensile strength	2900 pounds (20,000 kPa)	_____

Securely fasten each section of base rail to the barrier wall in at least three locations. The connections shall have a pullout strength of at least 2900 psi (20,000kPa) and a shear strength of at least 2900 psi (20,000kPa).

(c) **Weatherability.** Glare screen blades and base rail shall retain mechanical properties over a temperature range of -40°F and 150°F (-40° C and +65° C) and show minimum degradation after 3,000 hours in a weatherometer.

(d) **Certification.** A Type D materials certification shall be furnished in accordance with Subsection 106.04.

878.04. CONSTRUCTION METHODS.

Install all component parts of the units in accordance with the Plans and the manufacturer's specifications.

878.05 METHOD OF MEASUREMENT.

The quantity of each *modular glare screen* units will be measured by the number of units installed. Modular glare screen may also be measured by the linear foot (meter).

Upon completion of the project, modular glare screen paid for by each unit shall become the property of the state. Modular glare screen paid for on a sign day basis shall remain property of the contractor. Payment for one sign day will constitute payment for the installation and maintenance—including replacing any damaged or broken parts—of one 10 foot (3.05 m) section of glare screen for one day.

878.06. BASIS OF PAYMENT.

Accepted modular glare screen units, measured as provided above, will be paid for at the contract unit price as follows:

- (A) MODULAR GLARE SCREEN EACH
- (B) MODULAR GLARE SCREEN LINEAR FOOT (METER)
- (C) MODULAR GLARE SCREEN SIGN DAY

Such payment shall be full compensation for furnishing all materials, equipment, labor, and incidentals for the installation of the glare screen modules.

**SECTION 880
CONSTRUCTION SIGNING AND TRAFFIC CONTROL**

880.01. DESCRIPTION.

This work shall consist of furnishing and erecting signs, lights, barricades, and devices as shown on the Plans or as required by the Engineer or as proposed by the Contractor and approved by the Engineer.

880.02. MATERIALS .

- (a) **Construction Signing and Traffic Control Materials.** Materials for construction signing and traffic control shall meet the applicable requirements of NCHRP #350 crash requirements and these specifications as follows:

- 1. *Arrow Display.* The arrow display shall consist of the following components:
 - (1) Sign panel with yellow colored sealed beam lamps attached, meeting the requirements of Section 6F-3 of the Manual on Uniform Traffic Control Devices.
 - (2) Circuitry control unit.
 - (3) Mounting frame.

Panel. The face of the panels which are exposed to oncoming traffic shall be a nonreflective black finish.

Circuitry control unit. The level of intensity of light displayed by the lamps shall be changed through means of the control unit for either high intensity for day or reduced intensity for night operations. All lamps shall display essentially the same intensity of light for a given intensity setting.

Larger panels may be substituted for smaller panels at the discretion of the Contractor, but smaller panels may not be substituted for larger panels.

Mounting frame. The sign panel shall be supported on a mounting frame such that when displayed to oncoming traffic the bottom edge of the panel shall be not less than 7 feet (2.1 m) above the roadway surface. Mount the arrow display so that the panel can be rotated on a horizontal axis to be hidden from the view of on-coming traffic when not in use. Mount all mobile arrow displays on pneumatic-tired vehicles.

The flashing lights shall be operated from a dependable power source, and shall have a separate auxiliary source of power immediately available. At least one power source on a mobile arrow display shall be a self-contained source, either battery or electric generator operated.

The arrow display shall contain a special circuitry control unit. The circuitry control unit shall be a solid state electronic unit with four modes which shall contain switching controls for operator selection as follows:

- (1) Pass Right: flashing arrow.
 - (2) Pass Left: flashing arrow.
 - (3) Pass Either Side: the outermost chevrons, one at either end of the panel with the apex of each chevron pointing toward the nearest panel edge.
 - (4) *Caution - four or more lamps, arranged in a pattern which will not indicate a direction.*
2. *Construction Signs and Barricades.* The supports and sign blanks may be either metal, wood, or plastic, the only requirement being satisfactory performance. Install all signs 10 square feet (1 square meter) and larger with two supporting legs. Retroreflectorize all signs and barricades whether for day or night use by means of wide angle flat top reflective sheeting meeting the specifications for Type II-A sheeting, unless otherwise specified on the plans.

Construct all sign messages and symbols in accordance with the Manual on Uniform Traffic Control Devices and the Oklahoma Department of Transportation Sign Detail Standards.

NOTE: Any construction sign not meeting retroreflectivity specification of Section 719.04 at any time during the life of a project shall be clearly marked and immediately replaced.

3. *Construction Signs.* 32.3 square feet (3.0 square meters) and Over. Construct signs 32.3 square feet (3.0 square meters) and over of extruded aluminum or galvanized steel. All signs in this item which are to be ground mounted shall be of a breakaway design and installed in accordance with the latest revision of the following standard drawings: GMS-1, FGS-1, FGS-2 and SPA-1. Installation locations shall be approved by the Engineer prior to construction. Due to the temporary nature of these signs, no reinforcing steel will be required in the sign footings. Installation of this item may also include placement on existing overhead sign structures and will be shown on the Plans.

Retroreflectorize all signs in this item in accordance with current specifications. Sign color and specific design shall be as shown on the Plans.

4. *Vertical Panels.* Vertical Panels shall meet the requirements of Section 6F-5 of the Manual on Uniform Traffic Control Devices. Type II-A reflectorized sheeting shall be on both sides of each vertical panel.
5. *Warning Lights.* Warning lights shall meet the requirements of Section 6F-7OF of the Manual on Uniform Traffic Control Devices.
6. *Cones.* Cones shall conform to the requirements of Section 6F-5 of the Manual on Uniform Traffic Control Devices.

7. *Surveillance of Traffic Control.* Under the Surveillance of Traffic Control pay item, provide a person at the construction site 24 hours a day, seven days a week, to maintain and keep all traffic control devices in position any time traffic is directed away from the normal traffic lanes or anytime the Engineer deems it necessary.
 8. *Traffic Surveillance, Police.* The price bid for this item shall include the following:
 - Two officially marked Oklahoma Highway Patrol Cars.
 - Two law enforcement officers with jurisdictional authority to write and issue traffic citations.
 - The law enforcement officers will be insured, licensed, and bonded by their employer, and specifically approved and assigned to this work activity.
 - Make all the necessary arrangements with the law enforcement agency to provide the required law enforcement on this project. These arrangements should be made through the Chief's office, Oklahoma Highway Patrol at (405) 425-2424.

NOTE: Duty hours for these officers and vehicles will be the same as the Contractor's working hours on this project.
 9. *Flagger.* Included in this item is the cost of providing two flaggers for a twenty-four-hour period. Also included is the cost of providing any lighting needed to adequately illuminate the flagger stations at night. Care shall be taken so that the lighting does not cause visibility problems (blinding) for passing vehicles. This item will only be used when flaggers are required during nonworking hours.
 10. *Drums.* Drums used for traffic warning or channelization shall be constructed of lightweight, flexible, and deformable materials and be a minimum of 36 inches (900 mm) in height; and have at least an 18 inches (450 mm) minimum width, regardless of orientation.

NOTE: Steel drums shall not be used. The markings on drums shall be horizontal circumferential, alternating orange and white Type III reflective stripes 4 inch (100 mm) to 6 inch (150 mm) wide. Each drum shall have a minimum of two orange and two white stripes not more than 2 inches (50 mm) wide. Drums shall have closed tops that will not allow collection of roadwork or other debris.
 11. *Tube channelizers.* Tube channelizers shall be predominantly orange, not less than 27 inches (700 mm) high, a minimum 2 inches (50mm) wide when facing traffic, and made of a material that can be struck without damaging impacting vehicles. For nighttime use, tube channelizers shall have a minimum retroreflectivity of Type III sheeting. Provide retroreflection of tube channelizers by two 3 inches (75 mm) wide white bands placed a maximum of 2 inches (50 mm) from the top, with a maximum of 6 inches (150 mm) between the bands.
- (b) **Sampling and Testing.** A type D certification shall be furnished in accordance with subsection 106.04.

880.04. CONSTRUCTION METHODS.

Place signs, lights, and barricades on either portable or fixed supports as project requirements dictate.

Traffic control devices shall meet the requirements of the current Manual on Uniform Traffic Control Devices, published by the U.S. Department of Transportation, as pertains to shape, size, color, mounting height and placement.

When, in the opinion of the Engineer, any sign or other device which has been damaged needs cleaning, or has deteriorated to the extent it is no longer effective, it shall be cleaned or replaced immediately as required.

Conduct night time reviews of traffic control devices in coordination with the Department personnel at the beginning of the project, in conjunction with major changes to traffic signing, and at monthly intervals. Record the date and result of the night-time inspection in the contractor signing log.

880.05. METHOD OF MEASUREMENT.

If specified on the plans, *construction traffic control* may be paid for as a lump sum pay item. When the plans specify lump sum payment for construction traffic control, construction signing will be installed in a manner approved by the Engineer and in accordance with Chapter VI of the Manual on Uniform Traffic Control Devices, latest edition, and applicable O.D.O.T. standard drawings. Price bid for this item shall be payment in full for the installation and subsequent removal of all necessary construction traffic control required for completion of the project.

When *construction traffic control* devices are itemized pay items on the plans, each sign, barricade, light, drum, arrow display, or other traffic control device will be measured by the unit, complete in place, each calendar day the device is required and is in place in an acceptable condition and position to meet all of the above requirements. Measurement for payment will begin on the day that signs and other devices are in place for traffic control and direction.

Furnish a log of the signing and other traffic control devices and update this log throughout the life of the project to confirm the addition or deletion of individual traffic control items. Prior to each pay period, physically count the traffic control devices to substantiate the log.

Monitor the traffic control devices to evaluate their physical condition. When signs and devices are not needed for traffic control, they will not be measured, even though left in place. No unnecessary traffic control devices shall be left in place more than 5 days unless covered in a manner approved by the Engineer. There shall be a deduction in payment of one sign day for each day after the first 5 days that a traffic control device is left in place and not covered. Unnecessary traffic control devices that remain in place for more than 30 days shall become the property of the Department. This includes any time before, during, or after construction of the project. During nonworking periods—such as holidays, Sunday, etc.—the log of signs in place and measured for payment on the day preceding and on the day following such down time will be used to determine the signs to be paid for. When it is necessary to move an item from one location to another, it will be measured for payment only one time on the day of movement.

The necessary flags, flagman signs and jackets, posts, traffic cones, and other incidental items included in a detour or other traffic control system or installation, as shown on the Plans or as required

by the Engineer, will not be measured for payment, but their costs shall be included in the price of other bid items.

Signs and other traffic control devices will not be measured for payment during any time the Contractor is being charged for liquidated damages. This in no way relieves the Contractor from responsibility for providing signing on the project or maintaining the required log until it has been completed and accepted. Such signing will be at the Contractor’s expense.

During any period that contract time is suspended in accordance with Subsection 108.07, any traffic control devices required for the safety of the motoring public will continue to be measured and paid for.

Quantities included in the Plans for traffic control items are estimated quantities based upon a given sequence of construction and schedule of work and should not be considered as definite quantities for final payment. The quantities computed for final payment will be based on daily measurements recorded and approved by the Engineer.

880.06. BASIS OF PAYMENT.

Signs and other traffic control devices, measured as provided above, will be paid for at the contract unit price as follows:

- (A) ARROW DISPLAY SIGN DAY
- (B) CONSTRUCTION SIGNS. SIGN DAY
- (C) CONSTRUCTION BARRICADES SIGN DAY
- (D) VERTICAL PANELS SIGN DAY
- (E) WARNING LIGHTS SIGN DAY
- (F) DRUMS SIGN DAY
- (G) TUBE CHANNELIZERS SIGN DAY
- (H) CONES SIGN DAY
- (I) FLAGGER SIGN DAY
- (J) CONSTRUCTION TRAFFIC CONTROL LUMP SUM
- (K) SURVEILLANCE OF TRAFFIC CONTROL SIGN DAY
- (L) TRAFFIC SURVEILLANCE, POLICE HOUR

Such payment shall be full compensation for furnishing all materials, equipment, labor, and incidentals to complete the work as specified. Unless otherwise designated on the Plans or special provisions, all traffic control devices under this item will remain the property of the Contractor upon completion of the project.

SECTION 882 CHANGEABLE MESSAGE SIGN

882.01. DESCRIPTION.

Work under this item shall include furnishing, maintaining—and delivery to a storage yard designated by the Engineer—a trailer-mounted, Changeable Message Sign or Remote-Controlled Changeable Message Sign, whichever is applicable, at the locations indicated on the plans or as directed by the Engineer.

882.02. MATERIALS.

The internally illuminated variable message sign shall consist of the following:

- (1) A magnetically operated matrix, LED, fiber optic, or lamp matrix message board
- (2) A solar and battery power supply
- (3) Hardware for connection to a 110 volt power source
- (4) An on-board computer
- (5) A computer operated interface, all mounted on a towable, heavy duty trailer

The sign shall have a three line message panel with minimum dimensions of 7 1/2 feet (2.3 m) high and 8 feet (2.5 m) wide for 7 characters per line and 7 1/2 feet (2.3 m) high and 9 1/2 feet (2.9 m) wide for 8 characters per line. The letter height shall not be less than 18 inches (460 mm). The sign shall rotate 360 degrees atop the lift mechanism.

In the raised position, the bottom of the sign shall be at least 7 feet (2.1 m) above the roadway. The sign shall be clearly legible for a distance of 1000 feet (305 m).

The sign shall be controlled by an onboard computer. Upon failure, the sign shall automatically change to a preselected default message which shall remain on display until the problem is corrected. The Remote Controlled Changeable Message Sign unit shall be equipped with a cellular telephone and a security system to prevent unauthorized access. The security system shall allow access only through password or code unique to that sign. If the proper password or code is not entered within 60 seconds of initial telephone contact, the call will be terminated. Remote Control for the Remote Controlled Changeable Message Sign shall be done through a touch tone modem decoder.

Each element in a magnetically operated matrix message board shall consist of a movable flap operated by an electromagnet, which shall be positioned so that by changing polarity the flap is reversed. When closed, the black side shall be exposed; when opened, the colored section shall be exposed.

The lamp matrix, LED, or fiber optic sign shall be equipped with a top-mounted photocell for automatic sign dimming during nighttime use.

The sign shall be capable of storing 100 preprogrammed messages and be able to display any one of those messages upon call via the trailer mounted terminal for both the Changeable Message Sign and the Remote Controlled Changeable Message Sign.

Comply with section 801.02.

882.04. CONSTRUCTION METHODS.

Furnish, place, operate, maintain, and relocate the sign as required. When the sign is no longer required, remove it, at which time it becomes the property of the State, if paid for by each unit. The cellular telephone required for the Remote Controlled Changeable Message Sign shall also become the property of the State.

882.05. METHOD OF MEASUREMENT.

This work will be measured for payment for each *changeable message sign* or *remote controlled changeable message sign*, whichever applies, furnished and installed. Upon completion of the project, portable changeable message signs paid for by each unit shall become the property of the State. The cellular telephone required for the *remote controlled changeable message sign* shall also become the property of the State. Changeable message signs paid for on a sign day basis shall remain property of the contractor. Payment for one sign day shall constitute payment for furnishing, placing at a location designated by the Engineer, maintaining, and operating one acceptable changeable message sign for one day.

882.06. BASIS OF PAYMENT.

This work will be paid for at the contract unit price per sign day for each "Changeable Message Sign" or "Remote Controlled Changeable Message Sign," which price shall include furnishing placing, maintaining, relocating, and removing the sign and its appurtenances, as well as all material, labor, tools, and equipment incidental thereto. Additionally, for the "Remote Controlled Changeable Message Sign," the cellular telephone and telephone charges shall be included.

- (A) CHANGEABLE MESSAGE SIGN EACH
- (B) CHANGEABLE MESSAGE SIGN SIGN DAY
- (C) REMOTE CONTROLLED CHANGEABLE MESSAGE SIGN EACH
- (D) REMOTE CONTROLLED CHANGEABLE MESSAGE SIGN SIGN DAY

Such payment shall be full compensation for furnishing all materials, equipment, labor, and incidentals to complete the work as specified.

SECTION 884 BRIDGE GUARDRAIL RETROFITS

884.01. DESCRIPTION.

This work shall consist of furnishing materials and installing bridge guardrail retrofits in accordance with these specifications and in reasonably close conformity with the locations and dimensions shown on the plans or established by the engineer.

884.02. MATERIALS.

Materials shall meet the requirements of the following specifications:

Portland Cement Concrete	Section 701
Reinforcing Steel	Section 723
Metal Beam Railing	Subsection 732.01
Aluminum Alloy Tubes for Railings	Subsection 732.03
Cast Aluminum Alloy Bridge Railing Posts	Subsection 732.03
Pipe Railing	Subsection 732.04

884.04. CONSTRUCTION METHODS.

Carry out the installation of bridge guardrail retrofits in conformance with the details shown on the plans.

884.05. METHOD OF MEASUREMENT.

Guardrail retrofits and removal, measured by the linear foot (meter), shall include all materials and hardware necessary for installation.

884.06. BASIS OF PAYMENT.

Accepted bridge guardrail retrofit and removal, measured as provided above, will be paid for at the contract unit price as follows:

- (A) BRIDGE GUARDRAIL RETROFIT LINEAR FOOT (METER)
- (B) BRIDGE PARPET RETROFIT LINEAR FOOT (METER)
- (C) REMOVE BRIDGE RAIL & POSTS LINEAR FOOT (METER)

Such payment shall be full compensation for furnishing all materials, equipment, labor, and incidentals required to complete the work as specified.

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Section 100- Page 71, Subsection 108.03,tenth line: "Specifications" should be "Specifications".

Section 100 - Page 57 Section 106.04(d)

From "Certifications shall be mailed to the Resident Engineer, with one copy mailed to : Materials Engineer"
To "Certifications shall be mailed to the Materials Engineer, with one copy to be mailed the Resident Engineer."
The Resident only needs one copy until the approved copies are sent out by Materials Division.

In Section 100, on page 67, in subsection 108.01, second paragraph, second line;
substitute "Resident Engineer" with "Director or his authorized representative".

Section 100- Page 55, Subsection 102.06, insert the following paragraph after the first paragraph.

The prospective bidder shall take no advantage of any apparent error or omission in the Plans or Contract. In the event that the prospective bidder discovers an error or omission, he shall immediately notify the Department. The Department will make such corrections necessary to fulfill the intent of the Plans and Contract.

A reoccurring error is the use of 202.02 when it should have been edited to 202.04.:

- * Section 200-Page 7, Subsection 202.04(a)(1): paragraph two, line 3 and line 4,
- * Section 200-Page 8, Subsection 202.04(a)(1): paragraph one, line 3; paragraph 4, line 2 and line 6,
- * Section 200-Page 9, Subsection 202.04(a)(1): paragraph four, line 8,
- * Section 200-Page 10, Subsection 202.04(a)(2): paragraph two, line 3,
- * Section 200-Page 12, Subsection 202.04(b)(2): paragraph one, line 14,
- * Section 200-Page 12, Subsection 202.04(c): paragraph seven, line 2, twice,
- * Section 200-Page 18, Subsection 205.05: paragraph two, line 2,
- * Section 200-Page 19, Subsection 209.04: paragraph two, line 4 and 5,
- * Section 300-Page 5, Subsection 301.02(b): paragraph one, line 1,
- * Section 300-Page 17, Subsection 307.04(g): paragraph one, line 10,
- * Section 300-Page 20, Subsection 310.04: paragraph three, line 2,
- * Section 300-Page 20, Subsection 310.04: paragraph four, line 3,
- * Section 300-Page 21, Subsection 310.04: paragraph four, line 4 and 6,
- * Section 300-Page 26, Subsection 317.04: paragraph one, line 1,
- * Section 300-Page 26, Subsection 317.04: paragraph three, line 3,
- * Section 602-Page 11, Subsection 602.04(g): paragraph one, line 1,
- * Section 600-Page 34, Subsection 613.04(f): paragraph one, line 5,
- * Section 600-Page 36, Subsection 613.04(h): paragraph two, line 3,
- * Section 600-Page 47, Subsection 619.04(a): paragraph three, line 7,
- * Section 600-Page 49, Subsection 619.04(e): paragraph four, line 5.

Section 200-Page 9, Subsection 202.04., paragraph two, forth sentence, word Sepulcre should have been Sepulture.

Section 200-Page 16, Subsection 203.03 remove the word abreast form the first line.

Section 200-Page 18, line 2 should read Subsection 230.04(d)(2).

Section 200-Page 18, Subsection 205.05, delete the last sentence of the first paragraph.

Section 200-Page 18, Subsection 205.05, delete the first sentence of the italicized paragraph starting with NOTE.

Section 200-Page 34 and 35: references to 230.04(g) should read 230.04(f); references to 230.04(h) should read 230.04(g); and reference to 230.04(i) in the 'NOTE' should have been 230.04(h). Should this be changed to 230.04(h).

Section 200-Page 34: the reference in th note to section 230.04(i) should have been 230.04(h).

Section 200-Page 44, Subsection 232.04(c), line two: reference to 230.04(f) should read 230.04(e).

Section 200-Page 47, Subsection 233.04.(b)(1), line six : the rate should be 200 gallons per acre, not 2000.

Section 400-Page 11: No. 3C Aggregate, change "0.3 to 3.5 gallons" to "0.3 to 0.35 gallons".

Section 400 page 45, (r) (2): reference to 701.01(d) should be 701.01(c).

Sect 500 - pg 7 Sub 501.02 (b) 2. 3rd paragraph, line 2 should read "replace 50 lb/cy (30 kg/m³) of fly ash with approximately 60 lb/cy (35 kg/m³) of sand. The"

Section 500-Page 7, Subsection 501.02.(b)2., paragraph three, line 2: the 't' should have been 'the'.

Section 500-Page 139, Subsection 514.03. (a)2., line 3: the "85" should be corrected to read "0.85".

Section 500-Page 125, Subsection 512.04. (a)2.2., paragraph two, second to the last line: word calculate should have been calculate.

Section 600-Page 7, Subsection 601.06. (B-2), delete the word 'CUBIC'.

Section 600-Page 73, Subsection 641.06. First bullet, last line change "105.17a" to "107.17".

Section 700-Page 44, Subsection 707.02.(c): correct the section sentence to read "Table 3C".

Change "work order" to "notice to proceed" in the following places in the 1999 Standard Specifications.

Section 100 Page 11 Sub-Section 101.16 Paragraph 2 Line 2.

Section 100 Page 45 Sub-Section 105.07 Paragraph 2 Line 4.

Section 600 Page 55 Sub-Section 602.04 Note Line 1.