STATE OF OKLAHOMA
DEPARTMENT OF TRANSPORTATION
GEOTECHNICAL SPECIFICATIONS FOR ROADWAY DESIGN

JUNE 29, 2011

APPENDIX 4. - GUIDE FOR PREPARING GEOTECHNICAL REPORTS

This purpose of this guide is to provide clear and concise methods for preparing geotechnical reports for the Oklahoma Department of Transportation. When used as described, this information will provide consistent and appropriately documented geotechnical reports.

Overview

Geotechnical reports provide written documentation of findings from preliminary investigations, field explorations, laboratory testing, geotechnical evaluations and construction planning reviews. The Geotechnical Engineer responsible for the report should have broad experience in geotechnical engineering and a background in engineering for the type of roadway work identified in the project. The project geotechnical specialist, responsible for the report preparation, should have a broad background in civil engineering with a good basic knowledge of the soils and geology of Oklahoma as well as an understanding of the designs that are required to remedy the problems at a certain specific location(s). The project geotechnical specialist should anticipate possible design and construction issues and provide recommendations and solutions to mitigate or eliminate problems as well as any comments concerning possible limitations or other construction problems. The recommendations should be brief, concise and include the reasons for the recommendations. Provide any supporting data (e.g., graphics, tabular data, and calculations) in the appendices of the report.

Supplemental Geotechnical Report

Occasionally, the project design team may request the Geotechnical Engineer to conduct additional geotechnical reviews or studies. Based on these reviews or studies, the project geotechnical specialist will prepare a supplemental report to the geotechnical report. The supplemental report should only address the analysis and alternatives for those elements requested for additional geotechnical review or study.

Special Reports

Occasionally, the project geotechnical specialist may be required to prepare a special geotechnical report not related to a particular project (e.g., landslides, rock falls). Typically, these reports are prepared under emergency conditions and, as a result, only include recommendations to mitigate immediate problems. The special report should include the methods of analysis, calculations, design assumptions, computer programs used and other information as applicable to arrive at the design recommendations.

Geotechnical Reports

The Final Geotechnical Report for Roadway Design should contain all the geotechnical data and recommendations required for design. The report should be organized to include Transmittal Information about the report, General Information about the project, Field Investigation and Laboratory Testing Information, and the Geotechnical Information required for Roadway Design projects. These are described in greater detail in succeeding sections of this appendix. In addition to this required information, the final geotechnical report should include the following, where applicable:

- design geotechnical data;
- design computations as required by the consultant's agreement;
- quality assurance/quality control certifications including lab and technician certification; and
- any alternative designs considered.

The Geotechnical Engineer is required to conduct a quality assurance review of the report before it is submitted to ODOT. The quality assurance review should include checking all calculations, as well as a review by a senior engineer or geologists of the approach, assumptions, results and conclusions/recommendations of any work carried out for the project. The report should also be edited to be free of grammatical and spelling errors, and graphics should be legible and easy to interpret. Geotechnical reports must be dated, signed, and sealed by a Professional Engineer licensed in the State of Oklahoma.

The Geotechnical Engineer shall submit the final geotechnical report to ODOT in two hard copies and one PDF copy on CD.

The Department, upon review of the final written report and boring logs, will exercise final authority as to whether the consultant has provided sufficient information or if additional data or borings are required. The Department further reserves the right to review all phases of the geotechnical report, including all field and laboratory data, computations and analysis.

GEOTECHNICAL EVALUATION REPORT

In general, organize all geotechnical project reports using the following format.

Transmittal Information

The project geotechnical specialist should use the following format when preparing the transmittal memorandum for the geotechnical report:

1. Addressee (To): Address the memorandum to the ODOT Division Engineer (e.g., Roadway Design Division, Bridge Division, Field Division) responsible for the project oversight.

2. Contact. Provide the name, telephone number and email of the individual(s) that can be contacted for additional information or questions.

3. Signature (From): Prepare the report for the Geotechnical Engineer's signature. Also, include the report author and title directly underneath the author's signature line.

4. Date. Include the date the report is submitted to the addressee.

5. Subject. In the subject, include the official construction project number, job piece number, and project description.

General Project Information

The project geotechnical specialist is responsible for preparing a detailed geotechnical engineering report outlining the findings of the field and laboratory investigations and, where applicable, results from the geotechnical engineering analyses, designs for geotechnical features and recommendations and alternatives for potential issues affecting the project alignment or construction.

Not all of the subject areas listed in the following Sections will be required for every geotechnical report and adjustments may be required as deemed necessary. The level of coverage for each item will also vary from project-to-project. Although in-depth coverage of individual details is usually not provided in the report, provide sufficient detail to allow the reader to fully understand the problem and any proposed recommendations. Detailed analyses may be added as appendices to the report.

The following provides the topic areas, listed in order, to be addressed in geotechnical reports:

1. Introduction. Identify the purpose of the report and provide a very brief summary of what is included in the report.

2. Project Information. Include the following in the project description:

    - construction project number and job piece number;
    - the county where the project is located;
    - route number or street name;
    - nearby towns and/or cities;

- the project location with respect to the highway mileage markers and/or project length;

- general scope of the project (e.g., roadway reconstruction, pavement widening and/or overlay);

- major features of the project (e.g., four-span structure, retaining wall, final roadway widths, design speed); and

- other applicable elements of the project (e.g., deep cuts or fills, special drainage considerations, detour requirements).

3. Area Geology. Note the topography of the project area. Identify the soil and rock type formations within the project area. Note the predominate soil and rock types that can be found within the project area. If available, provide a description of the soil and rock formations (e.g., expansive soils, dispersive clay, karst).

4. Site Reconnaissance. Note any geotechnical features found during the investigation, including, but not limited to, the following:

- outcrops of bedrock;
- existing cuts and fills, including slope angles;
- evidence of current or past landslides;
- surface soils;
- potential problem soils such as dispersive or expansive clays sulfate bearing soils;
- groundwater conditions (e.g., springs, streams, irrigation);
- wetland locations;
- areas that may require subexcavation or other foundation stabilization/drainage measures;
- locations that may require rock excavations, including areas that may require blasting;
- locations that will require extensive excavations and/or fills;
- roadway patching that may indicate subgrade problems;
- the type of vegetation or lack thereof;
- location of nearby buildings, drainage structures, bridges, utilities, etc.; and
- other features that may affect the project alignment, right-of-way and/or design.

5. Subsurface Investigation. Document the insitu tests conducted and their results. Provide the preliminary soil classifications determined from the subsurface investigation. Indicate any special considerations required for the subsurface investigation (e.g., location of utility lines, steep terrain, nearby structures, wetlands, private property, and required permits). Include the proposed scope of the field and laboratory work that appears to be necessary for future phases of the project.

6. Design and Construction Recommendations. Where applicable, provide design and construction recommendations to the project designer so that it can be considered during the design phase. Include the information noted in Sections 3.2.4 and 3.2.5, as applicable.

7. Report Limitations. Provide possible constraints so they may be considered during the preliminary stage of design.

Field Investigation and Labortory Testing Information

Geotechnical investigation and testing information is a vital part of geotechnical reports. The information in geotechnical reports should provide written documentation of findings from the field explorations and laboratory testing. Where applicable, the project geotechnical specialist should include the following information in the geotechnical report:

1. Pedological Investigation. The pedological investigation should include and consist of the following elements:

    - Include aerial photographs at 1:20,000 scale (or the scale that is used by NRCS in their county soil survey reports) with delineated map units and proposed location or center reference line/centerline alignment plotted thereon (reproduction from county soil survey report) are required. Obtain copies of Digital Orthophoto Quad sheets from the Oklahoma Conservation Commission website.

    - Sum and report the traversed distance of each alphabetized map unit in feet.

    - Include a set of official soil series description sheets from the official NRCS national database source (Iowa State). These are for the soil series found along the alignment extent or at the location of interest.

    - Provide a numerical listing in alphabetical order of the soil series found along the alignment along with their Taxonomic classification (e.g., Burleson Soil Series, Fine, smectitic, thermic, Udic Haplustert).

    - Include field logs of the soil samples taken from all soil horizons for each soil series. Describe the results according to the official soil series description. Also, a large composite sample of the major horizons, excluding the A horizon, are to be listed.

    - As an option to using county soil survey maps, the soil map units may be plotted on digital orthophoto quad sheets. These are at 1:24,000 scale and are

appropriate for the report. These can be obtained at the State of Oklahoma Conservation Commission.

- Provide a list of the required laboratory tests conducted and the findings from these tests. Standard forms for reporting Pedological Investigation information are provided in Appendix 5.

2. Shoulder Survey/In Place Soils Investigation. The Shoulder/In Place soils investigation should include the following information:

   - Field logs of the soil samples taken with depths and station extents of similar soil types within the project extents. Note on the logs which soils samples were used to conduct resilient modulus tests.

   - Provide a list of the required laboratory tests conducted and the findings from these tests. Standard forms for reporting Shoulder Soils/In Place Soils Investigation information are provided in Appendix 5.

3. Pavement and Subgrade Soils Investigation. The Pavement and Subgrade Soils Investigation should include the following information:

   - Back calculated FWD data of the pavement section in tabular format. Include a CD with the back calculated data in Excel format for further analysis.

   - Detailed core logs with color photo of core. Note the pavement layer thicknesses and condition.

   - Pavement surface condition survey as detailed in FHWA-RD-03-031

   - Field logs of the soil samples taken with depths and station extents of similar soil types within the project extents. Note on the logs which soils samples were used to conduct resilient modulus tests.

   - Provide a list of the required laboratory tests conducted and the findings from these tests. Standard forms for reporting Pavement and Subgrade Soils Investigation information are provided in Appendix 5.

4. Subsurface Investigation. When summarizing the subsurface investigation include the following information, where applicable:

   - permission from property owners;

   - number of borings taken and dates that the boring work took place;

   - summary of the soil and rock types found;

- general description of the land formation (e.g., gullies, excavations, slopes, stream banks) and vegetation;
- study of existing structures;
- location of underground and overhead utilities:
- presence of surface water and stream debris;
- subsurface water table and location on the boring logs;
- unusual drilling conditions;
- any additional subsurface testing that was conducted (e.g., groundwater monitoring, seismic), the equipment used, the stationing and other applicable information relative to the test;
- results of the in-situ tests (e.g., SPT, CPT);
- boring logs, maps indicating the boring locations, including the plan station and offset, data from site tests, etc., in the appendices; and
- location for material and borrow sources.

5. Laboratory Testing. Indicate the laboratory tests that were completed on the soil and rock samples. Include a summary of the laboratory testing results. Discuss the results of these laboratory tests.

6. Soil Classification. Identify soil classifications in sufficient detail to permit engineers to recognize features significant to design and, if need be, to obtain samples in the field.

7. Geological Surface and Subsurface Rock Formation Information. Geological rock formation information should be provided using the standard methods of rock type descriptions as described in Appendix 3. Provide complete and accurate rock type information useful to designer. In addition, include the descriptions of rock types as recovered from drill bit cuttings or as observed in cores. The geological information provided should be structured so that the description of rock characteristics more pertinent to the construction or repair of ODOT facilities is emphasized.

   Where cores are taken, provide the Rock Quality Designation (RQD) in accordance with ASTM D 6032. If Rock Mass Ratings (Geomechanics Classification) are required note these according to ASTM D 5878. The following is a listing of the rock characterization elements to be used in describing the rock units. The elements describing the character of Oklahoma rock types are to be presented in the report in the order listed:

- rock type (lithology),
- color,
- thickness,
- gradation,
- texture,
- pores,
- cementation,
- hardness,
- layering (or bedding), and
- joints.

Not all of the above elements will be present at a given site. The type of construction being considered, the character of the rock encountered, and the method of investigation are examples of situations that will dictate the elements used to describe the rock unit(s) in the report.

An example of the type of report is found in Appendix 3 "Standard Guide for the Description of Surface and SubSurface Geological Rock Formations of Oklahoma".

8. Plans and Boring Logs. Geographic locations of the geological log or outcroppings must be described from plans by Station to the nearest tenth of a foot, where the information is available. A minimum of a legal description accurate to the nearest 100 ft is required when plans or other detailed location information is not available. Global Positioning Systems (GPS) locations are acceptable; however, bore hole locations must be referenced to the plan station and offset. Elevations of the ground surface to the nearest tenth of a foot are required for all borings. At a minimum, include the following ancillary information on the logs:

- construction project number and job piece number;
- stratigraphic location, to nearest 0.1 ft, of any samples or tests taken;
- name of contractor;
- name of the driller
- name of logger;
- core or hole diameter, in inches;
- boring number;
- date the drilling or logging was performed;
- type of equipment used (e.g., bit type used);
- name of engineer and/or geologist, onsite, responsible for the field boring logs and interpretation of the geologic profile; and
- method (or combination) of drilling used.

Geotechnical Engineering for Roadway Design

This section of the report is generally prepared for the roadway design and covers roadway embankments, side slopes, rock cuts, pavement subgrade, etc. For each item discussed in the report, the project geotechnical specialist should clearly indicate the following:

- applicable station-to-station distance, width and depth of the area of concern;
- interpretation and analysis of the drawings, logs and data;
- any specific recommendations and/or alternatives to mitigate or eliminate the concern;
- detailed drawings or sketches and tabular data, these may be included in the appendices; and
- where necessary, include applicable special provisions.

The design portion of the geotechnical engineering roadway alignment section should include, but is not limited to, the following topics:

1. Alignment Recommendations. Identify recommended revisions to the horizontal and vertical alignment from the preliminary plans.

2. Right-of-Way Considerations. Note where additional right-of-way may be required to accommodate landslide areas, cut and embankment slopes, rock containment, etc.

3. Specific Findings and Design Recommendations. The alignment section may include discussions and recommendations on the following:

    a. Cuts and Embankments. If the project has cuts or embankments, address the following:

        - Provide the location and description of existing surface and subsurface drainage.
        - Identify and report springs and excessive wet areas.
        - Identify and report slides, slump and faults along the alignment.
        - Identify special cuts and embankments. Characterize the area or volume of material, station along alignment or reference line, distance left or right from alignment or reference line, etc.
        - Provide subsurface drainage recommendations.
        - Recommend undercut extents, if required.

- Identify unusual erosion control measures that may be necessary.
- Provide recommended limits on cut and fill slopes.
- Provide shrink-swell factors for earthwork calculations.
- Provide the parameters that characterize the discontinuity and rock mass, excavation, slopes, blasting requirements, containment areas, etc. Identify recommended rock extents that are rippable and areas that will need to be blasted.
- Provide recommended rock slope stabilization measures.

b. Soft Ground. If the embankment is over soft ground, provide the following:

- Include recommendations for alternative embankment designs if problematic soils (e.g., dispersive clays, silt) are anticipated from local embankment borrow sources.
- Provide the estimated short and long-term settlement.
- Provide alternative designs, conceptual construction sequencing, time needs, and address long-term settlement, including surcharging and/or wick drains where applicable, and slope stability. Identify methods of analysis, factors of safety, design codes with version, etc.
- Provide recommendations and specifications for monitoring settlement and slope stability.

c. Floodplains. If the embankment is in a floodplain, provide the following:

- Give recommendations for alternative embankment designs if problematic soils (i.e., dispersive clays, silty soils) are anticipated using local borrow sources.
- Include recommended special provisions for the embankment.
- Identify recommended embankment protection for hydraulic impacts on the embankment including rapid draw down, scour, wave action, etc.

d. Landslides. For landslides, address the following:

- Include landslide movement history, past maintenance works, previous correction measures, etc.

- Provide scaled cross-section showing ground surface conditions before and after failure.
- Identify failure planes, excavation/buttressing limits, recommended slopes, instrumentation requirements, results from the slope stability analysis, and drainage requirements.
- Summarize causes of the slide.
- Provide alternative designs and benefits/limitations of each design.
- Provide construction sequence and special provisions.

e. Retaining Walls. Provide internal wall stability design parameters and global retaining wall stability analysis.

f. Drainage. Discuss excavation concerns, erosion protection, culvert bedding materials, geotextile fabrics, water table levels, dewatering recommendations and settlement considerations.

g. Stability Analysis. Address the methods used (e.g., computer programs), assumptions made for soil strength parameters (e.g., strength), groundwater conditions, selected factors of safety or resistance factors, conclusions from analyses (slope angles and heights), and recommended methods of mitigation (e.g., regrading, reaction berms, ground improvement).

h. Settlement Analysis. Discuss methods used to calculate the settlement analysis, assumptions for soil parameters (e.g., preconsolidation pressure, compression index, recompression index, coefficient of consolidation), groundwater conditions, conclusions from analyses, recommended mitigation. (e.g., dig outs and subexcavation, use of light-weight fills, wick drains and preloading, staged construction).

i. Computer Programs. Include a summary of the analyses and list of software programs used.

j. Results. Describe the limitations of the analyses and results.

k. Special Issues. Identify special issues to consider during construction, including construction staging, scheduling of preloads, special field testing and instrumentation.

Appendices

If available, include the following in the appendix of the report:

1. Maps. If deemed appropriate, include geological or highway maps and indicate the applicable geotechnical features on the maps.

2. Boring Logs. If boring logs are available from previous projects in the area and they are applicable to the project, include copies of these logs.

3. Photographs. If photographs were taken during the site investigation, include applicable photographs showing only the major geotechnical features. On the photograph, indicate the reason for the photograph (e.g., steep rock cuts, landslides), the location (e.g., reference post, stationing) and direction the picture was taken.

4. Design Calculations. Include the detail design calculations and results used in making the analyses and recommendations.

REFERENCES

1. State of Oklahoma Department of Transportation *Geotechnical for Roadway Design*, Appendix A3, June 11, 2001.

2. State of Oklahoma Department of Transportation *Standard Guide for the Description of Surface and Subsurface Geological Rock Formation of Oklahoma*, Attachment 1 to Appendix A1 and Appendix A3, June 5, 2001.

3. State of Oklahoma Department of Transportation *Guidelines and Background Information for Providing Soil Classification Information*, Attachment 2 to Appendix A3, June 12, 2001.

4. State of Oklahoma Department of Transportation *Specifications for Geotechnical Investigation of Bridge and Related Structures*, Appendix A1, June 5, 2001.

5. *Subsurface Investigations – Geotechnical Site Characterization*, NHI-01-031, FHWA.

6. *Checklist and Guidelines for Review of Geotechnical Reports and Preliminary Plans and Specifications*, ED-88-053, FHWA.

7. Geotechnical Engineering Circular No. 5, *Evaluation of Soil and Rock Properties*, IF-02-034, FHWA.