TDOT Geotechnical Manual

Tennessee Department of Transportation
Geotechnical Engineering Section
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Summary

The Tennessee Department of Transportation (TDOT) Geotechnical Manual is intended for the use of TDOT Geotechnical Engineering Section personnel and TDOT geotechnical consultants who are retained to provide geotechnical services to TDOT. Others may also use the document as a general reference for understanding the roles, processes, and workflow and document delivery of the geotechnical discipline as they relate to developing TDOT transportation improvement projects. The Manual consists of an Administrative Introduction and three technical sections.

Section 1 describes Geotechnical Projects with Structural Components, mainly bridges and retaining walls along with noise walls and high mast lighting projects.

Section 2 describes Geotechnical Projects with Roadway Design Components including new alignments, widenings SIA projects and others.

Section 3 describes Geohazards as they relate to TDOT projects including Acid Producing Rock issues, Landslides and Rockfalls and Sinkholes and Subsidence.

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Introduction

Administrative Information

This discussion provides TDOT internal project administrative information required for standard and consistent electronic communication, letters, and reports.

TDOT Geotechnical Engineering Section (GES) Organization

The TDOT GES is a functional section area of the Division of Materials and Tests. While a statewide Division, the Division of Materials and Tests is located at the TDOT Region 3 complex in Nashville, TN. There are two geotechnical offices located within the state of Tennessee in the Department of Transportation: one located in Nashville and one located in Knoxville. All TDOT geotechnical work goes through one of these two offices. Region 1 work is primarily the responsibility of the Knoxville Geotechnical Office which is located at the TDOT Region 1 Facility. Work in Regions 2-4 is primarily the responsibility of the Nashville Geotechnical Office which is located at the TDOT Region 3 Facility. Senior TDOT Geotechnical Engineering staff is shown below:

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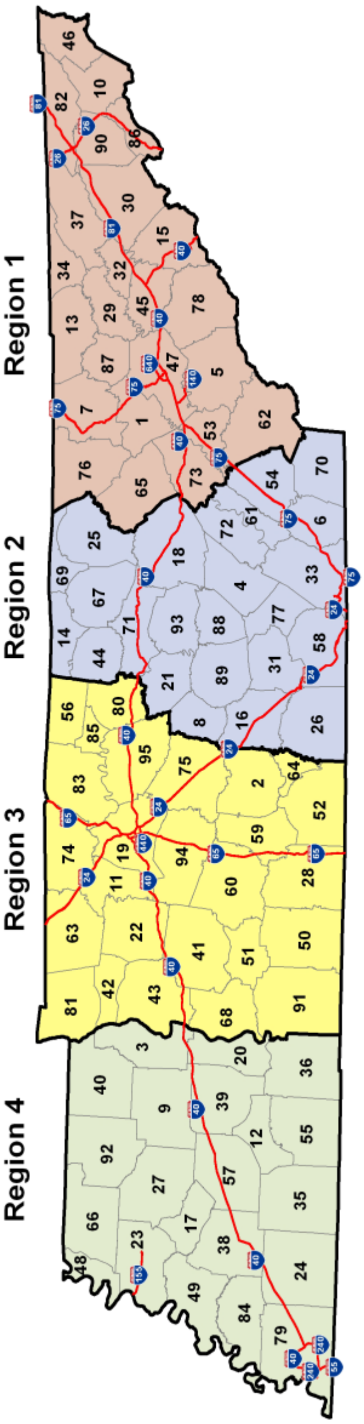
Figure 1. Map of Tennessee with TDOT Regions and Counties



Alphabetical List of Counties in Tennessee

01 Anderson	17 Crockett	33 Hamilton	49 Lauderdale	65 Morgan	81 Stewart
02 Bedford	18 Cumberland	34 Hancock	50 Lawrence	66 Obion	82 Sullivan
03 Benton	19 Davidson	35 Hardeman	51 Lewis	67 Overton	83 Sumner
04 Bledsoe	20 Decatur	36 Hardin	52 Lincoln	68 Perry	84 Tipton
05 Blount	21 DeKalb	37 Hawkins	53 Loudon	69 Pickett	85 Trousdale
06 Bradley	22 Dickson	38 Haywood	54 McMinn	70 Polk	86 Unicoi
07 Campbell	23 Dyer	39 Henderson	55 McNairy	71 Putnam	87 Union
08 Cannon	24 Fayette	40 Henry	56 Macon	72 Rhea	88 Van Buren
09 Carroll	25 Fentress	41 Hickman	57 Madison	73 Roane	89 Warren
10 Carter	26 Franklin	42 Houston	58 Marion	74 Robertson	90 Washington
11 Cheatham	27 Gibson	43 Humphreys	59 Marshall	75 Rutherford	91 Wayne
12 Chester	28 Giles	44 Jackson	60 Maury	76 Scott	92 Weakley
13 Claiborne	29 Grainger	45 Jefferson	61 Meigs	77 Sequatchie	93 White
14 Clay	30 Greene	46 Johnson	62 Monroe	78 Sevier	94 Williamson
15 Cocke	31 Grundy	47 Knox	63 Montgomery	79 Shelby	95 Wilson
16 Coffee	32 Hamblen	48 Lake	64 Moore	80 Smith	

TDOT Project Numbers and Geotechnical File Numbers

Any large agency depends upon numbers to track projects and TDOT is no different. Several project identification numbers are used for TDOT projects. All geotechnical services provided by GES require a GES File Number for internal management purposes. This file number is to be used on all reports, documents, drawings and correspondence as the GES file number is the primary means for tracking projects within the GES.

GES File Number Structure

The GES file number is assigned by GES when the specific project is assigned to the GES. The PE and PIN numbers are assigned by TDOT Project Planning/Development staff.

GES File Number	County	Sequence	Fiscal Year
2600106	26	001	06

County - All counties in Tennessee are numbered in Alphabetical Order 1-95. Anderson County is 01 and Wilson County is 95. Development district projects use 96, region wide projects use 98 and statewide projects use 99. See Figure 1 for the Map of Tennessee with TDOT Regions and Counties.

Sequence - Used with the GES File Number. A sequence number of 001 indicates the first project to be assigned a file number in a given fiscal year. Likewise a sequence number of 152 would be the 152nd project to be assigned a file number in a given year.

Fiscal Year - Fiscal year project was requested. In Tennessee, the fiscal year begins July 1 and ends June 30. So, the calendar date July 1, 2016, is associated with fiscal year 2016.

PIN Number

Another project reference number TDOT uses is the PIN number. This is a number that is permanently assigned to a project and should also always be placed in documents including the subject line of e-mails, letters and memoranda. The PIN Number is a unique identifying number generated by the Program Development and Administration Division at the project conception. The number is always an 8 digit number with a period symbol at the last two digits. The first 6 numbers are not related to any particular aspect of the project (such as county, route no., etc.). The last two digits represent a section or subsection of a project. If the project is developed as one segment of a route then there would be only one PIN for the project. If as the project development progresses a segment of a route is broken into smaller segments, then each segment would have a PIN no. with the first 6 digits remaining the same and the last two digits would be sequential signifying that particular segment. The PIN numbers with where additional sequential numbers are assigned are referred to as “baby” PIN number for that project.

PIN Number Example
100250.01

TDOT Project Number Structure

Department wide TDOT Project numbers are often shown on plans provided by Design and include the project number. This number is assigned for a project throughout the various phases of the project development such as survey, design, right-of-way (ROW) and construction. This number should also be used on all reports, documents and correspondence.

TDOT Project Number	County	Section Number	Job			Funds	
			Type Work	State System	Job Sequence Number	Federal	State
26011-1205-04	26	11	1	2	05	0	4

County - All counties in Tennessee are numbered in Alphabetical Order 1-95. Anderson County is 01 and Wilson County is 95. Development district projects use 96, region wide projects use 98 and statewide projects use 99. See Figure 1 for the Map of Tennessee with TDOT Regions and Counties.

Section Number - This is assigned by Planning. It is a number given to a section of a highway that has similar geometrics or operating characteristics. It is used to subdivide a roadway into convenient or logical units.

Job - This is the job number assigned to a project, it has 3 components: 1. Type Work, 2. State System, 3. Job Sequence Number.

Type Work - This code indicates what type of work is being performed under the project number. Geotechnical studies for new projects almost always come under Code 1. Note that a particular project may have more than one PE number where the Code for the type work changes as the project develops.

Code	Description
0	PE (Preliminary Engineering) for Planning and Environmental Studies
1	PE for Survey and Road Design
2	Right of Way Acquisition
3	Construction and Reconstruction
4	Routine Maintenance
5	PE for Structure Design
7	Planning and Research Projects
8	Resurfacing Projects
9	Outdoor Advertising, Mass Transit, Waterways and Rail

State System - This number indicates the roadway type.

Code	Description
1	Interstate
2	State Highway System (State Routes)
3	Rural System
4	Local County Roads
5	Local City Streets
6	No System
7	New Urban System

Job Sequence Number - Indicates the order a in which a project number was assigned along a section of roadway. A job sequence number of 001 indicates the first project issued along that section. Likewise a job sequence number of 011 indicate the 11th project issued along that section.

Funds - Indicates the funding source for the project. It has two components: 1. Federal and 2. State.

Federal Funds - This code indicates the Federal appropriation authorized for the project.

Code	Description
0	No federal funds
1	Federal Aid - Primary
2	Federal Aid - Secondary
3	Federal Aid - Grade Crossing, Overhead Separations, Tunnels,
4	Federal Aid - Interstate
5	Federal Aid - Urban
6	Federal Aid - Appalachia
7	Federal Aid - HPR
8	Federal Aid - Forest Highways
9	Federal Aid - Other

State Funds - This number indicates TDOT's accounting fund used for the project.

Code	Description
3	Rural and Secondary Roads Fund
4	State Highway Fund
9	Aeronautics

Correspondence with TDOT GES

Any and all TDOT correspondence should include project numbers. Much of TDOT's communication is done electronically using email and attachments. In addition to the issue, it is expected that the subject line of the email include the pin number and a small identifier like county name and state route number. If the pin number is used all email correspondence can be searched and quickly found.

Use of Geotechnical Consultants within TDOT

Almost all functional areas of TDOT use consultants to some extent. Consultants are procured for two purposes: 1) to provide a specialized service for which TDOT does not have or has limited in–house capability or expertise and 2) to provide some of the regular functions of a work unit in order to meet schedules-that is, to manage workloads.

There are also typically two types of consultant agreements from a functional perspective. The first type is a project specific agreement whereby TDOT enters into an agreement with a consultant to provide specific services, i.e. roadway design for a specific project. The second type is known as an "on-call" contract agreement whereby a consultant provides services over a given timeframe of multiple years for multiple projects.

Procurement of consultant contracts is governed by TDOT Policy 301-01 Standard Procurement of Engineering and Technical Services which can be viewed on the TDOT Website. Other details of consultant contracts, including useful contacts and example documents such as letters of interest, Statement of Qualifications and invoices can also be viewed on the TDOT website under Roadway Design Division-Consultant Information address. http://www.tn.gov/tdot/topic/consultantinfo.

Note that TDOT GES is responsible for reviewing and finalizing geotechnical reports and uploading the reports to FILENET server.

Geotechnical Consultants are used by TDOT or on behalf of TDOT (Local Programs) for the purposes and by the means summarized below (provided in order of most frequent use):

- A Geotechnical Consultant is retained as part of a Roadway Design contract for a specific project. The Geotechnical consultant is a sub-consultant in this case and is selected by the Roadway Design Consultant. The Roadway Design Consultant has direct control over the work of their selected Geotechnical Consultant including scheduling of work and making payments; however, the TDOT GES coordinates with the Geotechnical Consultant, the Roadway Design Consultant and the TDOT Roadway Design manager at the project start-up with regards to reviewing and commenting upon the Geotechnical Consultants proposed scope of work. Prior to submittal, TDOT GES is responsible for reviewing and commenting on deliverables for conformance to TDOT standard level of care.

- Multiple Geotechnical Consultants are procured by the Geotechnical Engineering Section for on-call contracts for a multi-year period. These contracts include drilling and laboratory technical services as well as professional engineering and geological services. The consultants may be assigned geotechnical work for all of the various TDOT transportation improvements, such as new bridges, new roadway projects, retaining walls, landslide investigation and repair, and others.

- Geotechnical Consultants are sometimes included as part of on-call contracts administered by the TDOT Maintenance Division usually for the purpose of providing engineering design and plans for Maintenance related projects such as landslides/rockfall remediation, sinkhole remediation, small structure repair, paving and drainage issues. The Geotechnical Consultant could be selected as a team member of the main Consultant. The Maintenance Division will coordinate as needed with the TDOT GES regarding geotechnical consultant's scope of work and technical recommendations.

- Geotechnical Consultants are sometimes included as part of on-call contracts administered by the TDOT Construction Division usually for the purpose of providing Construction Engineering and Inspection (CEI) contracts. The Geotechnical Consultant is selected as a team member by the main consultant. Usually the Geotechnical Consultant is used on construction projects that have major geotechnical components such as multiple retaining walls.

- Geotechnical Consultants may be retained by a Local government such as city or county to provide geotechnical services for a TDOT funded project but managed by the local government under the TDOT ”Locals” project program. In this case the geotechnical consultant is under the direction of the Local government personnel but the geotechnical work must comply with TDOT requirements. The TDOT GES may be requested to review the consultants' scope of work, cost and technical documents or provide other technical input if needed.

- Geotechnical Consultants are occasionally retained by General Contractors working on a TDOT project to provide geotechnical services such as for a Waste Site Plan design or as part of a Value Engineering Change Proposal. In these cases, the Geotechnical Engineer is not working for TDOT but may need to coordinate with the TDOT GES regarding geotechnical requirements of such type work requested by the General Contractor.

Geotechnical Consultant Scope of Work

Most contracts specify that it is the responsibility of a Geotechnical firm retained directly by TDOT or through another consultant to provide a detailed scope of work for approval before any work on the project begins. This may include a cover letter which provides a summary of the work to be completed at the site as well as, other supporting documentation. Firms in the past have provided charts of proposed boring locations as well as plans sheets which show proposed boring locations.

Under an on-call work order contractual agreement, TDOT GES will be ultimately responsible for preparing the project scope of work. The geotechnical consultant will discuss the terms of the scope of work with TDOT GES oversight until approval is authorized by TDOT GES.

Under a geotechnical consultant-roadway design consultant team, the scope of work is the ultimate responsibility of TDOT Roadway Design Division, although TDOT GES is expected to provide assistance and collaboration, as necessary or required. The cost estimate is typically submitted by TDOT Roadway Design Division to TDOT GES for review and comment prior to approval. All geotechnical consultant submittals are expected to go through the roadway design consultant and TDOT Roadway Design Division, not directly to TDOT GES.

Cost estimate preparation and any scope of work discussion is considered part of the cost of doing business with TDOT, and will not to be invoiced as a Manpower Cost. Following the executed approval of the contract, the geotechnical consultant is expected to deliver the terms of the contract, and is expected to invoice on those terms accordingly.

Invoicing and the Man-hour Requirements and Cost Estimate Form

For all geotechnical work to be conducted by a consultant either directly for TDOT or through another roadway design consultant, a “Man-hour Requirements and Cost Estimate” form must be filled out for the project and submitted to the TDOT GES. This cost estimate details the pricing for each item in the scope of work. To keep current, this form is updated from time to time, so contact TDOT GES to assure the latest form is being used. The form is developed in Microsoft Excel, and is easily sent electronically.

The total amount of geotechnical work invoiced to the State shall never exceed the “Total Not-to-Exceed” costs shown on an approved “Man-hour and Requirements Cost Estimate Form.” Individual item quantities are expected to vary slightly from the approved “Total Not-to-Exceed” amount depending upon the project requirements. In no case shall additional monies be invoiced, or paid by the State, prior to the consultant receiving an approved contract supplement.

The “Man-hour Requirements and Cost Estimate” form details expected items required for delivering the project. The following is a brief narrative of these items for information only, and not considered contractual language. Furthermore, if there are any discrepancies between the following narrative and the contract, the contract is binding.

Cost Cover Sheet – This sheet contains basic reference information including the project location data, Geotechnical Consultant Name, Date Prepared, Project Number, Geotechnical Office Number and Contact information for the preparer.

1.00 Drilling Costs – All drilling items are shown on this sheet and are to be listed on a per unit basis. For instance, SPT drilling\rock coring and sampling is charged on a per-foot basis, with all ancillary costs associated with drilling and sampling included in that per-foot cost. Specialty items not listed, could be added to this sheet, but never without the agreement of TDOT GES. The total estimated cost of drilling items is shown at the bottom of the page.

2.00 Laboratory Testing Costs – All laboratory testing items are shown on this sheet and are to be listed on a per unit basis. For instance, the Atterberg Limit test is charged on a per sample basis. Please note that tests which require multiple points, such as the C-U triaxial test are still charged on a per total test, not per point basis. So, a test which may take 3 samples to complete, would still be charged as only 1 single test, because several points are required in order to provide a complete single test result. Specialty items not listed may be added to this sheet with the agreement of TDOT GES. The total estimated cost of laboratory testing items is shown at the bottom of the page.

3.00 Manpower Costs – All expected manpower hours estimated for the project are to be detailed on this sheet. It breaks down cost by tasks and by category of staff. These are charged on a per man hour basis. The hourly rate is determined on sheet 3.01 Manpower Breakdown. If CAD services are to be provided by others, such as the Design Consultant, the CAD technicians estimated hours may be shown either on the Geotechnical Consultants cost estimate **or** on the Design Consultants cost estimate, not both. The total estimated cost of Man-hour costs is shown at the bottom of the page.

3.01 Manpower Breakdown – This portion of the Cost Estimate must be completed with accurate up to date information

Direct Pay Rate – This is the actual rate paid to a member(s) of the Geotechnical Consultants staff. Evidence that this is the case may be required by TDOT.

Maximum Overhead Rate – This rate is determined by audit and varies by Consultant. This maximum overhead rate only applies where there are state only funded projects. Federally funded projects use the overhead rate established by audit. For state funded only projects, if the consultant has an overhead rate higher than 1.45, the maximum allowable rate that may be used is 1.45.

Profit Multiplier – TDOT currently allows a profit multiplier of 2.35.

Profit Rate – For projects that are completed through a Design Consultant, the profit rate is the same as that established for the Design Consultant. This is typically no more than 0.12.

Hourly Rate – This is determined by the following formula:

= Direct Pay Rate + (Direct Pay Rate * Overhead Rate) + (Direct Pay Rate * Profit Multiplier *Profit Rate).

The following shows an example given: direct pay rate of $20.00; overhead rate of 1.75; profit multiplier of 2.35; and a profit rate of 0.12.

=$20.00 + ($20.00*1.75) + ($20.00*2.35*0.12) = $60.64

4.00 Other Costs – This sheet details other costs involved with the project that do not neatly fit onto one of the other sheets such as Per-Diem, Lodging and Mileage. Equipment rental and plans reproduction may also be included on this sheet. However, the only equipment rental which may be allowed will be specialty equipment. The consultant may not charge for standard geotechnical exploration nor supporting equipment, neither may laboratory testing equipment rental be charged. Charges will only be allowed with prior authorization from TDOT GES and this will only be granted in unusual cases. Further explanation and justification for these charges may be requested. Also, plans printing may not be charged by the Geotechnical Consultant if that function is to be handled by the Design Consultant, unless the Design Consultant is not charging TDOT for the printing. Items listed under other expenses may only be pre-approved, as is the case for equipment rental, and will only be granted in unusual cases. Appropriate item numbers will be assigned by TDOT as needed. As with other sheets, the total estimate of other expenses must be shown at the bottom of the page.

Costs-Summary – This final sheet summarizes the costs of Drilling Services, Laboratory Services, Manpower Requirements and Other Expenses in order to show a final “Total Not-to-Exceed” cost for the project.

Supporting Documentation

Manpower Requirements and Cost Estimate Sheet

Scope of Work document

Chapter 1.1:
Foundation Reports for West Tennessee Bridges

Introduction

West Tennessee Bridges refers to those bridge projects-either replacement bridges or new project bridges-primarily located west of the Tennessee River and in TDOT Region 4 where bedrock is generally greater than 100 feet in depth. However, the information provided herein can be used for any bridge where friction piles are the most feasible foundation alternative. Examples of these other locations include bridges over relatively large rivers where floodplain soil depths may be considerable. For other bridge projects located where foundations types other than frictions piles are the most feasible and common, please refer to Chapter 1.2: Foundation Reports for General Bridge Projects.

Note that a bridge foundation project may be part of a project involving constructing, improving, widening or relocating a roadway with one or multiple bridges. Requirements for geotechnical investigation, analysis and reporting for the roadway elements of the project are discussed in Chapters 2.1, 2.2, and 2.3. Geotechnical requirements such as slope stability and settlement issues would be provided in those reports although this information may also be included in the bridge foundation report so that all requirements of the bridge design and construction can be reviewed by the bridge designer. An example may be the requirement to let a bridge approach embankment sit for a time period to allow settlement to dissipate before driving abutment piles in order to eliminate or limit down drag on piles. Depending on the project scheduling it may be possible and/or necessary to combine geotechnical investigation efforts to accomplish goals of all project elements.

Initially, the Structures Division sends the GES a request to conduct the foundation investigation via a request letter and a Foundation Data Sheet. The Foundation Data Sheet provides a Preliminary Bridge layout along with other pertinent information such as preliminary estimated scour depths. The request is simultaneously sent to the appropriate Regional Survey Office to have stakes placed in the field and elevations determined at points corresponding to proposed bridge substructure locations. The geotechnical foundation investigation will then be assigned to a GES staff member or will be assigned to a Geotechnical Consultant.

Information below provides general guidance regarding geotechnical requirements for bridge projects. The Geotechnical Engineer should review and be familiar with AASHTO LRFD BRIDGE DESIGN SPECIFICATIONS (latest version). This document provides more detailed technical guidance and requirements regarding bridge foundation analysis and design requirements.

Goals of Investigation

The goal of a bridge project in West Tennessee is to gather subsurface data for the design of a driven pile bridge foundation, to provide information for scour analysis (conducted by the Structures Division), and to provide results and recommendations regarding liquefaction potential of the site soils. The product deliverable is a Foundation Report addressing these issues with a bridge foundation data sheet (.dgn) that is submitted to the Structures Division.

Drilling Requirements

Assume a stakeout will be provided by TDOT or the lead Design Consultant unless other arrangements are made. For relatively short bridge structures, the subsurface investigation involves drilling a minimum of 2 holes to 80 feet below ground surface. For more significant bridge structures, drilling of at least one boring per abutment and substructure is recommended depending on site access limitations. The borings must be advanced and sampled at least 10 feet below any layers that are predicted to liquefy. TDOT GES typically drills between, depending upon the material sampled, 75-90 feet in depth. SPT shall be performed sufficient to describe the site for the purposes of:

- Pile capacity,
- Liquefaction Analysis,
- Scour calculations, and
- Corrosion potential tests.

Samples shall be taken at least every 5 feet. Other drilling techniques that provide the necessary information may also be conducted. For projects where CPT testing is performed, at least one hole shall be SPT, in order to gather samples for laboratory testing and for verification of soil type. All layers of soil shall be identified and appropriate parameters recorded during exploration.

Laboratory Analysis

All dissimilar SPT samples shall have gradation, hydrometer, Atterberg limits, pH and Resistivity tests performed. Each sample shall be classified to AASHTO and USCS systems. Other testing may be performed as needed to provide sufficient information for the prediction of liquefaction and corrosion.

Engineering Analysis

Engineering analysis for these bridge projects mainly consists of the following:

1. Static pile analysis: The goal of this analysis is to determine and provide static pile bearing parameters Fs (side friction) an Qb (end bearing). This is mainly accomplished through utilizing the TDOT pile bearing charts that correlate Fs and Qb values for concrete piles with SPT values. These charts are provided at the end of this Section.

2. The TDOT charts provide ultimate bearing values. Drilling, sampling and therefore analysis should be done such that a minimum of 100 tons ultimate combined bearing is reached for the typical 14 inch square concrete pile. Consideration of potential scour depth should be taken into account in estimating ultimate total bearing. Other static pile analysis methods other that the TDOT charts can be utilized, however, the end result will still be a presentation of Fs and Qb values along the depth of the boring location. For some projects, other deep foundation types such as drilled shafts or auger cast piles can or must be considered. In this case the analysis should follow normal analysis methods provided in the most current AASHTO LRFD Bridge Design Specifications.

One of the main geotechnical issues in West Tennessee is the New Madrid Seismic Zone. Liquefaction analysis must be performed on all coarse-grained materials and TDOT Geotechnical typically performs these for every appropriate SPT sample taken. AASHTO requires that this analysis be performed within a seismic risk area for all bridges larger than 1 span. TDOT utilizes a Mathcad program incorporating the elements of Seed and Idris liquefaction charts to determine liquefaction potential for each layer. All layers that have the potential for liquefaction must be clearly noted on the foundation data sheet supplied with the foundation report. Critical and interstate bridges may require more complex analyses, please see current AASHTO guidelines for guidance. These analyses may include, site specific seismic analysis, CPT testing, soil-structure interaction considerations among others. If liquefaction analyses indicate significant liquefaction potential the engineer must determine and provide recommendations for mitigation. This may include recommendations for limiting or extending pile depths to avoid liquefaction layers, discounting bearing of piles in liquefaction layer, or ground improvement at the site. More details of liquefaction analysis and mitigation can be seen in the Publication FHWA-NHI-11-032, LRFD Seismic Analysis and Design of Transportation Geotechnical Features and Structural Foundation Reference Manual.

Foundation Report and Drawings

The geotechnical report for a West Tennessee bridge project should detail the investigations and the recommendations for the site. Recommendations for design parameters such as Fs and Qb shall be supplied for concrete friction piles, pipe piles and steel H piles. All typed boring logs shall be included with the report as well as any laboratory results. This report will primarily be used by the GES and as a reference for the exploration performed at the site.

Report Format

Executive Summary or Cover Letter – This section gives a brief summary of the report. It shall also state if potentially acid producing materials was found or not found on a project.

Introduction – Brief summary of the project and location. Any special constraints such as limited right of way are noted here.

Geology, Soils and Site Conditions – All geology, soils and site conditions that may affect the project.

Surface and Subsurface Exploration – Exploration Performed

Recommendations – Provide recommendations for construction purposes such as types of foundations recommended any site improvements and identification of soil layers that are representative for scour analysis.

Special Notes and Specifications – Any special notes to be included in the plans, these should also be on the cross sections, if provided. This section may be omitted if no special notes or specifications are required.

Appendix – Documents, boring logs and supporting information.

- Foundation Data Sheet (supplied by Structures Division in .dgn)
- Boring Logs
- Laboratory Testing
- Engineering Analyses and supporting Documents

The GES requires that all project documents be provided in both electronic and paper form. Please contact the section for information on formatting submittals properly.

Foundation Data Sheet Elements

The geotechnical sheets for a West Tennessee bridge project shall include a plan view layout of the drill holes, drill holes plotted by depth and any cross sections required to illustrate geotechnical design elements. The initial bridge sketch is provided either by the Structures Division or their designated representative. Drill holes and geotechnical information shall be plotted on these sheets. The following elements must be included:

General Layout of Site – Plan views showing drilling and sampling locations and is usually placed on the bridge sketch supplied by Structures.

Graphical Boring Logs – For each boring conducted graphical boring logs shall show elevations and material types with elevations included. Fs and Qb factors shall be shown as well as N values and all layers identified as subject to liquefaction shall be shown. Boring logs shall include a TDOT standardized legend that is representative of what is shown within the boring logs. In addition to the legend, indicate boring number, top of hole elevation and offset from centerline above the boring. Below the boring, indicate auger refusal (AR) or boring terminated (BT).

Static Pile Capacity Charts

"Static Pile Capacity" charts as developed and used at TDOT are provided. Please note that the sheet shows only the unit pile. If this chart is used for design, use the unit chart for Fs and Qb. This chart is to be used at the risk of the geotechnical engineer / engineering geologist. This chart when used as a field aid will *not* guarantee that adequate exploration has been performed, as this chart does not account for liquefaction. These values may not be accurate where proper SPT procedures are not used. They were developed for a CME drill rigs with use of automatic hammers calibrated to 60% energy (N_{60}). Other equipment may give different results. Please note that the maximum values of Fs and Qb are achieved with N=30. For blow counts above this value, do not extrapolate further values, but use the values for N=30. For steel or pipe piles the Fs values given on the chart can be reduced by one third to account for roughness/smoothness.

Static Pile Capacity

Unit Length Concrete Piles

Clay					Silt					Sand				
	English Units		Metric Units			English Units		Metric Units			English Units		Metric Units	
N	Fs (TSF)	Qb (TSF)	Fs (kPa)	Qb(kPa)	N	Fs (TSF)	Qb (TSF)	Fs (kPa)	Qb(kPa)	N	Fs (TSF)	Qb (TSF)	Fs (kPa)	Qb(kPa)
1	0.06	0	6	0	1	0.04	0	4	0	1	0.01	0	1	0
2	0.11	0	11	0	2	0.08	0	8	0	2	0.03	0	3	0
3	0.16	0	15	0	3	0.12	0	11	0	3	0.05	0	5	0
4	0.20	0	19	0	4	0.17	0	16	0	4	0.07	0	7	0
5	0.25	2	24	192	5	0.22	5	21	479	5	0.09	11	9	1053
6	0.30	3	29	287	6	0.26	7	25	670	6	0.11	13	11	1245
7	0.35	3	34	287	7	0.30	8	29	766	7	0.13	15	12	1436
8	0.40	4	38	383	8	0.33	9	32	862	8	0.14	17	13	1628
9	0.45	4	43	383	9	0.36	10	34	958	9	0.16	19	15	1819
10	0.50	5	48	479	10	0.40	11	38	1053	10	0.18	22	17	2107
11	0.54	5	52	479	11	0.44	12	42	1149	11	0.20	24	19	2298
12	0.58	6	56	575	12	0.48	13	46	1245	12	0.22	26	21	2490
13	0.62	6	59	575	13	0.51	14	49	1341	13	0.24	28	23	2681
14	0.66	7	63	670	14	0.54	15	52	1436	14	0.26	30	25	2873
15	0.70	7	67	670	15	0.58	16	56	1532	15	0.28	32	27	3064
16	0.74	7	71	670	16	0.62	17	59	1628	16	0.30	35	29	3352
17	0.78	8	75	766	17	0.66	19	63	1819	17	0.32	37	31	3543
18	0.82	8	79	766	18	0.70	20	67	1915	18	0.34	39	33	3735
19	0.86	9	82	862	19	0.74	21	71	2011	19	0.36	41	34	3926
20	0.90	9	86	862	20	0.77	22	74	2107	20	0.38	43	36	4118
21	0.93	10	89	958	21	0.80	23	77	2202	21	0.40	45	38	4309
22	0.96	10	92	958	22	0.84	24	80	2298	22	0.42	48	40	4596
23	1.00	11	96	1053	23	0.87	25	83	2394	23	0.44	50	42	4786
24	1.04	11	100	1053	24	0.90	26	86	2490	24	0.46	52	44	4980
25	1.08	12	103	1149	25	0.93	27	89	2586	25	0.48	54	46	5171
26	1.10	12	105	1149	26	0.95	28	91	2681	26	0.50	56	48	5363
27	1.13	13	108	1245	27	0.97	29	93	2777	27	0.52	58	50	5554
28	1.16	13	111	1245	28	1.00	31	96	2969	28	0.54	61	52	5841
29	1.20	14	115	1341	29	1.03	32	99	3064	29	0.56	63	54	6033
30	1.24	14	119	1341	30	1.06	33	102	3160	30	0.58	65	56	6224

English Units

End Area of a 14" square Pile = 1.36 ft2
Surface Area of a one foot length of Pile = 4.67 ft2
A bearing of 100 Tons is required when piles end in sand (70' min. depth for liquef.)
A bearing of 125 tons is required when piles end in clay
Friction = 4.67*Depth*Fs (T)
End Bearing = 1.36*Qb (T)

Metric Units

End Area of a .356 m square Pile = .1265 m2
Surface Area of a 1 m length of Pile= 1.422 m2
A bearing of 890kN is required when piles end in sand (21.5 m min. depth for liquef.)
A bearing of 1100 kN is required when piles end in clay
Friciton = 1.422*Depth*Fs (kN)
End Bearing = .1265*Qb (kN)

Chapter 1.2:
Foundation Reports for General (Non Friction Piles) Bridge Projects

Introduction

General bridge projects are all those which do not use friction piles for support. These projects will generally be all of those in Regions 1, 2 and 3 and in some areas of Region 4. When rock is greater than 100 feet, friction piles should be selected and if chosen as the foundation alternate, the provisions for West Tennessee Bridge Projects as discussed in Chapter 1.1 shall be followed.

General Goals of Investigation

Unless other agreements have been made, the survey stakeout will be provided by TDOT.

The goal for the general geotechnical bridge investigation is ultimately to provide sound recommendations for the appropriate bridge foundation types to the structural engineer. Highly variable and erratic bedrock elevations are expected to be encountered across Tennessee, as well as karst terrain. Sufficient drilling must be performed to provide the Structures Division designers appropriate foundation alternatives. The most common foundation type is probably derived from an end bearing driven H-pile with tip protection. But all deep and shallow foundation types should be considered for the specifics of the site, and value to the project. The results of the investigation are to deliver a bridge Foundation Data sheet and a Bridge Foundation Report which describes appropriate foundation alternatives. A particular foundation type could be deemed the most technically feasible solution, but other foundation alternatives may be offered. Foundation alternatives shall be discussed in the foundation report, but the foundation type used will be selected by Structures Division, often in consultation with TDOT GES leaders.

Geotechnical recommendations for slope development and embankment grading are contained in a separate document referred to at TDOT as the Soils & Geology Report. The separate Soils & Geology Report document shall be delivered during the ROW plans development phase, and is discussed in further detail in Chapters 2.1, 2.2, and 2.3. Many embankment construction issues contained in the Soils & Geology Report could be of interest to the Structures Division, but to state clearly, the Soils & Geology Report is a separate document and is to be delivered much earlier in the plans development process.

Under normal workflow, the proceed to work is normally triggered by a email request from the Structures Division for a stakeout sent to the appropriate Regional Survey Office, with a Foundation Data Sheet attachment, and copied to TDOT GES. The Foundation Data Sheet contains a preliminary bridge layout, and pertinent information such as preliminary estimated scour depths. Upon confirmation that the Regional Survey Office has placed stakes in the field at key points along the abutment and pier(s)\bent(s) with associated ground elevations, the geotechnical foundation investigation work will then be assigned and work will proceed.

Information below provides general guidance regarding geotechnical requirements for bridge projects. The geotechnical engineer should review and be familiar with AASHTO LRFD BRIDGE DESIGN SPECIFICATIONS (latest version). This document provides more detailed technical guidance and requirements regarding bridge foundation analysis and design requirements.

It is important to review the bridge layout sketch provided by Structures Division and determine if there are any proposed retaining walls adjacent to the proposed bridge. If proposed retaining walls are indicated on the Bridge Foundation Sheet, then appropriate Retaining Wall Detail sheets could be required. Further drilling, reporting and drawings for retaining walls is described in Chapter 1.3.

Drilling Requirements

The drilling locations and depths performed at the site can be highly variable according to the depth and variability of solid rock at the site. TDOT GES, in conformance with AASHTO guidelines generally recommends one to three borings per substructure, but this number may be increased when there is significant site variability. Appropriate explorations may include techniques, but are not limited to, rock core drilling, roller cone wash borings, SPT samples, auguring and hollow-stem auguring.

Site access difficulties may also have an effect on the location and number of borings drilled at the site. If great effort is taken to prepare a site to advance test borings, perform great effort to maximize the information obtained. If barge mobilization is necessary, advance one boring at the corner of each proposed footing.

Rock Quality Designation (RQD) and recovery shall be recorded for all rock samples and photographs shall be taken of all rock cores. Some general guidelines employed at TDOT for sufficient drilling at bridge substructure locations are as follows. These recommendations need to be adjusted for each individual project based on engineering judgement, AASHTO guidelines and industry accepted geotechnical practice.

1. Shallow foundations in rock: considered as potential foundation type if rock is generally encountered within 10 feet below proposed bottom of substructure foundation elevation. Core at least 10 feet of competent* bedrock.
2. Driven piles in rock considered as potential foundation type where rock is generally encountered greater than 10 feet below proposed bottom of substructure. Core at least 10 feet of competent * bedrock.
3. Drilled shafts in rock - at least 20-30 feet of competent * bedrock.

*competent bedrock for this purpose is defined as rock drilled within a 10 foot core run without encountering more than 3 instances of rock discontinuities-voids or very weathered seams-greater than two inches or a single discontinuity greater than 6 inches. If competent bedrock is not encountered for significant depths, the engineer or geologist will determine at what depth the test boring can be terminated. Core Recovery percentage and RQD should be analyzed during drilling in determining adequate rock core depth.

Laboratory Analysis

Laboratory analysis may include, but not be limited to, unconfined compressive tests for rock as well as gradation, classification, Atterberg limits, pH and hydrometer analysis for soils. Additionally, direct shear, triaxial or other strength tests may be appropriate for checking soil embankment or rock cut stability. Consolidation testing for settlement analysis shall be performed where soils embankments may settle, but verify this was not performed during the Soils & Geology Report.

Engineering Analysis

For bridges where spread footings are the most likely foundation type, bearing capacity analysis is the primary calculation that must be performed. Where end bearing piles are the most likely foundation type, analysis of pile tip elevation and pile installation issues are the predominant concerns. Other analyses may include stability analysis, settlement analysis, p-y analysis and others as needed. Side friction calculations may need to be made for drilled shafts and other deep foundations. There are many methods for calculating the appropriate factors in soils and rock. Where AASHTO code specifies a particular calculation method, this shall be used. When no AASHTO code specifies the calculations, TDOT requires that the methods used be generally accepted and have documentation in the engineering literature. If a new or unfamiliar method is applied, checks with other methods or documentation for the method may be requested. Kinematic analysis and rock slope stability checks shall be made where there is a rock cut below a bridge foundation that may affect that foundation.

Please note that if advanced methods such as p-y analyses are used for lateral capacity of soils for deep foundations, additional drilling and sampling may be required. At least one SPT hole per abutment or bent/pier is recommended where this analysis is to be performed. In general, this type of analysis will only be performed where there is a large bridge or where the geotechnical investigation shows instability or settlement problems in the approach embankment. Contact the TDOT Structural Engineer for if p-y analysis is desired due to geotechnical considerations or to check and see if this type analysis would be performed due to structural considerations. If required, then the soil modulus values required for a p-y analysis shall be provided on the foundation data sheets. Foundation types that are typically selected are shallow spread footings on rock, steel H piles and drilled shafts. Other alternatives such as micropiles and more innovative methods may also be recommended where appropriate, particularly if these methods are more suitable to site conditions than more "traditional" methods. Please note that the

Structures Division does not accept spread footings supported on soil for bridge foundations. It is the judgment of the Structures Division that the settlement risk is too high to allow such a foundation.

Regarding Bridges with Integral Abutments

TDOT Structures routinely designs bridges with integral abutments where the bridge lengths are less than 800 feet for concrete bridges and less than 400 feet for steel bridges. This abutment type, where feasible, eliminates the need for expensive expansion joints, reduces longitudinal loads on bents, simplifies abutment details and makes for a bridge more resistant to excessive loading and seismic events.[1] Basically, the integral abutment is where the abutment structure and the bridge beams are fully structurally connected by embedding the ends of the bridge beams in the abutment concrete structure thereby disallowing any movement of the beams independent of the abutment. This is in contrast to the more common abutment construction where bridge beams rest on the abutment seat, usually on bearing rockers allowing lateral movement of the beams.

Use of these type abutments has an effect on both drilling that is be performed at a site and recommendations for foundations. Bridges require the ability for some lateral movement and the length of the bridge as well as the material type will dictate whether or not a bridge required one or both of the integral abutments to be “free” for some lateral movement or if one can be “locked in.” The general rules of thumb as provided by the Structures Division are as follows in the table below:

TDOT Structures - Integral Abutment Use Guidelines[2]

Bridge Material	Length	Abutments
Concrete	400 feet or less	1 “free” integral abutment needed (providing up to 2” of lateral movement).
Steel	200 feet or less	1 “free” integral abutment needed (providing up to 2” of lateral movement).
Concrete	400 - 800 feet	2 “free” integral abutments needed (providing up to 4" of lateral movement).
Steel	200 - 800 feet	2 “free” integral abutments needed (providing up to 4" of lateral movement).
Concrete	>800 feet	Expansion joints required
Steel	>400 feet	Expansion joints required

[1] Integral Abutment Design (Practices in the United States), Wasserman, Edward. Presented at the 1st U.S.-Italy Seismic Bridge Workshop, Pavia, Italy, April 19-20, 2007.

[2] Oral communication: Cabrina Dieters, TDOT Structural Division, January 2011.

The type of foundation support dictates how the lateral movement of the abutment will be accommodated. Where abutment foundations will be supported by steel piles, the abutment can be considered “free” as lateral movement can be accommodated by lateral movement of the piles. If both abutments will be supported by piles, the general exploration requirements for pile foundations are sufficient. However, where a shallow spread footing foundation or drilled shaft foundation is being considered, additional exploration and more details regarding foundation recommendations may be required.

For a spread footing on rock to be used as a “free” integral abutment, a separator layer between the abutment concrete base and the supporting rock is needed, otherwise it is considered locked and cannot provide the lateral movement the bridge may require. TDOT Structures generally uses a one foot layer of No.57 stone as a separator layer between the bottom of the abutment and the rock layer below. Research has indicated this construction method accommodates the needed lateral movement of the integral abutment. This separator layer and use of a spread footing for an integral abutment is generally most cost effective where rock is within zero to three feet from the bottom of the abutment.

However, where there is more than 3 feet in depth from the bottom of the integral abutment to the supporting rock TDOT Structures prefers to use steel “H” piles, due primarily to cost considerations in the construction of the abutment. In this case, the steel piles are at a minimum of 10 feet in length from the bottom of the abutment base, and are “pre-drilled” into the underlying soils and rock. Piles are placed in these pre-drilled holes which are larger than the piles and surrounded by lean concrete, gravel or sand. Again, research has indicated this type construction allows for the required lateral movement of the abutment.

At this time, TDOT has not used an integral abutment design with either drilled shafts or micropiles. If one of these foundation alternatives deemed the most technically viable in order to solve a geotechnical site problem, the engineer/geologist should contact the project TDOT Structure designer in order to discuss the potential implementation of these type foundations.

Regarding Embankment Stability and Rock Cuts at Bridge Abutments

As discussed above, a bridge foundation project may involve a new embankment, widening or improvement of an existing bridge embankment in the investigation. The Soils & Geology Report for the embankment grading may have already provided recommendations. These recommendations may include slope ratio requirements, stage construction and settlement monitoring requirements. The geotechnical designer should determine if this work has already been completed ahead of the bridge foundation request. If not, the drilling, laboratory testing, analyses, and reporting of these elements need to be accomplished as part of the bridge foundation investigation. The drilling and sampling program can be coordinated and integrated for all elements of the project.

Some bridge approaches and abutments are located in roadway cuts either at bridge level or below bridge level for an underpass situation. These cuts may involve soil material or rock. If an abutment is located above/on top of a rock cut TDOT generally accepted policy is to set back the front edge of the abutment substructure from a rock cut face a minimum of 10 feet. This is done to accommodate weathering of the rock cut face over time, reduce the influence of the foundation on the rock cut face and to account for the potential of over-break or mistakes during construction. Whether part of the bridge and approach investigation or the bridge foundation investigation, every rock cut shall be drilled and/or investigated sufficiently to determine if this "default" offset is sufficient at the bridge location. Rock structure and potential structural failure modes shall be investigated and the rock shall be assessed for soundness. Where rock shows a high potential of weathering (shales, claystones, argillaceous limestones etc.) the weathering rate shall be assessed and a further offset may be required. Any potential structural failure of the rock, such as plane shear failures, wedge failures or toppling failures shall be clearly discussed and analyzed. The likelihood of raveling failures at the top of the rock cut due to blasting error or discontinuous slabs of rock shall also be assessed. If a further offset is required due to site conditions, this shall be clearly discussed in the report and accounted for in the geotechnical drawings and subsequently the project construction plans.

Foundation Report and Drawings

The document is to be formally referred to on the report title and in all correspondence as the Bridge Foundation Report. The Bridge Foundation Report and Appendix shall include a detailed narrative of the investigation, engineering analysis, recommendations, boring logs, and Foundation Data sheet. The recommendations should include all necessary foundation types and parameters deemed necessary for structural design of the foundation types recommended. These reports are generated to assist Structures Division engineers design, to document work, and share reasoning for the geotechnical recommendations.

Any innovative foundation types will require detailed explanation as to why these are most appropriate for the site. All foundation types recommended shall contain all necessary design parameters for the structural engineer's use. These may include, but are not limited to the following items:

- Elevation of foundation bearing layer
- Elevation of first encounter of rock
- Type(s) of foundations recommended
- Nominal Bearing Resistance of rock
- Offset of foundation from rock cut face required
- Appropriate depth of rock socket
- Lateral capacity of soil or rock
- Side Friction factors
- Either initial presentation or reiteration of issues regarding bridge approach embankment or rock cut recommendations.

Geotechnical Report Format

Executive Summary or Cover Letter – This section gives a brief summary of the report. It shall also state if potentially acid producing materials were found or not found on a project.

Introduction – Brief summary of the project and location. Any special constraints such as limited right of way are noted here.

Geology, Soils and Site Conditions – All geology, soils and site conditions that may affect the project.

Surface and Subsurface Exploration – Narrative of the geology, physiographic region, topography, equipment and tools used during the subsurface exploration.

Recommendations – Provide design parameters for each recommended foundation type given. This includes foundation type and all parameters needed for design.

Appendix – Documents and supporting data

- Foundation Data Sheet (see section below)
- Boring Logs - these must include location data on the typed logs.
- Laboratory Testing
- Engineering Analyses
- Other documents

Foundation Data Sheet Elements

The Foundation Data sheets are a reproduction of the preliminary bridge layout prepared by the Structures Division in the grade approval process. The sheets are CAD drawings in Microstation format (dgn). All foundation recommendations should be made in the Bridge Foundation Report, and not reflected on the Foundation Data sheet. The Structures Division will provide detailed drawings of the foundations. If any alterations need to be made to the site due to embankment stability issues or rock cut stability issues cross sections detailing these requirements may be required.

General Boring Layout – plan view depiction of test boring locations alongside bridge layout plan.

Boring Profile – graphical “sticks” depicting of drilling logs, showing elevations and material types. Graphical depiction must show associated graphical legend. In addition to the legend, please indicate boring number, top of hole elevation, and offset from centerline above the boring. Below the boring, please indicate auger refusal (AR) or boring terminated (BT).

Elevation Chart - showing the existing ground elevation at the time of exploration and first rock encounter elevation for all borings.

Chapter 1.3:

Retaining Walls

Introduction

Since approximately 1999, the vast majority of TDOT retaining walls have been designed and installed by general contractors, and their sub-contractors. Administering these wall installations often presents issues. As the demand for urban traffic capacity improvements grow, interchange improvement projects are expected to increase. Most urban interchange projects require tight grade separations, so the number of retaining wall projects could be expected to increase.

Goals of Investigation

The goal of the investigation is ultimately to provide the Retaining Wall Foundation Report to the Structures Division. The Report is to include recommended acceptable retaining wall types, all foundation improvements necessary to accommodate the proposed retaining wall, and all of the design parameters necessary for the retaining wall designer to produce a set of drawings and engineering computations. Also, the proposed retaining wall, all foundation improvements, and any reinforcing elements must be contained within TDOT ROW or a permanent easement.

Roadway Design Division designers typically recognize the need for a steep grade separation that could require a retaining wall during Preliminary/R.O.W. plans preparation. Roadway designers use *TDOT Design Guidelines* 2-175.00 Retaining Walls Determination Process and TDOT Standard Drawings W-CIP-1, W-MSE-1, W-MSE-2, W-SG-1, W-SP-1, and W-TW-1 in matters regarding retaining walls, particularly the steps required to prepare the retaining wall drawings, or the conceptual retaining wall drawings as the sheets are often referred.

Initially, the Structures Division initiates the request to the Materials and Tests Division, GES for a Retaining Wall Foundation Report to evaluate the geotechnical aspects of wall construction. Simultaneously, the Structures Division requests that the points along the retaining wall be staked out (PPRM Act # 500 Stake Sounding Holes) by the Regional Survey Office.

Following the location stake-out of the retaining wall, the subsurface exploration and draft Retaining Wall Foundation Report development can occur. All draft Retaining Wall Foundation Reports that are to be owned, funded, or administered by TDOT must be finalized by TDOT GES and the Structures Division prior to being let to bid. The draft report review process is intended to ensure consistent standard levels of care will be used on TDOT projects. In most cases, the final Retaining Wall Foundation Report will be submitted to the Structures Division and eventually inserted into Field Review and Construction plan sets.

Following bid letting, the awarded contractor prepares, then submits to TDOT, the retaining wall shop drawings. The preparation of the retaining wall shop drawings must be in accordance with the state's contract which includes, but is not limited to, geotechnical design parameters, notes furnished in RETAINING WALL DETAILS sheets, and Special Provision 624 - Retaining Walls (SP624). The Contractor submits retaining wall shop drawings to TDOT for review, comment and approval. Once the retaining wall shop drawings are finalized, the Contractor installs the wall in accordance with the shop drawings stamped "Approved" by the Structures Division.

Drilling Requirements

Subsurface explorations are to be conducted in accordance with the latest edition of the AASHTO LRFD Bridge Design Specifications (Table 10.4.2-1 in 6^{th} Ed.). In addition to being in compliance with AASHTO guidance, typical TDOT subsurface exploration plans include borings advanced a minimum of 1.5 times the wall height below the proposed bottom of the footing if in soil. This rule of thumb will generally result in getting data that is within 2 times the foundation width. If initial drilling indicates soft soil conditions, test borings should extend to 2 times the maximum wall height, to rock, or to firm or dense material is encountered. Split spoon samples shall be taken where needed. Representative Shelby tube samples shall be taken of each soil type expected beneath the foundation. If bedrock is encountered relatively shallow, consider advancing borings to refusal to identify the bedrock depth, especially if foundation improvements could include excavating \ backfilling to bedrock, or a soldier pile could be socketed. If rock is encountered less than about 10 feet below the approximate proposed bottom of footing, the rock below the footing support elevation shall be cored to obtain 7 to 10 feet of competent rock sufficient to support all retaining wall types feasible for the site.

Generally, a TDOT subsurface exploration plan would consist of advancing test borings on approximate fifty to one-hundred feet along the wall face alignment depending upon the expected subsurface soil and rock consistency. This spacing may be expanded or reduced, or a minimum of three borings, depending upon the consistency of conditions encountered and the judgment of the geotechnical engineer or engineering geologist. Consideration should also be given to advancing test borings behind the wall to characterize conditions for anchors, soil nail, or temporary excavation purposes.

The geotechnical engineer should consult the appropriate references such as ASHTO LRFD Bridge Design or other NHI publications on specific wall types for further details of recommended drilling/sampling/testing requirements.

Laboratory Analysis

The purpose of laboratory testing is to determine the geotechnical design parameters that shall be used for wall design, global stability, and structural settlement estimates. These tests typically include classification tests, strength tests and consolidation testing. Generally, more sophisticated testing could be necessary for critical wall heights (20-25 ft.). The engineering geologist or geotechnical engineer is responsible for selecting the appropriate strength parameters for the appropriate loading conditions that are necessary to properly evaluate the retaining wall structure.

Engineering Analysis

Preparing a Retaining Wall Foundation Report, and Retaining Wall Detail sheets for TDOT requires considerably more effort than supplying the wall design parameters to a retaining wall design engineer. The Report requires detailed analysis and evaluation of the specific site.

R.O.W. Limitations: Consideration must be given to the wall types that could be built within the R.O.W. provided by the State. If the R.O.W. was available, a soil\rock slope would be constructed, and a retaining wall would not be needed. When reviewing the plan Road Way Cross Sections, Present\Proposed Layout consider the construction methods. Many wall types are not considered acceptable, because there is insufficient area between the R.O.W. line and the wall to make a proper temporary excavation behind the wall. Expensive temporary shoring or temporary walls are often required.

Traffic Control Plan: The retaining wall must be built during one of the traffic control phases. At the time of discussion during the R.O.W. Field Review, convey to everyone the requirements of the wall construction. During Construction Field Review, verify that the wall can be built during one of the traffic control phases.

Utilities Conflicts: Be cognizant of the location of utilities during the development of the Report. At the time of discussion during the R.O.W. Field Review, convey to the utility owners and the group the requirements of the wall construction and how it will relate to utilities. During Construction Field Review, verify there will be no conflicts with existing utilities or utilities that will be relocated.

Per SP624, the Contractor responsibilities are to verify that the retaining wall design submitted meets only internal stability requirements. If existing site conditions of the proposed retaining wall do not meet requirements for external stability, the Retaining Wall Foundation Report preparer must detail the proposed construction effort, and translate the detailed effort onto the Retaining Wall Detail sheets.

Internal and External Stability Responsibilities

The Retaining Wall Foundation Report preparer is responsible for external stability requirements regarding **nominal bearing resistance**. For example, following preliminary calculations if it is determined that the proposed wall would apply excessive vertical bearing pressures to the unimproved ground, then foundation improvement techniques should be recommended in detail in the Retaining Wall Detail Sheets by the Report preparer. All foundation improvement must be clearly defined and quantified in the plan sheets. The foundation improvement detailed in the plan sheets must be sufficient so the proposed wall has an adequate CDR for nominal bearing resistance.

The Retaining Wall Foundation Report preparer is responsible for external stability requirements regarding **sliding**. For example, following preliminary calculations if it is determined that the base of the wall would be excessively wide for the given constraints of the site, proposed ground improvement shall be recommended to improve the sliding coefficient. The report preparer must evaluate the sliding coefficient and determine the effect of the size of the wall on the lateral requirements of the project.

The Retaining Wall Foundation Report preparer is responsible for external stability requirements regarding **global stability**. For example, following preliminary calculations it is determined that the proposed slope will not meet global stability requirements after the wall is constructed. The Report preparer is responsible for specifying the construction effort necessary to prepare a retaining wall building pad or platform that will satisfy global stability requirements. This includes but is not limited to the depth of undercutting required, the material required to backfill the undercut excavation, pile spacing\minimum pile tip elevation, deep foundation design parameters, or compacted aggregate piers. The Report preparer shall convey in the Retaining Wall Detail sheets the construction effort in terms of item numbers, often quantities, and notes in the sheet.

All retaining wall design principles are to be in accordance with the AASHTO LRFD requirements in effect at the time of the evaluation. This section is not intended to discuss all of the various design checks that should be considered. Some of the more common issues that the Department must resolve involve retaining wall constructability as it relates to R.O.W. availability, traffic phasing requirements, and utilities relocation. For critical wall design cross-sections, the external and global stability shall be evaluated based on the bearing capacity and sliding coefficients selected. The geotechnical design parameters used shall be considered for several critical design sections. For conventional and M.S.E. walls, the base length is to be evaluated based on the sliding coefficients recommended. If the base length is not constructible for reasons discussed above, then another acceptable wall type must be considered. At minimum, the following geotechnical recommendations must be made:

Appropriate φ and Unit Weight if In-situ Soils and Backfill (pcf): Highly plastic clay material shall not be used as backfill.

Coefficient of Sliding (unitless): The retaining wall designer will compute $R\tau$, the nominal sliding resistance between the soil and foundation. The equation for $R\tau$, is given in the AASHTO LRFD Bridge Design Specifications (10.6.3.4-2 in 6th edition). The product of the 'coefficient of sliding' and the total vertical force, V, results in the nominal sliding resistance between soil and foundation.

Nominal Bearing Resistance (psf): Based on appropriate bearing capacity analysis in accordance with AASHTO LRFD Bridge Design Specifications.

Allowable construction slopes: For example 1:1. Where there is insufficient room for a slope and a vertical cut is needed, recommendations for additional shoring shall be shown.

Lateral Capacity of Rock: For any walls using piles or shafts socketed into rock, the lateral capacity of the rock shall be provided.

Foundation Improvements: Detail any foundation improvements needed to support the wall types shown.

Settlement: Estimate both total and differential settlement from consolidation tests or compressibility tests of soil below footing level using net increase in pressure. That is, subtract removed overburden (if any) from increase in pressure due to wall to obtain net increase in pressure.

Global Stability: Check the global slope stability of existing and proposed site conditions. Refer to AASHTO LRFD Bridge Design Manual for further discussion of criteria.

Seismic Considerations: Seismic design values are assigned by the TDOT Structures Division. Check liquefaction of soil and seismic stability as needed. See current AASHTO specifications for requirements.

Unusual Problems: Determine if any potential problems need analysis such as lateral squeeze. Where retaining walls are founded on soils in a slide complex area, the foundation alternatives shall be clearly evaluated and stated on the report and drawings. Discussion of risks of founding the retaining wall in a slide complex deposit shall be discussed and the potential influence of that slide deposit on the retaining wall and surrounding structures / roadway features shall be analyzed and discussed.

Retaining Wall Foundation Report Requirements

The Retaining Wall Detail sheets are inserted in the Construction plans, and serve as a binding contract between the State and the Contractor. These Retaining Wall Details sheets are used by the Contractor to develop the retaining wall shop drawing design plans. The Retaining Wall Foundation Report, while an important document for reference, in most cases will not be considered part of the contract documents. The Retaining Wall Foundation Report should essentially contain duplicate geotechnical design parameters of the Retaining Wall Details sheet. Care should be taken that there are no contradictions, and no discrepancies, between the Retaining Wall Foundation Report and Retaining Wall Details sheets.

The Retaining Wall Foundation Report is often sought for reference to clarify the rationale for parameters selected or assumptions made. Every effort should be made to include the Retaining Wall Details sheets into the R.O.W. and Construction Field Review plan sets.

To reduce administrative effort, consultants shall present a Retaining Wall Foundation Report draft to TDOT GES for comment, prior to finalizing and submitting to TDOT Structures Division.

Geotechnical Reports and Drawings

All the information included on the Retaining Wall Details sheets shall be included in the report along with appendices that detail the analyses performed for the project. All typed boring logs shall be included with the report. The initial layout sheet (conceptual drawing) is provided by the Design Manager and geotechnical data is added after exploration.

Geotechnical Report Elements

Executive Summary or Cover Letter – This section gives a brief summary of the report. It shall also state if potentially acid producing materials was found or not found on a project.

Introduction – Brief summary of purpose of the wall, general size, general type (cut or fill) and location. Any special constraints such as limited right of way are noted here.

Geology, Soils and Site Conditions – Geology, soils and site conditions that may affect the project.

Surface and Subsurface Exploration – Exploration Performed

Recommendations – For retaining wall projects, the text of the retaining wall sheet is included in this section, along with any pertinent discussion of the recommendations. Detail acceptable wall types and provide parameters for design including any required foundation improvements. Provide recommendations for construction purposes such as allowable temporary cut slopes, special drainage, undercutting or other pertinent recommendations. Use concise, direct language in notes.

Appendix – Retaining Wall Details drawing sheet, Boring Logs and Test Reports

Retaining Wall Foundation Report Delivery

In an effort to standardize the electronic delivery process of TDOT GES Retaining Wall Foundation Report, the following procedures are to be used for internal and consultant projects. The electronic deliverables will now be uploaded to TDOT's server, FileNet, or sent to Structures Division.

For a single wall on the project:

xxxxxx-yy-GeoFoundRptRW-GESzzzzzzz.zip
where: xxxxxx-yy is the PIN number
zzzzzzz is the GES number
example: 117511-00-GeoFoundRptRW-GES2504313

For multiple bridges or walls on the project:
xxxxxx-yy-GeoFoundRptRWX-GESzzzzzzz.zip
where X will be the individual wall or bridge number supplied

The compressed (*.zip) file will contain the following:

- The sealed report with attachments (boring logs, test results, retaining wall sheets, notes, etc.) combined in a *.pdf format. The naming convention of the *.pdf file is to be:
  xxxxxx-yy-GeoFoundRptRW-GESzzzzzzz.pdf
- Unsealed retaining wall cad drawing sheets in (*.dgn) format. The file name is to follow the convention below:
  xxxxxx-yy-GeoFoundRW-SHT-GESzzzzzzz.dgn

Chapter 1.4:

Noise Walls

Introduction

The TDOT Environmental Division conducts studies to determine if a proposed project warrants the use of noise walls for noise abatement. If a noise wall is deemed to be necessary, the location, height and material properties of the noise wall are determined by the Environmental Division and this information is provided to the Structures Division which then develops a set of plans for the noise walls. In a manner similar to bridges and retaining walls the Structures Division sends a request letter along with a set of plans to the Geotechnical Section requesting that a geotechnical investigation be conducted for the noise wall. The Geotechnical Section conducts the geotechnical investigation and provides the Structures Division with a report which provides subsurface data and foundation recommendations.

While there are variations regarding the noise wall dimensions, construction methods and material properties, the typical noise wall is 12 feet high and is constructed of precast concrete panels set in between precast concrete posts which are typically spaced 20 feet apart. The precast concrete posts are placed in predrilled holes in the ground, typically 24 inches in diameter (essentially small diameter drilled shafts). The depth of the foundation hole depends on several factors but the subsurface soil or rock conditions have the most influence. Other common foundation support methods include: 1) constructing the small diameter drilled shafts and then the posts are bolted onto the top of the shaft foundation and 2) constructing a shallow spread foundation with the precast posts then bolted to the shallow spread foundation.

Goals of Investigation

The goals of the geotechnical investigation are to determine subsurface conditions at the proposed noise wall location and to provide geotechnical foundation recommendations. This information will be used by the Structure designer to complete the noise wall foundation design and to provide estimate quantities and also by the contractor to determine his bid price and his means and methods of construction.

Drilling Requirements

Ideally, one test boring will be advanced for each proposed noise wall post, typically every 20 feet along the noise wall alignment as discussed above. The ability to achieve this ideal drilling pattern will be influenced by site access conditions, presence of utilities and project schedule.

The test hole drilling should include Standard Penetration Testing every 5 vertical feet until rock is encountered or until such depth that sufficient foundation design information has been collected within the soil horizon. A maximum depth of 30 feet in soil is usually sufficient. Note that the depth of hole is based on being relative to proposed bottom of noise wall and therefore must be adjusted for site grading requirements, e.g. will there be cut or fill at the wall location. Once rock is encountered the rock should be cored until it has been determined that the rock is suitable for foundation support. A depth of rock core of 10 feet is generally sufficient unless significant voids or soil seams are encountered.

Depending on soil conditions encountered some test holes should include collecting of representative undisturbed samples (“Shelby tubes”). All samples including SPT, Shelby tubes and rock cores should be retained and taken to the laboratory for inspection by the engineer/geologist and for potential laboratory testing.

Laboratory Analysis

Representative SPT samples collected during drilling should be tested for the suite of classification testing including natural moisture content, Atterberg Limits and grain size analysis (sieve test plus hydrometer test with 82 minute reading). Any undisturbed samples collected should be tested for classification and unconfined compression testing including stress-strain measurements. Normally, more complex testing such as consolidation or triaxial testing is not required for noise wall projects.

If rock cores are collected during drilling, unconfined compression testing of representative samples should be conducted. The rock core should be inspected by a geologist or engineer to ascertain basic mineralogy composition of the rock.

Engineering Analysis

The actual engineering design of the noise wall, including the foundation, post and panel design is conducted by the Structure designer. However, some noise wall component suppliers have predesigned components which simplify the design process. The geotechnical engineering requirements include determination of nominal axial bearing components, both end bearing and side friction bearing for the soil and or rock layers. These values are determined through typical pile or drilled shaft bearing analysis.

In addition to the axial bearing geotechnical design values, lateral capacity design values are required. Depending on the Structure Designer design method, the lateral design values may include nominal shear strength, modulus values such as E50 of the soil or rock, or recommended p-y analysis values. TDOT Structures utilizes an in-house program that utilizes correlations of soil SPT blow counts and rock compressive strength to determine the noise wall post foundation requirements.

The Geotechnical Engineer for the project should communicate with the project Structure Designer to discuss the design methodology to be used so that appropriate information can be presented in the report and drawings.

Geotechnical Reports and Drawings

Geotechnical Report Elements

Executive Summary or Cover Letter – This section gives a brief summary of the report. It shall also state if potentially acid producing materials was found or not found on the project.

Introduction – Brief summary of purpose of the noise wall, general size, location and known foundation design (i.e. whether it is known that the posts will be on 20 centers and on drilled shafts or footings). Any special constraints such as limited right of way are noted here.

Geology, Soils and Site Conditions – General site geology, surficial soil conditions, and site topography and site drainage should be discussed in this section of the report.

Subsurface Exploration – A summary of the exploration methods such as type drilling and/or coring conducted should be discussed. A description of pertinent subsurface conditions encountered during drilling should be discussed including soil and rock descriptions and discussion of any groundwater encountered. Useful soil and/or rock properties determined from drill testing and laboratory testing should be summarized.

Recommendations – Based on an understanding of the preferred foundation type, the geotechnical design parameters for the soil and rock layers should be provided here. Expected foundation installation conditions should be discussed such as whether drilling through soil and/or rock layers will be required and whether groundwater is expected.

Special Notes and Specifications – Any special notes to be included in the plans, these should also be on the noise wall sheet(s).

Appendix – Documents and supporting information

Noise Wall Sheet(s) and any applicable cross sections
Boring Logs
Laboratory Testing
Engineering Analyses

Noise Wall Sheet Elements

General Layout of Noise Wall – The Noise Wall Layout sheet will show the wall in relationship to its surroundings. This sheet will be provided by the Structures Division. Additional plan or profile information that may be useful to present can be obtained from the general project plans.

Cross Sections – At least one cross section showing the noise wall in relation to other aspects of the project such as ROW limits and proximity to utilities should be shown.,

All boring data for the project – These must show elevations and material types, test data such as SPT blow counts. This is a graphical log that should match up with written boring logs.

Any explanatory foundation notes –add any explanatory material needed such as depths of excavation and replacement or other pertinent data.

Other notes – any notes needed for design or construction not specified above.

Chapter 2.1:

Preliminary Investigations

Introduction

A preliminary geotechnical investigation is provided to the Planning Section within the TDOT Environmental Bureau in order to provide information in support of environmental documents and to provide a preliminary assessment as to the feasibility of a project or its alternates. These investigations differ from other TDOT projects in that drilling and sampling may not be required, or if they are required, are performed on a much more limited basis than with a full scale investigation. Cross sections of the project are often not available and the project is typically shown on a set of “Functional Drawings” (a set of drawings where the proposed alignment or corridor boundaries are shown on a backdrop of aerial photos of the site).

Goals of Investigation

Preliminary investigations are provided as a first look at the feasibility of a project and to identify potential geotechnical and environmental related issues that may come up on the project. For an alignment project there may be only one alignment to be studied; there may be multiple alignments or only a corridor may have been defined. Where there are multiple alternate alignments, a preferred alignment from a geotechnical standpoint shall be identified. Geological hazards and other geotechnical issues that may cause problems with design, permitting and construction have a significant cost of mitigation or pose environmental issues and threats shall be identified for all alternates. Specific attention should be paid to the presence of sinkholes, landslides, rockfall, subsidence areas, soft or unstable ground, wetland locations, springs, seeps and potentially acid producing rock. Any of these geologic hazards which are identified at the site shall be clearly noted in the report. See Chapters 3.1 through 3.3 for guidance on these individual features.

Unlike many other TDOT projects, the end product of a preliminary investigation is a report which may be supported with maps, drawings or cross sections; but is not included in contract plans. Preliminary investigations are used by TDOT in order to support feasibility studies, selecting an alignment, assessing alternate alignments, as technical support for environmental documents and for assessing preliminary costs of a project. These projects may be very simple and require a single site visit and a reasonable desk study or they may be complex and require drilling, sampling and complex analyses.

Drilling Requirements

For simple projects, drilling and sampling may not be required. For more complex projects, it will depend upon the specific project and the goals for the investigation at the time of investigation. This will need to be assessed on a case by case basis depending upon the complexity of the project and TDOT needs.

Laboratory Analysis

For simple projects, laboratory analysis may not be required. For more complex projects, it will depend upon the specific project and the goals for the investigation at the time of the investigation. This will need to be assessed on a case by case basis depending upon the complexity of the project and TDOT needs. For projects located in Acid Producing Rock (APR) areas, APR testing of rock is conducted. Typically these samples would be pieces of rock obtained from rock cuts or outcrops along the proposed alignment.

Engineering Analysis

For simple projects, engineering analysis may not be required. For more complex projects, it will depend upon the specific project and the goals for the investigation at the time of the investigation. This will need to be assessed on a case by case basis depending upon the complexity of the project and TDOT needs. These may include any or all of the techniques described in other chapters of this manual.

Geotechnical Reports and Drawings

The geotechnical report for a preliminary investigation project should detail the investigation and the recommendations for the site. Geohazards at the site and any features which are expected to cause geotechnical problems shall be clearly identified. Maps, drawings and photographs may be attached as needed in order to clarify or bring out key points and issues. This report will be used by the GES as a reference for the exploration performed at the site and as support for Planning and Environmental documents.

Geohazard Documentation Needed:

For all geohazards, GPS coordinates shall be taken and reported in WGS84 (NAD83) datum in decimal degrees. The area affected shall be mapped and noted. A geohazard inventory form shall be filled out for all geohazard sites as this will be used to upload the data into the TDOT Geohazard Management System. In addition to the inventory form, the features and area of the geohazard shall be shown on an aerial photograph of the site. Google maps, Bing or other online resources may be used as the “base map” aerial photograph of the site.

Geotechnical Report Elements

Executive Summary or Cover Letter – This section gives a brief summary of the report. It shall also state if potentially acid producing materials was found or not found on a project.

Introduction – Brief summary of the project and location. Any special constraints such as limited right of way are noted here.

Geology, Soils and Site Conditions – Any geology, soils and site conditions that may affect the project.

Surface and Subsurface Exploration – Include descriptions of site visits and surface exploration. Subsurface investigation, if performed shall be detailed here as well.

Recommendations – Discuss geological and geotechnical issues associated with the proposed alignments. Provide recommendations for selecting a preferred alignment and documentation of problems noted at the site along with potential mitigation methods. These may be very detailed or very general depending upon the complexity of the project.

Appendix – Documents and other supporting data

- Geotechnical Sheets and drawings
- Maps
- Boring Logs - if applicable
- Laboratory Testing - if applicable
- Engineering Analyses -

If geotechnical sheets are to be used for a preliminary report, please see other chapters in the manual for general guidance as to the appropriate information to include on the sheet for the type of project. For example, a preliminary investigation of an alignment which included surface or subsurface exploration should include Soils sheets to convey the information of an alignment project.

Chapter 2.2:
Roadway Alignment Projects: New Location or Widening

Introduction

Transportation improvements to the TDOT roadway network include new roadway alignments over "open" ground, or capacity improvements (widening, realignment, etc.) to an existing roadway. The request for a Soils & Geology Report geotechnical services is initiated by the roadway designer (PPRM #445), typically following finalization of final Preliminary plans (PPRM#390), but the request for services could be made as early in the project development schedule as after approval of the grade and alignment (PPRM#345). Ideally, the geotechnical field investigation should be complete, and the Soils & Geology Report (including Soils Sheets as Report Appendix), be delivered prior to ROW plans preparation (PPRM#535). TDOT Design Guidelines 3-110.05 *Soils and Geology Reports* states all "soils data" should be incorporated into the final ROW Plans prior to delivery. In summary, the Soils & Geology Report purpose is to address not only the R.O.W. acquisition process (including construction easements), but any additional construction costs including undercutting, rock pads, etc. that will be required to complete construction of the roadway improvement. This is quite important, because the roadway designer submits a preliminary budget estimate at this time in the project development schedule.

The request for a geotechnical investigation is often made for a multi-county corridor planning study for purposes of obtaining environmental documents, and then broken down into smaller, fundable segments for purposes of ROW acquisition and construction. Mindful of this, it is the responsibility of TDOT GES to address all of the administrative issues, such as but not limited to breaking up the geotechnical reports and drawings to , tracking the correct internal GES project file numbers, PE numbers, and PIN Nos for the smaller segments.

Roadway alignment projects can include elements such as bridges, retaining walls, noise walls or high mast lighting. The complete grading plan of all of these project elements may or may not be determined at this point in the project development schedule. Therefore, the report deliverables for these geotechnical investigations are delivered separately as required in the project development schedule. These project elements such are discussed in separate Chapters of this document. In as much as the Soils & Geology Report precedes the R.O.W. Field Review, it is imperative that the proposed R.O.W. acquisition be established at this point in the project development schedule.

Note: In an attempt to reduce the review process administration effort, the Soils and Geology Report Checklist has been developed and is available in Appendix 2. This Checklist is to be delivered concurrently with the Soils and Geology Report.

Goals of Investigation

The goals of the geotechnical investigation for the alignment project include:

1. Conduct subsurface investigation to define all pertinent subsurface materials.
2. Conduct laboratory analysis of soil and rock materials in support of engineering analysis and for construction purposes.
3. Make recommendations in support of engineering/geologic analysis.
4. Prepare Soils & Geology Report (with Soils sheets).

The results of the investigation provide the roadway designer information pertinent to final design of cut and fill slope ratios, material properties for quantity estimates and discussion of any other geotechnical issues that may have an effect on roadway design. The Pavement Design Section utilizes the CBR test data for pavement design purposes. The report and drawings are also used by the Environmental Section in preparation of necessary permits related to geotechnical or geologic issues such as sinkholes or acid producing rock issues. The construction personnel also utilize the geotechnical information during the construction phase for material quality control (i.e. proctor density tests for compaction control). The geotechnical drawings become part of the Construction Plans for the project.

Drilling and Sampling Requirements

The geologic characterization of a site is a craft, and there are no hard and fast policies regarding how much or how little drilling, sampling, and testing should be done to characterize a site. Insinuations such as “that was too much drilling”, or “that was not nearly enough drilling” are usually levelled during the construction phase.

With that said, TDOT GES considers the drilling and sampling guidelines found in Publication No. FHWA NHI-01-031 NHI Course No. 132031 Subsurface Investigations - *Geotechnical Site Characterization Reference Manual* a good reference. Admittedly, the reference is more dated every day. Staying current in regard to evolving drilling and sampling techniques is encouraged.

Considerations for the extent of drilling and sampling include but are not limited to the depth of the proposed excavation cuts, the height of the proposed embankment fills, and the variability of the local geological conditions. The effort expended to access a site should be directly related to the risk assumed if good geotechnical information is not obtained at that location. Smaller project scopes could only require a few test borings be advanced, and only a few days spent in the field, whereas complex project scopes require extensive drilling, and could take multiple months of field testing.

Generally Accepted Practices for Drilling and Sampling Frequency

The following table entitled, TDOT Test Boring Frequency, represents TDOT GES generally accepted guidelines with regard to test borings frequency. The frequency is based on proposed geometrics of the roadway cross sections. This table is to be used for preliminary scope estimation purposes, and the site investigation scope may be adjusted in the field as required, based on actual site conditions encountered.

And it is recognized that flight auger soundings are often useful to rapidly obtain refusal elevations.

TDOT Test Boring Frequency[1]

Cut or Fill	Depth of Fill; Height of Cut	Length of Cut or Fill	Number of Borings	Depth
Soil Cut	D < 40	L < 600'	At least 1	Located in deepest portion of the cut, at least 15 feet below ditchline.
	D < 40	L > 600'	Spaced out at no more than 400' in length	Located in deepest portion of the cut, at least 15 feet below ditchline.
	D > 40	L < 600'	Spaced out at no more than 400' in length, minimum of 2 borings	Attempt to sample deepest portion of the cut, at least 15 feet below ditchline.
	D > 40	L < 600'	Spaced out at no more than 300' in length, minimum of 2 borings	Attempt to sample deepest portion of the cut, at least 15 feet below ditchline.
Rock Cuts	D > 10'	L < 200'	At least 2	To 5 feet below ditchline
Rock Cuts	D > 10'	L > 200'	Spaced out at no more than 200' in length. Minimum of 3	To 5 feet below ditchline
Fills	H < 30	L < 600'	At least 1	To 2 x depth of proposed embankment. Core at least 5 feet of rock if refusal is higher than 2 x embankment depth
	H < 30	L > 600'	At least 2, spaced no more than 400 feet apart	To 2 x depth of proposed embankment. Core at least 5 feet of rock if refusal is higher than 2 x embankment depth
	H > 30	L < 600'	At least 2	To 2 x depth of proposed embankment.
	H > 30	L > 600'	At least 2, spaced no more than 300 feet apart	Core at least 5 feet of rock if refusal is higher than 2 x embankment depth

[1] Includes rock core, split spoon sampling and Shelby tube sampling as appropriate. Please note that these guidelines may not be sufficient in structurally complex rock. Additional drilling will be required if needed to predict potential structural failures in rock cuts such as plane shear, wedge failure and toppling failures.

The soil and rock sampling conducted in conjunction with the drilling will also vary greatly depending on the size and nature of the project. Generally, TDOT GES finds the following sampling guidelines to be reasonable:

- Bulk bag sample (approximately 50 pounds) of each type soil encountered during auger drilling process. The soil sample is subjected to Proctor Density testing and classification. A moisture content sample is also obtained. Samples should be taken whenever there is a change in sample texture, moisture content. If the soil is consistent, additional samples should be obtained on an approximate 1,500 feet station spacing.
- Bulk bag sample (approximately 80 pounds) of each type soil encountered for Proctor\CBR testing for subgrade evaluation for pavement design. The CBR test sample frequency should be approximately spaced on 2,500 feet of alignment station.
- Standard Penetration Tests and/or Shelby Tube undisturbed sampling. Samples should be AASHTO classified to characterize all of the different soil types on the site. Strength and consolidation properties should be determined, using the appropriate test methods on the undisturbed tube samples. The moisture content should be determined across the site.
- Rock core samples should be obtained in cut areas. Typically, photographs of rock core are taken and made a part of the geotechnical boring record.
- Note that if potential Acid Producing Material (APR) is suspected, sampling\testing frequency will be increased and conducted in accordance with requirements outline in Chapter 3.1.

Laboratory Analysis

Representative soil samples shall have moisture, gradation, plasticity and classification tests completed. Where settlement is a concern, samples shall have a 1-D consolidation test performed. Where slope stability issues are expected, appropriate tests that provide slope stability parameters for use in slope stability analysis shall be performed. These include triaxial tests, direct shear or unconfined compression tests.

The California Bearing Ratio test (CBR) is a requirement for TDOT projects as pavement designers evaluate the test results. As typical for the CBR tests, Proctors, gradation, plasticity and classification shall be reported along with the CBR results. Where the CBR sample results consistently show CBR < 5, lime stabilization or other subgrade stabilization methods should be evaluated, this may require additional laboratory analysis with lime stabilized CBR tests performed.

Laboratory testing on rock samples include compressive strengths, sodium sulfate soundness and specialty tests discussed in Chapter 3.1 if the rock is suspected of leaching acid off the site. Any rock encountered should be examined or tested to characterize the type of rock and the mineralogy to the extent necessary for construction of the project.

Engineering Analysis

Sound engineering analyses must be performed to obtain geotechnical recommendations for the proposed roadway alignment. It is not the intent of this manual to provide a comprehensive reference on geotechnical engineering analysis. Some of the more references that TDOT GES frequently uses and are available are listed below.

- Publication No. FHWA NHI-06-088 December 2006 NHI Course No. 132012 Soils and Foundations Reference Manual
- Training Course in Geotechnical and Foundation Engineering: Rock Slopes 1999 FHWA-HI-99-007
- Advanced Course on Slope Stability, Volume 1 1994 FHWA-SA-94-005

Engineering analyses typically required to prepare the Soils & Geology Report include:

- Slope stability for soils cuts
- Slope stability for soil embankments
- Slope stability for rock cuts
- Rockfall hazard mitigation through slope design or mitigation measures. See Chapter 3.2 for details.
- Settlement analyses of embankments including settlement magnitude and time rate, as deemed appropriate.

Typical slopes used for TDOT projects are 2H:1V or flatter in soil. Typical shot rock \ graded solid rock embankment fill slopes may be recommended 1.5H:1V or flatter. Surface sloughing and rilling of the sandy soils are concern to projects in Region 4, and therefore 3:1 soil cut and fill slopes are used effectively.

The economic impact of landslides occurring on TDOT embankment slopes is always a critical concern. It is recognized that 2:1 fill slopes are used in an attempt to lessen the impact of the roadway footprint, to limit R.O.W. acquisition, and to reduce the quantity of fill placement. It is felt, however, that the costs of contractor change orders and contractor time delays following a landslide on a 2:1 embankment slope far outweigh the savings that would have otherwise been realized. Footnote 4 of TDOT Standard Drawing RD01-S-11 DESIGN AND CONSTRUCTION DETAILS FOR ROADSIDE SLOPE DEVELOPMENT seems to recognize slope stability concerns are to be addressed by TDOT GES. With this said, it is advised to carefully evaluate 2:1 soil embankment slopes higher than 30 ft. If poor subgrade drainage conditions exist, consider a rock pad. If karst terrain drainage is prevalent, consider the different typical TDOT sinkhole treatments. Slope “benches” provide a break in the slope, and are often used effectively in slope stability modelling to increase the CDR, but are difficult to construct in the field. Slopes flatter than 2:1 should be recommended as necessary.

Typically, TDOT excavates unweathered (high quality-high RQD) rock cuts on vertical pre-split slopes. There are exceptions, of course, if the rock is weathered and of inferior quality. If the rock is of sufficiently poor quality, if the bedrock elevation is inconsistent, or if the jointing pattern is not conducive to pre-split or steep 0.25:1 slopes, it is often advisable to set slope ratios flatter, or base the slope design on a slope configuration used for soil slopes.

Rock slope stability including rockfall considerations shall also be checked at the site where appropriate. This may involve the use of rock bolts, welded wire mesh draping, rockfall catchment fences, shotcrete and other mitigation methods. Guidance for typical rockfall design can be found in Chapter 3.2 of this manual.

Another aspect of analyses includes subgrade stability evaluations and assessments. Undercutting of soft surficial soils is often required. Surface and subsurface drainage treatment considerations may be beneficial or required. Karst features (sinkholes) may require treatment.

Geotechnical Reports and Drawings

In an attempt to increase administration efficiency, the Soils and Geology Report Checklist has been developed and is available upon request. This Checklist is to be delivered concurrently with the Soils and Geology Report. Deliverables for the Soils and Geology Report (with Soils Sheets) are defined below with brief narrative.

Geotechnical Report Elements:

Executive Summary– This section is a brief one page narrative describing the site. It briefly describes significant geotechnical issues of the project. These significant issues include but are not limited to especially difficult grading conditions the contractor is likely to encounter, acid producing materials that will be encountered at the site, unsuitable subgrade soils, and recommended sinkhole treatment methods.

Introduction – Brief summary of the project and location. Any special site conditions such as limited right of way, topography and geography are noted here.

Geology, Soils and Site Conditions – Provide a complete description of site geology, soils and site terrain conditions.

Surface and Subsurface Exploration – Provide a summary of the exploration performed such as number and type of test borings, sampling techniques, site access issues, and property owner issues, etc.

Recommendations – This section of the report is best discussed in terms of project station interval segments that share proposed geometric roadway cross section characteristics. Each segment interval discussion should include recommendations for cut slope ratios and/or embankment slope ratios, special embankment construction recommendations such as rock pads, rock buttresses, undercutting and replacement of soft soils, mitigation of sinkholes, settlement issues along with settlement mitigation such as stage construction or other pertinent recommendations. All geotechnical cross sections provided with the report shall have explanatory material included in the report. For example, if a cross section is provided that proposes a fill embankment on a 2:1 slope from interval segment station 30+00 to 36+00, there shall be a section in the report that specifically references this interval segment and discusses what recommendations are made and why. Also, in the Soils sheets this station interval segment shall contain a typical roadway cross section, with boring profiles included, that depict the recommendations for that station interval segment.

Pavement Subgrade Recommendations- The CBR values recommended for pavement design shall be included here. Any special recommendations regarding the subgrade such as special compaction requirements, drainage requirements, or stabilization requirements should be discussed here.

Geotechnical Notes and Specifications – Provide and discuss any geotechnical notes and specifications that should be included in the plans. These should also be transferred onto the Soils sheet(s).

Appendix – Documents and supporting information

- Soils sheets
- Soil and Subgrade report
- Soils Description Sheet
- Boring Logs
- Laboratory Testing
- Engineering Analyses

Geotechnical Sheet Elements-The Soils Sheets

The Soils and Geology Report request, includes a digital set of project plans in portable document format (pdf) and also Microstation CAD drawing files (.dgn). The project plans on .dgn files is required to develop the Soils sheets. These sheets should be entitled Soils, to match the Index of Sheets description.

In an effort to standardize sheet appearance a Soils sheet template has been developed and is available upon request.

The Soils sheet number, project number text, and year of construction is found in the upper right portion of the sheet cell. Throughout the duration of the project development, this text must be modified with each set of field review plan sets, as well as the final Construction plans. At time of Construction plans “turn-in” (see details in TDOT Design Guidelines-Section 1), the Soils sheets must be processed to pdf, and affixed with an electronic seal of an engineer registered in Tennessee. Field Review plan sets do not require an engineer’s seal to be affixed, only Construction plan sets.

Great emphasis is to be placed on the quality of Soils sheets. Consideration should be given to using as few sheets, to convey all of the recommendations. Unnecessary blank “real estate” on any sheet should be avoided, although some area beneath the title sheet project information (upper right) should be left unused for any plans revisions that could become necessary. Microstation reference files shall not be used. An attempt to keep the drawing files simple is encouraged.

For standardization and consistency, the Soils sheets will consist of the following:

SOILS – GEOTECHNICAL NOTES & EST. QTYS. Any notes required to expound upon the notes in the plans or the TDOT Standard Specifications for Road and Bridge Construction should be placed here. In the event of a contradiction in a plans note and the Standard Specifications, the plans note governs, per Standard Specifications 105.04. So, know and understand the Standard Specifications, and take care in adding ambiguous notes that are not clear. On less complex projects, there may be no need for this sheet. Often, a note can be added to one of the Soils sheets listed below. Also, this is the appropriate sheet to place geotechnical related roadway quantities. The quantities should be inserted in a block with appropriate item number and associated description, and unit.

SOILS – BORING LAYOUT A plan view sheet, based on the proposed layout showing test boring locations. This may also show limits of recommended geotechnical work, such as a plan view of undercutting limits, rock pad limits, select fill bridges over low lying ground, or sinkhole treatment. Soils data, especially Proctor Density, should be shown. This boring layout sheet should not be cluttered with curve information, etc. but appear clean. If test borings are limited, the number of Soils sheets may be reduced by using an appropriate scale other than 1”=50’.

SOILS – BORING PROFILE These sheets provide a profile view of the vertical roadway grade contrasted with boring profile “sticks” along the subject station interval. Actual graphical area patterns of the different soil or rock material shall be standard, and the boring legend provided. Soil layers should be identified in accordance with Roadway Design Guidelines Section 4-203.02 DEFINITION OF TERMS USED FOR EARTHWORK GRADING CALCULATIONS

SOILS – TYPICAL SECTIONS Boring profile “sticks” should be placed within the roadway cross sections provided in the Microstation design files to describe the geology encountered along the proposed roadway alignment. Sufficient information should be included to convey to the bidding contractors what material will be encountered. Sufficient information should be included to convey the slope design recommendations to the roadway designer. All Soils Typical Sections should have associated recommendations within the Soils and Geology Report. i.e. if a Soils Typical Section is provided that is a typical representation of the proposed slope geometry and geology from station segment between 30+00 to 34+50, there shall be a section in the Soils and Geology Report that specifically addresses this station segment. For bid preparation identify all soil horizons in accordance with Roadway Design Guidelines Section 4-203.02 DEFINITION OF TERMS USED FOR EARTHWORK GRADING CALCULATIONS

SOILS – SPECIALTY SHEETS SUCH AS ACID PRODUCING MATERIAL, SINKHOLE TREATMENT, etc The latter sheets can convey to the bidder and the roadway designer any recommendations that cannot be captured in the other sheets in the front.

Soils and Geology Report Delivery

In an effort to standardize the electronic delivery process of TDOT GES Soils and Geology Reports, the following procedures are to be used for internal and consultant projects. It is the intention that the electronic deliverables be uploaded to TDOT's server, FileNet, for distribution to TDOT Roadway Design Division \ Regional Project Delivery, TDOT Environmental Division, and others at an appropriate time in the project schedule, prior to ROW Plans Preparation.

Prior to the project being let to bid, each project has a designated plans turn-in date. Prior to the turn-in date the roadway designer will supply the appropriate sheet number, year of construction, and project number to the Soils sheets. At this point in time, TDOT GES \ geotechnical consultant is expected to modify the text on the Soils sheet Microstation .dgn file accordingly. Then the .dgn sheet file renamed appropriately, electronically sealed, processed to a .pdf, and delivered to the roadway designer, who will ultimately insert theses sheets into the Construction Plans.

FOR TDOT ROADWAY DESIGN DIVISION DELIVERABLES

The main deliverable will be a compressed (*.zip) file. The file naming convention should follow the example below:

xxxxxx-yy-SoilsGeoRpt-GESzzzzzzz.zip

where: xxxxxx-yy is the PIN number
zzzzzzz is the GES number
example: 117511-00-SoilsGeoRpt-GES2504313

The compressed folder will contain:

- The Soils and Geology Report Checklist
- The Soils & Geology Report, will be a combined file containing the report body (sealed) all appendices (boring logs, test results, Soils Sheets, etc.). Combine all of these elements of the Soils & Geology Report into a pdf file with the following convention:
  xxxxxx-xx-SoilsGeoRpt-GESzzzzzzz.pdf

- The entire set of Soils Sheets in a single .pdf format in the following naming convention:
  117511-00-SoilsShts-GESzzzzzzz.pdf

- The cad sheets in .dgn format. During this stage of plans development, the naming convention of the sheets should follow something similar to the following:
  xxxxxx-xx-SoilsSht-01
  where 01 is the sheet number and will increase sequentially.

Chapter 2.3: Bridge and Approaches

Introduction

A Bridge and Approach project within TDOT refers to a project where an existing bridge is being replaced, improved or relocated such that some modification of the roadway on either side of the bridge is required. This modification may include widening of the existing roadway, construction of new roadway or simply repaving the existing roadway leading up to the bridge. The Geotechnical Engineering Section receives the request to conduct a geotechnical investigation for the Bridge and Approach project from the Design Division. The request includes a set of roadway preliminary plans and cross-sections. Despite the project type designation, the project does not include the geotechnical investigation for the actual bridge structure, covered under Chapters 1.1 and 1.2. The Geotechnical investigation, report and recommendations are focused on providing pertinent recommendations regarding slope ratio requirements, and pavement design recommendations as well as any special geotechnical related requirements such as sinkhole mitigation.

The TDOT Geotechnical Engineer or consultant should ascertain whether the bridge structure associated with the project has been designed to the point where the Structures Division can provide the preliminary bridge layout along with the Bridge Foundation Investigation request. If so, then geotechnical investigations for both project aspects could be coordinated. However, geotechnical reports and drawings for each aspect should be provided separately since they are provided to their respective Divisions. The Construction plans for a Bridge and Approach project will include both roadway and structure plans and the project will be let to contract as one project.

Goals of Investigation

The goals of the bridge and approach geotechnical investigation are to conduct drilling, laboratory analysis, and engineering analysis sufficient to prepare a geotechnical report with recommendations and geotechnical drawings. The report and drawings will be used by the Roadway Designer to finalize cut and/or fill slope ratios, incorporate geotechnical requirements into plans and quantities (i.e. required undercutting of soft surface soil and replacing with graded solid rock). Information regarding the pavement subgrade should be provided so the Pavement Designer can complete the pavement design for the project.

As project plans development progresses to the construction letting phase, the Geotechnical Engineer should review project plans to make sure the geotechnical drawings are included in the plans, and that geotechnical recommendations and requirements have been implemented into the construction plans and quantities.

Drilling Requirements

The level of the drilling and sampling program for a bridge and approach project will greatly depend on the magnitude of the grading requirements associated with the project and also, to some extent, the site accessibility. For a project where the approach work for the project involves very minor grading or just repaving then no drilling may be appropriate. In this case, the engineer/geologist may just make a site visit to observe and note any site conditions relative to recommendations. Obtaining a sample of surficial site soils for the purpose of CBR testing may be accomplished by hand digging the sample.

At the other extreme, if the bridge and approach project involves major grading of cuts and/or fills to achieve planned roadway profiles and grade. Then the drilling and sampling program may be fairly extensive and would follow guidelines given in Chapter 2.2-Roadway Alignment Lines. Most bridge and approach projects, however, would typically involve moderate grading activities and therefore moderate drilling and sampling, with several drill holes needed on either side of the bridge. The engineer/geologist would determine the actual amount of drilling based on judgment of project requirements. The bottom line would be to accomplish enough drilling and sampling to provide appropriate recommendations for cut and fill slope ratios, settlement evaluation and material types involved in the grading.

Laboratory Analysis

For Bridge and Approach projects the California Bearing Ratio test (CBR) is a requirement for TDOT projects as TDOT Pavement Design uses the results from this test. As typical for the CBR tests, Proctor density tests, gradation, plasticity and classification shall be reported along with the CBR results. Additionally, a small sample shall be taken of the CBR sample sufficient to obtain in-situ moisture for the soil. Other samples may be taken at the site as well, depending upon the scale and nature of the cuts and fills for the project. Representative soil samples shall have gradation, hydrometer, and plasticity tests and shall be classified by both USCS and AASHTO soil classification systems. Samples taken in order to perform slope stability and settlement calculations may be required and include, but are not limited to triaxial tests, unconfined compression tests and direct shear tests. On some projects consolidation tests may be deemed necessary.

Where the CBR sample gives a result of $CBR < 5$, lime or cement stabilization or other subgrade stabilization methods must be evaluated, this may require additional laboratory analysis with lime or cement stabilized CBR tests performed.

Engineering Analysis

Types of analysis that have been needed for past TDOT Bridge and Approach projects include slope stability, settlement, or subgrade improvement evaluations. Other analyses may be needed for complex and non-routine projects.

Geotechnical Reports and Drawings

The geotechnical report for a bridge and approach project shall detail the investigations and the recommendations for the site. All geotechnical cross sections provided with the report shall have explanatory material included in the report. For example, if a cross section is provided that is typical for station 30+00 to 34+50, there shall be a section in the report that specifically references this drawing and provides a description of the recommendation and any needed geotechnical notes. A "Soil and Subgrade" report shall be included in the appendix and any CBR sample taken shall be included on this sheet. All typed boring logs shall be included with the report as well as any laboratory results. This report will primarily be used by the GES and as a reference for the exploration performed at the site.

Geotechnical Report Elements

Executive Summary or Cover Letter – This section gives a brief summary of the report. It shall also state if potentially acid producing materials was found or not found on a project.

Introduction – Brief summary of the project and location. Any special constraints such as limited right of way are noted here.

Geology, Soils and Site Conditions – Any geology, soils and site conditions that may affect the project.

Surface and Subsurface Exploration – Provide a brief summary of the exploration performed.

Recommendations – Provide recommendations for construction purposes such as allowable slopes, undercutting and replacement or other pertinent recommendations. The CBR values recommended for pavement design shall be included here.

Special Notes and Specifications – Any special notes to be included in the plans, these should also be on the retaining wall sheet(s). This section may be omitted if no special notes or specifications are required.

Appendix – Documents and other supporting data

- Geotechnical Sheets
- Soil and Subgrade report
- Boring Logs
- Laboratory Testing
- Engineering Analyses

Geotechnical Sheet Elements

The geotechnical sheets for a bridge and approach project shall include a plan view layout of the drill holes, drill holes plotted in relationship to centerline grade and any cross sections required to illustrate geotechnical design elements.

The initial layout sheets come from the preliminary design plans. Geotechnical data is added after exploration. These are the sheets that will be included in the contract plans. It is critical that geotechnical recommendations/requirements be illustrated with geotechnical plans sheets.

General Layout of Site – Plan view showing drilling and sampling locations. This may also show limits of geotechnical design elements, such as plan view limits of undercutting. It shall include a soil description chart. Examples of this soil description table format are available and should be used for standardization and consistency when creating these sheets. Where soils on the chart show an “in-situ moisture” that is significantly wetter or dryer of optimum than the proctor test, this shall be clearly noted on these sheets with a statement that includes a notice to the contractor that wetting, drying or additional handling of these soils may be required.

Centerline grade sheets with graphical logs of drilling – Showing all drill logs, these must show elevations and material types in relationship to the grade at centerline for the project. These may also show interpretations.

Cross Sections for the Project – Cross sections that describe the recommendations shall be included with the geotechnical sheets. For very small and simple projects, only one cross section may be needed. Cross sections shall be provided to illustrate geotechnical design elements that are recommended for the project or to illustrate materials to be encountered. Recommended slope ratios shall be shown.

Geotechnical Notes – Added as needed. They could be included directly on the cross sections or on the general layout sheets. These notes can also be included on a separate plans sheet. Please remember that these will be plans documents, so only appropriate material should be included.

Note: As an aid to the Geotechnical Designer/Report Developer a Report Checklist is provided in Chapter 2.2.

Bridge and Approaches Report Delivery

In an effort to standardize the electronic delivery process of TDOT Geotechncial Engineering Section geotechnical investigation reports, the following procedures are to be used for internal and consultant projects. The electronic deliverables will now be uploaded to TDOT’s server, FileNet, to be shared with other customers of TDOT such as the Environmental Division.

The main deliverable will be a compressed (*.zip) file. The file naming convention should follow the example below:

For a single bridge or wall on the project:

xxxxxx-yy-GeoFoundRptBr-GESzzzzzzz.zip
xxxxxx-yy-GeoFoundRptRW-GESzzzzzzz.zip
where: xxxxxx-yy is the PIN number

zzzzzzz is the GES number
example: 117511-00-GeoFoundRptBr-GES2504313

For multiple bridges or walls on the project:

xxxxxx-yy-GeoFoundRptBrX-GESzzzzzzz.zip
xxxxxx-yy-GeoFoundRptRWX-GESzzzzzzz.zip
where X will be the individual wall or bridge number supplied

The compressed (*.zip) file will contain the following:

- The sealed report with attachments (boring logs, test results, bridge foundation data sheets, retaining wall sheets, notes, etc.) combined in a *.pdf format. The naming convention of the *.pdf file is to be:
  xxxxxx-yy-GeoFoundRptBrX-GESzzzzzzz.pdf
- Unsealed bridge cad drawing sheets or retaining wall cad drawing sheets in (*.dgn) format. The file name is to follow the convention below:
  xxxxxx-yy-GeoFoundBr-SHT-GESzzzzzzz.dgn
  xxxxxx-yy-GeoFoundRW-SHT-GESzzzzzzz.dgn

Chapter 2.4:

Limited Extent Projects:

Intersections, State Industrial Access (SIA) Projects, Road Safety Audit Review (RSAR) Projects, Expedited Project Delivery (EPD) Projects

Introduction

The projects discussed in this Chapter are similar to those projects discussed in Chapter 2.2, Alignments and Chapter 2.3, Bridge and Approaches with respect to requirements of geotechnical reports and geotechnical drawings. The main differences are the limited geographical extent of these projects and the project development process and schedule. These projects are typically developed and let to contract on an accelerated time frame as compared to a typical roadway alignment project. The request for the geotechnical investigation for these projects is given by the Roadway Design Manager for the project. These projects may or may not have bridges and/or retaining walls associated with them. If so, the processes for the geotechnical investigation for those elements of the project are provided in the appropriate Chapter of this Manual.

Brief descriptions of these projects are given below.

Intersections: These projects typically consist of improvement of an existing roadway or highway intersection or interchange to enhance the capacity, efficiency or safety of the facility. The improvements may include lane widenings, lane additions, and signalization. Of note to the Geotechnical professional is that these projects are usually in urbanized or heavy traffic areas with numerous utilities in the project footprint. These conditions potentially limit the extent of subsurface investigation that can be accomplished for the project.

State Industrial Access (SIA) Projects: As described on the TDOT Website: “The State Industrial Access (SIA) Program provides funding and technical assistance for highway access to new and expanding industries across the state. The Tennessee Department of Transportation contracts with local governments for projects that will be developed under the SIA Program. The State Industrial Access Act, formerly known as the Industrial Highway Act, makes these partnerships possible.” The Highway access required for these projects may be very limited in nature, such as repaving an existing roadway or could involve a significant project with major grading required.

Typically these projects are developed and let to contract on an accelerated schedule and requires the geotechnical investigation be expedited in order to meet project schedules.

Road Safety Audit Review (RSAR) Projects: These projects are the result of a RSAR performed under the direction of the TDOT RSAR Coordinator. The RSAR reviews a particular section of roadway where it has been reported that there is possibly a recurring safety issue (i.e. a high incidents of guardrail impacts). Based on the review there may be recommendations for improvements that can range from simply installing guardrail to fully realigning a road or sections of a road, for instance adding a truck climbing lane. The Geotechnical Section would typically only be requested to perform a geotechnical investigation if the project involved realignment including significant new cuts and fills.

Expedited Project Delivery (EPD) and “Right –Sizing” Projects: Like the RSAR projects these projects ae typically limited in scope and may be developed on a fast track basis to alleviate a fairly localized safety or functional issue. These projects may evolve from a larger project that was originally a major new alignment or widening project, and then due to limited funding or further analysis, the project scope is reduced. Again, the need for and scope of a geotechnical investigation for these projects will greatly depend on the nature of the project.

Goals of Investigation

The goals of the geotechnical investigation for the Limited Extent Projects are the same as for Alignment Projects as given below:

1. Conduct geotechnical investigation to define all pertinent subsurface materials.
2. Conduct laboratory analysis of soil and rock materials in support of engineering analysis and for construction purposes.
3. Conduct Engineering/geologic analysis in support of recommendations
4. Prepare report providing data, analysis and recommendations
5. Provide geotechnical drawings showing results of subsurface investigation, recommendations and requirements.

The results of the investigation provide the roadway designer information pertinent to final design of cut and fill slope ratios, material properties for quantity estimates and discussion of any other geotechnical issues that may have an effect on roadway design. The Pavement Design Section utilizes the CBR test data for pavement design purposes. The report and drawings are also used by the Environmental Section in preparation of necessary permits related to geotechnical or geologic issues such as sinkholes or acid producing rock issues. The construction personnel also utilize the geotechnical information during the construction phase for material quality control (i.e. proctor density tests for compaction control). The geotechnical drawings become part of the Construction Plans for the project.

Drilling Requirements

Drilling and sampling guidelines and requirements are discussed in the references in the Manual Introduction and in Chapter 2.2. The extent of drilling and sampling for a particular projects will depend on the magnitude of the project's width-(e.g. number of lanes involved)-magnitude of cuts and fills-geologic setting, topography, site accessibility issues and other factors. Smaller projects of limited magnitude may only require a few drill holes and hand dug surface samples taking only a few days of field work whereas larger scale projects require extensive drilling that could take multiple months or more of time to complete.

At least one CBR sample sufficient for pavement design shall be taken at each site. It is appropriate to take several CBR samples from the site, depending upon the soils present and the extent of the project. Proctor samples from on-site soils that may be used as fill shall also be taken. Other drilling and site investigation needed shall be at the judgment of the engineering geologist or geotechnical engineer as needed to support the goals of the investigation.

Laboratory Analysis

The California Bearing Ratio test (CBR) is a requirement for TDOT projects as TDOT Pavement Design uses the results from this test. As typical for the CBR tests, proctors, gradation, plasticity and classification shall be reported along with the CBR results. Where the CBR sample gives a result of CBR < 5, lime stabilization or other subgrade stabilization methods must be evaluated, this may require additional laboratory analysis with lime stabilized CBR tests performed.

All soil sampled at the site shall have moisture, gradation, plasticity and classification tests completed. Where settlement is a concern, samples shall have a 1-D consolidation test performed. Where slope stability issues are expected, appropriate tests that provide slope stability parameters for use in slope stability analysis shall be performed. These include triaxial tests, direct shear or unconfined compression tests.

Engineering Analysis

Engineering Analyses required for these projects depends on the nature of the project but may include:

- Slope stability for soils cuts
- Slope stability for soil embankments
- Slope stability for rock cuts
- Rockfall hazard mitigation through slope design or mitigation measures. See Chapter 7 for details.
- Settlement analyses of embankments including settlement magnitude and time rate.

Typical slopes used for TDOT projects are 2H:1V or flatter for soil and 1.5:1 for rock fill slopes. Soil slopes in Region 4 are typically 3:1 or flatter. Rock cuts may vary from vertical to 0.25:1 to other slope ratios as appropriate. If the rock is of sufficiently poor quality it may be wise to set slope ratios in a more typical soil configuration. These slopes can be altered at the discretion of the geotechnical engineer / engineering geologist if the analysis supports different slope configurations. Rock slope stability including rockfall considerations shall also be checked at the site where appropriate. This may involve the use of rock bolts, welded wire mesh draping, rockfall catchment fences, shotcrete and other mitigation methods. Guidance for typical rockfall design can be found in Chapter 3.2 of this manual.

Another aspect of engineering/geological analyses, albeit non-numerical, for the Alignment project includes assessments regarding subgrade stability (e.g. is undercutting of soft surficial soils required), surface and subsurface drainage considerations and sinkhole mitigation.

Geotechnical Reports and Drawings

The end products of the geotechnical investigation for these projects are the Geotechnical Report and Geotechnical Drawings as detailed below.

Geotechnical Report Elements:

Executive Summary– This section gives a brief summary of the report. It shall also briefly discuss any major geotechnical or geologic issues involved at the project such as potentially acid producing materials was encountered at the site, whether there are major problematic grading issues such as significant quantities of under cutting, sinkhole mitigation or other.

Introduction – Brief summary of the project and location. Any special site conditions such as limited right of way, topography and geography are noted here.

Geology, Soils and Site Conditions – Provide a description of site geology, soils and site conditions and how that may affect the project.

Surface and Subsurface Exploration – Provide a summary of the exploration performed such as number and type of drill holes, sampling, site access issues, property owner issues, etc.

Recommendations – Typically this section of the report should be segmented into project station intervals where the recommendations for that segment are discussed. Each segment interval discussion should include recommendations for cut and/or embankment slope ratios, special slope construction recommendations such as rock pads or buttresses undercutting and replacement of soft soils, mitigation of sinkholes, settlement issues along with settlement mitigation such as stage construction or other pertinent recommendations.

Pavement Subgrade Recommendations- The CBR values recommended for pavement design shall be included here. Any special recommendations regarding the subgrade such as special compaction requirements, drainage requirements, or stabilization requirements should be discussed here

Special Notes and Specifications – Provide and discuss any special notes and specifications to be included in the plans. These should also be on the geotechnical sheet(s).

Appendix – Documents and supporting information
Geotechnical Sheets
Soil and Subgrade report
Soils Description Sheet
Boring Logs
Laboratory Testing
Engineering Analyses

Geotechnical Sheet Elements

The Design Division, as part of the Geotechnical Investigation request, will provide a digital set of project plans including plans view sheets, profile sheets and cross-sections, usually on 50- foot station intervals. The Geotechnical Section CADD person (or consultant) will sue these digital files to develop the Geotechnical Sheets. These sheets include the following:

Plan View – A plan view, usually based on the proposed layout should show drilling and sampling locations. This may also show limits of geotechnical design elements, such as plan view limits of undercutting or rock pads. Selected soils data are also shown on these sheets. Note that if the drilling is very limited or the project is very small, then the ROW plan view layout which is typically done to a smaller scale may be used.

Centerline Profile grade sheets – These sheets provide a profile view of the roadway grade along with depictions of the soil and rock conditions based on borings conducted in the subject station interval. Actual graphical boring information should be shown from boring records. Soil and/or rock layering may be depicted if, in the opinion of the engineer/geologist, the boring information is sufficient to illustrate the assumed layer boundaries. Soil layers should be identified in accordance with Roadway Design Guidelines Section 4-203.02 DEFINITION OF TERMS USED FOR EARTHWORK GRADING CALCULATIONS

Cross Sections for the Project – Cross sections that describe the recommendations should be included with the geotechnical sheets. For very small and simple projects, only a few cross sections may be needed. Cross sections shall be provided to illustrate geotechnical design elements that are recommended for the project. Soil layers should be identified in accordance with Roadway Design Guidelines Section 4-203.02 DEFINITION OF TERMS USED FOR EARTHWORK GRADING CALCULATIONS

Specialty Geotechnical Sheets- some projects may require development or inclusion of some specialty geotechnical sheets. These may include APR handling sheets as described in Chapter 10, Sinkhole Mitigation Sheets, subsurface drainage requirements, or shotcrete treatment on rock cut faces

Soil Description Sheet/Table - For all soils that have been sampled on the project, the laboratory analysis along with descriptions of the soil shall be included on the plans. This includes proctor test results, Atterberg limits as well as in-situ moisture and soil classification by both AASHTO and the Unified Soil Classification System. This can be presented as a chart at the beginning of the plans sheets or the soils present on a particular sheet can be shown as a table on that sheet. Examples of this soil description table format are available and should be used for standardization and consistency when creating these sheets. Where soils on the chart show an “in-situ moisture” that is significantly wetter or dryer of optimum than the proctor test, this shall be clearly noted on these sheets with a statement that includes a notice to the contractor that wetting, drying or additional handling of these soils may be required.

Geotechnical Notes – These would be added as needed. They could be included directly on the cross sections or on the general layout. These notes can also be included on a separate plans sheet. Please remember that these will be plans documents, so only appropriate material should be included.

Note: As an aid to the Geotechnical Designer/Report Developer a Report Checklist is provided in the Appendix.

Chapter 2.5:

Value Engineering Change Proposal (VECP)

Introduction

The Value Engineering Change Proposal (VECP) process occurs during project construction and is described in Section 104.11 of Tennessee Department of Transportation Standard Specifications for Road and Bridge Construction. An excerpt which summarizes the process is given below.

The Contractor may request a modification to the Plans, the Specifications, or other Contract requirements based on a Value Engineering Change Proposal (VECP) submitted to the Department specifying a cost reduction change. This will not apply to a proposal unless it is identified as a VECP at the time of its submittal.
VECP are those proposals that would require a change in the Contract and would result in an immediate net savings to the Department without impairing the essential functions and characteristics of the Project, including but not limited to, any warranties, service life, reliability, economy of operation, and maintenance and safety features. The Department will not normally consider VECPs that propose a total savings of less than $25,000 unless there are other non-monetary savings to be realized.

Role of the Geotechnical Engineer/Engineering Geologist

A VECP may involve geotechnical elements or design. An example would be where a general contractor proposes to shorten the length of a bridge by using retaining walls near the abutments and eliminating the end fill slopes. The geotechnical components of such a design change would include bearing capacity evaluation, settlement analysis, sliding, global stability and others. When a VECP involves such geotechnical elements, a geotechnical engineer retained by the General Contractor must submit engineering calculations, details of investigations (if any), a geotechnical report and supporting drawings summarizing recommendations. The General Contractor's geotechnical engineer is taking responsibility for the geotechnical elements of the plans and should not consider their role as merely supporting with no professional responsibility. It is recommended that a Geotechnical Consultant / Designer who has been retained by a the General Contractor contact the Geotechnical Engineering Section to discuss, clarify and confirm what geotechnical information /design is expected and required.

It is not sufficient for a project that contains significant geotechnical elements to provide only drilling with no recommendations. Neither is it acceptable to only discuss the potential "cost savings" of the project. All VECPs need to have supporting documentation that indicates professional staff have designed and evaluated the proposed plan. While the Contractor's geotechnical consultant may review and consider the geotechnical information available in the TDOT plans, additional geotechnical information and analyses are typically required and it is the responsibility to General Contractor and its consultants to provide all necessary information.

The VECP is submitted to the appropriate TDOT Construction office who then distributes the VECP to the various TDOT Divisions that may include Design, Structures, Environmental, Geotechnical Section for their review. The GES will review the geotechnical aspects of the proposal and provide the Construction Office with any comments and recommendations regarding the validity and acceptability of the VECP from the geotechnical engineering perspective.

It is possible that the GES may retain a geotechnical consultant to review a VECP on behalf of TDOT. This is most likely the case where a geotechnical consultant was involved in the original project design. A conflict of interest must be avoided in the case where the General Contractor retains a geotechnical consultant to be involved in their VECP. It would not be acceptable for the General Contractor to retain the geotechnical consultant originally retained by TDOT for the project.

Chapter 3.1:

Pyrite and Potential Acid Producing Material (APM)

Introduction

Naturally occurring potentially acid producing material may be found in any soil or rock horizon on any project type; however, as these projects present special environmental and permitting issues, some additional information is required. TDOT maintains a guideline document "Guideline for Acid Producing Rock Investigation, Testing, Monitoring and Mitigation" October 2007 as well as Special Provision107L and guideline drawings for material treatment. These documents shall be used as a reference for both appropriate testing and suggested methods of mitigation.

A rock or soil formation may produce acid when excavated and exposed to air, water and *Thiobacillius* bacteria. Sulfide minerals, most commonly pyrite, produce this acid as a byproduct of the breakdown of the sulfur. This can cause environmental issues and impacts resulting from pH change and the material may require special handling and procedures.

APM can possibly be found statewide. However, it is predominately east of the Tennessee River in shales, sandstones, and some siltstones. In Region 1 the following formations are often acid producing: Anakeesta, Pennsylvanian, and Fentress. In Region 2 the following formations are often acid producing: the Precambrian and Cambrian rock of the Great Smokey Group, Chattanooga Shale, Fentress, and other shales related to coal bearing formations. In Region 3 acid producing materials are often found in the Chattanooga Shale Formation.

Goals of Investigation

Projects with suspected potentially acid producing material must have the potential problem formations identified and tested. Intervals of excavated material that may produce acid under the right conditions need to be assessed and recommendations as to handling and final placement of the material shall be established. At this time, TDOT uses several standard methods for dealing with these materials. For material judged not to present a potential for acid production, for example limestone with no pyrite present, no further investigation or mitigation is required. For material with a low potential for producing acid blending with Ag lime is used and for material with a moderate to high potential for producing acid, encapsulation of the material is used.

Drilling Requirements

Sufficient drilling to identify, sample and test historically problematic and potentially problematic formations shall be completed in general accordance with the document "Guideline for Acid Producing Rock Investigation, Testing, Monitoring and Mitigation" October 2007. Drilling must be sufficient to show the horizontal and vertical extent of problem layers on the project identifying areas that must have special treatment and provide quantity calculations.

Laboratory and Engineering Analyses

For projects with potential acid producing material, an Acid Based accounting of the samples will be required. The TDOT GES maintains a laboratory testing contract with firms capable of providing the appropriate tests. This includes an assessment of the paste pH, Acid Potential (AP), Neutralization Potential (NP), AP-NP (the calcium carbonate deficiency, or net acid-base account value) as well as tests of total sulfur and pyritic sulfur. All samples should be assessed for whether or not they are representative of the material out in the field. Multiple parameters may be needed in order to assess whether or not a soil or rock can produce acid in the field. Additionally, site assessments of the same material placed in the field may also need to be completed or addressed.

Geotechnical Reports and Drawings

Geotechnical Report

Any project containing acid producing material should be addressed in the Soils and Geology report. Please see other chapters in this manual for the appropriate report format for the specific project type on which these materials have been identified. The procedure for treating acid producing material is not commonly seen in roadway design, so good communication with designers is imperative. Include the APM soils sheets in both ROW and Construction field review plans. Review all plans sets that include APM treatment closely throughout the plans development process.

Once it has been determined that APM is present and must be mitigated, immediately notify the GES. The GES will arrange a meeting with TDOT Design and TDOT Environmental to determine a mitigation strategy.

Geotechnical Sheet Elements

If encapsulation or other special handling procedures are required these shall be shown in the soils sheets. Please use the guidance "design drawings" developed for encapsulation and blending designs on projects. Please contact the TDOT GES for the latest version of these drawings.

Chapter 3.2: Landslides and Rockfalls

Introduction

Landslide (including rockslides) and rockfall projects can be the most challenging of TDOT Geotechnical projects, but often vary significantly in size and scope. These projects may be small scale typical soil failures to very large scale projects which require extensive investigation and analysis. Typically, these projects will be given out to consultants only on an emergency basis just after a slide has occurred at a site where rapid repair is a high priority. Potential landslides and rockfalls may need to be analyzed on other projects such as lines or interchanges in order to ensure that an existing slide does not worsen or cause a failure in the roadway. Stability checks should be made in rock with complex structure to ensure that new rock cuts will not result in an increased risk of sliding or rockfall. A variety of methods are available to mitigate or repair landslides and rockfall sites. TDOT will require recommendations for alternatives that may include both short term recommendations and longer term mitigation and repair.

Goals of Investigation

The end result of a landslide and rockfall investigation for TDOT is to provide comprehensive deliverables, including construction plan sheets, and a report containing recommendations and alternatives for the repair or mitigation of the landslide or rockfall. Many projects may be so large in scope that complete repair of these sites may not be feasible. In these cases, recommendations for mitigation of the problem will be needed. Multiple reports may be required for these investigations with early reports detailing possible alternatives with a discussion of relative risk and costs.

Drilling Requirements

Unlike typical geotechnical work, there are no specific rules of thumb for drilling landslide and rockfall projects. Sufficient drilling to analyze the problem in order to design appropriate repair and mitigation strategies shall be used. It is the responsibility of the Geotechnical Engineer to ensure that sufficient work has been completed in order to properly analyze the problem. There are numerous publications available that detail investigations of landslides, rockfall and rockslides. Split spoon sampling, test pits, Shelby tubes, auguring, washboring and coring are all drilling methods which may be used on a project depending upon the type and nature of the failure at the site. It is critical to identify the limits of the failure surface when completing an investigation.

Laboratory Analysis

Appropriate tests that provide slope stability parameters for use in slope stability analysis shall be performed. These include triaxial tests, direct shear or unconfined compression tests. Other specialty tests may be used as needed. Additional soil testing includes, but is not limited to: grain size, liquid limit, plastic limit, unit weight, void ratio, etc.

Engineering Analysis

Slope stability calculations sufficient to predict and mitigate or repair the site shall be performed. TDOT presently uses GSTABL 7 with STEDWin for soil slope stability issues, although other software may be used to analyze the problem. Back calculation of the failure may be particularly useful for these projects and may provide more realistic data than laboratory sampling under some circumstances. Slope inclinometers are commonly used to identify failure planes and rate of movement.

Rock slope failures are more problematic, and it is critical that the failure surfaces be adequately identified and analyzed by recognized methods. Plotting dip/strike or dip direction on a stereonet may be required to identify failure modes within a rock cut. Plane shear, and topple wedge failures will need to be analyzed with appropriate analysis methods. Again, there are numerous geotechnical publications which detail these analyses as well as the potential pitfalls and necessary parameters. One such publication is by the Transportation Research Board and is entitled “Rockfall: Characterization and Control”. TDOT has two Special Provisions (SP707D and SP707H) that deal with rockfalls.

Geotechnical Reports and Drawings

Geotechnical notes sheets will typically be needed for these projects. Additionally, any sheets needed to explain design elements such as rock bolts, soil nails, horizontal drainage, etc. shall also be included. Effort should be taken to assign a TDOT Item Number to all rockfall design elements. Examples of this geotechnical notes sheet are available and should be used for standardization and consistency when creating these sheets. Information included in the report, but not on these sheets, may not make it into the construction plans. If this occurs, these geotechnical recommendations would then likely be ignored. It is critical that recommendations be illustrated with geotechnical plans sheets.

Geohazard Documentation Needed

For all landslides, rockfalls, and rockslides, GPS coordinates of the site shall be taken and reported in WGS84 (NAD83) datum in decimal degrees. The area of the slide shall be mapped, and individual features may also be mapped, photographed, and noted. A geohazard inventory form shall be filled out for all sites as this will be used to upload the data on the slide/rockfall area into the TDOT Geohazard Management System. Examples of this geohazard inventory form are available and should be used for standardization and consistency when creating these sheets. In addition to the inventory form, the features and area of the slide shall be shown on an aerial photograph of the site. Google maps, Bing or other online resources may be used as the "base map" aerial photograph of the site.

Geotechnical Report Elements

Executive Summary or Cover Letter – This section gives a brief summary of the report. It shall also state if potentially acid producing materials was found or not found on a project.

Introduction – Brief summary of the project and location. Any special constraints such as limited right of way are noted here.

Geology, Soils and Site Conditions – Geology, soils and site conditions that may affect the project.

Surface and Subsurface Exploration – Exploration Performed

Recommendations – Provide recommendations for construction purposes such as allowable slopes, undercutting and replacement, change of slope ratio, increases of ditch for additional catchment area, additional excavation of unstable material, mitigation materials (fence, mesh, etc.), or other pertinent recommendations.

Special Notes and Specifications – Any special notes to be included in the plans, these should also be on the geotechnical sheet(s).

Appendix – Documents and supporting information
Geotechnical Sheets
Boring Logs
Laboratory Testing
Engineering Analyses
Geohazard Inventory Forms / Map

Geotechnical Sheet Elements

General Layout of Site – Plan view showing drilling and sampling locations along with general limits of the slope failure and other pertinent features including the limits to the new repair.

Centerline grade sheets – Showing all drill logs, these must show elevations and material types in relationship to the grade at centerline for the project.

Cross Sections for the Project – Cross sections that describe the recommendations should be included with the geotechnical sheets. For very small and simple projects, only a few cross sections may be needed. Cross sections shall be provided to illustrate geotechnical design elements that are recommended for the project. Graphical boring logs, as appropriate, may also be included on these cross sections.

Photographs-For rockfalls, photographs may be required to show specific limitations of the area to be remediated.

Geotechnical Notes – These would be added as needed. They could be included directly on the cross sections or on the general layout. These notes can also be included on a separate plans sheet. Please remember that these will be plans documents, so only appropriate material should be included.

Chapter 3.3:

Sinkholes and Subsidence

Introduction

Sinkholes and subsidence issues will generally be part of other projects, rather than being given out to consultants as separate projects. They may occur on many different project types, but all require additional investigation and recommendations. Many areas of Tennessee are prone to sinkhole and karst related problems due to the underlying geology. Sinkholes and subsidence areas may already be present on a site, or may occur during or after construction. Non-landslide subsidence problems may be due to settlement of soils or as is frequently the case in West Tennessee due to erodible soils, piping and water problems.

Goals of Investigation

The end result of a sinkhole or subsidence investigation for TDOT is to provide comprehensive recommendations and alternatives for the repair or mitigation. This includes delineating the affected areas and to the extent possible examining the causes of the sinkhole or subsidence problem. It is particularly important to examine potential causes of failure when there is a “sudden” sinkhole collapse as a repair not designed to address the root cause may not fix the problem. Multiple reports may be required for these investigations with early reports detailing possible alternatives with a discussion of relative risk and costs. Later, after consultation with TDOT, plans and cross sections along with a final report may be needed.

All details on construction of the mitigation or repair will need to be shown in the geotechnical sheets. The report will be used by the GES and will also be a reference available at request. It provides supplementary data and explanatory materials, some of which will not be included in the contract plans and documents. These are of great importance when evaluating geotechnical designs, dealing with construction related issues and understanding the reasons behind recommendations given. Remember that the report will be used by the GES, but the geotechnical sheets become part of the contract plans.

All sinkholes on any type of project are to be spatially located by both station and offset and GPS coordinates. A sinkhole evaluation form shall be filled out for every sinkhole location whether or not mitigation is recommended. Examples of this sinkhole evaluation form are available and should be used for standardization and consistency when creating these sheets. The Geotech shall bring all of these locations to the attention of Design to ensure that all of these locations are included on the plans.

Drilling Requirements

Unlike typical geotechnical work, there are no specific rules of thumb for drilling sinkhole and subsidence projects. Sufficient drilling to analyze the problem and design appropriate repair and mitigation strategies should be used. It is the responsibility of the geotechnical engineer to ensure that sufficient work has been completed in order to properly analyze the problem. TDOT will generally drill around sinkholes and in some subsidence areas in order to better define the nature and type of problem presented by the problem site. There are numerous publications available that detail investigations of sinkholes. Split spoon sampling, test pits, Shelby tubes, auguring, washboring and coring are all drilling methods which may be used on a project depending upon the type and nature of the failure at the site. It is critical to identify the limits of the failure when completing an investigation. A sinkhole repair along a linear feature may require a larger repair than first appears from surface expression. Sinkholes have been known in the past to fail right beside an existing repair.

Laboratory Analysis

In the case of sinkholes, TDOT typically will perform soil classification, Atterberg limits and sieve analysis. However, other subsidence problems may require additional tests such as the 1D Consolidation test or tests that better define the erodibility of the on-site soils.

Engineering Analysis

There are few reliable mathematical methods for analyzing sinkhole related geotechnical problems. The Design Division or Structures Division Hydraulics Section may conduct some drainage capacity issues. Here, as with many areas of geotechnical work, experience and judgement have to be the guide. Subsidence issues, depending on the cause, can be modeled using the 1D Consolidation Test for sites where the problem is due to the consolidation and settlement of soils. For subsidence areas where a surcharge or drainage may be needed sufficient analysis shall be performed to predict the magnitude of the surcharge, the drainage needed and the time of settlement. Erodibility calculations are also available, but may or may not provide additional guidance when repairing sites where water is plucking or piping soils.

Geotechnical Reports and Drawings

The geotechnical report for sinkhole and subsidence projects shall detail the investigations and the recommendations for the site. All cross sections provided with the report shall have explanatory material included in the report. For example, if a cross section is provided that is typical for station 30+00 to 34+50, there should be a section in the report that specifically references this drawing and provides a description of the repair and any needed geotechnical notes. A plan view layout sheet showing the locations of the drilling and sampling sites along with limits of existing failure and any other important features are required. Cross sections showing all of the geotechnical design elements shall be included with the final report. A geotechnical notes sheet will also typically be needed for these projects. Additionally, any sheets needed to explain design elements such as rock pads, geotextile fabric, compaction grouting points or any other elements. TDOT has a standard drawing for sinkhole repair alternatives which may be used as guidance. However, as with other TDOT drawings, these must be used with caution and judgement. It is up to the Geotechnical Engineer to make sure that the repair is appropriate for the site. It is insufficient simply to site the standard drawing and provide no additional thought or judgement to the matter. Examples of these geotechnical sheets and geohazard inventory form are available and should be used for standardization and consistency when creating these sheets.

Information included in the report, but not on the geotechnical sheets, may not make it into the construction plans. If this occurs, these geotechnical recommendations would then likely be ignored. It is critical that recommendations be illustrated with geotechnical plans sheets. A separate report is not needed where the sinkhole or subsidence issue is part of a larger report i.e. a line project. It may be included as part of other reports, though separate sheets detailing the specific repairs and mitigation techniques will be needed. A separate report will only be needed if the project assigned is specifically a sinkhole or subsidence project. This would occur, for example, if a Geotechnical firm were called to come out in response to a sinkhole problem on a construction site where the report had already been previously completed.

Geohazard Documentation Needed

For all sinkholes and settlement areas, whether or not mitigation will be performed, GPS coordinates of the site shall be taken and reported in WGS84 (NAD83) datum in decimal degrees. The area affected shall be mapped and noted. A geohazard inventory form shall be filled out for all sites as this will be used to upload the data on the sinkhole or settlement area into the TDOT Geohazard Management System. In addition to the inventory form, the features and area of the sinkhole shall be shown on an aerial photograph of the site. Google maps, Bing or other online resources may be used as the “base map” aerial photograph of the site.

Geotechnical Report Elements

Executive Summary or Cover Letter – This section gives a brief summary of the report. It shall also state if potentially acid producing materials was found or not found on a project.

Introduction – Brief summary of the project and location. Any special constraints such as limited right of way are noted here.

Geology, Soils and Site Conditions – Geology, soils and site conditions that may affect the project.

Surface and Subsurface Exploration – Exploration Performed

Recommendations – Provide recommendations for construction purposes such depth of excavation, compaction grouting parameters, geotechnical elements and limits of repairs.

Special Notes and Specifications – Any special notes to be included in the plans, these should also be on the geotechnical sheet(s).

Appendix – Documents and supporting information
Geotechnical Sheets
Boring Logs
Laboratory Testing
Engineering Analyses
Sinkhole Evaluation Form(s) - as appropriate

Geotechnical Sheet Elements

General Layout of Site – plan view showing drilling and sampling locations along with general limits of the failure and other pertinent features including the limits to the new repair.

Cross Sections for the Project – Cross sections that describe the recommendations should be included with the geotechnical sheets. For very small and simple projects, only a few cross sections may be needed. Cross sections shall be provided to illustrate geotechnical design elements that are recommended for the project. Graphical boring logs, as appropriate may be included on these cross sections.

Geotechnical Notes – These would be added as needed. They could be included directly on the cross sections or on the general layout. These notes can also be included on a separate plans sheet. Please remember that these will be plans documents, so only appropriate material should be included.

APPENDIX 1

RETAINING WALL SHOP DRAWING CHECKLIST

TDOT Geotechnical Engineering Section

Retaining Wall Review

TN TDOT Department of Transportation

Retaining Wall Information

Project:			Wall No.:
Contractor Name			Contact:
Wall Supplier/Designer			Date :
Structures Contact			Reviewer
PE Number	Pin No.	GES File No.	Contract No.:

YES NO

☐ ☐ IS WALL TYPE SUBMITTED A TYPE LISTED AS ACCEPTABLE IN PLANS?
COMMENTS:

☐ ☐ IS WALL SYSTEM ON APPROVED SYSTEM LIST?
COMMENTS:

☐ ☐ DOES WALL GEOMETRY CONFORM TO PLANS?
COMMENTS:

☐ ☐ IS PLANS WALL GEOMETRY SAME AS PROVIDED FOR DURING ORIGINAL GEOTECHNICAL INVESTIGATION?
COMMENTS:

☐ ☐ DO WALL CALCULATIONS PROVIDE ASSUMED SOIL/ROCK PARAMETERS USED IN DESIGN?
COMMENTS:

☐ ☐ IS THE SOIL/ROCK PARAMETERS IN CONFORMANCE WITH CONTRACT PLANS REQUIREMENTS?
COMMENTS:

☐ ☐ DO CALCUALTIONS SHOW APPLIED BEARING FOR VARIOUS DESIGN CASES?
COMMENTS:

☐ ☐ IS APPLIED BEARING LESS THAN THE ALLOWABLE SHOWN IN PLANS?
COMMENTS:

☐ ☐ DO PLANS SHOW REQUIRED FOUNDATION IMPROVENT (I.E. UNDERCUTTING/ROCK REPLACEMENT?)
COMMENTS:

☐ ☐ DO CALCULATIONS DEMONSTRATE SLIDING IS CALCULATED USING APPRPOPRIATE PARAMETERS?
COMMENTS:

☐ ☐ DO PLANS CLEARLY DEFINE WHAT TYPE OF BACKFILL WILL BE USED?
COMMENTS:

DESIGN SUBMITTAL APPROVED AS SUBMITTED:

REQUIRED REVISIONS:

ATTACH ANY E-MAIL OR MAIL CORRESPONDENCE REGARDING THE WALL REVIEW TO THIS FORM

APPENDIX 2

SOILS AND GEOLOGY REPORT CHECKLIST

TDOT Geotechnical Engineering Section *Soils and Geology Report Checklist*

General Project Information		
Project Description:		**Phone Number:**
GES:		**Date:**
Pin Number:	**Geo/Consultant:**	**TDOT Oversight:**

General – For all sheets except first, develop a page header/footer containing brief description of project.

	Yes	No	N/A
Coversheet includes:			
• County	☐	☐	☐
• PPRMI Project Description	☐	☐	☐
• P.E. Project No.	☐	☐	☐
• PIN No.	☐	☐	☐
• Geotechnical Engineering File No.	☐	☐	☐
Sealed Scope & Liability Limitations on Letterhead (if applicable)	☐	☐	☐
Table of Contents (if applicable)	☐	☐	☐
Executive Summary: Brief Description of Project to include:			
• General slope recommendations	☐	☐	☐
• CBR value for pavement design	☐	☐	☐
• Describe special construction considerations recommended (rock pads, buttresses, undercut, grouting, acid producing material, etc.)	☐	☐	☐
Introduction:			
• Brief summary of project and any unusual considerations	☐	☐	☐
• Vicinity Location Map	☐	☐	☐
Existing Site Conditions and Geology:			
Existing geological conditions and effects on project (geography, topography, physiographic Region, geologic formations, unusual geologic conditions.	☐	☐	☐
Description of any geologic hazards present (rockfalls, sinkholes, wetlands, APR, seismic)	☐	☐	☐
Recommendations:			
• Specific recommendations presented in station to station format	☐	☐	☐
• Cut slope/fill slope recommendations	☐	☐	☐
• Unsuitable soil recommendations	☐	☐	☐
• Sinkhole treatment recommendations	☐	☐	☐
• APR mitigation recommendations	☐	☐	☐
• Do referenced typical cross sections correspond to intervals where treatment occurs	☐	☐	☐
Pavement Design Recommendations:			
• Was CBR test performed	☐	☐	☐
• Actual recommended CBR value for pavement design given in bold type	☐	☐	☐
Appendix:			
• Typed Boring Logs	☐	☐	☐
• Laboratory Test Results	☐	☐	☐
• Slope Stability Analysis Results	☐	☐	☐
• Site Specific Seismic Study (as required)	☐	☐	☐
• Unsealed Soils Sheets (see separate Soils Sheets checklist) w/app. Proj. phase stamp	☐	☐	☐

Electronic submittal to be loaded on TDOT FileNet server archiving: .zip files containing:

Sealed Soils & Geology Report combined with Appendix (PDF)

- File Naming Convention nnnnnn-nn-SoilsGeoRpt-GESyyyyyy.zip
- Where nnnnnn-nn represents the project pin no.
- Where yyyyyy represents the project GES no.

Un-Sealed Soils Sheets Folder for insertion to Field Review Plans (individual. Dgn files)

- File naming convention nnnnnn-nn-Soils-YYY-Descr.dgn
- Where nnnnnn-nn represents the project pin no.
- Where YYY represents the sequential sheet number (first to last)
- Where Descr represents the title block abbreviated sub-name (i.e. Notes, TypicalSec, Plan, SoilProf)

Separate Gint file folder with project pin no. contained in the file name