Chapter 22

PLAN PREPARATION

GEOTECHNICAL DESIGN MANUAL

January 2019

Table of Contents

List of Tables

CHAPTER 22

PLAN PREPARATION

22.1 INTRODUCTION

This Chapter presents the requirements for the Plan Notes that are required to be included in the final geotechnical reports (BGER and RGER, see Chapter 21) and the preparation of plans specific to geotechnical engineering efforts (i.e., ground improvement). Plan Notes specific to geotechnical items are prepared by the GEOR and included in the Plan Note section of the geotechnical report. The Plan Notes provided in the geotechnical report are required to be placed on the final construction plans.

22.2 PLAN NOTES

Plan Notes are required for bridges, road, ground improvements, geotechnical instrumentation, and ERSs. The list included herein is not meant to be comprehensive of the Plan Notes required. If in the opinion of the GEOR additional plan notes are required, the additional Plan Notes shall be provided in the geotechnical report. It is incumbent on the GEOR to select and modify the notes presented in this Chapter as appropriate for the specific project. Any Plan Notes that modify or replace a Standard Specification, Supplemental Specification or Supplemental Specification should indicate which specification is being modified or replaced.

22.2.1 Bridge Plan Notes

The Plan Notes required on bridge plans have traditionally been the most complete and comprehensive notes prepared by the GEOR. These Plan Notes cover installation of the foundation (typically, driven piles, drilled shafts or drilled piles). Plan Notes shall be developed on a project specific basis. The RPG/GDS along with the PCS/GDS shall be consulted in the development of shallow foundation Plan Notes.

22.2.1.1 Driven Piles

The following Plan Notes apply to driven piles. Provided first are notes that are general to all driven pile foundations, with the subsequent Sections covering notes specific to particular types of driven piles. It should be noted that Plan Notes are required for both end and interior bents and the general notes should be used accordingly. The notes and tables included herein are generic in nature and should be made project specific. Underlined capital letters are used to indicate areas where project specific information is required. Instructions to the GEOR are indicated in Italics after the note and shall not be included in the plans. In addition, when the tables presented herein include numbers, these numbers shall be changed to the requirements of specific projects.

The plan quantities for Index piles should include an additional 2 feet, minimum, to allow for PDA testing, when testing is required. In addition, an additional 2 feet, minimum, of production piling should be included in the plan quantities when PDA testing of the production piling is required.

22.2.1.1.1 General

Place the following notes on the plans for end (interior) bents X and Y: *(THE NUMBERED FOOTNOTES BENEATH TABLE 22-1 SHALL NOT BE INCLUDED ON THE PLANS.)*

Table 22-1, Pile Resistance

	Strength or Service Limit State[1,2]	**EE I or EE II Limit State[1,3]**
Factored Design Load	112 kips[4]	152 kips[4]
Geotechnical Resistance Factor[5]	0.40	1.00
Nominal Resistance	280 kips	152 kips
Resistance from: Design Flood Scourable Soils[6] Soils undergoing static downdrag[6]	 40 kips 0 kips	NA
Resistance from Liquefiable Soils[7]	NA	220 kips
Required Driving Resistance	320 kips	372 kips

[1]Use only 1 column; middle column represents static resistance while last column represents Extreme Event resistance. Use the column that governs driving resistance.

[2]Indicate whether Strength or Service limit state controls resistance

[3]Indicate whether EE I or EE II limit state controls resistance

[4]Factored design loads include DD or DD_{SL}. Note that in this example the Strength limit state DD = 0.0 kips

[5]Use appropriate construction control resistance factor

[6]Design flood scour and static downdrag are not included with Extreme Event limit state loading conditions

[7]Full resistance that is developed by soils within the liquefiable zone during pile installation

The GEOR shall determine the method of controlling pile installation. If however, the wave equation without stress measurements is to be used, use the first note listed below. If the resistance is to be verified by the Pile Driving Analyzer and CAse Pile Wave Analysis Program (CAPWAP) analysis of index piles use the appropriate PDA notes following the first note below.

Method of controlling installation of piles and verifying their resistance: Pile Installation Chart from wave equation analysis without stress measurements during driving.

Method of controlling installation of piles and verifying their resistance: Resistance and stresses will be verified by Pile Driving Analyzer (PDA) and CAPWAP analysis of index pile(s) during driving. A Pile Installation Chart developed from the analysis will be used to verify the resistance of production piles.

The required minimum tip elevation to achieve critical penetration for the (PILE TYPE HERE) at end (interior) bent X is M feet MSL.

Perform Pile Driving Analyzer (PDA) testing on the first production pile driven at the end (interior) bent X. If a CAPWAP analysis determines that resistance has not been achieved, restrike 1 of the production piles. Perform the restrike on the production pile exhibiting the least blows per foot. On initial drive, piles shall be stopped at the highest allowable finished grade on the plans to accommodate a restrike while still remaining within an allowable plan finished grade elevation. Perform PDA testing during the restrike. The time between initial drive and restrike is estimated at D days. Payment for the restrike will be as indicated in the Standard Specifications.

An additional 2 feet, minimum, of (*PROJECT SPECIFIC PILE TYPE HERE)* has been included in order to accommodate the initial PDA testing. *(DO NOT INCLUDE THIS NOTE IF THE EXTRA 2 FEET IS NOT INCLUDED.)*

Perform Pile Driving Analyzer (PDA) testing on the index pile(s) driven at end (interior) bent X. Drive index pile to grade or to practical refusal, whichever occurs first. If a CAPWAP analysis determines that resistance has not been achieved, restrike the index pile(s). Perform PDA testing during the restrike. The time between initial drive and restrike is estimated at D days. Payment for the restrike will be as indicated in the Standard Specifications.

Each pile is to be installed in one continuous operation. Include details of any anticipated temporary driving discontinuances including anticipated time intervals in the Pile Installation Plan.

Reference the Standard Specifications for Highway Construction for Driven Pile Foundations, Section 711. Notes included in these plans are in addition to the requirements of the Standard Specifications.

In addition the GEOR shall select 1 of the following notes to be placed on the plans depending on the required Earth-borne Vibration Monitoring level required (see Chapter 24 for level determination).

Level 1 – SCDOT has elected to not monitor the site; therefore, no Earth-borne Vibration Monitoring is required. SCDOT assumes all risk for any potential damage

Level 2 – Earth-borne Vibration Monitoring is required. Earth-borne Vibration Monitoring will be performed by the Department. The RCE or his/her designated representative will coordinate with the Contractor for site access, the schedule of vibration inducing activities and the placement of the required equipment. The Contractor is required to provide at least 48 hours' notice prior to commencing any vibration inducing activity to the RCE. Any damage caused by vibrations in excess of permitted levels will be the responsibility of the Contractor.

22.2.1.1.2 Uniform Section Piles

The following notes apply to piles that have a uniform cross section for the entire length of the pile. Included in this group are prestressed concrete piles with a steel H-pile (typically) pile point extending no more than 2-1/2 feet out of the concrete.

The following estimated parameters were used for performing a drivability analysis for end (interior) bents X & Y: *(THE NUMBERED FOOTNOTES BENEATH TABLE 22-2 SHALL NOT BE INCLUDED ON THE PLANS.)*

Table 22-2, Drivability Analysis

Skin Quake (QS)	0.10 in
Toe Quake (QT)	0.08 in
Skin Damping (SD)	0.20 s/ft
Toe Damping (TD)	0.15 s/ft
% Skin Friction	80%
Distribution Shape No.[1]	1
Resistance Distribution Model	Proportional[2]
Pile Penetration	80%
Hammer Energy Range	25 – 60 ft-kips

Note: GRLWEAP (XXXX) was used to perform the wave equation analysis.

[1]Distribution Shape No. varies with depth: 0 at the ground surface (creek bottom); 1 at a depth of 5 ft; and 1 to a depth beyond driving depth below the ground surface.
[2]Pile Installation Chart options – proportional, constant skin friction, constant end bearing

A pile hammer having the rated energy as indicated above is considered suitable for driven pile installation. However, final hammer approval is based on a wave equation analysis that accurately reflects the Contractor's proposed driving system.

The required minimum tip elevation to achieve critical penetration for the (PILE TYPE HERE) at end (interior) bent X is M feet MSL.

22.2.1.1.3 Non-Uniform Section Piles

The following notes apply to combination (composite, non-uniform) piles (i.e., piles that consist of a prestressed concrete pile with a steel H-pile (typically) pile point extending greater than 2-1/2 feet out of the concrete).

The following estimated parameters were used for performing a drivability analysis for end (interior) bents X & Y: *(THE NUMBERED FOOTNOTES BENEATH TABLE 22-3 SHALL NOT BE INCLUDED ON THE PLANS.)*

Table 22-3, Drivability Analysis

Skin Quake (QS)	0.10 in
Toe Quake (QT)	0.08 in
Skin Damping (SD)	0.20 s/ft
Toe Damping (TD)	0.15 s/ft
% Skin Friction	80%
Distribution Shape No.[1]	1
Resistance Distribution Model	Proportional[2]
Toe No. 2 Quake	0.15 in
Toe No. 2 Damping	0.15 s/ft
End Bearing Fraction (Toe No. 2)	0.95
Pile Penetration	80%
Hammer Energy Range	25 – 60 ft-kips

Note: GRLWEAP (XXXX) was used to perform the wave equation analysis.

[1]Distribution Shape No. varies with depth: 0 at the ground surface (creek bottom); 1 at a depth of 5 ft; and 1 to a depth beyond driving depth below the ground surface.
[2]Pile Installation Chart options – proportional, constant skin friction, constant end bearing

The required minimum tip elevation (to achieve critical penetration) for the X-inch pre-stressed concrete piles is M feet MSL. This equates to a minimum tip elevation of the steel pile points of M feet MSL. Fabricate and deliver piles to the job site with either a 2.5-foot length of HP Y pile point or the full length of HP Y pile point extending from the tip of the prestressed concrete pile.

A pile hammer having the rated energy as indicated above is considered suitable for driven pile installation. However, final hammer acceptance is based on a wave equation analysis that accurately reflects the Contractor's proposed driving system.

The Contractor may elect to drive a portion of the HP Y steel piling extension prior to attaching the remaining prestressed portion. If the Contractor elects to attach the additional extension to the piling prior to picking up the pile, it is expressly understood

that the Department is not responsible for any piles damaged during pick-up. Damaged piles are to be replaced at the Contractor's expense.

22.2.1.1.4 Driven Piles – Rock

The previous notes apply to piles driven into soil materials. The following notes should be used for piles driven into intermediate geomaterials (IGM) (i.e., partially weathered rock (PWR)) or to rock. Only 1 of these notes should be used, it is incumbent upon the GEOR to determine if reinforced pile tips with teeth are required.

Reinforced pile tips are required to penetrate partially weathered rock. Install the reinforced pile tips in accordance with the manufacturer's installation recommendations.

Reinforced pile tips with teeth are required to penetrate partially weathered rock. Install the reinforced pile tips with teeth in accordance with the manufacturer's installation recommendations. Include the cost of providing teeth on the reinforced pile tips in the price bid for Reinforced Pile Tips.

22.2.1.2 Drilled Shafts

The following Plan Notes apply to drilled shafts. Drilled shafts are typically used at interior bents only, but Plan Notes are also required if drilled shafts are used at end bents. If the column supported on a drilled shaft would be less than 5 feet tall, the Contractor should be given the option, at no additional cost to SCDOT, of extending the shaft to the bottom of the bent cap. The SEOR shall also provide for permissible construction joints in casings to facilitate construction on projects with large water fluctuations. The notes and tables included are generic in nature and should be made project specific. Underlined capital letters are used to indicate areas where project specific information is required. Instructions to the GEOR are indicated in Italics after the note and shall not be included in the plans. In addition, when the tables presented herein include numbers, these numbers shall be changed to the requirements of specific projects.

Add the following notes to the plans for Interior Bents X, Y, and Z: *(THE NUMBERED FOOTNOTES BENEATH TABLE 22-4 SHALL NOT BE INCLUDED ON THE PLANS.)*

Table 22-4, Drilled Shaft Resistance

	Strength or Service Limit State[1,2]	**EE I or EE II Limit State[1,3]**
Factored Design Load	1400 kips[4]	1800 kips[4]
Factored Resistance – Side	1130 kips	1430 kips
Factored Resistance – End	270 kips	370 kips
Geotechnical Resistance Factor – Side[5]	0.50	1.0
Geotechnical Resistance Factor – End[5]	0.50	1.0
Total Nominal Resistance	2800 kips	1800 kips

[1]Use only 1 column; middle column represents static resistance while last column represents Extreme Event resistance, use the column that governs resistance

[2]Indicate whether Strength or Service limit state controls resistance

[3]Indicate whether EE I or EE II limit state controls resistance

[4]Factored design loads include DD or DD_{SL}. Note that in this example the Strength limit state DD = 0.0 kips

[5]Use appropriate construction control resistance factor for static and φ_{EQ} equal to 1.0 for seismic

Assess the actual ground and/or water level conditions and determine the required top of casing elevation and casing length before ordering. Prior to installing any proposed top

of casing or top of drilled shaft elevation different from that shown in the plans, obtain approval in writing from the Bridge Construction Office. Support the top of casing to maintain construction tolerances during construction. To extend oversized temporary casing larger in diameter than the construction casing below the scour elevation that is shown on the bridge plan and profile, obtain approval from the Bridge Construction Office.

If a dry hole is attempted and the hole becomes a wet hole with no slurry equipment on site, immediately backfill the hole with spoils 3 feet up inside the casing or to the top of hole until slurry and desanding equipment are ready on site.

Include the details for anticipated or contingency temporary cessation of work in the Drilled Foundation Installation Plan. Such details shall include shaft maintenance during the temporary cessation.

The estimated bottom of casing elevation and the minimum tip elevation of the drilled shaft are indicated in the table below. The minimum diameter of the drilled shafts is A inches.

Table 22-5, Drilled Shaft Elevations

Interior Bent No.	Estimated Bottom of Casing Elevation	Minimum Shaft Tip Elevation
2	+125 ft msl	+57 ft msl
3	+121 ft msl	+57 ft msl
4	+125 ft msl	+55 ft msl

Shaft lengths shown below the bottom elevation of the casing shall be uncased.

Reference the Standard Specifications for Highway Construction for Drilled Shafts and Drilled Pile Foundations (Section 712) and for Crosshole Sonic Logging of Drilled Shafts (Section 727). Notes included in these plans are in addition to the requirements of the Standard Specifications.

The following notes shall be used if the wet method using mineral slurry is required by the GEOR.

Wet construction method for drilled shafts is required. Use mineral slurry throughout the excavation and construction of the shafts. The tolerances for testing (including time intervals) and maintaining the mineral slurries are indicated in the Standard Specifications for Highway Construction, Section 712. Do not use plain water, salt water, and/or polymer slurries.

The following notes shall be used as applicable for drilled shafts where a seal is required.

Casing shall be extended into the Cooper Marl *(USE APPROPRIATE FORMATION)* a sufficient distance to obtain an effective water seal (approximately 1 foot).

Extend casing until the full circumference of the casing penetrates the rock sufficient enough to produce an effective seal against overburden material falling into the shaft. Water may still enter the shaft through seams in the rock.

The following note shall be used for drilled shafts cased to rock where water is an acceptable drilling fluid.

Extend casing until the full circumference of the casing penetrates the rock sufficient enough to produce an effective seal against overburden material falling into the shaft. Water may still enter the shaft through seams in the rock. If the wet method is used, either mineral slurry or potable water may be used during excavation and construction of the shafts. The tolerance for testing (including time intervals) and maintaining the mineral slurry are indicated in the Standard Specifications for Highway Construction, Section 712. (*INCLUDE ANY REQUIRED WATER TESTS HERE*.) Do not use salt water and/or polymer slurries.

The following notes shall be used for drilled shafts placed into intermediate geomaterials (IGM) (i.e., partially weathered rock (PWR)) or to rock.

The estimated bottom of casing and estimated tip elevations for the rock sockets are indicated in the table below. The referenced rock socket penetration depths for Bents X through Y are uncased lengths and the depths indicated are required to be obtained below the top of continuous rock. The minimum diameter for the rock sockets is A inches and the minimum diameter of the drilled shafts is B inches. Support the top of casing to maintain construction tolerances during construction.

Table 22-6, Drilled Shaft Elevations

Int. Bent No.	Estimated Bottom of Casing Elevation	A" Wet & Dry Excavation Per Shaft	B" Rock Excavation Per Shaft	Estimated Shaft Tip Elevation
2	+789 ft msl	31 ft	12 ft	+777 ft msl
3	+794 ft msl	25.5 ft	12 ft	+782 ft msl
4	+803 ft msl	15 ft	20 ft	+784 ft msl

During construction, the bottom elevation of the shaft may vary if rock is encountered at a different elevation than shown in the plans. If rock is encountered less than 2 feet higher than the elevation shown, extend the socket to the tip elevation shown. If rock is encountered less than 2 feet lower than the elevations shown, lower the tip elevation as needed to maintain the required depth of rock excavation. If rock is encountered more than 2 feet higher or lower than the elevation shown, immediately notify the Resident Construction Engineer (RCE). The RCE will then immediately notify the Bridge Construction Office.

Provide equipment capable of drilling through rock at the site that may be twenty-five percent (25%) greater than the strength indicated in the Table below.

Table 22-7, Summary of Rock Core Compressive Strength Testing

Boring No.	Recovery	RQD (%)	Core Number	Depth (ft)	Compressive Strength (psi)
B-1	100	41	NQ-2	3 – 4	6,920
B-1	100	68	NQ-4	10 – 10-1/2	5,150
B-3	100	91	NQ-2	31 – 32	6,030
B-4	90	90	NQ-2	57-1/2 - 59	6,840
B-5	100	61	NQ-1	49 - 50	15,620

22.2.1.3 Drilled Piles

The following Plan Notes apply to drilled piles. It should be noted that drilled piles are typically used when the subsurface conditions consist of either IGM or rock at the foundation locations. This type of foundation is used primarily at end bents; but may be used at interior bents with the approval of PC/SDS and PC/GDS (see Chapter 16 for details). The notes and tables included herein are generic in nature and should be made project specific. Underlined capital letters are used to indicate areas where project specific information is required. Instructions to the GEOR are indicated in Italics after the note and shall not be included in the plans. In addition, the tables presented herein include numbers; these numbers shall be changed to the requirements of specific projects.

Place the following notes on the plans for end (interior) bents X and Y: (*THE NUMBERED FOOTNOTES BENEATH TABLE 22-8 SHALL NOT BE INCLUDED ON THE PLANS*)

Table 22-8, Drilled Pile Resistance

	Strength or Service Limit State[1,2]	**EE I or EE II Limit State[1,3]**
Factored Design Load	112 kips[4]	152 kips[4]
Geotechnical Resistance Factor[5]	0.40	1.00
Nominal Resistance	280 kips	152 kips
Resistance from Design Flood Scourable Soils[6]	40 kips	NA
Resistance from Liquefiable Soils[7]	NA	220 kips
Required Driving Resistance[8]	320 kips	372 kips

[1]Use only 1 column; middle column represents static resistance while last column represents Extreme Event resistance. Use the column governs driving resistance.

[2]Indicate whether Strength or Service limit state controls resistance

[3]Indicate whether EE I or EE II limit state controls resistance

[4]Factored design loads include DD or DD_{SL}. Note that in this example the Strength limit state DD = 0.0 kips

[5]Use appropriate construction control resistance factor

[6]Design flood scour is not included with seismic loading conditions

[7]Full resistance that is developed by soils within the liquefiable zone during pile installation

[8]Delete the word “Driving” if the piles are not driven.

The estimated drilled pile tip elevation for End Bent X is M feet below existing grade based on partially weathered rock (*CHANGE TO “rock” AS REQUIRED*) at A feet below existing grade (*reference soil boring PUT ACTUAL BORING NUMBER HERE*). Extend the drilled piles into partially weathered rock a minimum of M feet from top of partially weathered rock. The top of partially weathered rock elevation may be variable across bent location and may result in varying pile lengths. Regardless of the pile lengths, extend the drilled piles M feet into partially weathered rock.

Do not extend the temporary casing for the drilled pile foundations below the top of rock elevation. Prior to concreting and backfilling, remove (pump) any accumulation of water from the excavation. If the hole is a wet hole, concreting using wet construction method may be required as specified in Section 712 (Drilled Shafts and Drilled Pile Foundations) of the Standard Specifications for Highway Construction. After installation of the pile, concrete the HP Y piling at End Bent X in the bottom M feet of the rock socket using Class 4000DS concrete. Wait at least 24 hours after concrete has been placed and then backfill the space between the pile and the excavation with clean sand and tamp in an approved manner. Remove temporary casing used for drilled pile construction.

Payment for concrete in the drilled pile foundations is determined using the contract unit bid price for the pay item.

Concrete, backfill and remove temporary casing prior to drilling any adjacent piles within a 20-foot radius.

Reference the Standard Specifications for Highway Construction for Driven Pile Foundations (Section 711) and Drilled Shafts and Drilled Pile Foundations (Section 712). Notes included in these plans are in addition to the requirements of the Standard Specifications.

The following notes shall be used if the pile is to be driven after placement in the drilled hole.

The following estimated parameters were used for performing a drivability analysis for End Bents X and Y: (*THE NUMBERED FOOTNOTES BENEATH TABLE 22-9 SHALL NOT BE INCLUDED ON THE PLANS*.)

Table 22-9, Drilled Pile Drivability Table

Skin Quake (QS)	0.10 in
Toe Quake (QT)	0.08 in
Skin Damping (SD)	0.20 s/ft
Toe Damping (TD)	0.15 s/ft
% Skin Friction	80%
Distribution Shape No.[1]	1
Resistance Distribution Model	Proportional[2]
Pile Penetration	80%
Hammer Energy Range	25 – 60 ft-kips

Note: GRLWEAP (XXXX) was used to perform the wave equation analysis.

[1]Distribution Shape No. varies with depth: 0 at the ground surface (creek bottom); 1 at a depth of 5 ft; and 1 to a depth beyond driving depth below the ground surface.

[2]Pile Installation Chart options – proportional, constant skin friction, constant end bearing

The GEOR shall determine the method of controlling pile installation. If the resistance is to be verified by the PDA and CAPWAP analysis of index piles use the following notes.

Method of controlling installation of piles and verifying their resistance: Resistance and stresses will be verified by Pile Driving Analyzer (PDA) and CAPWAP analysis of index pile(s) during driving. A Pile Installation Chart developed from the analysis will be used to verify the resistance of production piles.

The required minimum tip elevation to achieve critical penetration for the (*PILE TYPE HERE*) at end (interior) bent X is M feet MSL.

Perform Pile Driving Analyzer (PDA) testing on the first production pile driven at the end (interior) bent X. If a CAPWAP analysis determines that resistance has not been achieved, restrike 1 of the production piles. Perform the restrike on the production pile exhibiting the least blows per foot. On initial drive, piles shall be stopped at the highest allowable finished grade on the plans to accommodate a restrike while still remaining within an allowable plan finished grade elevation. Perform PDA testing during the restrike. The time between initial drive and restrike is estimated at D days. Payment for the restrike will be as indicated in the Standard Specifications.

An additional 2 feet, minimum, of (*PROJECT SPECIFIC PILE TYPE HERE)* has been included in order to accommodate the initial PDA testing. *(DO NOT INCLUDE THIS NOTE IF THE EXTRA 2 FEET IS NOT INCLUDED.)*

Perform Pile Driving Analyzer (PDA) testing on the index pile(s) driven at end (interior) bent X. Drive index pile to grade or to practical refusal, whichever occurs first. If a CAPWAP analysis determines that resistance has not been achieved, restrike the index pile(s). Perform PDA testing during the restrike. The time between initial drive and restrike is estimated at D days. Payment for the restrike will be as indicated in the Standard Specifications.

Only 1 of the following notes should be used, if the wave equation without stress measurements is to be used. It is incumbent upon the GEOR to determine which is appropriate.

Method of controlling installation of piles and verifying their resistance: Pile Installation Chart from wave equation analysis without stress wave measurements during driving. Do not strike the pile over 20 blows with less than 1 inch of pile movement.

After excavation of drilled pile foundations have occurred, drive the HP Y (change pile type as appropriate) piling to practical refusal. Do not strike the pile over 20 blows with less than 1 inch of pile movement.

Only 1 of the following notes should be used, it is incumbent upon the GEOR to determine if reinforced pile tips with teeth are required.

Reinforced pile tips are required. Install the reinforced pile tips in accordance with the manufacturer's installation recommendations.

Reinforced pile tips with teeth are required to penetrate partially weathered rock. Install the reinforced pile tips with teeth in accordance with the manufacturer's installation recommendations. Include the cost for providing teeth on the reinforced pile tips in the price bid for Reinforced Pile Tips.

22.2.1.4 Temporary Shoring (Bridge)

The following Plan Notes apply to temporary shoring walls.

Use buoyant unit weights in computations for soils below the water level. Designer shall determine appropriate water level and consider all unbalanced water forces in design. Design shall accommodate live loading. Use the following soil strength parameters for determining earth pressure coefficients.

Table 22-10, Temporary Shoring Wall Soil Design Parameters

Depth (ft)	c (psf)	Phi (ϕ) (degrees)	Saturated Unit Weight (γ_{sat}) (pcf)	K_o	K_a	K_p
0-7	-	32	100	0.47	0.31	3.25
7-14	343	-	86	1.0	1.0	1.0
14-19	-	30	109	0.50	0.33	3.0
> 19	550	35	120	0.43	0.27	3.69

22.2.2 Road Plan Notes

The Plan Notes required on road plans are a relatively recent development in geotechnical practice as the requirements for design of embankments have increased, leading to a requirement for more detailed notes on the plans.

These notes and tables included herein are generic in nature and should be made project specific. Underlined capital letters are used to indicate areas where project specific information is required. In addition, the tables presented herein include numbers; these numbers shall be changed to the requirements of specific projects. Instructions to the GEOR are indicated in Italics after the note and shall not be included in the plans. The table provided below presents geotechnical bid items and quantities that should be included in the plans. The Estimated Quantity is the total quantity estimated for a specific item to be used on the project, while the Inclusion Quantity is the quantity that may be required in areas, not previously identified on the plans as needing the item. The difference between the Estimated Quantity and the Inclusion Quantity is quantity of a specific item that is specifically identified on the plans as being required. It is incumbent on the design team to make sure that all bid items required to assure geotechnical performance have been included.

Table 22-11, Geotechnical Bid Items and Quantities

Item No.	Pay Item	Estimated Quantity	Inclusion Quantity[1]
2033030	Borrow Material – Controlled Fill	*3,000 CY*	*2,000 CY*
2034000	Muck Excavation	*200 CY*	*100 CY*
2036020	Geotextile, Separation	*362 SY*	*150 SY*
2037030	Geogrid, Stabilization	*362 SY*	*150 SY*
2037000	Geogrid Reinforcement (Uniaxial)	*1944 SY*	*2000 SY*
2037010	Geogrid Reinforcement (Biaxial)	*100 SY*	*150 SY*
2052010	Stone Bridge Lift Material	*818 TONS*	*180 TONS*

[1]The inclusion quantities associated with mucking and undercutting, i.e. mucking, stone bridge lift material, geogrid, and geotextile for separation of sub-grade and sub-base are for bid estimation purposes only. Do not purchase or stockpile these items on site without written approval from the RCE unless specific areas and details are defined on the plans.

(*THE NUMBERED FOOTNOTES BENEATH TABLE 22-11 SHALL NOT BE INCLUDED ON THE PLANS*)

22.2.2.1 Borrow Materials

The following notes apply to borrow materials that require shear strength in excess of that typically found in the project county. If these notes are to be used, all material shall be called "Borrow Material – Controlled Fill" and shall use Item No.: 2033030. Underlined capital letters are used to indicate areas where project specific information is required.

The following areas have been identified as requiring Borrow Material – Controlled Fill:

Sta. X+XX, Y ft L(R) of Existing Centerline to Sta. U+UU, V ft L(R) of Existing Centerline
Sta. T+TT, S ft L(R) of Existing Centerline to Sta. M+MM, N ft L(R) of Existing Centerline

Provide borrow materials meeting the following minimum requirements:

- A material meeting the classifications of A-1, A-2-4, A-2-5, A-2-6(0), A-3 and A-4(0) as defined by AASHTO M145, *Classification of Soil and Soil-Aggregate Mixtures for Highway Construction Purposes* and having a minimum total soil unit weight, γ_{total} of A pcf at optimum moisture.
- Minimum friction angle, ϕ', of B° and cohesion, c', of D psf.

In addition, determine the moisture-density relationship, classification and soil shear strength parameters of the proposed borrow material and provide to the RPG T GDS for acceptance. An AASHTO certified laboratory is required to perform the testing. Contact the RPG T GDS for a list of locally available AASHTO certified laboratories. The Department may perform independent testing to assure quality.

Determine the soil shear strength parameters using either direct shear testing or consolidated-undrained triaxial shear testing with pore pressure measurements. The borrow material samples shall have the following laboratory tests performed:

Classification Testing
- Moisture-density Relationship (Standard Proctor)
- Grain-size Distribution with wash No. 200 Sieve
- Moisture-Plasticity Relationship Determination (Atterberg Limits)
  - Performed only on samples with more than 20 percent passing #200 sieve
- Natural Moisture Content

Shear Strength Testing
- Direct Simple Shear Test
  - Performed only on samples with less than or equal to 20 percent passing #200 sieve
  - Sample remolded to 95 percent of Standard Proctor value
  - Sample moisture content shall be between -1 percent to +2 percent of optimum moisture content
  - At normal pressures of X, Y, and Z psi
- Consolidated-Undrained Triaxial Shear Test with pore pressure measurements
  - Performed only on samples with more than 20 percent passing #200 sieve
  - Sample remolded to 95 percent of Standard Proctor value
  - Sample moisture content shall be between -1 percent to +2 percent of optimum moisture content
  - At consolidation stresses of X, Y, and Z psi

Conduct shear strength testing at the initial selection of the borrow pit, any subsequent changes in borrow pits, and for every 50,000 cy of materials placed. Perform classification testing for every R cy of materials placed including the material used for the shear strength testing. Additional shear testing may be required if, in the opinion of the RCE, the materials being placed are different from those originally tested.

If these minimum criteria cannot be met, provide the soil parameters for the intended borrow excavation material for the project site to the RPG T GDS for review and acceptance. After acceptable borrow material is obtained, compact the fill to the required finish grade line using the compactive effort indicated in the Standard Specifications for Highway Construction, Sections 203 (Roadway and Drainage Excavation) and 205 (Embankment Construction).

22.2.2.2 Muck Excavation

The following notes apply to muck excavation. Underlined capital letters are used to indicate areas where project specific information is required. The term L is for left and R is for right of either the Existing Centerline as indicated here or the Proposed Centerline, use the appropriate designations. In addition, the elevation for the bottom of the muck excavation may be substituted for depth. A copy of a template drawing may be obtained from the SCDOT website.

The following areas have been identified as requiring muck excavation:

Sta. X+XX, Y ft L(R) of Existing Centerline to Sta. U+UU, V ft L(R) of Existing Centerline to a depth of Z ft beneath the existing ground surface

Sta. T+TT, S ft L(R) of Existing Centerline to Sta. M+MM, N ft L(R) of Existing Centerline to a depth of P ft beneath the existing ground surface

Any additional areas that are discovered to deflect or settle may require muck excavation as directed by the RCE. The RCE will determine the lateral extent of the undercutting. The undercutting should not extend beyond the toe of slope. The final depth of muck excavation shall not exceed 5 feet, unless otherwise specified in the plans and/or Specifications. Contact the Geotechnical Engineer-of-Record (GEOR) if muck excavation needs to exceed 5 feet and it has not been previously specified in the plans or Specifications.

If the undercutting completely removes the materials identified as muck, then bridge lift materials may be placed directly on the firm materials.

If because of the depth of muck, muck materials must be left in place, place a stabilization geosynthetic meeting the requirements of SC-M-203-6, *Geosynthetic Materials for Separation and Stabilization*. After the placement of the initial bridge lift material, expose approximately 1 square foot of the geosynthetic for visual observation to identify any damage caused by the placement of the bridge lift material. After ascertaining that the geosynthetic has not been damaged, replace the bridge lift material excavated to allow observation of the geosynthetic. If the geosynthetic appears to be damaged, expose a larger area and contact the GEOR for instructions. Any damaged areas shall be repaired by the Contractor at no expense to the Department.

Any ruts that develop in bridge lift materials shall be filled in with similar bridge lift materials. Do not blade down the ruts, since this will decrease the thickness of the bridge lift.

In areas that require mucking or undercutting, borrow material soil may be placed as a bridge lift as long as the grade on which the material is being placed is at least 2 feet above the groundwater or surface water level. Place borrow material bridge lifts in single lift thicknesses no greater than 2 feet. Do not place a bridge lift consisting of borrow material within 3 feet of the base of the pavement section. Place only compacted borrow material soil or stone bridge lift within this zone.

In the event that groundwater/surface water does not allow backfilling with borrow material soil, use either stone or granular bridge lift materials meeting the requirements of *Bridge Lift Materials* Supplement Specification. Place the bridge lift materials in single lifts not exceeding a 2-foot thickness. If additional compacted borrow material soil is needed to reach grade, place a geotextile for separation meeting the requirements of SC-M-203-6, *Geosynthetic Materials for Separation and Stabilization* between the stone

bridge lift and the overlying compacted soil. After the placement of the initial lift of compacted material, expose approximately 1 square foot of the geosynthetic for visual observation to identify any damage caused by the placement of the compacted material. After ascertaining that the geosynthetic has not been damaged, replace and compact the material excavated to allow observation of the geosynthetic. If the geosynthetic appears to be damaged, expose a larger area and contact the GEOR for instructions. Any damaged areas shall be repaired by the Contractor at no expense to the Department.

The quantities associated with mucking and undercutting, i.e. mucking, bridge lift material, geogrid, and geotextile for separation of sub-grade and sub-base, are for bid estimation purposes only. Do not purchase or stockpile these bid items on site without prior written approval from the RCE unless specific areas and details are defined in the plans.

22.2.2.3 Temporary Shoring (Road)

The following Plan Notes apply to temporary shoring walls.

Use buoyant unit weights in computations for soils below the water level. Designer shall determine appropriate water level and consider all unbalanced water forces in design. Design shall accommodate live loading. Use the following soil strength parameters for determining earth pressure coefficients.

Table 22-12, Temporary Shoring Wall Soil Design Parameters

Depth (ft)	c (psf)	Phi (ϕ) (degrees)	Saturated Unit Weight (γ_{sat}) (pcf)	K_o	K_a	K_p
0-7	-	32	100	0.47	0.31	3.25
7-14	343	-	86	1.0	1.0	1.0
14-19	-	30	109	0.50	0.33	3.0
> 19	550	35	120	0.43	0.27	3.69

22.2.3 Ground Improvement

Because there are many different types of ground improvement methods and the notes required for each method are so varied, Appendix E contains a list of template drawings that can be used for the various ground improvement methods. The notes specific to each ground improvement method are contained on the drawings. The requirement for field verification will be based on the intended use of the ground improvement method. The GEOR will determine what the verification program will consist of and will develop appropriate plan notes to achieve the required results. Copies of template drawings may be obtained from the SCDOT website.

The GEOR shall select 1 of the following notes to be placed on the plans depending on the required Earth-borne Vibration Monitoring level required (see Chapter 24 for level determination).

Level 1 – SCDOT has elected to not monitor the site; therefore, no Earth-borne Vibration Monitoring is required. SCDOT assumes all risk for any potential damage

Level 2 – Earth-borne Vibration Monitoring is required. Earth-borne Vibration Monitoring will be performed by the Department. The RCE or his/her designated representative will coordinate with the Contractor for site access, the schedule of vibration inducing

activities and the placement of the required equipment. The Contractor is required to provide at least 48 hours' notice prior to commencing any vibration inducing activity to the RCE. Any damage caused by vibrations in excess of permitted levels will be the responsibility of the Contractor.

22.2.4 Earth Retaining Structures

Similar to the ground improvement notes, the notes concerning ERSs are placed on drawings depicting the ERS details. ERS notes specific to the particular structure being designed shall be developed on a case-by-case basis. Copies of template drawings may be obtained from the SCDOT website.

The GEOR shall select 1 of the following notes to be placed on the plans depending on the required Earth-borne Vibration Monitoring level required (see Chapter 24 for level determination).

Level 1 – SCDOT has elected to not monitor the site; therefore, no Earth-borne Vibration Monitoring is required. SCDOT assumes all risk for any potential damage

Level 2 – Earth-borne Vibration Monitoring is required. Earth-borne Vibration Monitoring will be performed by the Department. The RCE or his/her designated representative will coordinate with the Contractor for site access, the schedule of vibration inducing activities and the placement of the required equipment. The Contractor is required to provide at least 48 hours' notice prior to commencing any vibration inducing activity to the RCE. Any damage caused by vibrations in excess of permitted levels will be the responsibility of the Contractor.

22.3 PLANS

From time to time, the GEOR will be required to or find it necessary to develop plans for use on a specific project (see Appendix E). Plan development procedures presented in the Roadway Design Manual *(RDM)* shall be used in the development of plans. All plans prepared at the direction of the GEOR shall be numbered "G-#" for ground improvement and other geotechnical considerations. All plans prepared for ERSs shall be numbered "S-#." The layout of the border shall conform to the latest standard of SCDOT.