South Carolina
Department of Transportation

January 4, 2021

GEOTECHNICAL DESIGN BULLETIN NO. 2021-1

SUBJECT: Various Changes to the Geotechnical Design Manual, v2.0

EFFECTIVE DATE: Immediately

SUPERSEDES: None

RE: Pile Construction Costs - PDA vs No PDA
Selection of Resistance Factor for Partially Weathered Rock
ERS and Ground Improvement Matrix inclusion in Reports

The Geotechnical Design Support Office is deleting and replacing the following from the 2019 Geotechnical Design Manual:

Section 9.5.1 – Delete and replace 3rd Paragraph
Section 9.5.1 – Delete and replace Table 9-2
Section 9.5.1 – Delete and replace 6th Paragraph
Section 9.8 – Delete and replace Table 9-9
Section 16.3.1 – Add new 2nd Paragraph
Section 21.3.1 – Delete and replace Item g.
Section 21.3.2 – Delete and replace 10th Paragraph
Section 21.4.1 – Delete and replace Item f.
Section 21.4.2 – Delete and replace 9th Paragraph
Appendix G – Delete and replace Non-Commercial Software

The spreadsheet (Pile Cost-PDAvsNo-PDA) is available on the Geotechnical Design Webpage of the SCDOT Website. Please note that this spreadsheet will be updated annually in January. Further additional updates may be made as necessary and will be posted to the SCDOT website.

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9.5.1 Driven Piles

Additional considerations that have gone into the selection of SCDOT geotechnical resistance factors are as follows:

- The definition of a "Site" is the same as presented in the AASHTO LRFD specifications with the exception that a "Site" cannot have a variability greater than "Medium". If a "Site" classifies as a "High" variability, the "Site" shall be reduced in size to maintain a variability of "Low" or "Medium." The Site Variability shall be determined as indicated in Chapter 7.
- Resistance factors are based on a Site Variability of "Low" or "Medium"
- When field load testing is used, a minimum of 1 test pile is required per "Site" and it is typically placed at the weakest location based on the subsurface soil investigation and design methodology.
- The Contractor's pile installation plan is reviewed by SCDOT and the pile driving installation equipment is evaluated using the Wave Equation.
- At a minimum, Wave Equation Analysis is used to verify the field pile resistance during pile driving.
- If a Pile Driving Analyzer test is performed, the Wave Equation is calibrated using signal matching (CAPWAP) with the dynamic testing results.
- Determine the length of piling using the appropriate φ factor for the Wave Equation (only) and using the Wave Equation and PDA together. Use the Pile Cost-PDAvsNo-PDA spreadsheet to determine the cost benefit of using the PDA versus not using the PDA. The spreadsheet is available on the Geotechnical Design Webpage of the SCDOT Website.
- If the PDA testing is not going to be used, then the Pile Cost-PDAvsNo-PDA spreadsheet does not need to be used.
- When load tests are performed, the test pile installation is monitored with the Pile Driving Analyzer (PDA).
- All bridges, regardless of the OC, will be designed using the same geotechnical Resistance Factors to maintain the same level of variability.

Table 9-2, Geotechnical Resistance Factors for Driven Piles

Analysis and Method of Determination	Limit States			
	Strength		Service	Extreme Event
	Redundant	Non-Redundant		
Nominal Resistance Single Pile in Axial Compression (soil) with Wave Equation [1]	0.50	0.40	N/A	1.00
Nominal Resistance Single Pile in Axial Compression (rock) with Wave Equation [1, 4]	0.60	0.50	N/A	1.00
Nominal Resistance Single Pile in Axial Compression with High Strain Load Testing (PDA) and calibrated Wave Equation [2]	0.65	0.55	N/A	1.00
Nominal Resistance Single Pile in Axial Compression with Static Load Testing. Dynamic Monitoring (PDA) of test pile installation and calibrated Wave Equation [2, 3].	See Table 9-3		N/A	1.00
Nominal Resistance Single Pile in Axial Compression with Rapid Load Testing For Friction Piles. Dynamic Monitoring (PDA) of test pile installation and calibrated Wave Equation [2]	0.65	0.55	N/A	1.00
Nominal Resistance Single Pile in Axial Compression with Rapid Load Testing For End Bearing Piles in Rock or Very Dense Sand. Dynamic Monitoring (PDA) of test pile installation and calibrated Wave Equation [2].	0.70	0.55	N/A	1.00
Pile Group Block Failure (Clay)	0.60	N/A	N/A	1.00
Nominal Resistance Single Pile in Axial Uplift Load with High Strain Load Testing (PDA) and calibrated Wave Equation [2]	0.50	0.40	N/A	0.80
Nominal Resistance Single Pile in Axial Uplift Load with Static Load Testing	0.60	0.50	N/A	0.80
Group Uplift Resistance	0.50	N/A	N/A	N/A
Single or Group Pile Lateral Load Geotechnical Analysis (Lateral Displacements)	1.00	1.00	1.00	1.00
Single or Group Pile Vertical Settlement	1.00	1.00	1.00	1.00
Pile Driveability – Geotechnical Analysis	1.00	1.00	N/A	N/A

[1] Applies only to factored loads less than or equal to 600 kips.
[2] Dynamic testing is required on at least 2 piles per pile type and per "site", but no less than 2 percent of the total production piles per pile type for each approved hammer type used.
[3] See Table 9-3 for number of static load testing required.
[4] Use this resistance factor if the N-value is greater than or equal to 50 blows per 2 inches of penetration.

9.5.1 Driven Piles

When dynamic testing is used, dynamic testing controls the construction of pile foundations by verifying pile resistance (signal matching required - CAPWAP), calibrating wave equation inspector charts based on signal matching, and monitoring the pile driving hammer performance throughout the project.

Table 9-9, Resistance Factors for Reinforced Soils (Internal)

Performance Limit			Limit States		
			Strength	Service	Extreme Event
Tensile Resistance of Reinforcement and Connectors	Metallic Reinforcement[1]	Strip Reinforcement	0.75	N/A	1.00
		Grid Reinforcement [2]	0.65		0.85
	Geosynthetic Reinforcement	Geotextiles and Geogrid Reinforcement	0.80	N/A	1.00
Tensile Pullout Resistance	Metallic Reinforcement[1]	Strip and Grid Reinforcement	0.90	N/A	1.20
	Geosynthetic Reinforcement	Geotextiles and Geogrid Reinforcement	0.70	N/A	1.00

[1]Apply to gross cross-section less sacrificial area. For sections with holes, reduce the gross area and apply to net section less sacrificial area.

[2]Applies to grid reinforcements connected to a rigid facing element (concrete panel or block). For grid reinforcements connected to a flexible facing mat or which are continuous with the facing mat, use the resistance factor for strip reinforcements.

16.3.1 Axial Compressive Resistance

As indicated in Chapter 9, if PDA testing is not being used then the "Pile Cost-PDAvsNo-PDA" spreadsheet does not need to be used. However, if PDA testing is be considered then, the length of driven piling shall be determined both with and without the use of the PDA being used during construction. Therefore, 2 different φs will be used to determine the different lengths. The length to be used for the remainder of the design will be based on the economic impact (i.e., the cost benefit) of using or not using PDA testing. This impact is determined using the "Pile Cost-PDAvsNo-PDA" spreadsheet developed by the PCS/GDS. The spreadsheet is available on the Geotechnical Design Webpage of the SCDOT Website. The spreadsheet shall be provided as part of the Appendix of the Bridge Geotechnical Engineering Report. The GEOR may provide a written technical justification for using PDA testing when the spreadsheet indicates PDA testing is not cost effective.

21.3.1 Preliminary Bridge Geotechnical Engineering Report (PBGER)

g. Geohazards
   + Mucking requirements
   + Potential for long waiting periods for settlement
   + Preliminary ERS Selection Matrix
   + Preliminary Ground Improvement Selection Matrix
   + Karst voids/sink holes
   + Artesian conditions

21.3.2 Final Bridge Geotechnical Engineering Report (BGER)

The Appendix of BGER should include the locations of the soil tests, a subsurface profile and the completed GeoScoping form (also called a Site Reconnaissance form). The soil testing reports should be followed by the report of laboratory testing. Only the testing reports that pertain to the bridge and bridge embankment should be included in the Appendix. The BGER Appendix should include the final ADRS curve and the results of the detailed liquefaction study, if performed. The results of lateral pile analyses should also be included in the Appendix of the report. For projects performed by the PC/GDS, the lateral pile analysis input screens will be provided and the SEOR will perform the actual lateral pile analysis. For GEC prepared reports, the GEC may provide a complete analysis or may provide the input for the analysis depending on the contractual relationship between the GEC and the SEOR. Further include the final ERS Selection Matrix; the final Ground Improvement Selection Matrix; and the final Pile Cost – PDAvsNo-PDA spreadsheets as separate Appendices. In addition, the Appendix of the BGER shall include any Special Provisions pertaining to geotechnical issues that are required for the project. Included in this section of the Appendix are those Special Provisions previously prepared by SCDOT as well as any Special Provisions written by the GEC. Contact the PC/GDS to determine which Special Provisions are currently available.

21.4.1 Preliminary Roadway Geotechnical Engineering Report (PRGER)

f. Geohazards
   + Mucking requirements
   + Potential for long waiting periods for settlement
   + Preliminary ERS Selection Matrix
   + Preliminary Ground Improvement Selection Matrix
   + Karst voids/sink holes

21.4.2 Final Roadway Geotechnical Engineering Report (RGER)

The Appendix of RGER should include the locations of the soil tests, a subsurface profile and the completed GeoScoping form (also called a Site Reconnaissance form). The soil testing reports should be followed by the report of laboratory testing. Only the testing reports that pertain to the embankment and roadway structures should be included in the Appendix. The RGER Appendix should include the final ADRS curves and the results of the detailed liquefaction study, if performed. The results of slope stability analyses should also be included in the Appendix of the report. Further include the final ERS Selection Matrix and the final Ground Improvement Selection Matrix as separate Appendices. In addition, the Appendix of the RGER shall include any Special Provisions pertaining to geotechnical issues that are required for the project. Included in this section of the Appendix are those Special Provisions previously prepared by SCDOT as well as any Special Provisions written by the GEC. Contact the PC/GDS to determine which Special Provisions are currently available.

Appendix G – SCDOT Software List

Non-Commercial Software

SCENARIO-PC
SCDOT SHAKE
ADRS - Site Class & Andrus (Excel spreadsheet)
SPT-SSL_Idriss and Boulanger (Excel spreadsheet)
SPLiq (Excel Spreadsheet)
Bridge Abutment Backwall Seismic Passive Pressures (Excel spreadsheet)
ERS-Grd Imp Selection Matrix (Excel Spreadsheet)
Pile Cost-PDAvsNo-PDA (Excel Spreadsheet)