BRIDGE DESIGN MEMORANDUM – DM0310

TO: RPG Structural Engineers
Design Consultants

DATE: July 22, 2010

RE: *SCDOT Geotechnical Design Manual*, Version 1.1
Revisions to Chapter 9, Chapter 16, and Appendix A

Tables 9-1, 9-2, 9-6, 9-7, 9-9, and 9-10 of the *SCDOT Geotechnical Design Manual* shall be deleted and replaced with the following tables:

Table 9-1, Resistance Factors for Shallow Foundations

Performance Limit		Limit States		
		Strength	Service	Extreme Event
Soil Bearing Resistance (Soil)	OC= I, II, III; ROC = I	0.40	N/A	0.60
	ROC = II or III	0.45		0.65
Soil Bearing Resistance (Rock)	OC= I, II, III; ROC = I	0.40	N/A	0.60
	ROC = II or III	0.45		0.65
Sliding Frictional Resistance (Cast-in-place Concrete on Sand)	OC= I, II, III; ROC = I	0.70	N/A	0.90
	ROC = II or III	0.80		0.95
Sliding Frictional Resistance (Cast-in-place Concrete on Clay)	OC= I, II, III; ROC = I	0.75	N/A	0.90
	ROC = II or III	0.85		0.95
Sliding Frictional Resistance (Precast Concrete on Sand)	OC= I, II, III; ROC = I	0.80	N/A	0.95
	ROC = II or III	0.90		1.00
Sliding Soil on Soil	OC= I, II, III; ROC = I	0.80	N/A	0.95
	ROC = II or III	0.90		1.00
Sliding Passive Resistance (Soil)	OC= I, II, III; ROC = I	0.40	N/A	0.55
	ROC = II or III	0.50		0.65
Lateral Displacement		N/A	1.00	1.00
Vertical Settlement		N/A	1.00	1.00

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 with Wave Equation [(1)] (Soil)	0.40	0.30	N/A	1.00
Nominal Resistance Single Pile in Axial Compression with Wave Equation [(1)] (IGM and Rock)	0.50	0.40	N/A	1.00
Nominal Resistance Single Pile in Axial Compression with Dynamic 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 9-4		N/A	1.00
Nominal Resistance Single Pile in Axial Compression with Statnamic 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 Statnamic Load Testing For End Bearing Piles in Rock, IGM, 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 No Verification	0.35	0.25	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	1.00	1.00	1.00	1.00
Single or Group Pile Vertical Settlement	N/A	N/A	1.00	1.00
Pile Drivability – Geotechnical Analysis	1.00	1.00	N/A	N/A

[(1)] Applies only to factored loads less than or equal to 600 kips.
[(2)] See Table 9-3 for frequency of dynamic testing required.
[(3)] See Table 9-4 for number of static load testing required.

Table 9-6, Resistance Factors for Rigid Gravity Retaining Walls

Performance Limit		Limit States		
		Strength	Service	Extreme Event
Soil Bearing Resistance (Soil)	ROC = I, II	0.45	N/A	0.60
	ROC = III	0.45	N/A	0.60
Soil Bearing Resistance (Rock)		0.45	N/A	0.60
Sliding Frictional Resistance (Cast-in-place Concrete on Sand)	ROC = I, II	0.70	N/A	0.90
	ROC = III	0.80		0.95
Sliding Frictional Resistance (Cast-in-place Concrete on Clay)	ROC = I, II	0.75	N/A	0.90
	ROC = III	0.85		0.95
Sliding Frictional Resistance (Precast Concrete on Sand)	ROC = I, II	0.80	N/A	0.95
	ROC = III	0.90		1.00
Sliding Soil on Soil	ROC = I, II	0.80	N/A	0.95
	ROC = III	0.90		1.00
Lateral Displacement		N/A	1.00	1.00
Vertical Settlement		N/A	1.00	1.00
Global Stability Fill Walls	ROC= I, II	N/A	0.65	0.90 (1)
	ROC = III		0.75	1.00 (1)
Global Stability Cut Walls	ROC= I, II	N/A	0.60	0.90 (1)
	ROC = III		0.70	1.00 (1)

(1) Global stability analyses for Extreme Event I limit state that have resistance factors greater than specified require a displacement analysis to determine if it meets the performance limits presented in Chapter 10.

Table 9-7, Resistance Factors for Flexible Gravity Retaining Walls

Performance Limit		Limit States		
		Strength	Service	Extreme Event
Soil Bearing Resistance		0.65	N/A	1.00
Sliding Frictional Resistance		1.00	N/A	1.00
Lateral Displacement		N/A	1.00	1.00
Vertical Settlement		N/A	1.00	1.00
Global Stability Fill Walls	ROC= I, II	N/A	0.65	0.90 (1)
	ROC = III		0.75	1.00 (1)
Global Stability Cut Walls	ROC= I, II	N/A	0.60	0.90 (1)
	ROC = III		0.70	1.00 (1)

(1) Global stability analyses for Extreme Event I limit state that have resistance factors greater than specified require a displacement analysis to determine if it meets the performance limits presented in Chapter 10.

Table 9-9, Resistance Factors for Embankments (Fill / Cut Section)

Performance Limit		Limit States		
		Strength	Service	Extreme Event
Lateral Displacement		N/A	1.00	1.00
Vertical Settlement		N/A	1.00	1.00
Global Stability Embankment (Fill)	ROC= I, II	N/A	0.65	0.90 [1]
	ROC = III		0.75	1.00 [1]
Global Stability Cut Section	ROC= I, II	N/A	0.60	0.90 [1]
	ROC = III		0.70	1.00 [1]

[1] Global stability analyses for Extreme Event I limit state that have resistance factors greater than specified require a displacement analysis to determine if it meets the performance limits presented in Chapter 10.

Table 9-10, Resistance Factors for Reinforced Soils

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

[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.

The sixth paragraph of Section16.8 of the *Manual* (Lateral Capacity) shall be deleted and replaced with the following:

> Lateral designs for determining performance (deflections) are governed by the Service Limit State. The Strength Limit State is used in the determination of the lateral stability (critical depth) of the deep foundation. For group loadings using the P-y method of analysis, P-multipliers should be used in accordance with *AASHTO LRFD Bridge Design Specifications* Article 10.7 – Driven Piles.

In Appendix A of the *Manual*, Forms GDF 001 (Bridge Load Data Sheet), GDF 002 (Consultant Seismic Information Request), and GDF 003 (Consultant Geotechnical Seismic Response) shall be deleted and replaced with the attached forms dated July 22, 2010.

Please note these revisions in your copy of the *Manual.*

Original Signed by Barry W. Bowers on July 22, 2010 for
Preconstruction Support

BWB:afg
Attachments
ec: Bridge Construction Engineer
Bridge Maintenance Engineer
FHWA Structural Engineer
Preconstruction Support Managers
Regional Production Engineers
RPG Design Managers
File: PC/BWB

Bridge Load Data Sheet

<table>
<tr><th colspan="6">PROJECT INFORMATION</th></tr>
<tr><td colspan="3">File No.</td><td colspan="3">PCN:</td></tr>
<tr><td colspan="3">County:</td><td colspan="3">Route:</td></tr>
<tr><td colspan="6">Description:</td></tr>
<tr><td colspan="3">Loads Provided By:</td><td colspan="3">Date Loads Provided:</td></tr>
<tr><td>Bridge Type:</td><td colspan="5"></td></tr>
<tr><td>No. Spans /Lengths:</td><td colspan="2"></td><td>Width / No. Lanes:</td><td colspan="2"></td></tr>
<tr><td colspan="3">Edition of AASHTO LRFD Bridge Design Specifications:</td><td colspan="3"></td></tr>
<tr><td colspan="3">Edition of SCDOT Seismic Design Specifications for Highway Bridges:</td><td colspan="3"></td></tr>
<tr><td colspan="2">Bridge Operational Classification (OC):</td><td></td><td colspan="2">Site Class:</td><td></td></tr>
<tr><td colspan="2">Seismic Design Category (SDC):</td><td></td><td colspan="2">Scour Report Attached</td><td></td></tr>
<tr><td rowspan="2">Proposed Foundations (foundation type, size, and number per bent)</td><td>End Bent</td><td colspan="4"></td></tr>
<tr><td>Interior Bent</td><td colspan="4"></td></tr>
<tr><td>Location/Elev. of Applied Loads:</td><td>End Bent:</td><td></td><td>Int. Bent:</td><td colspan="2"></td></tr>
<tr><td>Location/Elev. Est. Point of Fixity:</td><td>End Bent:</td><td></td><td>Int. Bent:</td><td colspan="2"></td></tr>
</table>

Bridge Load Data Sheet

	Limit State	Strength			Service		
	Load Cases:	Case 1FL ($P=P_{max}$)	Case 2FL ($V=V_{max}$)	Case 3FL ($M=M_{max}$)	Case 1SL ($P=P_{max}$)	Case 2SL ($V=V_{max}$)	Case 3SL ($M=M_{max}$)
End Bent - Longitudinal	P (kips) =						
	V (kips) =						
	M (ft-kip) =						
End Bent - Transverse	P (kips) =						
	V (kips) =						
	M (ft-kip) =						
Interior Bent - Longitudinal	P (kips) =						
	V (kips) =						
	M (ft-kip) =						
Interior Bent - Transverse	P (kips) =						
	V (kips) =						
	M (ft-kip) =						

	Limit State	Extreme Event I			Extreme Event II[a]			Extreme Event II[b]		
	Load Cases:	Case 1EL ($P=P_{max}$)	Case 2EL ($V=V_{max}$)	Case 3EL ($M=M_{max}$)	Case 1EEL ($P=P_{max}$)	Case 2EEL ($V=V_{max}$)	Case 3EEL ($M=M_{max}$)	Case 1EEL ($P=P_{max}$)	Case 2EEL ($V=V_{max}$)	Case 3EEL ($M=M_{max}$)
End Bent - Longitudinal	P (kips) =									
	V (kips) =									
	M (ft-kip) =									
End Bent - Transverse	P (kips) =									
	V (kips) =									
	M (ft-kip) =									
Interior Bent - Longitudinal	P (kips) =									
	V (kips) =									
	M (ft-kip) =									
Interior Bent - Transverse	P (kips) =									
	V (kips) =									
	M (ft-kip) =									

Notes:

P – Axial; V – Shear; M – Moment; [a] – Check Flood w/o collision loads; [b] – Collision loads w/o check flood

Consultant Seismic Information Request

PROJECT INFORMATION			
File No.			**PCN:**
County:	**RPG[1]:**		**Route:**
Description:			
Latitude (4 decimals): .			**Longitude (4 decimals):** .

SEISMIC REQUEST

The SCDOT Geotechnical Design Manual and Seismic Design Specifications for Highway Bridges, latest editions, provide detailed seismic design requirements for transportation structures. The RPG Geotechnical Design Section (GDS) will be generating seismic design information from, *SCENARIO_PC*, the seismic analysis software. The consultant is encouraged to review the software documentation, *Information on Analysis Software*, for assistance in completing this form. The RPG GDS will be providing the pseudo-spectral acceleration (PSA) oscillator response for frequencies 0.5, 1.0, 2.0, 3.3, 5.0, 6.7 and 13 Hz, for 5% critical damping and peak horizontal ground acceleration (PGA) at either the **B-C Boundary** (Geologically Realistic) or **Hard Rock** Outcrop for specific project locations within South Carolina. The Geologically Realistic option is for sites in the Coastal Plain with sediment thickness greater than 100 feet to firm sediment (V_s=2,500 feet per second (ft/s) or NEHRP B-C Boundary). Geologically Realistic conditions can also be encountered outside of the Coastal Plain where the sediment thickness is 100 feet or less above the basement rock and the V_s = 8,000 ft/s. The Hard Rock Outcrop option is for an outcrop of hard rock ($V_s \geq$ 11,500 ft/s). The Preconstruction Support – Geotechnical Design Section (PCS/GDS) has developed a map to assist in determining the site condition. South Carolina has been divided in two zones, Zone **I** – Physiographic Units Outside of the Coastal Plain and Zone **II** – Physiographic Units of the Coastal Plain. This information can be provided for the Safety Evaluation Earthquake (SEE) 3% probability of exceedance for 75-year exposure periods or for the Functional Evaluation Earthquake (FEE) 15% probability of exceedance for 75-year exposure periods. The consultant is reminded that all embankment structures are required to be designed for both the SEE and FEE. The consultant will use this information in developing the Acceleration Design Response Spectrum (ADRS) in accordance with the SCDOT Geotechnical Design Manual and Seismic Design Specifications for Highway Bridges. The RPG GDS can also provide the Time Series for use in performing a Site-Specific Response Analysis.

STRUCTURE SEISMIC INFORMATION

Bridge Operational Classification (OC):	
Site Class:	
Bridge Seismic Level of Design:	

Select Design Earthquake

SEE – 3% Probability of Exceedance in 75 years	☐
FEE – 15% Probability of Exceedance in 75 years	☐

Geologically Realistic ☐ **Hard Rock Basement Outcrop** ☐

Requestor Information

Requestor Name:	
Company Name:	
Phone Number:	( ) -
Email Address	
Request Date:	

[1]**RPG – Regional Production Group**

- **Lowcountry** – Beaufort, Berkeley, Charleston, Colleton, Dorchester, Hampton, Jasper
- **Pee Dee** – Chesterfield, Clarendon, Darlington, Dillon, Florence, Georgetown, Horry, Kershaw, Lee, Marion, Marlboro, Sumter, Williamsburg
- **Midlands** – Aiken, Allendale, Bamberg, Barnwell, Calhoun, Chester, Fairfield, Lancaster, Lexington, Newberry, Orangeburg, Richland, Union, York
- **Upstate** – Abbeville, Anderson, Cherokee, Edgefield, Greenville, Greenwood, Laurens, McCormick, Oconee, Pickens, Saluda, Spartanburg

Consultant Seismic Information Request

PROJECT INFORMATION	
File No.	**PCN:**

TIME SERIES GENERATION REQUEST

Time Series information is required if a Site-Specific Response Analysis is to be conducted. The SCDOT Geotechnical Design Manual requires a Site-Specific Response Analysis for Seismic Site Class "F". Unscaled and Scaled time series will be generated for the **B-C Boundary** in Shake91 data format. The Scaled time series are based on the earthquake magnitude (Mw) and Epicentral distance provided.

Request Time Series: Yes ☐ No☐

Sediment Thickness

The sediment thickness is used by *SCENARIO_PC*, to generate the time series simulation. The time series can be generated with the default sediment thickness as indicated in *2.2.2.1 Site Response Modeling* of the *Seismicity Study Report* (http://www.scdot.org/doing/pdfs/Reporttxt.pdf) or can adjusted specifically for the geology and analysis requirements at the specific project location. This option only applies to those site were the Geologically Realistic Model is used.

Change Sediment Thickness: Yes meters **No** ☐

Match Entire Uniform Spectrum

In cases where the uniform hazard spectrum is dominated by a single scenario (a well defined modal event in the Deaggregation plots), the spectrum of the modal event may closely match that of the uniform hazard spectrum, even without much scaling. This will be the case for sites in the Coastal Plain near Charleston, for the 3% in 75 year hazard level. However, at sites where there are two or maybe 3 modes in the deaggregation, matching the entire spectrum with a single modal event will require much scaling. This scaling can be done automatically over the entire spectrum. Matching the entire spectrum involves a phase-invariant spectral scaling of the scenario time series. It is often preferable to use two or more modal events, each matching a specific frequency of the uniform hazard spectrum. This results in a simple constant (frequency independent) scaling of the scenario time series. If the consultant selects to not match the entire spectrum, the spectrum may be scaled using either an oscillator frequency/PSA or a PGA that will be matched when simulating the ground motion.

Match Entire Spectrum:	**Yes** ☐	**No** ☐		
		Scaling Parameter	**M_{w1}**	**M_{w2}**
If Not matching Entire Spectrum, Select PSA or PGA Scaling	**PSA Scaling** ☐	**Oscillator Frequency**	**Hertz**	**Hertz**
		PSA	**g**	**g**
	PGA Scaling ☐	**PGA**	**g**	**g**

Scenario Earthquake Magnitude and Distance

Determine earthquake magnitude, M_W, and epicentral distance from the deaggregation plots provided by the U.S. Geological Survey (http://eqint.cr.usgs.gov/deaggint/2002/index.php). The 3% and 15% in 75-year events are equivalent to the 2% and 10% in 50-year events, respectively.

M_{W1} =	**Epicentral Distance =** Kilometers
M_{W2} =	**Epicentral Distance =** Kilometers

Consultant Geotechnical Seismic Response

To:	
Consultant:	
Date Requested:	

PROJECT INFORMATION	
File No.	**PCN:**
County:	**Route:**
Description:	
Latitude (4 decimals): .	**Longitude (4 decimals):** .
Bridge Operational Classification (OC):	
Type of Seismic Information Requested:	
Site Class:	

Pseudo-Spectral Acceleration (PSA)

The SCDOT Geotechnical Design Section has generated the required Design Earthquake the pseudo-spectral acceleration (PSA) oscillator response for frequencies 0.5, 1.0, 2.0, 3.3, 5.0, 6.7 and 13 Hz, for 5% critical damping and peak horizontal ground acceleration (PGA) at the **B-C Boundary.**

SEE – 3% Probability of Exceedance in 75 years

PSA and PGA as Percentage of g

0.5Hz	1.0Hz	2.0Hz	3.3Hz	5.0Hz	6.7Hz	13.0Hz	PGA

Thickness of sediments:	meters

FEE – 15% Probability of Exceedance in 75 years

PSA and PGA as Percentage of g

0.5Hz	1.0Hz	2.0Hz	3.3Hz	5.0Hz	6.7Hz	13.0Hz	PGA

Thickness of sediments:	meters

Time Series

Unscaled and Scaled time series were generated for the **B-C Boundary** in Shake91 data format. The Scaled time series are based on the earthquake magnitude (Mw) and Epicentral distance requested.

The Time Series Files are Attached:	**Yes** ☐	**No** ☐

Design Response Spectrum

Two-Point Method	☐
Three-Point Method	☐

The Design Response Spectrum is Attached:	**Yes** ☐	**No** ☐

Geotechnical Designer:		**RPG[1]:**	
Date:		**Phone Number:**	( ) -
Geotechnical Review:		**RPG[1,2]:**	

[1]**RPG – Regional Production Group**

- **Lowcountry** – Beaufort, Berkeley, Charleston, Colleton, Dorchester, Hampton, Jasper
- **Pee Dee** – Chesterfield, Clarendon, Darlington, Dillon, Florence, Georgetown, Horry, Kershaw, Lee, Marion, Marlboro, Sumter, Williamsburg
- **Midlands** – Aiken, Allendale, Bamberg, Barnwell, Calhoun, Chester, Fairfield, Lancaster, Lexington, Newberry, Orangeburg, Richland, Union, York
- **Upstate** – Abbeville, Anderson, Cherokee, Edgefield, Greenville, Greenwood, Laurens, McCormick, Oconee, Pickens, Saluda, Spartanburg

[2]**RPG – Preconstruction Support – Geotechnical Design Section (PCS/GDS)**