VIRGINIA ELECTRIC AND POWER COMPANY
RICHMOND, VIRGINIA 23261

September 12, 2013

U.S. Nuclear Regulatory Commission
Attention: Document Control Desk
Washington, DC 20555

Serial No. 13-243C
NL&OS/WDC R0
Docket Nos. 50-338/339
License Nos. NPF-4/7

VIRGINIA ELECTRIC AND POWER COMPANY
NORTH ANNA POWER STATION UNITS 1 AND 2
RESPONSE TO MARCH 12, 2012 INFORMATION REQUEST
REGARDING SEISMIC ASPECTS OF RECOMMENDATION 2.1 – 1.5 YEAR
RESPONSE FOR CEUS SITES

References:

1. NRC Letter, "Request for Information Pursuant to Title 10 of the Code of Federal Regulations 50.54(f) Regarding Recommendations 2.1, 2.3, and 9.3, of the Near-Term Task Force Review of Insights from the Fukushima Dai-ichi Accident," dated March 12, 2012
2. NRC Letter, Endorsement of EPRI Final Draft Report 1025287, "Seismic Evaluation Guidance," dated February 15, 2013
3. EPRI Report 1025287, Seismic Evaluation Guidance: Screening, Prioritization and Implementation Details (SPID) for the Resolution of Fukushima Near-Term Task Force Recommendation 2.1: Seismic
4. NEI letter to NRC, Proposed Path Forward for NTTF Recommendation 2.1: Seismic Reevaluations, dated April 9, 2013
5. NRC Letter, EPRI Final Draft Report 3002000704, "Seismic Evaluation Guidance: Augmented Approach for the Resolution of Near-Term Task Force Recommendation 2.1: Seismic," as an Acceptable Alternative to the March 12, 2012, Information Request for Seismic Reevaluations, dated May 7, 2013

On March 12, 2012, the Nuclear Regulatory Commission (NRC) issued Reference 1 to all power reactor licensees and holders of construction permits in active or deferred status. Enclosure 1 of Reference 1 requested each addressee in the Central and Eastern United States (CEUS) to submit a written response consistent with the requested seismic hazard evaluation information (items 1 through 7) by September 12, 2013. On February 15, 2013, NRC issued Reference 2, endorsing the Reference 3 industry guidance for responding to Reference 1. Section 4 of Reference 3 identifies the detailed information to be included in the seismic hazard evaluation submittals.

On April 9, 2013, NEI submitted Reference 4 to the NRC, requesting NRC agreement to delay submittal of some of the CEUS seismic hazard evaluation information so that an update to the EPRI (2004, 2006) ground motion attenuation model could be completed and used to develop that information. NEI proposed that descriptions of subsurface materials and properties and base case velocity profiles (items 3a and 3b in Section 4 of Reference 3) be submitted to NRC by September 12, 2013 as an interim product of seismic hazard development efforts being performed in accordance with Reference 3. The final seismic hazard and screening information will be submitted to NRC by March 31, 2014. In Reference 5, NRC agreed with this recommendation.

A001
NRR

The attachment to this letter contains the requested descriptions of subsurface materials and properties and base case velocity profiles for North Anna Power Station.

If you have any questions regarding this information, please contact Mr. Thomas Shaub at (804) 273-2763.

Sincerely,

Eugene S. Grecheck
Vice President – Nuclear Engineering and Development

COMMONWEALTH OF VIRGINIA)
)
COUNTY OF HENRICO)

The foregoing document was acknowledged before me, in and for the County and Commonwealth aforesaid, today by Eugene S. Grecheck, who is Vice President – Nuclear Engineering and Development of Virginia Electric and Power Company. He has affirmed before me that he is duly authorized to execute and file the foregoing document in behalf of that company, and that the statements in the document are true to the best of his knowledge and belief.

Acknowledged before me this 12TH day of September, 2013.

My Commission Expires: May 31, 2014

Vicki L. Hull
Notary Public

VICKI L. HULL
Notary Public
Commonwealth of Virginia
140542
My Commission Expires May 31, 2014

Commitments made in this letter: No new regulatory commitments

Attachment: Subsurface Materials and Properties and Base Case Velocity Profiles (SPID Section 4, Items 3a and 3b)

cc: U.S. Nuclear Regulatory Commission, Region II
Regional Administrator
Marquis One Tower
245 Peachtree Center Ave. NE
Suite 1200
Atlanta, Georgia 30303-1257

Dr. V. Sreenivas
Project Manager – North Anna
U.S. Nuclear Regulatory Commission
One White Flint North, Mail Stop 08 G-9A
11555 Rockville Pike
Rockville, MD 20852-2738

K. R. Cotton Gross
Project Manager - Surry
U.S. Nuclear Regulatory Commission
One White Flint North, Mail Stop 08 G-9A
11555 Rockville Pike
Rockville, MD 20852-2738

NRC Senior Resident Inspector
North Anna Power Station

J. E. Reasor, Jr.
Old Dominion Electric Cooperative
Innsbrook Corporate Center, Suite 300
4201 Dominion Blvd.
Glen Allen, Virginia 23060

ATTACHMENT

SUBSURFACE MATERIALS AND PROPERTIES AND BASE CASE VELOCITY PROFILES (SPID SECTION 4, ITEMS 3A AND 3B)

VIRGINIA ELECTRIC AND POWER COMPANY (DOMINION)
NORTH ANNA POWER STATION UNITS 1 AND 2

North Anna Power Station Units 1 and 2

Subsurface Materials and Properties and Base Case Velocity Profiles

1 Introduction

This document provides the rationale for developing a base profile to be used in computing the ground motion response spectrum (GMRS) consistent with the methodology outlined in the Electric Power Research Institute's (EPRI) Screening Prioritization and Implementation Details (SPID) document (Reference 1).
The following properties are considered in this report:

- geologic setting,
- stratigraphy,
- safety related structures,
- shear wave velocity,
- layer thickness,
- unit weight and Poisson's ratio,
- shear modulus and material damping versus cyclic shear strain,
- groundwater level, and
- profile selected for use.

2 Geologic Setting

The North Anna Power Station is located in Louisa County, Virginia, on a peninsula on the southern shore of Lake Anna. This places the station in the central portion of the Piedmont physiographic province with the Blue Ridge province about 40 miles to the west and the Coastal Plain province about 15 miles to the east. The Piedmont terrain is characterized by gently sloping upland areas and broad, relatively shallow valleys. Bedrock within the Piedmont is metamorphic, consisting of granites, gneisses, and schists. The bedrock typically is deeply weathered into a saprolite mantle of up to approximately 100 ft thick.

As described in Reference 2, the Piedmont Upland section is underlain by Late Precambrian and Paleozoic age crystalline rocks. The crystalline rocks consist of deformed and metamorphosed sedimentary, igneous and volcanic rocks, intruded by mafic dikes and granitic plutons. The North Anna site is located in the Chopawamsic belt which is bounded on the west and east by the Chopawamsic and Spotsylvania thrust faults, respectively. The Chopawamsic belt comprises the Chopawamsic Formation and the Ta River Metamorphic Suite, which is overlain unconformably by the Quantico Formation and intruded by rocks of the Falmouth Intrusive Suite.

3 Stratigraphy

Bedrock at North Anna consists mainly of metamorphic gneiss and schist. There has been extensive in-place weathering of the rock. The rock has weathered completely into saprolitic soil near the ground surface.

The general subsurface profile at North Anna can be divided into 6 zones (Reference 2):

I	Residual clays and clayey silts – all structure of parent rock is lost.
IIA	Saprolite – medium dense silty sand, with some fine-grained layers.
IIB	Saprolite – very dense silty sand.
III	Weathered rock – core stone more than 50% of volume of overall mass.
III-IV	Moderately weathered to slightly weathered rock.
IV	Parent rock – slightly weathered to fresh rock.

The weathering across the site is uneven, and the thickness of the various zones varies widely and randomly throughout the site. The rock zones are defined by both rock quality designation (RQD) and shear wave velocity (V_s). Considering the original site investigations at Units 1 and 2 site and the more recent site investigations at the proposed Unit 3 site (which shares the same geologic characteristics), the North Anna site is well-characterized and extensively investigated with abundant high-quality data (>200 borings, including five deep borings with P-S Suspension shear wave velocity measurements), which reduces epistemic uncertainty in the site properties. These data also provide information to characterize the aleatory variation in layer thickness and shear-wave velocity across the site. These variations will be included in considerations of aleatory uncertainties for the base-case profile. No alternate profiles were considered because of the relative insignificance of epistemic uncertainty with respect to the aleatory variability for this site.

4 Safety-Related Structures

Reference 1 provides very specific guidelines on how a nuclear power facility is to identify the Safe Shutdown Earthquake (SSE) Control Point elevation for a plant or unit if this control point was not identified in the Updated Final Safety Analysis Report (UFSAR). In the case of a plant designated as a rock site, the SSE control point is defined as the foundation bearing elevation of the highest rock-supported, safety-related structure. According to Reference 3, at the North Anna Power Station, the highest rock-founded, safety-related structure is the Casing Cooling Tank and Pumphouse structure. This is a single slab-supported structure founded above weathered bedrock and on concrete backfill. The concrete backfill was placed to create a level bearing surface above the varying elevation of the exposed bedrock surface. Due to its limited horizontal extent, the concrete backfill will not be included in the GMRS calculation.

With plant grade at El. 271 ft (Reference 4), the base of the Casing Cooling Tank and Pumphouse foundation is at El. 268 ft. The GMRS will thus be calculated at El. 268 ft. Outside the foundation, there is 3 ft of saprolite from El. 268 ft to El. 271 ft.

5 Shear Wave Velocity

Bedrock

The dynamic rock profile for Units 1 and 2 up to plant grade at El. 271 ft, developed for the North Anna Unit 3 COLA and modified for Units 1 and 2, is shown in the following table:

Elevation (ft)	Shear Wave Velocity (ft/s)		
	Profile 1 (V_{LB})	Profile 2 (V_{UB})	Best Estimate, V_{BE}
271 - 224	3,115	5,800	4,251
224 - 205	4,475	6,635	5,449
205 - 170	3,450	7,770	5,177
170 - 135	8,800	8,800	8,800
135 - 25	9,740	9,740	9,740

The best estimate value is the log-mean of the Profile 1 (V_{LB}) and Profile 2 (V_{UB}) values:

V_{BE} = 10^{Average[Log(V_{LB}), Log(V_{UB})]}

The Profile 1 and Profile 2 values capture the majority of the measured V_S values in the bedrock, as well as V_S values correlated from other parameters (such as RQD). Thus (V_{BE} – Profile 1) and (Profile 2 - V_{BE}) are assumed to approximate one standard deviation.

The V_{BC} profile (base case) using V_{BE} is shown in Table 1.

Saprolite

The saprolite V_S profile developed from the V_S measurements in saprolite (including those developed for the North Anna Unit 3 COLA) can be used in this situation. Using the original ground surface in the area at about El. 290 ft, the 3 ft of saprolite between El. 271 ft and El. 268 ft would have been at 19 ft to 22 ft depth. The rounded V_S values of the saprolite between 20 and 25 ft depth are V_{BE} = 795 ft/sec, V_{LB} = 560 ft/sec, and V_{UB} = 1,030 ft/sec. These can be used for the El. 271 ft to El. 268 ft interval. V_{UB} and V_{LB} = V_{BE} +/- 1 standard deviation.

The V_{BC} profile (base case) using V_{BE} is shown in Table 1.

This base case V_S profile is plotted in Figure 1.

6 Zone Thickness

The following approximate V_S and RQD limits for the various zones were developed for the North Anna Unit 3 COLA:

Zone IIA	V_S < 1,200 ft/sec	RQD = 0
Zone IIB	V_S = 1,200 – 2,000 ft/sec	RQD = 0
Zone III	V_S = 2,000 – 4,000 ft/sec	RQD < 50%
Zone III-IV	V_S = 4,000 – 8,000 ft/sec	RQD 50% - 90%
Zone IV	V_S > 8,000 ft/sec	RQD > 90%

Comparing the V_S values with the values in Table 1, it is concluded that:

El. 271 ft to El. 268 ft (3 ft thickness) is Zone IIA.
El. 268 ft to El. 224 ft (44 ft thickness) is primarily Zone III (with some overlap into Zone III-IV).
El. 224 ft to El. 170 ft (54 ft thickness) is Zone III-IV.
Below El. 170 ft is Zone IV.

These thicknesses are shown in Table 1. Note that the considerable variation in zone thickness will be accounted for later in the randomization process.

7 Unit Weight & Poisson's Ratio

Unit weights and Poisson's ratio values were developed for the North Anna Unit 3 COLA. Values are shown in Table 1.

8 Shear Modulus & Damping Ratio versus Shear Strain

Shear Modulus

The shear modulus values of the Zone III-IV and Zone IV bedrock are independent of shear strain.

The ratios of shear modulus values (G) to the maximum shear modulus value (G_{MAX}) of the Zone IIA saprolite are the average of the 0 to 20 ft and 20 ft to 50 ft curves provided in Reference 5, and are based on the results of Resonant Column and Torsional Shear (RCTS) tests on the saprolite. These values are shown versus shear strain in Table 2 and are plotted in Figure 2.

The G/G_{MAX} values of the Zone III weathered rock are based on values for relatively soft rock in Reference 6. These values are shown versus shear strain in Table 2 and are plotted in Figure 2.

The variation in G/G_{MAX} values will be accounted for later in the randomization process.

Damping Ratio

As with the shear modulus, the damping ratio (D) values for the Zone III-IV and Zone IV bedrock are independent of shear strain. The value of D for these materials is 1%.

The D values of the Zone IIA saprolite are the average of the 0 to 20 ft and 20 ft to 50 ft curves provided in Reference 5, and are based on the results of RCTS tests on the saprolite. These values are shown versus shear strain in Table 3 and are plotted in Figure 3.

The D values of the Zone III weathered rock are shown in Table 3 and plotted in Figure 3. Note that for analysis, values of D are typically truncated at 15%.

The variation in D will be accounted for later in the randomization process.

9 Groundwater Level

Reference 4 indicates that structures for Units 1 and 2 were designed and analyzed using a uniform groundwater level at El. 256 ft.

10 Profile Selected for Use

As discussed in Section 4, considering the original site investigations at Units 1 and 2 site and the more recent site investigations at the proposed Unit 3 site, the epistemic uncertainty is considered insignificant relative to the observed aleatory variability for this site. Thus, a single base-case profile is considered for the site as presented in Table 1 and Figure 1. The variations in shear-wave velocity, layer thicknesses, and shear-modulus reduction and damping curves will be included in considerations of aleatory uncertainties for the base-case profile through the randomization process.

11 References

1. Electric Power Research Institute (EPRI). *Seismic Evaluation Guidance, Screening, Prioritization and Implementation Details (SPID) for the Resolution of Fukushima Near-Term Task Force Recommendation 2.1: Seismic*, Final Report No. 1025287, Electric Power Research Institute, Palo Alto, CA, 2013.

2. North Anna Early Site Permit Application, Rev. 9, 2006.

3. Dominion, "Seismic Screening GMRS Subsurface Profiles for Millstone and North Anna Power Stations," ETE-CCE-2013-0001, Revision 0.

4. North Anna Power Station Units 1 and 2 Updated Final Safety Analysis Report (UFSAR), Revision 48.

5. Electric Power Research Institute (EPRI). *Guidelines for Determining Design Basis Ground Motions*, Vol. 1-5, EPRI TR-102293, Palo Alto, CA.

6. Sun, J.I., Golesorkhi, R., and Seed, H.B. *Dynamic Moduli and Damping Ratios for Cohesive Soils*, Earthquake Engineering Research Center, University of California – Berkeley California, Report No. EERC-88/15, 1988.

Table 1: Base Case V_S Profile and Related Properties

Material	Elevation (ft)	Thickness (ft)	V_{BC}	Poisson's Ratio	Unit Wt (lb/ft^3)
Zone IIA	271-268	3	795	0.35	125
Zone III	268-224	44	4250	0.40	150
Zone III-IV	224-205	19	5450	0.33	163
Zone III-IV	205-170	35	5180	0.33	163
Zone IV	170-135	35	8800	0.27	164
Zone IV	<135	-	9740	0.27	164

Note:
Groundwater at El. 256 ft

Table 2: Modulus Reduction Relationship

Shear Strain (%)	G/G_{MAX}, Zone IIA Saprolite	G/G_{MAX}, Zone III Weathered Rock
0.0001	1.00	1.00
0.000316	1.00	1.00
0.001	0.99	1.00
0.00316	0.94	1.00
0.01	0.79	1.00
0.0316	0.57	0.98
0.1	0.32	0.87
0.316	0.15	0.63
1.0	0.05	0.33

Table 3: Damping Ratio Relationship

Shear Strain (%)	D (%) for Zone IIA Saprolite	D (%)for Zone III Weathered Rock
0.0001	1.3	0.6
0.000316	1.3	0.6
0.001	1.6	0.6
0.00316	2.4	0.6
0.01	4.4	0.6
0.0316	8.2	0.6
0.1	14.3	2.7
0.316	20.6	8.2
1.0	27.9	17.0

Notes:
D = 1% for Zone III-IV, Zone IV
For analysis, values of D are typically truncated at 15%

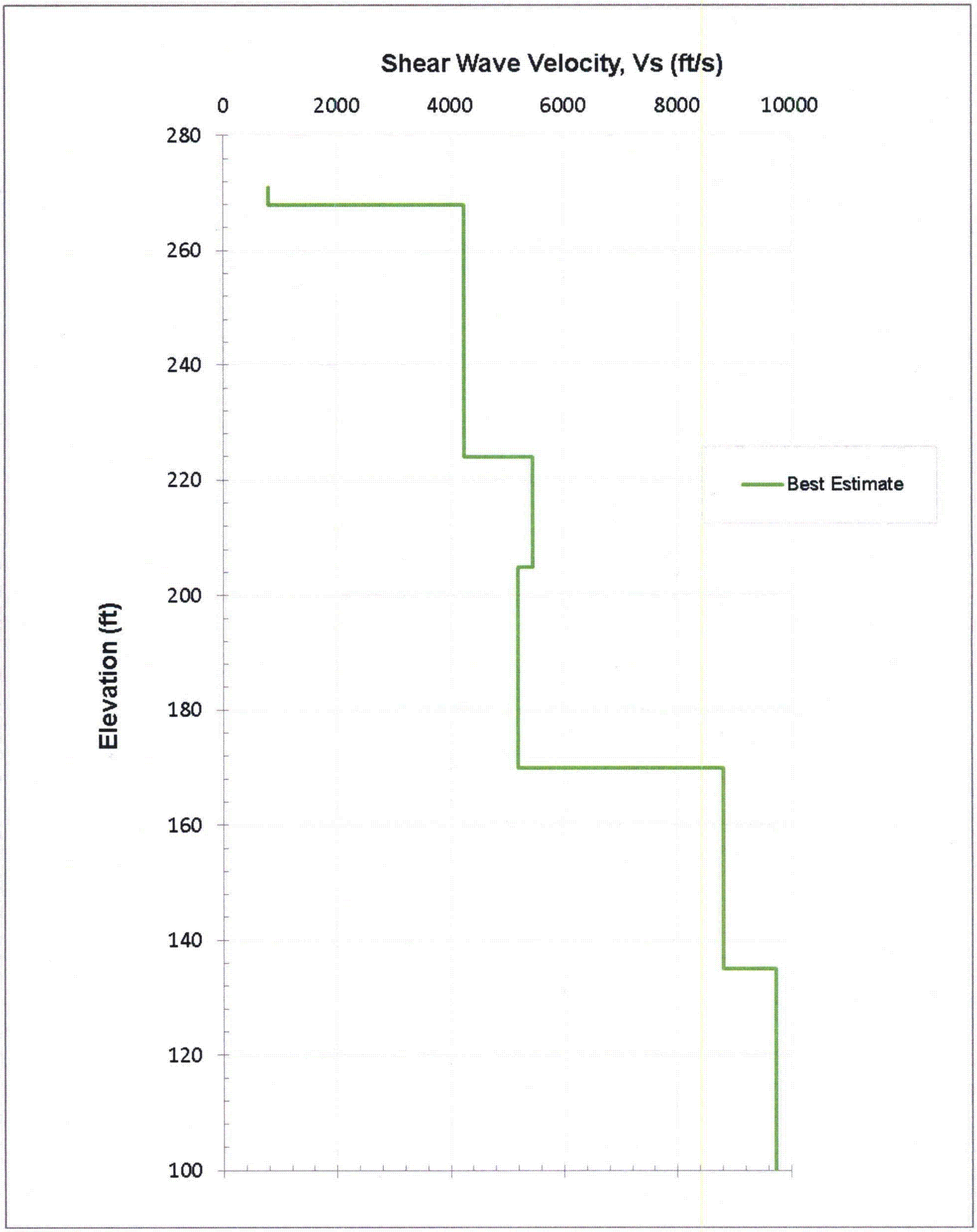

Figure 1: Base Case V_S Profile

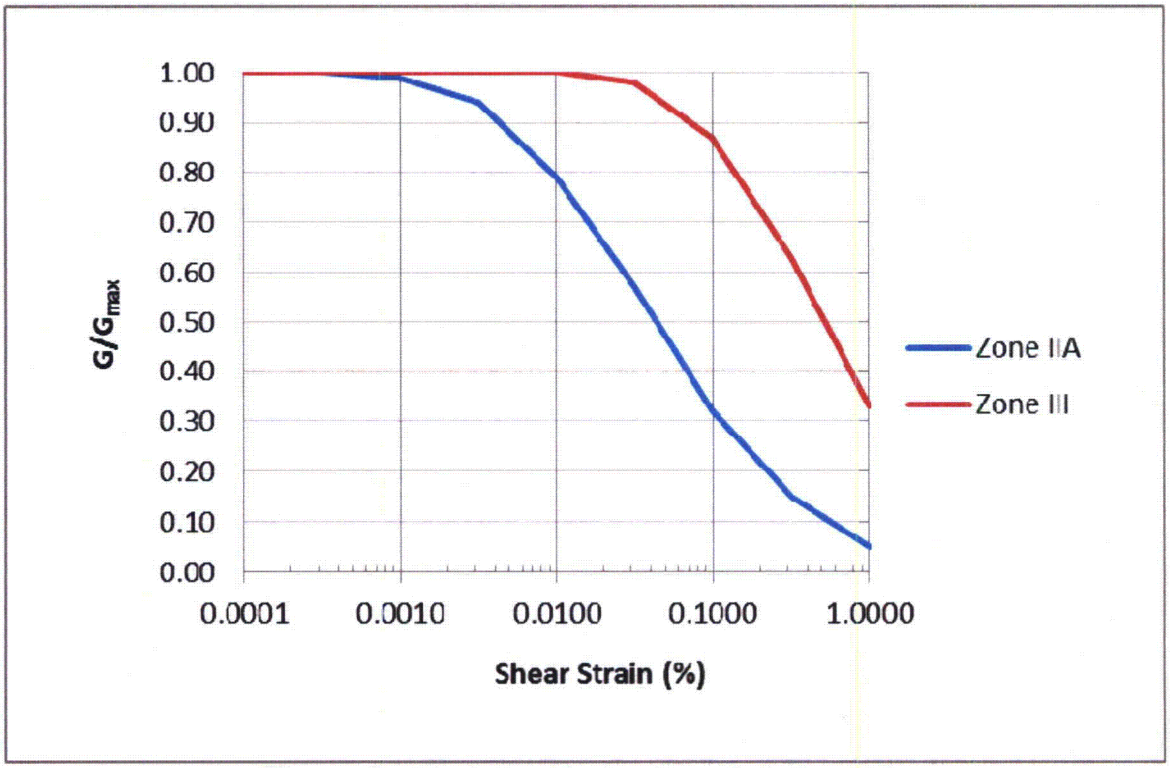

Figure 2: Modulus Reduction Relationship

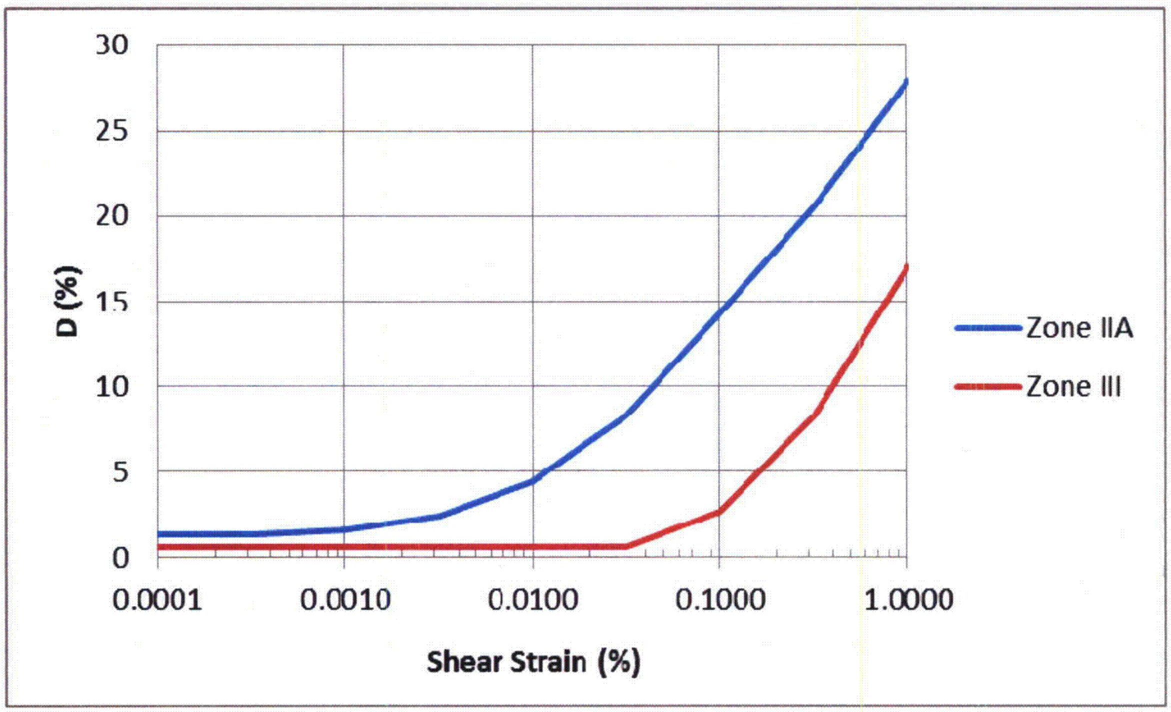

Figure 3: Damping Ratio Relationship