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December 23, 2008

Document Control Desk
U.S. Nuclear Regulatory Commission
Washington, DC 20555-0001

Subject: Duke Energy Carolinas, LLC.
William States Lee III Nuclear Station - Docket Nos. 52-018 and 52-019
AP1000 Combined License Application for the
William States Lee III Nuclear Station Units 1 and 2
Response to Request for Additional Information
(RAI No. 1473)
Ltr# WLG2008.12-28

Reference: Letter from Brian Hughes (NRC) to Peter Hastings (Duke Energy), *Request For Additional Information Letter No. 044 Related To SRP Section 02.05.04 – Stability of Subsurface Materials and Foundations Application for the William States Lee III Units 1 and 2 Combined License Application*, dated October 29, 2008

This letter provides the Duke Energy responses to the Nuclear Regulatory Commission's request for additional information (RAI) included in the referenced letter.

The responses to the NRC information request described in the referenced letter are addressed in separate enclosures, which also identify associated changes, when appropriate, that will be made in a future revision of the Final Safety Analysis Report for the Lee Nuclear Station.

If you have any questions or need any additional information, please contact Peter S. Hastings, Nuclear Plant Development Licensing Manager, at 980-373-7820.

Bryan J. Dolan
Vice President
Nuclear Plant Development

D093
NRO

Enclosures:

1) Duke Energy Response to Request for Additional Information Letter 044, RAI 02.05.04-001
2) Duke Energy Response to Request for Additional Information Letter 044, RAI 02.05.04-002
3) Duke Energy Response to Request for Additional Information Letter 044, RAI 02.05.04-003
4) Duke Energy Response to Request for Additional Information Letter 044, RAI 02.05.04-004
5) Duke Energy Response to Request for Additional Information Letter 044, RAI 02.05.04-005
6) Duke Energy Response to Request for Additional Information Letter 044, RAI 02.05.04-006
7) Duke Energy Response to Request for Additional Information Letter 044, RAI 02.05.04-007
8) Duke Energy Response to Request for Additional Information Letter 044, RAI 02.05.04-008
9) Duke Energy Response to Request for Additional Information Letter 044, RAI 02.05.04-009

AFFIDAVIT OF BRYAN J. DOLAN

Bryan J. Dolan, being duly sworn, states that he is Vice President, Nuclear Plant Development, Duke Energy Carolinas, LLC, that he is authorized on the part of said Company to sign and file with the U. S. Nuclear Regulatory Commission this supplement to the combined license application for the William States Lee III Nuclear Station and that all the matter and facts set forth herein are true and correct to the best of his knowledge.

Bryan J. Dolan

Subscribed and sworn to me on December 23, 2008

Notary Public

My commission expires: April 19, 2010

SEAL

KIM N. SLAYS
NOTARY PUBLIC
NEW HANOVER COUNTY, N.C.

xc (w/o enclosures):

Loren Plisco, Deputy Regional Administrator, Region II
Stephanie Coffin, Branch Chief, DNRL

xc (w/ enclosures):

Brian Hughes, Senior Project Manager, DNRL

Lee Nuclear Station Response to Request for Additional Information (RAI)

RAI Letter No. 044

NRC Technical Review Branch: Geotechnical Engineering Branch 1 (RGS1)

Reference NRC RAI Number(s): 02.05.04-001

NRC RAI:

FSAR Section 2.5.4.8, "Liquefaction Potential" states: "In meeting the requirements of 10 CFR Parts 50 and 100, if the foundation materials at the site adjacent to and under Category I structures and facilities are saturated soils and the water table is above bedrock, then an analysis of the liquefaction potential at the site is required." The compaction criteria is 95% of standard Proctor compacted within 3 % wet of optimum, which does not necessarily preclude liquefaction in the backfill. Given that the AP1000 DCD Tier 1 requirement is for no liquefaction, please provide additional justification/analysis to demonstrate the stability of the backfill during strong ground motion shaking.

Duke Energy Response:

Liquefaction analysis for foundation materials adjacent to Seismic Category I structures is described in a supplemental technical report titled, *"Summary of Liquefaction Evaluation Results for Seismic Category II and Nonseismic Power Block Structures for William States Lee III Nuclear Station."* This report was submitted to the NRC Document Control desk on May 23, 2008 (ML081500028) (Reference 1). Evaluations summarized in this report do not extend to the seismic Category I nuclear island structures because, as indicated in FSAR Subsection 2.5.4.8 and elsewhere, these safety-related structures are founded on continuous rock or fill concrete over continuous rock. Neither fill concrete nor rock are susceptible to seismically induced liquefaction as discussed in FSAR Section 2.5.4.8.

The analyses presented in Reference 1 confirm the absence of liquefaction in the proposed backfill materials and demonstrate that the William States Lee III Nuclear Site condition has been evaluated as specified in DCD Rev. 16 Subsection 2.5.4.6.5 and meets the Tier 1 criterion in DCD Table 5.0-1. Since DCD Rev. 17 Subsection 2.5.4.6.5 is unchanged from Rev. 16, and the Tier 1 criterion in DCD Table 5.0-1 was changed from "none" to "negligible" in Rev. 17, compliance with DCD Rev. 17 is also assured.

Reference:

1) Bryan J. Dolan to Document Control Desk, U.S. Nuclear Regulatory Commission, *William States Lee III Nuclear Station Units 1 and 2, Liquefaction Evaluation Results for Seismic Category II and Non-Seismic Power Block Structures*, dated May 23, 2008.

Associated Revision to the Lee Nuclear Station Final Safety Analysis Report:

None

Attachments:

None

Lee Nuclear Station Response to Request for Additional Information (RAI)

RAI Letter No. 044

NRC Technical Review Branch: **Geosciences and Geotechnical Engineering Branch 1 (RGS1)**

Reference NRC RAI Number(s): **02.05.04-002**

NRC RAI:

In FSAR Section 2.5.4.7, "Response of Soil and Rock to Dynamic Loading," Figures 2.5.4-253 2.5.4-254, you present the RCTS testing performed in conformance with the requirements of Regulatory Guide 1.138. There is variability in the RCTS test data over the range of testing pressures and the plotted test data lie outside beyond the limits of the two selected EPRI curves. Please justify how the selected curves represent the site-specific test data.

Duke Energy Response:

FSAR Subsection 2.5.4.7.3 describes the results of dynamic laboratory testing of five samples, two undisturbed existing fill and three remolded (laboratory compacted) borrow area fill samples, that are used to define the dynamic properties of Group I engineered fill. These materials were evaluated for backfill outside the Category I nuclear island structures as described in FSAR Subsection 2.5.4.5.3.5. The damping ratio and modulus reduction curves were obtained from Resonant Column Torsional Shear (RCTS) testing under the supervision of Dr. K.H. Stokoe II of the Geotechnical Engineering Center at the University of Texas at Austin. Laboratory confining stresses over a range of values were used in the testing. The modulus reduction curve test values were compared to the depth dependent modulus reduction ratios developed by EPRI (1993, FSAR Reference 2.5.2-273).

The RCTS lab testing was performed on a range of isotropic pressures to bracket estimates of in-situ confining pressure (K_o). The K_o values used for sample testing were estimated values. The K_o for compacted fill is estimated to be 0.9 (FSAR 2.5.4.10.3). The laboratory-measured small strain shear modulus shear wave velocity, G_{max} (V_s), value from the RCTS tests should approximately agree with the field-measured in-situ V_s value at the corresponding depth if the K_o assumption is approximately correct and if the effect of aging on the in-situ G_{max} is relatively minor. The laboratory and in-situ V_s values were compared at small strain conditions to estimate if the RCTS tests at 1X estimated confining stress in-situ (σ_o) using K_o = 1 appear to be representative of the in-situ measured V_s. The evaluation of the lab-measured V_s to field-measured V_s for the existing Group I engineered fill, samples, B-1068-UD, S-3 (Figure 1) and B-1068-UD, S-5, (Figure 2) show good correlation using the lab mean confining stress to represent the in-situ confining stress at K_o equal to 1 (field V_s 750fps/lab V_s 870 fps) and (field V_s 740fps/lab V_s 788 fps), respectively. Therefore, the lab tests at 1X estimated in-situ confining stress are considered representative of the in-situ condition.

The factors considered in matching results of the RCTS tests with the appropriate EPRI curves included the material index properties, groundwater conditions, depth of sample, and potential thickness of fill. Because the soil types considered for backfill are generally low plasticity to nonplastic, the sand curves as presented in FSAR Figures 2.5.4-253 and 2.5.4-254 were selected. Figures 3 through 7 describe shear modulus and damping ratio plots for two Existing Group I Engineered Fill and three Remolded Samples at 1X in-situ confining stress, (σ_0 estimated with K_0 equal to 1). These plots justify the selection of the two EPRI curves, 0-20 feet and 20-50 feet, as described in FSAR Subsection 2.5.4.7.3. The selected curves span the observed range of dynamic properties and are used to evaluate site-specific epistemic variability of proposed Group I engineered fill. For site response analyses (Reference 1) of non-Category I structures founded on or over compacted Group I engineered fill over continuous rock, or Group I engineered fill over saprolite soils overlying partially weathered / continuous rock, the process used in evaluating epistemic variability adequately accounts for the minor differences in the test curves and the two EPRI curves. One remolded sample, T-1422, Figure 7, is somewhat inconsistent with the EPRI curve but this is not considered significant since this is only one out of the five RCTS tests representing the future Group I engineered backfill.

Reference:

1) Bryan J. Dolan to Document Control Desk, U.S. Nuclear Regulatory Commission, *William States Lee III Nuclear Station Units 1 and 2, Liquefaction Evaluation Results for Seismic Category II and Non-Seismic Power Block Structures*, dated May 23, 2008.

Associated Revision to the Lee Nuclear Station Final Safety Analysis Report:

None

Attachment:

1) Figures 1 and 2, illustrating variation in low amplitude shear wave velocity with isotropic confining pressure from RC tests of existing engineered fill, and Figures 3 through 7, illustrating shear modulus and damping ratio plots for selected existing engineered fill and remolded samples (1X confining stress)

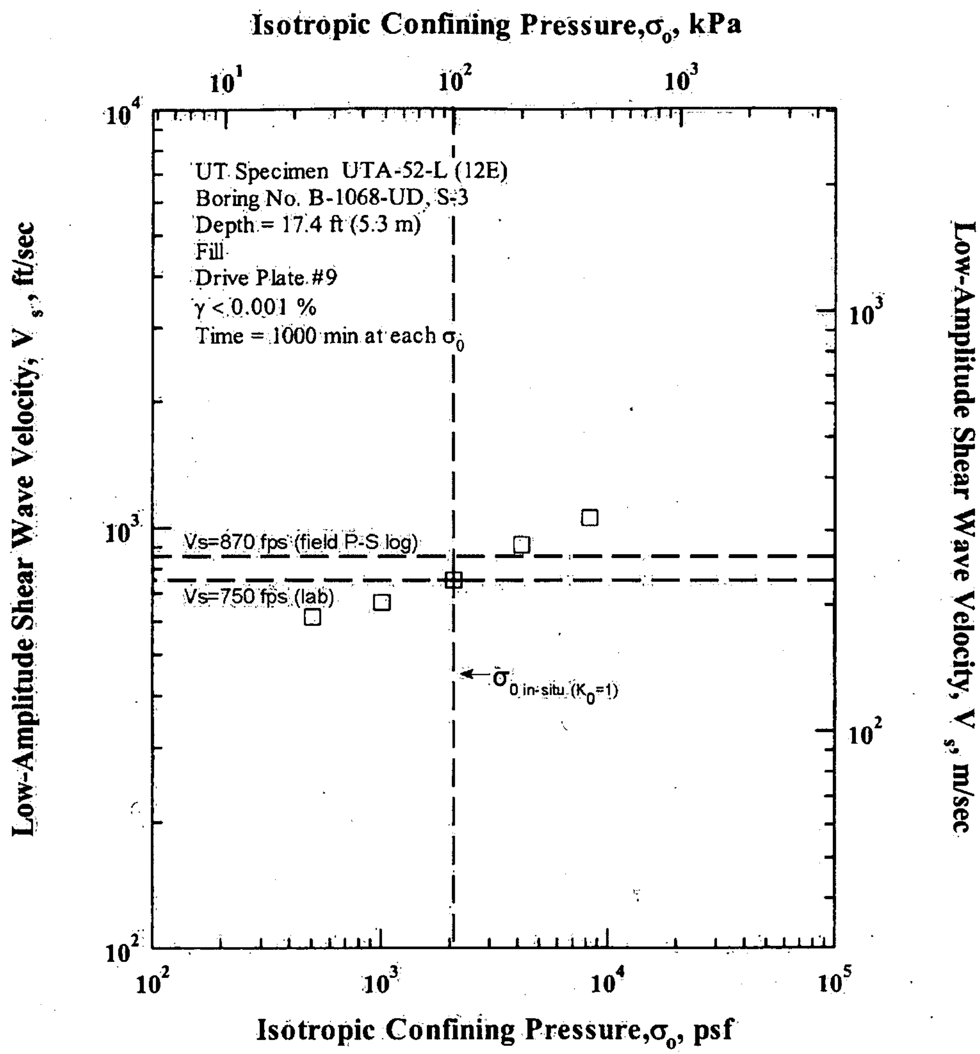
Lee Nuclear Station Response to Request for Additional Information (RAI)

Attachment 1 to RAI 02.05.04-002

Figures 1 and 2. Variation in Low Amplitude Shear Wave Velocity with Isotropic Confining Pressure from RC Tests of Existing Engineered Fill

Figures 3 through 7. Shear Modulus and Damping Ratio Plots for RCTS

Existing Engineered Fill and Remolded Samples



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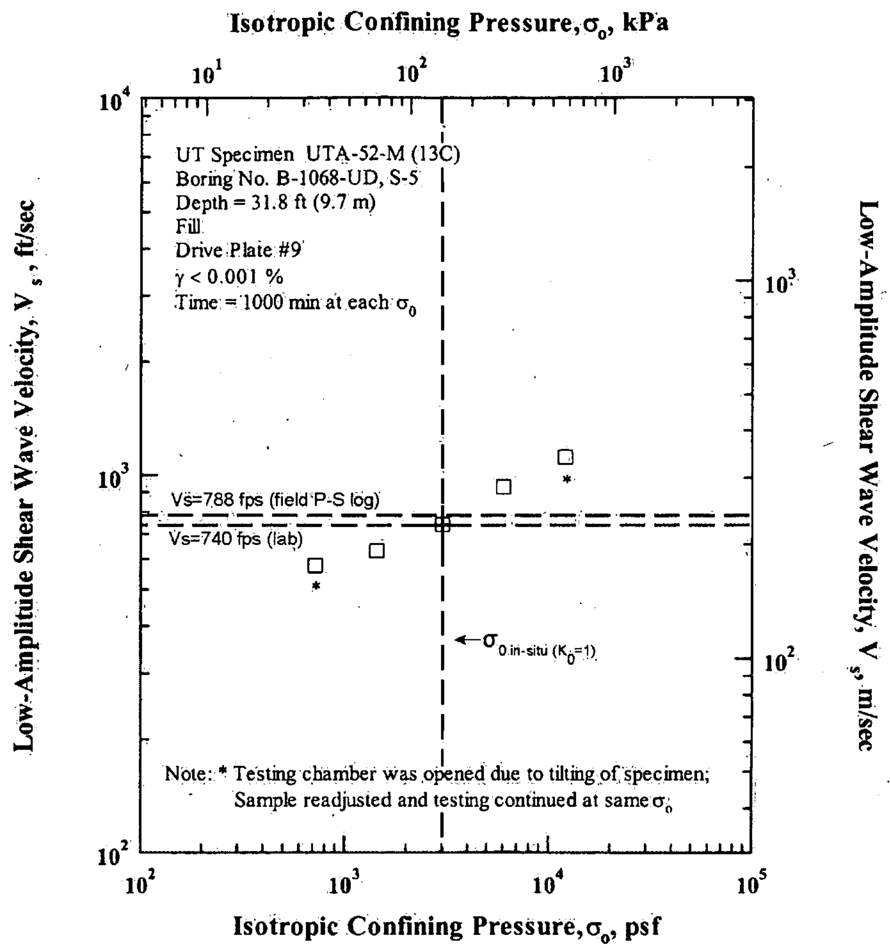
NUCLEAR STATION UNITS 1 & 2

Variation in Low-Amplitude Shear Wave Velocity with Isotropic Confining Pressure from Resonant Column Test of Fill Specimen Sample B-1068-UD3 (UTA-52-L (12E))

FIGURE 1 Rev 0

1990 RAI Duke Lee Phase 2_NK_2.5.4-2



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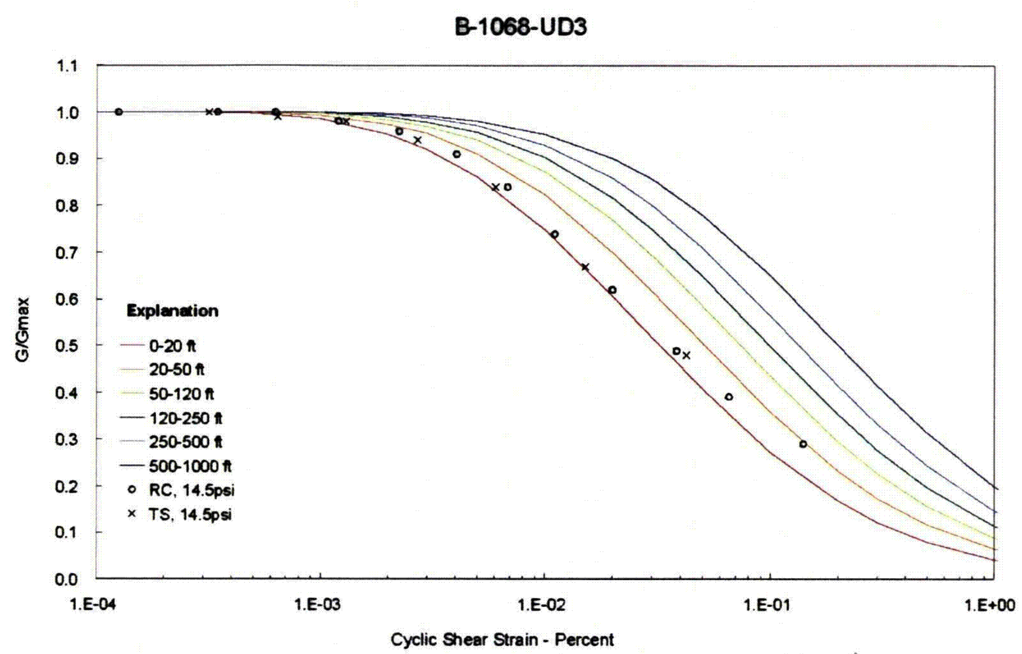
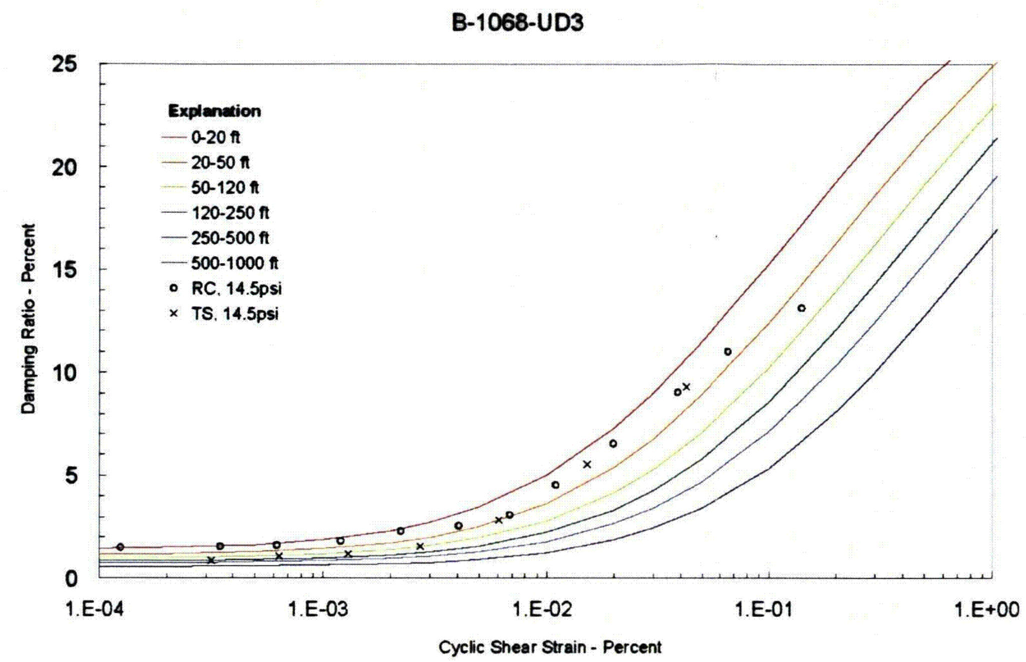
NUCLEAR STATION UNITS 1 & 2

Variation in Low-Amplitude Shear Wave Velocity with Isotropic Confining Pressure from Resonant Column Test of Fill Specimen Sample B-1068-UD5 (UTA-52-M (13C))

FIGURE 2 Rev 0

1990 RAI Duke Lee Phase 2_NK_2.5.4-2





Sample Mid-Depth = 17.4 ft.

Resonant Column Tests - In Situ (Isotropic Confining Pressure = 14.5 psi)

Peak Shear Strain %	G/Gmax	Damping Ratio %
1.25E-04	1.00	1.48
3.46E-04	1.00	1.56
6.23E-04	1.00	1.61
1.20E-03	0.98	1.83
2.23E-03	0.96	2.29
4.04E-03	0.91	2.54
6.82E-03	0.84	3.06
1.10E-02	0.74	4.54
1.99E-02	0.62	6.54
3.83E-02	0.49	9.02
6.55E-02	0.39	11.03
1.40E-01	0.29	13.12

Torsional Shear Tests, 10th Cycle - In Situ (Isotropic Confining Pressure = 14.5 psi)

Peak Shear Strain %	G/Gmax	Damping Ratio %
3.18E-04	1.00	0.83
6.40E-04	0.99	1.04
1.30E-03	0.98	1.16
2.71E-03	0.94	1.53
6.07E-03	0.84	2.80
1.52E-02	0.67	5.51
4.22E-02	0.48	9.30

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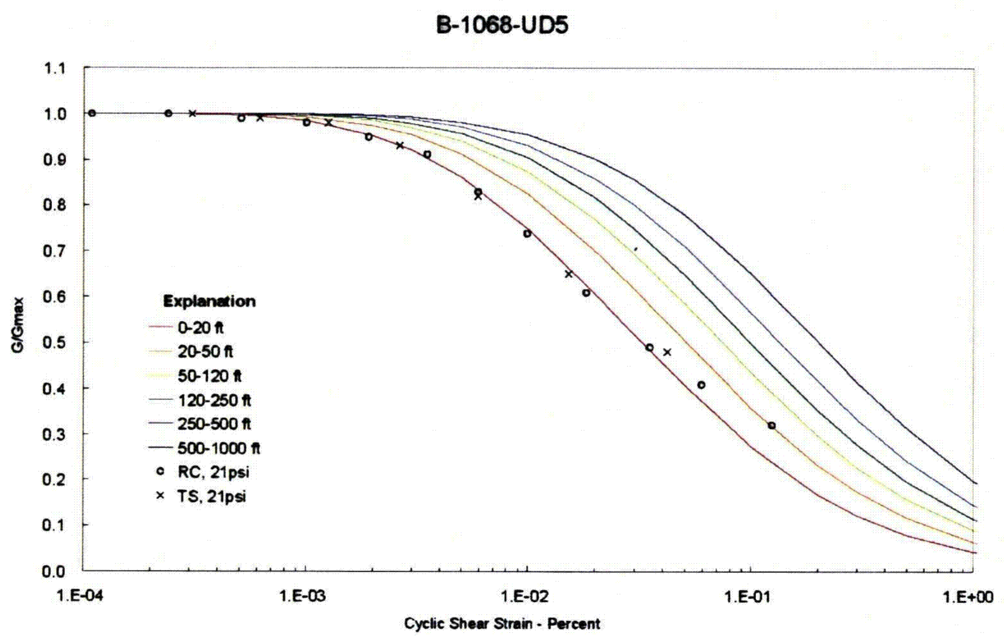
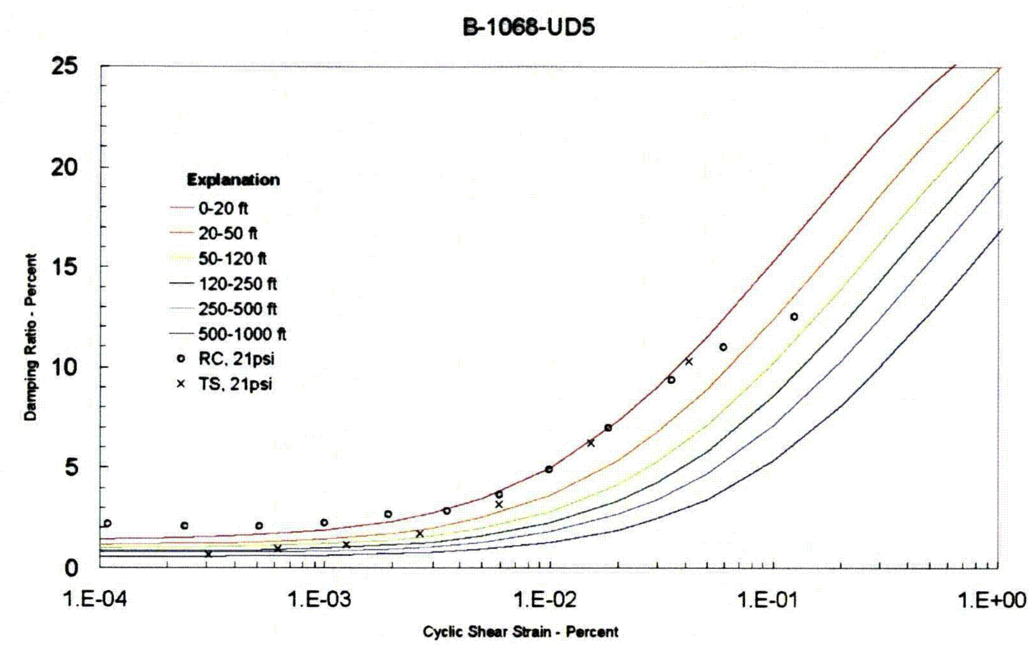
NUCLEAR STATION UNITS 1 & 2

Shear Modulus and Damping Ratio Plots for RCTS Sample B-1068-UD3 - Existing Engineered Fill (1X Confining Stress)

FIGURE 3 Rev 0

1990 RAI Duke Lee Phase 2_NK_2.5.4-2





Sample Mid-Depth = 31.8 ft.

Resonant Column Tests - In Situ (Isotropic Confining Pressure = 21.0 psi)

Peak Shear Strain %	G/Gmax	Damping Ratio %
3.11E-05	1.00	1.76
1.08E-04	1.00	2.17
2.38E-04	1.00	2.05
5.10E-04	0.99	2.05
1.00E-03	0.98	2.23
1.90E-03	0.95	2.65
3.49E-03	0.91	2.82
5.96E-03	0.83	3.64
9.93E-03	0.74	4.89
1.81E-02	0.61	6.99
3.49E-02	0.49	9.37
5.94E-02	0.41	11.04
1.24E-01	0.32	12.55

Torsional Shear Tests, 10th Cycle - In Situ (Isotropic Confining Pressure = 21.0 psi)

Peak Shear Strain %	G/Gmax	Damping Ratio %
3.07E-04	1.00	0.67
6.18E-04	0.99	0.94
1.25E-03	0.98	1.13
2.64E-03	0.93	1.67
5.98E-03	0.82	3.14
1.52E-02	0.65	6.25
4.17E-02	0.48	10.33

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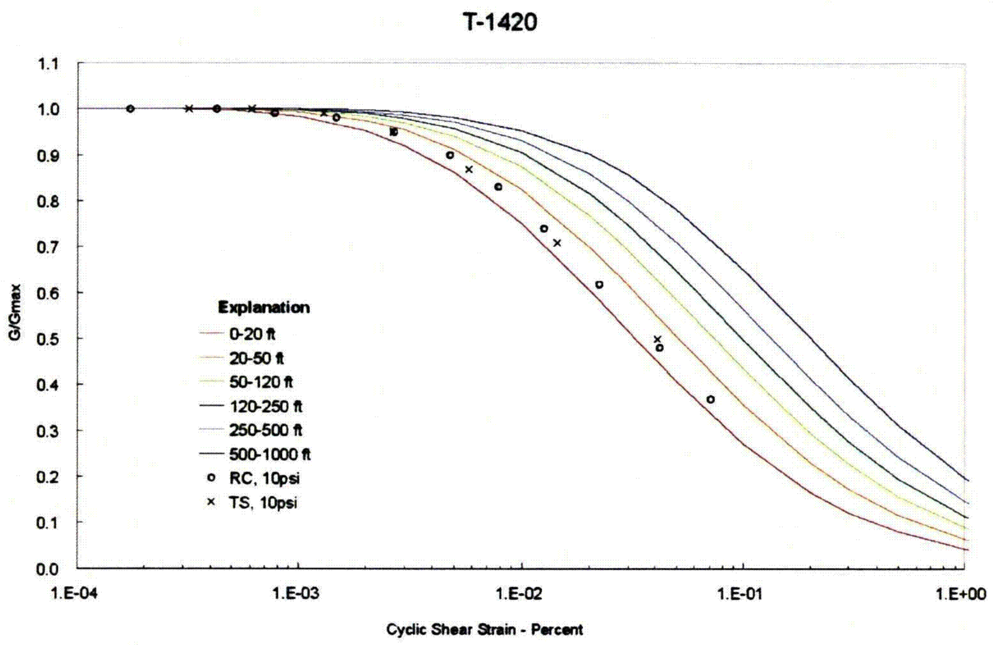
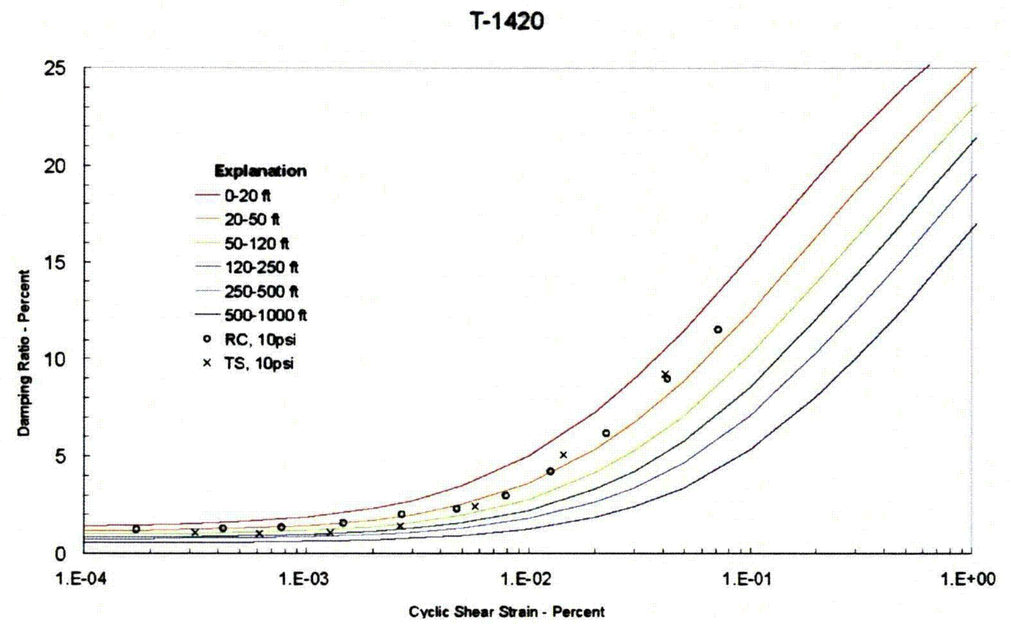
NUCLEAR STATION UNITS 1 & 2

Shear Modulus and Damping Ratio Plots for RCTS Sample B-1068-UD5 - Existing Engineered Fill (1X Confining Stress)

FIGURE 4 Rev 0





Sample Mid-Depth = 10 ft.

Resonant Column Tests - In Situ (Isotropic Confining Pressure = 10 psi)

Peak Shear Strain %	G/Gmax	Damping Ratio %
4.12E-05	1.00	1.33
1.72E-04	1.00	1.26
4.23E-04	1.00	1.28
7.69E-04	0.99	1.35
1.47E-03	0.98	1.58
2.67E-03	0.95	2.03
4.77E-03	0.90	2.33
7.85E-03	0.83	2.98
1.26E-02	0.74	4.25
2.22E-02	0.62	6.21
4.19E-02	0.48	9.02
7.13E-02	0.37	11.55

Torsional Shear Tests, 10th Cycle - In Situ (Isotropic Confining Pressure = 10 psi)

Peak Shear Strain %	G/Gmax	Damping Ratio %
3.15E-04	1.00	1.06
6.13E-04	1.00	1.04
1.28E-03	0.99	1.09
2.65E-03	0.95	1.43
5.76E-03	0.87	2.43
1.44E-02	0.71	5.04
4.08E-02	0.50	9.25

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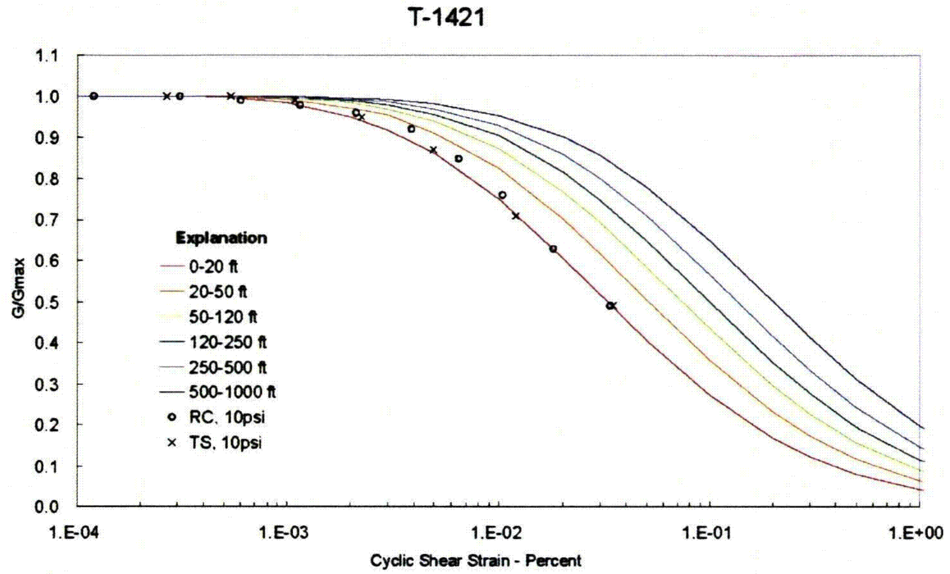
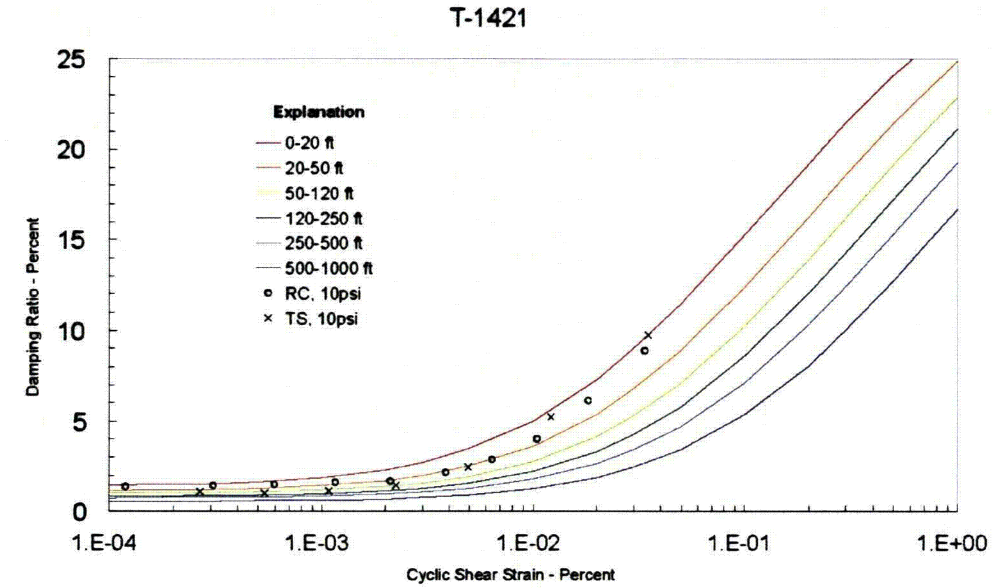
NUCLEAR STATION UNITS 1 & 2

Shear Modulus and Damping Ratio Plots for RCTS Sample T-1420 - Remolded (1X Confining Stress)

FIGURE 5 Rev 0

1990 RAI Duke Lee Phase 2_NK_2.5.4-2





Sample Mid-Depth = 10 ft.

Resonant Column Tests - In Situ (Isotropic Confining Pressure = 10 psi)

Peak Shear Strain %	G/Gmax	Damping Ratio %
3.73E-05	1.00	1.39
1.20E-04	1.00	1.38
3.08E-04	1.00	1.43
5.98E-04	0.99	1.50
1.15E-03	0.98	1.60
2.12E-03	0.96	1.66
3.86E-03	0.92	2.17
6.45E-03	0.85	2.86
1.04E-02	0.76	4.04
1.81E-02	0.63	6.10
3.35E-02	0.49	8.88

Torsional Shear Tests, 10th Cycle - In Situ (Isotropic Confining Pressure = 10 psi)

Peak Shear Strain %	G/Gmax	Damping Ratio %
2.66E-04	1.00	1.06
5.35E-04	1.00	1.04
1.08E-03	0.99	1.14
2.24E-03	0.95	1.45
4.92E-03	0.87	2.48
1.21E-02	0.71	5.20
3.47E-02	0.49	9.76

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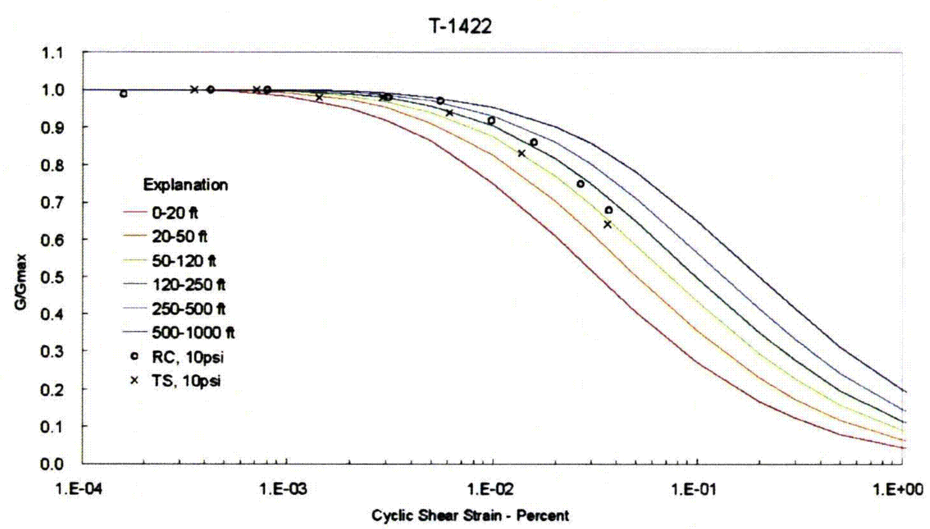
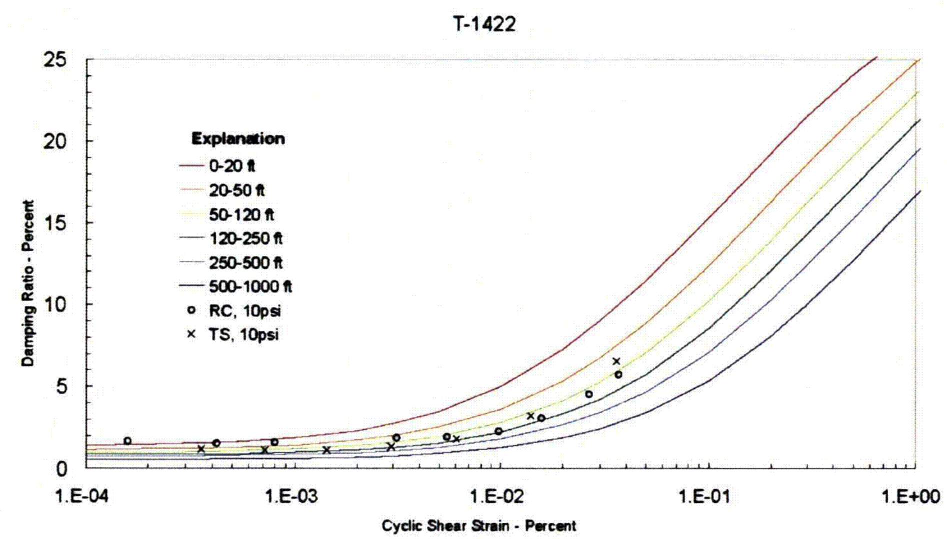
NUCLEAR STATION UNITS 1 & 2

Shear Modulus and Damping Ratio Plots for RCTS Sample T-1421 - Remolded (1X Confining Stress)

FIGURE 6 Rev 0

1990 RAI Duke Lee Phase 2_NK_2 5.4-2





Sample Mid-Depth = 10 ft.

Resonant Column Tests - In Situ (Isotropic Confining Pressure = 10 psi)

Peak Shear Strain %	G/Gmax	Damping Ratio %
1.66E-05	1.00	1.52
4.22E-04	1.00	1.55
8.03E-04	1.00	1.58
1.59E-04	0.99	1.65
3.08E-03	0.98	1.84
5.48E-03	0.97	1.94
9.73E-03	0.92	2.29
1.57E-02	0.86	3.06
2.66E-02	0.75	4.53
3.68E-02	0.68	5.75

Torsional Shear Tests, 10th Cycle - In Situ (Isotropic Confining Pressure = 10 psi)

Peak Shear Strain %	G/Gmax	Damping Ratio %
3.55E-04	1.00	1.21
7.14E-04	1.00	1.16
1.43E-03	0.98	1.16
2.91E-03	0.98	1.31
6.06E-03	0.94	1.80
1.38E-02	0.83	3.22
3.62E-02	0.64	6.58

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NUCLEAR STATION UNITS 1 & 2

Shear Modulus and Damping Ratio Plots for RCTS Sample T-1422 - Remolded (1X Confining Stress)

FIGURE 7 Rev 0

1990 RAI Duke Lee Phase 2_NK_2.5.4-2

Lee Nuclear Station Response to Request for Additional Information (RAI)

RAI Letter No. 044

NRC Technical Review Branch: Geotechnical Engineering Branch 1 (RGS1)

Reference NRC RAI Number(s): 02.05.04-003

NRC RAI:

FSAR Figure 2.5.4-240 shows adjacent borings 1074 and 1074A at the northwest edge of the Lee Unit 1 nuclear island. The near surface Rock Quality Designations (RQDs) for these two core borings are quite dissimilar, with boring 1074 not demonstrating sound rock (RQD > 65%) until approximately El. 505. Figure 2.5.4-245 shows conceptually the planned excavation to continuous rock at that location. Please describe how you will ensure that your excavation scheme will meet your design assumptions for continuous rock (RQD > 65%). Also, if rock of lower RQD and less structural integrity remains after the excavation reaches the final depth, please describe how this will affect the dynamic bearing capacity of the northwest corner.

Duke Energy Response:

Boring 1074 encountered difficulty during drilling, and the driller abandoned 1074 and moved six ft away to drill 1074A. Boring 1074 had not indicated sound rock (RQD > 65%) when it was terminated at approximately El. 501.5; Boring 1074A indicated sound rock (RQD > 65%) at approximately El. 505. The RQD values above these elevations are dissimilar as pointed out in the RAI. The lower RQD in Boring 1074 may be due to mechanical drill breakage of the core and/or the presence of steeply dipping meta-diorite dike in the vicinity of these borings. Where such dikes are encountered in the rock, if a narrow soft zone of lower RQD is observed, it is treated as described in FSAR Subsection 2.5.4.12 and Figures 2.5.4-257 through 2.5.4-259. The procedure described in the FSAR and shown on these Figures results in a rock surface that meets the design assumptions for continuous rock. Thus any rock of lower RQD and less structural integrity that remains after the excavation reaches the final depth will be confined to narrow zones treated as shown on FSAR Figures 2.5.4-257 through 2.5.4-259 and will not affect the static or dynamic bearing capacity of the northwest corner.

Associated Revision to the Lee Nuclear Station Final Safety Analysis Report:

None

Attachments:

None

Lee Nuclear Station Response to Request for Additional Information (RAI)

RAI Letter No. 044

NRC Technical Review Branch: Geotechnical Engineering Branch 1 (RGS1)

Reference NRC RAI Number(s): 02.05.04-004

NRC RAI:

FSAR Table 2.5.4-211, note "h" states, "The design engineer (i.e., engineer that will use data for design) must give careful consideration to compressibility and strength parameters based on test data, and the values reported in this table are estimates." This note applies to the existing soils, fill soils and partially weathered rock for the following parameters: overconsolidation ratio, preconsolidation pressure, compression index, re-compression index, consolidation coefficient, total cohesion, total friction angle, effective cohesion, and effective friction angle. Since the nuclear islands are founded on either rock or concrete overlying rock, please confirm that this comment does not refer to the foundation support of the nuclear island. Please also clarify how this data was used in the design of safety related structures. If any aspect of the design of safety related structures depended on assumed or estimated soil properties, please justify using estimated strength parameters for that purpose.

Duke Energy Response:

FSAR Table 2.5.4-211 does not address rock and/or concrete over rock used to support the nuclear island. Table 2.5.4-211 addresses only soil used to support non-safety related structures. No safety related structures are supported on soil. FSAR Table 2.5.4-211, note "h" does not refer to the rock used for foundation support of the nuclear island. The data being referenced is for soil and was not used in the design of foundations for safety related structures. The only soil data in Table 2.5.4-211 relevant to the design of safety-related structures is for remolded fill which is input for calculation of the static and dynamic lateral earth pressure against the nuclear island walls. Note "h" is referring to the design of foundations for the non-safety related structures to be supported on or over the backfill and other soils. FSAR Subsection 2.5.4.2.4.2 will be updated to clarify the intended use of Table 2.5.4-211.

The FSAR revisions described above will be included in a future FSAR revision.

Associated Revision to the Lee Nuclear Station Final Safety Analysis Report:

FSAR Subsection 2.5.4.2.4.2 Static Properties of Geotechnical Materials

Attachments:

1) Mark-up of FSAR Subsection 2.5.4.2.4.2

Lee Nuclear Station Response to Request for Additional Information (RAI)

Attachment 1 to RAI 02.05.04-004

Mark-up of FSAR Subsection 2.5.4.2.4.2

COLA Part 2, FSAR. Chapter 2, Subsection 2.5.4.2.4.2 will be revised as follows:

2.5.4.2.4 Static Properties of Geotechnical Materials

Static geotechnical properties were compiled for the materials which comprise the Geotechnical Model, as described in Subsection 2.5.4.2.4.1. Material properties for alluvial soils are not included due to the limited presence of these materials at the site.

Static geotechnical properties for the soil materials described in the Geotechnical Model are provided in Table 2.5.4-211. Table 2.5.4-211 lists soil properties used to support non-safety related structures as no safety related structures are supported on soil. Table values listed for remolded fill samples are used as input for calculation of the static and dynamic lateral earth pressure against the nuclear island walls. Corrosion test results (pH, resistivity, chlorides, and sulfates) for remolded fill soils are provided in Table 2.5.4-212. Static geotechnical properties for the rock materials described in the Geotechnical Model are provided in Table 2.5.4-213. The properties reported in these tables are average properties based on the laboratory results from samples obtained during the Lee Nuclear Station Site exploration in 2006-2007. Standard deviations are reported when the amount of data was sufficient to allow calculation of this value. Data from the Cherokee Nuclear Station Preliminary Safety Analysis Report was used, only where indicated in the table, to supplement the information obtained during the Lee Nuclear Station Site exploration for soils where limited data was available, such as the partially weathered rock.

Static geotechnical properties for the concrete placed during Cherokee Nuclear Station are not available at the time of the application. Portions of the Cherokee Nuclear Station concrete that will remain under Lee Nuclear Station Unit 1 are described in Subsection 2.5.4.5. Additional field and laboratory testing will be performed on portions of the Cherokee Nuclear Station concrete where it will remain in place beneath the Lee Nuclear Station Unit 1 nuclear island. This testing will verify that the Cherokee Nuclear Station concrete conforms to the requirements for plain structural concrete in DCD Subsection 2.5.4.6.3.

Dynamic geotechnical properties for the soil and rock materials described in the Geotechnical Model are described in Subsection 2.5.4.7.

Lee Nuclear Station Response to Request for Additional Information (RAI)

RAI Letter No. 044

NRC Technical Review Branch: Geotechnical Engineering Branch 1 (RGS1)

Reference NRC RAI Number(s): 02.05.04-005

NRC RAI:

Section 2.5.4.7.4.1 of the FSAR states, "The rock conditions described for the Lee Nuclear Station Unit 1 nuclear island northwest corner have no practical significance on differential shear wave velocity, site amplification or foundation performance and comply with the subsurface uniformity criteria as described in DCD Subsection 2.5.4.5." Please clarify the statement, i.e., does the statement refer only to rock motions under the Lee Unit 1 nuclear island? Does the statement also refer to the non-uniform overburden and fill conditions above the rock? Figure 2.5.4-245 shows a significant difference between the combined overburden and backfill depths east and west of Lee Unit 1. Please describe how the variable site conditions above the rock were considered in the liquefaction analyses.

Duke Energy Response:

The statement from FSAR Subsection 2.5.4.7.4.1, cited by the reviewer, applies to both static stability and the dynamic response of foundation rock within the influence zone of the Unit 1 nuclear island foundation. In the context of FSAR Subsection 2.5.4.7.4.1, the statement specifically applies to dynamic response of materials. FSAR Subsection 2.5.4.10 describes the Lee Nuclear Station nuclear island static stability evaluations for foundation bearing capacity, foundation settlement, and lateral pressures against below-grade walls. The results of dynamic and static evaluations described in the FSAR Subsections 2.5.4.7.4.1 and 2.5.4.10 confirm that the rock to support fill concrete under the nuclear island foundations in the northwest corner is foundation-quality rock. Thus the relative variations in rock properties between the rock beneath the northwest corner and elsewhere are not significant; the northwest corner rock strength and moduli are well above requirements for foundation bearing capacity and settlement, and therefore do not represent a potential for adverse differential foundation response to applied loads.

FSAR Figure 2.5.4-245, Planned Excavation Profile, Geologic Cross Section U-U' (Unit 1, East-West) was updated as part of the response to RAI response 03.08.05-002 (Reference 1). The original FSAR Figure 2.5.4-245 did not portray the character of the excavated slope that will, of necessity, be irregular due to the controlled blasting required to remove the rock designated as "transition to continuous rock" in order to reach the continuous rock within the influence zone of the nuclear island foundation. Revised FSAR Figure 2.5.4-245 clarifies that the sloping rock surface to receive and support fill concrete will be formed by excavating in benches formed in the continuous rock (refer to the Typical Rock Excavation Detail, Note 1, on the revised figure). Note 1 states that the benches shall be no more than 8 ft apart vertically and shall be at least 2 ft wide. Also, FSAR Figure 2.5.4-245 is revised to show that the entire excavated area below the top of "transition to continuous rock" is to be backfilled with the fill concrete rather than with the "artificial (soil) fill" within the influence zone of the nuclear island foundation. This excavation configuration provides a uniform subgrade condition in this area.

The range of post-construction site conditions and material properties were considered in the liquefaction analyses for seismic Category II and nonseismic power block structures. The liquefaction analysis results are contained in Reference 1. Variable site conditions were considered in the liquefaction analyses by utilizing the appropriate boring data. The peak ground acceleration used in the liquefaction analyses was obtained from an envelope of surface accelerations from multiple soil column analyses including fill over hard rock and fill over saprolite which lies over hard rock. In this way, the variable overburden and backfill depths above the rock were considered and fully evaluated in the liquefaction analysis.

Reference:

1) Bryan J. Dolan to Document Control Desk, U.S. Nuclear Regulatory Commission, WLG2008.12-25, *William States Lee III Nuclear Station Units 1 and 2 Response to Request for Additional Information (RAI Nos. 1003 and 1004)*, dated December 17, 2008.

2) Bryan J. Dolan to Document Control Desk, U.S. Nuclear Regulatory Commission, *William States Lee III Nuclear Station Units 1 and 2, Liquefaction Evaluation Results for Seismic Category II and Non-Seismic Power Block Structures)*, dated May 23, 2008.

Associated Revision to the Lee Nuclear Station Final Safety Analysis Report:

None

Attachments:

None

Lee Nuclear Station Response to Request for Additional Information (RAI)

RAI Letter No. 044

NRC Technical Review Branch: Geotechnical Engineering Branch 1 (RGS1)

Reference NRC RAI Number(s): 02.05.04-006

NRC RAI:

The bearing capacity for Lee Units 1 and 2, described in FSAR Section 2.5.4.10.1 "Bearing Capacity," was calculated based on the strength of continuous rock properties (Rock Quality Designation, RQD > 65%) and/or intact rock strength. Both methods indicated a substantial bearing capacity greater than the bearing demand. Under the northwest edge of Unit 1, the borings indicate rock of lesser RQD. Please describe whether the bearing capacity of the rock mass under the northwest corner of Unit 1 was determined for comparison with the dynamic bearing demand. Please also provide the allowable bearing capacity of the rock mass under the northwest corner of Unit 1. What is the factor of safety considering the dynamic bearing demand of 35,000 psf?

Duke Energy Response:

In the response to RAI 02.05.04-003, in this letter, it was described how the rock mass under the Lee Unit 1 northwest corner is treated such that the bearing surface is prepared to create a rock surface that meets the design assumptions for continuous rock. FSAR Section 2.5.4.10.1 states that the allowable bearing pressure on the rock is at least 190,000 psf (190 ksf). This allowable bearing value is based on the lowest average RQD at an individual boring and is per Peck, Hanson and Thornburn (FSAR Reference 213). A summary of the results thus obtained at individual borings is shown in Table 1.

Table 1 Summary of Minimum RQD_{avg} and Allowable Bearing Pressure
Lee Nuclear Station Unit 1

Boring	Rock Elevation Range (feet, MSL)		Foundation Width B, (ft)	Minimum RQD_{avg} %	Allowable Bearing Pressure on rock (ksf)	Comments ($q_{allowable}$ >q applied?)
	Top	Bottom				
B-1001	524.1	459	91	86	349	Yes – Ok
B-1001A	550.0	459	91	82	309	Yes – Ok
B-1002	535.5	459	91	65[(1)]	190	Yes – Ok
B-1003	533.2	497.2	91	86	349	Yes – Ok
B-1004	544.0	459	91	86	349	Yes – Ok
B-1004A	528.5	459	91	79	279	Yes – Ok
B-1011	537.7	459	91	70[(1)]	214	Yes – Ok
B-1074A[(2)]	505.2	459	91	95	492	Yes – Ok
B-1075A[(2)]	511.5	459	91	91	422	Yes – Ok

[(1)] Minimum RQD_{avg} at B-1002 results from 1 ft core run from elevation 531.3 to elevation 530.3 and having RQD = 0.
Minimum RQD_{avg} at B-1011 results from 1 ft core run from elevation 530.7 to 529.7 and having RQD=0

[(2)] No results available for borings B-1074 and B-1075 as each boring was abandoned at shallow depth due to drilling difficulties, and was replaced by B-1074A and B-1075A, respectively.

The allowable bearing pressure of the rock mass under the northwest corner of Unit 1 would be 492 ksf by the Peck, Hanson and Thornburn (FSAR Reference 213) method applied to boring 1074A. No increase in allowable bearing pressure is allowed for embedment, since the Peck et. al. criteria are based on limitation of settlement, not available strength of the rock. Peck, et. al, estimate that the settlement of foundations using the full allowable bearing pressures by this method would be no more than ½ inch.

The ultimate bearing capacity based on the strength of the rock supporting the new nuclear islands for Lee Nuclear Station Units 1 and 2 is calculated as described in FSAR Section 2.5.4.10.1. The Factor of Safety (FS) was then calculated as the ultimate bearing capacity divided by the applied bearing pressure. As the FSAR text indicates, for seismic loading conditions, considering eccentric loading, the lowest calculated ultimate bearing pressure is 3,590,000 psf using the Hoek-Brown parameters of the rock mass to establish the Mohr-Coulomb parameters of friction angle and cohesion for the rock. For an applied seismic demand of 35,000 psf, (DCD, Rev. 17, Subsection 2.5.4.2 and DCD Table 2-1) this results in a factor of safety equal to 102.5.

Associated Revision to the Lee Nuclear Station Final Safety Analysis Report:

None

Attachments:

None

Lee Nuclear Station Response to Request for Additional Information (RAI)

RAI Letter No. 044

NRC Technical Review Branch: Geotechnical Engineering Branch 1 (RGS1)

Reference NRC RAI Number(s): 02.05.04-007

NRC RAI:

FSAR Figure 2.5.4-229, left-side, shows two different scales along the X-axes, top and bottom. Please correct the figure.

Duke Energy Response:

The editorial error in the X-axis scale is corrected in the attached markup of FSAR Figure 2.5.4-229. This updated figure will be included in a future FSAR revision.

Reference:

None.

Associated Revision to the Lee Nuclear Station Final Safety Analysis Report:

Revised FSAR Figure 2.5.4-229, Boring Summary Sheet, B-1070

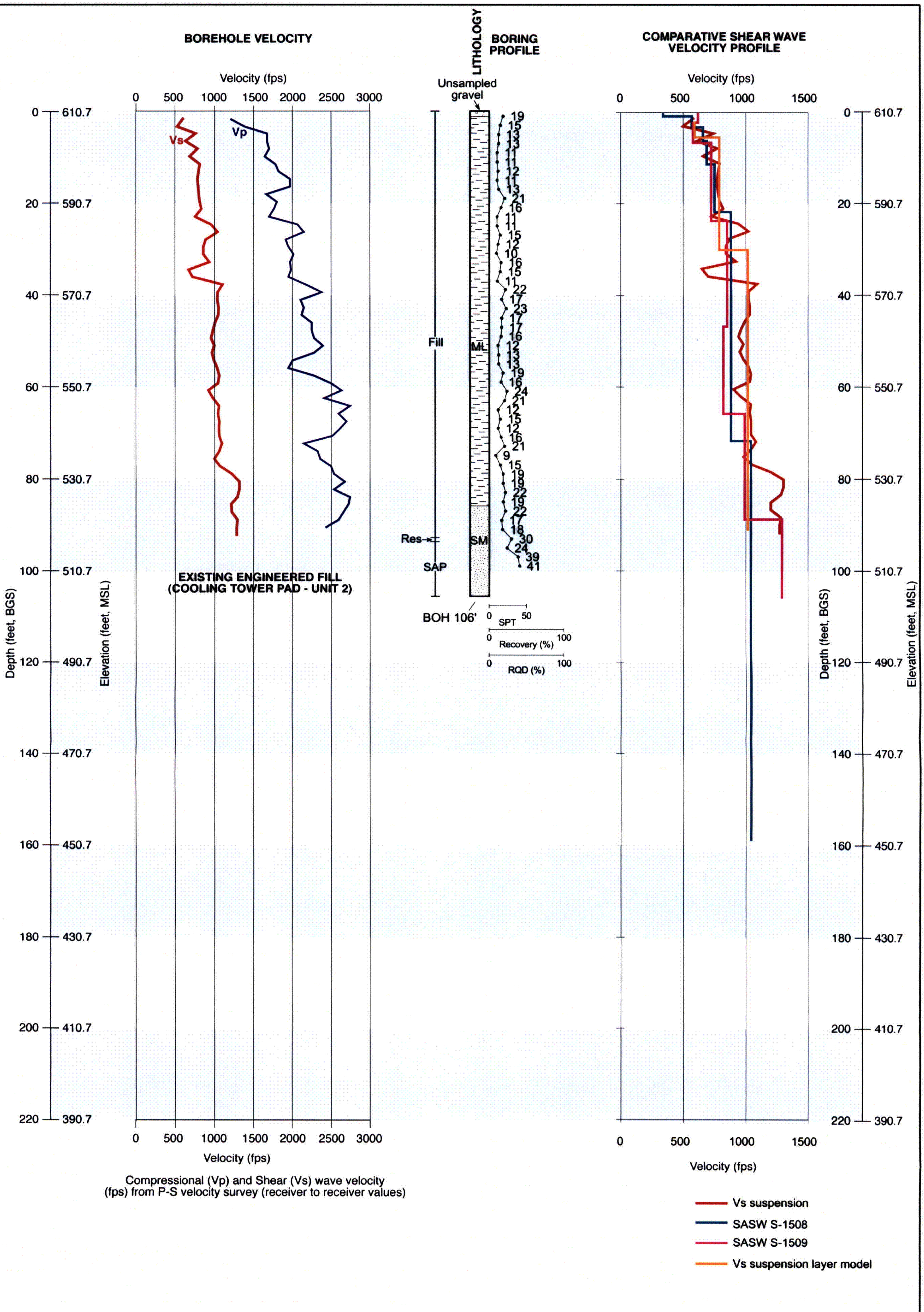
Attachments:

1) Revised FSAR Figure 2.5.4-229, Boring Summary Sheet, B-1070

Lee Nuclear Station Response to Request for Additional Information (RAI)

Attachment 1 to RAI 02.05.04-007

Revised FSAR Figure 2.5.4-229, Boring Summary Sheet, B-1070, Rev. 1



WLS COL 2.5-1

Notes:

1. Borehole geophysics performed by R. Stellar of GEOVision Geophysical Services
2. Surface geophysics performed by Dr. K. Stokoe, U. Texas
3. SPT field blows determined with a 140 lb. hammer, 30" drop - uncorrected
4. RQD (Rock Quality Designation) - a percentage of solid core segments larger than 0.33 feet relative to core run length, excluding mechanical breaks

WILLIAM STATES LEE III
NUCLEAR STATION UNITS 1 & 2

Boring Summary Sheet, Boring B-1070

Figure 2.5.4-229 Rev 1

Lee Nuclear Station Response to Request for Additional Information (RAI)

RAI Letter No. 044

NRC Technical Review Branch: Geotechnical Engineering Branch 1 (RGS1)

Reference NRC RAI Number(s): 02.05.04-008

NRC RAI:

FSAR Section 2.5.4.10.3, "Lateral Earth Pressures" does not include the dynamic lateral stresses. According to AP1000 DCD, Tier 2, Section 2.5.4.6.7, "Earth Pressures," "The Combined License applicant will describe the design for static and dynamic lateral earth pressures and hydrostatic groundwater pressures acting on plant safety-related facilities using soil parameters as evaluated in previous subsections." Please provide dynamic lateral earth pressures acting on the nuclear island below grade walls.

Duke Energy Response:

The dynamic earth pressure is calculated in accordance with Reference 1 - ASCE 4-98, Section 3.5.3, Figure 3.5-1, "Variation of Normal Dynamic Soil Pressures for the Elastic Solution." Soil properties of the backfill adjacent to the exterior walls and basemat for dynamic earth pressure calculation are as follows for remolded backfill:

- Saturated unit weight of backfill =119 lb/ft^3(from FSAR Table 2.5.4-211)
- Poisson's ratio (ν) = 0.47 (see discussion below)

The Poisson's ratio = 0.47 is consistent with the at rest earth pressure coefficient = 0.9 in FSAR Subsection 2.5.4.10.3. However, ν = 0.5 is used for convenience and is slightly conservative. The seismic acceleration used (0.345g) is the highest surface acceleration associated with the site response of the soil columns (Reference 2) for backfill adjacent to the nuclear island. Use of the surface acceleration as the seismic coefficient is conservative since acceleration below the surface is lower, and the dynamic soil pressure defined in ASCE 4-98 is based on a uniform seismic acceleration along the height of the wall.

FSAR Subsection 2.5.4.10.3 is revised to address dynamic lateral earth pressures, and a new FSAR Table 2.5.4-227 is added to tabulate those values. FSAR Section 2.5.4.13 is revised to add references used in the discussion of lateral earth pressures. These updates will be included in a future FSAR revision.

References:

1) ASCE Standard 4-98, *Seismic Analysis of Safety-Related Nuclear Structures and Commentary*, American Society of Civil Engineers, 2000.

2) Bryan J. Dolan to Document Control Desk, U.S. Nuclear Regulatory Commission, *William States Lee III Nuclear Station Units 1 and 2, Liquefaction Evaluation Results for Seismic Category II and Non-Seismic Power Block Structures*, dated May 23, 2008.

Associated Revisions to the Lee Nuclear Station Final Safety Analysis Report:

FSAR Subsection 2.5.4.10.3

FSAR Table 2.5.4-227 Dynamic Earth Pressures from Soil Backfill

FSAR Subsection 2.5.4.13

Attachments:

1) FSAR Table 2.5.4-227 Dynamic Earth Pressures from Soil Backfill
2) Mark-up of FSAR Subsection 2.5.4.10.3
3) Addition to FSAR Subsection 2.5.4.13

Lee Nuclear Station Response to Request for Additional Information (RAI)

Attachment 1 to RAI 02.05.04-008

FSAR Table 2.5.4-227 Dynamic Earth Pressures from Backfill Soil

TABLE 2.5.4-227

DYNAMIC LATERAL EARTH PRESSURES FROM BACKFILL SOIL

Plant Elevation (feet)	Site-Specific WLS Backfill Seismic Earth Pressure (1) (ksf)
100 (=590WLS)	1.745
96.05	2.081
92.1	2.189
88.15	2.215
84.2	2.175
80.25	2.081
76.3	1.936
72.35	1.751
68.4	1.513
64.45	1.219
60.5	0.884

(1) Per Reference 220, ASCE 4-98, Section 3.5.3, Figure 3.5-1, "Variation of Normal Dynamic Soil Pressures for the Elastic Solution".

Soil Properties:

γ = 119 lb/ft^3 (saturated)

υ = 0.47 (use 0.5)

Acceleration:

a = 0.345g, assumed uniform along the height of the wall

Lee Nuclear Station Response to Request for Additional Information (RAI)

Attachment 2 to RAI 02.05.04-008

Mark-up of FSAR Subsection 2.5.4.10.3

COLA Part 2, FSAR. Chapter 2, Subsection 2.5.4.10.3, will be revised as follows:

2.5.4.10.3 Lateral Pressure

Lateral pressures are developed against the below grade nuclear island wall resulting from the placement and compaction of soil backfill materials. Earth pressure envelops are calculated for at-rest and passive pressure conditions as developed in Figures 2.5.4-255 and 2.5.4-256. Enveloping values based on both minimum and maximum groundwater elevations are provided in Tables 2.5.4-225 and 2.5.4-226. Assumptions used to develop the at-rest and passive earth pressure envelopes are described in the following list.

Earth Pressure Assumptions:

- The soil used to backfill around the Nuclear Islands will come from on-site borrow areas described in Subsection 2.5.4.5 or on similar soils from other sources, and have material properties as described in Subsection 2.5.4.2.
- Backfill soil is compacted to 95 percent of the maximum dry density determined from the standard Proctor laboratory test performed in accordance with ASTM D698.
- Backfill is compacted at water contents ranging from near the laboratory optimum value to no wetter than three percentage points above the optimum value. This results in as-compacted initial degree of saturation of 80 percent or less.
- Light hand-guided compaction equipment is used to compact the soil within 5 feet of the nuclear island walls. Heavier compaction equipment may be used at distances greater than 5 feet from the walls. The use of light, hand-guided compaction equipment near the wall avoids excessive compaction-induced soils stresses against the wall.
- The groundwater table elevation may vary over time between Elevations 584 and 574 feet. The design water table elevation from the Design Control Document is up to Elevation 588.
- The nuclear island walls do not yield due to the lateral earth pressure applied to them. The at-rest pressure is the appropriate earth pressure to assume for design of the walls.
- An at-rest earth pressure coefficient (K_0) of 0.9 is appropriate for the Lee Nuclear Station backfill soils if compacted to 95 percent on the wet side of the optimum moisture content and with an initial degree of saturation equal to 80 percent. This K_0 value is based on total stress conditions, as is most applicable for the end of construction.

The Rankine earth pressure theory is used to compute the passive (ultimate) earth pressure.

The dynamic lateral earth pressure in Table 2.5.4-227 is calculated in accordance with Reference 220 - ASCE 4-98, Section 3.5.3, Figure 3.5-1, "Variation of Normal Dynamic Soil Pressures for the Elastic Solution". Soil properties for remolded backfill adjacent to the vertical surface of the nuclear island exterior walls and basemat for dynamic earth pressure calculation are as follows:

- Saturated unit weight of backfill (γ) =119 lb/ft^3 (from Table 2.5.4-211)
- Poisson's ratio (ν) = 0.47 (see discussion below)

The Poisson's ratio ν = 0.47 is consistent with the at rest earth pressure coefficient = 0.9 given earlier herein. However, ν = 0.5 is used for convenience and is slightly conservative.

The seismic acceleration used, (a) = 0.345g, is the highest surface acceleration associated with the site response of the soil columns and is applied to the backfill beside the Nuclear Island (Reference 221). Use of the surface acceleration as the seismic coefficient is conservative since acceleration below the surface is lower, and the dynamic soil pressure defined in ASCE 4-98 is based on a uniform seismic acceleration along the height of the wall.

Lee Nuclear Station Request for Additional Information (RAI)

Attachment 3 to RAI 02.05.04-008

Addition to FSAR Subsection 2.5.4.13

COLA Part 2. FSAR, Chapter 2, Subsection 2.5.4.13 will be revised as follows:

220. ASCE Standard 4-98, *Seismic Analysis of Safety-Related Nuclear Structures and Commentary*, American Society of Civil Engineers, 2000.

221. Bryan J. Dolan to Document Control Desk, U.S. Nuclear Regulatory Commission, *William States Lee III Nuclear Station Units 1 and 2, Liquefaction Evaluation Results for Seismic Category II and Non-Seismic Power Block Structures)*, dated May 23, 2008.

Lee Nuclear Station Response to Request for Additional Information (RAI)

RAI Letter No. 044

NRC Technical Review Branch: Geotechnical Engineering Branch 1 (RGS1)

Reference NRC RAI Number(s): 02.05.04-009

NRC RAI:

AP1000 DCD, Tier 2, Section 2.5.4.5.3.1, "Site-Specific Subsurface Uniformity Design Basis" states in part: "The key attribute for acceptability of the site for an AP1000 is the bearing pressure on the underside of the basemat. A site having local soft or hard spots within a layer or layers does not meet the criteria for a uniform site." Please clarify how the Lee Unit 1 site meets the uniformity criteria given the shear wave velocity differences between the centerline of Unit 1 and the northwest corner of Unit 1.

Duke Energy Response:

Please refer to the Duke Energy responses to RAIs 02.05.04-003 and 02.05.04-006 (this letter, NRC RAI Letter 044) and the Duke Energy response to RAI 03.07.01-001 (Reference 1, NRC RAI Letter 041), as discussed below.

The Duke Energy response to RAI 02.05.04-003, explains how the rock mass under the Lee Unit 1 northwest corner is treated such that the bearing surface is prepared to create a rock surface that meets the design assumptions for continuous rock.

The Duke Energy response to RAI 02.05.04-006 explains how the bearing capacity under the Lee Unit 1 northwest corner is calculated and demonstrates a factor of safety of 102.5 for an applied seismic demand of 35,000 psf. The applied loading for the Lee Unit 1 nuclear island is, therefore, low compared to the available capacity of the rock that will support the northwest corner. Foundation deflections will be negligible. Any minor differences in modulus within the foundation quality rock are thus not indicative of "soft spots" that will adversely affect the basemat behavior under the low applied loads.

The Duke Energy response to RAI 03.07.01-001 explains how the Lee Unit 1 nuclear island meets the AP1000 DCD Rev. 16 Case 1 uniformity criteria and includes a detailed evaluation of the localized lower velocity continuous rock zone in the Unit 1 northwest corner that represents the nuclear island foundation rock and post-construction configuration. That RAI response also describes site-specific uniformity analyses performed by Westinghouse Electric Company (WEC) confirming the Lee Nuclear Station is a uniform hard rock site that complies with the AP1000 DCD Rev. 16 Case 1 uniformity criteria. Since the Case 1 criteria are unchanged in DCD Rev. 17, compliance with that DCD version is also confirmed.

The combination of foundation bearing on quality fill concrete and competent rock, limited and isolated extent of lower velocity rock, and foundation preparation improvement criteria described in the Lee Nuclear Station FSAR 2.5.4.12 mitigates concern regarding non-uniformity associated with this localized zone beneath the Unit 1 northwest corner. Therefore, the foundation subgrade represents a uniform, competent bearing surface that complies with the AP1000 DCD Rev. 16 Case 1 uniformity criteria. Since the Case 1 criteria are unchanged in DCD Rev. 17, compliance with that DCD version is also confirmed. This conclusion is further supported by the confirming WEC uniformity analyses described above.

Reference:

1. Letter from Bryan J. Dolan to Document Control Desk, U.S. Nuclear Regulatory Commission, WLG2008.12-25, *William States Lee III Nuclear Station Units 1 and 2 Response to Request for Additional Information (RAI Nos. 1003 and 1004)*, dated December 17, 2008.

Associated Revision to the Lee Nuclear Station Final Safety Analysis Report:

None

Attachments:

None