Progress Energy

Serial: NPD-NRC-2010-006 10CFR52.79
January 19, 2010

U.S. Nuclear Regulatory Commission
Attention: Document Control Desk
Washington, D.C. 20555-0001

LEVY NUCLEAR PLANT, UNITS 1 AND 2
DOCKET NOS. 52-029 AND 52-030
RESPONSE TO REQUEST FOR ADDITIONAL INFORMATION LETTER NO. 071 RELATED TO STABILITY OF SUBSURFACE MATERIALS AND FOUNDATIONS

Reference: Letter from Brian C. Anderson (NRC) to Garry Miller (PEF), dated November 2, 2009, "Request for Additional Information Letter No. 071 Related to SRP Section 2.5.4 for the Levy County Nuclear Plant, Units 1 and 2 Combined License Application"

Ladies and Gentlemen:

Progress Energy Florida, Inc. (PEF) hereby submits our response to the Nuclear Regulatory Commission's (NRC) request for additional information provided in the referenced letter.

A response to the NRC request is addressed in the enclosure. The enclosure also identifies changes that will be made in a future revision of the Levy Nuclear Plant Units 1 and 2 application.

If you have any further questions, or need additional information, please contact Bob Kitchen at (919) 546-6992, or me at (727) 820-4481.

I declare under penalty of perjury that the foregoing is true and correct.

Executed on January 19, 2010.

Sincerely,

John Elnitsky
Vice President
Nuclear Plant Development

Enclosure

cc : U.S. NRC Region II, Regional Administrator
Mr. Brian C. Anderson, U.S. NRC Project Manager

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NRO

Levy Nuclear Plant Units 1 and 2
Response to NRC Request for Additional Information Letter No. 071 Related to SRP Section 2.5.4 for the Combined License Application, dated November 2, 2009

NRC RAI #	Progress Energy RAI #	Progress Energy Response
02.05.04-24	L-0591	Response enclosed – see following pages

NRC Letter No.: LNP-RAI-LTR-071

NRC Letter Date: November 2, 2009

NRC Review of Final Safety Analysis Report

NRC RAI NUMBER: 02.05.04-24

Text of NRC RAI:

The results of liquefaction evaluations for the existing overburden configuration have been performed using time-dependent estimates of soil demand/capacity ratio that may be developed from the site-specific PSHA. These results indicate that safety factors are generally greater than 1.4, except for several areas away from the NI. However, compacted backfill will be placed on top of the existing site profiles to bring the site to plant grade. The effect of this added overburden will be to increase the effective confining pressures of the soils below (increasing soil capacity) while at the same time increasing induced shears (increasing seismic demands). However, these effects are not affected equally.

Please provide similar liquefaction evaluations for the modified soil columns including the planned surface backfill.

PGN RAI ID #: L-0591

PGN Response to NRC RAI:

The top 16 ft. below final grade at El. 51 ft. NAVD88 will consist of engineered backfill; any existing soils within 16 ft. of finished grade will be removed and replaced. Liquefaction evaluations for the modified soil columns, including the added overburden, have been performed. The factor of safety against liquefaction, calculated as the ratio of Cyclic Stress Ratio (CSR) to Cyclic Resistance Ratio (CRR), was calculated for soils within the Nuclear Island (NI) passive wedge but outside the NI, and for soils under the footprint of structures adjacent to the NI for LNP1 and LNP2.

Assessment of seismically-induced soil liquefaction at nuclear power plant sites is outlined by NRC Regulatory Guide (RG) 1.198. According to RG 1.198, liquefaction susceptibility can be determined in terms of factor of safety against liquefaction, which is described as:

$$FS_{\text{against liquefaction}} = \frac{CRR}{CSR} \qquad (1)$$

where CRR (Cyclic Resistance Ratio) is the available soil resistance to liquefaction and CSR (Cyclic Stress Ratio) is the cyclic stress generated by the design earthquake.

In accordance with the method described by Youd et al. (Ref. 1), CRR data were corrected considering the overburden pressure (K_σ) and the slope of the existing ground surface (K_α) of the site. Corrected CRR values used in this calculation are calculated in two sets considering the location of the boreholes. In set one, corrected CRR data were calculated to support the evaluation of the liquefaction potential within the Nuclear Island (NI) passive wedge but outside the NI footprints for LNP 1 and LNP 2. The second set of corrected CRR data is determined to support the evaluation of the liquefaction potential of soils under the footprint of structures adjacent to the nuclear islands.

In addition to CRR, CSR is calculated for the FS determination. An evaluation of CSR requires a detailed ground response analysis in order to determine the effective cyclic shear stresses that will cause liquefaction. For most sites, a detailed ground response analysis is not available; therefore, Youd et al. recommends a simplified approach for CSR determination. Given the shortcomings of the simplified approach, such as limited applicability depth and poor representation of the earthquake effects by only horizontal peak ground acceleration (a_{max}), using ground response analysis-derived shear stresses is preferable for CSR determination. Such analysis produces time histories with the transient, irregular characteristics of actual earthquakes and will most likely yield realistic results. It is important to note that the frequency dependency of the site response, the duration of the earthquake, and the amplification/ attenuation behavior of the subsurface can be taken into account with this approach.

The soil stratigraphy at the LNP1 and LNP2 sites consists of approximately 15 feet of engineered fill materials (top elevation of 51 ft NAVD88) overlying the first competent layer (S2), which begins at approximately elevation 36 ft NAVD88. For the CSR calculation, the stratigraphy is divided into 40 discrete layers for modeling purposes. The effective shear strain and the strain-compatible shear modulus are calculated for each of the 40 layers as part of the site response analyses. The effective cyclic shear stresses for each layer were calculated from the effective shear strain and the strain-compatible shear modulus using the following formula:

$$\tau_{cyc}' = \gamma_{cyc}' \, G_{cyc} \qquad (2)$$

where γ_{cyc}' is the effective cyclic shear strains, and G_{cyc} is the strain compatible shear modulus.

Subsequently, CSR values for LNP 1 and LNP 2 are calculated using the following expression:

$$CSR = \frac{\tau_{cyc}'}{\sigma_{vo}'} \qquad (3)$$

where τ_{cyc}' is the effective cyclic shear stress, and σ_{vo}' is the effective overburden pressure.

The effective cyclic shear stresses were calculated using Equation (2) and the effective shear strain and strain-compatible shear modulus. The PBSRS for the LNP site lies between the 10^{-4} and 10^{-5} ground motion levels and interpolation was required to compute the respective effective cyclic shear stress. The effective cyclic shear stresses were determined using mean high frequency input ground motion with 1000 fps shear wave velocity engineered fill.

The performance based surface response spectra (PBSRS) peak ground acceleration (PGA) at the surface elevation (51 feet) using the ASCE/SEI design response spectrum is 0.1181 g.

The effective overburden stress ($\sigma_{vo'}$), at the locations where the effective cyclic shear stresses were calculated, are also determined by considering the final grade of the site at elevation 51 ft. NAVD 88 for both the CSR and CRR computations. The groundwater level was conservatively considered at elevation 43 ft. NAVD 88.

Finally, the CRR values used are relative to a magnitude 7.5 earthquake; therefore, a magnitude scaling factor (MSF) was included into the factor of safety (FS) determination. The lower bound MSF recommended by Youd et al. for magnitude (M_w) <7.5 is described as MSF =

$10^{2.24}/M_w^{2.56}$. In this calculation, earthquake magnitude of 7.1 is considered conservatively as a typical representation of the input earthquakes used in the GMRS analysis. MSF is equal to $10^{2.24}/7.1^{2.56}$ =1.15.

The factor of safety against liquefaction used is shown below:

$$FS_{\text{against liquefaction}} = \frac{CRR}{CSR} MSF \quad (4)$$

Regarding to the liquefaction potential, the following criteria from Reg. Guide 1.198 are followed.

a) Soil elements with low FS (FS ≤ 1.1) would achieve conditions wherein soil liquefaction should be considered to have been triggered. Conservative undrained residual strengths from laboratory and field tests should be assigned to these zones for further stability and deformation analyses.

b) Soil elements with a high FS (FS≥1.4) would suffer relatively minor cyclic pore pressure generation and should be assigned some large fraction of their (drained) static strength, obtained from laboratory tests, for further stability and deformation analysis.

c) Soil elements with intermediate FS (FS≈1.1 to 1.4) should be assigned strength values between the values appropriate to conditions *a* and *b* above for further stability and deformation analyses. In strongly contractive soils, the possibility of progressive failure or deformation should be considered and mobilization of undrained residual strengths should be assumed.

Tables RAI 02.05.04-24-01 and 02.05.04-24-02 below list only the zones for which low and intermediate factors of safety (<1.4) for liquefaction were calculated. These tables also include data from boreholes completed in the Offset Boring Program.

Table RAI 02.05.04-24-01
Liquefaction Assessment for LNP1 Boreholes

Borehole	Bottom Depth of SPT Sample (ft.)	Elevation (ft. NAVD 88)	Soil Type	Field SPT N-Value (bpf)	Factor of Safety (FS)	Reg. Guide 1.198 FS Level	Passive Wedge
A-15	16	26.5	SP	5	1.0	Low	Within
	21	21.5	SP	1	0.8	Low	Within
	26	16.5	SC	2	1.1	Low	Within
A-18	20	22.3	NR	0	0.7	Low	Within
O-2	9	33.7	SP-SC	2	0.9	Low	Within
	10.5	32.2	SP-SC	2	0.9	Low	Within
	12.0	30.7	SP-SC	1	0.8	Low	Within
O-4	24.0	18.3	ML	0	0.9	Low	Within
A-13	16.5	24.1	SM	3	1.2	Intermediate	Below
B-16	11.5	31.1	SM	3	1.3	Intermediate	Below
B-28	36.5	5.0	ML	0	0.9	Low	Outside

NR: No recovery, SPT: Standard Penetration Test, CH: Fat clay, CL: Lean clay, silty clay, sandy clay, ML: Silt, sandy silt, clayey silt, SM: Silty sand, GM: Silty gravel, SP: Poorly graded sand, SC: Clayey sand

Table RAI 02.05.04-24-02
Liquefaction Assessment for LNP2 Boreholes

Borehole	Bottom Depth of SPT Sample (ft.)	Elevation (ft. NAVD 88)	Soil Type	Field SPT N-Value (bpf)	Factor of Safety (FS)	Reg. Guide 1.198 FS Level	Passive Wedge
B-01	26.5	14.3	SM	2	0.8	Low	Below
	31.5	9.3	SM	2	0.8	Low	Below
B-03	26.5	17.4	SM	3	1.3	Intermediate	Below
B-06	41.5	1.0	SC	3	1.3	Intermediate	Below
B-07	31.5	11.6	SP-SM	3	1.0	Low	Outside
	36.5	6.6	SP-SM	2	0.8	Low	Outside
	51.5	-8.4	SP-SM	2	0.8	Low	Outside
	56.5	-13.4	SP-SM	2	0.8	Low	Outside
	61.5	-18.4	SP-SM	3	0.9	Low	Outside
	76.5	-33.4	SP-SM	3	1.0	Low	Outside
B-07A	26.5	16.7	SP-SM	5	1.0	Low	Outside
	31.5	11.7	SM	4	1.1	Low	Outside
	36.5	6.7	SP-SM	3	0.8	Low	Outside
	41.5	1.7	SM	3	0.8	Low	Outside
	46.5	-3.3	SM	3	1.2	Intermediate	Outside
	51.5	-8.3	SM	2	1.1	Low	Outside
	76.5	-33.3	SP-SM	6	0.9	Low	Outside
B-31	37.5	5.9	SP	5	1.2	Intermediate	Outside
	39	4.4	SP	6	1.3	Intermediate	Outside
	40.5	2.9	SP	4	1.0	Low	Outside
	69	-25.6	SP	5	1.0	Low	Outside
	70.5	-27.1	SP	6	1.1	Low	Outside
	72	-28.6	SP	7	1.2	Intermediate	Outside
	73.5	-30.1	SP	5	1.0	Low	Outside
	76.5	-33.1	SP	2	0.7	Low	Outside
	78	-34.6	SP	6	1.1	Low	Outside
	79.5	-36.1	SP	4	0.9	Low	Outside
	81	-37.6	SP	2	0.7	Low	Outside
	82.5	-39.1	SP	3	0.8	Low	Outside
	84	-40.6	SP	3	0.8	Low	Outside
	85.5	-42.1	SP	3	0.8	Low	Outside
	87	-43.6	SP	2	0.7	Low	Outside
	88.5	-45.1	SP	1	0.7	Low	Outside
	90	-46.6	SP	0	0.7	Low	Outside
	91.5	-48.1	SP	4	0.9	Low	Outside
	93	-49.6	SP	3	0.8	Low	Outside
	94.5	-51.1	SP	7	1.1	Low	Outside
	96	-52.6	SP	0	0.6	Low	Outside
	97.5	-54.1	SP	0	0.6	Low	Outside
	99	-55.6	SP	1	0.6	Low	Outside
	102	-58.6	SP-SM	10	1.3	Intermediate	Outside
	103.5	-60.1	SP-SM	7	1.1	Low	Outside
	109.5	-66.1	SP-SC	5	0.9	Low	Outside
	118.5	-75.1	SP-SM	0	0.7	Low	Outside
	120	-76.6	SP-SM	0	0.7	Low	Outside

Borehole	Bottom Depth of SPT Sample (ft.)	Elevation (ft. NAVD 88)	Soil Type	Field SPT N-Value (bpf)	Factor of Safety (FS)	Reg. Guide 1.198 FS Level	Passive Wedge
B-31 (con't)	121.5	-78.1	SP-SM	0	0.7	Low	Outside
	123	-79.6	SP-SM	0	0.7	Low	Outside
	124.5	-81.1	SP-SM	0	0.7	Low	Outside
	126	-82.6	SP-SM	0	0.7	Low	Outside
	127.5	-84.1	SP-SM, ML	0	1.0	Low	Outside
	129	-85.6	SP-SM	0	0.7	Low	Outside
	130.5	-87.1	SP-SM	0	0.7	Low	Outside
	132	-88.6	SP-SM	12	1.3	Intermediate	Outside
B-33	28.5	14.5	SP	4	1.0	Low	Outside
	30	13.0	SP	5	1.2	Intermediate	Outside
	31.5	11.5	SP	3	0.9	Low	Outside
	33	10.0	SP	2	0.8	Low	Outside
	34.5	8.5	SP	2	0.8	Low	Outside
	36	7.0	SP	1	0.7	Low	Outside
	37.5	5.5	SP	2	0.8	Low	Outside
	39	4.0	SP	2	0.8	Low	Outside
	40.5	2.5	SP	2	0.8	Low	Outside
	42	1.0	SP	1	0.7	Low	Outside
	43.5	-0.5	SP	0	0.7	Low	Outside
	45	-2.0	SP	0	0.7	Low	Outside
	46.5	-3.5	SP	0	0.7	Low	Outside
	58.5	-15.5	SP	5	1.1	Low	Outside
	66.0	-23.0	SP	7	1.1	Low	Outside

SPT: Standard Penetration Test, CH: Fat clay, CL: Lean clay, silty clay, sandy clay, ML: Silt, sandy silt, clayey silt, SM: Silty sand, GM: Silty gravel, SP: Poorly graded sand, SC: Clayey sand

At LNP1, low FS were observed at boreholes O-2 (shallow elevations), A-15 and A-18/O-4. These pockets are within the NI excavation limits, and thus will be excavated. Random zones of soil with low or intermediate FS were also observed at boreholes A-13, B-16, and B-28 at LNP1 and at boreholes B-01, B-03, B-06, B-07, B-07A, B-31, and B-33 at LNP2.

The results of this liquefaction analysis, which considers the soil column to finished grade at El. 51 ft, are consistent with our earlier conclusion that liquefaction is confined to isolated pockets.

References:

1. Youd, T. L., et al. "Liquefaction Resistance of Soils: Summary Report from the 1996 NCEER and 1998 NCEER/NSF Workshops on Evaluation of Liquefaction Resistance of Soils", Journal of Geotechnical and Geo environmental Engineering, ASCE, 127 (10) October 2001.

Associated LNP COL Application Revisions:

The following changes will be made to the LNP FSAR in a future revision:

1. FSAR Table 2.5.4.8-202A will be replaced with Table RAI 02.05.04-24-01.
2. FSAR Table 2.5.4.8-202B will be replaced with Table RAI 02.05.04-24-02.

Attachments/Enclosures:

None.