Progress Energy

Serial: NPD-NRC-2010-013 10CFR52.79
January 29, 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
SUPPLEMENT 2 TO RESPONSE TO REQUEST FOR ADDITIONAL INFORMATION LETTER NO. 009 RELATED TO STABILITY OF SUBSURFACE MATERIALS AND FOUNDATIONS

References:

1. Letter from Brian C. Anderson (NRC) to Garry Miller (PEF), dated February 24, 2009, "Request for Additional Information Letter No. 009 Related to SRP Section 2.5.4 for the Levy County Nuclear Plant, Units 1 and 2 Combined License Application"

2. Letter from Garry D. Miller (PEF) to U. S. Nuclear Regulatory Commission, dated April 2, 2009, "Response to Request for Additional Information Letter No. 009 Related to Stability of Subsurface Materials and Foundations", Serial: NPD-NRC-2009-046

3. Letter from John Elnitsky (PEF) to U. S. Nuclear Regulatory Commission, dated January 19, 2010, "Supplement 1 to Response to Request for Additional Information Letter No. 009 Related to Stability of Subsurface Materials and Foundations", Serial: NPD-NRC-2010-007

Ladies and Gentlemen:

Progress Energy Florida, Inc. (PEF) hereby submits a revised response to the Nuclear Regulatory Commission's (NRC) request for additional information provided in Reference 1. A revised response to one of the NRC questions (02.05.04-7) is addressed in the enclosure.

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 29, 2010.

Sincerely,

John Elnitsky
Vice President
Nuclear Plant Development

Progress Energy Florida, Inc.
P.O. Box 14042
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NRO

Enclosure

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

Levy Nuclear Plant Units 1 and 2
Supplement 2 to Response to NRC Request for Additional Information Letter No. 009
Related to SRP Section 2.5.4 for the Combined License Application,
Dated February 24, 2009

NRC RAI #	Progress Energy RAI #	Progress Energy Response
02.05.04-4	L-0024	April 2, 2009; NPD-NRC-2009-046
02.05.04-5	L-0025 & L-0209	April 2, 2009; NPD-NRC-2009-046 & January 19, 2010; NPD-NRC-2010-007
02.05.04-6	L-0026 & L-0210	April 2, 2009; NPD-NRC-2009-046 & January 19, 2010; NPD-NRC-2010-007
02.05.04-7	L-0691	Revised response enclosed – see following pages
02.05.04-8	L-0028 & L-0212	April 2, 2009; NPD-NRC-2009-046 & January 19, 2010; NPD-NRC-2010-007
02.05.04-9	L-0029	April 2, 2009; NPD-NRC-2009-046

NRC Letter No.: LNP-RAI-LTR-009

NRC Letter Date: February 24, 2009

NRC Review of Final Safety Analysis Report

NRC RAI NUMBER: 02.05.04-7

Text of NRC RAI:

The Mohr-Coulomb strength parameters for the rock mass were based on Hoek-Brown methodology and incorporate among other factors, the intact rock compressive strength and a factor, GSI, to account for geologic features within the mass rock. FSAR Section 2.5.4 shows that great variability exists in the measured uniaxial compressive strength on intact samples (one standard deviation being as great as the average compressive strength in most cases), and the availability of intact rock samples was limited because of low recovery.

Please describe how you determined the GSI factor. Include a discussion on how the joint sets and bedding planes and low or no recovery zones were factored into the derivation of the GSI. Please describe any sensitivity analyses you may have performed to determine the influence of lower bound assumptions of the compressive strength and stiffness of intact rock and lower bound GSI factors on stability (bearing capacity and settlement) and stress calculations in the foundation rock.

PGN RAI ID #: L-0691

PGN Response to NRC RAI:

This RAI was previously addressed in Letter NPD-NRC-2009-046 (dated April 2, 2009), and supplemented by Letter NPD-NRC-2010-007 (dated January 19, 2010). This revision represents a complete response to this RAI, incorporating both of these previous responses. In addition, this revision incorporates minor changes that were made to the bearing capacity sensitivity analysis described herein.

Rock Mass Rating (RMR) and Geological Strength Index (GSI) were obtained for rock mass classification and strength evaluation. For a specific borehole, RMR and GSI values were obtained on each particular rock core run. Rock mass classification is influenced by the following six parameters: intact rock strength, drill core quality (measured through rock quality designation RQD), discontinuity spacing, discontinuity conditions, orientation of the discontinuities and groundwater conditions. Based on rock mass rating system proposed by Bieniawski (1989) and Robertson (1988), a rating is assigned to each of the six parameters listed above. RMR is the sum of all the individual parameters rating. GSI is estimated from a correlation with RMR proposed by Hoek and Brown (1997).

a. In order to obtain RMR, ratings were assigned to the following parameters mainly based on the Rock Mass Rating system proposed by Bieniawski (1989): intact rock strength, drill core quality (measured through Rock Quality Designation), discontinuity spacing, discontinuity conditions, orientation of the discontinuities and groundwater conditions. In assigning the rating to the discontinuity conditions, the modification to the Geomechanics Classification for weak rock proposed by Robertson (1988) was used, considering that some of the rock mass at LNP is relatively weak. RMR is the sum of all the individual parameter ratings for each rock core run.

b. To be conservative in the calculation of RMR values, the lowest rating for groundwater was assigned to all rock core runs. RMR values were not used in subsequent analyses, except for deriving GSI.

c. GSI was estimated from a correlation with RMR proposed by Hoek and Brown (1997). The equation for estimating GSI is:

$$GSI = RMR_{89} - 5$$

where the subscript 89 refers to the year in which the rock mass rating system was proposed by Bieniawski (1989). It should be noted that RMR_{89} is equal to RMR prior to adjustments for discontinuity orientations and with a groundwater rating of 15 (Wyllie 1999 p. 60); (Hoek and Brown 1997, p. 1172).

d. Statistics of RMR and GSI for the North Reactor (LNP 2) were calculated from individual rock core run results at the following elevation ranges: elevations above -97 feet (ft) mean sea level (msl), elevations between -97 ft msl and -148 ft msl, elevations between -148 ft msl and -303 ft msl, and elevations between -303 ft msl and -458 ft msl (corresponding to NAV-1 through NAV-4). Borings A-1 through A-12, AD-1 and AD-2 were used for the RMR and GSI statistics for the North Reactor (LNP 2).

e. Statistics of RMR and GSI for the South Reactor (LNP 1) were calculated from individual rock core run results at the following elevation ranges: elevations above -180 ft msl, elevations between -180 ft msl and -309 ft msl, and elevations between -309 ft msl and -458 ft msl (corresponding to SAV-1 through SAV-3). Borings A-13 through A-24A, AD-3 and AD-4 were used for the RMR and GSI statistics for the South Reactor (LNP 1).

f. R-scale of rock core, determined using hammer blow, was used to quantify the strength of intact rock core. Additionally, unconfined compressive strength (UCS) of intact rock core and the strength description of rock core from borings logs were used to quantify intact rock core strength.

g. Discontinuity condition classification was determined based on five parameters: rock strength (R-scale), infilling thickness, discontinuity separation, weathering condition, and fracture surface condition. In assigning the discontinuity condition classification, the R-scale of the rock core run was reduced for those core runs with low recovery considering that the unrecovered materials would be weaker than those recovered and used for R scale determination. A conservative approach was used to assign the RMR discontinuity condition rating when the R-scale was reduced due to low recovery.

Because this methodology for determining GSI explicitly considers joint sets and bedding planes, it is suitable for use in this application. In addition, since the determination of GSI values was based on an extensive data set (every core run at LNP, as described above) it is overly conservative to consider lower-bound values for GSI in sensitivity analysis.

Further analysis, which considers infilled or weathered-in-place material present in entire bedding planes as an alternate approach, is presented in the response to RAI 02.05.04-8. The typical analytical approach for this material is as previously described in the FSAR and is investigated further here to provide a sensitivity of resulting bearing capacity and settlement using mass properties that result from Hoek-Brown approach. As indicated in the supplemental response to 02.05.04-8, this sensitivity study is conservative.

In order to determine the sensitivity of the unconfined compressive strength on the bearing capacity, a sensitivity analysis was performed wherein the bearing capacity of the Avon Park Formation limestone was evaluated considering certain variations in the rock mass parameters based on a statistical analysis of the subsurface properties.

A statistical analysis was performed for the Unconfined Compressive Strength to determine the variation range to be used in the sensitivity analysis. A log-normal probability distribution was determined to be appropriate for the analysis to describe the UCS. As shown below on Figure RAI 02.05.04-7-1 for the NAV-1 and SAV-1 layers, the log-normal probability distribution of the UCS data gives a better approximation of the variation range than a normal distribution of the data.

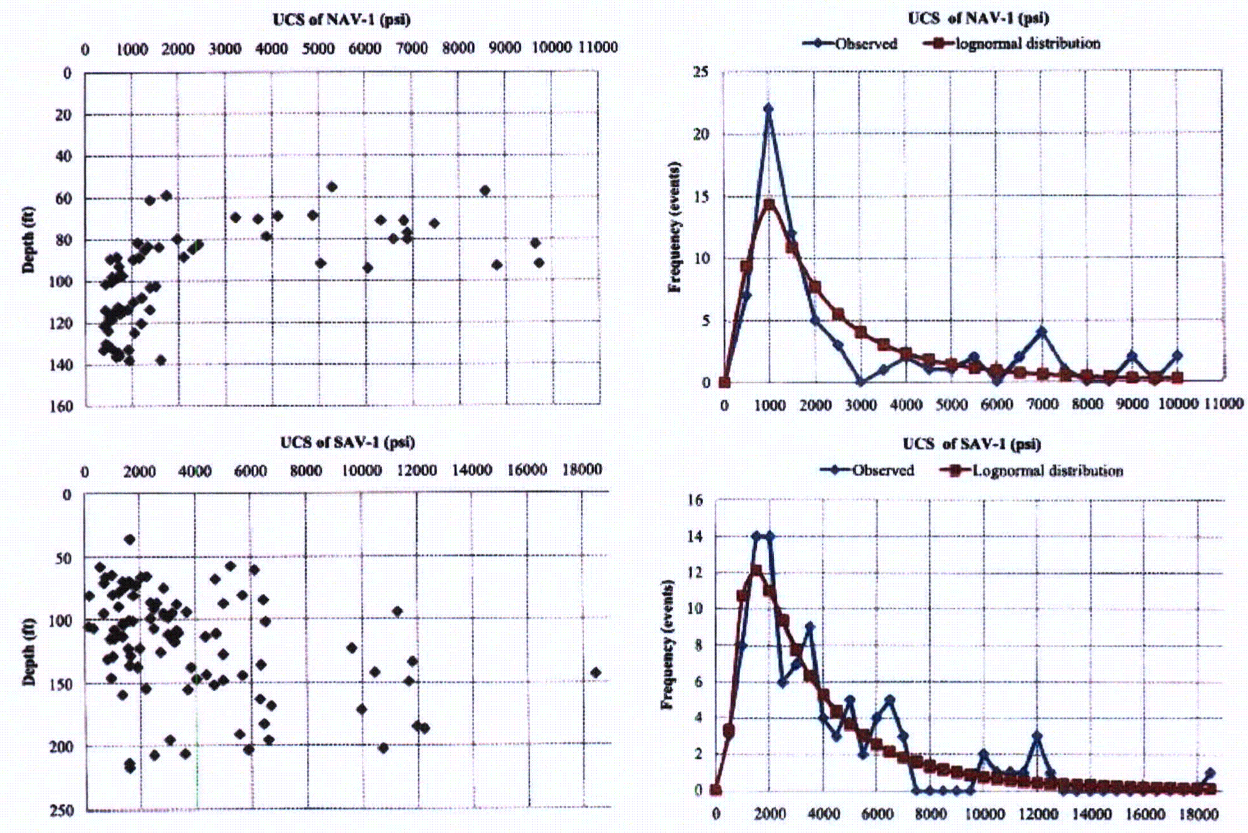

FIGURE RAI 02.05.04-7-1
EXAMPLE OF STATISTICAL ANALYSIS OF UNCONFINED COMPRESSIVE STRENGTH DATA BASED ON NAV-1 AND SAV-1 LAYERS

Average values were considered for the other parameters (GSI, unit weight, layer thickness and Poisson's ratio).

The bearing capacity of the Avon Park Formation, including the variability of the UCS previously defined in the statistical analysis, was calculated using three different methods:

1. US Army Corps of Engineers (USACE) formulation for two different failure modes of the rock subsurface.

2. Hoek-Brown strength criterion

3. Serrano and Olalla (1994)

The factors of safety comparing the bearing capacity of the Avon Park Formation with the corresponding static bearing pressures were also calculated.

The factors of safety for static loading of the subsurface of both units are shown to be above 3.0 for all mean and median cases. Factors of safety are shown to be 1.9 or greater for the conservative lower bound cases.

The Hoek-Brown strength criterion gives similar results as the general shear failure of the USACE formulation, validating its applicability to this analysis. A more comprehensive procedure for calculating the ultimate bearing capacity of fractured rock was also included in this analysis by using the Serrano-Olalla method.

Two cases are presented for both LNP 1 and LNP 2, with USACE, Hoek-Brown, and Serrano-Olalla bearing capacities presented for each. Case I refers to the bearing capacity at the top of the Avon Park Formation (NAV-1 for LNP2 / SAV-1 for LNP1). Case II refers to the bearing capacity at the top of the lower strength zones NAV-3 (LNP2) and SAV-2 (LNP1).

Factors of safety for these cases are shown in the table below where lower bound is the 84th percentile.

TABLE RAI 02.05.04-7-1
BEARING CAPACITY SENSITIVITY RESULTS

		NORTH (LNP 2)						SOUTH (LNP 1)					
		I			II			I			II		
		Mean UCS	Median UCS	Lower Bound UCS	Mean UCS	Median UCS	Lower Bound UCS	Mean UCS	Median UCS	Lower Bound UCS	Mean UCS	Median UCS	Lower Bound UCS
Rock Mass Properties	Unit Weight (pcf)	125.7	125.7	125.7	118.0	118.0	118.0	132.1	132.1	132.1	125.0	125.0	125.0
	Cohesion (ksf)	4.2	3.3	1.9	3.0	2.4	1.5	3.5	3.0	1.8	3.2	2.9	1.8
	Friction Angle (degrees)	20.0	18.3	14.8	16.3	14.8	11.6	20.3	19.2	15.8	15.5	14.8	11.9
USACE (1996) General Shear Failure	Ultimate Bearing Capacity (ksf)	76.6	60.5	37.4	87.4	72.9	51.2	74.0	63.0	40.0	96.8	89.4	64.3
	FS	6.0	4.8	2.9	6.2	5.2	3.6	5.8	5.0	3.2	6.2	5.7	4.1
USACE (1996) Local Shear Failure	Ultimate Bearing Capacity (ksf)	57.3	43.4	24.2	-	-	-	54.3	44.8	25.8	-	-	-
	FS	4.5	3.4	1.9	-	-	-	4.3	3.5	2.0	-	-	-
Hoek-Brown (2002)	Ultimate Bearing Capacity (ksf)	75.6	59.2	36.0	82.3	67.8	46.8	80.8	66.1	40.0	90.6	83.2	58.6
	FS	6.0	4.7	2.8	5.9	4.8	3.3	6.4	5.2	3.1	5.8	5.3	3.8
Serrano-Olalla (1994)	Ultimate Bearing Capacity (ksf)	112.0	84.3	47.2	102.2	83.0	52.7	121.1	95.9	53.3	110.8	100.3	66.5
	FS	8.8	6.6	3.7	7.3	5.9	3.8	9.5	7.6	4.2	7.1	6.4	4.3

Factors of safety for dynamic loading were not calculated in the sensitivity study because they are not critical for the Levy Nuclear Plant Site.

A settlement sensitivity analysis was also performed, considering the static loads defined in the DCD and the weight of the RCC. In addition to the settlement analysis using average elastic rock mass properties, different cases were analyzed using reduced rock mass modulus values in order to consider the variation in the rock mass elastic properties. Two analytical procedures were used in this analysis to calculate elastic settlements.

Available statistical information was used to account for the variations in the rock mass modulus of each subsurface layer. The rock mass average values were reduced by 1/3, 2/3 and 1 standard deviations in order to calculate elastic settlements. A normal probability distribution was determined to be appropriate for the analysis to describe the observed data. Borehole geophysics information was used to develop rock mass properties, and subsequent statistical parameters based on the data set. Only average values are considered for the other elastic parameters (Poisson's ratio, RCC unit weight, RCC dimensions, layer thickness).

Elastic settlements were calculated using two analytical procedures, based on the Theory of Elasticity:

A) The elasticity deformation theory, considering a constrained rock mass elastic modulus and the Boussinesq solution for vertical stress distribution.

B) Immediate settlements on the surface of an elastic half-space. This procedure is based on the same formulation as described in FSAR Subsection 2.5.4.10.3.1.

The results correspond to surface settlements at EL. -24.0 ft NAVD (beneath the RCC). The increments in elastic settlement are proportional to the reduction of the rock mass modulus. Using elastic differential deformations, the maximum elastic settlement resulted in approximately 0.27 inches of settlement at LNP 2 and 0.33 inches at LNP 1. Using the elastic half-space, the maximum average settlement resulted in approximately 0.26 inches at LNP 2 and 0.30 inches at LNP 1.

The rock mass modulus standard deviations of LNP 1 are higher than in LNP 2 as a consequence of a larger dispersion of the geophysical survey data. This results in higher rock mass reductions and, therefore, higher elastic settlements.

Properties obtained in the Offset Boring Program (which was described in the response to RAI 02.05.04-5) were compared to those used in the aforementioned sensitivity analyses. Based on the data obtained in during the Offset Boring Program, the mass property analysis presented herein is conservative. As described in the supplemental response to RAI 02.05.04-8, the rock mass modulus range used in these bearing capacity and settlement analyses is bounding.

References:

1) Bieniawski, Engineering Rock Mass Classification, p. 251. Wiley, New York, 1989.

2) Hoek, E., and Brown, E.T. "Practical estimates of rock mass strength." Int. J. Rock Mech. Min. Sci., 34(8), p. 1165-1186, 1997.

3) Robertson, A. MacG., "Estimating Weak Rock Strength." AIME Annual General Meeting, Tucson, AZ, 1988.

4) Wyllie, D. Foundations on Rock, Second Edition, E&FN Spon, an imprint of Routledge, London and New York, 1999.

5) Serrano, Alcibiades and Olalla, Claudio, "Ultimate Bearing Capacity of Rock Masses," International Journal of Rock Mechanics and Mining Sciences & Geomechanics Abstracts, Vol. 31, No. 2, pp. 93-106, 1994.

Associated LNP COL Application Revisions:

No COLA revisions have been identified associated with this response.

Attachments/Enclosures:

None.