Progress Energy

Serial: NPD-NRC-2009-109 10 CFR 52.79
June 23, 2009

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

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

Reference: Letter from Brian C. Anderson (NRC) to Garry Miller (PEF), dated May 8, 2009, "Request for Additional Information Letter No. 029 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 partial response to the NRC request is addressed in the enclosure. The enclosure also identifies responses made in a previous response, NPD-NRC-2009-103, dated June 8, 2009.

If you have any further questions, or need additional information, please contact Bob Kitchen at (919) 546-6992, or me at (919) 546-6107.

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

Executed on June 23, 2009.

Sincerely,

Garry D. Miller
General Manager
Nuclear Plant Development

Enclosure

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

Progress Energy Carolinas, Inc.
P.O. Box 1551
Raleigh, NC 27602

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Levy Nuclear Power Plant Units 1 and 2
Response to NRC Request for Additional Information Letter No. 029 Related to SRP Section 2.5.4 for the Combined License Application, dated May 8, 2009

NRC RAI #	Progress Energy RAI #	Progress Energy Response
02.05.04-10	L-0191	NPD-NRC-2009-103, dated June 8, 2009
02.05.04-11	L-0192	Response enclosed – see following pages
02.05.04-12	L-0193	NPD-NRC-2009-103, dated June 8, 2009
02.05.04-13	L-0195	NPD-NRC-2009-103, dated June 8, 2009
02.05.04-14	L-0196	NPD-NRC-2009-103, dated June 8, 2009

NRC Letter No.: LNP-RAI-LTR-029

NRC Letter Date: May 8, 2009

NRC Review of Final Safety Analysis Report

NRC RAI NUMBER: 02.05.04-11

Text of NRC RAI:

The description provided of the finite element analysis of the coupled RCC bridging mat and rock/void materials does not provide information on the sensitivity of the computed responses (stresses developed in and around the rock mass) to uncertainties and variability in material properties.

Please provide information on sensitivity of calculated stresses and displacements in the Avon Park rock foundation to (a) variability in assumed elastic properties and uniformity of the rock material, and (b) impact of potential void sizes and shapes on calculated stresses and safety factors, and (c) boundary conditions.

PGN RAI ID #: L-0192

PGN Response to NRC RAI:

a. A 3-D Finite Element Model (FEM) was used to perform a sensitivity analysis, considering the static loads defined in the DCD and the weight of the RCC, to evaluate stresses and settlements considering variation in the rock mass elastic properties.

   Rock mass statistical parameters were obtained from borehole geophysics data. Statistical information about the rock mass modulus was used to account for the variation in each subsurface layer. A normal probability distribution was then used to describe the observed data. The rock mass average values were reduced by 1/3, 2/3, and 1 standard deviation in order to calculate elastic settlements. Average values were considered for other elastic parameters: Poisson's ratio, RCC unit weight, RCC dimensions, and layer thickness.

   Elastic settlements were then calculated using two analytical procedures:

   1. Elasticity deformation theory, considering a constrained rock mass elastic modulus and the Boussinesq solution for vertical stress distribution; and
   2. Immediate settlements on the surface of an elastic half-space.

   Results were then compared for all different cases for the North and South reactors. The increments in elastic settlement were proportional to the reduction in the rock mass modulus. Using the elasticity deformation theory, the maximum settlement was 0.27 inches at LNP 2 and 0.33 inches at LNP 1. Using the elastic half-space method, the maximum settlement was 0.26 inches at LNP 2 and 0.30 inches at LNP 1. These settlements are within acceptable tolerances for this parameter. These results were presented in the response to RAI 02.05.04-7.

   Sensitivity analyses were also previously performed on the RCC to calculate the bridging mat elastic stresses and settlements due to total loads applied to the structure, as part of the response to RAI 02.05.04-8. Horizontally-oriented soft zones were included as lenses of soft material within the limestone subsurface. These conservatively postulated lenses of low-strength material were modeled using FEM analysis of the LNP 2 rock profile. A total of 13 one-foot-thick beds were included in the FEM analysis to consider the vertical variation of the rock mass elastic properties.

Another sensitivity analysis is being presented in this RAI response whereby RQD data for each borehole were used to horizontally vary the elastic properties of the soft zones. In order to maximize the occurrence of differential settlements and associated tensile stresses within the RCC bridging mat, the elastic properties of the soft zones were divided in two groups: zones with medium-high RQD (RQD>50%) and zones with medium-low RQD (RQD<50%). In this way, there are localized zones of soft material surrounded by zones of stiffer material, which results in higher differential settlement. Three cases were identified for analysis:

A) Case A: the possible presence of soft zones with medium-low RQD values (less than 50%), located in the northeast area of the nuclear island. The boundary conditions are constrained lateral displacement.

B) Case B: the possible presence of soft zones with medium-low RQD values (less than 50%), located in the southwest corner of the nuclear island. The boundary conditions are constrained lateral displacement.

C) Case C: the possible presence of soft zones with medium-low RQD values (less than 50%), located in both the northeast area and the southwest corner of the nuclear island. For this case, the analysis was performed using two different boundary conditions for the finite element model: Case C-1 corresponds to a FEM with lateral displacement constraints (pinned supports), and Case C-2 corresponds to a FEM with lateral stress constraints. Part (c) of this RAI response provides a more detailed description of the different boundary conditions).

RCC elastic stresses and settlements are calculated for each of the three cases. In addition, a base case without soft zones and a case without horizontal variation within each bed are also analyzed.

Total and differential settlements for all cases are calculated to be less than approximately 0.5 inches. The largest total and differential settlements occur when the beds are modeled as having continuous properties. By modeling the soft zones as described above, total settlements were reduced by approximately 25 percent, and differential settlements were reduced by approximately 13 percent.

The highest tensile stress and compressive stresses for all cases are less than 100 psi and 1000 psi, respectively.

Thus, while it was reasonably postulated that differential settlement would be increased by horizontally variable soft zones, the flexure associated with modeling these layers as continuously soft has created the most conservative estimates of settlement and stress induction. Based on the above, both vertical and horizontal variation within the Avon Park Formation does not result in unacceptable total or differential settlements or stresses of the nuclear islands.

b. The impact of potential void sizes, locations, and shapes has been presented in responses to RAI 02.05.01-7 and 02.05.04-23.

The results within those RAI responses indicate that the impact of various sizes, shapes, and locations of potential voids is within the acceptable tolerance associated with the RCC bridging mat.

With respect to the stresses and safety factor of the Avon Park Formation, a subsurface failure analysis was conducted. This analysis evaluated the potential for subsurface collapse and subsequent surface subsidence due to a design-sized karst feature (10 feet by 10 feet by 10 feet) beneath the nuclear island.

The analysis was conducted in three parts: first, the minimum depth required between the RCC bridging mat and the karst feature to preclude cavity collapse under nuclear island loading was determined; second, assuming that the karst feature were to collapse at this minimum depth, the size of the surface depression at the bottom of the RCC bridging mat was determined; and third, a finite element model (FEM) was used to evaluate the adequacy of RCC bridging mat to support this surface depression.

Three methods were used to determine the minimum depth of limestone required to preclude cavity collapse under nuclear island loading: the roof-beam method (Craig, 2000), the strut-and-tie model for deep beam method (ACI 318-05), and the plate theory method (Timoshenko & Woinowksy-Krieger, 1959) all indicate that if a 20-foot mass of Avon Park Formation limestone is present between the RCC bridging mat and the design karst feature, the imposition of nuclear island loads are not sufficient to cause collapse of the feature.

Based on conventional rock mechanics and subsidence analysis (Pariseau, 2007), including a highly conservative approximation of the angle of draw (35 degrees), a 38-foot-wide depression is postulated immediately beneath the RCC bridging mat, based on the postulated collapse of a design-sized karst feature at the deepest elevation that such a collapse can be induced by the loads of the nuclear island. This conservatively neglects any bonding between the RCC bridging mat and the Avon Park Formation limestone, and considers a wide, upper bound angle of draw.

Using this conservatively estimated depression, a finite element analysis is performed whereby a 40-foot void is modeled immediately beneath the RCC bridging mat. The maximum tensile stress induced in the RCC bridging mat due to this conservative condition is 123 psi.

The analysis concludes that nuclear island loading is not sufficient to collapse design karst features located more than twenty feet below the RCC bridging mat. If a design karst feature were to exist just above this elevation, and if it were to collapse, the surface depression caused immediately beneath the RCC bridging mat is not large enough to induce unacceptable stresses within the RCC bridging mat.

c. An elastic stress analysis was performed using the finite element model of the LNP 2 subsurface. This analysis determined the subsurface rock elastic stresses and the RCC bridging mat elastic stresses and settlements by considering two different laterally constrained conditions in the FEM boundaries, as well as two different subsurface conditions. For the purposes of this calculation, the FEM boundaries were defined at a lateral extension where vertical stresses due to surcharge (external loads) are approximately 10-12 percent of the surface pressure, based on theoretical solutions.

These two cases considered the following different boundary conditions:

1. Lateral displacement constraints: Pinned supports are applied to the lateral boundary solid elements constraining the solid element's lateral displacements and allowing displacement only in the vertical direction. The elements are free to rotate in the three principal directions.
2. Lateral stress constraints: Lateral stresses are applied to the boundary solid elements. The stress distribution for horizontal stresses is obtained based on the in-situ vertical stress distribution and the coefficient of horizontal pressure Ko. Vertical stresses are calculated for each rock layer using effective unit weights.

In both cases, solid elements at the bottom boundary are constrained in the lateral and vertical directions with pinned supports; rotations are allowed.

The analysis was performed for two different subsurface conditions:

1. Base case (no voids or soft zones), without voids or beds of soft material.
2. Thirteen soft zones, with 13 beds of soft material within the rock mass subsurface.

For the base case, the maximum tensile stress in the E-W direction, due to the change in boundary conditions from lateral stress to lateral displacement constraints, increased from 59 to 66 psi. Maximum settlements increased from 0.27 inches to 0.33 inches.

For the case with thirteen soft zones, the maximum tension in the RCC, due to the change in boundary conditions from lateral stress to lateral displacement constraints, increased marginally. Maximum settlements increased from 0.54 inches to 0.60 inches.

The variation range of elastic stresses and settlements in the RCC, when different boundary conditions are applied to the FEM, is considered to be within acceptable limits. Tensile stresses increased less than 5% when stress boundaries are applied. Therefore, based on these results, lateral displacement constraints (pinned supports) used as boundary conditions do not significantly impact the results from the FEM analyses.

References:

1. ACI committee 318, "BUILDING CODE REQUIREMENTS FOR STRUCTURAL CONCRETE (ACI 318-05) AND COMMENTARY (ACI 318R-05)," October, 2004
2. Craig, R.W. "Stresses in Beams," Mechanics of Materials, 2nd Edition, pp. 338-419, New York: John Wiley and Sons, 2000
3. Timoshenko S. and S. Woinowsky-Krieger, "Theory of Plates and Shells," McGraw-Hill Book Company, 1959

Associated LNP COL Application Revisions:

No COLA revisions have been identified associated with this response.