TVA

Tennessee Valley Authority, 1101 Market Street, LP 5A, Chattanooga, Tennessee 37402-2801

February 18, 2009

10 CFR 52.79

U.S. Nuclear Regulatory Commission
ATTN: Document Control Desk
Washington, D.C. 20555

In the Matter of)
Tennessee Valley Authority)

Docket No. 52-014 and 52-015

BELLEFONTE COMBINED LICENSE APPLICATION – RESPONSE TO REQUEST FOR ADDITIONAL INFORMATION – STABILITY OF SUBSURFACE MATERIALS AND FOUNDATIONS

References:
1) Letter from Ravindra G. Joshi (NRC) to Andrea L. Sterdis (TVA), Request for Additional Information Letter No. 101 Related to SRP Section 2.5.4 for the Bellefonte Units 3 and 4 Combined License Application, dated August 5, 2008.
2) Letter from Andrea L. Sterdis (TVA) to Document Control Desk (NRC), Response to Request for Information Stability of Subsurface Material and Foundations, dated September 19, 2008.

This letter provides the Tennessee Valley Authority's (TVA) supplemental response to the Nuclear Regulatory Commission's (NRC) request for additional information (RAI) item 02.05.04-18 included in Reference 2. This supplement is based on NRC clarification of expectations for the response subsequent to the original response.

This response also identifies associated changes that will be made in a future revision of the BLN application.

If you should have any questions, please contact Tom Spink at 1101 Market Street, LP5A, Chattanooga, Tennessee 37402-2801, by telephone at (423) 751-7062, or via email at tespink@tva.gov.

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

Executed on this 18th day of Feb, 2009.

Andrea L. Sterdis

Andrea L. Sterdis
Manager, New Nuclear Licensing and Industry Affairs
Nuclear Generation Development & Construction

D085
NRO

Enclosure

cc: See Page 3

cc: (w/Enclosure)
J. P. Berger, EDF
E. Cummins, Westinghouse
S. P. Frantz, Morgan Lewis
M.W. Gettler, FP&L
R. C. Grumbir, NuStart
P. S. Hastings, NuStart
P. Hinnenkamp, Entergy
R. G. Joshi, NRC/HQ
M. C. Kray, NuStart
D. Lindgren, Westinghouse
G. D. Miller, PG&N
M. C. Nolan, Duke Energy
N. T. Simms, Duke Energy
G. A. Zinke, NuStart

cc: (w/o Enclosure)
B.C. Anderson, NRC/HQ
M. M. Comar,NRC/HQ
B. Hughes,NRC/HQ
R. H. Kitchen, PGN
M. C. Kray, NuStart
A. M. Monroe, SCE&G
C. R. Pierce, SNC
R. Reister, DOE/PM
L. Reyes, NRC/RII
T. Simms, NRC/HQ
K. N. Slays, NuStart
J. M. Sebrosky, NRC/HQ

Enclosure
TVA letter dated February 18, 2009
RAI Responses

Responses to NRC Request for Additional Information letter No. 101 dated August 5, 2008
(6 pages, including this list)

Subject: Stability of Subsurface Materials and Foundations as detailed in the Final Safety Analysis Report

RAI Number	Date of TVA Response
02.05.04-01	September 19, 2008, Supplemented January 13, 2009
02.05.04-02	September 19, 2008, Supplemented January 13, 2009
02.05.04-03	September 19, 2008
02.05.04-04	September 19, 2008
02.05.04-05	September 19, 2008
02.05.04-06	September 19, 2008
02.05.04-07	September 19, 2008
02.05.04-08	September 19, 2008
02.05.04-09	September 19, 2008
02.05.04-10	September 19, 2008
02.05.04-11	September 19, 2008
02.05.04-12	September 19, 2008
02.05.04-13	September 19, 2008
02.05.04-14	September 19, 2008
02.05.04-15	September 19, 2008
02.05.04-16	September 19, 2008
02.05.04-17	September 19, 2008
02.05.04-18	September 19, 2008; Supplemented by this letter – see following pages
02.05.04-19	September 19, 2008
02.05.04-20	September 19, 2008
02.05.04-21	September 19, 2008

Associated Additional Attachments / Enclosures

Attachment 02.05.04-05A (previously provided)

Attachment 02.05.04-06A (previously provided)

Attachment 02.05.04-14A (previously provided)

Attachment 02.05.04-15A (previously provided)

Attachment 02.05.04-18A (previously provided)

Attachment 02.05.04-19A (previously provided)

Attachment 02.05.04-21A (previously provided)

Attachment 02.05.04-21B (previously provided)

NRC Letter Dated: August 5, 2008

NRC Review of Final Safety Analysis Report

NRC RAI NUMBER: 02.05.04-18

FSAR Section 2.5.4.10.1 states that the bearing capacity was evaluated for each Unit using two independent methods. Method 1 uses the ultimate bearing capacity of the Terzaghi approach based on the strength of the rock mass. Due to the finite dimension of the Bellefonte Nuclear (BLN) island designs, the Terzaghi equation originally developed for infinite base needs to be modified to incorporate the correction factor for parameters Nc and Nγ to take into account the footing finite geometry configuration, such as rectangular or circular, etc.. Furthermore, due to the non-symmetrical configuration of the footing of the nuclear island designs, the consequences of the eccentric loading need to be considered during the bearing capacity evaluation. Please explain whether the geometric correction factors were incorporated into your use of the Method 1 approach for the bearing capacity evaluation. If not, please update the bearing capacity values for the Method 1 approach with the correction factors. Please explain whether the effect of the eccentricity of the loading applied to the footing was considered for the bearing capacity investigation. If not, please update the bearing capacity analysis with the eccentric loading consideration.

BLN RAI ID: 3068

BLN RESPONSE:

Shape Correction Factors - Geotechnical engineering experience has been that settlement, rather than bearing capacity, is the controlling factor with regard to performance of foundations on rock. The initial bearing capacity calculations reported in the FSAR were based on an equivalent area mat with dimensions of 127 by 256 feet to represent the reactor mat. The resulting allowable bearing capacity far exceeded that required in DCD Table 2-1, and further refinement was not done. In response to this RAI, the initial calculations were checked by updating the ultimate bearing capacity values calculated using the Terzaghi approach (FSAR Section 2.5.7, Reference 456). The Terzaghi equation is based on length to width (L/B) ratios greater than 10. For L/B ratios less than 10, shape correction factors are applied to the corresponding bearing capacity factors. Correction factors are provided in Table 6-1 of EM 1110-1-2908 (FSAR Subsection 2.5.7, Reference 456; copy of table attached as Attachment 02.05.04-18A). Because the value of cohesion for the rock was taken as 0, only the correction factor for the Nγ term was used in the current calculations. For the equivalent area mat dimensions, the L/B is 2, which has a corresponding correction factor of 0.9.

Applying the shape correction factor for Nγ results in a static ultimate bearing pressure of 692,000 pounds per square foot (psf), resulting in a factor of safety of 78 with respect to the DCD Table 2-1 required value of 8900 psf.

Consideration of Eccentric Loading - The bearing capacity calculations for the COLA considered that the very large static bearing capacity was also much greater than the required dynamic bearing capacity, and did not make a separate calculation to consider the effects of eccentric loading. For this response, analysis of eccentric loading was considered by comparing the available ultimate bearing capacity computed using a reduced footprint which would result during transient overturning loading events, creating the maximum stress at the edge of the reduced area.

As described in Westinghouse Electric Company, APP-GW-GLR-044 (TR 85), the maximum bearing pressure under dynamic loading occurs under the west (southeast for Bellefonte site orientation) edge of the thick concrete basemat below the shield building. To approximate the reduced footprint area, the Nuclear Island foundation area was first converted to a circular area of radius r_o using the equation for the area moment of inertia for a circle:

$$Ixx = \frac{\pi(2 \cdot r_0)^4}{64}$$

The estimated area moment of Inertia (Ixx) of the entire Nuclear Island foundation about the northeast-southwest axis is Ixx = 5.451E+07 ft^4. Using this value for Ixx and solving for r_0 gives r_0 = 91.3 feet. Figure 1, adapted from Bowles (Bowles, J. E., Foundation Analysis and Design, 4th Edition, McGraw-Hill, Inc., 1988), describes a procedure for utilizing this circular area to compute an equivalent rectangular area subject to the eccentric loading.

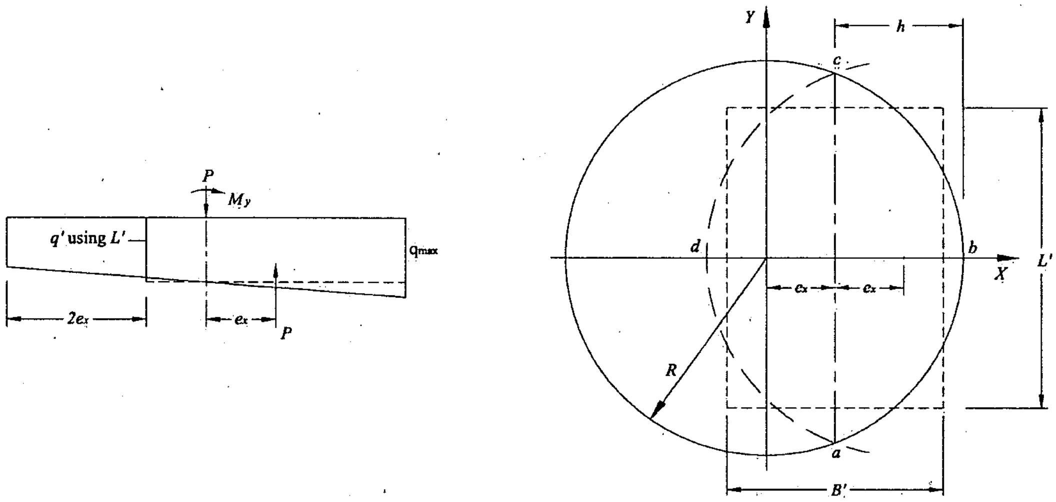

Figure 1. Effective foundation size of eccentrically loaded foundation (after Bowles, Figure 4-4)

Referring to Figure 1, the following nomenclature is used to simplify the equation for calculating the size and area:

R = r_0 = 91.3 feet

h = R-e = r_o – e

distance $ac = 2\sqrt{h(2 \cdot r_0 - h)}$

B' = Bcir (see below)

L' = Lcir (see below)

$$area\_abc \equiv ro^2 \cdot \arccos\left(\frac{ro-h}{ro}\right) - (ro-h)\cdot\sqrt{2\cdot ro\cdot h - h^2}$$

$$Lcir \equiv 1.0 \cdot ac$$ (Figure 1 schematically shows Lcir =0.85 · ac)

$$Bcir \equiv \frac{2\cdot area\_abc}{Lcir}$$

The resulting equivalent rectangle is approximately 51.7 ft. by 146.7 ft.

Using this reduced width, the rock properties as described in FSAR Subsection 2.5.4.10.2, and a shape factor of 0.917 (calculated as described in section 1 above for a L/B of 3) results in a calculated ultimate bearing capacity of 368,000 psf, or a factor of safety of 10.5 with respect to the DCD Table 2-1 required value of 35,000 psf.

The indicated FSAR changes will be made in a future revision of the BLN COLA.

This response is PLANT-SPECIFIC.

ASSOCIATED BLN COL APPLICATION REVISIONS:

1. COLA Part 2, FSAR. Chapter 2, Subsection 2.5.4.10.1, third paragraph, will be revised from:

The value for ø was conservatively taken as 46°, the lower bound value for Unit A argillaceous limestone (the weaker of the two rock types) determined from Hoek-Brown analyses discussed in Subsection 2.5.4.2.3.4.

To read:

The value for ø was conservatively taken as 46°, the lower bound value for Unit A argillaceous limestone (the weaker of the two rock types) determined from Hoek-Brown analyses discussed in Subsection 2.5.4.2.3.4. The value of c was taken as zero.

2. COLA Part 2, FSAR. Chapter 2, Subsection 2.5.4.10.1 will be revised to add a new paragraph following the third paragraph to read:

The Terzaghi equation used in Method 1 is based on length to width (L/B) ratios greater than 10. For L/B ratios less than 10, shape correction factors are applied to the corresponding bearing capacity factors. Correction factors are provided in Table 6-1 of EM 1110-1-2908 (Reference 456). Because the value of cohesion for the rock was taken as 0, only the correction factor for the $N\gamma$ term was used in the calculations. The equivalent area mat dimensions for static loading are approximately 127 feet by 256 feet, for an approximate L/B of 2, and a corresponding correction factor of 0.9. To consider eccentric loading that produces the maximum DCD design bearing pressure of 35,000 psf under dynamic loading, the shield building area was converted to an equivalent rectangle having approximate dimensions of 51.7 feet by 146.7 feet. These dimensions are an approximate L/B of 3 with a corresponding shape correction factor of 0.92.

3. COLA Part 2, FSAR. Chapter 2, Section 2.5.4.10.1; last paragraph, first and second bullets will be revised from:

Using the lower bound rock properties, both methods show bearing capacities well above the requirements in DCD Table 2-1 (8600 pounds per square foot [psf] for static and 35000 psf for dynamic). The calculated bearing capacities under both static and dynamic conditions are:

• Method 1; 251,000 psf, and

• Method 2; 236,000 psf.

To read:

Using the lower bound rock properties for argillaceous limestone as shown in Table 2.5-236, both methods show bearing capacities well above the requirements in DCD Table 2-1 (8900 pounds per square foot [psf] for static and 35,000 psf for dynamic). The calculated ultimate bearing capacities for Method 1 considering shape factor corrections and eccentric loading and allowable bearing capacity for Method 2 are:

• Method 1: 692,000 psf static, and 368,000 psf dynamic, and

• Method 2: 236,000 psf. This method provides an allowable bearing pressure based on rock properties only, not the process by which loading is applied. It is therefore applicable to both static and dynamic loading.

ASSOCIATED ATTACHMENTS/ENCLOSURES:

Attachment 02.05.04-18A

Attachment 02.05.04-18A

Table 6-1 from EM 1110-1-2908

Attachment 02.05.04-18A

(previously provided)