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SOUTHERN COMPANY

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U.S. Nuclear Regulatory Commission
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Southern Nuclear Operating Company
Vogtle Electric Generating Plant Units 3 and 4 Combined License Application
Response to Request for Additional Information Letter No. 030

Ladies and Gentlemen:

By letter dated March 28, 2008, Southern Nuclear Operating Company (SNC) submitted an application for a combined license (COL) for proposed Vogtle Electric Generating Plant (VEGP) Units 3 and 4 to the U.S. Nuclear Regulatory Commission (NRC) for two Westinghouse AP1000 reactor plants, in accordance with 10 CFR Part 52. During the NRC's detailed review of this application, the NRC identified a need for additional information, involving lateral earth pressures and hydrostatic pressures at the site, required to complete their review of the COL application's Final Safety Analysis Report (FSAR) Section 2.5, "Geology, Seismology, and Geotechnical Engineering." By letter dated March 10, 2009, the NRC provided SNC with Request for Additional Information (RAI) Letter No. 030 concerning this information need. This RAI letter contains two RAI questions numbered 02.05.04-3 and -4. The enclosure to this letter provides the SNC response to these RAIs.

If you have any questions regarding this letter, please contact Mr. Wes Sparkman at (205) 992-5061.

D092
NRO

Mr. J. A. (Buzz) Miller states he is an Executive Vice President of Southern Nuclear Operating Company, is authorized to execute this oath on behalf of Southern Nuclear Operating Company and to the best of his knowledge and belief, the facts set forth in this letter are true.

Respectfully submitted,

SOUTHERN NUCLEAR OPERATING COMPANY

Joseph A. (Buzz) Miller

Sworn to and subscribed before me this 9th *day of* April, *2009*

Notary Public: Gloria H. Buie

My commission expires: 05/06/09

JAM/BJS/dmw

Enclosure: Response to NRC RAI Letter No. 030 on the VEGP Units 3 & 4 COL Application Involving Lateral Earth Pressures and Hydrostatic Pressures at the Site

cc: Southern Nuclear Operating Company
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Southern Nuclear Operating Company

ND-09-0511

Enclosure

Response to NRC RAI Letter No. 030

on the VEGP Units 3 & 4 COL Application

Involving

Lateral Earth Pressures and Hydrostatic Pressures

at the Site

FSAR Section 2.5, Geology, Seismology, and Geotechnical Engineering

eRAI Tracking No. 2171

NRC RAI Number 02.05.04-3:

SSAR Section 2.5.4 does not include a discussion of the lateral earth pressures or hydrostatic pressures at the site. RAI 2.5.4-1 requested an explanation of the methodologies used to determine the lateral earth pressures and the hydrostatic pressures acting on the safety-related structures at the VEGP Units 3 and 4 site. The response to RAI 2.5.4-1 stated that the static lateral earth pressures were evaluated using Rankine's theory for active, at-rest, and passive conditions; seismic lateral earth pressures for active and at-rest conditions were evaluated using methods presented by Mononobe-Okabe and ASCE 4-98, respectively; and lateral earth pressures resulting from an areal surcharge applied at the ground surface alongside below-grade walls were evaluated for active and at-rest conditions. Sample earth pressure diagrams for active and at-rest conditions were provided.

As a result of the response to RAI 2.5.4-1, the following concerns were noted:

1) It appears the ASCE 4-98 reference for at-rest conditions is not for the case of Rankine at-rest conditions but rather refers to the Wood solution for dynamic pressures against a rigid wall, as Figure 2 of the response to the RAI resembles the Wood dynamic pressure solution. It is not obvious how this relates to the at-rest pressure conditions, as an at-rest condition is associated with a static overburden condition where pressures increase with depth due to dead weight of the soil under a presumed zero displacement assumption of the wall.

2) The M-O active pressure solution presumes that the rigid wall moves enough under the soil loads to generate shear failure in the soil along a potential failure surface, and the M-O solution assumes that the failure surface is a simple linear one emanating from the base of the wall. The guidance provided in ASCE 4-98 is to not use this approach unless the wall displacements are expected to be enough to generate this reduction. Previous discussions had indicated that the use of tieback construction of the MSE walls was intended to ensure that wall displacements would be minimal during backfill operations behind the walls. Additionally, backfill placement and construction methods would be such that the displacements of the wall during backfill operations would be such as to minimize the shear wave velocity contrasts between the compacted soil immediately behind the wall and the soils compacted away from the MSE wall by heavy equipment.

3) When comparing the resulting seismic force against the wall computed by the M-O method and the dynamic Wood solution, the MO solution is less than half of the Wood solution for walls away from other adjacent walls.

4) The AP1000 exterior walls of the nuclear island were designed to resist the envelope of both the dynamic Wood solution and the peak passive pressure solution. The envelope pressure may be very much larger than the M-O solution, particularly along the lower two-thirds of the wall. The lateral seismic pressures acting on the vertical walls will be generated in SASSI and are typically approximated by the Wood solution.

Please address each of the concerns listed above and provide justification for the use of or any reference made to wall pressure calculations discussing active soil pressures conditions employing the Mononobe-Okabe method.

SNC Response:

This response includes individual responses to the specific concerns raised in the RAI as well as an overview discussion of the earth retaining structures at the VEGP Units 3 and 4 site, including the methodologies used to determine lateral earth pressures (subject of RAI 02.05.04-1). The response also addresses the conclusion voiced in the discussion held between SNC and the NRC on a RAI clarification phone call held on March 10, 2009. In particular, on this phone call, the NRC requested SNC to compare the site specific lateral earth pressures to the enveloping lateral design pressures for the AP1000. In addition, the previous response was developed to address lateral earth pressures from a generic perspective by including diagrams for both active and at-rest conditions. However, based on the clarification phone call referenced above, and closer scrutiny of the original RAI, it is clear that the original RAI was intended to address safety-related structures only. For the AP1000 and the VEGP Units 3 and 4 site, the only safety related structure for each unit is the Nuclear Island (NI), for which only at-rest earth pressure conditions apply. Thus, this response only addresses at-rest earth pressure conditions for safety-related rigid walls. It is intended that this response supersede the response to RAI 02.05.04-01.

Concern 1): In accordance with NUREG-0800, Section 3.8.1 – Concrete Containment, ASCE 4-98 was used to evaluate the dynamic (seismic) earth pressures at the VEGP Units 3 and 4 site, based on site-specific soil properties of the backfill soil. The elastic solution method was used to evaluate non-yielding walls, such as the NI below grade walls, under at-rest conditions. As the RAI notes, this elastic solution is also referred to as the Wood's solution as it was developed by J.H. Wood in 1973. In accordance with ASCE 4-98 Section 3.5.3, a summation of dynamic seismic soil pressures and static earth pressures were evaluated.

Concern 2): As noted in the RAI and provided for in ASCE 4-98 guidance, the Mononobe-Okabe method of evaluating dynamic earth pressures is used for yielding walls where active earth pressure conditions exist. This is common practice in the industry for active earth pressure conditions. As previously stated, the NI below grade walls are under at-rest earth pressure conditions; therefore, the M-O method is not an appropriate method to evaluate the dynamic earth pressures against the NI walls and thus has not been used for this purpose.

The presence of the MSE wall directly behind the NI wall will likely reduce the lateral earth pressures exerted on the NI wall. However, for the evaluation of site-specific lateral earth pressures against the NI wall, the influence of the MSE wall has conservatively been neglected and full at-rest earth pressure conditions on the NI wall are assumed.

Concern 3): The RAI notes that the seismic forces computed by the M-O method are less than half of the forces computed by the ASCE 4-98 elastic solution method (Dynamic Wood solution). This difference is expected given the stress conditions under which these methods are applied – active conditions for the M-O method and at-rest conditions for the ASCE 4-98 method. As discussed above, the NI below grade walls are evaluated under at-rest conditions only. Thus, the M-O method was not utilized for these walls; rather the ASCE 4-98 elastic solution method was utilized for the rigid NI walls.

Concern 4): As stated, the AP1000 NI walls have been designed to resist the envelope of the passive earth pressure and the dynamic earth pressure determined from the ASCE 4-98 solution, as recommended in the Standard Review Plan, including surcharge loads. As discussed above, the M-O method does not apply.

Discussion

Two types of earth retaining structures are planned for the powerblock at the VEGP Units 3 and 4 site. These structures are mechanically stabilized earth (MSE) walls and the below grade walls of the NI. As discussed in Vogtle Early Site Permit (ESP) Application Site Safety Analysis Report (SSAR) Subsection 2.5.4.5.7, the MSE walls will be constructed to facilitate placement of the backfill in the powerblock excavation. These walls are constructed by placing and compacting layers (lifts) of soil and embedding reinforcing members at regular intervals in the soil. Friction along these reinforcing members develops due in part to the weight of subsequent lifts of soil. This friction resists lateral movement of the soil and permits the construction of a vertical retaining structure. At the VEGP Units 3 and 4 site, this wall will retain the backfill for later construction of the NI and will also serve as the outside form for the NI below grade walls. The NI below grade walls are rigid and non-yielding and thus lateral earth pressures are exerted under at-rest stress conditions. However, given the presence of the reinforced soils of the MSE wall, the NI below grade walls will likely not experience full at-rest conditions. Nevertheless, when evaluating the lateral earth pressure on the NI rigid below grade walls, any influence from the MSE walls has been conservatively ignored and full at-rest earth pressure conditions are evaluated.

The site-specific at-rest lateral earth pressure diagram for rigid walls (at-rest case) is presented in new FSAR Figure 2.5-201 (enclosed). A saturated unit weight of 133 pcf for the backfill was used to calculate static and dynamic earth pressures. The site-specific at-rest pressure diagram presented utilizes the ASCE 4-98 elastic solution method to evaluate dynamic earth pressures, which is appropriate for rigid walls. Figure 2.5-201 also includes lateral earth pressure components attributed to a conservatively chosen vertical areal surcharge of 2,500 psf (using a k_o of 0.5 results in a lateral surcharge pressure of 1,250 psf). This Vogtle site specific lateral surcharge pressure of 1,250 psf envelops the AP1000 maximum lateral static plus dynamic design surcharge pressures. Figure 2.5-201 also includes static earth pressures and compaction-induced pressures. A summation of components is presented in Figure 2.5-201 as the total at-rest lateral earth pressure. Groundwater is located well below the basemat elevation at the VEGP Units 3 and 4 site; thus hydrostatic pressure is not included in the site-specific earth pressure diagrams.

In new FSAR Figure 2.5-202 (enclosed), the site specific at-rest total lateral earth pressures, as presented in Figure 2.5-201 for the safety related NI walls, are compared to the enveloping lateral earth pressures for the AP1000 DCD (design case for the below grade NI walls), as provided by Westinghouse Electric Company (WEC). The AP1000 enveloping pressure diagram includes evaluation of the following earth pressure components:

- at-rest earth pressure
- hydrostatic (from 2 ft below the ground surface to the bottom of the walls)
- static surcharge using actual foundation contact pressures
- dynamic surcharge
- dynamic earth pressure
- passive earth pressure

The AP1000 DCD enveloping design pressures shown on Figure 2.5-202 are the maximum lateral earth pressure in the north-south (N-S) and east-west (E-W) directions. The result is a design lateral earth pressure that envelopes the site-specific earth pressures at all depths of the NI walls, in both the N-S and E-W directions.

Associated VEGP COL Application Revision:

VEGP COLA Part 2, FSAR Section 2.5, will be revised to add new Subsection 2.5.4.10.3, and associated references and figures as follows:

VEGP COL 2.5-11 2.5.4.10.3 Lateral Earth Pressure

The development of lateral earth pressures, static and dynamic (seismic), against the below-grade walls of safety-related structures is expected to be minimized with the construction of the mechanically stabilized earth (MSE) walls. As described in ESP SSAR Subsection 2.5.4.5.7, the MSE walls are constructed adjacent to the Nuclear Island (NI) to facilitate the placement of backfill in the powerblock excavation. This bottom-up construction occurs prior to construction of the NI, and the MSE walls serve as the outside form for the NI below-grade walls. Although the MSE walls are expected to relieve much of the static lateral earth pressures exerted on the below-grade walls, over time these pressures may be transferred to the below-grade structure. Thus, the evaluation of site-specific lateral earth pressures for safety-related structures does not consider any influence from the MSE walls and full at-rest lateral earth pressures are assumed.

Site-specific static lateral earth pressures, assuming frictionless vertical walls and horizontally-placed backfill, are evaluated using Rankine's theory for active, at-rest, and passive conditions (Reference 201). The earth pressure coefficients, $k_a = 0.26$, k_o, = 0.4, and $k_p = 3.9$ are based on a drained friction angle of 36 degrees for the compacted structural fill as presented in ESP SSAR Table 2.5.4-1a. The at-rest earth pressure coefficient, k_o, for the compacted structural fill against the NI below grade walls is conservatively taken as 0.5.

The evaluation of site-specific lateral earth pressures includes the influence from surcharges. A vertical areal surcharge of 2,500 psf is used. This pressure conservatively represents construction loading prior to construction of adjacent buildings and subsequent adjacent permanent building loads. The vertical areal surcharge of 2,500 psf equates to a lateral surcharge pressure of 1,250 psf, which exceeds the AP1000 maximum lateral static plus dynamic design surcharge pressures.

Close-in compaction (behind the MSE wall) with a heavy vibratory roller is also considered. Lateral earth pressures increase as a result of compaction. These pressures are controlled at the construction stage by limiting the size of compaction equipment and its proximity to the walls. The influence of compaction was evaluated based on the characteristics of the vibratory compactor used for the Phase 1 Test Pad program (ESP SSAR Appendix 2.5D). Compaction-induced lateral earth pressures under at-rest conditions were evaluated using procedures developed by Duncan, et al. (Reference 203). The inclusion of compaction-induced pressures is conservative given that these pressures will be exerted on the MSE wall prior to construction of the below-grade NI walls.

Site-specific seismic lateral earth pressures are evaluated for at-rest conditions using ASCE 4-98 (Reference 202) The site-specific ground acceleration at a frequency of 100 hertz for the Vogtle 3 and 4 site is taken as 0.266g (ESP SSAR Subsection 2.5.2.6, Table 2.5.2-22b and Figure 2.5.2-38b).

Hydrostatic pressures, attributed to the groundwater level, exert lateral pressure on below-grade structures. At the VEGP Units 3 and 4 site, in the power block areas, the design groundwater elevation of 165 ft msl, as noted in ESP SSAR Subsection 2.4.12, is about 15 feet below the NI basemat elevation of approximately 180 ft msl. The post construction water level, as identified in

ESP SSAR Appendix 2.4B, will also be well below the basemat elevation. Since the groundwater level is located well below the basemat, hydrostatic forces will not be exerted on the below-grade walls and hydrostatic pressures are not considered in the site-specific evaluation of lateral earth pressure for the NI.

In summary, Figure 2.5-201 presents the site-specific total at-rest lateral earth pressures for the below grade NI rigid walls. This diagram was developed assuming level ground surface, a post-construction groundwater level below the basemat elevation (no hydrostatic pressure), an areal surcharge pressure of 2,500 psf, and compaction-induced pressure increases. Figure 2.5-202 presents the comparison of the site-specific total at-rest lateral earth pressure distribution compared to the AP1000 DCD design envelope in both the N-S and E-W directions. In both cases, the site-specific at-rest earth pressure is enveloped by the DCD design earth pressure envelopes by significant margins.

2.5.8 References

201. Lambe, T.W. and R.V. Whitman, *Soil Mechanics*, John Wiley & Sons, Inc., New York, NY, 1969.

202. ASCE 4-98 (2000), *Seismic Analysis of Safety-Related Nuclear Structures and Commentary,* ASCE, Reston, VA, 2000.

203. Duncan, J.M., G.W. Williams, A.L. Sehn and R.B. Seed, "Closure of 'Estimation of Earth Pressures due to Compaction'", *Journal of Geotechnical Engineering*, ASCE, New York, NY, 119(7):1172-1177, July, 1993.

Figure 2.5-201 – Vogtle Site-Specific At-Rest Lateral Earth Pressure Diagrams for Rigid Below Grade Nuclear Island (NI) Walls

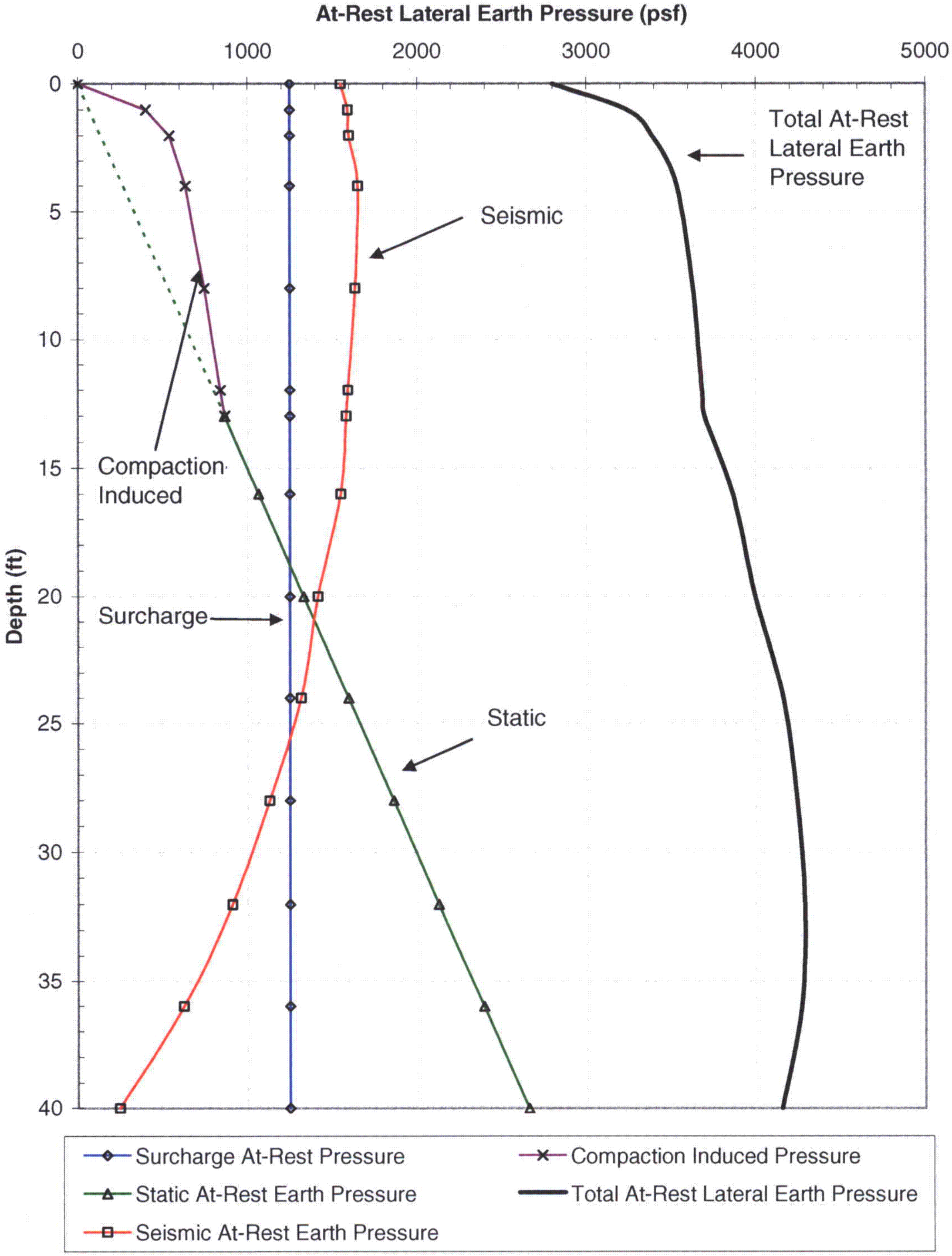
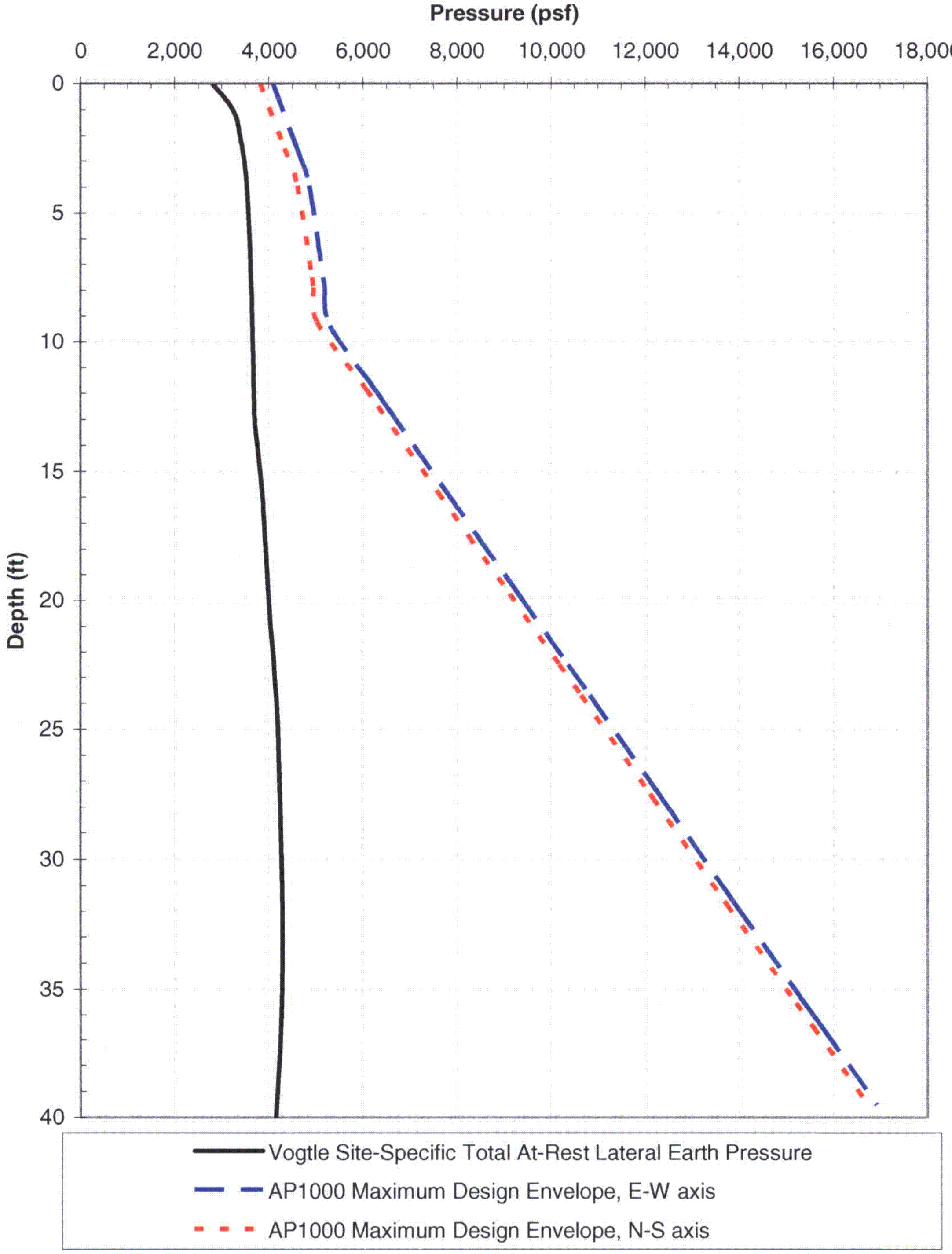


Figure 2.5-202 – Comparison of Vogtle Site-Specific Total At-Rest Lateral Earth Pressure Diagrams and AP1000 Maximum Design Envelopes



NRC RAI Number 02.05.04-4:

AP1000 DCD, Revision 17, Table 2.5-1, provides the limits of acceptable settlement without additional evaluation. The table provides that the total settlement for the nuclear island foundation mat is three (3) inches, and the differential settlement across the nuclear island foundation mat is limited to ½ inch in fifty (50) feet. Additionally, the differential settlement between the nuclear island and the turbine building is limited to 3 inch[es], and the differential settlement between the nuclear island and other buildings is also limited to 3 inch[es].

In the case of the nuclear island foundations, turbine buildings, and other surrounding buildings supported on structural backfill, please provide a description of the program and/or method that will be implemented to ensure that the actual settlement and differential settlement of structures does not exceed the AP1000 DCD settlement criteria.

Relates to AP1000 DCD Revision 17.

SNC Response:

The settlement monitoring program for VEGP Units 3 and 4 will address the expected heave or rebound during the excavation and dewatering phase as well as the settlement due to building construction. Please see the Southern Nuclear response dated December 11, 2008 to NRC RAI 02.05.04-2 for information on the planned benchmarks and settlement monitoring points.

Heave monitor installation will be required prior to excavation. Heave measurements will be used to quantify heave due to excavation and recompression during reloading to measure actual net settlements. Heave gauges will be embedded in the geologic layer(s) of interest and will be periodically measured and recorded to detect heave during excavation. The heave measurements will be evaluated if they exceed expected values. The heave data will be used to evaluate the total settlement of the NI during and following construction. The number of heave monitoring instruments and monitoring points will be established to provide reasonable data correlation and to provide some redundancy in case of damage during construction.

During construction and pre-operational testing, those settlement monitoring points designated as required for meeting DCD settlement guidance will be measured on a frequency which provides reasonable assurance that DCD described settlement guidance will not be exceeded for a given point between sequential surveys without prior evaluation. This frequency may change over the construction and pre-operational testing period due to the variable rate of construction loading, other site activities such as dewatering, and expected settlement rates.

During commercial operation, required settlement monitoring points will be measured on a no less than a semi-annual basis for the first three years of commercial operation, on no less than an annual basis for the fourth through sixth year of commercial operation, and after six years, the survey interval will be evaluated and revised under an engineering program. VEGP Units 3 and 4 settlement calculations indicate that the majority of settlement occurs during construction and the first years of operation such that the frequencies described above will be sufficient to identify any potential settlement issues adverse to quality.