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Subject: AP1000 Response to Request for Additional Information (TR 85)

Westinghouse is submitting responses to NRC requests for additional information (RAI) on Technical Report No. 85. This RAI response is submitted in support of the AP1000 Design Certification Amendment Application (Docket No. 52-006). The information included in this response is generic and is expected to apply to all COL applications referencing the AP1000 Design Certification and the AP1000 Design Certification Amendment Application.

Enclosure 1 provides the response for the following RAI(s):

RAI-TR85-SEB1-37 R4

Questions or requests for additional information related to the content and preparation of this response should be directed to Westinghouse. Please send copies of such questions or requests to the prospective applicants for combined licenses referencing the AP1000 Design Certification. A representative for each applicant is included on the cc: list of this letter.

Very truly yours,

A handwritten signature in black ink, appearing to read 'Robert Sisk'.

Robert Sisk, Manager
Licensing and Customer Interface
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/Enclosure

1. Response to Request for Additional Information on Technical Report No. 85

cc: D. Jaffe - U.S. NRC 1E
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ENCLOSURE 1

Response to Request for Additional Information on Technical Report No. 85

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Response to Request For Additional Information (RAI)

RAI Response Number: RAI-TR85-SEB1-37

Revision: 4

Question:

In Section 5.1, entitled "Proposed Revisions to DCD Section 2.5," the DCD mark up of Section 2.5.4.6.2 states that "Seismic stability requirements are satisfied if the soil layers below and adjacent to the nuclear island foundation are composed predominantly of rock or sand and rock (gravel), or sands that can be classified as medium to dense (standard penetration test having greater than 10 blows per foot)." This criterion of 10 blows per foot, places the soil at the boundary of loose to medium and not medium to dense soils. Also, using the criteria of 10 blows per foot places the soil friction angle below the minimum required 35 degrees for the NI stability calculations. Therefore, provide the technical justification for the adequacy of the blow count criteria and demonstrate that it is consistent with the minimum soil friction angle of 35 degrees used in design and stability calculations. The soil friction angle should also be specified separately as a site interface criteria for soil in DCD Table 2-1 and in DCD Tier 1.

Additional Request (Revision 1)

The RAI response indicates that the phrase "medium to dense" will be revised to read "medium or dense" when describing the sands for which the stability requirements were satisfied. This change addresses the first part of the original RAI. However, this change does not address the second part of the RAI which indicates that using the criterion of 10 blows per foot for medium or dense sands, places the soil friction angle below the minimum required 35 degrees for the nuclear island stability evaluations. Therefore, Westinghouse is requested to revise the blow count criteria or to provide the technical justification for the adequacy of the 10 blows per foot criteria and demonstrate that it is consistent with the minimum soil friction angle of 35 degrees used in the design and stability calculations.

Additional Request (Revision 2)

Based on the information provided in Revision 1 to this RAI response, the remaining concern with the second part of the RAI relates to the acceptable blow count for the soil beneath the basemat and the soil used as backfill at the side of the foundation/walls. The Westinghouse response indicates that a change to the DCD in the second paragraph of subsection 2.5.4.6.2 will be made to indicate that for medium sand a blow count greater than 10 blows per foot, or for dense sand a blow count greater than 30 blows per foot is representative of acceptable backfill. While the blow count of 10 blows per foot has been demonstrated as being acceptable for the backfill material at the side walls of the foundation for the types of soils listed, this criterion has not been demonstrated as being acceptable for the soil beneath the basemat. In the response to other RAIs and as specified in Table 2.0-1 of the DCD, the criterion for the soil beneath the basemat is that a soil internal friction angle of 35 degrees will be demonstrated by the COL

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applicant. Therefore, the proposed mark-up of Section 2.5.4.6.2 of Revision 17 should be revised to reflect the criterion of 35 degrees for the soil internal friction angle.

In addition, the prior RAI response indicated that the soil friction angle will be specified separately as a site interface criterion for soil in DCD Table 2-1 and in DCD Tier 1 for soils below the NI. Currently, DCD Rev. 17, Tier 1, Table 5.0-1 does not provide this criterion. The RAI response also does not provide the mark-up for this criterion. Therefore, Westinghouse is requested to include the soil friction angle site parameter requirement of 35 degrees beneath the foundation in DCD Tier 1, Table 5.0-1, consistent with criterion in DCD Tier 2, Table 2-1.

Additional Request (Revision 3)

1. Add reference to Section 3.8.5.5.4 and 3.8.5.5.5, as appropriate, to the DCD section. Page 5 first full paragraph of the RAI response.

Additional Request (Revision 4)

The staff reviewed the response provided in Westinghouse letter dated September 22, 2009. In the response, revisions are proposed in subsection 2.5.4.6.2 to add a cross reference to DCD subsection 3.8.5.5.5 and a requirement for the minimum soil angle of internal friction to DCD Tier 1, Table 5.0-1. The RAI response is technically acceptable to the staff; however, the proposed wording in the DCD markup for Table 5.0-1 needs to be corrected. The present wording states, "If the minimum soil angle of internal friction is below 35 degrees, a site specific analysis of the stability against sliding and the seismic stability shall demonstrate stability using the site specific soil properties." Please correct if the words are inconsistent or justify why the phrase "and the seismic stability" is inserted in this statement.

Westinghouse Response:

References 1 and 2 provide the technical justification linking the SPT blow count to the internal angle of friction. Table RAI-TR85-SEB1-37-1 (shown below) provides the illustration that a Medium sand with a SPT blow count of 10-30 blows/ft is consistent with an internal angle of friction ranging from 32 to 36 degrees. The NRC is correct that the blow count of greater than 10 places the soil on the boundary of loose to medium. The description "medium to dense" was not intended to define the minimum but rather to state the sands for which the stability requirements were satisfied. The DCD will be clarified to read "medium or dense".

The soil friction angle will be specified separately as a site interface criterion for soil in DCD Table 2-1 and in DCD Tier 1. However, this is limited to soils below the nuclear island. Where side soils do not satisfy the internal friction angle of 35 degrees, DCD subsection 2.2.5.4.6.2 requires the Combined License applicant to evaluate the seismic stability against sliding as described in subsection 3.8.5.5.3 using the site-specific soil properties. In many cases, such as

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cases where groundwater is significantly below grade, seismic stability can be demonstrated without taking credit for the resistance of the side soils.

Table RAI-TR85-SEB1-37-1 – Soil Properties

Soil Types	Standard Penetration Test N - Blows/ft	Angle of Internal Friction Φ – degrees
Sands ⁽¹⁾	[Ref. 1, Table 10, page 294]	[Ref. 2, Section 5, Table 2] ⁽²⁾
Very Dense	> 50	41° to 46°
Dense	30-50	36° to 41°
Medium	10-30	32° to 36°
Loose	4-10	28.5° to 32°
Very Loose	0-4	< 28.5°

Notes to Table RAI-TR85-SEB1-37-1:

- (1) As stated in Reference 2 “for dry silts and very silty sands values of Φ are usually 2 to 6 deg. less than those shown in Table 2.” The Table 2 values are those given in this table for dry sand composed primarily for quartz. Also it is stated in Reference 2, “for silts and very silty sands below the groundwater table, values of Φ are, for the great majority of cases, considerably less (one-third to one-half) than the values for dry material.” Reference 1, page 86, states that angle of friction values for silt and silty sand “obtained from slow-shear tests range from about 27° to 30° for the loose state, and 30° to 35° for the dense state. These values are almost as great as those for sand.”
- (2) Using Table 7, page 82 of Reference 1, a description of the soil can be obtained based on the angle of friction. For the loose sand as well as the combined category of dense/very dense sand, the sand with an angle of friction in the lower range, the sand is made up of uniform round grains, for the upper range it has angular grains that are well graded.

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Westinghouse Response (Revision 1):

A change to the DCD in the second paragraph of subsection 2.5.4.6.2 will be made to indicate that for medium sand a blow count greater than 10 blows per foot, or for dense sand a blow count greater than 30 blows per foot is representative of acceptable backfill. The standard penetration test having greater than 10 blows per foot provides the means of assuring that the side soil is competent. There has been no requirement placed on the applicant that the backfill adjacent to the Nuclear Island walls below grade must have a friction angle of 35° or greater. However, it is anticipated that the friction angle will be above 32° for the side soil backfill based on Table RAI-TR85-SEB1-37-1. Recognizing that not all of the passive pressure is required, as discussed in RAI-TR85-SEB1-34, 35, and 40, the sand backfill that ranges from medium to very dense, as well as sand and gravel, and rock provide adequate passive pressures as seen in Table RAI-TR85-SEB1-37-2, noting that Case 15 is used for the AP1000 design. Further, it is noted in the DCD that the COL applicant must do the following:

- Per Subsection 2.5.4.6.2, Revision 17, “If the soil below and adjacent to the exterior walls is made up of clay, sand and clay, or other types of soil other than those classified above as competent, then the Combined License applicant will evaluate the seismic stability against sliding as described in subsection 3.8.5.5.3 using the site-specific soil properties.”
- Per Subsection 2.5.4.6.7, Revision 17, “Earth Pressures – The Combined License applicant will describe the design for static and dynamic lateral earth pressures and hydrostatic groundwater pressures acting on plant safety-related facilities using soil parameters as evaluated in previous subsections.”
- Per Subsection 2.5.4.6.9, Revision 17, “Static and Dynamic Stability of Facilities – Soil characteristics affecting the stability of the nuclear island will be addressed including foundation rebound, settlement, and differential settlement.”
- Per Table 2-1 (Tier 2) and Table 5.0-1 (Tier 1), Revision 17, the minimum soil angle of internal friction must be greater than or equal to 35 degrees below the footprint of the Nuclear Island at its excavation depth.

With these COL required actions, it can be further verified that the backfill is competent and have adequate passive pressure to meet the seismic stability requirements.

Westinghouse Response (Revision 2 and 3):

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The response given in Revision 1 does indicate the change to the second paragraph of DCD Subsection 2.5.4.6.2. This response should have stated that the change was to the third paragraph. Westinghouse is in agreement that the blow count criterion is not acceptable for the soil beneath the basemat. For the soil beneath the basemat a soil internal friction angle of 35 degrees is specified in Table 2-1. As requested, Westinghouse will revise the second paragraph adding at the end:

“The Combined License applicant is to demonstrate that the minimum soil angle of internal friction is greater than or equal to 35 degrees below footprint of nuclear island at its excavation depth as specified in Table 2-1. If the minimum soil angle of internal friction is below 35 degrees, then the Combined License applicant will evaluate the seismic stability against sliding as described in subsection 3.8.5.5.3 **and the seismic stability described in subsection 3.8.5.5.5** using the site specific soil properties.”

Note: The reference to DCD section 3.8.5.5.5 is to the material added in the response to RAI-TR85-SEB1-10 to be included in Revision 18 of the DCD. Subsection 3.8.5.5.4 does not include soil friction angle as one of the parameters considered therefore, subsection 3.8.5.5.4 does not need to be referenced from Subsection 2.5.4.6.2.

Since it has been shown from non-linear sliding stability analyses that the Nuclear Island has negligible movement at the bottom of the Nuclear Island basemat (see RAI-TR85-SEB1-010, Revision 2) without consideration of passive pressure, it is no longer necessary to define properties for materials adjacent to nuclear island exterior walls to demonstrate they provide passive earth pressures greater than or equal to those used in the seismic stability evaluation for sliding of the Nuclear Island. Therefore, the third paragraph is removed.

For the Tier 1 reference, Revision 0 of the RAI response did appear to call for an update of the “Minimum Soil Angle of Internal Friction” for DCD Rev. 16, Tier 1, Table 5.0-1 as well as Tier 2, Table 2-1. However, this change was not incorporated in DCD Rev 17, Tier 1, Table 5.0-1, **and at this time, the Tier 1 table should not be changed to include this site interface criterion for soil.**

~~Referring to the statement added above (The Combined License applicant ...), this alternative evaluation of the seismic stability against sliding can be made without requiring an exemption; specifying this criterion in the Tier 1 table will require an exemption regardless of the depth or result of the evaluation. Westinghouse would prefer to avoid having Combined License applicants apply for exemptions wherever possible.~~

A requirement for the minimum soil angle of internal friction will be added to DCD Tier 1 Table 5.0-1 Site Parameters.

Westinghouse Response (Revision 4):

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Westinghouse has revised the wording in the DCD markup for Table 5.0-1 and in subsection 2.5.4.6.2. The wording given in the DCD revision section reflects the added subsection 3.8.5.5.5 as given in RAI-TR85-SEB1-10, Rev. 3.

Table RAI-TR85-SEB1-37-2 – Passive Pressure, El. 60' 6"

Type of Soil		Case	γ_{sub} #/ft ³	γ_{sat} #/ft ³	ϕ deg	P_P psf
Rock	Hard Rock	1	115	175	46	28563
	Rock	2	100	160	46	24933
	Soft Rock	3	100	160	52	34328
	Soft Rock	4	100	160	43	21527
	Soft Rock	5	85	145	52	29331
	Soft Rock	6	85	145	43	18393
Sand & Gravel		7	80	140	36	12634
		8	80	140	32	10675
Sands	Very Dense	9	100	160	46	24933
		10	100	160	41	19597
		11	70	130	46	17674
		12	70	130	41	13891
	Dense	13	88	150	41	17334
		14	88	150	36	13867
		15	87.6	150	35	13229
		16	65	110	36	10236
		17	65	110	36	10236
	Medium	18	68	130	36	10824
		19	68	130	32	9145
		20	60	95	36	9398
		21	60	95	32	7941

References:

1. Terzaghi, Karl, and Ralph B. Peck, Soil Mechanics in Engineering Practice, John Wiley & Sons, Inc., New York, 1948.

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2. Gaylord, E.H., et. al., ed, Structural Engineering Handbook, 4th ed, McGraw-Hill, 1997.

Design Control Document (DCD) Revision:

Revisions identified in Revision 0 of this response have been incorporated in DCD Rev 17.

The following change to DCD Tier 1 Table will be included.

Table 5.0-1 (cont.) Site Parameters	
Soil	
Average Allowable Static Soil Bearing Capacity	The allowable bearing capacity, including a factor of safety appropriate for the design load combination, shall be greater than or equal to the average bearing demand of 8,900 lb/ft ² over the footprint of the nuclear island at its excavation depth.
Minimum Soil Angle of Internal Friction	Minimum soil angle of internal friction is greater than or equal to 35 degrees below the footprint of nuclear island at its excavation depth. If the minimum soil angle of internal friction is below 35 degrees, a site specific analysis of the stability against sliding and the seismic stability shall demonstrate stability be performed using the site specific soil properties to demonstrate stability.

The following changes to Tier 2 subsection 2.5.4.6.2 of Revision 17 are to be made. The changes made to this subsection also reflect the new DCD subsection 3.8.5.5.5 given in RAI-TR85-SEB1-10, Rev. 3.

- 2.5.4.6.2** The Combined License applicant will establish the properties of the foundation soils to be within the range considered for design of the nuclear island basemat.

Properties of Underlying Materials – A determination of the static and dynamic engineering properties of foundation soils and rocks in the site area will be addressed. This information will include a discussion of the type, quantity, extent, and purpose of field explorations, as well as logs of borings and test pits. Results of field plate load tests, field permeability tests, and other special field tests (e.g., bore-hole extensometer or pressuremeter tests) will also be provided. Results of geophysical surveys will be presented in tables and profiles. Data will be provided pertaining to site-specific soil layers (including their thicknesses, densities, moduli, and Poisson's ratios) between the basemat and the underlying rock stratum. Plot plans and profiles of site explorations will be provided. The Combined

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License applicant is to demonstrate that the minimum soil angle of internal friction is greater than or equal to 35 degrees below footprint of nuclear island at its excavation depth as specified in Table 2-1. If the minimum soil angle of internal friction is below 35 degrees, then the Combined License applicant will evaluate the seismic stability against sliding as described in subsections 3.8.5.5.3 and 3.8.5.5.5. the seismic stability described in subsection using the site specific soil properties.

~~Properties of Materials Adjacent to Nuclear Island Exterior Walls—A determination of the static and dynamic engineering properties of the surrounding soil will be made to demonstrate they are competent and provide passive earth pressures greater than or equal to those used in the seismic stability evaluation for sliding of the nuclear island. Seismic stability requirements are satisfied if the soil layers below and adjacent to the nuclear island foundation are composed predominantly of rock, or sand and rock (gravel), or sands that can be classified as medium to dense (standard penetration test having greater than 10 blows per foot). If the soil below and adjacent to the exterior walls is made up of clay, sand and clay, or other types of soil other than those classified above as competent, then the Combined License applicant will evaluate the seismic stability against sliding as described in subsection 3.8.5.5.3 using the site specific soil properties.~~

Laboratory Investigations of Underlying Materials – Information about the number and type of laboratory tests and the location of samples used to investigate underlying materials will be provided. Discussion of the results of laboratory tests on disturbed and undisturbed soil and rock samples obtained from field investigations will be provided.

PRA Revision:

None

Technical Report (TR) Revision:

Section 5 of Technical Report 85 is being deleted from TR 85 Revision 1 as stated in the response to RAI-TR85-SEB1-017.