ArevaEPRDCPEm Resource

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Sent: Thursday, September 02, 2010 6:03 PM
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Subject: DRAFT Response to U.S. EPR Design Certification Application RAI No. 354, FSAR Ch. 3, Question 03.08.05-23
Attachments: RAI 354 Response Question 3.8.5-23 US EPR DC - DRAFT.pdf

Getachew,

Attached is a revised draft response to Question 3.8.5-23 and associated FSAR markup. The original draft response was sent to the NRC on July 8, 2010. Please let me know if the staff has questions or if this response can be sent as final.

Thanks

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Response to

Request for Additional Information No. 354
Question 03.08.05-23 Revision 1

3/16/2010

U. S. EPR Standard Design Certification
AREVA NP Inc.
Docket No. 52-020
SRP Section: 03.08.02 - Steel Containment
SRP Section: 03.08.05 - Foundations
SRP Section: 03.06.02 - Determination of Rupture Locations and Dynamic Effects Associated with the Postulated Rupture of Piping

Application Section: FSAR Ch 3

QUESTIONS for Structural Engineering Branch 2 (ESBWR/ABWR Projects) (SEB2)

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Question 03.08.05-23

(Follow-up to RAI 155, Supplement 4, Question 03.08.05-16)

The RAI response identified the sections in the FSAR that describe the soil properties used in many of the various seismic analyses and designs of Seismic Category I structures. From the review of this information, it is not clear whether all of the key soil parameters have been included in these FSAR sections. In addition, the staff notes that the information contained in FSAR Tier 1, Table 5.0-1 "Site Parameters" and FSAR Tier 2, Table 2.1-1 "Site Design Envelope," is not complete. Some of the soil parameters that are not included are the soil friction angle, the 3.0" global differential settlement criteria referred to in the response to RAI 3.8.5-15, and other key parameters that were relied upon in the design of the foundation walls and evaluations for foundation stability associated with FSAR Section 3.8. Therefore, to meet 10 CFR 52.47 (a) (1), AREVA is requested to ensure that FSAR Tier 1, Table 5.0-1 "Site Parameters" and FSAR Tier 2, Table 2.1-1, include the key soil parameters (e.g., soil angle of internal friction, global settlement criteria, properties used for soil backfill, and soil bearing capacity criteria with a factor of safety appropriate for the design load combinations for all seismic Category I structures) which were postulated in the analyses and design of the Seismic Category I structures and foundations.

Response to Question 03.08.05-23

U.S. EPR FSAR Tier 2, Table 2.1-1, Section 2.5.4.2, and Table 3.8.1-17 will be revised to include the soil angle of internal friction and the soil density values used in the analysis and design of Seismic Category I structures and foundations.

The static and dynamic soil bearing pressure values in U.S. EPR FSAR Tier 1, Table 5.0-1, U.S. EPR FSAR Tier 2, Table 2.1-1, and corresponding U.S. EPR FSAR Tier 2, Sections 2.5 and 3.8 were revised in the response to RAI 376, Question 03.08.05-29. This response adds the safety factors for both static and dynamic conditions to U.S. EPR FSAR Tier 1, Table 5.0-1 and U.S. EPR FSAR Tier 2, Table 2.1-1.

The global settlement between adjacent structures is a function of the design of the umbilicals between structures. The design of umbilicals is not within the scope of the design certification; and global settlement is not included in the U.S. EPR FSAR as a key soil parameter.

FSAR Impact:

U.S. EPR FSAR Tier 1, Table 5.0-1; and Tier 2, Table 2.1-1, Table 3.8-17 and Section 2.5.4.2 will be revised as described in the above response and indicated on the enclosed markup.

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U.S. EPR Final Safety Analysis Report Markups

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Table 5.0-1—Site Parameters for the U.S. EPR Design (3 Sheets)

Wind	
Parameter	**Value(s)**
Maximum Speed (Other than Tornado)	The normal maximum wind speed is 145 mph.
Tornado	
Parameter	**Value(s)**
Tornado (maximum speed, pressure drop, radius of maximum rotational speed, rate of pressure drop, missile spectra)	Maximum tornado wind speed of 230 mph. Maximum rotational speed of 184 mph. Maximum tornado pressure drop of 1.2 pounds per square inch at 0.5 psi per second. Radius of maximum rotational speed is 150 ft.
Soil	
Parameter	**Value(s)**
Soil properties:	
Minimum shear wave velocity	Minimum shear wave velocity (low strain best estimate average value at bottom of basemat) of 1000 feet per second.
Minimum static bearing capacity	~~Minimum~~ Maximum static bearing ~~capacity~~ demand is ~~of~~ 22,000 lb/ft^2 in localized areas at the bottom of the Nuclear Island, EPGB, and ESWB basemats and 15,000 lb/ft^2 ~~on~~ is the average ~~across the total area of the bottom of~~for the Nuclear Island, EPGB, and ESWB- basemats. The ultimate static bearing capacity divided by 3.0 is greater than or equal to the maximum static bearing demand. 03.08.05-23 ~~Minimum static bearing capacity of 3,800 lbs/ft^2 in localized areas at the bottom of the EPGB basemat and 2,700 lbs/ft^2 on average across total area at the bottom of the EPGB basemat.~~ ~~Minimum static bearing capacity of 17,800 lbs/ft^2 in localized areas at the bottom of the ESWB basemat and 5,500 lbs/ft^2 on average across total area at the bottom of the ESWB basemat.~~
Minimum dynamic bearing capacity	~~Minimum~~ Maximum dynamic bearing demand is ~~capacity of~~ 35,000 ~~26,000~~ lb/ft^2 at the ~~bottom~~ toe of the Nuclear Island, EPGB, and ESWB basemats. The ultimate dynamic bearing capacity divided by 2.0 is greater than or equal to the maximum dynamic bearing demand. ~~Minimum dynamic bearing capacity of 10,800 lbs/ft^2 at the bottom of the EPGB basemat.~~ ~~Minimum dynamic bearing capacity of 28,200 lbs/ft^2 at the bottom of the ESWB basemat.~~
Liquefaction potential	No potential for liquefaction under footprint of Seismic Category I structures from site-specific SSE.

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Table 2.1-1—U.S. EPR Site Design Envelope
Sheet 2 of 6

U.S. EPR Site Design Envelope	
Soil (Refer to Section 2.5)	
Minimum Static Bearing Capacity	Maximum static bearing demand is 22,000 lbs/ft^2 ~~ksf~~ in localized areas at the bottom of the Nuclear Island, EPGB, and ESWB basemats and ~~15 ksf~~ 15,000 lbs/ft^2 ~~on~~is the average ~~across the total area of the bottom of~~for the Nuclear Island, EPGB, and ESWB basemats. The ultimate static bearing capacity divided by 3.0 is greater than or equal to the maximum static bearing demand. 03.08.05-23 • ~~3,800 lbs/ft^2 in localized areas at the bottom of the EPGB basemat and 2,700 lbs/ft^2 on average across total area at the bottom of the EPGB basemat.~~ • ~~17,800 lbs/ft^2 in localized areas at the bottom of the ESWB basemat and 5,500 lbs/ft^2 on average across total area at the bottom of the ESWB basemat.~~
Minimum Dynamic Bearing Capacity	Maximum dynamic bearing demand is 35,000 lbs/ft^2~~26,000 psf~~ at the ~~bottom~~toe of the Nuclear Island, EPGB, and ESWB basemats. The ultimate dynamic bearing capacity divided by 2.0 is greater than or equal to the maximum dynamic bearing demand. • ~~10,800 lbs/ft^2 at the bottom of the EPGB basemat.~~ • ~~28,200 lbs/ft^2 at the bottom of the ESWB basemat.~~
Minimum Shear Wave Velocity (Low strain best estimate average value at bottom of basemat)	1000 fps
Liquefaction	None
Maximum Differential Settlement (across the basemat)	1/2 inch in 50 feet in any direction

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Table 2.1-1—U.S. EPR Site Design Envelope
Sheet 3 of 6

U.S. EPR Site Design Envelope	
Slope Failure Potential	No slope failure potential is considered in the design of safety-related SSC for U.S. EPR design certification.
Angle of Internal Friction (in situ and backfill)	26.6 degrees (minimum)
Soil Density (γ)	110 lb/ft^3 ≤ γ ≤ 134 lb/ft^3
Maximum Ground Water	3.3 ft below grade
Minimum Coefficient of Static Friction (representative of soil basemat interface)	0.~~7~~5
Inventory of Radionuclides Which Could Potentially Seep Into the Groundwater	
See Table 2.1-2—Bounding Values for Component Radionuclide Inventory	
Flood Level (Refer to Section 2.4)	
Maximum Flood (or Tsunami)	1 ft below grade
Wind (Refer to Section 3.3)	
Maximum Speed (Other than Tornado)	145 mph (Based on 3-second gust at 33 ft above ground level and factored for 50-yr mean recurrence interval)
Importance Factor	1.15 (Safety-related structures for 100-year mean recurrence interval.)
Tornado (Refer to Sections 3.3 and 3.5)	
Maximum Pressure and Rate of Drop	1.2 psi at 0.5 psi/s
Maximum Rotational Speed	184 mph

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A COL applicant that references the U.S. EPR design certification will investigate site-specific surface and subsurface geologic, seismic, geophysical, and geotechnical aspects within 25 miles around the site and evaluate any impact to the design. The COL applicant will demonstrate that no capable faults exist at the site in accordance with the requirements of 10 CFR 100.23 and of 10 CFR 50, Appendix S. If non-capable surface faulting is present under foundations for safety-related structures, the COL applicant will demonstrate that the faults have no significant impact on the structural integrity of safety-related structures, systems, or components.

2.5.4 Stability of Subsurface Materials and Foundations

The stability of subsurface materials under the ~~and~~ foundations for Seismic Category I structures is demonstrated in Section 3.8.5 for the U.S. EPR ~~10 generic~~ soil profiles described in Section 3.7.1 and Section 3.7.2. As described in Section 3.8.5, lateral soil pressure loads under saturated conditions are considered for the design of below-grade walls. Soil loads are based on the parameters described in Section 2.5.4.2.

A COL applicant that references the U.S. EPR design certification will present site-specific information about the properties and stability of soils and rocks that may affect the nuclear power plant facilities under both static and dynamic conditions, including the vibratory ground motions associated with the CSDRS and the site-specific SSE.

2.5.4.1 Geologic Features

Geologic features are site specific and will be addressed by the COL applicant.

2.5.4.2 Properties of Subsurface Materials

The following soil properties are used for design of U.S. EPR Seismic Category I structures.

- Soil density:
  - Saturated soil = 134 lb/ft^3.
  - Moist soil = 128 lb/ft^3.
  - Dry soil = 110 lb/ft^3.
- Angle of internal friction = ~~35~~26.6 degrees minimum.
- Coefficient of friction acting on foundation basemats and near surface foundations for Seismic Category I structures = 0.~~7~~5 minimum.

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For a cohesionless soil site, the soil below and adjacent to the safety-related foundation basemat will have a minimum friction angle ~~in excess~~ of ~~35~~26.6 degrees. For a cohesive soil site, the soil will have an undrained strength equivalent to or exceeding a

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drained strength of ~~35~~26.6 degrees ~~(~~yielding a friction coefficient greater than or equal to 0.~~7~~5~~)~~.

Section 2.5.4.5 discusses the use of mud mats under the foundation basemats to facilitate construction. When used, the governing friction value at the interface zone is determined by a thin soil layer (soil-on-soil) under the mud mat. As indicated above, the underlying soil (expected to be compacted backfill or lean concrete) will have a friction angle greater than ~~35~~26.6 degrees. Typical values of friction coefficient between concrete and dry soil and rock are in the range of approximately 0.~~7~~5. Due to the interlock of concrete with soil as the concrete is placed, the friction between the mud mat and underlying soil media is generally higher than the friction resistance of soil-on-soil so that continuity of load transfer across the interface is maintained. Waterproofing systems are addressed in Section 3.4.2.

Earthquake induced soil pressures for the design of the U.S. EPR are developed in accordance with Section 3.5.3 of ASCE 4-98 (Reference 2). Maximum ground water and maximum flood elevations used for determining lateral soil loads for the U.S. EPR are as specified in Table 2.1-1.

A COL applicant that references the U.S. EPR design certification will reconcile the site-specific soil properties with those used for design of U.S. EPR Seismic Category I structures and foundations described in Section 3.8.

2.5.4.3 Foundation Interfaces

Foundation interfaces with underlying materials are site specific and will be addressed by the COL applicant. The COL applicant will confirm that the site soils have (1) minimum sliding coefficient of friction of ~~equal to at least~~ 0.~~7~~5, (2) adequate shear strength to provide adequate static and dynamic bearing capacity, (3) adequate elastic and consolidation properties to satisfy the limits on settlement described in Section 2.5.4.10.2, and (4) adequate dynamic properties (i.e., shear wave velocity and strain-dependent modulus-reduction and hysteretic damping properties) to support the Seismic Category I structures of the U.S. EPR under earthquake loading.

2.5.4.4 Geophysical Surveys

Geophysical surveys are site specific and will be addressed by the COL applicant.

2.5.4.5 Excavations and Backfill

Excavations and backfill are site-specific and will be addressed by the COL applicant. Mud mats may be provided under foundations for ease of construction. Mud mats may be designed as structural plain concrete elements on a site-specific basis in accordance with ACI 318 (Reference 3).

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addressed subsurface stratigraphy, depth-to-bedrock, shear wave velocity, and its variation with depth. While the U.S. EPR design is intended to cover a broad range of soil conditions, it is recognized that it is impractical to address all possible subsurface variations. For this reason site specific subsurface conditions will be evaluated for applicability to the U.S. EPR.

The design of the U.S. EPR is based on analyses that assume the underlying layers of soil and rock are horizontal with uniform properties. Furthermore, the U.S. EPR is designed for application at a site where the foundation conditions do not have extreme variation within the foundation footprints. However, the design does have margin that allows for adaptation to many sites that might be classified as non-uniform or having highly variable properties.

A COL applicant that references the U.S. EPR design certification will investigate and determine the uniformity of the underlying layers of site specific soil conditions beneath the foundation basemats. The classification of uniformity or non-uniformity will be established by a geotechnical engine

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Soil structure interaction analysis, settlement analysis, and bearing ~~capacity~~pressure analysis for the U.S. EPR assume that the soil layers are horizontal and effects of non-horizontal layering are ignored. However, the layers of soil and rock beneath a specific site may dip with respect to the horizontal. If the dip is less than or equal to 20 degrees, the layer is defined as horizontal and analyses using horizontal layers are applicable, as described in NUREG/CR-0693 (Reference 4).

Guidance for performing a site-specific evaluation of uniformity for soil profiles under the Seismic Category I structures is provided below. Alternate site-specific methodologies may be used with appropriate technical justification.

Uniformity within the layer may be checked by determining from the boring logs a series of "best-estimate" planes beneath the foundation footprint that define the top (and bottom) of each layer. Depending on specific site conditions, the planes can be based on stratigraphy, lithology, unconformities, intrusives, weathering, other geologic/geotechnical properties or characteristics or combinations of the above. Uniformity and best estimate shear wave velocity within the layer will be established for all layers to a minimum depth of approximately 1.5 times an equivalent radius or no more than 1.0 times the maximum foundation basemat dimension. Typically this will be no less than 200 feet below the bottom of the foundation basemat. If the site can be classified as laterally uniform, it is satisfactory for the U.S. EPR based on analyses and evaluations performed to support design certification, provided that additional site-specific analyses are not required to consider differences in analytical modeling assumptions between the U.S. EPR design and those appropriate to the specific site.

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Section 3.7.2 for information on the extrapolation of the GT STRUDL finite element model for the seismic analysis).

- Conduct a static analysis of the EPGBs using equivalent static seismic loads; and other applicable design loads.
- Provide input for the design of reinforced concrete structural elements.

The finite element model of the EPGBs consists of SBHQ6 and SBHT6 elements representing the load carrying reinforced concrete walls and slabs, as these element types are suitable for capturing both the in-plane and out-of-plane effects from the corresponding applied loads.

Compression only spring boundary conditions are utilized to represent the soil ~~and accurately capture uplift effects in the foundation basemat design~~. The EPGB is a surface-founded structure. Bearing soil pressures were determined considering a rigid block subject to the accelerations obtained from the SSI analysis. The results were confirmed by a SASSI analysis. 03.08.05-23

For uniformity of site characteristics, the required bearing capacity will be the same as for the NI.

The equivalent SSI model includes modifications to the stiffness of the various composite beams at elevation 51 feet, 6 inches, as well as modifications to account for cracking. The stiffness of these composite beams is included in the SASSI 2000 model to capture out-of-plane response. Stiffness of the composite beams is not required in the static analysis model as only in-plane stresses in the concrete slab are determined.

For the composite beams and floor slab at elevation 51 feet, 6 inches, the corresponding floor accelerations from the SASSI analysis output are applied to tributary floor areas and walls to obtain the seismic loads associated with the out-of-plane loads. Dead load, live load, equipment loads, and piping loads are combined with the seismic loads. The composite beams are analyzed outside of the finite element model. Structural design of the composite beams is in accordance with the provisions of ANSI/AISC N690-1994 (R2004).

The in-plane and out-of-plane results from the GT STRUDL equivalent static analysis are extracted and used to design reinforced concrete shear walls and slabs according to provisions of ACI 349-01. The evaluation of walls and slabs for external hazards (e.g., tornado generated missiles and blast loads) is also performed by local wall and slab analyses. Structural element reinforcement is designed to provide sufficient ductility.

Additional information on the seismic analysis approach for the EPGBs is contained in Section 3.7.2.

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~~force. The~~ minimum safety factor against overturning is 1.9~~1.22 occurring for soil case 2sn4u~~.

3.8.5.5.2 Emergency Power Generating Buildings Foundation Basemats

Appendix 3E provides details of the design of the EPGB foundation basemats critical sections.

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Maximum soil bearing pressures under the EPGB foundation basemat are 3,800 pounds per square foot for static loading conditions, and 10,800 pounds per square foot for dynamic loading conditions. For uniformity of site characteristics, the required bearing capacity will be the same as for the NI. The factors of safety against overturning, sliding, and flotation are each greater than or equal to 1.1.

3.8.5.5.3 Essential Service Water Building Foundation Basemats

Appendix 3E provides details of the design of the ESWB foundation basemats critical sections.

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Maximum soil bearing pressures under the ESWB foundation basemat are 17,800 pounds per square foot for static loading conditions, and 28,200 pounds per square foot for dynamic loading conditions. For uniformity of site characteristics, the required bearing capacity will be the same as for the NI. The factors of safety against overturning, sliding, and flotation are each greater than or equal to 1.1.

3.8.5.6 Materials, Quality Control, and Special Construction Techniques

This section contains information relating to the materials, quality control programs and special construction techniques used in the fabrication and construction of Seismic Category I foundations.

3.8.5.6.1 Materials

Concrete, reinforcing steel, and structural steel materials for Seismic Category I foundations have been used in other nuclear facilities and are the same as described in Section 3.8.3.6 (GDC 1), except as follows:

- Materials for the portion of the foundation basemat that supports the RCB/RSB are the same as described in Section 3.8.1.6.
- Structural concrete used in the construction of Seismic Category I foundations has a minimum compressive strength of 4000 psi (f'_c) at 90 days.
- Waterproofing systems are addressed in Section 3.4.2.
- Concrete exposed to aggressive environments, as defined in ACI 349-01, Chapter 4, shall meet the durability requirements of ACI 349-01 Chapter 4 or ASME

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Table 3.8-17—Design Report Cross-Reference Table
Sheet 3 of 5

SRP Section 3.8.4, Appendix C		U.S. EPR FSAR Sections			
		Concrete Containment (Section 3.8.1)	Steel Containment (Section 3.8.2) & Concrete and Steel Internal Structures (Section 3.8.3)	Other Seismic Category I Structures (Section 3.8.4)	Foundations (Section 3.8.5)
4. Prestressing Stage	A. Type of System	Section 3.8.1.1.2	N/A	N/A	N/A
	B. Description of Tendons	Sections 3.8.1.1.2, 3.8.1.6.3	N/A	N/A	N/A
	C. Description of Surcharge	Table 3.8-5	N/A	N/A	N/A
	D. Tendons and Sheeting Layout	Section 3.8.1.1.2, 3.8.1.6.3, Figures 3.8-18 and 3.8-19	N/A	N/A	N/A
	E. Dome Prestressing	Section 3.8.1.1.2	N/A	N/A	N/A
5. Foundation Media	A. General Description	Section 2.5, 3.7.1.3, Table 3.7.2-9			
	B. Unit Weight	Section 2.5.4.2; Table 2.1-1; Table 3.7.2-9			
	C. Shear Modulus	Table 3.7.2-9			
	D. Angle of Internal Friction	Section 2.5.4.2, Table 2.1-1 03.08.05-23			
	E. Cohesion	Section 2.5.4.2			
	F. Bearing Capacity	Section 2.5.4.10.1, Table 2.1-1			
6. Special Considerations		None	None	None	None

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Next File