RESPONSE TO REQUEST FOR ADDITIONAL INFORMATION

APR1400 Design Certification

Korea Electric Power Corporation / Korea Hydro & Nuclear Power Co., LTD

Docket No. 52-046

RAI No.:	**255-8285**
SRP Section:	**03.08.05 – Foundations**
Application Section:	**03.08.05**
Date of RAI Issue:	**10/19/2015**

Question No. 03.08.05-8

10 CFR 50.55a and 10 CFR Part 50, Appendix A, General Design Criteria (GDC) 1, 2, 4 and 5 provide the regulatory requirements for the design of the seismic Category I structures. Standard Review Plan (SRP) Section 3.8.5.II4.H.A states, “Appropriateness of the method for determination of the bending moments and shear forces in the mat foundation for seismic loads.”

DCD Tier 2, Section 3.8.5.4, “Design and Analysis Procedures,” states, “The analysis of the foundation mat is performed by a three-dimensional finite element structure model, and the forces and moments determined in the analysis are input to the structural design.” However, it is not clear to the staff how seismic and other loads are determined and applied to the various structures within the scope of the APR1400 design. Therefore, the applicant is requested to address the following, and include this information accordingly in DCD Sections 3.8.1, 3.8.3, 3.8.4 and 3.8.5:

(a) Provide identification and description of the method of analysis used, whether response spectra analysis method, equivalent static method of analysis, or the use of forces from the SSI/SSSI analyses and application of these to the separate FEM design model.

(b) Provide description how the response spectra, equivalent static accelerations, or forces from the SSI/SSSI were developed and then applied to the FEM design model.

(c) For the response spectra analysis (RSA), provide the RSA curves used in the analysis of the structure.

(d) Explain how the static accelerations from the seismic SSI/SSSI analyses were transferred to the separate FEM design model since the two models have different nodes and elements.

Response

(a) In the basemat analysis, seismic and other loads are determined by reaction forces from the superstructure structural analysis results. The seismic loads are applied by different methods for each superstructure to reflect results from the SSI analysis. The methods used are summarized in Table 1.

Table 1. Methods Used for Seismic Analysis in Superstructure Analyses

	Superstructures		
	Auxiliary Building	RCB Internal Structure	RCB shell & dome
Method	Equivalent Acceleration Method	Response Spectrum Analysis	Response Spectrum Analysis

The equivalent acceleration is calculated from the auxiliary building seismic analysis. To calculate equivalent acceleration, the shear forces in each floor are divided by the total mass of each floor including the wall above floor. And equivalent acceleration is then applied to the auxiliary building finite element model at each respective floor.

Response spectrum analysis was used for the RCB internal structure and shell & dome finite element models. This analysis is based on the floor response spectra computed at the base level (top of the RCB basemat, EL. 78′-0″).

The rocking effects due to horizontal ground movement are considered in the soil-structure interaction analysis as described in DCD Tier 2 subsection 3.7.2. In the SASSI analysis, the structural response to all components of base motion including rocking motion components for an embedded foundation is automatically accounted for in the solution.

Based on the same concept from original basemat analysis as explained above, the new basemat analysis is performed. To consider phasing issue (in-phase and out-of-phase) corresponding to each seismic excitation, the seismic loads from the each superstructure analysis in new NI basemat analysis are divided into four case.

Figure 1. The direction of an arrow corresponding to each seismic excitation **TS**

TS

Based on four cases, new NI common basemat analysis determined total 71 cases including phase issues of superstructures with one another.

Abnormal/Extreme condition cases are summarized as shown below Table2. In the Table, "+" means the direction of arrow as shown figure 1 and "-" means the reverse direction.

Table 2 The Load Combination in Abnormal/Extreme Condition

TS

TS

TS

Considering explanation above, the new NI common basemat analysis is performed and the detailed explanation is summarized in attachment to this response. Also, this attachment will be incorporated in the technical report, APR1400-E-S-NR-14006-P/NP.

(b) The reaction forces from the superstructure analysis are input loads in the NI basemat analysis. Based on explanation (a), each directional reaction from seismic excitation X, Y, Z is expressed as shown in Table 3.

Table 3. Expression for Directional Reactions Corresponding to Each Superstructure

Seismic Excitation	AB (A)**	RCB Internal Structure (I)	RCB Shell &Dome (S)
X-direction	$(Fx)_x$, $(Fy)_x$, $(Fz)_x$ $(Mx)_x$, $(My)_x$, $(Mz)_x$	$(Fx)_x$, $(Fy)_x$, $(Fz)_x$	$(Fx)_x$, $(Fy)_x$, $(Fz)_x$
Y-direction	$(Fx)_y$, $(Fy)_y$, $(Fz)_y$ $(Mx)_y$, $(My)_y$, $(Mz)_y$	$(Fx)_y$, $(Fy)_y$, $(Fz)_y$	$(Fx)_y$, $(Fy)_y$, $(Fz)_y$
Z-direction	$(Fx)_z$, $(Fy)_z$, $(Fz)_z$ $(Mx)_z$, $(My)_z$, $(Mz)_z$	$(Fx)_z$, $(Fy)_z$, $(Fz)_z$	$(Fx)_z$, $(Fy)_z$, $(Fz)_z$

* $(Fx)_i$, $(Fy)_i$, $(Fz)_I$, $(Mx)_i$, $(My)_i$ and $(Mz)_i$ denote the three directional reaction forces and moments corresponding to *i* (X, Y, and Z) directional seismic excitation.

** For details of reaction from AB, See the response to Question 03.08.05-11, c)

In the new NI basemat analysis, in order to determine the maximum seismic responses from structural responses from three spatial earthquake components, the 100-40-40 rule described in Regulatory Guide (RG) 1.92 is applied in APR1400 project. To justify the adequacy of the 100-40-40 rule, the square root of the sum (SRSS) is compared. For example, using all nodes in the basemat, node number 1000002 in auxiliary building is arbitrarily chosen for comparison between the 100-40-40 method and SRSS method as shown Table 4 and 5. Only the reaction force (FZ), and one moment (MY) are considered at a section in this example for simplicity. Figure 2 shows the location of node number 1000002.

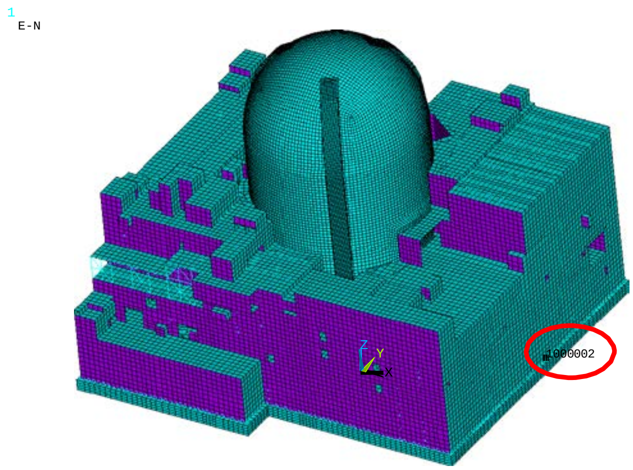

Figure 2. Location of example node 1000002

Table 4 Example of Reaction force and moment for node number 1000002

TS

Table 5 Example of Application of the 100-40-40 method, SRSS and RG1.92

TS

TS

In the new NI basemat analysis, the maximum seismic response attributable to the three orthogonal spatial earthquakes is considered in accordance with RG 1.92. These positive values are used with the ± sign variations corresponding to phasing issue as shown Table 2.

(c) For the response spectrum analysis, each floor response spectra is used in the RCB internal structure and shell & dome analysis to consider the effects of seismic excitation in the X, Y, and Z directions.

For the RCB shell & dome analysis, the three (two horizontal and one vertical) response spectrum at EL. 78′-0″ are used as the base excitation. Figure 3 shows the response spectrum of the SSE at EL. 78′-0″ with 5% damping.

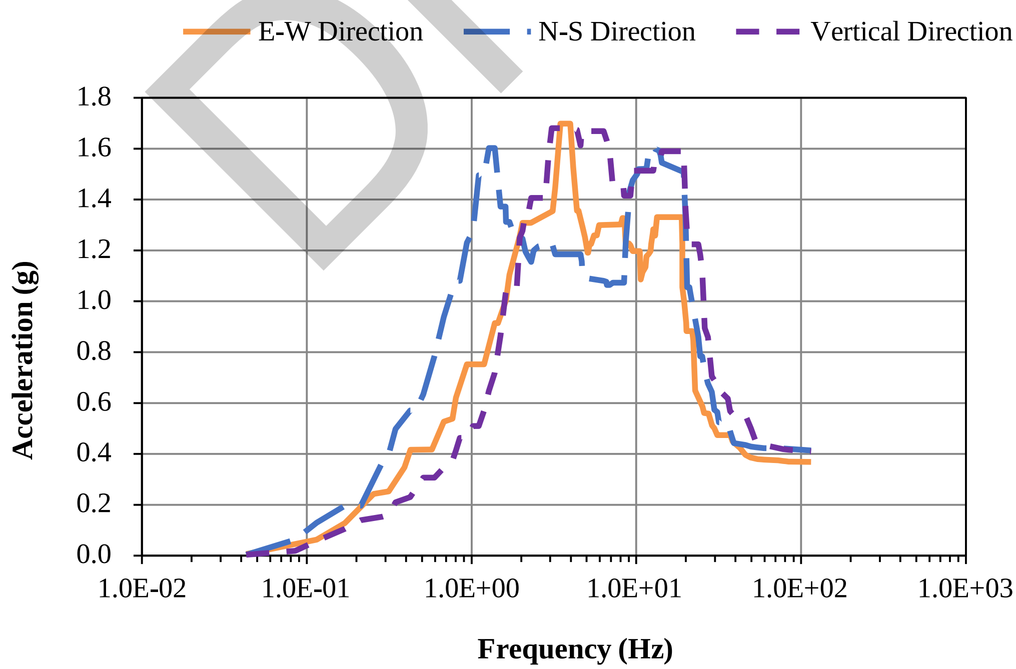

Figure 3 Seismic Input Response Spectra in the RCB Shell & Dome FE Model (5%)

For RCB internal structure analysis, the response spectrum at El. 78′-0″ was used.

Figures 4 and 5 show the response spectrum of the SSE at EL. 78′-0″ with 3% damping for the RCS model and 7% damping for reinforced concrete structures.

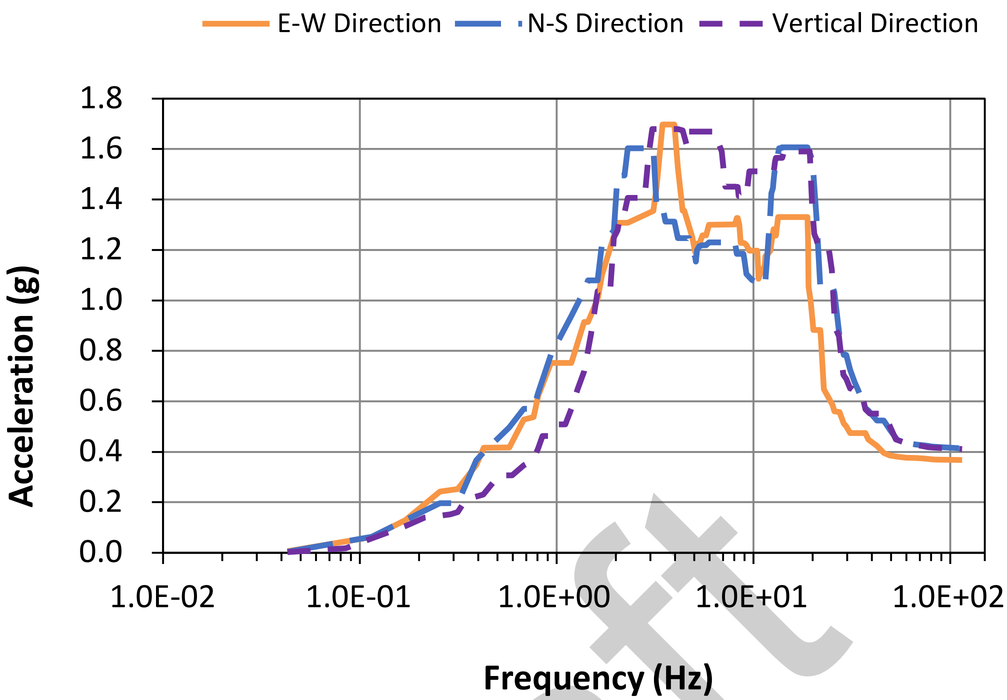

Figure 4 Seismic Input Response Spectra in the RCB Internal Structure FE Model (3%)

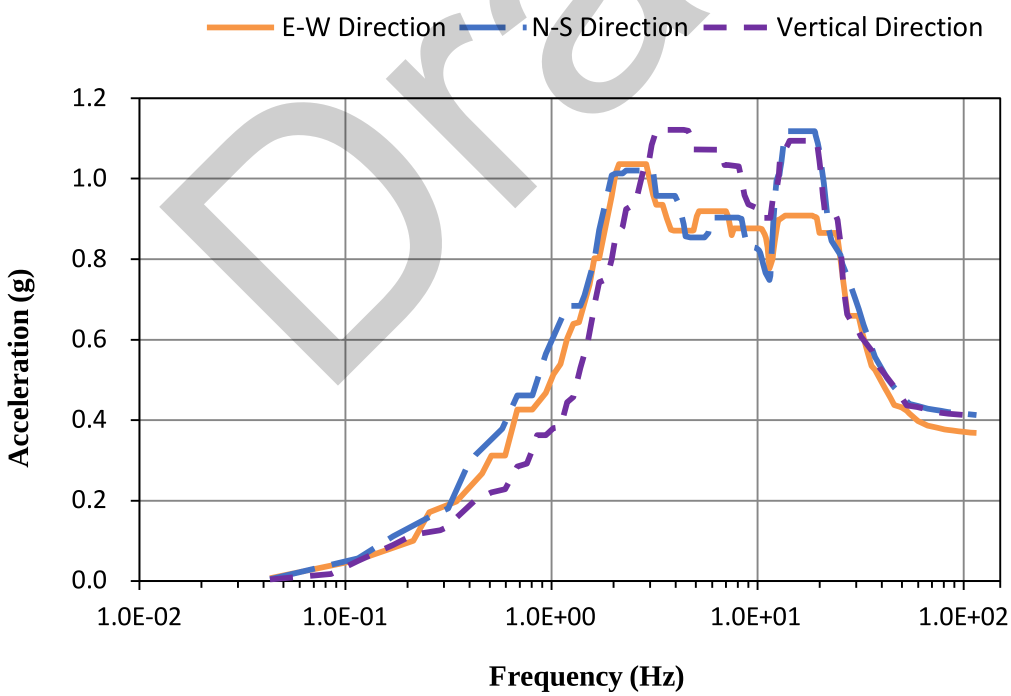

Figure 5 Seismic Input Response Spectra in the RCB Internal Structure FE Model (7%)

(d) Although the two models have different nodes and elements, the equivalent accelerations from the SSI are applied to the structural analysis model based on each slab level since

the equivalent accelerations are computed for each slab level. Therefore, different nodes and elements have no effect when considering the equivalent accelerations.

Impact on DCD

There is no impact on the DCD.

Impact on PRA

There is no impact on the PRA.

Impact on Technical Specifications

There is no impact on the Technical Specifications.

Impact on Technical/Topical/Environmental Reports

Technical report APR1400-E-S-NR-14006-P/NP, Rev.1 will be revised as indicated in the attachment.

ATTACHMENT.

New NI Common Basemat

B.1 APR1400 NEW NUCLEAR ISLAND COMMON BASEMAT ANALYSIS MODEL

In new NI common basemat analysis, the soil springs and foundation media model represented the soil are added in accordance with 3.8.5.II.4.K (Ref #1). The soil spring described in section 2.3.1 is considered for stability evaluation (differential settlement, bearing pressure) and load combination (LC01 ~ 07) under static loading cases. The foundation media model described in section 2.3.2 is considered for load combination (LC08 ~ 71) including seismic cases.

B.1.1 Soil Spring

The subgrade moduli of three soil profiles are obtained from the ANSYS analysis. The soil properties considered in ANSYS foundation media model having 11 layers are based on the table 2-3 in Technical Report (TeR) APR1400-E-S-NR-14006-P, Rev.1. For each subgrade moduli (horizontal and vertical subgrade modulus), the unit pressure (1ksf) is applied in the foundation media model and calculated separately. The vertical subgrade modulus is calculated based on the vertical displacement of each node of foundation media model to consider the variation in soil. Due to difference of mesh shape between the basemat and foundation model, we assumed that the closest foundation node is utilized as the vertical displacement of each basemat node. The applied horizontal subgrade modulus is the same as Table 2-4 in TeR (APR1400-E-S-NR-14006-P, Rev.1). Table B1-1 shows the subgrade modulus of site profiles.

B.1.2 Foundation Media

The NI structure with foundation model is modeled using the following ANSYS program:

- Foundation Model: Solid185

The material properties of foundation media is used dynamic elastic modulus, poisson's ratio and unit weight described in Table B1-2. These properties are calculated by strain-compactable shear wave velocity based on the same procedure described in subsection 1.4 of TeR (APR1400-E-S-NR-14006-P, Rev.1). The strain-compactable shear wave velocity is provided in DCD Table 3.7A-1 ~ 9.

To consider the connection between the basemat structure and foundation, the contact element is applied. The contact element (Conta174 element) is used to represent contact and sliding between target surfaces and a deformable surface. Of the conta174 elements characteristic, the contact surface behaviors is applied to standard option for vertical contact. It means normal pressure equals zero if separation occurs. The coefficient of friction (S1, S4: 0.35, S8: 0.7) is considered between the bottom of contact element and target element corresponding to each soil profiles. In addition, the bonded option for horizontal contact is used. Table B1-4 shows summary of contact method corresponding to each direction.

Figure B1-1 shows the full FE model for the New NI Common basemat structural analysis with foundation media model. In addition, the Figure B1-2 shows 3D FE foundation model.

B.1.2.1 Boundary Condition

In case considered soil spring, the fixed boundary condition is applied to the other side node of LINK180 element. In case considered foundation media model, the edge node of foundation model (Solid185) is used for boundary conditions as shown Figure B1-3.

B.1.2.2 Applied Loads

The applied loads analysis considers dead loads including hydrostatic pressure due to tanks, live loads including static earth pressure, post-tension loads for tendons embedded in the RCB shell and dome, containment pressure loads, pipe break load, seismic load, and buoyancy load due to groundwater.

The dead load of the NI common basemat is calculated by applying the vertical acceleration to the basemat structure. Self-weight of the FE model is calculated in the ANSYS analysis automatically.

Reaction forces for dead loads, live loads, post-tension loads of tendon embedded RCB shell and dome, containment pressure loads, pipe break load, seismic load, and buoyance load calculated from the analysis results for each superstructure are applied as nodal force to the basemat structure model.

The reactions from seismic analyses of the RCB shell and dome, RCB internal structure, and AB are applied as the seismic loads in the basemat model. The response spectrum analysis is used for the RCB shell and dome and RCB internal structure and the equivalent static analysis is used for the AB for seismic analyses of superstructures. In the response spectrum analysis, the maximum values of individual modes occur simultaneously; hence, the mode combination effect is obtained by using Complete Quadratic Combination (CQC) of the individual modal responses. Each directional reaction force at an arbitrary point corresponding to each seismic excitation from the seismic analysis reactions of superstructures is expressed as shown in Table B1-3. Also, the reactions from 5% torsion analysis and dynamic earth pressure are considered in NI common basemat as described Table B1-6.

Maximum seismic responses attributable to the three orthogonal spatial earthquakes are determined by 100 percent - 40 percent – 40 percent (100-40-40) proposed by Regulatory Guide (RG 1.92) (Ref.4). Because this method result in conservative outcome comparing SRSS method according to BNL report (Ref.2) The 100-40-40 rule introduced in RG1.92 is following below.

(1) Let R1, R2, R3 be the maximum responses caused by each of the three earthquake components calculated separately, such that

$$|R1| \geq |R2| \geq |R3|$$

(2) The maximum seismic response attributable to earthquake loading in three orthogonal directions is given by the following equation:

$$R= (1.0|R1|+0.4|R2|+0.4|R3|)$$

Additionally, to consider the effect the interaction among the superstructures (e.g. RCB shell & dome, RCB internal structure, and AB) let the direction of each excitation decide below figure B1-4 and the seismic load combinations for NI common basemat are expressed as shown Figure B1-6.

Finally, based on Figure, new analysis with foundation model determines total 71 cases including phasing issue of superstructures one another. Specially, Abnormal/Extreme condition cases are summarized as shown below Table B1-5. In the Table B1-5, (+) means the direction of arrow as shown figure 1. On the other hand, (-) means the reverse direction.

B.1.2.3 Load Combinations

Load combinations and load factors for the RCB and AB basemats are selected based on the relevant design code as shown in TeR Figure 3-12. The five loading combinations (i.e., test, normal, severe, abnormal, and abnormal/extreme environmental conditions) are selected as the critical loading combinations in the NI common basemat analysis. The abnormal/extreme environmental loading combination includes the seismic load. Therefore, the load combinations are conservatively divided into the 64 cases to account for the possibility of phase behaviors (In-phase and Out-of-phase). Therefore, the load cases for the NI common basemat can be summarized as shown in Table B1-6. A total of 213 load combinations (71 combinations x 3 site profiles) are examined for the APR1400 NI common basemat.

B.2 STABILITY EVALUATION OF THE NUCLEAR ISLAND COMMON BASEMAT

This section presents the settlement evaluation of the APR1400 NI common basemat with soil spring model considered the variation of soil.

B.2.1 Settlement of the Nuclear Island Common Basemat

B.2.1.1 Differential Settlement

Checks of the differential settlements of the NI common basemat with soil spring considered the variation of soil are presented in this section. The method for check pertaining to differential settlement throughout NI common basemat and between the NI basemat and other buildings is the exactly the same method described in subsection TeR 4.1.2.

For the differential settlements by static loading, the dead and live loads (D+L) are applied in the basemat. In addition, the nodes within a distance of approximately 50 ft are selected to check the differential settlement as shown TeR Figure 4-4. Table B2-1 shows the differential settlements at S1, S4, and S8. The maximum differential settlements per 50 ft for S1, S4, and S8 are 0.21, 0.09, and 0.04 in., respectively.

For the differential settlements by seismic loading, refer to TeR subsection 4.1.2

In addition, the differential settlement between the NI basemat and the other buildings is checked. For the differential settlement between the NI basemat and other buildings, TGB basemat is not considered. Because TGB basemat analysis is not performed. And TGB basemat is not safety related structure and no safety system piping are connected between the NI basemat and TGB.

B.2.1.2 Site Interface for the Nuclear Island Common Basemat

The bearing pressures of the NI common basemat by static and seismic loadings are evaluated in this section. For the bearing pressure, the D+L load (static) case is applied in the basemat and the average bearing pressures of the basemat are obtained from ANSYS static analysis. Each bearing pressure on vertical soil spring is checked and calculated based on equation (soil spring reaction/ tributary area). Table B2-2 shows the average bearing pressures by static loadings.

B.3 REFERENCES

1. Standard Review Plan (SRP) 3.8.5 “Foundations”, Revision 4, September, 2013

2. BNL Report, On the Correct Application of 100-40-40 Rule for Combining Responses due to Three Directions of Earthquake Loading, BNL-91335-2010 CP

3. ANSYS Version 15.0 User’s Manual, KEPCO E&C Registration Number E-P-CE-1327-15.0/DC

4. Regulatory Guide 1.92 (RG1.92), Combining Modal Responses and Spatial Components in Seismic Response Analysis

Table B1-1 Equivalent Subgrade Moduli of Soil Profiles

NI Basemat				
	Displacement (ft)		Subgrade modulus (kcf)	Remark
Soil 01	Max	0.03017	**k_v=33.14~178.70**	-
	Min	0.0056		
	0.072731 (X, Horizontal)		k_h=20.62	2/3 of maximum value
	0.073070 (Y, Horizontal)		**k_h=20.53**	
Soil 04	Max	0.00654	**k_v=152.88~777.06**	-
	Min	0.00129		
	0.023239 (X, Horizontal)		k_h=64.55	2/3 of maximum value
	0.023245 (Y, Horizontal)		**k_h=64.53**	
Soil 08	Max	0.00123	**k_v=809.91~2507.84**	-
	Min	0.0004		
	0.001099 (X, Horizontal)		k_h=1364.88	2/3 of maximum value
	0.001123 (Y, Horizontal)		**k_h=1335.71**	
TGB Basemat				
	Max. Displacement (ft)		Subgrade modulus (kcf)	Remark
Soil 01	0.035069 (Z, Vertical)		**k_v=28.52**	-
	0.041371 (X, Horizontal)		k_h=24.17	
	0.041708 (Y, Horizontal)		**k_h=23.98**	
Soil 04	0.008239 (Z, Vertical)		**k_v=121.37**	
	0.013406 (X, Horizontal)		k_h=74.59	
	0.013465 (Y, Horizontal)		**k_h=74.27**	
Soil 08	0.001140 (Z, Vertical)		**k_v=877.20**	
	0.000595 (X, Horizontal)		k_h=1680.67	
	0.000608 (Y, Horizontal)		**k_h=1644.74**	

∗ Subgrade modulus (kcf) = Pressure (1ksf) / Displacement (ft)

Table B1-2 Site Profiles Based on Strain-Compactible Shear Velocity

Ground Level (ft)	S1			S4			S8		
	Unit Weight (kcf)	Static Modulus Estatic (ksf)	Poisson's Ratio (v)	Unit Weight (kcf)	Static Modulus Estatic (ksf)	Poisson's Ratio (v)	Unit Weight (kcf)	Static Modulus Estatic (ksf)	Poisson's Ratio (v)
0 ~ 25	0.125	14416	0.47	0.130	37308	0.42	0.145	489538	0.33
25 ~ 55	0.125	15254	0.47	0.130	38531	0.42	0.145	505211	0.33
55 ~ 75	0.125	17770	0.46	0.130	41954	0.40	0.145	519804	0.33
75 ~ 100	0.125	19564	0.46	0.130	43721	0.40	0.145	531564	0.33
100 ~ 150	0.125	24389	0.45	0.135	177544	0.35	0.145	554481	0.34
150 ~ 200	0.125	30931	0.43	0.135	191116	0.35	0.145	581716	0.34
200 ~ 300	0.130	97717	0.39	0.145	469662	0.34	0.155	1083760	0.33
300 ~ 400	0.130	120145	0.39	0.145	506992	0.34	0.155	1083760	0.33
400 ~ 500	0.130	140396	0.39	0.145	539990	0.34	0.155	1083760	0.33
500 ~ 750	0.135	402807	0.35	0.155	1083760	0.33	0.155	1083760	0.33
750 ~ 1,000	0.135	438371	0.35	0.155	1083760	0.33	0.155	1083760	0.33

Table B1-3 Reactions at Arbitrary Points Corresponding to Each Seismic Excitation

Seismic Excitation	Auxiliary Building (A)	RCB Shell and Dome (C)	RCB Internal Structure (I)
X-direction	$(F_x)_x$, $(F_y)_x$, $(F_z)_x$ $(Mx)_x$, $(My)_x$, $(Mz)_x$	$(F_x)_x$, $(F_y)_x$, $(F_z)_x$	$(F_x)_x$, $(F_y)_x$, $(F_z)_x$
Y-direction	$(F_x)_y$, $(F_y)_y$, $(F_z)_y$ $(Mx)_y$, $(My)_y$, $(Mz)_y$	$(F_x)_y$, $(F_y)_y$, $(F_z)_y$	$(F_x)_y$, $(F_y)_y$, $(F_z)_y$
Z-direction	$(F_x)_z$, $(F_y)_z$, $(F_z)_z$ $(Mx)_z$, $(My)_z$, $(Mz)_z$	$(F_x)_z$, $(F_y)_z$, $(F_z)_z$	$(F_x)_z$, $(F_y)_z$, $(F_z)_z$

(1) $(F_x)_i$, $(M_x)_i$, $(F_y)_i$, $(M_y)_I$, $(F_z)_i$ $(M_z)_i$ denote the three directional reaction forces corresponding to i (X, Y, and Z) directional seismic excitation.

Table B1-4 The Contact Method between Foundation Media Model and NI Common Basemat

Direction	Contact Algorism	Contact Behavior	Remark
Vertical	Augmented Lagrangian	Standard	
Horizontal	Multipoint Constraint (MPC)	Bonded	-

Table B1-5 Seismic Load Combinations for NI Common Basemat

TS

TS

Table B1-6 Load Combinations for NI Common Basemat Analysis

Position	Condition	Load Case	Load Combination
RCB Basemat	Test	LC01	$1.0D+1.0L+1.0L_1+1.0F+1.0P_t$
	Normal	LC02	$1.0D+1.0L+1.0L_1+1.0F$
	Severe	LC03	$1.0D+1.3L+1.3L_1+1.0F$
	Abnormal	LC04	1.0D+1.0L+1.0L1+1.0F+1.5Pa
AB Basemat	Test	LC05	$1.1D+1.3L+1.1L_1+1.0F+1.0P_t$
	Normal	LC06	$1.4D+1.7L+1.4L_1+1.0F$
	Abnormal	LC07	1.0D+1.0L+1.0L1+1.0F+1.4Pa
RCB & AB Basemat	Abnormal /Extreme	LC08	$1.0D+1.0L+1.0L_1+1.0F+1.0P_a+1.0Y_r$ +1.0Es01+Lg_d
		LC09	$1.0D+1.0L+1.0L_1+1.0F+1.0P_a+1.0Y_r$ +1.0Es02+Lg_d
		LC10	$1.0D+1.0L+1.0L_1+1.0F+1.0P_a+1.0Y_r$ +1.0Es03+Lg_d
		LC11	$1.0D+1.0L+1.0L_1+1.0F+1.0P_a+1.0Y_r$ +1.0Es04+Lg_d
		LC12	$1.0D+1.0L+1.0L_1+1.0F+1.0P_a+1.0Y_r$ +1.0Es05+Lg_d
		LC13	$1.0D+1.0L+1.0L_1+1.0F+1.0P_a+1.0Y_r$ +1.0Es06+Lg_d
		LC14	$1.0D+1.0L+1.0L_1+1.0F+1.0P_a+1.0Y_r$ +1.0Es07+Lg_d
		LC15	$1.0D+1.0L+1.0L_1+1.0F+1.0P_a+1.0Y_r$ +1.0Es08+Lg_d
		LC16	$1.0D+1.0L+1.0L_1+1.0F+1.0P_a+1.0Y_r$ +1.0Es09+Lg_d
		LC17	$1.0D+1.0L+1.0L_1+1.0F+1.0P_a+1.0Y_r$ +1.0Es10+Lg_d
		LC18	$1.0D+1.0L+1.0L_1+1.0F+1.0P_a+1.0Y_r$ +1.0Es11+Lg_d
		LC19	$1.0D+1.0L+1.0L_1+1.0F+1.0P_a+1.0Y_r$ +1.0Es12+Lg_d
		LC20	$1.0D+1.0L+1.0L_1+1.0F+1.0P_a+1.0Y_r$ +1.0Es13+Lg_d
		LC21	$1.0D+1.0L+1.0L_1+1.0F+1.0P_a+1.0Y_r$ +1.0Es14+Lg_d
		LC22	$1.0D+1.0L+1.0L_1+1.0F+1.0P_a+1.0Y_r$ +1.0Es15+Lg_d
		LC23	$1.0D+1.0L+1.0L_1+1.0F+1.0P_a+1.0Y_r$ +1.0Es16+Lg_d
RCB & AB Basemat	Abnormal /Extreme	LC24	$1.0D+1.0L+1.0L_1+1.0F+1.0P_a+1.0Y_r$ +1.0Es17+Lg_d
		LC25	$1.0D+1.0L+1.0L_1+1.0F+1.0P_a+1.0Y_r$ +1.0Es18+Lg_d

		LC26	$1.0D+1.0L+1.0L_1+1.0F+1.0P_a+1.0Y_r$ $+1.0Es19+Lg\_d$
		LC27	$1.0D+1.0L+1.0L_1+1.0F+1.0P_a+1.0Y_r$ $+1.0Es20+Lg\_d$
		LC28	$1.0D+1.0L+1.0L_1+1.0F+1.0P_a+1.0Y_r$ $+1.0Es21+Lg\_d$
		LC29	$1.0D+1.0L+1.0L_1+1.0F+1.0P_a+1.0Y_r$ $+1.0Es22+Lg\_d$
		LC30	$1.0D+1.0L+1.0L_1+1.0F+1.0P_a+1.0Y_r$ $+1.0Es23+Lg\_d$
		LC31	$1.0D+1.0L+1.0L_1+1.0F+1.0P_a+1.0Y_r$ $+1.0Es24+Lg\_d$
		LC32	$1.0D+1.0L+1.0L_1+1.0F+1.0P_a+1.0Y_r$ $+1.0Es25+Lg\_d$
		LC33	$1.0D+1.0L+1.0L_1+1.0F+1.0P_a+1.0Y_r$ $+1.0Es26+Lg\_d$
		LC34	$1.0D+1.0L+1.0L_1+1.0F+1.0P_a+1.0Y_r$ $+1.0Es27+Lg\_d$
		LC35	$1.0D+1.0L+1.0L_1+1.0F+1.0P_a+1.0Y_r$ $+1.0Es28+Lg\_d$
		LC36	$1.0D+1.0L+1.0L_1+1.0F+1.0P_a+1.0Y_r$ $+1.0Es29+Lg\_d$
		LC37	$1.0D+1.0L+1.0L_1+1.0F+1.0P_a+1.0Y_r$ $+1.0Es30+Lg\_d$
		LC38	$1.0D+1.0L+1.0L_1+1.0F+1.0P_a+1.0Y_r$ $+1.0Es31+Lg\_d$
		LC39	$1.0D+1.0L+1.0L_1+1.0F+1.0P_a+1.0Y_r$ $+1.0Es32+Lg\_d$
		LC40	$1.0D+1.0L+1.0L_1+1.0F+1.0P_a+1.0Y_r$ $+1.0Es33+Lg\_d$
		LC41	$1.0D+1.0L+1.0L_1+1.0F+1.0P_a+1.0Y_r$ $+1.0Es34+Lg\_d$
		LC42	$1.0D+1.0L+1.0L_1+1.0F+1.0P_a+1.0Y_r$ $+1.0Es35+Lg\_d$
		LC43	$1.0D+1.0L+1.0L_1+1.0F+1.0P_a+1.0Y_r$ $+1.0Es36+Lg\_d$
		LC44	$1.0D+1.0L+1.0L_1+1.0F+1.0P_a+1.0Y_r$ $+1.0Es37+Lg\_d$
		LC45	$1.0D+1.0L+1.0L_1+1.0F+1.0P_a+1.0Y_r$ $+1.0Es38+Lg\_d$
		LC46	$1.0D+1.0L+1.0L_1+1.0F+1.0P_a+1.0Y_r$ $+1.0Es39+Lg\_d$
		LC47	$1.0D+1.0L+1.0L_1+1.0F+1.0P_a+1.0Y_r$ $+1.0Es40+Lg\_d$
		LC48	$1.0D+1.0L+1.0L_1+1.0F+1.0P_a+1.0Y_r$ $+1.0Es41+Lg\_d$
RCB & AB Basemat	Abnormal /Extreme	LC49	$1.0D+1.0L+1.0L_1+1.0F+1.0P_a+1.0Y_r$ $+1.0Es42+Lg\_d$
		LC50	$1.0D+1.0L+1.0L_1+1.0F+1.0P_a+1.0Y_r$ $+1.0Es43+Lg\_d$
		LC51	$1.0D+1.0L+1.0L_1+1.0F+1.0P_a+1.0Y_r$ $+1.0Es44+Lg\_d$
		LC52	$1.0D+1.0L+1.0L_1+1.0F+1.0P_a+1.0Y_r$ $+1.0Es45+Lg\_d$

		LC53	$1.0D+1.0L+1.0L_1+1.0F+1.0P_a+1.0Y_r$ +1.0Es46+Lg_d
		LC54	$1.0D+1.0L+1.0L_1+1.0F+1.0P_a+1.0Y_r$ +1.0Es47+Lg_d
		LC55	$1.0D+1.0L+1.0L_1+1.0F+1.0P_a+1.0Y_r$ +1.0Es48+Lg_d
		LC56	$1.0D+1.0L+1.0L_1+1.0F+1.0P_a+1.0Y_r$ +1.0Es49+Lg_d
		LC57	$1.0D+1.0L+1.0L_1+1.0F+1.0P_a+1.0Y_r$ +1.0Es50+Lg_d
		LC58	$1.0D+1.0L+1.0L_1+1.0F+1.0P_a+1.0Y_r$ +1.0Es51+Lg_d
		LC59	$1.0D+1.0L+1.0L_1+1.0F+1.0P_a+1.0Y_r$ +1.0Es52+Lg_d
		LC60	$1.0D+1.0L+1.0L_1+1.0F+1.0P_a+1.0Y_r$ +1.0Es53+Lg_d
		LC61	$1.0D+1.0L+1.0L_1+1.0F+1.0P_a+1.0Y_r$ +1.0Es54+Lg_d
		LC62	$1.0D+1.0L+1.0L_1+1.0F+1.0P_a+1.0Y_r$ +1.0Es55+Lg_d
		LC63	$1.0D+1.0L+1.0L_1+1.0F+1.0P_a+1.0Y_r$ +1.0Es56+Lg_d
		LC64	$1.0D+1.0L+1.0L_1+1.0F+1.0P_a+1.0Y_r$ +1.0Es57+Lg_d
		LC65	$1.0D+1.0L+1.0L_1+1.0F+1.0P_a+1.0Y_r$ +1.0Es58+Lg_d
		LC66	$1.0D+1.0L+1.0L_1+1.0F+1.0P_a+1.0Y_r$ +1.0Es59+Lg_d
		LC67	$1.0D+1.0L+1.0L_1+1.0F+1.0P_a+1.0Y_r$ +1.0Es60+Lg_d
		LC68	$1.0D+1.0L+1.0L_1+1.0F+1.0P_a+1.0Y_r$ +1.0Es61+Lg_d
		LC69	$1.0D+1.0L+1.0L_1+1.0F+1.0P_a+1.0Y_r$ +1.0Es62+Lg_d
		LC70	$1.0D+1.0L+1.0L_1+1.0F+1.0P_a+1.0Y_r$ +1.0Es63+Lg_d
		LC71	$1.0D+1.0L+1.0L_1+1.0F+1.0P_a+1.0Y_r$ +1.0Es64+Lg_d

Where:

D = Dead load (Including Hydrostatic load)
L = Live load (Including Static Earth Pressure)
F = Post-tension load of tendon embedded RCB shell and dome
Pa = Design internal pressure of RCB shell and dome
Pt = Internal pressure of RCB shell and dome at testing phase
Yr = Pipe break load
E_s = Seismic load (Including 5% Torision)
L_{g_d} = Dynamic Earth Pressure
L_1 = Buoyance load

Table B2-1 Differential Settlements According to Site Profiles (Static Loading Case)

Section	Node Number		Distance (ft)	Differential Settlement (in.)		
	Start	End		S1	S4	S8
AB1	26810	27829	48.58	0.197	0.091	0.026
AB2	27829	29466	46.26	0.206	0.085	0.037
AB3	29466	28901	46.59	0.189	0.067	0.019
AB4	28901	1367	44.70	0.209	0.088	0.033
AB5	26811	27246	48.73	0.067	0.054	0.013
AB6	27246	26610	44.08	0.074	0.041	0.021
AB7	26610	27669	41.54	0.087	0.047	0.020
AB8	27669	790	39.68	0.123	0.076	0.034
AB9	26620	28027	48.73	0.001	0.032	0.004
AB10	28027	26667	44.08	0.019	0.034	0.031
AB11	26667	27610	41.54	0.010	0.018	0.011
AB12	27610	822	39.68	0.059	0.048	0.024
AB13	26826	27117	48.58	0.166	0.091	0.026
AB14	27117	29708	46.26	0.180	0.088	0.039
AB15	29708	30238	46.59	0.155	0.066	0.019
AB16	30238	1466	44.70	0.170	0.087	0.036
RCB1	5929	18822	46.06	0.072	0.010	0.007
RCB2	15931	15467	47.09	0.006	0.010	0.001
RCB3	6135	14571	46.06	0.025	0.002	0.005
RCB4	16131	15368	47.09	0.051	0.009	0.005
Total Max. Differential Settlement				0.21	0.09	0.04

Table B2-2 Bearing Pressure of NI Common Basemat

Case	Average Bearing Pressure (ksf)		
	S1	**S4**	**S8**
Static Case	10.6	11.03	11.21

∗ Bearing pressure (ksf) = Soil spring reaction (kips) / Tributary area (ft^2)

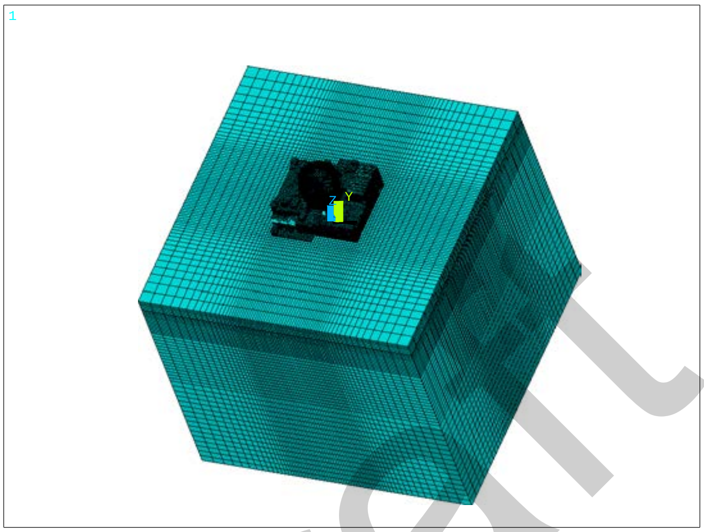

Figure B1-1 Full APR1400 NI Common Basemat Structural Analysis

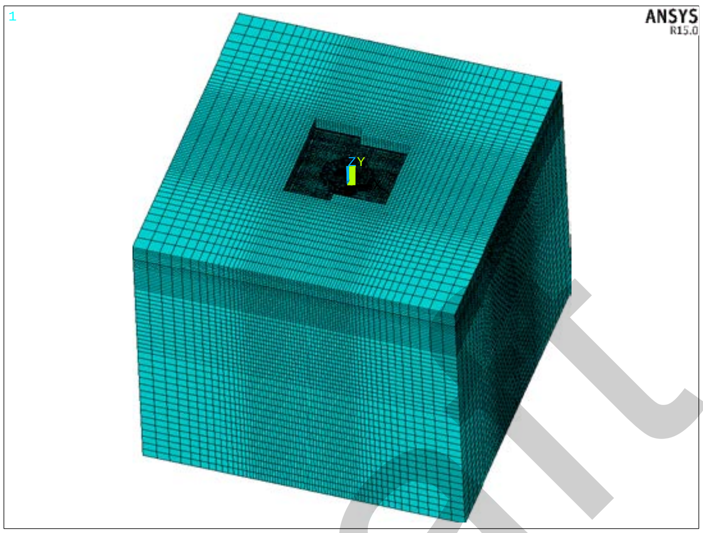

Figure B1-2 APR1400 NI Common Basemat Foundation View

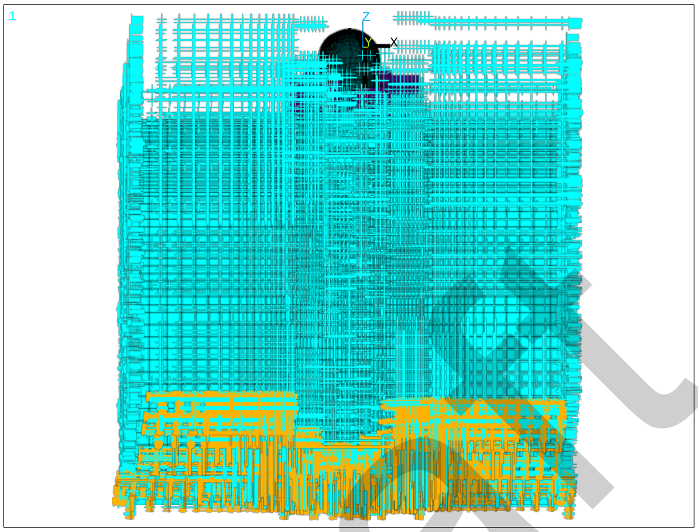

Figure B1-3 Boundary Condition of New Ni common basemat analysis

TS

Figure B1-4 The direction of an arrow corresponding to each seismic excitation (Continued)

TS

Figure B1-4 The direction of an arrow corresponding to each seismic excitation