NUSCALE POWER™

RAIO-0118-58468

January 31, 2018

Docket No. 52-048

U.S. Nuclear Regulatory Commission
ATTN: Document Control Desk
One White Flint North
11555 Rockville Pike
Rockville, MD 20852-2738

SUBJECT: NuScale Power, LLC Response to NRC Request for Additional Information No. 128 (eRAI No. 8966) on the NuScale Design Certification Application

REFERENCE: U.S. Nuclear Regulatory Commission, "Request for Additional Information No. 128 (eRAI No. 8966)," dated August 04, 2017

The purpose of this letter is to provide the NuScale Power, LLC (NuScale) response to the referenced NRC Request for Additional Information (RAI).

The Enclosure to this letter contains NuScale's response to the following RAI Question from NRC eRAI No. 8966:

- 03.08.04-3

Final Safety Analysis Report (FSAR) Table 3.7.2-35, referenced in this RAI response, has been provided. This table will be included in Revision 1 of the FSAR as indicated in response to eRAI No. 8975, Question 03.08.04-33.

This letter and the enclosed response make no new regulatory commitments and no revisions to any existing regulatory commitments.

If you have any questions on this response, please contact Marty Bryan at 541-452-7172 or at mbryan@nuscalepower.com.

Sincerely,

Zackary W. Rad
Director, Regulatory Affairs
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Enclosure 1: NuScale Response to NRC Request for Additional Information eRAI No. 8966

Enclosure 1:

NuScale Response to NRC Request for Additional Information eRAI No. 8966

NuScale Power™

Response to Request for Additional Information
Docket No. 52-048

eRAI No.: 8966
Date of RAI Issue: 08/04/2017

NRC Question No.: 03.08.04-3

10 CFR 50, Appendix A, GDC 1, 2, and 4, provide requirements to be met by SSC important to safety. In accordance with these requirements, DSRS Section 3.8.4 provides review guidance pertaining to the design of seismic Category I structures, other than the containment. Consistent with DSRS Section 3.8.4, the staff reviews description of the structures, loads and loading combinations, and design and analysis procedures.

FSAR Figures in chapter 1, Section 3.8, and Appendix 3B show stiffener walls under the sloping portion of the roof. Clarify whether there are any stiffening members under the flat portion of the roof which has dimensions of approximately 82'-6" by 346'. If not, describe the process for determining that the flat roof plate without stiffening members is sufficiently stiff and strong to resist and transfer seismic demands from and to the two inclined roof plates. Provide maximum allowable roof deformation values for each of the North-South and East-West directions and the calculated corresponding roof deformation values. Provide the frequency, modal mass ratio, and mode shape, for the most significant torsional mode in the RXB.

NuScale Response:

There are no stiffening members under the flat portion of the roof with dimensions of approximately 82'-6" by 346'. Beams used for construction purposes are planned to be left in place, but they are not considered as part of the roof design.

The reactor building (RXB) was modeled in SAP2000 and SASSI2010. SASSI models the seismic demand on the RXB, and the SAP model includes the other non-seismic loads (dead, live, wind, etc). Both models were run with cracked and uncracked concrete conditions, as described in FSAR Section 3.7.2. The models also include equipment weights and the ultimate heat sink (UHS) fluid. The RXB roof was modeled with plate elements in SAP.

The SASSI2010 RXB model used shell elements for the RXB roof. For both cracked and uncracked cases, this model analyzed five certified seismic design response spectra (CSDRS) compatible time histories for soil types 7, 8, and 11, and two CSDRS high frequency compatible

time histories for soil types 7 and 9. This was done for both a standalone RXB model and a model that included the radioactive waste building (RWB), RXB, and control building (CRB). See FSAR Table 3.7.2-35 for a summary of all structural analysis models.

Although North-South walls under the flat portion of the RXB roof have been omitted in order to provide space for the RXB crane, there are East-West walls supporting the RXB roof near column lines RXB and RXD (see FSAR Figure 1.2-19).

Post processing of the analysis provided the loads, bending moments, and shears used to verify the slab thickness and reinforcing steel design requirements. Demand/capacity ratios for the RXB roof are discussed in FSAR Section 3B.2.3.2 and are presented in FSAR Table 3B-18. These demand/capacity ratios include seismic effects transferred into the flat portion of the roof by the two inclined roof plates. Note that all demand capacity ratios in FSAR Table 3B-18 are less than 1.0.

The maximum allowable drift at the RXB roof corners is calculated below using ASCE 43-05, Seismic Design Criteria for Structures, Systems, and Components in Nuclear Facilities, Section 5.2.3.1, Allowable Drift Limits for Structural Systems. The RXB walls are shear controlled walls per ASCE 43-05 Table 5-2. The maximum allowable drift for the RXB roof corners in the North-South and East-West directions is (163' - 126') x 12 x 0.004 = 1.776".

The calculated storey drifts for the RXB roof corners are presented in the Table 1 below.

Table 1: Calculated Storey Drifts for the RXB Roof Corners

	NW Corner	NE Corner	SE Corner	SW Corner
Top Jt	**29098**	**29365**	**29343**	**29076**
	(in)	(in)	(in)	(in)
Top dx (E), Static	0.003	0.001	0.003	0.003
Top dx (E), Ess	0.319	0.337	0.334	0.319
Top Jt dy (N), Static	0.008	0.004	0.003	0.000
Top Jt dy (N), Ess	0.941	0.772	0.773	0.942
Bot Jt	**25509**	**26471**	**26449**	**25487**
	(in)	(in)	(in)	(in)
Bot Jt dx (E), Static	0.003	0.002	0.003	0.002
Bot Jt dx (E), Seismic	-0.207	-0.228	-0.229	-0.209
Bot Jt dy (N), Static	0.008	0.005	0.004	0.001
Bot Jt dy (N), Seismic	-0.652	-0.556	-0.556	-0.64
Drift X (E) = Sum Top dx - Sum Bot dx	**0.526**	**0.564**	**0.563**	**0.529**
Drift Y (N) = Sum Top dy - Sum Bot dy	**1.593**	**1.327**	**1.328**	**1.581**

Notes:

- Top joints shown are at EL 163.0’ and bottom joints are at EL 126.0’.
- Maximum seismic displacements at the bottom joints have conservatively been taken as negative values.
- N, S, E, W denotes North, South, East and West respectively

Table 2 provides the frequencies and modal mass participation ratios for the most significant torsional modes in the RXB for the RXB cracked model.

Table 2: Frequencies and Modal Mass Participation Ratios for the RXB Cracked Model

Step Type	Mode Number	Period (sec)	Frequency (Hz)	Torsional Participation Factors	Summation of Torsional Participation Factors
Mode	12	0.23	4.30	0.260	0.400
Mode	13	0.22	4.50	0.110	0.500
Mode	19	0.20	5.02	0.041	0.560
Mode	477	0.01	107.52	0.000	0.820
Mode	500	0.00	749.18	0.000	0.820

Figures 1 through 3, below, show the related RXB cracked model mode shapes.

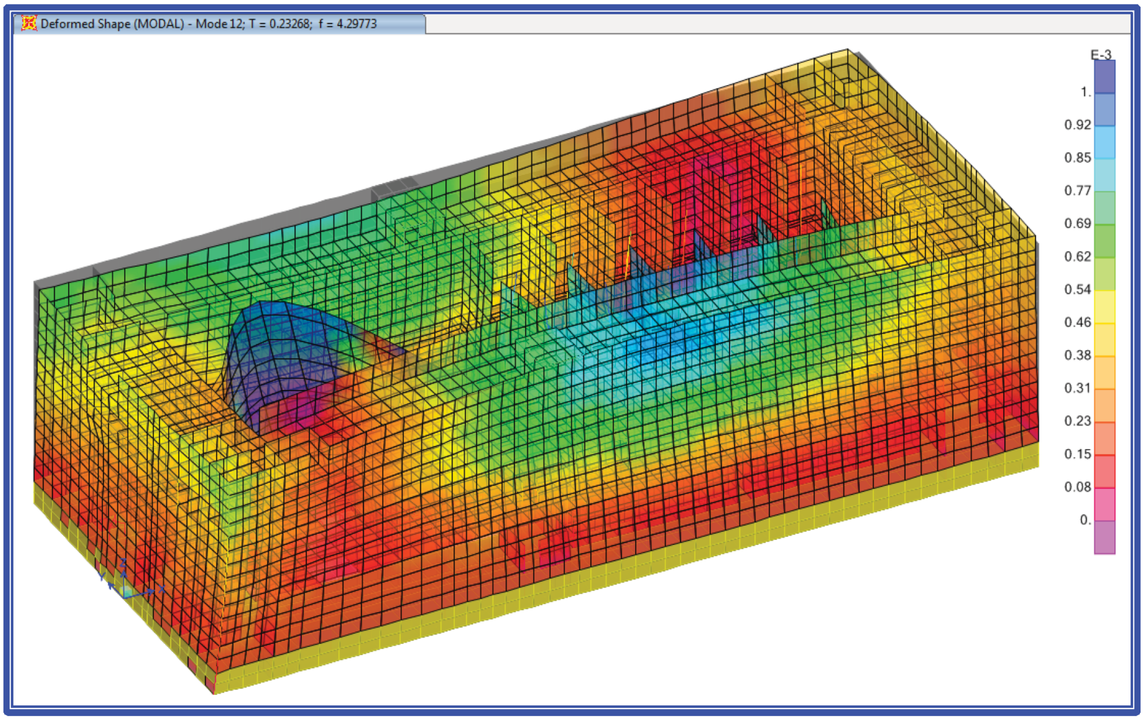

Figure 1: Partial Exaggerated Mode Shape for Mode 12 for Cracked Concrete RXB

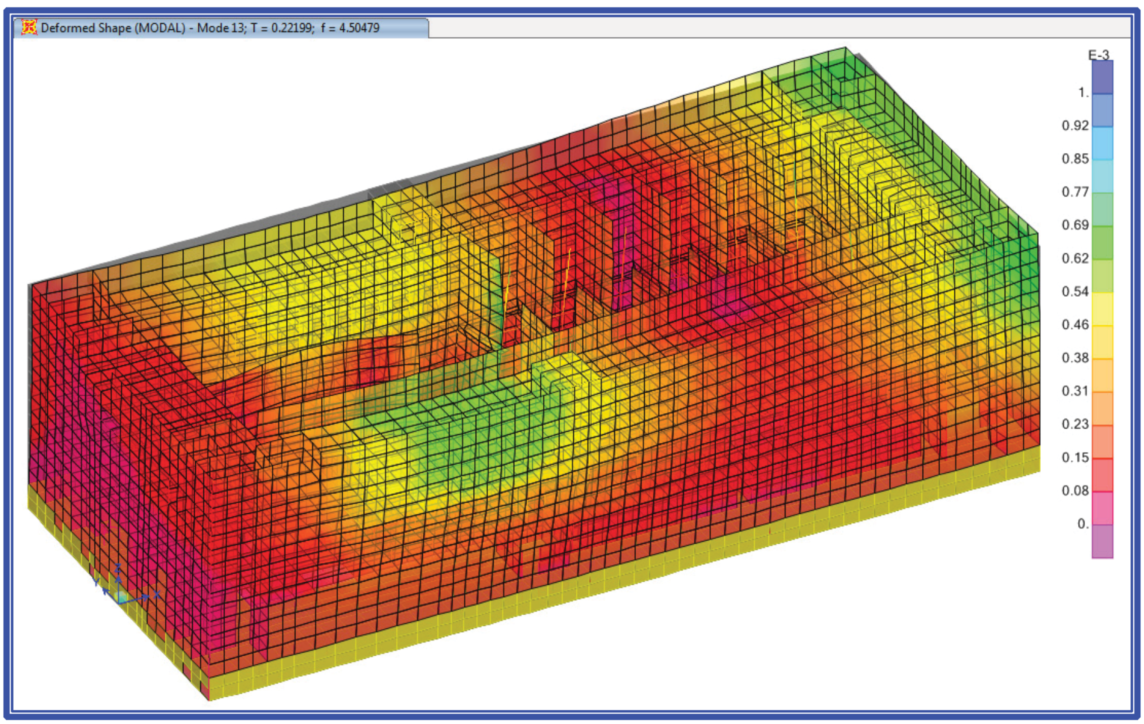

Figure 2: Partial Exaggerated Mode Shape for Mode 13 for Cracked Concrete RXB

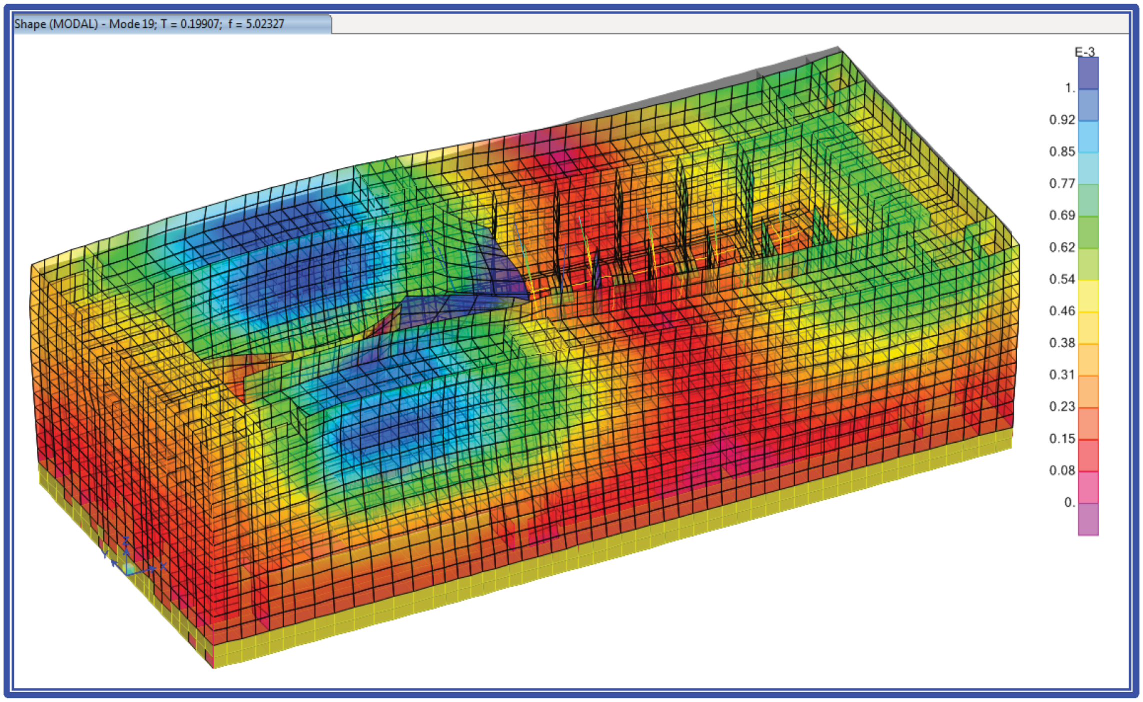

Figure 3: Partial Exaggerated Mode Shape for Mode 19 for Cracked Concrete RXB.

Table 3 provides the frequencies and modal mass participation ratios for the most significant torsional modes in the RXB for the RXB uncracked model.

Table 3: Frequencies and Modal Mass Participation Ratios for the RXB Uncracked Model

Step Type	Mode Number	Period (sec)	Frequency (Hz)	Torsional Participation Factors	Summation of Torsional Participation Factors
Mode	7	0.23	4.29	0.350	0.350
Mode	9	0.22	4.53	0.120	0.490
Mode	14	0.20	5.05	0.082	0.580
Mode	474	0.01	100.35	0.000	0.830
Mode	500	0.00	788.20	0.000	0.830

Figures 4 through 6, below, show the related RXB uncracked model mode shapes.

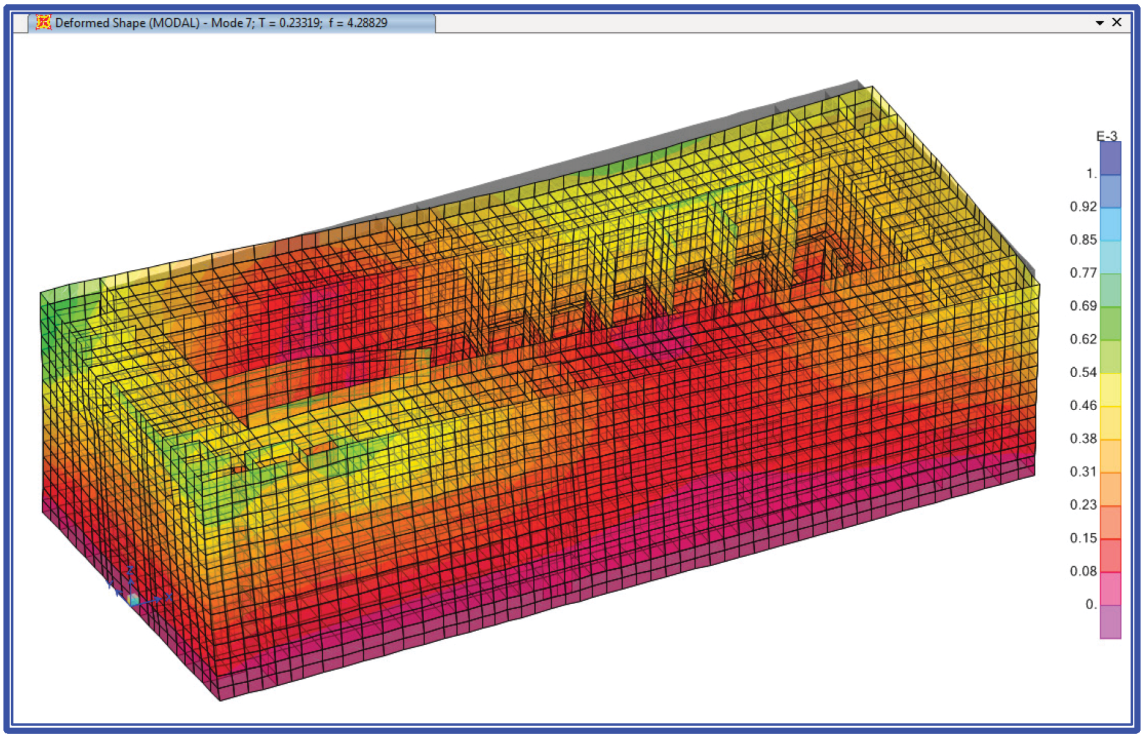

Figure 4: Partial Exaggerated Mode Shape for Mode 7 for Uncracked Concrete RXB

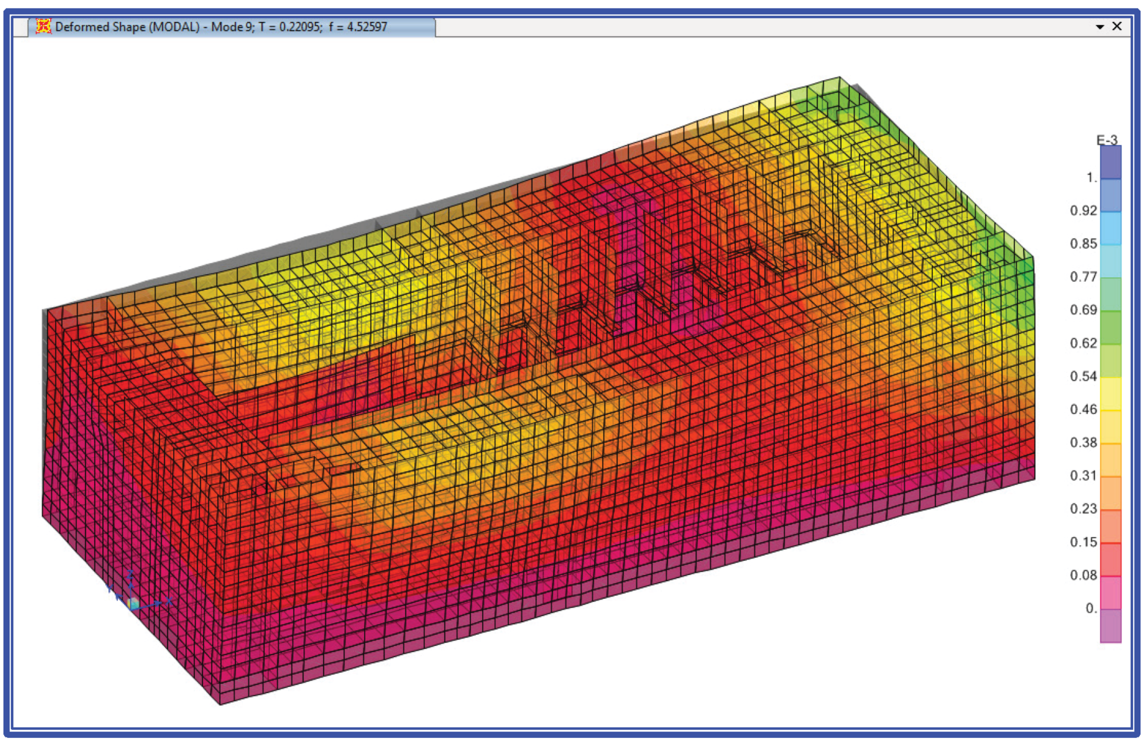

Figure 5: Partial Exaggerated Mode Shape for Mode 9 for Uncracked Concrete RXB

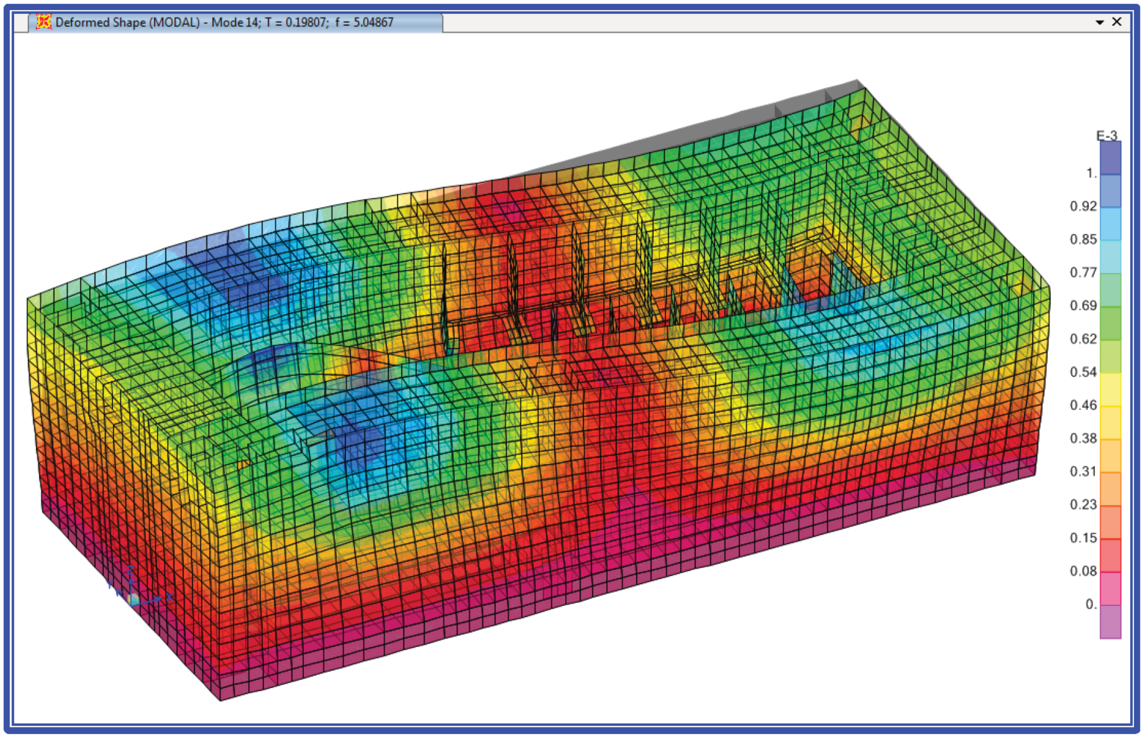

Figure 6: Partial Exaggerated Mode Shape for Mode 14 for Uncracked Concrete RXB

Impact on DCA:

There are no impacts to the DCA as a result of this response.

RAI 03.08.04-33

Table 3.7.2-35: Analysis Model Summary

No.	Analysis Model	Concrete Condition	Computer Program	SSI and SSSI Soil Types Considered	SSI and SSSI Time History Inputs Used	Purpose	Building Response	FSAR Explanation and Figures	FSAR Results
1	RXB Stand-Alone Bldg	Uncracked & Cracked	SAP2000	N/A	N/A	Static Analysis	Member Forces	Sections: 3.7.2.1.1.1, 3.7.2.1.2.1, 3.8.4.1.1, 3.8.4.3, 3.8.4.4.1, 3.8.5.4.1.2; Figures: 3.7.2-4, 3.8.4-15 through -20	Tables 3B-2 through -25, Figures 3B-7 through -47
2	RXB Stand-Alone Bldg	Uncracked & Cracked	SASSI2010	7, 8 & 11 (with CSDRS Input); 7 & 9 (with CSDRS-HF Input)	CSDRS: Capitola, Chi-Chi, El Centro, Izmit, Yermo. CSDRS-HF: Lucerne	Seismic SSI Analysis Using 7% Material Damping	Member Forces	Sections: 3.7.2.1.1.3, 3.7.2.1.2.1, 3.7.2.1.2.4, 3.7.2.4, 3.7.2.11, 3.7.5.1.4, 3.8.4.3, 3.8.5.4.1.2; Figures 3.7.2-15 through -21 & -34 (SASSI Input); Table 3.7.2-8 (SASSI Input)	Tables 3B-2 through -25, Figures 3B-7 through -47
3	RXB Stand-Alone Bldg	Uncracked & Cracked	SASSI2010	7, 8 & 11 (with CSDRS Input); 7 & 9 (with CSDRS-HF Input)	CSDRS: Capitola, Chi-Chi, El Centro, Izmit, Yermo. CSDRS-HF: Lucerne	Seismic ISRS Generation Using 4% Material Damping	ISRS	Sections: 3.7.2.1.1.3, 3.7.2.1.2.1, 3.7.2.1.2.4, 3.7.2.4, 3.7.2.5, 3.7.2.5.3, 3.7.2.9, 3.7.5.1.4, 3.8.4.3; Figures 3.7.2-15 through -21 & -34 (SASSI Input); Table 3.7.2-8 (SASSI Input)	Figures 3.7.2-99 through -103
4	RXB Stand-Alone Bldg	Uncracked	ANSYS	Wall accelerations are based on soil types 7, 8, and 11 w CSDRS Input.	CSDRS: Capitola	Slosh Heights in Reactor Pool and determine fluid-structure interaction effects of the RXB Pool	Accelerati-ons, Fluid Pressures	Sections: 3.7.2.1.1.2, 3.7.2.1.2.4, 3.7.5.1.4, 3.8.4.3; Figures: 3.7.2-33 through -35, 3.8.5-8 through -14	Table 3.7.2-8, Figures 3.7.2-36 through -39
5	RXB Stand-Alone Bldg - 7 NPM	Cracked	SASSI2010	7 (CSDRS) & 9 (CSDRS-HF)	CSDRS: Capitola CSDRS-HF: Lucerne	Seismic ISRS Generation Using 4% Material Damping & 7 NuScale Power Modules (NPMs) - Study for comparision purposes only.	ISRS	Sections: 3.7.2.9.1, 3.8.4.3, 3.8.4.3.22.3; Figure 3.7.2-97	Figures 3.7.2-107, -113, and 3.7.2-123 through -128

Table 3.7.2-35: Analysis Model Summary (Continued)

No.	Analysis Model	Concrete Condition	Computer Program	SSI and SSSI Soil Types Considered	SSI and SSSI Time History Inputs Used	Purpose	Building Response	FSAR Explanation and Figures	FSAR Results
6	RXB Base Mat - Partial Model	Uncracked	SAP2000	RXB soil pressures applied envelope the RXB stand-alone and triple building SAP and SASSI models.	RXB soil pressures applied envelope the RXB stand-alone and triple building SAP and SASSI models.	Static Analysis of RXB Base Mat. Uses both stand alone and combined models.	Member Forces	Sections: 3.8.4.3, 3.8.5.4.1.2; Figures 3.8.5-1 & -2	Figures 3.8.5-4 and 3.8.5-5
7	RXB Base Mat - Partial Model	Uncracked	SAP2000	RXB soil pressures applied envelope the RXB stand-alone and triple building SAP and SASSI models.	RXB soil pressures applied envelope the RXB stand-alone and triple building SAP and SASSI models.	Seismic Analysis of RXB Base Mat. Uses both stand alone and combined models.	Member Forces	Sections: 3.8.4.3, 3.8.5.4.1.2, 3.8.5.5.4, & 3.8.5.6.3; Figures 3.8.5-1 thru -7.	Section 3.8.5.1
8	CRB Base Mat - Partial Model	Uncracked	SAP2000	CRB soil pressures applied envelope the CRB stand-alone and triple building SAP and SASSI models.	CRB soil pressures applied envelope the CRB stand-alone and triple building SAP and SASSI models.	Seismic Analysis of CRB Base Mat. Uses both stand alone and combined models.	Member Forces	Sections: 3.8.5.4.1.3, 3.8.5.5.4, 3.8.5.6.3; Figure 3.8.5-3a	Sections 3.8.5.1 & 3B.3.3.1; Figures 3B-75 & -76; Tables 3B-34 through -41
9	RXB Lug Restraint -Partial Model	Cracked	SAP2000	N/A	N/A	Design of the RXM lug supports	Member Forces	Sections: 3.7.2.1.2.2, 3.8.2.1.3, 3.8.2.4.2, 3.8.4.3; Figures: 3.7.2-22, -23, -26, -27, -28, & 3.8.2-3	Tables 3B-26 & 27, Figures 3B-51 through -64
10	CRB Stand-Alone Bldg	Uncracked and Cracked	SAP2000	N/A	N/A	Static Analysis	Member Forces	Sections: 3.7.2.1.1.1, 3.7.2.1.2.5, 3.8.4.1.2, 3.8.4.3, 3.8.4.4.2; Figures: 3.7.2-50 through -52, 3.8.4-21 through - 26, 3.8.5-40	Tables 3B-28 through - 51, Figures 3B-65 through - 85
11	CRB Stand-Alone Bldg	Uncracked and Cracked	SASSI2010	7, 8 & 11 (with CSDRS Input); 7 & 9 (with CSDRS-HF Input)	CSDRS: Capitola, Chi-Chi, El Centro, Izmit, Yermo. CSDRS-HF: Lucerne	Seismic SSI Analysis Using 7% Material Damping	Member Forces	Sections: 3.7.2.1.1.3, 3.7.2.1.2.5, 3.7.2.4, 3.7.2.11, 3.8.4.3; Figures: 3.7.2-53 through -58, 3.8.5-34 & -35	Tables 3B-28 through - 51, Figures 3B-65 through - 85

Table 3.7.2-35: Analysis Model Summary (Continued)

No.	Analysis Model	Concrete Condition	Computer Program	SSI and SSSI Soil Types Considered	SSI and SSSI Time History Inputs Used	Purpose	Building Response	FSAR Explanation and Figures	FSAR Results
12	CRB Stand-Alone Bldg	Uncracked and Cracked	SASSI2010	7, 8 & 11 (with CSDRS Input); 7 & 9 (with CSDRS-HF Input)	CSDRS: Capitola, Chi-Chi, El Centro, Izmit, Yermo. CSDRS-HF: Lucerne	Seismic ISRS Generation Using 4% Material Damping	ISRS	Sections: 3.7.2.1.1.3, 3.7.2.1.2.5, 3.7.2.4, 3.7.2.5, 3.7.2.5.6, 3.7.2.9, 3.8.4.3; Figures: 3.7.2-53 through -58, 3.8.5-34 & -35	See envelope of cracked and uncraked condition - Figures: 3.7.2-117 through -122.
13	RXB-CRB-RWB Multiple Bldg	Uncracked and Cracked	SAP2000	N/A	N/A	Static Analysis	Member Forces	Sections: 3.7.2.1.2.7, 3.8.4.3; Figures: 3.7.2-59 through -66	Tables: 3B-2 through -25, 3B-28 through -51; Figures: 3B-7 through -47 and 3B-65 through -85
14	RXB-CRB-RWB Multiple Bldg (RXB)	Uncracked and Cracked	SASSI2010	7, 8 & 11 (with CSDRS Input); 7 & 9 (with CSDRS-HF Input)	CSDRS: Capitola, Chi-Chi, El Centro, Izmit, Yermo. CSDRS-HF: Lucerne	Seismic SSI Analysis Using 7% Material Damping	RXB Member Forces	Sections: 3.7.2.1.1.3, 3.7.2.1.2.7, 3.7.2.4, 3.7.2.11, 3.8.4.3; Figures: 3.7.2-67 through -75	Tables: 3B-2 through -25, 3B-28 through -51; Figures: 3B-7 through -47 and 3B-65 through -85
15	RXB-CRB-RWB Multiple Bldg (CRB)	Uncracked and Cracked	SASSI2010	7 (CSDRS) & 9 (CSDRS-HF)	CSDRS: Capitola, Chi-Chi, El Centro, Izmit, Yermo. CSDRS-HF: Lucerne	Seismic SSI Analysis Using 7% Material Damping	CRB Member Forces	Sections: 3.7.2.1.1.3, 3.7.2.1.2.7, 3.7.2.4, 3.7.2.11, 3.8.4.3; Figures: 3.7.2-67 through -75	Tables: 3B-2 through -25, 3B-28 through -51; Figures: 3B-7 through -47 and 3B-65 through -85
16	RXB-CRB-RWB Multiple Bldg (RXB)	Uncracked and Cracked	SASSI2010	7, 8 & 11 (with CSDRS Input); 7 & 9 (with CSDRS-HF Input)	CSDRS: Capitola, Chi-Chi, El Centro, Izmit, Yermo. CSDRS-HF: Lucerne	Seismic ISRS Generation Using 4% Material Damping	RXB ISRS	Sections: 3.7.2.1.1.3, 3.7.2.1.2.7, 3.7.2.4, 3.7.2.5, 3.7.2.9, 3.8.4.3	Figures 3.7.2-104 through -106
17	Envelope of ISRS for RXB	Envelope of Cracked & Uncracked	SASSI2010	See above	See above	Seismic ISRS Generation Using 4% Material Damping	ISRS	Sections: 3.7.2.5.3, 3.7.2.9	Figures 3.7.2-107 through -113
18	Envelope of ISRS for CRB	Envelope of Cracked & Uncracked	SASSI2010	See above	See above	Seismic ISRS Generation Using 4% Material Damping	ISRS	Sections:3.7.2.5.6, 3.7.2.9	Figures: 3.7.2-117 through -122
19	RXB Linear Stability - Stand-Alone Building	Cracked & Uncracked	N/A	N/A	N/A	Evaluate Flotation, Sliding, and Overturning	Factor of Safety	Sections: 3.8.4.3, 3.8.5, 3.8.5.4.1.2, 3.8.5.5, 3.8.5.6.1	Table 3.8.5-5

Table 3.7.2-35: Analysis Model Summary (Continued)

No.	Analysis Model	Concrete Condition	Computer Program	SSI and SSSI Soil Types Considered	SSI and SSSI Time History Inputs Used	Purpose	Building Response	FSAR Explanation and Figures	FSAR Results
20	RXB Nonlinear Stability - Stand-Alone Model (However, input seismic base reactions envelope both the RXB Stand-Alone and Triple Bldg SASSI Models)	Cracked & Uncracked	ANSYS	7, 8 & 11 (with CSDRS Input); 9 (with CSDRS-HF Input)	CSDRS Averaged Reactions from: Capitola, Chi-Chi, El Centro, Izmit, Yermo. CSDRS-HF: Lucerne	Evaluate Flotation, Sliding, and Overturning	Displace-ment	Sections: 3.8.4.3, 3.8.5, 3.8.5.4.1.2, 3.8.5.6.1; Table 3.8.5-6	Figures 3.8.5-53 through -76, Table 3.8.5-12
21	CRB Linear Stability - Stand-Alone Building	Cracked & Uncracked	N/A	N/A	N/A	Evaluate Flotation, Sliding, and Overturning	Factor of Safety	Sections: 3.8.4.3, 3.8.5, 3.8.5.4.1.3, 3.8.5.5	Not presented
22	CRB Nonlinear Stability - Stand Alone Model	Cracked & Uncracked	ANSYS	7 & 11 (with CSDRS Input)	CSDRS: Capitola	Evaluate Flotation, Sliding, and Overturning	Displace-ment	Sections: 3.8.4.3, 3.8.5, 3.8.5.4.1.4, 3.8.5.6.2; Figures: 3.8.5-26 & -27, 3.8.5-48	Table 3.8.5-13, Figures 3.8.5-49 & -50, Sections 3.8.5.6.2.2 & 3.8.5.6.2.3
23	RXB-CRB-RWB Multiple Bldg - Settlement	Cracked & Uncracked	SAP2000	N/A	N/A	Evaluate settlement for RXB and CRB	Settlement	Sections: 3.8.4.3; Figures: 3.8.5-41	Table 3.8.5-8
24	NuScale Power Module (NPM's 1 and 6)	Cracked & Uncracked	ANSYS	7 (with CSDRS Input)	CSDRS: Capitola	Determine reaction forces for NPM and ISRS for NPM components.	Reactions, forces, moments, ISRS,	Sections: 3.7.2.1.2.2, 3.7.3, Appendix 3A, Table 3.9-8, TR-0916-51502 Sections 3.1.5 & 5.0	TR-0916-51502 Tables 8-1 through 8-7 and Table C-2, Figures B-1 through B-27, Figures C-22 & C-23
25	RXB Fuel Storage Racks	N/A	ANSYS	Analysis based on RXB ISRS	Analysis based on RXB ISRS	Structural analysis of the RXB Fuel Storage Racks	Member Stresses	Sections: 3.7.3, 3.8.4.3.1.7, 9.1, TR-0816-49833	TR-0816-49833: Tables 3-30 through 3-36
26	Reactor Building Crane (RBC)	N/A	ANSYS	Analysis based on RXB ISRS	Analysis based on RXB ISRS	Structural Analysis of RBC	Member Forces	Section 9.1.5	Not presented
27	RXB Bioshield - Partial Model	Cracked & Uncracked	SAP2000	Analysis based on RXB ISRS	Analysis based on RXB ISRS	Structural analysis of Bioshield	Member Forces	Sections 3.7.3, 3.7.3.3.2, Figures 3.7.3-1 & -2, Tables 3.7.3-8 through -12	Table 3.7.3-14