June 29, 2018

Docket No. 52-048

U.S. Nuclear Regulatory Commission
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SUBJECT: NuScale Power, LLC Supplemental Response to NRC Request for Additional Information No. 185 (eRAI No. 8963) on the NuScale Design Certification Application

REFERENCES:
1. U.S. Nuclear Regulatory Commission, "Request for Additional Information No. 185 (eRAI No. 8963)," dated August 18, 2017
2. NuScale Power, LLC Response to NRC "Request for Additional Information No. 185 (eRAI No.8963)," dated October 17, 2017
3. NuScale Power, LLC Supplemental Response to NRC "Request for Additional Information No. 185 (eRAI No. 8963)," dated March 15, 2018

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

The Enclosure to this letter contains NuScale's supplemental response to the following RAI Question from NRC eRAI No. 8963:

- 03.08.05-12

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 Supplemental Response to NRC Request for Additional Information eRAI No. 8963

Enclosure 1:

NuScale Supplemental Response to NRC Request for Additional Information eRAI No. 8963

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NuScale Power™

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

eRAI No.: 8963
Date of RAI Issue: 08/18/2017

NRC Question No.: 03.08.05-12

10 CFR Part 50, Appendix A, GDC 1, 2, 4 and 5 provide the regulatory requirements for the design of the seismic Category I structures. DSRS Section 3.8.5 provides review guidance pertaining to representing the dynamic characteristics of foundations.

FSAR Tier 2, 3.8.5.4.1.2, "RXB Basemat Analysis Model Description," states *"The static forces and moments in the basemat are calculated with both the standalone and the combined building SAP2000 models."* Additionally, this section states *"The seismic forces, moments and stresses in all structural elements such as walls, pilasters, and basemat were calculated using the standalone and combined SASSI 2010 models. The enveloped base pressures were applied to the solid foundation model to evaluate the responses. To be consistent with the SASSI 2010 analysis, absolute values of all responses obtained by applying base pressures from SASSI2010 were used together with the fixed end forces and moments from walls and pilasters to arrive at the seismic demands."* It is not clear to the staff which structures or portions of the structures are included in the standalone and the combined building SAP2000 and SASSI2010 models, and whether there is a standalone basemat model. Therefore, describe each of the different models used for the basemat design.

NuScale Response:

During a Public Meeting on May 29, 2018, the NRC asked NuScale to submit a supplement to to RAI 8963 question 03.08.05-12 with an update to the FSAR to include the Reactor Building (RXB) tables that were included in the October 17, 2017 response as well as similar Control Building (CRB) tables. Also, the supplement should clarify what is meant by 'SAP2000 CRB **global** model.'

The tables for the RXB basemat models are added to FSAR Section 3.7.2.

Similar tables for the CRB basemat models are also added to FSAR Section 3.7.2.

The CRB global model in the previous RAI response means the SAP2000 model for the entire Control Building.

Impact on DCA:

FSAR Tier 2, Section 3.7.2 has been revised as described in the response above and as shown in the markup provided in this response.

model, where the ground surface is indicated by a gray horizontal plane. In this figure, the rigid soil springs connecting the RXB and backfill soil model with the excavated soil model are seen as dots.

Figure 3.7.2-19 shows the excavated soil model without the hidden lines. The length, width, and height dimensions of the excavated soil are identical to those of the backfill soil shown in Figure 3.7.2-17. Figure 3.7.2-20 shows the north half of the SASSI2010 model without the hidden lines. The floors, beam elements modeling the pilasters in walls, and the six NPMs in the north side of the RXB and a portion of the reactor building crane can be seen modeled by beam elements in red. Figure 3.7.2-21 shows all beam elements in the SASSI2010 model.

The free field soil is defined such that the RXB with backfill soil can fit exactly to the 'pit' in the excavated soil halfspace. The connectivity between the RXB with backfill soil and the excavated free field soil is achieved by connecting the skin nodes of the excavated soil model with the nodes on the embedded skin of the RXB with backfill model using rigid soil springs. The skin nodes of the excavated soil model and the skin nodes of the RXB with backfill model have identical coordinates, and they are in one-to-one correspondence matching pairs.

The rigid springs have a zero length and have a stiffness value large enough to simulate rigid connection. The large stiffness used is arbitrarily chosen to be ten billion lbs per inch, or 10^{10} lbs/inch, in the three global directions.

The model dimensions, the quantities of elements and masses, and structural damping ratios used for the SASSI2010 model are summarized in Table 3.7.2-1.

The NPMs and the Reactor Building crane (RBC) are included in the RXB model as beam models. These two subsystems are discussed in the following sections.

RAI 03.08.05-12S2

The reactor building basemat is designed using a combination of different models. First, the structural responses from the building models are extracted. Then they are applied to separate basemat models to determine structural design forces and moments for the basemat. Table 3.7.2-49 and Table 3.7.2-50 show which models are used, what results are extracted, and how these results are used to design the basemat.

3.7.2.1.2.2 NuScale Power Modules

Up to twelve NPMs will be inside the RXB. The modules are partially immersed in the reactor pool. The NPMs are not permanently bolted or welded to the pool floor or walls. Instead they are geometrically supported and constrained at four locations. The geometrical constraints are designed to keep each NPM in its location before, during, and after a seismic event.

55. In the SASSI2010 analysis, the properties of the backfill soil are assumed those of Soil Type 11.

Figure 3.7.2-56 shows the SASSI2010 solid elements modeling the concrete basemat. Figure 3.7.2-57 show the shell and beam elements of the CRB SASSI2010 model. Figure 3.7.2-58 shows all beam elements in the SASSI2010 model, which are identical to those shown in Figure 3.7.2-51.

The CRB and backfill soil is modeled surrounded by the free-field soil. The connectivity between the CRB with backfill and the free-field is achieved by connecting the skin nodes of the embedded model of the CRB and backfill soil with the skin nodes of the free-field soil model using soil springs. The skin nodes of the excavated soil model, and the skin nodes of the CRB and backfill model have identical coordinates and are in matching pairs.

The springs have a zero length and have a large stiffness value to simulate rigid connection. The large stiffness used is arbitrarily chosen as 10^{10} lbs/inch, in the three global directions. This high stiffness value does not cause numerical instability and keeps the displacements of two connected nodes to be the same.

The model dimensions, the quantities of elements and masses, and structural damping ratios used for the SASSI2010 model are summarized in Table 3.7.2-9.

RAI 03.08.05-12S2

The control building basemat is designed using a combination of different models. First, the structural responses from the building models are extracted. Then they are applied to a separate basemat model to determine structural design forces and moments for the basemat. Table 3.7.2-51 and Table 3.7.2-52 show which models were used, what results are extracted, and how these results are used to design the basemat.

3.7.2.1.2.6 Comparison of SAP2000 and SASSI2010 Models

The SASSI2010 model data were obtained by converting the data of the SAP2000 models. To verify that the SAP2000 model has been converted accurately into the SASSI2010 model, the total weights of the two models and the fixed base modal frequencies of the two models are compared.

The model frequencies and mode shapes of the fixed base SAP2000 model were calculated by a modal frequency analysis. The SASSI2010 analysis does not perform modal analysis. However, the major vibration frequencies of a certain location can be obtained to be those of the major amplitudes in the acceleration response transfer functions of the location.

RAI 03.07.02-19S1

In the calculation of the structural frequencies for comparison, the structure is assumed to be surface founded in both the SAP2000 and SASSI2010 analyses.

RAI 03.08.05-12S2

Table 3.7.2-49: Building Models Used for RXB Basemat Design

Software	Bldgs. Included in the Model	Basemat Modeled As	Bldg. Model Results Used
SASSI	Standalone (RXB) FSAR Table 3.7.2-1	2 Layers of Solid Elements	Envelope of Soil Bearing Pressure from Seismic Loads of both Models
	Triple Bldg. (RXB, CRB, and RWB) FSAR Table 3.7.2-12	2 Layers of Solid Elements	
SAP2000	Standalone (RXB) FSAR Table 3.8.4-6	2 Layers of Solid Elements	Envelope of Soil Bearing Pressure from Static Loads of both Models
	Triple Bldg. (RXB, CRB, and RWB) FSAR Section 3.7.2.1.2.7	2 Layers of Solid Elements	

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Table 3.7.2-50: Basemat Model Used for RXB Basemat Design

Software	Bldgs. Included in the Model	Basemat Modeled As	Results Used
SAP2000	Standalone (RXB) FSAR Figure 3.8.5-1	1 Layer of Shell Elements	Enveloping Soil Bearing Pressure from Static and Seismic Loads Applied as Pressures on the Basemat Model

RAI 03.08.05-12S2

Table 3.7.2-51: Building Models Used for CRB Basemat Design

<table>
<tr><th>Software</th><th>Bldgs. Included in the Model</th><th>Basemat Modeled As</th><th>Bldg. Model Results Used</th></tr>
<tr><td rowspan="2">SASSI</td><td>Standalone (CRB)
FSAR Table 3.7.2-9</td><td>1 Layer of Solid Elements</td><td rowspan="2">1) Enveloping foundation forces and moments are obtained by post-processing the forces and moments in the bottom of the shell elements of the exterior walls joining the basemat as the forces and moments for the perimeter area of the basemat.

2) Envelop the centroidal vertical stresses (σ_{zz}) in the foundation solid elements of the entire basemat.</td></tr>
<tr><td>Triple Bldg. (RXB, CRB, and RWB)
FSAR Table 3.7.2-12</td><td>1 Layer of Solid Elements</td></tr>
<tr><td rowspan="2">SAP2000</td><td>Standalone (CRB)
FSAR Table 3.8.4-8</td><td>1 Layer of Solid Elements</td><td rowspan="2">1) Enveloping foundation forces and moments are obtained by post-processing the forces and moments in the bottom of the shell element walls joining the basemat.

2) Enveloping foundation static forces and moments are obtained by post-processing the foundation solid element nodal forces of the entire basemat.</td></tr>
<tr><td>Triple Bldg. (RXB, CRB, and RWB)
FSAR Section 3.7.2.1.2.7</td><td>1 Layer of Solid Elements</td></tr>
</table>

RAI 03.08.05-12S2

Table 3.7.2-52: Basemat Model Used for CRB Basemat Design

Software	Bldgs. Included in the Model	Basemat Modeled As	Results Used
SAP2000	Standalone (CRB) FSAR Figure 3B-74	1 Layer of Shell Elements	1) Total (static + seismic) enveloping centroidal vertical stresses (σ_{zz}) obtained from the building model are applied as upward pressure to the isolated basemat shell model in the foundation solid elements of the entire basemat. This provides forces and moments in the interior region of the foundation. 2) For elements in the perimeter region, the (static + seismic) enveloping wall forces and moments are used as foundation forces and moments. 3) For the elements in the tunnel: a) the total (static + seismic) wall forces and moments are used as foundation seismic forces and moments. b) In addition, total (static + seismic) enveloping centroidal vertical stresses (σ_{zz}) obtained from the building model are applied as upward uniformly distributed loads on tunnel dimension by hand calculation. c) Total demand forces and moments are obtained as (3a+3b).