February 14, 2019

Docket No. 52-048

U.S. Nuclear Regulatory Commission
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11555 Rockville Pike
Rockville, MD 20852-2738

SUBJECT: NuScale Power, LLC Submittal of Changes to Final Safety Analysis Report, Section 3.7.1, “Seismic Design Parameters”

REFERENCES: Letter from NuScale Power, LLC to Nuclear Regulatory Commission, “NuScale Power, LLC Submittal of the NuScale Standard Plant Design Certification Application, Revision 2,” dated October 30, 2018 (ML18311A006)

During a January 23, 2019 public teleconference with Marieliz Vera, NRC Project Manager and Ata Istar of the NRC Staff, NuScale Power, LLC (NuScale) discussed potential updates to the Final Safety Analysis Report (FSAR). As a result of this discussion, NuScale changed Section 3.7.1, “Seismic Design Parameters.” The Enclosure to this letter provides a mark-up of the FSAR pages incorporating revisions in redline/strikeout format. NuScale will include this change as part of a future revision to the NuScale Design Certification Application.

This letter makes no regulatory commitments or revisions to any existing regulatory commitments.

If you have any questions, please feel free to contact Marty Bryan at 541-452-7172 or at mbryan@nuscalepower.com.

Sincerely,

Zackary W. Rad
Director, Regulatory Affairs
NuScale Power, LLC

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Enclosure: “Changes to NuScale Final Safety Analysis Report Sections Section 3.7.1, “Seismic Design Parameters ”

Enclosure:

"Changes to NuScale Final Safety Analysis Report Sections Section 3.7.1, "Seismic Design Parameters "

COL Item 3.7-9: A COL applicant that references the NuScale Power Plant design certification will include an analysis of the performance-based response spectra established at the surface and intermediate depth(s) that take into account the complexities of the subsurface layer profiles of the site and provide a technical justification for the adequacy of V/H spectral ratios used in establishing the site-specific foundation input response spectra and the performance-based response spectra for the vertical direction.

The COL applicant may use site-specific ground motion for the design of site-specific safety-related SSC.

3.7.1.2 Percentage of Critical Damping Values

3.7.1.2.1 System and Component Damping

For analyses of Seismic Category I and Seismic Category II SSC, the damping values of RG 1.61, Revision 1, "Damping Values for Seismic Design of Nuclear Power Plants" are used. These values are presented in Table 3.7.1-6. For a discussion of damping used for the NPM subsystem, refer to Appendix 3A.

3.7.1.2.2 Structural Damping

The reinforced concrete may experience some cracking during a seismic event. Two levels of stiffness are included in the models to account for any cracking the concrete may experience. To represent cracked conditions, the stiffness of walls and diaphragms are reduced by 50 percent for flexure and shear. These effective stiffness values are provided in Table 3.7.1-7.

For static analysis using SAP2000, the in-plane (normal forces and in-plane shear) and out-of-plane plate stiffness (bending and out-of-plane shear) are changed independently by changing the stiffness modifier factors. For dynamic analysis using SASSI2010 (Reference 3.7.1-12) the plate stiffnesses are controlled by Young's modulus and the plate thickness. It is not possible to reduce the bending stiffness by 50 percent for cracked concrete while preserving the axial stiffness to 100 percent for in-plane forces by modifying Young's modulus. A compromise approach is used by reducing the thickness by a factor equal to cubic root of 0.5, or 0.7937 to reduce the bending stiffness by 50 percent for the cracked concrete condition. In this approach, the uncracked axial stiffness is reduced by a factor of 0.7937. This is summarized in Table 3.7.1-7a.

RAI 03.07.01-2, RAI 03.07.01-3

It is possible that for the SSI analyses with cracked concrete condition, all structural members might not have reached their cracked shear and moment values. Therefore, envelope forces and moments from the SSI analyses with uncracked and cracked reinforced concrete are used for the design of the structures. Both uncracked and cracked conditions are evaluated with 7 percent damping. This is SSE damping for reinforced concrete as specified in RG 1.61.

Table 3.7.1-7: Effective Stiffness of Reinforced Concrete Members

Member	Flexural Rigidity	Shear Rigidity	Axial Rigidity
Beams-nonprestressed	0.5 E_cI_g	G_cA_w	-
Beams-prestressed	E_cI_g	G_cA_w	-
Columns in compression	0.7 E_cI_g	G_cA_w	E_cA_g
Columns in tension	0.5 E_cI_g	G_cA_w	E_sA_s
Walls and diaphragms - uncracked	E_cI_g ($f_b < f_{cr}$)	G_cA_w ($V < V_c$)	E_cA_g
Walls and diaphragms - cracked	0.5 E_cI_g ($f_b > f_{cr}$)	0.5 G_cA_w ($V > V_c$)	E_cA_g

Where,

A_g = Gross area of the concrete section

A_s = Gross area of the reinforcing steel

A_w = Web area

E_c = Concrete compressive modulus, from ACI-349 = $57{,}000(f'c)^{1/2}$

E_s = Steel modulus

f_b = Bending stress

f_{cr} = Cracking stress

G_c = Concrete shear modulus = $0.4E_c$

I_g = Gross moment of inertia

V = Wall shear

V_c = Nominal concrete shear capacity

Table 3.7.1-7a: Effective Stiffness Changes of Cracked Reinforced Concrete Finite Element Model Members

Flexural Rigidity	Shear Rigidity	Axial Rigidity
$0.5\ E_cI_g$	$0.7937G_cA_w$	$0.7937E_cA_g$

Fixed-base SAP2000 finite element models are used to determine the structural response due to non-seismic loads. The SAP2000 results (element forces and moments) from the various non-seismic loads are used in conjunction with the results of the seismic analysis described in Section 3.7.2 to perform the design assessments for the Seismic Category I RXB and CRB.

Load combinations are defined in the analysis models according to Table 3.8.4-1 and Table 3.8.4-2. The acceptance criteria are discussed in Section 3.8.4.5, and Appendix 3B provides the results for selected sections within the RXB and CRB.

In the SAP2000 model, the global coordinate axes are as follows:

- X axis - east-west (Positive X direction pointing east)
- Y axis - north-south (Positive Y direction pointing north)
- Z axis - vertical (Positive Z direction pointing upward)

The origin of the global coordinate system of the finite element models is located at the intersection of Grid Lines RX-C and RX-1 as shown in Figure 3.7.2-3 and Figure 3.7.2-4.

The global origin of the CRB is the same origin as the RXB, and the axis are the same.

3.8.4.4.1 Reactor Building Analysis

SAP2000 Model of the Reactor Building

RAI 03.08.04-27

Two SAP2000 analysis models with fixed base boundary conditions were created to consider the conditions of cracked and uncracked concrete. The level of cracking considered for the cracked SAP2000 analysis model was based on guidance from ASCE 43-05 Section 3.4.1 and Table 3-1. Section 3.7.1.2.2 and Table 3.7.1-7 and Table 3.7.1-7a specify the level of cracking used in these models.

RAI 03.08.04-27

The basis associated with the assumed level of cracking is that this approach accounts for fully enveloped conditions. Envelope demand forces and moments from the uncracked and cracked condition are used regardless of the demand moments and the shear reach of their cracking limits.

RAI 03.08.04-27, RAI 03.08.05-5

The purpose of these models is to envelope the extracted demand forces and moments from the cracked and uncracked models from the static analysis. These maximum demand forces and moments are then used in the design. Figure 3.8.4-15 through Figure 3.8.4-20 provides different views of the RXB SAP2000 finite element model. Table 3.8.4-6 tabulates the total number of joints and elements developed in both the uncracked and cracked SAP2000 analysis models.

3.8.4.4.2 Control Building Analysis

SAP2000 Model of the Control Building

RAI 03.08.04-27

Two analysis models with fixed base boundary conditions were created to consider the cracked and uncracked concrete conditions. The level of cracking considered for the cracked SAP2000 analysis model was based on guidance from ASCE 43-05 Section 3.4.1 and Table 3-1. Section 3.7.1.2.2 and Table 3.7.1-7 and Table 3.7.1-7a specify the level of cracking used in these models.

RAI 03.08.04-27

The basis associated with the assumed level of cracking is that this approach accounts for fully enveloped conditions. Envelope demand forces and moments from the uncracked and cracked condition are used regardless the demand moments and shear reach their cracking limits.

RAI 03.08.04-27

The purpose of these models is to envelope the extracted demand forces and moments from the cracked and uncracked models from the static analysis. These maximum demand forces and moments are then used in the design. The two CRB SAP2000 analysis models are identical in geometry and applied loads.
Figure 3.8.4-21 through Figure 3.8.4-26 show the CRB SAP2000 model in various isometric and perspective views. Table 3.8.4-8 tabulates the total number of joints and elements developed in both the uncracked and cracked SAP2000 analysis models.

The CRB finite element models are developed to represent the primary structural members including walls, beams, columns, pilasters, floors and roofs. Walls, floors, metal decking and wind siding elements are represented by shell elements and the beams, columns, braces and pilasters are modeled by frame (beam) elements. The basemat foundation is modeled by solid elements and shell elements. The excavated soil is modeled by solid elements only. All shell and frame elements are modeled at their centerlines (neutral planes). All structural steel connections have fixed boundary condition. Penetrations in the walls or slabs are approximated in the SAP2000 model.

RAI 03.08.04-28

The bottom of the foundation basemat of the CRB SAP2000 model has a link element at each node. One end of each link element in the CRB SAP2000 model is connected to the CRB basemat and the other end to a fixed node.

Solid elements are added to the exterior of the CRB embedded walls to model the backfill soil with Soil Type 11 properties (see Section 3.7.1.3). The assumed uniform backfill width is 25 feet.

SAP2000 Analysis