March 02, 2018

Docket No. 52-048

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

SUBJECT: NuScale Power, LLC Response to NRC Request for Additional Information No. 317 (eRAI No. 9254) on the NuScale Design Certification Application

REFERENCE: U.S. Nuclear Regulatory Commission, "Request for Additional Information No. 317 (eRAI No. 9254)," dated January 03, 2018

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. 9254:

- 03.07.02-33

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
NuScale Power, LLC

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Enclosure 1: NuScale Response to NRC Request for Additional Information eRAI No. 9254

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NuScale Response to NRC Request for Additional Information eRAI No. 9254

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NuScale Power

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

eRAI No.: 9254
Date of RAI Issue: 01/03/2018

NRC Question No.: 03.07.02-33

10 CFR 52.47(a)(20) requires that an application for Design Certification must include the information necessary to demonstrate that the standard plant complies with the earthquake engineering criteria in Appendix S to 10 CFR 50 that the required safety functions of structures, systems, and components (SSCs) must be assured during and after the vibratory ground motion associated with the Safe Shutdown Earthquake (SSE) through design, testing, or qualification methods.

In RAI 8936 Question 03.07.02-9, the staff requested the applicant to provide justification for the use of Eq. 3.7-17 in the NuScale DCD, Revision 0, in view of the guidance in DSRS Section 3.7.2 on accidental torsion. DCD Eq. 3.7-17 represents a methodology chosen by the applicant to account for the effect of accidental torsion. In its response, dated October 03, 2017 (ML17276B886), the applicant stated that (1) the methodology chosen to account for accidental torsion was to increase the maximum horizontal element forces by 5% and combine them with the maximum vertical forces by means of the square root of the sum of the squares (SRSS), and (2) because torsion is the product of force and distance, increasing the seismic forces by 5% is equivalent to increasing the eccentricity by 5%.

The staff reviewed the applicant's approach to addressing accidental torsion by increasing the horizontal element forces by 5% in lieu of increasing the eccentricity by 5%. The staff is unable to determine the validity of the applicant's approach that involves a uniform increase of horizontal element forces by 5% in contrast to the DSRS methodology that involves an increase of 5% torsional eccentricity on a floor level. DSRS 3.7.2, Acceptance Criteria II.11 specifies that, to account for accidental torsion, an additional eccentricity of plus or minus 5% of the maximum building dimension should be assumed for both horizontal directions and that the magnitude and location of the two eccentricities are determined separately for each floor elevation. The staff also notes that similar guidance on accounting for accidental torsion is available in industry standards; e.g., ASCE 4-16 specifies that the effect of accidental torsion be calculated at each floor level by static analysis assuming a torsional moment equal to the product of the story shear and 5% of the plan dimension perpendicular to the direction of motion of the structure at that level.

The staff finds that the applicant has not demonstrated that an eccentricity of 5% of the building dimension is equivalent to a 5% increase in the elemental horizontal forces. Therefore, the applicant is requested to provide additional information that provides the requested technical justification to demonstrate the equivalency to the DSRS methodology or conservatism in the method used by the applicant. Compliance with the DSRS is not a requirement; however, the applicant should identify differences between the analytical methods used for its design and the DSRS acceptance criteria and evaluate the technical acceptability of its methods. The applicant may choose to use a smaller model to illustrate the comparison of the results from the two approaches.

NuScale Response:

As outlined in DSRS 3.7.2, Acceptance Criteria 11, typically, to account for accidental torsion, the centers of mass and stiffness are assumed to be moving away from one another by 5% of the building dimension, thus creating additional torsion. Since this type of modeling in a transient analysis that includes soil structure interaction (SSI) effects is not practical, NuScale has employed an alternate method that is equivalent and more conservative, in order to incorporate the resulting effects of a 5% mass offset. The methodology chosen to account for accidental torsion is to increase the maximum horizontal element forces by 5% and combine them with the maximum vertical forces by means of the square root of the sum of the squares (SRSS). The following outlines how this alternate methodology is conservatively equivalent and meets the intent of DSRS 3.7.2, Acceptance Criteria 11.

The lateral load-resisting system of the reactor building is the reinforced concrete shear walls. The most efficient shear walls to resist the torsional effects are the exterior walls along the perimeter of the building. Only these exterior walls are considered to resist accidental torsion; the effects of the interior walls are conservatively ignored. This reduces the problem to a closed, thin-wall section subject to torsional effects. The additional shear in the walls is calculated and compared with direct shear due to direct base shear to show technical justification that the 5% amplification factor of the seismic demand is conservatively equivalent to the 5% mass offset method for addressing accidental torsion.

Shear stresses in the exterior walls (plan view shown in Figure 1) due to both direct base shear and accidental torsion are calculated. Comparing the difference between them will show the significance of accidental torsion in the seismic demands.

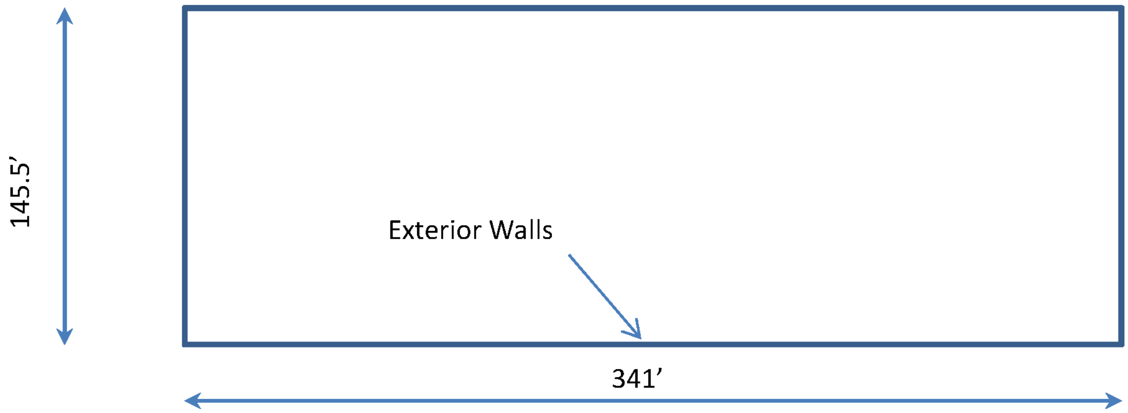

Figure 1: Plan View Dimensions of the Exterior Shear Walls

Direct base shear creates in-plane shear on the 5 foot thick exterior walls that are parallel to the base shear. Due to the rigid diaphragms in the reactor building, under direct shear, all exterior walls will experience the same shear stress, to satisfy deformation compatibility.

The total shear areas of the exterior walls in each direction are as follows:

In the N-S Direction: A=2*145.5’*5’=1455 ft^2

In the E-W Direction: A=2*341’*5’=3410 ft^2

For a 1 kip base shear in the N-S or E-W direction, the shear stresses in the exterior walls are calculated and provided in Table 1.

Table 1: Shear Stresses in the Exterior Walls due to Direct Base Shear

Shear Stress (kips/ft^2) 1 kip shear in the N-S Direction	Shear Stress (kips/ft^2) 1 kip shear in the E-W Direction
1/1455=6.87x10^{-4}	1/3410=2.93x10^{-4}

For shear due to accidental torsion, a closed, thin-walled section subject to torsion resists the applied shear in the form of in-plane shear flow in the exterior walls.

The twisting angle of a closed, thin-walled section under torsion is measured using the following equation:

$$\theta = \frac{TL}{GR}$$

Where the torsional rigidity is calculated from the following equation:

$$R = \frac{4A^2}{\int \frac{ds}{t}}$$

And the shear flow in the section thickness is calculated as follows:

$$f = \frac{T}{2A}$$

And the shear stress in the wall due to torsion is:

$$\tau = \frac{T}{2tA}$$

The torsional section properties of the exterior walls are:

t=5 ft

A=341'*145.5'=49616 ft^2

For a 1 kip base shear in the N-S or E-W direction, the accidental torsions are:

For unit shear in the N-S direction: $T_{N\text{-}S}$= 1 kip*(0.05*341’) =17.05 ft-kips

For unit shear in the E-W direction: $T_{E\text{-}W}$= 1 kip*(0.05*145.5’) =7.28 ft-kips

The corresponding shear in the exterior walls due to accidental torsion is shown in Table 2:

Table 2: Shear Stresses in the Exterior Walls due to Accidental Torsion

Shear Stress (kips/ft^2) 1 kip shear in the N-S Direction	Shear Stress (kips/ft^2) 1 kip shear in the E-W Direction
17.05/(2*5’*49616)=3.44x10^{-5}	7.28/(2*5’*49616)=1.47x10^{-5}

The comparison between the calculated direct shear and the accidental torsion shear shows the effect due to accidental torsion.

The ratio of the shear stress in the exterior walls due to accidental torsion to the shear stress due to direct shear is shown in Table 3:

Table 3: Comparison of Direct Base Shear and Accidental Torsion

Shear Stress (kips/ft^2) 1 kip shear in the N-S Direction			Shear Stress (kips/ft^2) 1 kip shear in the E-W Direction		
Direct	Acc. Torsion	Acc./Direct	Shear	Acc. Torsion	Acc./Direct
6.87x10^{-4}	3.44x10^{-5}	5.0%	2.93x10^{-4}	1.47x10^{-5}	5.0%

As shown by these calculations, the effect of accidental torsion is 5% of the effect of direct base shear. This, in turn, indicates that, to equivalently account for accidental torsion effects, seismic demands can be increased by 5%.

Impact on DCA:

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