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Sent:	Monday, May 10, 2021 11:39 AM
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Subject:	Final Request for Additional Information No. 0002 (eRAI Nos. 9833 and 9844)
Attachments:	Final RAI_9833.pdf; Final RAI_9834.pdf

Attached please find NRC staff's request for additional information (RAI) concerning the review of Licensing Topical Report TR-0920-71621-P, Revision 0, "Building Design and Analysis Methodology for Safety-Related Structures," (Agencywide Documents Access and Management System (ADAMS) Accession No. ML20353A404).

Please submit your technically correct and complete response by the agreed upon date to the NRC Document Control Desk.

If you have any questions, please do not hesitate to contact me.

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Request for Additional Information 0002 (eRAI No. 9833)

Issue Date: 05/06/2021
Application Title: Pre-Application Activities for NuScale SDA Application
Operating Company: NuScale
Docket No. 99902078
Review Section: NTR - NuScale Topical Report for SDA
Application Section: TR-0920-71621-P, Revision 0

QUESTIONS

NTR-6

Requirement

10 CFR Part 50, Appendix A, General Design Criteria (GDC) 1, 2 and 4 as it relates to the design of seismic Category I structures, systems and components (SSCs).

DSRS 3.8.4, "Other Seismic Category I Structures," states the structural acceptance criteria for seismic Category I structures appear in ACI 349, with additional guidance provided by RG 1.142 for concrete structures, AISC N690-1994 for steel structures, and Subsection II.4.J for structures that use modular construction methods evaluated on a case-by-case basis.

Issue

In Section 6.7.2, "Evaluation of the Local Response of Steel-Plate Composite Walls to Impactive and Impulsive Loads," of the TR, the applicant stated *"70 percent of the thickness for a RC wall was determined using Section 6.3.2.1.2 of DOE-STD-3014-2006 (Reference 10.1.11)."* Based on review of the referenced documents of Section 6.3.2.1.2 of DOE-STD-3014-2006, and Section 2.1.2.2 of NEI 07-13, Revision 8, it is not clear to staff whether Equation 6-53 can be applicable for the SC walls.

Request

The staff requests the applicant to describe whether Equation 6-53, in the TR, is applicable for the SC walls.

NTR-7

Requirement

10 CFR Part 50, Appendix A, General Design Criteria (GDC) 1, 2 and 4 as it relates to the design of seismic Category I structures, systems and components (SSCs).

DSRS 3.8.4, "Other Seismic Category I Structures," states the structural acceptance criteria for seismic Category I structures appear in ACI 349, with additional guidance provided by NRC Regulatory Guide (RG) 1.142 for concrete structures, AISC N690-1994 for steel structures, and Subsection II.4.J for structures that use modular construction methods evaluated on a case-by-case basis.

Issue

The TR described new developments in the design and evaluation of complex seismic Category I and II structures for the new generation of SMR designs but did not provide the definitions of seismic Category I and II structures.

Request

The staff requests the applicant to provide the definitions of seismic Category I and II structures.

NTR-8

Requirement

10 CFR Part 50, Appendix A, GDC 1, 2 and 4 as it relates to the design of seismic Category I SSCs.

DSRS 3.8.4 states the structural acceptance criteria for seismic Category I structures appear in ACI 349, with additional guidance provided by RG 1.142 for concrete structures, AISC N690-1994 for steel structures, and Subsection II.4.J for structures that use modular construction methods evaluated on a case-by-case basis.

Issue

In Section 8.1, "General Information," of the TR, the applicant compared "the element-based approach" and "the member-based or section cut-based approach." The applicant concluded that "the member-based or section cut-based approach" yields design demands that are more realistic based on TR Reference 10.1.27, "Kohli, T., Gurbuz, O., Ostadan, F., "Integrated Seismic Analysis and Design of Shear Wall Structures," Bechtel Technology Journal, 2008."

The staff review of reference 10.1.27 in the TR provided an integrated design approach using information from SASSI2000 (transfer functions) and SAP2000 (dead-loads)) that are imported into the "optimum concrete (OPTCOM)" reinforced concrete design proprietary computer code that performs, on a time-step basis for the entire time-history, a "best-fit" reinforcement solution at each concrete slab/wall element in an element grouping. However, it is not clear to the staff how the applicant will use this integrated design approach with SASSI2000 and ANSYS finite element computer codes.

Request

The staff requests the applicant to describe the implementation of this integrated design approach using SASSI2000 and ANSYS finite element computer codes.

NTR-9

Requirement

10 CFR Part 50, Appendix A, GDC 1, 2 and 4 as it relates to the design of seismic Category I SSCs.

DSRS 3.8.4 states the structural acceptance criteria for seismic Category I structures appear in ACI 349, with additional guidance provided by RG 1.142 for concrete structures, AISC N690-1994 for steel structures, and Subsection II.4.J for structures that use modular construction methods evaluated on a case-by-case basis.

Issue

In Section 8.4, "Design Methodology," of the TR, the applicant described the details of section cuts at a slab panel modeled with shell elements and section cuts for columns and T-beams. In Figure 8-3, "Section cut for columns and section cut local coordinate system," the applicant presented the selected finite element as a section cut. It is not clear to the staff how the applicant would consider the effective length (k factor) of a column in the design.

Request

The staff requests the applicant to describe how the effective length (k factor) of a column is considered in the design.

NTR-10

Requirement

10 CFR Part 50, Appendix A, GDC 1, 2 and 4 as it relates to the design of seismic Category I SSCs.

DSRS 3.8.4 states the structural acceptance criteria for seismic Category I structures appear in ACI 349, with additional guidance provided by RG 1.142 for concrete structures, AISC N690-1994 for steel structures, and Subsection II.4.J for structures that use modular construction methods evaluated on a case-by-case basis.

Issue

In Section 8.2, "Purpose," of the TR, the applicant described the objectives of Section 8.0 which is to develop a methodology for the design of Seismic Category I and II structures to the requirements of ACI 349-13 and RG 1.142. The staff compared Table 8-2, "Load Combinations for Concrete Structures," in Section 8.9, "Load Combinations," against Table 1, "Loads, Load Factors and Load Combinations," in RG 1.142, and noted differences, e.g. factors and load combinations.

Request

The staff requests the applicant to provide the justification for the differences between the load combinations in Table 8-2 of the TR and those listed in Table 1 in RG 1.142.

NTR-11

Requirement

10 CFR Part 50, Appendix A, GDC 1, 2 and 4 as it relates to the design of seismic Category I SSCs.

DSRS 3.8.4 states the structural acceptance criteria for seismic Category I structures appear in ACI 349, with additional guidance provided by RG 1.142 for concrete structures, AISC N690-1994 for steel structures, and Subsection II.4.J for structures that use modular construction methods evaluated on a case-by-case basis.

Issue

In Section 8.5, "Required Strengths for Slab and Basemat Design," of the TR, the applicant stated *"Conservatively, the length of section cuts is defined to be less than three times the member thickness,"* and *"In this case, section cut lengths are not limited to three times the member thickness."* In Section 8.5.1, "Section Cuts for Out-of-Plane Forces," the applicant stated, *"Based on recommendations in Reference 10.1.29, the section cut length is limited to three times the basemat thickness."* In Section 8.5.4 "Determination of Section Cut Locations using FEA Stress Resultants," the applicant stated*, "The length of section cuts need not be less than three times the slab thickness unless the stress resultant changes sign along the cut or it is limited by openings."*

Based on these statements, it is not clear to the staff how the optimal length of the section cuts were determined (e.g. in Section 8.5, the section cut length is less than three times the member thickness which may be conservative, while in Section 8.5.4, the cut length need not to be less than three times the slab thickness.)

Request

The staff requests the applicant to describe the basis for how to interpret Sections 8.5, 8.5.1 and 8.5.4 in determining the most appropriate section cut length.

NTR-12

Requirement

10 CFR Part 50, Appendix A, GDC 1, 2 and 4 as it relates to the design of seismic Category I SSCs.

DSRS 3.8.4 states the structural acceptance criteria for seismic Category I structures appear in ACI 349, with additional guidance provided by RG 1.142 for concrete structures, AISC N690-1994 for steel structures, and Subsection II.4.J for structures that use modular construction methods evaluated on a case-by-case basis.

Issue

In Section 8.5.1, "Section Cuts for Out-of-Plane Forces," of the TR, the applicant stated, *"The SC wall connection to the basemat is designed to sustain 125 percent of the SC wall tensile capacity. The tension demand in the SC walls translate to out-of-plane shear in the basemat. For this reason, the out-of-plane shear demand obtained at the section cut defined in TR Figure 8-9 is increased by 25 percent to account for the overstrength and to ensure ductile behavior in the SC wall-basemat connection."* It is not clear to the staff why the applicant increased the out-of-plane shear demand by 25 percent to account for the overstrength and to ensure ductile behavior in the SC wall-basemat connection.

Request

The staff requests the applicant to describe the basis to increase the out-of-plane shear demand by 25 percent to account for the overstrength and to ensure ductile behavior in the SC wall-basemat connection.

NTR-13

Requirement

10 CFR Part 50, Appendix A, GDC 1, 2 and 4 as it relates to the design of seismic Category I SSCs.

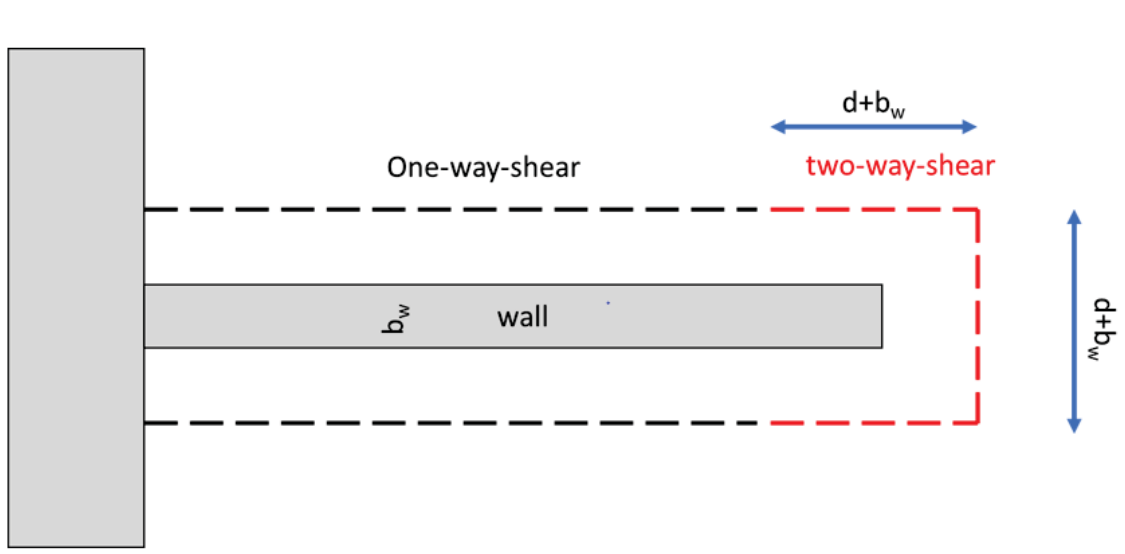
DSRS 3.8.4 states the structural acceptance criteria for seismic Category I structures appear in ACI 349, with additional guidance provided by RG 1.142 for concrete structures, AISC N690-1994 for steel structures, and Subsection II.4.J for structures that use modular construction methods evaluated on a case-by-case basis.

Issue

1. In Figure 8-9 of the TR, the applicant depicted the out-of-plane shear (shown in red) section cut "d" distance (from extreme compression fiber to centroid of longitudinal tension reinforcement) away from the wall. It is not clear to the staff why the applicant chose a distance of "d" for the out-of-plane shear (shown in red) section cut.

2. In Figure 8-10, "Section cut for two-way shear in basemat subject to wall overturning," of the TR, the applicant depicted the square section cut, in red, with a distance of "$d+b_w$," at each side at the end of continuous wall. In Section 8.5.1, "Section Cuts for Out-of-Plane Forces," the applicant also stated, *"if the out-of-plane shear demand calculated at these section cuts exceeds the basemat capacity corresponding to one-way or beam shear, then the failure mode would change to two-way or punching shear. In this situation, the shear capacity associated with this failure mode is instead considered and the associated demands are calculated at the section cut shown in red in Figure 8-10."*

   However, it is not clear to the staff the source for the change of the failure mode of section cuts from one-way shear to two-way shear (punching shear), when the out-of-plane shear demand at these section cuts exceeds the basemat capacity corresponding to one-way shear. As shown below, it would be more correct to consider, both one-way shear and two-way shear, to get more accurate shear distribution around the shear perimeter of a slender blade-column in a foundation.



Plan View

Request

a) The staff requests the applicant to describe the basis for choosing the distance "d" for the out-of-plane shear (shown in red) section cut.

b) The staff requests the applicant to describe how the failure mode of cutouts change from one-way shear to two-way shear could independently be evaluated in a slender blade-column in the foundation if the out-of-plane shear demand corresponding to one-way section cuts exceeds the basemat capacity.

NTR-14

Requirement

10 CFR Part 50, Appendix A, GDC 1, 2 and 4 as it relates to the design of seismic Category I SSCs.

DSRS 3.8.4 states the structural acceptance criteria for seismic Category I structures appear in ACI 349, with additional guidance provided by RG 1.142 for concrete structures, AISC N690-1994 for steel structures, and Subsection II.4.J for structures that use modular construction methods evaluated on a case-by-case basis.

{{See ADAMS Accession No ML21116A145 for proprietary information}}

NTR-15

Requirement

10 CFR Part 50, Appendix A, GDC 1, 2 and 4 as it relates to the design of seismic Category I SSCs.

DSRS 3.8.4 states the structural acceptance criteria for seismic Category I structures appear in ACI 349, with additional guidance provided by RG 1.142 for concrete structures, AISC N690-1994 for steel structures, and Subsection II.4.J for structures that use modular construction methods evaluated on a case-by-case basis.

Issue

In Section 8.10.6, "Bundled Bars for Beams and Columns," of the TR, the applicant provided an equation of $d_{be} = (4\ A_s / \pi)^{1/2}$ that derives a single bar diameter from a unit of bundled bars. It is not clear to the staff from where the applicant obtained that equation.

Request

The staff requests the applicant to provide the source of the above equation.

NTR-16

Requirement

10 CFR Part 50, Appendix A, GDC 1, 2 and 4 as it relates to the design of seismic Category I SSCs.

DSRS 3.8.4 states the structural acceptance criteria for seismic Category I structures appear in ACI 349, with additional guidance provided by RG 1.142 for concrete structures, AISC N690-1994 for steel structures, and Subsection II.4.J for structures that use modular construction methods evaluated on a case-by-case basis.

Issue

a) In Section 8.10.2.1, "Slab and Basemat," of the TR, the applicant tabulated calculated minimum reinforcement ratios for slab and basemat in Table 8-3 for member thicknesses of 24 inches, 36 inches, 60 inches and 96 inches. It is not clear to the staff how the applicant determined the tabulated minimum reinforcement ratios for "ρ other face," and "ρ both faces," in Table 8-3.

b) The applicant provided a formula of $f'_t = f_{ct} = 6.7\ (f_c)^{1/2}$ to determine the tensile strength of concrete. The applicant did not reference the source of this equation for determining the tensile strength of concrete. However, the tensile strength of concrete is about 10 to 15 percent of the compressive strength of concrete, as described in Commentary R10.2.5 of ACI 318-08.

Request

a) The staff requests the applicant to describe how the tabulated minimum reinforcement ratios for "ρ other face" and "ρ both faces," in TR Table 8-3, were determined.

b) The staff requests the applicant to reference the source for the equation determining the tensile strength of concrete.

NTR-17

Requirement

10 CFR Part 50, Appendix A, GDC 1, 2 and 4 as it relates to the design of seismic Category I SSCs.

DSRS 3.8.4 states the structural acceptance criteria for seismic Category I structures appear in ACI 349, with additional guidance provided by RG 1.142 for concrete structures, AISC N690-1994 for steel structures, and Subsection II.4.J for structures that use modular construction methods evaluated on a case-by-case basis.

Issue

In Section 8.10.2.2, "T-Beams," of the TR, the applicant stated, *"Based on the requirements specified in ACI 349, Section 10.6.4, the maximum bar spacing for beams is 20 inches."* The staff could not find the basis for this statement.

Request

The staff requests the applicant to confirm whether the appropriate provision in ACI 349 was referred to for the maximum bar spacing of 20 inches for T-Beams.

NTR-18

Requirement

10 CFR Part 50, Appendix A, GDC 1, 2 and 4 as it relates to the design of seismic Category I SSCs.

DSRS 3.8.4 states the structural acceptance criteria for seismic Category I structures appear in ACI 349, with additional guidance provided by RG 1.142 for concrete structures, AISC N690-1994 for steel structures, and Subsection II.4.J for structures that use modular construction methods evaluated on a case-by-case basis.

Issue

Equations 8-4 and 8-5 in Section 8.10.2.3, "Columns," of the TR, are not consistent with the corresponding equations in Section 10.9.1 of ACI 318-03.

$A_{st,min} \geq 0.01\ A_g$ Equation (8-4)

$A_{st,max} \leq 0.08\ A_g$ Equation (8-5)

Request

The applicant should review the listed equations and may need to modify "the equal signs (=)" to "greater than or equal to sign (≥)" and "less than or equal to sign (≤)", respectively in the TR.

NTR-19

Requirement

10 CFR Part 50, Appendix A, GDC 1, 2 and 4, as it relates to the design of seismic Category I SSCs.

DSRS 3.8.4, "Other Seismic Category I Structures," states the structural acceptance criteria for seismic Category I structures appear in ACI 349, with additional guidance provided by RG 1.142 for concrete structures, AISC N690-1994 for steel structures, and Subsection II.4.J for structures that use modular construction methods evaluated on a case-by-case basis."

Issue

In Section 8.11.6, "In-Plane Shear Transfer through Shear Friction," of the TR, the applicant provided equation of $V_n = (A_y f_y + N_u)\ \mu$ (Equation 8-19) for the nominal shear-friction capacity. It is not clear to the staff why the applicant added the axial load (N_u) into the equation. Section 11.6.4.1 of ACI 318-08 (Equation 11-25) and Section 21.11.9.3 of ACI-349-13 (Equation 21-10) define the shear friction equations as $V_n = A_y f_y\ \mu$.

Request

The staff requests the applicant describe why the axial load (N_u) was considered in the Equation 8-19.

NTR-20

Requirement

10 CFR Part 50, Appendix A, GDC 1, 2 and 4 as it relates to the design of seismic Category I SSCs.

DSRS 3.8.4 states the structural acceptance criteria for seismic Category I structures appear in ACI 349, with additional guidance provided by RG 1.142 for concrete structures, AISC N690-1994 for steel structures, and Subsection II.4.J for structures that use modular construction methods evaluated on a case-by-case basis.

Issue

In Section 8.12.5, "Collector Capacity," and Section 8.5.2, "t Section Cuts for In-Plane (Diaphragm) Forces," of the TR, the applicant provided information about the collector forces in diaphragms using Figures 8-14 and 8.15. However, the applicant did not describe whether the collector forces are to be considered at the same width (thickness) of the walls (non-continuous) or spread into the diaphragms (slabs).

Request

The staff requests the applicant describe whether the collector forces are to be considered at the same width (thickness) of the walls or spread into the slabs (diaphragms). Furthermore, the applicant is requested to describe how the spread widths are determined if the collector forces were to be considered spreading into the slabs (diaphragms), and whether the collector forces only apply at the base of discontinuous walls.

NTR-21

Requirement

10 CFR Part 50, Appendix A, GDC 1, 2 and 4 as it relates to the design of seismic Category I SSCs.

DSRS 3.8.4 states the structural acceptance criteria for seismic Category I structures appear in ACI 349, with additional guidance provided by RG 1.142 for concrete structures, AISC N690-1994 for steel structures, and Subsection II.4.J for structures that use modular construction methods evaluated on a case-by-case basis.

Issue

In Section 8.14.1, "Slabs and Diaphragms," of the TR, the applicant stated, "The reinforcement used in the P-M interaction diagrams is chosen so that the DCR obtained as explained in Section 8.13 is close to *one."* However, the applicant did not describe how to account for the interaction between in-plane and out-of-plane shears. As it was described in Commentary Section R21.1.1 of ACI 349-13, *"Compression members and slabs and walls under out-of-plane shear loads should be designed for full elastic forces." Further in Section 3, "Principles for Special Structural Wall Design," of NIST GCR 11-917-11, Revision 1, "Seismic Design of Cast-in-Place Concrete Special Structural Walls and Coupling Beams," states "Although ACI 318 permits factored shear on individual wall segments as high as Vu = 10Φ(f'c)1/2Acv, the flexural ductility capacity for such walls is reduced compared with identical walls having lower shear. This Guide recommends factored shear, calculated considering flexural overstrength (see Section 3.1.3), not exceed approximately 4Φ(f'c)1/2Acv to 6Φ(f'c)1/2Acv so that flexural ductility capacity is not overly compromised."*

Request

The staff requests the applicant describe how to account for the effects of the interaction between in-plane and out-of-plane shears.

NTR-22

Requirement

10 CFR Part 50, Appendix A, GDC 1, 2 and 4 as it relates to the design of seismic Category I SSCs.

DSRS 3.8.4 states the structural acceptance criteria for seismic Category I structures appear in ACI 349, with additional guidance provided by RG 1.142 for concrete structures, AISC N690-1994 for steel structures, and Subsection II.4.J for structures that use modular construction methods evaluated on a case-by-case basis.

Issue

In Section 8.11.1, "One-Way Out-of-Plane Shear Capacity of Slabs and Basemat," of the TR, the applicant described a code provision of *"The spacing s of the shear reinforcement does not exceed d/2 nor 24 in. (ACI 349 Section 11.4.5.1). For the case when, Vs > 4 (fc')1/2bwd, the maximum spacing is reduced by one-half."* The staff noted that the applicant did not refer to the appropriate code provision for this requirement, as: *"(ACI 349 Section 11.4.5.3)."*

Request

The staff requests the applicant to provide the appropriate code provision of "(ACI 349 Section 11.4.5.3)."

NTR-23

Requirement

10 CFR Part 50, Appendix A, GDC 1, 2 and 4 as it relates to the design of seismic Category I SSCs.

DSRS 3.8.4 states the structural acceptance criteria for seismic Category I structures appear in ACI 349, with additional guidance provided by RG 1.142 for concrete structures, AISC N690-1994 for steel structures, and Subsection II.4.J for structures that use modular construction methods evaluated on a case-by-case basis.

Issue

In Section 8.14.1, "Slabs and Diaphragms," of the TR, the applicant tabulated reinforcement ratios on Table 8-6, "Reinforcement design in slabs," at X, Y and Z global directions and clearly depicted X and Y directional reinforcement in Figure 8-25, "Force and moment demand at two perpendicular section cuts in a slab." The applicant tabulated reinforcement ratios in Table 8-6 but did not show Z directional reinforcement (stirrups) in Figure 8-25. In Section 8.10.4 "Out-of-plane Shear Reinforcement for Beams and Slabs," the applicant also provided the applicable code provisions for the out-of-plane reinforcement (stirrups).

Because the arrangements of the out-of-plane reinforcement (stirrups) vary based on the column and slab/diaphragm configurations, the applicant should refer to Section 8.10.4, of TR in Sections 8.14.1 describing the applicable code provisions for the out-of-plane reinforcement (stirrups).

Request

The staff requests the applicant to refer to Section 8.10.4, of TR in Sections 8.14.1 describing the applicable code provisions for the out-of-plane reinforcement (stirrups).

NTR-24

Requirement

10 CFR Part 50, Appendix A, GDC 1, 2 and 4 as it relates to the design of seismic Category I SSCs.

DSRS 3.8.4 states the structural acceptance criteria for seismic Category I structures appear in ACI 349, with additional guidance provided by RG 1.142 for concrete structures, AISC N690-1994 for steel structures, and Subsection II.4.J for structures that use modular construction methods evaluated on a case-by-case basis.

SRP 3.8.5, "Foundations," Section II.4.J, states, "Explanation of how loads attributable to construction are evaluated in the design. Some examples of items to be discussed include the excavation sequence and loads from the construction sequence of the mat foundation and walls, as well as the potential for loss of subgrade contact (e.g., because of loss of cement from a mud mat) that may lead to a differential pressure distribution on the mat."

Issue

The applicant did not provide any information related to the evaluations of open configurations of seismic Category I and II structures during the construction sequence phases. The applicant considered the analysis/design forces of members (section cuts) under the completed closed configurations of seismic Category I and II structures. The applicant should also discuss the details for performing additional structural evaluations of the members of seismic Category I and II structures during construction as they are erected in open configurations under the same postulated loadings and load combinations.

Request

The staff requests the applicant to discuss the need to perform additional structural analysis/design evaluations on the members of seismic Category I and II structures as they are erected in open configurations during construction under the same postulated loadings and load combinations.

Request for Additional Information 0002 (eRAI No. 9834)

Issue Date: 05/06/2021
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Operating Company: NuScale
Docket No. 99902078
Review Section: NTR - NuScale Topical Report for SDA
Application Section: TR-0920-71621-P, Revision 0

QUESTIONS

NTR-1

Requirement

10 CFR Part 50, Appendix A, General Design Criteria 2, as it relates to the design of seismic Category I structures, systems and components (SSCs).

10 CFR Part 50, Appendix S, provides criteria for the implementation of GDC 2 with respect to earthquakes and requires, in part, that the safety functions of SSCs important to safety must be assured during and after the vibratory ground motion associated with the Safe Shutdown Earthquake Ground Motion, and that the evaluation must take into account soil-structure interaction (SSI) effects.

DSRS Section 3.7.2 states for the seismic design of nuclear power plants, it is customary to specify earthquake design ground motions that are exerted on the plant structures and used in SSI analyses.

Issue

In Section 4.0 of the TR, the applicant assumes the soil surrounding the triple building (TRB) model TRB-Static is of soil type 11 (soft soil) with stiffness reduced by 50% to account for the settlement effects. However, no basis for the assumption is given. It is not clear why 50% reduction of the stiffness of the surrounding soil mass would appropriately account for both immediate settlement and long-term settlement due to load exerted by the TRB.

Request

Please provide the basis for assuming that a 50% reduction of the stiffness of the surrounding soil mass would be adequate to bound the predicted effects from both immediate and long-term settlements.

NTR-2

Requirements

10 CFR Part 50, Appendix A, General Design Criteria 2, as it relates to the design of seismic Category I structures, systems and components (SSCs).

10 CFR Part 50, Appendix S, provides criteria for the implementation of GDC 2 with respect to earthquakes and requires, in part, that the safety functions of SSCs important to safety must be assured during and after the vibratory ground motion associated with the Safe Shutdown Earthquake Ground Motion, and that the evaluation must take into account soil-structure interaction (SSI) effects.

DSRS Section 3.7.2 states for the seismic design of nuclear power plants, it is customary to specify earthquake design ground motions that are exerted on the plant structures and used in SSI analyses.

Issues

a) Three different surrounding media have been described in the TR representing soil, rock, and hard soil (soil types 11, 9, and 7, respectively). It is not clear what are the differences among these three different media types.

b) It has been assumed that the surrounding medium can be represented by only one material type; either a soil type 9 (hard rock), a soil type 7 (rock), or a soil type 11 (soft soil). It is not clear in the TR whether a layered medium (with several soil or rock layers, or both; such as soil underlain by rock) can be considered as the surrounding medium.

c) It is not clear whether the soil library models account for the nonlinear behavior at the structure-surrounding medium interfaces and also in the surrounding medium, especially for soil type 9 (hard rock). At a scale of the reactor, the hard rockmass may have naturally occurring discontinuities, such as, rock joints, bedding planes, or faults. These discontinuities can make the surrounding medium a discontinuum with potential for sliding and opening along and/or across the discontinuities exhibiting nonlinear behavior. Similarly, structure-medium interfaces may slide exhibiting nonlinear behavior. It is not clear how the potential discontinuum medium with associated nonlinear response would be addressed with the strategy described in Section 4 of the TR to develop the in-structure response spectra and design methodology for Seismic Category I and II structures, systems, and components.

Request

a) Describe the characteristics of each soil type, especially those characteristics that separate among three soil types.

b) Clarify whether a layered medium with either several soil layers, rock layers, or soil layers underlain by rock layers can be analyzed with the strategy described in the TR.

c) Discuss in detail the strategy to develop the in-structure response spectra and design methodology, especially in hard rock (soil type 9), where the surrounding medium exhibits nonlinear and discontinuous behavior.

NTR-3

Requirement

10 CFR Part 50, Appendix A, General Design Criteria 2, as it relates to the design of seismic Category I structures, systems and components (SSCs).

10 CFR Part 50, Appendix S, provides criteria for the implementation of GDC 2 with respect to earthquakes and requires, in part, that the safety functions of SSCs important to safety must be assured during and after the vibratory ground motion associated with the Safe Shutdown Earthquake Ground Motion, and that the evaluation must take into account soil-structure interaction (SSI) effects.

DSRS Section 3.7.2 states for the seismic design of nuclear power plants, it is customary to specify earthquake design ground motions that are exerted on the plant structures and used in SSI analyses.

Issue

In Section 4.1, "Determination of Effective Stiffness and Damping," of the TR, a damping value of 4% was used, as shown in Table 4-1, for steel-plate composite (SC) walls at Response Level 1. As stated in the TR, this value is based on the report "S. Epackachi and A. S. Whittaker, "Experimental, numerical, and analytical studies on the seismic response of steel-plate concrete (SC) composite walls," Multidisciplinary Center for Earthquake Engineering Research (MCEER) 2016, as the specific value to be used in the analysis is not given in ASCE 4-16. However, Table 3-1, "Specified Damping Values for Dynamic Analysis," of ASCE 43-19, gives a damping value of 3% of the critical damping for the Response Level 1 for the SC walls. The TR referred to ASCE 43-05, not ASCE 43-19, which is the latest version.

Request

The staff requests the applicant to provide the rationale as to why a value of 4% of the critical damping would be appropriate for SC walls, given the latest revision of ASCE 43-19 gives a value of 3%.

NTR-4

Requirement

10 CFR Part 50, Appendix A, General Design Criteria 2, as it relates to the design of seismic Category I structures, systems and components (SSCs).

10 CFR Part 50, Appendix S, provides criteria for the implementation of GDC 2 with respect to earthquakes and requires, in part, that the safety functions of SSCs important to safety must be assured during and after the vibratory ground motion associated with the Safe Shutdown Earthquake Ground Motion, and that the evaluation must take into account soil-structure interaction (SSI) effects.

DSRS Section 3.7.2 states for the seismic design of nuclear power plants, it is customary to specify earthquake design ground motions that are exerted on the plant structures and used in SSI analyses.

Issue

The text in many places in the TR may be misleading or incorrect. For example:

1) In Section 5.5.2.1, "Method 1 for Implementing Effective Stiffness Using SOLSH190 Elements," it is confusing which numbers are used to specify the outer layers: are they 1 and 2 or 1 and 3? Figure 5-2 shows they should be 1 and 3 and so does the equation on page 31. However, it seems the equations on pages 32 and 33 indicate that they are 1 and 2.

2) In Section 5.5.2, "Implementation of Effective Stiffness Values for Solid-Shell Elements," the text refers to AISC 4-16 which is not in the reference list.

3) On page 33 of the TR, the term "$t_{1\text{-}Lay1}$" has been defined twice, the second definition on line 3 appears to be incorrect.

4) On page 35, reference to Equation (5-12) and Equation (5-13) seems incorrect. Similarly, reference to Equation (5-17) seems incorrect on page 36.

5) Equation (5-29) relating the strain and stress vectors for an orthotropic material appears incorrect.

6) On page 25 of the TR for the condition "if Srxy > 2Scr," the reference to AISC N60-18 Equation A-N9-12 to calculate the effective shear stiffness appears incorrect.

Request

1) Clarify the layer numbers used to refer the outer layers.

2) Correct the reference standard.

3) Clarify and, if necessary, correct the equations.

4) Verify that referenced equations (5-12), (5-13), and (5-17) are correct; if not, correct.

5) Clarify whether equation (5-29) for the orthotropic material is correct as written. If not, correct.

6) Clarify whether the referred equation in AISC 690-18 is correct. If not, correct.

NTR-5

Requirement

10 CFR Part 50, Appendix A, General Design Criteria (GDC) 2, as it relates to the design of seismic Category I structures, systems and components (SSCs).

10 CFR Part 50, Appendix S, provides criteria for the implementation of GDC 2 with respect to earthquakes and requires, in part, that the safety functions of SSCs important to safety must be assured during and after the vibratory ground motion associated with the Safe Shutdown
Earthquake Ground Motion, and that the evaluation must take into account soil-structureinteraction (SSI) effects.

DSRS Section 3.7.2, states for the seismic design of nuclear power plants, it is customary to specify earthquake design ground motions that are exerted on the plant structures and used in soil-structure interaction (SSI) analyses.

Issue

In the TR, the applicant used six strong motion earthquakes identified by the station name where it was recorded; namely, Capitola (CAP), Chi-Chi (CHI), El Centro (ELC), Izmit (IZM), Lucerne (LCN), and Yermo (YER). The seismic motion of each of the recorded earthquake was converted to the Certified Seismic Design Response Spectra (CSDRS) or Certified Seismic Design Response Spectra−high frequency (CSDRS−HF), and used selectively in the analysis. For example, only {{ }} was used to calculate the in-plane shear and bending stresses and compared with the cracking limits given in Section 4.1, as shown in Figure 4-1. Similarly, {{ }} was used as the only high frequency input motion (CSDRS−HF), as shown in Figure 4-1 of the TR. In Section 4.1.2, Effective Stiffness and Damping Ratio Assignment, it has been stated that "For soil types 7 and 9, a representative in-column input motion is considered as the SSE in load combination 4-1 (e.g. Capitola). For soil type 11, the only in-column input motion is Lucerne." It is not clear what characteristics of each of these six CSDRSs would make one suitable for a specific analysis with a specific soil type, as described in the TR.

Request

The staff requests the applicant to provide the characteristics of each seismic motion record. Additionally, discuss the rationale and the unique characteristic(s) of each recorded seismic motion that distinguishes it suitable for a specific analysis with a specific soil type; e.g. why {{ }} would be suitable for as CSDRS−HF but not others, why only {{ }} can be used to determine whether a structural member develops cracks or not, and why {{ }} (CSDRS−HF) can be used with soil type 11 (soft soil).