UNITED STATES
NUCLEAR REGULATORY COMMISSION
ADVISORY COMMITTEE ON REACTOR SAFEGUARDS
WASHINGTON, DC 20555 - 0001

February 18, 2022

Mr. Daniel H. Dorman
Executive Director for Operations
U.S. Nuclear Regulatory Commission
Washington, DC 20555-0001

SUBJECT: NUSCALE TOPICAL REPORT, TR-0920-71621-P, "BUILDING DESIGN AND ANALYSIS METHODOLOGY FOR SAFETY-RELATED STRUCTURES," REVISION 1

Dear Mr. Dorman:

During the 692nd meeting of the Advisory Committee on Reactor Safeguards (ACRS), February 2-4, 2022, we reviewed the NuScale Topical Report (TR), TR-0920-71621-P, "Building Design and Analysis Methodology for Safety-Related Structures," Revision 1, and the NRC staff's associated safety evaluation (SE). Our NuScale Subcommittee also reviewed this matter on January 19, 2022. During this review, we had the benefit of discussions with representatives of the NRC staff and NuScale. We also benefited from the referenced documents.

CONCLUSION AND RECOMMENDATION

1. The NuScale TR describes an acceptable building design and analysis methodology to evaluate Seismic Category I and II structures.

2. The staff's SE approves the methodology with limitations and conditions. The SE report should be issued.

BACKGROUND

The NuScale TR captures efficiencies from recent developments in the civil, structural, and seismic design areas that can be applied to the evaluation of a new generation of small modular reactor designs currently being considered for design certification and licensing. The TR describes an advanced building design and analysis methodology to evaluate Seismic Category I and II steel-plate composite (SC) and reinforced concrete (RC) structures. It is intended, but not required, to be used in conjunction with the NuScale TR-0118-58005, "Improvements in Frequency Domain Soil-Structure-Fluid Interaction Analysis," for the seismic evaluation of complex structures. In our letter, dated November 23, 2020, on TR-0118-58005, we concluded that NuScale's seismic analysis approach, which addresses soil-structure interaction and fluid-structure interaction, improves the analysis process and its accuracy.

The building design TR defines methods to analyze steel-plate composite walls designed for various load combinations in accordance with ANSI/AISC N690-18, “Specification for Safety-Related Steel Structures for Nuclear Facilities,” and ANSI/AISC 360-16, “Specification for Structural Steel Buildings.” New reactor designs have considered adopting modular SC structures as one of the design options for safety-related structures. An SC wall consists of two steel plates (faceplates) with structural concrete (poured at the site) between them. The faceplates are connected to each other using tie rods and are anchored to the basemat or floors using steel anchors. Appropriately designed SC walls have high strength and shear resistance. Their use in safety-related nuclear applications has recently been codified in consensus national standards. Offsite fabricated SC walls eliminate the need for construction formwork and reinforcing bars, while meeting strength, stability, and seismic requirements. This potentially increases the efficiency and productivity of construction as well as reducing costs.

The TR covers methods for analyzing the interaction of SC walls with traditionally constructed RC members such as basemats, slabs, and roofs. It also provides requirements and design parameters for SC walls and installation connections. NuScale would apply these methodologies in the design of the Reactor Building, Control Building, and Radioactive Waste Building structures as part of a design certification or standard design application. We note that SC wall construction has been used extensively in non-nuclear applications, as well as for the AP1000 shield walls at Vogtle Units 3 and 4.

DISCUSSION

The TR presents an overall methodology for design and analysis to be used in evaluating Seismic Category I and II structures, systems, and components, particularly for complex SC and RC structures envisioned for new reactor designs. The finite element code ANSYS version 18.2.2, a widely used commercial software product, is the primary tool used in this methodology for seismic design and analysis. The TR presents a method for determining in-structure response spectra (ISRS) for evaluating subsystem design and member forces based on actual static and seismic stresses, using effective stiffness and damping values. To cover a broad range of siting options, this seismic analysis is used in conjunction with soil-structure libraries for three representative soil types and five certified seismic design response spectra. Demand-to-capacity ratios are determined for loads on members in the representative buildings, and reinforcement is added as needed. An extensive section in the TR documents methods for determining effective stiffness of RC and SC structures for use in the finite element models, ANSYS. In accordance with the specifications of ANSI/ASCI standards N690-18 and 360-16, the TR further details SC wall design (in lieu of RC wall construction), impact and impulse loading, and connection design (to SC wall sections and to RC basemats and slabs). The TR identifies the need for site-specific mitigation of corrosion effects for deploying SC walls, particularly for below-grade external environments. The TR concludes with methods for design of RC structures in accordance with ACI 349-13, “Code Requirements for Nuclear Safety-Related Concrete Structures and Commentary.”

The staff concluded that the methods presented in the TR are acceptable to perform building design and analysis for Seismic Category I and II safety-related SC and RC structures (other than containment). The TR methodologies were deemed by the staff to be a conservative application of the requirements of N690-18, Appendix N9, and 360-16, as endorsed in Regulatory Guide (RG) 1.243. This RG provides additional guidance for attachments to SC walls. The principal limitations imposed by the staff on the proposed NuScale methodology are that: 1) all material properties are considered linear elastic; and 2) all materials perform linear

elastically during seismic events. Nonlinear response, due to circumstances such as liquefaction of the subgrade or significant cracking of structural components, is outside the scope of their approval.

We found this companion report to NuScale's soil-structure-fluid interaction analysis TR to be a significant advancement in the field of seismic analysis of complex structures for new reactor designs. We look forward to reviewing its use in future license applications. Of particular interest will be the integration of field-installed, sectioned SC walls with conventional RC basemat and slab construction. The risk of damage to SC panels and associated surface coatings during transport and installation also needs to be considered. Additionally, for certain applications, dissimilar steels may be used for SC wall construction. This may be of concern regarding long-term chemistry effects on anchors, ties, fasteners, and connectors. Likewise, we share the concerns about long-term structural performance of SC walls under corrosive conditions, especially subsurface environmental effects. Coating systems for site-specific soil and environmental conditions as well as corrosion monitoring, evaluation, and mitigation methods will be needed to assure lifetime structural integrity of SC walls (for up to eighty years). The establishment of appropriate aging management programs will dictate condition and performance monitoring requirements for safety-related structures at each site.

SUMMARY

NuScale has developed a building design and analysis methodology to be used in evaluation of Seismic Category I and II structures applicable to new reactor and facility designs. The SE concludes that the TR implements, in a conservative manner, accepted industry seismic-structural standards. The SE approves the NuScale methodology with limitations and conditions. The staff's SE report should be issued.

Member Sunseri did not participate in deliberations on this subject matter.

We are not requesting a formal response from the staff to this letter report.

Sincerely,

Signed by Rempe, Joy
on 02/18/22

Joy L. Rempe
Chairman

REFERENCES

1. U. S. Nuclear Regulatory Commission, "Safety Evaluation for NuScale Power, LLC, Licensing Topical Report, TR-0920-71621, Revision 1, 'Building Design and Analysis Methodology for Safety-Related Structures'," November 30, 2021 (ML21299A043).

2. NuScale Power, LLC, Licensing Topical Report, TR-0920-71621, "Building Design and Analysis Methodology for Safety-Related Structures," Revision 1,October 6, 2021 (ML21279A337).

3. Advisory Committee on Reactor Safeguards, “NuScale Topical Report, TR-0118-58005, Revision 1, ‘Improvements in Frequency Domain Soil-Structure-Fluid Interaction Analysis’," November 23, 2020 (ML20322A442).

4. American National Standards Institute/American Institute of Steel Construction, ANSI/AISC N690-18, “Specification for Safety-Related Steel Structures for Nuclear Facilities,” June 28, 2018.

5. American National Standards Institute/American Institute of Steel Construction, ANSI/AISC 360-16, “Specification for Structural Steel Buildings,” July 7, 2016.

6. American Concrete Institute, ACI 349-13, “Code Requirements for Nuclear Safety-Related Concrete Structures and Commentary,” June 1, 2014.

7. U.S. Nuclear Regulatory Commission, Regulatory Guide 1.243, “Safety-Related Steel Structures and Steel-Plate Composite Walls for Other Than Reactor Vessels and Containments,” August 31, 2021 (ML21089A032).

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