Fundamental Differences and Questions Need to be Answered and Resolved

between the DPO panel report and mine

DPO-2020-004

John S. Ma

April 20, 2021

Introduction

There are several fundamental differences between the DPO panel report and mine, and they need to be questioned and resolved: (1) the interpretation of the NRC Policy in SECY 93-087 with respect to the seismic margin of the reactor building, (2) the method the structural engineering profession uses to design or/and evaluate a building and to achieve a required or specified seismic margin, and (3) is the NuScale reactor building design adequate and safe?

1. How should the NRC Policy in SECY 93-087 be interpretated with respect to the NuScale reactor building design?

The NRC Policy in SECY 93-087 states: “The Commission approves the use of 1.67 times the Design Basis SSE for a margin-type assessment of seismic events.”

My interpretation, as a licensed professional (structural) engineer, is that the building shall not collapse wholly or partially, such as roofs falling into the spent fuel pool, during the review level earthquake (RLE) which equals 1.67 times the design basis SSE (or CSDRS in the NuScale design) and that 1.67 is the seismic margin of the building design.

The DPO panel did not clearly state its interpretation. It needs to state whether it agrees with my interpretation or not. If not, at what earthquake level over the SSE (or CSDRS) the building shall not collapse to provide a seismic margin beyond the design basis SSE (or CSDRS).

2. The method the structural engineering profession uses to design or/and evaluate a building and to achieve a required or specified seismic margin

   My answer is using “the structural engineering analysis/design method” because the method is based on physics and verified by laboratory tests and data of seismic sensors embedded in buildings during earthquakes. The method is required by building codes, such as the most used International Building Code and the American Concrete Institute (ACI) Building Code, and it is enforced by local building officials (departments) and performed by practicing professional structural engineers. As shown on page 13 in my DPO report, the maximum story drift, the maximum coupling beam rotations, the maximum wall shear stress, and the maximum wall shear strains of the Salesforce Tower building were calculated and displaced in graphic forms using the structural analysis/design method when the building is subject to an earthquake. When all the demands of story drift, coupling beams rotations, shear stress and strain are less than the allowable criteria (capacity), it demonstrates the building will not collapse. Four examples were provided in my DPO report:

(1) The “Stanford Seismic Design Guidelines (for Engineers & Architects).”
(2) The Vancouver House building in Vancouver, Canada.
(3) The Salesforce Tower in San Francisco, United States.
(4) The shield building of AP1000 nuclear power plant.

The safe design of these buildings and their seismic margins are **explicitly** designed into the buildings using the structural engineering analysis/design method through a trial-and-error process, as illustrated in my DPO report. The excerpt from the Stanford Seismic Design Guidelines states “When evaluating a building, the engineer of record (EOR) should determine the expected performance level of the building (structural components, non-structural components, and equipment) under the postulated earthquake levels DE/BSE-1N and MCER /BSE-2N. This determination should be based on a **structural analysis** of the building’s lateral load resisting system....” Therefore, a structural analysis should be based, not a probabilistic risk analysis (PRA) method, for evaluating the adequacy of a building design including the seismic margin.

The applicant of the NuScale reactor building used a probabilistic risk analysis (PRA) method to demonstrate that the reactor building will not collapse at the RLE and the DPO panel concurred with that approach. The PRA method is based on the theory of probability, not on physics like the structural engineering method. The PRA method cannot predict the stress and strain and the story drift of the reactor building and of its components (such as roofs, walls, beams, and columns) when the building is subjected to an earthquake. No building codes, no local building departments’ regulations, allows or even mentions the use of the PRA method for the design of a building and its seismic margin. No existing building was designed with the PRA method. All existing buildings are designed with their required or specified seismic margin using the structural engineering method. Therefore, the DPO panel needs to present at least one existing building that has been designed by the PRA method to demonstrate that the PRA method can and has been or is accepted for building design and building seismic margin design.

3. Is the NuScale reactor building design adequate and safe?

As stated in my DPO report that Element number 4942 of the NuScale reactor building had a demand of the in-plane shear force of 3791 kips (1 kip = 1000 pounds), but only has a shear capacity of 1184 kips. Also stated in my DPO report is that the American Concrete Institute (ACI) president’s memo, dated January 2020, warned that the probable cause of the March 15, 2018 collapse of the pedestrian bridge over a roadway at Florida International University in Miami, FL., was design error by underestimating the demand that drove the actual capacity/demand (C/D) ratios of critical structural elements toward 1.0. Investigations were conducted after the bridge collapse and the structural analysis/design method was performed to pinpoint the cause of the collapse. The result was that only one critical element in the entire bridge was overstressed (or acting forces on the element were greater than the capacity of that element) and that caused the collapse of the whole bridge.

In the NuScale reactor building design, the capacity/demand (C/D) ratio for Element 4942 is 0.31 (1184 kips/3791 kips). The DPO panel report also stated that exceedances of demand over capacity were in several structural elements (or locations). Then the DPO panel stated that “During the safety review of the NuScale application, the NRC staff reviewed the structural element exceedances and the averaging method and did not identify any issues,” as the reason to accept the design being adequate. Neither the NRC staff nor the DPO panel members

reported whether these elements with exceedance were critical elements or not. What a structural engineer should or usually do under such a condition? As stated in the Salesforce Tower design "Where predicted demand levels exceeded Acceptance Criteria, **design modifications** were implemented," as stated in my DPO report. That design modifications were performed using the structural engineering method with a trail-and-error process to make the demand less than the acceptance criteria (capacity). Such a process is called structural analysis/design and is routinely performed by practicing structural engineers.

With the understanding that it is required to use design modifications to achieve the predicted demand to be less than the capacity for structural elements, as stated in the Salesforce Tower design, and in the light of the collapse of the whole pedestrian bridge over a roadway at Florida International University in Miami, FL. due to a single critical structural element exceedance of its demand (forces acted on he element) to its capacity, the NuScale reactor building design cannot be adequate and acceptable with several known elements that had exceeded their capacities, including Element 4942 with a C/D ratio as low as 0.31, and without knowing whether these elements are critical elements or not. Therefore, the DPO panel needs to provide a better argument than "the NRC staff did not identify any issues" as the reason for its acceptance of the reactor building design during the CSDRS design earthquake.

Furthermore, when the intensity of earthquakes increases beyond the CSDRS, the demand (forces) in structural elements also increases accordingly. However, the capacity of the same structural elements remains unchanged. Therefore, the C/D ratio for Element 4942 will keep decreasing from 0.31 during the CSDRS to lesser value during the RLE. These low C/D values in several structural elements in conjunction with no knowledge whether they are critical elements or not present a condition that the reactor building is likely to collapse when it is subjected to the RLE. However, the applicant used the PRA method and concluded that the reactor building will not collapse when it is subjected to the RLE. This is another indication that the PRA method contradicts to the structural engineering method. Since the structural engineering method has been verified, the PRA method may not be safe to use.

<u>Conclusion</u>

1. The intensity of the earthquake that causes the building to collapse beyond the intensity of the design-basis earthquake is the seismic margin that the building possesses. For the NuScale reactor building, the NRC Policy requires that margin to be 1.67.
2. The structural engineering profession has established the structural engineering analysis/design method for the design of a building and for achieving the required or specified seismic margin both at the design basis earthquake level and at the most credit earthquake level.
3. The DPO panel concurred with the applicant to use the structural engineering analysis/design method for the reactor building when it is subjected to CSDRS, but it used a PRA method at the review level earthquake (RLE).
4. The structural engineering analysis/design method is based on physics and thus can predict the movement and stresses generated in a building during earthquakes. All existing building are designed with the structural engineering analysis/design method.

5. The PRA method is based on the theory of probability, and it cannot predict the movement and stresses generated in a building. No existing building was designed by the PRA method.
6. Based on the structural engineering analysis/design method, there are indications that several structural elements have less capacity than the forces acting on them during the CERS earthquake level, an indication that the building is likely to collapse during the RLE level. However, the applicant used the PRA method and concluded that the building will not collapse during the RLE. This contradictory is another indication that the PRA method should not be used for the evaluation of the seismic margin of a building.