RAIO-1218-63784

December 11, 2018

Docket No. 52-048

U.S. Nuclear Regulatory Commission
ATTN: Document Control Desk
One White Flint North
11555 Rockville Pike
Rockville, MD 20852-2738

SUBJECT: NuScale Power, LLC Response to NRC Request for Additional Information No. 132 (eRAI No. 8971) on the NuScale Design Certification Application

REFERENCES:
1. U.S. Nuclear Regulatory Commission, "Request for Additional Information No. 132 (eRAI No. 8971)," dated August 05, 2017
2. NuScale Power, LLC Response to NRC "Request for Additional Information No. 132 (eRAI No. 8971)," dated October 2, 2017
3. NuScale Power, LLC Response to NRC "Request for Additional Information No. 132 (eRAI No. 8971)," dated April 30, 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 Enclosures to this letter contain NuScale's response to the following RAI Question from NRC eRAI No. 8971:

- 03.08.04-13

The responses to RAI questions 03.08.04-12 and 03.08.04-14 were provided in reference 2 and reference 3. The response to RAI question 03.08.04-11 will be provided by December 20, 2018.

Enclosure 1 is the proprietary version of the NuScale Response to NRC RAI No. 132 (eRAI No. 8971). NuScale requests that the proprietary version be withheld from public disclosure in accordance with the requirements of 10 CFR § 2.390. The enclosed affidavit (Enclosure 3) supports this request. Enclosure 2 is the nonproprietary version of the NuScale response.

This letter and the enclosed responses 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

Distribution: Gregory Cranston, NRC, OWFN-8G9A
Samuel Lee, NRC, OWFN-8G9A
Marieliz Vera, NRC, OWFN-8G9A

Enclosure 1: NuScale Response to NRC Request for Additional Information eRAI No. 8971, proprietary

Enclosure 2: NuScale Response to NRC Request for Additional Information eRAI No. 8971, nonproprietary

Enclosure 3: Affidavit of Zackary W. Rad, AF-1218-63785

Enclosure 1:

NuScale Response to NRC Request for Additional Information eRAI No. 8971, proprietary

Enclosure 2:

NuScale Response to NRC Request for Additional Information eRAI No. 8971, nonproprietary

Response to Request for Additional Information

eRAI No.: 8971
Date of RAI Issue: 08/05/2017

NRC Question No.: 03.08.04-13

10 CFR 50, Appendix A, GDC 1, 2, and 4, provide requirements to be met by SSC important to safety. In accordance with these requirements, DSRS Section 3.8.4 provides review guidance pertaining to the design of seismic Category I structures, other than the containment. Consistent with DSRS Section 3.8.4, the staff reviews loads and loading combinations.

FSAR Section 3.8.4.4.1 indicates that an ANSYS model was created to evaluate the effects of thermal loads on the structure. Further, FSAR Section 3.8.4.5 indicates that load combination 10 from Table 3.8.4-1 has been determined to be the controlling load combination. The staff request the applicant to provide the following information.

1. Magnitude of the bounding forces and moments profiles for walls and basemat resulting from thermal loads, To
   and Ta. Clarify whether such values were used in the load combinations 10 and 13 in Tables 3.8.4-1.

2. Describe how load combination 10 was determined to be the controlling load combination instead of load combination 13, and provide an example of how the loads were combined.

NuScale Response:

1.0 Introduction

RAI No. 9309 03.08.04-37 considered the effects of jet impingement, jet reactions and pipe whip.

It was shown that such effects resulted in low local reaction forces/penetrations. Per ACI 349-01 Section F.7, design for punching shear is not required if the concrete thickness is at least 20% greater than that required to prevent perforation. Pipe Rupture Hazards Analysis (PRHA) Technical Report, TR-0818-61384, shows that for the 60-inch thick concrete pool wall, the maximum depth (20 foot pipe length whip through an angle of 90 degrees) represents approximately 22 percent of the overall wall thickness for pipe whip. This evaluation did not consider the effects of reinforcement in the wall and liner which would only improve the behavior. For jet impingement and reactions, the penetration depth was not calculated but the demand-capacity ratio for punching shear was obtained as 0.02 without any contribution from the liner.

To respond to RAI 8971 03.08.04-13 and partly to RAI No. 9309 03.08.04-37, 3D Reactor Building (RXB) half models are developed using the ANSYS program for thermal and pressurization analysis. The half model considers that the RXB structure is approximately symmetric about the East-West (X) axis. In order to explicitly model the as-designed reinforcing steel inside the concrete foundation; roof, slabs, walls, pilasters, and buttresses are explicitly developed and integrated within the concrete volume of the RXB ANSYS structural analysis model. Since the thermal loads cause significant amount of concrete cracking, only cracked concrete properties are used.

The ANSYS RXB thermal model provides the nodal temperatures throughout the entire RXB model for the operating and accident temperatures, T_0 and T_a. The nodal temperature values at each node are then applied as an input to RXB structural analysis model for the operating and accident temperatures T_0 and T_a. The high energy line break (HELB) maximum pressures, P_a, are also applied inside the RXB along with accident temperature, T_a, to produce the combined rebar strains for the design check using ACI 349-06, Eq. 9-9 load combination.

Two steady-state thermal analyses are performed on the RXB, one to represent the operating thermal loads (T_0) and one to represent the accident thermal loads (T_a). The results of these analyses provide the thermal gradients through the thickness and along the length of the structural members. The temperature loads are added to the operating and other accident loads such as dead weight and pressurization, appropriately, and two structural analyses performed to determine the rebar strains.

The rebar strains from thermal loads, T_0 and T_a, and the pressure load, P_a, are explicitly obtained from the ANSYS analyses, hence the design check evaluation is performed for ACI 349-06 Load Combinations (LC) 9-6 (now including T_0) and 9-9 (now including $T_a$and P_a).

These correspond to LC 10 and 13 respectively in Table 3.8.4-1 of the DCA. The two load combinations that involve T_0, T_a, and P_a are shown below:

- LC 9-6 ACI 349-06 (LC 10 in Table 3.8.4-1 of the DCA):
  COMB-Static (1GZ+H+F+0.8L) + E_{ss} + 0.28GZ + T_0= SDH + T_0
- LC 9-9 ACI 349-06 (LC 13 in Table 3.8.4-1 of the DCA):
  COMB-Static (1GZ+H+F+0.8L) + E_{ss} + 0.28GZ + T_a + P_a= SDH + T_a + P_a

For brevity, the demand loads for the ACI 349-06 Load Combinations 9-6 and 9-9 without the thermal effects are named as SDH (Static + Dynamic/Seismic + Hydrodynamic Effect).
Since the demand loads for the ACI 349-06 Load Combinations 9-6 and 9-9 without the thermal effects (namely, SDH loads) are already available from the FSAR phase, those results are directly used. The new ANSYS thermal stress analyses provides the detailed calculated strains in the reinforcing steel for the T_0 loads (in load combination 9-6) and T_a+P_a loads (in load combination 9-9). These strains are added to the strains computed from SDH loads of the FSAR for each critical section to check the RXB design with consideration of thermal and pressure effects.

The rebar finite elements for the following critical locations are selected to explicitly determine the strain levels for the T_0 and T_a+P_a loads.

- Walls
  - Outer Wall - North (Grid Line A)
  - Outer Wall - East (Grid Line 7)
  - Outer Wall - West (Grid Line 1)
  - Pool Wall - North (Grid Line B)
  - Pool Wall - East (Grid Line 6)
  - Pool Wall - West (Grid Line 2)
  - Pool Wall - Middle (Grid Line C)
  - Pool Gate Support Wall
  - Roof Support Stiffeners (Grid Lines 2, 3, 4, 5, 6)
  - Roof Support Wall Above Crane (Grid Line A.7)
  - NPM Support Walls (Grid Lines 4, 4.3, 4.7, 5, 5.3, 5.7)
- Slabs
  - Roof
  - Major Slabs (TOC EL 50'-0", 75'-0", 100'-0", and 126'-0")
- Pilasters

- Pilasters at Grid Line A
- Buttresses
    - Buttresses at TOC EL 126'-0" and 145'-0"
- Foundation
- Steel Pool Liner
-

The results from SAP2000 model were used for the static load [COMB-Static (1GZ+H+F+0.8L)] and additional hydrodynamic load (0.28GZ) input to the load combinations.

The results from SASSI2010 model were used for the dynamic input to the load combinations.

2.0 RXB Analysis under Thermal and Pressure Loads

2.1 Development of Half Symmetric 3D Thermal and Structural Model

The finite element modeling tools available in the ANSYS structural analysis computer program were utilized to generate the finite element mesh of the ANSYS RXB north half model from the Solidworks geometry for the concrete, shown in Figure 2-1 and Figure 2-2. The half model considers that the RXB structure is approximately symmetric about the East-West (X) axis based on the RXB geometry. Reinforcing steel inside concrete elements are explicitly modeled. The ANSYS RXB thermal model, which provides the nodal temperatures throughout the entire RXB, uses higher-order thermal solid elements (SOLID87 and SOLID90) which capture the quadratic variation in temperatures across each of the element edges and provide the nodal temperature values for operating and accident temperatures, T_0 and T_a. These nodal temperature values at each node are then applied as input to the RXB structural analysis model for operating and accident temperatures, T_0 and T_a. The HELB maximum pressure loading, P_a, is applied in conjunction with accident temperature T_a to produce the combined rebar strains for the design check using ACI 349-06, Eq. 9-9 load combination.

The ANSYS RXB thermal model is converted to the ANSYS RXB structural model. The ANSYS RXB structural model has identical geometry, number of solid elements and nodes as the ANSYS RXB thermal model. In the RXB structural model, the thermal solid elements are replaced by the structural elements (SOLID186 and SOLID187), and typical rebars are explicitly added. The steel rebars embedded in the concrete were explicitly modeled using the REINF264 uniaxial tension-compression line/truss elements. These REINF264 elements share the same nodes as the base solid elements. The reinforcing elements are firmly attached to its base solid element. No relative movement between the reinforcing element and the base is allowed. The bilinear isotropic hardening plasticity material model was used for the rebars to capture any local yielding and permanent plastic strains in case the rebar stresses exceed their tensile rebar strength. In addition, there is a 0.25" thick inner steel liner for the wet regions of the pool walls.

The cracked concrete properties were used everywhere except for the foundation. All exterior concrete elements that are above grade level were assigned 7,000 psi compressive strength properties. All exterior concrete elements that are below grade and all interior walls and slabs were assigned 5,000 psi compressive strength properties.

For the operating thermal load condition, the convection loads are applied in the thermal model. All exterior surfaces are assigned a convective heat transfer coefficient of 1.1347×10^{-5} BTU/s-in^{2}·°F. All interior surfaces are assigned a convective heat transfer coefficient of 2.8368×10^{-5} BTU/s-in^{2}·°F. The convective fluid bulk temperatures are constant over the entire region. The only exceptions are:

- the exterior walls from elevation 100' to 50' where the bulk temperature varies linearly from 21°F to 46°F.

- the wet regions of the pool walls where the bulk temperature varies linearly from 212°F at the free surface of the pool and 275°F at the pool floor.

The bottom of the foundation has all degrees of freedom fixed in the structural analyses. There are no other constraints defined. For the $T_a + P_a$ load case, both the maximum temperatures and pressures are applied at the same time without consideration of phasing.

In the thermal analysis, there are no temperature constraints in the model. In the RXB thermal analysis model no water mass, equipment, or surrounding soil are included since they have no effect on the thermal analyses.

In the ANSYS model, the global coordinate axes are defined 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)

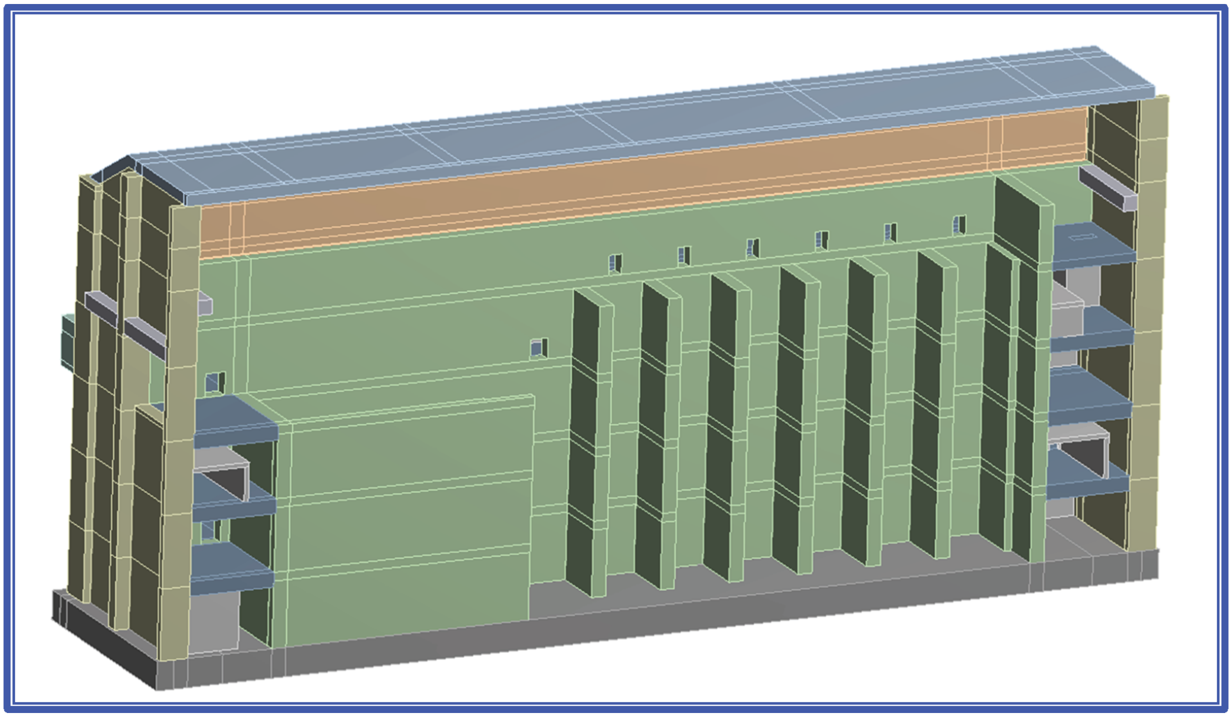

Figure 2-1. RXB 3D Solid Model Geometry (Looking North).

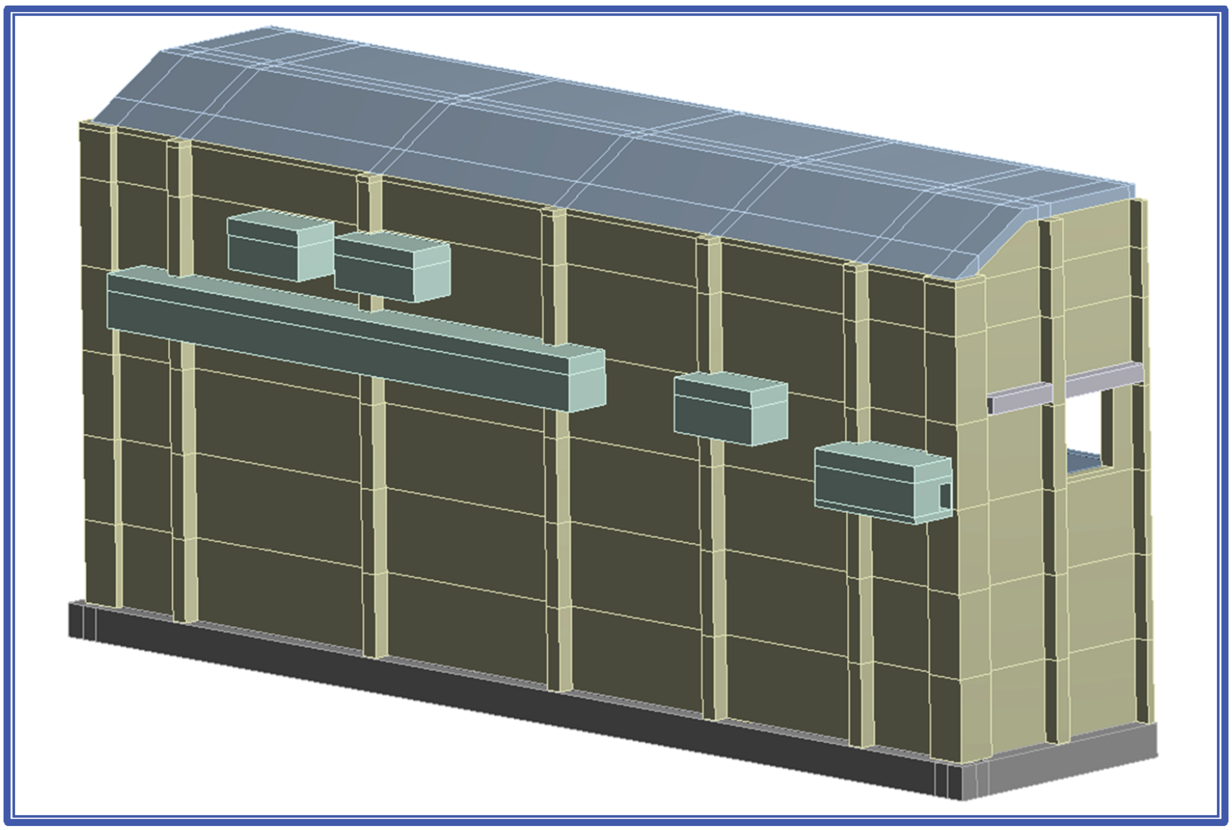

Figure 2-2. RXB 3D Solid Model Geometry (Looking South).

2.2 RXB Thermal and Structural Analyses Models

The ANSYS RXB thermal model provides the nodal temperatures throughout the section thicknesses of RXB walls, buttresses, pilasters, slabs, roof and foundations for the operating and accident temperatures T_0 and T_a. These nodal temperature values at each node are then applied as input to RXB structural analysis model for operating and accident temperatures T_0 and $T_{a.}$ The HELB maximum pressures, P_a, are applied with accident temperature, Ta, to produce the combined rebar strains for the design check using ACI 349-06, Eq. 9-9 load combination.

2.3 RXB Thermal Analyses - T_0 and T_a

The ANSYS RXB thermal analyses provide the nodal temperature values throughout the RXB walls, buttresses, pilasters, slabs, roof and foundations for operating and accident temperatures, T_0 and T_a.

An ANSYS steady-state thermal analysis is performed using this temperature information. The results of the steady-state thermal analysis provide the thermal distribution profile (thermal gradients through the thickness as well as in-plane thermal variation along the length of the structural members). The temperatures from the thermal distribution are read in as body forces on to the corresponding structural analysis due to operating temperature distribution for T_0.
An ANSYS steady-state thermal analysis is performed using this temperature information. The results of the steady-state thermal analysis provide the thermal distribution profile (thermal gradients through the thickness as well as in-plane thermal variation along the length of the structural members). The temperatures from the thermal distribution are read in as body forces on to the corresponding structural analysis due to accident temperature distribution for T_a.
NuScale standard structures are zero percent exceedance dry bulb values of -40°F and +115°F. The external soil temperature is assumed to be 21°F in the winter and 40°F in the summer. The RXB has a design internal air temperature range of 70°F to 130°F, and a design pool temperature range of 40°F to 140°F.

The maximum post-accident temperature in the RXB is assumed to be 212°F. This temperature is used in conjunction with the external temperature for the evaluation.

2.4 RXB Accident Pressure Load Condition - P_a

The maximum accident pressures developed during the HELB are on the interior roof and walls during an accident scenario. An accident pressure P_a of 3 psi has been evaluated in the roof and pool area to account for the energy release of a high energy line break.

2.5 Results of RXB Structural Analysis For Rebar Strains

Since the demand loads for ACI 349-06 Load Combinations 9-6 and 9-9 without thermal effects are already available from the FSAR phase, those results are directly used for the SDH loads. The ANSYS structural analyses provide the detailed strains in the reinforcing steel for the T_0 loads (in load combination 9-6) and T_a+P_a loads (in load combination 9-9). These strains are added to the strains computed from SDH loads of the FSAR for each critical section to check the RXB design with consideration of thermal and pressure effects.

The following figures (Figure 2-3 through Figure 2-10) provide RXB rebar strains distributions throughout the building for T_0, T_a, P_a and combined T_a+P_a loads.

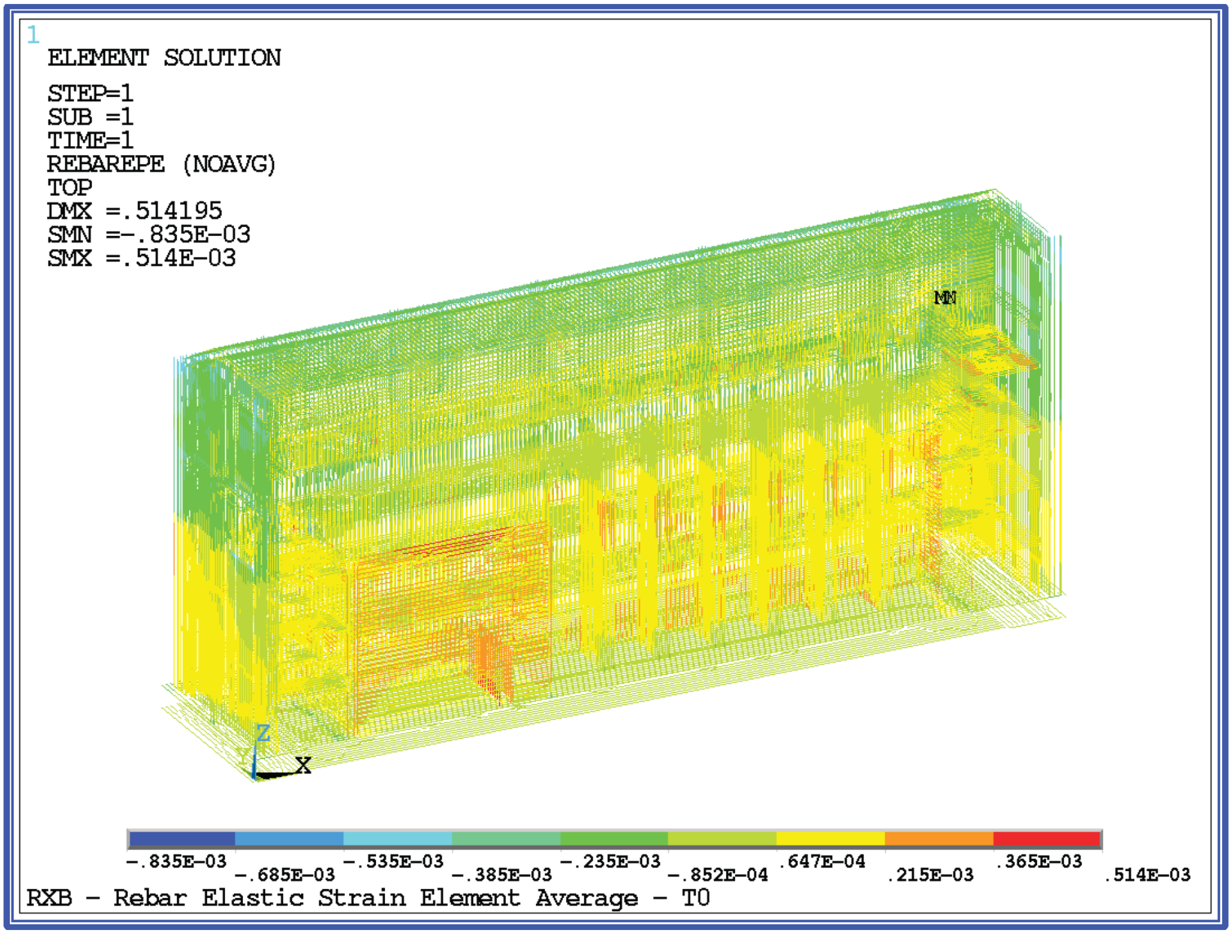

Figure 2-3. RXB Rebar Elastic Strain - T0 - All Sections (View 1).

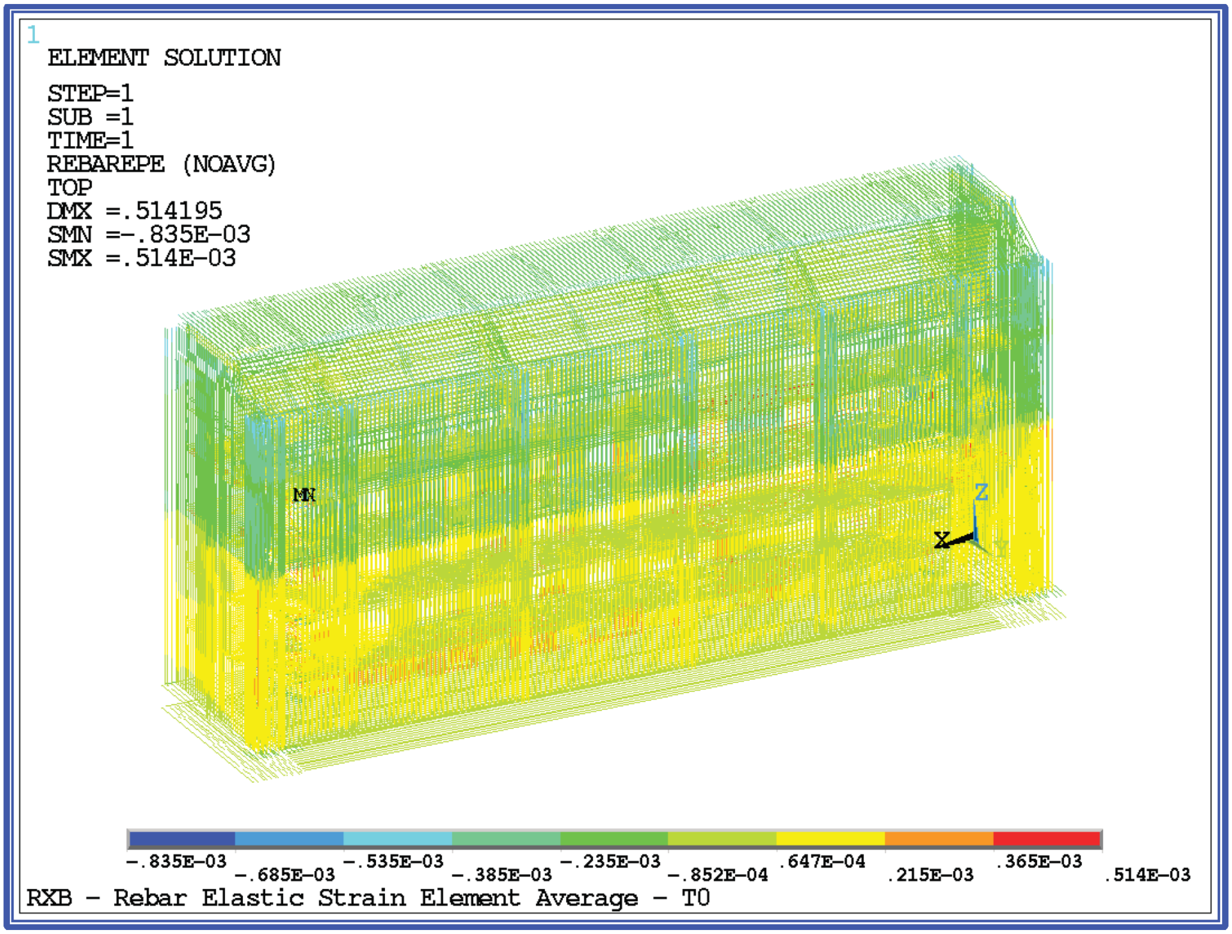

Figure 2-4. RXB Rebar Elastic Strain - T0 - All Sections (View 2).

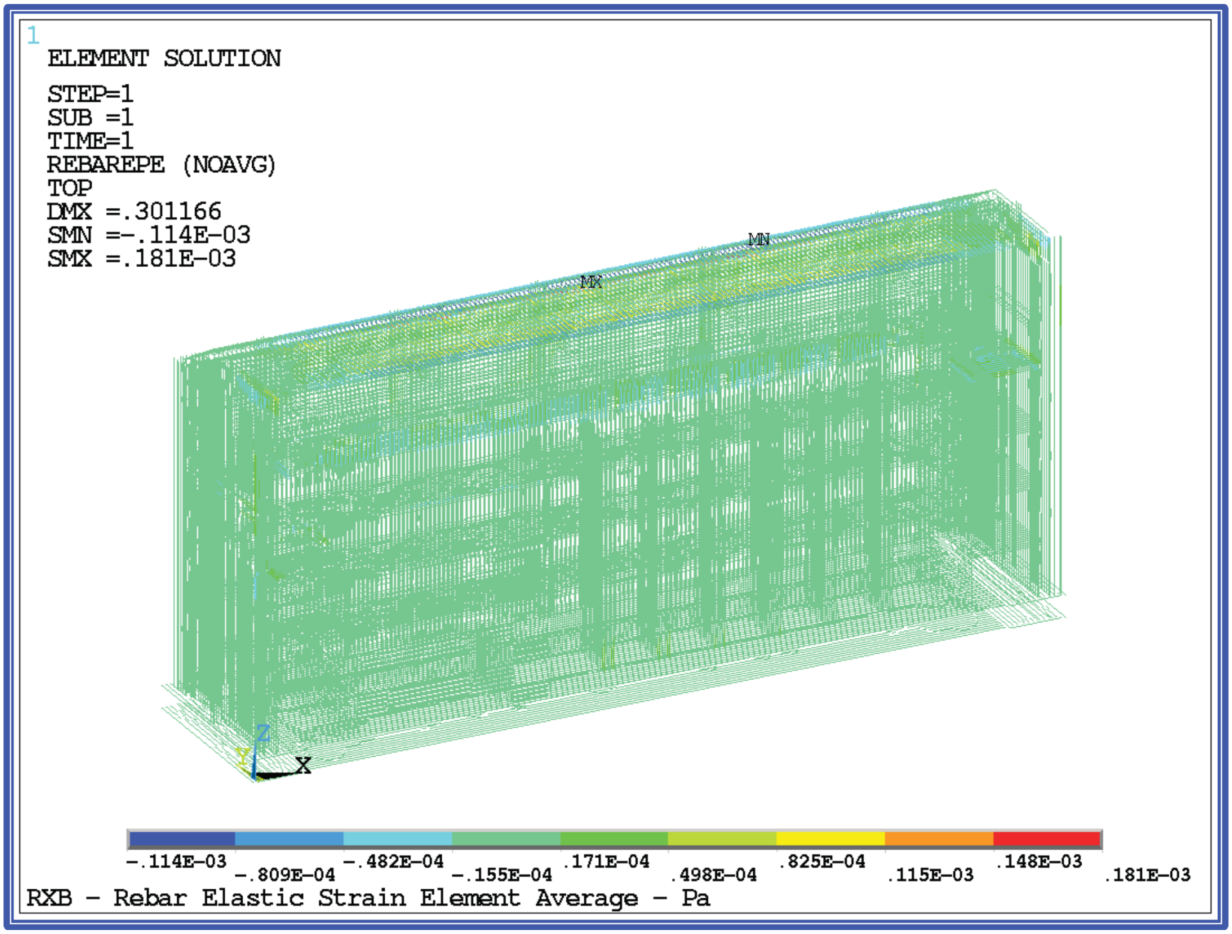

Figure 2-5. RXB Rebar Elastic Strain - Pa - All Sections (View 1).

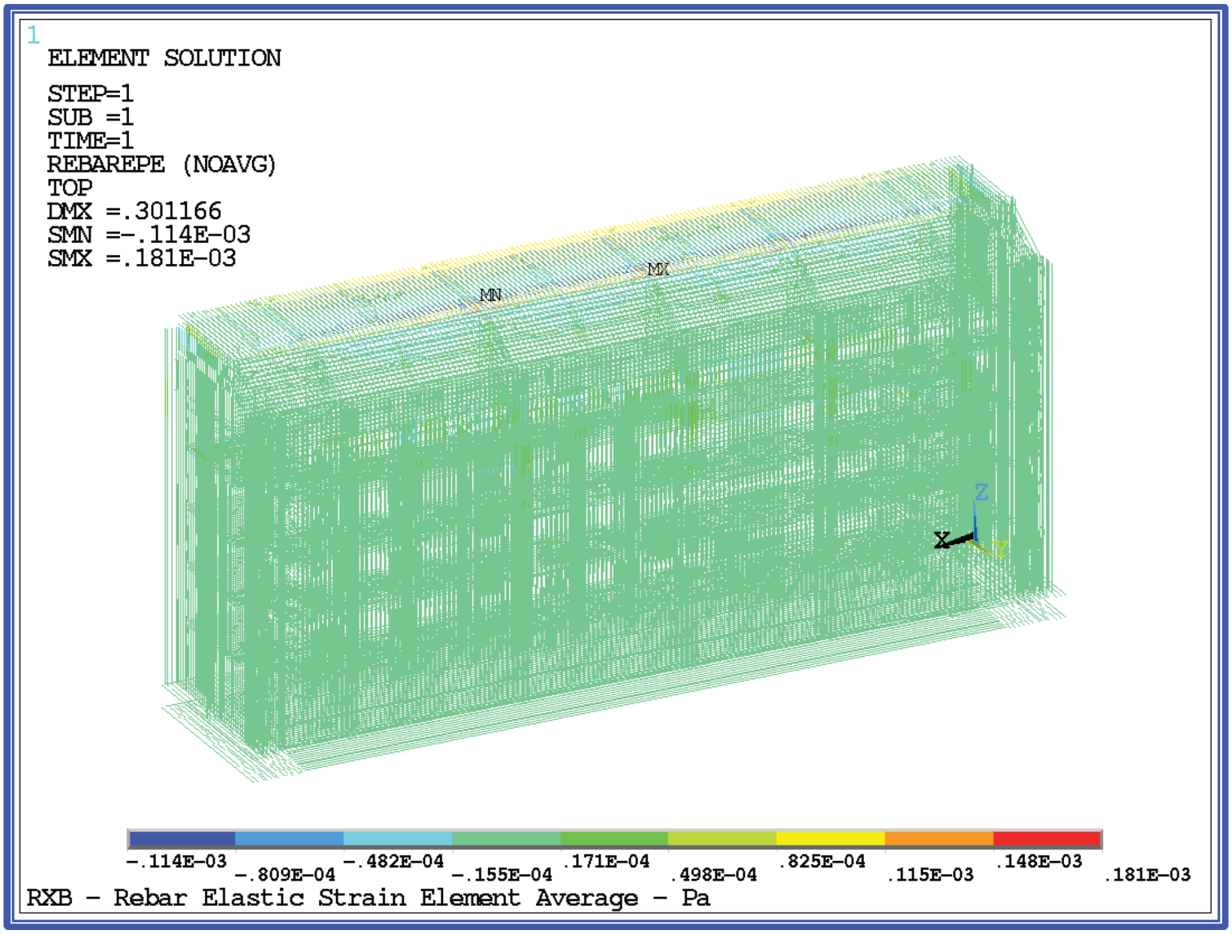

Figure 2-6. RXB Rebar Elastic Strain - Pa - All Sections (View 2).

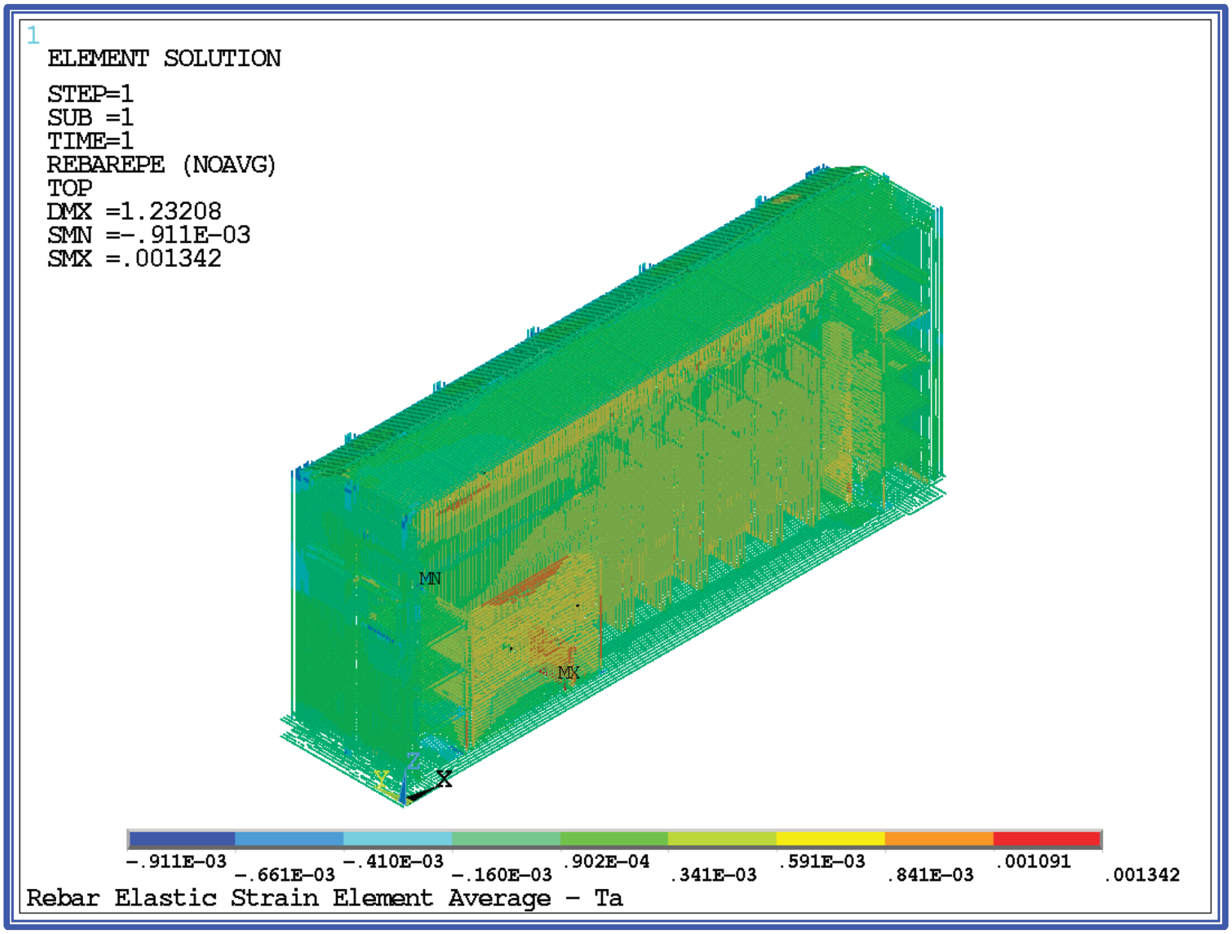

Figure 2-7. RXB Rebar Elastic Strain - Ta - All Sections (View 1).

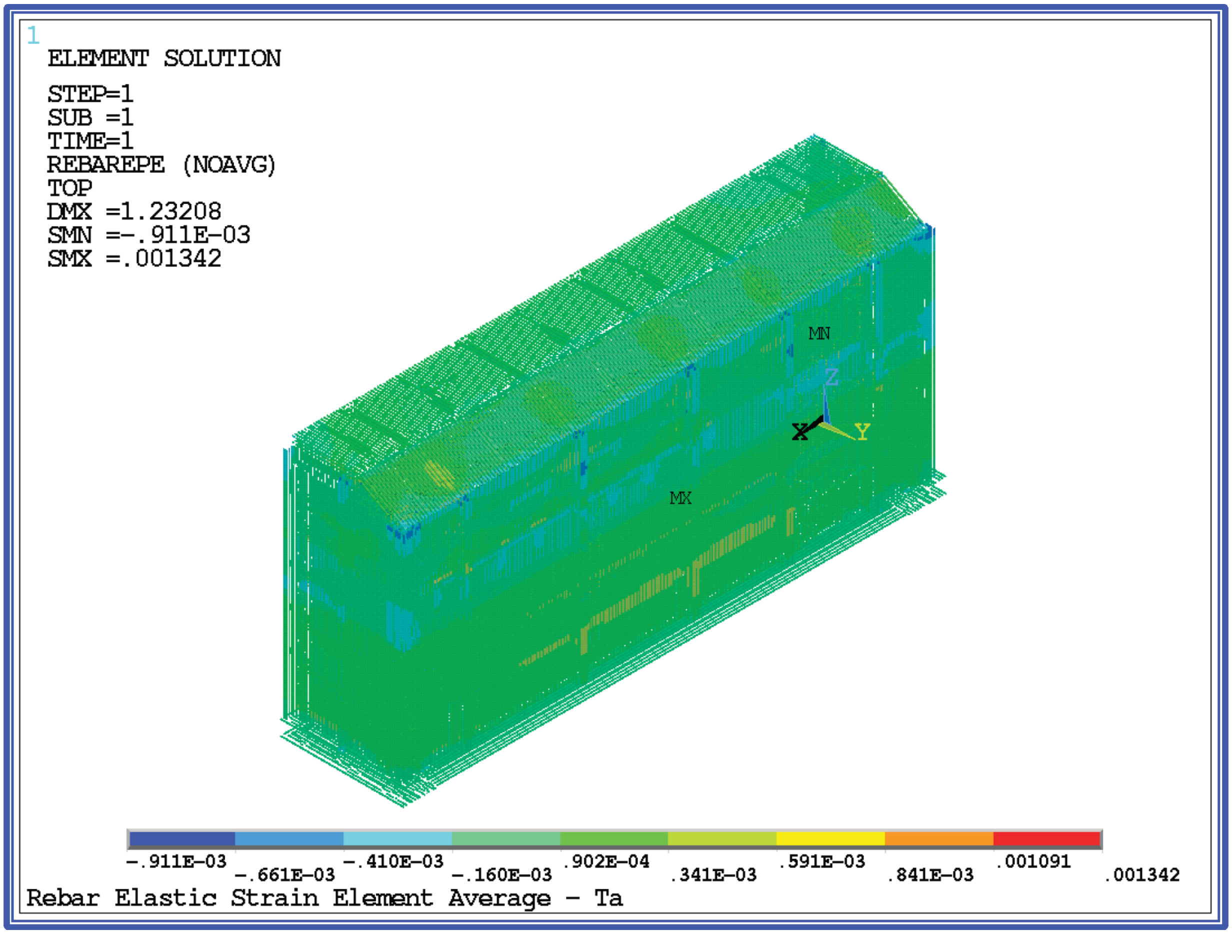

Figure 2-8. RXB Rebar Elastic Strain - Ta - All Sections (View 2).

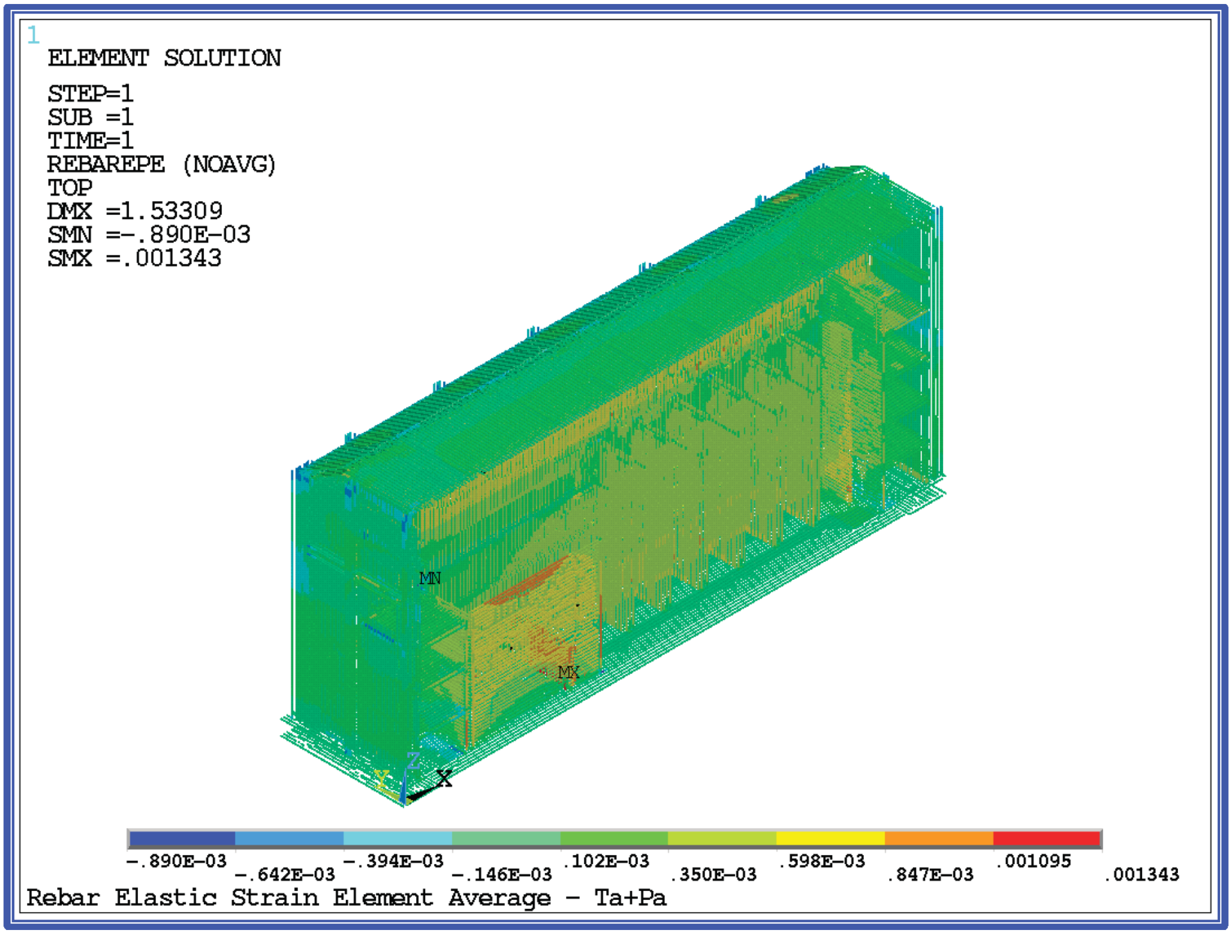

Figure 2-9. RXB Rebar Elastic Strain - Ta+Pa - All Sections (View 1).

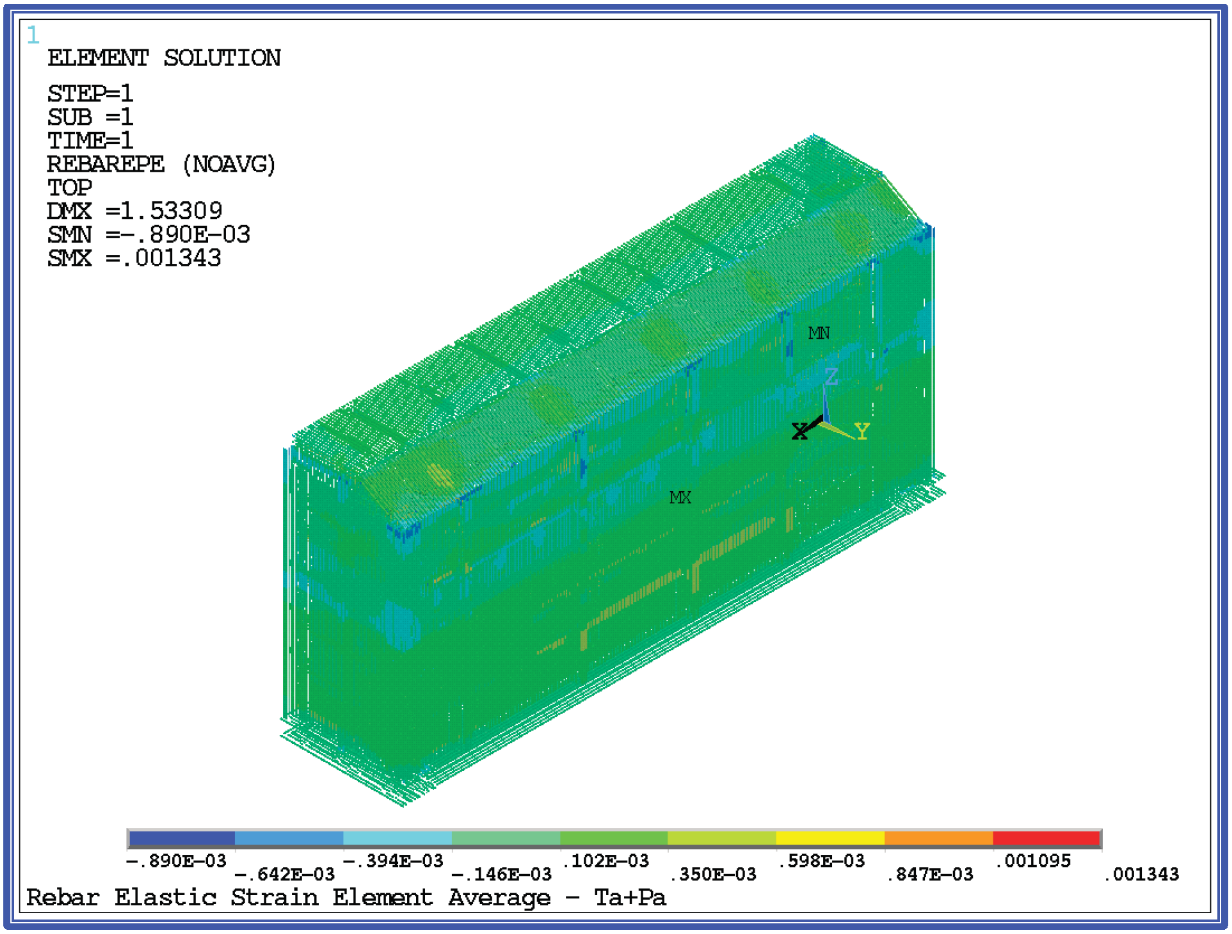

Figure 2-10. RXB Rebar Elastic Strain - Ta+Pa - All Sections (View 2).

2.6 Rebar and Pool Liner Strains Summary under Thermal and Pressure Loads

A summary of the strains within different locations of RXB is presented in Table 2-1.

Table 2-1. ANSYS RXB Reinforcing Steel and Liner Steel Elastic Strain Summary.

Type	Location	Maximum Strain (×10^{-3})			
		T_0	P_a*	T_a*	T_a+P_a
Reinforcing Steel	All Sections	0.514	0.181	1.342	1.343
	Outer Wall - North	0.373	0.055	0.666	0.672
	Outer Wall - East	0.231	0.063	0.426	0.426
	Outer Wall - West	0.256	0.062	0.677	0.687
	Pool Wall - North	0.393			1.053
	Pool Wall - East	0.317			0.85
	Pool Wall - West	0.352			1.016
	Pool Wall - Middle	0.444			1.057
	Pool Gate Support Wall	0.459			1.343
	Roof Support Stiffeners	0.333			0.87
	Roof Support Wall Above Crane	0.24			0.665
	NPM Support Walls	0.294			0.776
	Roof	0.115	0.181	0.485	0.488
	Major Slabs	0.514			0.961
	Pilasters	0.373			0.672
	Buttresses	0.373			0.616
	T-beams	0.514			0.961
	Foundation	0.112			0.367
Liner Steel	Steel Pool Liner	0.895			2.181

* Shaded cell resultants are not extracted for individual load case and locations

3.0 RXB Design Evaluation

3.1 Evaluation Approach

The design criteria for the RXB include load combinations that contain operating temperature, accident temperature, and accidental pressure effects. The third bullet in Section 1.3 of ACI 349.1R-07 states the following:

“In nuclear power structures, the controlling load combinations are generally those that include Eo and Ess. These load cases provide sufficient reinforcement to control cracking. It would be counterproductive to add reinforcement to mitigate thermal effects because the additional reinforcement would stiffen the structure, thus increasing the stresses due to thermal effects. This is unnecessary because thermal effects typically self-relieve without the need for additional reinforcement.”

The evaluation of the various structural elements (slabs, walls, pilasters, buttresses, T-beams, and foundation) of the RXB structure for load combinations involving T_0, T_a, and P_a are based on the strain criteria described below:

- From the FSAR RXB results, the strains for static, dynamic, and hydrodynamic pressure loads (FSAR RXB) used for load combinations 9-6 and 9-9 are calculated from the resulting stresses in the reinforcing steel. The static load is 1GZ+H+F+0.8L, the dynamic load is E_{ss}, and the hydrodynamic pressure load is 0.28GZ. This strain calculation approach is described in Section 3.2.

- The strains for the reinforcing steel using T_0 loads for load combination 9-6 and T_a + P_a loads for load combination 9-9 are obtained from the ANSYS analysis given in Section 2.6.

- The total strain in the reinforcing steel is the addition of the two strains above.

The following steps are used to evaluate the final strain obtained for each load case:

Step 1: If the total strain in the reinforcing steel is less than 1.2εy, the section is considered acceptable based on the 4th bullet in Section 1.3 of ACI 349.1R-07, which states the following about the reinforcing steel strain with thermal gradient, 1.2εy: "Such an exceedance is inconsequential, and will not reduce the capacity of the concrete section for mechanical loads."

If the strain in the concrete is less than 0.003 in/in, the section is considered acceptable since this value is the limiting strain set by Section 10.2.3 of ACI-349-06.

Step 2: If the total strain in the steel exceeds 1.2εy for any element in Step 1, the average strains from adjoining elements are calculated, since the finite element models often show highly localized forces and moments and the average presents a more realistic value.
For computation of average strain, an effective length of approximately 4 times the thickness of the structural component (such as wall or slab) is considered. However, for the walls with liner plates such as pool walls, elements that correspond to larger lengths of the walls (up to the extent of the entire wall length) can be used for average strain determination. It is rationalized that the concrete walls confined within the liner plates provide enhanced integrity of the concrete walls to withstand the applied forces as an integrated entity that will enable consideration of larger wall lengths.

If the average strain is less than 1.2εy, the section is considered acceptable.

Step 3: For sections that did not pass Step 2, the reinforcing steel in the region is further reviewed to determine if there is additional steel from the intersecting members that are underutilized.

The extreme concrete compression fiber strain is 0.003 in/in according to Section 10.2.3 of ACI 349-06. The additional concrete strain for thermal effects of a fully constrained component can be estimated to be approximately 0.0006 in/in according to the 5th bullet in Section 1.3 of ACI 349.1R-07, and such a small exceedance in the extreme fiber of the cross-section will not be detrimental to the overall strength of the structure. Furthermore, the calculated maximum compressive strain in the rebar for the entire RXB for the P_a loads is 0.000181 in/in, which is insignificant compared to the extreme concrete fiber strain of 0.003 in/in. Hence, compressive strain for the P_a loads is ignored.

HELB at the pool region causes the worst pressurization case, P_a from the global structural evaluation standpoint, and accordingly, this loading is applied in conjunction with thermal loads. Table 2-1 shows the maximum strain levels in the critical locations of the RXB from T_0, P_a, and T_a+P_a loads. It should be noted from the strains provided in this table that the contribution of strains from P_a to total strains from T_a+P_a is much smaller. The comparison of strain plots presented in Figure 2-5 through Figure 2-10 indicates that maximum strains due to P_a and T_a+P_a do not occur at the same locations, which further reduces the effect of strain contribution due to P_a loads. The use of global maximum HELB pressure loads adequately envelops other HELB loadings that may occur in the galleries and these would produce lower strain levels than shown in Table 2-1.

For acceptance, it is ensured that the strain in the concrete is less than 0.003 for SDH loads and that the strain in the reinforcing steel is less than $1.2\varepsilon y$ for SDH and thermal loads. A summary of the limiting strains is presented in Table 3-1. The idealized stress-strain curves for concrete and steel are shown in Figure 3-1 and Figure 3-2, respectively. Please note that for steel stresses beyond yield, the corresponding strain (εs_1) produces an area equivalent to that of a linear stress beyond f_y (i.e. the yellow trapezoid and blue triangle have the same area). Typical stress-strain curves for Grade 60 reinforcing steel are shown in Figure 3-3.

Table 3-1. Limiting Strains for Thermal Design.

Description	Parameters	Value (in/in)
Maximum concrete strain for SDH loads per Section 10.2.3 of ACI 349-06	ε_{cu}	0.003000
Reinforcing steel yield strain, $\varepsilon_y = f_y/E_s$	ε_y	0.002069
Reinforcing steel strain with SDH and thermal loads per Section 1.3 of ACI 349.1R-07	$1.2\varepsilon_y$	0.002483

{{

}}2(a),(c)

{{

}}2(a),(c)

{{

}}2(a),(c)

{{

}}2(a),(c)

{{

}}2(a),(c)

{{

}}2(a),(c)

{{

}}2(a),(c)

{{

}}2(a),(c)

{{

}}2(a),(c)

{{

}}2(a),(c)

{{

}}2(a),(c)

{{

}}2(a),(c)

{{

}}2(a),(c)

{{

}}2(a),(c)

{{

}}2(a),(c)

{{

}}2(a),(c)

{{

}}2(a),(c)

{{

}}2(a),(c)

{{

}}2(a),(c)

{{

}}2(a),(c)

{{

}}2(a),(c)

{{

}}2(a),(c)

{{

}}2(a),(c)

NUSCALE™
Power for all humankind

{{

}}2(a),(c)

{{

}}2(a),(c)

{{

}}2(a),(c)

{{

}}2(a),(c)

{{

}}2(a)(c)

4.0 Design Check Results

The following sections perform the design evaluation of the various structural elements in the RXB.

4.1 Walls

4.1.1 Concrete Check for All Walls

The maximum concrete strains from SDH for any element of the different walls are extracted. Table 4-1 shows a summary of the strain-based concrete design check for all walls. The total strain in the concrete is less than ε_{cu} = 0.003 at all locations except for the middle pool wall at Grid Line C.

Figure 4-1 and Figure 4-2 present the elements that exceed the allowable strain of ε_{cu} = 0.003 for the X and Y direction, respectively.

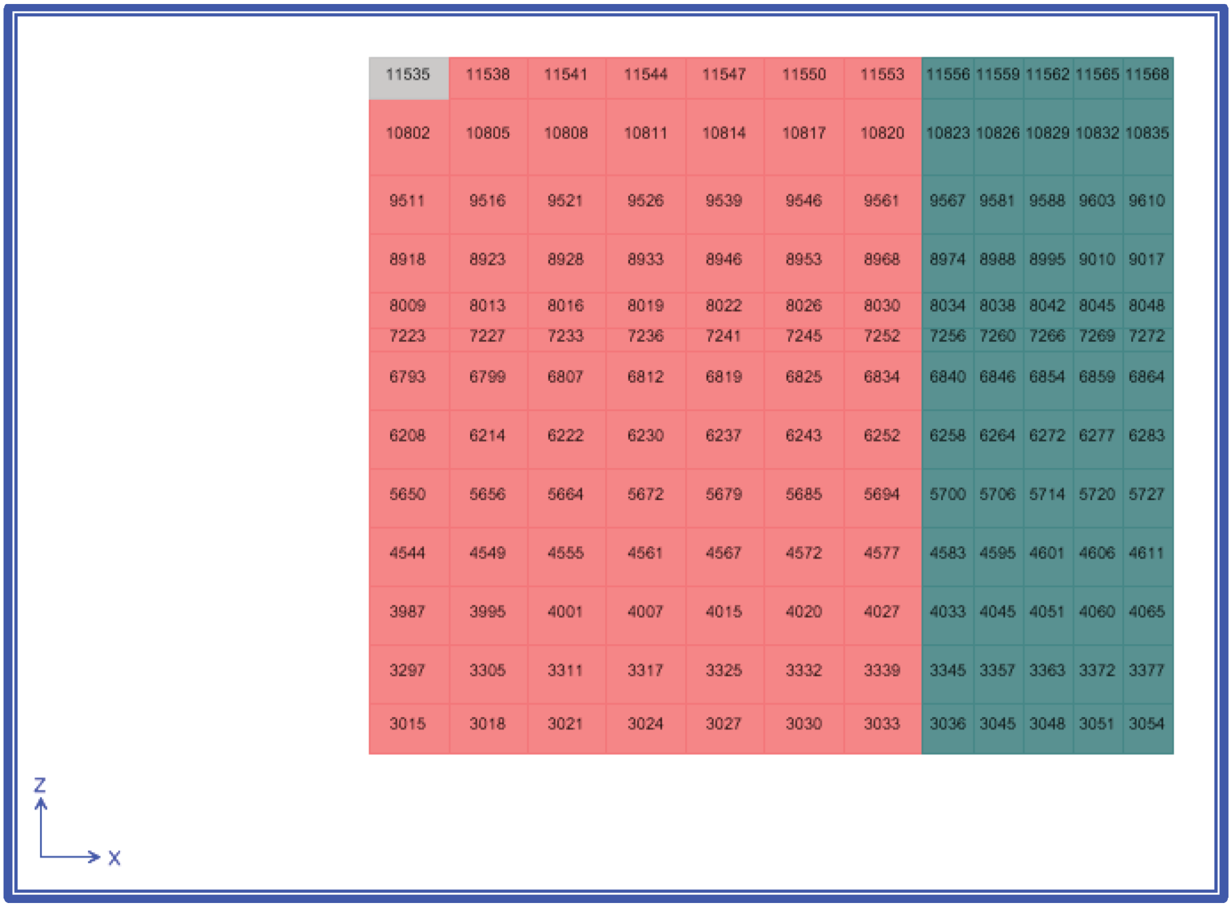

Figure 4-1. Single Elements from Pool Wall - Middle (Grid Line C) Exceeding Allowable Concrete Strain in X Direction.

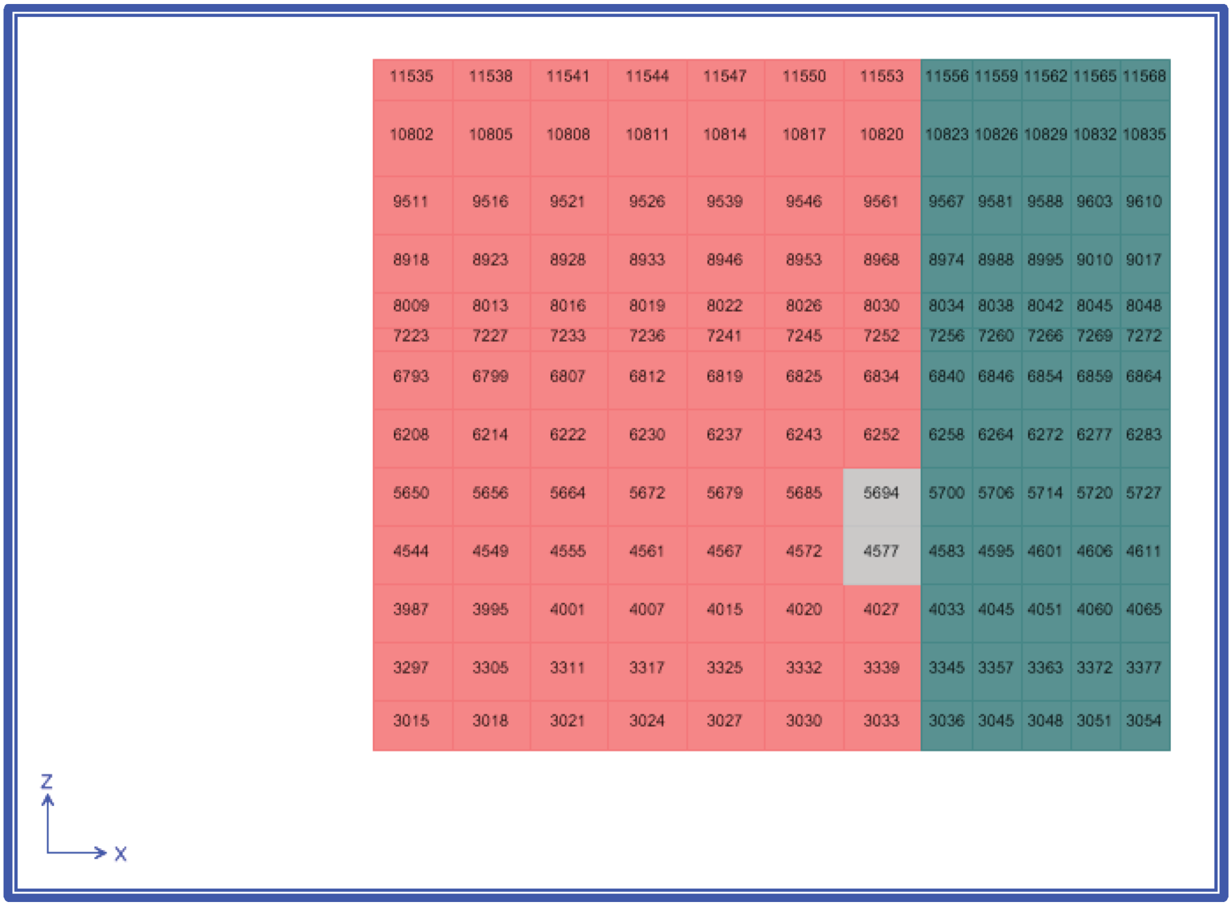

Figure 4-2. Single Elements from Pool Wall - Middle (Grid Line C) Exceeding Allowable Concrete Strain in Y Direction.

Table 4-1. Strain-Based Concrete Design Check for All Walls After Averaging Affected Elements.

Location	Max ε_c ($\times 10^{-3}$) from SDH		$\varepsilon c < \varepsilon_{cu}$?
	X	Y	Concrete
Outer Wall - North (Grid Line A)	0.348	1.173	OK
Outer Wall - East (Grid Line 7)	0.323	0.786	OK
Outer Wall - West (Grid Line 1)	0.290	0.434	OK
Pool Wall - North (Grid Line B)	0.764	1.182	OK
Pool Wall - East (Grid Line 6)	0.616	0.354	OK
Pool Wall - West (Grid Line 2)	0.574	0.322	OK
Pool Wall - Middle (Grid Line C)	**2.094***	**2.025***	OK
Pool Gate Support Wall	0.786	0.330	OK
Roof Support Stiffeners (Grid Lines 2, 3, 4, 5, 6)	0.576	0.170	OK
Roof Support Wall Above Crane (Grid Line A.7)	0.399	1.140	OK
NPM Support Walls (Grid Lines 4, 4.3, 4.7, 5, 5.3, 5.7)	0.607	0.920	OK

*Bold cell indicates averaging was employed.

4.1.2 Outer Wall - North (Grid Line A)

The north outer wall at Grid Line A is an exterior structural wall that is 5 feet thick. The maximum strains from SDH for any element for the different reinforcement configurations for this wall are combined with thermal strains. Table 4-2 shows the strain-based steel design check for this wall, where SDH strains are combined with T_0 strains for load combination 9-6 or T_a+P_a strains for load combination 9-9.

The total strain in Y-direction exceeds 1.2ε_y for SDH+T_a+P_a case for certain elements given in Figure 4-3. After averaging the single elements for load combination 9-9 using a strain contour based on the location, the strain check criteria is satisfied and the wall is considered acceptable.

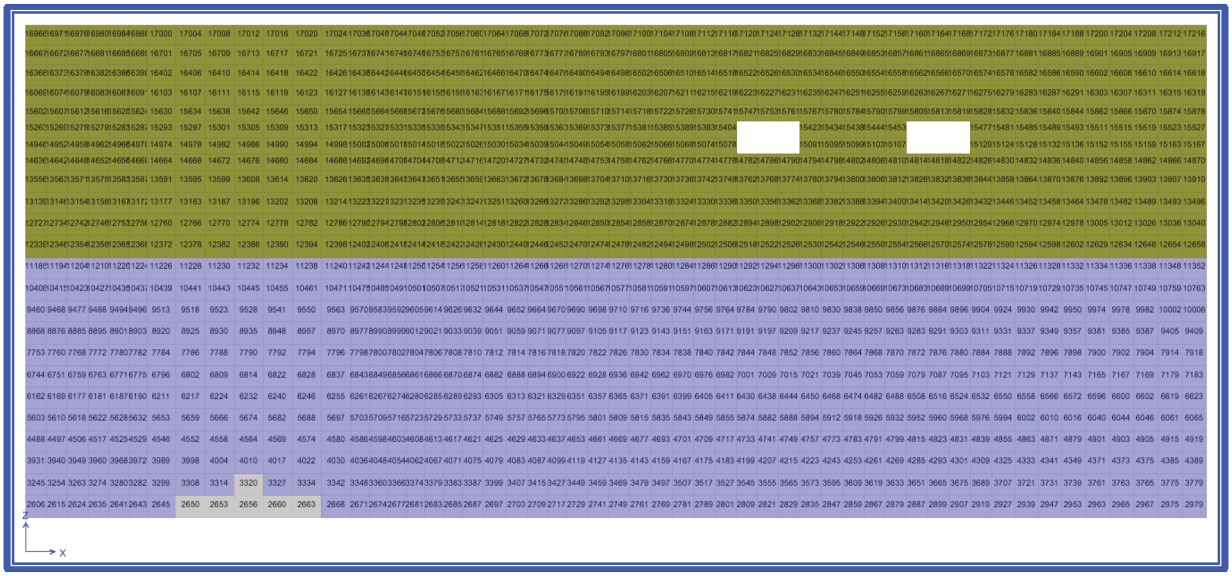

Figure 4-3. Single Elements from Outer Wall - North (Grid Line A) with Insufficient Thermal Ta+Pa Strain Capacity for Load Combination 9-9 in Y Direction.

Table 4-2. Strain-Based Steel Design Check for Outer Wall - North (Grid Line A) After Averaging Affected Elements.

Location	Max ε_s ($\times10^{-3}$) from SDH		Max ε_s ($\times10^{-3}$) from T_0	Max ε_s ($\times10^{-3}$) from LC 9-6 (SDH+T_0)	$\varepsilon_s < 1.2\varepsilon_y$?
	X	Y	X, Y	X, Y	LC 9-6
5'-0" Ext Wall, Above Grade	1.200	1.343	0.373	1.716	OK
5'-0" Ext Wall, Below Grade	0.824	1.458	0.373	1.831	OK
5'-0" Ext Wall, Below Grade	0.964	1.202	0.373	1.575	OK
5'-0" Ext Wall, Below Grade	0.746	1.962	0.373	2.335	OK
Location	**Max ε_s ($\times10^{-3}$) from SDH**		**Max ε_s ($\times10^{-3}$) from T_a+P_a**	**Max ε_s ($\times10^{-3}$) from LC 9-9 (SDH+T_a+P_a)**	**$\varepsilon_s < 1.2\varepsilon y$?**
	X	**Y**	**X, Y**	**X, Y**	**LC 9-9**
5'-0" Ext Wall, Above Grade	1.200	1.343	0.672	2.015	OK
5'-0" Ext Wall, Below Grade	0.824	1.458	0.672	2.130	OK
5'-0" Ext Wall, Below Grade	0.964	1.202	0.672	1.874	OK
5'-0" Ext Wall, Below Grade	0.746	1.937	0.672	**2.469***	OK

*Bold cell indicates averaging was employed.

4.1.3 Outer Wall - East (Grid Line 7)

The east outer wall at Grid Line 7 is an exterior structural wall that is 5 feet thick.

The maximum strains from SDH for any element for the different reinforcement configurations for this wall are combined with thermal strains. Table 4-3 shows the strain-based steel design check for this wall, where SDH strains are combined with T_0 strains for load combination 9-6 or T_a+P_a strains for load combination 9-9.

Table 4-3. Strain-Based Steel Design Check for Outer Wall - East (Grid Line 7).

Location	Max ε_s ($\times 10^{-3}$) from SDH		Max ε_s ($\times 10^{-3}$) from T_0	Max ε_s ($\times 10^{-3}$) from LC 9-6 (SDH+T_0)	ε_s < 1.2εy?
	X	Y	X, Y	X, Y	LC 9-6
5'-0" Ext Wall, Above Grade	0.706	1.044	0.231	1.275	OK
5'-0" Ext Wall, Below Grade	1.352	1.339	0.231	1.583	OK
Location	**Max ε_s ($\times 10^{-3}$) from SDH**		**Max ε_s ($\times 10^{-3}$) from T_a+P_a**	**Max ε_s ($\times 10^{-3}$) from LC 9-9 (SDH+T_a+P_a)**	**ε_s < 1.2εy?**
	X	**Y**	**X, Y**	**X, Y**	**LC 9-9**
5'-0" Ext Wall, Above Grade	0.706	1.044	0.426	1.470	OK
5'-0" Ext Wall, Below Grade	1.352	1.339	0.426	1.778	OK

As shown in Table 4-3, the total strain in the steel is less than 1.2ε_y (2.483 $\times 10^{-3}$) for all sections within this wall, satisfying both load combinations 9-6 and 9-9. Therefore, the wall is considered acceptable.

4.1.4 Outer Wall - West (Grid Line 1)

The west outer wall at Grid Line 1 is an exterior structural wall that is 5 feet thick.

The maximum strains from SDH for any element for the different reinforcement configurations for this wall are combined with thermal strains. Table 4-4 shows the strain-based steel design check for this wall, where SDH strains are combined with T_0 strains for load combination 9-6 or T_a+P_a strains for load combination 9-9. Total strain in the steel is less than 1.2ε_y(2.483 $\times 10^{-3}$) for all sections within this wall, satisfying both load combinations 9-6 and 9-9. Therefore, the wall is considered acceptable.

Table 4-4. Strain-Based Steel Design Check for Outer Wall - West (Grid Line 1).

Location	Max ε_s ($\times10^{-3}$) from SDH		Max ε_s ($\times10^{-3}$) from T_0	Max ε_s ($\times10^{-3}$) from LC 9-6 (SDH+T_0)	$\varepsilon_s < 1.2\varepsilon y$?
	X	Y	X, Y	X, Y	LC 9-6
5'-0" Ext Wall, Above Grade	0.731	0.984	0.256	1.240	OK
5'-0" Ext Wall, Above Grade	1.076	1.516	0.256	1.772	OK
5'-0" Ext Wall, Below Grade	0.687	1.166	0.256	1.422	OK
5'-0" Ext Wall, Below Grade	1.441	1.222	0.256	1.697	OK
Location	**Max ε_s ($\times10^{-3}$) from SDH**		**Max ε_s ($\times10^{-3}$) from T_a+P_a**	**Max ε_s ($\times10^{-3}$) from LC 9-9 (SDH+T_a+P_a)**	**$\varepsilon_s < 1.2\varepsilon_y$?**
	X	Y	X, Y	X, Y	LC 9-9
5'-0" Ext Wall, Above Grade	0.731	0.984	0.687	1.671	OK
5'-0" Ext Wall, Above Grade	1.076	1.516	0.687	2.203	OK
5'-0" Ext Wall, Below Grade	0.687	1.166	0.687	1.853	OK
5'-0" Ext Wall, Below Grade	1.441	1.222	0.687	2.128	OK

4.1.5 Pool Wall - North (Grid Line B)

The north pool wall is an interior wall of the RXB that is 5 feet thick.

The maximum strains from SDH for any element for the different reinforcement configurations for this wall are combined with thermal strains. Table 4-5 shows the strain-based steel design check for this wall, where SDH strains are combined with T_0 strains for load combination 9-6 or T_a+P_a strains for load combination 9-9.

As shown in Table 4-5, the total strain in the steel is less than 1.2ε_y (2.483 ×10^{-3}) at all locations for load combination 9-6. However, there is exceedance for load combination 9-9. For groups of elements where adding the maximum strain from T_a+P_a would make the average fail, a more accurate T_a+P_a strain was obtained based on its location using the strain contour. Please note that the maximum SDH strain and maximum thermal strain do not necessarily occur at the same location, therefore, the maximum combined strain is not the sum of both maximum strains. Since the strain from T_a+P_a is 1.053×10^{-3}, the remaining allowed strain from SDH is 1.430×10^{-3}. The elements that exceed this allowed strain are presented in Figure 4-4 and Figure 4-5 for the X and Y directions, respectively.

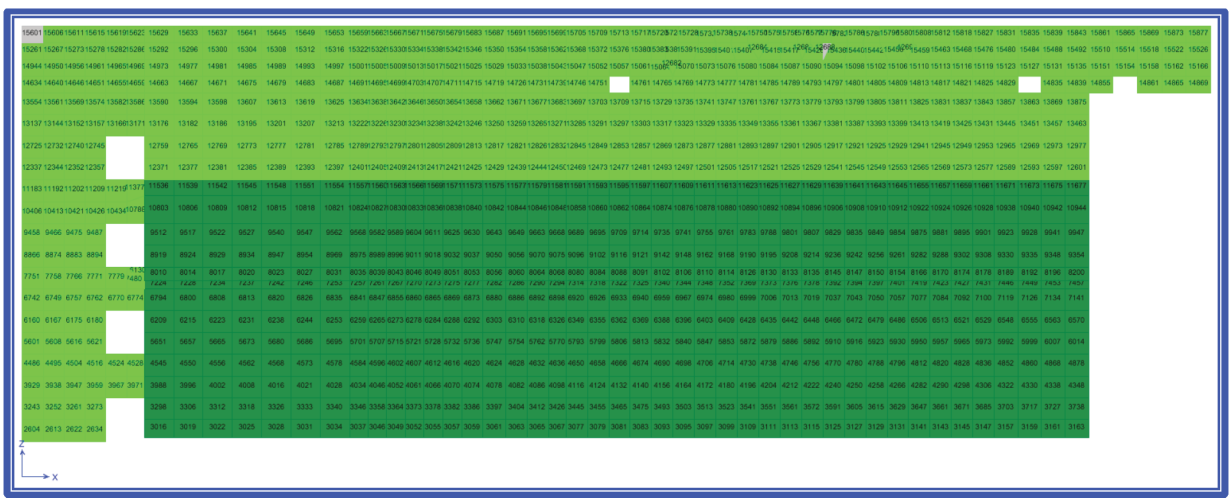

Figure 4-4. Single Elements from Pool Wall - North (Grid Line B) with Insufficient Thermal Ta+Pa Strain Capacity for Load Combination 9-9 in X Direction.

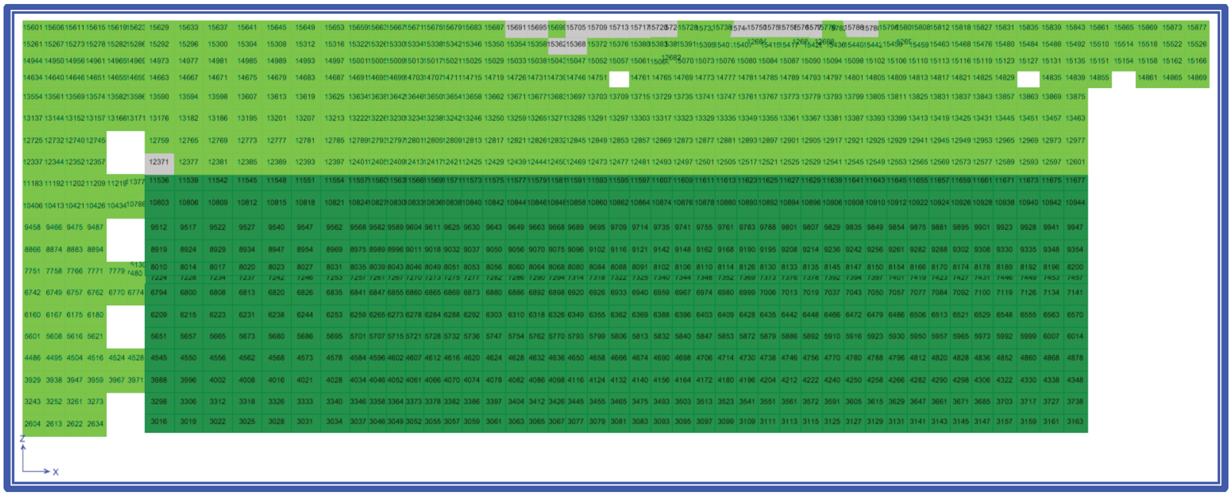

Figure 4-5. Single Elements from Pool Wall - North (Grid Line B) with Insufficient Thermal Ta+Pa Strain Capacity for Load Combination 9-9 in Y Direction.

Table 4-5. Strain-Based Steel Design Check for Pool Wall - North (Grid Line B) After Averaging Affected Elements.

Location	Max ε_s ($\times10^{-3}$) from SDH		Max ε_s ($\times10^{-3}$) from T_0	Max ε_s ($\times10^{-3}$) from LC 9-6 (SDH+T_0)	$\varepsilon s < 1.2\varepsilon_y$?
	X	Y	X, Y	X, Y	LC 9-6
5'-0" Pool Wall	1.574	1.782	0.393	2.175	OK
Location	**Max ε_s ($\times10^{-3}$) from SDH**		**Max ε_s ($\times10^{-3}$) from T_a+P_a**	**Max ε_s ($\times10^{-3}$) from LC 9-9 (SDH+T_a+P_a)**	**$\varepsilon_s < 1.2\varepsilon_y$?**
	X	**Y**	**X, Y**	**X, Y**	**LC 9-9**
5'-0" Pool Wall	1.368	1.627	1.053	**2.481***	OK

*Bold cell indicates averaging was employed.

4.1.6 Pool Wall - East (Grid Line 6)

The east pool wall at Grid Line 6 consists of several wall thicknesses.

The maximum strains from SDH for any element for the different reinforcement configurations for this wall are combined with thermal strains. Table 4-5 shows the strain-based steel design check for this wall, where SDH strains are combined with T_0 strains for load combination 9-6 or T_a+P_a strains for load combination 9-9. The total strain in the steel exceeds $1.2\varepsilon_y$for one type of reinforcement for load combinations 9-6 and 9-9.

Since the strain from $T_0$is 0.317×10^{-3}, the remaining allowed strain from SDH is 2.166×10^{-3}. The elements that exceed this allowed strain are presented in Figure 4-6 and Figure 4-7 for the X direction for load combinations 9-6 and 9-9 respectively. An averaging for these exceeding elements is performed in Table7-17.

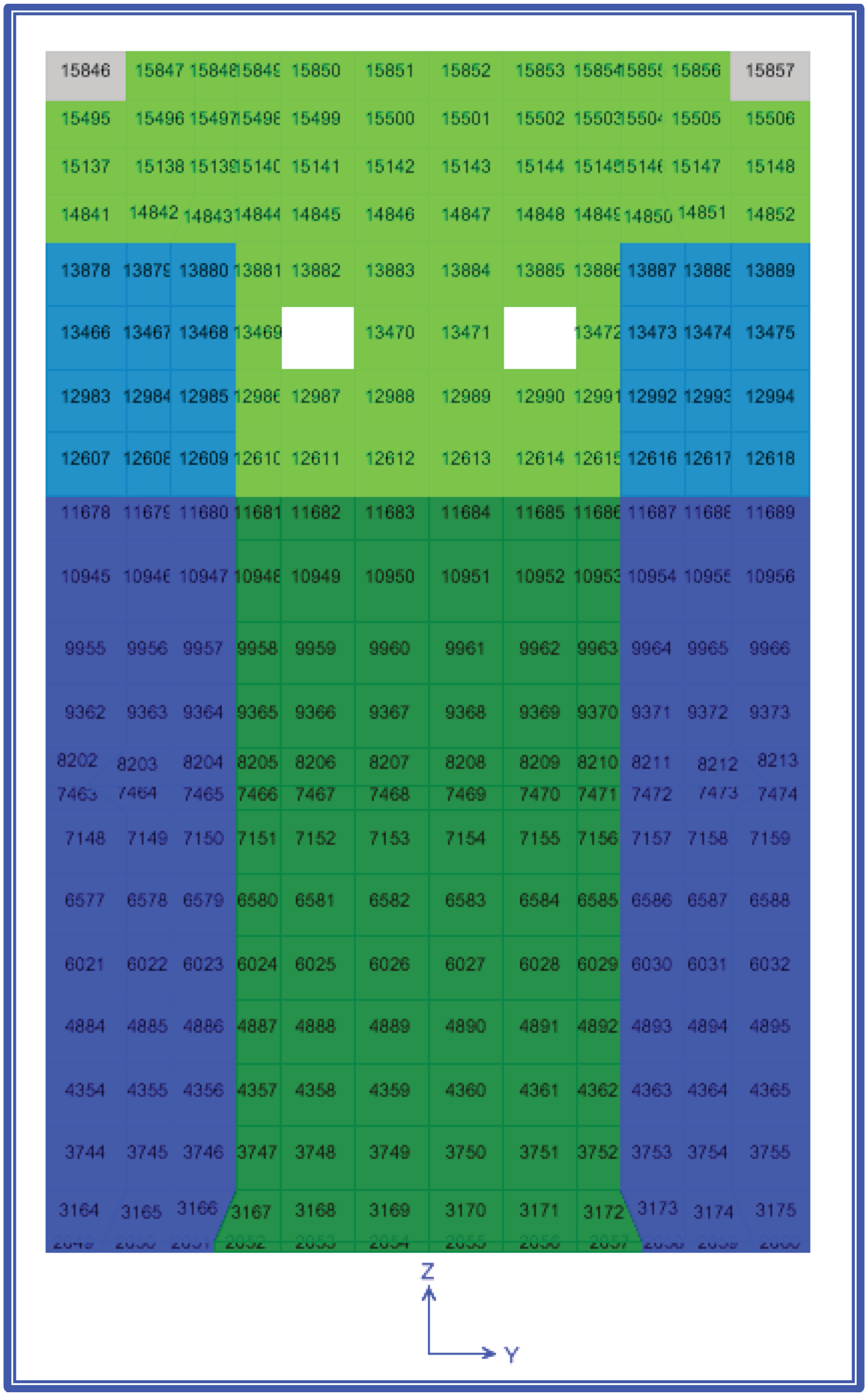

Figure 4-6. Single Elements from Pool Wall - East (Grid Line 6) with Insufficient Thermal T0 Strain Capacity for Load Combination 9-6 in X Direction.

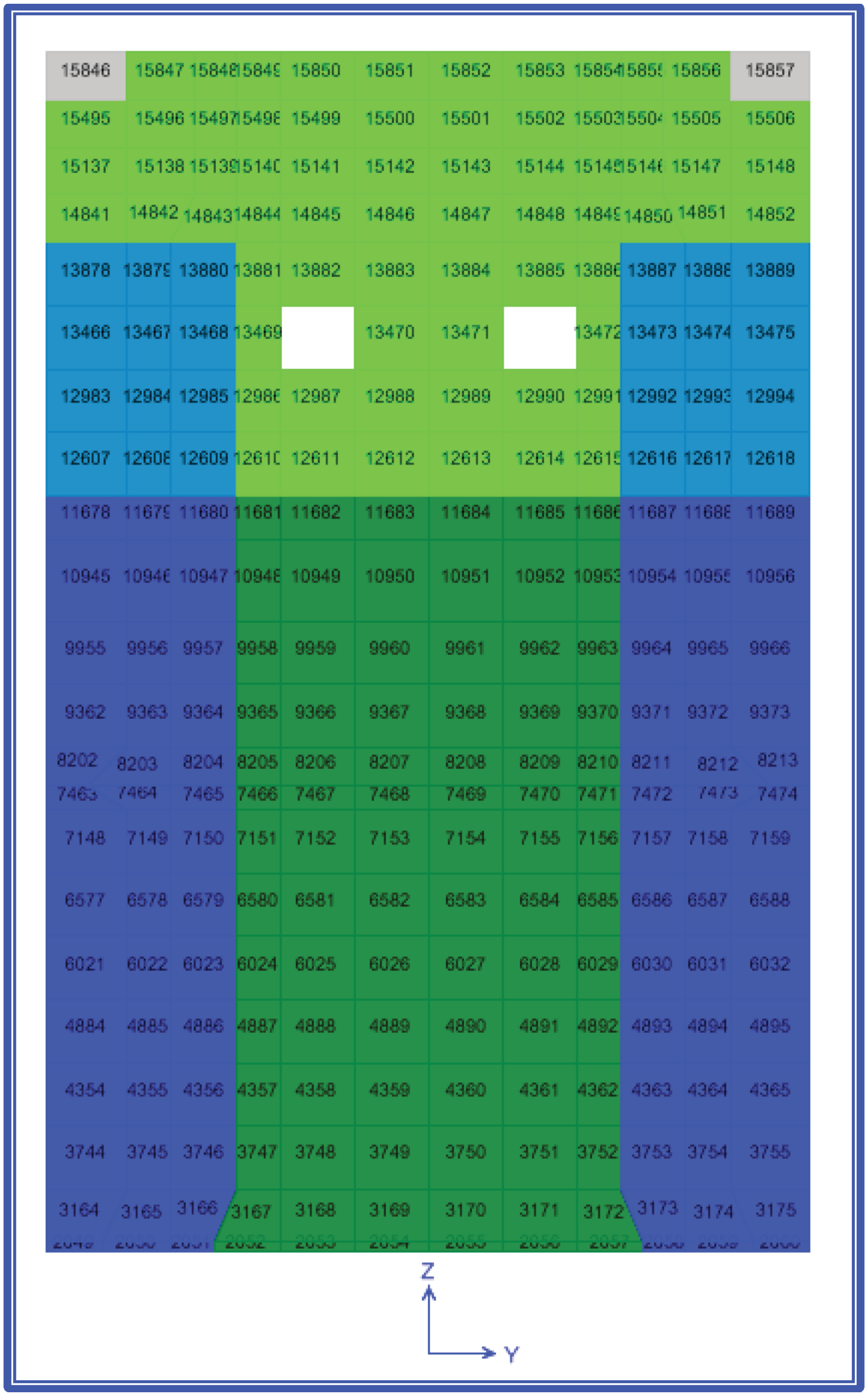

Figure 4-7. Single Elements from Pool Wall - East (Grid Line 6) with Insufficient Thermal Ta+Pa Strain Capacity for Load Combination 9-9 in X Direction.

Table 4-6. Strain-Based Steel Design Check for Pool Wall - East (Grid Line 6) After Averaging Affected Elements.

Location	Max ε_s ($\times 10^{-3}$) from SDH		Max ε_s ($\times 10^{-3}$) from T_0	Max ε_s ($\times 10^{-3}$) from LC 9-6 (SDH+T_0)	$\varepsilon_s < 1.2\varepsilon_y$?
	X	Y	X, Y	X, Y	LC 9-6
5'-0" Pool Wall	0.837	0.967	0.317	1.284	OK
5'-0" Pool Wall	1.838	0.698	0.317	**2.155***	OK
7'-6" Pool Wall	0.875	0.941	0.317	1.258	OK
Location	**Max ε_s ($\times 10^{-3}$) from SDH**		**Max ε_s ($\times 10^{-3}$) from T_a+P_a**	**Max εs ($\times 10^{-3}$) from LC 9-9 (SDH+T_a+P_a)**	**$\varepsilon_s < 1.2\varepsilon_y$?**
	X	Y	X, Y	X, Y	LC 9-9
5'-0" Pool Wall	0.837	0.967	0.850	1.817	OK
5'-0" Pool Wall	1.511	0.698	0.850	**2.361***	OK
7'-6" Pool Wall	0.875	0.941	0.850	1.791	OK

*Bold cell indicates averaging was employed.

4.1.7 Pool Wall - West (Grid Line 2)

The west pool wall at Grid Line 2 consists of a 5 ft thick wall.

The maximum strains from SDH for any element for the different reinforcement configurations for this wall are combined with thermal strains. Table 4-7 shows the strain-based steel design check for this wall, where SDH strains are combined with T_0 strains for load combination 9-6 or T_a+P_a strains for load combination 9-9. Total strain in the steel is less than $1.2\varepsilon_y$(2.483×10^{-3}) for all sections within this wall, satisfying both load combinations 9-6 and 9-9. Therefore, the wall is considered acceptable.

Table 4-7. Strain-Based Steel Design Check for Pool Wall - West (Grid Line 2).

Location	Max ε_s ($\times10^{-3}$) from SDH		Max ε_s ($\times10^{-3}$) from T_0	Max ε_s ($\times10^{-3}$) from LC 9-6 ($SDH+T_0$)	$\varepsilon s < 1.2\varepsilon_y$?
	X	Y	X, Y	X, Y	LC 9-6
5'-0" Pool Wall	1.451	0.945	0.352	1.803	OK
Location	**Max ε_s ($\times10^{-3}$) from SDH**		**Max ε_s ($\times10^{-3}$) from T_a+P_a**	**Max ε_s ($\times10^{-3}$) from LC 9-9 ($SDH+T_a+P_a$)**	**$\varepsilon s < 1.2\varepsilon_y$?**
	X	**Y**	**X, Y**	**X, Y**	**LC 9-9**
5'-0" Pool Wall	1.451	0.945	1.016	2.467	OK

4.1.8 Pool Wall - Middle (Grid Line C)

The middle pool wall at Grid Line C consists of an interior wall that has two different thicknesses.

The maximum strains from SDH for any element for the different reinforcement configurations for this wall are combined with thermal strains. Table 4-8 shows the strain-based steel design check for this wall, where SDH strains are combined with T_0 strains for load combination 9-6 or T_a+P_a strains for load combination 9-9.

The total strain in the steel exceeds $1.2\varepsilon_y$ for both wall thicknesses for both load combination 9-6 and 9-9. Figure 4-8 through Figure 4-11 show the elements that exceed the allowable strain for combinations 9-6 and 9-9 in X and Y directions.

The total strain in the steel is less than $1.2\varepsilon_y$ (2.483×10^{-3}) after averaging the single elements without sufficient thermal capacity for load combination 9-6, therefore the condition is satisfied and the wall is considered acceptable. For groups of elements where adding the maximum strain from T_a+P_a would make the average fail, a more accurate T_a+P_a strain was obtained based on its location using the strain contour.

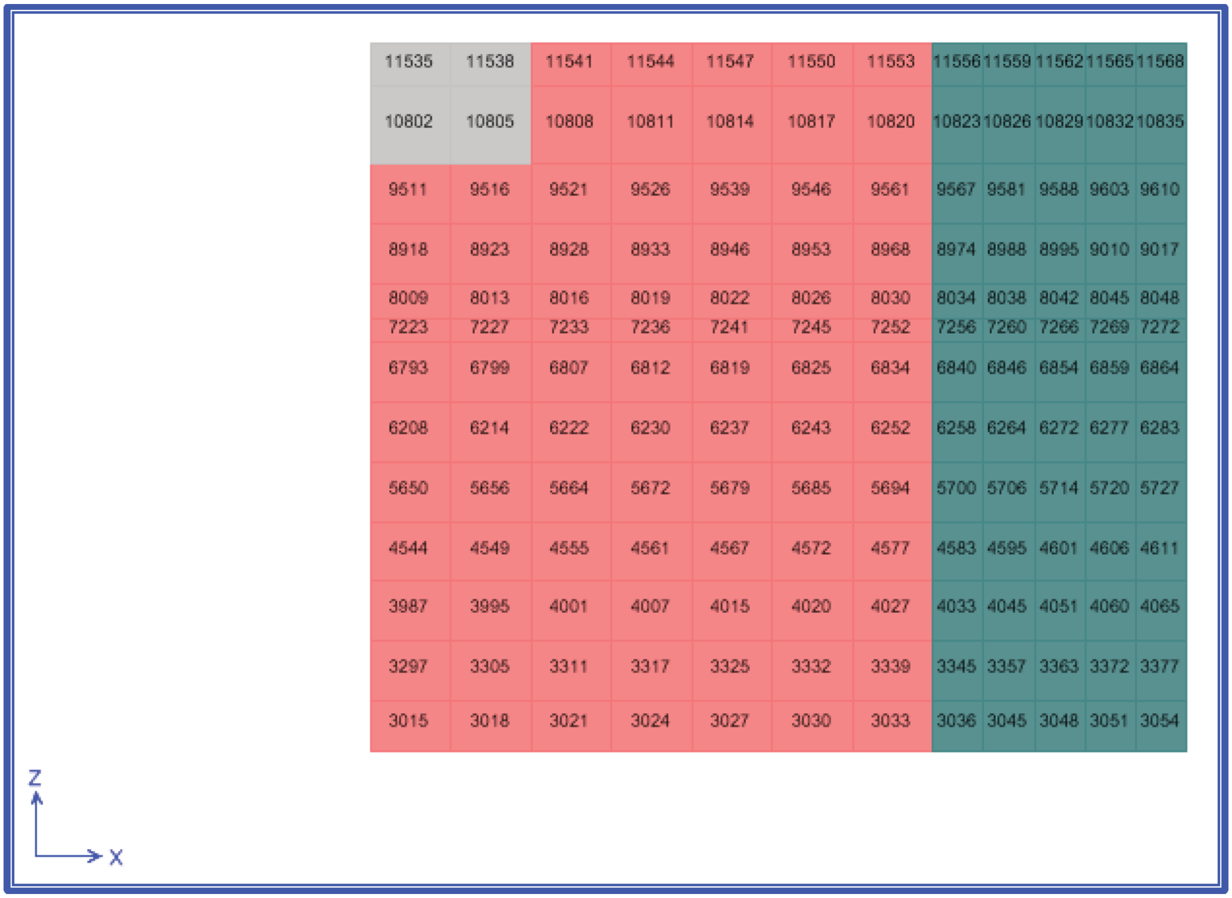

Figure 4-8. Single Elements from Pool Wall - Middle (Grid Line C) with Insufficient Thermal T0 Strain Capacity for Load Combination 9-6 in X Direction.

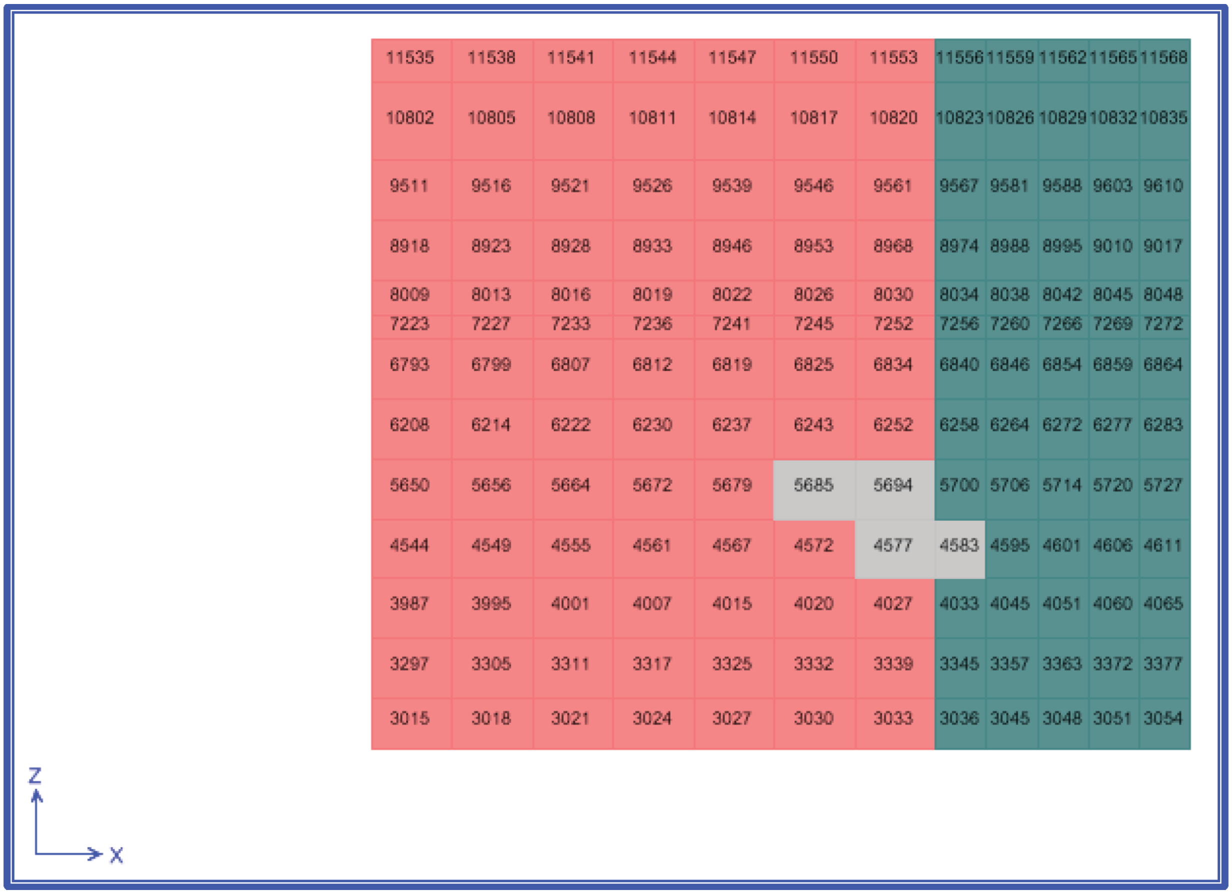

Figure 4-9. Single Elements from Pool Wall - Middle (Grid Line C) with Insufficient Thermal T0 Strain Capacity for Load Combination 9-6 in Y Direction.

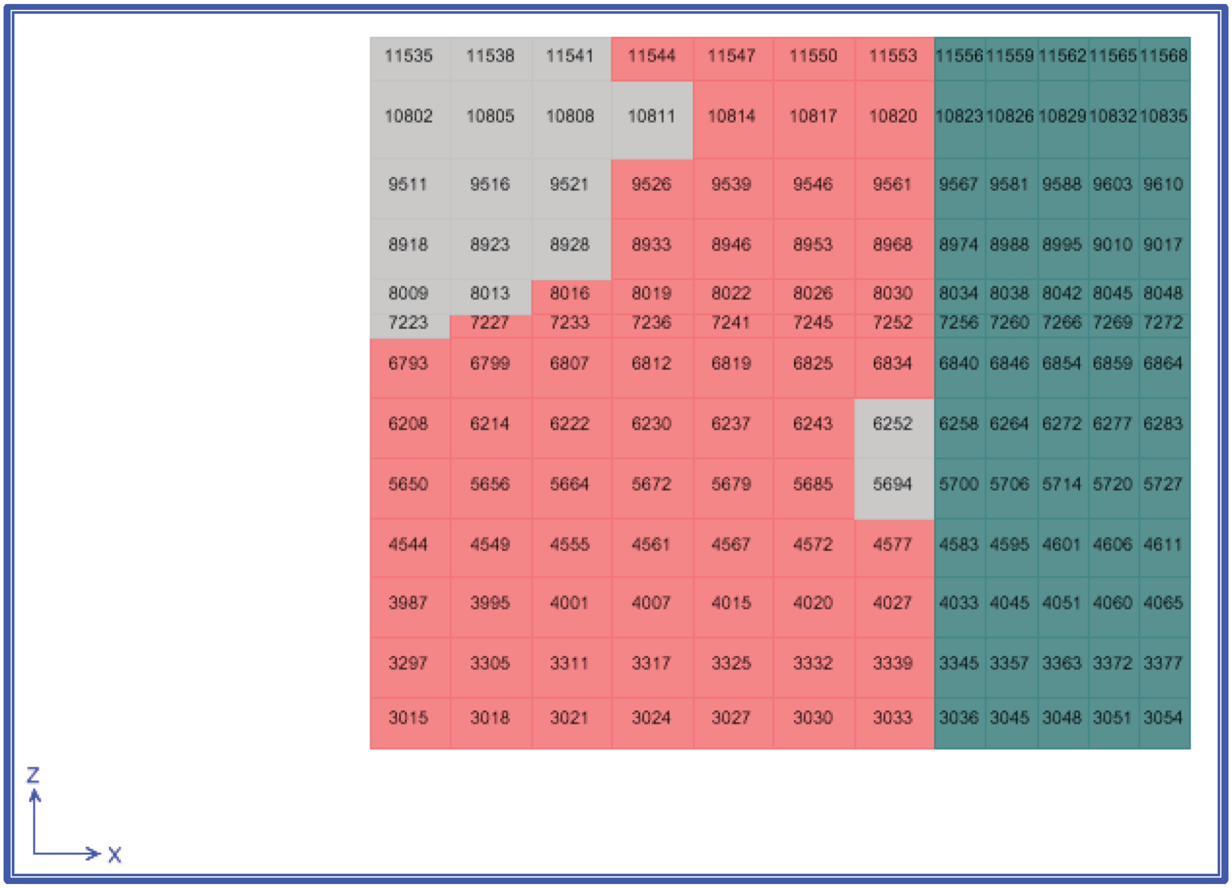

Figure 4-10. Single Elements from Pool Wall - Middle (Grid Line C) with Insufficient Thermal Ta+Pa Strain Capacity for Load Combination 9-9 in X Direction.

NUSCALE
Power for all humankind

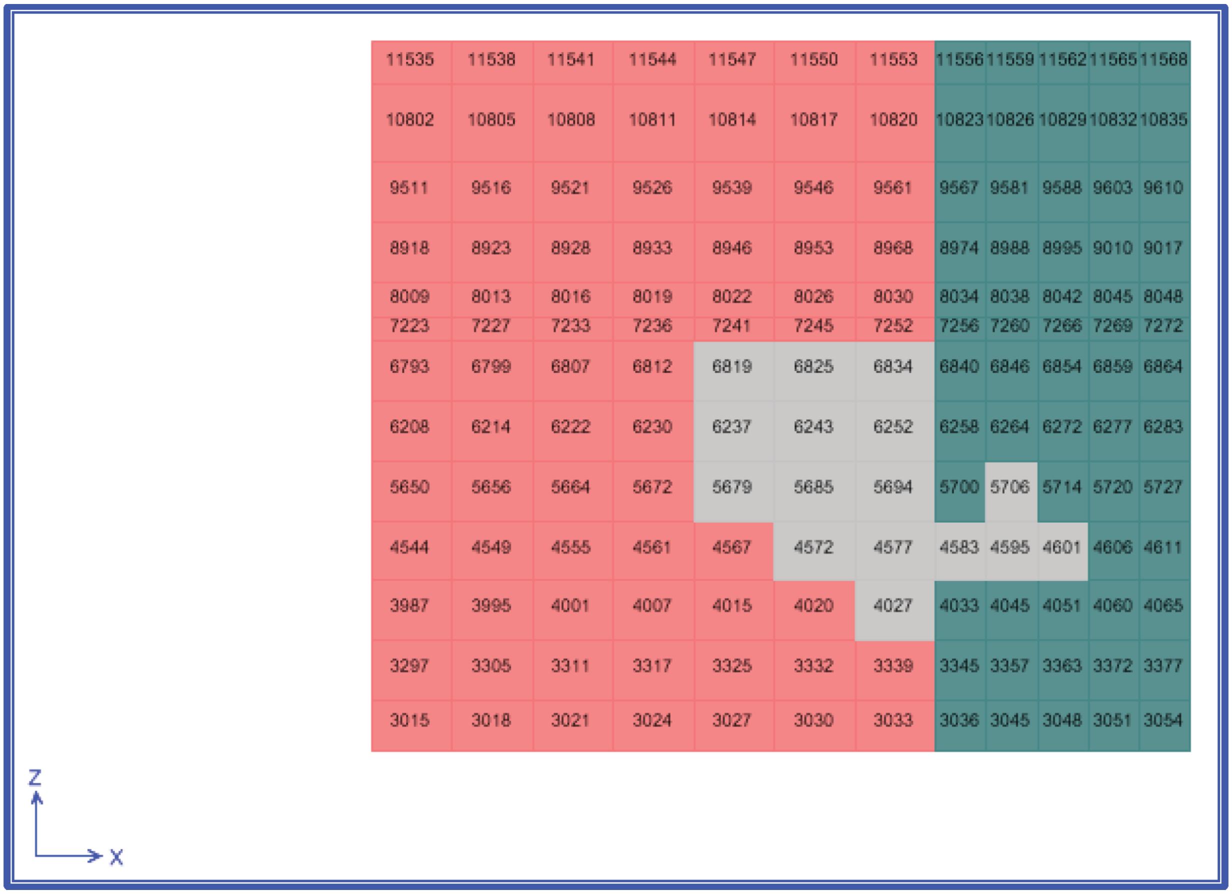

Figure 4-11. Single Elements from Pool Wall - Middle (Grid Line C) with Insufficient Thermal Ta+Pa Strain Capacity for Load Combination 9-9 in Y Direction.

Table 4-8. Strain-Based Steel Design Check for Pool Wall - Middle (Grid Line C) After Averaging Affected Elements.

Location	Max ε_s ($\times 10^{-3}$) from SDH		Max ε_s ($\times 10^{-3}$) from T_0	Max ε_s ($\times 10^{-3}$) from LC 9-6 (SDH+T_0)	$\varepsilon_s < 1.2\varepsilon_y$?
	X	Y	X, Y	X, Y	LC 9-6
5'-0" Wall	1.370	2.014	0.444	**2.458***	OK
6'-0" Dry Dock Wall	2.137	2.020	0.444	**2.461***	OK
Location	Max ε_s ($\times 10^{-3}$) from SDH		Max ε_s ($\times 10^{-3}$) from T_a+P_a	Max ε_s ($\times 10^{-3}$) from LC 9-9 (SDH+T_a+P_a)	$\varepsilon_s < 1.2\varepsilon_y$?
	X	Y	X, Y	X, Y	LC 9-9
5'-0" Wall	1.370	1.718	1.057	**2.479***	OK
6'-0" Dry Dock Wall	1.627	1.546	1.057	**2.469***	OK

*Bold cell indicates averaging was employed.

4.1.9 Pool Gate Support Wall

The pool gate support wall consists of a 6 ft thick wall under the pool gate.

The maximum strains from SDH for any element for the different reinforcement configurations for this wall are combined with thermal strains. Table 4-9 shows the strain-based steel design check for this wall, where SDH strains are combined with T_0 strains for load combination 9-6 or T_a+P_a strains for load combination 9-9. The total strain in the steel exceeds 1.2ε_y for the 6'-0" wall for both load combination 9-6 and 9-9.

The total strain in the steel exceeds 1.2ε_y for both wall thicknesses for both load combination 9-6 and 9-9. Figure 4-12 through Figure 4-15 show the elements that exceed the allowable strain for combinations 9-6 and 9-9 in X and Y directions.

The total strain in the steel is less than 1.2ε_y(2.483 $\times 10^{-3}$) after averaging the single elements without sufficient thermal capacity for load combination 9-6, therefore the condition is satisfied and the wall is considered acceptable. For groups of elements where adding the maximum strain from T_a+P_a would make the average fail, a more accurate T_a+P_a strain was obtained based on its location using the strain contour.

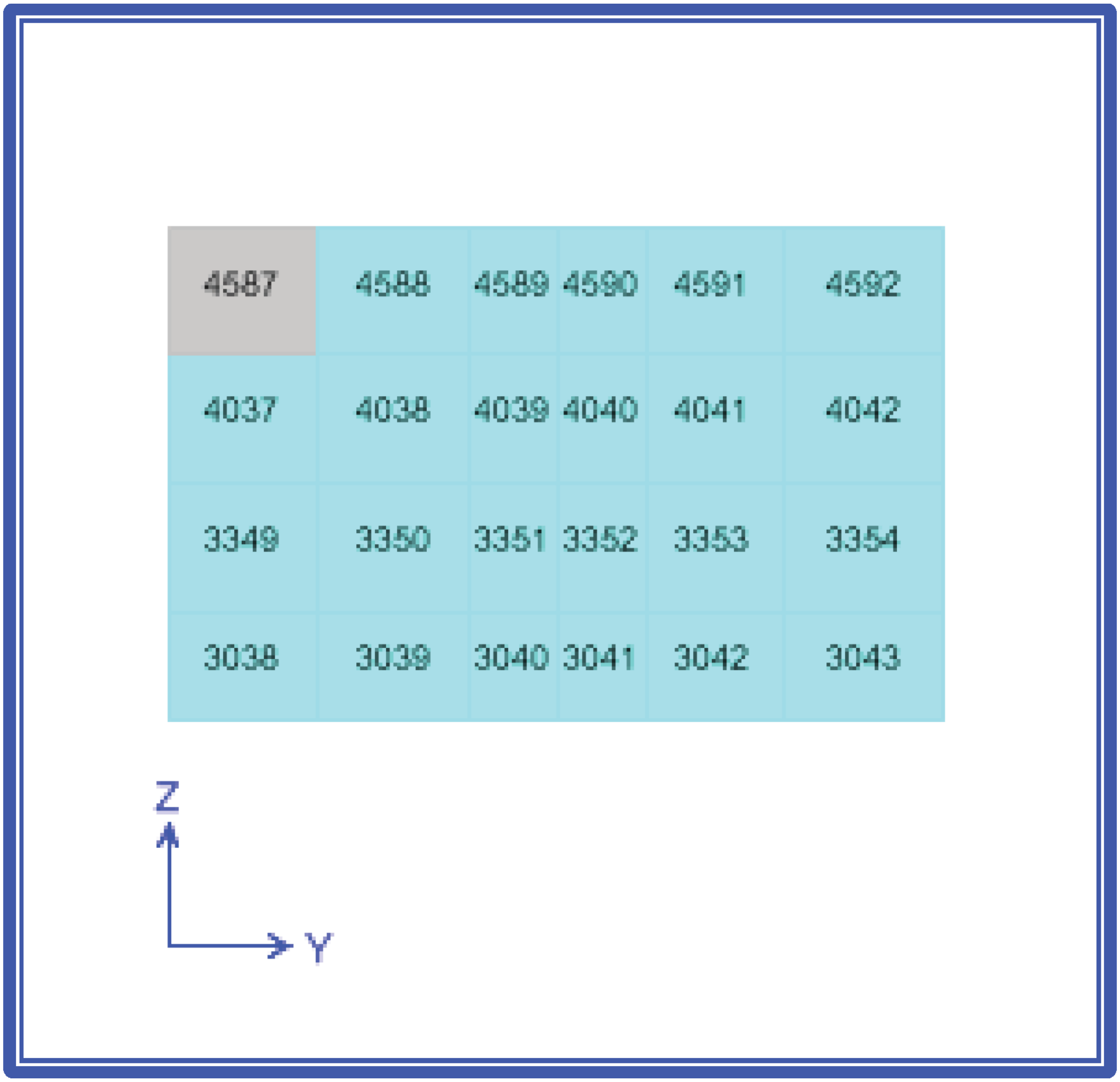

Figure 4-12. Single Elements from Pool Gate Support Wall with Insufficient Thermal T0 Strain Capacity for Load Combination 9-6 in X Direction.

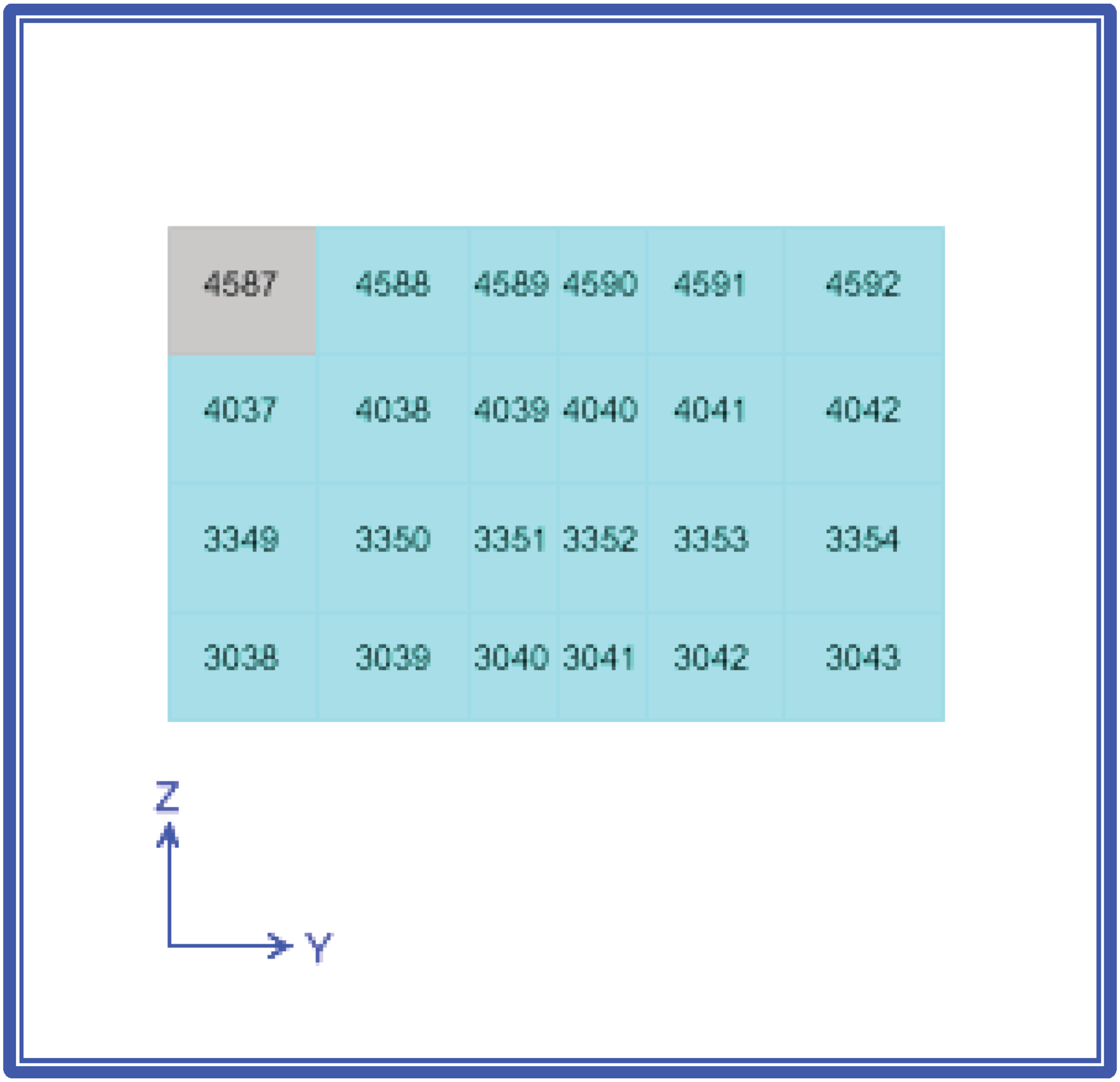

Figure 4-13. Single Elements from Pool Gate Support Wall with Insufficient Thermal T0 Strain Capacity for Load Combination 9-6 in Y Direction.

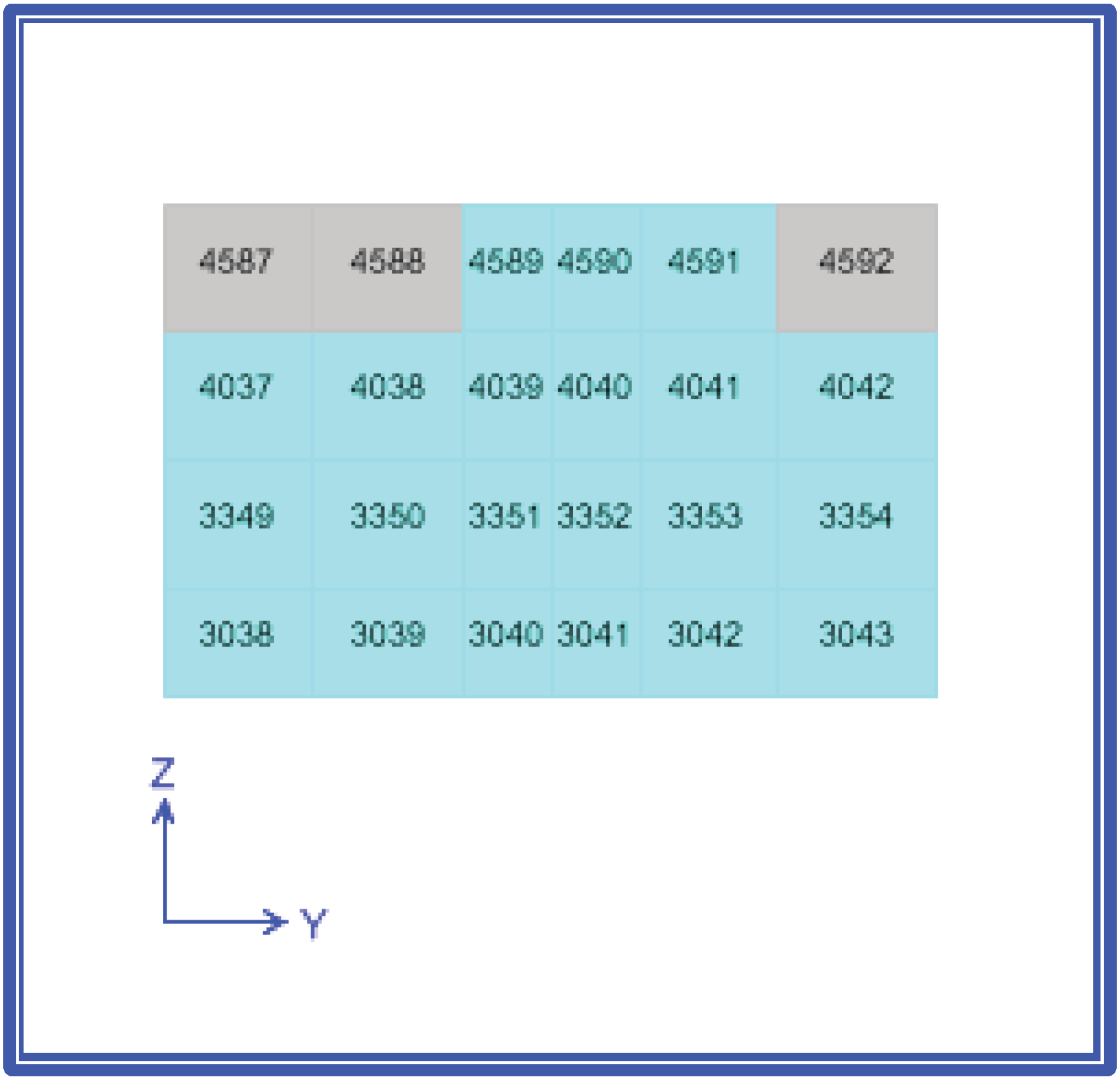

Figure 4-14. Single Elements from Pool Gate Support Wall with Insufficient Thermal Ta+Pa Strain Capacity for Load Combination 9-9 in X Direction.

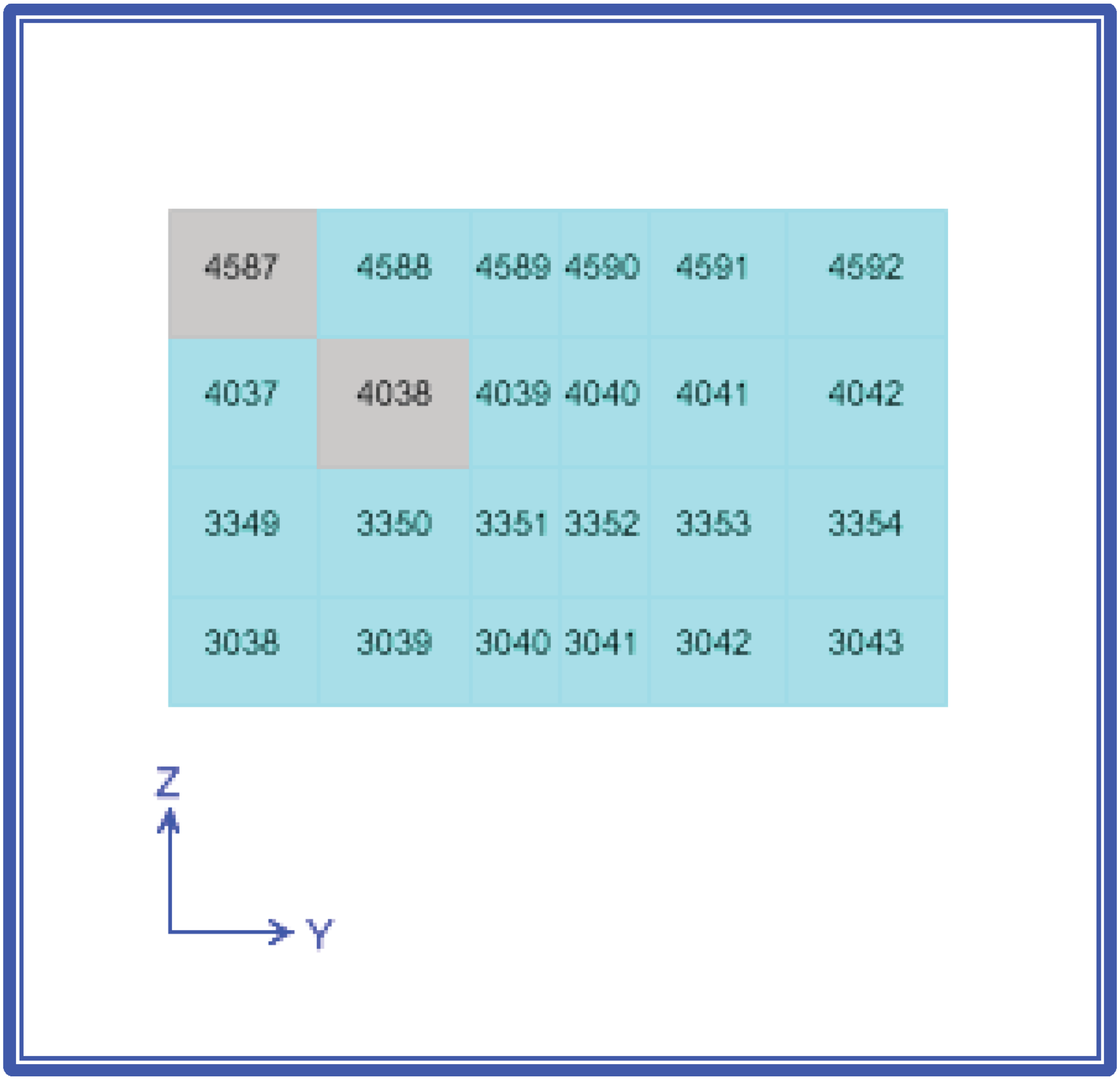

Figure 4-15. Single Elements from Pool Gate Support Wall with Insufficient Thermal Ta+Pa Strain Capacity for Load Combination 9-9 in Y Direction.

Table 4-9. Strain-Based Steel Design Check for Pool Gate Support Wall After Averaging Affected Elements.

Location	Max ε_s (×10^{-3}) from SDH		Max ε_s (×10^{-3}) from T_0	Max ε_s (×10^{-3}) from LC 9-6 (SDH+T_0)	$\varepsilon_s < 1.2\varepsilon y$?
	X	Y	X, Y	X, Y	LC 9-6
6'-0" Dry Dock Wall	2.023	1.351	0.459	2.482*	OK
Location	**Max ε_s (×10^{-3}) from SDH**		**Max ε_s (×10^{-3}) from T_a+P_a**	**Max ε_s (×10^{-3}) from LC 9-9 (SDH+T_a+P_a)**	**$\varepsilon_s < 1.2\varepsilon_y$?**
	X	**Y**	**X, Y**	**X, Y**	**LC 9-9**
6'-0" Dry Dock Wall	1.229	0.976	1.343	2.402*	OK

*Bold cell indicates averaging was employed.

4.1.10 Roof Support Stiffeners

The roof support stiffeners are 4 foot thick segments at Grid Lines 2, 3, 4, 5 and 6 under the roof.

The maximum strains from SDH for any element for the different reinforcement configurations for this wall are combined with thermal strains. Table 4-10 shows the strain-based steel design check for this wall, where SDH strains are combined with T_0 strains for load combination 9-6 or T_a+P_a strains for load combination 9-9.

The total strain in the steel is less than 1.2ε_y (2.483 ×10^{-3})for only one type of reinforcement for load combination 9-6. The total strain in the steel exceeds 1.2ε_y (2.483 ×10^{-3})for all other reinforcement types. Figure 4-16 and Figure 4-17 show the roof support stiffeners with insufficient thermal capacity in X direction for load combinations 9-6 and 9-9 respectively. The total strain in the steel is less than 1.2ε_y (2.483 ×10^{-3}) after averaging the single elements without sufficient thermal capacity for both load combinations 9-6 and 9-9, therefore the condition is satisfied and the wall is considered acceptable.

Table 4-10. Strain-Based Steel Design Check for Roof Support Stiffeners After Averaging Affected Elements.

Location	Max ε_s ($\times 10^{-3}$) from SDH		Max ε_s ($\times 10^{-3}$) from T_0	Max ε_s ($\times 10^{-3}$) from LC 9-6 (SDH+T_0)	$\varepsilon_s < 1.2\varepsilon_y$?
	X	Y	X, Y	X, Y	LC 9-6
4'-0" Interior Wall	2.092	1.139	0.333	2.425	OK
4'-0" Interior Wall	1.864	1.080	0.333	**2.197***	OK
Location	**Max ε_s ($\times 10^{-3}$) from SDH**		**Max ε_s ($\times 10^{-3}$) from T_a+P_a**	**Max ε_s ($\times 10^{-3}$) from LC 9-9 (SDH+T_a+P_a)**	**$\varepsilon_s < 1.2\varepsilon_y$?**
	X	**Y**	**X, Y**	**X, Y**	**LC 9-9**
4'-0" Interior Wall	1.308	1.139	0.870	**2.178***	OK
4'-0" Interior Wall	1.269	1.080	0.870	**2.139***	OK

*Bold cell indicates averaging was employed.

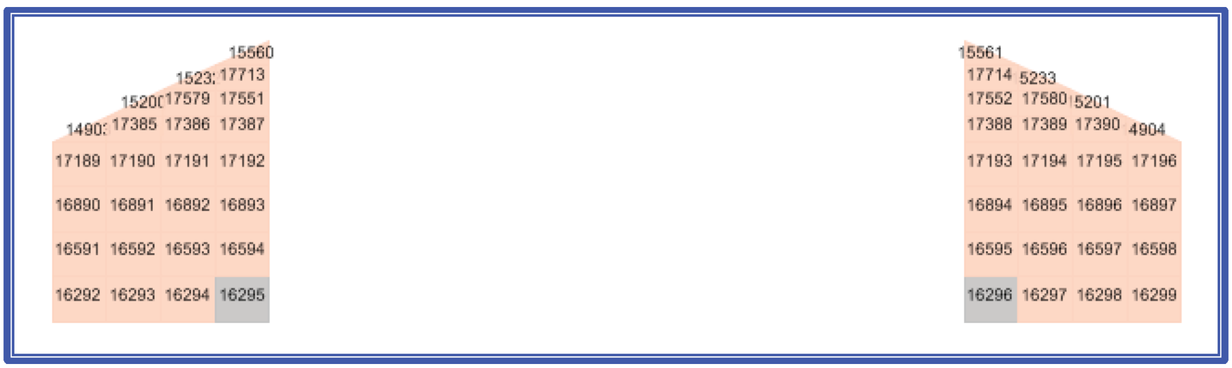

Figure 4-16. Single Elements from Roof Support Stiffeners with Insufficient Thermal T0 Strain Capacity for Load Combination 9-6 in X Direction.

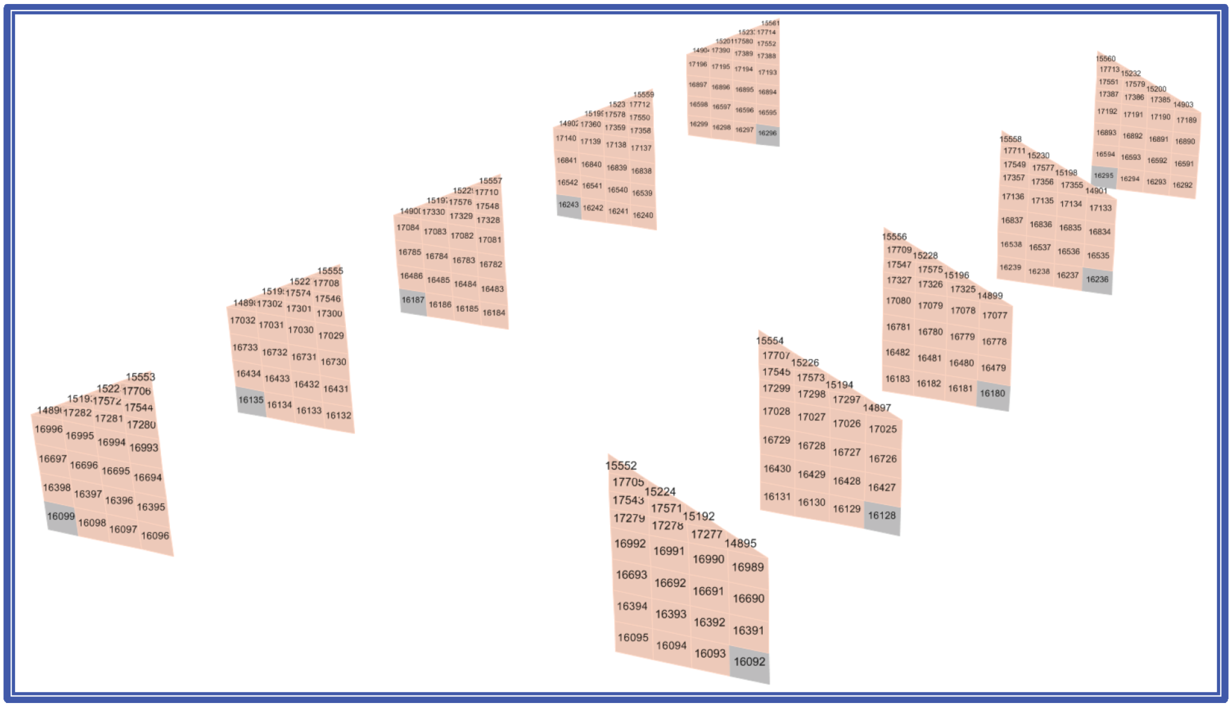

Figure 4-17. Single Elements from Roof Support Stiffeners with Insufficient Thermal Ta+Pa Strain Capacity for Load Combination 9-9 in X Direction.

4.1.11 Roof Support Wall Above Crane (Grid Line A.7)

The roof support wall above the crane is a 4 foot thick wall at Grid Line A.7 under the roof. . The maximum strains from SDH for any element for the different reinforcement configurations for this wall are combined with thermal strains. Table 4-11 shows the strain-based steel design check for this wall, where SDH strains are combined with T_0 strains for load combination 9-6 or T_a+P_a strains for load combination 9-9.

Table 4-11. Strain-Based Steel Design Check for Roof Support Wall Above Crane (Grid Line A.7).

Location	Max ε_s ($\times 10^{-3}$) from SDH		Max ε_s ($\times 10^{-3}$) from T_0	Max ε_s ($\times 10^{-3}$) from LC 9-6 (SDH+T_0)	$\varepsilon s < 1.2\varepsilon_y$?
	X	Y	X, Y	X, Y	LC 9-6
4'-0" Interior Wall	0.955	1.770	0.240	2.010	OK
Location	**Max ε_s ($\times 10^{-3}$) from SDH**		**Max ε_s ($\times 10^{-3}$) from T_a+P_a**	**Max ε_s ($\times 10^{-3}$) from LC 9-9 (SDH+T_a+P_a)**	**$\varepsilon_s < 1.2\varepsilon_y$?**
	X	**Y**	**X, Y**	**X, Y**	**LC 9-9**
4'-0" Interior Wall	0.955	1.770	0.665	2.435	OK

4.1.12 NPM Support Walls

The NPM support walls are 5 feet thick interior walls inside the pool area.

The maximum strains from SDH for any element for the different reinforcement configurations for this wall are combined with thermal strains. Table 4-12 shows the strain-based steel design check for this wall, where SDH strains are combined with T_0 strains for load combination 9-6 or T_a+P_a strains for load combination 9-9.

As shown in Table7-41, the total strain in the steel is less than $1.2\varepsilon_y$ (2.483×10^{-3}) at all locations for load combination 9-6. However, the total strain in the steel exceeds $1.2\varepsilon_y$ (2.483×10^{-3}) for one type of reinforcement for load combination 9-9. An averaging for these exceeding elements shown in Figure 4-18 is performed.

Table 4-12. Strain-Based Steel Design Check for NPM Support Walls After Averaging Affected Elements.

Location	Max ε_s ($\times 10^{-3}$) from SDH		Max ε_s ($\times 10^{-3}$) from T_0	Max ε_s ($\times 10^{-3}$) from LC 9-6 (SDH+T_0)	$\varepsilon_s < 1.2\varepsilon_y$?
	X	Y	X, Y	X, Y	LC 9-6
5'-0" Interior Wall	1.909	1.451	0.294	2.203	OK
Location	**Max ε_s ($\times 10^{-3}$) from SDH**		**Max ε_s ($\times 10^{-3}$) from T_a+P_a**	**Max ε_s ($\times 10^{-3}$) from LC 9-9 (SDH+T_a+P_a)**	**$\varepsilon_s < 1.2\varepsilon_y$?**
	X	**Y**	**X, Y**	**X, Y**	**LC 9-9**
5'-0" Interior Wall	1.487	1.451	0.776	**2.263***	OK

*Bold cell indicates averaging was employed.

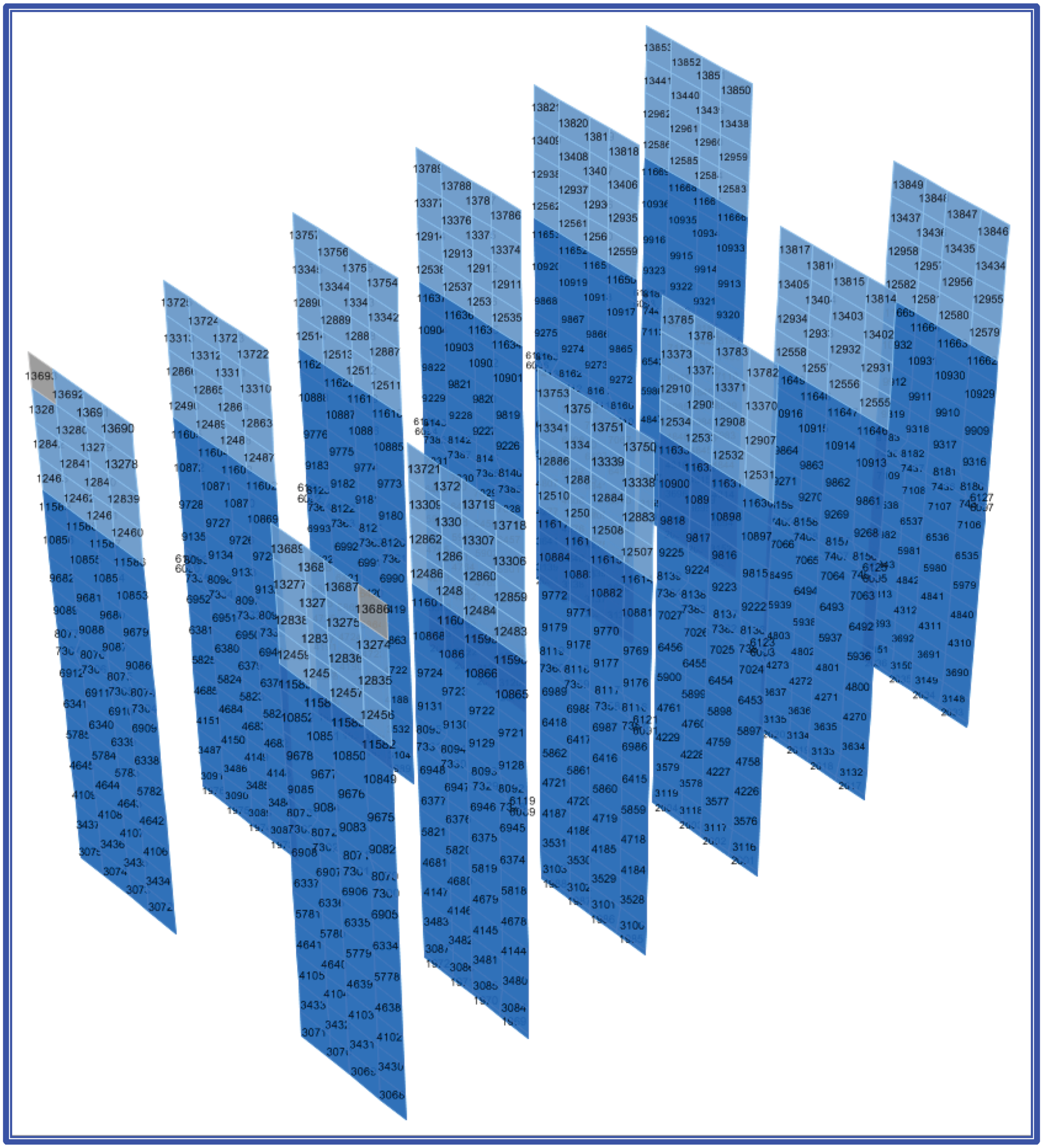

Figure 4-18. Single Elements from NPM Support Walls with Insufficient Thermal Ta+Pa Strain Capacity for Load Combination 9-9 in X Direction.

4.2 Slabs

4.2.1 Concrete Check for All Slabs

The maximum concrete strains from SDH for any element of the different slabs were extracted. Table 4-13 shows the strain-based concrete design check for all slabs. The total strain in the concrete is less than ε_{cu} = 0.003 at all locations.

Table 4-13. Strain-Based Concrete Design Check for All Slabs.

Location	Max ε_c ($\times 10^{-3}$) from SDH		$\varepsilon c < \varepsilon_{cu}$?
	X	Y	Concrete
Roof	0.564	1.062	OK
Major Slabs (TOC EL 50', 75', 100', 126')	0.572	1.069	OK

4.2.2 Roof

The roof is a 4 foot thick slab that begins at EL 163'-0", slopes inward, and is flat at TOC EL 181'-0".

The maximum strains from SDH for any element for the different reinforcement configurations for this slab are combined with thermal strains. Table 4-14 shows the strain-based steel design check for this wall, where SDH strains are combined with T_0 strains for load combination 9-6 or T_a+P_a strains for load combination 9-9. The total strain in the steel is less than 1.2ε_y (2.483 $\times 10^{-3}$) for all sections within the roof, satisfying both load combinations 9-6 and 9-9. Therefore, the roof is considered acceptable.

Table 4-14. Strain-Based Steel Design Check for Roof.

Location	Max ε_s ($\times10^{-3}$) from SDH		Max ε_s ($\times10^{-3}$) from T_0	Max ε_s ($\times10^{-3}$) from LC 9-6 (SDH+T_0)	$\varepsilon_s < 1.2\varepsilon_y$?
	X	Y	X, Y	X, Y	LC 9-6
4'-0" Roof	1.507	1.834	0.115	1.949	OK
Location	**Max ε_s ($\times10^{-3}$) from SDH**		**Max ε_s ($\times10^{-3}$) from T_a+P_a**	**Max ε_s ($\times10^{-3}$) from LC 9-9 (SDH+T_a+P_a)**	**$\varepsilon_s < 1.2\varepsilon_y$?**
	X	**Y**	**X, Y**	**X, Y**	**LC 9-9**
4'-0" Roof	1.507	1.834	0.488	2.322	OK

4.2.3 Major Floor Slabs

The major floor slabs for the RXB are found at EL 50'-0", 75'-0", 100'-0", and 126'-0". They are all 3 foot thick sections.

The maximum strains from SDH for any element for the different reinforcement configurations for these slabs are combined with thermal strains. Figure 4-15 shows the strain-based steel design check for this wall, where SDH strains are combined with T_0 strains for load combination 9-6 or T_a+P_a strains for load combination 9-9. For groups of elements where adding the maximum strain from T_0 would make the average fail, a more accurate T_0 strain was obtained based on its location using the strain contour. For groups of elements where adding the maximum strain from T_a+P_a would make the average fail, a more accurate T_a+P_a strain was obtained based on its location using the strain contour. Figure 4-19 and Figure 4-20 show the elements with insufficient capacity in Y-direction for load combinations 9-6 and 9-9 respectively.

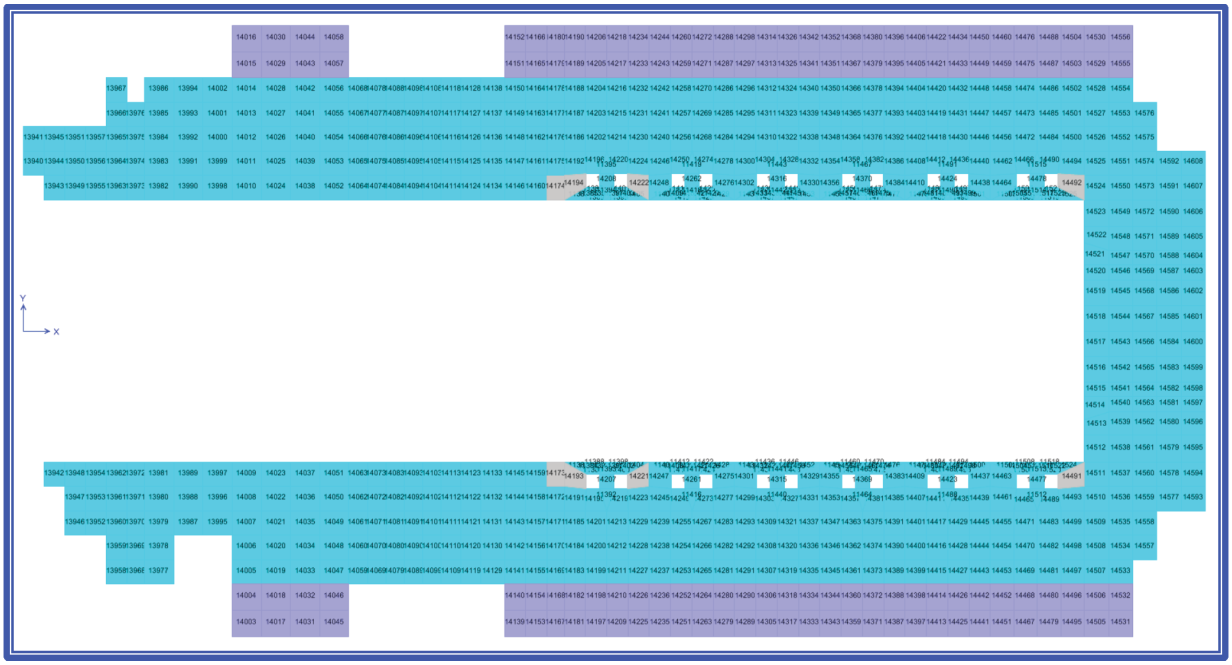

Figure 4-19. Single Elements from Major Floor Slabs with Insufficient Thermal T0 Strain Capacity for Load Combination 9-6 in Y Direction.

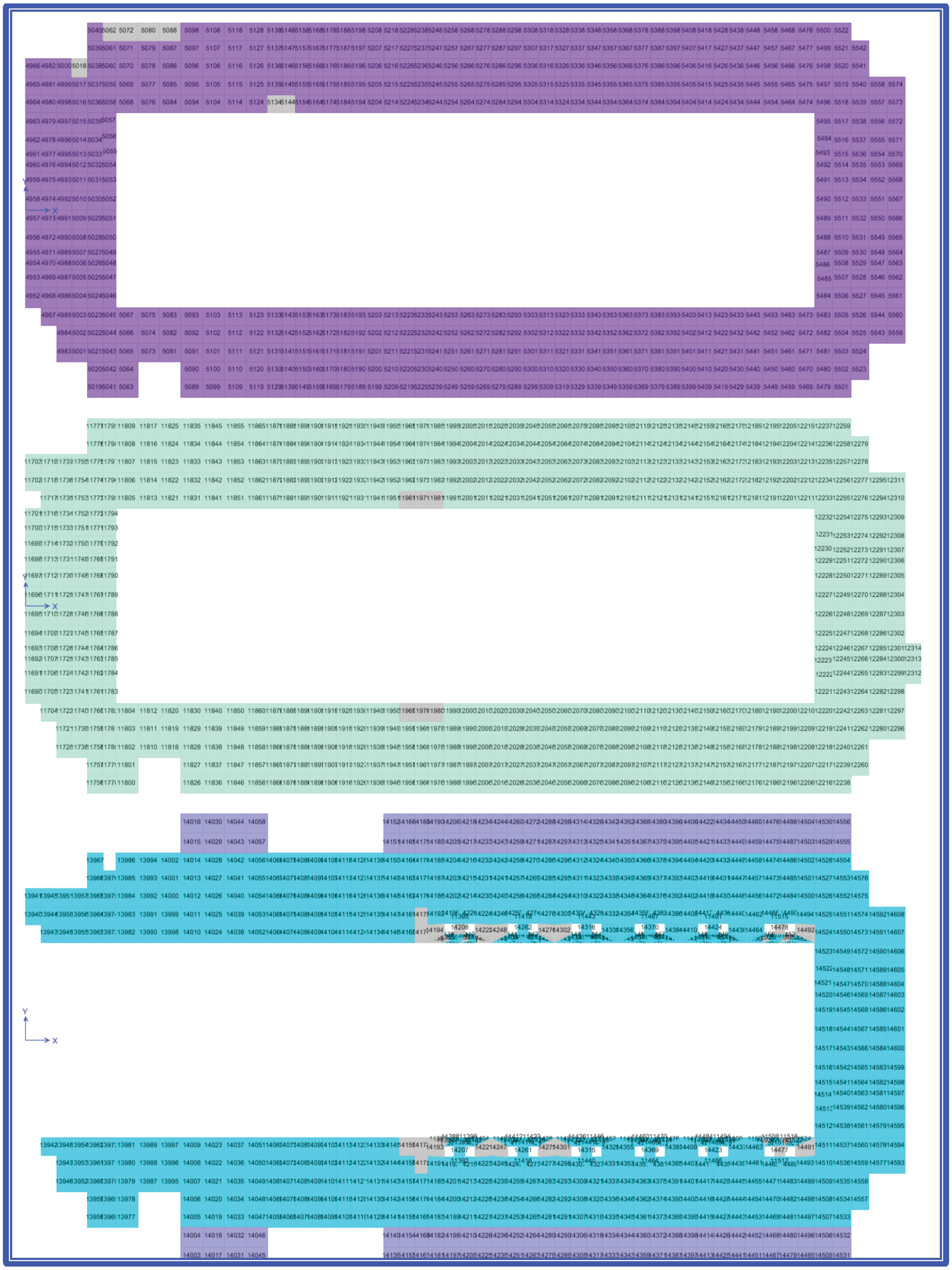

Figure 4-20. Single Elements from Major Floor Slabs with Insufficient Thermal Ta+Pa Strain Capacity for Load Combination 9-9 in Y Direction.

Table 4-15. Strain-Based Steel Design Check for Major Floor Slabs After Averaging Affected Elements.

Location	Max ε_s ($\times10^{-3}$) from SDH		Max ε_s ($\times10^{-3}$) from T_0	Max ε_s ($\times10^{-3}$) from LC 9-6 (SDH+T_0)	$\varepsilon_s < 1.2\varepsilon y$?
	X	Y	X, Y	X, Y	LC 9-6
3'-0" Floor Slab at EL 50'-0"	1.228	1.935	0.514	2.449	OK
3'-0" Floor Slab at EL 75'-0"	0.917	1.085	0.514	1.599	OK
3'-0" Floor Slab at EL 100'-0"	1.170	1.897	0.514	2.411	OK
3'-0" Floor Slab at EL 126'-0"	1.406	2.228	0.514	**2.443***	OK
Location	**Max ε_s ($\times10^{-3}$) from SDH**		**Max ε_s ($\times10^{-3}$) from T_a+P_a**	**Max ε_s ($\times10^{-3}$) from LC 9-9 (SDH+T_a+P_a)**	**$\varepsilon_s < 1.2\varepsilon_y$?**
	X	**Y**	**X, Y**	**X, Y**	**LC 9-9**
3'-0" Floor Slab at EL 50'-0"	1.228	1.776	0.961	**2.459***	OK
3'-0" Floor Slab at EL 75'-0"	0.917	1.085	0.961	2.046	OK
3'-0" Floor Slab at EL 100'-0"	1.170	1.767	0.961	**2.469***	OK
3'-0" Floor Slab at EL 126'-0"	1.406	2.164	0.961	**2.469***	OK

*Bold cell indicates averaging was employed.

4.3 Pilasters

4.3.1 Concrete Check for Pilasters at Grid Line A

The maximum concrete strains from SDH for any element of the pilasters at Grid Line A are then extracted. Table 4-16 shows the strain-based concrete design check for the pilasters at Grid Line A. The total strain in the concrete is less than ε_{cu} = 0.003 at all locations.

Table 4-16. Strain-Based Concrete Design Check for Pilasters at Grid Line A.

Location	Max ε_c ($\times10^{-3}$) from SDH	$\varepsilon_c < \varepsilon_{cu}$?
	X, Y	Concrete
Pilasters at Grid Line A	1.007	OK

4.3.2 Pilasters at Grid Line A

The pilasters on the wall at Grid Line A consist of five types of reinforcement. The maximum strains from SDH for any element considering all reinforcement configurations for these pilasters are combined with thermal strains. Table 4-17 shows the strain-based steel design check for this wall, where SDH strains are combined with T_0 strains for load combination 9-6 or T_a+P_a strains for load combination 9-9.

Figure 4-21 and Figure 4-22 show the elements that showed exceedances. An averaging for these exceeding elements is performed.

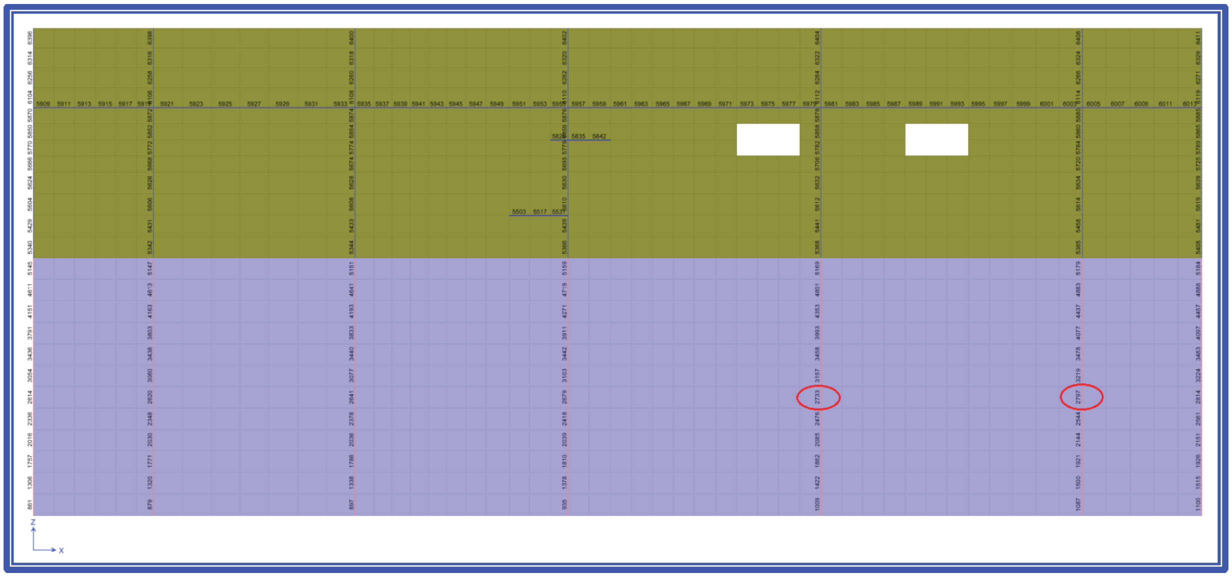

Figure 4-21. Single Elements from Pilasters at Grid Line A with Insufficient Thermal T0 Strain Capacity for Load Combination 9-6.

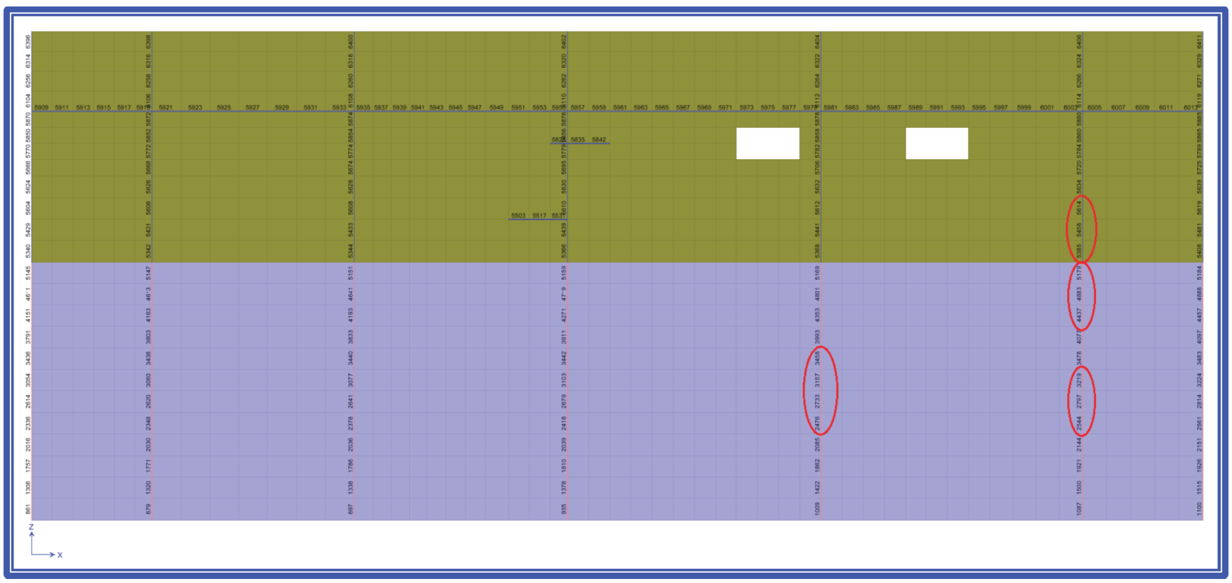

Figure 4-22. Single Elements from Pilasters at Grid Line A with Insufficient Thermal Ta +Pa Strain Capacity for Load Combination 9-9.

Table 4-17. Strain-Based Steel Design Check for Pilasters at Grid Line A After Averaging Affected Elements.

Location	Max ε_s ($\times 10^{-3}$) from SDH	Max ε_s ($\times 10^{-3}$) from T_0	Max ε_s ($\times 10^{-3}$) from LC 9-6 (SDH+T_0)	$\varepsilon s < 1.2\varepsilon_y$?
	X, Y	X, Y	X, Y	LC 9-6
Pilasters at Grid Line A	2.131	0.373	**2.482***	OK
Location	**Max ε_s ($\times 10^{-3}$) from SDH**	**Max ε_s ($\times 10^{-3}$) from T_a+P_a**	**Max ε_s ($\times 10^{-3}$) from LC 9-9 (SDH+T_a+P_a)**	**$\varepsilon_s < 1.2\varepsilon_y$?**
	X, Y	**X, Y**	**X, Y**	**LC 9-9**
Pilasters at Grid Line A	2.078	0.672	**2.468***	OK

*Bold cell indicates averaging was employed.

4.4 Buttresses

4.4.1 Concrete Check for Buttresses

The maximum concrete strains from SDH for any element of the buttresses were extracted. Table 4-18 shows the strain-based concrete design check for the buttresses. The total strain in the concrete is less than ε_{cu} = 0.003 at all locations.

Table 4-18. Strain-Based Concrete Design Check for Buttresses.

Location	Max ε_c ($\times 10^{-3}$) from SDH	$\varepsilon c < \varepsilon_{cu}$?
	X, Y	Concrete
Buttress at TOC EL 126'-0" and 145'-0"	0.918	OK

4.4.2 Buttress at TOC EL 126'-0" and 145'-0"

The buttresses at TOC EL 126'-0' and 145'-0" consist of a single reinforcement type.
The maximum strains from SDH for any element for the different reinforcement configurations for these buttresses are combined with thermal strains. Table 4-19 shows the strain-based steel design check for this wall, where SDH strains are combined with T_0 strains for load combination 9-6 or T_a+P_a strains for load combination 9-9. The total strain in the steel is less than $1.2\varepsilon_y$ (2.483 $\times 10^{-3}$) at all locations for load combination 9-6. However, the total strain in the steel exceeds $1.2\varepsilon_y$(2.483 $\times 10^{-3}$) for load combination 9-9. Figure 4-23 show the elements with exceedances. An averaging for these exceeding elements is performed.

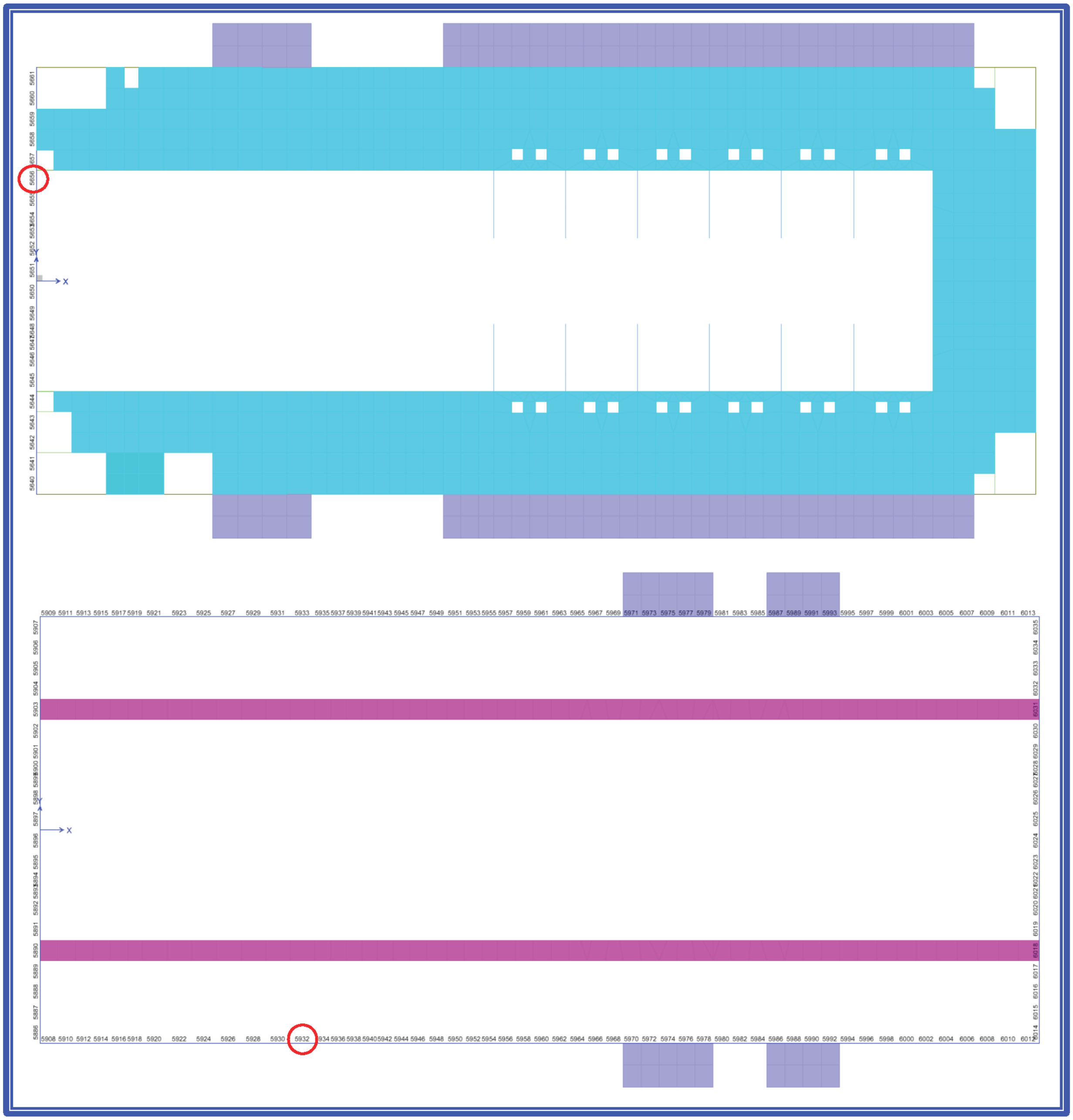

Figure 4-23. Single Elements from Buttress at TOC EL 126'-0" and 145'-0" with Insufficient Thermal T_a+P_a Strain Capacity for Load Combination 9-9.

Table 4-19. Strain-Based Steel Design Check for Buttress at TOC EL 126'-0" and 145'-0" After Averaging Affected Elements.

Location	Max ε_s ($\times 10^{-3}$) from SDH	Max ε_s ($\times 10^{-3}$) from T_0	Max ε_s ($\times 10^{-3}$) from LC 9-6 (SDH+T_0)	$\varepsilon_s < 1.2\varepsilon_y$?
	X, Y	X, Y	X, Y	LC 9-6
10'x5' Buttress at EL 126'-0"	1.937	0.373	2.310	OK
10'x5' Buttress at EL 145'-0"	1.881	0.373	2.254	OK
Location	**Max ε_s ($\times 10^{-3}$) from SDH**	**Max ε_s ($\times 10^{-3}$) from T_a+P_a**	**Max ε_s ($\times 10^{-3}$) from LC 9-9 (SDH+T_a+P_a)**	**$\varepsilon_s < 1.2\varepsilon_y$?**
	X, Y	**X, Y**	**X, Y**	**LC 9-9**
10'x5' Buttress at EL 126'-0"	1.862	0.616	**2.478***	OK
10'x5' Buttress at EL 145'-0"	1.857	0.616	**2.473***	OK

*Bold cell indicates averaging was employed.

4.5 T-Beams

4.5.1 Concrete Check for T-Beams

The maximum concrete strains from SDH for any element of the T-beams are then extracted. Table 4-20 shows the strain-based concrete design check for the T-beams. The total strain in the concrete is less than ε_{cu} = 0.003 at all locations.

Table 4-20. Strain-Based Concrete Design Check for T-Beams.

Location	Max ε_c ($\times 10^{-3}$) from SDH	$\varepsilon_c < \varepsilon_{cu}$?
	X, Y	Concrete
T-Beams at TOC EL 50'-0", 75'-0", and 100'-0"	0.872	OK

4.5.2 T-Beams at TOC EL 50'-0", 75'-0", and 100'-0"

The T-beams are embedded within the slabs at EL 50'-0", 75'-0", and 100'-0".

The maximum strains from SDH for any element for the different reinforcement configurations for these T-beams are combined with thermal strains. Table 4-21 shows the strain-based steel design check for this wall, where SDH strains are combined with T_0 strains for load combination 9-6 or T_a+P_a strains for load combination 9-9.

The total strain in the steel is less than $1.2\varepsilon_y$ (2.483×10^{-3}) at all locations for load combination 9-6. However, the total strain in the steel exceeds $1.2\varepsilon_y$ (2.483×10^{-3}) for two elevations for load combination 9-9 as shown in Figure 4-24.

An averaging for these exceeding elements is performed. After averaging the single elements without sufficient thermal capacity for load combination 9-9, therefore, the condition is satisfied and the wall is considered acceptable.

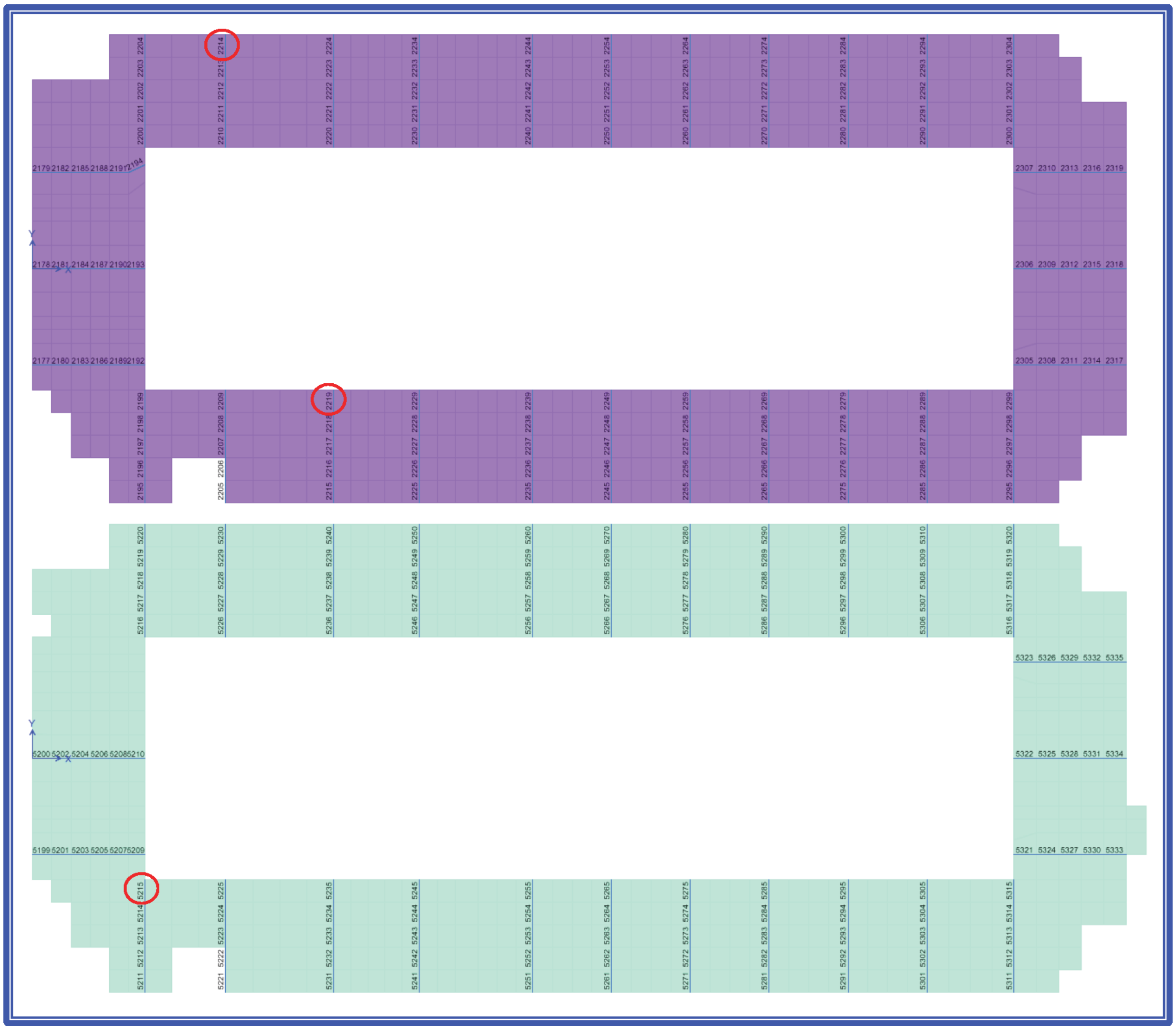

Figure 4-24. Single Elements from T-Beams at TOC EL 50'-0", 75'-0", and 100'-0" with Insufficient Thermal T_a+P_a Strain Capacity for Load Combination 9-9.

Table 4-21. Strain-Based Steel Design Check for T-Beams at TOC EL 50'-0", 75'-0", and 100'-0" After Averaging Affected Elements.

Location	Max ε_s ($\times10^{-3}$) from SDH	Max ε_s ($\times10^{-3}$) from T_0	Max ε_s ($\times10^{-3}$) from LC 9-6 (SDH+T_0)	$\varepsilon_s < 1.2\varepsilon_y$?
	X, Y	X, Y	X, Y	LC 9-6
T-Beams at EL 50'-0"	1.913	0.514	2.427	OK
T-Beams at EL 75'-0"	1.430	0.514	1.944	OK
T-Beams at EL 100'-0"	1.699	0.514	2.213	OK
Location	**Max ε_s ($\times10^{-3}$) from SDH**	**Max ε_s ($\times10^{-3}$) from T_a+P_a**	**Max ε_s ($\times10^{-3}$) from LC 9-9 (SDH+T_a+P_a)**	**$\varepsilon s < 1.2\varepsilon_y$?**
	X, Y	**X, Y**	**X, Y**	**LC 9-9**
T-Beams at EL 50'-0"	1.405	0.961	**2.366***	OK
T-Beams at EL 75'-0"	1.430	0.961	2.391	OK
T-Beams at EL 100'-0"	1.330	0.961	**2.291***	OK

*Bold cell indicates averaging was employed.

4.6 Foundation

4.6.1 Concrete Check for Foundation

Figure 4-22 shows the strain-based concrete design check for the foundation. The total strain in the concrete is less than ε_{cu} = 0.003 at all locations.

Table 4-22. Strain-Based Concrete Design Check for Foundation.

Location	Max ε_c ($\times10^{-3}$) from SDH		$\varepsilon_c < \varepsilon_{cu}$?
	X	Y	Concrete
RXB Basemat (Perimeter Region)	0.919	0.852	OK
RXB Basemat (Interior Region)	0.806	0.687	OK

4.6.2 Reinforcing Steel Check for Foundation

The reinforced concrete section for the basemat is comprised of a 120 in. overall thickness concrete slab. The strains for static, dynamic, and hydrodynamic pressure (SDH) for the maximum demand forces and moments for the RXB foundation basemat were calculated in Section 3.3.4 and combined with thermal strains. Table 4-23 shows the strain-based steel design check for the foundation, where SDH strains are combined with T_0 strains for load combination 9-6 or T_a+P_a strains for load combination 9-9.

Table 4-23. Strain-Based Steel Design Check for Foundation.

Location	Max ε_s ($\times10^{-3}$) from SDH		Max ε_s ($\times10^{-3}$) from T_0	Max ε_s ($\times10^{-3}$) from LC 9-6 ($SDH+T_0$)	$\varepsilon_s < 1.2\varepsilon y$?
	X	Y	X, Y	X, Y	LC 9-6
RXB Basemat (Perimeter Region)	2.157	2.230	0.112	2.342	OK
RXB Basemat (Interior Region)	1.628	1.523	0.112	1.740	OK
Location	**Max ε_s ($\times10^{-3}$) from SDH**		**Max ε_s ($\times10^{-3}$) from T_a+P_a**	**Max ε_s ($\times10^{-3}$) from LC 9-9 ($SDH+T_a+P_a$)**	**$\varepsilon_s < 1.2\varepsilon y$?**
	X	**Y**	**X, Y**	**X, Y**	**LC 9-9**
RXB Basemat (Perimeter Region)	2.157	2.230	0.367	2.597	OK
RXB Basemat (Interior Region)	1.628	1.523	0.367	1.995	OK

The total strain in the steel is less than $1.2\varepsilon_y$ (2.483×10^{-3}) at all locations except at the perimeter region for load combination 9-9 where it is exceeded by 5%. However, the SDH strains calculated are conservative because they are based on the maximum axial, shear, and moment components over all of the elements. These do not occur at the same location or time. If the strains were based on the forces and moments occurring simultaneously at the same location, and if averaging were used, the strains would be lower. Also, the thermal strain of 0.000367 for T_a+P_a is the maximum over the entire basemat and occurs in the pool area. The thermal strains in the foundation perimeter region are lower. Therefore, the strains are extremely conservative, and the foundation design is considered acceptable.

4.6.3 Steel Pool Liner

4.6.3.1 Steel Check for Pool Liner

The pool walls and NPM support walls are lined with a ¼" thick stainless steel plate to protect the concrete and reinforcing steel from the boron-containing water and to protect the water chemistry from contaminants.

Table 4-24 shows the strain-based steel design check for the steel pool liner, where SDH strains are combined with T_0 strains for load combination 9-6 or T_a+P_a strains for load combination 9-9.

Table 4-24. Strain-Based Steel Design Check for Steel Pool Liner.

Location	Max ε_s ($\times 10^{-3}$) from SDH		Max ε_s ($\times 10^{-3}$) from T_0	Max ε_s ($\times 10^{-3}$) from LC 9-6 ($SDH+T_0$)	$\varepsilon_s < 0.004$?
	X	Y	X, Y	X, Y	LC 9-6
Steel Pool Liner	0.363	0.066	0.895	1.258	OK
Location	Max ε_s ($\times 10^{-3}$) from SDH		Max ε_s ($\times 10^{-3}$) from T_a+P_a	Max ε_s ($\times 10^{-3}$) from LC 9-9 ($SDH+T_a+P_a$)	$\varepsilon_s < 0.004$?
	X	Y	X, Y	X, Y	LC 9-9
Steel Pool Liner	0.363	0.066	2.181	2.544	OK

Per Table CC-3720-1 of ASME Boiler and Pressure Vessel Code, the allowable strain limit for the liner plate is 0.004 in/in for service load conditions. The total strain in the steel is less than 0.004 in/in at all locations for load combinations 9-6 and 9-9. Therefore, the steel pool liner is considered acceptable.

5.0 References

5.1 American Concrete Institute, "Reinforced Concrete Design for Thermal Effects on Nuclear Power Plant Structures," ACI 349.1R-07, Farmington Hills, MI.

5.2 ASME Boiler and Pressure Vessel Code, Section III, Division 2, 2017.

and +115°F. The external soil temperature is assumed to be 21°F in the winter and 40°F in the summer.

RAI 03.08.04-13

The RXB has a design internal air temperature range of 70°F to 130°F, and a design pool temperature range of 40°F to 14~~2~~0°F. These temperatures are used to determine the stresses and displacements.

The CRB has a maximum temperature differential of 110°F, based on an external temperature of -40°F and an internal temperature of 70°F. This gradient has been determined not to affect the design stresses in the building. T_0 is not a load for the CRB.

3.8.4.3.9 Accident Thermal Loads (T_a)

The maximum post accident temperature in the RXB is assumed to be 212°F. This temperature is used in conjunction with the external temperature to determine the stresses and displacements.

The CRB does not have any high energy or high temperature piping. T_a is not a load for the CRB.

3.8.4.3.10 Rain Load (R)

RAI 02.03.01-3

The flat portion of the roof of the RXB does not have a parapet or any means to retain water. The CRB roof is sloped and the parapet has scuppers to disperse rainwater. An additional drainage pipe limits the average water depth on the CRB roof to a maximum of 4 inches. Therefore a rain load is assumed bounded by the snow load and extreme snow load.

3.8.4.3.11 Snow Loads (S)

RAI 02.03.01-2, RAI 02.03.01-3

As shown in Table 2.0-1, a roof snow load of 50 psf is assumed for normal load combinations. Equation 3.8-1 (taken from Equation 7-1 of Reference 3.8.4-8) is used to convert from ground-level snow loads to roof snow loads. An exposure factor of 1.0 is used. A thermal factor of 1.0 is used. An importance factor of 1.2 is used for buildings listed as Seismic Category I in Table 3.2-1 and an importance factor of 1.0 is used for the other buildings.

$$p_f = 0.7C_eC_tIp_g \qquad \text{Equation 3.8-1}$$

where,

p_f is the roof snow load,

The SSE for the site independent evaluation of the RXB and CRB is the CSDRS and the CSDRS-HF from Table 2.0-1. SSE Seismic Loads (E_{ss}) are derived from evaluation of the structures using ground motion accelerations from the CSDRS and the CSDRS-HF as described in Section 3.7.

Seismic dynamic analyses of the buildings considered 100 percent of the dead load and, 25 percent of the floor live load during normal operation and 75 percent of the roof snow load as the accelerated mass.

3.8.4.3.17 Crane Load (C_{cr})

This load comes from the RBC. The RBC is a bridge crane located at EL. 145'-6" and provide lifting and handling for the NPMs. The RBC is described in more detail in Section 9.1 and Section 3.7.3. The RBC has a total weight of approximately 1,000 tons and a lifting capacity of 850 tons.

The crane live loads are used for the design of the runways beams, connections and crane supports. These crane live loads are due to the moving crane and include the maximum wheel load, vertical impact, lateral impact and longitudinal impact loads.

The maximum wheel load for the RBC is produced by the weight of the bridge, plus the sum of the maximum lift capacity and the weight of the trolley positioned on its runway at the location where the resulting load effect is maximum. The hook and trolley are assumed to align with the crane wheel location. Therefore, the trolley and lift load are assumed to act 100% on the ends. The bridge weight is distributed 50% to each end. There are 16 crane wheels at each end of the crane.

There are no large cranes in the CRB. C_{cr} is not a load for the CRB.

3.8.4.3.18 Accident Pressure Loads (P_a)

RAI 03.08.04-13

Accident pressure loads, within a compartment or the entire building are due to the differential pressure generated by a postulated pipe rupture, including the dynamic effects due to pressure time-history is considered in the design. In the RXB an accident pressure of ~~1~~3.0psi has been evaluated in the pool area to account for the energy release of a high energy line break.

There are no accident pressure loads in the CRB. P_a is not a load for the CRB.

3.8.4.3.19 Jet Impingement Load (Y_j)

RAI 03.08.04-12, RAI 03.08.04-13

This is a localized load on the structure due to the steam/water jet from a high energy line break and is evaluated per COL Item 3.6-2 and COL Item 3.6-3. The magnitude of the Jet Impingement Load in the RXB is 57.2 kips.

There are no high energy lines in the CRB. Y_j is not a load for the CRB.

3.8.4.3.20 Pipe Break Reaction Loads (Y_r)

RAI 03.08.04-12, RAI 03.08.04-13

This is a localized load on the structure generated by the pipe hanger that is due to a high energy line break and is evaluated per COL Item 3.6-2 and COL Item 3.6-3. The magnitude of the Pipe Break Reaction Load in the RXB is 57.2 kips.

There are no high energy lines in the CRB. Y_r is not a load for the CRB.

3.8.4.3.21 Missile Impact Loads (Y_m)

This is a localized load on the structure due to the whipping high energy line or a missile from a high energy line break. Internal missile loads, if they occur, will be evaluated on an individual basis as a localized load per COL Item 3.6-2 and 3.6-3.

There are no high energy lines in the CRB. Y_m is not a load for the CRB.

3.8.4.3.22 Other Loads

3.8.4.3.22.1 Buoyant Force (B)

The buoyant force is the upward pressure exerted on the bottom of the foundation during a saturated condition. It is the equivalent weight of the water that would otherwise occupy the below grade volume of the structure. The buoyant force is equal to the volume of the building below grade multiplied by the density of water. See Section 3.8.5.3 for use of buoyant force with the RXB and the CRB structures.

3.8.4.3.22.2 Construction Loads

Construction loads are loads from events and activities during construction. These loads will be developed in accordance with Standard SEI/ASCE 37-02, "Design Loads on Structures During Construction." Construction loads are not included when determining seismic loads.

3.8.4.3.22.3 Operation with Less than 12 NuScale Power Modules

The NuScale design allows for operation with less than twelve NPMs. The building analysis was performed with all twelve NPMs in place. However, a study was performed as described in Section 3.7.2.9.1 to evaluate the dynamic effects of an earthquake when operating with less than twelve NPMs. That study concluded that the dynamic effects on the building with less than twelve modules installed would be similar to the dynamic effects when all twelve modules are in place.

hydrodynamic mass), equipment joint nodal and uniform loads, uniform floor live loads, and roof snow loads. The specified load cases used in computing dynamic mass are defined by specifying the multiplier for each load case considered. In this model, all long term loads were assigned a multiplier of 1.0, live loads a multiplier of 0.25, and snow loads a multiplier of 0.75. Live load mass participation requirements for dynamic analyses are described in Section 3.8.4.3.4. Table 3.8.4-7 lists the additional masses included from various load cases and its corresponding multipliers, which are considered as one of the mass sources for the RXB SAP2000 models for 1-g and dynamic analyses performed. The purpose of the 1-g analysis is to verify the SAP2000 model has been converted accurately to the SASSI2010 model. In addition to comparing structural frequencies of the two models, 1-g analysis (i.e., total weight) is performed in the three global directions, and the total model weight is obtained at the fixed base of the model in the loading direction. As shown in Table 3.8.4-13 and Table 3.8.4-14, total weights of the two models are nearly identical. Thus, it is concluded that the SAP2000 model of the RXB with backfill has been accurately converted to the SASSI2010 model.

RAI 03.08.04-29

Lumped joint masses for use in dynamic analyses also apply to time history analyses performed to assess fluid-structure interaction (FSI) and sloshing of the pool water in the RXB. Table 3.8.4-11 provides the type of dynamic analysis, computer code name, and purpose of these analyses.

RAI 03.08.04-29

The crane weight is included by providing an RBC model in the RXB SAP2000 and SASSI2010 models with its associated mass properties. In the ANSYS models, the RBC self-weight and its lift load are applied as nodal masses along the crane rail locations.

RAI 03.08.04-29

Only load patterns EQ-125, EQ-100, EQ-75, EQ-50, EQ-24, L-LIVE, and S-SNOW, identified in Table 3.8.4-7, apply to the ANSYS models.

Load cases are developed in (or converted to) SAP2000 to address the different design loads discussed in Section 3.8.4.3. These cases are individually evaluated or combined to address the load combinations identified in Table 3.8.4-1 and Table 3.8.4-2 for the RXB.

RAI 03.08.04-13

ANSYS Model for Thermal and Pressurization Analysis

RAI 03.08.04-13

3D RXB half models are developed using the ANSYS program for thermal and pressurization analysis. The half model considers that the RXB structure is approximately symmetric about the East-West (X) axis. In order to explicitly model the as-designed reinforcing steel inside the concrete foundation; roof, slabs, walls, pilasters, and buttresses are explicitly developed and integrated within the concrete volume of the RXB ANSYS structural analysis model. Since the thermal loads cause a significant amount of concrete cracking, only cracked concrete properties are used.

RAI 03.08.04-13

First, two steady-state thermal analyses are performed on the RXB, one to represent the operating thermal loads (T_0) and one to represent the accident thermal loads (T_a). The results of these analyses provide the nodal temperatures through the thickness and along the length of the structural members. The nodal temperature values at each node are then applied as an input to RXB structural analysis model for the operating and accident temperatures, T_0 and T_a. The HELB maximum pressures, P_a, are also applied inside the RXB along with accident temperature T_a.

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 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 03.08.04-12, RAI 03.08.04-13

Table 3.8.4-1: Concrete Design Load Combinations

Load Combinations[1]	Design Loads																					ACI 349-06 Section (Equation)
	D	F	H	L	L_r	R_o	R_a	T_o[3]	T_a[3]	R	S	S_e	W	W_t/W_h	E_o	E_{ss}	C_{cr}	P_a[3]	Y_j[2]	Y_m[2]	Y_r[2]	
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	
1	1.4	1.4				1.4		1														9.2.1 (9-1)
2	1.2	1.2	1.6	1.6	0.5	1.2		1.2									1.4					
3	1.2	1.2	1.6	1.6		1.2		1.2			0.5						1.4					9.2.1 (9-2)
4	1.2	1.2	1.6	1.6		1.2		1.2		0.5							1.4					
5	1.2	1.2	0.8	0.8	1.6	1.2											1.4					
6	1.2	1.2	0.8	0.8		1.2					1.6						1.4					9.2.1 (9-3)
7	1.2	1.2	0.8	0.8		1.2				1.6							1.4					
8	1.2	1.2	1.6	1.6		1.2									1.6							9.2.1 (9-4)
9	1.2	1.2	1.6	1.6		1.2							1.6									9.2.1 (9-5)
10	1	1	1	0.8		1		1								1	1					9.2.1 (9-6)
11	1	1	1	0.8		1		1						1								9.2.1 (9-7)
12	1	1	1	0.8			1		1								1	1.2				9.2.1 (9-8)
13	1	1	1	0.8			1		1							1		1	1	1	1	9.2.1 (9-9)
14	1	1	1	0.8		1		1				1										-

Notes:

1. The load combinations are also evaluated with 0.9D to assess the adverse effects of reduced dead load.
2. Design loads Y_j, Y_m, and Y_r, from load combination 13 will be re-evaluated per COL Item 3.6-2 and COL Item 3.6.3 for localized effects. Also see Section 3.8.4.3.19 and Section 3.8.4.3.20.
3. Design loads T_0, T_a, and P_a in the RXB are per Section 3.8.4.3.8, Section 3.8.4.3.9, and Section 3.8.4.3.18.

Section 3.8.5.6.1. There is negligible tilt north to south. The east end of the building contains the pool and the NPMs.

RAI 02.03.01-2, RAI 03.08.05-22S2

The CRB settles approximately 1¾ inch on the west end and approximately 1 inch on the east end. The tilt settlement of 0.75" is less than the 1" limit cited in Section 3.8.5.6.2. North to south tilt is negligible. The CRB tilts toward the RXB. Differential settlement between the two buildings is on the order of ¼ inch. The displacements at the four corners of the tunnel foundation calculated for the cracked concrete condition are provided in Table 3.8.5-17, and the rotation of the tunnel foundation is –0.0361°, as shown in Table 3.8.5-18. The tunnel foundation has negligible differential settlement in the north-south direction, and the differential settlement over 50 ft length in the east-west direction is -0.36."

The Seismic Category II Radioactive Waste Building settles approximately ½ inch on the west end and approximately 1½ inch on the east end. The RWB tilts toward the RXB. The RWB tilts approximately 1/5 inch in the north-south direction. Differential settlement between the RWB and the RXB is also on the order of ¼ inch.

3.8.5.6.5 Thermal Loads

RAI 03.08.04-13

During normal operation or accident conditions, a linear temperature gradient across the RXB foundation may develop. An explicit analysis considering these loads has been performed and described in Section 3.8.4.4.1 and Appendix 3B.1.3.

RAI 03.08.04-13

~~An explicit analysis considering these loads has not been performed, as thermal loads are a minor consideration. Thermal loads are, by nature, self-relieving by means of concrete cracking and moment distribution. This is especially true of the NuScale RXB, as it is not a traditional pre-stressed/post-tensioned, cylindrical containment vessel, but, rather, a rectangular reinforced concrete building with several members framing into the roof, external walls, and basemat.~~

3.8.5.6.6 Construction Loads

The entire RXB basemat is poured in a very short time. The building is essentially constructed from the bottom up. The main loads (the reactor pool and the NPMs) are not added until the building is complete. Therefore, there are no construction-induced settlement concerns. The CRB basemat is much smaller and will be poured later than the RXB basemat in the construction sequence.

3.8.5.6.7 Basemat Soil Pressures along Basemat Edges (Toe Pressures)

RAI 03.08.05-22S1

The static deadweight reaction at an edge node is added to the seismic reaction of the node to calculate the total reaction. The seismic reaction is obtained with the subtracted from the static axial load to create a minimum and maximum value. Compression is not checked if both the minimum and maximum values are positive and tension is not checked if both values are negative.

Axial compression capacity:

$$\phi P_C = \phi_c 0.8 f'_c A_g \qquad \text{Eq. 3B-37}$$

Compression D/C ratio:

$$D/C_C = \frac{P}{\phi P_C} \qquad \text{Eq. 3B-38}$$

Axial tension capacity:

$$\phi P_T = \phi_m f_y A_s \qquad \text{Eq. 3B-39}$$

Tension D/C ratio:

$$D/C_T = \frac{P}{\phi P_T} \qquad \text{Eq. 3B-40}$$

RAI 03.08.04-13

3B.1.3 Thermal and Pressurization Analysis and Design Methodology

RAI 03.08.04-13

The strains for static, dynamic, and hydrodynamic pressure loads are calculated from the resulting stresses in the reinforcing steel. The strains for the reinforcing steel using T_0 loads for load combination 10 and $T_a + P_a$ loads for load combination 13 of Table 3.8.4-1 are obtained from the ANSYS analysis described in Section 3.8.4.4.1. The total strain in the reinforcing steel is obtained by summing the two strains. The following steps are used to evaluate the final strain obtained for each load case:

RAI 03.08.04-13

Step 1: If the total strain in the reinforcing steel is less than $1.2\varepsilon_y$, the section is considered acceptable based on the 4th bullet in Section 1.3 of ACI 349.1R-07, which states the following about the reinforcing steel strain with thermal gradient, $1.2\varepsilon_y$: "Such an exceedance is inconsequential, and will not reduce the capacity of the concrete section for mechanical loads." If the strain in the concrete is less than 0.003 in/in, the section is considered acceptable since this value is the limiting strain set by Section 10.2.3 of ACI-349-06.

RAI 03.08.04-13

Step 2: If the total strain in the steel exceeds 1.2ε_y for any element in Step 1, the average strains from adjoining elements are calculated, since the finite element models often show highly localized forces and moments and the average presents a more realistic value. For computation of average strain, an effective length of approximately 4 times the thickness of the structural component (such as wall or slab) is considered. However, for the walls with liner plates such as pool walls, elements that correspond to larger lengths of the walls (up to the extent of the entire wall length) can be used for average strain determination. It is rationalized that the concrete walls confined within the liner plates provide enhanced integrity of the concrete walls to withstand the applied forces as an integrated entity that will enable consideration of larger wall lengths. If the average strain is less than 1.2ε_y, the section is considered acceptable.

RAI 03.08.04-13

Step 3: For sections that did not pass Step 2, the reinforcing steel in the region is further reviewed to determine if there is additional steel from the intersecting members that are underutilized.

3B.2 Reactor Building

3B.2.1 Design Report

Structural Description and Geometry

The RXB is a Seismic Category I concrete structure. For a detailed description of the RXB, see Section 3.8.4.1.1. The RXB geometry and floor layout are shown in Figure 1.2-11 through Figure 1.2-20.

Structural Material Requirements

The RXB design is based on the following material properties:

- Concrete
  - Compressive Strength - 5 ksi (7 ksi for exterior walls of the RXB above grade)
  - Modulus of Elasticity - 4, 031 ksi
  - Shear Modulus - 1,722 ksi
  - Poisson's Ratio - 0.17
- Reinforcement
  - Yield Stress - 60 ksi (ASTM A615 Grade 60 or ASTM A706 Grade 60)
  - Tensile Strength - 90 ksi (A615 Grade 60), 80 ksi (A706 Grade 60)
  - Elongation - See ASTMs A615 and A706
- Structural Steel
  - Grade - ASTM A992 (W shapes), ASTM A500 Grade B (Tube Steel), ASTM A36 (plates)

In addition to shear, there will be tensile load on the fins. This is because the NPM lug load is applied with an eccentricity, causing moment that results in a tensile load on some of the fins. The tensile loads are designed to be resisted by 2.5" diameter through bolts made of ASTM A193 Gr B7 material having a yield strength of 105 ksi and an ultimate strength of 125 ksi.

RAI 03.08.04-21S3

Figure 3B-51 shows a layout of the shear lugs and the through bolts. There are 32 through-bolts that correspond to each lug of the NPM as shown in Figure 3B-51.

The tensile capacity of the through bolts is the smaller of the bolt steel strength and the concrete strength.

The bending stress in the 2" thick liner plate can be bounded by considering the moment at the base of highest loaded shear lug as an upper bound moment in the liner plate.

RAI 03.08.04-21S3, RAI 03.08.04-36

From Table 3B-26, the maximum moment on the plate occurs at the shear lug at Y = 88.2" for lug load in the +Y direction. Please see Table 3B-57, which provides D/C ratios for the various lug component stress checks. The D/C ratios listed in Table 3B-57 are for the individual modes of failure for components of the lug assembly. In this table, the demand is the load that is resisted by each component, due to an applied total load of 3500 kips in the SAP2000 model.

RAI 03.08.04-21S3

The highest D/C ratio is for concrete bearing against the shear lugs at 0.777. Since this maximum ratio is due to the 3500 kips load, the maximum capacity of the lug assembly is 3500 kips/0.777=4500 kips.

3B.2.7.4.2 Overall Lug Restraint Reaction

RAI 03.07.02-10, RAI 03.07.02-10S1, RAI 03.08.04-36

Table 3B-28 presents the envelope lug reactions, for all twelve bays, using the three analysis cases with Soil Type 7 for Capitola input motion with 4 percent structural damping of the SASSI RXB model and the equivalent analysis performed on the NPM detailed seismic model (Reference TR-0916-51502). Since the maximum lug reactions are below the lug support design capacity of 4,500 kips, the design is acceptable.

RAI 03.08.04-13

3B.2.8 Evaluation of RXB for Load Combinations Involving Thermal and Accident Pressure Loads

RAI 03.08.04-13

T_0, T_a, and P_a strains in the reinforcing steel and liner steel of the RXB are given in Table 3B-58. Concrete strains under combined static load cases are given in Table 3B-59. Reinforcing steel and liner steel strains for Load Combinations 10 and 13 are given in Table 3B-60 and Table 3B-61 respectively along with demand from combined static demand and individual maximum T_0 and $T_a + P_a$ strains.

RAI 03.08.04-13

Strain averaging is employed at some localized regions as described in Section 3B.1.3. It should be noted that, for regions where averaging is employed, linear addition of T_0 and $T_a + P_a$ strains with static load cases do not necessarily give load combination 10 and 13 resultants as these strains do not necessarily occur at the same location, therefore, the maximum combined strain is not the sum of both maximum strains.

RAI 03.08.04-13

As an example, in the foundation, the total strain in the steel is less than $1.2\varepsilon_y$ (2.483×10^{-3}) at all locations except at the perimeter region for load combination 13 where it is exceeded by 5%. However, the static strains calculated are conservative because they are based on the maximum axial, shear, and moment components over all of the elements. These do not occur at the same location or time. If the strains were based on the forces and moments occurring simultaneously at the same location, and if averaging were used, the strains would be lower. Also, the thermal strain of 0.000367 for $T_a + P_a$ is the maximum over the entire basemat and occurs in the pool area. The thermal strains in the foundation perimeter region are lower.

RAI 03.08.04-13

The pool walls and NPM support walls are lined with a ¼" thick stainless steel plate. Per Table CC-3720-1 of ASME Boiler and Pressure Vessel Code, the allowable strain limit for the liner plate is 0.004 in/in even for service load conditions. The total strain in the steel is less than 0.004 in/in at all locations for load combinations 10 and 13. Therefore, the steel pool liner is considered acceptable.

3B.3 Control Building

3B.3.1 Design Report

Structural Description and Geometry

The CRB is a Seismic Category I concrete structure at elevation 120'-0" and below, except as noted in Section 1.2.2.2. Above EL 120'-0" the CRB is a Seismic Category II steel structure. For a detailed description of the CRB, see Section 3.8.4.1.2. The CRB geometry and floor layout are shown in Figure 1.2-21 through Figure 1.2-27.

Structural Material Requirements

The CRB design is based on the following material properties:

- Concrete

3B-5 American National Standards Institute/American Institute of Steel Construction, "Specification for Structural Steel Buildings," ANSI/AISC 360-10, Chicago, IL.

RAI 03.08.04-21S2

3B-6 NuScale Power, LLC, "NuScale Power Module Seismic Analysis," TR-0916-51502.

RAI 03.08.04-13

3B-7 ASME Boiler and Pressure Vessel Code, Section III, Division 2, 2017.

RAI 03.08.04-13

3B-8 American Concrete Institute, "Reinforced Concrete Design for Thermal Effects on Nuclear Power Plant Structures," ACI 349.1R-07, Farmington Hills, MI.

RAI 03.08.04-13

Table 3B-58: ANSYS RXB Reinforcing Steel and Liner Steel Elastic Strain Summary for T_0 and T_a+P_a

Type	Location	Maximum Strain (×10^{-3})			
		T_0	P_a*	T_a	T_a+P_a
Reinforcing Steel	All Sections	0.514	0.181	1.342	1.343
	Outer Wall - North	0.373	0.055	0.666	0.672
	Outer Wall - East	0.231	0.063	0.426	0.426
	Outer Wall - West	0.256	0.062	0.677	0.687
	Pool Wall - North	0.393			1.053
	Pool Wall - East	0.317			0.850
	Pool Wall - West	0.352			1.016
	Pool Wall - Middle	0.444			1.057
	Pool Gate Support Wall	0.459			1.343
	Roof Support Stiffeners	0.333			0.870
	Roof Support Wall Above Crane	0.240			0.665
	NPM Support Walls	0.294			0.776
	Roof	0.115	0.181	0.485	0.488
	Major Slabs	0.514			0.961
	Pilasters	0.373			0.672
	Buttresses	0.237			0.616
	T-Beams	0.514			0.961
	Foundation	0.112			0.367
Liner Steel	Steel Pool Liner	0.895			2.181

*Shaded cell resultants are not extracted for individual load case and locations

RAI 03.08.04-13

Table 3B-59: ANSYS RXB Strain Based Concrete Design Check for Static Loads

Location	Max εc(×10^{-3}) from SDH		εc < εcu?
	X	Y	Concrete
Outer Wall – North (Grid Line A)	0.348	1.173	OK
Outer Wall – East (Grid Line 7)	0.323	0.786	OK
Outer Wall – West (Grid Line 1)	0.290	0.434	OK
Pool Wall – North (Grid Line B)	0.764	1.182	OK
Pool Wall – East (Grid Line 6)	0.616	0.354	OK
Pool Wall – West (Grid Line 2)	0.574	0.322	OK
Pool Wall – Middle (Grid Line C)	**2.094***	**2.025***	OK
Pool Gate Support Wall	0.786	0.330	OK
Roof Support Stiffeners (Grid Lines 2, 3, 4, 5, 6)	0.576	0.170	OK
Roof Support Wall Above Crane (Grid Line A.7)	0.399	1.140	OK
NPM Support Walls (Grid Lines 4, 4.3, 4.7, 5, 5.3, 5.7)	0.607	0.920	OK
Roof	0.564	1.062	OK
Major Slabs (TOC EL 50', 75', 100', 126')	0.572	1.069	OK
Pilasters at Grid Line A	1.007	1.007	OK
Buttress at TOC EL 126'-0" and 145'-0"	0.918	0.918	OK
T-Beams at TOC EL 50'-0", 75'-0", and 100'-0"	0.872	0.872	OK
RXB Basemat (Perimeter Region)	0.919	0.852	OK
RXB Basemat (Interior Region)	0.806	0.687	OK

*Bold cell indicates averaging was employed.

RAI 03.08.04-13

Table 3B-60: ANSYS RXB Reinforcing Steel and Liner Steel Elastic Strain Summary for Load Combination 10

Type	**Location**	**Max εs(×10^{-3}) from static loads**		**Max εs (×10^{-3}) from T_0**	**Max εs (×10^{-3}) from LC 10**	**εs < 1.2 εy?**
		X	**Y**	**X, Y**	**X, Y**	**LC 10**
Reinforcing Steel	Outer Wall – North	0.746	1.962	0.373	2.335	OK
	Outer Wall – East	1.352	1.339	0.231	1.583	OK
	Outer Wall – West	1.076	1.516	0.256	1.772	OK
	Pool Wall – North	1.574	1.782	0.393	2.175	OK
	Pool Wall – East	1.838	0.698	0.317	**2.155***	OK
	Pool Wall – West	1.451	0.945	0.352	1.803	OK
	Pool Wall – Middle	2.137	2.020	0.444	**2.461***	OK
	Pool Gate Support Wall	2.023	1.351	0.459	**2.482***	OK
	Roof Support Stiffeners	1.864	1.080	0.333	**2.197***	OK
	Roof Support Wall Above Crane	0.955	1.770	0.240	2.010	OK
	NPM Support Walls	1.909	1.451	0.294	2.203	OK
	Roof	1.507	1.834	0.115	1.949	OK
	Major Slabs	1.406	2.228	0.514	**2.443***	OK
	Pilasters	2.131	2.131	0.373	**2.482***	OK
	Buttress	1.937	1.937	0.373	2.310	OK
	T-Beams	1.913	1.913	0.514	2.427	OK
	Foundation	2.157	2.230	0.112	2.342	OK
	Steel Pool Liner	0.363	0.066	0.895	1.258	OK

*Bold cell indicates averaging was employed.

RAI 03.08.04-13

Table 3B-61: ANSYS RXB Reinforcing Steel and Liner Steel Elastic Strain Summary for Load Combination 13

Type	Location	Max εs(×10^{-3}) from static loads		Max εs (×10^{-3}) from T_a+P_a	Max εs (×10^{-3}) from LC 13	εs < 1.2 εy?
		X	Y	X, Y	X, Y	LC 13
Reinforcing Steel	Outer Wall – North	0.746	1.962	0.672	**2.469***	OK
	Outer Wall – East	1.352	1.339	0.426	1.778	OK
	Outer Wall – West	1.076	1.516	0.687	2.203	OK
	Pool Wall – North	1.368	1.627	1.053	**2.481***	OK
	Pool Wall – East	1.511	0.698	0.850	**2.361***	OK
	Pool Wall – West	1.451	0.945	1.016	2.467	OK
	Pool Wall – Middle	1.370	1.718	1.057	**2.479***	OK
	Pool Gate Support Wall	1.229	0.976	1.343	**2.402***	OK
	Roof Support Stiffeners	1.308	1.139	0.870	**2.178***	OK
	Roof Support Wall Above Crane	0.955	1.770	0.665	2.435	OK
	NPM Support Walls	1.487	1.451	0.776	**2.263***	OK
	Roof	1.507	1.834	0.488	2.322	OK
	Major Slabs	1.406	2.164	0.961	**2.469***	OK
	Pilasters	2.078	2.078	0.672	**2.468***	OK
	Buttress	1.862	1.862	0.616	**2.478***	OK
	T-Beams	1.405	1.405	0.961	**2.366***	OK
	Foundation	2.157	2.230	0.367	2.597	OK
	Steel Pool Liner	0.363	0.066	2.181	2.544	OK

*Bold cell indicates averaging was employed.

Enclosure 3:

Affidavit of Zackary W. Rad, AF-1218-63785

NuScale Power, LLC

AFFIDAVIT of Zackary W. Rad

I, Zackary W. Rad, state as follows:

1. I am the Director, Regulatory Affairs of NuScale Power, LLC (NuScale), and as such, I have been specifically delegated the function of reviewing the information described in this Affidavit that NuScale seeks to have withheld from public disclosure, and am authorized to apply for its withholding on behalf of NuScale.
2. I am knowledgeable of the criteria and procedures used by NuScale in designating information as a trade secret, privileged, or as confidential commercial or financial information. This request to withhold information from public disclosure is driven by one or more of the following:
    a. The information requested to be withheld reveals distinguishing aspects of a process (or component, structure, tool, method, etc.) whose use by NuScale competitors, without a license from NuScale, would constitute a competitive economic disadvantage to NuScale.
    b. The information requested to be withheld consists of supporting data, including test data, relative to a process (or component, structure, tool, method, etc.), and the application of the data secures a competitive economic advantage, as described more fully in paragraph 3 of this Affidavit.
    c. Use by a competitor of the information requested to be withheld would reduce the competitor's expenditure of resources, or improve its competitive position, in the design, manufacture, shipment, installation, assurance of quality, or licensing of a similar product.
    d. The information requested to be withheld reveals cost or price information, production capabilities, budget levels, or commercial strategies of NuScale.
    e. The information requested to be withheld consists of patentable ideas.
3. Public disclosure of the information sought to be withheld is likely to cause substantial harm to NuScale's competitive position and foreclose or reduce the availability of profit-making opportunities. The accompanying Request for Additional Information response reveals distinguishing aspects about the method by which NuScale performs its design check for the Reactor Building.

    NuScale has performed significant research and evaluation to develop a basis for this method and has invested significant resources, including the expenditure of a considerable sum of money.

    The precise financial value of the information is difficult to quantify, but it is a key element of the design basis for a NuScale plant and, therefore, has substantial value to NuScale.

    If the information were disclosed to the public, NuScale's competitors would have access to the information without purchasing the right to use it or having been required to undertake a similar expenditure of resources. Such disclosure would constitute a misappropriation of NuScale's intellectual property, and would deprive NuScale of the opportunity to exercise its competitive advantage to seek an adequate return on its investment.

4. The information sought to be withheld is in the enclosed response to NRC Request for Additional Information RAI No. 132, eRAI No. 8971 . The enclosure contains the designation "Proprietary" at the top of each page containing proprietary information. The information considered by NuScale to be proprietary is identified within double braces, "{{ }}" in the document.
5. The basis for proposing that the information be withheld is that NuScale treats the information as a trade secret, privileged, or as confidential commercial or financial information. NuScale relies upon the exemption from disclosure set forth in the Freedom of Information Act ("FOIA"), 5 USC § 552(b)(4), as well as exemptions applicable to the NRC under 10 CFR §§ 2.390(a)(4) and 9.17(a)(4).
6. Pursuant to the provisions set forth in 10 CFR § 2.390(b)(4), the following is provided for consideration by the Commission in determining whether the information sought to be withheld from public disclosure should be withheld:
   a. The information sought to be withheld is owned and has been held in confidence by NuScale.
   b. The information is of a sort customarily held in confidence by NuScale and, to the best of my knowledge and belief, consistently has been held in confidence by NuScale. The procedure for approval of external release of such information typically requires review by the staff manager, project manager, chief technology officer or other equivalent authority, or the manager of the cognizant marketing function (or his delegate), for technical content, competitive effect, and determination of the accuracy of the proprietary designation. Disclosures outside NuScale are limited to regulatory bodies, customers and potential customers and their agents, suppliers, licensees, and others with a legitimate need for the information, and then only in accordance with appropriate regulatory provisions or contractual agreements to maintain confidentiality.
   c. The information is being transmitted to and received by the NRC in confidence.
   d. No public disclosure of the information has been made, and it is not available in public sources. All disclosures to third parties, including any required transmittals to NRC, have been made, or must be made, pursuant to regulatory provisions or contractual agreements that provide for maintenance of the information in confidence.
   e. Public disclosure of the information is likely to cause substantial harm to the competitive position of NuScale, taking into account the value of the information to NuScale, the amount of effort and money expended by NuScale in developing the information, and the difficulty others would have in acquiring or duplicating the information. The information sought to be withheld is part of NuScale's technology that provides NuScale with a competitive advantage over other firms in the industry. NuScale has invested significant human and financial capital in developing this technology and NuScale believes it would be difficult for others to duplicate the technology without access to the information sought to be withheld.

I declare under penalty of perjury that the foregoing is true and correct. Executed on December 11, 2018.

Zackary W. Rad