August 28, 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 Supplemental Response to NRC Request for Additional Information No. 134 (eRAI No. 8934) on the NuScale Design Certification Application

REFERENCES:
1. U.S. Nuclear Regulatory Commission, "Request for Additional Information No. 134 (eRAI No. 8934)," dated August 05, 2017
2. NuScale Power, LLC Response to NRC "Request for Additional Information No. 134 (eRAI No.8934)," dated December 21, 2017
3. NuScale Power, LLC Supplemental Response to "NRC Request for Additional Information No. 134 (eRAI No. 8934)" dated May 7, 2018
4. NuScale Power. LLC Supplemental Response to "NRC Request for Additional Information No. 134 (eRAI 8934)" dated June 29, 2018

The purpose of this letter is to provide the NuScale Power, LLC (NuScale) supplemental response to the referenced NRC Request for Additional Information (RAI).

The Enclosure to this letter contains NuScale's supplemental response to the following RAI Question from NRC eRAI No. 8934:

- 03.07.02-15

This supplement replaces the previous supplement provided on June 29, 2018 (Reference 4).

This letter and the enclosed response make no new regulatory commitments and no revisions to any existing regulatory commitments.

If you have any questions on this response, please contact Marty Bryan at 541-452-7172 or at mbryan@nuscalepower.com.

Sincerely,

Zackary W. Rad
Director, Regulatory Affairs
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Enclosure 1: NuScale Supplemental Response to NRC Request for Additional Information eRAI No. 8934

Enclosure 1:

NuScale Supplemental Response to NRC Request for Additional Information eRAI No. 8934

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

eRAI No.: 8934
Date of RAI Issue: 08/05/2017

NRC Question No.: 03.07.02-15

10 CFR 50 Appendix S requires that the safety functions of structures, systems, and components (SSCs) must be assured during and after the vibratory ground motion associated with the Safe Shutdown Earthquake (SSE) through design, testing, or qualification methods.

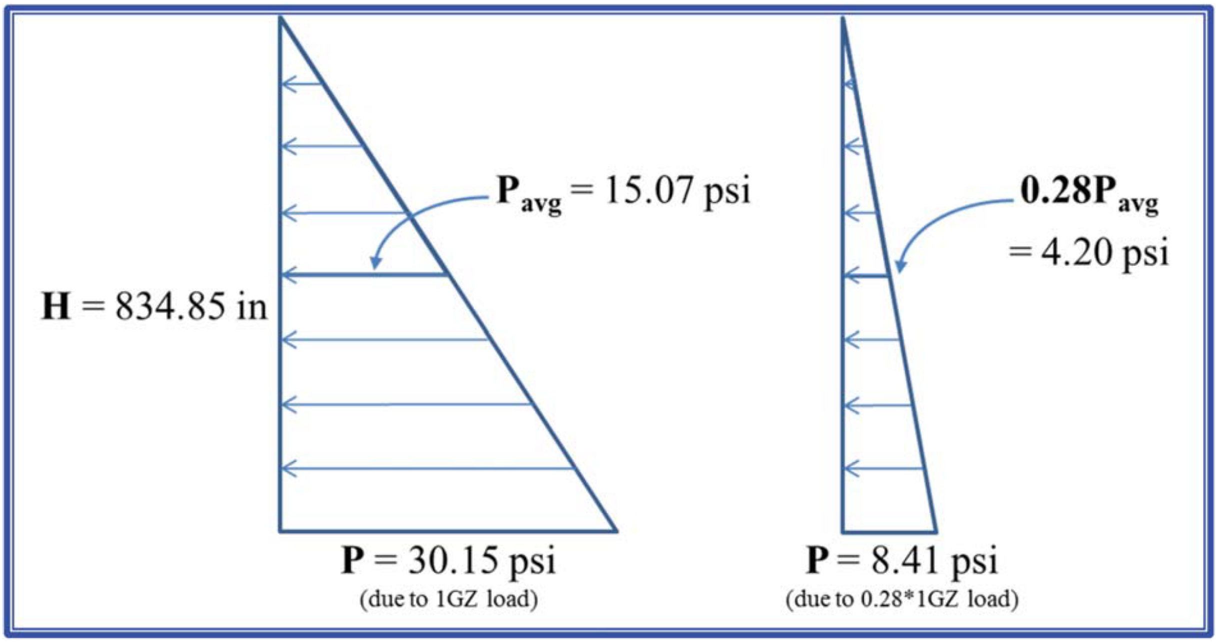
a. On Page 3.7-30 of the FSAR, Eq. 3.7-14 represents the conversion of ANSYS FSI-based hydrodynamic pressure to SASSI2010 equivalent static pressure. In this process, ANSYS used the CSDRS-compatible Capitola time history input on a fixed-base model and SASSI2010 used the CSDRS-compatible Capitola time history input for Soil Types 7, 8, and 11, respectively. The applicant is requested to explain why FSI correction factors for the case of CSDRS-HF-compatible time history input for Soil Type 9 (hard rock) are not considered. Since the boundary conditions for an ANSYS fixed-base model and a SASSI model with Soil Type 9 (hard rock) are similar, it appears that FSI- correction factors developed for Soil Type 9 may be more representative.

b. On Page 3.7-31 of the FSAR, the fourth paragraph, "The pressure at the bottom of the pool due to …", describes an approach the applicant took in taking into account the FSI effects on vertical water pressure estimation. The applicant is requested to provide a technical basis for the approach taken.

NuScale Response:

During a Public Meeting on May 29, 2018, the NRC asked NuScale to submit a supplement to RAI 8932 question 03.07.02-15 to clarify the distribution of pressure on the foundations in figure 3.7.2-129, and to explain how the hydrostatic load is applied. Additional NRC comments were received during a Public Meeting on June 12, 2018 on hydrodynamic pressure accounting for 3D FSI effects prior to the meeting.

In order to correct for the "missing" or underestimated hydrodynamic pressure, it was determined that an average pressure of 4.2 psi must be applied to the walls. This additional pressure was added to the SAP2000 model by amplifying the gravity load by a factor of 1.28. Because the applied horizontal hydrostatic wall pressure varies linearly with water depth, the walls below mid-height of the pool, as well as the foundation, will experience greater than 4.2 psi hydrostatic pressure, as illustrated in FSAR Figure 3.7.2-129. This is a conservative approach to capturing the "missing" hydrodynamic pressure.



NRC follow-up Questions:

1. FSAR Eq. 3.7-14 (Page 3.7-118, Revision 1) represents the corrected equivalent static pressure due to hydrodynamic effects (including 3D FSI). The applicant derived “missing” FSI pressure as difference between pressures obtained from Eq 3.7-14 and from the original SASSI2010 lumped-mass analysis. In implementing the missing FSI pressure in SAP2000, the applicant did not apply an actual pressure profile (i.e., pressure differential between Eq 3.7-14 and original SASSI2010). Instead, the applicant chose to amplify the gravity load by a factor of 1.28 in order to add missing FSI pressure loading to the SAP2000 model. The staff’s concern is whether the use of a gravity load factor will result in an equivalent or conservative design demand compared to the use of an actual pressure profile.

   Therefore, the applicant is requested to provide figures or tables that compare pressure profiles on the pool walls and foundation obtained from the actual missing FSI pressure and from amplifying the gravity load by a factor of 1.28. If significant differences are identified in such comparison, the applicant should provide an evaluation demonstrating that the use of a gravity load factor of 1.28 results in an incremental design demand (forces, moments, deformations, etc.) that would have bound the increased demand should the applicant have used the actual pressure profile accounting for the missing FSI effect in SAP2000, for both the RXB pool walls and foundation.

Response: NuScale has performed analyses that confirm that the 1.28 x gravity load bounds a 4.2psi pressure profile and is providing these results as part of this response.

2. Explain how the “Water Weight” Dead Loads (FSAR Section 3.8.4.3.1.2) and “Liquid Loads” (FSAR Section 3.8.4.3.2) are distinct and implemented in SAP2000.

   Response: “Water weight” is the actual weight of the water and is part of the dead load/self-weight of the RXB. “Liquid load” includes the hydrostatic and hydrodynamic pressures exerted on the RXB pool walls and foundation. Both of these loads are part of the governing load combinations for concrete and steel.

3. Also, clarify whether such water weight/mass is implemented in SAP2000 for addressing hydrodynamic loads only or both hydrodynamic and hydrostatic loads.

   Response: The SAP2000 model accounts for both hydrostatic and hydrodynamic loads. The hydrostatic pressure distribution is applied as a surface pressure to all wetted area elements. The SASSI2010 analysis with lumped water masses does not represent fluid-structure-interaction behavior, and, therefore, underestimates the hydrodynamic pressures on the RXB walls. In order to account for this, an ANSYS FSI analysis, in which the water elements were explicitly modeled, was performed. It was determined that an additional 4.2 psi of hydrodynamic pressure on the walls should be included. This additional pressure was added to the SAP2000 model as an equivalent static load by amplifying the gravity load by a factor of 1.28.

4. Additionally, clarify whether the hydrostatic water pressure described in FSAR Section 3.8.4.3.2 is addressed in SAP2000 by applying an actual pressure profile to the pool walls and foundation or by the use of a gravity load factor. If the latter, address the adequacy of the use of a gravity load factor as requested in item a above also in the context of hydrostatic pressures.

   Response: As described above, the hydrostatic pressure distribution is applied as a surface pressure to all wetted area elements in the SAP2000 model. The “missing” hydrodynamic pressure was added to the SAP2000 model as an equivalent static load by amplifying the gravity load by a factor of 1.28. NuScale has performed analyses that confirm that the 1.28 x gravity load bounds a 4.2psi pressure profile.

5. In a new proposed paragraph in the FSAR markup (middle of Page 3.7-122, Draft Revision 2), the applicant states “The missing hydrodynamic load is added to the hydrostatic load to determine the total fluid pressure on the RXB walls.” Here, pressure on the foundation is not mentioned. Please revise the sentence to include foundation.

   Response: “Foundation” will be added, see markup.

6. The proposed paragraph in the FSAR markup includes a statement “These hydrodynamic effects from SASSI2010 are included in the Ess term of the governing load combination.” Please refer to FSAR Section that provides the definition of Ess.

   Response: Ess is defined in FSAR, Tier 2, Section 3.8.4.3.16, see markup.

7. In FSAR Section 3.7.2.1.2.4 (Revision 1), the applicant describes how the additional pressure on the pool walls accounting for the missing 3D FSI effects are obtained. However, it does not fully describe how the additional pressure on the pool foundation is obtained. For example, the applicant indicates that the wall pressures (for Segments X1, X2, …, Y5) in Tables 3.7.2-2 and 3.7.2-3 are obtained by averaging the pressure values over the depth of the wall; however, it is not clear how the foundation pressures (Z Foundation) in these tables are obtained. Please augment FSAR Section 3.7.2.1.2.4 to include a description of how the additional pressure on the pool foundation accounting for the missing 3D FSI effects is obtained.

   Response: Clarification will be added, see markup.

8. In the paragraph under the title “Equivalent Static Pressure Estimation” (Page 3.7-118, Revision 1), a symbol, Paddl, is introduced with a description of “additional equivalent static pressure”. However, in view of FSAR Tables 3.7.2-4 to 3.7.2-6 (Revision 1), the symbol should denote “equivalent static pressure”. Please clarify and make corrections as needed.

   Response: “Additional” will be removed from the description under “Equivalent Static Pressure Estimation”, see markup.

9. The bottom paragraph under the title “Development of Correction Factor” (Page 3.7-118, Revision 1) includes a statement, “Therefore, a 1.28g vertical static loading was added to the SAP2000 model to ensure this additional pressure is accounted for in the design.” Here, the wording “1.28g vertical static loading” may cause a confusion that it induces only vertical pressure on the foundation. Please consider revising the statement so that it indicates both vertical pressure on the foundation and horizontal pressure on the walls are induced.

   Response: A clarifying statement will be added: Horizontal hydrostatic load is a function of fluid density and depth. Fluid density can be altered by changing the acceleration due to gravity. Increasing the vertical gravitational acceleration increases the horizontal hydrostatic pressure. See markup.

Comparison of 1.28GZ and 4.2 psi Loading Effects

The hydrodynamic pressures on the pool walls applied in the SASSI2010 seismic analysis are based on lumped masses and do not include the additional hydrodynamic pressures due to FSI effects. To account for this "missing" FSI pressure, demands from a scaled gravity (1GZ) loading on the SAP2000 model were also included in the design. This section provides the technical details and the basis for using the scaled 1GZ loading results to account for the missing or underestimated loads due to 3D FSI effects in the SSI analysis.

It was determined that the missing pressure due to FSI effects is equivalent to an average hydrostatic pressure of 4.2 psi and that applying a scale factor of 0.28 to the 1GZ load will simulate the FSI effects. This term is defined as FSIMiss in the ACI 349-06 load combination in the following paragraphs.

Due to the unique RXB design, the vertical loading causes horizontal wall displacements in the north-south and east-west directions. Under the dead weight conditions alone, the walls are moved outwards. In addition, the gallery floors, being supported by the inner pool walls and outer walls, produce significant moments in the pool walls and outer walls at various elevations throughout the RXB. Similarly, the lateral hydrostatic pressure on the pool walls causes lateral displacements in the pool walls. Thus, the application of the 0.28GZ load simulates the added load on the pool walls due to FSI effects. It should be noted that the hydrodynamic pressures could be positive or negative during a seismic event and the use of positive and negative response is easily accommodated using a ±0.28GZ loading. The 0.28GZ loading conservatively creates additional horizontal and vertical demand forces and moments throughout the building.

In this section, it will be shown that the structural response from the 0.28GZ load creates demands in the RXB wall that are higher than the demands from the 4.2 psi average hydrostatic pressure representing FSIMiss on the pool walls. The high wall demand forces and moments are used to determine the wall reinforcement.

Since the 1GZ load is part of the ACI 349-06 load combinations, using a factor of this load makes the addition of the "missing or underestimated" loads due to 3D FSI effects simple and straightforward. Since the FSI effects are due to seismic loading, the 0.28GZ load is applied in both the positive and negative directions.

RXB ACI 349-06 Load Combination

The following ACI-349-06 load combination produces the dominant RXB demands from the SSI analyses.

D + H + 0.8L + F + FSIMiss + ESS ACI Load Combination Eq. 9-6

Where:

D = Dead Loads

L = Live Loads

F = Liquid Loads

H = Static Soil Pressure - induced by the weight of soil, hydrostatic pressure, and a surcharge load at grade level.

FSIMiss = Static Pressure on all pool walls due to missing hydrodynamic or underestimated 3D FSI effects from the SSI-induced pool wall forces and moments. It is simulated by applying additional demand loads with a 0.28g vertical inertial load on the RXB.

ESS = SSE Load

1. Load Combinations

Figure 1-1 shows a cross-sectional elevation view of the RXB and the inertial loading in the vertical direction. Figure 1-2 shows a cross-sectional plan view of the RXB and the fluid pressure loading in the horizontal direction. Figure 1-3 shows a cross-sectional plan view of the RXB and the fluid pressure loading in the vertical direction. Figure 1-4 shows a cross-sectional elevation view of the RXB with the combined soil pressure and fluid pressure for the static portion of ACI Equation 9-6.

The RXB SAP2000 model, has been analyzed for the following loads and load combinations:

1. 0.28GZ = 0.28×1GZ
2. 4.2PSI = additional FSI fluid pressure
3. COMB-Static + 0.28GZ = D + H + 0.8L + F + 0.28×1GZ
4. COMB-Static + 4.2PSI = D + H + 0.8L + F + additional FSI fluid pressure
5. F-FluidPR-V = Vertical fluid pressure on the pool floor

In Section 2 through Section 5, results from load combinations 3 and 4 will be compared to justify the use of the additional 0.28GZ loading to simulate the FSI effects.

F-FluidPR and F-FluidPR-V are hydrostatic loads on the pool walls and floor, respectively.

Table 1-1 provides the applied static soil pressure on the outer walls and the fluid hydrostatic pressures on the pool walls. The horizontal soil and fluid pressure act in opposite directions. However, the static soil pressure is much higher than the hydrostatic pressure.

Table 1-2 provides the vertical reaction due to full hydrostatic pressure on the pool floor. It should be noted that base reaction due to F-FluidPR-V is 13% higher than the weight of the water (72,774 kips as compared to 64,200 kips). The increase in base reaction and foundation pressures due to the 0.28GZ load will be much more than the increase due to F-FluidPR-V scaled to an average of 4.2 psi.

Table 1-1. Total Soil and Fluid Hydrostatic Pressures.

No.	Elev. Ft	Soil Static psi	Fluid Hydrostatic Pressure psi
1	95.875	3.0	0.0
2	89.625	7.1	2.1
3	83.375	11.3	4.9
4	77.125	15.5	7.6
5	70.875	19.7	10.3
6	64.625	23.8	13.0
7	58.375	28.0	15.7
8	52.125	32.2	18.4
9	45.875	36.4	21.1
10	39.625	40.5	23.8
11	33.375	44.7	26.5
12	27.125	48.9	29.2
13	25	50.3	30.1

Table 1-2. Total Base Reactions from Cases F-FluidPR-V and 0.28GZ.

Output Case	Base Reaction (GlobalFZ) (lbs)
F-FluidPR-V	72,773,906*
0.28GZ	240,494,076

* The actual base reaction due to hydrostatic pressure scaled to an average of 4.20 psi will be much smaller.

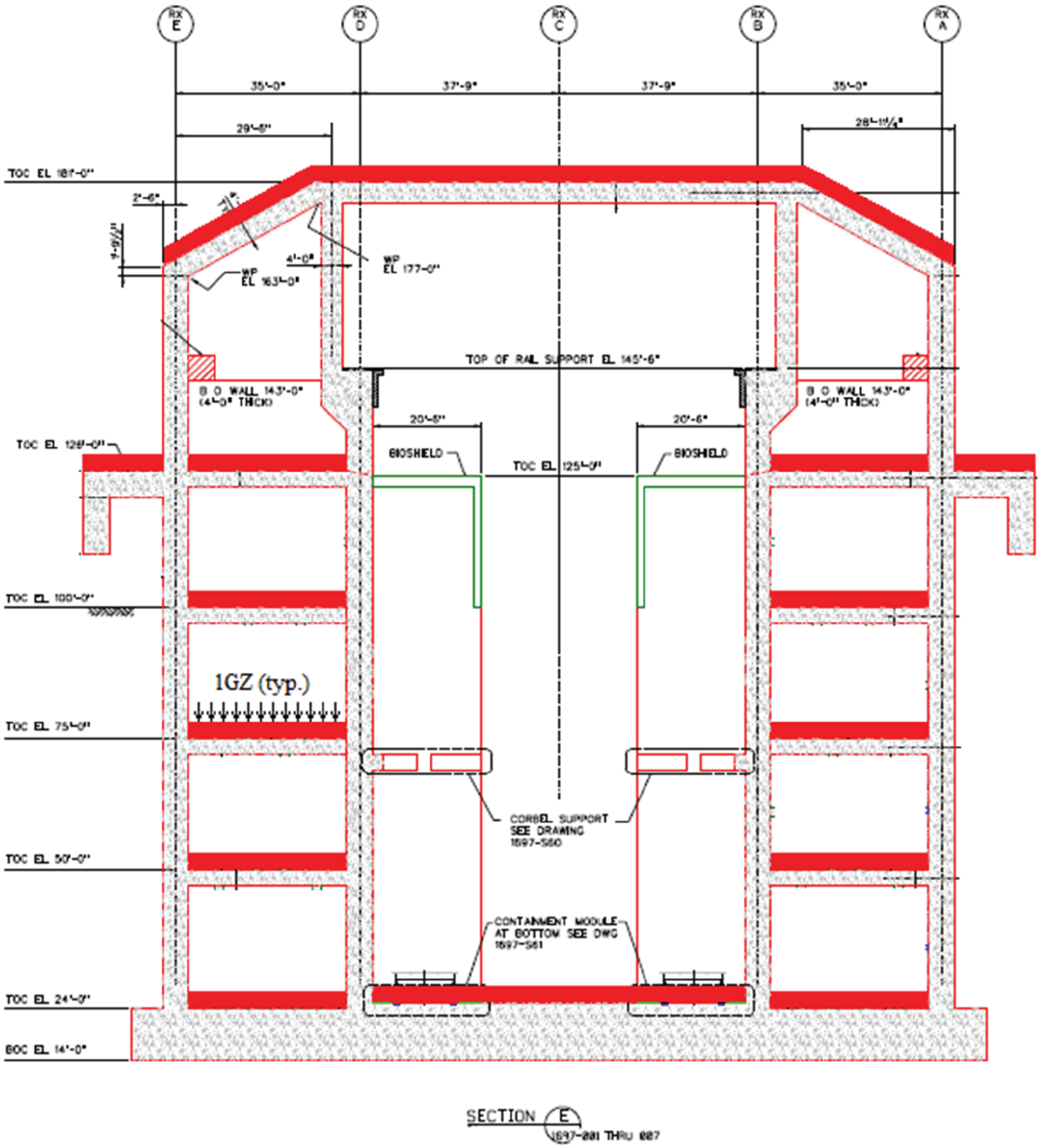


Figure 1-1. RXB Elevation View Showing Gravity Loading (in red).

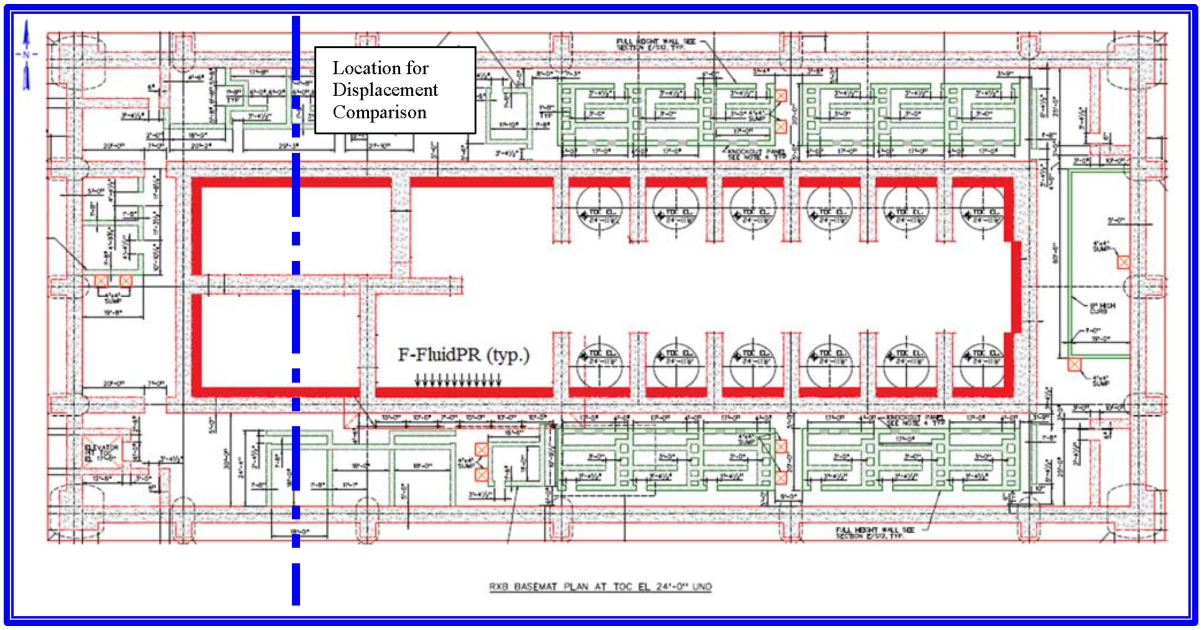


Figure 1-2. RXB Plan View Showing Hydrodynamic Loading on Pool Walls (in red).

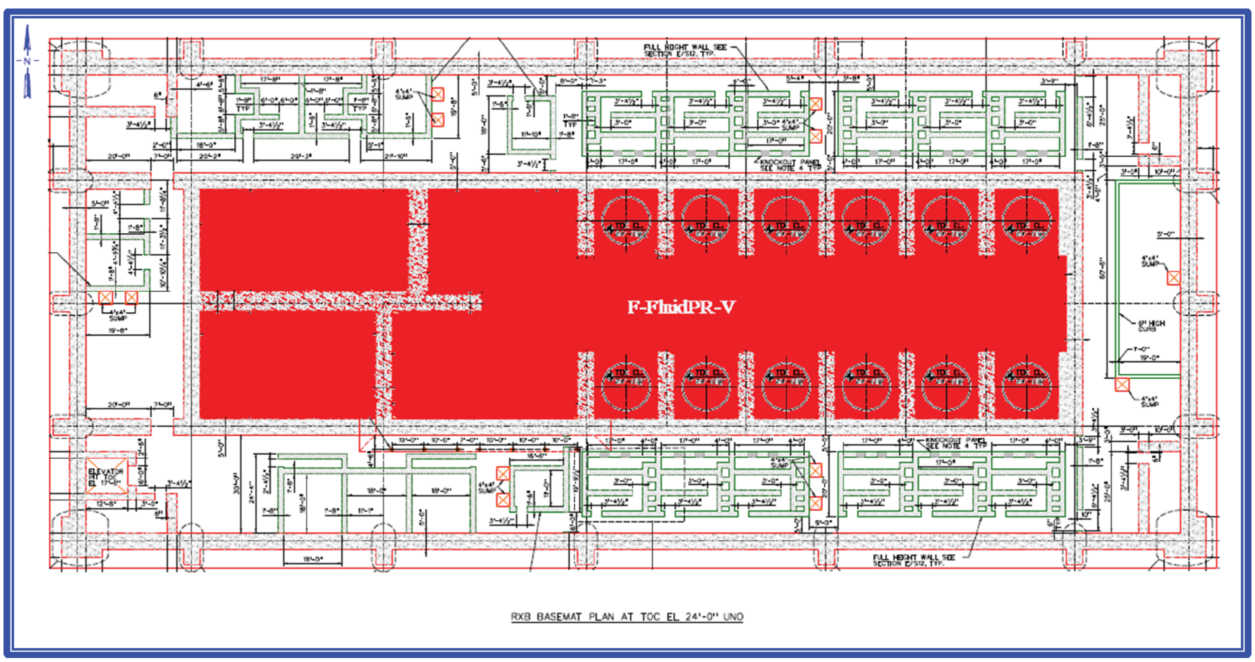


Figure 1-3. RXB Plan View Showing Hydrodynamic Loading on Pool Base (in red).

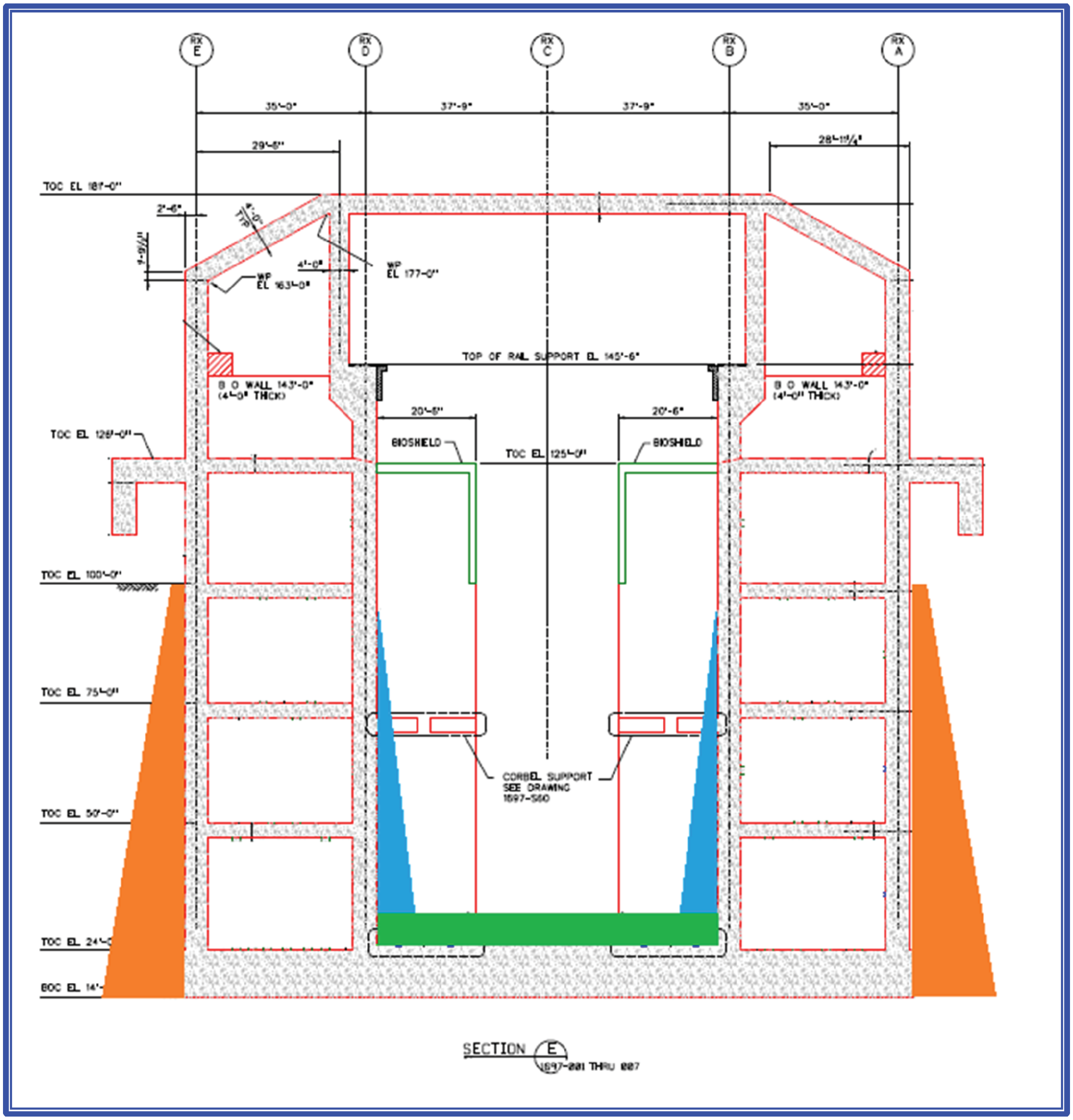


Figure 1-4. RXB Elevation View Showing Soil Static (orange), Horizontal Hydrostatic (blue), and Vertical Hydrostatic Pressure (green).

2. Displacement Combinations

In this section, the RXB pool wall and roof displacement comparisons are provided. To demonstrate the wall lateral displacements, a slice of the RXB at the west end of the pool between X=824″ and X=1026″ will be considered. The horizontal location on the pool is in the dry dock area and is shown in Figure 1-2. This location has high lateral wall displacements due to hydrostatic pressure. The east-west pool wall displacements are smaller than the north-south displacements.

Figure 2-1 shows the 3D view of the RXB slice section indicating the location of selected nodes for displacement comparison. The comparison of displacements values at the four selected nodes from the 0.28GZ and 4.2psi cases is listed in Table 2-1. The comparison of displacement values at the four selected nodes from the COMB-Static+0.28GZ and COMB-Static+4.2PSI cases is listed in Table 2-2. The corresponding lateral deformed shape plots of the RXB slice are plotted with identical contour zoom factors in Figure 2-4 through Figure 2-7. The RXB wall and roof displacements with 0.28GZ loading are generally higher than those with 4.2psi loading.

Figure 2-2 shows the undeformed and deformed shape of the RXB slice with the 0.28GZ load.

Figure 2-3 shows the undeformed and deformed shape of the RXB slice with the 4.2PSI hydrostatic load.

Figure 2-4 shows the comparison of the deformed shape of the RXB slice with the ACI 9-6 static portion of load combination COMB-Static+0.28GZ and COMB-Static+4.2PSI for Node 14020.

Figure 2-5 shows the comparison of the deformed shape of the RXB slice with the ACI 9-6 static portion of load combination COMB-Static+0.28GZ and COMB-Static+4.2PSI for Node 20059.

Figure 2-6 shows the comparison of the deformed shape of the RXB slice with the ACI 9-6 static portion of load combination COMB-Static+0.28GZ and COMB-Static+4.2PSI for Node 24704.

Figure 2-7 shows the comparison of the deformed shape of the RXB slice with the ACI 9-6 static portion of load combination COMB-Static+0.28GZ and COMB-Static+4.2PSI for Node 30125.

Table 2-1. Comparison of Joint Displacements between 0.28GZ and 4.2PSI Hydrostatic Loads (Slice X=824″ to X=1026″).

Joint Text	Location Text	Output Case Text	Lateral Displacement (Y) in	Vertical Displacement (Z) in
14020	North Pool Wall, El. 61′-6″	0.28GZ	0.004846	-0.009166
14020		4.2PSI	0.012473	-0.000490
20059	North Pool Wall, El. 86′-6″	0.28GZ	0.009694	-0.013442
20059		4.2PSI	0.009080	-0.000543
24704	North Pool Wall, El. 111′-6″	0.28GZ	0.012123	-0.016917
24704		4.2PSI	0.007270	-0.000579
30125	Roof Center, El. 179′-0″	0.28GZ	0.000412	-0.351684
30125		4.2PSI	-0.000156	-0.001644

Table 2-2. Comparison of Joint Displacements for ACI 349-06 Static Loads Combination (Slice X=824″ to X=1026″).

Joint Text	Location Text	Output Case Text	Lateral Displacement (Y) in	Vertical Displacement (Z) in
14020	North Pool Wall, El. 61′-6″	COMB-Static+0.28GZ	-0.0680	-0.0388
14020		COMB-Static+4.2PSI	-0.0604	-0.0301
20059	North Pool Wall, El. 86′-6″	COMB-Static+0.28GZ	-0.0716	-0.0574
20059		COMB-Static+4.2PSI	-0.0722	-0.0445
24704	North Pool Wall, El. 111′-6″	COMB-Static+0.28GZ	-0.0256	-0.0727
24704		COMB-Static+4.2PSI	-0.0305	-0.0563
30125	Roof Center, El. 179′-0″	COMB-Static+0.28GZ	0.0044	-1.6144
30125		COMB-Static+4.2PSI	0.0038	-1.2644

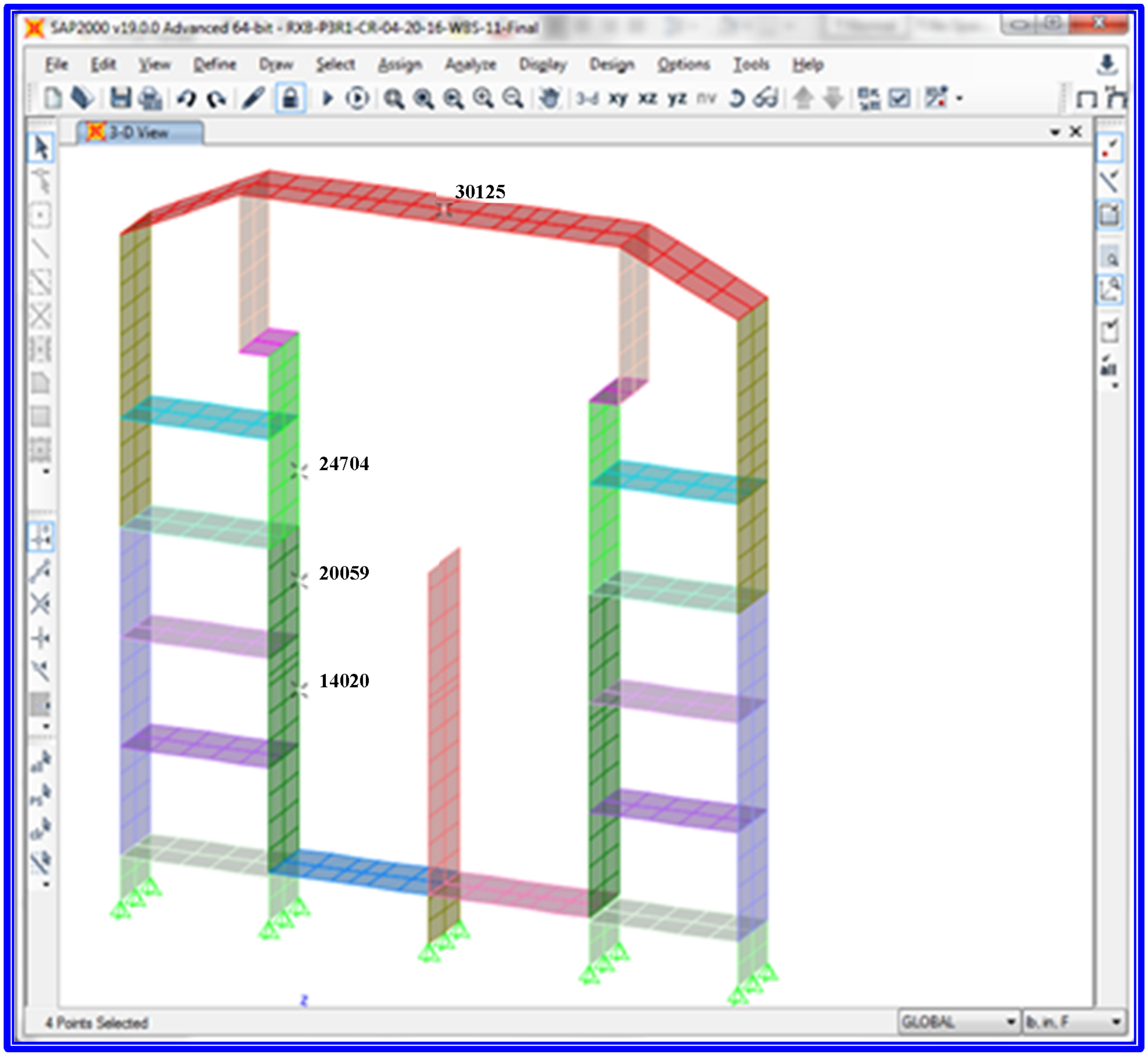


Figure 2-1. RXB Slice Between X=824″ and X=1026″ and Nodes Selected for Displacement Comparison.

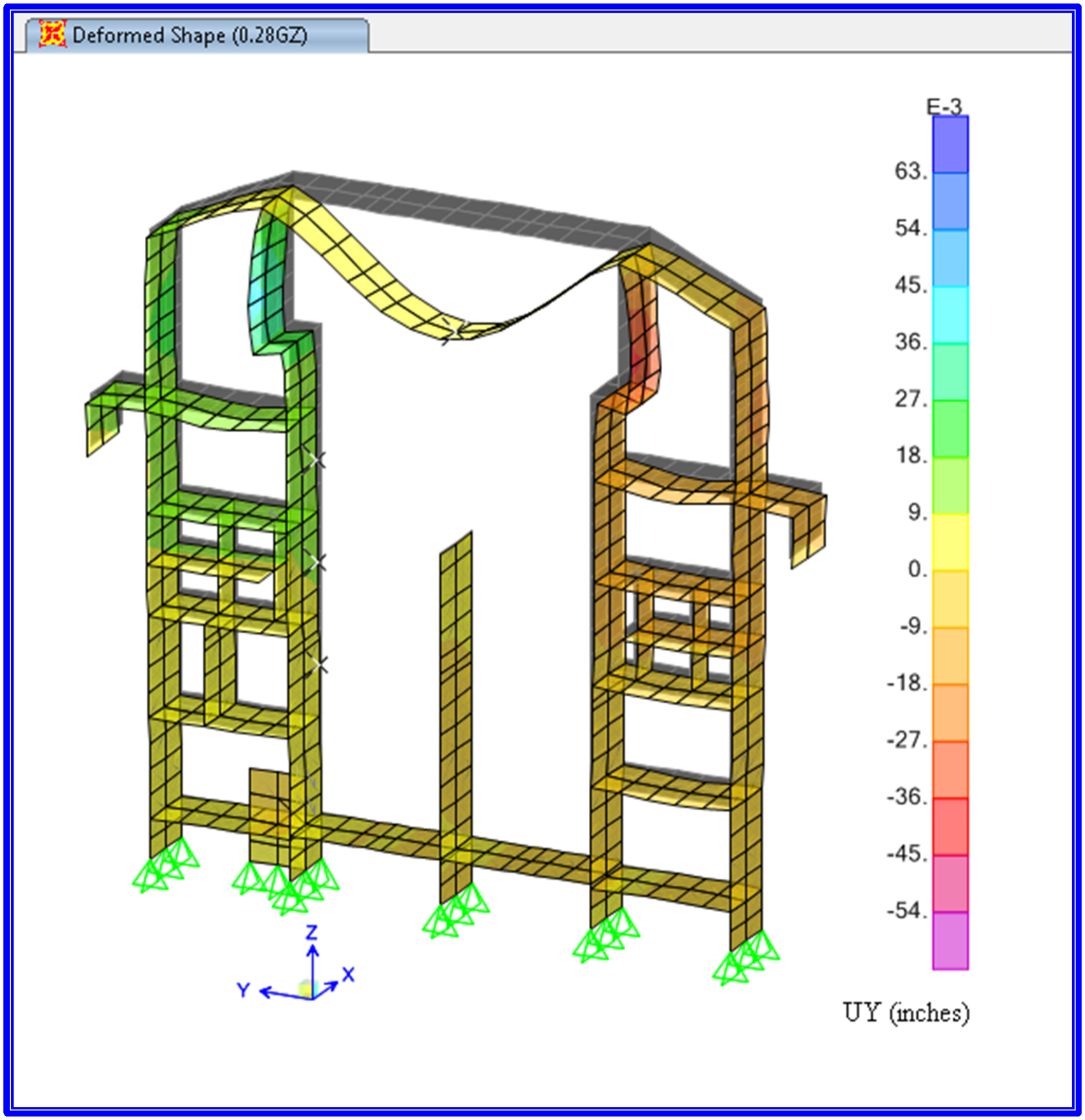


Figure 2-2. RXB Slice for Lateral Displacement Contour for 0.28GZ Loading.

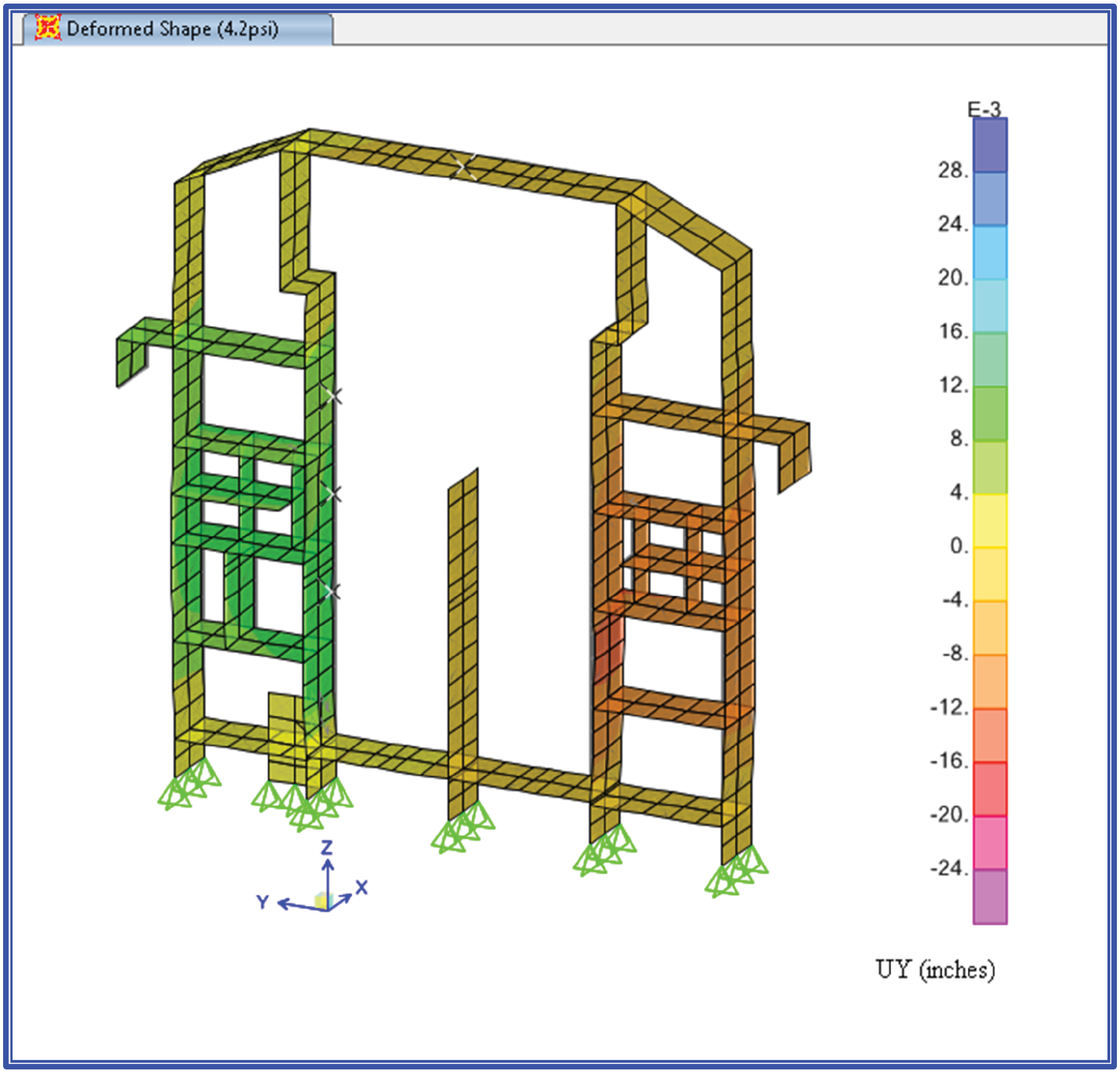


Figure 2-3. RXB Slice for Lateral Displacement Contour for 4.2PSI Hydrostatic Pressure Loading.

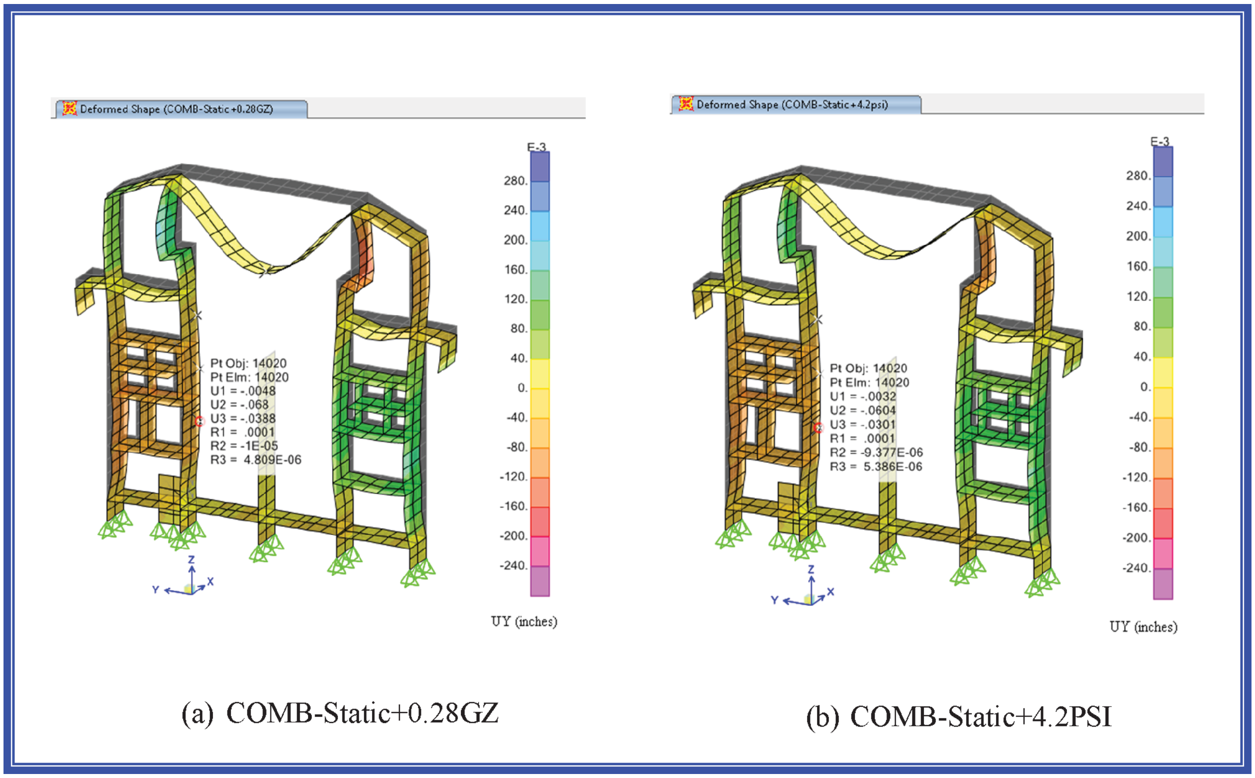


Figure 2-4. Comparison of Displacements for COMB-Static+0.28GZ and COMBStatic+4.2PSI at Node 14020 (Between El. 50′ and 75′).

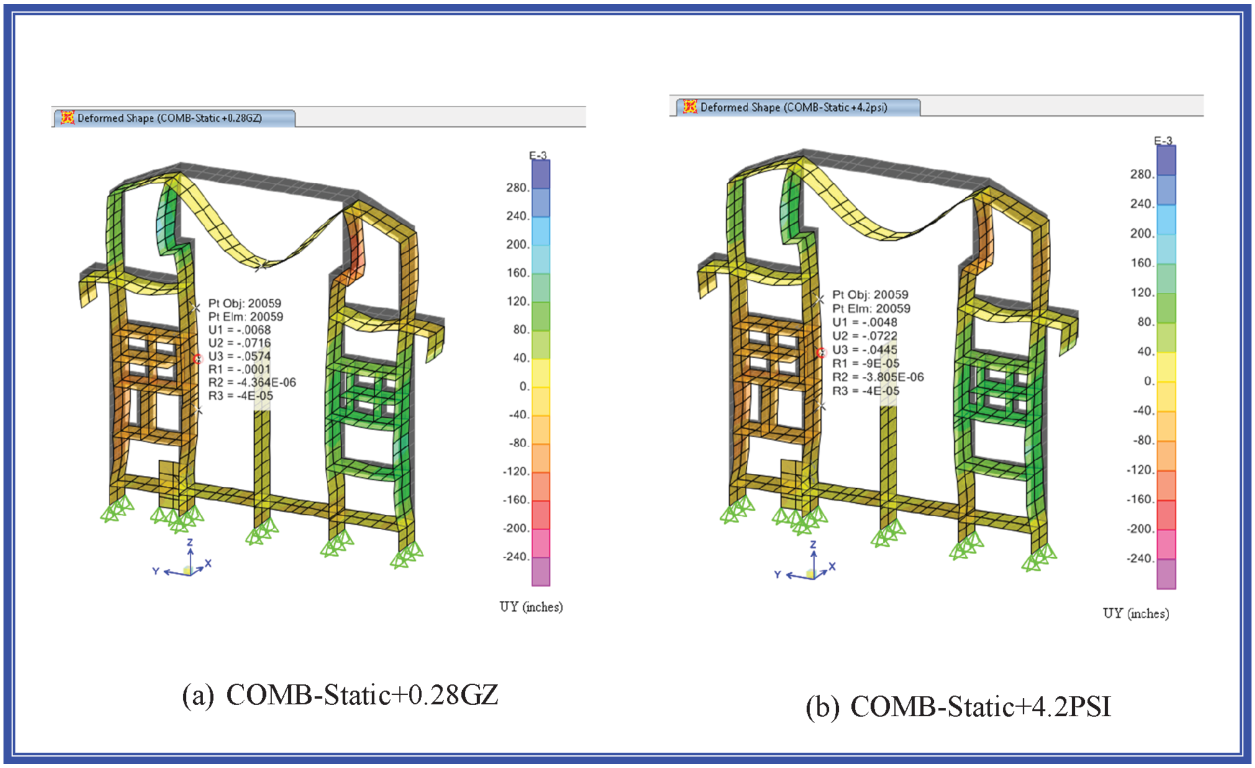
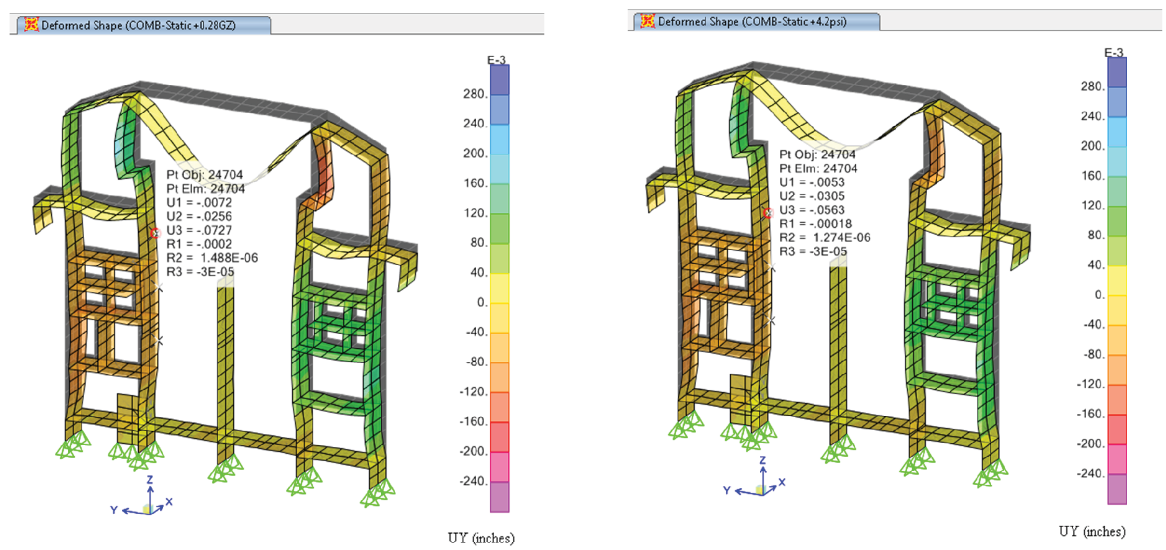


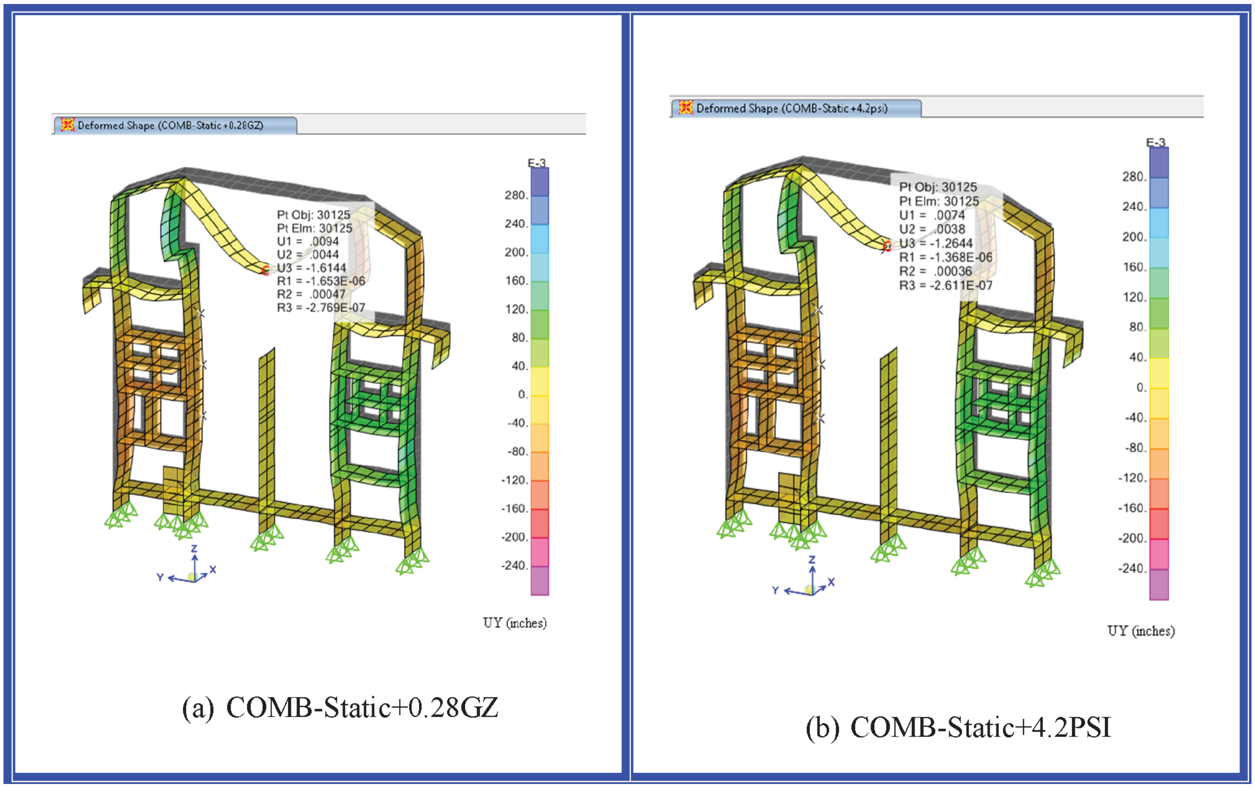
Figure 2-5. Comparison of Displacements for COMB-Static+0.28GZ and COMBStatic+4.2PSI at Node 20059 (Between El. 75′ and 100′).



(a) COMB-Static+0.28GZ

(b) COMB-Static+4.2PSI

Figure 2-6. Comparison of Displacements for COMB-Static+0.28GZ and COMB-Static+4.2PSI at Node 24704 (Between El. 100′ and 125′).



(a) COMB-Static+0.28GZ

(b) COMB-Static+4.2PSI

Figure 2-7. Comparison of Displacements for COMB-Static+0.28GZ and COMB-Static+4.2PSI at Node 30125 (Roof Center).

3. Comparison of Forces and Moments in Pool Walls

In Sections 4 and 5, forces and moments for the two load cases, COMB-Static+4.2PSI and COMB-Static+0.28GZ, of all north and east pool wall elements, respectively, are compared.

4. Forces and Moments in North Pool Wall

In this section, the maximum forces and moments in only the north pool wall for the two static load cases are compared. Comparisons of the maximum forces and moments are provided in Table 4-1 and Table 4-2, respectively. The maximum forces and moments are calculated over all the north pool wall elements between Elevation 25′-0″ (Z=132″) and Elevation 143′-0″ (Z=1548″).

Table 4-1 and Table 4-2 show that the forces and moments from COMB-Static+0.28GZ envelope those from COMB-Static+4.2PSI.

Table 4-1. Comparison of Maximum Forces in Elements at North Pool Wall (Grid Line B).

Output Case	F11	F22	F12	V13	V23
	Lb/in	Lb/in	Lb/in	Lb/in	Lb/in
[A] COMB-Static+4.2PSI	8,029	18,797	5,379	3,270	3,733
[B] COMB-Static+0.28GZ	8,929	23,742	6,825	3,858	4,820
Ratio [A]-[B]	**0.90**	**0.79**	**0.79**	**0.85**	**0.77**

Table 4-2. Comparison of Maximum Moments in Elements at North Pool Wall (Grid Line B).

Output Case	M11	M12	M11+M12	M22	M12	M22+M12
	Lb-in/in	Lb-in/in	Lb-in/in	Lb-in/in	Lb-in/in	Lb-in/in
[A] COMB-Static+4.2PSI	73,120	41,096	114,217	225,002	41,096	266,099
[B] COMB-Static+0.28GZ	94,741	53,319	148,060	300,376	53,319	353,695
Ratio [A]-[B]			**0.77**			**0.75**

5. Forces and Moments in East Pool Wall

In this section, the maximum forces and moments in only the east pool wall for the two static load cases are compared. Comparisons of the maximum forces and moments are provided in Table 5-1 and Table 5-2, respectively. The maximum forces and moments are calculated over all of the east pool wall elements between Elevation 25′-0″ (Z=132″) and Elevation 143′-0″ (Z=1548″).

Table 5-1 and Table 5-2 show that the forces and moments from COMB-Static+0.28GZ envelope those from COMB-Static+4.2PSI.

Table 5-1. Comparison of Maximum Forces in Elements at East Pool Wall (Grid Line 6).

Output Case	F11	F22	F12	V13	V23
	Lb/in	Lb/in	Lb/in	Lb/in	Lb/in
[A] COMB-Static+4.2PSI	14,831	22,658	4,043	2,388	4,680
[B] COMB-Static+0.28GZ	19,046	28,507	5,223	2,688	4,949
Ratio [A]-[B]	**0.78**	**0.79**	**0.77**	**0.89**	**0.95**

Table 5-2. Comparison of Maximum Moments in Elements at East Pool Wall (Grid Line 6).

Output Case	M11	M12	M11+M12	M22	M12	M22+M12
	Lb-in/in	Lb-in/in	Lb-in/in	Lb-in/in	Lb-in/in	Lb-in/in
[A] COMB-Static+4.2PSI	77,647	51,370	129,017	182,163	51,370	233,533
[B] COMB-Static+0.28GZ	81,100	50,427	131,527	195,609	50,427	246,036
Ratio [A]-[B]			**0.98**			**0.95**

Impact on DCA:

FSAR Tier 2, Section 3.7.2 has been revised as described in the response above and as shown in the markup provided in this response.

The RXB SASSI2010 model is an embedded model. For this study it was run with soil types 7, 8 and 11 and separate X, Y, and Z input motion time histories in order to obtain the pool wall segment (X1 to X3 and Y1 to Y5) and foundation acceleration results. The CSDRS-compatible Capitola time history was applied to the model with uncracked concrete conditions.

For each segment, the absolute acceleration results from the three input motion time histories were combined using SRSS and are shown in Figure 3.7.2-40 through Figure 3.7.2-45 for the X and Y segments with soil types 7, 8 and 11.

Equivalent wall pressures are determined from the nodal wall accelerations, the tributary area surrounding the nodes, and the lumped water mass values assigned to the nodes. The average SASSI2010 equivalent hydrostatic pressure was calculated in the following fashion:

- Using SAP2000, extract a list of nodes where water weight is applied to the model, w_w.
- Using SASSI2010, extract a list of accelerations at these nodes, a_{SASSI}.
- Obtain the force at a single node by:

$$f_n = ma = \frac{w_w}{g} \times a_{SASSI} \quad \text{Eq. 3.7-10}$$

- Divide each nodal force by tributary area to obtain nodal pressures:

$$P_n = \frac{f_n}{TribArea} \quad \text{Eq. 3.7-11}$$

- Calculate the average static pressure of slices made of elevation and wall section by finding the average of the nodal pressures contained in that slice
- Find the height difference between elevations
- Create trapezoidal areas from this height by the difference in pressures, i.e.,

$$A = h \times \frac{P_{above} + P_{below}}{2} \quad \text{Eq. 3.7-12}$$

- The average pressure is the sum of pressures over heights, i.e.

$$P_{static} = \frac{\Sigma A}{\Sigma h} \quad \text{Eq. 3.7-13}$$

RAI 03.07.02-15S2

Average vertical pressure (Z) on the pool floor was obtained from the nodal pressure values on all pool bottom nodes for the X, Y, and Z direction CSDRS Capitola input motions. The average pressure values on the pool floor in the Z direction due to X, Y, and Z input motions were combined via SRSS to obtain the total vertical (Z) pressure reported in Table 3.7.2-2. Average equivalent static pressure from SASSI2010 for each soil type and each wall segment are presented in Table 3.7.2-3. The table also includes a weighted wall average based on the lengths of the walls.

Equivalent Static Pressure Estimation

The SASSI2010 (corrected) equivalent static pressure due to hydrodynamic effects is calculated as follows:

$$P_{addl} = P_{hd} \times \frac{a_{SASSI}}{a_{ANSYS}} \qquad \text{Eq. 3.7-14}$$

Where:

RAI 03.07.02-15S2

- P_{addl} = ~~additional~~ equivalent static pressure,
- P_{hd} = hydrodynamic pressure from ANSYS,
- a_{SASSI} = acceleration from SASSI2010 using either soil type 7, 8, or 11; and
- a_{ANSYS} = acceleration from ANSYS.

RAI 03.07.02-15S1

The FSI analysis uses synthetic ground motions based on Capitola seed time histories. Based on the overall building base shear comparison in Table 3.8.5-3, these runs using soil types 7, 8, and 11, and the CSDRS spectrum are more controlling than the soil type 9, CSDRS-HF spectrum case. Therefore, the factors used to convert ANSYS FSI hydrodynamic pressures to equivalent static pressures for soil types 7, 8, and 11 adequately envelope soil type 9.

Once the factors between SASSI2010 and ANSYS acceleration are obtained, the additional equivalent hydrostatic pressure for SASSI2010 can be computed. Table 3.7.2-4 through Table 3.7.2-6 present the average values for each segment and soil type, and includes a weighted value for each wall.

Table 3.7.2-7 compares this equivalent static pressure with the original static pressures obtained from SASSI2010.

Development of Correction Factor

RAI 03.07.02-15S1

The maximum static wall pressure differences between the ANSYS and SASSI2010 models are summarized in Table 3.7.2-7. ~~These maximum pressures were initially underestimated in the SASSI2010 analysis using lumped nodal masses. The ANSYS RXB analysis provided a more accurate wall pressure due to Fluid-Structure Interaction effects.~~The SASSI2010 analysis with lumped water masses does not represent fluid-structure-interaction behavior, and, therefore, underestimates the hydrodynamic pressures on the RXB walls. In order to account for this, an ANSYS FSI analysis, in which the water elements were explicitly modeled, was performed. Based on these results, an average pressure of 4.20 psi was added as static pressure to the SAP2000 RXB model. This added pressure accounts for the missing 3D effects of fluid-impulsive pressure on the pool walls and foundation.

RAI 03.07.02-15S1, RAI 03.07.02-15S2

The pressure at the bottom of the pool due to gravity loading of the water is approximately 30 psi (62.4 lb/ft^3 * 69 ft depth *1/144 ft^2/in^2). Consequently, the average pressure on the wall is half this amount, or 15 psi. The pressure of 4.20 psi is 28 percent of the average pressure (4.20 psi/15 psi = 0.28). Therefore, a 1.28g vertical static loading was added to the SAP2000 model to ensure this additional pressure is accounted for in the design. See Figure 3.7.2-129. Increasing the downward acceleration by a factor of 1.28 corrects for the underestimated fluid pressure, due to mass lumping, in the SSI model. Horizontal hydrostatic load is a function of fluid density and depth. Fluid density can be altered by changing the acceleration due to gravity. Increasing the vertical gravitational acceleration increases the horizontal hydrostatic pressure.

RAI 03.07.02-15S1, RAI 03.07.02-15S2

The total hydrodynamic load consists of the lumped-mass hydrodynamic load from the SASSI2010 analysis (which underestimates the hydrodynamic load) and the fluid-structure-interaction correction load from the ANSYS analysis. The effects of the lumped-mass-based hydrodynamic pressures on the pool walls and floor are included in the determination of forces on the walls and floor from the SSI analysis. These hydrodynamic effects from SASSI2010 are included in the E_{ss} term of the governing load combination (see FSAR Section 3.8.4.3.16 for the definition of E_{ss}). The "missing" hydrodynamic load is added to the hydrostatic load to determine the total fluid pressure on the RXB walls and foundation.

3.7.2.1.2.5 Control Building

A general discussion of the CRB and the major features and components is provided in Section 1.2.2.2. Architectural drawings, including plan and section views are provided in Figure 1.2-21 through Figure 1.2-27.

The CRB is located approximately 34 feet to the east of the RXB and its primary function is to house the Main Control Room and the Technical Support Center.

The CRB is a reinforced concrete building with an upper steel structure supporting the roof. The reinforced concrete portion of the building is Seismic Category I. The SSC on the top floor have no safety-related or risk-significant functions. The walls and roof above this floor are provided for weather protection/climate control. This part of the structure is not required to be