NuScale Power

RAIO-1217-57899

December 21, 2017

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. 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) on the NuScale Design Certfication Application, dated October 3, 2017 (ML17277A300)

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

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

- 03.07.02-15

The response to RAI Questions 03.07.02-13 and 03.07.02-14 were previously provided in Reference 2. This completes all responses to RAI No. 134 (eRAI No. 8934).

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
NuScale Power, LLC

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Enclosure 1: NuScale Response to NRC Request for Additional Information eRAI No. 8934

Enclosure 1:

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

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NuScale Power

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:

The following response provides an explanation as to why the fluid structure interaction (FSI) correction factors for the case of high frequency certified seismic design response spectra (CSDRS-HF) compatible time history input for Soil Type 9 are not considered and a technical basis for the approach taken to account for the FSI effects on vertical water pressure estimation.

a)

Both the FSI and the NPM analyses used synthetic ground motions based on Capitola seed time histories. Based on the overall building base shear comparison in Table 1 below, these runs using soil types 7, 8, and 11, and CSDRS spectrum are more controlling than the soil type 9 with synthetic time history based on Lucerne seed time history and CSDRS-HF spectrum. 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.

Table 1: Seismic Base Reactions* (Extracted from FSAR Table 3.8.5-3)

Model	Concrete Case	Soil Type	Seismic Load Case	Global FX (kips)	Global Fy (kips)	Global Fz (kips)
Reactor Building	Cracked 7% Damping	S7 CSDRS	Capitola	**326528**	177221	**222932**
		S8 CSDRS	Capitola	306274	**206799**	205032
		S11 CSDRS	Capitola	151960	135837	185963
		S7 CSDRS- HF	Lucerne	119790	77946	147529
		S9 CSDRS- HF	Lucerne	126622	82652	162443
		% Reaction Ratio = S9 CSDRS- HF/ Maximum	-	39	40	73
	Uncracked 7% Damping	S7 CSDRS	Capitola	**331587**	203856	**225014**
		S8 CSDRS	Capitola	311880	**212752**	208268
		S11 CSDRS	Capitola	152056	138287	186456
		S7 CSDRS- HF	Lucerne	114361	82076	156119
		S9 CSDRS- HF	Lucerne	155572	99573	167031
		% Reaction Ratio = S9 CSDRS- HF/ S7 CSDRS	-	47	47	74

*These loads are the maximums of the total base reaction time histories obtained by the step-by-step combination of the reactions in all springs below the foundation

The ANSYS FSI analysis determined that an average equivalent static pressure can be applied as a load to the RXB to account for the effects of 3-D FSI that are underestimated in SSI results that use fluid mass lumping methodology. Figure 1 shows the equivalent static pool water pressure to be added is 4.20 psi, and it can be produced by applying a hydrostatic pressure due to 0.28g.

Table 2 shows a summary of average equivalent static pressure for Soil Types 7, 8, and 11 that were based on the SSI analyses results for the pool floor and wall accelerations using the CSDRS compatible Capitola time histories. The highest 4.20 psi equivalent static pressure value is based on Soil Type 7. The equivalent static pressures for Soil Type 11 (the soil type that more closely matches the SSI base reactions of Soil Type 9) are twenty to sixty percent lower than Soil Type 7. This indicates that the average equivalent static pressure for soil Type 9 will be lower than the maximum from Soil Type 7.

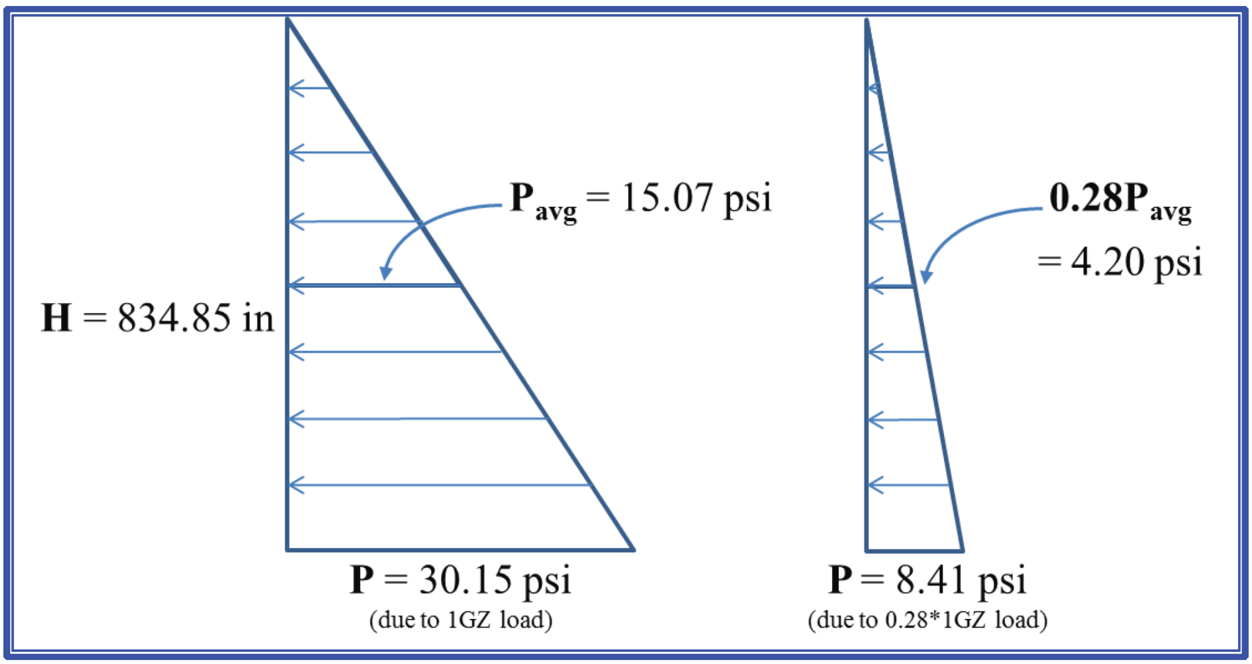

Figure 1: Development of Average Static Pressure of 4.20 psi at Mid Height of Pool Water for SAP2000 Model to Account for 3D FSI Effects

Table 2: Equivalent Wall Pressure to Be Adjusted in SAP2000 Model Due to FSI Effects

Section	Soil Type 7 Difference between ANSYS and SASSI2010 Wall Pressures	Soil Type 8 Difference between ANSYS and SASSI2010 Wall Pressures	Soil Type 11 Difference between ANSYS and SASSI2010 Wall Pressures	Maximum Difference per Section	Envelope Pressure to be Added to SAP2000 Model
	(psi)	(psi)	(psi)	(psi)	(psi)
All X Wall	3.090	2.428	1.286	3.090	4.20
All Y Wall	4.129	3.637	1.960	4.129	
Z Foundation	4.203	3.921	3.373	4.203	
	Soil Type 7 Governs the Pressure Estimation				

In addition, reactor building ANSYS analyses in the X, Y, and Z directions were performed using the CSDRS-HF Lucerne time histories. Table 3 summarizes the results. Figure 2 through Figure 19 provide the pressure contours on the RXB outer walls and foundation resisting the X, Y, Z fluid motions. The pressures on the walls and foundations for CSDRS-HF cases are within four percent of respective CSDRS pressure values. This demonstrates that results from the high frequency soil types are similar to results from the non-high frequency soil types.

The average equivalent static pressure scaling factor based on the SSI analyses results for the pool floor and wall accelerations results obtained for Soil Types 7, 8, and 11 using the CSDRS adequately envelope the Soil Type 9 CSDRS-HF demand forces used for the RXB design.

Table 3: ANSYS Wall Pressure Contours Comparison between CSDRS and CSDRS-HF

PRESSURE DIRECTION	CSDRS	CSDRS-HF	Pressure Range (PSI)	Remarks from Pressure Contours
X-Wall due to X	Figure 2	Figure 3	0.35 to 10.7 (CSD) 0.44 to 10.9 (CSD-HF)	The pressure contours are close
Y-Wall due to X	Figure 4	Figure 5	0.55 to 10.5 (CSD) 0.58 to 10.9 (CSD-HF)	The pressure contours are close
Z-Foundation due to X	Figure 6	Figure 7	1.92 to 11.5 (CSD) 1.35 to 10.9 (CSD-HF)	The pressure contours are close
X-Wall due to Y	Figure 8	Figure 9	0.39 to 7.6 (CSD) 0.19 to 7.7 (CSD-HF)	The pressure contours are close
Y-Wall due to Y	Figure 10	Figure 11	1.11 to 8.2 (CSD) 1.01 to 8.1 (CSD-HF)	The pressure contours are close
Z-Foundation due to Y	Figure 12	Figure 13	0.73 to 7.9 (CSD) 0.52 to 7.4 (CSD-HF)	The pressure contours are close
X-Wall due to Z	Figure 14	Figure 15	0.75 to 16.8 (CSD) 0.61 to 15.0 (CSD-HF)	The pressure contours for CSD are slightly higher
Y-Wall due to Z	Figure 16	Figure 17	0.75 to 16.8 (CSD) 0.77 to 15.0 (CSD-HF)	The pressure contours for CSD are slightly higher
Z-Foundation due to Z	Figure 18	Figure 19	10.2 to 18.8 (CSD) 8.44 to 15.0 (CSD-HF)	The pressure contours for CSD are slightly higher

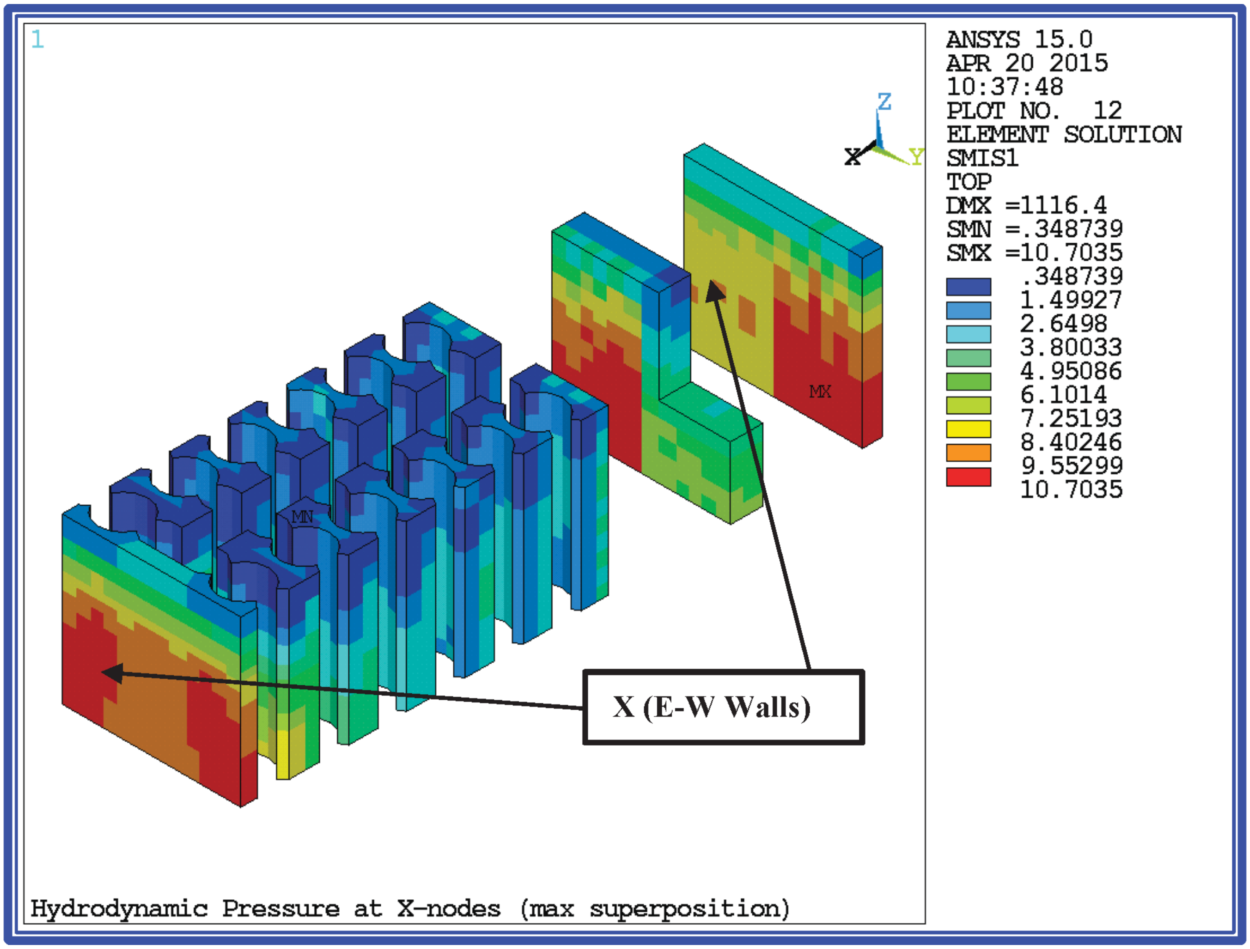

Figure 2: Hydrodynamic Pressure at X Nodes due to X Input Time History using CSDRS

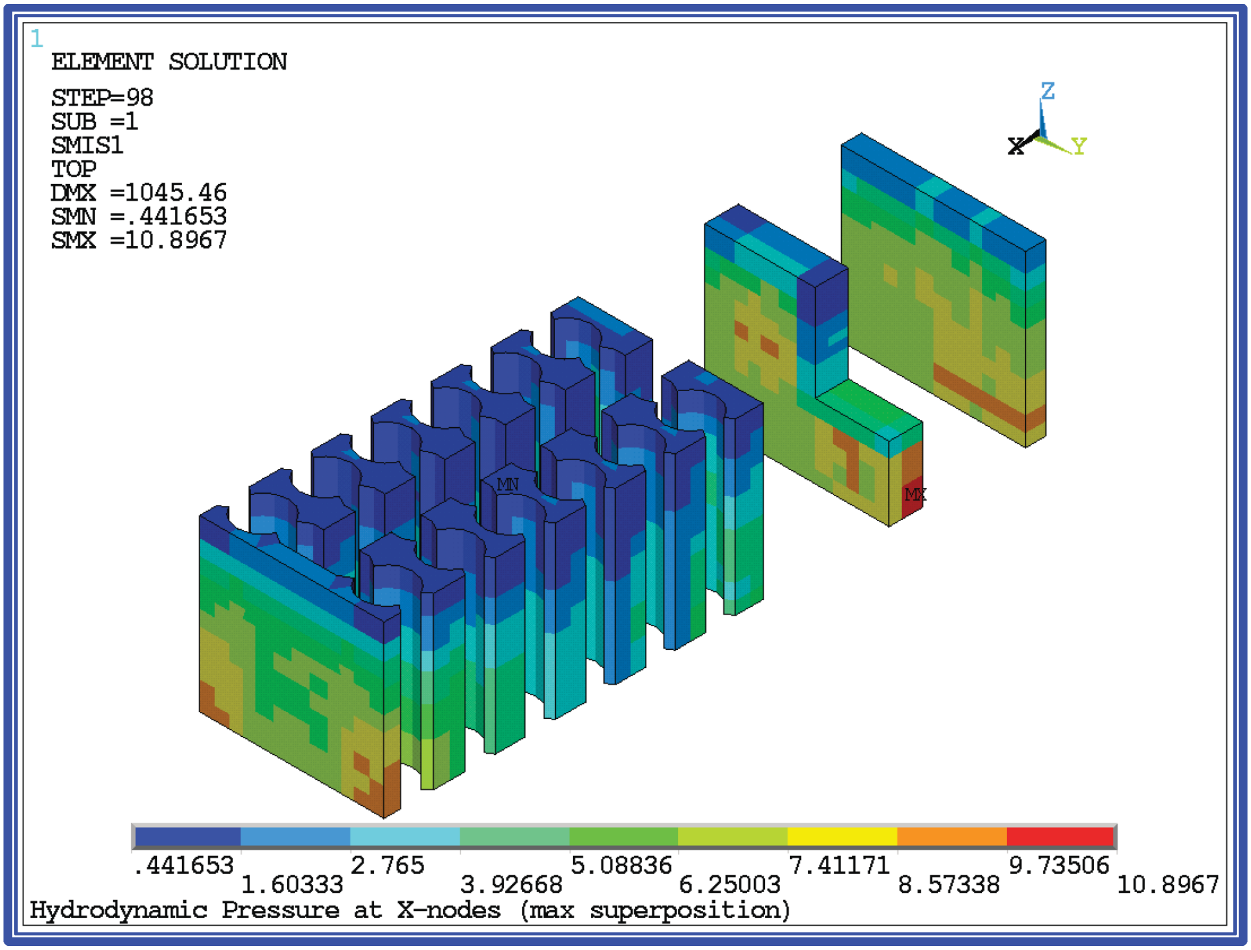

Figure 3: Hydrodynamic Pressure at X Nodes due to X Input Time History using CSDRS-HF

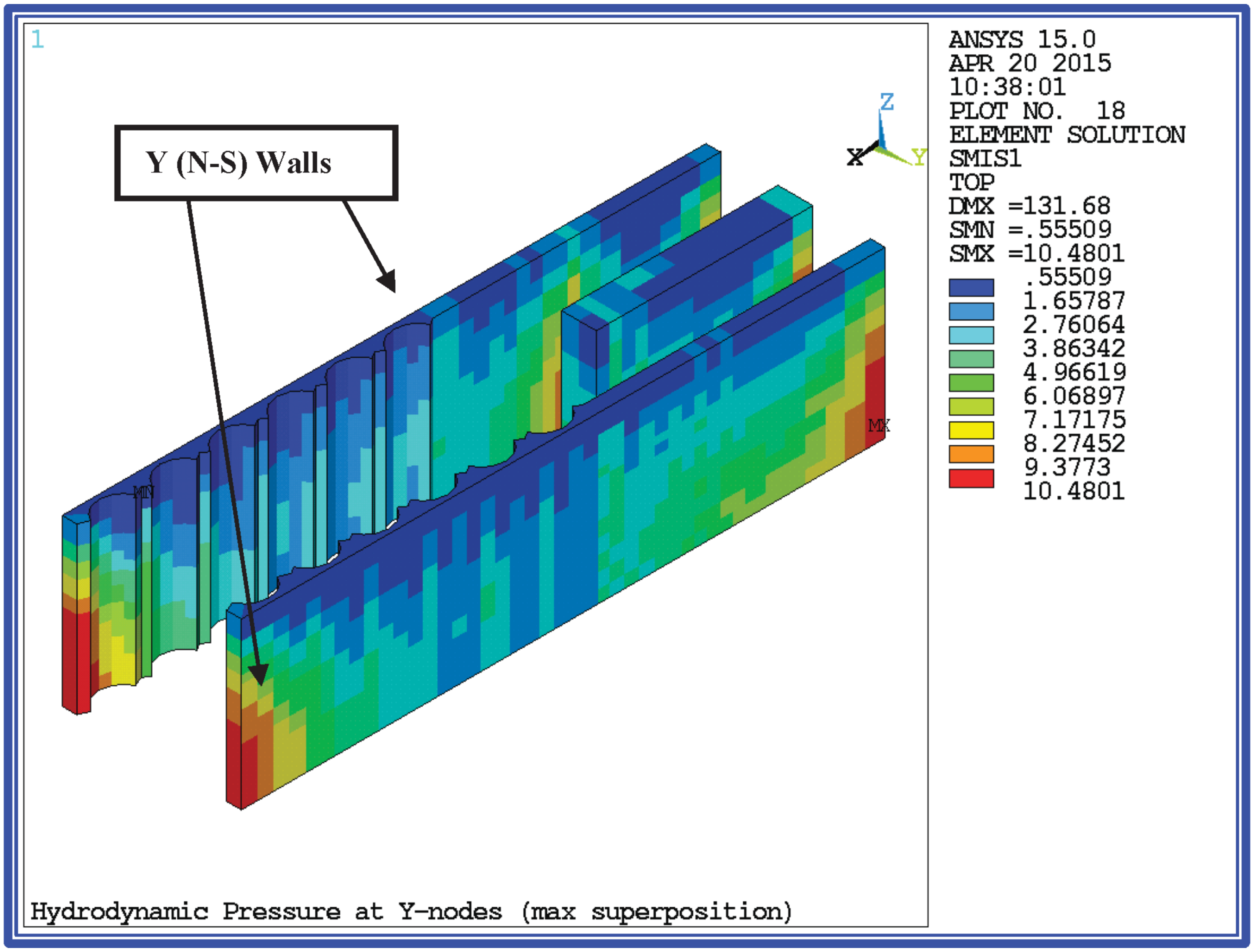

Figure 4: Hydrodynamic Pressure at Y Nodes due to X Input Time History using CSDRS

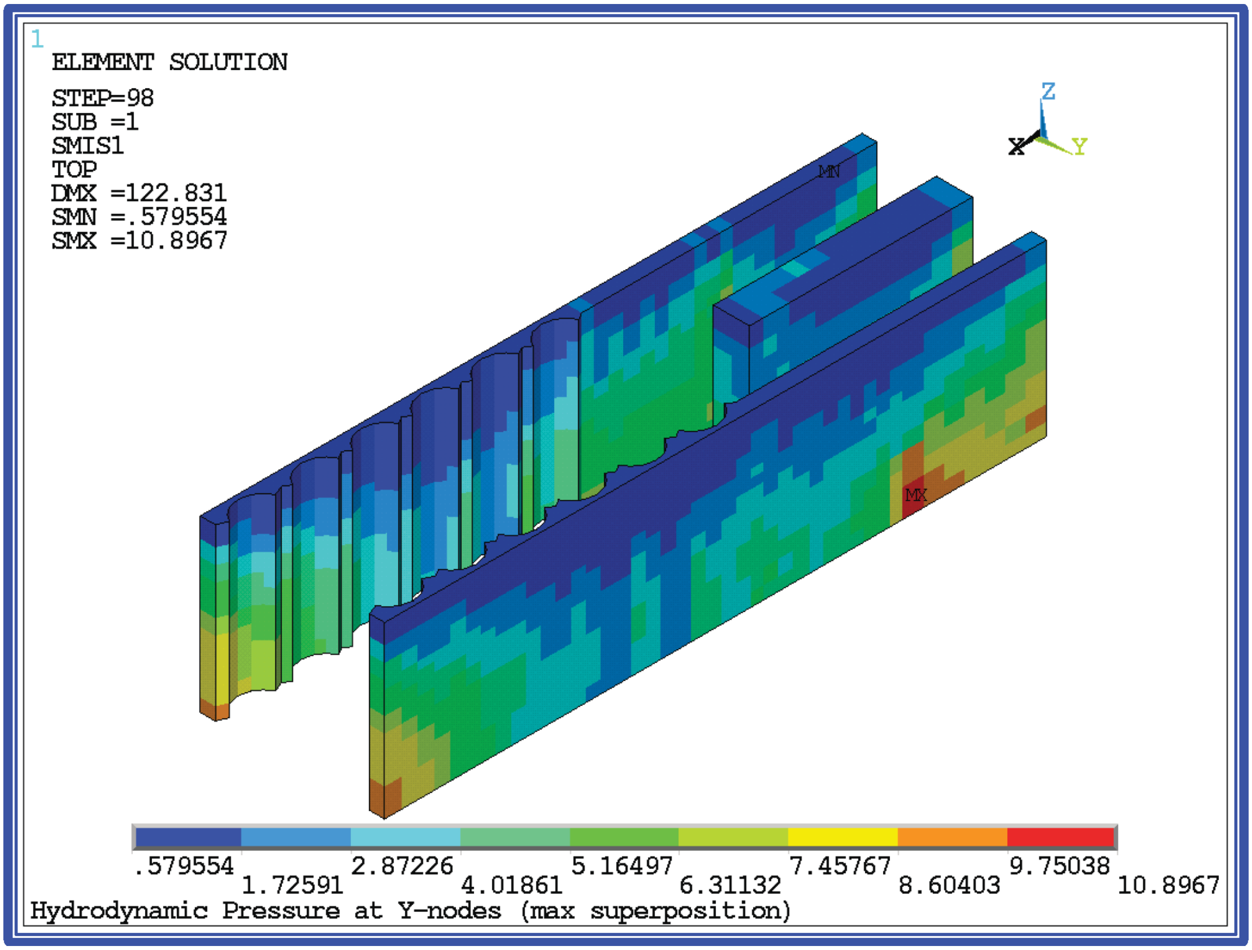

Figure 5: Hydrodynamic Pressure at Y Nodes due to X Input Time History using CSDRS-HF

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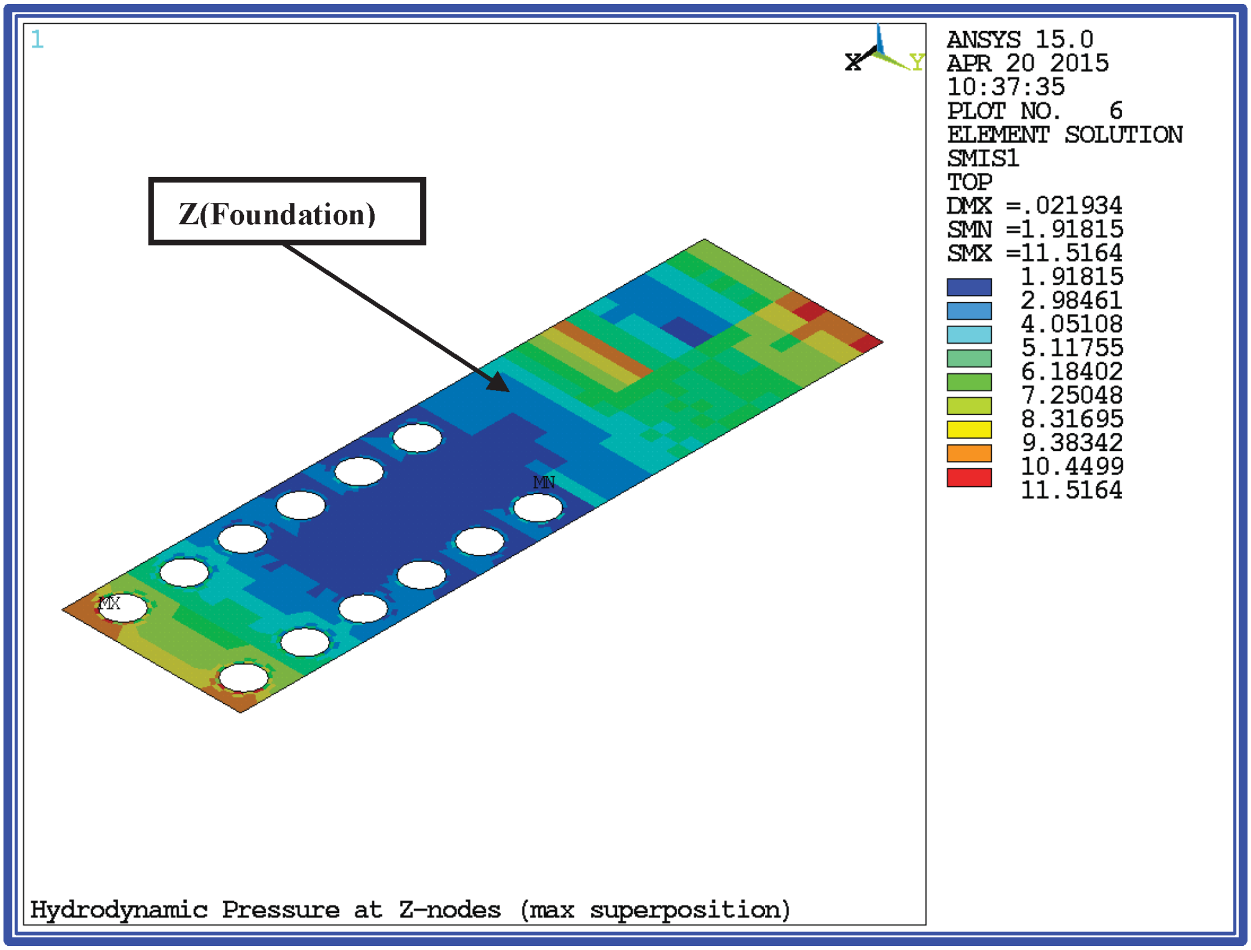

Figure 6: Hydrodynamic Pressure at Z Nodes due to X Input Time History using CSDRS

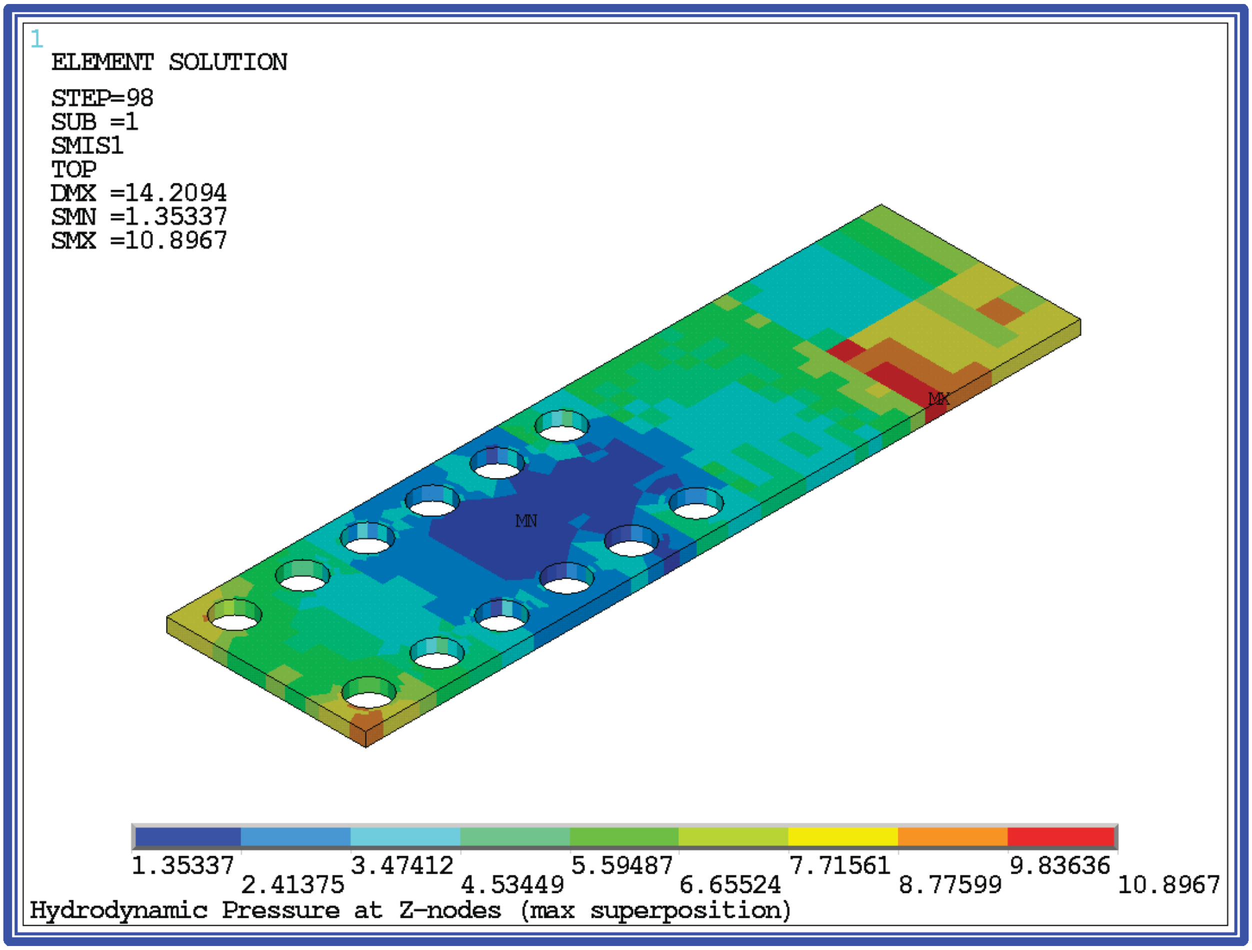

Figure 7: Hydrodynamic Pressure at Z Nodes due to X Input Time History using CSDRS-HF

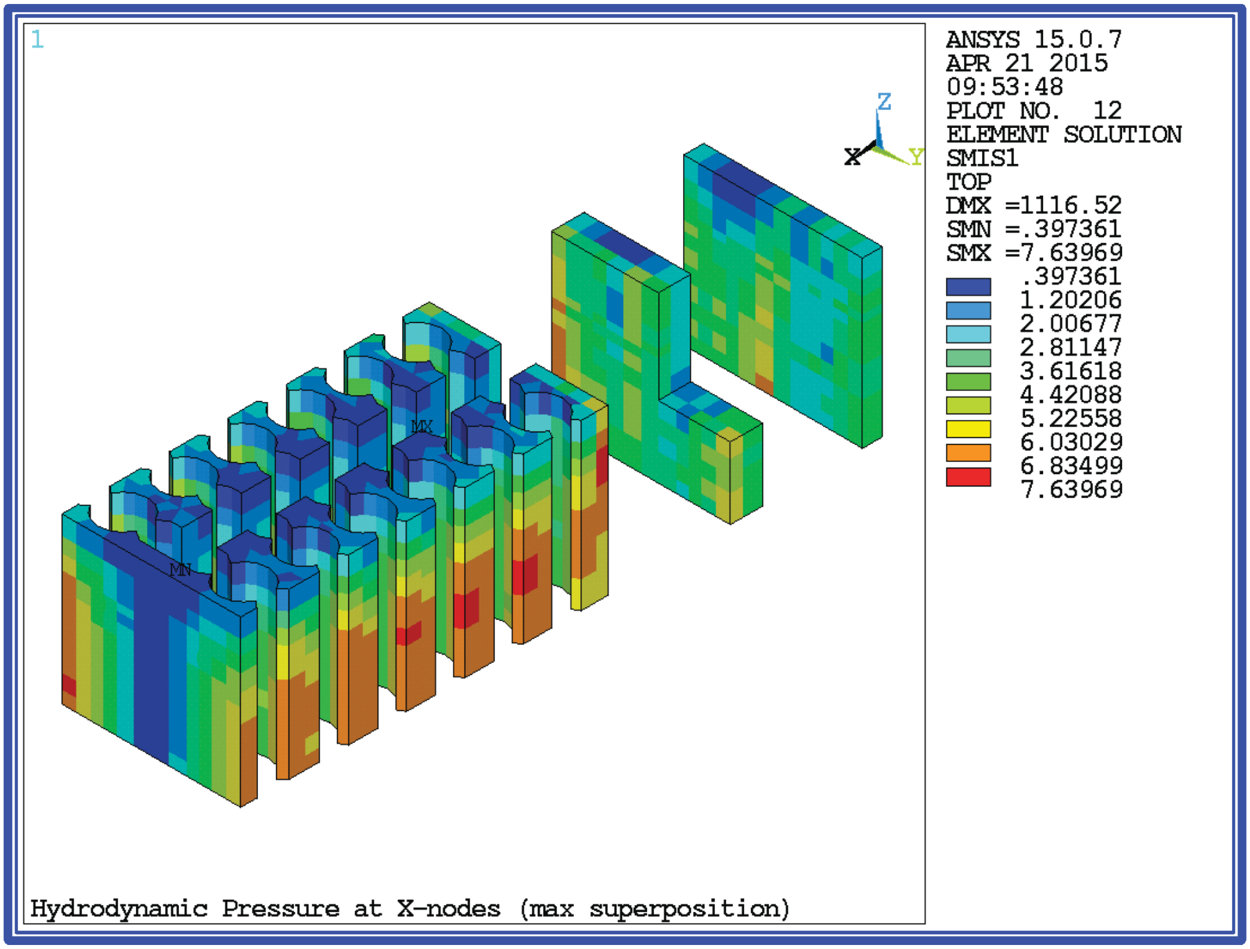

Figure 8: Hydrodynamic Pressure at X Nodes due to Y Input Time History using CSDRS

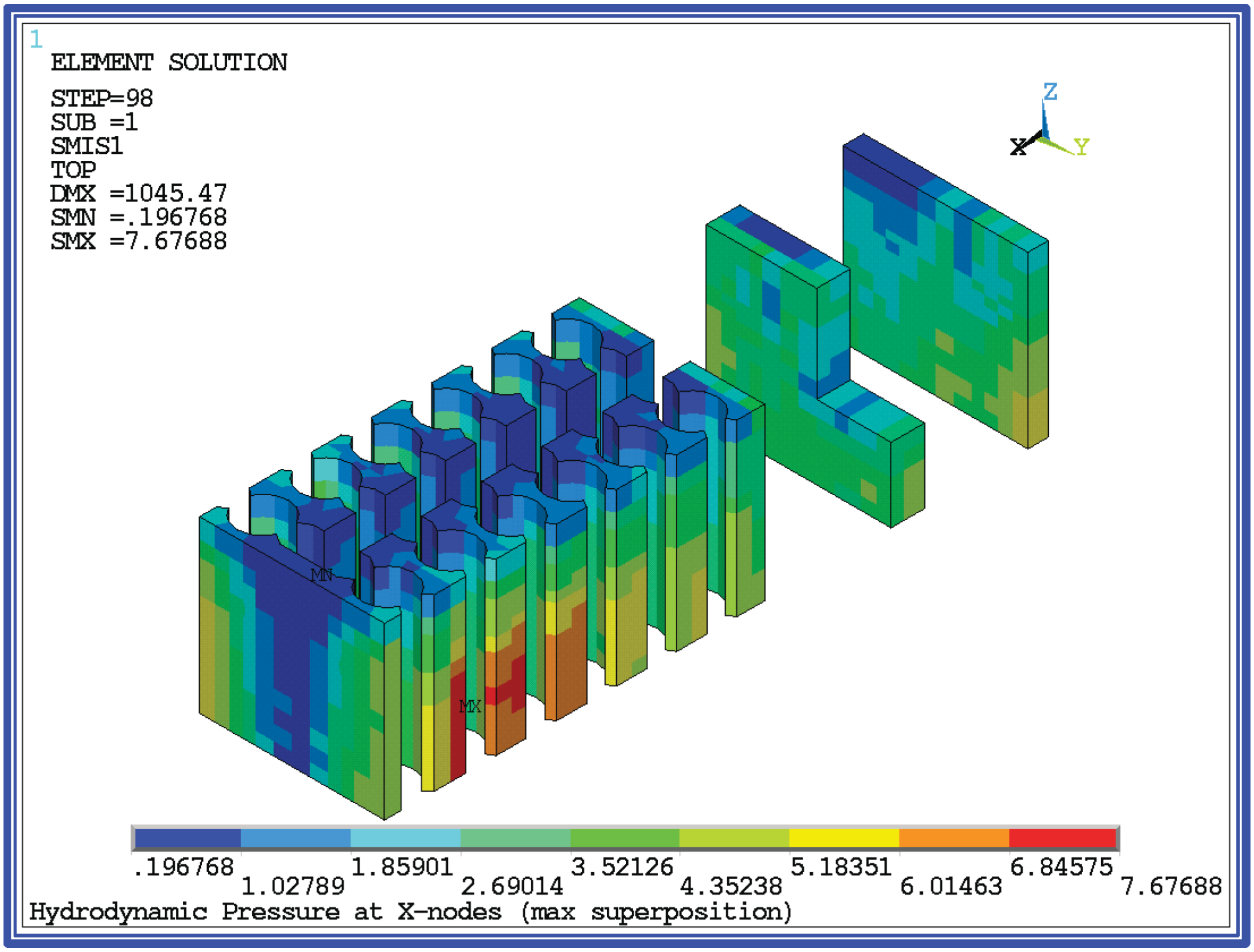

Figure 9: Hydrodynamic Pressure at X Nodes due to Y Input Time History using CSDRS-HF

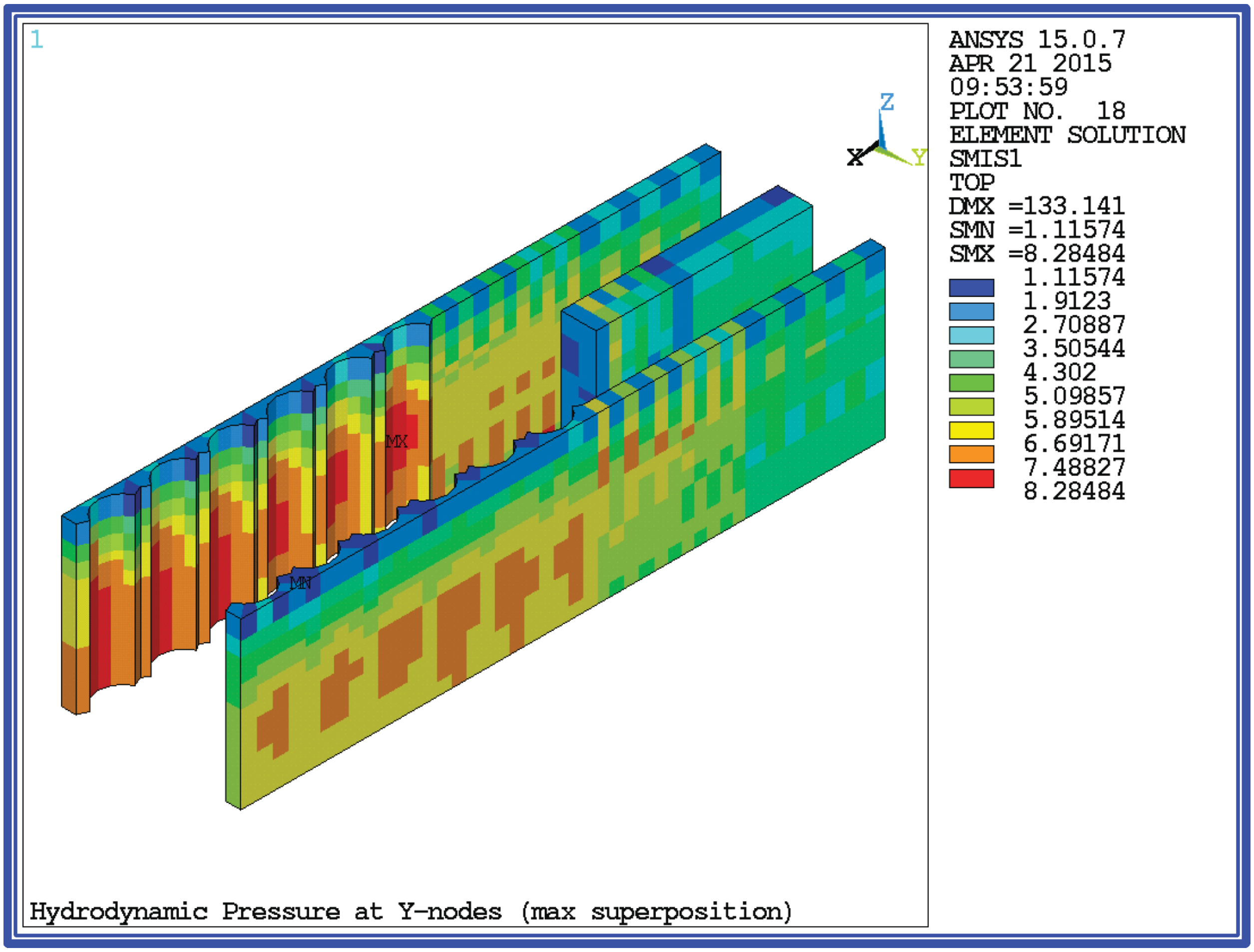

Figure 10: Hydrodynamic Pressure at Y Nodes due to Y Input Time History using CSDRS

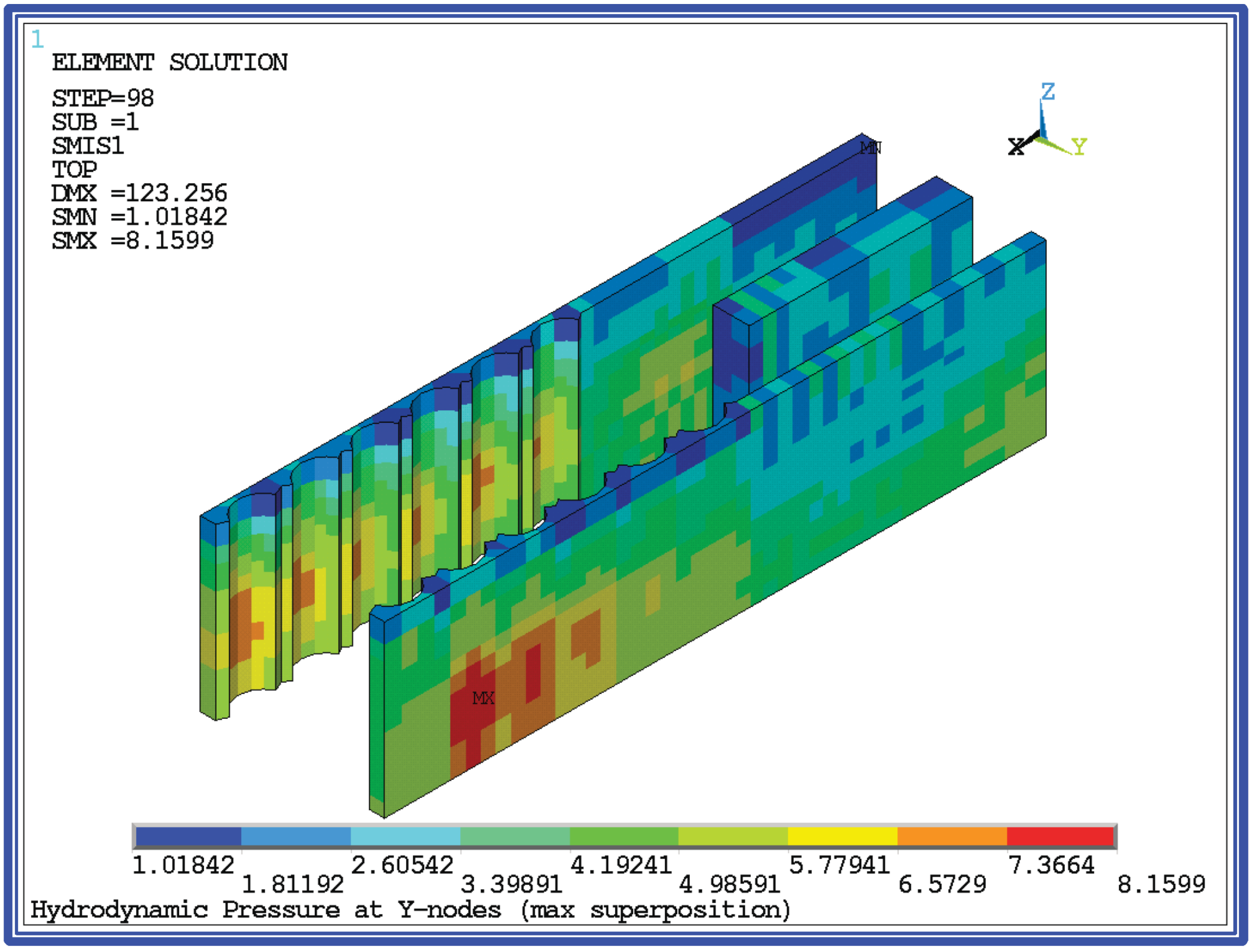

Figure 11: Hydrodynamic Pressure at Y Nodes due to Y Input Time History using CSDRS-HF

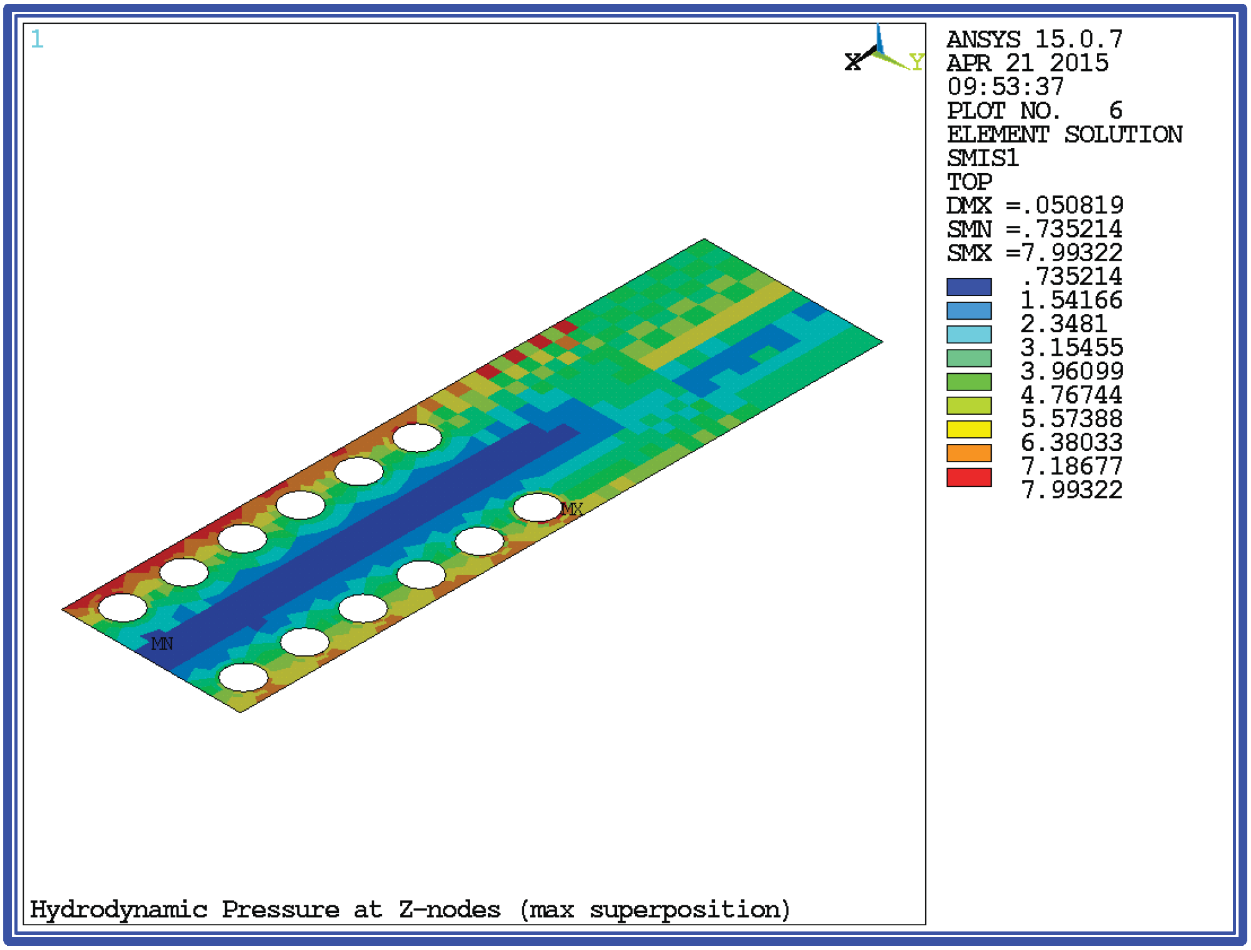

Figure 12: Hydrodynamic Pressure at Z Nodes due to Y Input Time History using CSDRS

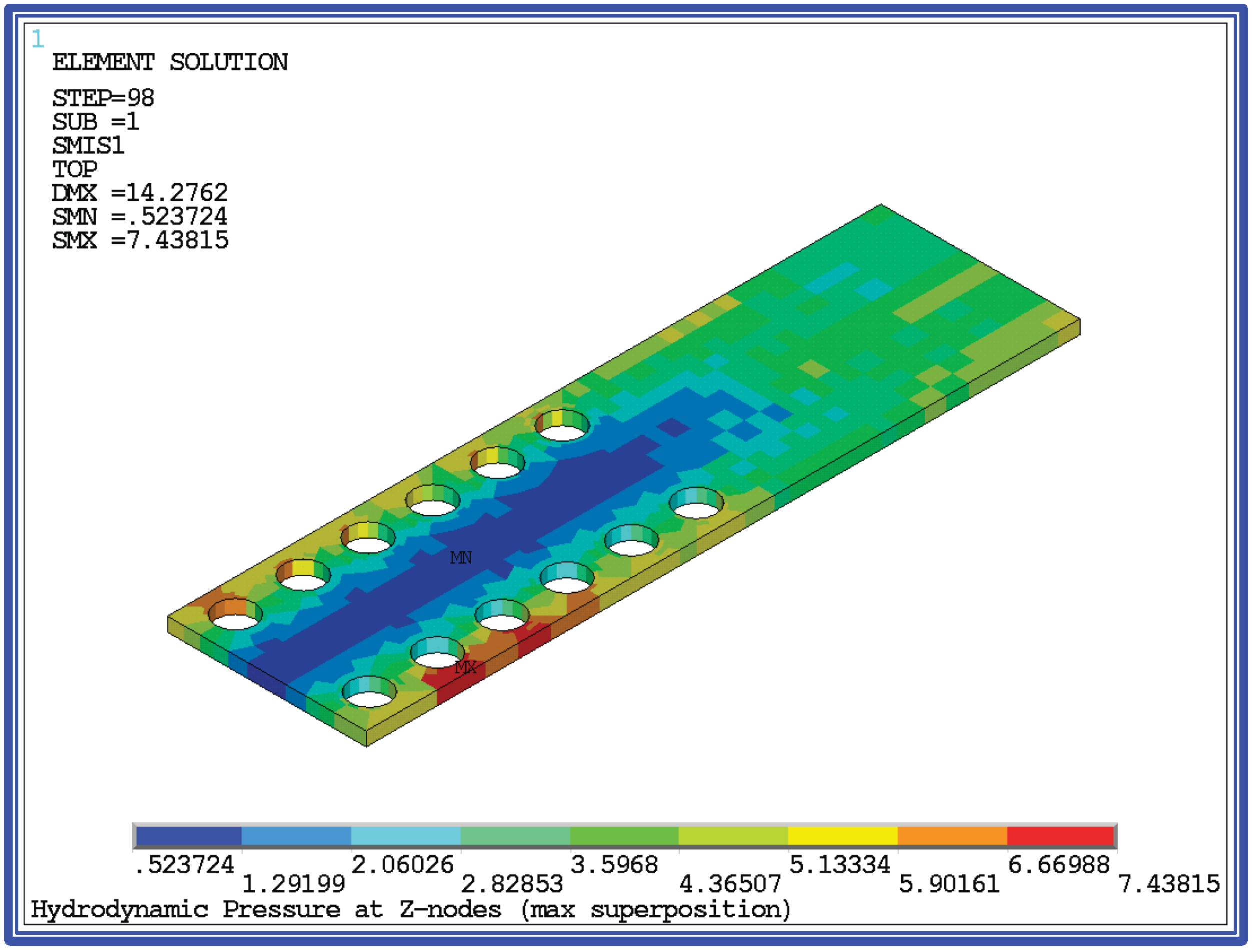

Figure 13: Hydrodynamic Pressure at Z Nodes due to Y Input Time History using CSDRS-HF

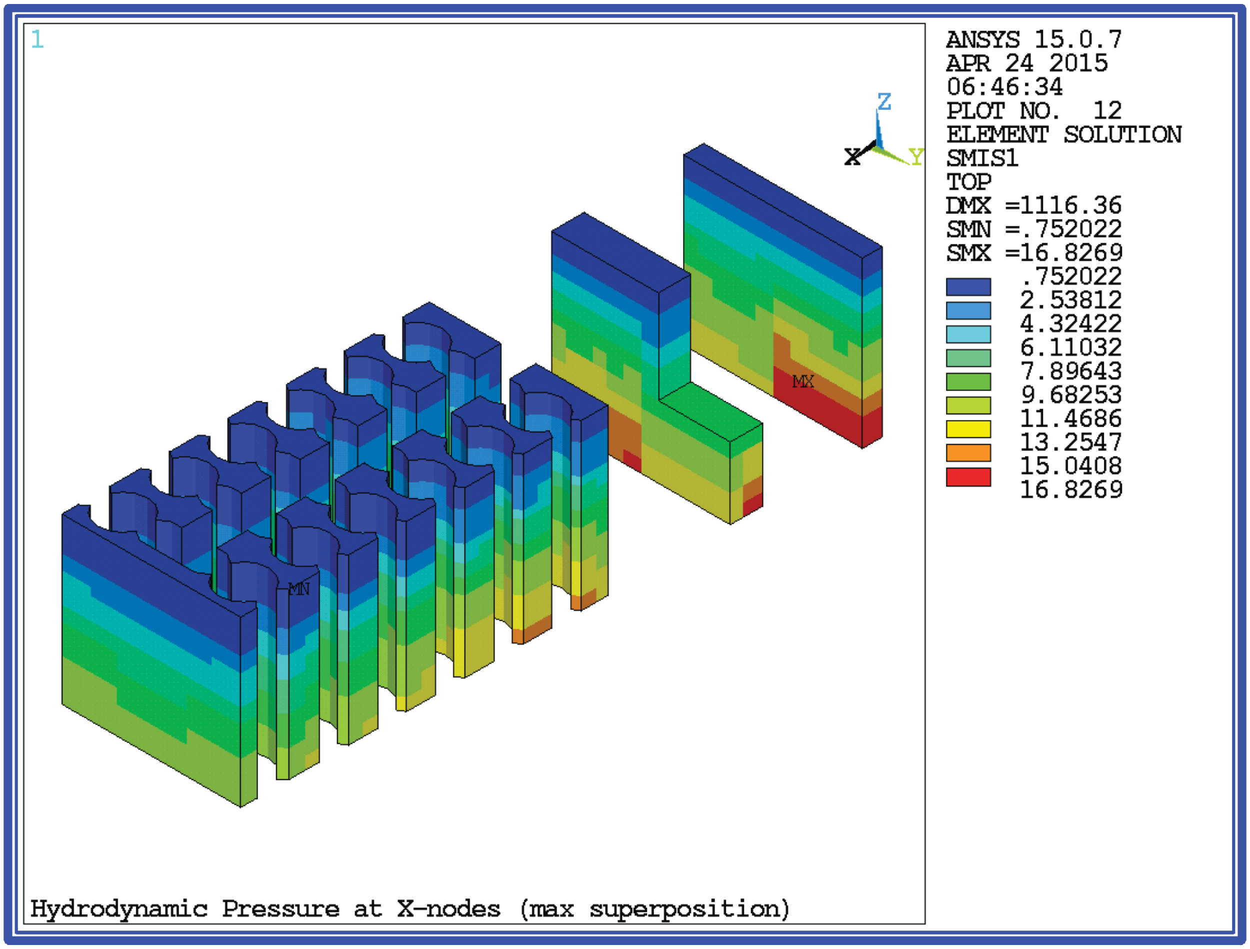

Figure 14: Hydrodynamic Pressure at X Nodes due to Z Input Time History using CSDRS

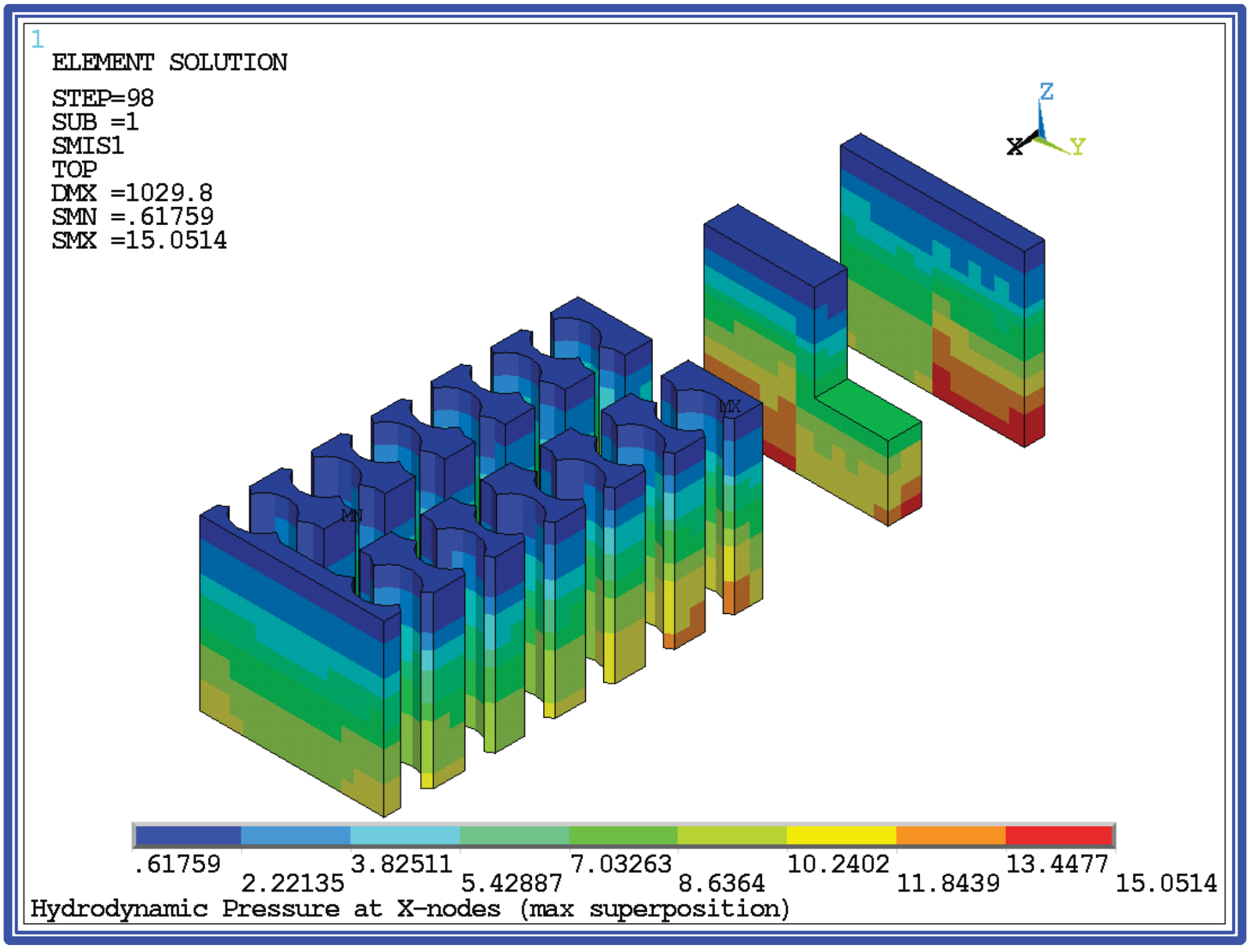

Figure 15: Hydrodynamic Pressure at X Nodes due to Z Input Time History using CSDRS-HF

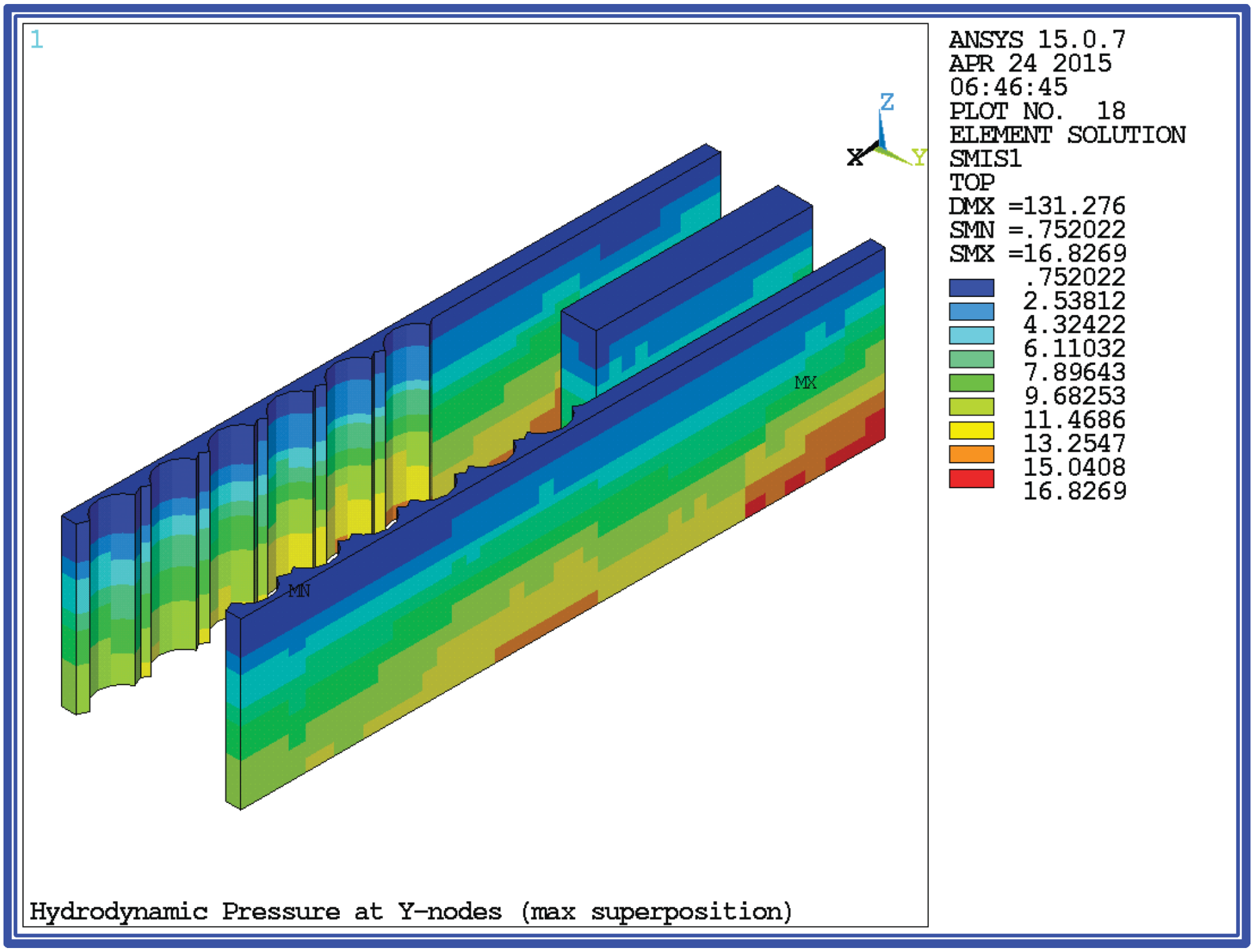

Figure 16: Hydrodynamic Pressure at Y Nodes due to Z Input Time History using CSDRS

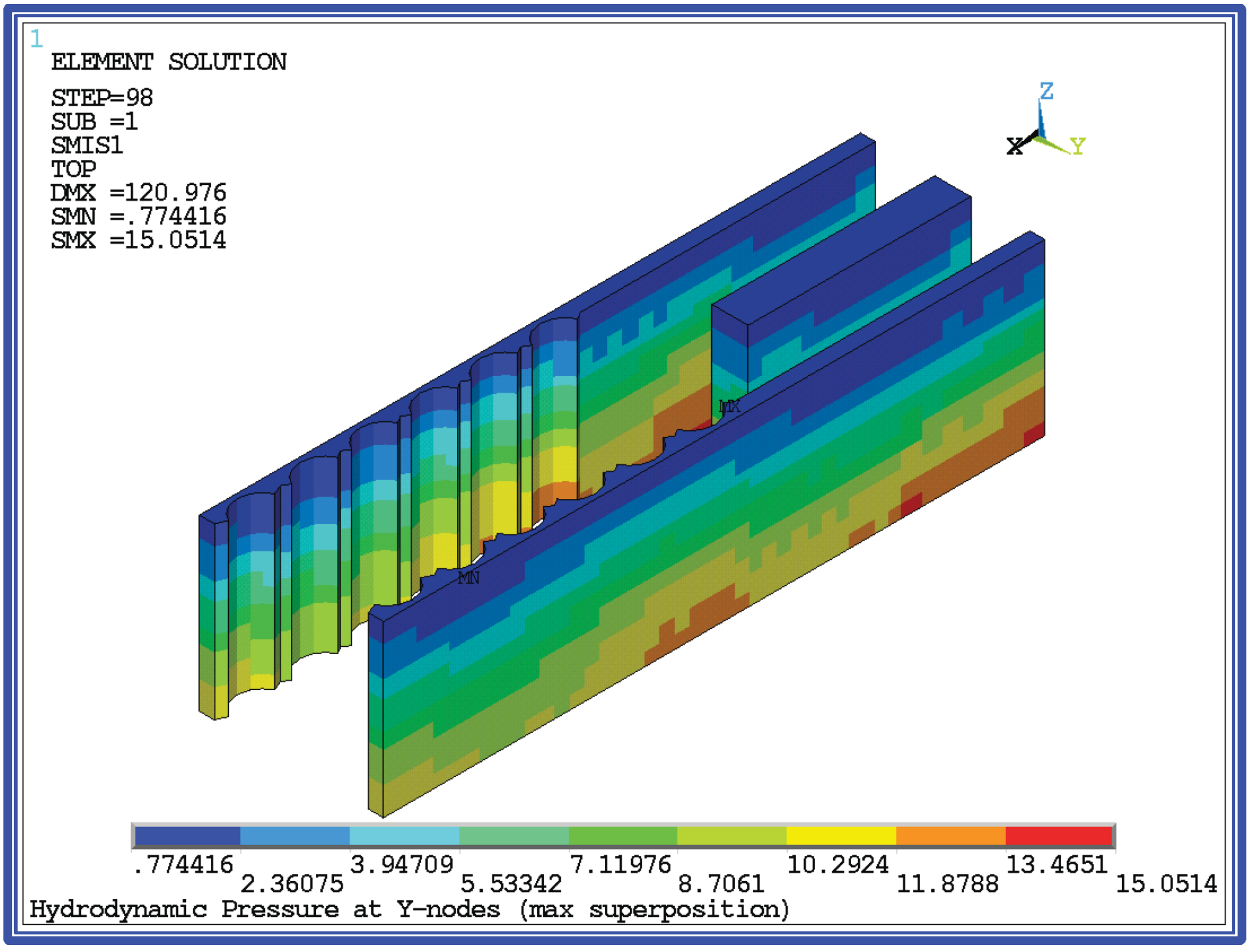

Figure 17: Hydrodynamic Pressure at Y Nodes due to Z Input Time History using CSDRS-HF

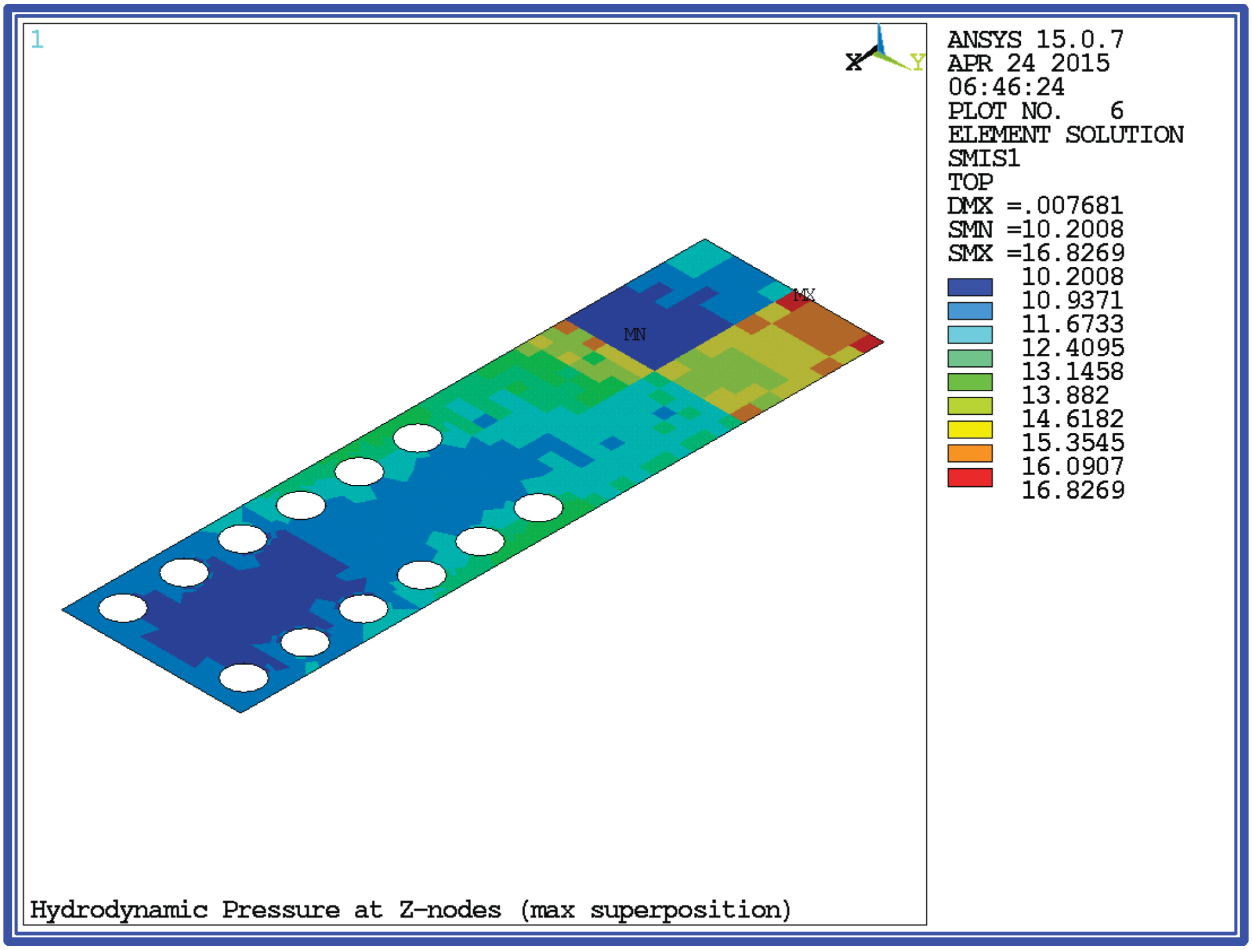

Figure 18: Hydrodynamic Pressure at Z Nodes due to Z Input Time History using CSDRS

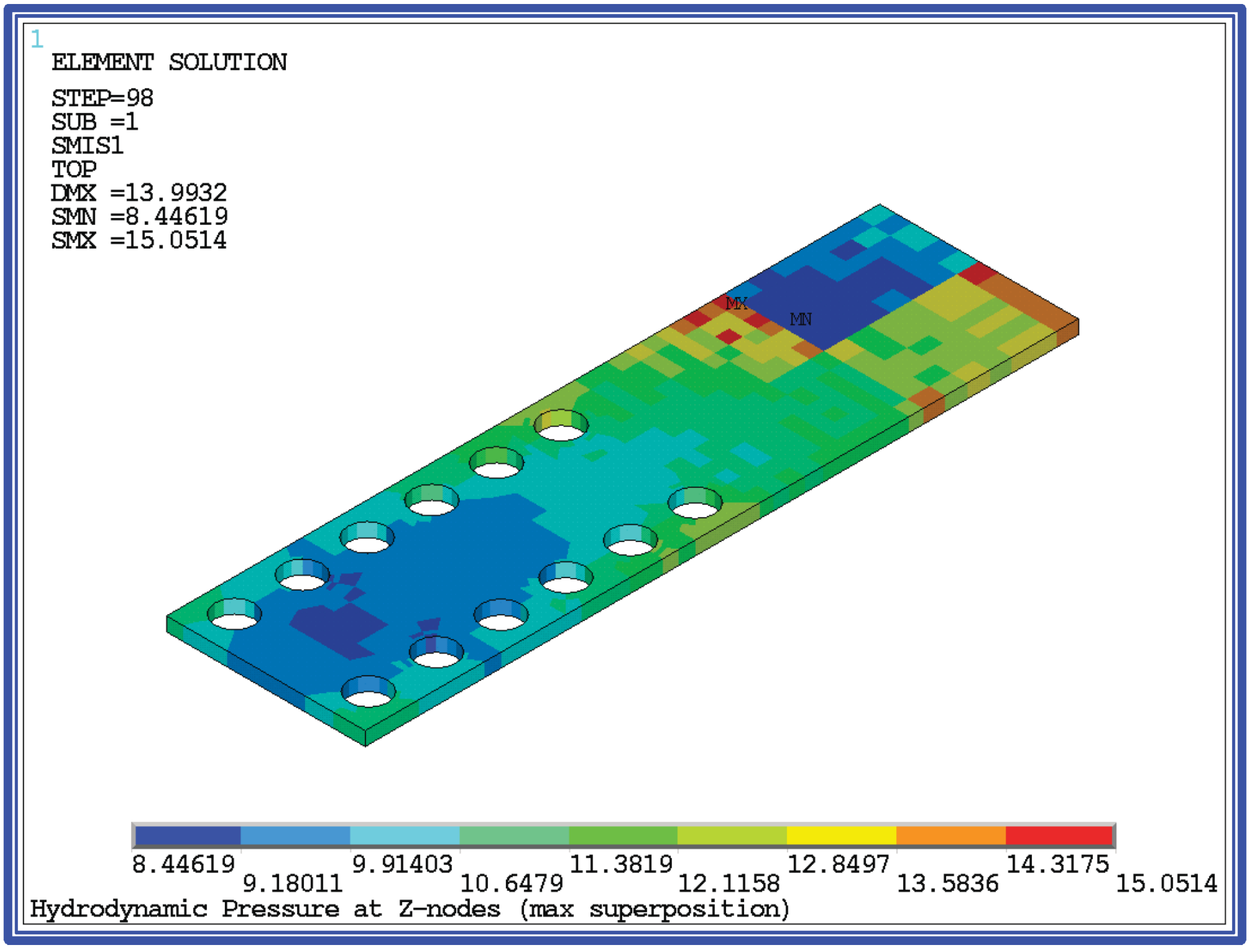

Figure 19: Hydrodynamic Pressure at Z Nodes due to Z Input Time History using CSDRS-HF

b)

The FSI effects are accounted for by adding a pressure of 4.2 psi, obtained from ANSYS FSI analysis, to the SAP2000 model. The SAP2000 program is capable of incorporating only the lumped fluid masses and does not have the FSI analysis capability. Consequently, hydrodynamic pressures were computed separately using ANSYS FSI analysis and were added to the SAP2000 model as equivalent static load.

Total fluid pressure on wall = Hydrostatic pressure (15 psi) + Hydrodynamic pressure (4.2 psi, obtained from ANSYS FSI analysis) = 19.2 psi =1.28* 15 psi = 1.28* Hydrostatic pressure

Therefore, a 1.28g vertical static loading was added to the SAP2000 model to ensure the additional hydrodynamic pressure is accounted for in the design.

Impact on DCA:

There are no impacts to the DCA as a result of this response.