Nuclear Operating Company
South Texas Project Electric Generating Station P.O. Box 289 Wadsworth, Texas 77483

April 29, 2010
U7-C-STP-NRC-100093

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

South Texas Project
Units 3 and 4
Docket Nos. 52-012 and 52-013
Response to Request for Additional Information

References:
1. Letter, Mark A. McBurnett to Document Control Desk, "Response to Request for Additional Information," dated December 16, 2009. U7-C-STP-NRC-090225 (ML093520627)
2. Letter, Scott Head to Document Control Desk, "Response to Request for Additional Information," dated February 4, 2010. U7-C-STP-NRC-100035 (ML100480204)
3. Letter, Scott Head to Document Control Desk, "Response to Request for Additional Information," dated February 10, 2010. U7-C-STP-NRC-100036 (ML100550613)

Attachments 2 through 7 are revised or supplemental responses to NRC staff questions included in Request for Additional Information (RAI) letter numbers 289, 299 and 302 related to Combined License Application (COLA) Part 2, Tier 2, Sections 3.7 and 3.8. References 1, 2 and 3 provided the original response to the following RAI questions:

RAI 03.07.01-18	RAI 03.07.02-19
RAI 03.07.01-19	RAI 03.07.03-3
RAI 03.07.02-13	RAI 03.08.04-19

Additionally, supplemental information dates, as originally provided in Attachment 15 of Reference 3 for Sections 3.7 and 3.8, have been updated and are provided in Attachment 1 to this letter.

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Where there are COLA markups, they will be made at the first routine COLA update following NRC acceptance of the RAI response.

There are no commitments in this letter.

If you have any questions regarding this response, please contact me at (361) 972-7136, or Bill Mookhoek at (361) 972-7274.

I declare under penalty of perjury that the foregoing is true and correct.

Executed on 4/29/10

Scott Head
Manager, Regulatory Affairs
South Texas Project Units 3 & 4

jep

Attachments:

1. Supplemental Information Dates
2. RAI 03.07.01-18, Revision 1
3. RAI 03.07.01-19, Revision 1
4. RAI 03.07.02-13, Supplement 1
5. RAI 03.07.02-19, Revision 1
6. RAI 03.07.03-3, Revision 1
7. RAI 03.08.04-19, Revision 1

cc: w/o attachment except*
(paper copy)

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SUPPLEMENTAL INFORMATION DATES (UPDATED)

RAI Number	INFORMATION DESCRIPTION	STPNOC LETTER NUMBER	SUPPLEMENTAL / REVISION DATE
03.07.01-18	Increase in Soil Pressure due to Structure to Structure interaction	U7-C-STP-NRC-100035 U7-C-STP-NRC-100093	Submitted
03.07.01-19	Details for Diesel Generator Fuel Oil Storage Vaults	U7-C-STP-NRC-100035 U7-C-STP-NRC-100093	Submitted
03.07.01-24	Effects of Crane Wall on the Reactor and Control Buildings	U7-C-STP-NRC-100036 U7-C-STP-NRC-100083	Submitted
03.07.02-13	Stability Evaluations for Seismic Category II Structures	U7-C-STP-NRC-100036 U7-C-STP-NRC-100093	Submitted
03.07.02-19	Seismic Input for II/I Evaluation for Radwaste Building	U7-C-STP-NRC-100035 U7-C-STP-NRC-100093	Submitted
03.07.03-3	Revise previous RAI response for Control Building Annex Input Motion based on DCD model – As previously discussed in the January 19-20 meeting	U7-C-STP-NRC-090225 U7-C-STP-NRC-100036 U7-C-STP-NRC-100093	Submitted
03.08.01-8	Effect of Increase in Pool Swell Height and Pressure	U7-C-STP-NRC-100018 U7-C-STP-NRC-100036 U7-C-STP-NRC-100083	Submitted
03.08.04-18	Radwaste Building Analysis Results and Design Details	U7-C-STP-NRC-100036	May 31, 2010
03.08.04-19	Results of Sliding Evaluation	U7-C-STP-NRC-100036 U7-C-STP-NRC-100093	Submitted
03.08.04-25	Details of Interface Connections Between the RSW Piping Tunnel and Buildings	U7-C-STP-NRC-100036 U7-C-STP-NRC-100083	Submitted
03.08.05-2	Results of Time Rate of Settlement and Evaluation of Gaps for Site-Specific Structures	U7-C-STP-NRC-100018 U7-C-STP-NRC-100036 U7-C-STP-NRC-100083	Submitted
03.08.05-3	Revise previous RAI response for Acceptance Criteria for Building Tilt due to Settlement – As previously discussed in the January 19-20 meeting	U7-C-STP-NRC-100018 U7-C-STP-NRC-100036 U7-C-STP-NRC-100083	Submitted

RAI 03.07.01-18, Revision 1

QUESTION:

(Follow-up Question to RAI 03.07.01-5)

In the response to RAI 03.07.01-5, the applicant cited DCD Appendix 3A in concluding that "the potential effect of structure-to-structure interaction is relatively small." However, DCD (see DCD Section 3A.9.7, Effect of Adjacent Buildings) also concluded that seismic soil pressure in between the RB and CB increased due to structure-to-structure interaction (SSSI) effect. The applicant is requested to provide soil pressure profile between the RB and CB, and discuss how the potential effects of the increase in the seismic soil pressure in between the RB and CB due to SSSI effect has been addressed and bounded by the certified design.

REVISED RESPONSE:

The original response to this RAI was submitted with STPNOC letter U7-C-STP-NRC-100035, dated February 4, 2010 and committed to provide the increased soil pressure profile between the Reactor Building (RB) and Control Building (CB) due to structure-to-structure interaction effect by April 30, 2010 and show that this pressure profile is bounded by the certified design soil pressures. The following revised response provides this information and completely supersedes the previous response. The revised portion of the response is marked with a revision bar.

Attached Figures RAI 03.07.01-18a and RAI 03.07.01-18b provide the increased soil pressure profiles between the RB and CB due to structure-to-structure interaction for site-specific Safe Shutdown Earthquake (SSE) obtained from Soil-Structure Interaction (SSI) analysis along with the design soil pressures reported in DCD Table 3A-18 and Figures 3H.1-11 and 3H.2-14. As can be seen from these figures, the soil pressure profiles from the SSI analysis are bounded by the envelope of the certified design soil pressures from DCD Table 3A-18 and Figures 3H.1-11 and 3H.2-14 with one exception. The soil pressure from the SSI analysis for the CB slightly exceeds the certified design soil pressure at a depth of about 26 to 30 feet below the ground surface. At all other elevations the DCD soil pressures are higher (significantly higher at most elevations) than the site-specific soil pressure. Therefore, the total force due to the certified design soil pressure on the wall panel will be significantly higher than the total force due to soil pressure from the SSI analysis. Therefore, the design based on certified design soil pressures will be adequate for soil pressure profiles from the SSI analysis.

No COLA change is required for this response.

Figure RAI 03.07.01-18a: Comparison of DCD SSE and Site-Specific SSE Seismic Soil Pressures for Reactor Building North Wall

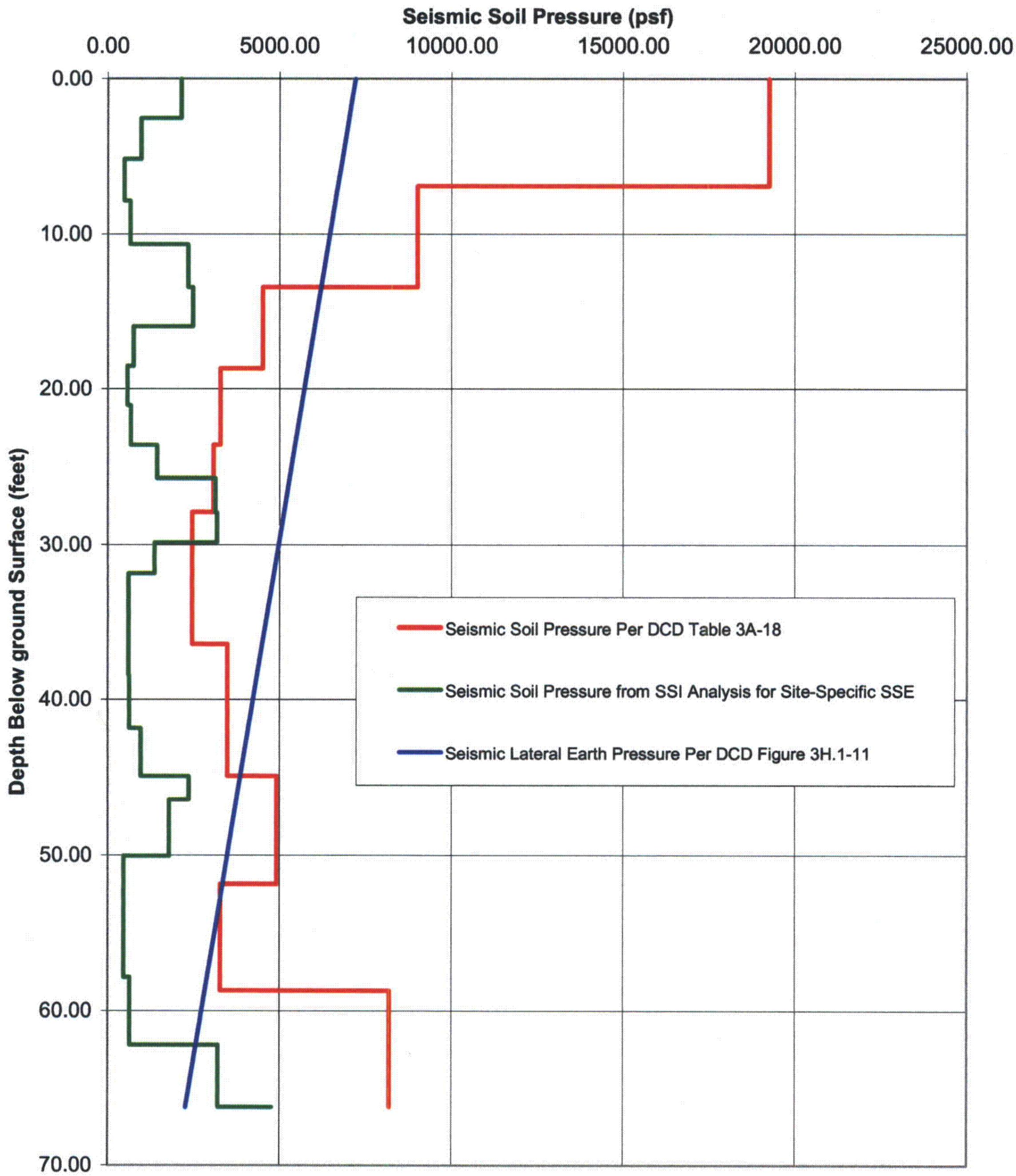
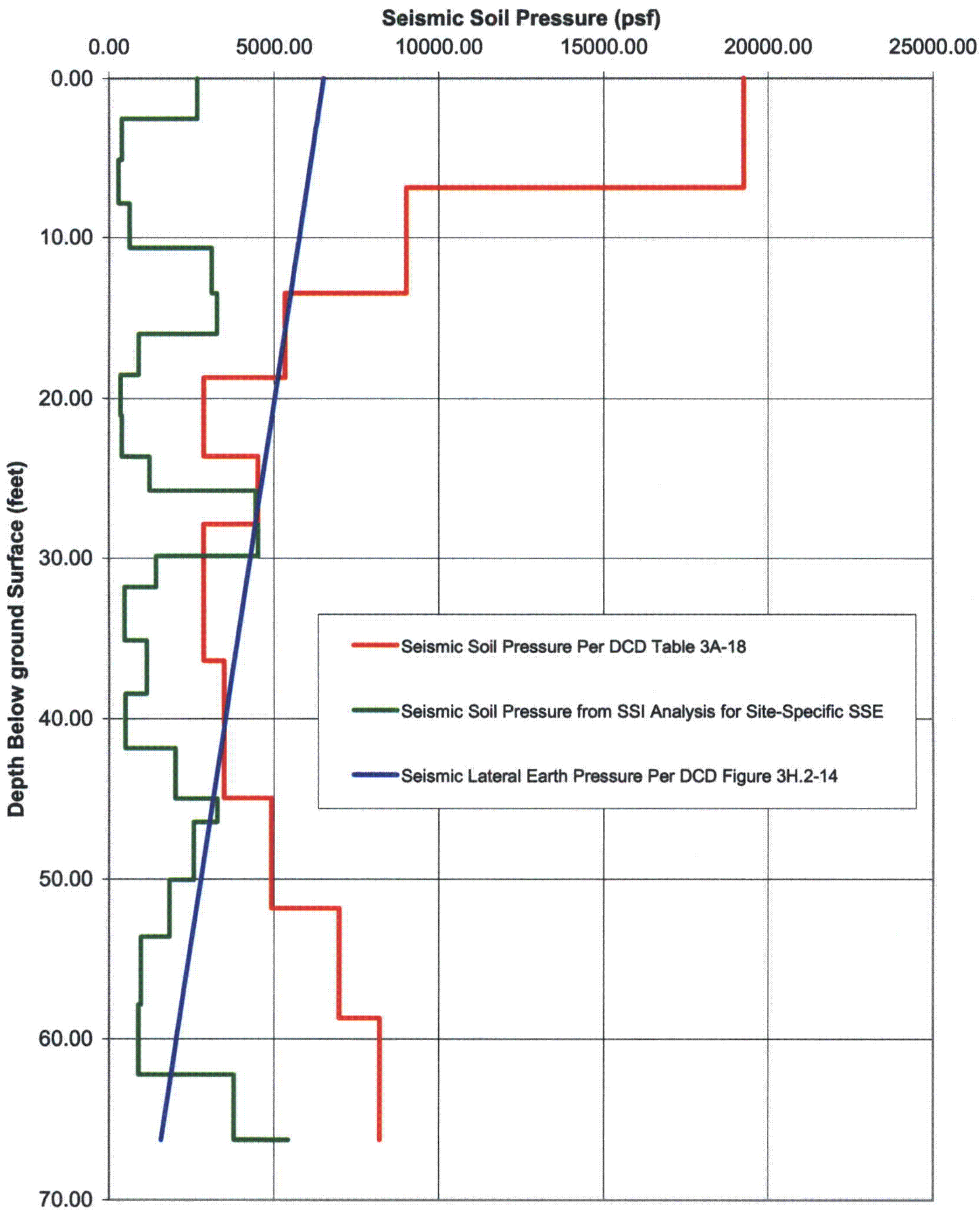


Figure RAI 03.07.01-18b: Comparison of DCD SSE and Site-Specific SSE Seismic Soil Pressures for Control Building South Wall



RAI 03.07.01-19, Revision 1

QUESTION:

(Follow-up Question to RAI 03.07.01-6)

In response to RAI 03.07.01-6, the applicant referred to COLA Part 2, Tier 2, Section 3A.17 for description of the supporting media, dimensions of the structural foundation, and total structural height for the Reactor Building (RB) and Control Building (CB). However, the referenced section does not include the requested information for the Diesel Generator Fuel Oil Storage Vaults (DGFOSV) which is listed as Seismic Category I structure in Revision 3 of the FSAR Section 2.5S.4.10.2. As such, the applicant was requested to provide information on supporting media for DGFOSV. Since the shear wave velocity parameter of the subgrade material (soil or backfill) supporting this structure may be less than 1000 fps, the applicant is also requested to provide quantitative results of the reconciliatory site specific seismic analysis (with appropriate consideration of dynamic soil or backfill properties) addressing the potential impact on FIRS, SSI, settlement calculations, and structural design concerning DGFOSV.

2. In the response to item 3 of RAI 03-07-01-6 it was stated that "The resulting strain-compatible properties for the three profiles are presented in COLA Part 2, Tier 2 Table 3H.6-1." A review of Table 3H.6-1 indicates that the S-wave and P-wave damping ratio used in the SSI analysis for an individual layer is the same. The applicant is requested to provide the basis for maintaining the S-wave and P-wave damping the same for an individual layer.

3. In response to RAI 03.07.01-6, Item 3, the applicant states that, "The seismic site response analysis was conducted, as described in Section 2.5S.2.5, using P-SHAKE to develop Ground Motion Response Spectrum (GMRS). ...." No reference to P-SHAKE program was found in Section 2.5S.2.5 of Revision 3, and no proposed FSAR markup is provided for future incorporation. As such, the applicant is requested to clarify whether P-SHAKE program has been used to develop GMRS and strain-compatible soil properties, as described in Section 2.5S.2.5, and if so, how P-SHAKE program performs site-response analysis (e.g. deterministic or probabilistic method, etc.). The applicant is further requested to clarify whether P-SHAKE program was also used to perform deconvolution of the SSE design motion specified at the freefield ground surface to calculate the foundation motion for the Seismic Category I structures.

REVISED RESPONSE:

The original response to this RAI was submitted with STPNOC letter U7-C-STP-NRC-100035, dated February 4, 2010 and committed to provide the analysis and design results for the Diesel Generator Fuel Oil Storage Vaults (DGFOSV) by April 30, 2010. The following revised response provides this information and completely supersedes the previous response. The revised portions of the response are marked with a revision bar.

(Paragraph 1)

The Diesel Generator Fuel Oil Storage Vaults (DGFOSV) are reinforced concrete structures, located below grade with an access room above grade. The DGFOSV house fuel oil tanks and transfer pumps. The DGFOSV are buried in the structural back-fill. The embedment depth to the bottom of the 2 ft thick mudmat is approximately 43 ft, the maximum height from the bottom of the mudmat is approximately 59 ft, and the basemat dimensions are approximately 81.5 ft by 48 ft. Properties of the backfill are described in COLA Part 2, Tier 2 Section 3H.6.5.2.4. Conservatively, a 3-dimensional SAP2000 response spectrum analysis was used to obtain the safe-shutdown earthquake (SSE) design forces due to structure inertia. The seismic induced dynamic soil pressures on DGFOSV walls were computed using the method of ASCE 4-98, Subsection 3.5.3.2.

Two DGFOSV are located about 50 feet away from the south face of the Reactor Building (RB), which is a heavy multistory structure. The third DGFOSV is located approximately 38 feet away from the north face of the Reactor Service Water (RSW) Pump House. Considering the soil profile at the STP Units 3 & 4 site, the induced acceleration at the foundation level of the DGFOSV during a SSE event may be amplified due to their close proximity to the RB (for the two) or the RSW Pump House (for the third). To establish the input motion for the soil-structure interaction (SSI) analysis of the DGFOSV, considering the impact of the nearby heavy RB (for the two) and RSW Pump House (for the third) structures, an analysis as described below was performed.

Five interaction nodes at the ground surface and five at the depth corresponding to the bottom elevation of the DGFOSV foundations are added to the three dimensional SSI SASSI2000 model of the RB for obtaining free field responses for the two DGFOSV close to the RB. These five nodes correspond to the four corners and the center of the DGFOSV. This RB SSI model is analyzed for the STP site-specific SSE. For each of these two DGFOSV, first an average of the spectra at five nodes at the surface and foundation each is calculated and then envelope of the two average spectra is calculated. A similar SSI analysis is performed for the third DGFOSV close to the RSW Pump House. Finally, the envelope of the envelope average spectra for the three DGFOSV and the 0.3g Regulatory Guide 1.60 response spectrum is used as the input response spectrum for the SSI analysis of the DGFOSV. The DGFOSV and the equipment and components inside the vault are designed using the results of the SSI analysis.

The comparison of response spectra (the minimum required 0.1g Regulatory Guide 1.60 spectra, the FIRS, and the deconvolved SHAKE outcrop spectra) at the foundation level of the DGFOSV is presented in Figures 3H.6-11d through 3H.6-11L, included in Enclosure 1. As can be seen from these figures, the deconvolved SHAKE outcrop spectra envelop the minimum required spectra and FIRS for the three sets of soil properties.

The applicable codes, standards, and specifications from COLA Part 2, Tier 2 Section 3H.6.4 are used for analysis and design of the DGFOSV.

The DGFOSV are designed to the applicable loads and load combinations specified in COLA Part 2, Tier 2 Section 3H.6.4.

The settlement information on the DGFOSV is included in COLA Part 2, Tier 2, Section 2.5S.4.10.

The forces and moments at critical locations in the DGFOSV along with the provided longitudinal and transverse reinforcement are included in Table 3H.6-11 in conjunction with Figures 3H.6-140 through 3H.6-208, provided in Enclosure 2.

The calculated factors of safety against sliding, overturning, and flotation for the DGFOSV are included in Table 3H.6-12, provided in Enclosure 2.

The tornado missile impact evaluation results for the DGFOSV are included in Table 3H.6-13, provided in Enclosure 2.

2. The P-wave damping ratios are assigned the same values as those calculated for the S-wave damping ratios. This is based on the recommendations of the upcoming ASCE 4-09 standards (see Reference below). The recommendation is based on the recent observation of earthquake data and the realization that the waves generated due to SSI effects are mainly surface and shear waves. It should be noted that the S-wave damping ratios for the best estimate profile are very low (around 1.5% and not exceeding 2%). Moreover, using the maximum strains, as shown in FSAR Figure 2.5S.2-47, and applying the effective strain ratio of 0.65, as described in FSAR Subsection 2.5S.2.5.4, the uniform strains for 1E-4 hazard level do not exceed 0.02%.

   Reference Used for this RAI Response:

   American Society of Civil Engineers (ASCE), Seismic Analysis of Safety-Related Nuclear Structures, ASCE 4-09, to be published in 2010.

3. The P-SHAKE program was used to develop the GMRS in Section 2.5S.2.5. A mark-up of COLA Part 2, Tier 2, Section 2.5S.2.5, that describes the P-SHAKE program and its use in site response analysis, is included as part of the response to RAI 02.05.02-23 submitted with STPNOC Letter U7-C-STP-NRC-090146, dated September 21, 2009.

   The SHAKE program was used to perform deconvolution of the SSE design motion specified at the free field ground surface to calculate the SHAKE outcrop motion at the foundation elevation of the Seismic Category I structures.

   The COLA mark-up for Section 2.5S.2.5 provided in response to RAI 02.05.02-23 is reproduced in the following for ready reference:

   "The description of the RVT approach in the STP COLA will be modified and expanded to include a more detailed discussion.

The first and second paragraphs of FSAR Section 2.5S.2.5.4, COLA Revision 3 will be revised as follows:

The site response analysis performed for the STP 3 & 4 site is conducted using the program P-SHAKE (refer to Appendix 3C), which uses a procedure based on Random Vibration Theory (RVT) (References 2.5S.2-52 and 2.5S.2-53) with the following assumptions:

- Vertically-propagating shear waves are the dominant contributor to site response
- An equivalent-linear formulation of soil nonlinearity is appropriate for the characterization of site response

These are the same assumptions that are implemented in the SHAKE program (Reference 2.5S.2-54). ~~and that constitute standard practice for site-response calculations. In this respect, RVT and SHAKE solve the same problem, but RVT works with ground-motion power spectral densities or response spectra (and its relation to peak values), while SHAKE works with individual time histories and their Fourier spectra.~~ With respect to RVT implementation, the major steps used in P-SHAKE are as follows:

1. The input motion is provided in terms of acceleration response spectrum (ARS) and its associated spectral damping, instead of spectrum-compatible acceleration time histories. The input ARS is converted to acceleration power spectral density (PSD) using the RVT based procedure with the peak factor function.
2. From the frequency domain solution of the soil profile (following SHAKE approach), the transfer function for shear strain in each layer is obtained and convolved with the power spectral density (PSD) of input motion to get the PSD and the maximum strain in each layer. The effective strain is obtained from the maximum strain and is used to obtain the new soil properties (soil shear modulus and damping) for the next iteration.
3. The iterations are repeated until convergence is reached in all layers to the convergence limit set by the user.
4. Once the final frequency domain solution is obtained, the acceleration response spectrum at each layer interface can be computed from the solution using an inverse process of obtaining PSD from the acceleration response spectrum.

References:

2.5S.2-52 "Structural Response to Stationary Excitation," Journal of the Engineering Mechanics Division ASCE, v. 106, No. EM6, December, pp. 1195-1213, Der Kiureghian, A., 1980.

2.5S.2-53 "Site-Specific Validation of Random Vibration Theory-Based Seismic Site Response Analysis," Journal of Geotechnical and Geoenvironmental Engineering, Vo. 132, No. 7, July, pp. 911-922, Rathje, E. and Ozbey, C.M., 2006.

2.5S.2-54 "SHAKE91: A computer program for conducting equivalent linear seismic response analyses of horizontally layered soil deposits," Idriss, I. M., and Sun, J. I., Dept. of Civil and Environmental Engineering, Center for Geotechnical Modeling, Univ. of California, 1992."

The STP Units 3 and 4 COLA will be revised as follows as a result of this response.

1. Revise Sections 3H.6.1 and 3H.6.3 as follows:

3H.6.1 Objective and Scope

The objective of this appendix is to describe the structural analysis and design of the STP 3 & 4 site-specific seismic Category I structures that are identified below. ~~and shown in Figures 1.2-34 through 1.2-36.~~

(1) Ultimate Heat Sink (UHS) for each unit consists of a water retaining basin with enclosed cooling towers situated above the basin and a Reactor Service Water (RSW) pump house that is integral with the UHS basin.

(2) RSW piping tunnel for each unit.

(3) Diesel Generator Fuel Oil Storage Vault for each unit.

The details of analysis and design for Items (1) and (2) are provided in Sections 3H.6.3 through 3H.6-6. The details for Item (3) are provided in Section 3H.6.7.

3H.6.3 Structural Descriptions

The site-specific Seismic Category I structures at STP 3 & 4 consist of one set of the following for each unit: UHS basin, enclosed UHS cooling towers located on top of the basin, RSW pump house contiguous with and adjacent to the UHS basin, and buried RSW piping tunnels and access shafts to the tunnels (see Figures 1.2-34 through 1.2-36). Each UHS basin and RSW pump house has a 10-ft (3.05-m) thick foundation mat and are connected at a common wall; and the RSW piping tunnels extend from the pump house to the Control Buildings. Each of these structures is described in more detail in the following subsections.

2. Add the following new subsection in Section 3H.6, and revise the subsection number for the References:

3H.6.7 Diesel Generator Fuel Oil Storage Vaults (DGFOSV)

The Diesel Generator Fuel Oil Storage Vaults (DGFOSV) are reinforced concrete structures, located below grade with an access room above grade. The DGFOSV house fuel oil tanks and transfer pumps. The DGFOSV are buried in the structural back-fill. The embedment depth to the bottom of the 2 ft thick mudmat is approximately 43 ft, the maximum height from the bottom of the mudmat is approximately 59 ft, and the basemat dimensions are approximately 81.5 ft by 48 ft. Properties of the backfill are described in Section 3H.6.5.2.4. A 3-dimensional SAP2000 response spectrum analysis was used to obtain the SSE design forces due to structure inertia. The seismic induced dynamic soil pressures on DGFOSV walls and roof were computed using the method of ASCE 4-98, Subsection 3.5.3.2.

Two DGFOSV are located about 50 feet away from the south face of the Reactor Building (RB), which is a heavy multistory structure. The third DGFOSV is located approximately 38 feet away from the north face of the Reactor Service Water (RSW) Pump House. Considering the soil profile at the STP Units 3 & 4 site, the induced acceleration at the foundation level of the DGFOSV during a SSE event may be amplified due to their close proximity to the RB (for the two) or the RSW Pump House (for the third). To establish the input motion for the soil-structure interaction (SSI) analysis of the DGFOSV, considering the impact of the nearby heavy RB (for the two) and RSW Pump House (for the third) structures, an analysis as described below was performed.

Five interaction nodes at the ground surface and five at the depth corresponding to the bottom elevation of the DGFOSV foundations are added to the three dimensional SSI SASSI2000 model of the RB for obtaining free field responses for the two DGFOSV close to the RB. These five nodes correspond to the four corners and the center of the DGFOSV. This RB SSI model is analyzed for the STP site-specific SSE. For each of these two DGFOSV, first an average of the spectra at five nodes at the surface and foundation each is calculated and then envelope of the two average spectra is calculated. A similar SSI analysis is performed for the third DGFOSV close to the RSW Pump House. Finally, the envelope of the envelope average spectra for the three DGFOSV and the 0.3g Regulatory Guide 1.60 response spectrum is used as the input response spectrum for the SSI analysis of the DGFOSV. The DGFOSV and the equipment and components inside the vault are designed using the results of the SSI analysis.

The comparison of response spectra (the minimum required 0.1g Regulatory Guide 1.60 spectra, the FIRS, and the deconvolved SHAKE outcrop spectra) at the foundation level of the DGFOSV is presented in Figures 3H.6-11d through 3H.6-11L. As can be seen from these figures, the deconvolved SHAKE outcrop spectra envelop the minimum required spectra and FIRS for the three sets of soil properties.

The applicable codes, standards, and specifications from Section 3H.6.4 are used for analysis and design of the DGFOSV.

The DGFOSV are designed to the applicable loads and load combinations specified in Section 3H.6.4.

The settlement information on the DGFOSV is included in Section 2.5S.4.10.

The forces and moments at critical locations in the DGFOSV along with the provided longitudinal and transverse reinforcement are included in Table 3H.6-11 in conjunction with Figures 3H.6-140 through 3H.6-208.

The calculated factors of safety against sliding, overturning, and flotation for the DGFOSV are included in Table 3H.6-12.

The tornado missile impact evaluation results for the DGFOSV are included in Table 3H.6-13.

~~3H.6.6.6~~ 3H.6.8 References

3. Add enclosed Figures 3H.6-11d through 3H.6-11L, and 3H.6-140 through 3H.6-208. Also, add Tables 3H.6-11 through 3H.6-13.

Enclosure 1 to Response to RAI 03.07.01-19

New COLA Figures 3H.6-11d through 3H.6-11L

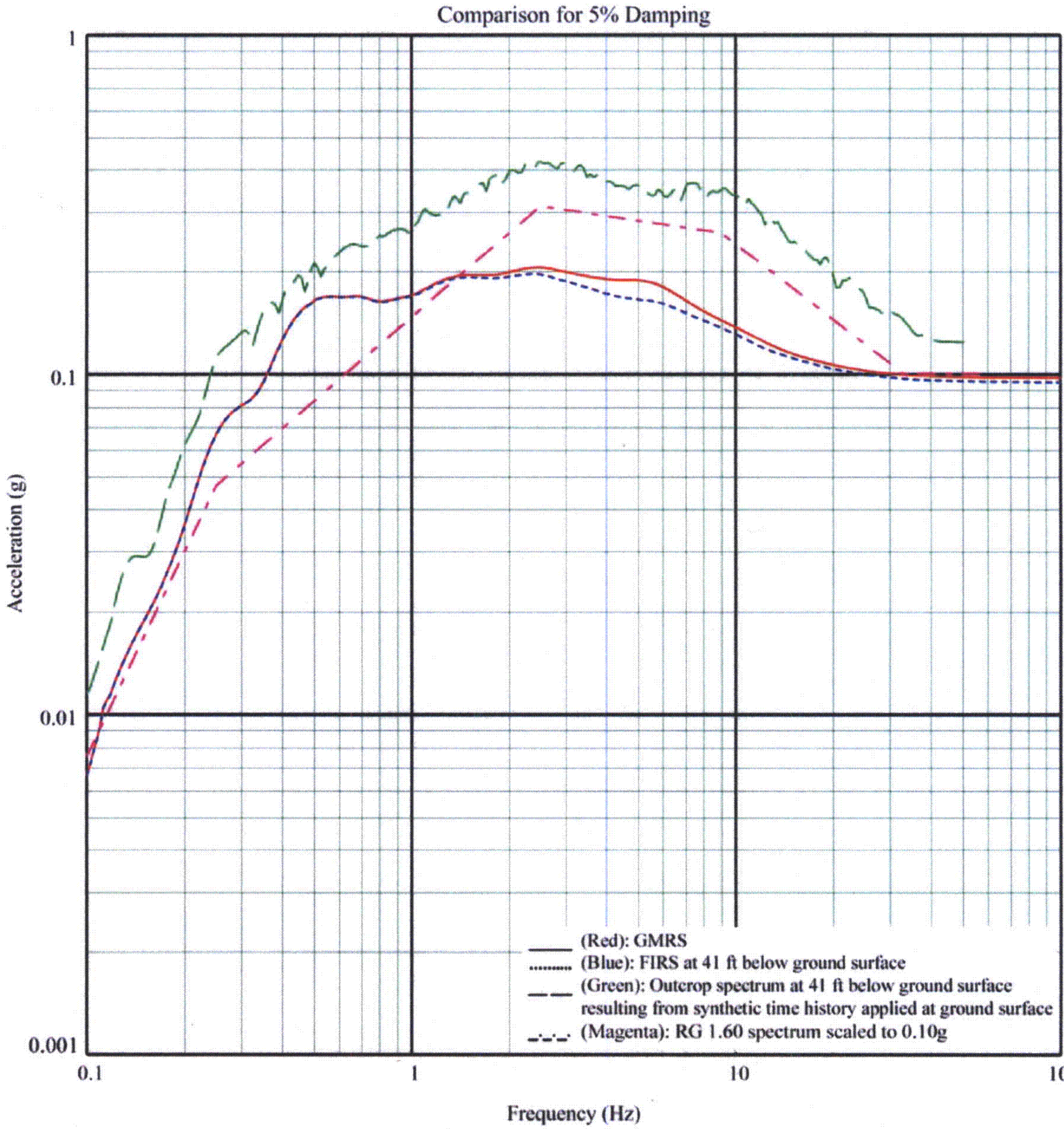


Figure 3H.6-11d: Comparison of Spectra at Foundation of Emergency Diesel Generator Fuel Storage Vault – Mean Soil Properties, E-W Direction

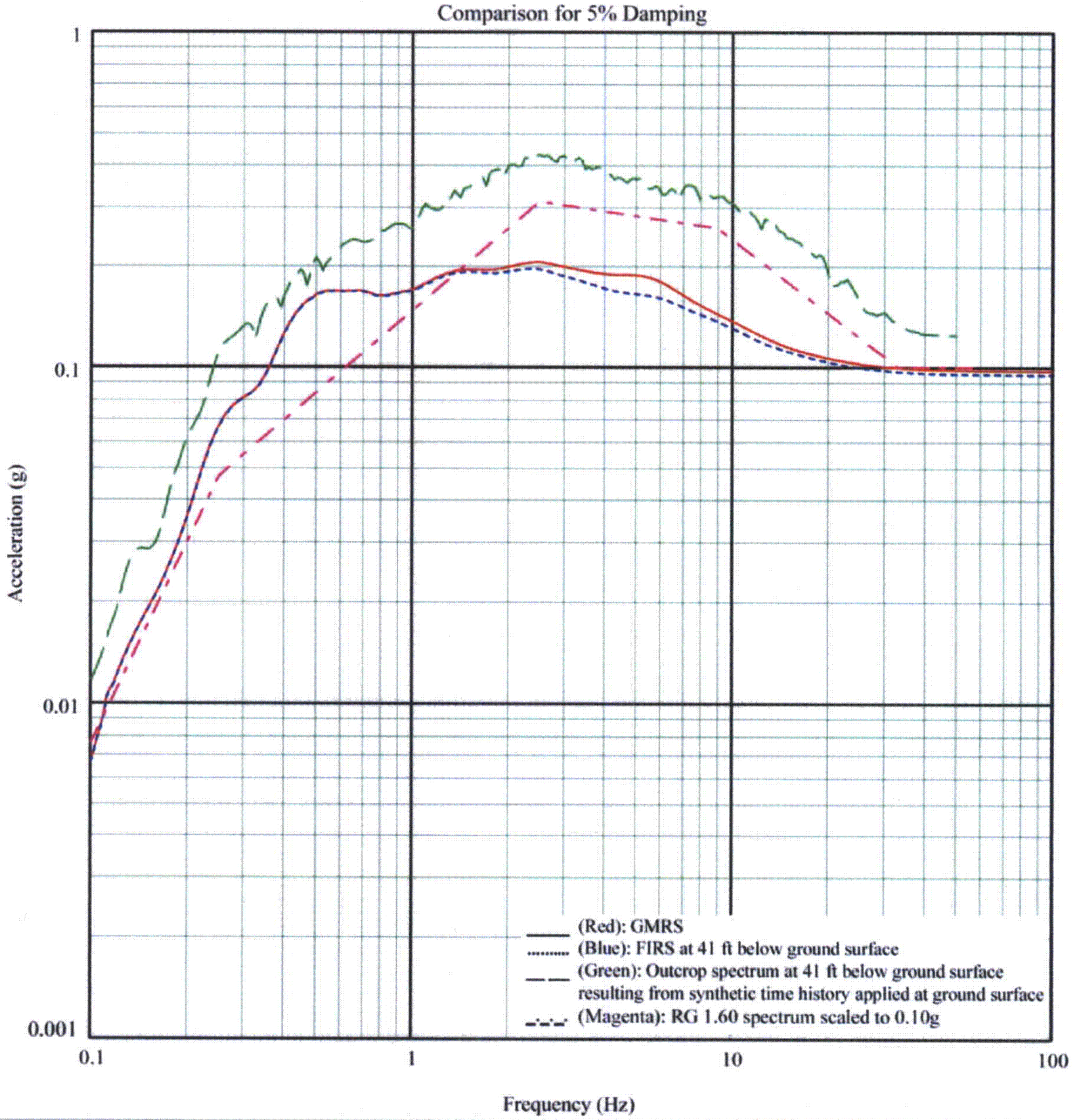


Figure 3H.6-11e: Comparison of Spectra at Foundation of Emergency Diesel Generator Fuel Storage Vault – Upper Bound Soil Properties, E-W Direction

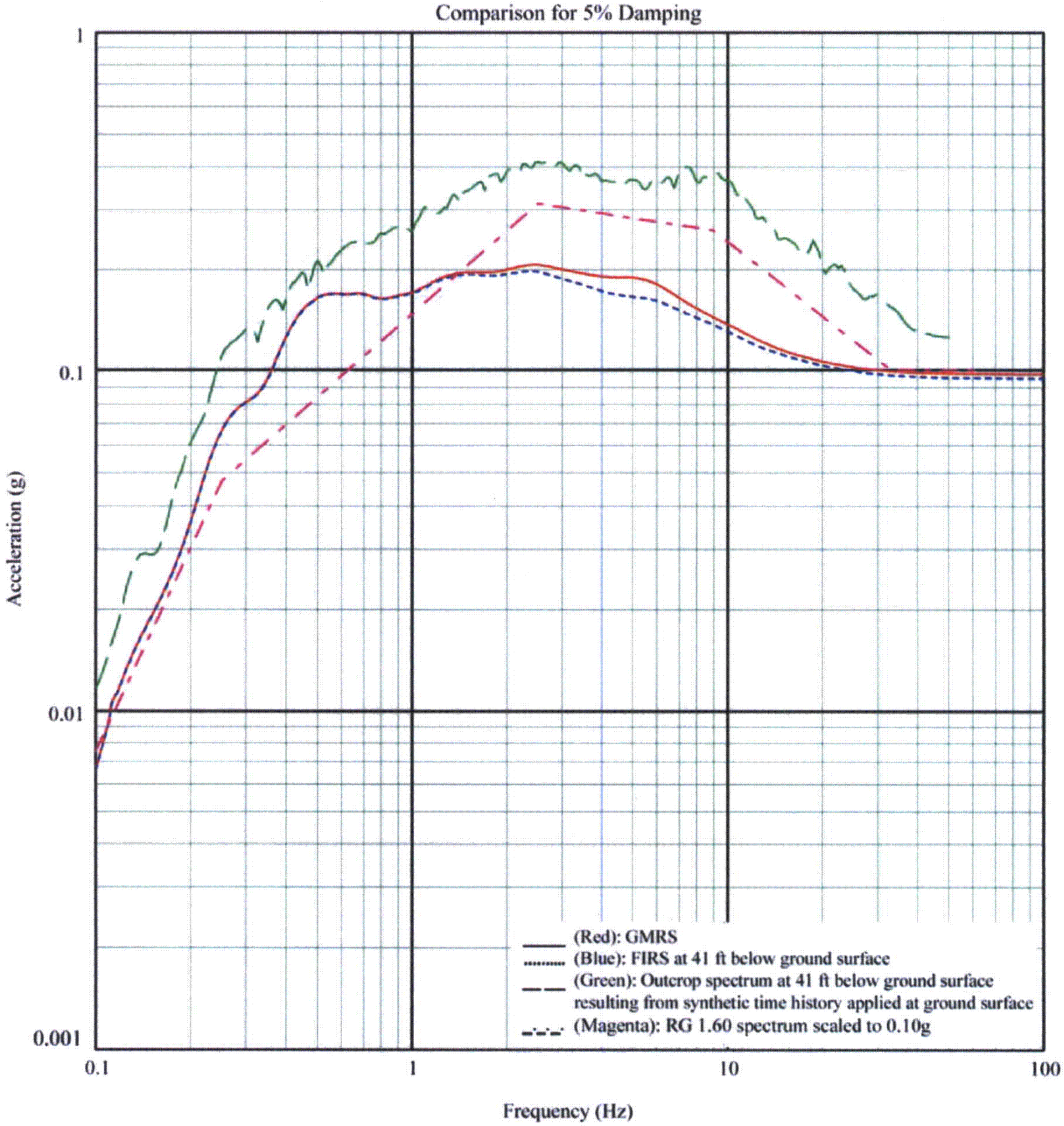


Figure 3H.6-11f: Comparison of Spectra at Foundation of Emergency Diesel Generator Fuel Storage Vault – Lower Bound Soil Properties, E-W Direction

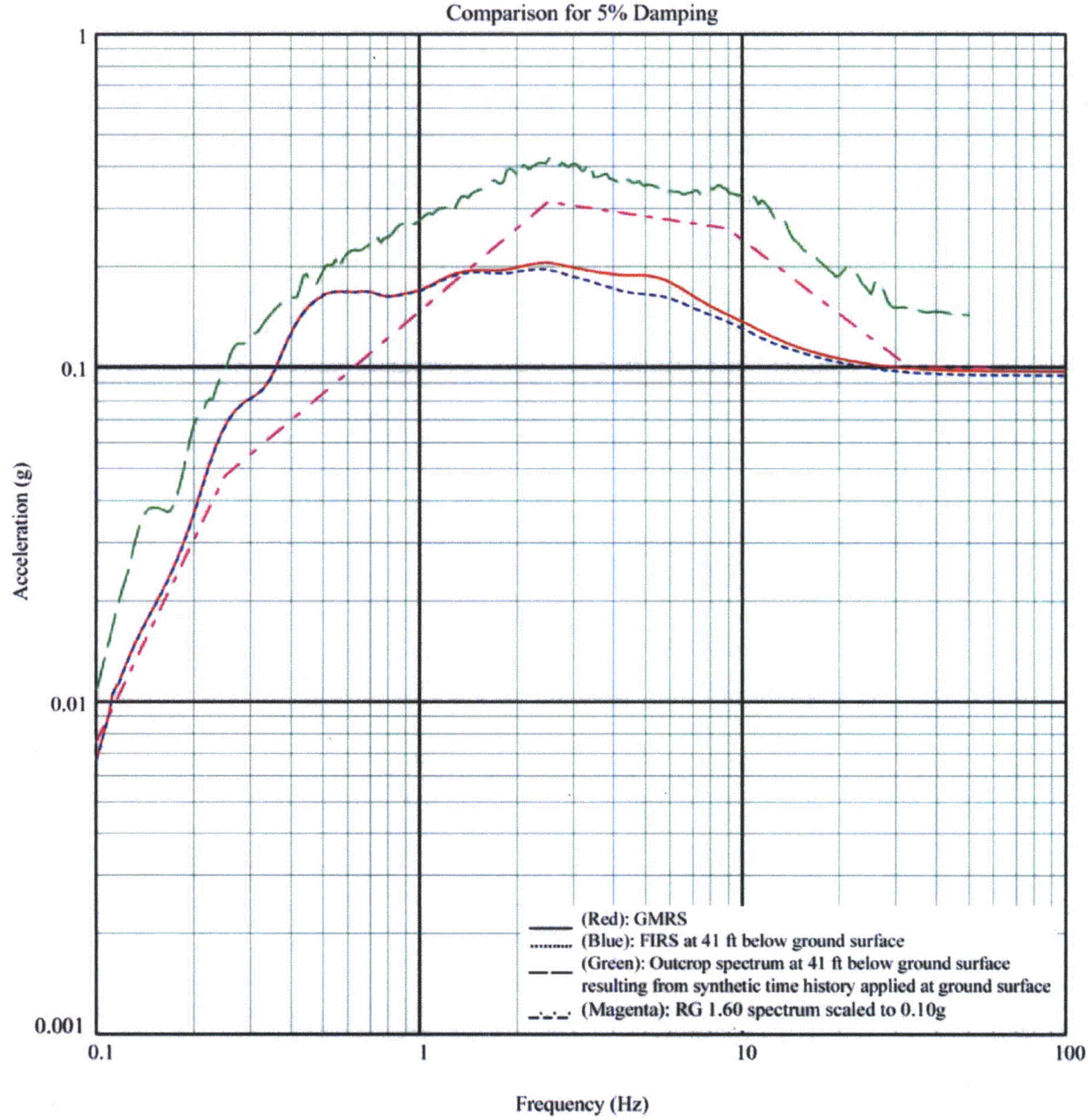


Figure 3H.6-11g: Comparison of Spectra at Foundation of Emergency Diesel Generator Fuel Storage Vault – Mean Soil Properties, N-S Direction

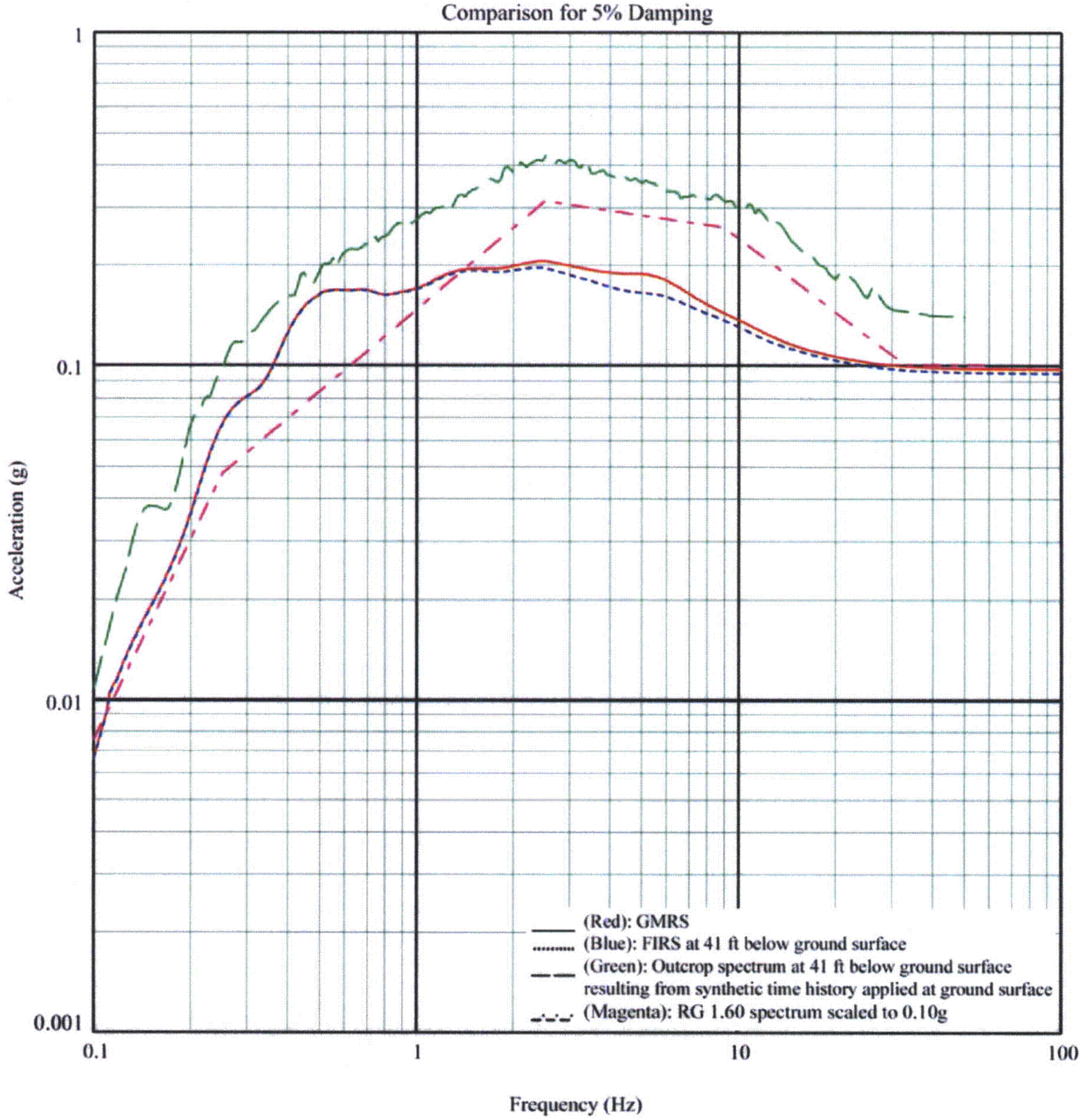


Figure 3H.6-11h: Comparison of Spectra at Foundation of Emergency Diesel Generator Fuel Storage Vault – Upper Bound Soil Properties, N-S Direction

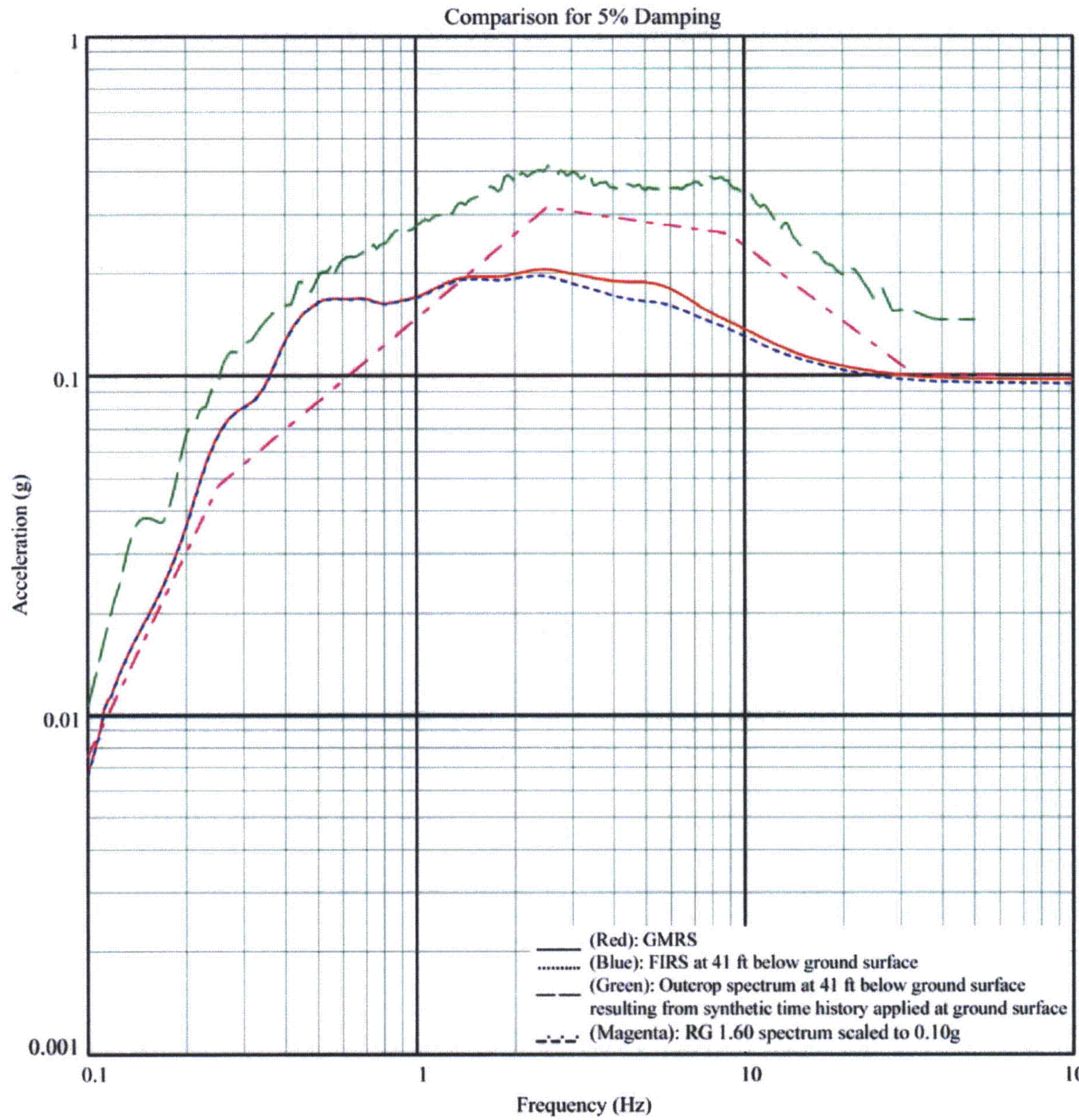


Figure 3H.6-11i: Comparison of Spectra at Foundation of Emergency Diesel Generator Fuel Storage Vault – Lower Bound Soil Properties, N-S Direction

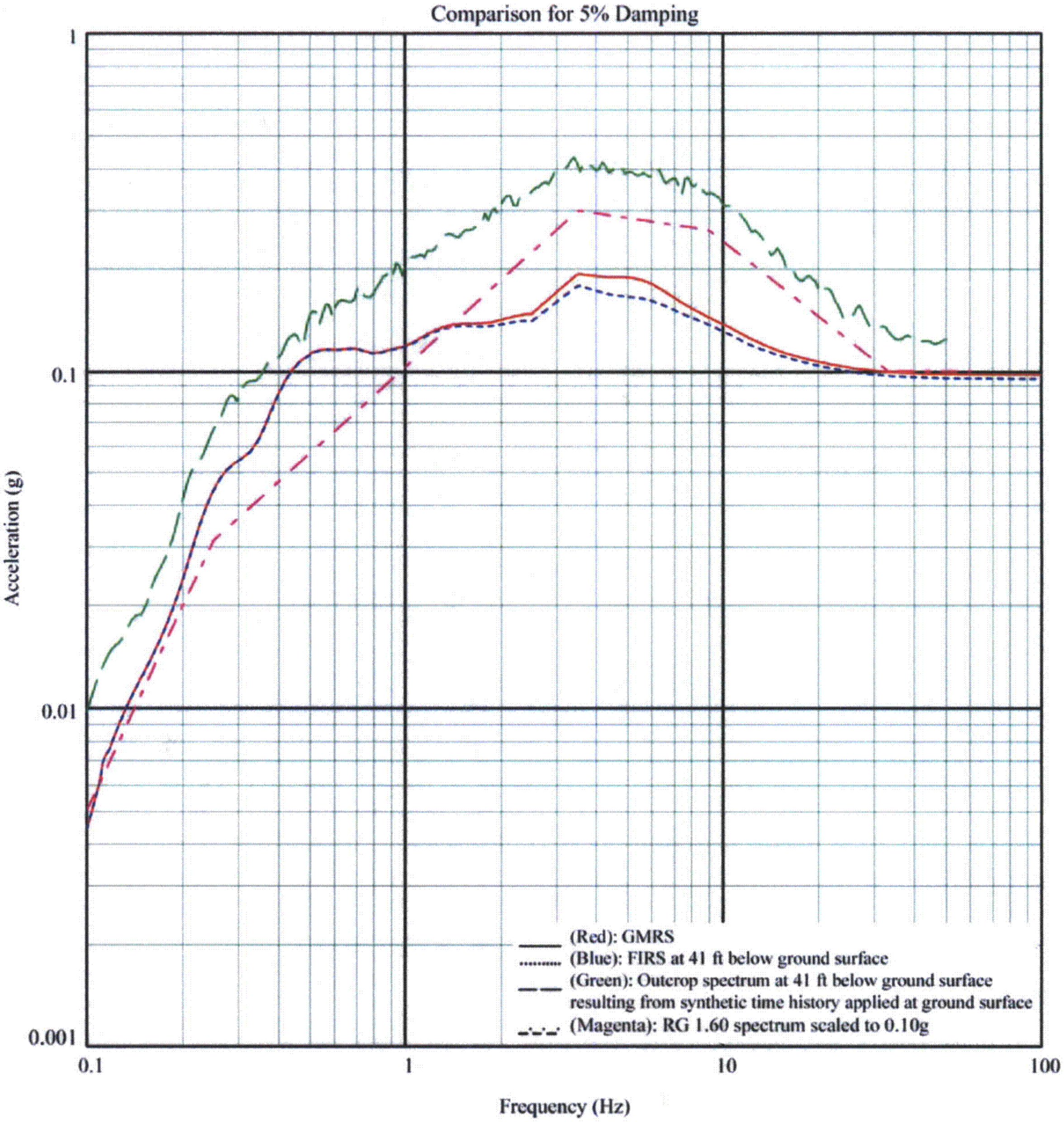


Figure 3H.6-11j: Comparison of Spectra at Foundation of Emergency Diesel Generator Fuel Storage Vault – Mean Soil Properties, Vertical Direction

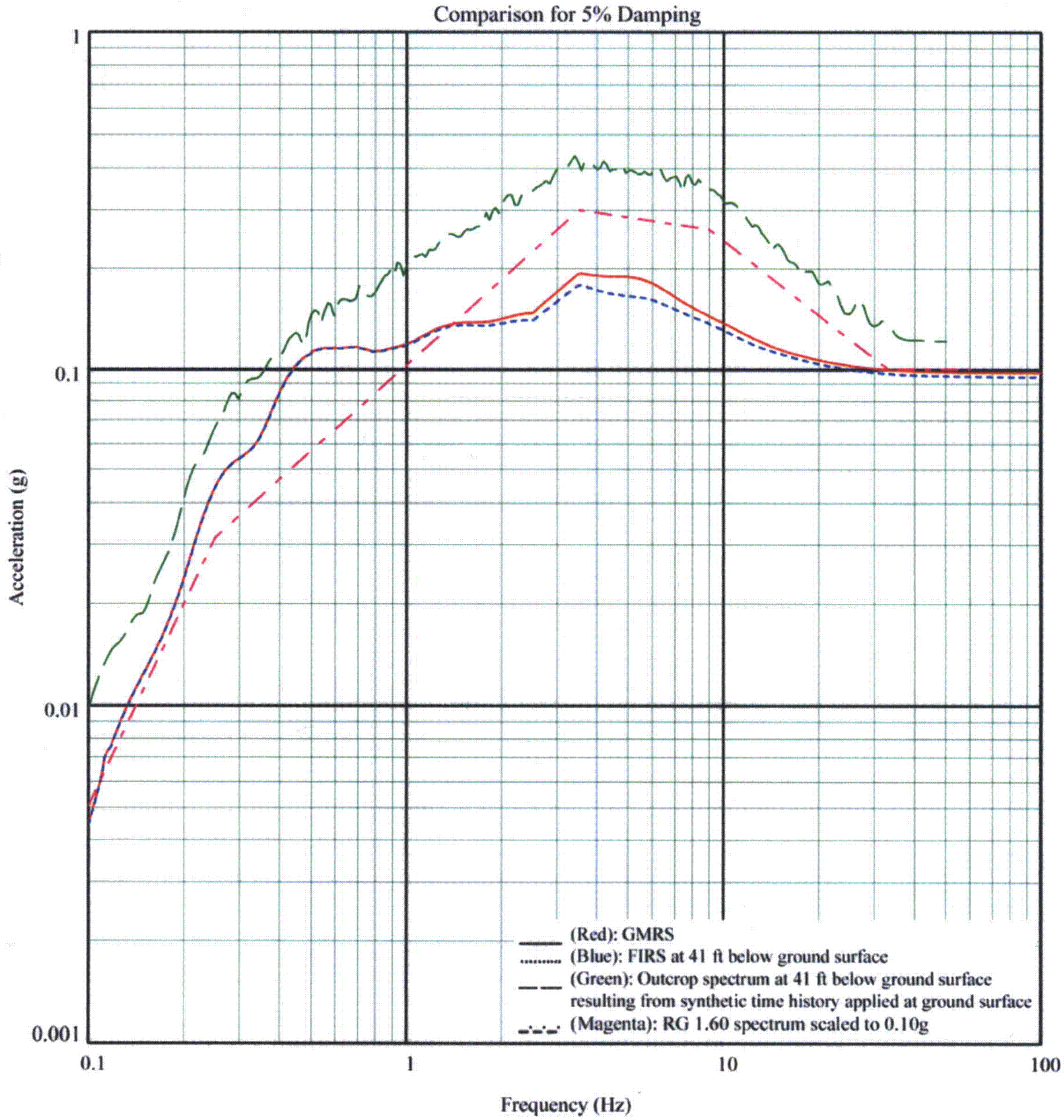


Figure 3H.6-11k: Comparison of Spectra at Foundation of Emergency Diesel Generator Fuel Storage Vault – Upper Bound Soil Properties, Vertical Direction

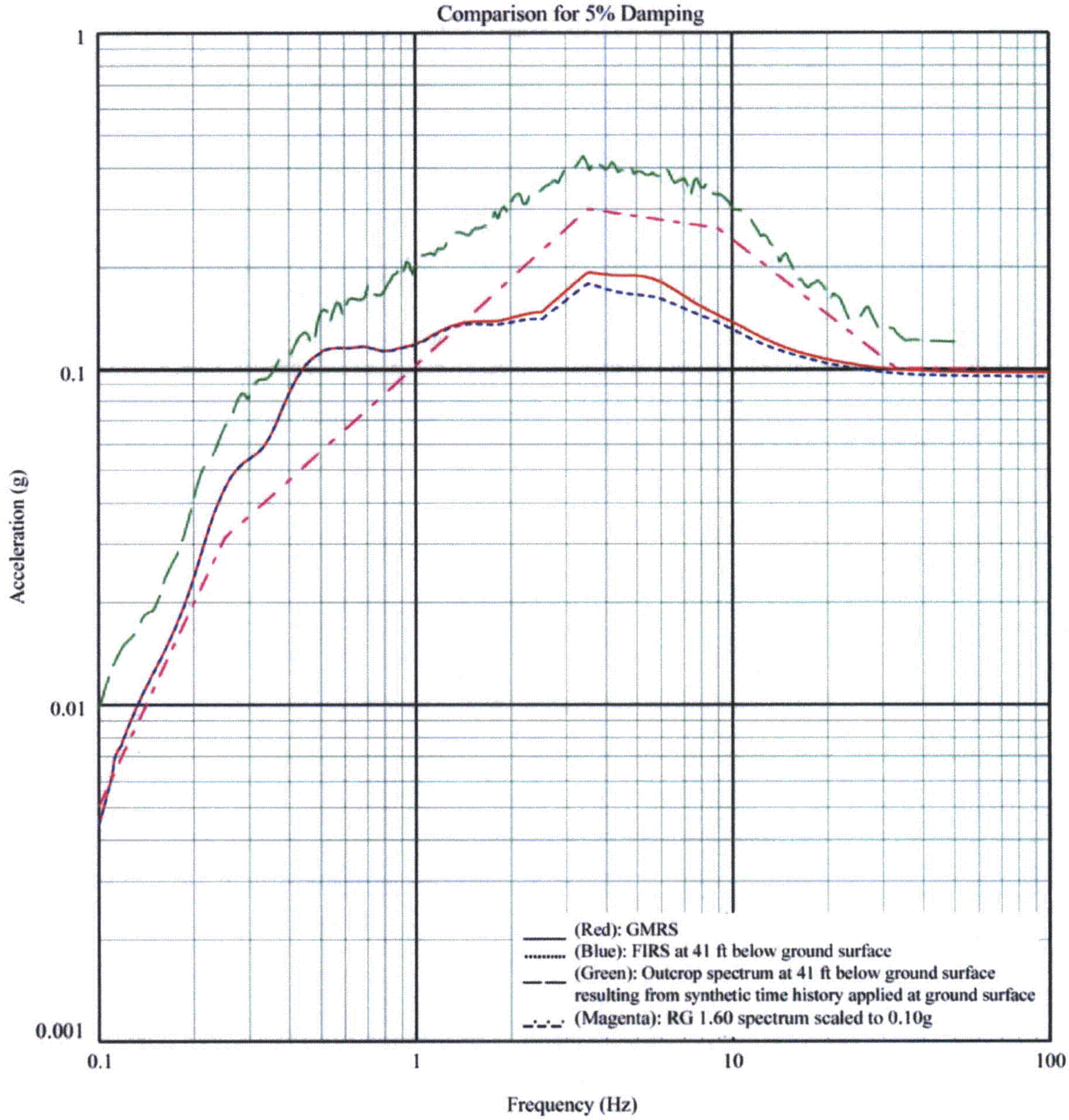


Figure 3H.6-11L: Comparison of Spectra at Foundation of Emergency Diesel Generator Fuel Storage Vault – Lower Bound Soil Properties, Vertical Direction

Enclosure 2 to Response to RAI 03.07.01-19

New COLA Tables 3H.6-11 through 3H.6-13 and Figures 3H.6-140 through 3H.6-208

Table 3H.6-11: Results of DGFOS Vault Concrete Design

Location	Thickness (ft)	Face	Direction	Reinforcement Layout Drawing Number [1]	Reinforcement Zone Number [2]	Maximum Forces [3]	Element	Longitudinal Reinforcement Design Loads: Axial and Flexure Loads: Load Combination	Axial [4] (kips / ft)	Flexure [4] (ft-kips / ft)	In-Plane Shear Loads: Load Combination	In-plane [5] Shear (kips / ft)	Longitudinal Reinforcement Provided (in²/ ft)	Transverse Shear Design Loads: Load Combination	Transverse Shear [6] Reinforcement Design Loads (kips / ft)	Transverse Shear [7] Reinforcement Provided (in²/ft²)	Remarks
Slab 1	6	Near Side	Horizontal	3H 6-142	1-H-L	Max Tension w/ corresponding moment	372	D + F + L + H' +E'	54	-302	D + F + L + H' +E'	21	3.12	-	-	-	
						Max Compression w/ corresponding moment	367	D + F + L + H' +E'	-49	-164							
						Max Moment with axial tension	25	D + F + L + H' +E'	3	-555							
						Max Moment with axial compression	367	D + F + L + H' +E'	-7	-486							
					2-H-L	Max Tension w/ corresponding moment	35	D + F + L + H' +E'	49	-275	D + F + L + H' +E'	21	7.8	-	-	-	
						Max Compression w/ corresponding moment	36	D + F + L + H' +E'	-64	-1064							
						Max Moment with axial tension	36	D + F + L + H' +E'	8	-1264							
						Max Moment with axial compression	36	D + F + L + H' +E'	-7	-1264							
					3-H-L	Max Tension w/ corresponding moment	377	D + F + L + H' +E'	59	-201	D + F + L + H' +E'	21	7.8	-	-	-	
						Max Compression w/ corresponding moment	378	D + F + L + H' +E'	-67	-994							
						Max Moment with axial tension	377	D + F + L + H' +E'	3	-968							
						Max Moment with axial compression	378	D + F + L + H' +E'	-42	-1127							
					4-H-L	Max Tension w/ corresponding moment	22	D + F + L + H' +E'	54	-189	D + F + L + H' +E'	21	7.8	-	-	-	
						Max Compression w/ corresponding moment	22	D + F + L + H' +E'	-63	-206							
						Max Moment with axial tension	21	D + F + L + H' +E'	9	-1183							
						Max Moment with axial compression	21	D + F + L + H' +E'	-7	-1183							
					5-H-L	Max Tension w/ corresponding moment	364	D + F + L + H' +E'	64	-211	D + F + L + H' +E'	21	7.8	-	-	-	
						Max Compression w/ corresponding moment	364	D + F + L + H' +E'	-70	-214							
						Max Moment with axial tension	363	D + F + L + H' +E'	1	-1252							
						Max Moment with axial compression	363	D + F + L + H' +E'	-44	-1252							

Table 3H.6-11: Results of DGFOS Vault Concrete Design (Continued)

Location	Thickness (ft)	Face	Direction	Reinforcement Layout Drawing Number (1)	Reinforcement Zone Number (2)	Maximum Forces (3)	Element	Longitudinal Reinforcement Design Loads – Axial and Flexure Loads – Load Combination	Axial (4) (kips / ft)	Flexure (4) (ft-kips / ft)	In-Plane Shear Loads – Load Combination	In-plane (5) Shear (kips / ft)	Longitudinal Reinforcement Provided (in²/ ft)	Transverse Shear Design Loads – Load Combination	Transverse Shear (6) Reinforcement Design Loads (kips / ft)	Transverse Shear (7) Reinforcement Provided (in²/ft²)	Remarks
Slab 1	6	Near Side	Vertical	3H 6-143	1-V-L	Max Tension w/ corresponding moment	346	D + F + L + H' +E'	73	502	D + F + L + H' +E'	21	3.12	-	-	-	
						Max Compression w/ corresponding moment	364	D + F + L + H' +E'	-70	65							
						Max Moment with corresponding axial tension	346	D + F + L + H' +E'	46	719							
						Max Moment with corresponding axial compression	378	D + F + L + H' +E'	-1	709							
					2-V-L	Max Tension w/ corresponding moment	183	D + F + L + H' +E'	106	-477	D + F + L + H' +E'	13	4.68	-	-	-	
						Max Compression w/ corresponding moment	342	D + F + L + H' +E'	-126	-96							
						Max Moment with axial tension	72	D + F + L + H' +E'	2	-785							
						Max Moment with axial compression	327	D + F + L + H' +E'	-13	-764							
					3-V-L	Max Tension w/ corresponding moment	4	D + F + L + H' +E'	17	-731	D + F + L + H' +E'	17	4.68	-	-	-	
						Max Compression w/ corresponding moment	2	D + F + L + H' +E'	-44	-46							
						Max Moment with axial tension	18	D + F + L + H' +E'	3	-705							
						Max Moment with axial compression	18	D + F + L + H' +E'	0	-501							
					4-V-L	Max Tension w/ corresponding moment	21	D + F + L + H' +E'	43	-695	D + F + L + H' +E'	29	7.8	-	-	-	
						Max Compression w/ corresponding moment	36	D + F + L + H' +E'	-196	-421							
						Max Moment with axial tension	36	D + F + L + H' +E'	24	-1317							
						Max Moment with axial compression	36	D + F + L + H' +E'	-8	-1317							
					5-V-L	Max Tension w/ corresponding moment	345	D + F + L + H +W'	51	-755	D + F + L + H' +E'	30	7.8	-	-	-	
						Max Compression w/ corresponding moment	378	D + F + L + H' +E'	-190	-320							
						Max Moment with axial tension	363	D + F + L + H' +E'	26	-1259							
						Max Moment with axial compression	363	D + F + L + H' +E'	-6	-1259							
		Far side	Horizontal	3H 6-144	1-H-L	Max Tension w/ corresponding moment	382	D + F + L + H' +E'	23	-540	D + F + L + H' +E'	18	3.12	-	-	-	
						Max Compression w/ corresponding moment	397	D + F + L + H' +E'	-35	-84							
						Max Moment with axial tension	381	D + F + L + H' +E'	4	-634							
						Max Moment with axial compression	381	D + F + L + H' +E'	-2	-432							
			Vertical	3H 6-145	1-V-L	Max Tension w/ corresponding moment	346	D + F + L + H' +E'	137	1110	D + F + L + H' +E'	30	7.8	-	-	-	
						Max Compression w/ corresponding moment	36	D + F + L + H' +E'	-196	416							
						Max Moment with corresponding axial tension	292	D + F + L + H' +E'	3	1381							
						Max Moment with corresponding axial compression	202	D + F + L + H' +E'	-128	1810							
					2-V-L	Max Tension w/ corresponding moment	16	D + F + L + H' +E'	44	382	D + F + L + H' +E'	17	3.12	-	-	-	
						Max Compression w/ corresponding moment	19	D + F + L + H' +E'	-45	89							
						Max Moment with axial tension	17	D + F + L + H' +E'	4	660							
						Max Moment with axial compression	17	D + F + L + H' +E'	0	634							
					3-V-L	Max Tension w/ corresponding moment	394	D + F + L + H' +E'	44	388	D + F + L + H' +E'	18	3.12	-	-	-	
						Max Compression w/ corresponding moment	397	D + F + L + H' +E'	-42	85							
						Max Moment with axial tension	382	D + F + L + H' +E'	6	748							
						Max Moment with axial compression	382	D + F + L + H' +E'	-11	746							
		-	Horizontal Plane	3H 6-146	1-H-T		-	-	-	-	-	-	-	D + F + L + H' +E'	120	0.20 (#4 @12)	
				3H 6-146	2-H-T		-	-	-	-	-	-	-	D + F + L + H' +E'	120	0.20 (#4 @12)	

Table 3H.6-11: Results of DGFOS Vault Concrete Design (Continued)

Location	Thickness (ft)	Face	Direction	Reinforcement Layout Drawing Number (1)	Reinforcement Zone Number(2)	Maximum Forces(3)	Element	Longitudinal Reinforcement Design Loads – Axial and Flexure Loads – Load Combination	Axial (4) (kips / ft)	Flexure (4) (ft-kips / ft)	In-Plane Shear Loads – Load Combination	In-plane Shear (5) (kips / ft)	Longitudinal Reinforcement Provided (in^2/ ft)	Transverse Shear Design Loads – Load Combination	Transverse Shear (6) Reinforcement Design Loads (kips / ft)	Transverse Shear (7) Reinforcement Provided (in^2/ft^2)	Remarks
Roof 2	7	Near Side	Horizontal	3H 6-147	1-H-L	Max Tension w/ corresponding moment	553	D + F + L + H +Wt	169	-40	D + F + L + H +Wt	67	3.12	-	-	-	
						Max Compression w/ corresponding moment	553	D + F + L + H' +E'	-189	-20							
						Max Moment with axial tension	554	D + F + L + H +Wt	50	-123							
						Max Moment with axial compression	407	1.4D + 1.4F +1.7L + 1.7H + 1.7W	-33	-107							
					2-H-L	Max Tension w/ corresponding moment	566	D + F + L + H +Wt	143	-33	D + F + L + H +Wt	54	4.68	-	-	-	
						Max Compression w/ corresponding moment	566	D + F + L + H' +E'	-180	-21							
						Max Moment with axial tension	566	D + F + L + H +Wt	92	-89							
						Max Moment with axial compression	566	D + F + L + H' +E'	-21	-61							
					3-H-L	Max Tension w/ corresponding moment	553	D + F + L + H +Wt	189	-40	D + F + L + H +Wt	67	4.68	-	-	-	
						Max Compression w/ corresponding moment	553	D + F + L + H' +E'	-189	-20							
						Max Moment with axial tension	554	D + F + L + H +Wt	50	-123							
						Max Moment with axial compression	553	D + F + L + H' +E'	-115	-62							
			Vertical	3H 6-148	1-V-L	Max Tension w/ corresponding moment	528	D + F + L + H +Wt	34	11	D + F + L + H +Wt	55	1.56	-	-	-	
						Max Compression w/ corresponding moment	472	D + F + L + H' +E'	-62	2							
						Max Moment with corresponding axial tension	567	D + F + L + H' +E'	2	66							
						Max Moment with corresponding axial compression	556	D + F + L + H +Wt	-12	82							
		Far side	Horizontal	3H 6-149	1-H-L	Max Tension w/ corresponding moment	566	D + F + L + H +Wt	90	15	D + F + L + H +Wt	54	3.12	-	-	-	
						Max Compression w/ corresponding moment	566	D + F + L + H' +E'	-180	33							
						Max Moment with axial tension	565	D + F + L + H' +E'	7	59							
						Max Moment with axial compression	565	D + F + L + H +Wt	-22	98							
					2-H-L	Max Tension w/ corresponding moment	553	D + F + L + H +Wt	130	19	D + F + L + H +Wt	67	3.12	-	-	-	
						Max Compression w/ corresponding moment	553	D + F + L + H' +E'	-189	37							
						Max Moment with axial tension	656	D + F + L + H' +E'	5	56							
						Max Moment with axial compression	554	D + F + L + H +Wt	-62	113							
					3-H-L	Max Tension w/ corresponding moment	554	D + F + L + H' +E'	109	-1	D + F + L + H' +E'	80	4.68	-	-	-	
						Max Compression w/ corresponding moment	553	D + F + L + H' +E'	-311	-182							
						Max Moment with axial tension	553	D + F + L + H' +E'	1	-125							
						Max Moment with axial compression	553	D + F + L + H' +E'	-184	-266							
			Vertical	3H 6-150	1-V-L	Max Tension w/ corresponding moment	554	D + F + L + H' +E'	113	4	D + F + L + H' +E'	80	3.12	-	-	-	
						Max Compression w/ corresponding moment	566	D + F + L + H' +E'	-297	14							
						Max Moment with corresponding axial tension	565	D + F + L + H +Wt	21	44							
						Max Moment with corresponding axial compression	490	1.4D + 1.4F +1.7L + 1.7H + 1.7W	-51	77							

Table 3H.6-11: Results of DGFOS Vault Concrete Design (Continued)

Location	Thickness (ft)	Face	Direction	Reinforcement Layout Drawing Number [1]	Reinforcement Zone Number [2]	Maximum Forces [3]	Element	Longitudinal Reinforcement Design Loads: Axial and Flexure Loads: Load Combination	Axial [4] (kips / ft)	Flexure [4] (ft-kips / ft)	In-Plane Shear Loads: Load Combination	In-plane [5] Shear (kips / ft)	Longitudinal Reinforcement Provided (in^2/ft)	Transverse Shear Design Loads: Load Combination	Transverse Shear [6] Reinforcement Design Loads (kips / ft)	Transverse Shear [7] Reinforcement Provided (in^2/ft^2)	Remarks
Slab 3	2	Near Side	Horizontal	3H 6-151	1-H-L	Max Tension w/ corresponding moment	651	D + F + L + H' +E'	52	-21	D + F + L + H +Wt	31	1.56	-	-	-	
						Max Compression w/ corresponding moment	651	D + F + L + H' +E'	-119	-18							
						Max Moment with axial tension	642	D + F + L + H +Wt	1	-40							
						Max Moment with axial compression	644	D + F + L + H +Wt	-10	-56							
Slab 3	2	Near Side	Vertical	3H 6-152	1-V-L	Max Tension w/ corresponding moment	651	D + F + L + H +Wt	59	10	D + F + L + H +Wt	31	1.66	-	-	-	
						Max Compression w/ corresponding moment	651	D + F + L + H' +E'	-119	5							
						Max Moment with corresponding axial tension	638	D + F + L + H +Wt	34	36							
						Max Moment with corresponding axial compression	573	D + F + L + H +Wt	-10	74							
		Far side	Horizontal	3H 6-153	1-H-L	Max Tension w/ corresponding moment	574	D + F + L + H' +E'	64	-34	D + F + L + H +Wt	21	1.66	-	-	-	
						Max Compression w/ corresponding moment	574	D + F + L + H' +E'	-122	-13							
						Max Moment with axial tension	651	D + F + L + H +Wt	3	-47							
						Max Moment with axial compression	574	D + F + L + H' +E'	-17	-43							
			Vertical	3H 6-154	1-V-L	Max Tension w/ corresponding moment	574	D + F + L + H +Wt	61	14	D + F + L + H +Wt	21	1.56	-	-	-	
						Max Compression w/ corresponding moment	574	D + F + L + H +Wt	-206	51							
						Max Moment with corresponding axial tension	638	D + F + L + H +Wt	11	29							
						Max Moment with corresponding axial compression	574	D + F + L + H +Wt	-156	90							
Roof 5	2	Near Side	Horizontal	3H 6-155	1-H-L	Max Tension w/ corresponding moment	690	D + F + L + H +Wt	107	-17	D + F + L + H +Wt	61	1.56	-	-	-	
						Max Compression w/ corresponding moment	695	D + F + L + H +Wt	-91	-7							
						Max Moment with axial tension	770	D + F + L + H' +E'	1	-32							
						Max Moment with axial compression	768	D + F + L + H' +E'	-9	-41							
			Vertical	3H 6-156	1-V-L	Max Tension w/ corresponding moment	704	D + F + L + H +Wt	77	4	D + F + L + H +Wt	61	1.56	-	-	-	
						Max Compression w/ corresponding moment	768	D + F + L + H +Wt	-271	22							
						Max Moment with corresponding axial tension	699	D + F + L + H +Wt	5	37							
						Max Moment with corresponding axial compression	698	D + F + L + H +Wt	-138	48							
		Far side	Horizontal	3H 6-157	1-H-L	Max Tension w/ corresponding moment	767	D + F + L + H +Wt	136	-13	D + F + L + H +Wt	29	1.56	-	-	-	
						Max Compression w/ corresponding moment	719	D + F + L + H +Wt	-126	0							
						Max Moment with axial tension	731	D + F + L + H' +E'	1	-20							
						Max Moment with axial compression	731	D + F + L + H' +E'	-4	-20							
			Vertical	3H 6-158	1-V-L	Max Tension w/ corresponding moment	761	D + F + L + H +Wt	39	7	D + F + L + H +Wt	29	1.56	-	-	-	
						Max Compression w/ corresponding moment	732	D + F + L + H +Wt	-334	14							
						Max Moment with corresponding axial tension	732	D + F + L + H' +E'	1	19							
						Max Moment with corresponding axial compression	695	D + F + L + H +Wt	-190	20							

Table 3H.6-11: Results of DGFOS Vault Concrete Design (Continued)

Location	Thickness (ft)	Face	Direction	Reinforcement Layout Drawing Number (1)	Reinforcement Zone Number(2)	Maximum Forces(3)	Element	Longitudinal Reinforcement Design Loads: Axial and Flexure Loads: Load Combination	Axial (4) (kips / ft)	Flexure (4) (ft-kips / ft)	In-Plane Shear Loads: Load Combination	In-plane (5) Shear (kips / ft)	Longitudinal Reinforcement Provided (in^2/ft)	Transverse Shear Design Loads: Load Combination	Transverse Shear (6) Reinforcement Design Loads (kips / ft)	Transverse Shear (7) Reinforcement Provided (in^2/ft^2)	Remarks
Roof 6	2	Near Side	Horizontal	3H 6-159	1-H-L	Max Tension w/ corresponding moment	684	D + F + L + H +Wt	111	-8	D + F + L + H +Wt	66	1.56	-	-	-	
						Max Compression w/ corresponding moment	689	D + F + L + H +Wt	-335	-83							
						Max Moment with axial tension	689	D + F + L + H' +E'	27	-52							
						Max Moment with axial compression	689	D + F + L + H +Wt	-190	-84							
			Vertical	3H 6-160	1-V-L	Max Tension w/ corresponding moment	673	D + F + L + H +Wt	86	3	D + F + L + H +Wt	69	1.56	-	-	-	
						Max Compression w/ corresponding moment	656	D + F + L + H +Wt	-432	26							
						Max Moment with corresponding axial tension	659	D + F + L + H +Wt	14	53							
						Max Moment with corresponding axial compression	689	D + F + L + H' +E'	-59	45							
Roof 6	2	Far side	Horizontal	3H 6-161	1-H-L	Max Tension w/ corresponding moment	689	D + F + L + H +Wt	39	-6	D + F + L + H +Wt	125	2.08	-	-	-	
						Max Compression w/ corresponding moment	689	D + F + L + H +Wt	-209	-12							
						Max Moment with axial tension	659	D + F + L + H' +E'	0	-11							
						Max Moment with axial compression	689	D + F + L + H +Wt	-209	-12							
			Vertical	3H 6-162	1-V-L	Max Tension w/ corresponding moment	689	D + F + L + H' +E'	22	5	D + F + L + H +Wt	125	2.08	-	-	-	
						Max Compression w/ corresponding moment	666	D + F + L + H +Wt	-429	26							
						Max Moment with corresponding axial tension	656	D + F + L + H +Wt	12	12							
						Max Moment with corresponding axial compression	672	D + F + L + H +Wt	-262	34							
Wall 7	4	Near Side	Horizontal	3H 6-163	1-H-L	Max Tension w/ corresponding moment	859	D + F + L + H' +E'	154	-53	D + F + L + H' +E'	67	3.12	-	-	-	
						Max Compression w/ corresponding moment	859	D + F + L + H' +E'	-213	-15							
						Max Moment with axial tension	811	D + F + L + H' +E'	2	-238							
						Max Moment with axial compression	809	D + F + L + H' +E'	-139	-330							
					2-H-L	Max Tension w/ corresponding moment	803	D + F + L + H' +E'	63	-132	D + F + L + H' +E'	67	7.8	-	-	-	
						Max Compression w/ corresponding moment	799	D + F + L + H' +E'	-178	-763							
						Max Moment with axial tension	803	D + F + L + H' +E'	3	-283							
						Max Moment with axial compression	800	D + F + L + H' +E'	-169	-766							
					3-H-L	Max Tension w/ corresponding moment	891	D + F + L + H +Wt	421	-100	D + F + L + H +Wt	43	6.24	-	-	-	
						Max Compression w/ corresponding moment	1042	D + F + L + H +Wt	-412	-63							
						Max Moment with axial tension	1042	D + F + L + H' +E'	150	-315							
						Max Moment with axial compression	1057	D + F + L + H' +E'	-145	-319							
					4-H-L	Max Tension w/ corresponding moment	1046	D + F + L + H +Wt	65	-35	D + F + L + H' +E'	67	7.8	-	-	-	
						Max Compression w/ corresponding moment	1053	D + F + L + H' +E'	-179	-817							
						Max Moment with axial tension	1016	D + F + L + H' +E'	13	-98							
						Max Moment with axial compression	1065	D + F + L + H' +E'	-173	-853							
			Vertical	3H 6-164	1-V-L	Max Tension w/ corresponding moment	1042	D + F + L + H +Wt	463	94	D + F + L + H' +E'	67	3.12	-	-	-	
						Max Compression w/ corresponding moment	891	D + F + L + H' +E'	-404	70							
						Max Moment with corresponding axial tension	1047	D + F + L + H' +E'	14	227							
						Max Moment with corresponding axial compression	887	D + F + L + H' +E'	-122	372							
					2-V-L	Max Tension w/ corresponding moment	804	D + F + L + H' +E'	14	90	D + F + L + H' +E'	67	4.68	-	-	-	
						Max Compression w/ corresponding moment	806	D + F + L + H' +E'	-140	309							
						Max Moment with corresponding axial tension	804	D + F + L + H' +E'	14	90							
						Max Moment with corresponding axial compression	814	D + F + L + H' +E'	-99	379							

Table 3H.6-11: Results of DGFOS Vault Concrete Design (Continued)

Location	Thickness (ft)	Face	Direction	Reinforcement Layout Drawing Number [1]	Reinforcement Zone Number [2]	Maximum Forces [3]	Element	Longitudinal Reinforcement Design Loads: Axial and Flexure Loads: Load Combination	Axial [4] (kips / ft)	Flexure [4] (ft-kips / ft)	In-Plane Shear Loads: Load Combination	In-plane [5] Shear (kips / ft)	Longitudinal Reinforcement Provided (in²/ ft)	Transverse Shear Design Loads: Load Combination	Transverse Shear [6] Reinforcement Design Loads (kips / ft)	Transverse Shear [7] Reinforcement Provided (in²/ft²)	Remarks
Wall 7	4	Far side	Horizontal	3H 6-165	1-H-L	Max Tension w/ corresponding moment	1042	D + F + L + H +Wt	292	-82	D + F + L + H' +E'	105	4.68	-	-	-	
						Max Compression w/ corresponding moment	1042	D + F + L + H +Wt	-340	-68							
						Max Moment with axial tension	804	D + F + L + H' +E'	6	-441							
						Max Moment with axial compression	804	D + F + L + H' +E'	-108	-442							
					2-H-L	Max Tension w/ corresponding moment	812	D + F + L + H' +E'	71	-288	D + F + L + H' +E'	81	10.92	-	-	-	
						Max Compression w/ corresponding moment	1014	D + F + L + H' +E'	-137	-46							
						Max Moment with axial tension	852	D + F + L + H' +E'	13	-1205							
						Max Moment with axial compression	852	D + F + L + H' +E'	-39	-1208							
			Vertical	3H 6-166	1-V-L	Max Tension w/ corresponding moment	691	D + F + L + H +Wt	339	94	D + F + L + H' +E'	105	6.24	-	-	-	
						Max Compression w/ corresponding moment	796	D + F + L + H' +E'	-299	67							
						Max Moment with corresponding axial tension	856	D + F + L + H' +E'	11	693							
						Max Moment with corresponding axial compression	856	D + F + L + H' +E'	-31	693							
			Horizontal Plane	3H 6-167	1-H-T		-	-	-	-	-	-	-	D + F + L + H' +E'	92	0.31 (#5 @12)	
				3H 6-167	2-H-T		-	-	-	-	-	-	-	D + F + L + H' +E'	148	0.62 (#5 @6)	
			Vertical Plane	3H 6-167	1-V-T		-	-	-	-	-	-	-	D + F + L + H' +E'	98	0.31 (#5 @12)	
				3H 6-167	2-V-T		-	-	-	-	-	-	-	D + F + L + H' +E'	99	0.31 (#5 @12)	
				3H 6-167	3-V-T		-	-	-	-	-	-	-	D + F + L + H' +E'	124	0.62 (#5 @6)	
Wall 8	4	Near Side	Horizontal	3H 6-168	1-H-L	Max Tension w/ corresponding moment	1140	D + F + L + H' +E'	152	-37	D + F + L + H' +E'	66	3.12	-	-	-	
						Max Compression w/ corresponding moment	1140	D + F + L + H' +E'	-213	-30							
						Max Moment with axial tension	1188	D + F + L + H' +E'	2	-712							
						Max Moment with axial compression	1183	D + F + L + H' +E'	-145	-336							
					2-H-L	Max Tension w/ corresponding moment	1276	D + F + L + H +Wt	50	-44	D + F + L + H' +E'	66	7.8	-	-	-	
						Max Compression w/ corresponding moment	1306	D + F + L + H' +E'	-179	-833							
						Max Moment with axial tension	1282	D + F + L + H' +E'	0	-129							
						Max Moment with axial compression	1311	D + F + L + H' +E'	-179	-888							
					3-H-L	Max Tension w/ corresponding moment	1108	D + F + L + H' +E'	251	-310	D + F + L + H +Wt	40	6.24	-	-	-	
						Max Compression w/ corresponding moment	1280	D + F + L + H +Wt	-406	-71							
						Max Moment with axial tension	1280	D + F + L + H' +E'	189	-382							
						Max Moment with axial compression	1301	D + F + L + H' +E'	-156	-387							
					4-H-L	Max Tension w/ corresponding moment	1196	D + F + L + H' +E'	63	-109	D + F + L + H' +E'	66	7.8	-	-	-	
						Max Compression w/ corresponding moment	1192	D + F + L + H' +E'	-178	-785							
						Max Moment with axial tension	1196	D + F + L + H' +E'	5	-250							
						Max Moment with axial compression	1192	D + F + L + H' +E'	-178	-786							

Table 3H.6-11: Results of DGFOS Vault Concrete Design (Continued)

Location	Thickness (ft)	Face	Direction	Reinforcement Layout Drawing Number [1]	Reinforcement Zone Number [2]	Maximum Forces [3]	Element	Longitudinal Reinforcement Design Loads – Axial and Flexure Loads – Load Combination	Axial [4] (kips / ft)	Flexure [4] (ft-kips / ft)	In-Plane Shear Loads – Load Combination	In-plane [5] Shear (kips / ft)	Longitudinal Reinforcement Provided (in²/ft)	Transverse Shear Design Loads – Load Combination	Transverse Shear [6] Reinforcement Design Loads (kips / ft)	Transverse Shear [7] Reinforcement Provided (in²/ft²)	Remarks
Wall 8	4	Near Side	Vertical	3H 6-169	1-V-L	Max Tension w/ corresponding moment	1280	D + F + L + H + Wt	368	142	D + F + L + H' + E'	66	3.12	-	-	-	
						Max Compression w/ corresponding moment	1108	D + F + L + H' + E'	-382	105							
						Max Moment with corresponding axial tension	1275	D + F + L + H' + E'	13	282							
						Max Moment with corresponding axial compression	1280	D + F + L + H' + E'	-209	384							
					2-V-L	Max Tension w/ corresponding moment	1181	D + F + L + H' + E'	14	96	D + F + L + H' + E'	66	4.68	-	-	-	
						Max Compression w/ corresponding moment	1183	D + F + L + H' + E'	-140	331							
						Max Moment with corresponding axial tension	1181	D + F + L + H' + E'	11	97							
						Max Moment with corresponding axial compression	1175	D + F + L + H' + E'	-99	399							
		Far side	Horizontal	3H 6-170	1-H-L	Max Tension w/ corresponding moment	1189	D + F + L + H' + E'	286	-100	D + F + L + H' + E'	107	4.68	-	-	-	
						Max Compression w/ corresponding moment	1280	D + F + L + H + Wt	-326	-61							
						Max Moment with axial tension	1161	D + F + L + H' + E'	7	-446							
						Max Moment with axial compression	1161	D + F + L + H' + E'	-108	-449							
					2-H-L	Max Tension w/ corresponding moment	1173	D + F + L + H' + E'	72	-294	D + F + L + H' + E'	82	10.92	-	-	-	
						Max Compression w/ corresponding moment	1272	D + F + L + H' + E'	-135	-36							
						Max Moment with axial tension	1133	D + F + L + H' + E'	13	-1206							
						Max Moment with axial compression	1133	D + F + L + H' + E'	-38	-1209							
			Vertical	3H 6-171	1-V-L	Max Tension w/ corresponding moment	1280	D + F + L + H + Wt	293	86	D + F + L + H' + E'	107	6.24	-	-	-	
						Max Compression w/ corresponding moment	1189	D + F + L + H' + E'	-299	73							
						Max Moment with corresponding axial tension	1145	D + F + L + H' + E'	11	694							
						Max Moment with corresponding axial compression	1145	D + F + L + H' + E'	-30	694							
			Horizontal Plane	3H 6-172	1-H-T		-	-	-	-	-	-	-	D + F + L + H' + E'	92	0.31 (#5 @12)	
				3H 6-172	2-H-T		-	-	-	-	-	-	-	D + F + L + H' + E'	148	0.62 (#5 @6)	
			Vertical Plane	3H 6-172	1-V-T		-	-	-	-	-	-	-	D + F + L + H' + E'	123	0.62 (#5 @6)	
				3H 6-172	2-V-T		-	-	-	-	-	-	-	D + F + L + H' + E'	98	0.31 (#5 @12)	
				3H 6-172	3-V-T		-	-	-	-	-	-	-	D + F + L + H' + E'	98	0.31 (#5 @12)	
Wall 9	2	Near Side	Horizontal	3H 6-173	1-H-L	Max Tension w/ corresponding moment	1019	D + F + L + H + Wt	131	-2	D + F + L + H + Wt	125	3.12	-	-	-	
						Max Compression w/ corresponding moment	995	D + F + L + H + Wt	-165	-4							
						Max Moment with axial tension	1016	D + F + L + H' + E'	30	-94							
						Max Moment with axial compression	1035	D + F + L + H' + E'	-36	-111							
					2-H-L	Max Tension w/ corresponding moment	1030	D + F + L + H + Wt	271	-12	D + F + L + H + Wt	125	4.68	-	-	-	
						Max Compression w/ corresponding moment	1030	D + F + L + H + Wt	-241	-13							
						Max Moment with axial tension	1030	D + F + L + H' + E'	90	-112							
						Max Moment with axial compression	1030	D + F + L + H' + E'	-19	-112							

Table 3H.6-11: Results of DGFOS Vault Concrete Design (Continued)

Location	Thickness (ft)	Face	Direction	Reinforcement Layout Drawing Number (1)	Reinforcement Zone Number (2)	Maximum Forces (3)	Element	Longitudinal Reinforcement Design Loads: Axial and Flexure Loads: Load Combination	Axial (4) (kips / ft)	Flexure (4) (ft-kips / ft)	In-Plane Shear Loads: Load Combination	In-plane (5) Shear (kips / ft)	Longitudinal Reinforcement Provided (in²/ ft)	Transverse Shear Design Loads: Load Combination	Transverse Shear (6) Reinforcement Design Loads (kips / ft)	Transverse Shear (7) Reinforcement Provided (in²/ft²)	Remarks
Wall 9	2	Near Side	Vertical	3H.6-174	1-V-L	Max Tension w/ corresponding moment	1019	D + F + L + H +Wt	148	6	D + F + L + H +Wt	125	3.12	-	-	-	
						Max Compression w/ corresponding moment	996	D + F + L + H +Wt	-316	6							
						Max Moment with corresponding axial tension	975	D + F + L + H +Wt	2	62							
						Max Moment with corresponding axial compression	983	D + F + L + H +Wt	-13	64							
					2-V-L	Max Tension w/ corresponding moment	1030	D + F + L + H +Wt	160	17	D + F + L + H +Wt	125	4.68	-	-	-	
						Max Compression w/ corresponding moment	1030	D + F + L + H' +E'	-218	56							
						Max Moment with corresponding axial tension	1030	D + F + L + H' +E'	0	23							
						Max Moment with corresponding axial compression	1030	D + F + L + H' +E'	-169	56							
					3-V-L	Max Tension w/ corresponding moment	1019	D + F + L + H +Wt	203	-16	D + F + L + H +Wt	114	3.12	-	-	-	
						Max Compression w/ corresponding moment	1019	D + F + L + H +Wt	-205	-20							
						Max Moment with corresponding axial tension	1031	D + F + L + H' +E'	33	-114							
						Max Moment with corresponding axial compression	1031	D + F + L + H' +E'	-59	-114							
		Far side	Horizontal	3H.6-175	1-H-L	Max Tension w/ corresponding moment	1030	D + F + L + H +Wt	596	-38	D + F + L + H +Wt	100	6.24	-	-	-	
						Max Compression w/ corresponding moment	1030	D + F + L + H +Wt	-525	-52							
						Max Moment with axial tension	1030	D + F + L + H' +E'	131	-197							
						Max Moment with axial compression	1030	D + F + L + H' +E'	-171	-197							
					2-H-L	Max Tension w/ corresponding moment	1035	D + F + L + H +Wt	161	-9	D + F + L + H +Wt	109	4.68	-	-	-	
						Max Compression w/ corresponding moment	1035	D + F + L + H +Wt	-219	-14							
						Max Moment with axial tension	1035	D + F + L + H' +E'	68	-62							
						Max Moment with axial compression	1035	D + F + L + H' +E'	-30	-62							
			Vertical	3H.6-176	1-V-L	Max Tension w/ corresponding moment	1001	D + F + L + H +Wt	158	5	D + F + L + H +Wt	114	3.12	-	-	-	
						Max Compression w/ corresponding moment	1011	D + F + L + H +Wt	-197	3							
						Max Moment with corresponding axial tension	956	D + F + L + H +Wt	1	57							
						Max Moment with corresponding axial compression	995	D + F + L + H +Wt	-5	71							
					2-V-L	Max Tension w/ corresponding moment	1006	D + F + L + H +Wt	306	8	D + F + L + H +Wt	100	6.24	-	-	-	
						Max Compression w/ corresponding moment	1030	D + F + L + H' +E'	-403	21							
						Max Moment with corresponding axial tension	1018	D + F + L + H +Wt	11	28							
						Max Moment with corresponding axial compression	1018	D + F + L + H' +E'	-248	43							
Wall 10	2	Near Side	Horizontal	3H.6-177	1-H-L	Max Tension w/ corresponding moment	1246	D + F + L + H' +E'	63	-28	D + F + L + H +Wt	100	3.12	-	-	-	
						Max Compression w/ corresponding moment	1204	D + F + L + H +Wt	-163	-3							
						Max Moment with axial tension	1258	D + F + L + H' +E'	29	-91							
						Max Moment with axial compression	1197	D + F + L + H' +E'	-36	-107							
					2-H-L	Max Tension w/ corresponding moment	1257	D + F + L + H' +E'	122	-63	D + F + L + H +Wt	95	4.68	-	-	-	
						Max Compression w/ corresponding moment	1257	D + F + L + H +Wt	-233	-16							
						Max Moment with axial tension	1257	D + F + L + H' +E'	85	-107							
						Max Moment with axial compression	1257	D + F + L + H' +E'	-13	-107							

Table 3H.6-11: Results of DGFOS Vault Concrete Design (Continued)

Location	Thickness (ft)	Face	Direction	Reinforcement Layout Drawing Number (1)	Reinforcement Zone Number (2)	Maximum Forces (3)	Element	Longitudinal Reinforcement Design Loads: Axial and Flexure Loads: Load Combination	Axial (4) (kips / ft)	Flexure (4) (ft-kips / ft)	In-Plane Shear Loads: Load Combination	In-plane (5) Shear (kips / ft)	Longitudinal Reinforcement Provided (in²/ ft)	Transverse Shear Design Loads: Load Combination	Transverse Shear (6) Reinforcement Design Loads (kips / ft)	Transverse Shear (7) Reinforcement Provided (in²/ft²)	Remarks
Wall 10	2	Near Side	Vertical	3H 6-178	1-V-L	Max Tension w/ corresponding moment	1346	D + F + L + H +Wt	117	10	D + F + L + H +Wt	100	3.12	-	-	-	
						Max Compression w/ corresponding moment	1265	D + F + L + H +Wt	-308	17							
						Max Moment with corresponding axial tension	1199	D + F + L + H' +E'	1	51							
						Max Moment with corresponding axial compression	1232	D + F + L + H +Wt	-36	65							
					2-V-L	Max Tension w/ corresponding moment	1257	D + F + L + H +Wt	214	16	D + F + L + H +Wt	95	4.68	-	-	-	
						Max Compression w/ corresponding moment	1257	D + F + L + H' +E'	-206	43							
						Max Moment with corresponding axial tension	1345	D + F + L + H' +E'	3	33							
						Max Moment with corresponding axial compression	1257	D + F + L + H' +E'	-158	52							
					3-V-L	Max Tension w/ corresponding moment	1261	D + F + L + H +Wt	159	-7	D + F + L + H +Wt	64	3.12	-	-	-	
						Max Compression w/ corresponding moment	1246	D + F + L + H +Wt	-182	-22							
						Max Moment with corresponding axial tension	1345	D + F + L + H' +E'	21	-123							
						Max Moment with corresponding axial compression	1345	D + F + L + H' +E'	-54	-123							
		Far side	Horizontal	3H 6-179	1-H-L	Max Tension w/ corresponding moment	1197	D + F + L + H +Wt	152	-9	D + F + L + H +Wt	80	4.68	-	-	-	
						Max Compression w/ corresponding moment	1197	D + F + L + H +Wt	-176	-7							
						Max Moment with axial tension	1197	D + F + L + H' +E'	65	-68							
						Max Moment with axial compression	1197	D + F + L + H' +E'	-32	-68							
					2-H-L	Max Tension w/ corresponding moment	1757	D + F + L + H' +E'	261	-130	D + F + L + H +Wt	71	6.24	-	-	-	
						Max Compression w/ corresponding moment	1257	D + F + L + H +Wt	-482	-59							
						Max Moment with axial tension	1257	D + F + L + H' +E'	111	-204							
						Max Moment with axial compression	1257	D + F + L + H' +E'	-139	-204							
			Vertical	3H 6-180	1-V-L	Max Tension w/ corresponding moment	1246	D + F + L + H +Wt	156	0	D + F + L + H +Wt	84	3.12	-	-	-	
						Max Compression w/ corresponding moment	1199	D + F + L + H +Wt	-149	1							
						Max Moment with corresponding axial tension	1234	D + F + L + H' +E'	0	29							
						Max Moment with corresponding axial compression	1265	D + F + L + H +Wt	-25	69							
					2-V-L	Max Tension w/ corresponding moment	1257	D + F + L + H +Wt	456	11	D + F + L + H +Wt	71	6.24	-	-	-	
						Max Compression w/ corresponding moment	1257	D + F + L + H' +E'	-340	16							
						Max Moment with corresponding axial tension	1257	D + F + L + H' +E'	70	23							
						Max Moment with corresponding axial compression	1258	D + F + L + H' +E'	-229	42							
Wall 11	2	Near Side	Horizontal	3H 6-181	1-H-L	Max Tension w/ corresponding moment	951	D + F + L + H +Wt	116	-54	D + F + L + H +Wt	46	3.12	-	-	-	
						Max Compression w/ corresponding moment	934	D + F + L + H +Wt	-131	-4							
						Max Moment with axial tension	951	D + F + L + H +Wt	70	-63							
						Max Moment with axial compression	944	D + F + L + H' +E'	-16	-40							
			Vertical	3H 6-182	1-V-L	Max Tension w/ corresponding moment	944	D + F + L + H +Wt	58	7	D + F + L + H +Wt	46	3.12	-	-	-	
						Max Compression w/ corresponding moment	907	D + F + L + H +Wt	-426	30							
						Max Moment with corresponding axial tension	935	D + F + L + H +Wt	7	84							
						Max Moment with corresponding axial compression	927	D + F + L + H +Wt	-6	83							

Table 3H.6-11: Results of DGFOS Vault Concrete Design (Continued)

Location	Thickness (ft)	Face	Direction	Reinforcement Layout Drawing Number (1)	Reinforcement Zone Number (2)	Maximum Forces (3)	Element	Longitudinal Reinforcement Design Loads: Axial and Flexure Loads: Load Combination	Axial (4) (kips / ft)	Flexure (4) (ft-kips / ft)	In-Plane Shear Loads: Load Combination	In-plane (5) Shear (kips / ft)	Longitudinal Reinforcement Provided (in²/ ft)	Transverse Shear Design Loads: Load Combination	Transverse Shear (6) Reinforcement Design Loads (kips / ft)	Transverse Shear (7) Reinforcement Provided (in²/ft²)	Remarks
Wall 11	2	Far side	Horizontal	3H 6-183	1-H-L	Max Tension w/ corresponding moment	944	D + F + L + H +Wt	137	-5	D + F + L + H' +E'	20	1.66	-	-	-	
						Max Compression w/ corresponding moment	944	D + F + L + H +Wt	-173	-6							
						Max Moment with axial tension	943	D + F + L + H +Wt	13	-30							
						Max Moment with axial compression	948	D + F + L + H +Wt	-11	-30							
			Vertical	3H 6-184	1-V-L	Max Tension w/ corresponding moment	944	D + F + L + H +Wt	99	10	D + F + L + H' +E'	20	1.66	-	-	-	
						Max Compression w/ corresponding moment	944	D + F + L + H +Wt	-134	7							
						Max Moment with corresponding axial tension	935	D + F + L + H +Wt	2	73							
						Max Moment with corresponding axial compression	907	D + F + L + H +Wt	-80	104							
Wall 12	4	Near Side	Horizontal	3H 6-185	1-H-L	Max Tension w/ corresponding moment	1349	D + F + L + H' +E'	87	-151	D + F + L + H' +E'	127	3.12	-	-	-	
						Max Compression w/ corresponding moment	1345	D + F + L + H' +E'	-187	-340							
						Max Moment with axial tension	1349	D + F + L + H' +E'	17	-207							
						Max Moment with axial compression	1348	D + F + L + H' +E'	-174	-382							
					2-H-L	Max Tension w/ corresponding moment	1341	D + F + L + H' +E'	95	-79	D + F + L + H' +E'	127	7.8	-	-	-	
						Max Compression w/ corresponding moment	1337	D + F + L + H' +E'	-189	-759							
						Max Moment with axial tension	1341	D + F + L + H' +E'	3	-211							
						Max Moment with axial compression	1337	D + F + L + H' +E'	-187	-761							
					3-H-L	Max Tension w/ corresponding moment	1437	D + F + L + H' +E'	99	-119	D + F + L + H' +E'	127	6.24	-	-	-	
						Max Compression w/ corresponding moment	1433	D + F + L + H' +E'	-188	-487							
						Max Moment with axial tension	1445	D + F + L + H' +E'	1	-219							
						Max Moment with axial compression	1442	D + F + L + H' +E'	-175	-746							
			Vertical	3H 6-186	1-V-L	Max Tension w/ corresponding moment	1445	D + F + L + H' +E'	90	7	D + F + L + H' +E'	127	3.12	-	-	-	
						Max Compression w/ corresponding moment	1409	D + F + L + H' +E'	-181	47							
						Max Moment with corresponding axial tension	1357	D + F + L + H' +E'	2	118							
						Max Moment with corresponding axial compression	1393	D + F + L + H' +E'	-157	310							
					2-V-L	Max Tension w/ corresponding moment	1336	D + F + L + H' +E'	120	-64	D + F + L + H' +E'	107	3.12	-	-	-	
						Max Compression w/ corresponding moment	1336	D + F + L + H' +E'	-220	-58							
						Max Moment with corresponding axial tension	1373	D + F + L + H' +E'	2	-222							
						Max Moment with corresponding axial compression	1373	D + F + L + H' +E'	-24	-222							
					3-V-L	Max Tension w/ corresponding moment	1304	D + F + L + H' +E'	284	-81	D + F + L + H' +E'	105	6.24	-	-	-	
						Max Compression w/ corresponding moment	1304	D + F + L + H' +E'	-305	-69							
						Max Moment with corresponding axial tension	1350	D + F + L + H' +E'	53	-427							
						Max Moment with corresponding axial compression	1350	D + F + L + H' +E'	-40	-427							
					4-V-L	Max Tension w/ corresponding moment	1366	D + F + L + H' +E'	95	-610	D + F + L + H' +E'	107	7.8	-	-	-	
						Max Compression w/ corresponding moment	1398	D + F + L + H' +E'	-105	-56							
						Max Moment with corresponding axial tension	1374	D + F + L + H' +E'	27	-653							
						Max Moment with corresponding axial compression	1358	D + F + L + H' +E'	-5	-646							

Table 3H.6-11: Results of DGFOS Vault Concrete Design (Continued)

Location	Thickness (ft)	Face	Direction	Reinforcement Layout Drawing Number (1)	Reinforcement Zone Number (2)	Maximum Forces (3)	Element	Longitudinal Reinforcement Design Loads – Axial and Flexure Loads – Load Combination	Axial (4) (kips / ft)	Flexure (4) (ft-kips / ft)	In-Plane Shear Loads – Load Combination	In-plane (5) Shear (kips / ft)	Longitudinal Reinforcement Provided (in²/ ft)	Transverse Shear Design Loads – Load Combination	Transverse Shear (6) Reinforcement Design Loads (kips / ft)	Transverse Shear (7) Reinforcement Provided (in²/ft²)	Remarks
Wall 12	4	Far side	Horizontal	3H 6-187	1-H-L	Max Tension w/ corresponding moment	1438	D + F + L + H' +E'	286	-73	D + F + L + H' +E'	105	6.24	-	-	-	
						Max Compression w/ corresponding moment	1438	D + F + L + H' +E'	-304	-59							
						Max Moment with axial tension	1406	D + F + L + H' +E'	56	-462							
						Max Moment with axial compression	1406	D + F + L + H' +E'	-30	-462							
			Vertical	3H 6-188	1-V-L	Max Tension w/ corresponding moment	1438	D + F + L + H' +E'	184	8	D + F + L + H' +E'	107	6.24	-	-	-	
						Max Compression w/ corresponding moment	1334	D + F + L + H' +E'	-209	17							
						Max Moment with corresponding axial tension	1384	D + F + L + H' +E'	10	323							
						Max Moment with corresponding axial compression	1392	D + F + L + H' +E'	0	321							
			Horizontal Plane	3H 6-189	1-H-T		-	-	-	-	-	-	-	D + F + L + H' +E'	94	0.31 (#5 @12)	
			Vertical Plane	3H 6-189	1-V-T		-	-	-	-	-	-	-	D + F + L + H' +E'	102	0.31 (#5 @12)	
				3H 6-189	2-V-T		-	-	-	-	-	-	-	D + F + L + H' +E'	109	0.31 (#5 @12)	
Wall 13	4	Near Side	Horizontal	3H 6-190	1-H-L	Max Tension w/ corresponding moment	1860	D + F + L + H' +W	15	-13	D + F + L + H' +E'	119	3.12	-	-	-	
						Max Compression w/ corresponding moment	1944	D + F + L + H' +E'	-183	-191							
						Max Moment with axial tension	1867	D + F + L + H' +E'	0	-69							
						Max Moment with axial compression	1874	D + F + L + H' +E'	-56	-216							
					2-H-L	Max Tension w/ corresponding moment	1871	D + F + L + H' +E'	68	-12	D + F + L + H' +E'	119	7.8	-	-	-	
						Max Compression w/ corresponding moment	1941	D + F + L + H' +E'	-187	-802							
						Max Moment with axial tension	1871	D + F + L + H' +E'	36	-465							
						Max Moment with axial compression	1955	D + F + L + H' +E'	-178	-838							
					3-H-L	Max Tension w/ corresponding moment	1884	D + F + L + H' +E'	49	-240	D + F + L + H' +E'	119	7.8	-	-	-	
						Max Compression w/ corresponding moment	1954	D + F + L + H' +E'	-188	-818							
						Max Moment with axial tension	1884	D + F + L + H' +E'	34	-455							
						Max Moment with axial compression	1968	D + F + L + H' +E'	-179	-870							
			Vertical	3H 6-191	1-V-L	Max Tension w/ corresponding moment	1871	D + F + L + H' +E'	68	12	D + F + L + H' +E'	119	3.12	-	-	-	
						Max Compression w/ corresponding moment	1952	D + F + L + H' +E'	-161	126							
						Max Moment with corresponding axial tension	1882	D + F + L + H' +E'	4	259							
						Max Moment with corresponding axial compression	1564	D + F + L + H' +E'	-150	377							
					2-V-L	Max Tension w/ corresponding moment	1870	D + F + L + H' +E'	209	-42	D + F + L + H' +E'	114	4.60	-	-	-	
						Max Compression w/ corresponding moment	1857	D + F + L + H' +E'	-265	-55							
						Max Moment with corresponding axial tension	1860	D + F + L + H' +E'	37	-389							
						Max Moment with corresponding axial compression	1860	D + F + L + H' +E'	-60	-389							
		Far side	Horizontal	3H 6-192	1-H-L	Max Tension w/ corresponding moment	1866	D + F + L + H' +E'	106	-150	D + F + L + H' +E'	88	7.6	-	-	-	
						Max Compression w/ corresponding moment	1868	D + F + L + H' +E'	-138	-64							
						Max Moment with axial tension	1865	D + F + L + H' +E'	27	-686							
						Max Moment with axial compression	1866	D + F + L + H' +E'	-1	-652							

Table 3H.6-11: Results of DGFOS Vault Concrete Design (Continued)

Location	Thickness (ft)	Face	Direction	Reinforcement Layout Drawing Number (1)	Reinforcement Zone Number (2)	Maximum Forces (3)	Element	Longitudinal Reinforcement Design Loads: Axial and Flexure Loads: Load Combination	Axial (4) (kips / ft)	Flexure (4) (ft-kips / ft)	In-Plane Shear Loads: Load Combination	In-plane Shear (5) (kips / ft)	Longitudinal Reinforcement Provided (in²/ ft)	Transverse Shear Design Loads: Load Combination	Transverse Shear (6) Reinforcement Design Loads (kips / ft)	Transverse Shear (7) Reinforcement Provided (in²/ft²)	Remarks
Wall 13	4	Far side	Vertical	3H 6-193	1-V-L	Max Tension w/ corresponding moment	1857	D + F + L + H +Wt	161	3	D + F + L + H' +E'	114	4.68	-	-	-	
						Max Compression w/ corresponding moment	1857	D + F + L + H' +E'	-260	13							
						Max Moment with corresponding axial tension	1922	D + F + L + H' +E'	1	310							
						Max Moment with corresponding axial compression	1922	D + F + L + H' +E'	-9	309							
			Horizontal Plane	3H 6-194	1-H-T		-	-	-	-	-	-	-	D + F + L + H' +E'	92	0.31 (#5 @12)	
			Vertical Plane	3H 6-194	1-V-T		-	-	-	-	-	-	-	D + F + L + H' +E'	125	0.62 (#5 @6)	
				3H 6-194	2-V-T		-	-	-	-	-	-	-	D + F + L + H' +E'	107	0.31 (#5 @12)	
				3H 6-194	3-V-T		-	-	-	-	-	-	-	D + F + L + H' +E'	90	0.31 (#5 @12)	
				3H 6-194	4-V-T		-	-	-	-	-	-	-	D + F + L + H' +E'	118	0.62 (#5 @6)	
Wall 14	2	Near Side	Horizontal	3H 6-195	1-H-L	Max Tension w/ corresponding moment	1652	D + F + L + H +Wt	96	-7	D + F + L + H +Wt	97	3.12	-	-	-	
						Max Compression w/ corresponding moment	1652	D + F + L + H' +E'	-311	-66							
						Max Moment with axial tension	1653	D + F + L + H' +E'	7	-77							
						Max Moment with axial compression	1652	D + F + L + H' +E'	-136	-90							
			Vertical	3H 6-196	1-V-L	Max Tension w/ corresponding moment	1640	D + F + L + H' +E'	114	16	D + F + L + H +Wt	97	3.12	-	-	-	
						Max Compression w/ corresponding moment	1659	D + F + L + H +Wt	-314	28							
						Max Moment with corresponding axial tension	1652	D + F + L + H' +E'	81	68							
						Max Moment with corresponding axial compression	1567	D + F + L + H +Wt	-103	71							
					2-V-L	Max Tension w/ corresponding moment	1498	D + F + L + H +Wt	241	-4	D + F + L + H +Wt	82	3.12	-	-	-	
						Max Compression w/ corresponding moment	1498	D + F + L + H +Wt	-231	-5							
						Max Moment with corresponding axial tension	1628	D + F + L + H +Wt	14	-105							
						Max Moment with corresponding axial compression	1508	D + F + L + H +Wt	-1	-82							
					3-V-L	Max Tension w/ corresponding moment	1496	D + F + L + H' +E'	229	-65	D + F + L + H +Wt	82	4.68	-	-	-	
						Max Compression w/ corresponding moment	1496	D + F + L + H' +E'	-283	-3							
						Max Moment with corresponding axial tension	1496	D + F + L + H' +E'	90	-73							
						Max Moment with corresponding axial compression	1496	D + F + L + H +Wt	-3	-79							
		Far side	Horizontal	3H 6-197	1-H-L	Max Tension w/ corresponding moment	1652	D + F + L + H +Wt	560	-15	D + F + L + H +Wt	47	6.24	-	-	-	
						Max Compression w/ corresponding moment	1652	D + F + L + H' +E'	-341	-6							
						Max Moment with axial tension	1640	D + F + L + H +Wt	42	-133							
						Max Moment with axial compression	1652	D + F + L + H' +E'	-62	-92							

Table 3H.6-11: Results of DGFOS Vault Concrete Design (Continued)

Location	Thickness (ft)	Face	Direction	Reinforcement Layout Drawing Number (1)	Reinforcement Zone Number (2)	Maximum Forces (3)	Element	Longitudinal Reinforcement Design Loads: Axial and Flexure Loads: Load Combination	Axial (4) (kips / ft)	Flexure (4) (ft-kips / ft)	In-Plane Shear Loads: Load Combination	In-plane (5) Shear (kips / ft)	Longitudinal Reinforcement Provided (in²/ ft)	Transverse Shear Design Loads: Load Combination	Transverse Shear (6) Reinforcement Design Loads (kips / ft)	Transverse Shear (7) Reinforcement Provided (in²/ft²)	Remarks
Wall 14	2	Far side	Vertical	3H 6-199	1-V-L	Max Tension w/ corresponding moment	1497	D + F + L + H +Wt	316	6	D + F + L + H +Wt	82	3.12	-	-	-	
						Max Compression w/ corresponding moment	1653	D + F + L + H +Wt	-340	15							
						Max Moment with corresponding axial tension	1504	D + F + L + H +Wt	15	72							
						Max Moment with corresponding axial compression	1640	D + F + L + H +Wt	-78	120							
					2-V-L	Max Tension w/ corresponding moment	1496	D + F + L + H +Wt	433	10	D + F + L + H +Wt	82	4.68	-	-	-	
						Max Compression w/ corresponding moment	1496	D + F + L + H +Wt	-442	101							
						Max Moment with corresponding axial tension	1496	D + F + L + H' +E'	8	70							
						Max Moment with corresponding axial compression	1496	D + F + L + H +Wt	-242	123							
					3-V-L	Max Tension w/ corresponding moment	1496	D + F + L + H +Wt	433	10	D + F + L + H +Wt	47	4.68	-	-	-	
						Max Compression w/ corresponding moment	1652	D + F + L + H +Wt	-504	104							
						Max Moment with corresponding axial tension	1652	D + F + L + H' +E'	12	86							
						Max Moment with corresponding axial compression	1652	D + F + L + H +Wt	-315	134							
		-	Horizontal Plane	3H 6-199	1-H-T		-	-	-	-	-	-	-	D + F + L + H +Wt	25	0.20 (#4 @12)	
Wall 15	2	Near Side	Horizontal	3H 6-200	1-H-L	Max Tension w/ corresponding moment	1784	D + F + L + H +Wt	138	-17	D + F + L + H +Wt	59	3.12	-	-	-	
						Max Compression w/ corresponding moment	1696	D + F + L + H +Wt	-178	-8							
						Max Moment with axial tension	1845	D + F + L + H' +E'	3	-95							
						Max Moment with axial compression	1689	D + F + L + H' +E'	-35	-107							
			Vertical	3H 6-201	1-V-L	Max Tension w/ corresponding moment	1711	D + F + L + H +Wt	32	7	D + F + L + H +Wt	59	1.56	-	-	-	
						Max Compression w/ corresponding moment	1697	D + F + L + H +Wt	-359	13							
						Max Moment with corresponding axial tension	1740	D + F + L' + H' +E'	2	46							
						Max Moment with corresponding axial compression	1796	D + F + L + H +Wt	-103	66							
					2-V-L	Max Tension w/ corresponding moment	1690	D + F + L + H +Wt	153	-24	D + F + L + H +Wt	81	3.12	-	-	-	
						Max Compression w/ corresponding moment	1846	D + F + L + H' +E'	-105	-11							
						Max Moment with corresponding axial tension	1690	D + F + L + H' +E'	3	-39							
						Max Moment with corresponding axial compression	1796	D + F + L + H' +E'	-11	-43							
					3-V-L	Max Tension w/ corresponding moment	1689	D + F + L + H +Wt	163	-36	D + F + L + H +Wt	81	4.68	-	-	-	
						Max Compression w/ corresponding moment	1689	D + F + L + H' +E'	-110	-3							
						Max Moment with corresponding axial tension	1689	D + F + L + H' +E'	75	-44							
						Max Moment with corresponding axial compression	1689	D + F + L + H' +E'	-24	-44							
		Far side	Horizontal	3H 6-202	1-H-L	Max Tension w/ corresponding moment	1845	D + F + L + H +Wt	154	-35	D + F + L + H +Wt	50	4.68	-	-	-	
						Max Compression w/ corresponding moment	1845	D + F + L + H' +E'	-112	-10							
						Max Moment with axial tension	1845	D + F + L + H' +E'	62	-42							
						Max Moment with axial compression	1845	D + F + L + H' +E'	-28	-42							
			Vertical	3H 6-203	1-V-L	Max Tension w/ corresponding moment	1689	D + F + L + H' +E'	103	6	D + F + L + H +Wt	81	3.12	-	-	-	
						Max Compression w/ corresponding moment	1689	D + F + L + H +Wt	-220	42							
						Max Moment with corresponding axial tension	1696	D + F + L + H +Wt	11	74							
						Max Moment with corresponding axial compression	1697	D + F + L + H +Wt	-2	71							

Table 3H.6-11: Results of DGFOS Vault Concrete Design (Continued)

Location	Thickness (ft)	Face	Direction	Reinforcement Layout Drawing Number (1)	Reinforcement Zone Number (2)	Maximum Forces (3)	Element	Longitudinal Reinforcement Design Loads: Axial and Flexure Loads: Load Combination	Axial (4) (kips / ft)	Flexure (4) (ft-kips / ft)	In-Plane Shear Loads: Load Combination	In-plane (5) Shear (kips / ft)	Longitudinal Reinforcement Provided (in²/ ft)	Transverse Shear Design Loads: Load Combination	Transverse Shear (6) Reinforcement Design Loads (kips / ft)	Transverse Shear (7) Reinforcement Provided (in²/ft²)	Remarks
Wall 10	2	Near Side	Horizontal	3H 6-204	1-H-L	Max Tension w/ corresponding moment	1447	D + F + L + H' +E'	31	-3	D + F + L + H +Wt	63	1.56	-	-	-	
						Max Compression w/ corresponding moment	1447	D + F + L + H +Wt	-104	-25							
						Max Moment with axial tension	1492	D + F + L + H +Wt	4	-30							
						Max Moment with axial compression	1478	D + F + L + H +Wt	-35	-29							
			Vertical	3H 6-205	1-V-L	Max Tension w/ corresponding moment	1447	D + F + L + H' +E'	-31	4	D + F + L + H +Wt	69	1.64	-	-	-	
						Max Compression w/ corresponding moment	1491	D + F + L + H +Wt	-362	87							
						Max Moment with corresponding axial tension	1489	D + F + L + H +Wt	6	31							
						Max Moment with corresponding axial compression	1478	D + F + L + H +Wt	-35	82							
		Far Side	Horizontal	3H 6-206	1-H-L	Max Tension w/ corresponding moment	1450	D + F + L + H +Wt	101	-15	D + F + L + H' +E'	15	1.56	-	-	-	
						Max Compression w/ corresponding moment	1447	D + F + L + H +Wt	-151	-76							
						Max Moment with axial tension	1455	D + F + L + H +Wt	5	-64							
						Max Moment with axial compression	1447	D + F + L + H +Wt	-70	-88							
			Vertical	3H 6-207	1-V-L	Max Tension w/ corresponding moment	1451	D + F + L + H +Wt	108	17	D + F + L + H' +E'	15	1.56	-	-	-	
						Max Compression w/ corresponding moment	1491	D + F + L + H +Wt	-143	8							
						Max Moment with corresponding axial tension	1454	D + F + L + H +Wt	-40	57							
						Max Moment with corresponding axial compression	1491	D + F + L + H +Wt	-40	68							
		-	Horizontal Plane	3H 6-208	1-H-T		-	-	-	-	-	-	-	-	-	0.62 (#5 @6)	Transverse shear reinforcement provided due to tornado missile impact evaluation
				3H 6-208	2-H-T		-	-	-	-	-	-	-	-	-	0.62 (#5 @6)	

Notes:

(1) The reinforcement layout drawings show the various zones used to define the minimum reinforcement that will be provided based on finite element analysis results. Actual provided reinforcement based on final rebar layout may exceed the reported provided reinforcement and the zones with higher reinforcement may be extended beyond their reported boundaries.

(2) Each reinforcement layout drawing is divided into reinforcement zones. The reinforcement zone naming convention is as follows: "H" = horizontal, "V" = vertical, "L" = longitudinal reinforcement, "T" = transverse reinforcement.

(3) The maximum tension and compression axial forces are provided with the corresponding moment from the same load combination. The maximum moment that has a corresponding tension in the same load combination and the maximum moment that has a corresponding compression in the same load combination are also provided. For zones where either axial tension or axial compression does not occur for any load combination, dashes are input into the corresponding cell.

(4) Negative axial load is compression and positive axial load is tension. Negative moment applies tension to the top face of the shell element and positive moment applies tension to the bottom face of the shell element. For walls or slabs where the same reinforcement is provided on both faces, the moment is shown as absolute value.

(5) The reported in-plane shear is the maximum average in-plane shear along a plane that crosses the longitudinal reinforcement zone.

(6) The reported transverse shear is the maximum average transverse shear along a plane in that transverse reinforcement zone.

(7) In areas where horizontal and vertical transverse shear zones overlap, the total transverse shear reinforcement to be supplied in the overlapping area is the sum of the transverse reinforcement required from the horizontal and vertical zones.

(8) For certain areas of the structure, the standard element post-processing methods were too conservative. For such cases, detailed manual design was performed and the design forces determined by the detailed manual design are provided in the table.

Table 3H.6-12: Factors of Safety Against Sliding, Overturning, and Flotation for Diesel Generator Fuel Oil Storage Vaults

Load Combination	Calculated Safety Factor			Notes
	Overturning	Sliding	Flotation	
D + F'	---	---	1.28	2,3
D + H + W	73.3	63.1	---	
D + H + Wt	32.5	27.3	---	
D + H + E'	1.1	1.1	---	3,4

Notes:

1) Loads D, H, W, Wt, and E` are defined in Subsection 3H.6.4.3.4.1. F` is the buoyant force corresponding to the design basis flood.

2) Reported safety factors are conservatively based on considering empty weight of the fuel oil tank.

3) Coefficients of friction for sliding resistance are 0.58 for static conditions and 0.39 for dynamic conditions for the Diesel Generator Fuel Oil Storage Vault.

4) The calculated safety factors consider less than half of the full passive pressure. The calculated saftey factors increase if full passive pressure (Kp = 3.0) is considered.

Table 3H.6-13: Tornado Missile Impact Evaluation for Diesel Generator Fuel Oil Storage Vault

Local Check	**DGFOS Vault**	Minimum required thickness to prevent pentration, perforation, and scabbing = 13.6" Minimum provided thickness = 18"
Overall Check of Impacted Element	**Roof**	Flexure controls. Maximum impact load including Dynamic Load Factor (DLF) = 432 kips Ductility demand = 0.5 < Ductility limit = 10
	Protection Hood	Flexure controls. Maximum impact load including Dynamic Load Factor (DLF) = 432 kips Ductility demand = 5 < Ductility limit = 10
	Walls	Flexure controls. Maximum impact load including Dynamic Load Factor (DLF) = 938 kips Ductility demand = 0.7 < Ductility limit = 10
	Entry Way Wall	Shear controls. Maximum impact load including Dynamic Load Factor (DLF) = 617 kips Minimum capacity = 929 kips Shear ties are required locally to withstand a missile strike near the top and bottom panel supports. See Table 3H.6-11 and Figure 3H.6-208 for reinforcement size and location.
Global Check		Equivalent static impact forces are applied to the FEM analysis of the DGFOS Vault. The analysis results presented in Table 3H.6-11 provide a summary of the results for all load combinations including those affected by the tornado missile impact.

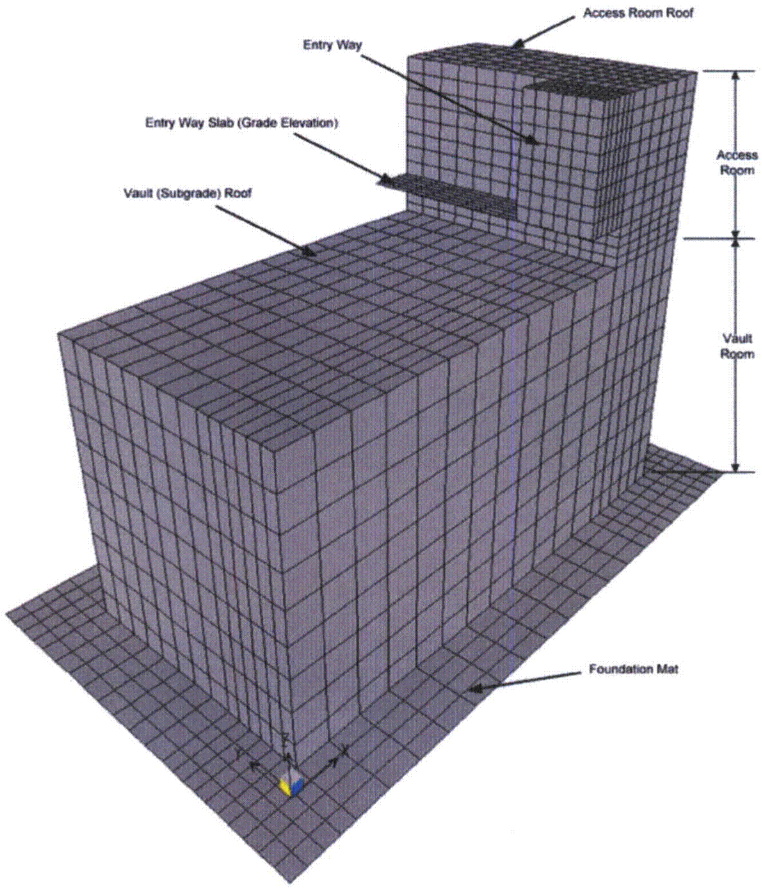


FIGURE 3H.6-140: DGFOSV SAP2000 Model

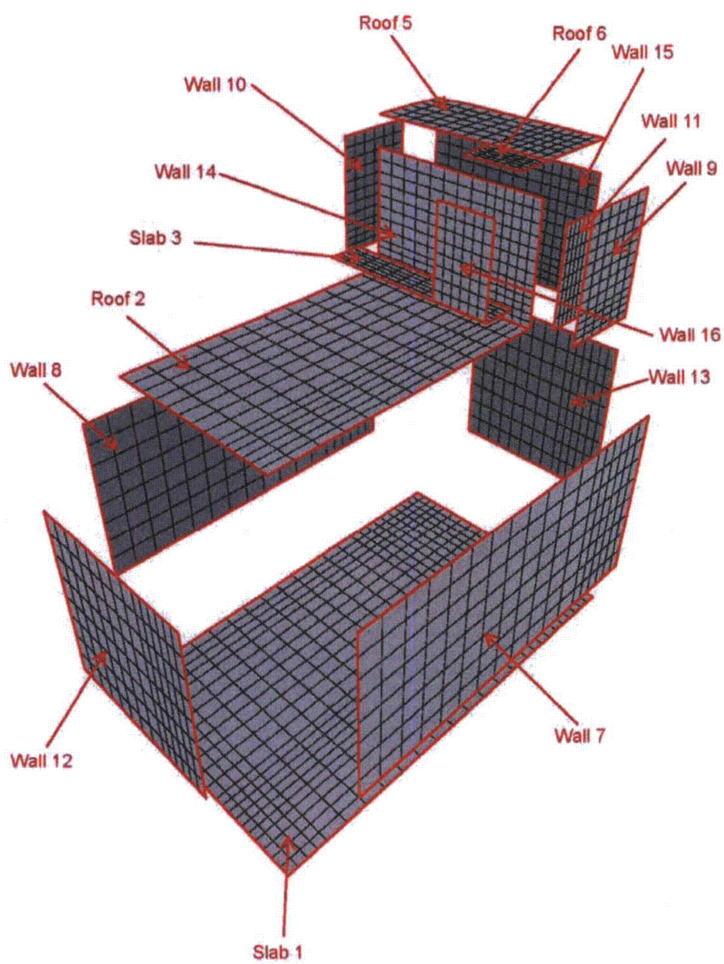


FIGURE 3H.6-141: DGFOSV Wall and Slab Labeling Convention

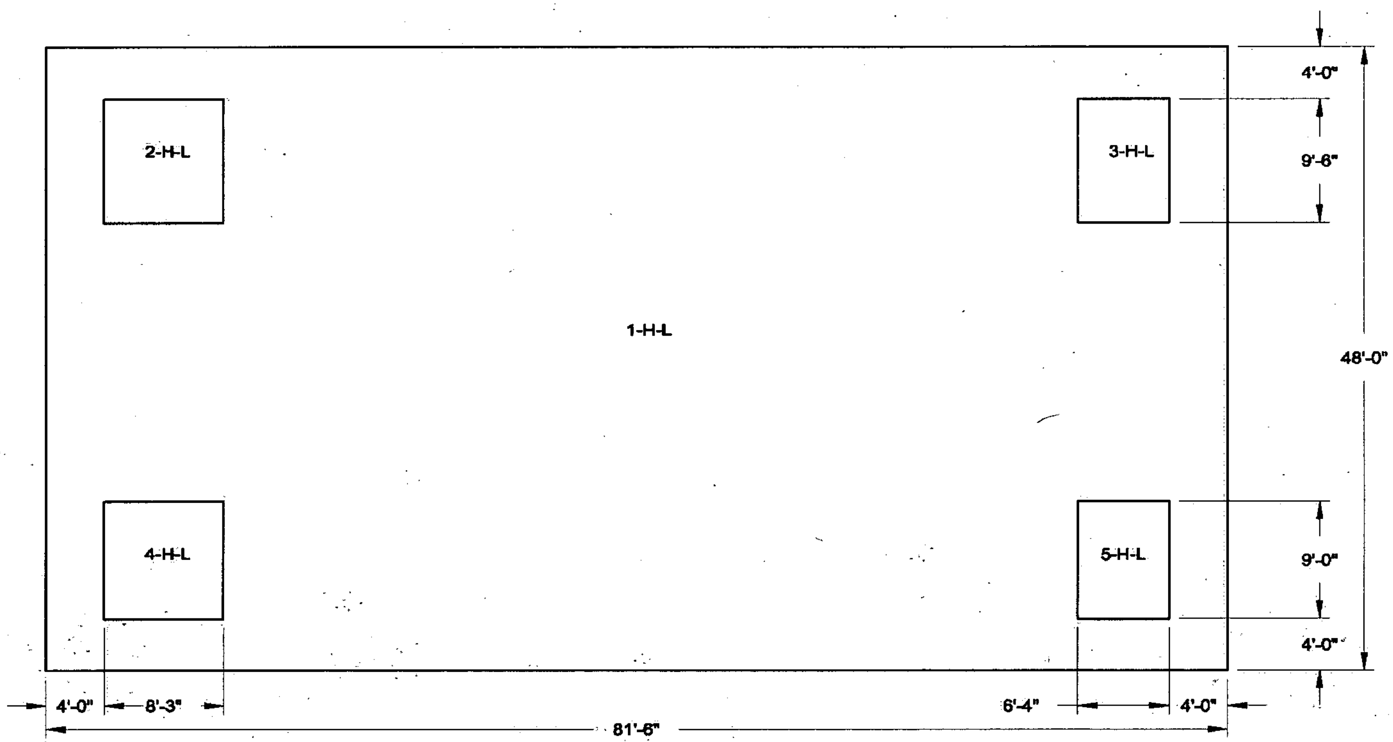


FIGURE 3H.6-142: SLAB 1 LOOKING DOWN
HORIZONTAL REINFORCEMENT ZONES
NEAR SIDE FACE

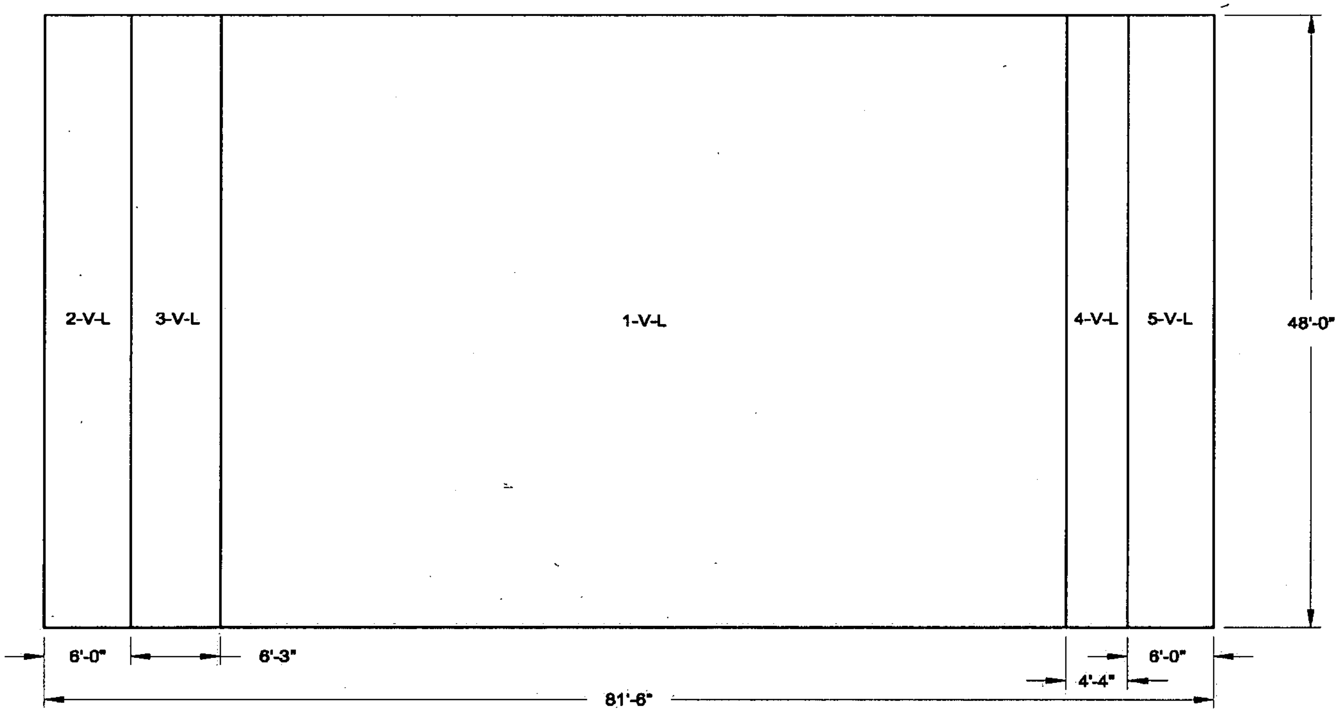


FIGURE 3H.6-143: SLAB 1 LOOKING DOWN
VERTICAL REINFORCEMENT ZONES
NEAR SIDE FACE

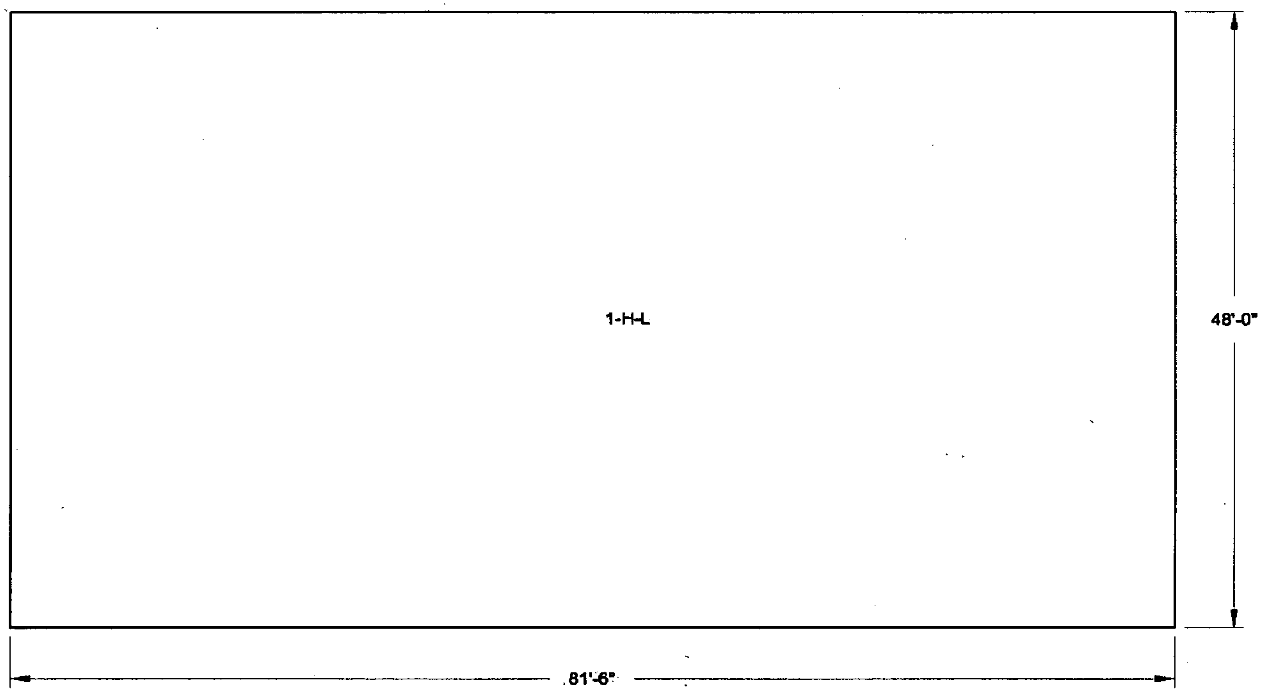


FIGURE 3H.6-144: SLAB 1 LOOKING DOWN
HORIZONTAL REINFORCEMENT ZONES
FAR SIDE FACE

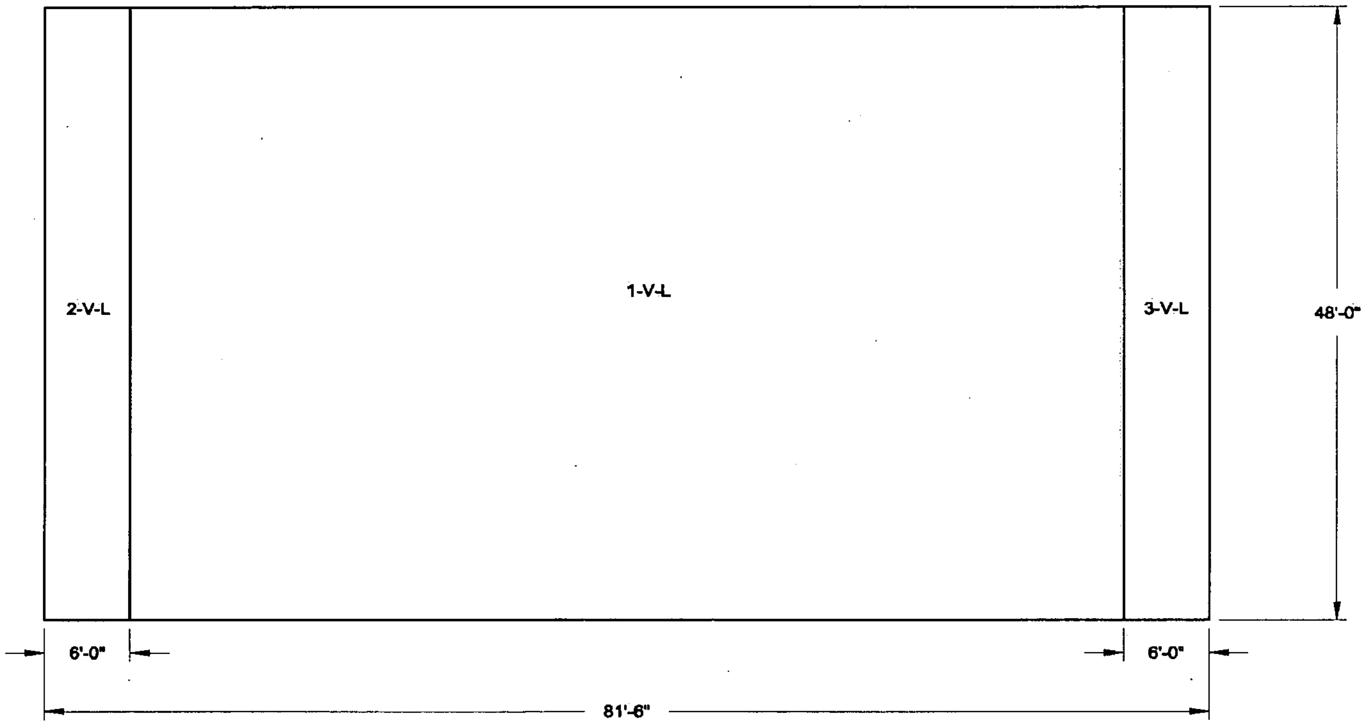


FIGURE 3H.6-145: SLAB 1 LOOKING DOWN
VERTICAL REINFORCEMENT ZONES
FAR SIDE FACE

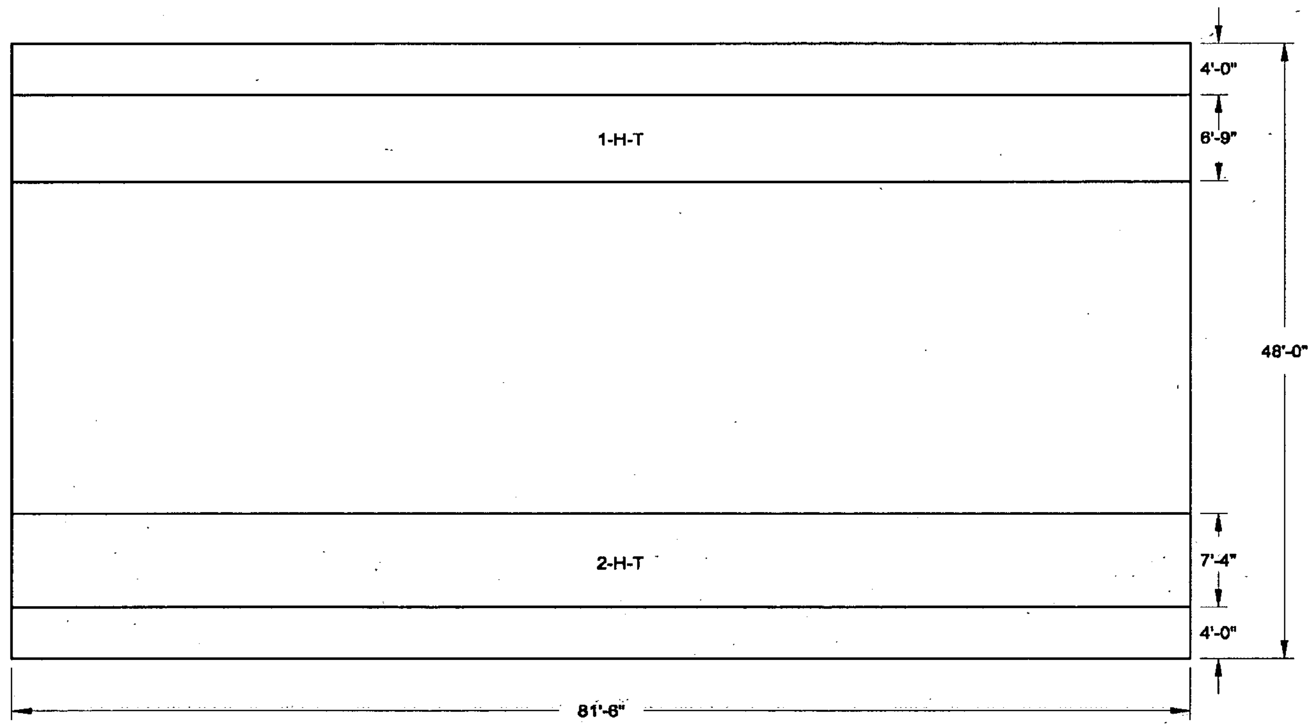


FIGURE 3H.6-146: SLAB 1 LOOKING DOWN
TRANSVERSE REINFORCEMENT ZONES

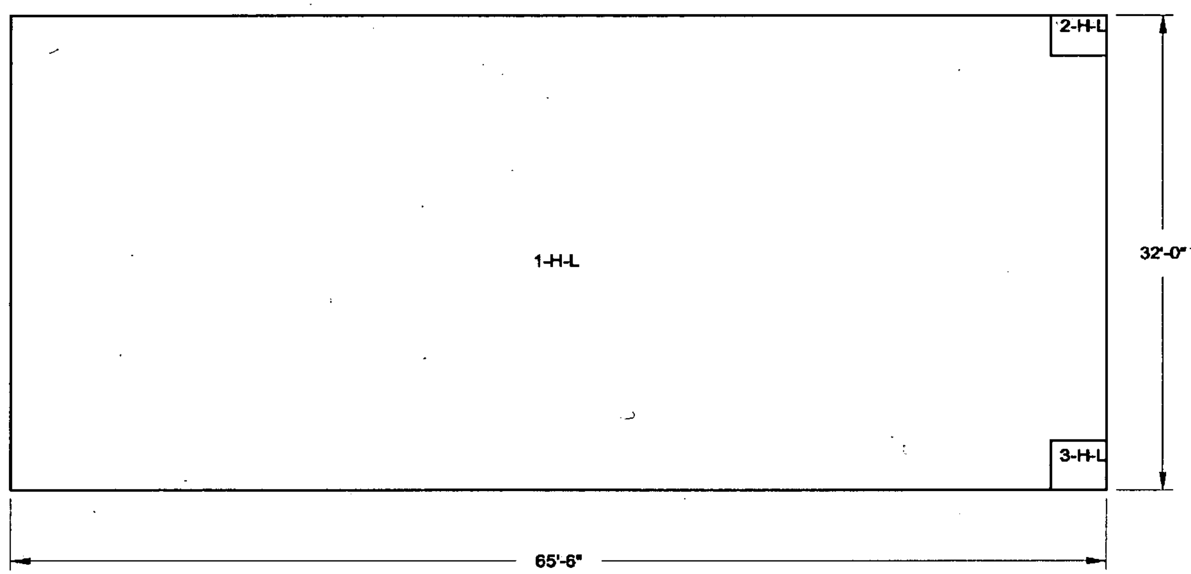


FIGURE 3H.6-147: ROOF 2 LOOKING DOWN
HORIZONTAL REINFORCEMENT ZONES
NEAR SIDE FACE

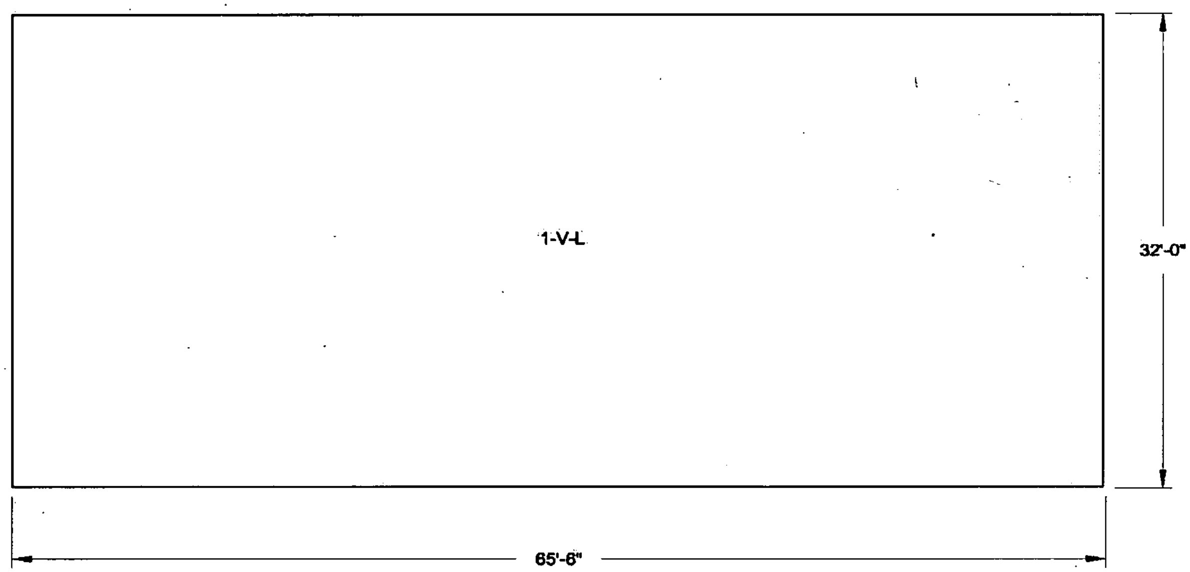


FIGURE 3H.6-148: ROOF 2 LOOKING DOWN
VERTICAL REINFORCEMENT ZONES
NEAR SIDE FACE

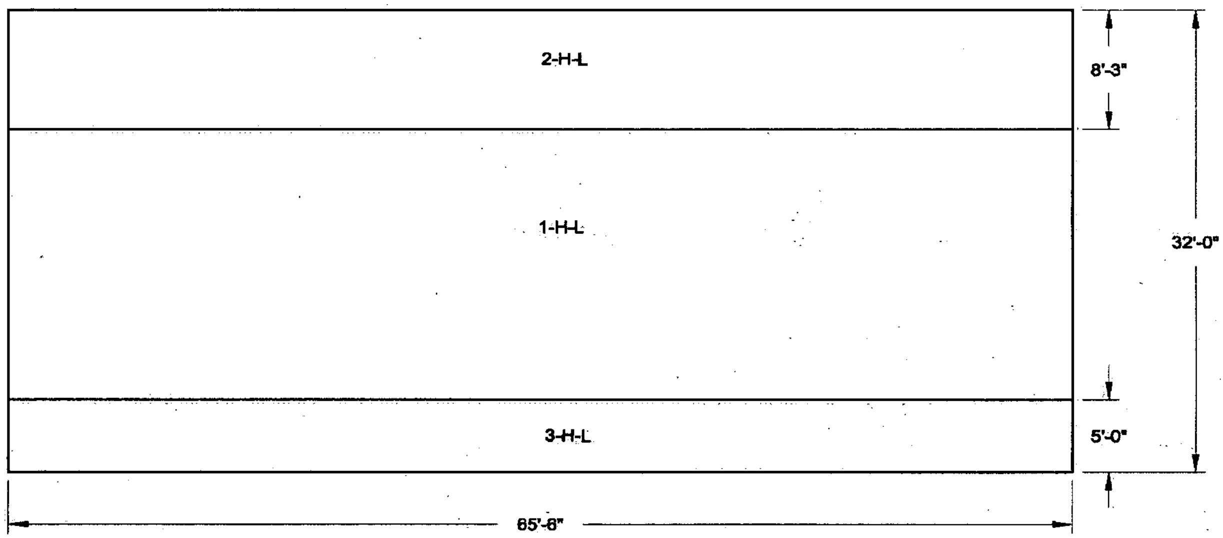


FIGURE 3H.6-149: ROOF 2 LOOKING DOWN
HORIZONTAL REINFORCEMENT ZONES
FAR SIDE FACE

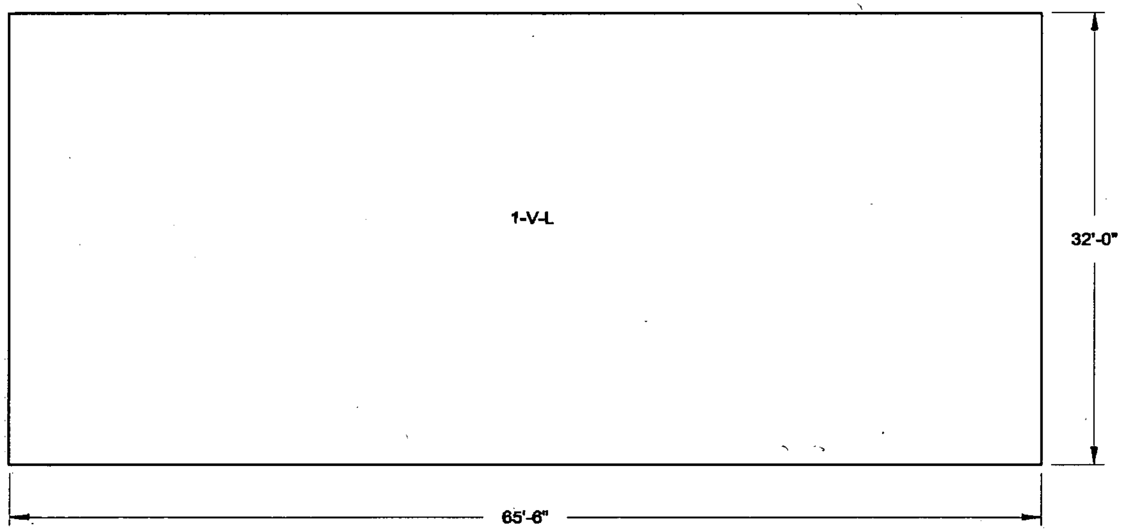


FIGURE 3H.6-150: ROOF 2 LOOKING DOWN
VERTICAL REINFORCEMENT ZONES
FAR SIDE FACE

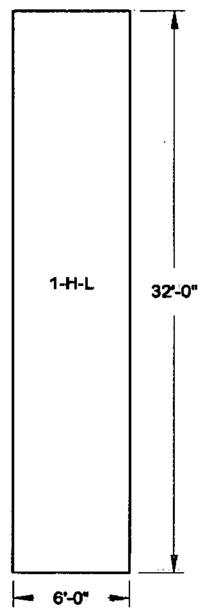


FIGURE 3H.6-151: SLAB 3 LOOKING DOWN
HORIZONTAL REINFORCEMENT ZONES
NEAR SIDE FACE

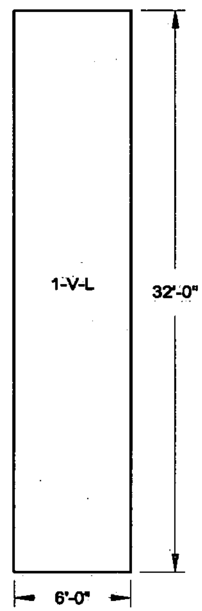


FIGURE 3H.6-152: SLAB 3 LOOKING DOWN
VERTICAL REINFORCEMENT ZONES
NEAR SIDE FACE

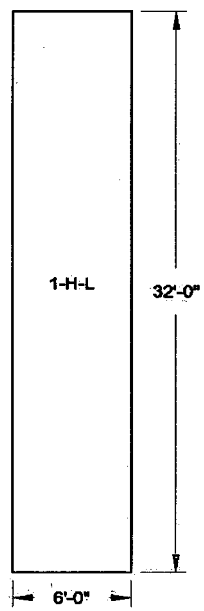


FIGURE 3H.6-153: SLAB 3 LOOKING DOWN
HORIZONTAL REINFORCEMENT ZONES
FAR SIDE FACE

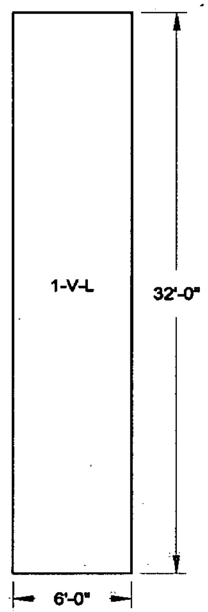


FIGURE 3H.6-154: SLAB 3 LOOKING DOWN
VERTICAL REINFORCEMENT ZONES
FAR SIDE FACE

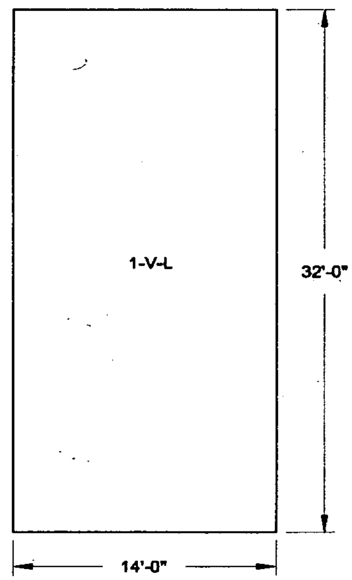


FIGURE 3H.6-156: ROOF 5 LOOKING DOWN
VERTICAL REINFORCEMENT ZONES
NEAR SIDE FACE

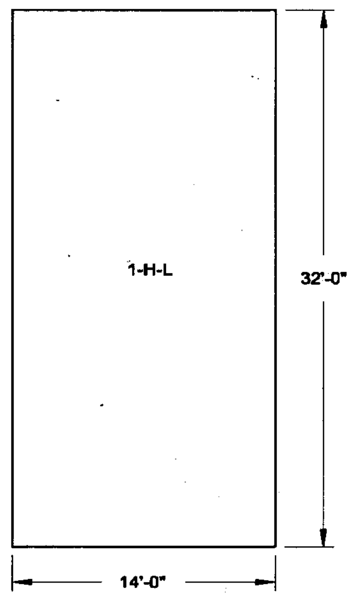


FIGURE 3H.6-157: ROOF 5 LOOKING DOWN
HORIZONTAL REINFORCEMENT ZONES
FAR SIDE FACE

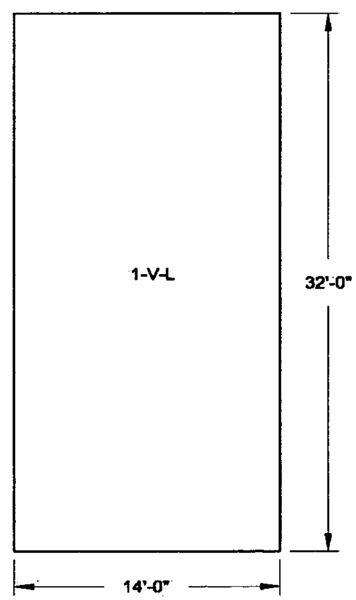


FIGURE 3H.6-158: ROOF 5 LOOKING DOWN
VERTICAL REINFORCEMENT ZONES
FAR SIDE FACE

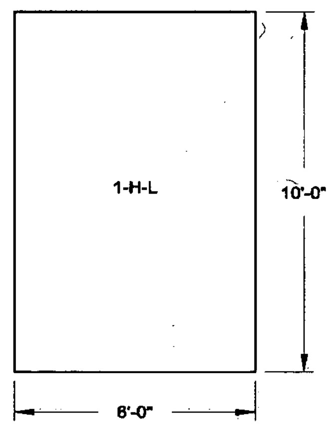


FIGURE 3H.6-159: ROOF 6 LOOKING DOWN
HORIZONTAL REINFORCEMENT ZONES
NEAR SIDE FACE

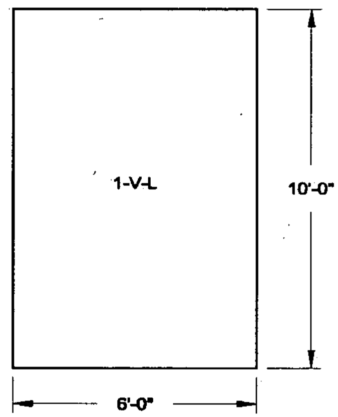


FIGURE 3H.6-160: ROOF 6 LOOKING DOWN
VERTICAL REINFORCEMENT ZONES
NEAR SIDE FACE

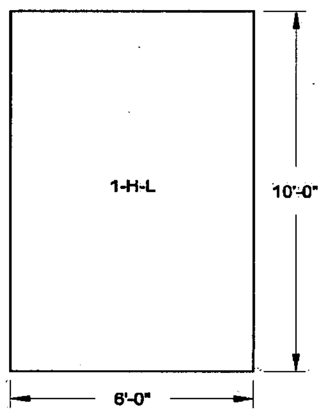


FIGURE 3H.6-161: ROOF 6 LOOKING DOWN
HORIZONTAL REINFORCEMENT ZONES
FAR SIDE FACE

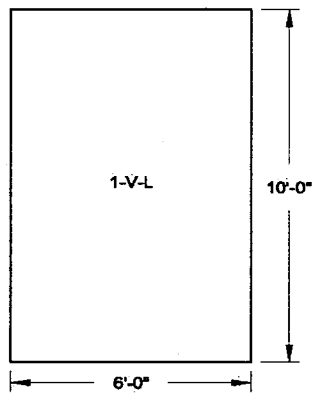


FIGURE 3H.6-162: ROOF 6 LOOKING DOWN
VERTICAL REINFORCEMENT ZONES
FAR SIDE FACE

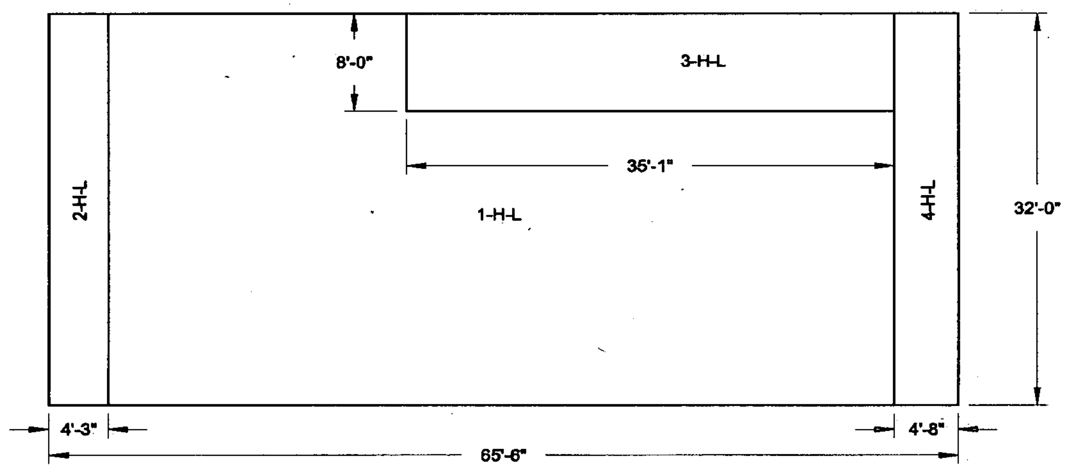


FIGURE 3H.6-163: WALL 7 LOOKING FROM OUTSIDE
HORIZONTAL REINFORCEMENT ZONES
NEAR SIDE FACE

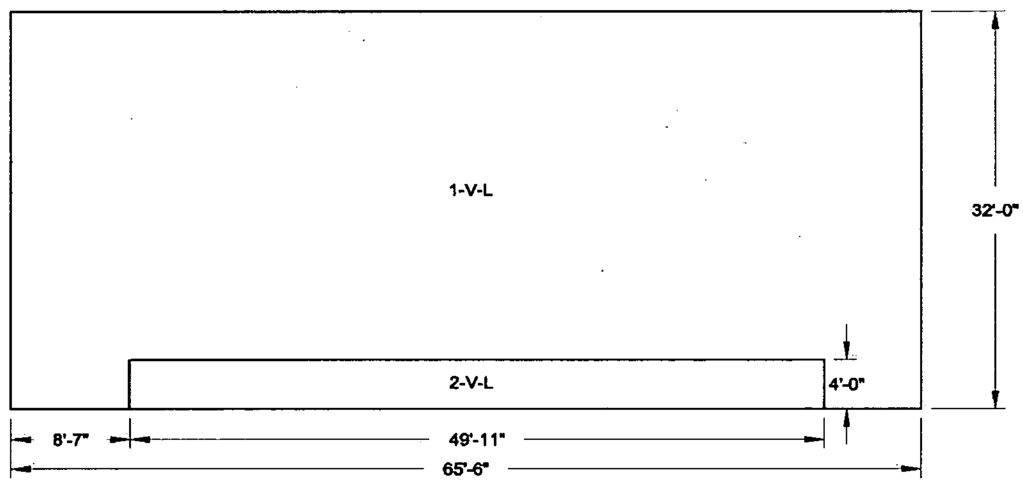


FIGURE 3H.6-184: WALL 7 LOOKING FROM OUTSIDE
VERTICAL REINFORCEMENT ZONES
NEAR SIDE FACE

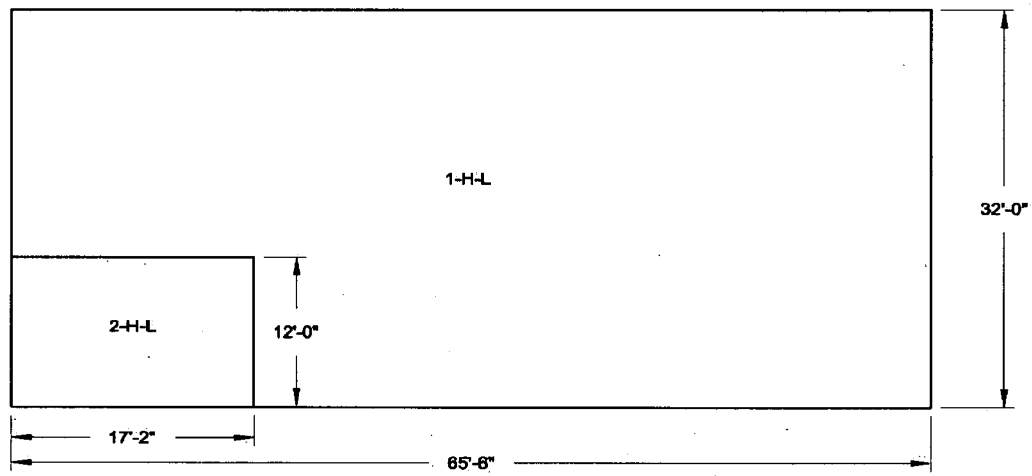


FIGURE 3H.6-165: WALL 7 LOOKING FROM OUTSIDE
HORIZONTAL REINFORCEMENT ZONES
FAR SIDE FACE

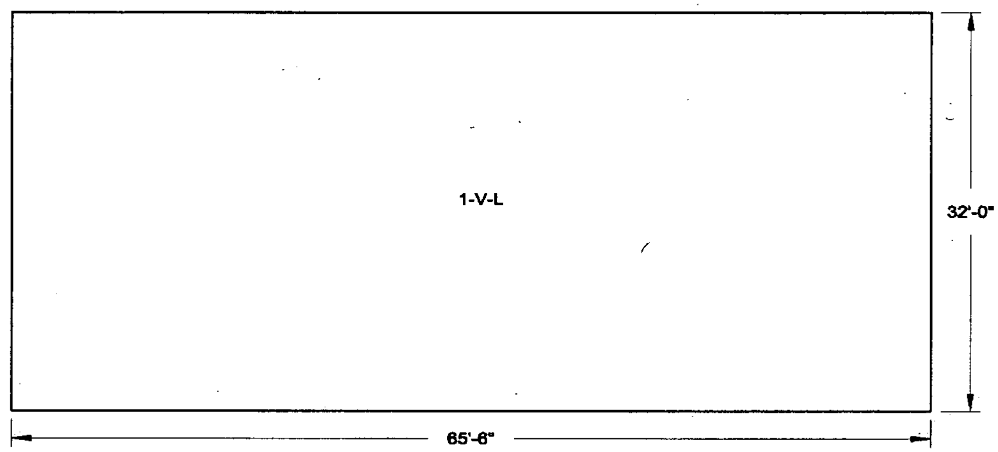


FIGURE 3H.6-166: WALL 7 LOOKING FROM OUTSIDE
VERTICAL REINFORCEMENT ZONES
FAR SIDE FACE

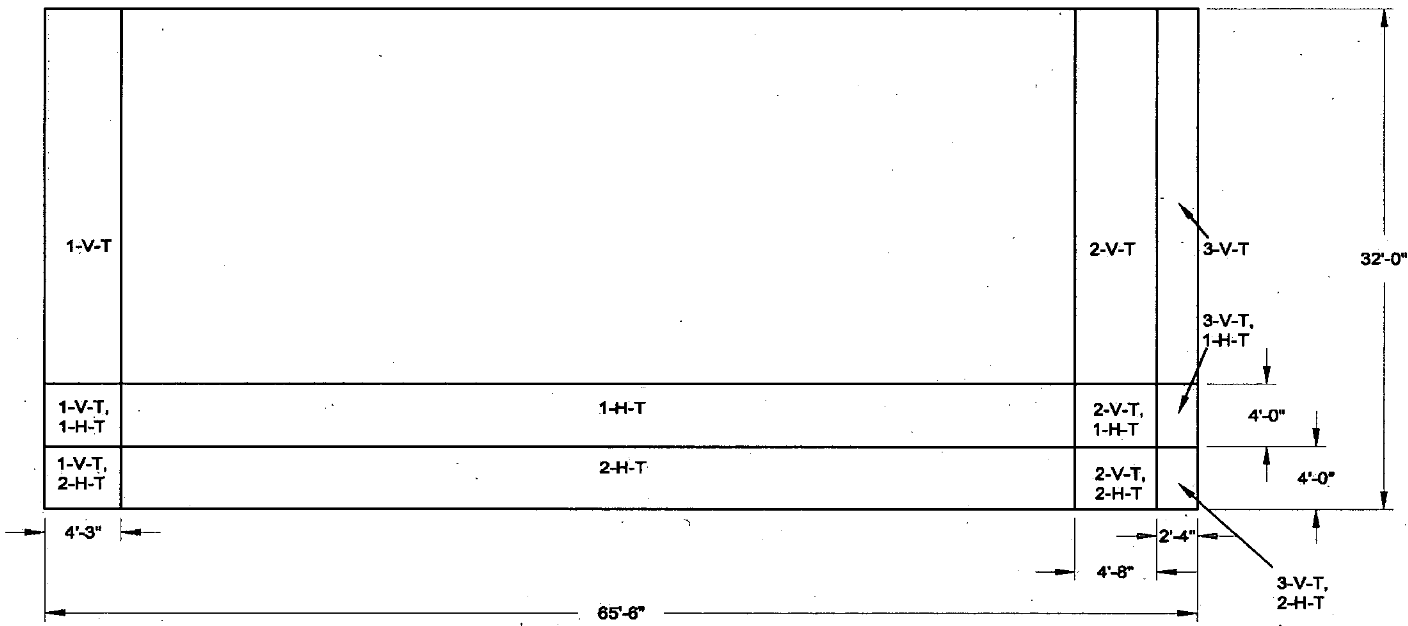


FIGURE 3H.6-167: WALL 7 LOOKING FROM OUTSIDE
TRANSVERSE REINFORCEMENT ZONES

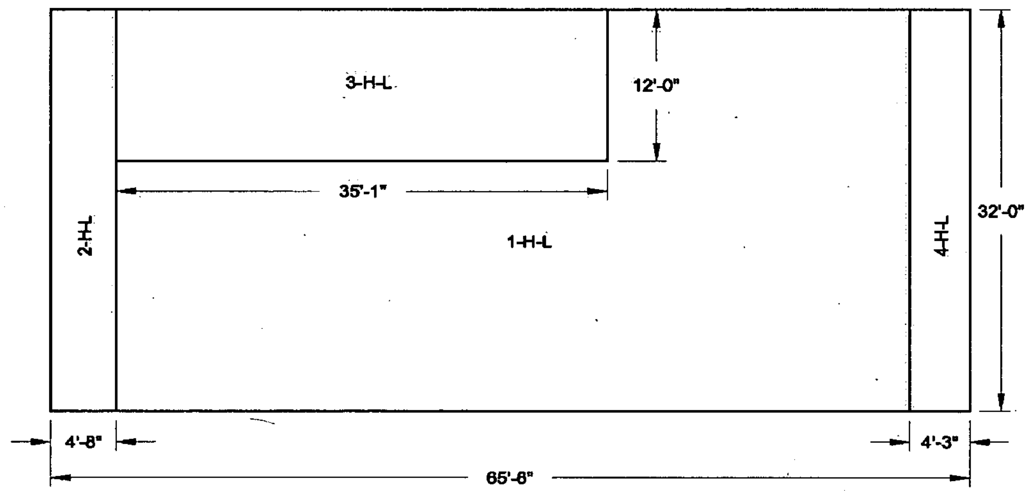


FIGURE 3H.6-168: WALL 8 LOOKING FROM OUTSIDE
HORIZONTAL REINFORCEMENT ZONES
NEAR SIDE FACE

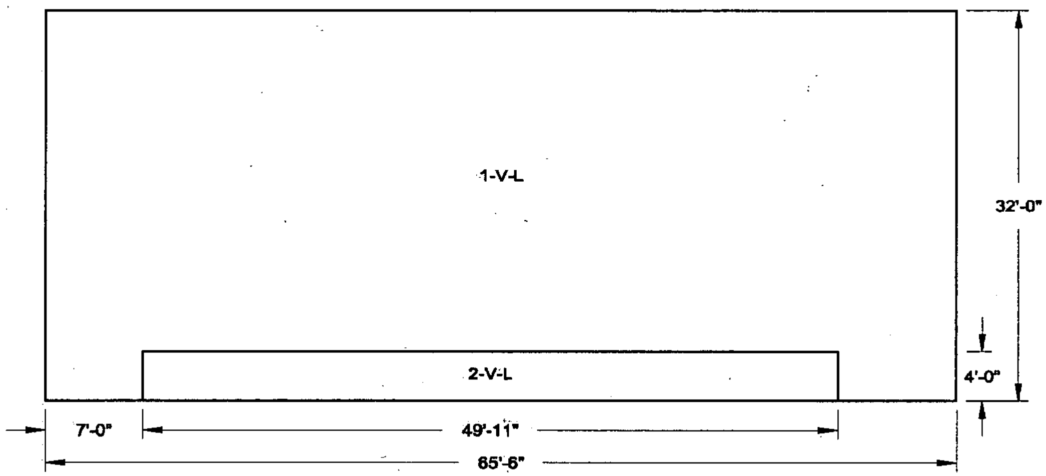


FIGURE 3H.6-169: WALL 8 LOOKING FROM OUTSIDE
VERTICAL REINFORCEMENT ZONES
NEAR SIDE FACE

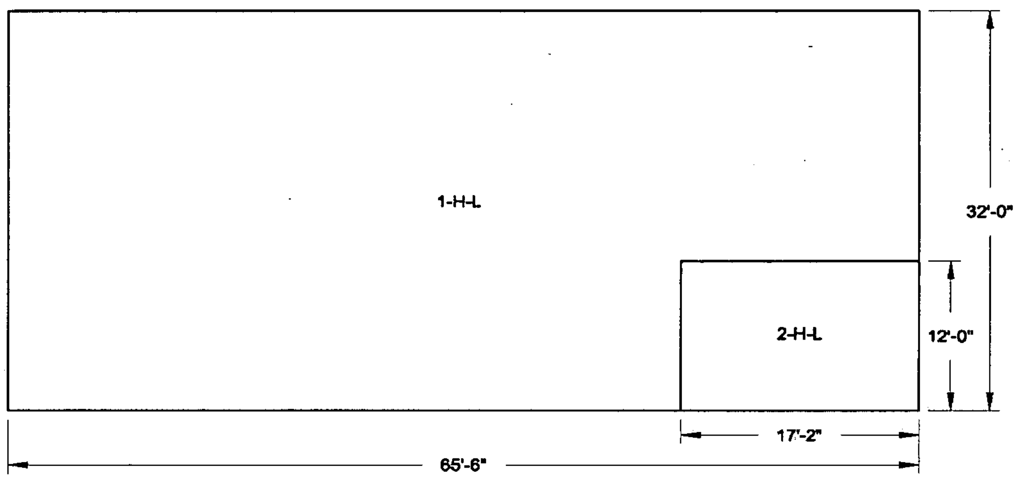


FIGURE 3H.6-170: WALL 8 LOOKING FROM OUTSIDE
HORIZONTAL REINFORCEMENT ZONES
FAR SIDE FACE

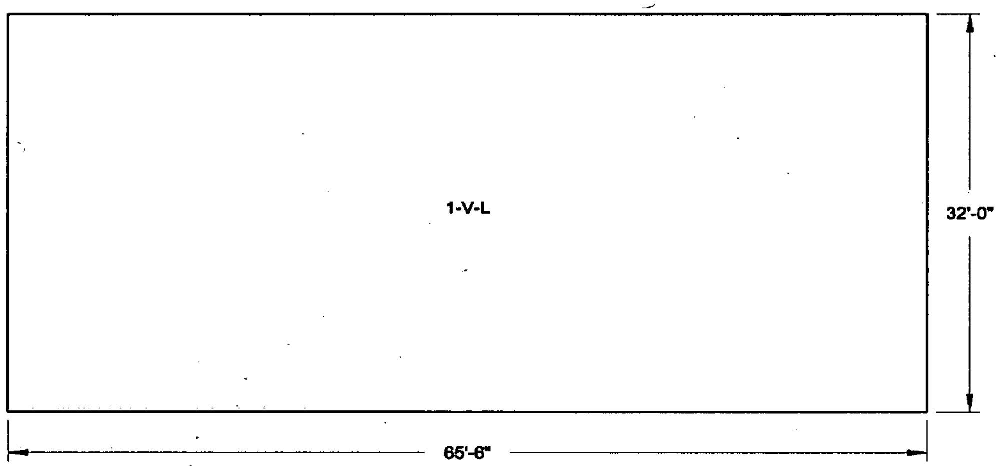


FIGURE 3H.6-171: WALL 8 LOOKING FROM OUTSIDE
VERTICAL REINFORCEMENT ZONES
FAR SIDE FACE

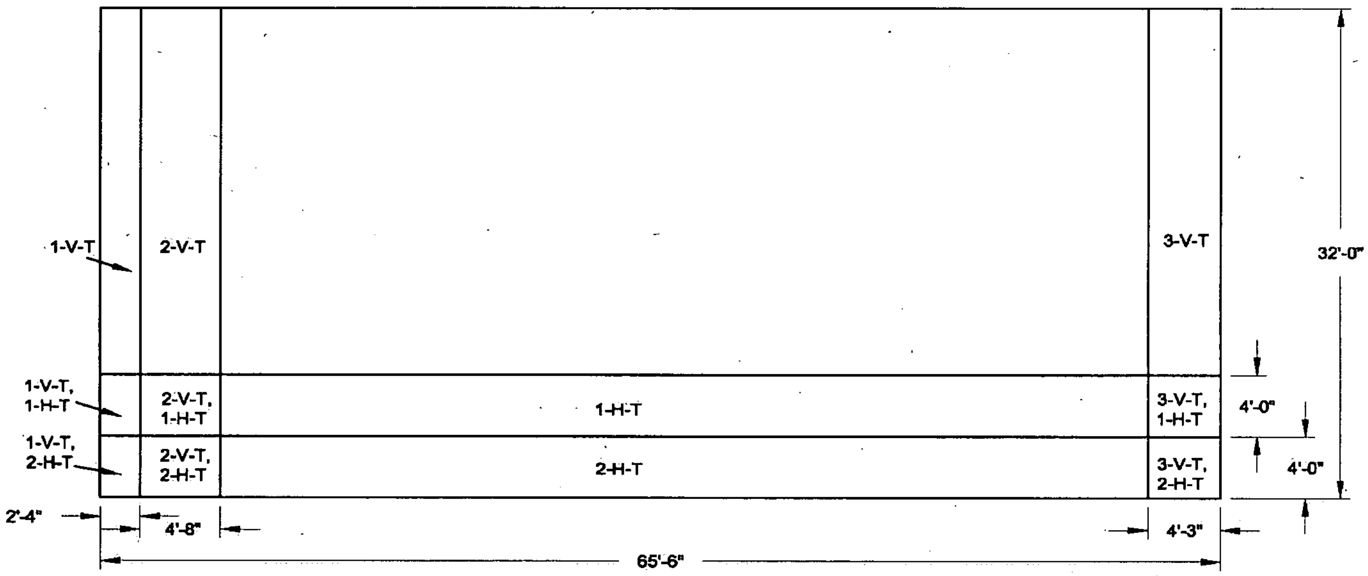


FIGURE 3H.6-172: WALL 8 LOOKING FROM OUTSIDE
TRANSVERSE REINFORCEMENT ZONES

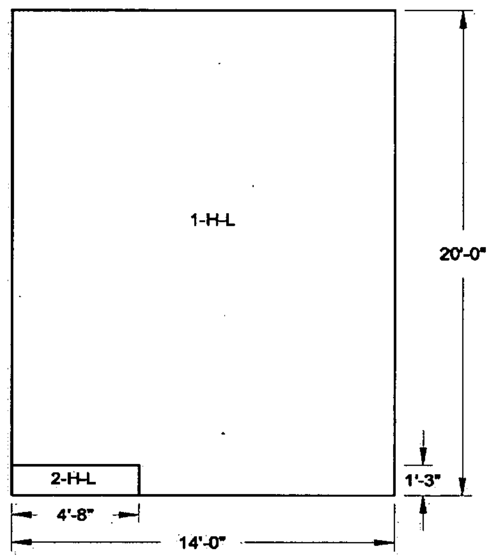


FIGURE 3H.6-173: WALL 9 LOOKING FROM OUTSIDE
HORIZONTAL REINFORCEMENT ZONES
NEAR SIDE FACE

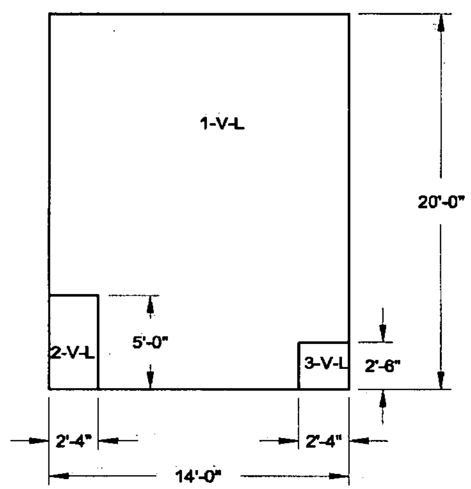


FIGURE 3H.6-174: WALL 9 LOOKING FROM OUTSIDE
VERTICAL REINFORCEMENT ZONES
NEAR SIDE FACE

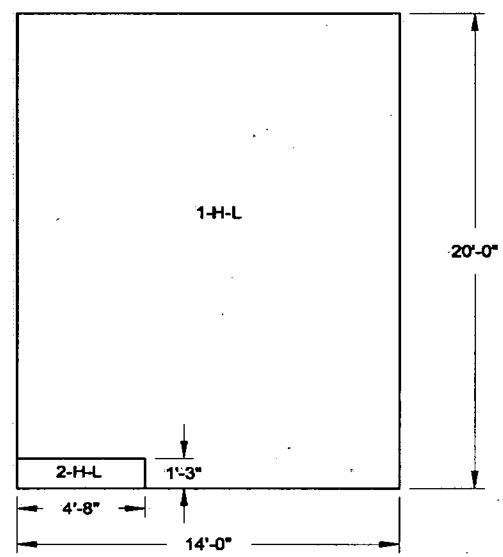


FIGURE 3H.6-175: WALL 9 LOOKING FROM OUTSIDE
HORIZONTAL REINFORCEMENT ZONES
FAR SIDE FACE

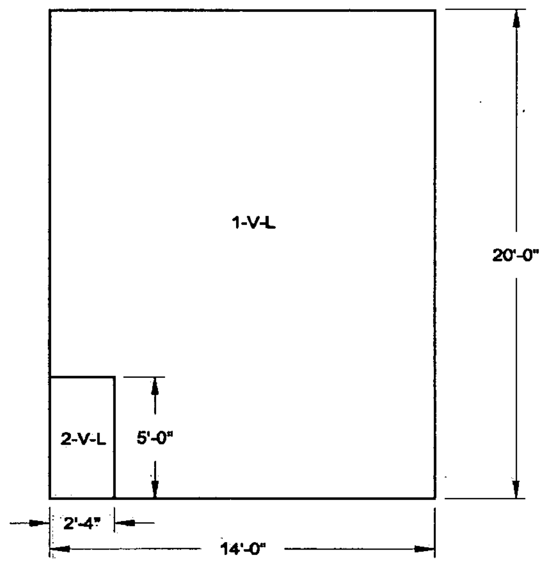


FIGURE 3H.6-176: WALL 9 LOOKING FROM OUTSIDE
VERTICAL REINFORCEMENT ZONES
FAR SIDE FACE

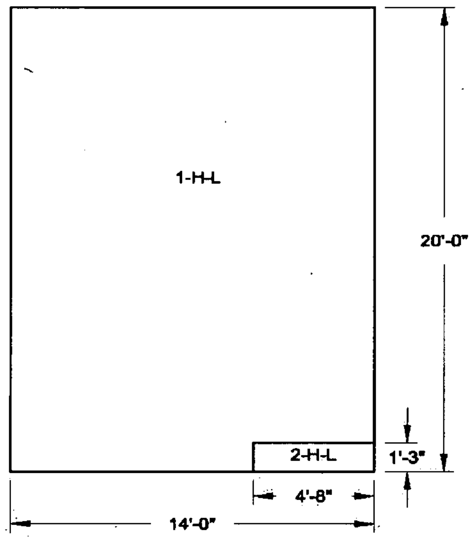


FIGURE 3H.6-177: WALL 10 LOOKING FROM OUTSIDE
HORIZONTAL REINFORCEMENT ZONES
NEAR SIDE FACE

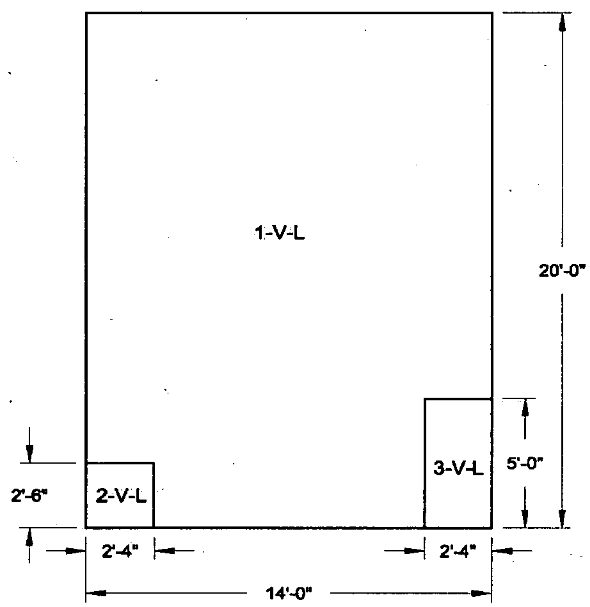


FIGURE 3H.6-178: WALL 10 LOOKING FROM OUTSIDE
VERTICAL REINFORCEMENT ZONES
NEAR SIDE FACE

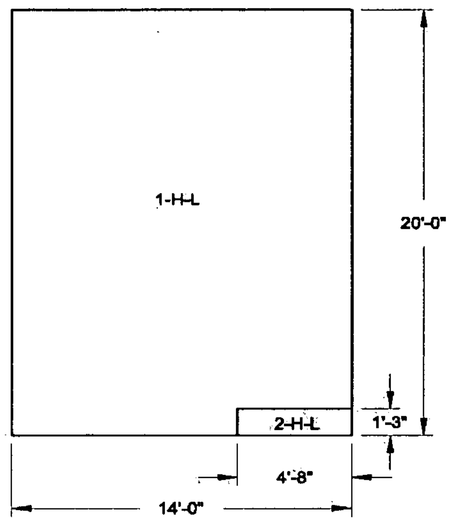


FIGURE 3H.6-179: WALL 10 LOOKING FROM OUTSIDE
HORIZONTAL REINFORCEMENT ZONES
FAR SIDE FACE

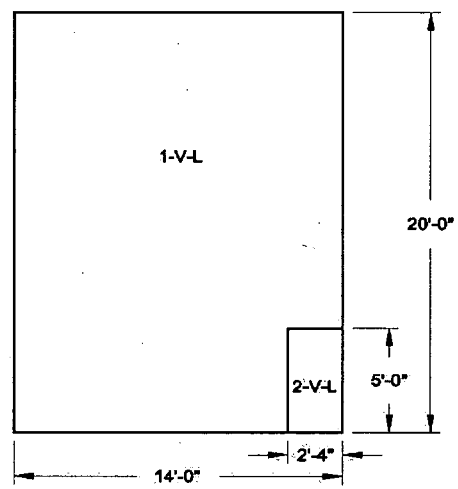


FIGURE 3H.6-180: WALL 10 LOOKING FROM OUTSIDE
VERTICAL REINFORCEMENT ZONES
FAR SIDE FACE

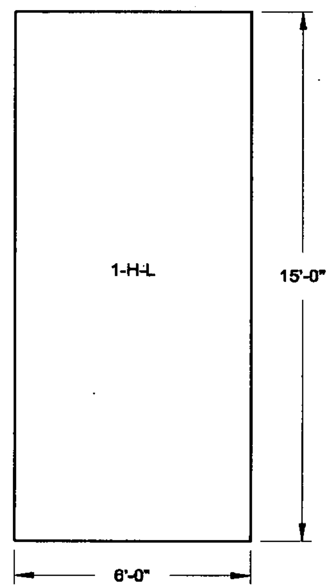


FIGURE 3H.6-181: WALL 11 LOOKING FROM OUTSIDE
HORIZONTAL REINFORCEMENT ZONES
NEAR SIDE FACE

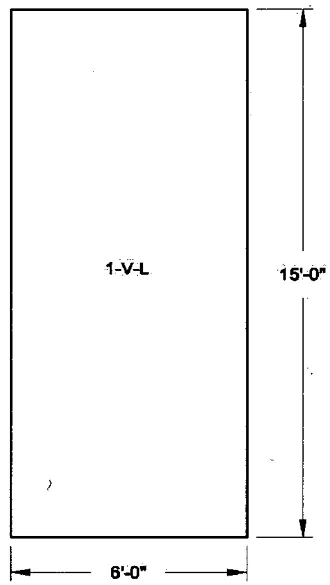


FIGURE 3H.6-182: WALL 11 LOOKING FROM OUTSIDE
VERTICAL REINFORCEMENT ZONES
NEAR SIDE FACE

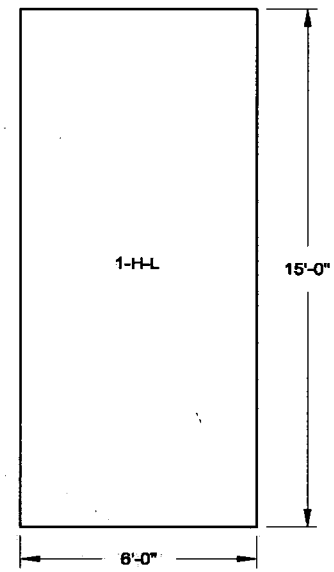


FIGURE 3H.6-183: WALL 11 LOOKING FROM OUTSIDE
HORIZONTAL REINFORCEMENT ZONES
FAR SIDE FACE

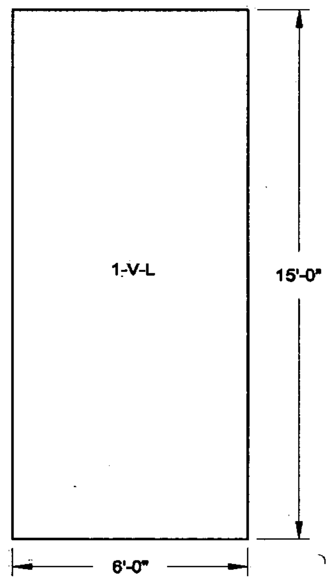


FIGURE 3H.6-184: WALL 11 LOOKING FROM OUTSIDE
VERTICAL REINFORCEMENT ZONES
FAR SIDE FACE

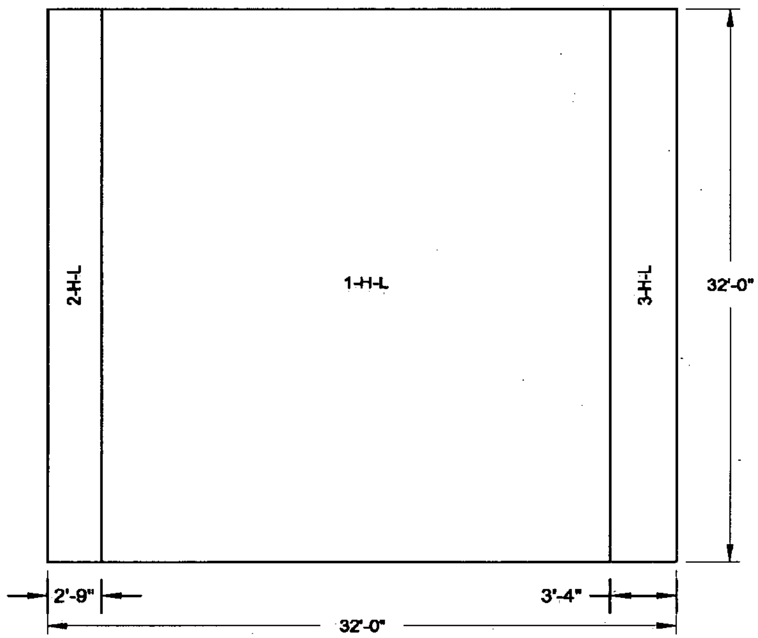


FIGURE 3H.6-185: WALL 12 LOOKING FROM OUTSIDE
HORIZONTAL REINFORCEMENT ZONES
NEAR SIDE FACE

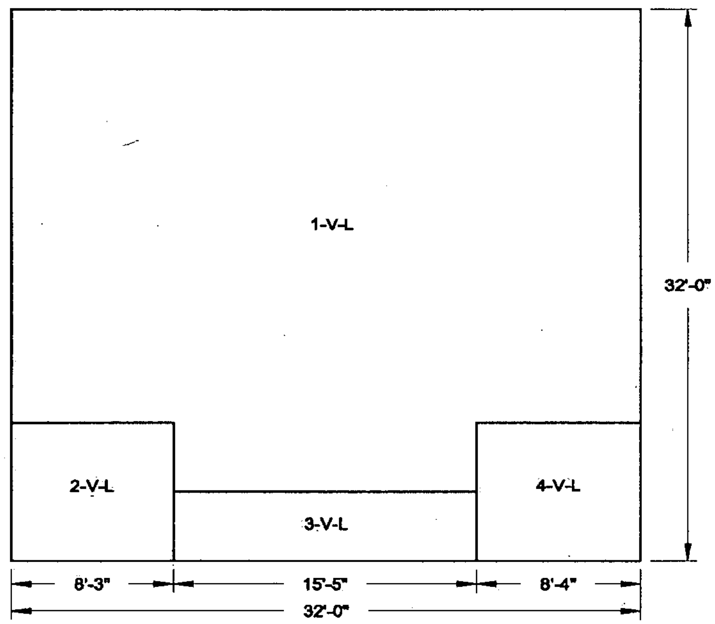


FIGURE 3H.6-186: WALL 12 LOOKING FROM OUTSIDE
VERTICAL REINFORCEMENT ZONES
NEAR SIDE FACE

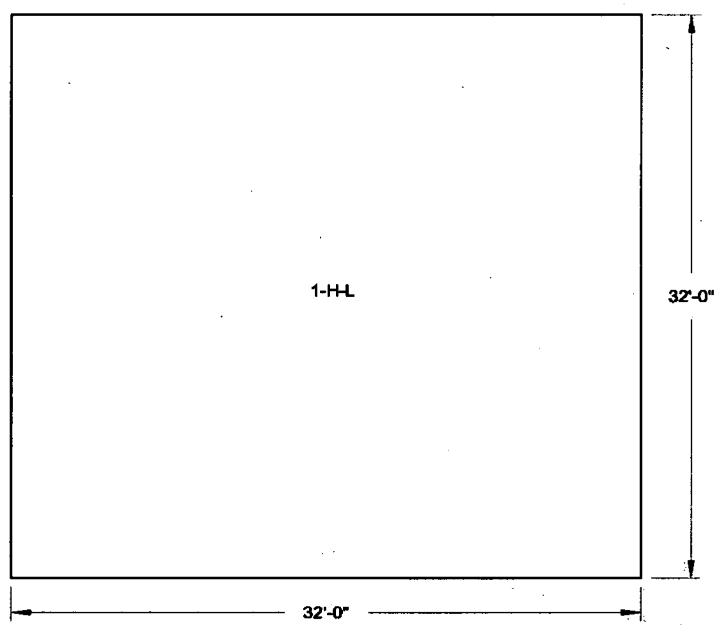


FIGURE 3H.6-187: WALL 12 LOOKING FROM OUTSIDE
HORIZONTAL REINFORCEMENT ZONES
FAR SIDE FACE

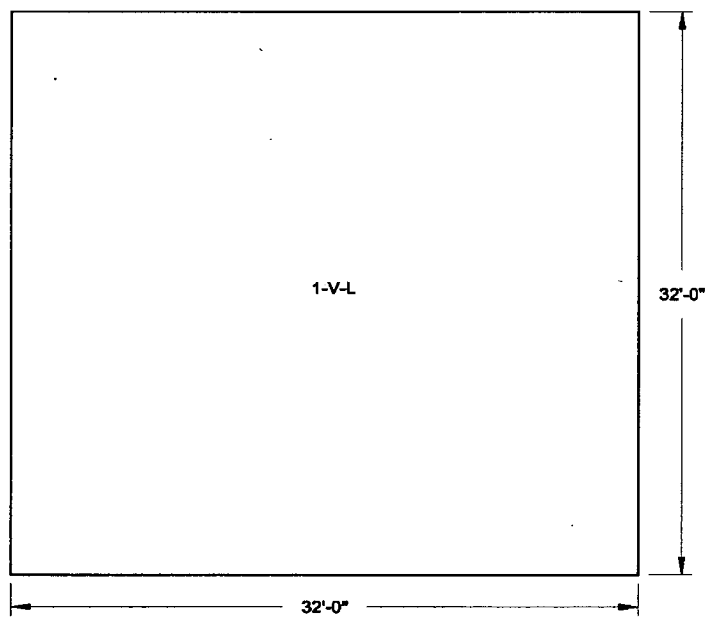


FIGURE 3H.6-188: WALL 12 LOOKING FROM OUTSIDE
VERTICAL REINFORCEMENT ZONES
FAR SIDE FACE

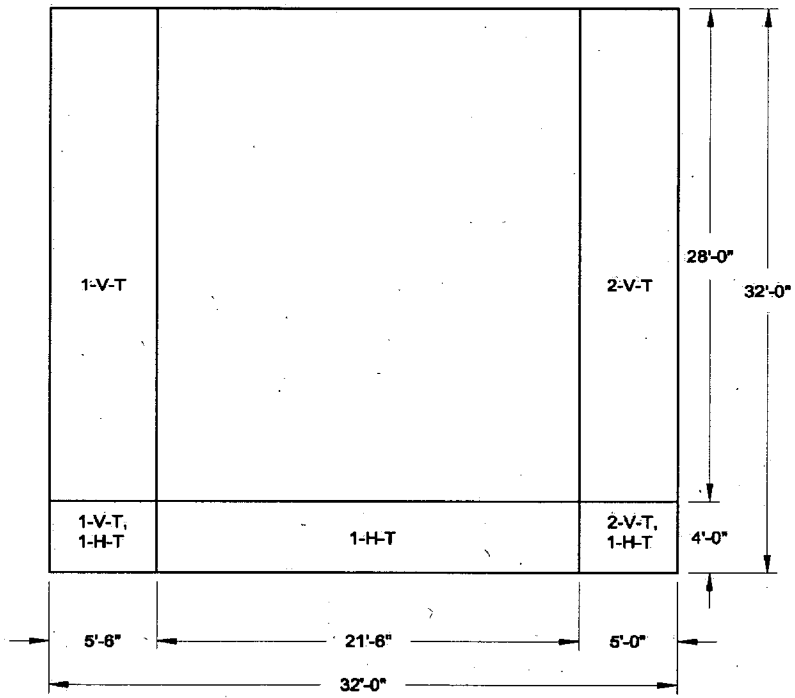


FIGURE 3H.6-189: WALL 12 LOOKING FROM OUTSIDE
TRANSVERSE REINFORCEMENT ZONES

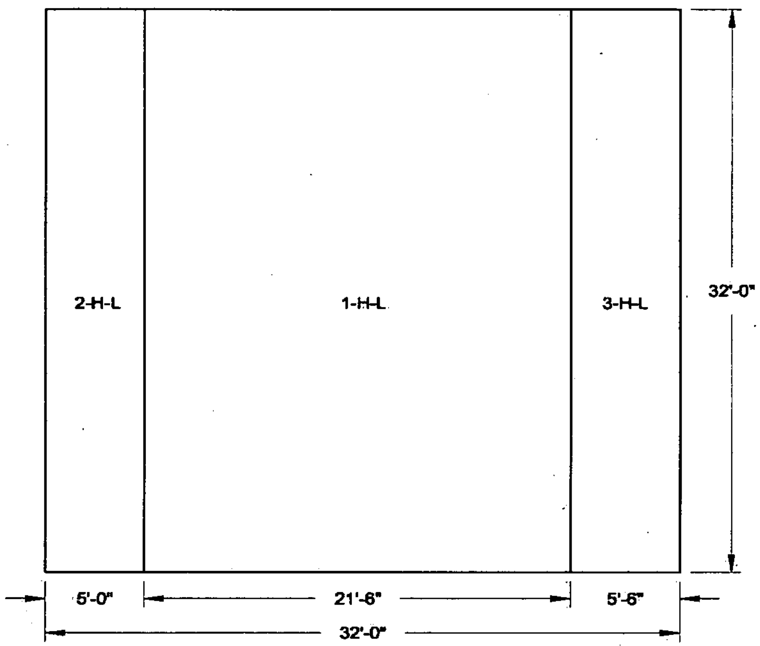


FIGURE 3H.6-190: WALL 13 LOOKING FROM OUTSIDE
HORIZONTAL REINFORCEMENT ZONES
NEAR SIDE FACE

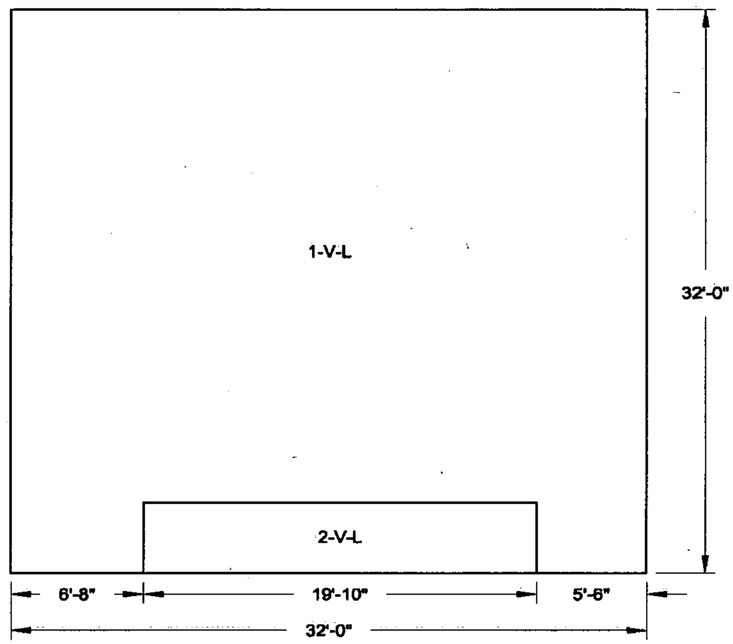


FIGURE 3H.6-191: WALL 13 LOOKING FROM OUTSIDE
VERTICAL REINFORCEMENT ZONES
NEAR SIDE FACE

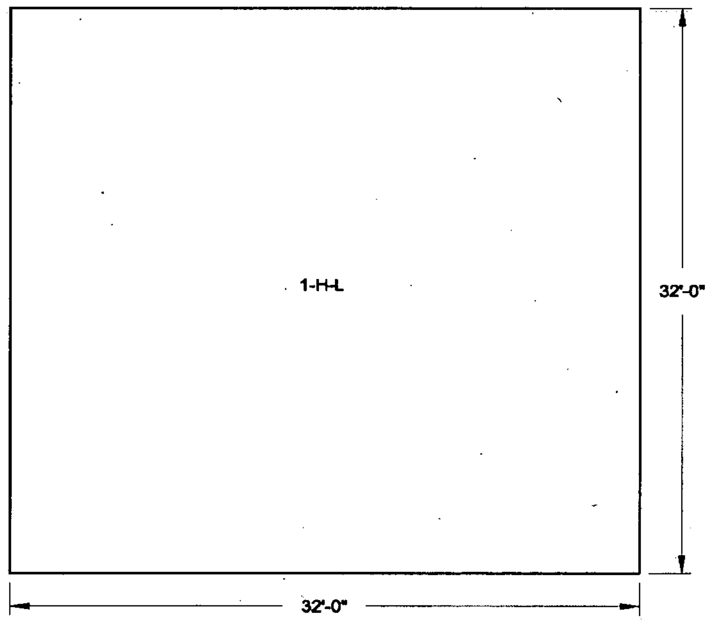


FIGURE 3H.6-192 WALL 13 LOOKING FROM OUTSIDE
HORIZONTAL REINFORCEMENT ZONES
FAR SIDE FACE

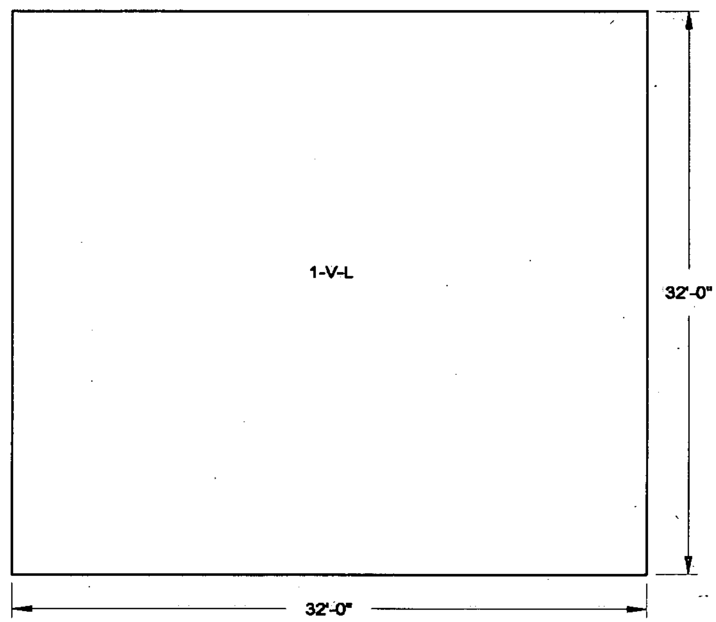


FIGURE 3H.6-193: WALL 13 LOOKING FROM OUTSIDE
VERTICAL REINFORCEMENT ZONES
FAR SIDE FACE

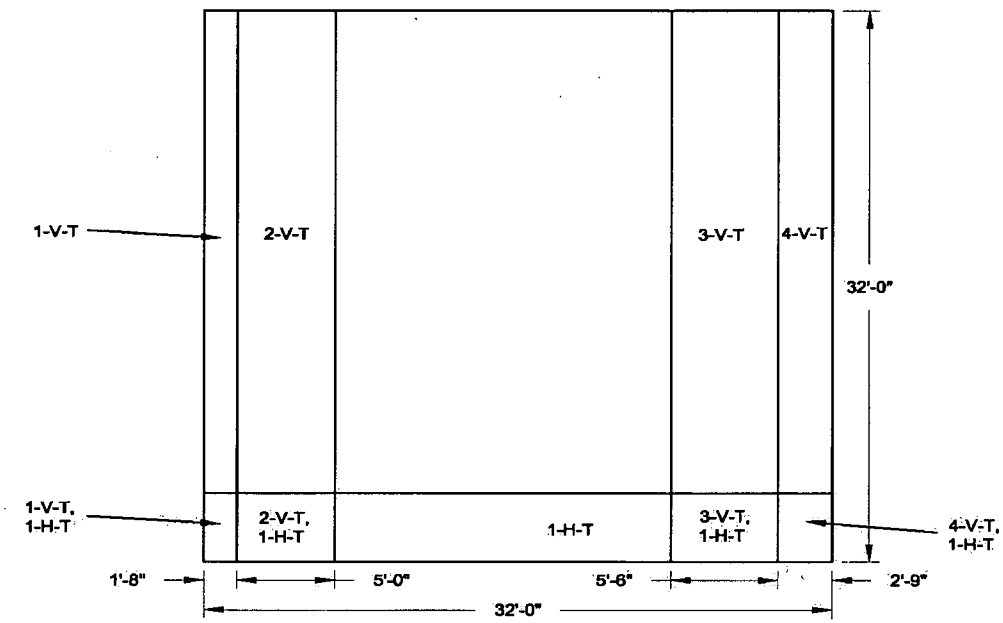


FIGURE 3H.6-194: WALL 13 LOOKING FROM OUTSIDE
TRANSVERSE REINFORCEMENT ZONES

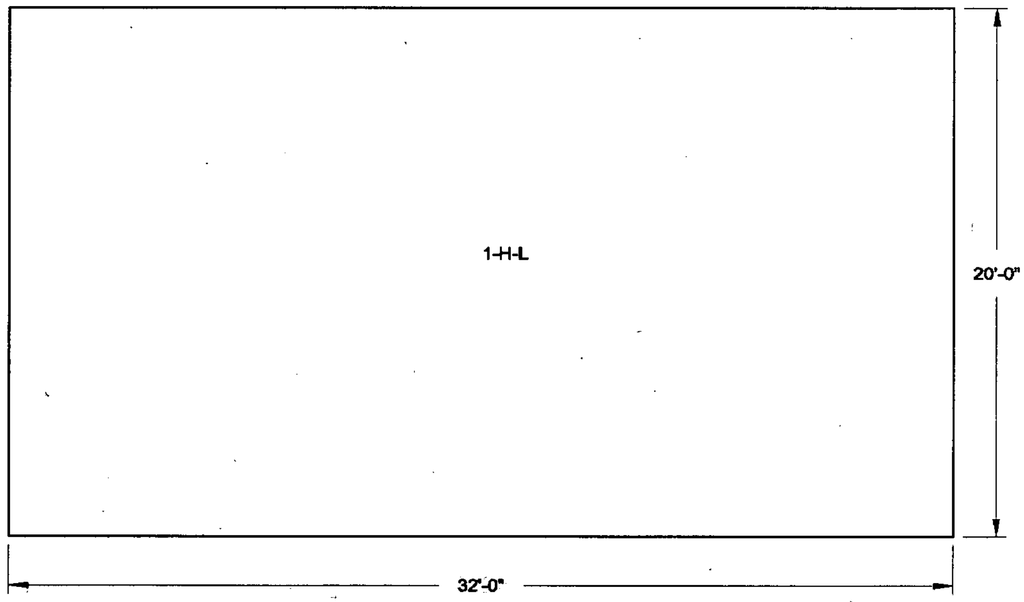


FIGURE 3H.6-195: WALL 14 LOOKING FROM OUTSIDE
HORIZONTAL REINFORCEMENT ZONES
NEAR SIDE FACE

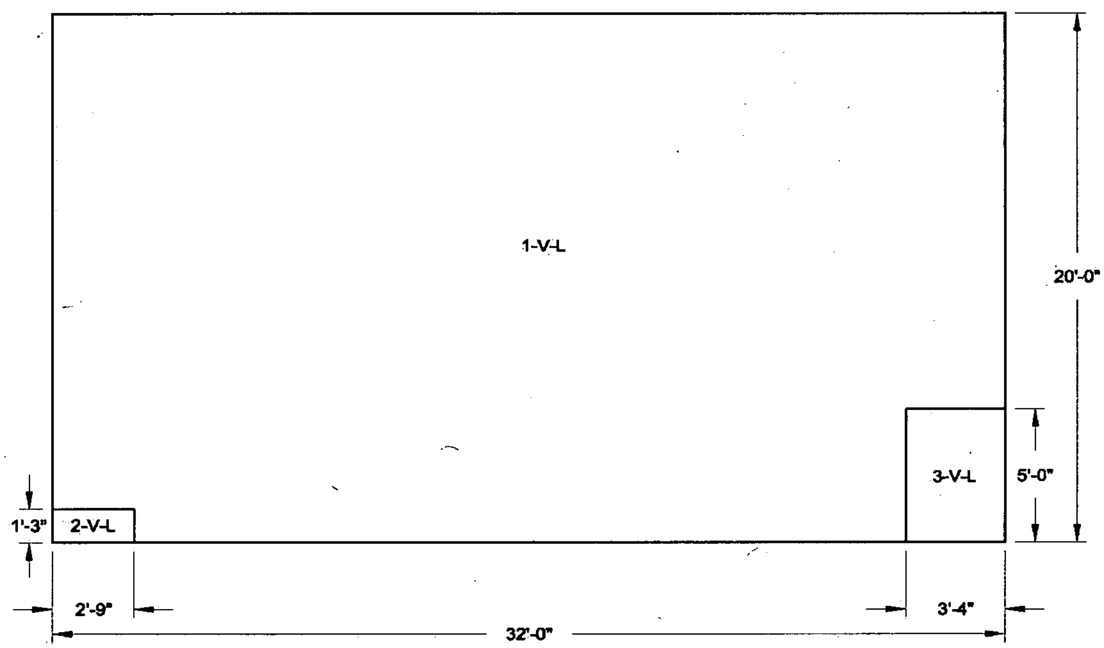


FIGURE 3H.6-196: WALL 14 LOOKING FROM OUTSIDE
VERTICAL REINFORCEMENT ZONES
NEAR SIDE FACE

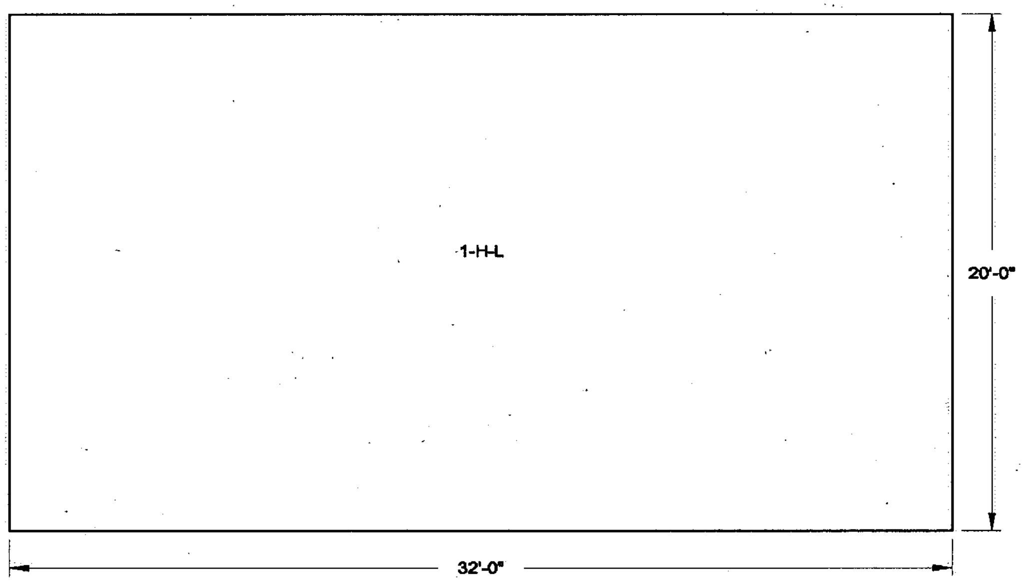


FIGURE 3H.6-197: WALL 14 LOOKING FROM OUTSIDE
HORIZONTAL REINFORCEMENT ZONES
FAR SIDE FACE

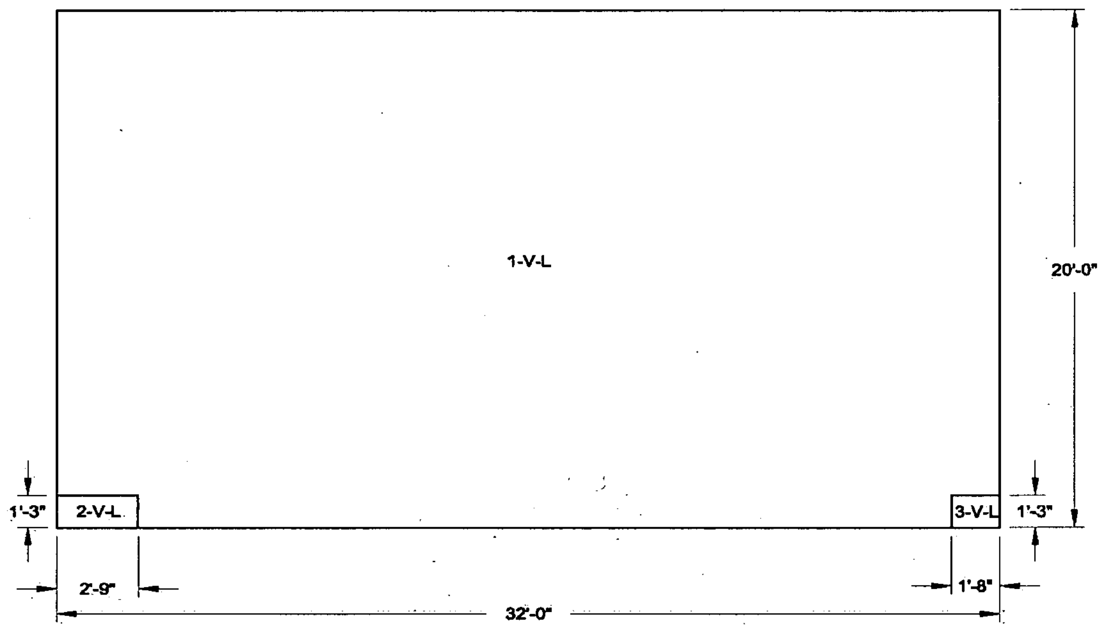


FIGURE 3H.6-198: WALL 14 LOOKING FROM OUTSIDE
VERTICAL REINFORCEMENT ZONES
FAR SIDE FACE

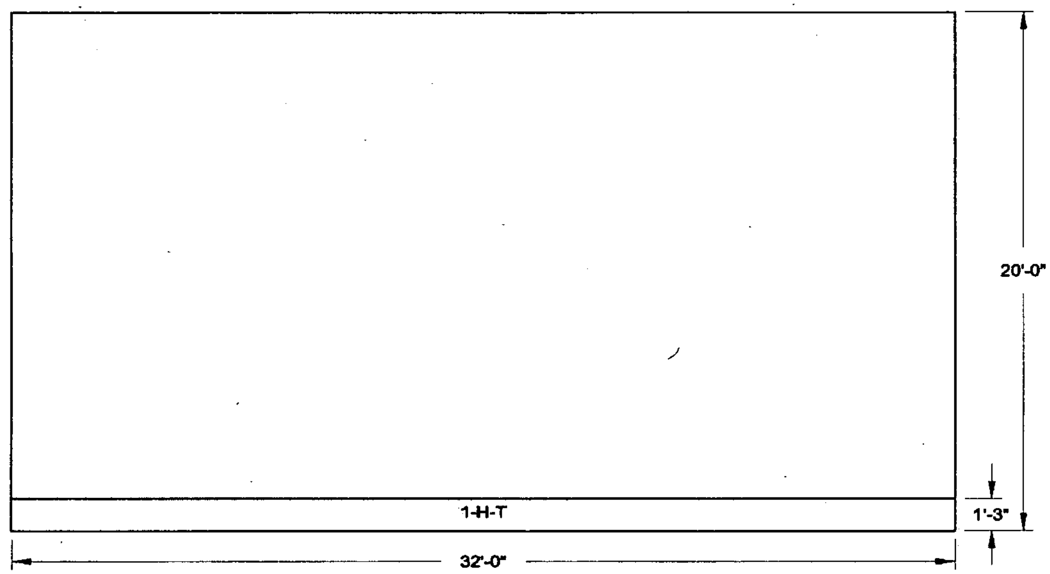


FIGURE 3H.6-199: WALL 14 LOOKING FROM OUTSIDE
TRANSVERSE REINFORCEMENT ZONES

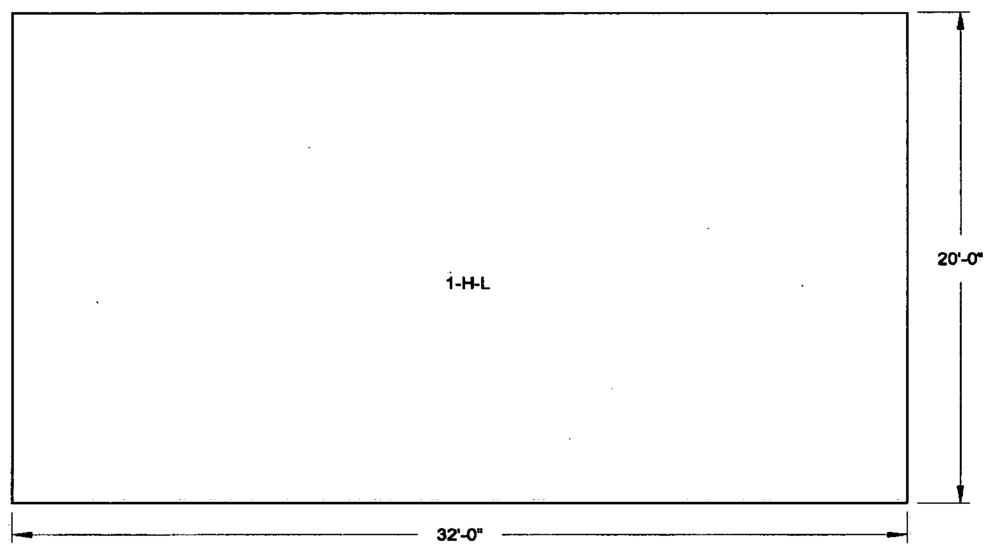


FIGURE 3H.6-200: WALL 15 LOOKING FROM OUTSIDE
HORIZONTAL REINFORCEMENT ZONES
NEAR SIDE FACE

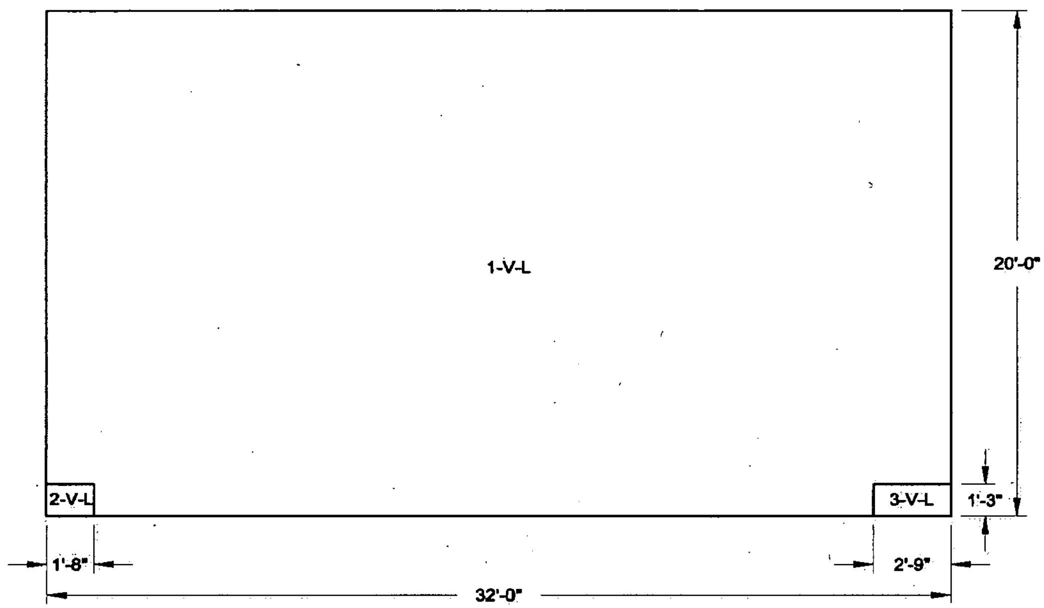


FIGURE 3H.6-201: WALL 15 LOOKING FROM OUTSIDE
VERTICAL REINFORCEMENT ZONES
NEAR SIDE FACE

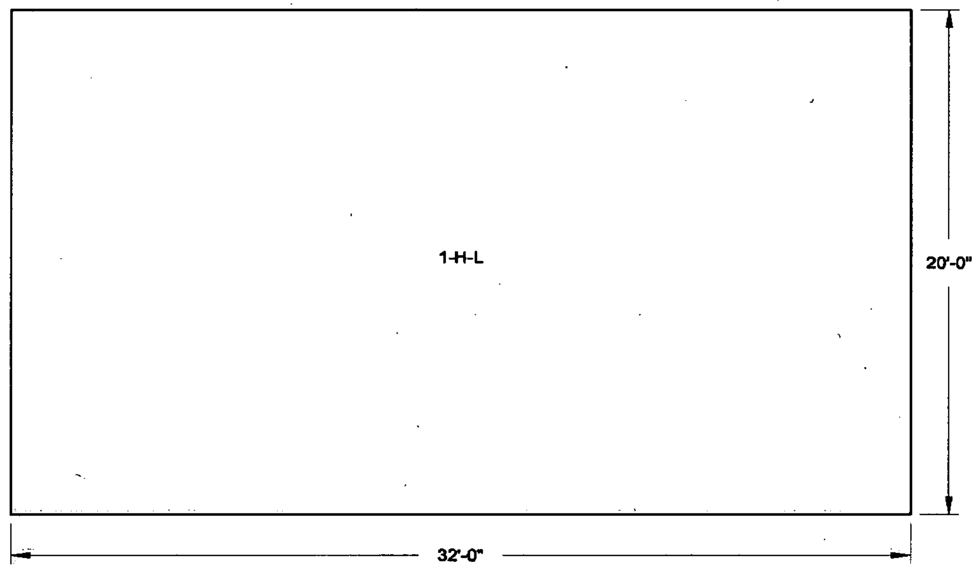


FIGURE 3H.6-202: WALL 15 LOOKING FROM OUTSIDE
HORIZONTAL REINFORCEMENT ZONES
FAR SIDE FACE

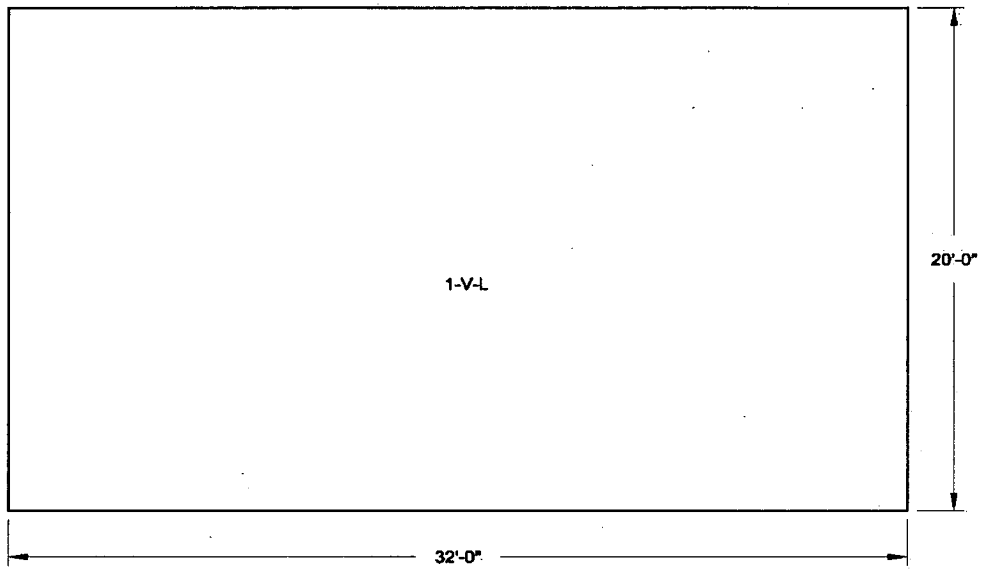


FIGURE 3H.6-203: WALL 15 LOOKING FROM OUTSIDE
VERTICAL REINFORCEMENT ZONES
FAR SIDE FACE

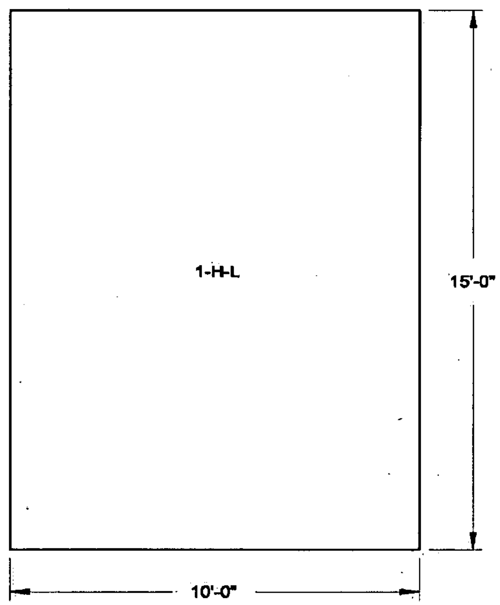


FIGURE 3H.6-204: WALL 16 LOOKING FROM OUTSIDE
HORIZONTAL REINFORCEMENT ZONES
NEAR SIDE FACE

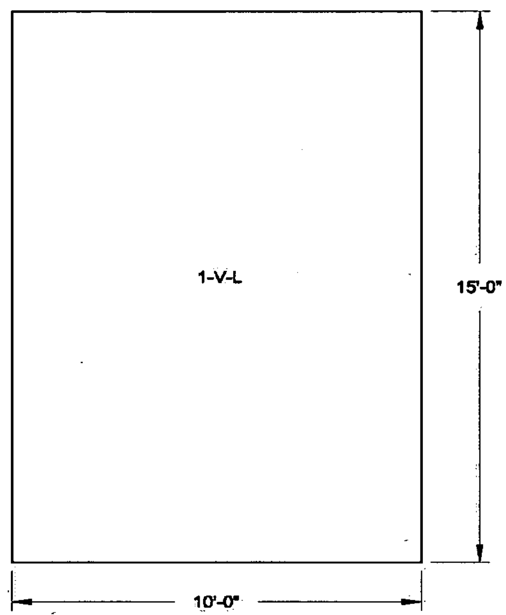


FIGURE 3H.6-205: WALL 16 LOOKING FROM OUTSIDE
VERTICAL REINFORCEMENT ZONES
NEAR SIDE FACE

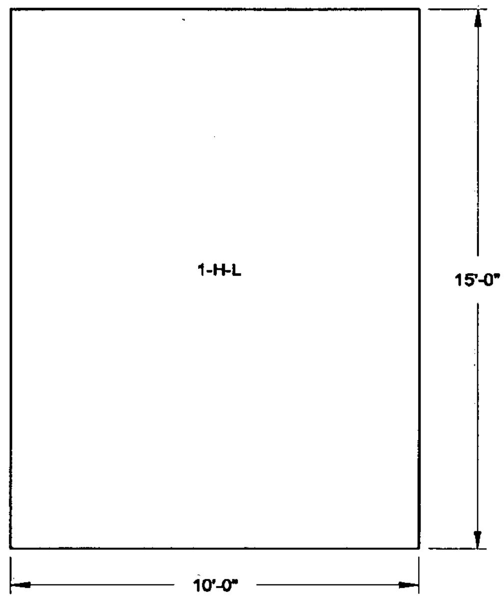


FIGURE 3H.6-206: WALL 16 LOOKING FROM OUTSIDE
HORIZONTAL REINFORCEMENT ZONES
FAR SIDE FACE

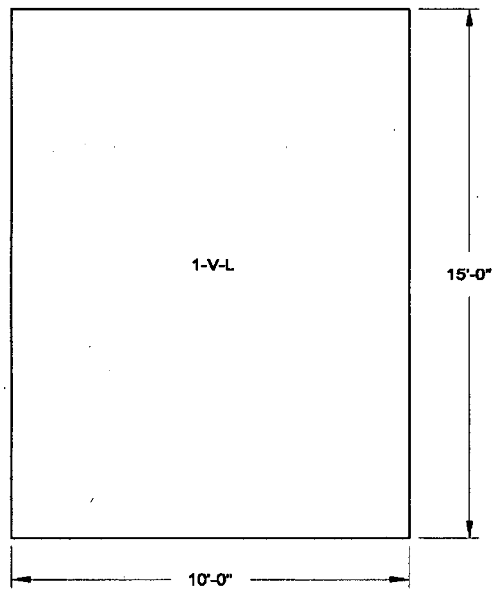


FIGURE 3H.6-207: WALL 18 LOOKING FROM OUTSIDE
VERTICAL REINFORCEMENT ZONES
FAR SIDE FACE

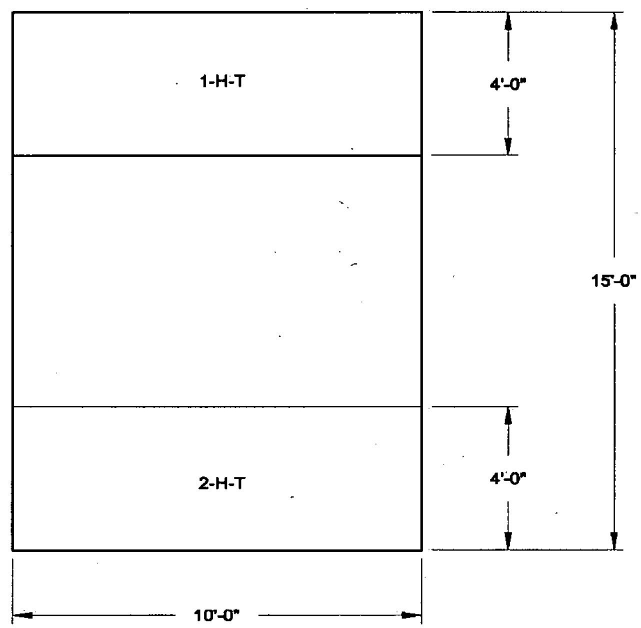


FIGURE 3H.6-208: WALL 16 LOOKING FROM OUTSIDE
TRANSVERSE REINFORCEMENT ZONES

RAI 03.07.02-13, Supplement 1

QUESTION:

(Follow-up Question to RAI 03.07.02-1)

With regard to Item c of the response to RAI 03.07.01-13, the applicant is requested to address the following:

1. The FSAR mark-up in the response to item (b) of RAI 03.07.02-1, did not include the list of non- Category I structures requiring the enhanced seismic design and analysis. The applicant is requested to include in FSAR 3.7.2.8 the five identified non-Category I structures that could interact with the Category I structures.

2. The response to item (c) of RAI 03.07.02-1 indicated that non-Category I structures with the potential to interact with Category I structures have not yet progressed to a point where sliding and overturning potential as a result of the SSE can be evaluated. However, as identified in SRP guidance 3.7.2I.8., the staff must review the applicant's seismic design of these non- Category I structures. As such, the applicant is requested to provide in the FSAR factors of safety against sliding and overturning including the basis of coefficient of friction used in the analysis during an SSE for Turbine Building, Radwaste Building, Service Building, Control Building Annex, and Plant Stack.

SUPPLEMENTAL RESPONSE:

The original response to this RAI was submitted with STPNOC letter U7-C-STP-NRC-100036, dated February 10, 2010 and committed to confirm that the design meets the minimum required factor of safety for sliding and overturning and to provide the basis for coefficient of friction used for the Turbine Building, Service Building, Radwaste Building, and Control Building Annex by April 30, 2010. This information is provided in this supplemental response.

Table 3H.6-14 provides the calculated factors of safety for overturning and sliding for site-specific Safe Shutdown Earthquake (SSE). These factors of safety were calculated in accordance with the criteria described in the original response. As can be seen from this table, all calculated factors of safety are in excess of minimum required factor of safety of 1.1. Also included in this table are the coefficients of friction used for sliding stability evaluations. The basis for these coefficients of friction is the shear resistance of the supporting foundation soil, similar to that described for the Control Building (CB) and Reactor Building (RB) in the revised response to RAI 03.08.04-19, being submitted concurrently with this letter.

COLA Part 2, Tier 2, Section 3.7.2.8 will be revised as shown below:

3.7.2.8 Interaction of Non-Seismic Category I Structures, Systems and Components with Seismic Category I Structures, Systems and Components

The Category I structures and their physical proximity to nearby non-Category I structures are shown in Figure 3.7-38. None of the non-Category I structures proposed as part of STP Units 3 and 4 is intended to meet Criterion (2) of DCD Section 3.7.2.8. Rather, for each non-Category I structure, either: (1) it is determined that the collapse of the non-Category I structure will not cause the non-Category I structure to strike a Category I structure; or (2) the non-Category I structure will be analyzed and designed to prevent its failure under SSE conditions in a manner such that the margin of safety of the structure is equivalent to that of Seismic Category I structures. Non-Category I structures that can interact with Seismic Category I structures include the Turbine Building (TB), Radwaste Building (RWB), Service Building (SB), Control Building Annex (CBA) and the stack on the Reactor Building roof. Table 3H.6-14 provides sliding and overturning factors of safety under site-specific SSE for TB, RWB, SB, and CBA.

Table 3H.6-14: Calculated Overturning and Sliding Factors of Safety Under Site-Specific SSE for TB, SB, RWB and CBA

Structure	Calculated Factor of Safety		Minimum Required Factor of Safety	Coefficient of Friction for Sliding Evaluation
	Overturning	Sliding		
Turbine Building (TB)	2.18	1.11	1.1	0.30
Service Building (SB)	2.65	1.81	1.1	0.39
Radwaste Building (RWB)	4.23	1.92	1.1	0.39
Control Building Annex (CBA)	2.03	1.16	1.1	0.58

RAI 03.07.02-19, Revision 1

QUESTION:

(Follow-up Question to RAI 03.07.02-11)

In the response to RAI 03.07.02-11, the applicant stated that, "***The analysis and design results will be available for review following the completion of the detailed design of the RWB currently scheduled for December 2010***." Since this is part of the seismic SSI analysis and RWB is classified as a non-Category I structure with the potential to interact with Category I structures, the applicant is requested to provide the seismic input motion incorporating the effects of SSSI for design of the RWB. The applicant also is requested to include the method proposed in the response for establishing the design response spectra for RWB together with the design spectra input for RWB in the FSAR.

REVISED RESPONSE:

The original response to this RAI was submitted with STPNOC letter U7-C-STP-NRC-100035, dated February 4, 2010 and committed to provide the resulting input motion from the Soil-Structure Interaction (SSI) analysis for II/I design of the Radwaste Building (RWB) by April 30, 2010. The following revised response provides this information and completely supersedes the previous response. The revised portion of the response is marked with a revision bar.

Attached Figures 3.7-40 through 3.7-42 provide the input motion at the foundation level for II/I design of the RWB. These input motions were developed in accordance with the method described in response to RAI 03.07.02-11.

Previous COLA Section 3.7.3.16 revision provided in response to RAI 03.07.03-1 regarding the determination of the input motion for the Control Building Annex (see letter U7-C-STP-NRC-090136, dated September 15, 2009) will be supplemented as shown below:

3.7.3.16 Analysis Procedure for Non-Seismic Structures in Lieu of Dynamic Analysis

Add the following paragraph at the end of this section.

For the Radwaste Building (RWB), the SSE input (see Figures 3.7-40 through 3.7-42) at the foundation level is the envelope of 0.3g RG 1.60 response spectrum and the induced acceleration response spectrum due to site-specific SSE that is determined from an SSI analysis which accounts for the impact of the nearby Reactor Building (RB). In this SSI analysis, five interaction nodes at the depth corresponding to the bottom elevation of the RWB foundation are added to the three dimensional SSI model of the RB. These five interaction nodes correspond to the four corners and the center of the RWB foundation. The average response of these five interaction nodes is enveloped with the 0.3g RG 1.60 spectra to determine the SSE input at the foundation level.

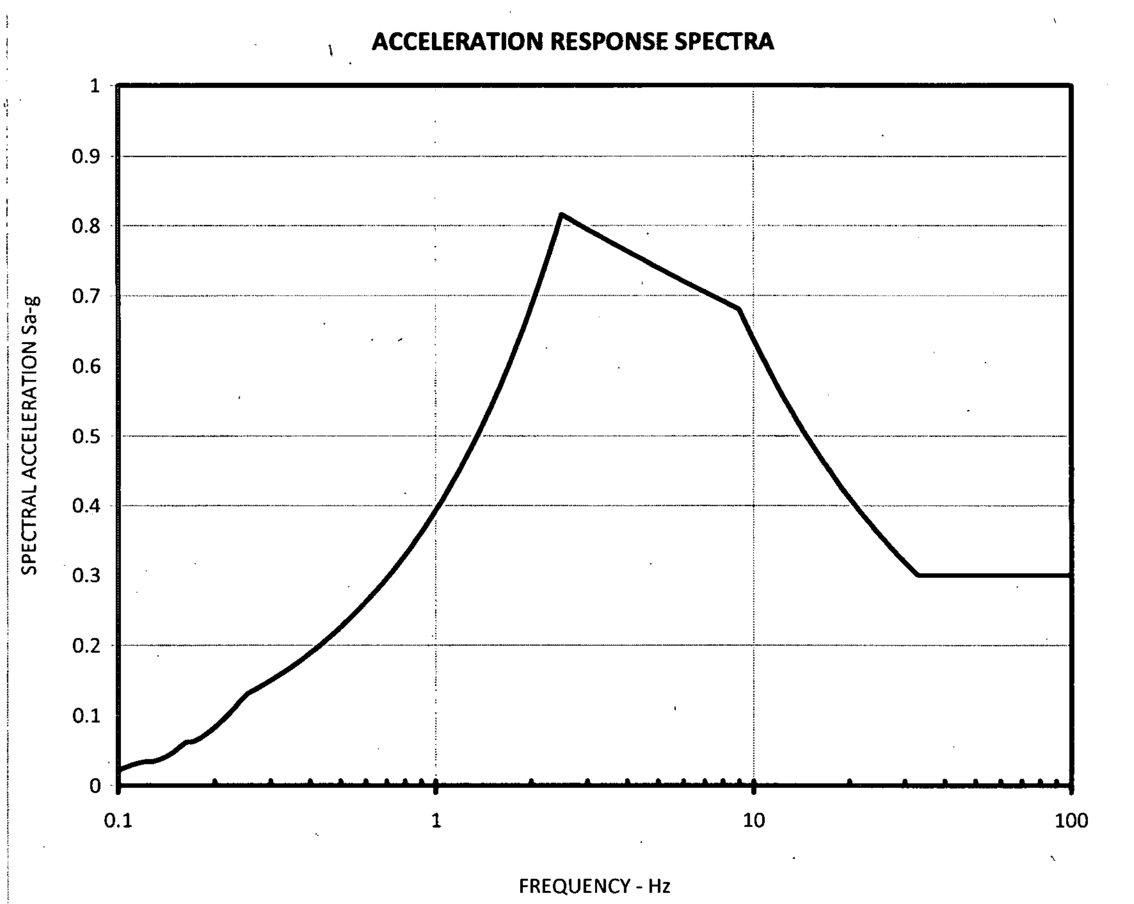


Figure 3.7-40: Horizontal (N-S) Radwaste Building Mat Foundation Response Spectrum (7% Damping)

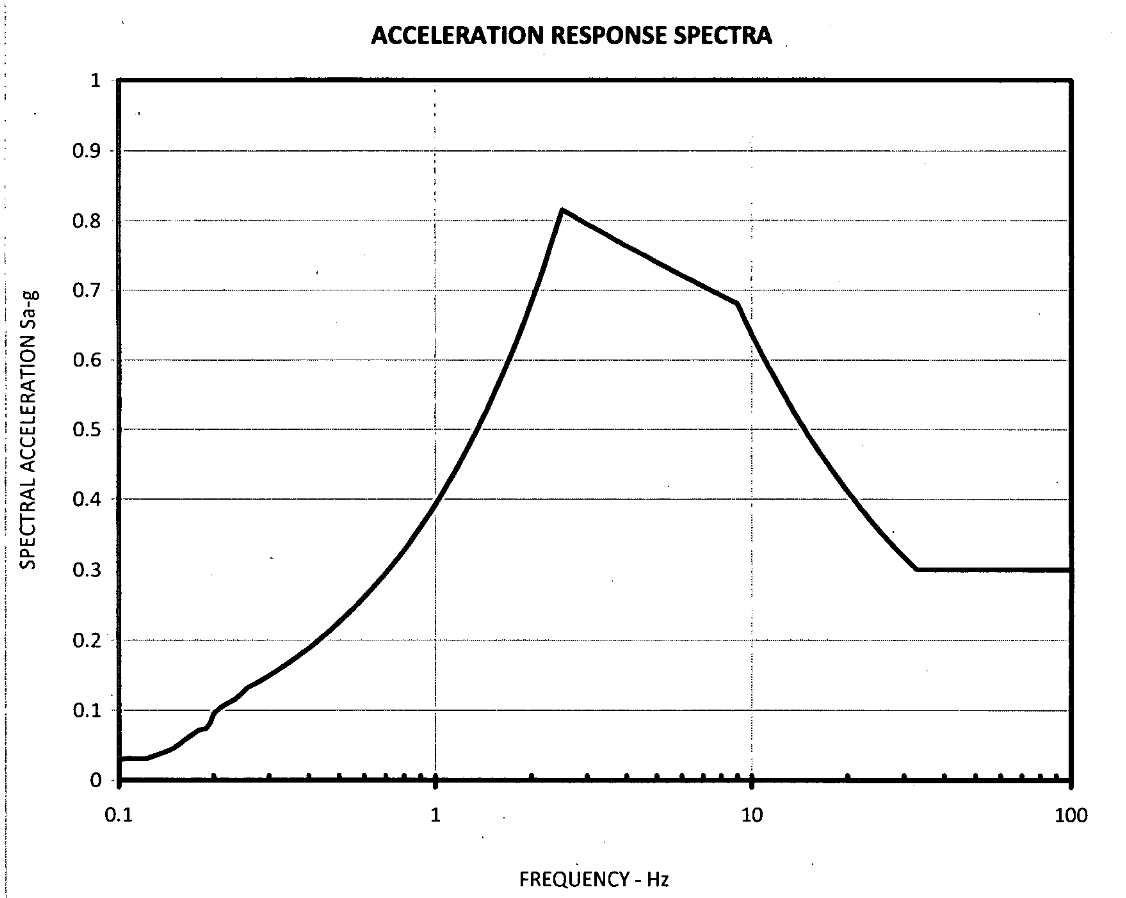


Figure 3.7-41: Horizontal (E-W) Radwaste Building Mat Foundation Response Spectrum (7% Damping)

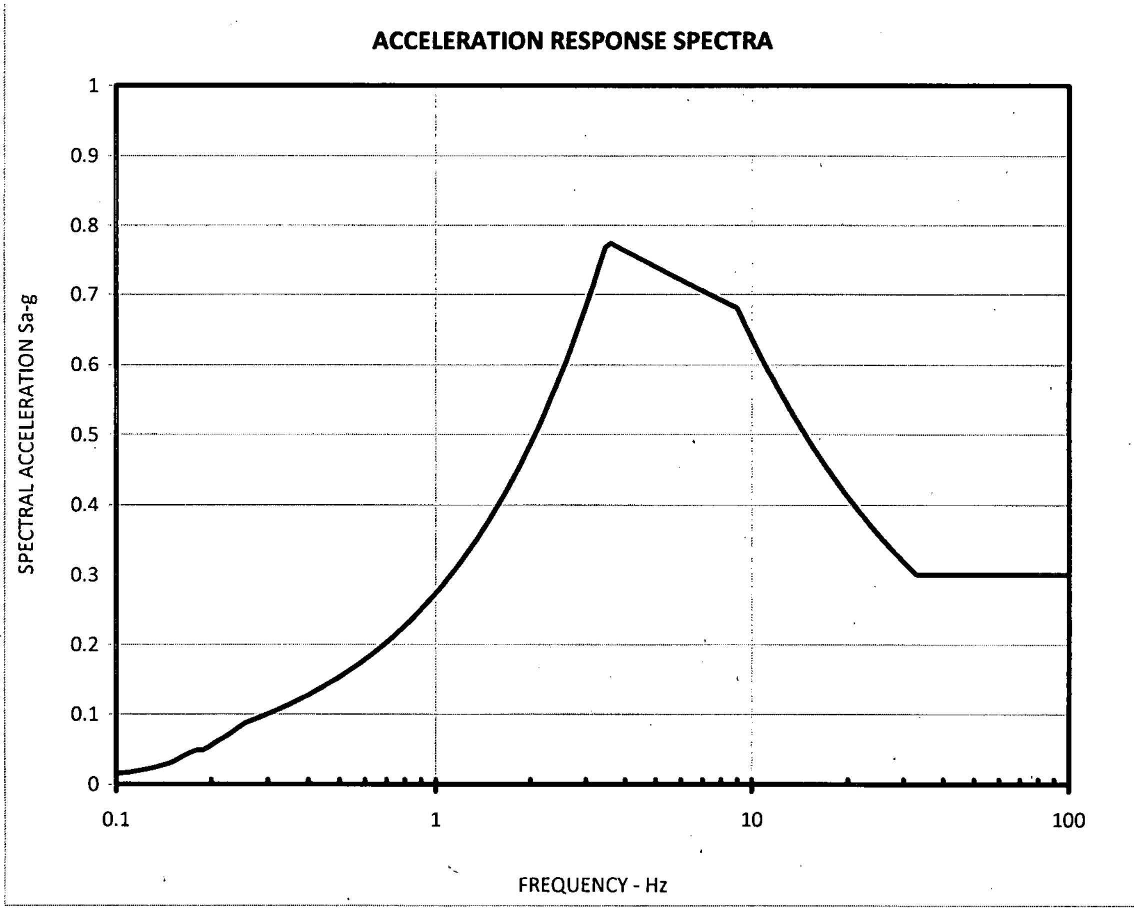


Figure 3.7-42: Vertical Radwaste Building Mat Foundation Response Spectrum (7% Damping)

RAI 03.07.03-3, Revision 1

QUESTION:

(This is a follow-up question to RAI 03.07.03-1 (in eRAI 2928))

The applicant is requested to provide the results of the SSI analysis as described in the response together with the seismic input motion for the Control Building Annex in the FSAR. The results should include enveloped SSE input response spectra obtained for CBA foundation mat and In-Structure Response Spectra at CB foundation mat.

REVISED RESPONSE:

The original response to this RAI was submitted with STPNOC letter U7-C-STP-NRC-090225, dated December 16, 2009. The results reported in the original response have slightly changed due to revised Soil-Structure Interaction (SSI) analysis. The following revised response provides the revised results and completely supersedes the previous response. The revised portion of the response is marked with a revision bar.

Attached Figures 3.7-38 and 3.7-39 are the resulting Safe Shutdown Earthquake (SSE) input spectra at the foundation level of the Control Building Annex for 7% damping. Seven percent damping spectrum is presented since it is consistent with the structural damping used for SSE. These input spectra were determined as described in response to RAI 03.07.03-1 (see letter U7-C-STP-NRC-090136, dated September 15, 2009, ML092610377). Attached Figures RAI 03.07.03-3A and RAI 03.07.03-3B are the corresponding site-specific in-structure response spectra at the top of the Control Building foundation mat.

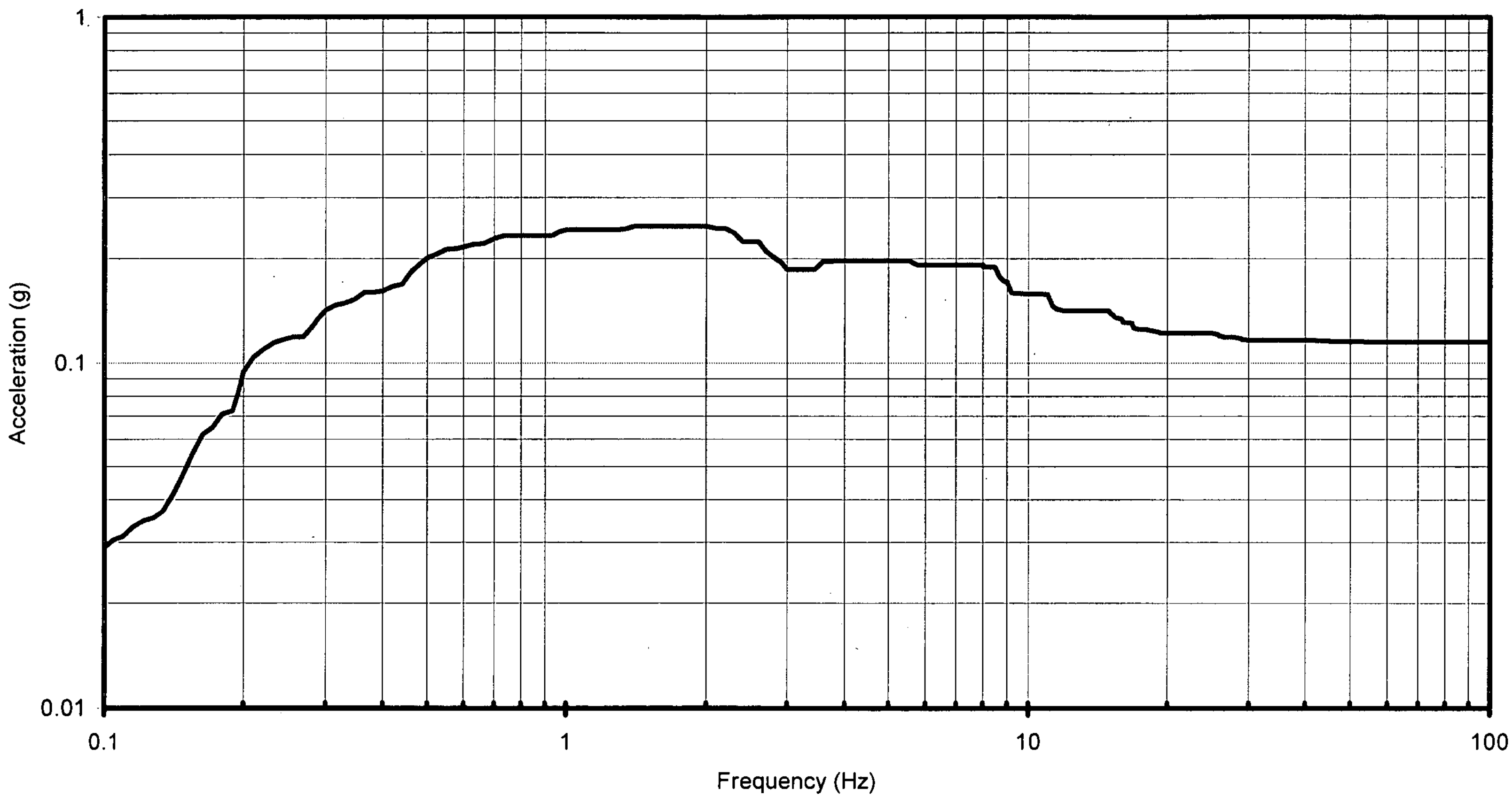


Figure RAI 03.07.03-3A: Horizontal In-Structure Response Spectrum at Top of Control Building Mat (7% Damping)

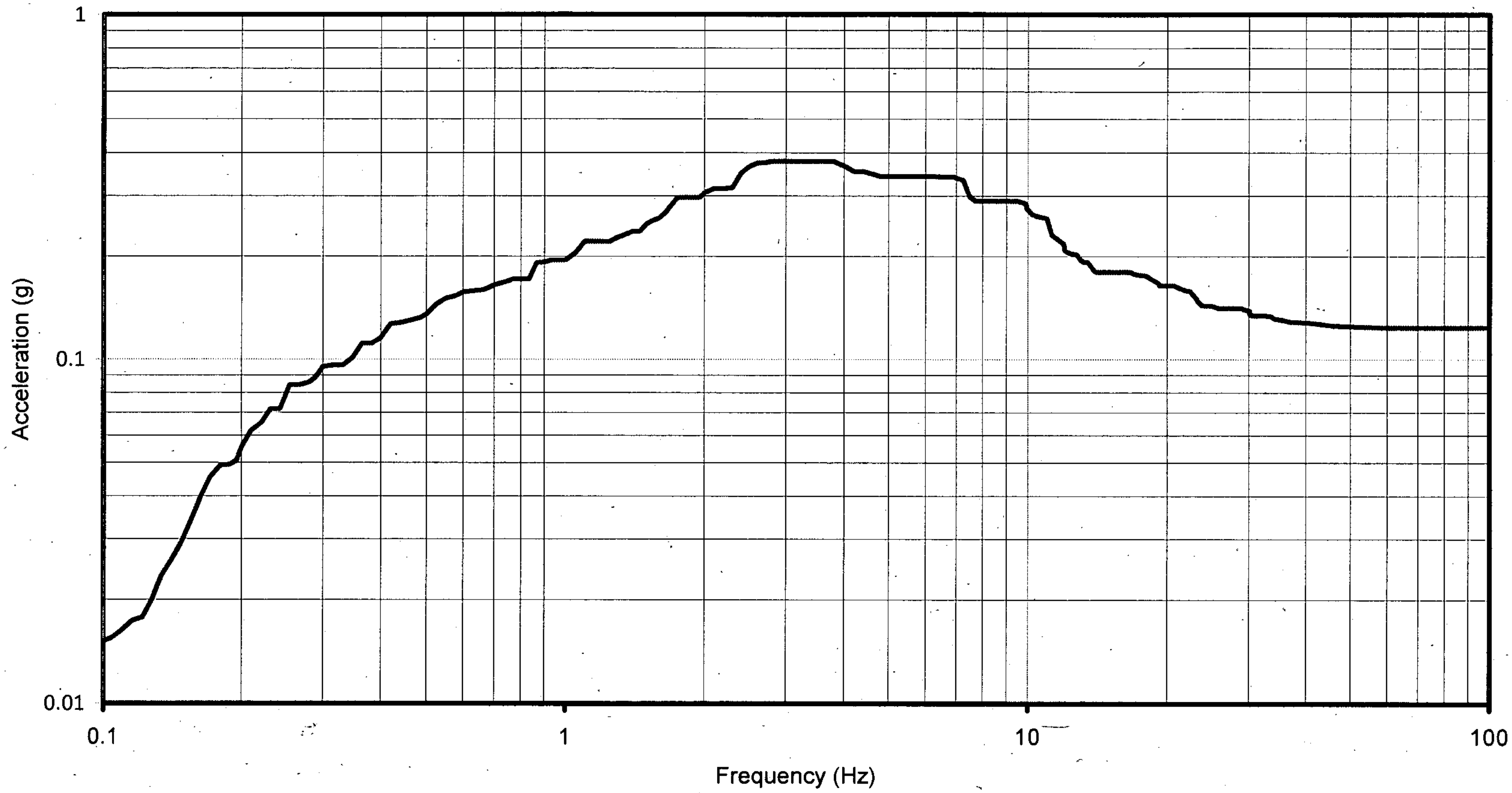


Figure RAI 03.07.03-3B: Vertical In-Structure Response Spectrum at Top of Control Building Mat (7% Damping)

Previous COLA Section 3.7.3.16 revision provided in response to RAI 03.07.03-1 will be supplemented with Figures 3.7-38 and 3.7-39 as shown below:

3.7.3.16 Analysis Procedure for Non-Seismic Structures in Lieu of Dynamic Analysis

For the Control Building Annex (CBA), the SSE input at the foundation level (Figures 3.7-38 and 3.7-39) is the envelop of 0.3g RG 1.60 response spectra and the induced acceleration response spectra due to site-specific SSE that is determined from an SSI analysis which accounts for the impact of the nearby Control Building (CB). In this SSI analysis, five interaction nodes at the depth corresponding to the bottom elevation of the CBA foundation are added to the three dimensional SSI model of the CB. These five interaction nodes correspond to the four corners and the center of the CBA foundation. The average response of these five interaction nodes is enveloped with the 0.3g RG 1.60 spectra to determine the SSE input at the CBA foundation level.

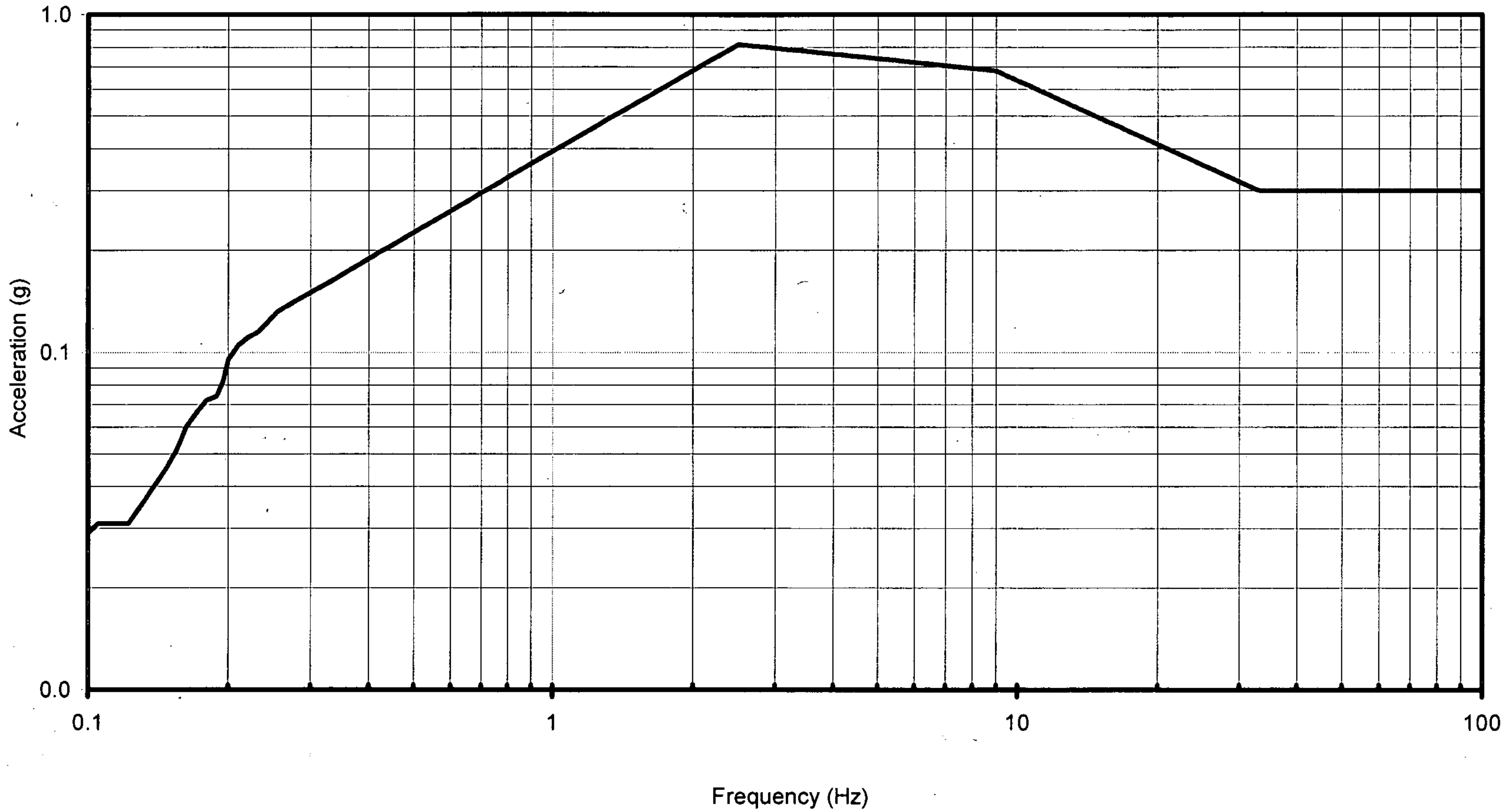


Figure 3.7-38: Horizontal (E-W) Control Building Annex Mat Foundation Response Spectrum (7% Damping)

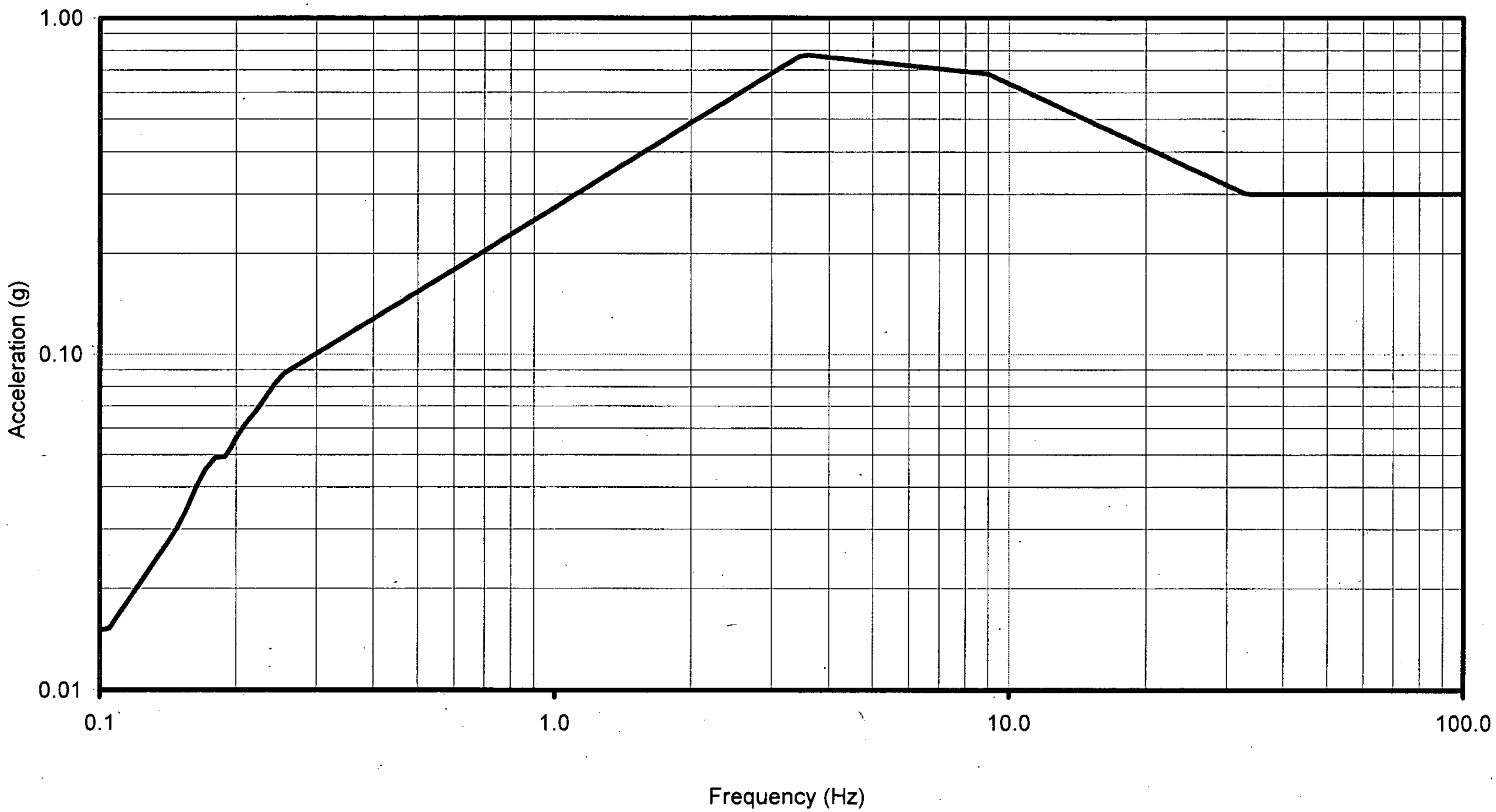


Figure 3.7-39: Vertical Control Building Annex Mat Foundation Response Spectrum (7% Damping)

RAI 03.08.04-19, Revision1

QUESTION:

Follow-up to Question 03.08.04-5 (RAI 2965)

The applicant's response to Question 03.08.04-5 regarding placing a chemical agent on the exposed concrete surface of the mudmat provides descriptive explanations of the waterproofing. Per the SRP 3.8.5 guidance, the applicant needs to show that the foundation can transfer the forces from the structure to soil with the proper factor of safety. Also, because a new material is being used, the applicant needs to provide additional data on testing and other relevant information to meet guidance of SRP 3.8.5. Therefore, the applicant is requested to provide the following additional information, and update FSAR as appropriate:

(1) the specific material that will be used for the waterproof membrane; sufficient data showing that the selected waterproofing will adequately protect the concrete foundations against degradation from soil/groundwater conditions at the STP Units 3 and 4 site;

(2) the final thickness of the membrane based on the physical properties of the selected material;

(3) the application procedures for all aspects of the coating application including batch qualification, surface preparation, application techniques, film thickness, cure time, and repairs;

(4) tests demonstrating that the waterproofing requirements and the coefficient of friction required to transfer seismic loads for STP Units 3 and 4 have been met;

(5) methods for testing that simulate field conditions to demonstrate that the minimum required coefficient of friction is achieved by the structural concrete fill-waterproof membrane structural interface; and documentation summarizing the basis for determining that the material will meet the friction factor and waterproofing requirements;

(6) site-specific sliding evaluation for the Reactor Building and the Control Building to demonstrate that the minimum coefficient of friction needed for maintaining the minimum factor of safety against sliding is available at all sliding interfaces between the structures and foundation soil; and,

(7) specification and properties of the structural concrete fill below the RB and CB foundations.

REVISED RESPONSE:

The original response to this RAI, which was submitted with STPNOC letter U7-C-STP-NRC-100036, dated February 10, 2010, committed to provide a confirmatory evaluation that the minimum factor of safety against sliding is available at all sliding interfaces between the Reactor and Control Buildings and foundation soil by April 30, 2010. This revised response provides that information and completely supersedes the original response. The portions of the original response which have been revised are marked with a revision bar.

(1) The material used for the waterproof membrane will be a two-coat color-coded Methyl Methacrylate (MMA) resin, which is an elastomeric "spray-on" membrane. The physical properties have been specifically designed to cope with the rigorous requirements of below grade conditions.

(2) The final thickness of all coats of the waterproofing membrane will be a nominal 120 mils.

(3) The vendor for the waterproofing membrane materials has not been selected. The application procedures for the coating application including batch qualification, surface preparation, application techniques, film thickness, cure time, and repairs will be determined based on manufacturer recommendations and the results of the qualification testing.

(4) As discussed in the response to RAI 03.08.04-5, the coefficient of friction will be determined with a qualification program prior to procurement of the membrane material. The qualification program will be developed to demonstrate that the selected material will meet the waterproofing and friction requirements. The qualification program will include testing to demonstrate that the waterproofing requirements and the coefficient of friction required to transfer seismic loads for STP 3&4 have been met. Testing methods will simulate field conditions to demonstrate that the minimum required coefficient of friction is achieved by the structural concrete fill - waterproof membrane structural interface. A technical report will document the basis for determining that the material will meet the required friction factor and waterproofing requirements. An ITAAC is added to the COLA to document that testing results comply with the required friction factor. The proposed ITAAC is provided at the end of this response.

(5) The test program will be based on the test methods contained in ASTM D1894. The tests will be performed with the expected range of normal compressive stresses. The coefficient of friction, as defined in ASTM D1894 is the ratio of the force required to move one surface over another to the total force applied normal to those surfaces. The test fixture assembly will be designed to obtain a series of shear / lateral forces and the corresponding applied normal compressive loads. The test data will be generally represented by a best fit straight line whose slope is the coefficient of friction. A proposed ITAAC is provided in the COLA markup included with this response.

(6) The site-specific sliding evaluation for the Reactor Building (RB) and the Control Building (CB) demonstrates that the minimum coefficient of friction needed for maintaining the

minimum factor of safety against sliding is available at all sliding interfaces between the structures and foundation soil.

The minimum coefficient of friction needed for maintaining the minimum factor of safety against sliding is:

- Reactor Building 0.47
- Control Building 0.47

The soil capacity exceeds these values. In order to transfer the loadings from the foundation to the soil, the loads must be transferred from the reinforced concrete foundation through the structural concrete fill to soil.

For the concrete interfaces, ACI 349-97, Section 11.7.4.3 specifies the coefficient of friction, μ, for concrete placed against hardened concrete that is not intentionally roughened as 0.6.

The Final Safety Evaluation Report Relating to the Certification of the Advanced Boiling Water Reactor Design, NUREG 1503, Main Report, Section 3.8.5 Foundations, pp 3-56 and 3-57) states, "...a layer of gravel will be placed on the excavated foundation surface for the soil site ... before pouring concrete and placing the waterproofing material. The treated foundation surface will increase the fiction between the structural foundation and the supporting foundation surface. Therefore, the staff concludes that the treated foundation surface will be capable to transfer the seismic shear loads."

The placement of a gravel layer on the excavated soil surface for STP Units 3 & 4, followed by placement of the concrete fill on the gravel layer, will improve the friction between the concrete fill and the supporting foundation soil. The wet structural concrete fill, when placed, will surround aggregate particles at the gravel surface and also penetrate some distance into the gravel layer. The resulting interface between the hardened concrete and gravel will feature penetration of the concrete into the gravel, and thus the shear resistance to sliding will be governed by gravel to gravel strength (μ equals 0.75-0.84 within the gravel layer) on a plane below the concrete to gravel interface. Use of angular particle shapes in the gravel will create intimate contact with the soil surface to assure that the shear resistance at the underlying gravel to soil interface will be governed by the shear resistance of gravel or soil, whichever is less.

Table RAI 03.08.04-19a below provides a summary of the coefficient of friction provided for each of the sliding interfaces between the structures and foundation soil. At each sliding interface, μ provided is greater than μ required.

Table RAI 03.08.04-19a

Upper Interface Surface	Lower Interface Surface	μ Provided	Basis
Bottom of reinforced concrete structure	Top of structural concrete fill	0.6	ACI 349-97, Section 11.7.4.3
Structural concrete fill	Structural concrete fill at waterproofing membrane	0.6	Testing Program per items (4) and (5) described above
Structural concrete fill	Structural concrete fill at a construction joint	0.6	ACI 349-97, Section 11.7.4.3
Structural concrete fill	Top of gravel layer	≥ 0.6	Discussion above
Bottom of gravel layer	Soil	≥ the smaller of 0.6 or the shear capacity of the soil	Discussion above

(7) The structural concrete fill below the RB and CB foundations will be comprised of unreinforced normal weight concrete with a minimum compressive strength (f'_c) of 3000 psi.

COLA will be revised as shown below as a result of this response:

1. COLA Part 2, Tier 2, Section 3.8.6.1 will be revised as follows:

3.8.6.1 Foundation Waterproofing

The following standard supplement addresses COL License Information Item 3.23.

Foundation waterproofing is done by placing a ~~chemical agent on the exposed concrete surface of the mudmat~~ waterproofing membrane near the top elevation of the concrete fill. The ~~concrete foundation is poured directly onto the concrete mudmat~~ remainder of the concrete fill is then poured on top of the waterproofing material. A waterproof membrane that could degrade the ability of the foundation to transfer loads is not used.

The coefficient of friction of the waterproofing material will be determined with a qualification program prior to procurement of the membrane material. The qualification program will be developed to demonstrate that the selected material will meet the waterproofing and friction requirements. The qualification program will include testing to demonstrate that the waterproofing requirements and the coefficient of friction required to transfer seismic loads for STP 3&4 have been met. Testing methods will simulate field conditions to demonstrate that the minimum required coefficient of friction is achieved by the structural concrete fill - waterproof membrane structural interface. The material will meet the required friction factor.

The test program will be based on the test methods contained in ASTM D1894. The tests will be performed with the expected range of normal compressive stresses. The coefficient of friction, as defined in ASTM D1894 is the ratio of the force required to move one surface over another to the total force applied normal to those surfaces. The test fixture assembly will be designed to obtain a series of shear / lateral forces and the corresponding applied normal compressive loads. The test data will be generally represented by a best fit straight line whose slope is the coefficient of friction.

2. COLA Part 9 will be revised to add the following site-specific ITAAC.

3.0 Site-Specific ITAAC

The reference ABWR DCD Tier 1, Chapter 4.0, "Interface Requirements," identifies significant design provisions for interface between systems within the scope of the ABWR standard design and other systems that are wholly or partially outside the scope of the ABWR standard design. The interface requirements define the attributes and performance characteristics that the out-of-scope (site-specific) portion of the plant must have in order to support the certified ABWR design.

The STP 3 & 4 site-specific systems that require ITAAC because they have a safety-related, safety-significant, or risk significant function are listed below:

- Ultimate Heat Sink (UHS)
- Offsite Power System
- Makeup Water Preparation (MWP) System
- Reactor Service Water (RSW) System
- Communication System (See Section 4.0 - Emergency Planning ITAAC)
- Site Security (See Section 5.0 - Physical Security ITAAC)
- Circulating Water (CW) System
- Backfill under Category 1 Structures
- Breathing Air (BA) System
- Waterproofing Membrane

Table 3.0-13
Waterproofing Membrane

Design Commitment	Inspections, Tests, Analyses	Acceptance Criteria
The friction coefficient to resist sliding meets the required friction coefficient to prevent sliding	Type testing will be performed to determine the minimum coefficient of friction of the type of material used in the mudmat-waterproofing-mudmat interface beneath the basemats of the Category I structures	A report exists and documents that the waterproof system (mudmat-waterproofing-mudmat interface) has a coefficient of friction to support the analysis against sliding.