Seismic Design Bases
of the US-APWR Standard Plant

January 2011

Revision History

Revision	Page	Description
0	All	Original Issue
1	All	General revision to update the description of modeling including the reactor coolant loop, including references to MUAP-10006 for results of analyses, and change to model verification methodology.
2	5-21 to 5-41	Updated soil profiles 270-200, 270-500, 561-100, 560-200 and 560-500. Revised figures 5.3.3.3-4 and 5.3.3.3-9 per response to RAI 603-4666, question 03.07.02-10. Revised sections 3.4, 4.2.1 and figure 5.3.3.1-2 per response to RAI 625-4924. Per response to RAI 542, question 03.07.02-35, the PS/B stick model is no longer used. Updated SASSI to version 2.3.0.

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Abstract

The purpose of this technical report is to present the seismic design bases of the US-APWR standard plant.

This report describes:

- Establishment of Input Ground Motion Acceleration Time Histories
- Development of Generic Layered Soil Profiles
- Enhancement and Validation of the SASSI Model of PS/B
- Development of SASSI Model of R/B Complex
- Consideration of Concrete Cracking in Dynamic Modeling

Table of Contents

Subject	Page No.
List of Tables	iv
List of Figures	vii
List of Acronyms	xiv
1.0 INTRODUCTION	1-1
2.0 PURPOSE	2-1
3.0 OBJECTIVES	3-1
3.1 CSDRS Compatible Ground Motion Time Histories	3-1
3.2 Generic Layered Soil Profiles and Strain Compatible Properties	3-1
3.3 Enhanced ACS SASSI Lumped-Mass-Stick Model of R/B Complex	3-1
3.4 ACS SASSI FE model of the PS/Bs	3-2
3.5 Consideration of Concrete Cracking in Dynamic Analyses	3-3
4.0 APPROACH	4-1
4.1 CSDRS Compatible Ground Motion Time Histories	4-1
4.2 Development of Soil Profiles and Strain Compatible Properties	4-5
4.2.1 Selection of Profiles	4-6
4.2.2 Development of US-APWR CSDRS Strain Compatible Properties	4-6
4.3 Enhanced ACS SASSI Lumped-Mass-Stick Model of R/B Complex	4-12
4.3.1 Structural Modeling Approach	4-12
4.3.2 Enhancement of the Lumped-Mass-Stick Models	4-12
4.3.3 Development of SASSI FE Model of R/B Basement	4-15
4.3.4 Model Verification Methodology	4-18
4.4 ACS SASSI FE model of PS/B	4-18

4.5	Consideration of Concrete Cracking in Dynamic Analyses		4-19
	4.5.1	Evaluation of Reinforced Concrete Members Cracking	4-19
	4.5.2	Adjusting Element Stiffness in FE Dynamic Models	4-21
	4.5.3	Evaluation of Concrete Cracking in Dynamic Analyses of SC Modules	4-22
5.0	RESULTS AND CONCLUSIONS		5-1
5.1	CSDRS Compatible Ground Motion Time Histories		5-1
5.2	Development of Soil Profiles		5-10
	5.2.1	Site Response Analyses	5-15
	5.2.2	Strain Compatible Properties	5-20
5.3	Enhanced ACS SASSI Lumped-Mass-Stick Model of R/B Complex		5-79
	5.3.1	R/B Complex Lumped-Mass-Stick Model	5-79
	5.3.1.1	SDOF Elements	5-79
	5.3.1.2	Lumped Mass Stick Model Properties	5-87
	5.3.1.3	Lumped-Mass-Stick Models of Major Equipment and Piping	5-98
	5.3.2	Reactor Building Basemat Model	5-114
	5.3.3	PCCV Verification Results	5-128
	5.3.3.1	1g Static Analysis	5-128
	5.3.3.2	Modal Analysis	5-129
	5.3.3.3	Mode-Superposition Transient Dynamic Analysis	5-133
	5.3.4	R/B and FH/A Verification Results	5-139
	5.3.4.1	1g Static Analysis	5-139
	5.3.4.2	Modal Analysis	5-148
	5.3.4.3	Mode-Superposition Transient Dynamic Analysis	5-152

5.3.5 CIS Verification Results 5-165

5.3.5.1 1g Static Analysis 5-165

5.3.5.2 Modal Analysis 5-170

5.3.5.3 Mode-Superposition Transient Dynamic Analysis 5-173

5.4 ACS SASSI FE model of PS/B 5-180

5.4.1 Description of the PS/B ACS SASSI Model 5-180

5.4.2 Validation of the PS/B ACS SASSI Model 5-186

5.5 Consideration of Concrete Cracking in Dynamic Analyses 5-206

5.5.1 Concrete Cracking of PS/B 5-206

5.5.2 Concrete Cracking of R/B Complex 5-209

6.0 REFERENCES 6-1

List of Tables

Table	Title	Page No.
Table 2.0-1	Resolution Methodology for RAI Questions on Seismic Design Basis	2-2
Table 4.1-1	Target Control Points for US-APWR CSDRS	4-2
Table 4.2-1	Initial Profile Categories	4-8
Table 5.1-1	Comparison of 5% Damping ARS of Artificial Time History and CSDRS	5-7
Table 5.1-2	Spectra Matching Requirements for Converted Time Histories	5-8
Table 5.1-3	Duration of Motion of US-APWR Artificial Time History Components Computed from Arias Intensity Values	5-9
Table 5.2-1	Final Profile Categories	5-11
Table 5.2-2	Magnitudes, Distances, and Median Peak Accelerations	5-16
Table 5.2-3	Deleted	5-21
Table 5.2-4	Strain Compatible Properties for Profile 270, 200 ft	5-22
Table 5.2-5	Strain Compatible Properties for Profile 270, 500 ft	5-25
Table 5.2-6	Strain Compatible Properties for Profile 560, 100 ft	5-31
Table 5.2-7	Strain Compatible Properties for Profile 560, 200 ft	5-33
Table 5.2-8	Strain Compatible Properties for Profile 560, 500 ft	5-35
Table 5.2-9	Strain Compatible Properties for Profile 900, 100 ft	5-41
Table 5.2-10	Strain Compatible Properties for Profile 900, 200 ft	5-42
Table 5.2-11	Strain Compatible Properties for Profile 2032, 100 ft	5-44
Table 5.3.1-1	Slab SDOF Properties (Cracked Concrete)	5-81
Table 5.3.1-2	Wall SDOF-X Properties	5-85
Table 5.3.1-3	Wall SDOF-Y Properties	5-86
Table 5.3.1-4	PCCV Model - Lumped Mass Inertia	5-88
Table 5.3.1-5	CIS Model - Lumped Mass Inertia	5-89

Table 5.3.1-6	**Mass of Stick Model for Buildings R/B and Basemat**	**5-90**
Table 5.3.1-7	**PCCV Model – Stick Elements**	**5-92**
Table 5.3.1-8	**CIS Model – Stick Elements**	**5-93**
Table 5.3.1-9	**R/B-FH/A Model – Stick Elements**	**5-94**
Table 5.3.1-10	**CIS and R/B Spring Elements**	**5-95**
Table 5.3.1-11	**Lumped Mass of RV Model**	**5-99**
Table 5.3.1-12	**Lumped Mass of SG Model**	**5-100**
Table 5.3.1-13	**Lumped Mass of RCP Model**	**5-101**
Table 5.3.1-14	**Lumped Mass of MCP Model**	**5-102**
Table 5.3.1-15	**Material Properties of RV Stick Model**	**5-105**
Table 5.3.1-16	**Element Properties of RV Stick Model**	**5-105**
Table 5.3.1-17	**Element Properties of SG Stick Model**	**5-106**
Table 5.3.1-18	**Material Properties of RCP Stick Model**	**5-107**
Table 5.3.1-19	**Element Properties of RCP Stick Model**	**5-108**
Table 5.3.1-20	**Specification of MCP Model**	**5-109**
Table 5.3.1-21	**Support Stiffness of RV, SG and RCP**	**5-110**
Table 5.3.1-22	**Node Connectivity between RCL and CIS**	**5-111**
Table 5.3.2-1	**Input Material Properties**	**5-114**
Table 5.3.2-2	**Basement Model Z-Coordinates (Down to Up)**	**5-116**
Table 5.3.2-3	**Basement Model X-Coordinates (South to North)**	**5-116**
Table 5.3.2-4	**Basement Model Y-Coordinates (East to West)**	**5-117**
Table 5.3.2-5	**Basement Model Radial Coordinates**	**5-118**
Table 5.3.2-6	**Finite Element Properties of R/B Basement Model**	**5-119**
Table 5.3.2-7	**Adjusted Material Properties of Basement Shear Walls with Openings**	**5-120**
Table 5.3.3.2-1	**Modal Properties of First 3 Modes, X-Direction (NS)**	**5-129**

Table 5.3.3.2-2	**Modal Properties of First 3 Modes, Y-Direction (EW)**	**5-129**
Table 5.3.3.2-3	**Modal Properties of First 3 Modes, Z-Direction (Vertical)**	**5-130**
Table 5.3.4.2-1	**Modal Properties of First 3 Modes, X-Direction (NS)**	**5-148**
Table 5.3.4.2-2	**Modal Properties of First 3 Modes, Y-Direction (EW)**	**5-148**
Table 5.3.4.2-3	**Modal Properties of First 3 Modes, Z-Direction (Vertical)**	**5-148**
Table 5.3.5.2-1	**Modal Properties of First 3 Modes, X-Direction (NS)**	**5-170**
Table 5.3.5.2-2	**Modal Properties of First 3 Modes, Y-Direction (EW)**	**5-170**
Table 5.3.5.2-3	**Modal Properties of First 3 Modes, Z-Direction (Vertical)**	**5-170**
Table 5.4.2-1	**Structural Weight of PS/B Dynamic FE Model**	**5-187**
Table 5.4.2-2	**Mass Properties of PS/B Dynamic FE Model**	**5-187**
Table 5.4.2-3	**Modal Properties of First 3 Modes, X-Direction (N-S)**	**5-193**
Table 5.4.2-4	**Modal Properties of First 3 Modes, Y-Direction (E-W)**	**5-193**
Table 5.4.2-5	**Modal Properties of First 3 Modes, Z-Direction (Vertical)**	**5-193**
Table 5.5.1-1	**PS/B Shear Wall In-Plane Shear Stress/Stiffness Evaluation**	**5-208**
Table 5.5.1-2	**Stiffness Evaluation due to Out-of-Plane Bending**	**5-208**
Table 5.5.1-3	**Stiffness Evaluation for Beam, Roof, and Floor Slabs**	**5-208**
Table 5.5.2-1	**R/B Shear Wall In-Plane Shear Stress/Stiffness Evaluation**	**5-210**
Table 5.5.2-2	**Stiffness Evaluation due to Out-of-Plane Bending**	**5-211**
Table 5.5.2-3	**Stiffness Evaluation for Slabs**	**5-212**
Table 5.5.2-4	**R/B Walls Shear Stress Levels Based on Updated SSI analyses**	**5-213**

List of Figures

Figure	Title	Page No.
Figure 4.1-1	Computation and Post-Processing Flow Chart	4-3
Figure 4.2-1	Top 500 ft of the Candidate Shear-Wave Velocity Profiles and associated $\overline{V_S}(30m)$ velocities	4-9
Figure 4.2-2	Cohesionless Soil Modulus Reduction and Hysteretic Damping Curves Used for Profile 270m/sec Followed by the Curves Used for the Soft and Firm Rock Profiles, 560m/sec and 900m/sec	4-10
Figure 4.3.2-1	FE Model of Floor Slabs	4-13
Figure 4.3.2-2	Floor Slab Model Boundary Conditions	4-14
Figure 4.3.2-3	SDOF Elements Connections	4-15
Figure 4.3.2-4	FE Models to Calculate Wall Stiffness Reduction Factors	4-17
Figure 5.1-1	Acceleration, Velocity and Displacement Time History for Component H1 (180)	5-1
Figure 5.1-2	Acceleration, Velocity and Displacement Time History for Component H2 (090)	5-2
Figure 5.1-3	Acceleration, Velocity and Displacement Time History for Component V (UP)	5-3
Figure 5.1-4	5% Damped Response Spectra Plots for Adjusted Northridge, BAL Component H1 (180)	5-4
Figure 5.1-5	5% Damped Response Spectra Plots for Adjusted Northridge, BAL Component H2 (090)	5-5
Figure 5.1-6	5% Damped Response Spectra Plots for Adjusted Northridge, BAL Component V (UP)	5-5
Figure 5.1-7	Normalized Arias Intensity of Time History Components Showing 5%-75% Duration	5-9
Figure 5.2-1	Final Foundation Level Base-Case Shear- And Compressional-Wave Velocity Profiles	5-12
Figure 5.2-2	Poisson Ratios Computed for the Four Base-Case Profiles	5-14
Figure 5.2-3	Median spectra (5% damped) Compared to CSDRS Horizontal Components	5-17

Figure 5.2-4	**Median spectra (5% damped) Compared to CSDRS Vertical Components**	**5-18**
Figure 5.2-5	**Median Spectra (5% damped) Compared to CSDRS Vertical Components Using RG 1.60 V/H Ratios**	**5-19**
Figure 5.2-6	**Strain Compatible Properties Computed for Profile 270 500 ft Depth to Bedrock**	**5-46**
Figure 5.2-7	**Strain Compatible Properties Computed for Profile 270 200 ft Depth to Bedrock**	**5-50**
Figure 5.2-8	**Deleted**	**5-54**
Figure 5.2-9	**Strain Compatible Properties Computed for Profile 560 500 ft Depth to Bedrock**	**5-55**
Figure 5.2-10	**Strain Compatible Properties Computed for Profile 560 200 ft Depth to Bedrock**	**5-59**
Figure 5.2-11	**Strain Compatible Properties Computed for Profile 560 100 ft Depth to Bedrock**	**5-63**
Figure 5.2-12	**Strain Compatible Properties Computed for Profile 900 200 ft Depth to Bedrock**	**5-67**
Figure 5.2-13	**Strain Compatible Properties Computed for Profile 900 100 ft Depth to Bedrock**	**5-71**
Figure 5.2-14	**Strain Compatible Properties Computed for Profile 2032 100 ft Depth to Bedrock**	**5-75**
Figure 5.3.1-1	**Enhanced Lumped-Mass-Stick Model of the R/B Complex**	**5-80**
Figure 5.3.1-2	**Lumped Mass Stick Model for Buildings (R/B, PCCV, CIS)**	**5-96**
Figure 5.3.1-3	**Stick Mass Spring Model for Reactor Coolant Loop**	**5-112**
Figure 5.3.1-4	**Connectivity between RCL and Buildings**	**5-113**
Figure 5.3.2-1	**Basemat Solid Elements**	**5-123**
Figure 5.3.2-2	**Plate Elements Modeling Additional Stiffness of the Central Reactor Mat**	**5-124**
Figure 5.3.2-3	**FE Model Components Under the PCCV**	**5-125**
Figure 5.3.2-4	**FE Model Shear Wall Elements**	**5-126**
Figure 5.3.2-5	**FE Model Plate Elements at Ground Elevation**	**5-127**

Figure 5.3.3.1-1	**Vertical Displacement Results under 1g Load in Vertical Direction (Z)**	**5-128**
Figure 5.3.3.1-2	**Horizontal Displacement Results under 1g Load in Horizontal Direction (X)**	**5-129**
Figure 5.3.3.2-1	**PCCV Lumped Mass Stick Model Transfer Functions, X-Direction**	**5-130**
Figure 5.3.3.2-2	**PCCV Lumped Mass Stick Model Transfer Functions, Y-Direction**	**5-131**
Figure 5.3.3.2-3	**PCCV Lumped Mass Stick Model Transfer Functions, Z-Direction**	**5-132**
Figure 5.3.3.3-1	**ARS, Node CV11, Horizontal Direction**	**5-133**
Figure 5.3.3.3-2	**ARS, Node CV09, Horizontal Direction**	**5-134**
Figure 5.3.3.3-3	**ARS, Node CV06, Horizontal Direction**	**5-134**
Figure 5.3.3.3-4	**ARS, Node CV03, Horizontal Direction**	**5-135**
Figure 5.3.3.3-5	**ARS, Node CV01, Horizontal Direction**	**5-135**
Figure 5.3.3.3-6	**ARS, Node CV11, Vertical Direction**	**5-136**
Figure 5.3.3.3-7	**ARS, Node CV09, Vertical Direction**	**5-136**
Figure 5.3.3.3-8	**ARS, Node CV06, Vertical Direction**	**5-137**
Figure 5.3.3.3-9	**ARS, Node CV03, Vertical Direction**	**5-137**
Figure 5.3.3.3-10	**ARS, Node CV01, Vertical Direction**	**5-138**
Figure 5.3.4.1-1	**Horizontal Displacement Results At Northwest Corner of Reactor Building Under 1g Load in Horizontal Direction (X)**	**5-140**
Figure 5.3.4.1-2	**Horizontal Displacement Results At Southwest Corner of Reactor Building Under 1g Load in Horizontal Direction (X)**	**5-141**
Figure 5.3.4.1-3	**Horizontal Displacement Results At Northeast Corner of Reactor Building Under 1g Load in Horizontal Direction (X)**	**5-142**
Figure 5.3.4.1-4	**Horizontal Displacement Results At Southeast Corner of Reactor Building Under 1g Load in Horizontal Direction (X)**	**5-143**
Figure 5.3.4.1-5	**Horizontal Displacement Results At Northwest Corner of Reactor Building Under 1g Load in Horizontal Direction (Y)**	**5-144**

Figure 5.3.4.1-6	**Horizontal Displacement Results At Southwest Corner of Reactor Building Under 1g Load in Horizontal Direction (Y)**	**5-145**
Figure 5.3.4.1-7	**Horizontal Displacement Results At Northeast Corner of Reactor Building Under 1g Load in Horizontal Direction (Y)**	**5-146**
Figure 5.3.4.1-8	**Horizontal Displacement Results At Southeast Corner of Reactor Building Under 1g Load in Horizontal Direction (Y)**	**5-147**
Figure 5.3.4.2-1	**ANSYS Dynamic Model Transfer Functions, X-Direction**	**5-149**
Figure 5.3.4.2-2	**ANSYS Dynamic Model Transfer Functions, Y-Direction**	**5-150**
Figure 5.3.4.2-3	**ANSYS Dynamic Model Transfer Functions, Z-Direction**	**5-151**
Figure 5.3.4.3-1	**Acceleration Response Spectrum Southwest Corner Elev. 101’-0” Node 2824, NS Direction**	**5-152**
Figure 5.3.4.3-2	**Acceleration Response Spectrum Southwest Corner Elev. 101’-0” Node 2824, EW Direction**	**5-153**
Figure 5.3.4.3-3	**Acceleration Response Spectrum Southwest Corner Elev. 25’-3” Node 2827, NS Direction**	**5-153**
Figure 5.3.4.3-4	**Acceleration Response Spectrum Southwest Corner Elev. 25’-3” Node 2827, EW Direction**	**5-154**
Figure 5.3.4.3-5	**Acceleration Response Spectrum Southeast Corner Elev. 115’-6” Node 2828, NS Direction**	**5-154**
Figure 5.3.4.3-6	**Acceleration Response Spectrum Southeast Corner Elev. 115’-6” Node 2828, EW Direction**	**5-155**
Figure 5.3.4.3-7	**Acceleration Response Spectrum Northeast Corner Elev. 101’-0” Node 2835, NS Direction**	**5-155**
Figure 5.3.4.3-8	**Acceleration Response Spectrum Northeast Corner Elev. 101’-0” Node 2835, EW Direction**	**5-156**
Figure 5.3.4.3-9	**Acceleration Response Spectrum Northeast Corner Elev. 25’-3” Node 2838, NS Direction**	**5-156**
Figure 5.3.4.3-10	**Acceleration Response Spectrum Northeast Corner Elev. 25’-3” Node 2838, EW Direction**	**5-157**
Figure 5.3.4.3-11	**Acceleration Response Spectrum Northeast Corner Elev. 124’-0” Node 2840, NS Direction**	**5-157**
Figure 5.3.4.3-12	**Acceleration Response Spectrum Northeast Corner Elev. 124’-0” Node 2840, EW Direction**	**5-158**
Figure 5.3.4.3-13	**Acceleration Response Spectrum Northeast Corner Elev. 101’-0” Node 2841, NS Direction**	**5-158**
Figure 5.3.4.3-14	**Acceleration Response Spectrum Northeast Corner Elev. 101’-0” Node 2841, EW Direction**	**5-159**

Figure 5.3.4.3-15	**Acceleration Response Spectrum Northeast Corner Elev. 101'-0" Node 2842, NS Direction**	**5-159**
Figure 5.3.4.3-16	**Acceleration Response Spectrum Northeast Corner Elev. 101'-0" Node 2842, EW Direction**	**5-160**
Figure 5.3.4.3-17	**Acceleration Response Spectrum Northeast Corner Elev. 50'-2" Node 2844, NS Direction**	**5-160**
Figure 5.3.4.3-18	**Acceleration Response Spectrum Northeast Corner Elev. 50'-2" Node 2844, EW Direction**	**5-161**
Figure 5.3.4.3-19	**Acceleration Response Spectrum Northeast Corner Elev. 25'-3" Node 2845, NS Direction**	**5-161**
Figure 5.3.4.3-20	**Acceleration Response Spectrum Northeast Corner Elev. 25'-3" Node 2845, EW Direction**	**5-162**
Figure 5.3.4.3-21	**Acceleration Response Spectrum R/B Slab ID 115_30 Elev. 124'-0" Node 3473, Vertical Direction**	**5-162**
Figure 5.3.4.3-22	**Acceleration Response Spectrum R/B Slab ID 76_20a Elev. 76'-5" Node 3545, Vertical Direction**	**5-163**
Figure 5.3.4.3-23	**Acceleration Response Spectrum R/B Slab ID 50_10b Elev. 50'-2" Node 3569, Vertical Direction**	**5-163**
Figure 5.3.4.3-24	**Acceleration Response Spectrum R/B Slab ID 3_32a Elev. 3'-7" Node 3639, Vertical Direction**	**5-164**
Figure 5.3.4.3-25	**Acceleration Response Spectrum R/B Slab ID 3_32d Elev. 3'-7" Node 3645, Vertical Direction**	**5-164**
Figure 5.3.5.1-1	**Horizontal Displacement Results IC00 – IC09 Under 1g Load in Horizontal Direction (X)**	**5-166**
Figure 5.3.5.1-2	**Horizontal Displacement Results IC00 – IC61 Under 1g Load in Horizontal Direction (X)**	**5-167**
Figure 5.3.5.1-3	**Horizontal Displacement Results IC00 – IC09 Under 1g Load in Horizontal Direction (Y)**	**5-168**
Figure 5.3.5.1-4	**Horizontal Displacement Results IC00 – IC61 Under 1g Load in Horizontal Direction (Y)**	**5-169**
Figure 5.3.5.2-1	**CIS Lumped Mass Stick Model Transfer Functions, X-Direction**	**5-171**
Figure 5.3.5.2-2	**CIS Lumped Mass Stick Model Transfer Functions, Y-Direction**	**5-172**
Figure 5.3.5.2-3	**CIS Lumped Mass Stick Model Transfer Functions, Z-Direction**	**5-172**
Figure 5.3.5.3-1	**Acceleration Response Spectrum Node IC03, NS Direction**	**5-173**
Figure 5.3.5.3-2	**Acceleration Response Spectrum Node IC03, EW Direction**	**5-174**
Figure 5.3.5.3-3	**Acceleration Response Spectrum Node IC03, Vertical Direction**	**5-175**

Figure 5.3.5.3-4	**Acceleration Response Spectrum Node IC05, NS Direction**	**5-175**
Figure 5.3.5.3-5	**Acceleration Response Spectrum Node IC05, EW Direction**	**5-176**
Figure 5.3.5.3-6	**Acceleration Response Spectrum Node IC05, Vertical Direction**	**5-176**
Figure 5.3.5.3-7	**Acceleration Response Spectrum Node IC61, NS Direction**	**5-177**
Figure 5.3.5.3-8	**Acceleration Response Spectrum Node IC61, EW Direction**	**5-177**
Figure 5.3.5.3-9	**Acceleration Response Spectrum Node IC61, Vertical Direction**	**5-178**
Figure 5.3.5.3-10	**Acceleration Response Spectrum Node IC62, NS Direction**	**5-178**
Figure 5.3.5.3-11	**Acceleration Response Spectrum Node IC62, EW Direction**	**5-179**
Figure 5.3.5.3-12	**Acceleration Response Spectrum Node IC62, Vertical Direction**	**5-179**
Figure 5.4.1-1	**ACS SASSI Dynamic Model Basemat (Elev. -26’-4”)**	**5-180**
Figure 5.4.1-2	**ACS SASSI Dynamic Model Intermediate Floor (Elev. -14’-2” & -4’-10”)**	**5-181**
Figure 5.4.1-3	**ACS SASSI Dynamic Model First Floor (Elev. 3’-7”)**	**5-182**
Figure 5.4.1-4	**ACS SASSI Dynamic Model Intermediate Floor (Elev. 24’-2”)**	**5-183**
Figure 5.4.1-5	**ACS SASSI Dynamic Model Roof (Elev. 39’’-6”)**	**5-184**
Figure 5.4.1-6	**ACS SASSI Dynamic Model Beams & Columns**	**5-185**
Figure 5.4.2-1	**Horizontal Displacement Results Under 1g Load in NS Direction (X)**	**5-188**
Figure 5.4.2-2	**Horizontal Displacement Results Under 1g Load in EW Direction (Y)**	**5-188**
Figure 5.4.2-3	**Vertical Displacement Results Under 1g Load in Vertical Direction (Z)**	**5-189**
Figure 5.4.2-4	**Verification of Mesh Size in X-Direction**	**5-190**
Figure 5.4.2-5	**Verification of Mesh Size in Y-Direction**	**5-191**
Figure 5.4.2-6	**Verification of Mesh Size in Z-Direction**	**5-192**
Figure 5.4.2-7	**ACS SASSI Dynamic Model Transfer Functions, X-Direction**	**5-194**
Figure 5.4.2-8	**ACS SASSI Dynamic Model Transfer Functions, Y-Direction**	**5-195**

Figure 5.4.2-9	**ACS SASSI Dynamic Model Transfer Functions, Z-Direction**	**5-196**
Figure 5.4.2-10	**ARS Comparison, Basemat X-Direction**	**5-197**
Figure 5.4.2-11	**ARS Comparison, Basemat Y-Direction**	**5-198**
Figure 5.4.2-12	**ARS Comparison, Basemat Z-Direction**	**5-199**
Figure 5.4.2-13	**ARS Comparison, Ground Floor X-Direction**	**5-200**
Figure 5.4.2-14	**ARS Comparison, Ground Floor Y-Direction**	**5-201**
Figure 5.4.2-15	**ARS Comparison, Ground Floor Z-Direction**	**5-202**
Figure 5.4.2-16	**ARS Comparison, Roof X-Direction**	**5-203**
Figure 5.4.2-17	**ARS Comparison, Roof Y-Direction**	**5-204**
Figure 5.4.2-18	**ARS Comparison, Roof Z-Direction**	**5-205**

List of Acronyms

The following list defines the acronyms used in this document.

3-D	**three dimensional**
ARS	**amplified response spectra**
CEUS	**Central and Eastern United States**
CIS	**containment internal structure**
CM	**center of mass**
CSDRS	**certified seismic design response spectra**
DCD	**design control document**
EW	**east-west**
FE	**finite element**
FH/A	**fuel handling area**
GMPE	**ground motion prediction equation**
ISRS	**in-structure response spectra**
MCP	**main coolant piping**
MHI	**Mitsubishi Heavy Industries**
NRC	**Nuclear Regulatory Commission**
NS	**north-south**
PCCV	**prestressed concrete containment vessel**
PGA	**peak ground acceleration**
PS/B	**power source building**
RAI	**request for additional information**
R/B	**reactor building**
RCL	**reactor coolant loop**
RCP	**reactor coolant pump**
RG	**Regulatory Guide**
RV	**reactor vessel**
SC	**steel-concrete**
SG	**steam generator**
SDOF	**single degree of freedom**
SRP	**Standard Review Plan**

SSC	**structure, system, and component**
SSI	**soil-structure interaction**
TF	**transfer functions**
TR	**technical report**
US	**United States**
V	**vertical**
WNA	**western North America**

1.0 INTRODUCTION

The design of US-APWR standard plant structures is based on the analyses of the seismic responses of dynamic models, considering the effects of soil-structure interaction (SSI). Consistent with the US-APWR design control document (DCD), the seismic response analyses incorporates each of the following issues:

- development of adequate acceleration time histories compatible to the US-APWR certified seismic design response spectra (CSDRS) used as input design ground motion in the analyses;

- consideration of generic soil profiles that can provide an adequate representation of conditions at candidate sites within the continental United States (US);

- adequate consideration of the frequency dependence of the SSI;

- ability of the models to adequately represent the dynamic properties of the structures, and to address the effects of concrete cracking on the seismic response.

This report documents the development of time histories of the three ground motion components compatible to US-APWR CSDRS. The time histories are synthesized using seed ground motion recordings that are in full compliance with the criteria of Standard Review Plan (SRP) 3.7.1 (Reference 1), Subsection 3.7.1.II.1B. In addition, the seismic design is to be based on a set of SSI analyses performed using the computer program ACS SASSI (Reference 2) that captures the frequency dependence of the SSI system and addresses the effect of the soil layering and elevation of the ground water table. These SSI analyses consider generic profiles representing layered subgrade properties. The development of the generic layered site profiles consistent with the CSDRS are documented in this technical report.

A finite element (FE) structural model for SSI analyses of the bounding power source building (PS/B) configuration is developed and converted into ACS SASSI format. This report presents the PS/B FE structural model and the results of the validation analyses performed to demonstrate its ability to accurately represent the dynamic properties of the PS/B at all important modes of vibration.

Lumped mass stick models are developed representing the dynamic properties of the prestressed concrete containment vessel (PCCV), containment internal structures (CIS) and the portion of the R/B located above the ground elevation. To account for the effects of dynamic coupling of the CIS with the equipment and the piping, the model of the R/B complex includes a lumped mass stick model of the reactor coolant loop (RCL) representing the stiffness and mass inertia properties of the major equipment and piping. The model of the R/B complex is further enhanced to incorporate single degree of freedom (SDOF) models representing the out-of-plane flexibility of slabs and walls. This report presents the methodology used for development of lumped mass stick model for SASSI analyses of the R/B complex in Section 4.3 and describes and these models in Section 5.3.

The methodology and structural modeling approach used in the SSI analyses of R/B complex and the PS/B address the effects of concrete cracking on the seismic response of the buildings by adjusting the stiffness properties of the structural members affected by the concrete cracking. This report describes how the effects of the concrete cracking are addressed in the dynamic modeling of R/B complex and PS/B.

The CSDRS compatible ground motion time histories, the generic layered profiles and the structural dynamic models described in this report define the input for the SSI analyses of the US-APWR standard plant seismic Category I structures. Refer to Technical Report MUAP-10006, "Soil-Structure Interaction Analyses and Results for the US-APWR Standard Plant" (Reference 24), for the results of these SSI analyses. The validation of the lumped mass stick models of the PCCV, CIS and R/B lumped mass stick model is performed following the methodology and results described in Section 4.3.4 and Section 5.3.3 through 5.3.5 of this Technical Report. The validation of the FE structural model is performed following the methodology and results described in Section 4.4 and Section 5.4.2 of this Technical Report.

The analytical models of the structures are described in Subsection 3.7.2 of the US-APWR DCD and are also presented in this report in Sections 4 and 5. The standard design of the R/B complex and PS/B is based on seismic response analyses of these models.

2.0 PURPOSE

The purpose of this technical report is to outline the technical approach related to the development of the design bases for the seismic response analyses of the US-APWR R/B complex and PS/Bs. This report outlines the general methodology used for the development of the structural models of the R/B complex and PS/Bs and the soil profiles used for standard design.

A detailed discussion regarding the following input parameters and modeling issues is also provided to resolve request for additional information (RAI) questions and comments by the NRC, as summarized in Table 2.0-1:

1. Establishment of CSDRS compatible acceleration time histories
2. Development of generic layered soil profiles and strain compatible properties
3. Development and validation of the SASSI lumped mass stick model of R/B complex
4. Development and validation of the SASSI FE Model of PS/B
5. Consideration of Concrete Cracking

Table 2.0-1 Resolution Methodology for RAI Questions on Seismic Design Basis (Sheet 1 of 4)

RAI #	Question #	Issue	Resolution Methodology
Generic Subgrade Profiles for SSI Analyses			
212	**3.7.2-1**	SSI frequency dependence and layering effects	Revised set of SSI analyses that consider effects of SSI frequency dependance and subgrade layering provide the basis for the standard sesimc design. This report presents the design basis used for the revised seismic analyses documented in MUAP-10006 (Reference 24).
496	**3.8.5-23**	Shape of basemat, mass center of structure	This report addresses the methods used for dynamic modeling of the re-configured R/B complex, which has a more uniform rectangular shape over its depth. The dynamic analysis results for the reconfigured R/B are presented in MUAP-10006 (Reference 24)"
496	**3.8.5-24**	Uncertainties in soil properties in each subgrade type	This report addresses changes which are incorporated in the standard plant seismic analysis with respect to consideration of layering effects in the subgrade, through the use of generic layered soil profiles and the consideration of frequency-dependence of the subgrade.
496	**3.8.5-25**	Effects of soil material damping	Soil material damping values are considered for the generic layered profiles that are used for the SSI analyses discussed in this report.
Concrete Cracking Effects in Dynamic Analysis and in Development of ISRS			
212	**3.7.2.4**	ISRS at support locations of Seismic Category I equipment	MUAP10006 (Reference 24) provides ISRS developed from the results of revised SSI analyses, that define the seismic design input for design of Seismic Category I equipment located at different locations within R/B complex and PS/B.
212	**3.7.2-8**	ISRS considering local vibration modes	The enhanced R/B dynamic stick model modeling method presented in this report incorporates single degree of freedom (SDOF) models representing the out-of-plane response of flexible slabs and walls. The stiffness of the SDOF is reduced to account for the concrete cracking. The development of the PS/B FE dynamic model captures slab and wall flexibility effects directly in the dynamic modeling. The properties of shell elements used to model slabs and walls are adjusted to consider reduction of out-of-plane stiffness due to concrete cracking.

Table 2.0-1 Resolution Methodology for RAI Questions on Seismic Design Basis (Sheet 2 of 4)

RAI #	Question #	Issue	Resolution Methodology
212	**3.7.2-15**	Effects of potential concrete cracking	The effects of potential concrete cracking on structural stiffnesses are considered in the development of ISRS. Updated ISRS, derived with consideration given to potential concrete cracking, are presented in MUAP-10006 (Reference 24). The structural modeling methodology presented in this report addresses the potential effects of concrete cracking by adjusting stiffness of those reinforced concrete members that are subjected to high stress levels under the most critical seismic load combination. The report also addresses modeling enhancements which capture the local effects of wall and slab flexibility. The updated ISRS which include both the broadened ISRS used for design and the unbroadened ISRS obtained from the raw analysis results are presented in MUAP-10006 (Reference 24).
490	**3.8.1-10**	Effects of cracking on the seismic analysis/response of the PCCV	The seismic modeling and analysis of the PCCV is based on uncracked section properties, and the stiffness of the PCCV is not reduced. Besides small localized areas, the pre-stressed concrete of the PCCV remains generally in compression under mechanical loads, such that cracking effects on the seismic response of the structure are insignificant.
491	**3.8.3-16**	Explanation and justification of analysis approach with respect to cracking effects of SC modules	The models used for revised SSI analyses of R/B complex address the effect of concrete cracking on the stiffness of the containment internal structure.

Table 2.0-1 Resolution Methodology for RAI Questions on Seismic Design Basis (Sheet 3 of 4)

RAI #	Question #	Issue	Resolution Methodology
491	**3.8.3-25**	Consideration of cracking effects of SC modules in load combinations involving seismic and thermal loading	As described in this report, the lumped mass stick model of the containment internal structure is revised and the stiffness of the model is adjusted to take into account the reduction of stiffness due to cracking of the concrete under thermal load.
497	**3.8.4-33**	Effects of concrete cracking on lateral displacement	The models account for the effects of concrete cracking by reducing their stiffness of the reinforced concrete members subjected to high stresses as described in this report. Thus, the SSI analyses results for lateral seismic displacements reflect directly the effects of concrete cracking. MUAP-10006 (Reference 24) presents results of SSI analyses for the maximum displacements of R/B complex and PS/B relative to the free field. The structural design of the standard plant uses these maximum displacement results in combination with displacements due to differential settlement to demonstrate that the gap between the buildings is sufficient to prevent their collision during earthquake. The current DCD limits for acceptable settlement are given in Chapter 2 Table 2.0-1.
497	**3.8.4-38**	Effects of concrete cracking on seismic analyses	The effects of concrete cracking on the seismic analysis results are discussed in detail in this report, including the discussion of how these effects are incorporated into the models used for seismic analyses.
Validation of the dynamic models (including sufficient ability to capture high-frequency content of the input motion)			
211	**3.7.1-6**	Ensuring adequate DOFs in the dynamic models to capture seismic response in high frequency range	Enhancements made to the dynamic models as described in this report ensure that the criteria of SRP 3.7.2 II A (iv) are met.
212	**3.7.2-3**	Validation of R/B lumped mass stick models	Additional information with respect to validation of the US-APWR lumped mass stick models is provided in this report.

Table 2.0-1 Resolution Methodology for RAI Questions on Seismic Design Basis (Sheet 4 of 4)

RAI #	Question #	Issue	Resolution Methodology
212	**3.7.2-17**	Description of how lumped mass and distributed mass models meet SRP 3.7.2.II.3C	Additional information is included on the validation comparison between the dynamic responses of the lumped mass stick models and the FE distributed mass models, including description of the frequency domain time history analysis of the fixed base detailed FE model.
212	**3.7.2-18**	Modeling methods and validation of dynamic model for PS/Bs	The seismic design of the PS/B is based on time history analysis of the PS/B FE model, which meets the dynamic analysis criteria of SRP 3.7.2, Section II.1.A.
Establishment of Input Ground Motion Acceleration Time Histories			
211	**3.7.1-1**	Nonexceedances of the ground motion time histories	This report presents time histories that are synthesized using seed ground motion recordings that are in full compliance with the requirements of SRP Subsection 3.7.1.II.1B, and therefore represent an appropriate time history representation of the modified Regulatory Guide 1.60 response spectrum.
211	**3.7.1-2**	Enveloping the target response spectra.	See resolution methodology for Question 3.7.1-1.
211	**3.7.1-3**	Generation of time histories based on seed recordings of earthquake motion.	See resolution methodology for Question 3.7.1-1.

3.0 OBJECTIVES

3.1 CSDRS Compatible Ground Motion Time Histories

In compliance with the requirements of SRP 3.7.1 (Reference 1), Subsection 3.7.1.II.1B, Option 1 Approach 2, the objective is to generate a set of three components of an artificial time history earthquake by adjusting real ground motion recordings from an actual earthquake as the seed. This results in a set of three statistically independent time history components that are compatible with the two horizontal directions and the vertical direction of the US-APWR CSDRS. These adjusted acceleration time histories are used as input ground motion for the SSI analyses described within this technical report. Development of the adjusted time history components also addresses RAI 211-1946, Questions 3.7.1-1, 3.7.1-2, and 3.7.1-3, regarding the content of the acceleration time histories used in previous revisions of the DCD.

3.2 Generic Layered Soil Profiles and Strain Compatible Properties

The objective is to provide a set of input subgrade properties for the SSI analyses that are compatible with the US-APWR CSDRS and the strains generated by the input ground motion. A set of generic layered soil profiles are developed and used as input for the set of SSI analyses described within this technical report. These subgrade properties envelopes the effects of geological, geotechnical, and hydrological site parameters for representative nuclear power plant sites within the continental US. The generic layered profiles, for which strain-compatible properties, shear- and compressional-wave velocities and corresponding hysteretic damping values are developed, provide a wide variation of properties that addresses ranges in dynamic soil properties expected at typical sites across Central and Eastern United States (CEUS). The use of generic layered profiles addresses the subject of soil properties in RAI 496-3735, Question 3.8.5-24, and soil damping in Question 3.8.5-25. The SSI analyses with the set of generic layered soil profiles also consider the effects of the frequency dependence of the SSI, the layering of the subgrade, and the elevation of water table. This technical report also addresses issues regarding seismic analyses requirements discussed during a conference call between the Nuclear Regulatory Commission (NRC) and Mitsubishi Heavy Industries (MHI) on September 28, 2009.

3.3 Enhanced ACS SASSI Lumped-Mass-Stick Model of R/B Complex

The objective of the ACS SASSI model is to provide an adequate representation of the dynamic properties of the building, and to be able to capture SSI effects related to the flexibility of the basemat foundation. The model is used for the SASSI analyses of the R/B complex and enables the incorporation of effects on the seismic response of the building due to frequency dependence of the SSI impedance, layering of the subgrade, elevation of the water table, and scattering of input ground motion.

An ACS SASSI lumped mass stick model of the R/B complex includes the lumped mass stick models of the R/B, PCCV, CIS coupled with the RCL and a (3-D) FE model of the R/B complex basement. The lumped mass stick model representing the dynamic properties of the R/B is enhanced by including SDOF models to capture the out-of-plane response of flexible slabs and walls and to address modeling concerns raised in RAI 212-1950, Question 3.7.2-8. The stiffness properties of the R/B complex model are also adjusted to address concerns raised in RAI 497-3734, Questions 3.8.4-33 and 3.8.4-38 regarding the effects of concrete cracking on the seismic response of the building. The R/B complex model incorporate the latest configuration of the R/B basement, which eliminates the previous “dent” in the foundation underneath the PCCV area and also “boxes out” the region underneath the

R/B fuel handling area. These configuration and modeling enhancements minimize irregularities in the R/B basement as noted in RAI 496-3735, Question 3.8.5-23. RAI 211-1946, Question 3.7.1-6, raised concerns about the adequacy of the R/B complex model. The R/B lumped mass stick model provides adequate degrees of freedom to ensure that the modeling requirements of SRP 3.7.2 (Reference 4), Section II A (iv) are met, and that the seismic response in the high frequency range is captured. The models use complex damping formulation in ACS SASSI (Reference 2) to model the dissipation of energy due to material damping of the structural members and the soil.

A set of validation analyses are performed to demonstrate the ability of the R/B complex lumped mass stick model to adequately represent the dynamic properties of the structure. The results of the validation analyses, which are also in response to RAI 212-1950, Question 3.7.2-3, are presented in Sections 5.3.3, 5.3.4 and 5.3.5 of this technical report.

A set of SSI analyses, documented in the Technical Report MUAP 10006 (Reference 24), are performed on the ACS SASSI lumped mass stick model of the R/B complex resting on the surface of the set of generic layered subgrade profiles. The set of acceleration time histories presented in this report are used as input ground motion at the bottom of the basemat foundation. The SASSI analyses provide results for 0.5%, 2%, 3%, 4%, 5%, 7%, 10% and 20% damping acceleration response spectra (ARS) at lumped mass locations and member forces of the stick elements representing the shear walls at each major floor elevation. The envelope of the ARS results are used to develop in-structure response spectra (ISRS) that are broadened in a manner that ensure applicability of the standard design for a wide variety of candidate sites. The resulting ISRS therefore capture the effects of potential concrete cracking on structural stiffness and local vibration modes, as noted in RAI 212-1950 Question 3.7.2-15. The results of these SSI analyses are presented inMUAP-10006 (Reference 24). The technical report MUAP-10006 includes both the broadened ISRS used for design as well as the unbroadened spectra extracted directly from the analyses results. The updated SSI analyses results also address the development of ISRS noted in RAI 498-3782, Questions 3.9.2-61 and 3.9.2-62.

3.4 ACS SASSI FE Model of the PS/Bs

The objective of the ACS SASSI FE model of the PS/B is to adequately represent the dynamic properties of the building and to capture SSI effects related to the flexibility of the basemat foundation. This dynamic model is used for the SASSI analyses of the PS/B documented in Technical Report MUAP-10006 (Reference 24) to provide input design parameters that appropriately address the effects of the frequency dependence of the SSI impedance, layering of the subgrade, elevation of the water table and scattering of input ground motion. The ACS SASSI analyses use complex damping formulation to account for the dissipation of energy due to material damping.

The ACS SASSI dynamic FE model is a 3D FE model of the west PS/B. It is initially developed using the computer program ANSYS before being translated into SASSI format using the built-in file converter in ACS SASSI.

The ACS SASSI dynamic FE model is validated as follows: First static and dynamic analyses are performed on a detailed static FE model of the PS/B, a 3D model translated from NASTRAN to ANSYS that was used in basic structural design of the PS/B, to obtain a validation basis. A set of fixed-base static and modal analyses are then performed on the dynamic ANSYS model and the results compared to those obtained from the detailed static FE model analyses to validate the dynamic properties and accuracy of the dynamic ANSYS model before being translated into ACS SASSI. Once translated to SASSI, validation SSI analyses are performed with the newly translated PS/B dynamic model resting on the surface of a uniform half-space with very high stiffness to simulate fixed base conditions. Transfer functions (TFs) and ARS are obtained from the SASSI validation analyses at selected nodes and are then compared to the results obtained from the analyses on the detailed static model.

The development and validation of the ACS SASSI FE Model described above, addresses the subject of RAI 212-1950, Question 3.7.2-18.

With the model validation completed, a set of SSI analyses are then performed on the ACS SASSI dynamic FE model of the PS/B using as input the set of generic layered subgrade profiles and acceleration time histories presented in this report. Acceleration Response Spectra (ARS) at selected locations within the building are then obtained for all subgrade profiles for various damping ratios (0.5%, 2%, 3%, 4%, 5%, 7%, 10% and 20%) 5% damping ISRS serving as input for seismic design of Category I equipment and components are then developed as a broadened envelope of all ARS obtained for each selected location. These ISRS thus ensure the applicability of the standard design of Category I equipment and components for a wide variety of candidate sites. The ISRS capture the effects of potential concrete cracking on structural stiffness and local vibration modes, which was noted in RAI 212-1950, Question 3.7.2-15._The effects of potential concrete cracking on structural stiffness and local vibration modes as noted in RAI 212-1950, Question 3.7.2-15 is also taken into account in these SSI analyses. Maximum acceleration results at all nodal points that are enveloped and used to develop SSE loads for the design of the PS/B structure are also obtained from these analyses. The updated ISRS presented in MUAP-10006 include both the broadened ISRS used for design, as well as the unbroadened spectra extracted directly from the enhanced seismic modeling and analyses results. The updated ISRS addresses the development of ISRS as noted by RAI 498-3782, Questions 3.9.2-61 and 3.9.2-62.

3.5 Consideration of Concrete Cracking in Dynamic Analyses

The objective of the concrete cracking evaluation is to appropriately address the effects of concrete cracking in the dynamic structural models used for SSI analyses of the R/B Complex and PS/B.

Provisions of the current NRC and industry standards are reviewed for consideration of the effects of concrete cracking when modeling the effective stiffness of reinforced concrete members for dynamic analyses. The stresses in the reinforced concrete members under the most critical seismic load combination are evaluated and used to assess the potential for concrete cracking. The stiffness of the reinforced concrete members that crack under the most critical load combination are adjusted based on the provisions and recommendations of the industry standards.

The stiffness of the lumped mass stick model of the containment internal structure is reduced by 25% in order to account for the effects of concrete cracking resulting from the thermal loads acting on the structure in combination with the design seismic load as noted in RAI 491-3733, Question 3.8.3-25. The SSI analyses documented in MUAP-10006 (Reference 24) consider the stiffness of the steel/concrete modules to be 75% of the nominal stiffness as a best estimate value for evaluation of seismic design loads and in-structure response spectra.

4.0 APPROACH

4.1 CSDRS Compatible Ground Motion Time Histories

One set of three statistically independent components of an artificial time history seismic motion is generated for use as the input seismic motion in the earthquake response analysis of the US-APWR standard plant. The three time history components were generated to represent the ground motion for three mutually orthogonal earthquake component directions. Following the requirements of SRP 3.7.1 (Reference 1), Subsection 3.7.1.II.1B, Option 1 Approach 2, two components (“H1” in the north-south [NS] direction, and “H2” in the east-west [EW] direction) compatible to the horizontal direction target response spectra and one component (“V” in the vertical direction) compatible to the vertical direction target response spectra are generated.

The three orthogonal directions may be alternately referred to within this technical report using the following different designations:

H1 (180) = Direction 1 = NS = Plant north-south = Global X-axis

H2 (090) = Direction 2 = EW = Plant east-west = Global Y-axis

V (UP) = Direction 3 = Vertical = UD = Up-Down = Global Z-axis

Approach 2 is implemented with the objective of generating artificial acceleration time histories such that when converted to response spectra achieve approximately mean based fits to the target CSDRS presented in Figures 3.7.1-1 and 3.7.1-2 of the DCD. The control points of the CSDRS are shown in Table 4.1-1 for damping of 0.5%, 2%, 5%, 7% and 10%. The control points of the CSDRS are based on a modified Regulatory Guide (RG) 1.60 (Reference 16) response spectra as described in Subsection 3.7.1.1 of the DCD. The modified RG 1.60 response spectra used as the target spectra is extended here to 0.1 Hz. The extension maintains the constant displacement below 0.25 Hz as shown on the tripartite curves of RG 1.60. The average ratio of the ARS calculated from the artificial time histories to the corresponding target CSDRS is kept only slightly greater than one. The spectral acceleration ratio is calculated at each of the 100 frequency points per decade. The PGA of the CSDRS is 0.3g which exceeds the minimum 0.1g value required per 10 Code of Federal Regulations (CFR) 50 Appendix S (Reference 23).

The BAL (Mt Baldy, CA) recording of the January 14, 1994, Northridge earthquake (magnitude **M**6.7), is used as the seed ground motion for generating the time history motions. The Northridge BAL recording was selected because it has the required duration and correlation (statistical independence among the three components comprising the time history earthquake).

The components of the recorded time history earthquake were spectrally matched to the target response spectra at the damping of 5%, using the RSPMatch code of “Non-Stationary Spectral Matching” (Reference 5). This code is based on a low frequency modification of the procedure described in “Generation of Synthetic Time Histories Compatible with Multi-Damping Design Response Spectra” (Reference 6). This method is developed to retain non-stationary features of the input ground motion in the course of spectrally matching it to the target spectra. To further confirm spectra match in accordance with SRP 3.7.1 of the time history motions generated using the RSPMatch code, independent conversion of the time history components to response spectra are also performed using the SPECTRA Computer Program (Reference

21). The method used here to generate this time history motions is also appropriate to generate other multiple time history motions to perform non-linear analyses.

Table 4.1-1 Target Control Points for US-APWR CSDRS

Horizontal Control Points			Vertical Control Points		
Frequency (Hz)		Acceleration (g)	Frequency (Hz)		Acceleration (g)
0.5% Damping			0.5% Damping		
A	(50)	0.3	A	(50)	0.3
B	(12)	1.49	B	(12)	1.49
C	(2.5)	1.79	C	(3.5)	1.70
D	(0.25)	0.22	D	(0.25)	0.15
E	(0.1)	0.035	E	(0.1)	0.024
2% Damping			2% Damping		
A	(50)	0.3	A	(50)	0.3
B	(12)	1.06	B	(12)	1.06
C	(2.5)	1.28	C	(3.5)	1.22
D	(0.25)	0.17	D	(0.25)	0.12
E	(0.1)	0.028	E	(0.1)	0.018
5% Damping			5% Damping		
A	(50)	0.3	A	(50)	0.3
B	(12)	0.78	B	(12)	0.78
C	(2.5)	0.94	C	(3.5)	0.89
D	(0.25)	0.14	D	(0.25)	0.094
E	(0.1)	0.0226	E	(0.1)	0.015
7% Damping			7% Damping		
A	(50)	0.3	A	(50)	0.3
B	(12)	0.68	B	(12)	0.68
C	(2.5)	0.82	C	(3.5)	0.78
D	(0.25)	0.13	D	(0.25)	0.086
E	(0.1)	0.021	E	(0.1)	0.014
10% Damping			10% Damping		
A	(50)	0.3	A	(50)	0.3
B	(12)	0.57	B	(12)	0.57
C	(2.5)	0.68	C	(3.5)	0.65
D	(0.25)	0.12	D	(0.25)	0.078
E	(0.1)	0.019	E	(0.1)	0.012

Notes:
1. 0.3 g PGA
2. Based on RG 1.60, Revision 1 amplification factors
3. For Control Point D & E, acceleration is computed as follows:
   Acceleration = $(\varpi^2 D / 386.4 \text{ in/sec}^2)(F_A)(0.3)$
   ϖ = 2π(frequency) [rad/sec]
   D = Displacement [in]
   F_A = Amplification Factor from Regulatory Guide 1.60

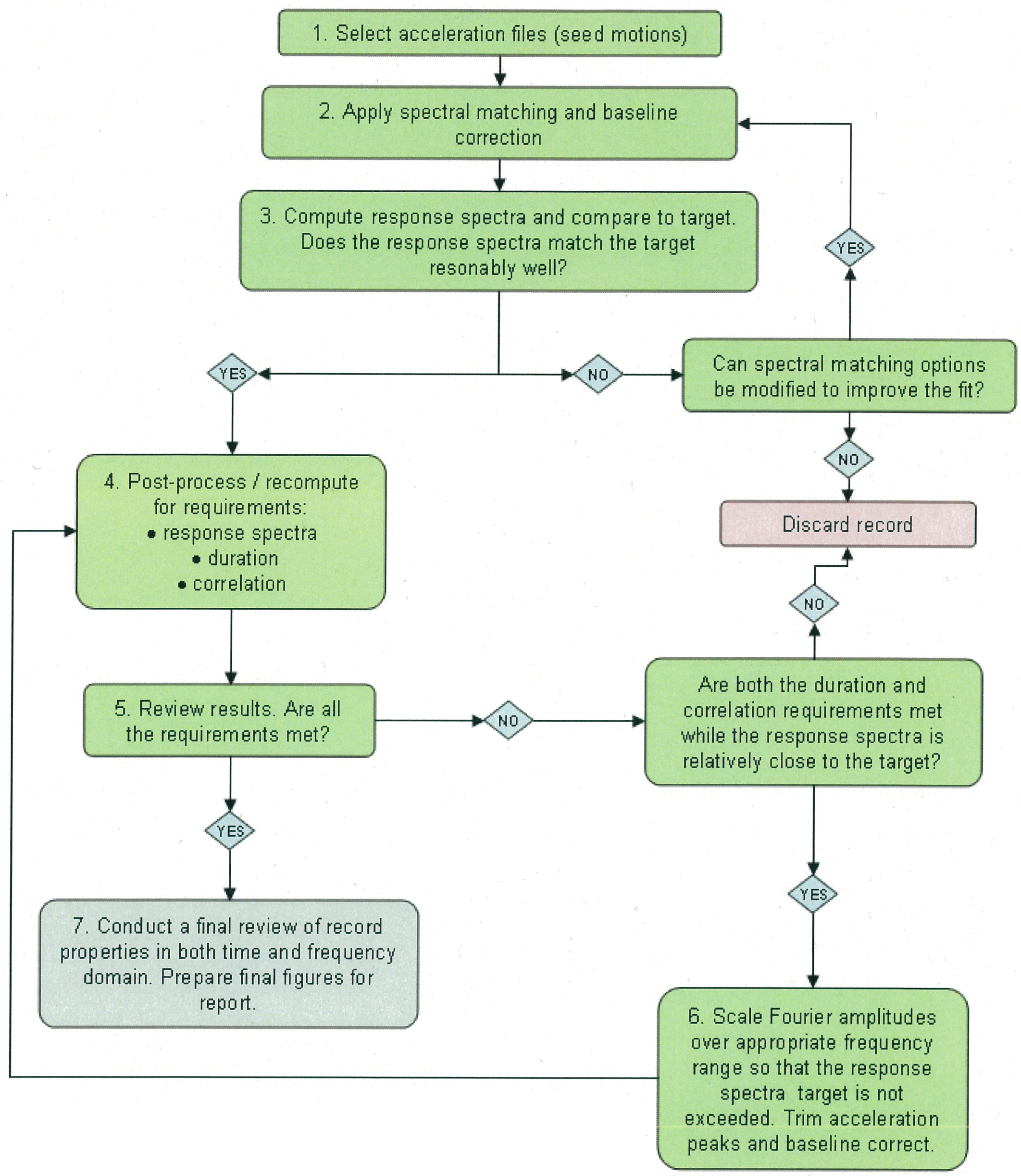


Figure 4.1-1 Computation and Post-Processing Flow Chart

The computation and SRP 3.7.1 post-processing verification scheme is summarized in Figure 4.1-1 and described in greater detail below:

1. Select seed ground motion time series. A segment of the record time series is selected to optimize the duration of the record. This selection is by visual inspection of the time series for truncation of the record. This is referred to as the original seed record.

2. Run the RSPMatch code. Complete a large number of runs to find the optimal combination of settings to use in RSPMatch. The procedure considered optimal follows:

    a. Run RSPMatch to simultaneously match the target for the five damping ratios defined in the target and multiple iterations.

    b. Apply baseline correction to the matched time history motion.

    c. Rerun RSPMatch to match only the 5% damped spectral target, only with a single iteration.

    d. Apply baseline correction to that time history motion.

3. Repeat these steps as needed to optimize the spectral match of the time series to the target.

4. Run the MatLab post-processors for SRP 3.7.1 verifications:

    a. Combine the data files after spectral matching and baseline correction using MatLab script. There is one file for each record component.

       This software reads the files and combines the data for a given station into a single matrix/table in a standardized fashion: Columns are as follow:

        1. Time vector
        2. First horizontal component H1
        3. Second horizontal component H2
        4. Vertical component V

    b. Post-process the data using MatLab script or tabularized computations. The script reads the files generated above and performs the following tasks: (Each task that is an option in the script can be enabled/disabled.)

        1. Plot time series (recorded and modified motions)
        2. Compute and plot response spectra (modified motions only)
        3. Compute the Arias intensity and duration (recorded and modified motions)
        4. Compute components correlation (recorded and modified motions)
        5. Compute and plot spectrograms (frequency content with time)

5. Review record properties from SRP 3.7.1 post-processing verifications. If the record matches all the criteria, it is considered to be final. If the record does not match one of the criteria, it is discarded. Exception: In cases where the duration and correlation criteria are matched but the 5% damped S_a is slightly below the target at isolated periods, proceed to step 6.

6. [Optional] For the exception case defined in Step 5, the post-processors from Step 2 of 4b are run. An iterative process for scaling the Fourier amplitudes over appropriate frequency bands can be used until the response spectra meets the target.

   The records are then re-processed for baseline correction before the final post-processing verifications. This involves the trimming of peaks exceeding the PGA target and baseline correction of the acceleration time series.

7. The baseline-corrected records are post-processed following the detailed procedure from Step 4. Final SRP 3.7.1 post-processing verifications are then independently performed using the SPECTRA computer program to review data and plots generated to verify that the time history components match all the applicable criteria.

4.2 Development of Soil Profiles and Strain Compatible Properties

In place of the generic subgrade properties for a uniform half-space that served as the basis for seismic analysis in Revision 2 of the DCD, a complete suite of soil profiles and depths to basement material (to be subsequently referred to as “baserock”) was developed. The soil profiles were initially developed to cover the entire range of generic site conditions from deep soft soil to firm rock that may exist across CEUS. The initial profile development recognizes that for the softer conditions, the shallow materials would be either removed or improved for appropriate foundation conditions. From the exhaustive suite of candidate sites, a subset of profiles and depths to baserock material is selected. Strain compatible properties, shear- and compressional-wave velocities and corresponding hysteretic damping values, are developed for the subset of profiles and baserock depths that are consistent with the CSDRS. The suite of profiles is based on averaging measured profiles with similar velocities at sites located in western North America (WNA), and CEUS, coupled with judgment. Because measurements typically do not extend to the same depths for all profiles averaged within groups of similar surficial geology or velocities, as the number of available profiles generally decreases rapidly with depth as noted in "Surface Geology Based Strong Motion Amplification Factors for the San Francisco Bay and Los Angeles Areas" (Reference 7). Therefore, judgment was used to extend the generic profiles at the deeper depths.

To make the suite of profiles regionally appropriate for CEUS sites, the baserock conditions are set to that of hard rock, about 9,300 ft/s (2.83 km/s, EPRI Technical Report [TR] TR-102293 [Reference 8]). This value is consistent with the hard rock site conditions defined in EPRI TR-1009684 (Reference 9) ground motion prediction equations (GMPEs) that are currently used to characterize the hard rock hazard in CEUS. The generic profiles are classified using $\overline{V_S}$ (30m), the average shear-wave velocity over the top 30 meters. This classification is consistent with current practice for building codes and is a convenient metric with which to distinguish the initial profiles, prior to soil removal or improvement. The initial suite of eight candidate profiles is illustrated in Figure 4.2-1 to depths of 500 feet and ranges in $\overline{V_S}$ (30m) from soft soil at 180 m/s to firm rock at 2,032 m/s. Also shown is the consensus baserock shear-wave velocity for CEUS at 2.83 km/s, as referenced by EPRI documents TR-102293 (Reference 8) and TR-1009684 (Reference 9). To accommodate the possible range in profiles for CEUS, a suite of profile depths to rock conditions is developed ranging from 25 feet to 2,000 feet. The suite of seven profile depth bins is listed on Table 4.2-1 along with the $\overline{V_S}$ (30m) values for each category. For the shallow profiles, 500 ft and less, a soft rock layer was inserted above the hard basement rock ($\overline{V_S}$ = 2.83 km/sec, Table 4.2-1) to accommodate the presence of dense cemented sands and sedimentary rocks (sandstones, shales, claystones) beneath the softer profiles, 560m/sec and below. Based on site conditions at existing nuclear power plants located in CEUS (EPRI TR-1016736, Reference 25), the soft rock layer was taken as 1,000 ft (304m) thick with a shear-wave velocity of 1 km/sec (compressional-wave velocity = 2.36 km/sec, density = 2.15g/cm^3, Table 5.2.3 to Table 5.2.6). The soft rock layer was assumed to exhibit linear behavior under the moderate loading levels of the site response analyses (Section 5.2.1) with the shear- and compressional-wave damping fixed at 0.5% ($Q_{S,P}$ = 100). For site conditions consisting of shallow soils or soft rock directly overlying hard rock (e.g. $V_S \geq$ 2.83 km/sec) site-specific analyses will be performed. Also listed on Table 4.2-1 for reference is the hard rock crustal model, the top layer of which defines the CEUS baserock conditions (EPRI TR-102293 [Reference 8] and TR-1009684 [Reference 9]).

4.2.1 Selection of Profiles

The profiles adopted for the development of CSDRS consistent strain compatible properties include 270 m/s, 560 m/s, 900 m/s, and 2,032 m/s. The development of strain compatible profiles considers additional soil removal if necessary to maintain a minimum (-1σ) strain compatible shear-wave velocity of at least 800 ft/s near the surface. Three depths of soil/rock profiles above the hard or soft rock foundations are considered: 100 ft, 200 ft, and 500 ft. Due to the stiffness of the 2,032 m/s firm rock profile, only a 100 ft deep profile reflects realistic site conditions and represents a residual soil (saprolite) over weathered rock and underlain by hard rock. The profile is intended to reflect hard rock foundation depths after removal of the soft surficial residual soils. The soft soil (270 m/s) with a depth of 100 feet was deemed not to be representative of conditions at candidate sites within the continental United States and therefore was not included in the SSI analysis. Due to the steep velocity gradient the depth range for soft rock profiles (900 m/s) is restricted to 100 feet and 200 feet.

For compressional-waves, a water table depth at the plant surface of each profile was assumed. The US-APWR DCD specifies a water table depth of 1 foot below the plant grade which, for the development of vertical motions, is equivalent to the surface. Due to the absence of fluids over the top 1 foot, the lower compressional-wave velocity has a very minor impact on vertical motions for the softer profiles.

4.2.2 Development of US-APWR CSDRS Strain Compatible Properties

To characterize the range in strain compatible properties for each profile and depth to hard or soft rock conditions in a fully probabilistic manner, each base-case profile is randomized in velocity as well as nonlinear dynamic material properties. Thirty realizations were generated for each profile category and depth to hard or soft rock. Random vibration theory (RVT) equivalent-linear site response analyses was then performed (refer to EPRI TR-102293 [Reference 8] and NUREG/CR-6728 [Reference 10]) on each random profile for horizontal motions while linear analyses were used for vertical motions (refer to EPRI TR-102293 [Reference 8] and NCEER 97-0010 [Reference 11]). For the horizontal component site response analyses, modulus reduction and hysteretic damping curves from EPRI TR-102293 (Reference 8) are used. The curves are appropriate for generic soils comprised of gravels, sands, and low PI clays (refer to Reference 8) and are shown in Figure 4.2-2. For the soft and firm rock profiles (560m/sec and 900m/sec) an unpublished suite of curves appropriate for soft and firm rock conditions were used. The rock curves are shown in Figure 4.2-2 and were developed during the EPRI project (refer to TR-102293, Reference 8) assuming soft and firm rock exhibits a nonlinear dynamic material behavior similar to gravels. The rock curves were not included in TR-102293 as the final suite of amplification factors was based on soil profiles intended to capture the behavior of soils ranging from gravels to low plasticity sandy clays at CEUS nuclear power plants.

Control motions reflect a representative magnitude of **M**7.5 for CEUS hazard and are consistent with the overall spectral shape of the CSDRS. A point-source model is used to develop control motions (refer to References 8 and 10). Source distances (loading levels) are adjusted such that the median 5% damped response spectrum developed for each profile and depth to baserock approaches, but does not exceed, the CSDRS. The use of a realistic control motion results in reasonable levels of cyclic shear strains for each soil/rock column and avoids the condition of overdriving the columns with the broad band CSDRS. The broad band nature of the CSDRS can be taken to reflect the envelope of motions from a single earthquake and a range in site conditions. With this approach, shear strain levels and associated strain compatible properties reflect realistic loading conditions for CEUS sites and are appropriate for follow-on SSI analyses. The resulting strain compatible properties were developed as median and ±1σ estimates from the analyses of the random profile realizations. It should be noted, because a single CSDRS reflects design motions representing a suite of profiles, its use to characterize input motions for SSI analyses with any single profile results in conservative motions within the structure.

Table 4.2-1 Initial Profile Categories

Categories $\overline{V_S}$ (30m)
180
270
400
560
740
900
1,364
2,032
Depth to Rock (ft) for each Category
25 ± 10
50 ± 20
100 ± 40
200 ± 80
500 ± 200
1,000 ± 400
2,000 ± 800

Hard rock crustal model (References 8 and 9)

tx (km)	Vs (km/s)	Vp (km/s)	ρ (cgs)
1	2.83	4.90	2.52
11	3.52	6.10	2.71
28	3.75	6.50	2.78
	4.62	8.00	3.35

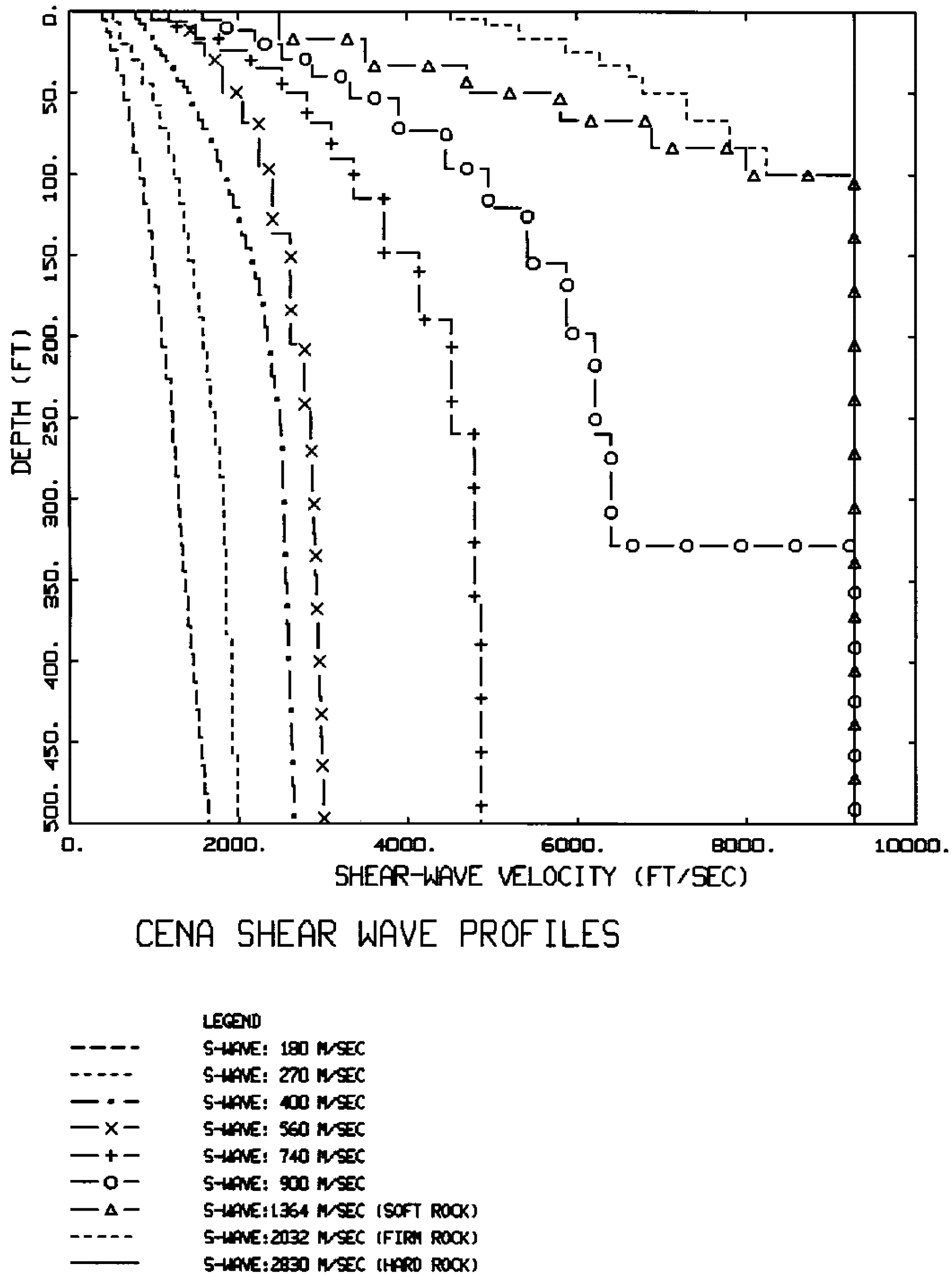


Figure 4.2-1 Top 500 ft of the Candidate Shear-Wave Velocity Profiles and associated $\overline{V_S}(30m)$ velocities

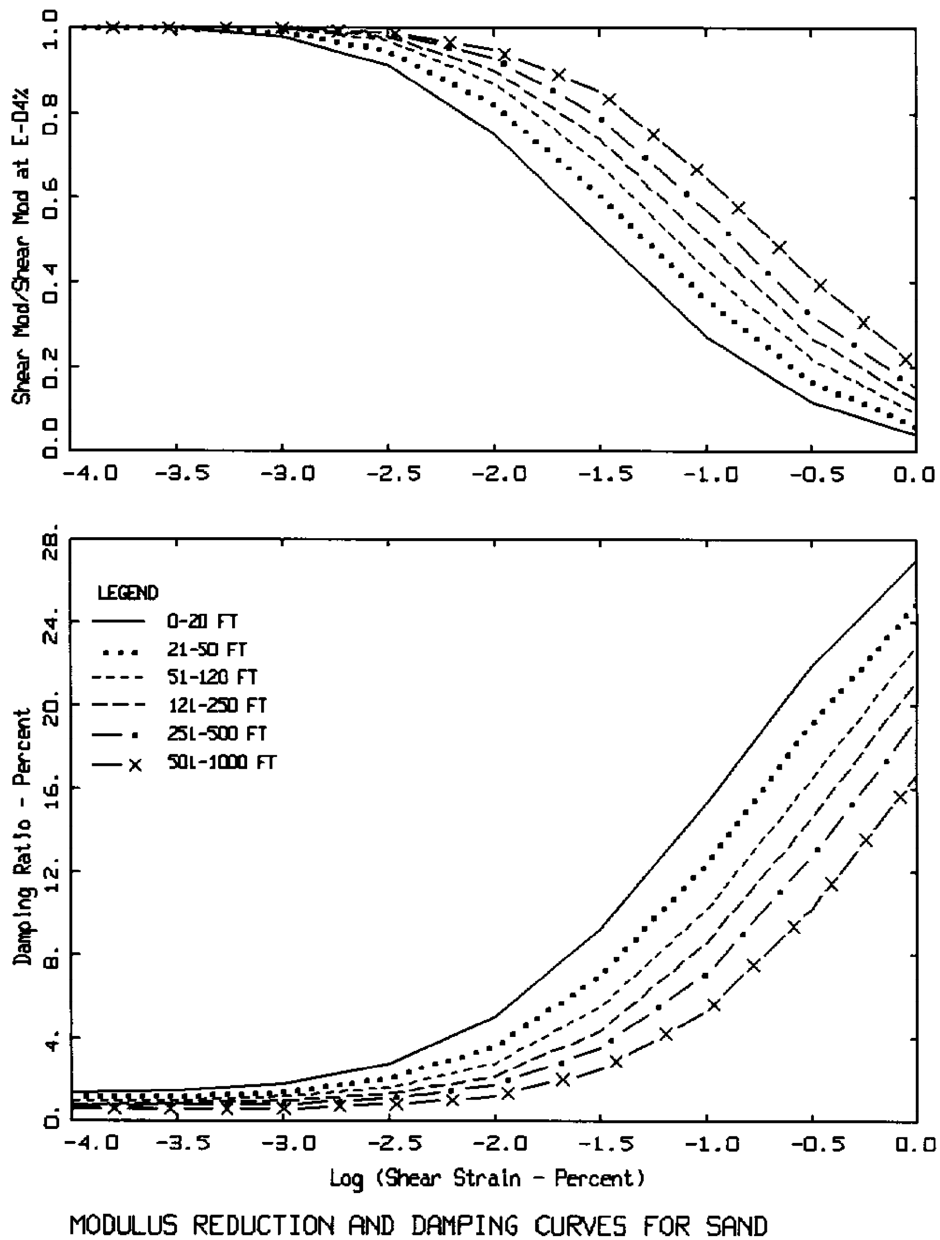


Figure 4.2-2. (TR-102293, Reference 8) Cohesionless Soil Modulus Reduction and Hysteretic Damping Curves Used for Profile 270m/sec Followed by the Curves Used for the Soft and Firm Rock Profiles, 560m/sec and 900m/sec

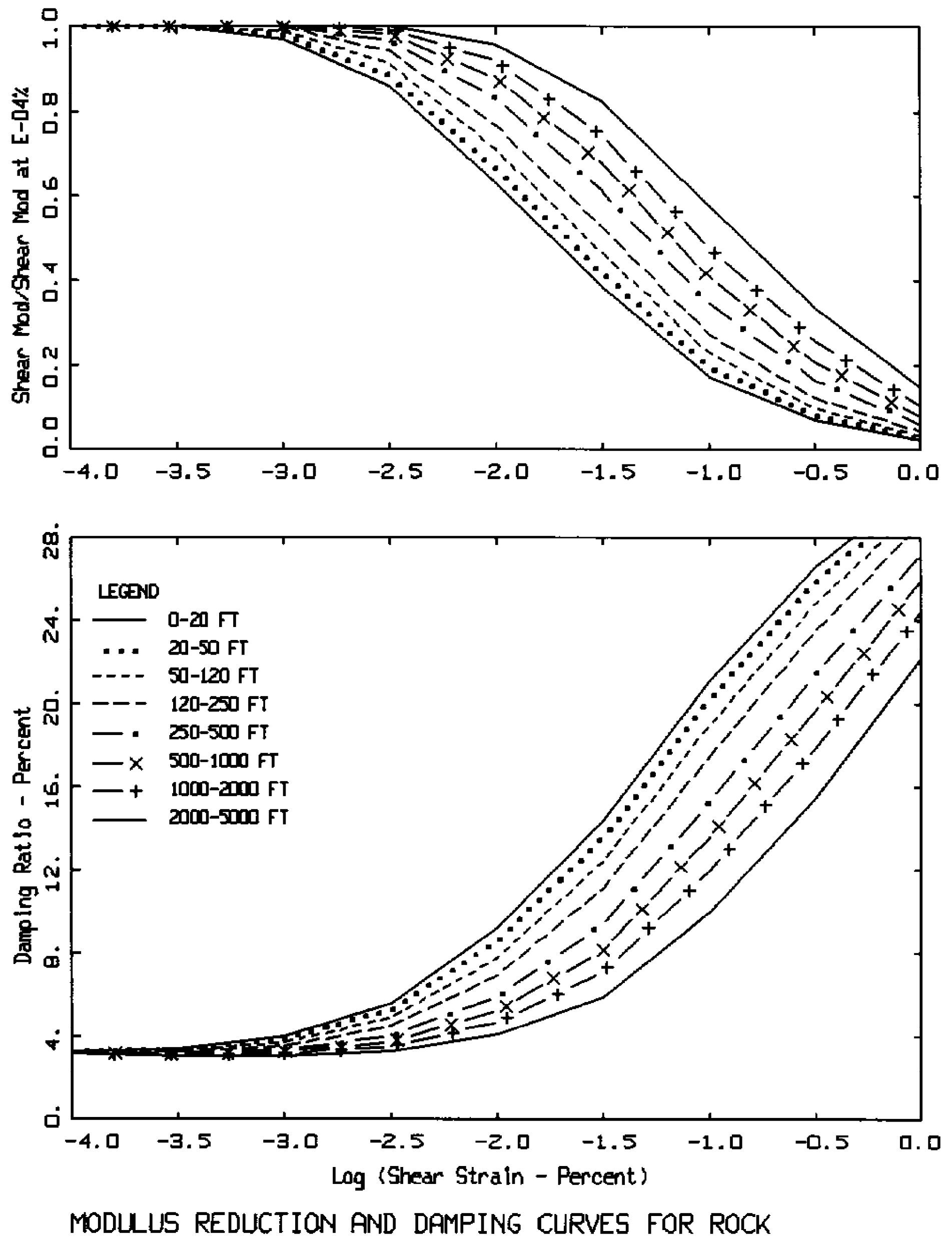


Figure 4.2-2 (Continued)

4.3 Enhanced ACS SASSI Lumped-Mass-Stick Model of R/B Complex

4.3.1 Structural Modeling Approach

Three lumped mass stick models of PCCV, CIS and R/B are used to represent the stiffness and mass inertia properties of the building structures above the ground elevation. Since the RCL spans several locations of the building and is characterized by several significant frequencies and participating masses, a lumped parameter model connected at appropriate locations of the CIS is used to represent the stiffness and mass inertia properties of the major piping and equipment, such as the reactor vessel (RV), steam generators (SGs), and main coolant piping (MCP). Based on the decoupling criteria of SRP 3.7.2 (Reference 4), with the exception of the RCL, the subsystems and components inside the containment and in the R/B are included in the coupled model by lumped masses placed at appropriate node locations.

ACS SASSI 3-D beam and spring elements are used to model the stiffness of the reinforced concrete shear walls of R/B, prestress concrete of PCCV, and the steel-concrete (SC) modules of the CIS above the ground elevation. The cross sectional properties of the beam elements and the stiffness properties of the spring elements are developed in Section 5.3.1 following the methodology described in Subsection 3.7.2.3.2 of the DCD. Based on the analyses of the concrete cracking presented in Section 5.5 of this technical report, the cross sectional properties of the stick elements modeling the stiffness of the part of the fuel handling area (FH/A) providing enclosure to the crane are reduced to account for the in-plane concrete cracking of the NS exterior walls.

SASSI 3-D beam elements with high stiffness properties are used to rigidly connect different nodal points at the same floor elevation. The mass inertia properties of the structure, the equipment, the water in the pools and 25% of the live loads are lumped at major floor elevations by assuming the floor slabs are rigid in the in-plane direction per DCD subsection 3.7.2.3.2. As a result, SDOF models are developed following the methodology described in Section 4.3.2 to capture the out-of-plane flexibility of the slabs and walls.

A 3-D FE model is developed as described in Section 4.3.3 to represents the stiffness of the basemat, the walls and the floor slabs of the building basement, and the floor slabs at ground elevation. At ground elevation, the PCCV and the coupled CIS lumped mass stick model are rigidly connected to the thick central portion of the building basemat. Rigid beams connect the basement shear walls with the lumped mass stick model representing the above ground portion of the R/B and FH/A structure. The integrated model of the R/B complex is developed using the ANSYS computer program (Reference 12) and translated into the format of the computer program ACS SASSI (Reference 2) by using the built-in converter in ACS SASSI. Prior to the translation, the numbering of the SASSI model nodes is adjusted in order to minimize the bandwidth of the dynamic system matrices.

SSE material damping values are assigned to the SASSI structural model using material damping values given in Table 3.7.3-1(a) of the DCD. The SSI analyses consider soil material damping values based on those associated with the generic soil profiles discussed in Section 5.2 of this report, and do not exceed 15%, as stipulated in SRP 3.7.1 (Reference 1).

4.3.2 Enhancement of the Lumped-Mass-Stick Models

The coupled lumped mass stick model of the R/B complex is enhanced by adding SDOF models to capture the out-of-plane flexibility of the slabs. SDOF oscillators are also used to capture the out-of-plane horizontal flexibility of walls. The vibrations of the masses, either slabs or walls, in the higher modes are assumed to be of secondary importance when the mass participation of these higher modes is much smaller than that of the primary mode and are included in the rigid mode response of the lumped floor mass.

The first step in constructing a SDOF stick model is to investigate the responses of the slabs on each of the major elevations of the reactor building. Each elevation (including the section of the interior/exterior walls from the elevations above and below) is isolated from the remainder of the structure while vertical restraints are placed along the edges of the slabs adjacent to the walls. Figure 4.3.2-1 shows a FE model of the R/B floor slabs that is extracted from the detailed FE model of the R/B complex used for static analyses of the building. The section of the selected shear wall elements are set as massless to preclude any lateral excitation and then laterally restrained along the top and bottom. The sketch in Figure 4.3.2-2 shows the boundary conditions for the model.

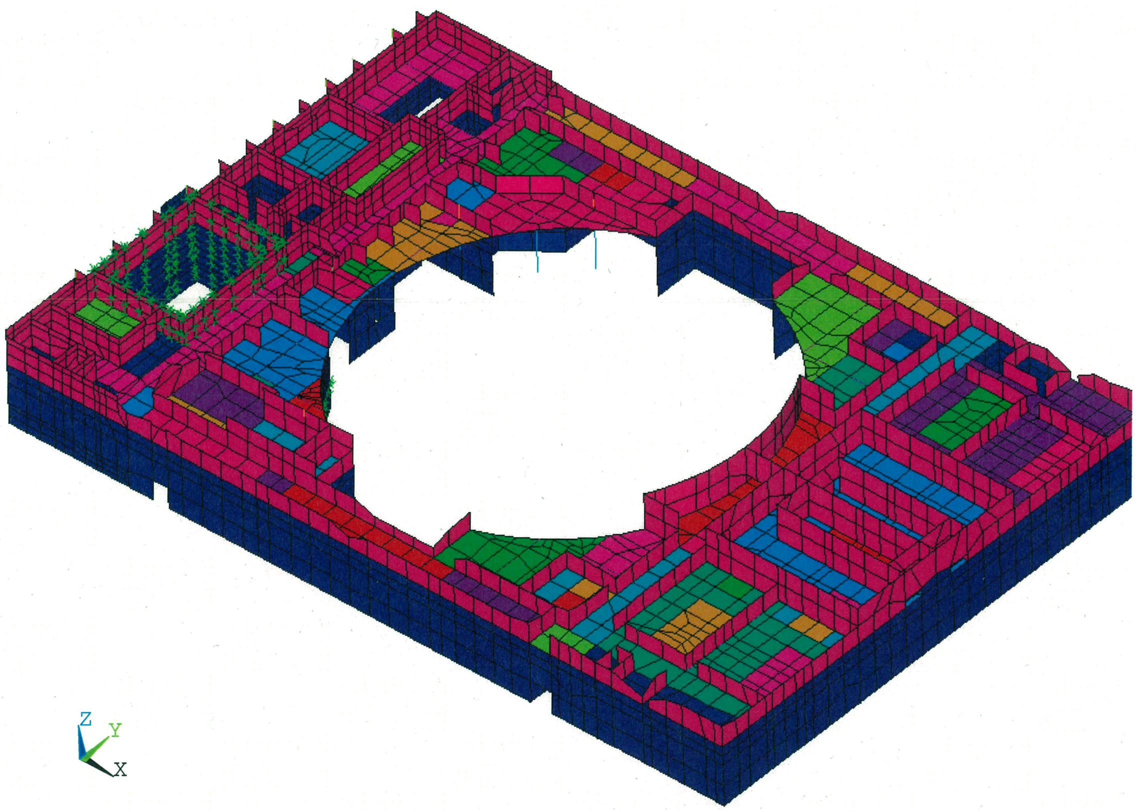


Figure 4.3.2-1 FE Model of Floor Slabs

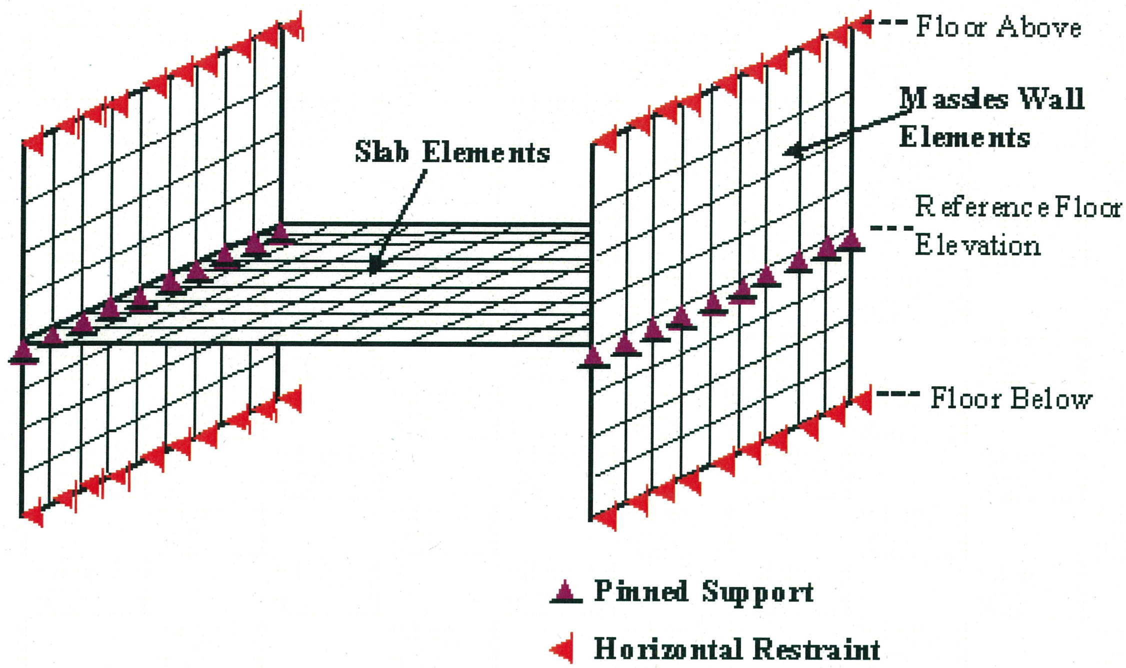


Figure 4.3.2-2 Floor Slab Model Boundary Conditions

The cracking analyses results presented in Section 5.5 indicate that under the most critical load condition the slabs of the R/B will crack, thus the modulus of elasticity of each selected slab is reduced by 50% to simulate a cracked condition. Once the slices of each elevation are set, a modal analysis is performed to determine the vertical modes of the slabs which contain a high mass participation. The corresponding mass participation, frequency, and slab location of each mode are then extracted. Based on the lowest mode frequency and the participating mass, the equivalent stiffness used in the global model can be obtained using the following equation:

$$k = m_1 \cdot (2\pi \cdot f_1)^2$$

where m_1 is the mass participation and f_1 is the slab's resonant frequency.

The same slicing procedure is used to investigate the predominant modes of the exterior walls of the R/B. Note that in the exterior wall modal analysis, the walls maintain their mass while the slabs are set as massless to prevent any vertical modes. Lateral restraints are also placed at the slab nodal points which are adjacent to the exterior walls.

In order to capture the effects of floor rocking through the out-of-plane response of the slab, the SDOF systems are attached to the stick models at the locations corresponding to the center of the actual floor slabs. This is achieved by adding massless rigid beams between the slab locations and the center of rigidity of the floor, as shown in the Figure 4.3.2-3 below. SDOF oscillators are only included in the lumped mass stick model for the slabs and walls which contain out-of-plane frequencies of vibrations below the cut-off frequency of 40 Hz (a significant amount of mass must also be excited to be included). The component is considered rigid above this value.

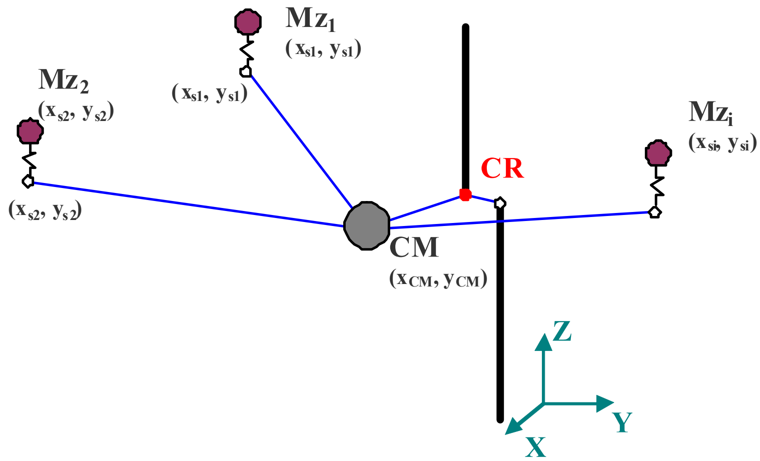


Figure 4.3.2-3 SDOF Elements Connections

In order to maintain the same overall mass inertia properties of the lumped mass stick model, at each floor elevation where flexible slabs or walls are present, the values of the lumped floor mass inertia parameters (Mz, Imx, Imy and Imz) that are assigned to the center of mass (CM) node have to be adjusted to account for the inclusion of the vertical slab masses. The following equations can be used to calculate the adjusted values of the vertical mass Mz_{CM} and mass moment inertia Imx_{CM}, Imy_{CM}, and Imz_{CM} lumped at the CM node:

$$Mz_{CM} = Mz - \sum_i Mz_{S1}$$

$$\mathrm{Im}\,x_{CM} = \mathrm{Im}\,x - \sum_i Mz_{S1} \cdot (y_i - y_{CM})^2$$

$$\mathrm{Im}\,y_{CM} = \mathrm{Im}\,y - \sum_i Mz_{S1} \cdot (x_i - x_{CM})^2$$

The FH/A walls were analyzed for a cracked concrete condition (the shear areas were reduced by 50%). This analysis modification was updated and incorporated into the FH/A properties of the stick model.

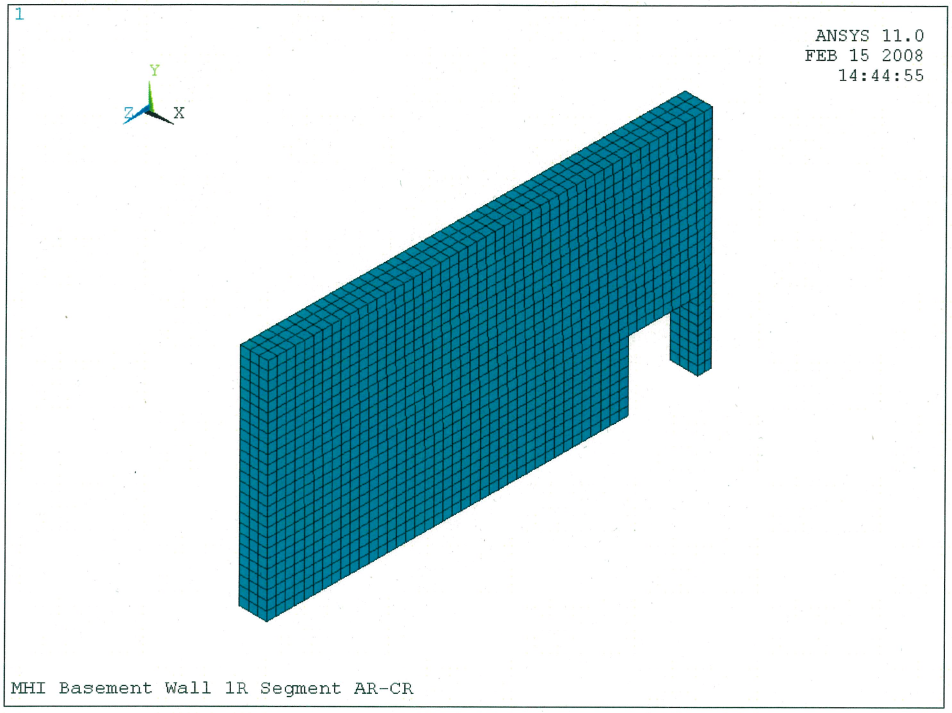
4.3.3 Development of SASSI FE Model of R/B Basement

A 3-D ACS SASSI FE model is developed for the R/B complex basement to capture the effects due to the flexibility of the basement on the seismic response of the building. The development of the FE model ensures that an accurate representation of the overall stiffness of the basement structure including its mass inertia properties is provided. The ANSYS (Reference 12) preprocessor is used to generate the model geometry and FE mesh in a manner that allows simple modification to the model mesh size. SASSI 3-D shell elements are used to model the basement shear walls and the R/B slabs at the ground floor elevation. 3-D beam elements are used to connect the shell elements at the top of the shear walls of the 3-D SASSI FE model of the R/B basement to the lumped mass stick model representing the above ground portion of the R/B and FH/A.

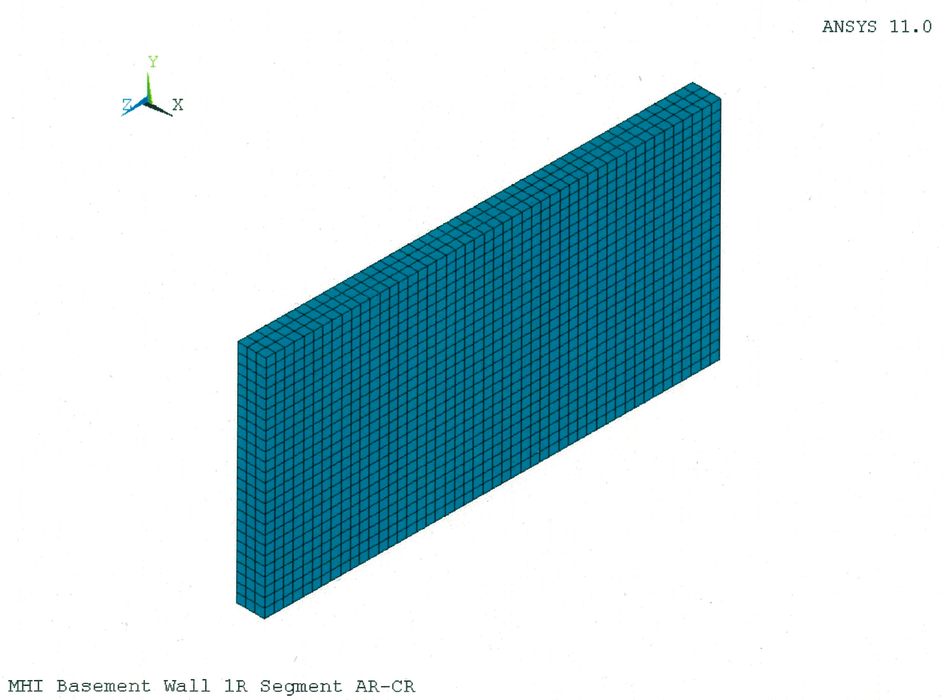
SASSI solid FE elements are used to model the stiffness and mass inertia properties of the basemat. The modeling of the thick central part of the basemat supporting the PCCV and CIS is simplified to minimize the size of the SASSI model. 3-D shell elements are added at the top of the basemat solid elements to accurately model the bending stiffness of the central part of the mat. Rigid shell elements are used to connect the thick portion of the basemat with the floor slabs at the ground elevation. Rigid 3-D beam elements connect the PCCV and CIS lumped mass stick models to the rigid shell elements.

The coarse FE mesh of the basement model does not always permit an accurate modeling of the openings of the walls. The elastic modulus material property assigned to the shell elements of the shear walls is adjusted to accurately model the wall's shear stiffness, and account for the reduction of wall stiffness at the openings. A set of FE analyses is performed using ANSYS to obtain the stiffness reduction factors needed to adjust the material properties to account for the reduced stiffness of the shear walls with openings. The correction factors are obtained by comparing the results from the static analyses of two detailed solid FE models shown in Figure 4.3.2-4. Model A represents the actual geometry of the wall with openings, and Model B represents the wall without openings. Unit displacements are applied at the top of each model in both the in-plane and the out-of-plane directions, to generate the reactions at the bottom, which can then be used to calculate the in-plane and out-of-plane wall stiffness. The ratio between the reaction obtained from Model A and Model B is used to determine stiffness reduction factors to adjust the elastic modulus of the wall material.

Unit mass weight is assigned only to the 3-D shell elements modeling the exterior shear walls of the basement and the portion of the basemat represented by 3-D brick elements. The remaining weight of the thick basement is lumped at a single node that is connected to the central portion of the foundation by rigid beams. The additional lumped mass and its location are calculated such that when combined with the mass assigned to the FE model of the basement it equals the overall lumped mass inertia properties of the basement.



Model A of Actual Wall



Model B of Wall in SASSI Model

Figure 4.3.2-4 FE Models to Calculate Wall Stiffness Reduction Factors

4.3.4 Model Verification Methodology

Three models are used to verify the stick models used for the SASSI analysis:

- ANSYS 3-D FE models of the R/B and FH/A, CIS, and PCCV
- ANSYS stick model of R/B complex
- SASSI stick model of R/B complex

Verification analyses are performed for each of the superstructures (R/B and FH/A, PCCV, and CIS). The tests performed are a 1g static analysis applied in all three orthogonal directions to investigate structure displacements and total weight (compares ANSYS 3-D FE model and ANSYS stick model), a modal analysis to compare the structures' dominant natural frequencies and mass participation factors (compares SASSI stick model and 3-D FE model), and a mode superposition transient dynamic analysis to investigate the acceleration response spectra for various nodes (compares all three models). In order to ensure each model properly represents the structure, a low margin of error for each set of results is obtained.

4.4 ACS SASSI FE Model of PS/B

The ACS SASSI dynamic FE model is generated only for the West PS/B of the US-APWR standard plant. Since the East and West PS/Bs are nearly identical structurally, this model is used to represent both structures. The PS/B structural walls and slabs, including floor and roof slabs, are modeled using shell elements. Beams and columns are modeled as beam elements and the basemat is modeled using solid elements. At the intersection of walls with the basemat, shell elements are extended into the basemat to transmit nodal rotations to the solid elements. The extended elements share nodes with the corresponding face of the solid elements but have no mass.

The dynamic structural model for the west PS/B is developed using ANSYS (Reference 12) and translated into the format of ACS SASSI (Reference 2) by using the built-in converter in ACS SASSI. The model is then validated by performing various static and dynamic structural analyses with a "fixed base condition," i.e. full constraints on translation and rotation at the bottom of the basemat. SSI analyses can then be performed on the validated dynamic structural model with SASSI using the proper soil profiles. Dynamic model development and validation are performed in three steps as follows:

- Static and dynamic analyses are performed on a detailed static model of the PS/B to obtain the validation basis. The detailed static model is in an ANSYS format, and is translated from a NASTRAN format model that was used for basic structural design of the PS/B. The mesh size of the model varies from 3' to 4' and structural details such as openings in walls and slabs are simulated in the model. The analyses include a 1g Static analysis, modal analysis and mode-superposition transient dynamic analysis using the corresponding ANSYS Solvers.
- An ANSYS dynamic Model is developed using the ANSYS preprocessor and ANSYS Program Design Language. Loading and element attributes are assigned before meshing the geometry model so that it can be easily modified for various mesh sizes. To reduce the size of the model and permit coarser mesh, some minor structural details and wall/slab openings are not modeled in the ANSYS model. A 1g static analysis and a modal analysis, under fixed base conditions, are performed to obtain static load/deformation distributions and dynamic properties. The results are compared to the ones obtained from the detailed static model analyses to demonstrate the ability

of the model to adequately represent the dynamic properties of the PS/B structure.

- The ANSYS dynamic Model is translated into a SASSI format using the built-in converter in ACS SASSI. Validation SSI analyses are performed with the PS/B dynamic FE model resting on the surface of a half-space with hard-rock properties to simulate the response of the structure under a fixed base condition. Transfer functions (TFs) and ARS are obtained from the SASSI validation analyses at selected nodes and are then compared to the results obtained from the detailed static model analyses.

- The dynamic model mesh is selected such that the structural response is not significantly affected by further refinement of the element sizes. The mesh also ensures the discretized structure is able to capture the local responses and the responses of the significant modes of vibration with a frequency up to 50 Hz. To validate the adequacy of the dynamic model mesh, dynamic modal analyses are performed on various models with different element sizes under a fixed base condition. Dominant modal frequencies and accumulative mass fractions, i.e. accumulative mass over total effective (mobilized) mass are compared to determine the adequacy of the mesh.

Since the PS/Bs are reinforced concrete structures, elastic properties of structural concrete are used directly in the model and/or as basis to develop equivalent linear elastic properties for the cracked concrete. Element/member stiffnesses are adjusted for cracked concrete section properties based on the stress level (refer to Section 4.5 of this technical report). Element stiffness of shear walls and slabs are further adjusted for openings not included in the model. The stiffness reduction factors for walls and slabs with openings are obtained from the results of static FE analyses performed on two models of each structural element: one with opening(s) representing the actual structural element and one without openings representing the slab or walls simulated in the dynamic Model.

Based on the criteria specified in SRP 3.7.2 (Reference 4), Section II.3.B, since the heaviest equipment weight (mass) is less that 1% of the total building weight (mass), equipment is not simulated in the ACS SASSI dynamic model. Instead, floor slab densities are adjusted to include the equipment weight (mass) distributed over a representative floor footprint area.

Floor and wall densities are further adjusted in the dynamic model to include, as recommended by the SRP 3.7.2 (Reference 4) Section II.3.D, additional masses equivalent to a floor load of 20 to 60 psf, depending on the floor level and location, representing piping loads as well as a . 25% design live load and a 75% design roof snow load.

4.5 Consideration of Concrete Cracking in Dynamic Analyses

4.5.1 Evaluation of Reinforced Concrete Members Cracking

Traditional reinforced concrete members and elements are modeled as either cracked or uncracked sections, depending on their stress level due to the most critical load combinations in accordance with ASCE 4-98 (Reference 13), Section 3.1.2, and ASCE/SEI 43-05 (Reference 14), Section 3.1.2. For the uncracked sections/elements, the stiffness is directly obtained from the concrete linear elastic properties and the section or element geometric dimensions. For the cracked concrete, a reduction to the uncracked concrete stiffness is taken into account. The reduction factors shown in Table 3-1 of ASCE/SEI 43-05 are used in linear elastic analysis to address the effects of concrete cracking on the seismic response of the US-APWR seismic Category I structures. These reduction factors have been validated by the following methodology.

A first hand estimate of member stress levels under unfactored load combinations per DCD Table 3.8.4-3 is made. To estimate the stress level of the reinforced concrete members, such as shear walls, beam/columns, and slabs, a few typical elements of each member are selected and member forces are obtained.

The provisions of ACI 349-01 (Reference 15), Subsections 9.5.2.3 and 9.5.2.4, are used to calculate the effective out-of-plane cracked moment of inertia of flexural and flexure dominated members (slabs or girders). The calculations provide the reduction factor for out-of-plane bending by accounting for the stress levels in these structural members under critical seismic load combinations.

The provisions of ACI 349-01 are also used to evaluate the cracking of the shear walls due to out-of-plane bending. If the bending stress level in the shear wall is higher than the concrete cracking stress, the reduction factor for flexural rigidity in Table 3-1 of ASCE 43-05 (Reference 14) is used after being validated as described in Step 2.

For shear walls with in-plane shear stress levels higher than the nominal concrete shear capacity, the stiffness reduction factor in Table 3-1 of ASCE 43-05 is used to calculate the cracked in-plane stiffness properties.

For shear walls with in-plane shear stress levels lower than the nominal concrete shear capacity, the uncracked in-plane stiffness properties are considered in the dynamic analysis.

Average shear stresses on the effective shear area of the shear wall at each major floor elevation are calculated and compared to the nominal shear capacity. The nominal shear capacity of the concrete wall is evaluated based in the provisions of ACI 349-01 as follows:

$V_c = 2 \cdot (f'_c)^{0.5}$ ACI 349-01, Equation 11-3

For 4,000 psi strength concrete:

$$V_c = 2 \cdot (4000\ psi)^{0.5} = 126\ psi$$

If the shear stress demand is greater than 126 psi, a detailed calculation of the shear strength that considers the effect of the ratio of wall height over length is performed based on ASCE 43-05 (Reference 14) Section 4.2.3.

Section 4.2.3 of ASCE 43-05 specifies that the in-plane shear capacity of low-rise concrete shear walls (i.e. walls where the ratio of height to length are less than 2.0) can be calculated as follows (refer to ASCE 43-05 for notation):

$$V_u = \phi \left[8.3 \cdot (f'_c)^{0.5} - 3.4 \cdot (f'_c)^{0.5} \cdot \left(\frac{h_w}{l_w} - 0.5 \right) + \frac{N_A}{4 \cdot l_w \cdot t_n} + \rho_{se} \cdot f_y \right]$$

The shear walls are also load bearing walls. The axial load 'N_A' on the wall is usually a compressive load. Ignoring the compression force 'N_A,' the above equation implies that the concrete nominal shear strength for a shear wall with a height of h_w and length L_w will be:

$$V_c = 8.3 \cdot (f'_c)^{0.5} - 3.4 \cdot (f'_c)^{0.5} \cdot \left(\frac{h_w}{l_w} - 0.5 \right)$$

NUREG/CR-6926 does not recommend ASCE 43-05 for in-plane shear evaluation, in general, since ACI 349-01 provides more conservative results. It also recommends limiting the normal shear stress to $20.\phi.\ \sqrt{f'_c}$, where ϕ=0.8 and f'_c is the concrete compressive strength. For 4000 psi concrete, this yields a value of 1000 psi nominal shear stress, which is greater than any expected shear stress. Therefore ASCE 43-05 may be used. The following calculation provides an example of evaluation shear capacity of a typical shear wall. Consider a typical ratio of 1.42 for wall height to length (35.92'/25.33' = 1.42) for a shear wall in the PS/B, with a concrete compressive strength of 4,000 psi, the nominal shear capacity is:

$$V_c = 8.3 \cdot (4000)^{0.5} - 3.4 \cdot (4000)^{0.5} \cdot (1.42 - 0.5) = 328\ psi$$

Note that, to calculate the total shear capacity, ASCE 43-05 (Reference 14) specifies the effective depth of the shear wall as:

$d = 0.6 \cdot l_w$ ASCE 43-05, Equation 4-5

Whereas, ASCE 349-01 (Reference 15), Section 11.10.4, specifies $d = 0.8 \cdot l_w$ as the effective depth. Therefore, the average shear capacity for a wall with height to length ratio of 1.42 over an effective depth of $0.8 \cdot l_w$ will be:

$$Vc = \frac{0.6}{0.8} \cdot 328 = 246\ psi$$

The corresponding shear stress demand is calculated by dividing the total shear force on the wall by an area of $0.8 \cdot l_w \cdot t_n = 0.8A_g$.

4.5.2 Adjusting Element Stiffness in FE Dynamic Models

Generally, shell and beam elements are used to simulate wall/slab, beam/column, respectively. Where cracking has been determined to occur due to out of plane bending of the reinforced concrete member, using the procedure described in Section 5.3.1, the material (elastic modulus) and geometric (area) properties of shell or beam elements are changed to model the cracked concrete properties, without changing the axial stiffness and mass. The cracked concrete properties are modeled for one-half of the flexural stiffness.

For shell elements (walls/slabs), the material (elastic modulus) and geometric (thickness) properties are changed to account for flexural cracking as follows:

$$t_{cracked} = \sqrt{C_F} \cdot t$$

$$W_{cracked} = \frac{1}{\sqrt{C_F}} \cdot W_{concrete}$$

$$E_{cracked} = C_F \cdot E_{concrete} \cdot \left(\frac{t}{t_{cracked}} \right)^3 = \frac{1}{\sqrt{C_F}} \cdot E_{concrete}$$

where:

C_F = factor for the reduction of flexural stiffness (1/2).

$t_{cracked}$ = effective slab thickness to account for cracking.

t = gross section thickness.

$W_{cracked}$ = effective unit weight to offset the reduced stiffness and provide the same total mass.

$E_{cracked}$ = effective modulus to account for the reduction in thickness that keeps the same axial stiffness while reducing the flexural stiffness by C_F.

For beam elements (beams/columns), the modification of section properties to account for flexural cracking as follows:

$$A_{cracked} = \frac{A}{C_F}$$

$$W_{cracked} = C_F \cdot W_{concrete}$$

$$E_{cracked} = C_F \cdot E_{concrete}$$

where:

C_F = factor for the reduction of flexural stiffness (1/2).

$A_{cracked}$ = effective beam/column area to offset the reduced flexural stiffness and provide unchanged shear and axial stiffness.

A = gross section area of the concrete beam/column.

$W_{cracked}$ = effective unit weight to offset the reduced stiffness and provide the same total mass.

$E_{cracked}$ = effective modulus to account for the reduction in thickness that keeps the same axial stiffness while reducing the flexural stiffness by CF.

4.5.3 Evaluation of Concrete Cracking in Dynamic Analyses of SC Modules

The stiffness of the lumped mass stick model of containment internal structure is reduced by 25% to address potential effects due to cracking of the SC modules. The use of stiffness of the SC modules in the seismic response analyses that is 75% of the nominal concrete stiffness to include stiffness reduction effects due to concrete cracking in conjunction with seismic and thermal loading provides a best estimate for the seismic response of the structure. This modeling approach address issues raised in RAI 497-3734, Question 3.8.4-42, and RAI 491-3733, Questions 3.8.3-16 and 3.8.3-25.

5.0 RESULTS AND CONCLUSIONS

5.1 CSDRS Compatible Ground Motion Time Histories

One set of three statistically independent components of a modified seed recorded time history motion is generated for use as the input seismic motion to the earthquake response analysis of the US-APWR standard plant including the R/B, PCCV, CIS, and PS/Bs. The three individual time history orthogonal direction components represent the CSDRS earthquake ground motion, labeled in this report as two horizontal (“H1” and “H2”) and one vertical (“V”). The artificial time history motion plots for the ground accelerations, velocity, and displacements in three orthogonal directions (“H1,” “H2,” and “V”) are shown in Figures 5.1-1, 5.1-2, and 5.1-3, respectively. The time history motion plots of the ground acceleration, velocity, and displacement are shown together to demonstrate their non-stationary process.

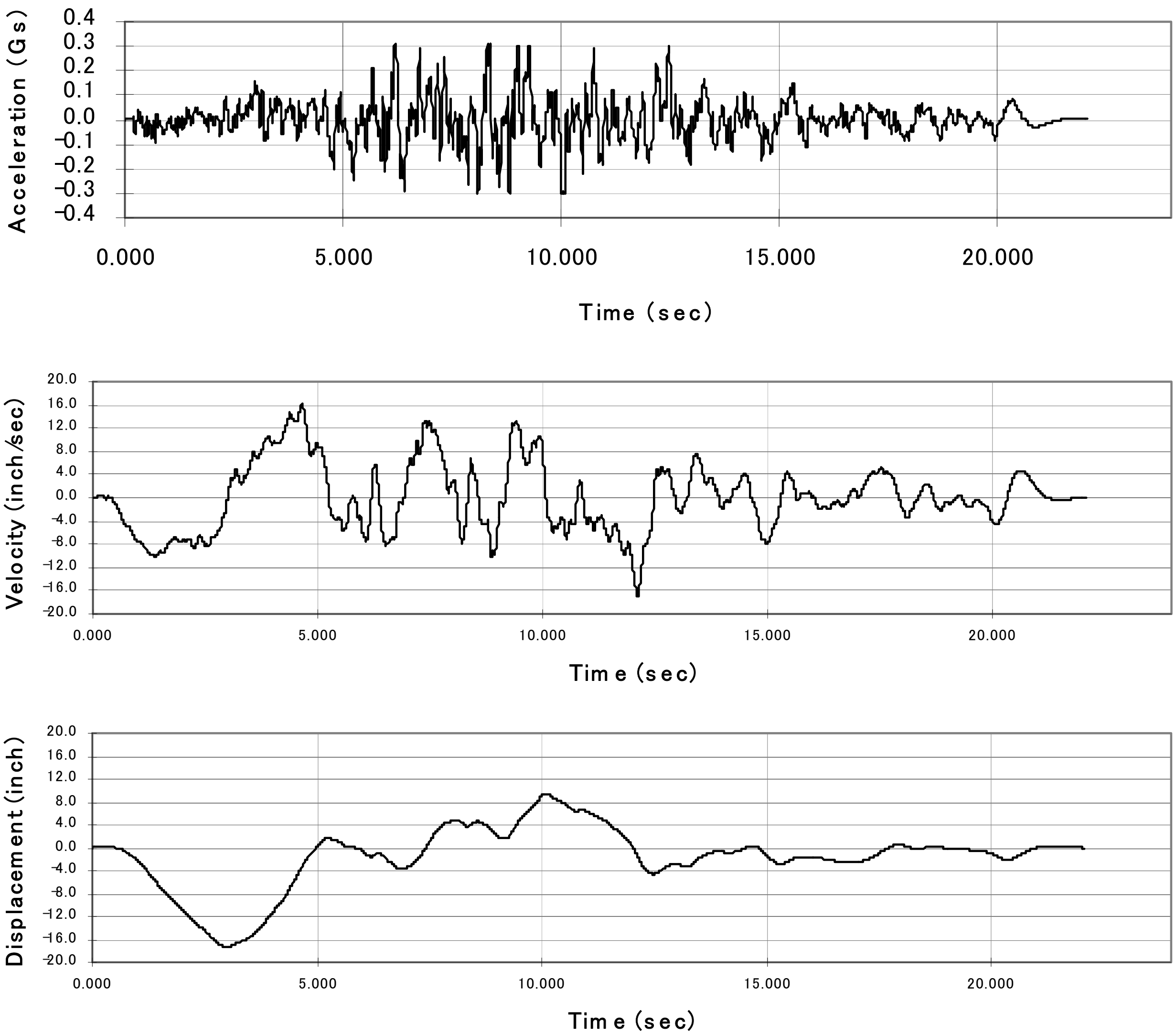


Figure 5.1-1 Acceleration, Velocity, and Displacement Time History for Component H1 (180)

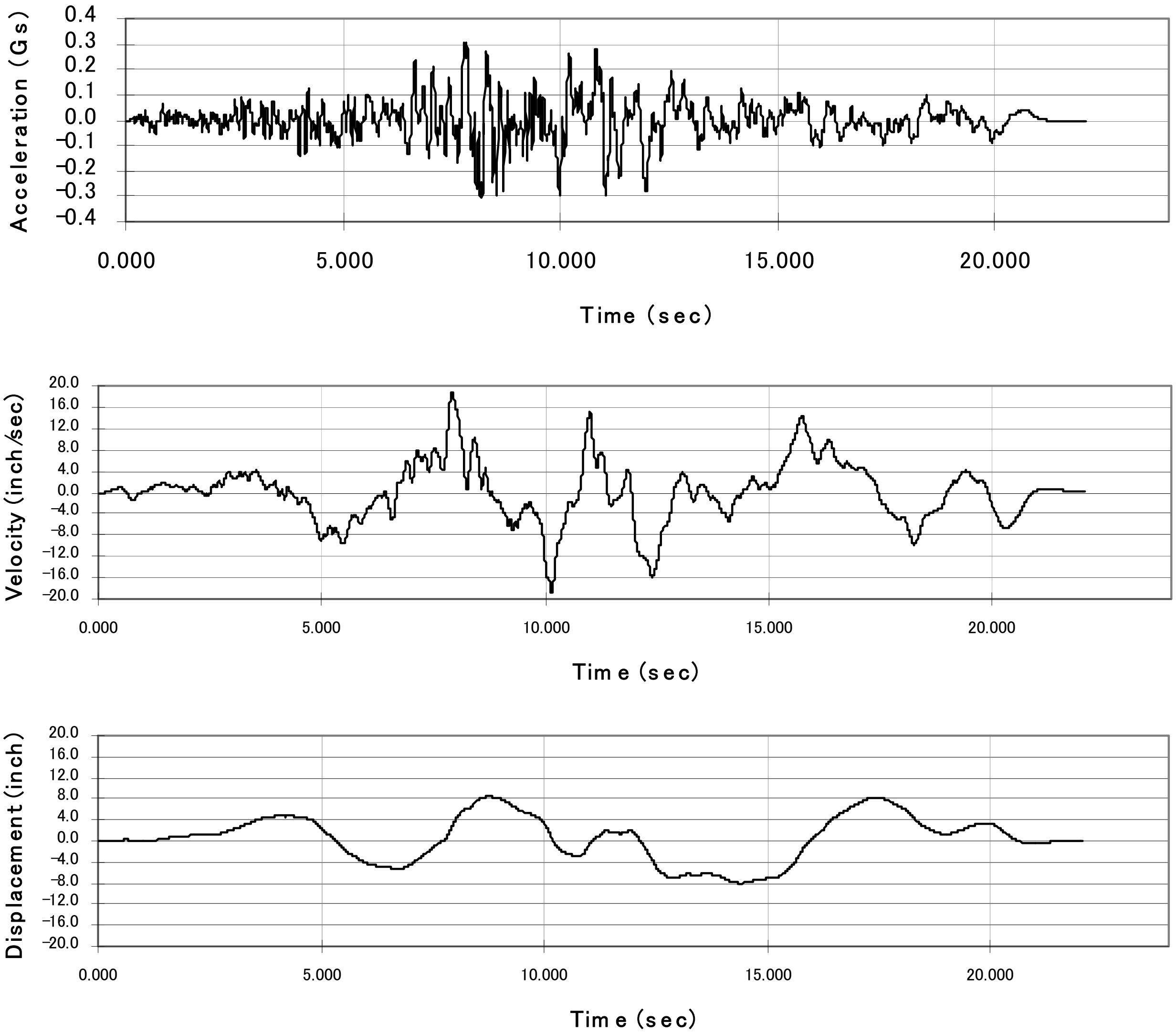


Figure 5.1-2 Acceleration, Velocity and Displacement Time History for Component H2 (090)

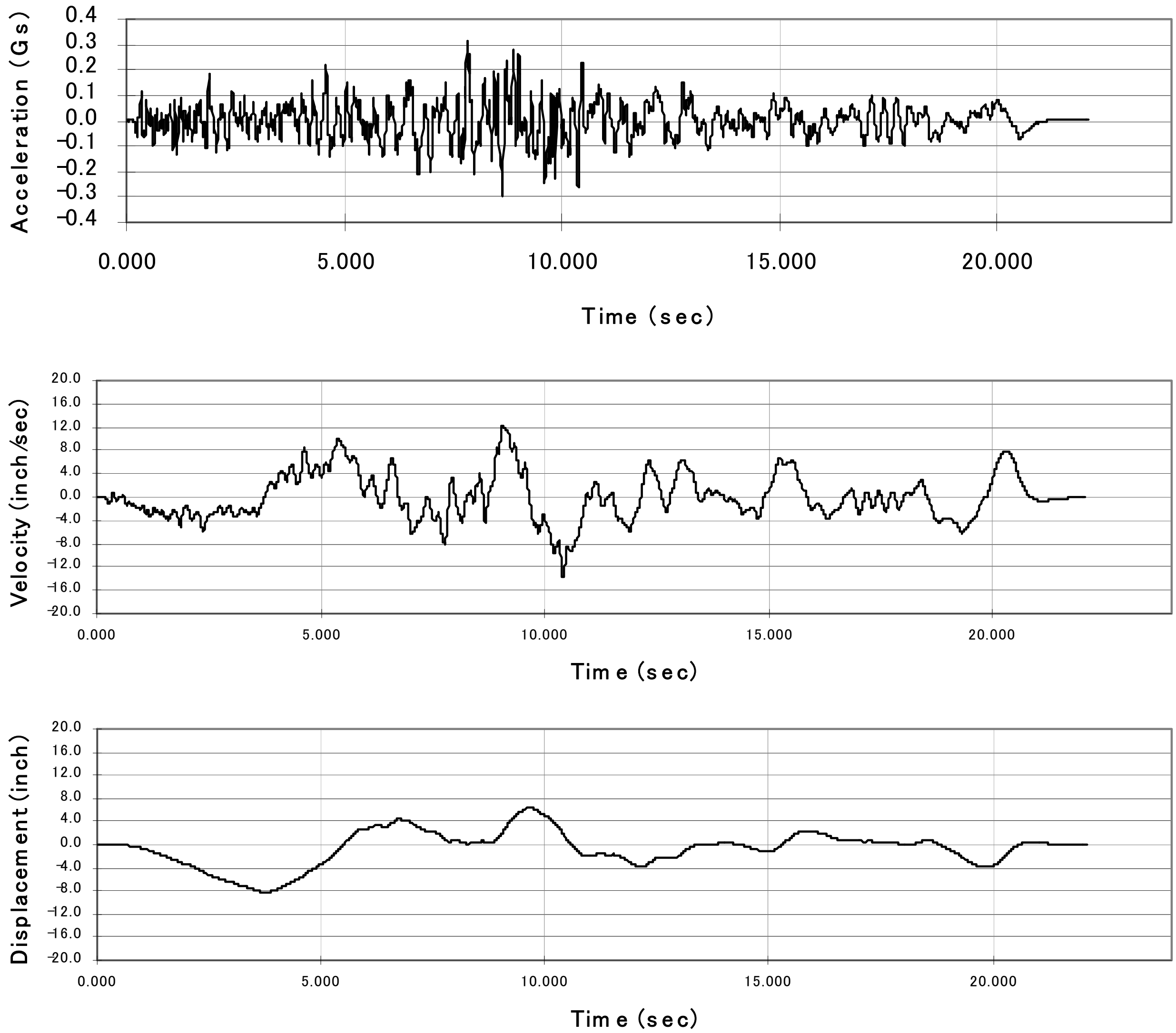


Figure 5.1-3 Acceleration, Velocity and Displacement Time History for Component V (UP)

Figures 5.1-4, 5.1-5 and 5.1-6 show the ARS of the US-APWR artificial time histories with 5% damping for the three orthogonal directions H1, H2, and V, respectively. The plots of the CSDRS are superimposed on the figures to illustrate that the ARS converted from the artificial time histories match those of the CSDRS for 5% damping. The CSDRS plots connect the control points shown in Table 4.1-1 and are based on the modified Regulatory Guide (RG) 1.60 (Reference 16) response spectra as described in Subsection 3.7.1.1 of the DCD. The horizontal and vertical modified RG 1.60 response spectra used as the target spectra are extended to a lower frequency of 0.1 Hz. These figures demonstrate that the artificial acceleration time histories do not have significant gaps in the response spectra, and are also not biased high with respect to the target CSDRS to demonstrate uniform energy distribution.

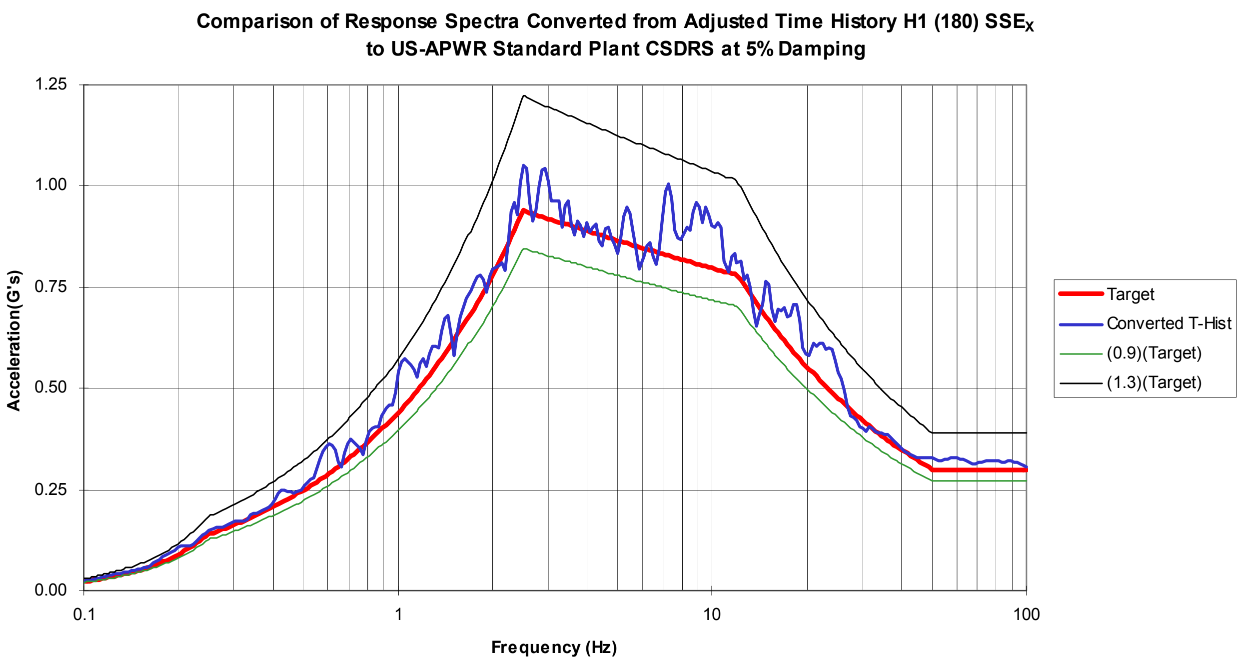


Figure 5.1-4 5% Damped Response Spectra Plots for Adjusted Northridge, BAL Component H1 (180)

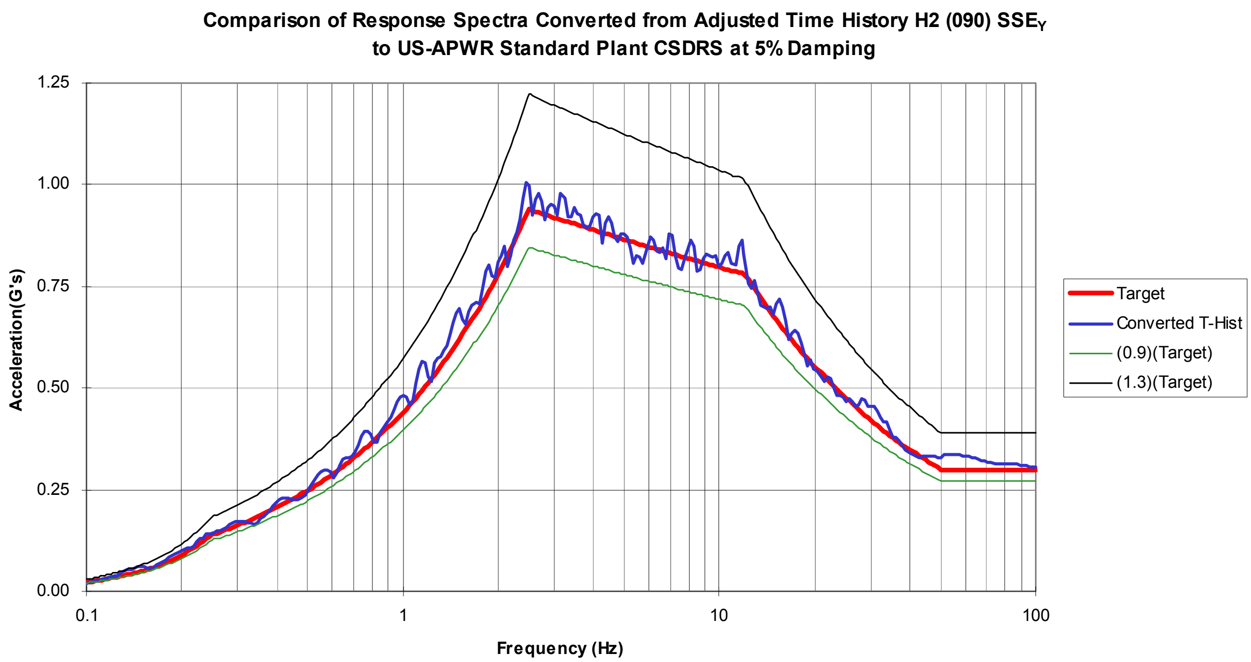


Figure 5.1-5 5% Damped Response Spectra Plots for Adjusted Northridge, BAL Component H2 (090)

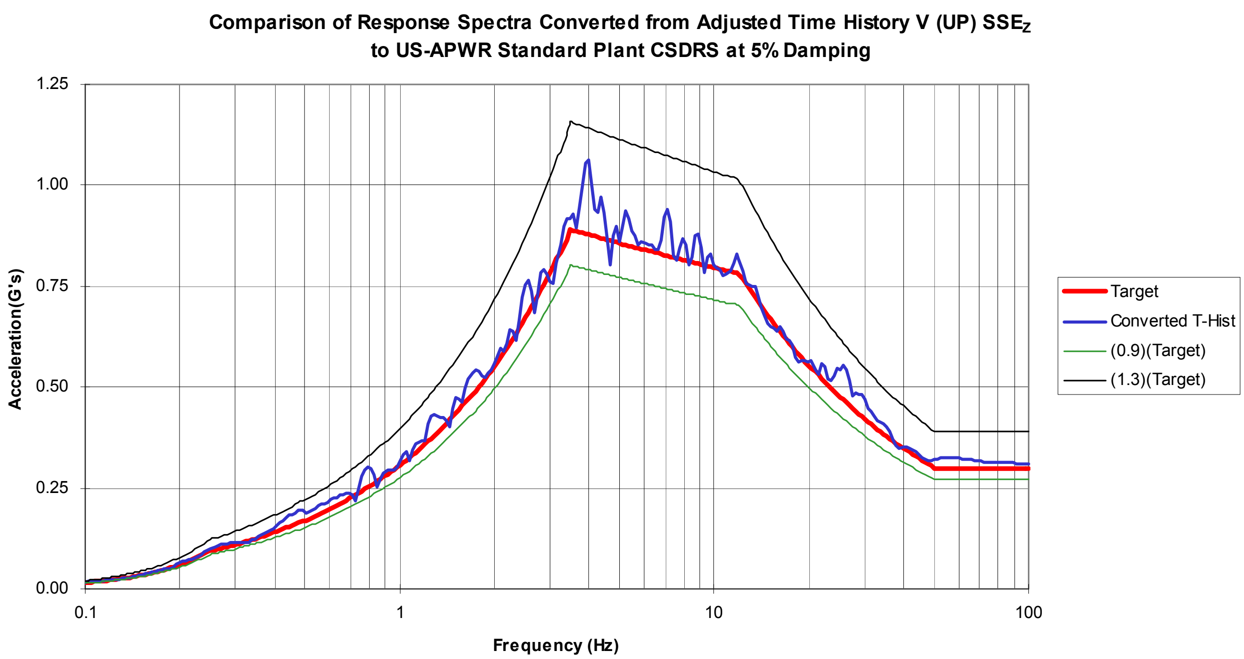


Figure 5.1-6 5% Damped Response Spectra Plots for Adjusted Northridge, BAL Component V (UP)

The time histories meet all of the requirements and conditions set forth in Section II of NUREG-0800, SRP 3.7.1 (Reference 1) for the generation of a single set of time histories Option 1, Approach 2, as summarized in Table 5.1-1 and described in the following, steps (a) through (d):

(a) The US-APWR artificial time histories have sufficiently small time increments (Δt =0.005 seconds) and a total duration of 22.005 seconds. The time history data records have a Nyquist frequency of $N_f = 1/(2\Delta t)$ =100 Hz, and meet the NUREG-0800 SRP 3.7.1 (Reference 1) requirement of a total duration of at least 20 seconds. The time increment of 0.005 seconds is lower than the maximum time increment of 0.01 seconds permitted by SRP 3.7.1. The Nyquist frequency of 100 Hz is considered to be above the range of frequencies important for the design of the US-APWR plant and assures that the seismic analysis capture the responses of SSCs in the high frequency range. This is particularly important for site-specific subgrade conditions where seismic category I structures are founded on a hard rock subgrade.

(b) The 5% damped ARSs of the US-APWR artificial time history components, shown in Figures 5.1-1, 5.1-2, and 5.1-3, are computed at 300 frequency points that are divided such that 100 frequency points are uniformly spaced over the log frequency scale from 0.1 Hz to 1 Hz, 1 Hz to 10 Hz, and 10 Hz to 100 Hz. Each ARS obtained from the three artificial ground motion time history components are compared with the target response spectra at each frequency computed in the frequency range from 0.1 Hz to 100 Hz.

(c) The 5% damped ARSs computed for each of the three US-APWR artificial time history components do not fall more than 10% below the corresponding CSDRS target response spectra at any particular frequency. In addition, within a frequency window no larger than ±10% centered at any frequency data point, none of the three ARSs (H1, H2, and V) falls below their corresponding target CSDRS. Exceeding the requirements of SRP 3.7.1 (Reference 1), is confirmed by assuring that, for each of the spectra derived from the artificial time history components, no more than nine (9) adjacent frequency points fall below the CSDRS target response spectra for frequencies between 0.1 Hz and 100 Hz. This ensures that the response spectra resulting from the artificial time history components do not fall below the corresponding target response spectra in large frequency windows. Table 5.1-1 demonstrates that these requirements are met by showing a summary of the frequency non-exceedances.

(d) In lieu of the power spectral density requirement of Option 1 Approach 1 in SRP 3.7.1 (Reference 1), Approach 2 specifies that the computed 5% damped response spectra of each artificial ground motion time history component does not exceed its target response spectra at any frequency by more than 30% (a factor of 1.3) in the frequency range of interest. For the US-APWR, the response spectra derived from the artificial time histories are checked to ensure that they do not exceed the corresponding target spectra (CSDRS) by more than 30% at any frequency range measured as described in item (b) above. The results of this check are presented in Table 5.1-2.

Table 5.1-1 Comparison of 5% Damping ARS of Artificial Time History and CSDRS

Time History	Frequency Range		0.1 – 1 Hz	1 – 10 Hz	10 – 100 Hz	0.1 – 100 Hz
	No. Freq. Data Points		**100**	**100**	**100**	**300**
Horizontal H1	ARS/CSDRS ratio	Min.	0.942	0.937	0.920	0.920
		Max	1.251	1.262	1.218	1.262
	Max. No. of Data Point Non-Exceedances Within Any One Particular Frequency Window (1)		1	4	7	7
Horizontal H2	ARS/CSDRS ratio	Min.	0.898	0.941	0.968	0.898
		Max	1.292	1.142	1.126	1.292
	Max. No. of Data Point Non-Exceedances Within Any One Particular Frequency Window (1)		7	6	6	7
Vertical V	ARS/CSDRS ratio	Min.	0.942	0.931	0.966	0.931
		Max	1.206	1.212	1.182	1.212
	Max. No. of Data Point Non-Exceedances Within Any One Particular Frequency Window (1)		6	3	6	6

(1) Maximum number of frequency data points in any one particular sequence (frequency window) for which the acceleration values of the time histories ARS are below those of the CSDRS.

Table 5.1-2 Spectra Matching Requirements for Converted Time Histories

SRP 3.7.1 Criterion for 5% Critical Damping:	H1 (180) SSE_x	H2 (090) SSE_y	V (up) SSE_z
Average of converted/target acceleration ratios for all frequency points (if > 1.0 o.k.)	1.0705	1.0402	1.0509
Rise time duration			
Arias Intensity 5%	3.94	4.635	2.08
Required for Magnitude 6.5 earthquake(1) (2)	1	1	1
Strong motion time duration			
Arias intensity 75% - 5%	7.52	7.145	8.77
Required for Magnitude 6.5 earthquake(1) (2)	7	7	7
Decay time duration			
Arias intensity 100% - 75%	10.63	10.31	11.24
Required for Magnitude 6.5 earthquake(1) (2)	5	5	5
Statistical Independence			
Correlation coefficient X and Y (if abs value < 0.16 o.k.)	0.0892	0.0892	
Correlation coefficient X and Z (if abs value < 0.16 o.k.)	-0.0654		-0.0654
Correlation coefficient Y and Z (if abs value < 0.16 o.k.)		-0.0836	-0.0836
SRP 3.7.1 Option 1, Approach 2			
Number of points with acceleration ratio > 1.30 (if = 0 o.k.)	0	0	0
Number of points with acceleration ratio < 0.90 (if = 0 o.k.)	0	0	0
Number of windows wider than 9 points below the target spectra (if = 0 o.k.)	0	0	0

(1) The seed recorded time history earthquake for the US-APWR Standard Plant CSDRS has a Magnitude of 6.5 (References 8 and 22).

(2) See Table 2.3-1 of ASCE 4-98 (Reference 13) for guidance on length of time appropriate for rise, strong motion, and decay

The time histories also meet the requirements set forth in Acceptance Criteria 1B, on page 3.7.1-9 of SRP 3.7.1 (Reference 1) as summarized in Table 5.1-2 and further described below:

Cross Correlation between Components

The cross-correlation coefficients between the three components of the artificial time history earthquake are as follows: ρ_{12} = 0.0892, ρ_{23} = -0.0654, and ρ_{31} = -0.0836 where 1, 2, and 3 are the three global directions corresponding to NS, EW, and vertical directions for the US-APWR standard plant**.** Since the absolute values of the cross-correlation coefficients of the US-APWR artificial time histories are less than 0.16, as listed above, in accordance with NUREG/CR-6728 (Reference 10), the time histories are considered statistically independent of each other.

Duration of Motion

The set of three statistically independent components of the artificial time history earthquake which are developed for design of the US-APWR seismic Category I buildings are characterized by the strong duration of motion times, listed in Table 5.1-2 and total duration of motion time of 22.085 seconds. The strong motion duration time is defined as the time required for the Arias Intensity to rise from 5% to 75%, and is required to meet a minimum of 6 seconds, in accordance with SRP 3.7.1 (Reference 1). The duration of motion of the US-APWR artificial time histories with respect to time achieved from 5% to 75% Arias intensities example provided in Table 5.1-3 shows the subtraction of Arias Intensity values to determine the duration. This is similarly computed for rise and decay times listed in Table 5.1-2. The guidance of ASCE 4-98 (Reference 13) for minimum duration, rise, and decay times for a Magnitude 6.5 earthquake is also met.

Table 5.1-3 Duration of Motion of US-APWR Artificial Time History Components Computed from Arias Intensity Values

	Arias Intensity		Arias Duration $75\%I_a$ - $5\%I_a$ (seconds)	ASCE 4-98 [(1)] Arias Min. Duration (seconds)
	Time for 5% (seconds)	Time for 75% (seconds)		
H1	3.94	11.46	7.52	7
H2	4.635	11.78	7.145	7
V	2.08	10.84	8.77	7

(1) ASCE 4-98 guidance for a 6.5 Magnitude Earthquake

The uniformity of the growth of this Arias Intensity is shown in Figure 5.1-7 for each of the three components of the artificial time history earthquake. The total duration of motion exceeds the minimum acceptance criterion of 20 seconds as given in SRP 3.7.1 design time histories, Option 1, Approach 2 Part (a).

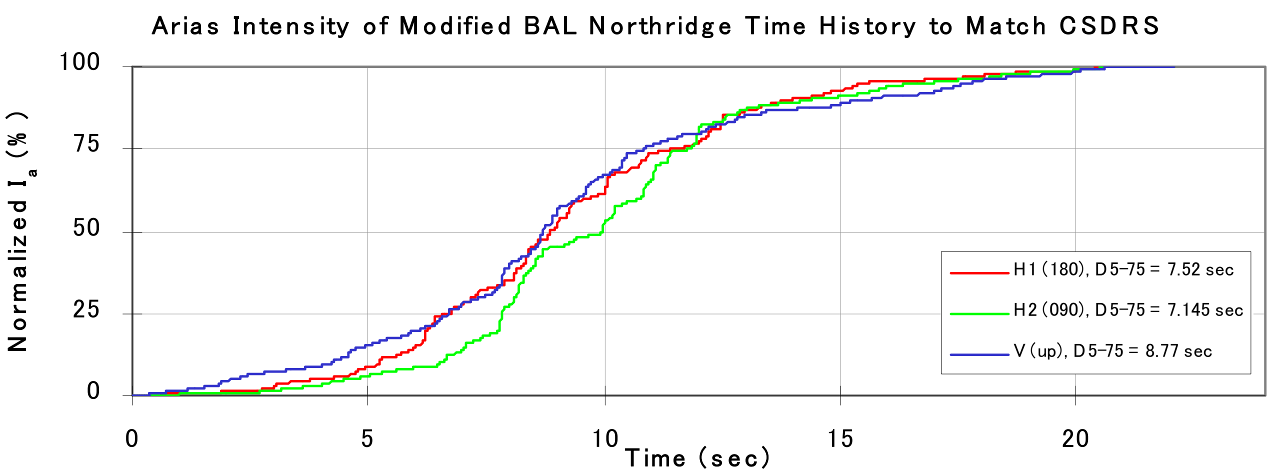


Figure 5.1-7 Normalized Arias Intensity of Time History Components Showing 5%-75% Duration

5.2 Development of Soil Profiles

Following the approach discussed in Section 4.2.2, strain compatible properties are developed for the $\overline{V_S}$ (30m) profile categories of 270 m/s, 560 m/s, 900 m/s, and 2,032 m/s. The selected shear- and compressional-wave profiles are shown in Figure 5.2-1 to their maximum depths with Poisson ratios shown in Figure 5.2-2. To accommodate realistic soil foundation conditions in developing the strain compatible properties, approximately 68 ft of soft soil is removed from the softest profile, $\overline{V_S}$ (30m) = 270 m/s. The soil removal increased the original surficial shear-wave velocity of 520 ft/s (Figure 4.2-1) to 1,247 ft/s at a foundation level, although the profile name of 270 m/s is retained (the $\overline{V_S}$ (30m) for the revised 270m/sec profile has increased to 425m/sec). The remaining three profiles are assumed to reflect appropriate conditions at the plant surface and are left unaltered. Due to their steep velocity gradients (Figure 5.2-1), the depth ranges for soft and firm rock profiles of 900 m/s and 2,032 m/s are restricted to 100 feet and 200 feet for soft rock (900 m/s) and 100 ft for firm rock (2,032 m/s). The final profile categories and depth bins are listed in Table 5.2-1.

Table 5.2-1 Final Profile Categories

Category (initial $\overline{V_S}$ [30m])	Depth to Rock* (ft)
270	200
	500
560	100
	200
	500
900	100
	200
2,032	100

* For soil and soft rock profiles 270m/sec and 560m/sec, underlying baserock conditions reflect soft rock with a shear-wave velocity of 1 km/sec. For firm rock profiles 900m/sec and 2,032m/sec, underlying baserock conditions reflect hard rock with a shear-wave velocity of 2.83 km/sec (Table 4.2-1).

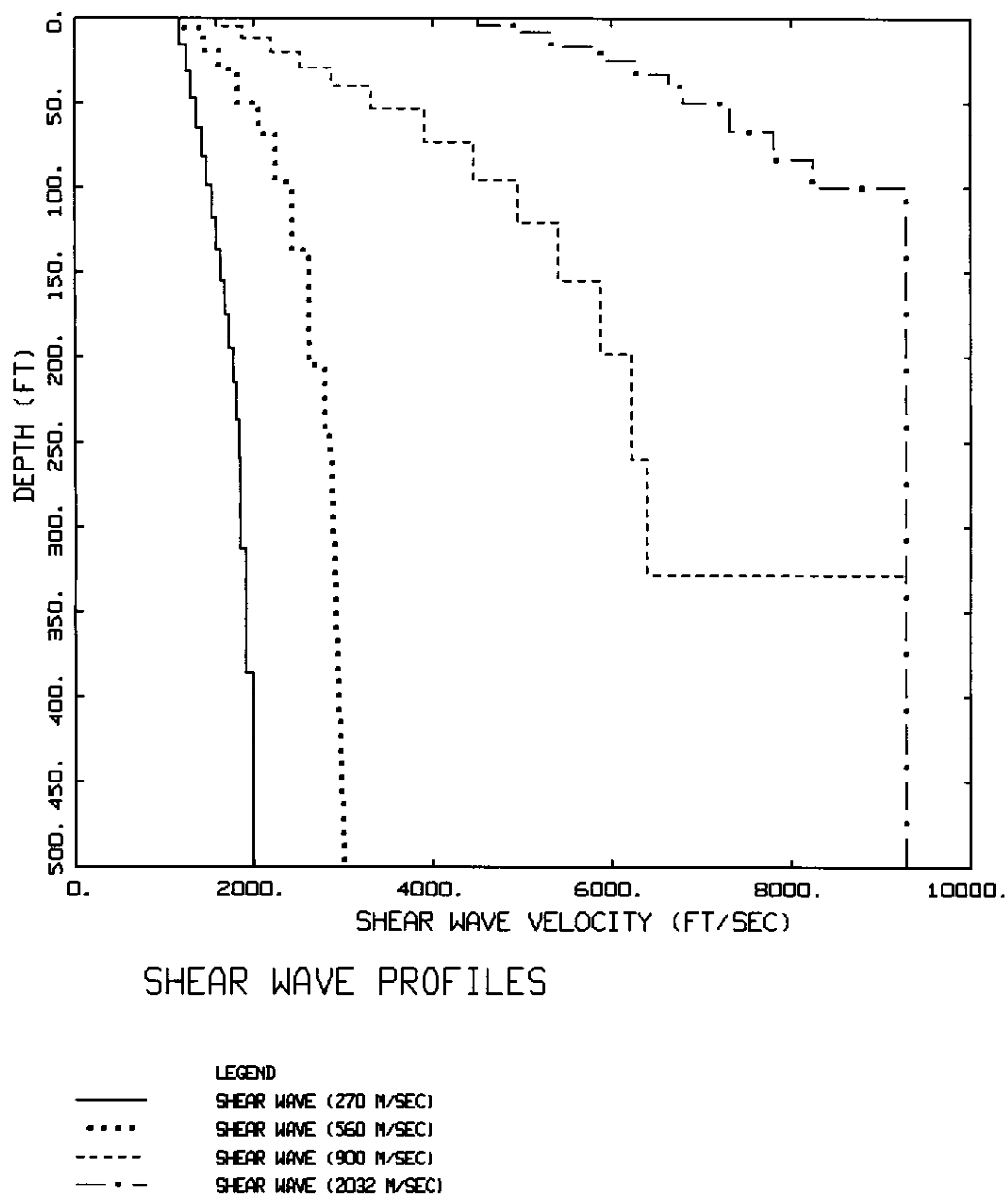


Figure 5.2-1 Final Foundation Level Base-Case Shear- And Compressional-Wave Velocity Profiles (Sheet 1 of 2)

Note: Since the water table was taken at the foundation level, the minimum compressional-wave velocity was set at 5,000 ft/s.

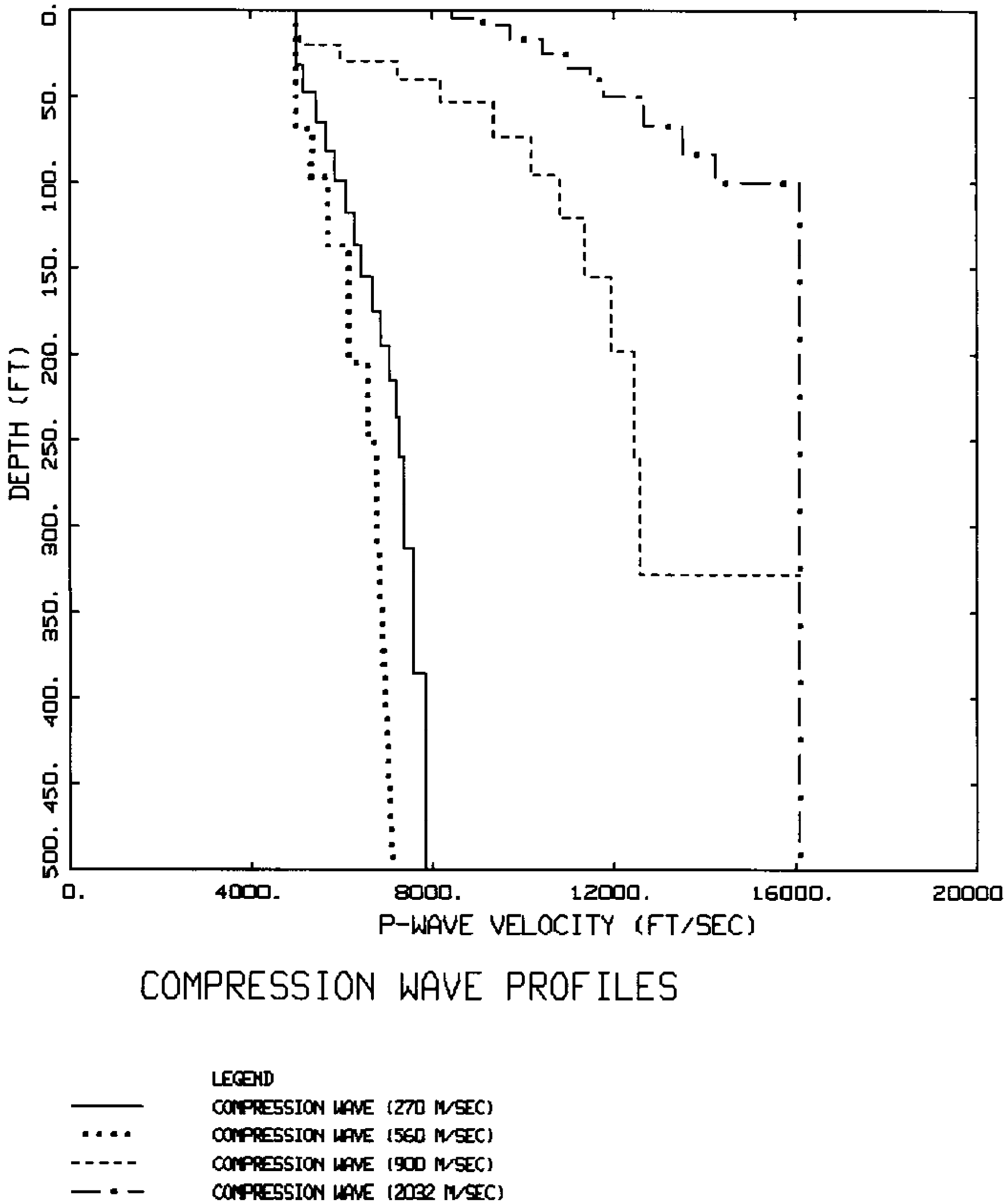


Figure 5.2-1 Final Foundation Level Base-Case Shear- And Compressional-Wave Velocity Profiles (Sheet 2 of 2)

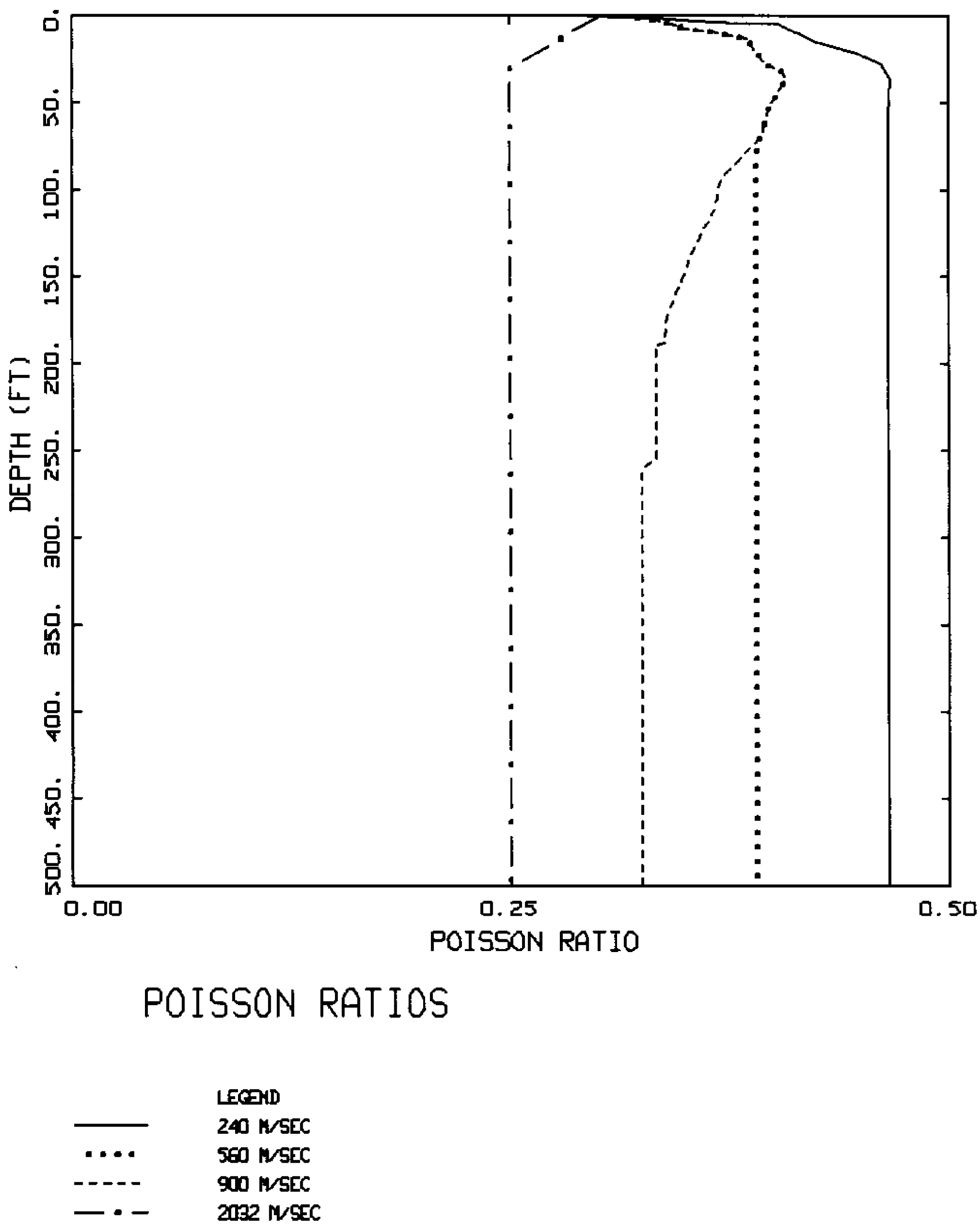


Figure 5.2-2 Poisson Ratios Computed for the Four Base-Case Profiles

5.2.1 Site Response Analyses

The site response analyses are conducted using the equivalent linear RVT approach (Reference 8, Reference 10, and NUREG/CR-6729 (Reference 17)) with the point-source model used to generate both the horizontal and vertical motions (References 8, 10, and 11). Magnitude **M**7.5 is used as its broad spectral shape is consistent with that of the CSDRS. Distances are adjusted such that the median spectrum computed for each profile approaches, but does not exceed, the horizontal and vertical CSDRS. The distances and median estimates of the horizontal and vertical peak accelerations are listed in Table 5.2-2 and the median spectrum computed for each profile is compared to the CSDRS spectrum in Figure 5.2-3 for horizontal components. Due to the shape of the US-AWPR CSDRS, nearly all the profile spectra approach the design spectrum at high frequency (approximately 25 Hz to 50 Hz). This frequency range then becomes the effective control for non exceedence and associated distance adjustment for most of the profiles. The exceptions being reflected by the fundamental low-frequency resonance of the softest (270 m/s and 560m/sec) and deepest (500 feet) profiles. Figure 5.2-3 also suggests a simple manner to update the CSDRS to reflect the expected spectral shape for CEUS strong ground motions.

For the vertical motions, Figure 5.2-4 compares the median spectra computed for the profiles with the vertical component CSDRS. In this case, the vertical motions are modeled assuming incident inclined P-SV wave using a linear analysis (References 8, 10, and 11). Linear analyses for vertical motions with incident inclined P-SV waves has been shown to be appropriate for loading levels up to about 0.5g (Reference 8) and consistent with empirical GMPEs from “Empirical Response Spectral Attenuation Relations for Shallow Crustal Earthquakes” (Reference 18). Use of linear analyses is also consistent with observations of spectral shapes for vertical motions at soil sites being independent of loading level (Reference 11). For applications to sites with a water table at or very near the surface, linearity of the constrained modulus is also a realistic assumption as compressional waves control the high-frequencies in vertical motions (Refer to “Properties of Vertical Ground Motions”, Reference 19), where nonlinearity has its largest effect.

As Figure 5.2-4 shows, most of the vertical spectra fall significantly below the vertical CSDRS design spectrum which was based on the RG 1.60 (Reference 16) V/H ratio. This trend is consistent with vertical spectra recorded at both soil and rock sites in WNA and is a result of the large source distances (Reference 10) (e.g. > 50 km, Table 5.2-2). Empirical (Refer to Reference 20) as well as simulated (References 10 and 11) V/H ratios decrease with increasing distance in both WNA and CEUS and are less than one at distances exceeding 50 km.

Using the RG 1.60 (Reference 16) V/H ratios, which are conservatively independent of distance, the vertical motions are considerably elevated as shown in Figure 5.2-5. With the conservative RG 1.60 V/H ratios, there are some minor exceedences near 0.5 Hz and 1.0 Hz for the softest profile (270 m/s) and largest depths to soft rock material (500 feet).

Table 5.2-2 Magnitudes, Distances, and Median Peak Accelerations

Profile	**M**	D(km)	PGA^{*}_{H}(g)	PGA^{*}_{V}(g)
270 – 200	7.5	58.0	0.262	0.124
270 – 500	7.5	50.0	0.246	0.149
560 -100	7.5	55.0	0.259	0.130
560 – 200	7.5	45.0	0.276	0.167
560 – 500	7.5	48.0	0.203	0.133
900 – 100	7.5	72.0	0.200	0.067
900 – 200	7.5	65.0	0.215	0.082
2032 - 100	7.5	58.0	0.172	0.067

$\Delta\sigma$ = 110 bars

$Q(f) = 670\ f^{0.33}$

κ = 0.006 sec, hard rock outcrop horizontal component

κ = 0.003 sec, hard rock outcrop vertical component

* Median peak acceleration at profile surface

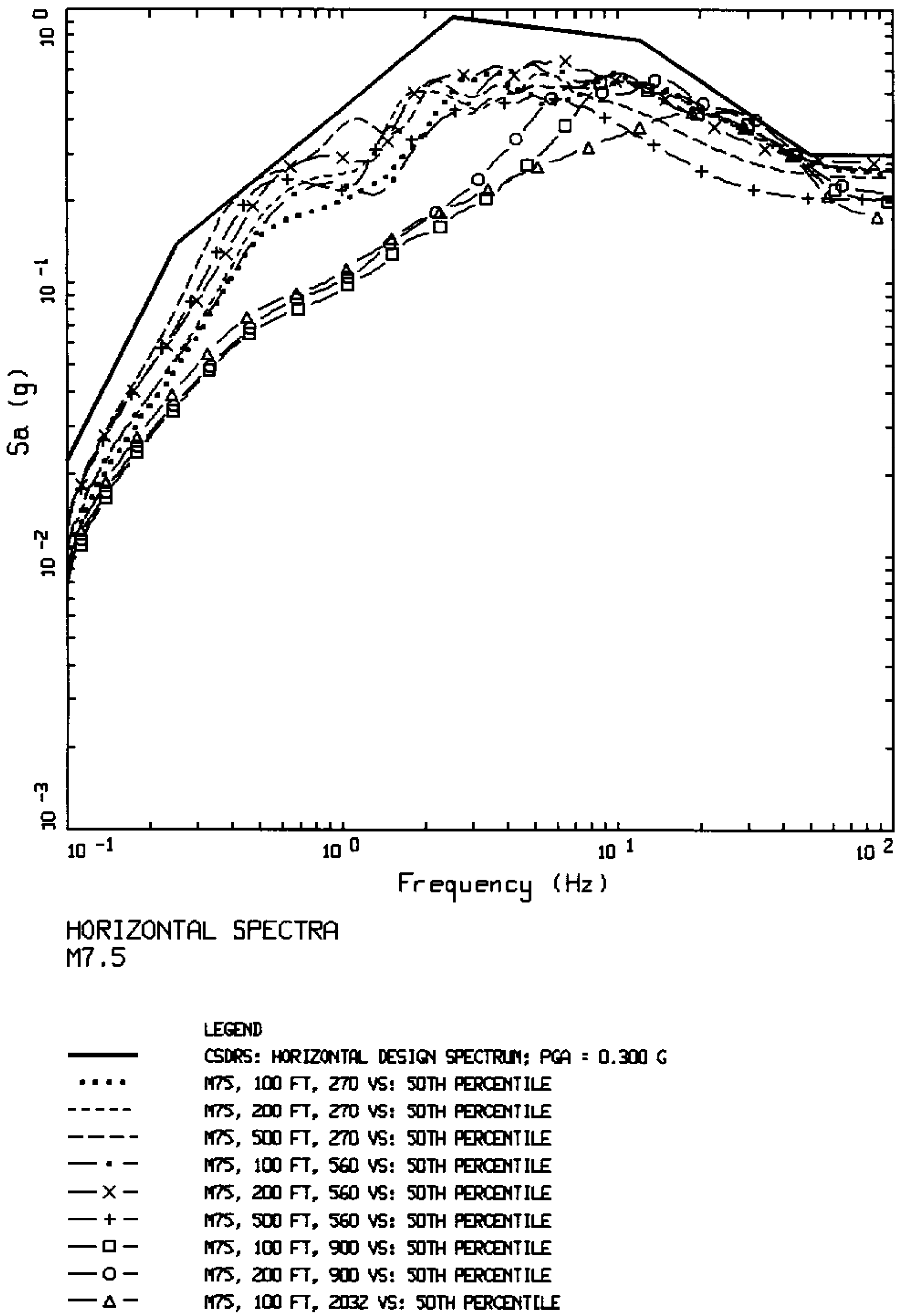


Figure 5.2-3 Median Spectra (5% damped) Compared to CSDRS Horizontal Components

Note: Magnitude is **M** 7.5 with median peak accelerations and distances listed in Table 5.2.2: Horizontal components

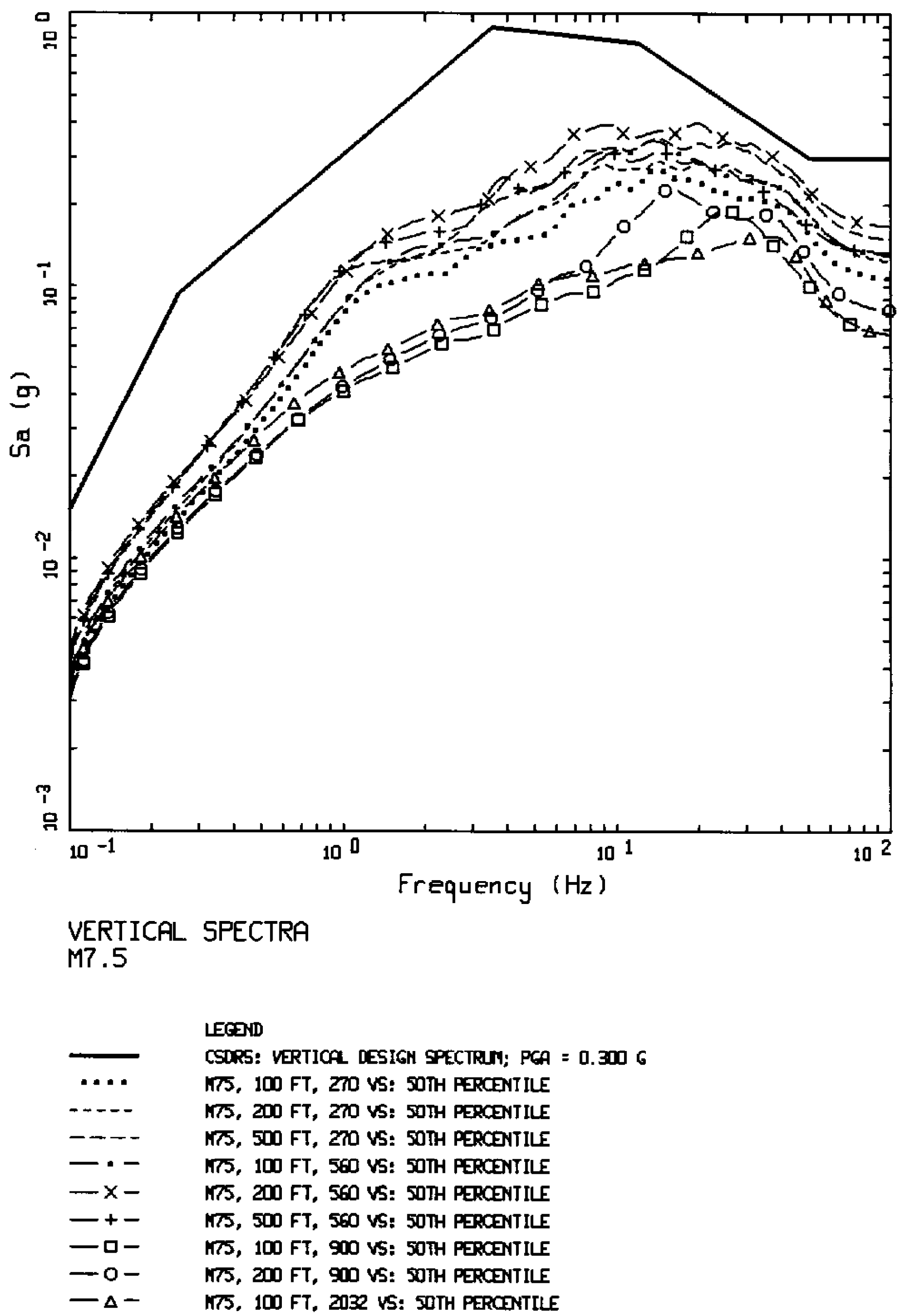


Figure 5.2-4 Median Spectra (5% damped) Compared to CSDRS Vertical Components

Note: Magnitude is **M**7.5 with median peak accelerations and distances listed in Table 5.2.2: Vertical components

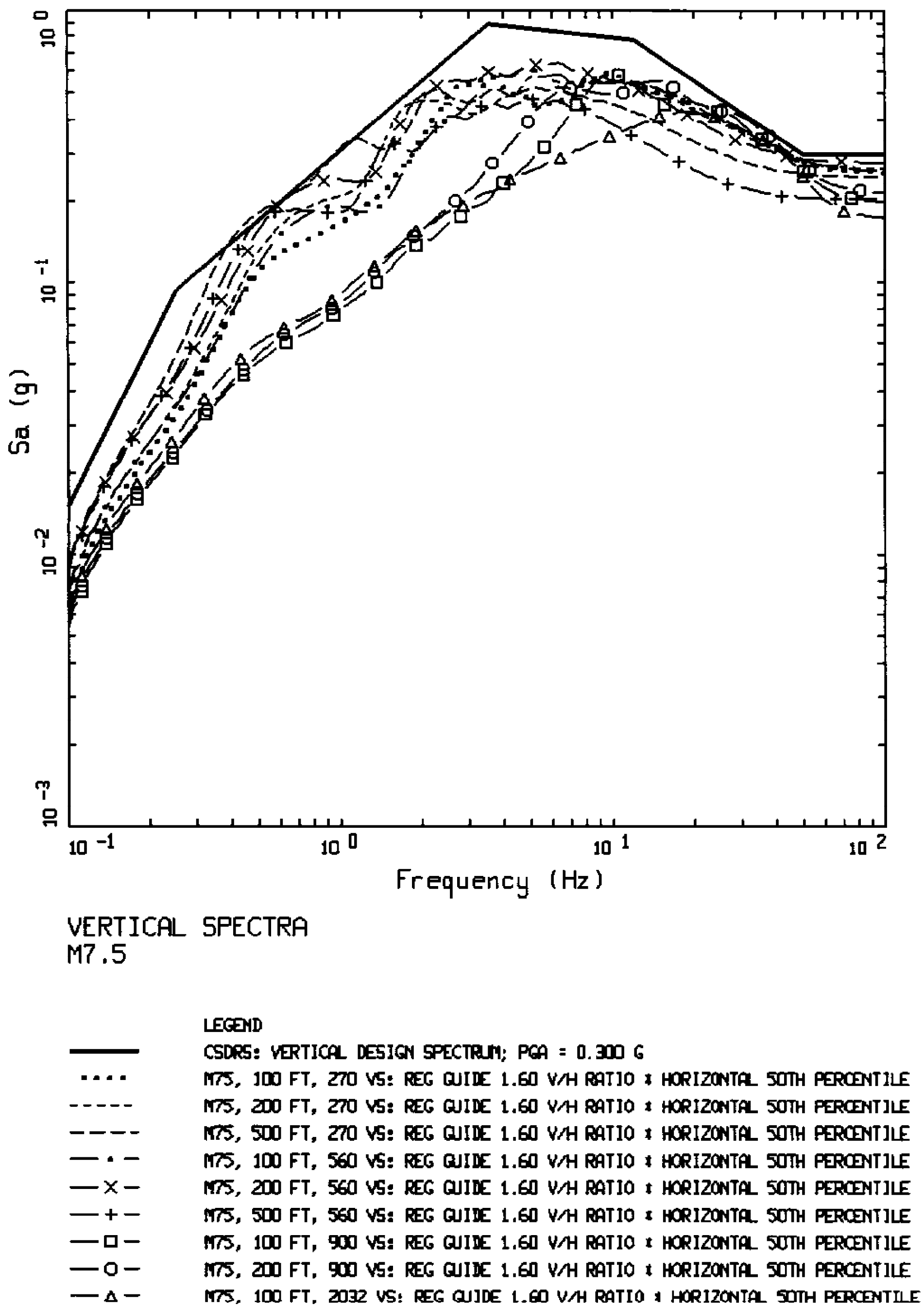


Figure 5.2-5 Median Spectra (5% damped) Compared to CSDRS Vertical Components Using RG 1.60 V/H Ratios

Note: Magnitude is **M**7.5 with median peak accelerations and distances listed in Table 5.2.2: Vertical components using RG 1.60 V/H ratios

5.2.2 Strain Compatible Properties

For the eight combinations of profile categories and depths to hard or soft rock material (Table 5.2-1) strain compatible properties are developed reflecting median (best estimate) and ± 1σ (upper and lower range) estimates over the thirty (30) realizations of profiles and G/G_{max} and hysteretic damping curves (Section 4.2.2). The strain compatible properties are summarized in Tables 5.2-4 to 5.2-11, with Figures 5.2-6 to 5.2-13 showing the median and ±1σ estimates for the shear- and compressional-wave velocities and associated damping.

Table 5.2-3 Deleted

Table 5.2-4 (Sheet 1 of 3) Strain Compatible Properties for Profile 270, 200 ft (Median)

Layer	Thick(ft)	Mean Vs(ft/s)	Mean Vp(ft/s)	Mean Damps(%)	Mean Dampp(%)	Mean Den(cgs)	Mean Poisson	Depth To Top(ft)
1	7.917	.11660E+04	.47982E+04	.16731E+01	.11972E+01	.20000E+01	.46857E+00	.00000E+00
2	7.914	.11590E+04	.49740E+04	.24599E+01	.11972E+01	.20000E+01	.47107E+00	.79170E+01
3	7.917	.12682E+04	.53387E+04	.23650E+01	.10045E+01	.20000E+01	.46991E+00	.15831E+02
4	7.914	.13236E+04	.56247E+04	.25578E+01	.10045E+01	.20000E+01	.47043E+00	.23748E+02
5	8.580	.12801E+04	.55066E+04	.28816E+01	.10045E+01	.20000E+01	.47120E+00	.31662E+02
6	8.580	.13021E+04	.56444E+04	.30293E+01	.10045E+01	.20000E+01	.47162E+00	.40242E+02
7	8.580	.13340E+04	.58000E+04	.31269E+01	.10045E+01	.20000E+01	.47182E+00	.48822E+02
8	8.580	.13034E+04	.57097E+04	.33445E+01	.10045E+01	.20000E+01	.47234E+00	.57402E+02
9	8.580	.13347E+04	.58709E+04	.33943E+01	.10045E+01	.20000E+01	.47253E+00	.65982E+02
10	8.580	.13721E+04	.60382E+04	.34092E+01	.10045E+01	.20000E+01	.47262E+00	.74562E+02
11	9.377	.13616E+04	.60297E+04	.26165E+01	.79917E+00	.20000E+01	.47291E+00	.83142E+02
12	9.374	.14165E+04	.62649E+04	.25768E+01	.79917E+00	.20000E+01	.47282E+00	.92519E+02
13	9.377	.14500E+04	.64048E+04	.25954E+01	.79917E+00	.20000E+01	.47279E+00	.10189E+03
14	9.374	.14561E+04	.64515E+04	.26530E+01	.79917E+00	.20000E+01	.47295E+00	.11127E+03
15	9.377	.14345E+04	.63909E+04	.27704E+01	.79917E+00	.20000E+01	.47325E+00	.12064E+03
16	9.374	.14158E+04	.63254E+04	.28695E+01	.79917E+00	.20000E+01	.47341E+00	.13002E+03
17	10.000	.14825E+04	.65707E+04	.27263E+01	.79917E+00	.21000E+01	.47301E+00	.13939E+03
18	10.000	.14939E+04	.66360E+04	.27590E+01	.79917E+00	.21000E+01	.47312E+00	.14939E+03
19	10.000	.15344E+04	.68038E+04	.27415E+01	.79917E+00	.21000E+01	.47303E+00	.15939E+03
20	10.000	.15417E+04	.68552E+04	.27789E+01	.79917E+00	.21000E+01	.47316E+00	.16940E+03
21	10.000	.15986E+04	.70896E+04	.27185E+01	.79917E+00	.21000E+01	.47300E+00	.17940E+03
22	10.000	.15437E+04	.68882E+04	.28633E+01	.79917E+00	.21000E+01	.47334E+00	.18939E+03
23	0.604	.15743E+04	.70220E+04	.28200E+01	.79917E+00	.21000E+01	.47330E+00	.19939E+03
24	997.424	.33172E+04	.78122E+04	.50000E+00	.50000E+00	.21500E+01	.39002E+00	.20000E+03
25	3281.000	.92850E+04	.16080E+05	.50000E-03	.50000E-03	.25200E+01	.24990E+00	.11974E+04

Table 5.2-4 (Sheet 2 of 3) Strain Compatible Properties for Profile 270, 200 ft (-1 Sigma)

Layer	Thick(ft)	Mean Vs(ft/s)	Mean Vp(ft/s)	Mean Damps(%)	Mean Dampp(%)	Mean Den(cgs)	Mean Poisson	Depth To Top(ft)
1	7.917	.87725E+03	.36762E+04	.12233E+01	.11713E+01	.20000E+01	.46696E+00	.00000E+00
2	7.914	.84561E+03	.38036E+04	.16669E+01	.11713E+01	.20000E+01	.46772E+00	.79170E+01
3	7.917	.94557E+03	.41115E+04	.16384E+01	.98294E+00	.20000E+01	.46687E+00	.15831E+02
4	7.914	.94365E+03	.41812E+04	.16501E+01	.98294E+00	.20000E+01	.46695E+00	.23748E+02
5	8.580	.95103E+03	.42300E+04	.19344E+01	.98294E+00	.20000E+01	.46794E+00	.31662E+02
6	8.580	.97668E+03	.43949E+04	.19984E+01	.98294E+00	.20000E+01	.46816E+00	.40242E+02
7	8.580	.10477E+04	.46883E+04	.20906E+01	.98294E+00	.20000E+01	.46856E+00	.48822E+02
8	8.580	.10748E+04	.47614E+04	.22837E+01	.98294E+00	.20000E+01	.46947E+00	.57402E+02
9	8.580	.10934E+04	.49078E+04	.23529E+01	.98294E+00	.20000E+01	.46939E+00	.65982E+02
10	8.580	.11709E+04	.52081E+04	.24367E+01	.98294E+00	.20000E+01	.46979E+00	.74562E+02
11	9.377	.11129E+04	.51576E+04	.20156E+01	.78362E+00	.20000E+01	.46952E+00	.83142E+02
12	9.374	.11514E+04	.53559E+04	.19176E+01	.78362E+00	.20000E+01	.46931E+00	.92519E+02
13	9.377	.12151E+04	.55600E+04	.19367E+01	.78362E+00	.20000E+01	.46962E+00	.10189E+03
14	9.374	.11993E+04	.55169E+04	.19644E+01	.78362E+00	.20000E+01	.46969E+00	.11127E+03
15	9.377	.11783E+04	.54576E+04	.20604E+01	.78362E+00	.20000E+01	.46991E+00	.12064E+03
16	9.374	.11692E+04	.53770E+04	.21042E+01	.78362E+00	.20000E+01	.47017E+00	.13002E+03
17	10.000	.12247E+04	.55242E+04	.19749E+01	.78362E+00	.21000E+01	.47008E+00	.13939E+03
18	10.000	.12545E+04	.57085E+04	.20425E+01	.78362E+00	.21000E+01	.47006E+00	.14939E+03
19	10.000	.12924E+04	.58501E+04	.21192E+01	.78362E+00	.21000E+01	.47004E+00	.15939E+03
20	10.000	.13129E+04	.60141E+04	.21177E+01	.78362E+00	.21000E+01	.47000E+00	.16940E+03
21	10.000	.13471E+04	.61840E+04	.20697E+01	.78362E+00	.21000E+01	.46975E+00	.17940E+03
22	10.000	.12810E+04	.58859E+04	.20747E+01	.78362E+00	.21000E+01	.47008E+00	.18939E+03
23	0.604	.12627E+04	.58380E+04	.20426E+01	.78362E+00	.21000E+01	.46990E+00	.19939E+03
24	997.424	.26524E+04	.62461E+04	.50000E+00	.50000E+00	.21500E+01	.38999E+00	.20000E+03
25	3281.000	.92850E+04	.16080E+05	.50000E-03	.50000E-03	.25200E+01	.24990E+00	.11974E+04

Table 5.2-4 (Sheet 3 of 3) Strain Compatible Properties for Profile 270, 200 ft (+1 Sigma)

Layer	Thick(ft)	Mean Vs(ft/s)	Mean Vp(ft/s)	Mean Damps(%)	Mean Dampp(%)	Mean Den(cgs)	Mean Poisson	Depth To Top(ft)
1	7.917	.15499E+04	.62626E+04	.22882E+01	.12237E+01	.20000E+01	.47019E+00	.00000E+00
2	7.914	.15884E+04	.65046E+04	.36304E+01	.12237E+01	.20000E+01	.47444E+00	.79170E+01
3	7.917	.17009E+04	.69321E+04	.34138E+01	.10265E+01	.20000E+01	.47297E+00	.15831E+02
4	7.914	.18566E+04	.75665E+04	.39647E+01	.10265E+01	.20000E+01	.47394E+00	.23748E+02
5	8.580	.17231E+04	.71685E+04	.42929E+01	.10265E+01	.20000E+01	.47448E+00	.31662E+02
6	8.580	.17359E+04	.72491E+04	.45920E+01	.10265E+01	.20000E+01	.47511E+00	.40242E+02
7	8.580	.16987E+04	.71754E+04	.46770E+01	.10265E+01	.20000E+01	.47511E+00	.48822E+02
8	8.580	.15806E+04	.68469E+04	.48981E+01	.10265E+01	.20000E+01	.47522E+00	.57402E+02
9	8.580	.16294E+04	.70229E+04	.48968E+01	.10265E+01	.20000E+01	.47569E+00	.65982E+02
10	8.580	.16078E+04	.70005E+04	.47699E+01	.10265E+01	.20000E+01	.47546E+00	.74562E+02
11	9.377	.16659E+04	.70492E+04	.33967E+01	.81502E+00	.20000E+01	.47632E+00	.83142E+02
12	9.374	.17426E+04	.73281E+04	.34628E+01	.81502E+00	.20000E+01	.47635E+00	.92519E+02
13	9.377	.17302E+04	.73780E+04	.34783E+01	.81502E+00	.20000E+01	.47599E+00	.10189E+03
14	9.374	.17678E+04	.75446E+04	.35830E+01	.81502E+00	.20000E+01	.47624E+00	.11127E+03
15	9.377	.17465E+04	.74839E+04	.37252E+01	.81502E+00	.20000E+01	.47661E+00	.12064E+03
6	9.374	.17143E+04	.74410E+04	.39130E+01	.81502E+00	.20000E+01	.47668E+00	.13002E+03
17	10.000	.17946E+04	.78154E+04	.37635E+01	.81502E+00	.21000E+01	.47595E+00	.13939E+03
18	10.000	.17788E+04	.77141E+04	.37267E+01	.81502E+00	.21000E+01	.47620E+00	.14939E+03
19	10.000	.18218E+04	.79130E+04	.35464E+01	.81502E+00	.21000E+01	.47603E+00	.15939E+03
20	10.000	.18103E+04	.78140E+04	.36466E+01	.81502E+00	.21000E+01	.47635E+00	.16940E+03
21	10.000	.18971E+04	.81277E+04	.35706E+01	.81502E+00	.21000E+01	.47627E+00	.17940E+03
22	10.000	.18602E+04	.80610E+04	.39515E+01	.81502E+00	.21000E+01	.47662E+00	.18939E+03
23	0.604	.19628E+04	.84461E+04	.38932E+01	.81502E+00	.21000E+01	.47672E+00	.19939E+03
24	997.424	.41487E+04	.97710E+04	.50000E+00	.50000E+00	.21500E+01	.39005E+00	.20000E+03
25	3281.000	.92850E+04	.16080E+05	.50000E-03	.50000E-03	.25200E+01	.24990E+00	.11974E+04

Table 5.2-5 (Sheet 1 of 6) Strain Compatible Properties for Profile 270, 500 ft (Median)

Layer	Thick(ft)	Mean Vs(ft/s)	Mean Vp(ft/s)	Mean Damps(%)	Mean Dampp(%)	Mean Den(cgs)	Mean Poisson	Depth To Top(ft)
1	7.917	.12299E+04	.50493E+04	.16601E+01	.11972E+01	.20000E+01	.46843E+00	.00000E+00
2	7.914	.11804E+04	.50528E+04	.25525E+01	.11972E+01	.20000E+01	.47098E+00	.79170E+01
3	7.917	.11883E+04	.50792E+04	.26953E+01	.10045E+01	.20000E+01	.47072E+00	.15831E+02
4	7.914	.11822E+04	.51407E+04	.30298E+01	.10045E+01	.20000E+01	.47167E+00	.23748E+02
5	8.580	.11640E+04	.51421E+04	.33561E+01	.10045E+01	.20000E+01	.47253E+00	.31662E+02
6	8.580	.12418E+04	.54980E+04	.33423E+01	.10045E+01	.20000E+01	.47261E+00	.40242E+02
7	8.580	.12999E+04	.57297E+04	.33919E+01	.10045E+01	.20000E+01	.47263E+00	.48822E+02
8	8.580	.13023E+04	.57789E+04	.35537E+01	.10045E+01	.20000E+01	.47301E+00	.57402E+02
9	8.580	.12966E+04	.57849E+04	.37461E+01	.10045E+01	.20000E+01	.47334E+00	.65982E+02
10	8.580	.12734E+04	.57444E+04	.39636E+01	.10045E+01	.20000E+01	.47387E+00	.74562E+02
11	9.377	.13165E+04	.59040E+04	.29232E+01	.79917E+00	.20000E+01	.47362E+00	.83142E+02
12	9.374	.13620E+04	.61017E+04	.29316E+01	.79917E+00	.20000E+01	.47358E+00	.92519E+02
13	9.377	.13027E+04	.58975E+04	.31497E+01	.79917E+00	.20000E+01	.47413E+00	.10189E+03
14	9.374	.13199E+04	.59871E+04	.31824E+01	.79917E+00	.20000E+01	.47421E+00	.11127E+03
15	9.377	.13377E+04	.60805E+04	.32145E+01	.79917E+00	.20000E+01	.47432E+00	.12064E+03
16	9.374	.13586E+04	.61789E+04	.32342E+01	.79917E+00	.20000E+01	.47436E+00	.13002E+03
17	10.000	.14876E+04	.66661E+04	.29353E+01	.79917E+00	.21000E+01	.47360E+00	.13939E+03
18	10.000	.14820E+04	.66630E+04	.30032E+01	.79917E+00	.21000E+01	.47376E+00	.14939E+03
19	10.000	.14934E+04	.67253E+04	.30253E+01	.79917E+00	.21000E+01	.47385E+00	.15939E+03
20	10.000	.14105E+04	.64237E+04	.32687E+01	.79917E+00	.21000E+01	.47445E+00	.16940E+03
21	10.000	.14468E+04	.65776E+04	.32370E+01	.79917E+00	.21000E+01	.47437E+00	.17940E+03
22	10.000	.14747E+04	.66981E+04	.32389E+01	.79917E+00	.21000E+01	.47433E+00	.18939E+03
23	10.598	.15474E+04	.69906E+04	.31260E+01	.79917E+00	.21000E+01	.47404E+00	.19939E+03
24	10.598	.16549E+04	.71804E+04	.26420E+01	.70326E+00	.21000E+01	.47181E+00	.20999E+03
25	11.500	.16334E+04	.71179E+04	.27211E+01	.70326E+00	.21000E+01	.47205E+00	.22059E+03
26	11.500	.16403E+04	.71529E+04	.27505E+01	.70326E+00	.21000E+01	.47210E+00	.23209E+03
27	17.668	.16864E+04	.73441E+04	.27070E+01	.70326E+00	.21000E+01	.47201E+00	.24359E+03
28	17.668	.16395E+04	.71817E+04	.28421E+01	.70326E+00	.21000E+01	.47234E+00	.26126E+03
29	17.668	.16660E+04	.73047E+04	.28448E+01	.70326E+00	.21000E+01	.47237E+00	.27893E+03
30	18.249	.16884E+04	.74114E+04	.28510E+01	.70326E+00	.21000E+01	.47242E+00	.29660E+03
31	18.249	.17179E+04	.75345E+04	.28563E+01	.70326E+00	.21000E+01	.47239E+00	.31484E+03
32	18.249	.17634E+04	.77217E+04	.28293E+01	.70326E+00	.21000E+01	.47230E+00	.33309E+03
33	18.249	.17587E+04	.77241E+04	.28719E+01	.70326E+00	.21000E+01	.47245E+00	.35134E+03

Table 5.2-5 (Sheet 2 of 6) Strain Compatible Properties for Profile 270, 500 ft (Median)

Layer	Thick(ft)	Mean Vs(ft/s)	Mean Vp(ft/s)	Mean Damps(%)	Mean Dampp(%)	Mean Den(cgs)	Mean Poisson	Depth To Top(ft)
34	20.001	.17507E+04	.77051E+04	.29245E+01	.70326E+00	.21000E+01	.47257E+00	.36959E+03
35	20.001	.17784E+04	.78225E+04	.29208E+01	.70326E+00	.21000E+01	.47255E+00	.38959E+03
36	20.001	.17942E+04	.78939E+04	.29289E+01	.70326E+00	.21000E+01	.47257E+00	.40959E+03
37	20.001	.17800E+04	.78500E+04	.29876E+01	.70326E+00	.21000E+01	.47271E+00	.42959E+03
38	20.001	.17642E+04	.78026E+04	.30439E+01	.70326E+00	.21000E+01	.47286E+00	.44960E+03
39	20.001	.17938E+04	.79186E+04	.30180E+01	.70326E+00	.21000E+01	.47281E+00	.46960E+03
40	10.404	.17807E+04	.78844E+04	.30544E+01	.70326E+00	.21000E+01	.47295E+00	.48960E+03
41	997.424	.31533E+04	.74231E+04	.50000E+00	.50000E+00	.21500E+01	.38991E+00	.50000E+03
42	3281.000	.92850E+04	.16080E+05	.50000E-03	.50000E-03	.25200E+01	.24990E+00	.14974E+04

Table 5.2-5 (Sheet 3 of 6) Strain Compatible Properties for Profile 270, 500 ft (-1 Sigma)

Layer	Thick(ft)	Mean Vs(ft/s)	Mean Vp(ft/s)	Mean Damps(%)	Mean Dampp(%)	Mean Den(cgs)	Mean Poisson	Depth To Top(ft)
1	7.917	.94391E+03	.39332E+04	.11679E+01	.11713E+01	.20000E+01	.46704E+00	.00000E+00
2	7.914	.86944E+03	.38399E+04	.16469E+01	.11713E+01	.20000E+01	.46825E+00	.79170E+01
3	7.917	.81988E+03	.36754E+04	.16798E+01	.98294E+00	.20000E+01	.46696E+00	.15831E+02
4	7.914	.83304E+03	.38435E+04	.18891E+01	.98294E+00	.20000E+01	.46755E+00	.23748E+02
5	8.580	.83922E+03	.39646E+04	.21364E+01	.98294E+00	.20000E+01	.46826E+00	.31662E+02
6	8.580	.89949E+03	.42980E+04	.21317E+01	.98294E+00	.20000E+01	.46824E+00	.40242E+02
7	8.580	.10653E+04	.48536E+04	.23980E+01	.98294E+00	.20000E+01	.46936E+00	.48822E+02
8	8.580	.10911E+04	.49963E+04	.25518E+01	.98294E+00	.20000E+01	.46970E+00	.57402E+02
9	8.580	.11214E+04	.50955E+04	.27350E+01	.98294E+00	.20000E+01	.47021E+00	.65982E+02
10	8.580	.10558E+04	.49410E+04	.28084E+01	.98294E+00	.20000E+01	.47043E+00	.74562E+02
11	9.377	.10870E+04	.50390E+04	.21358E+01	.78362E+00	.20000E+01	.47033E+00	.83142E+02
12	9.374	.11482E+04	.52918E+04	.21588E+01	.78362E+00	.20000E+01	.47040E+00	.92519E+02
13	9.377	.11013E+04	.51518E+04	.22948E+01	.78362E+00	.20000E+01	.47082E+00	.10189E+03
14	9.374	.11013E+04	.51876E+04	.22989E+01	.78362E+00	.20000E+01	.47074E+00	.11127E+03
15	9.377	.11221E+04	.53289E+04	.23883E+01	.78362E+00	.20000E+01	.47083E+00	.12064E+03
16	9.374	.11371E+04	.53847E+04	.24312E+01	.78362E+00	.20000E+01	.47090E+00	.13002E+03
17	10.000	.12501E+04	.57742E+04	.22078E+01	.78362E+00	.21000E+01	.47043E+00	.13939E+03
18	10.000	.12387E+04	.57546E+04	.21896E+01	.78362E+00	.21000E+01	.47048E+00	.14939E+03
19	10.000	.12169E+04	.56647E+04	.21489E+01	.78362E+00	.21000E+01	.47052E+00	.15939E+03
20	10.000	.11673E+04	.54874E+04	.24054E+01	.78362E+00	.21000E+01	.47113E+00	.16940E+03
21	10.000	.11972E+04	.55941E+04	.23149E+01	.78362E+00	.21000E+01	.47112E+00	.17940E+03
22	10.000	.12480E+04	.57842E+04	.23258E+01	.78362E+00	.21000E+01	.47122E+00	.18939E+03
23	10.598	.12929E+04	.59716E+04	.22580E+01	.78362E+00	.21000E+01	.47087E+00	.19939E+03
24	10.598	.14133E+04	.62323E+04	.18470E+01	.68591E+00	.21000E+01	.46920E+00	.20999E+03
25	11.500	.13989E+04	.62270E+04	.19221E+01	.68591E+00	.21000E+01	.46928E+00	.22059E+03
26	11.500	.14166E+04	.62870E+04	.19627E+01	.68591E+00	.21000E+01	.46945E+00	.23209E+03
27	17.668	.14275E+04	.63600E+04	.18876E+01	.68591E+00	.21000E+01	.46920E+00	.24359E+03
28	17.668	.14119E+04	.63143E+04	.19824E+01	.68591E+00	.21000E+01	.46953E+00	.26126E+03
29	17.668	.14337E+04	.64717E+04	.19796E+01	.68591E+00	.21000E+01	.46938E+00	.27893E+03
30	18.249	.14418E+04	.65566E+04	.19950E+01	.68591E+00	.21000E+01	.46931E+00	.29660E+03
31	18.249	.15043E+04	.67888E+04	.20254E+01	.68591E+00	.21000E+01	.46946E+00	.31484E+03
32	18.249	.15644E+04	.70375E+04	.20257E+01	.68591E+00	.21000E+01	.46943E+00	.33309E+03
33	18.249	.15442E+04	.70543E+04	.20417E+01	.68591E+00	.21000E+01	.46937E+00	.35134E+03

Table 5.2-5 (Sheet 4 of 6) Strain Compatible Properties for Profile 270, 500 ft (-1 Sigma)

Layer	Thick(ft)	Mean Vs(ft/s)	Mean Vp(ft/s)	Mean Damps(%)	Mean Dampp(%)	Mean Den(cgs)	Mean Poisson	Depth To Top(ft)
34	20.001	.15470E+04	.70860E+04	.21089E+01	.68591E+00	.21000E+01	.46949E+00	.36959E+03
35	20.001	.15888E+04	.72320E+04	.21376E+01	.68591E+00	.21000E+01	.46959E+00	.38959E+03
36	20.001	.15757E+04	.71363E+04	.21238E+01	.68591E+00	.21000E+01	.46964E+00	.40959E+03
37	20.001	.15967E+04	.72432E+04	.21894E+01	.68591E+00	.21000E+01	.46982E+00	.42959E+03
38	20.001	.15772E+04	.72018E+04	.22241E+01	.68591E+00	.21000E+01	.46991E+00	.44960E+03
39	20.001	.16277E+04	.72796E+04	.21970E+01	.68591E+00	.21000E+01	.47017E+00	.46960E+03
40	10.404	.15862E+04	.71998E+04	.22431E+01	.68591E+00	.21000E+01	.47009E+00	.48960E+03
41	997.424	.23741E+04	.55886E+04	.50000E+00	.50000E+00	.21500E+01	.38986E+00	.50000E+03
42	3281.000	.92850E+04	.16080E+05	.50000E-03	.50000E-03	.25200E+01	.24990E+00	.14974E+04

Table 5.2-5 (Sheet 5 of 6) Strain Compatible Properties for Profile 270, 500 ft (+1 Sigma)

Layer	Thick(ft)	Mean Vs(ft/s)	Mean Vp(ft/s)	Mean Damps(%)	Mean Dampp(%)	Mean Den(cgs)	Mean Poisson	Depth To Top(ft)
1	7.917	.16024E+04	.64820E+04	.23596E+01	.12237E+01	.20000E+01	.46982E+00	.00000E+00
2	7.914	.16025E+04	.66488E+04	.39560E+01	.12237E+01	.20000E+01	.47374E+00	.79170E+01
3	7.917	.17223E+04	.70193E+04	.43245E+01	.10265E+01	.20000E+01	.47451E+00	.15831E+02
4	7.914	.16778E+04	.68756E+04	.48592E+01	.10265E+01	.20000E+01	.47582E+00	.23748E+02
5	8.580	.16144E+04	.66694E+04	.52722E+01	.10265E+01	.20000E+01	.47685E+00	.31662E+02
6	8.580	.17144E+04	.70330E+04	.52404E+01	.10265E+01	.20000E+01	.47702E+00	.40242E+02
7	8.580	.15861E+04	.67639E+04	.47979E+01	.10265E+01	.20000E+01	.47593E+00	.48822E+02
8	8.580	.15544E+04	.66842E+04	.49489E+01	.10265E+01	.20000E+01	.47635E+00	.57402E+02
9	8.580	.14991E+04	.65676E+04	.51309E+01	.10265E+01	.20000E+01	.47648E+00	.65982E+02
10	8.580	.15357E+04	.66785E+04	.55941E+01	.10265E+01	.20000E+01	.47735E+00	.74562E+02
11	9.377	.15943E+04	.69174E+04	.40007E+01	.81502E+00	.20000E+01	.47694E+00	.83142E+02
12	9.374	.16156E+04	.70356E+04	.39812E+01	.81502E+00	.20000E+01	.47679E+00	.92519E+02
13	9.377	.15410E+04	.67511E+04	.43231E+01	.81502E+00	.20000E+01	.47747E+00	.10189E+03
14	9.374	.15820E+04	.69098E+04	.44054E+01	.81502E+00	.20000E+01	.47771E+00	.11127E+03
15	9.377	.15948E+04	.69382E+04	.43264E+01	.81502E+00	.20000E+01	.47784E+00	.12064E+03
16	9.374	.16231E+04	.70902E+04	.43025E+01	.81502E+00	.20000E+01	.47784E+00	.13002E+03
17	10.000	.17702E+04	.76957E+04	.39025E+01	.81502E+00	.21000E+01	.47678E+00	.13939E+03
18	10.000	.17731E+04	.77146E+04	.41192E+01	.81502E+00	.21000E+01	.47706E+00	.14939E+03
19	10.000	.18327E+04	.79844E+04	.42592E+01	.81502E+00	.21000E+01	.47720E+00	.15939E+03
20	10.000	.17045E+04	.75198E+04	.44420E+01	.81502E+00	.21000E+01	.47780E+00	.16940E+03
21	10.000	.17485E+04	.77340E+04	.45263E+01	.81502E+00	.21000E+01	.47764E+00	.17940E+03
22	10.000	.17427E+04	.77565E+04	.45103E+01	.81502E+00	.21000E+01	.47747E+00	.18939E+03
23	10.598	.18519E+04	.81836E+04	.43277E+01	.81502E+00	.21000E+01	.47723E+00	.19939E+03
24	10.598	.19379E+04	.82727E+04	.37793E+01	.72106E+00	.21000E+01	.47443E+00	.20999E+03
25	11.500	.19073E+04	.81362E+04	.38524E+01	.72106E+00	.21000E+01	.47482E+00	.22059E+03
26	11.500	.18994E+04	.81380E+04	.38546E+01	.72106E+00	.21000E+01	.47477E+00	.23209E+03
27	17.668	.19923E+04	.84805E+04	.38823E+01	.72106E+00	.21000E+01	.47483E+00	.24359E+03
28	17.668	.19038E+04	.81681E+04	.40747E+01	.72106E+00	.21000E+01	.47517E+00	.26126E+03
29	17.668	.19359E+04	.82449E+04	.40882E+01	.72106E+00	.21000E+01	.47538E+00	.27893E+03
30	18.249	.19771E+04	.83776E+04	.40741E+01	.72106E+00	.21000E+01	.47555E+00	.29660E+03
31	18.249	.19617E+04	.83622E+04	.40279E+01	.72106E+00	.21000E+01	.47534E+00	.31484E+03
32	18.249	.19878E+04	.84724E+04	.39517E+01	.72106E+00	.21000E+01	.47520E+00	.33309E+03
33	18.249	.20030E+04	.84576E+04	.40396E+01	.72106E+00	.21000E+01	.47555E+00	.35134E+03

Table 5.2-5 (Sheet 6 of 6) Strain Compatible Properties for Profile 270, 500 ft (+1 Sigma)

Layer	Thick(ft)	Mean Vs(ft/s)	Mean Vp(ft/s)	Mean Damps(%)	Mean Dampp(%)	Mean Den(cgs)	Mean Poisson	Depth To Top(ft)
34	20.001	.19811E+04	.83784E+04	.40553E+01	.72106E+00	.21000E+01	.47567E+00	.36959E+03
35	20.001	.19905E+04	.84613E+04	.39911E+01	.72106E+00	.21000E+01	.47554E+00	.38959E+03
36	20.001	.20430E+04	.87320E+04	.40392E+01	.72106E+00	.21000E+01	.47552E+00	.40959E+03
37	20.001	.19844E+04	.85076E+04	.40768E+01	.72106E+00	.21000E+01	.47561E+00	.42959E+03
38	20.001	.19735E+04	.84535E+04	.41659E+01	.72106E+00	.21000E+01	.47583E+00	.44960E+03
39	20.001	.19768E+04	.86137E+04	.41458E+01	.72106E+00	.21000E+01	.47546E+00	.46960E+03
40	10.404	.19991E+04	.86341E+04	.41593E+01	.72106E+00	.21000E+01	.47582E+00	.48960E+03
41	997.424	.41883E+04	.98597E+04	.50000E+00	.50000E+00	.21500E+01	.38995E+00	.50000E+03
42	3281.000	.92850E+04	.16080E+05	.50000E-03	.50000E-03	.25200E+01	.24990E+00	.14974E+04

Table 5.2-6 (Sheet 1 of 2) Strain Compatible Properties for Profile 560, 100 ft (Median)

Layer	Thick(ft)	Mean Vs(ft/s)	Mean Vp(ft/s)	Mean Damps(%)	Mean Dampp(%)	Mean Den(cgs)	Mean Poisson	Depth To Top(ft)
1	6.001	.13266E+04	.57657E+04	.39537E+01	.32280E+01	.20000E+01	.47198E+00	.00000E+00
2	6.500	.14181E+04	.53744E+04	.49677E+01	.32115E+01	.20000E+01	.46214E+00	.60010E+01
3	6.500	.14370E+04	.56856E+04	.56024E+01	.32115E+01	.20000E+01	.46488E+00	.12501E+02
4	11.001	.14688E+04	.51086E+04	.66315E+01	.32265E+01	.20000E+01	.45386E+00	.19001E+02
5	10.000	.16120E+04	.49549E+04	.66176E+01	.32212E+01	.21000E+01	.44032E+00	.30002E+02
6	10.000	.15880E+04	.49839E+04	.70567E+01	.32212E+01	.21000E+01	.44280E+00	.40002E+02
7	18.000	.17806E+04	.48546E+04	.67765E+01	.31953E+01	.21000E+01	.42133E+00	.50002E+02
8	14.502	.19139E+04	.51151E+04	.68377E+01	.31940E+01	.21000E+01	.41771E+00	.68002E+02
9	14.499	.20266E+04	.53755E+04	.68403E+01	.31934E+01	.21000E+01	.41608E+00	.82504E+02
10	2.997	.20156E+04	.53759E+04	.69727E+01	.31934E+01	.21000E+01	.41730E+00	.97003E+02
11	997.424	.33261E+04	.78330E+04	.50000E+00	.50000E+00	.21500E+01	.39001E+00	.10000E+03
12	3281.000	.92850E+04	.16080E+05	.50000E-03	.50000E-03	.25200E+01	.24990E+00	.10974E+04
-1 Sigma								
1	6.001	.92872E+03	.41522E+04	.27064E+01	.31715E+01	.20000E+01	.47018E+00	.00000E+00
2	6.500	.10131E+04	.40878E+04	.33698E+01	.31290E+01	.20000E+01	.45700E+00	.60010E+01
3	6.500	.96616E+03	.42533E+04	.36430E+01	.31290E+01	.20000E+01	.45792E+00	.12501E+02
4	11.001	.10294E+04	.39144E+04	.47033E+01	.31388E+01	.20000E+01	.44596E+00	.19001E+02
5	10.000	.12345E+04	.39648E+04	.48447E+01	.31109E+01	.21000E+01	.43335E+00	.30002E+02
6	10.000	.12417E+04	.41030E+04	.51764E+01	.31109E+01	.21000E+01	.43513E+00	.40002E+02
7	18.000	.14323E+04	.40781E+04	.50212E+01	.30422E+01	.21000E+01	.41154E+00	.50002E+02
8	14.502	.15726E+04	.43720E+04	.52065E+01	.30342E+01	.21000E+01	.40768E+00	.68002E+02
9	14.499	.16950E+04	.47158E+04	.52159E+01	.30309E+01	.21000E+01	.40558E+00	.82504E+02
10	2.997	.16949E+04	.47066E+04	.53134E+01	.30309E+01	.21000E+01	.40702E+00	.97003E+02
11	997.424	.26541E+04	.62501E+04	.50000E+00	.50000E+00	.21500E+01	.38998E+00	.10000E+03
12	3281.000	.92850E+04	.16080E+05	.50000E-03	.50000E-03	.25200E+01	.24990E+00	.10974E+04
+1 Sigma								
1	6.001	.18950E+04	.80063E+04	.57759E+01	.32854E+01	.20000E+01	.47380E+00	.00000E+00
2	6.500	.19849E+04	.70658E+04	.73232E+01	.32961E+01	.20000E+01	.46733E+00	.60010E+01
3	6.500	.21373E+04	.76002E+04	.86157E+01	.32961E+01	.20000E+01	.47195E+00	.12501E+02
4	11.001	.20959E+04	.66671E+04	.93502E+01	.33167E+01	.20000E+01	.46189E+00	.19001E+02
5	10.000	.21048E+04	.61923E+04	.90392E+01	.33355E+01	.21000E+01	.44740E+00	.30002E+02
6	10.000	.20309E+04	.60539E+04	.96199E+01	.33355E+01	.21000E+01	.45062E+00	.40002E+02
7	18.000	.22136E+04	.57790E+04	.91453E+01	.33562E+01	.21000E+01	.43136E+00	.50002E+02
8	14.502	.23293E+04	.59845E+04	.89800E+01	.33622E+01	.21000E+01	.42798E+00	.68002E+02
9	14.499	.24232E+04	.61274E+04	.89705E+01	.33645E+01	.21000E+01	.42685E+00	.82504E+02

Table 5.2-6 (Sheet 2 of 2) Strain Compatible Properties for Profile 560, 100 ft (Median)

Layer	Thick(ft)	Mean Vs(ft/s)	Mean Vp(ft/s)	Mean Damps(%)	Mean Dampp(%)	Mean Den(cgs)	Mean Poisson	Depth To Top(ft)
10	2.997	.23969E+04	.61403E+04	.91502E+01	.33645E+01	.21000E+01	.42783E+00	.97003E+02
11	997.424	.41683E+04	.98168E+04	.50000E+00	.50000E+00	.21500E+01	.39005E+00	.10000E+03
12	3281.000	.92850E+04	.16080E+05	.50000E-03	.50000E-03	.25200E+01	.24990E+00	.10974E+04

Table 5.2-7 (Sheet 1 of 2) Strain Compatible Properties for Profile 560, 200 ft (Median)

Layer	Thick(ft)	Mean Vs(ft/s)	Mean Vp(ft/s)	Mean Damps(%)	Mean Dampp(%)	Mean Den(cgs)	Mean Poisson	Depth To Top(ft)
1	6.001	.13798E+04	.59564E+04	.39117E+01	.32280E+01	.20000E+01	.46979E+00	.00000E+00
2	6.500	.13834E+04	.54764E+04	.53002E+01	.32115E+01	.20000E+01	.46000E+00	.60010E+01
3	6.500	.12748E+04	.54642E+04	.65224E+01	.32115E+01	.20000E+01	.46593E+00	.12501E+02
4	11.001	.12632E+04	.51382E+04	.77433E+01	.32265E+01	.20000E+01	.45998E+00	.19001E+02
5	10.000	.14481E+04	.48111E+04	.77877E+01	.32212E+01	.21000E+01	.43540E+00	.30002E+02
6	10.000	.15515E+04	.51606E+04	.78211E+01	.32212E+01	.21000E+01	.44442E+00	.40002E+02
7	18.000	.16240E+04	.47721E+04	.78823E+01	.31953E+01	.21000E+01	.43176E+00	.50002E+02
8	14.502	.17880E+04	.49812E+04	.77629E+01	.31940E+01	.21000E+01	.42080E+00	.68002E+02
9	14.499	.18009E+04	.50396E+04	.80277E+01	.31934E+01	.21000E+01	.42146E+00	.82504E+02
10	20.001	.19370E+04	.53775E+04	.79055E+01	.31934E+01	.21000E+01	.42168E+00	.97003E+02
11	20.001	.20180E+04	.56034E+04	.68614E+01	.31425E+01	.21000E+01	.42315E+00	.11700E+03
12	22.665	.21582E+04	.58524E+04	.68022E+01	.31425E+01	.21000E+01	.41558E+00	.13701E+03
13	22.665	.21879E+04	.58977E+04	.69478E+01	.31425E+01	.21000E+01	.41471E+00	.15967E+03
14	17.665	.21444E+04	.57412E+04	.71800E+01	.31425E+01	.21000E+01	.40840E+00	.18234E+03
15	997.424	.33925E+04	.73374E+04	.50000E+00	.50000E+00	.21500E+01	.79957E+00	.20000E+03
16	3281.000	.92850E+04	.16080E+05	.50000E-03	.50000E-03	.25200E+01	.24990E+00	.11974E+04
-1 Sigma								
1	6.001	.10955E+04	.47508E+04	.27033E+01	.31715E+01	.20000E+01	.45680E+00	.00000E+00
2	6.500	.10063E+04	.42951E+04	.35788E+01	.31290E+01	.20000E+01	.43656E+00	.60010E+01
3	6.500	.89170E+03	.42677E+04	.43596E+01	.31290E+01	.20000E+01	.44666E+00	.12501E+02
4	11.001	.87197E+03	.40042E+04	.57809E+01	.31388E+01	.20000E+01	.44166E+00	.19001E+02
5	10.000	.11059E+04	.38517E+04	.59770E+01	.31109E+01	.21000E+01	.37323E+00	.30002E+02
6	10.000	.12100E+04	.43597E+04	.59462E+01	.31109E+01	.21000E+01	.42078E+00	.40002E+02
7	18.000	.13430E+04	.41253E+04	.60608E+01	.30422E+01	.21000E+01	.41471E+00	.50002E+02
8	14.502	.14184E+04	.42793E+04	.58234E+01	.30342E+01	.21000E+01	.38970E+00	.68002E+02
9	14.499	.13964E+04	.43336E+04	.59039E+01	.30309E+01	.21000E+01	.39520E+00	.82504E+02
10	20.001	.15268E+04	.45869E+04	.57346E+01	.30309E+01	.21000E+01	.40209E+00	.97003E+02
11	20.001	.16532E+04	.47952E+04	.51326E+01	.29453E+01	.21000E+01	.40821E+00	.11700E+03
12	22.665	.17177E+04	.48870E+04	.51104E+01	.29453E+01	.21000E+01	.38604E+00	.13701E+03
13	22.665	.17795E+04	.49512E+04	.51623E+01	.29453E+01	.21000E+01	.38743E+00	.15967E+03
14	17.665	.17331E+04	.48943E+04	.55017E+01	.29453E+01	.21000E+01	.36167E+00	.18234E+03
15	997.424	.27849E+04	.58507E+04	.50000E+00	.50000E+00	.21500E+01	.29731E+00	.20000E+03
16	3281.000	.92850E+04	.16080E+05	.50000E-03	.50000E-03	.25200E+01	.24990E+00	.11974E+04

Table 5.2-7 (Sheet 2 of 2) Strain Compatible Properties for Profile 560, 200 ft (+1 Sigma)

Layer	Thick(ft)	Mean Vs(ft/s)	Mean Vp(ft/s)	Mean Damps(%)	Mean Dampp(%)	Mean Den(cgs)	Mean Poisson	Depth To Top(ft)
1	6.001	.17378E+04	.74680E+04	.56602E+01	.32854E+01	.20000E+01	.48315E+00	.00000E+00
2	6.500	.19018E+04	.69827E+04	.78495E+01	.32961E+01	.20000E+01	.48471E+00	.60010E+01
3	6.500	.18226E+04	.69961E+04	.97581E+01	.32961E+01	.20000E+01	.48603E+00	.12501E+02
4	11.001	.18299E+04	.65934E+04	.10372E+02	.33167E+01	.20000E+01	.47907E+00	.19001E+02
5	10.000	.18960E+04	.60095E+04	.10147E+02	.33355E+01	.21000E+01	.50793E+00	.30002E+02
6	10.000	.19894E+04	.61086E+04	.10287E+02	.33355E+01	.21000E+01	.46940E+00	.40002E+02
7	18.000	.19638E+04	.55203E+04	.10251E+02	.33562E+01	.21000E+01	.44951E+00	.50002E+02
8	14.502	.22539E+04	.57984E+04	.10348E+02	.33622E+01	.21000E+01	.45438E+00	.68002E+02
9	14.499	.23226E+04	.58607E+04	.10916E+02	.33645E+01	.21000E+01	.44947E+00	.82504E+02
10	20.001	.24573E+04	.63044E+04	.10898E+02	.33645E+01	.21000E+01	.44224E+00	.97003E+02
11	20.001	.24632E+04	.65478E+04	.91724E+01	.33528E+01	.21000E+01	.43864E+00	.11700E+03
12	22.665	.27117E+04	.70085E+04	.90540E+01	.33528E+01	.21000E+01	.44738E+00	.13701E+03
13	22.665	.26902E+04	.70251E+04	.93508E+01	.33528E+01	.21000E+01	.44391E+00	.15967E+03
14	17.665	.26533E+04	.67347E+04	.93702E+01	.33528E+01	.21000E+01	.46116E+00	.18234E+03
15	997.424	.41328E+04	.92019E+04	.50000E+00	.50000E+00	.21500E+01	.21503E+01	.20000E+03
16	3281.000	.92850E+04	.16080E+05	.50000E-03	.50000E-03	.25200E+01	.24990E+00	.11974E+04

Table 5.2-8 (Sheet 1 of 6) Strain Compatible Properties for Profile 560, 500 ft (Median)

Layer	Thick(ft)	Mean Vs(ft/s)	Mean Vp(ft/s)	Mean Damps(%)	Mean Dampp(%)	Mean Den(cgs)	Mean Poisson	Depth To Top(ft)
1	6.001	.13217E+04	.57203E+04	.38236E+01	.32280E+01	.20000E+01	.47173E+00	.00000E+00
2	6.500	.14358E+04	.53807E+04	.48580E+01	.32115E+01	.20000E+01	.46131E+00	.60010E+01
3	6.500	.13432E+04	.53015E+04	.58253E+01	.32115E+01	.20000E+01	.46511E+00	.12501E+02
4	11.001	.14994E+04	.51578E+04	.65047E+01	.32265E+01	.20000E+01	.45307E+00	.19001E+02
5	10.000	.17158E+04	.52061E+04	.64304E+01	.32212E+01	.21000E+01	.43849E+00	.30002E+02
6	10.000	.16982E+04	.52541E+04	.68593E+01	.32212E+01	.21000E+01	.44103E+00	.40002E+02
7	18.000	.18568E+04	.50461E+04	.65935E+01	.31953E+01	.21000E+01	.42021E+00	.50002E+02
8	14.502	.19803E+04	.52765E+04	.67480E+01	.31940E+01	.21000E+01	.41690E+00	.68002E+02
9	14.499	.20389E+04	.54083E+04	.68839E+01	.31934E+01	.21000E+01	.41638E+00	.82504E+02
10	20.001	.21110E+04	.56203E+04	.69776E+01	.31934E+01	.21000E+01	.41705E+00	.97003E+02
11	20.001	.21570E+04	.57199E+04	.61548E+01	.31425E+01	.21000E+01	.41656E+00	.11700E+03
12	22.665	.23136E+04	.61208E+04	.61085E+01	.31425E+01	.21000E+01	.41600E+00	.13701E+03
13	22.665	.23358E+04	.62186E+04	.62228E+01	.31425E+01	.21000E+01	.41718E+00	.15967E+03
14	22.668	.23730E+04	.63594E+04	.63608E+01	.31425E+01	.21000E+01	.41822E+00	.18234E+03
15	20.998	.24547E+04	.65804E+04	.63546E+01	.31425E+01	.21000E+01	.41826E+00	.20500E+03
16	20.998	.24518E+04	.66121E+04	.64640E+01	.31425E+01	.21000E+01	.41925E+00	.22600E+03
17	12.501	.26469E+04	.67333E+04	.58186E+01	.31508E+01	.21000E+01	.40820E+00	.24700E+03
18	12.501	.25915E+04	.66204E+04	.59320E+01	.31508E+01	.21000E+01	.40907E+00	.25950E+03
19	12.501	.27193E+04	.69146E+04	.58053E+01	.31508E+01	.21000E+01	.40810E+00	.27200E+03
20	12.501	.28421E+04	.71946E+04	.57023E+01	.31508E+01	.21000E+01	.40717E+00	.28450E+03
21	12.501	.28362E+04	.71872E+04	.57648E+01	.31508E+01	.21000E+01	.40748E+00	.29700E+03
22	12.501	.28196E+04	.71666E+04	.58295E+01	.31508E+01	.21000E+01	.40807E+00	.30950E+03
23	12.501	.28435E+04	.72286E+04	.58325E+01	.31508E+01	.21000E+01	.40811E+00	.32201E+03
24	12.501	.28395E+04	.72325E+04	.58872E+01	.31508E+01	.21000E+01	.40852E+00	.33451E+03
25	12.501	.27653E+04	.70782E+04	.60174E+01	.31508E+01	.21000E+01	.40954E+00	.34701E+03
26	12.501	.27388E+04	.70269E+04	.61000E+01	.31508E+01	.21000E+01	.41010E+00	.35951E+03
27	12.501	.27854E+04	.71390E+04	.60737E+01	.31508E+01	.21000E+01	.40987E+00	.37201E+03
28	12.501	.28390E+04	.72667E+04	.60288E+01	.31508E+01	.21000E+01	.40960E+00	.38451E+03
29	12.501	.27677E+04	.71172E+04	.61500E+01	.31508E+01	.21000E+01	.41056E+00	.39701E+03
30	12.501	.27878E+04	.71770E+04	.61685E+01	.31508E+01	.21000E+01	.41078E+00	.40951E+03
31	12.501	.27750E+04	.71536E+04	.62183E+01	.31508E+01	.21000E+01	.41109E+00	.42201E+03
32	12.501	.27582E+04	.71259E+04	.62614E+01	.31508E+01	.21000E+01	.41152E+00	.43451E+03
33	12.501	.26945E+04	.69940E+04	.63824E+01	.31508E+01	.21000E+01	.41248E+00	.44702E+03

Table 5.2-8 (Sheet 2 of 6) Strain Compatible Properties for Profile 560, 500 ft (Median)

Layer	Thick(ft)	Mean Vs(ft/s)	Mean Vp(ft/s)	Mean Damps(%)	Mean Dampp(%)	Mean Den(cgs)	Mean Poisson	Depth To Top(ft)
34	12.501	.26754E+04	.69630E+04	.64350E+01	.31508E+01	.21000E+01	.41300E+00	.45952E+03
35	13.124	.26416E+04	.68977E+04	.65190E+01	.31508E+01	.21000E+01	.41366E+00	.47202E+03
36	13.124	.26195E+04	.68601E+04	.65735E+01	.31508E+01	.21000E+01	.41421E+00	.48514E+03
37	1.732	.25695E+04	.67558E+04	.66759E+01	.31508E+01	.21000E+01	.41499E+00	.49827E+03
38	997.424	.33138E+04	.78040E+04	.50000E+00	.50000E+00	.21500E+01	.39002E+00	.50000E+03
39	3281.000	.92850E+04	.16080E+05	.50000E-03	.50000E-03	.25200E+01	.24990E+00	.14974E+04

Table 5.2-8 (Sheet 3 of 6) Strain Compatible Properties for Profile 560, 500 ft (-1 Sigma)

Layer	Thick(ft)	Mean Vs(ft/s)	Mean Vp(ft/s)	Mean Damps(%)	Mean Dampp(%)	Mean Den(cgs)	Mean Poisson	Depth To Top(ft)
1	6.001	.89776E+03	.40022E+04	.26798E+01	.31715E+01	.20000E+01	.46989E+00	.00000E+00
2	6.500	.97831E+03	.38756E+04	.32866E+01	.31290E+01	.20000E+01	.45663E+00	.60010E+01
3	6.500	.88911E+03	.37895E+04	.39458E+01	.31290E+01	.20000E+01	.45939E+00	.12501E+02
4	11.001	.10352E+04	.38275E+04	.45767E+01	.31388E+01	.20000E+01	.44570E+00	.19001E+02
5	10.000	.13280E+04	.42254E+04	.48054E+01	.31109E+01	.21000E+01	.43135E+00	.30002E+02
6	10.000	.13027E+04	.42418E+04	.50578E+01	.31109E+01	.21000E+01	.43353E+00	.40002E+02
7	18.000	.14628E+04	.42577E+04	.47629E+01	.30422E+01	.21000E+01	.40831E+00	.50002E+02
8	14.502	.16354E+04	.46005E+04	.49872E+01	.30342E+01	.21000E+01	.40638E+00	.68002E+02
9	14.499	.16994E+04	.46712E+04	.49713E+01	.30309E+01	.21000E+01	.40674E+00	.82504E+02
10	20.001	.17009E+04	.47001E+04	.49670E+01	.30309E+01	.21000E+01	.40744E+00	.97003E+02
11	20.001	.18092E+04	.49436E+04	.43902E+01	.29453E+01	.21000E+01	.40838E+00	.11700E+03
12	22.665	.19076E+04	.52290E+04	.43955E+01	.29453E+01	.21000E+01	.40715E+00	.13701E+03
13	22.665	.18841E+04	.52046E+04	.44382E+01	.29453E+01	.21000E+01	.40812E+00	.15967E+03
14	22.668	.18902E+04	.52974E+04	.46137E+01	.29453E+01	.21000E+01	.40804E+00	.18234E+03
15	20.998	.19889E+04	.55864E+04	.46855E+01	.29453E+01	.21000E+01	.40789E+00	.20500E+03
16	20.998	.19461E+04	.55166E+04	.46656E+01	.29453E+01	.21000E+01	.40849E+00	.22600E+03
17	12.501	.21632E+04	.56513E+04	.40773E+01	.29199E+01	.21000E+01	.40090E+00	.24700E+03
18	12.501	.21453E+04	.56360E+04	.41747E+01	.29199E+01	.21000E+01	.40155E+00	.25950E+03
19	12.501	.23201E+04	.60643E+04	.40509E+01	.29199E+01	.21000E+01	.40087E+00	.27200E+03
20	12.501	.24659E+04	.64081E+04	.40652E+01	.29199E+01	.21000E+01	.40034E+00	.28450E+03
21	12.501	.24848E+04	.64263E+04	.41369E+01	.29199E+01	.21000E+01	.40133E+00	.29700E+03
22	12.501	.24111E+04	.62789E+04	.41791E+01	.29199E+01	.21000E+01	.40129E+00	.30950E+03
23	12.501	.24993E+04	.65071E+04	.42265E+01	.29199E+01	.21000E+01	.40148E+00	.32201E+03
24	12.501	.24956E+04	.65189E+04	.42520E+01	.29199E+01	.21000E+01	.40173E+00	.33451E+03
25	12.501	.24293E+04	.63853E+04	.43182E+01	.29199E+01	.21000E+01	.40252E+00	.34701E+03
26	12.501	.24135E+04	.63241E+04	.43967E+01	.29199E+01	.21000E+01	.40359E+00	.35951E+03
27	12.501	.24735E+04	.64809E+04	.43443E+01	.29199E+01	.21000E+01	.40328E+00	.37201E+03
28	12.501	.25198E+04	.65955E+04	.42582E+01	.29199E+01	.21000E+01	.40306E+00	.38451E+03
29	12.501	.24708E+04	.65082E+04	.43289E+01	.29199E+01	.21000E+01	.40381E+00	.39701E+03
30	12.501	.24697E+04	.65174E+04	.42767E+01	.29199E+01	.21000E+01	.40388E+00	.40951E+03
31	12.501	.24729E+04	.65149E+04	.43357E+01	.29199E+01	.21000E+01	.40446E+00	.42201E+03
32	12.501	.24057E+04	.63547E+04	.43294E+01	.29199E+01	.21000E+01	.40472E+00	.43451E+03
33	12.501	.23504E+04	.62351E+04	.44656E+01	.29199E+01	.21000E+01	.40561E+00	.44702E+03

Table 5.2-8 (Sheet 4 of 6) Strain Compatible Properties for Profile 560, 500 ft (-1 Sigma)

Layer	Thick(ft)	Mean Vs(ft/s)	Mean Vp(ft/s)	Mean Damps(%)	Mean Dampp(%)	Mean Den(cgs)	Mean Poisson	Depth To Top(ft)
34	12.501	.23091E+04	.61517E+04	.45008E+01	.29199E+01	.21000E+01	.40592E+00	.45952E+03
35	13.124	.22629E+04	.60470E+04	.45886E+01	.29199E+01	.21000E+01	.40656E+00	.47202E+03
36	13.124	.22505E+04	.60450E+04	.46064E+01	.29199E+01	.21000E+01	.40681E+00	.48514E+03
37	1.732	.22296E+04	.60097E+04	.47494E+01	.29199E+01	.21000E+01	.40757E+00	.49827E+03
38	997.424	.29501E+04	.69472E+04	.50000E+00	.50000E+00	.21500E+01	.38999E+00	.50000E+03
39	3281.000	.92850E+04	.16080E+05	.50000E-03	.50000E-03	.25200E+01	.24990E+00	.14974E+04

Table 5.2-8 (Sheet 5 of 6) Strain Compatible Properties for Profile 560, 500 ft (+1 Sigma)

Layer	Thick(ft)	Mean Vs(ft/s)	Mean Vp(ft/s)	Mean Damps(%)	Mean Dampp(%)	Mean Den(cgs)	Mean Poisson	Depth To Top(ft)
1	6.001	.19457E+04	.81760E+04	.54556E+01	.32854E+01	.20000E+01	.47359E+00	.00000E+00
2	6.500	.21073E+04	.74703E+04	.71807E+01	.32961E+01	.20000E+01	.46605E+00	.60010E+01
3	6.500	.20293E+04	.74168E+04	.86001E+01	.32961E+01	.20000E+01	.47090E+00	.12501E+02
4	11.001	.21719E+04	.69505E+04	.92450E+01	.33167E+01	.20000E+01	.46056E+00	.19001E+02
5	10.000	.22169E+04	.64144E+04	.86048E+01	.33355E+01	.21000E+01	.44576E+00	.30002E+02
6	10.000	.22137E+04	.65079E+04	.93026E+01	.33355E+01	.21000E+01	.44865E+00	.40002E+02
7	18.000	.23571E+04	.59805E+04	.91278E+01	.33562E+01	.21000E+01	.43246E+00	.50002E+02
8	14.502	.23980E+04	.60518E+04	.91306E+01	.33622E+01	.21000E+01	.42768E+00	.68002E+02
9	14.499	.24461E+04	.62617E+04	.95324E+01	.33645E+01	.21000E+01	.42625E+00	.82504E+02
10	20.001	.26200E+04	.67206E+04	.98020E+01	.33645E+01	.21000E+01	.42689E+00	.97003E+02
11	20.001	.25715E+04	.66182E+04	.86287E+01	.33528E+01	.21000E+01	.42492E+00	.11700E+03
12	22.665	.28060E+04	.71646E+04	.84893E+01	.33528E+01	.21000E+01	.42503E+00	.13701E+03
13	22.665	.28958E+04	.74302E+04	.87249E+01	.33528E+01	.21000E+01	.42643E+00	.15967E+03
14	22.668	.29792E+04	.76344E+04	.87696E+01	.33528E+01	.21000E+01	.42865E+00	.18234E+03
15	20.998	.30295E+04	.77512E+04	.86183E+01	.33528E+01	.21000E+01	.42889E+00	.20500E+03
16	20.998	.30890E+04	.79252E+04	.89557E+01	.33528E+01	.21000E+01	.43030E+00	.22600E+03
17	12.501	.32387E+04	.80225E+04	.83035E+01	.34000E+01	.21000E+01	.41563E+00	.24700E+03
18	12.501	.31305E+04	.77767E+04	.84292E+01	.34000E+01	.21000E+01	.41672E+00	.25950E+03
19	12.501	.31872E+04	.78841E+04	.83195E+01	.34000E+01	.21000E+01	.41546E+00	.27200E+03
20	12.501	.32756E+04	.80776E+04	.79986E+01	.34000E+01	.21000E+01	.41412E+00	.28450E+03
21	12.501	.32372E+04	.80382E+04	.80332E+01	.34000E+01	.21000E+01	.41372E+00	.29700E+03
22	12.501	.32973E+04	.81797E+04	.81316E+01	.34000E+01	.21000E+01	.41496E+00	.30950E+03
23	12.501	.32351E+04	.80301E+04	.80487E+01	.34000E+01	.21000E+01	.41486E+00	.32201E+03
24	12.501	.32306E+04	.80242E+04	.81513E+01	.34000E+01	.21000E+01	.41542E+00	.33451E+03
25	12.501	.31478E+04	.78463E+04	.83853E+01	.34000E+01	.21000E+01	.41668E+00	.34701E+03
26	12.501	.31079E+04	.78077E+04	.84632E+01	.34000E+01	.21000E+01	.41673E+00	.35951E+03
27	12.501	.31366E+04	.78639E+04	.84915E+01	.34000E+01	.21000E+01	.41657E+00	.37201E+03
28	12.501	.31986E+04	.80063E+04	.85356E+01	.34000E+01	.21000E+01	.41624E+00	.38451E+03
29	12.501	.31002E+04	.77832E+04	.87372E+01	.34000E+01	.21000E+01	.41742E+00	.39701E+03
30	12.501	.31468E+04	.79034E+04	.88972E+01	.34000E+01	.21000E+01	.41780E+00	.40951E+03
31	12.501	.31141E+04	.78549E+04	.89183E+01	.34000E+01	.21000E+01	.41782E+00	.42201E+03
32	12.501	.31624E+04	.79907E+04	.90556E+01	.34000E+01	.21000E+01	.41844E+00	.43451E+03
33	12.501	.30889E+04	.78452E+04	.91220E+01	.34000E+01	.21000E+01	.41946E+00	.44702E+03

Table 5.2-8 (Sheet 6 of 6) Strain Compatible Properties for Profile 560, 500 ft (+1 Sigma)

Layer	Thick(ft)	Mean Vs(ft/s)	Mean Vp(ft/s)	Mean Damps(%)	Mean Dampp(%)	Mean Den(cgs)	Mean Poisson	Depth To Top(ft)
34	12.501	.30998E+04	.78813E+04	.92003E+01	.34000E+01	.21000E+01	.42019E+00	.45952E+03
35	13.124	.30837E+04	.78681E+04	.92615E+01	.34000E+01	.21000E+01	.42088E+00	.47202E+03
36	13.124	.30490E+04	.77851E+04	.93806E+01	.34000E+01	.21000E+01	.42175E+00	.48514E+03
37	1.732	.29612E+04	.75946E+04	.93837E+01	.34000E+01	.21000E+01	.42255E+00	.49827E+03
38	997.424	.37224E+04	.87665E+04	.50000E+00	.50000E+00	.21500E+01	.39004E+00	.50000E+03
39	3281.000	.92850E+04	.16080E+05	.50000E-03	.50000E-03	.25200E+01	.24990E+00	.14974E+04

Table 5.2-9 Strain Compatible Properties for Profile 900, 100 ft (Median)

Layer	Thick(ft)	Mean Vs(ft/s)	Mean Vp(ft/s)	Mean Damps(%)	Mean Dampp(%)	Mean Den(cgs)	Mean Poisson	Depth To Top(ft)
1	5.000	.19759E+04	.62284E+04	.35392E+01	.32618E+01	.20000E+01	.44404E+00	.00000E+00
2	6.998	.22224E+04	.60091E+04	.39036E+01	.32602E+01	.21000E+01	.42062E+00	.50000E+01
3	7.999	.22678E+04	.53479E+04	.41119E+01	.32577E+01	.21000E+01	.38981E+00	.11998E+02
4	9.000	.27389E+04	.66072E+04	.37298E+01	.31493E+01	.21000E+01	.39600E+00	.19997E+02
5	11.001	.30377E+04	.77486E+04	.37101E+01	.31598E+01	.21000E+01	.40887E+00	.28997E+02
6	12.999	.34027E+04	.84804E+04	.35983E+01	.31567E+01	.21500E+01	.40395E+00	.39998E+02
7	20.001	.40158E+04	.96892E+04	.35060E+01	.31189E+01	.21500E+01	.39626E+00	.52997E+02
8	23.000	.47306E+04	.10840E+05	.34603E+01	.31067E+01	.22400E+01	.38236E+00	.72998E+02
9	4.001	.49301E+04	.10793E+05	.34415E+01	.30944E+01	.22400E+01	.36815E+00	.95998E+02
10	3281.0	.89361E+04	.17520E+05	.10000E-05	.10000E-05	.25200E+01	.32419E+00	.99999E+02
-1 Sigma								
1	5.000	.14455E+04	.45772E+04	.27309E+01	.31528E+01	.20000E+01	.44307E+00	.00000E+00
2	6.998	.16631E+04	.45754E+04	.26029E+01	.31097E+01	.21000E+01	.41653E+00	.50000E+01
3	7.999	.16847E+04	.40848E+04	.25906E+01	.30566E+01	.21000E+01	.38101E+00	.11998E+02
4	9.000	.21549E+04	.52896E+04	.26371E+01	.29501E+01	.21000E+01	.39013E+00	.19997E+02
5	11.001	.23108E+04	.60363E+04	.27056E+01	.29805E+01	.21000E+01	.40265E+00	.28997E+02
6	12.999	.27709E+04	.69290E+04	.26535E+01	.29716E+01	.21500E+01	.40023E+00	.39998E+02
7	20.001	.33141E+04	.80263E+04	.27333E+01	.29043E+01	.21500E+01	.39397E+00	.52997E+02
8	23.000	.40444E+04	.92935E+04	.27312E+01	.28703E+01	.22400E+01	.38057E+00	.72998E+02
9	4.001	.41619E+04	.91355E+04	.27506E+01	.28366E+01	.22400E+01	.36610E+00	.95998E+02
10	3281.0	.63383E+04	.12427E+05	.99999E-06	.99999E-06	.25200E+01	.32410E+00	.99999E+02
+1 Sigma								
1	5.000	.27009E+04	.84754E+04	.45869E+01	.33745E+01	.20000E+01	.44501E+00	.00000E+00
2	6.998	.29699E+04	.78922E+04	.58543E+01	.34181E+01	.21000E+01	.42476E+00	.50000E+01
3	7.999	.30528E+04	.70016E+04	.65264E+01	.34720E+01	.21000E+01	.39880E+00	.11998E+02
4	9.000	.34812E+04	.82528E+04	.52754E+01	.33620E+01	.21000E+01	.40195E+00	.19997E+02
5	11.001	.39934E+04	.99465E+04	.50874E+01	.33499E+01	.21000E+01	.41519E+00	.28997E+02
6	12.999	.41784E+04	.10379E+05	.48795E+01	.33534E+01	.21500E+01	.40771E+00	.39998E+02
7	20.001	.48661E+04	.11697E+05	.44972E+01	.33494E+01	.21500E+01	.39856E+00	.52997E+02
8	23.000	.55331E+04	.12644E+05	.43839E+01	.33625E+01	.22400E+01	.38415E+00	.72998E+02
9	4.001	.58400E+04	.12752E+05	.43059E+01	.33757E+01	.22400E+01	.37021E+00	.95998E+02
10	3281.0	.12599E+05	.24700E+05	.10000E-05	.10000E-05	.25200E+01	.32428E+00	.99999E+02

Table 5.2-10 (Sheet 1 of 2) Strain Compatible Properties for Profile 900, 200 ft (Median)

Layer	Thick(ft)	Mean Vs(ft/s)	Mean Vp(ft/s)	Mean Damps(%)	Mean Dampp(%)	Mean Den(cgs)	Mean Poisson	Depth To Top(ft)
1	5.000	.19442E+04	.61418E+04	.37985E+01	.32618E+01	.20000E+01	.44430E+00	.00000E+00
2	6.998	.20426E+04	.55553E+04	.43178E+01	.32602E+01	.21000E+01	.42168E+00	.50000E+01
3	7.999	.23051E+04	.54548E+04	.44976E+01	.32577E+01	.21000E+01	.39085E+00	.11998E+02
4	9.000	.27398E+04	.66431E+04	.37017E+01	.31493E+01	.21000E+01	.39730E+00	.19997E+02
5	11.001	.27609E+04	.71078E+04	.38278E+01	.31598E+01	.21000E+01	.41088E+00	.28997E+02
6	12.999	.32366E+04	.81881E+04	.37513E+01	.31567E+01	.21500E+01	.40707E+00	.39998E+02
7	20.001	.40210E+04	.97553E+04	.36080E+01	.31189E+01	.21500E+01	.39757E+00	.52997E+02
8	23.000	.46531E+04	.10725E+05	.35859E+01	.31067E+01	.22400E+01	.38398E+00	.72998E+02
9	25.001	.47934E+04	.10559E+05	.35937E+01	.30944E+01	.22400E+01	.37013E+00	.95998E+02
10	34.001	.53296E+04	.11237E+05	.35554E+01	.31796E+01	.22400E+01	.35485E+00	.12100E+03
11	43.001	.58718E+04	.11956E+05	.34893E+01	.31770E+01	.22400E+01	.34102E+00	.15500E+03
12	1.998	.59183E+04	.11871E+05	.35175E+01	.31756E+01	.22400E+01	.33457E+00	.19800E+03
13	3281.000	.92641E+04	.18165E+05	.10000E-05	.10000E-05	.25200E+01	.32425E+00	.20000E+03
-1 Sigma								
1	5.000	.14247E+04	.45375E+04	.26730E+01	.31528E+01	.20000E+01	.44304E+00	.00000E+00
2	6.998	.15603E+04	.43292E+04	.27461E+01	.31097E+01	.21000E+01	.41737E+00	.50000E+01
3	7.999	.18261E+04	.44391E+04	.28096E+01	.30566E+01	.21000E+01	.38289E+00	.11998E+02
4	9.000	.21020E+04	.51680E+04	.25247E+01	.29501E+01	.21000E+01	.39173E+00	.19997E+02
5	11.001	.21557E+04	.56414E+04	.25792E+01	.29805E+01	.21000E+01	.40495E+00	.28997E+02
6	12.999	.24632E+04	.63655E+04	.26602E+01	.29716E+01	.21500E+01	.40045E+00	.39998E+02
7	20.001	.33443E+04	.82083E+04	.26943E+01	.29043E+01	.21500E+01	.39390E+00	.52997E+02
8	23.000	.37445E+04	.87038E+04	.26072E+01	.28703E+01	.22400E+01	.38058E+00	.72998E+02
9	25.001	.39467E+04	.87524E+04	.26881E+01	.28366E+01	.22400E+01	.36642E+00	.95998E+02
10	34.001	.45894E+04	.97232E+04	.26613E+01	.29227E+01	.22400E+01	.35212E+00	.12100E+03
11	43.001	.50114E+04	.10233E+05	.26798E+01	.29027E+01	.22400E+01	.33839E+00	.15500E+03
12	1.998	.51461E+04	.10370E+05	.26683E+01	.28930E+01	.22400E+01	.33118E+00	.19800E+03
13	3281.000	.71824E+04	.14082E+05	.99999E-06	.99999E-06	.25200E+01	.32413E+00	.20000E+03

Table 5.2-10 (Sheet 2 of 2) Strain Compatible Properties for Profile 900, 200 ft (+1 Sigma)

Layer	Thick(ft)	Mean Vs(ft/s)	Mean Vp(ft/s)	Mean Damps(%)	Mean Dampp(%)	Mean Den(cgs)	Mean Poisson	Depth To Top(ft)
1	5.000	.26531E+04	.83134E+04	.53977E+01	.33745E+01	.20000E+01	.44556E+00	.00000E+00
2	6.998	.26739E+04	.71287E+04	.67889E+01	.34181E+01	.21000E+01	.42604E+00	.50000E+01
3	7.999	.29097E+04	.67029E+04	.71996E+01	.34720E+01	.21000E+01	.39898E+00	.11998E+02
4	9.000	.35713E+04	.85394E+04	.54274E+01	.33620E+01	.21000E+01	.40295E+00	.19997E+02
5	11.001	.35360E+04	.89553E+04	.56807E+01	.33499E+01	.21000E+01	.41690E+00	.28997E+02
6	12.999	.42530E+04	.10533E+05	.52899E+01	.33534E+01	.21500E+01	.41379E+00	.39998E+02
7	20.001	.48346E+04	.11594E+05	.48316E+01	.33494E+01	.21500E+01	.40127E+00	.52997E+02
8	23.000	.57822E+04	.13215E+05	.49320E+01	.33625E+01	.22400E+01	.38740E+00	.72998E+02
9	25.001	.58218E+04	.12738E+05	.48043E+01	.33757E+01	.22400E+01	.37387E+00	.95998E+02
10	34.001	.61891E+04	.12987E+05	.47499E+01	.34590E+01	.22400E+01	.35761E+00	.12100E+03
11	43.001	.68800E+04	.13968E+05	.45434E+01	.34773E+01	.22400E+01	.34367E+00	.15500E+03
12	1.998	.68063E+04	.13590E+05	.46371E+01	.34858E+01	.22400E+01	.33800E+00	.19800E+03
13	3281.000	.11949E+05	.23433E+05	.10000E-05	.10000E-05	.25200E+01	.32437E+00	.20000E+03

Table 5.2-11 (Sheet 1 of 2) Strain Compatible Properties for Profile 2032, 100 ft (Median)

Layer	Thick(ft)	Mean Vs(ft/s)	Mean Vp(ft/s)	Mean Damps(%)	Mean Dampp(%)	Mean Den(cgs)	Mean Poisson	Depth To Top(ft)
1	4.167	.49064E+04	.91792E+04	.32250E+01	.31229E+01	.22400E+01	.30001E+00	.00000E+00
2	4.167	.51465E+04	.95494E+04	.32250E+01	.31208E+01	.22400E+01	.29533E+00	.41670E+01
3	8.334	.53930E+04	.98254E+04	.32250E+01	.31157E+01	.22400E+01	.28441E+00	.83340E+01
4	8.334	.56094E+04	.99644E+04	.32250E+01	.31082E+01	.22400E+01	.26803E+00	.16668E+02
5	8.334	.63151E+04	.11044E+05	.32250E+01	.31033E+01	.22400E+01	.25707E+00	.25002E+02
6	6.660	.65484E+04	.11343E+05	.32250E+01	.31002E+01	.22400E+01	.25003E+00	.33336E+02
7	10.007	.71260E+04	.12343E+05	.31580E+01	.31008E+01	.22400E+01	.25003E+00	.39996E+02
8	16.667	.73327E+04	.12701E+05	.31580E+01	.31008E+01	.22400E+01	.25004E+00	.50003E+02
9	16.667	.77463E+04	.13417E+05	.31580E+01	.31008E+01	.22400E+01	.24999E+00	.66670E+02
10	16.663	.81275E+04	.14077E+05	.31580E+01	.31008E+01	.22400E+01	.25001E+00	.83337E+02
11	3281.000	.85993E+04	.16794E+05	.10000E-05	.10000E-05	.25200E+01	.32231E+00	.10000E+03
-1 Sigma								
1	4.167	.36931E+04	.69093E+04	.32250E+01	.27247E+01	.22400E+01	.29993E+00	.00000E+00
2	4.167	.39987E+04	.74198E+04	.32250E+01	.27165E+01	.22400E+01	.29520E+00	.41670E+01
3	8.334	.41593E+04	.75775E+04	.32250E+01	.26973E+01	.22400E+01	.28432E+00	.83340E+01
4	8.334	.43808E+04	.77816E+04	.32250E+01	.26696E+01	.22400E+01	.26793E+00	.16668E+02
5	8.334	.50037E+04	.87506E+04	.32250E+01	.26516E+01	.22400E+01	.25690E+00	.25002E+02
6	6.660	.53247E+04	.92230E+04	.32250E+01	.26406E+01	.22400E+01	.24985E+00	.33336E+02
7	10.007	.60243E+04	.10435E+05	.31580E+01	.27293E+01	.22400E+01	.24983E+00	.39996E+02
8	16.667	.62740E+04	.10867E+05	.31580E+01	.27293E+01	.22400E+01	.24985E+00	.50003E+02
9	16.667	.65431E+04	.11333E+05	.31580E+01	.27293E+01	.22400E+01	.24978E+00	.66670E+02
10	16.663	.71188E+04	.12329E+05	.31580E+01	.27293E+01	.22400E+01	.24983E+00	.83337E+02
11	3281.000	.60295E+04	.11775E+05	.99999E-06	.99999E-06	.25200E+01	.32222E+00	.10000E+03
+1 Sigma								
1	4.167	.65181E+04	.12195E+05	.32250E+01	.35793E+01	.22400E+01	.30010E+00	.00000E+00
2	4.167	.66238E+04	.12290E+05	.32250E+01	.35853E+01	.22400E+01	.29545E+00	.41670E+01
3	8.334	.69927E+04	.12740E+05	.32250E+01	.35991E+01	.22400E+01	.28451E+00	.83340E+01
4	8.334	.71827E+04	.12760E+05	.32250E+01	.36188E+01	.22400E+01	.26814E+00	.16668E+02
5	8.334	.79703E+04	.13938E+05	.32250E+01	.36319E+01	.22400E+01	.25723E+00	.25002E+02
6	6.660	.80534E+04	.13949E+05	.32250E+01	.36399E+01	.22400E+01	.25020E+00	.33336E+02
7	10.007	.84293E+04	.14601E+05	.31580E+01	.35228E+01	.22400E+01	.25022E+00	.39996E+02

Table 5.2-11 (Sheet 2 of 2) Strain Compatible Properties for Profile 2032, 100 ft (Median)

Layer	Thick(ft)	Mean Vs(ft/s)	Mean Vp(ft/s)	Mean Damps(%)	Mean Dampp(%)	Mean Den(cgs)	Mean Poisson	Depth To Top(ft)
8	16.667	.85700E+04	.14845E+05	.31580E+01	.35228E+01	.22400E+01	.25023E+00	.50003E+02
9	16.667	.91706E+04	.15884E+05	.31580E+01	.35228E+01	.22400E+01	.25020E+00	.66670E+02
10	16.663	.92791E+04	.16073E+05	.31580E+01	.35228E+01	.22400E+01	.25018E+00	.83337E+02
11	3281.000	.12264E+05	.23952E+05	.10000E-05	.10000E-05	.25200E+01	.32241E+00	.10000E+03

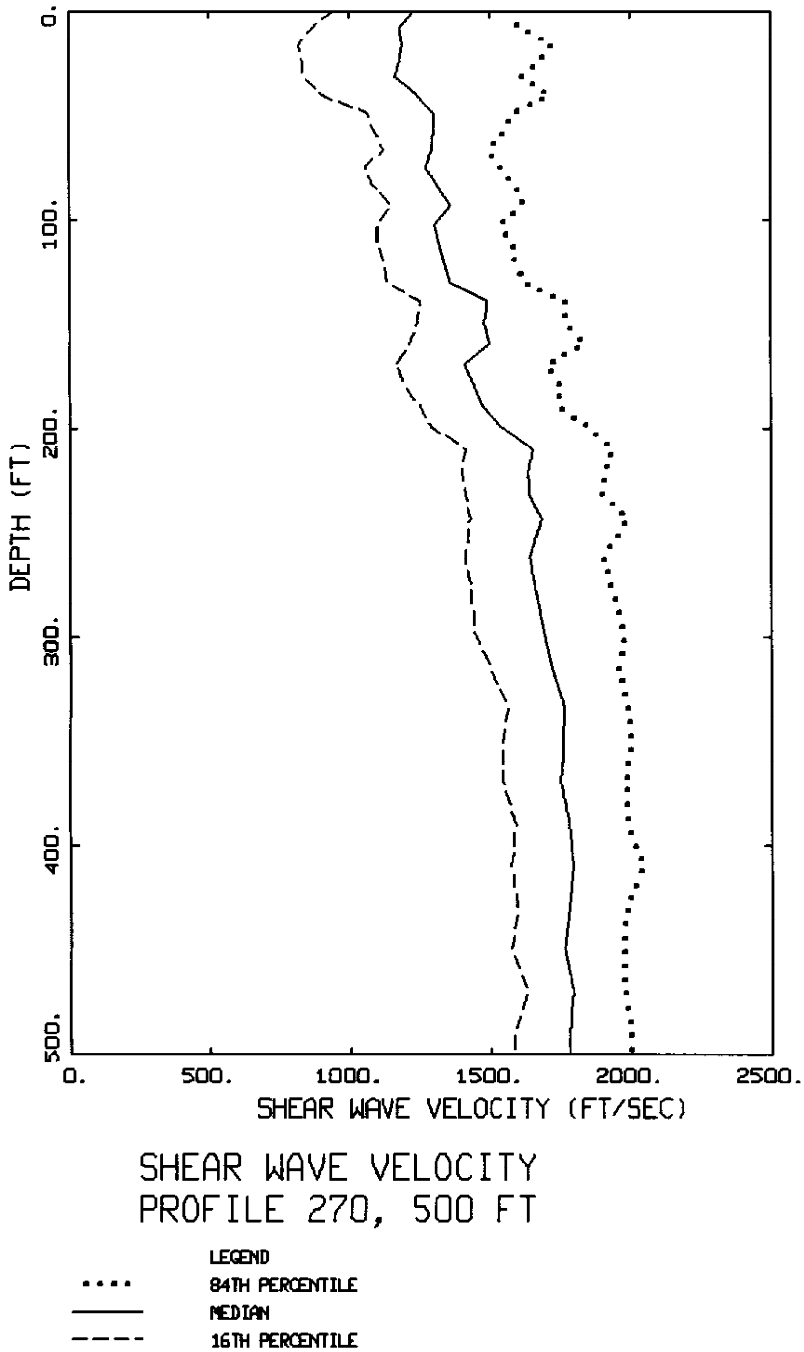


Figure 5.2-6 Strain Compatible Properties Computed for Profile 270 500 ft Depth to Bedrock (Sheet 1 of 4)

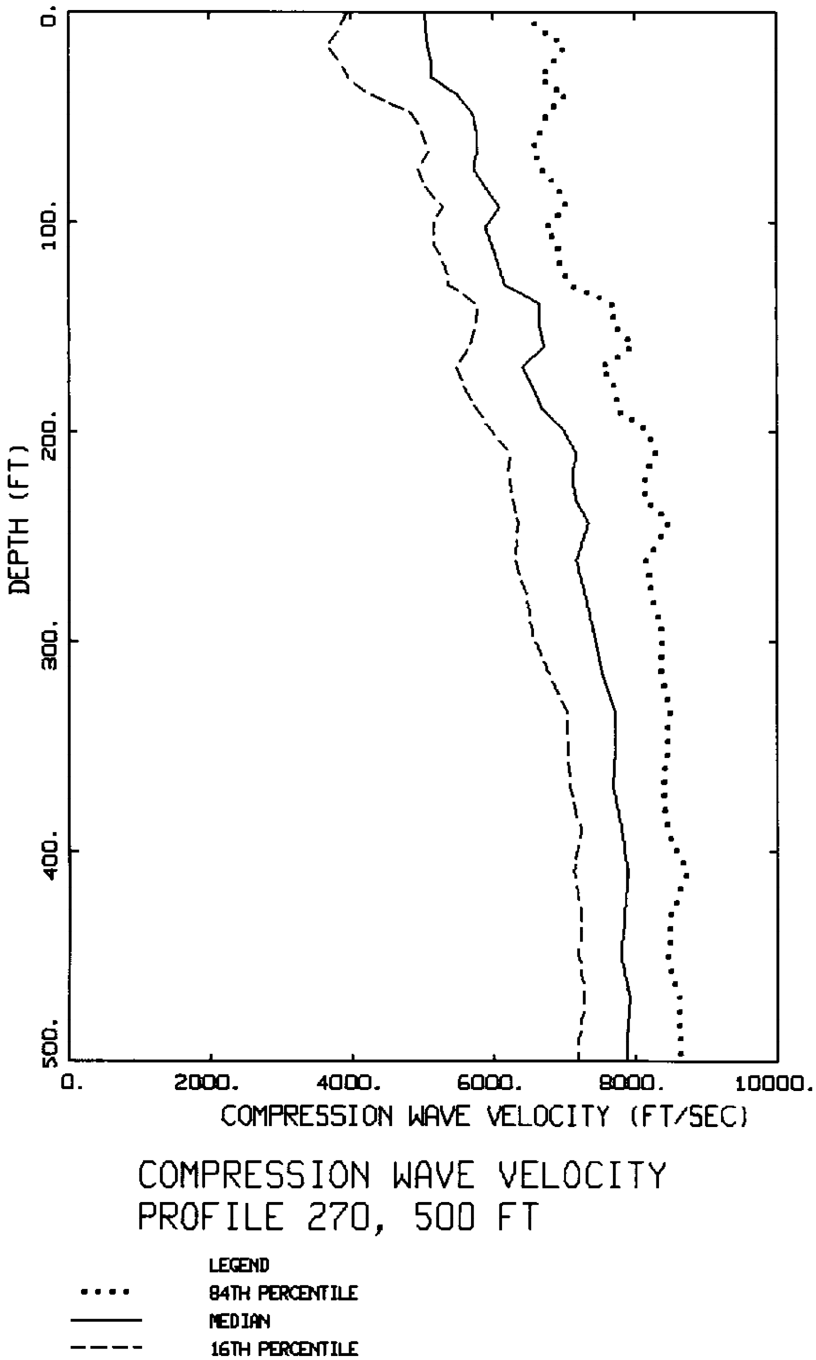


Figure 5.2-6 Strain Compatible Properties Computed for Profile 270 500 ft Depth to Bedrock (Sheet 2 of 4)

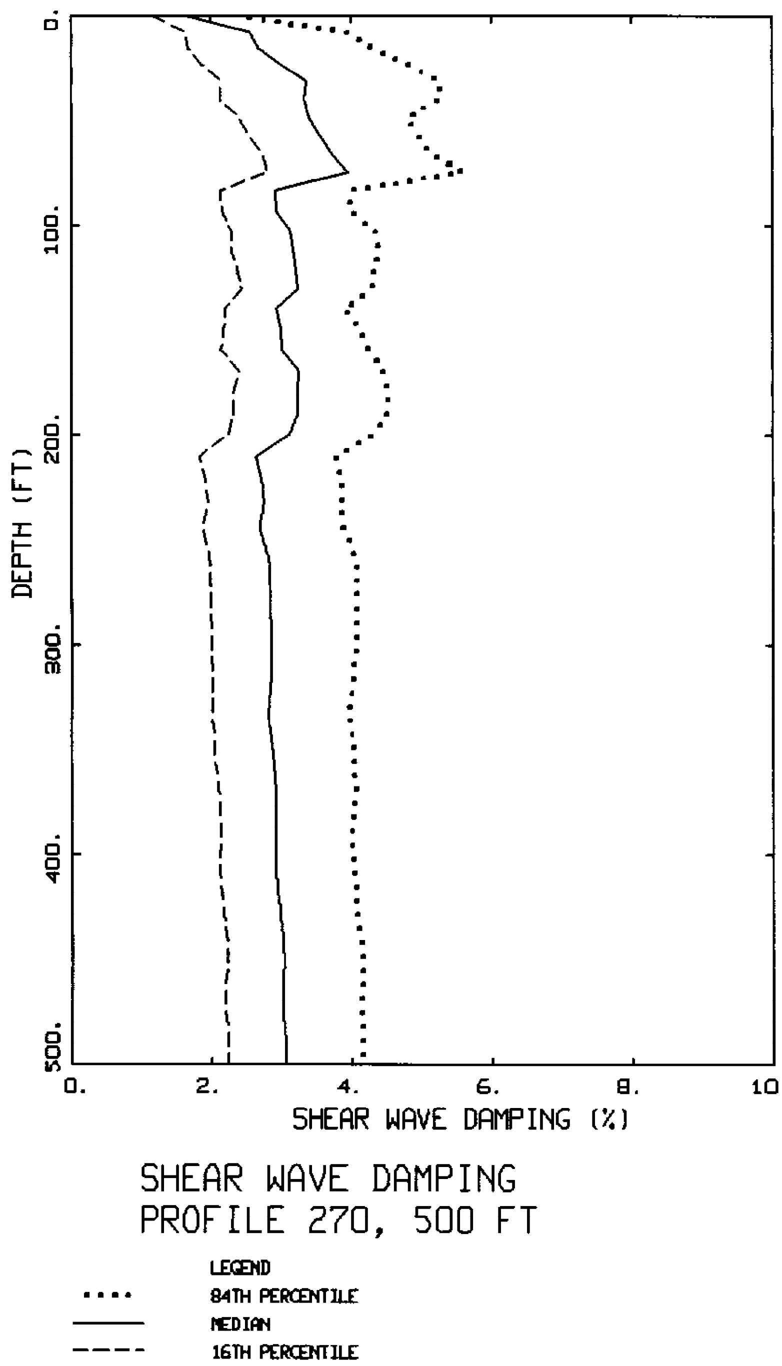


Figure 5.2-6 Strain Compatible Properties Computed for Profile 270 500 ft Depth to Bedrock (Sheet 3 of 4)

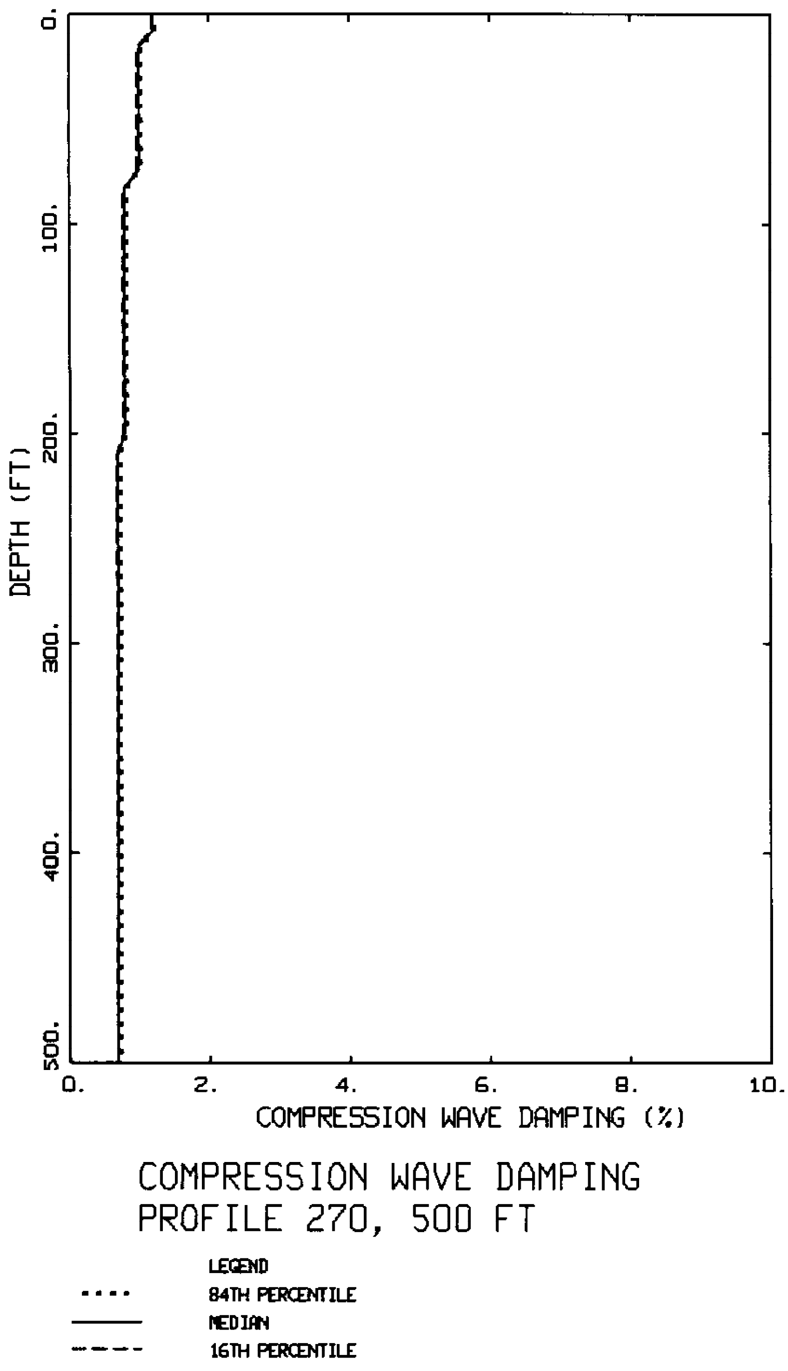


Figure 5.2-6 Strain Compatible Properties Computed for Profile 270 500 ft Depth to Bedrock (Sheet 4 of 4)

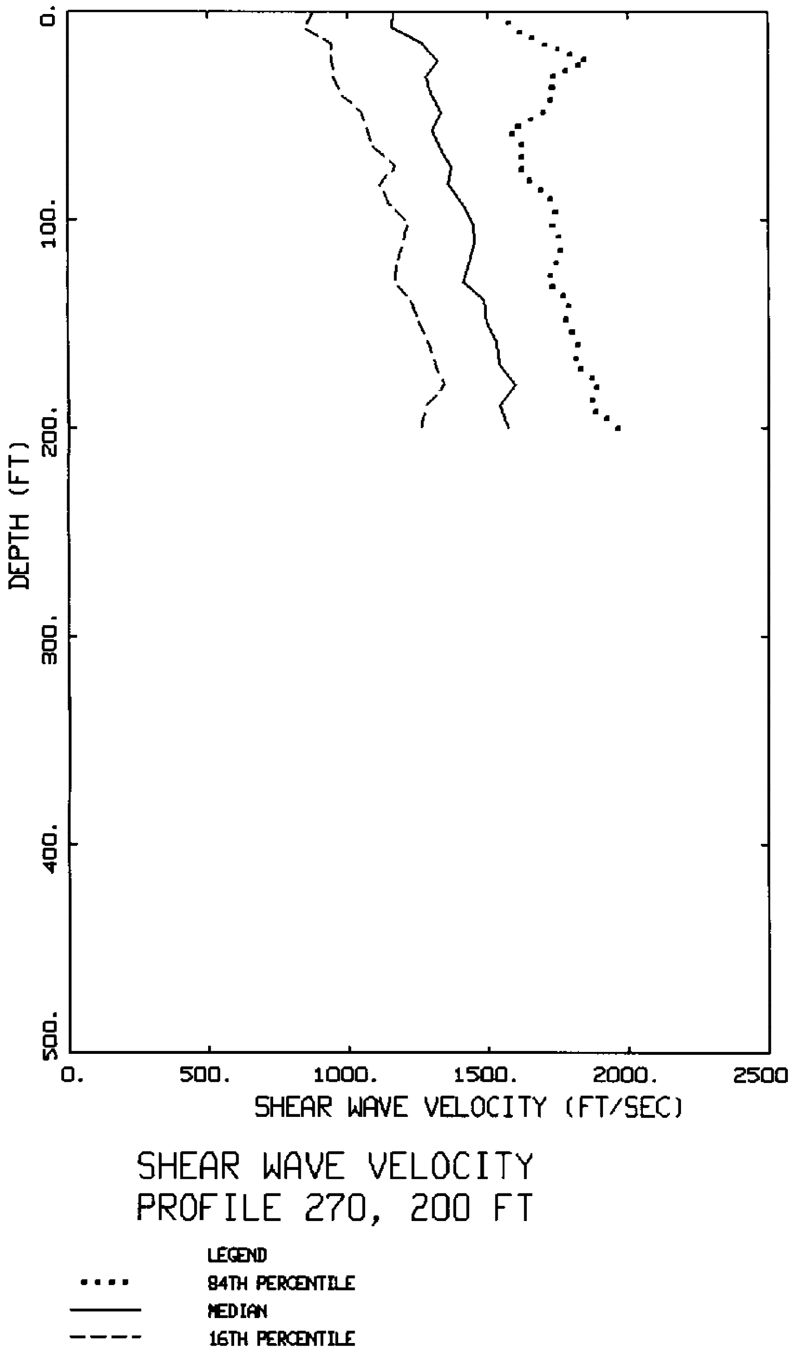


Figure 5.2-7 Strain Compatible Properties Computed for Profile 270 200 ft Depth to Bedrock (Sheet 1 of 4)

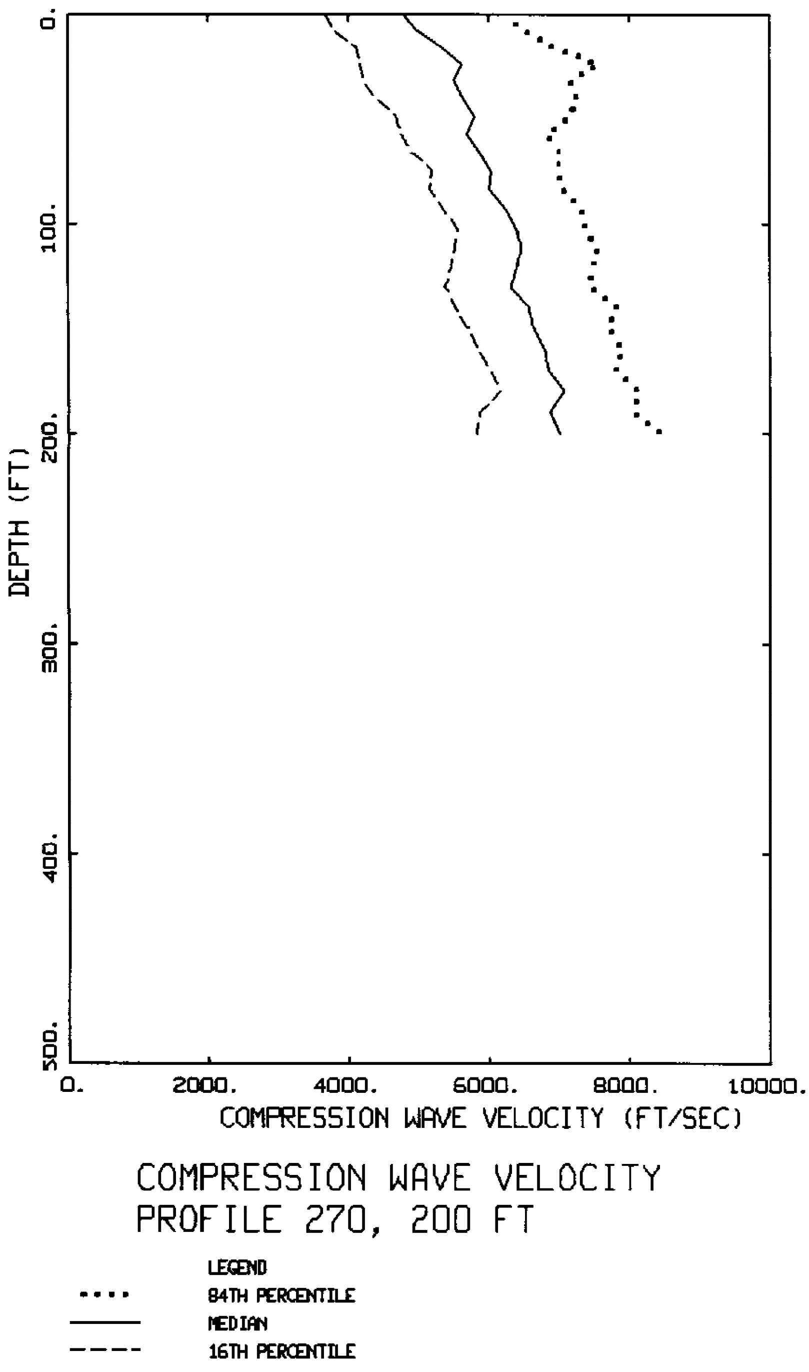


Figure 5.2-7 Strain Compatible Properties Computed for Profile 270 200 ft Depth to Bedrock (Sheet 2 of 4)

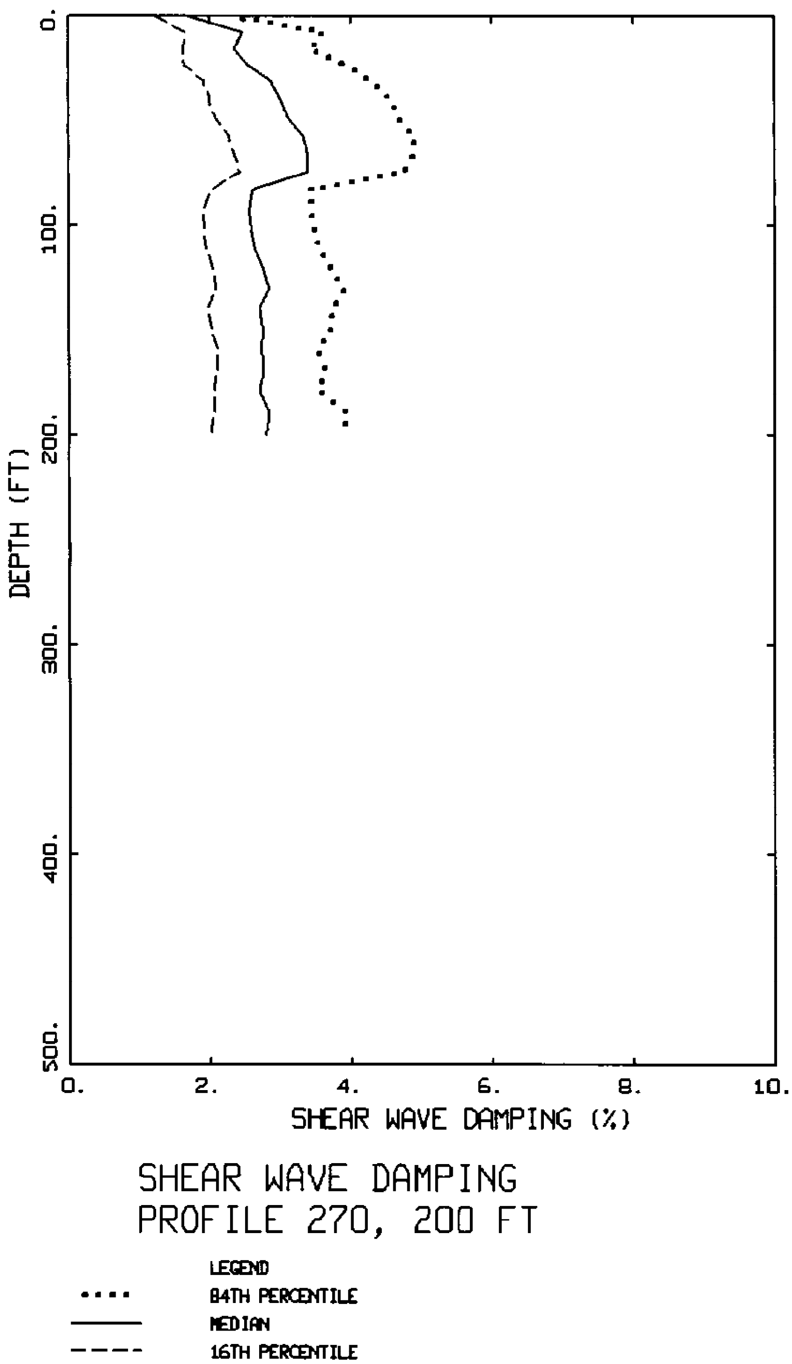


Figure 5.2-7 Strain Compatible Properties Computed for Profile 270 200 ft Depth to Bedrock (Sheet 3 of 4)

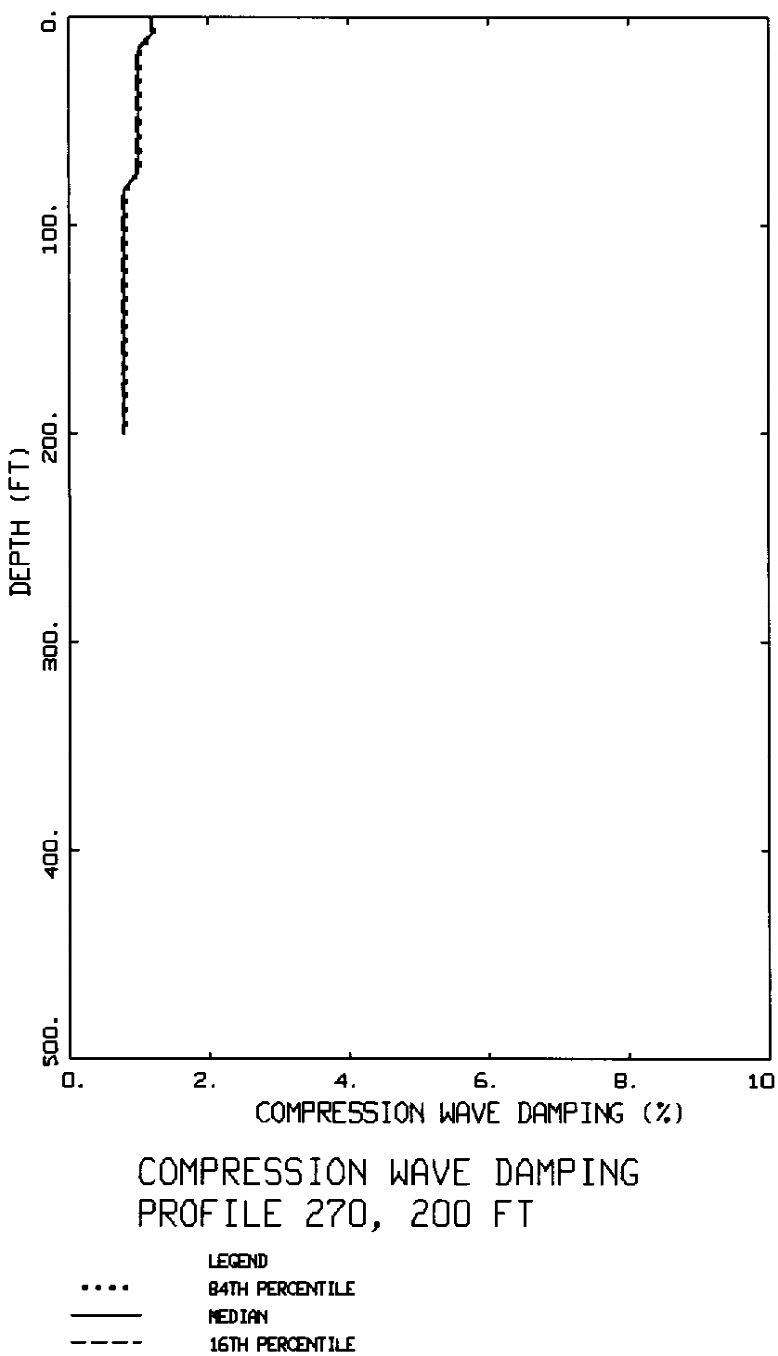


Figure 5.2-7 Strain Compatible Properties Computed for Profile 270 200 ft Depth to Bedrock (Sheet 4 of 4)

Figure 5.2-8 Deleted

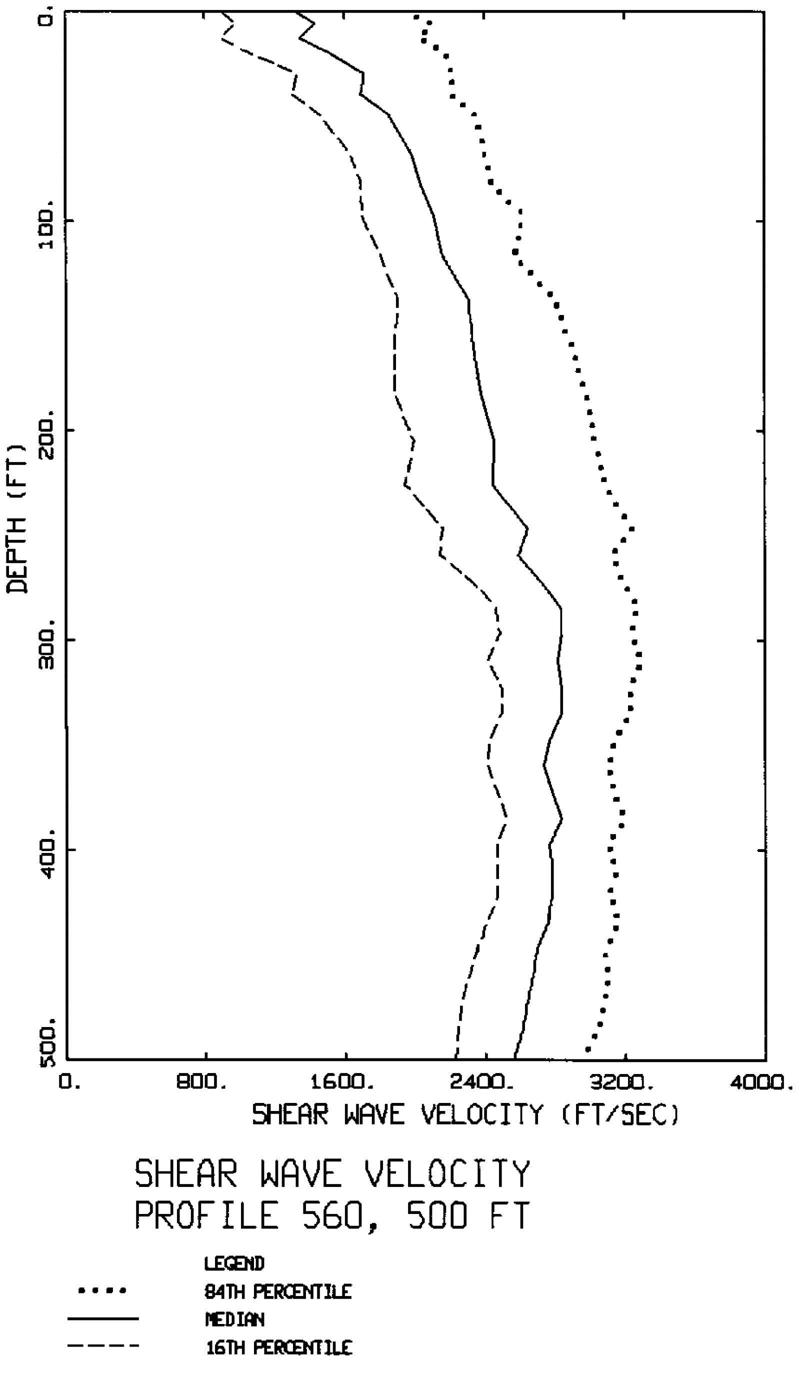


Figure 5.2-9 Strain Compatible Properties Computed for Profile 560 500 ft Depth to Bedrock (Sheet 1 of 4)

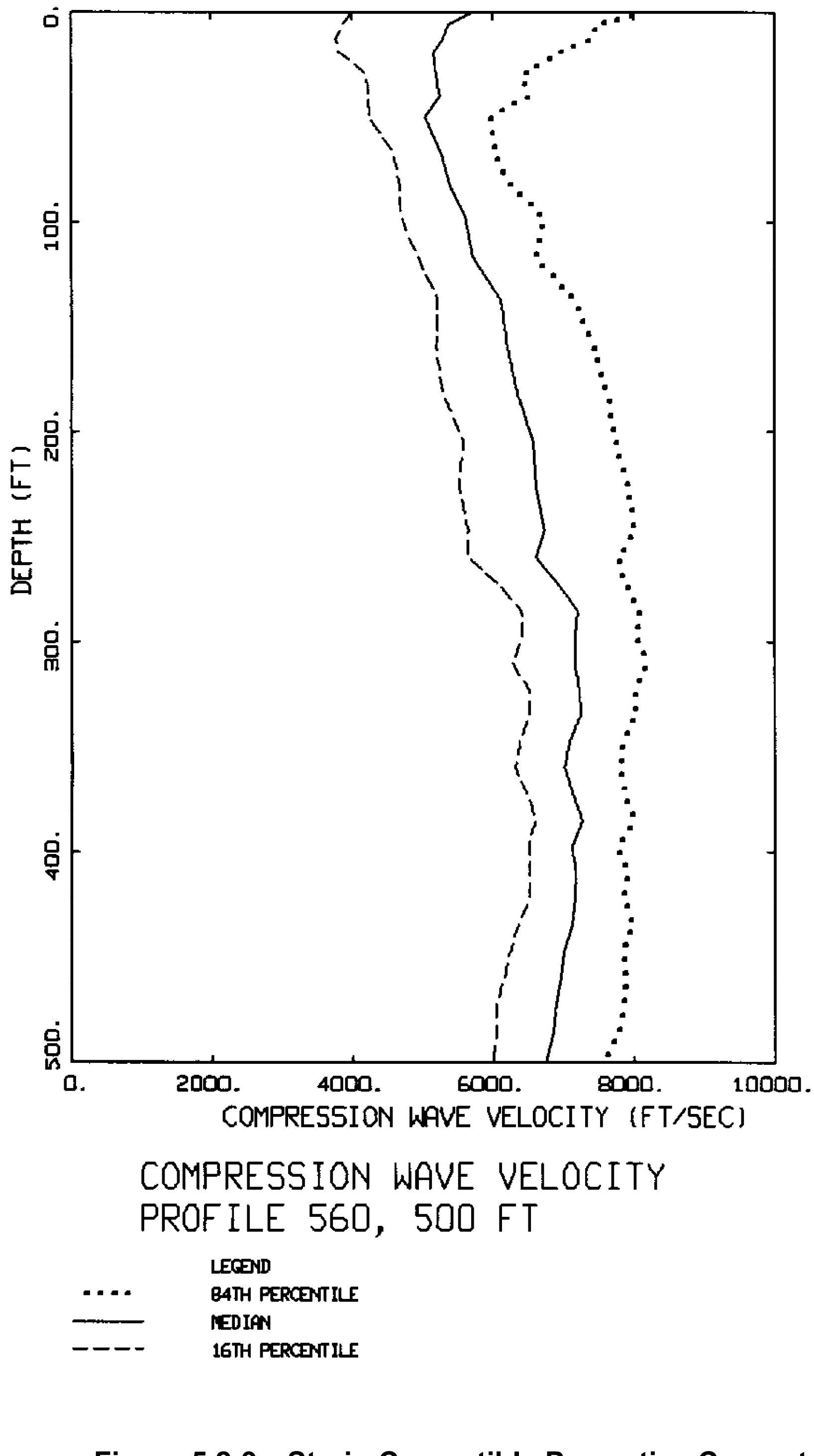


Figure 5.2-9 Strain Compatible Properties Computed for Profile 560 500 ft Depth to Bedrock (Sheet 2 of 4)

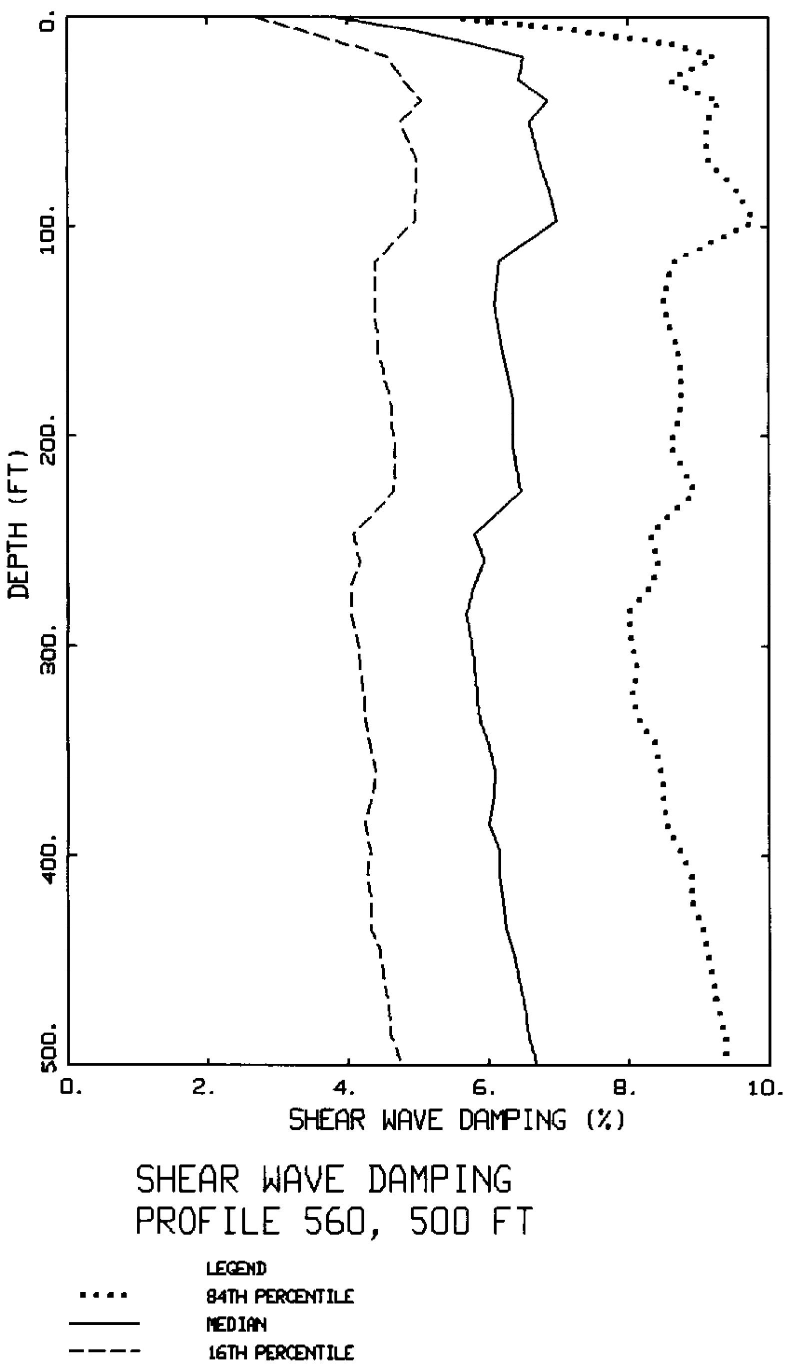


Figure 5.2-9 Strain Compatible Properties Computed for Profile 560 500 ft Depth to Bedrock (Sheet 3 of 4)

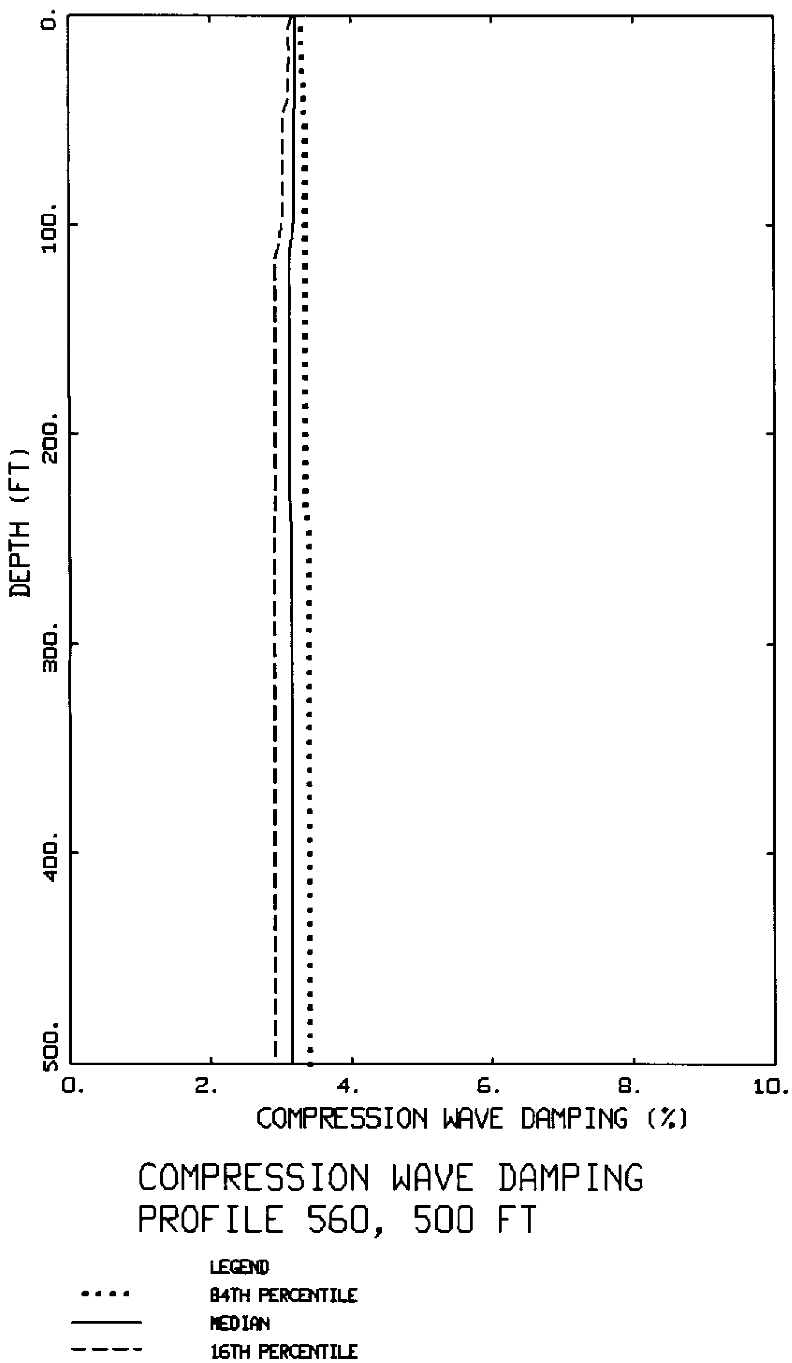


Figure 5.2-9 Strain Compatible Properties Computed for Profile 560 500 ft Depth to Bedrock (Sheet 4 of 4)

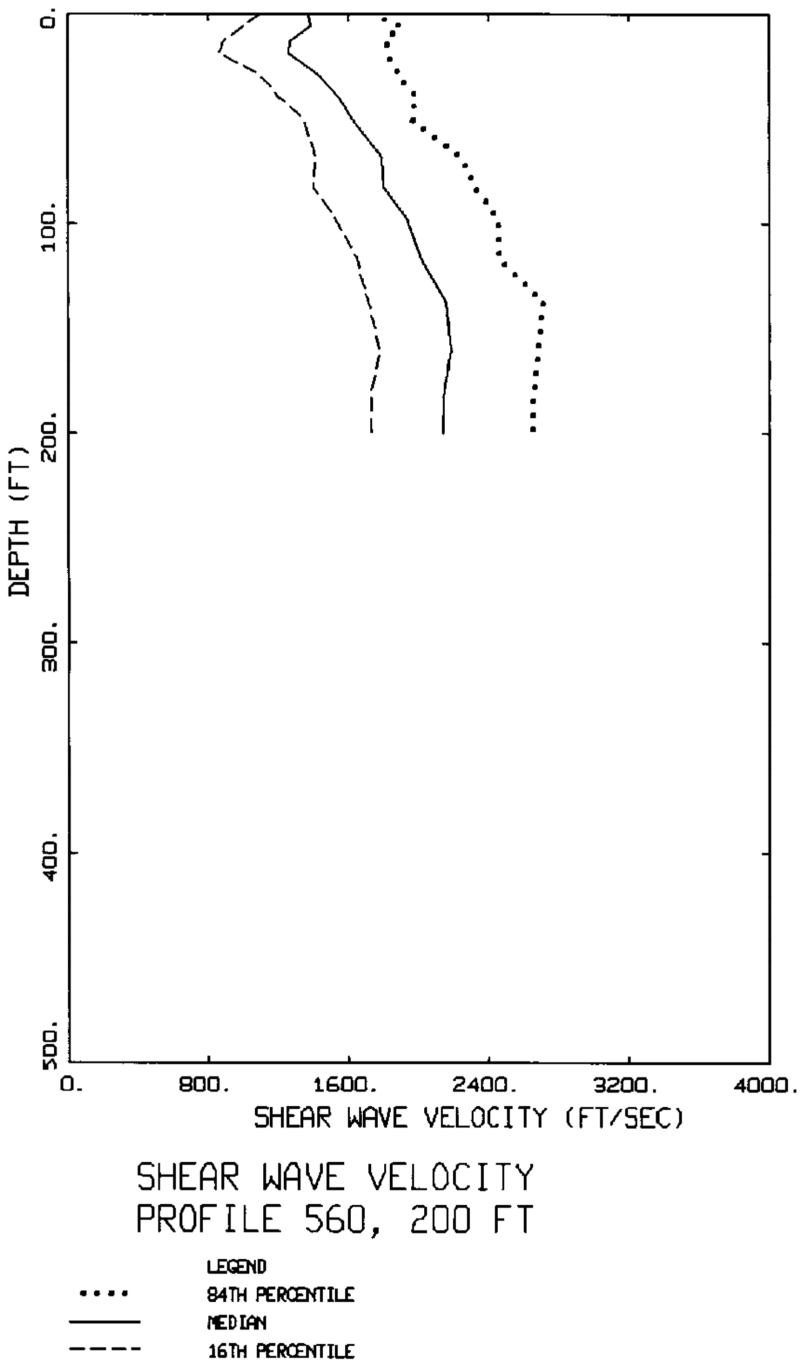


Figure 5.2-10 Strain Compatible Properties Computed for Profile 560 200 ft Depth to Bedrock (Sheet 1 of 4)

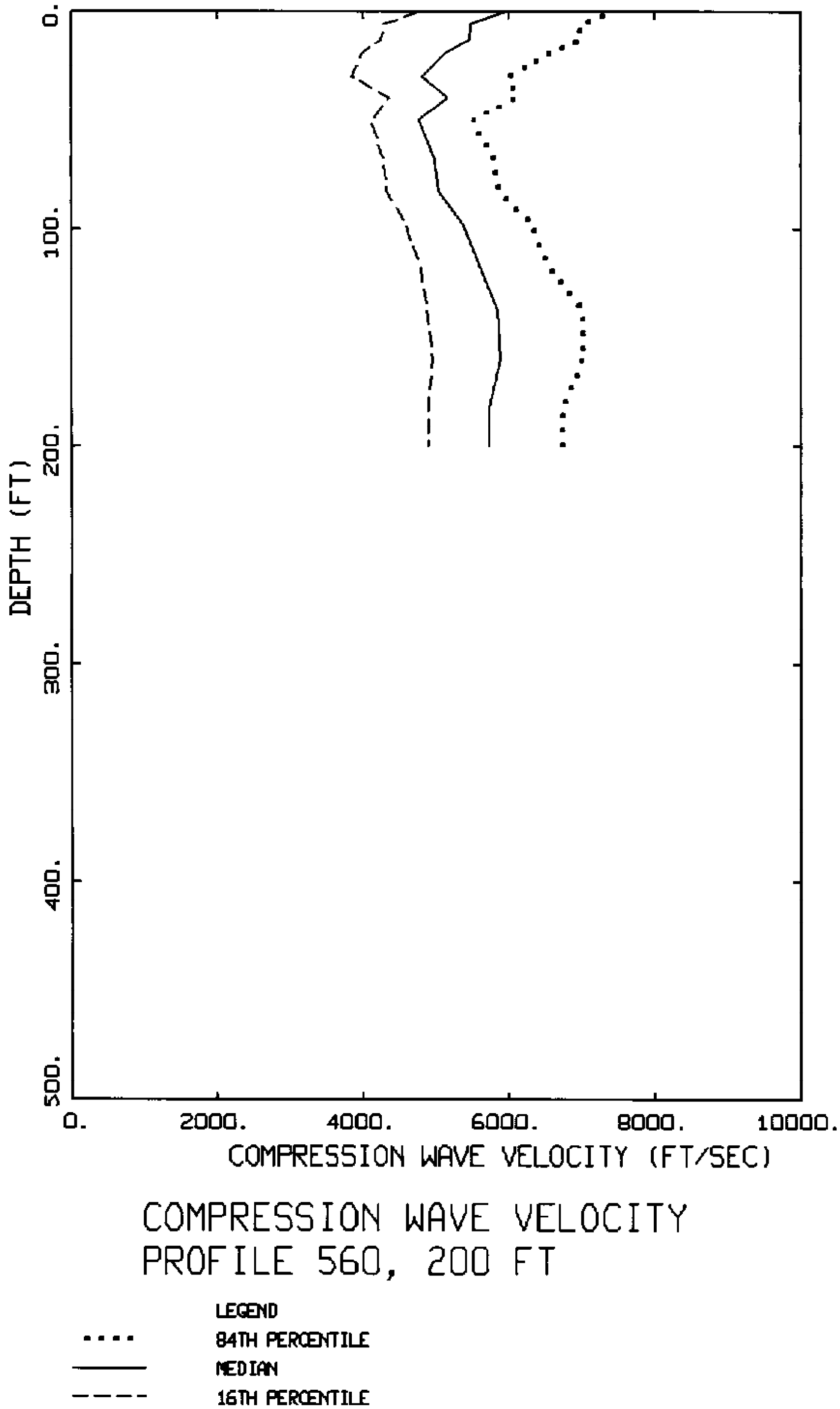


Figure 5.2-10 Strain Compatible Properties Computed for Profile 560 200 ft Depth to Bedrock (Sheet 2 of 4)

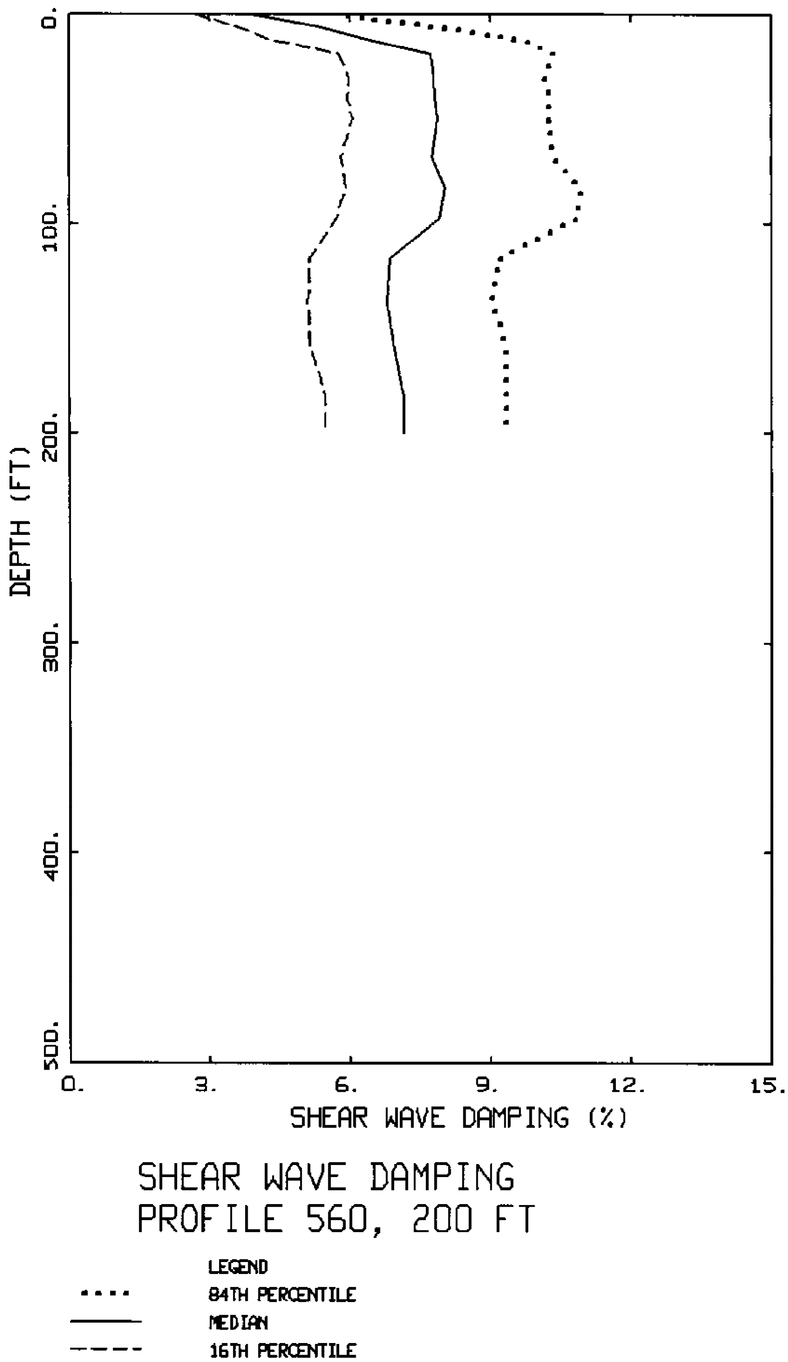


Figure 5.2-10 Strain Compatible Properties Computed for Profile 560 200 ft Depth to Bedrock (Sheet 3 of 4)

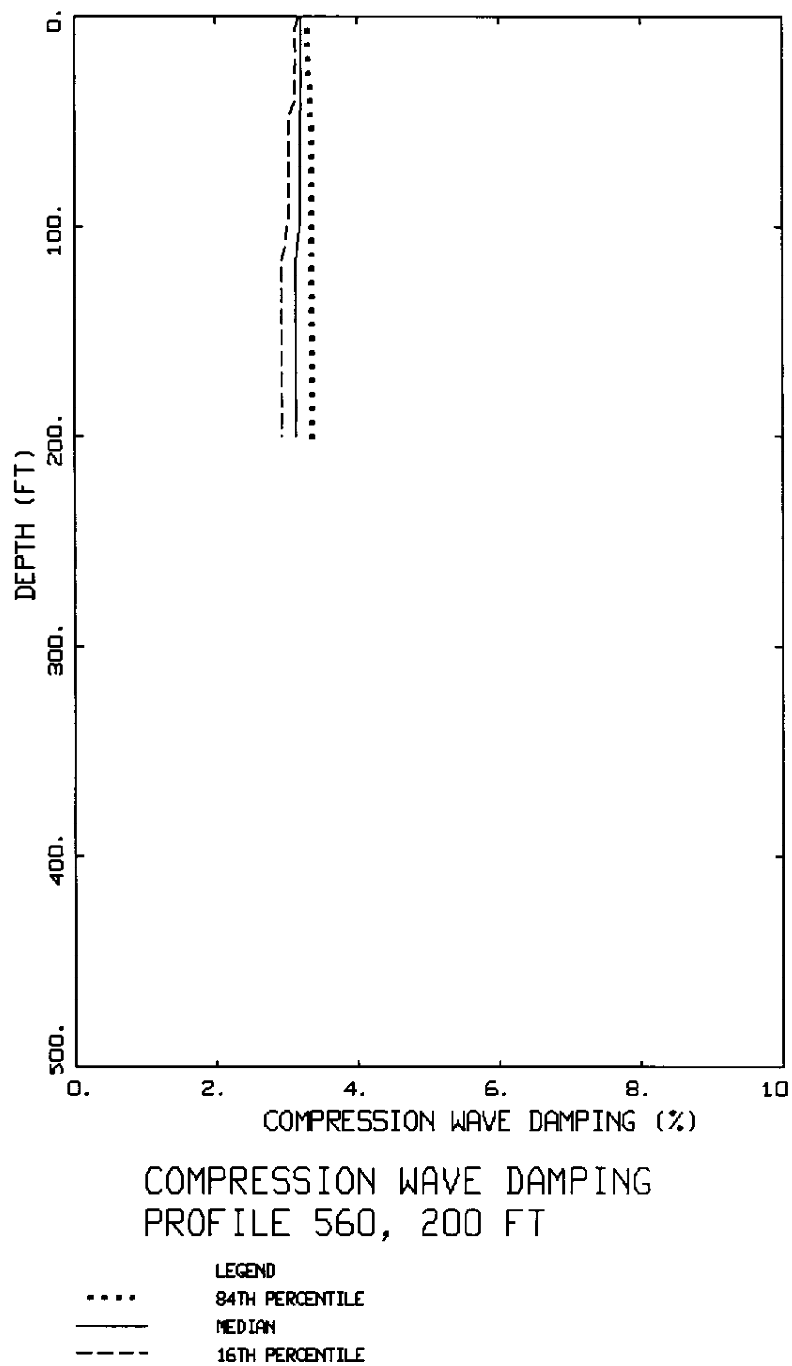


Figure 5.2-10 Strain Compatible Properties Computed for Profile 560 200 ft Depth to Bedrock (Sheet 4 of 4)

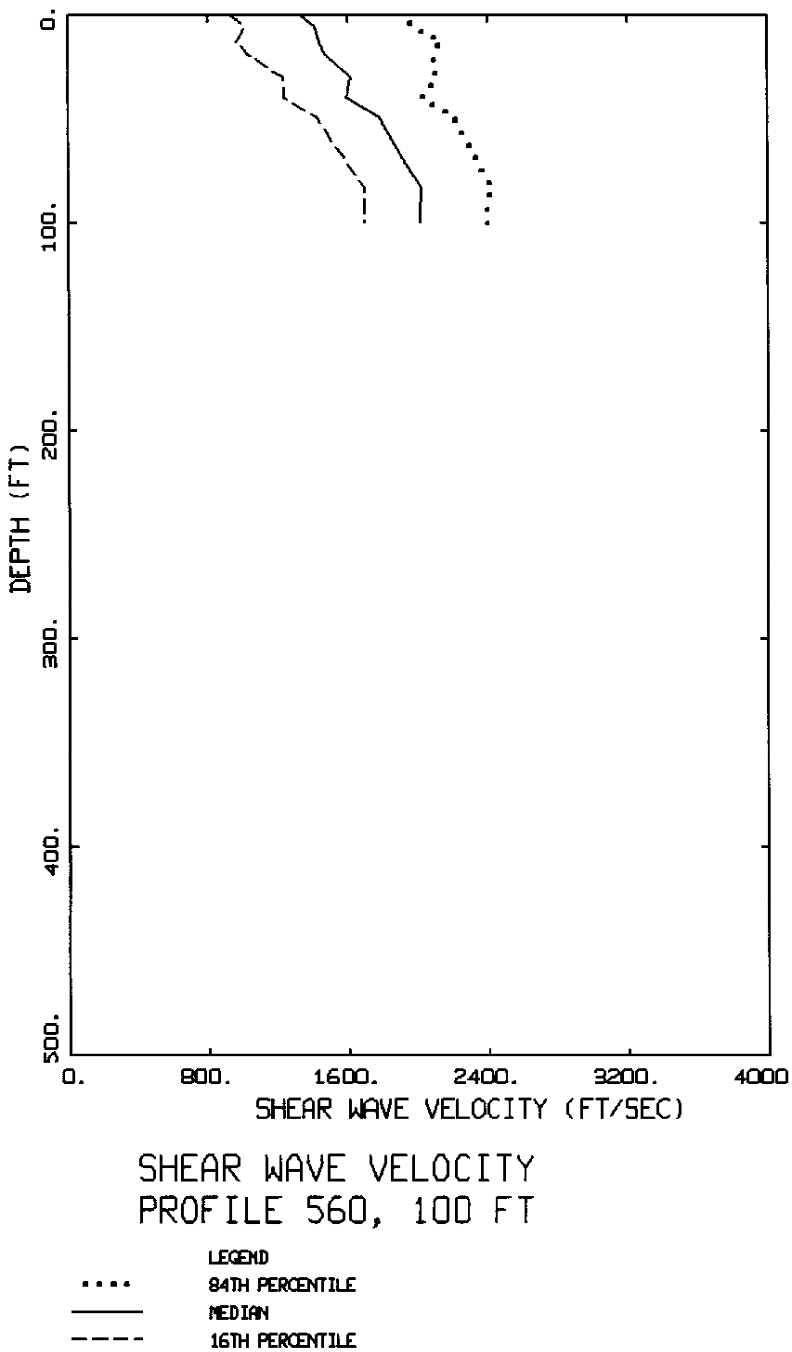


Figure 5.2-11 Strain Compatible Properties Computed for Profile 560 100 ft Depth to Bedrock (Sheet 1 of 4)

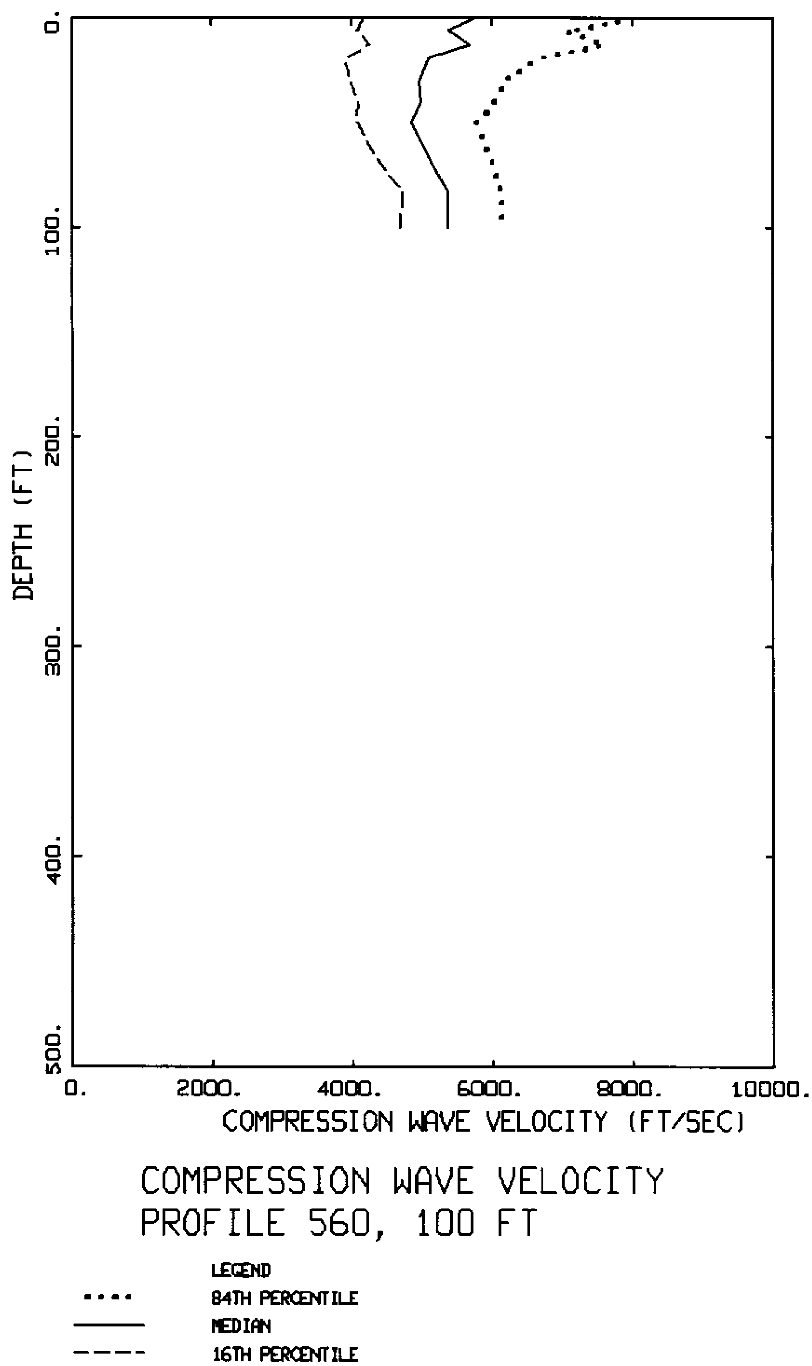


Figure 5.2-11 Strain Compatible Properties Computed for Profile 560 100 ft Depth to Bedrock (Sheet 2 of 4)

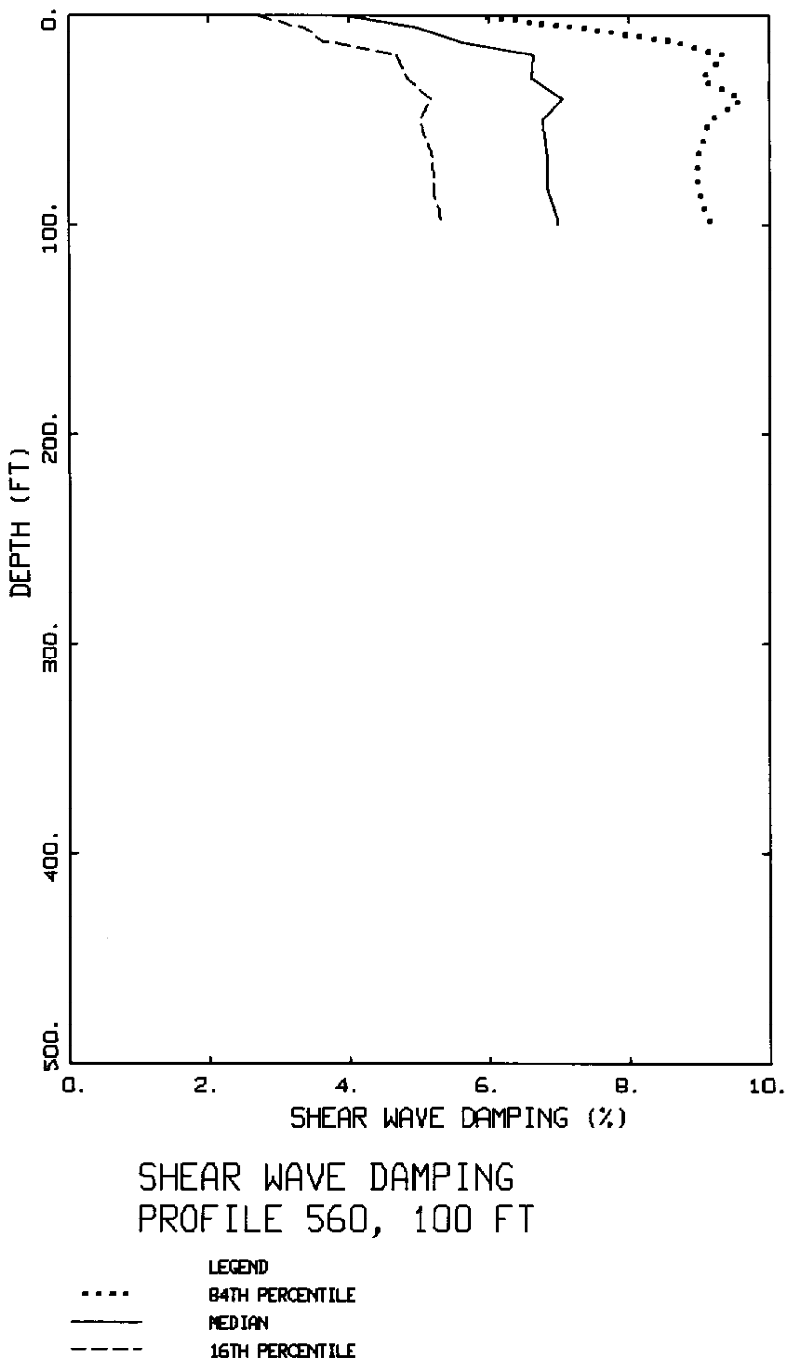


Figure 5.2-11 Strain Compatible Properties Computed for Profile 560 100 ft Depth to Bedrock (Sheet 3 of 4)

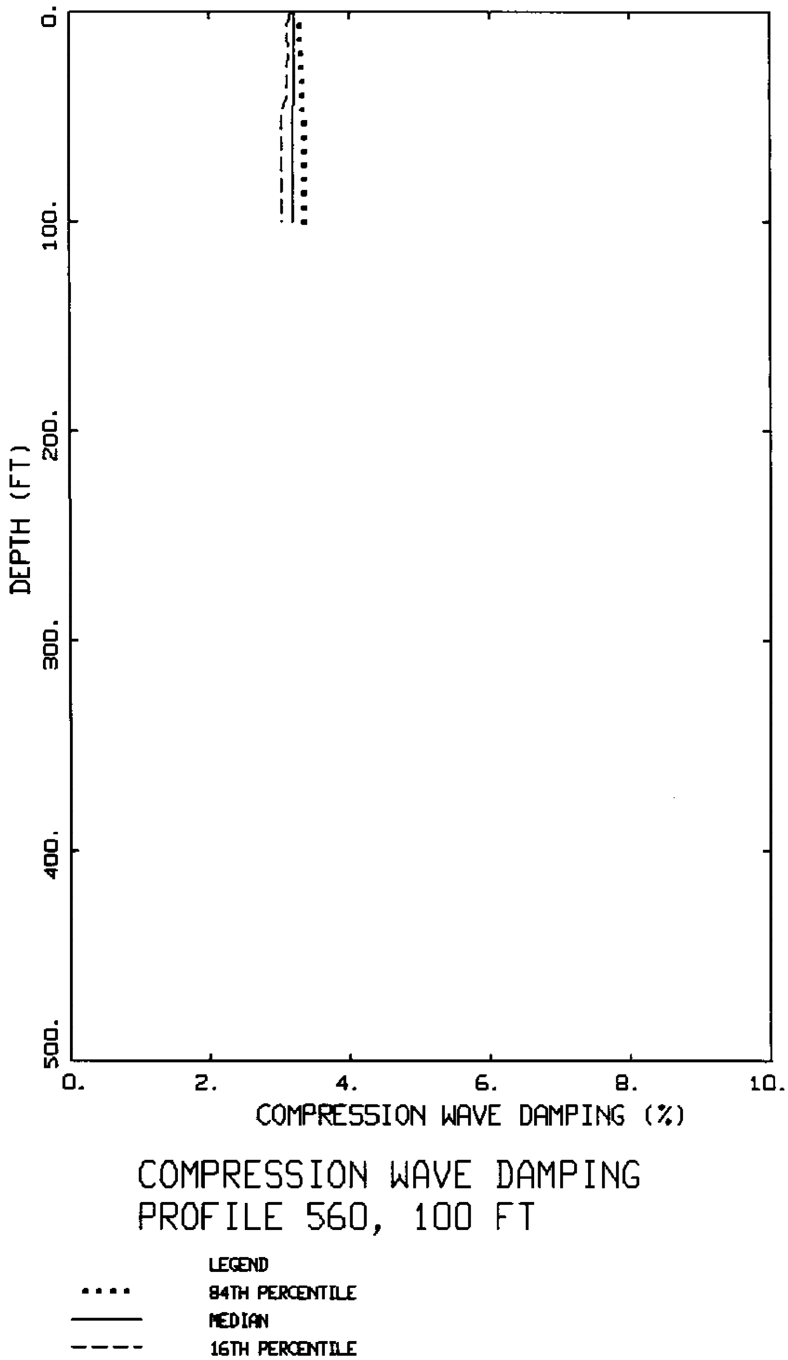


Figure 5.2-11 Strain Compatible Properties Computed for Profile 560 100 ft Depth to Bedrock (Sheet 4 of 4)

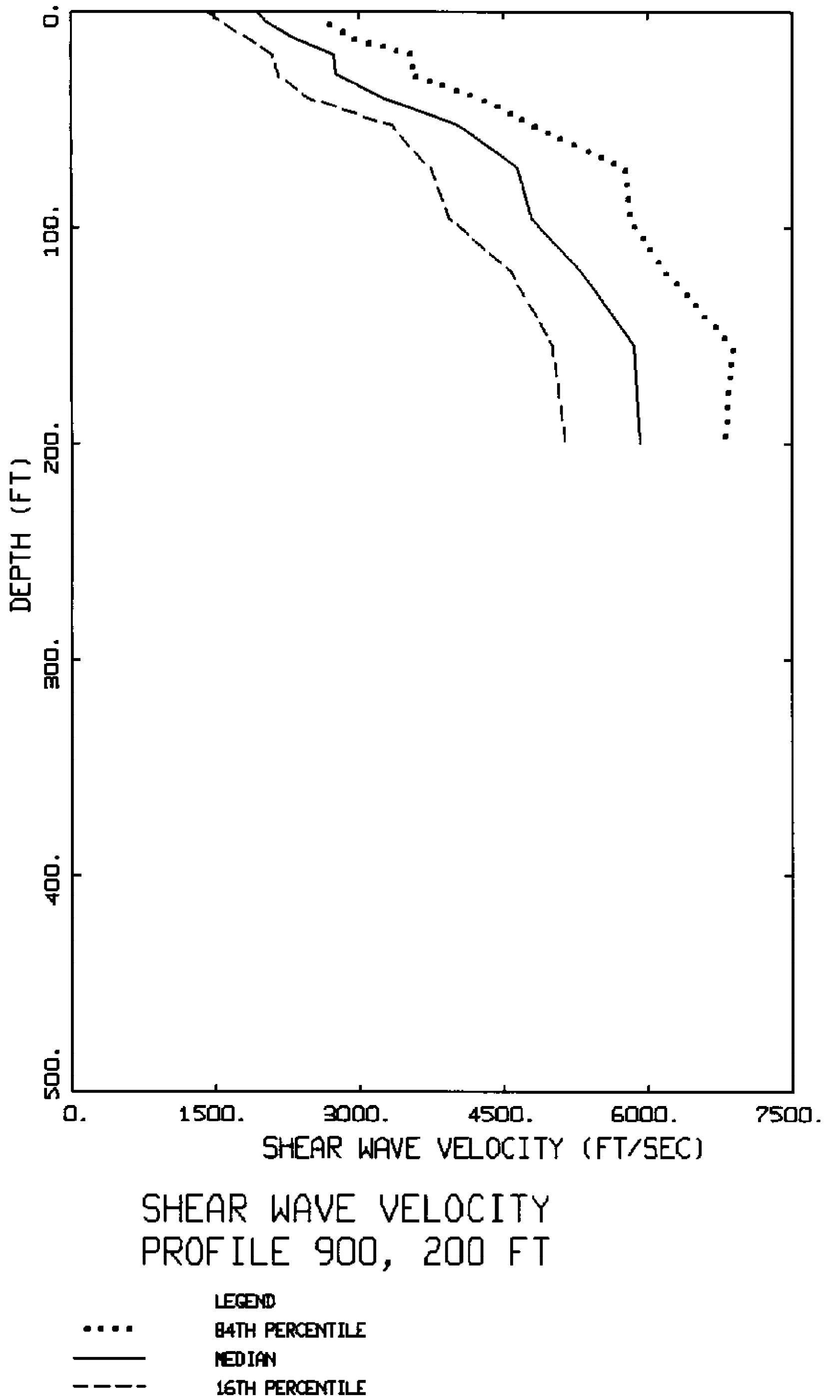


Figure 5.2-12 Strain Compatible Properties Computed for Profile 900 200 ft Depth to Bedrock (Sheet 1 of 4)

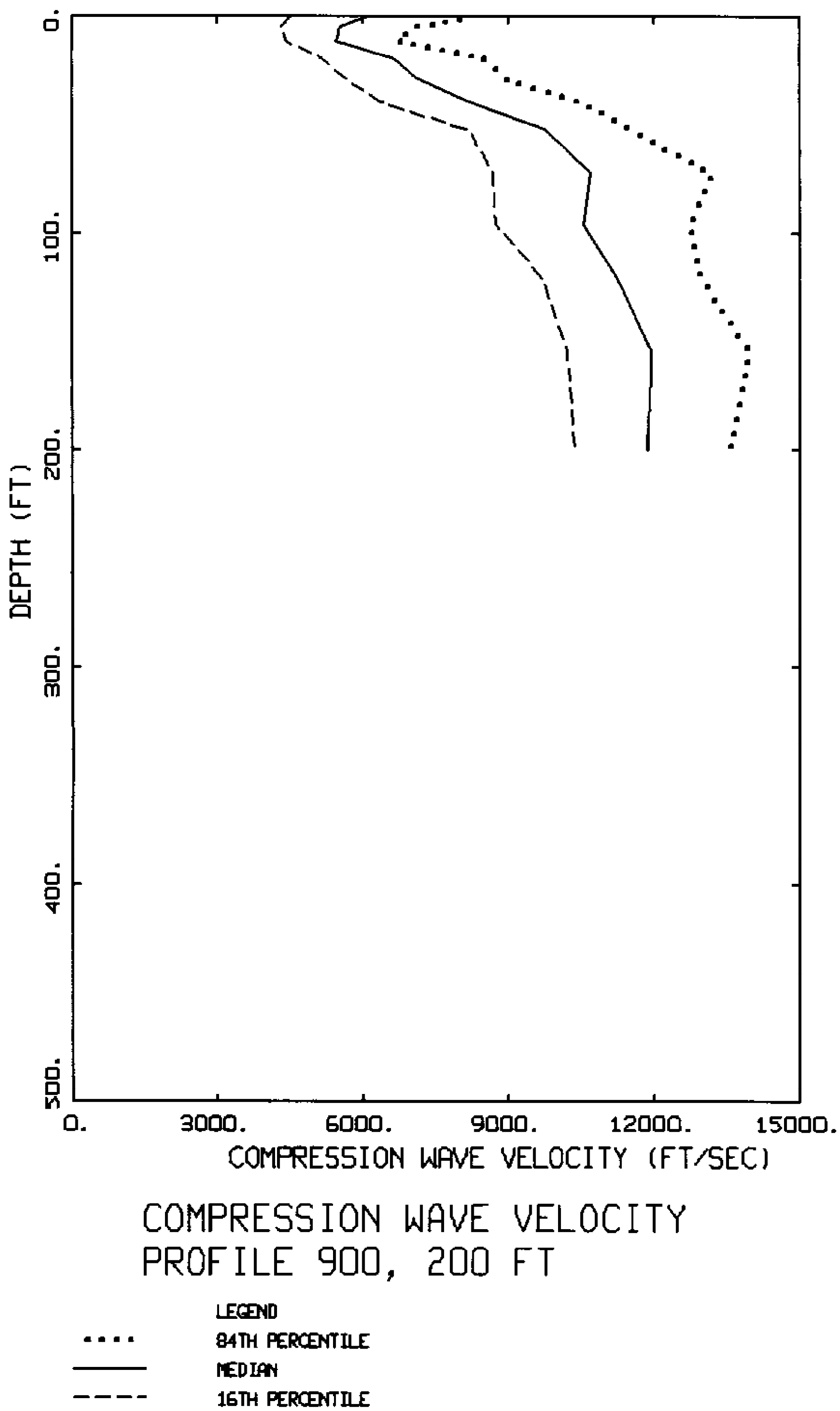


Figure 5.2-12 Strain Compatible Properties Computed for Profile 900 200 ft Depth to Bedrock (Sheet 2 of 4)

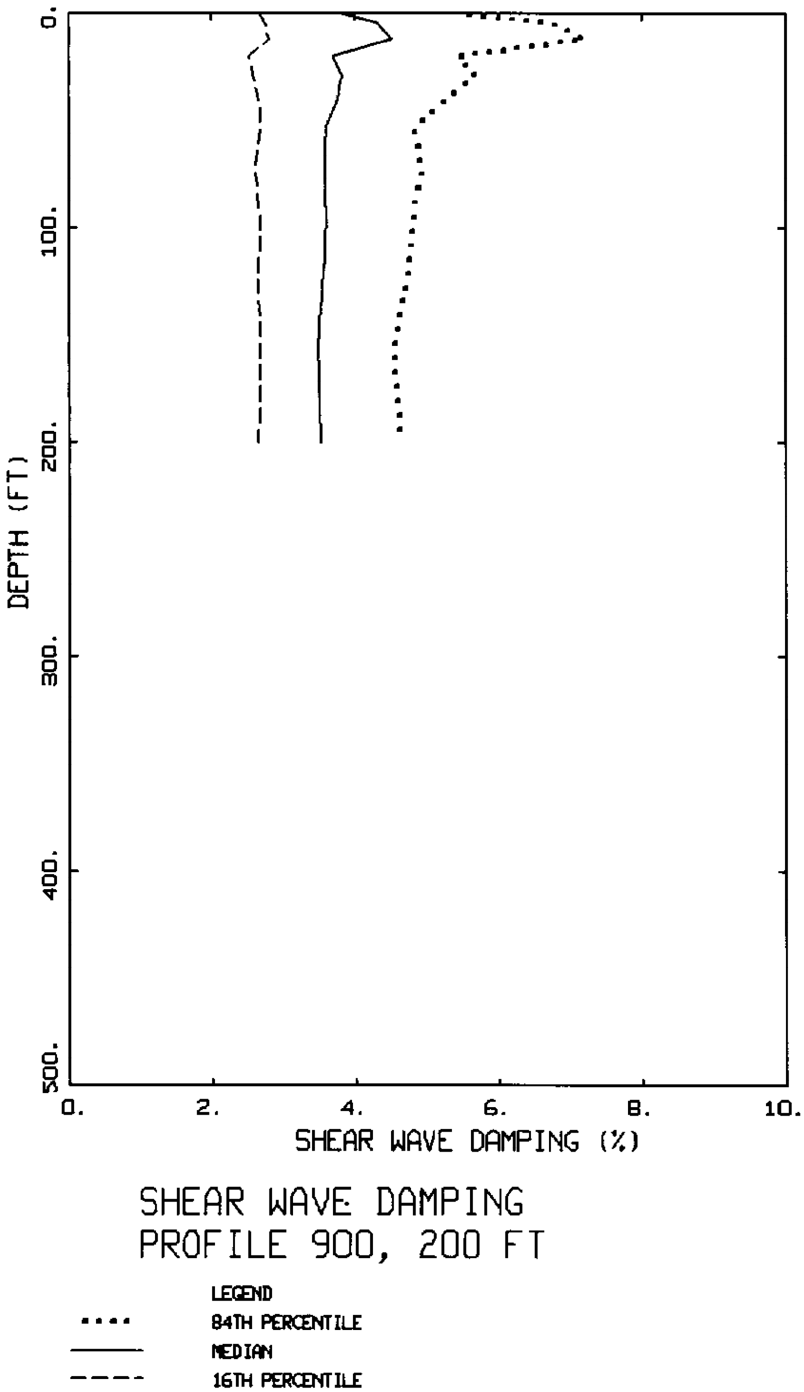


Figure 5.2-12 Strain Compatible Properties Computed for Profile 900 200 ft Depth to Bedrock (Sheet 3 of 4)

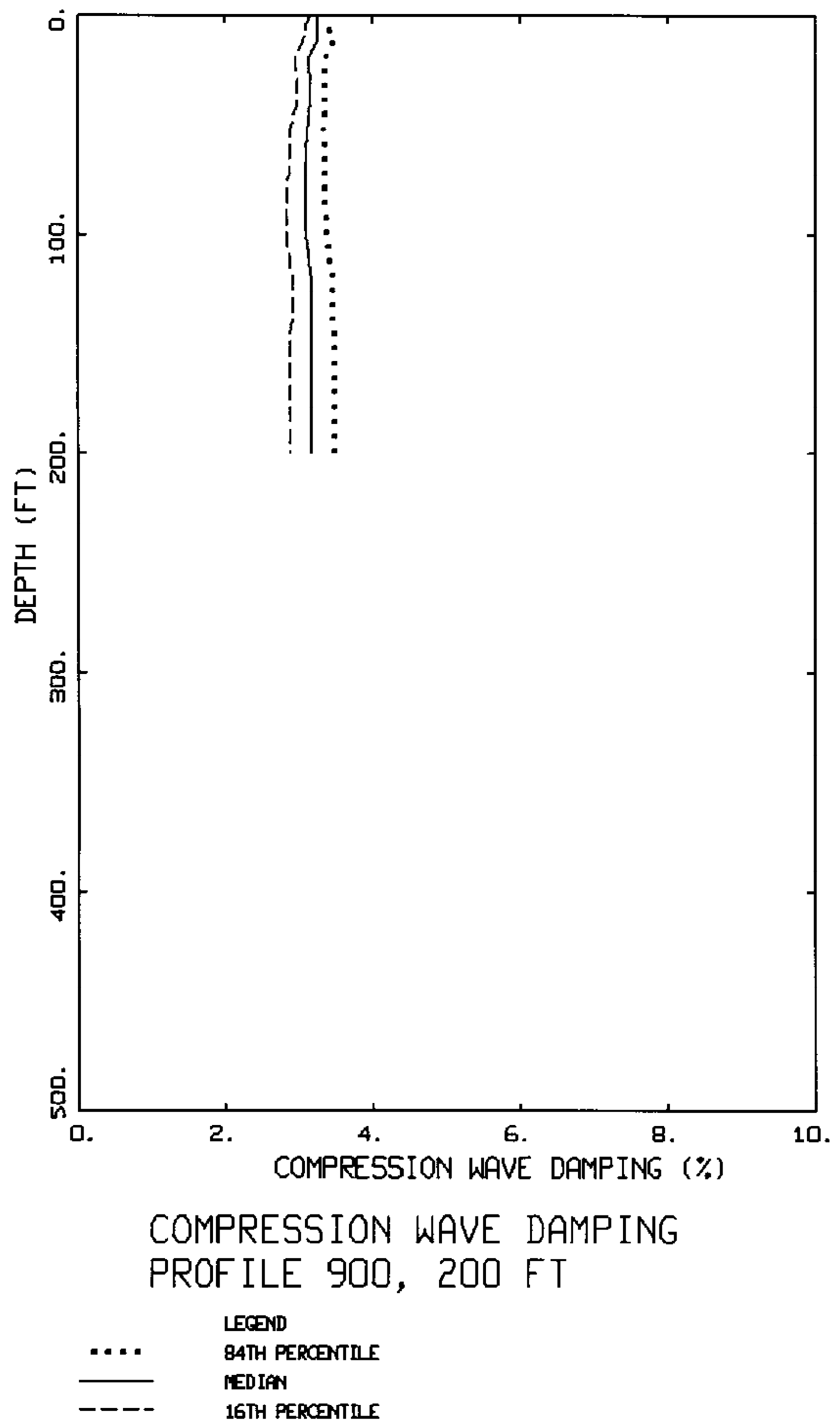


Figure 5.2-12 Strain Compatible Properties Computed for Profile 900 200 ft Depth toBedrock (Sheet 4 of 4)

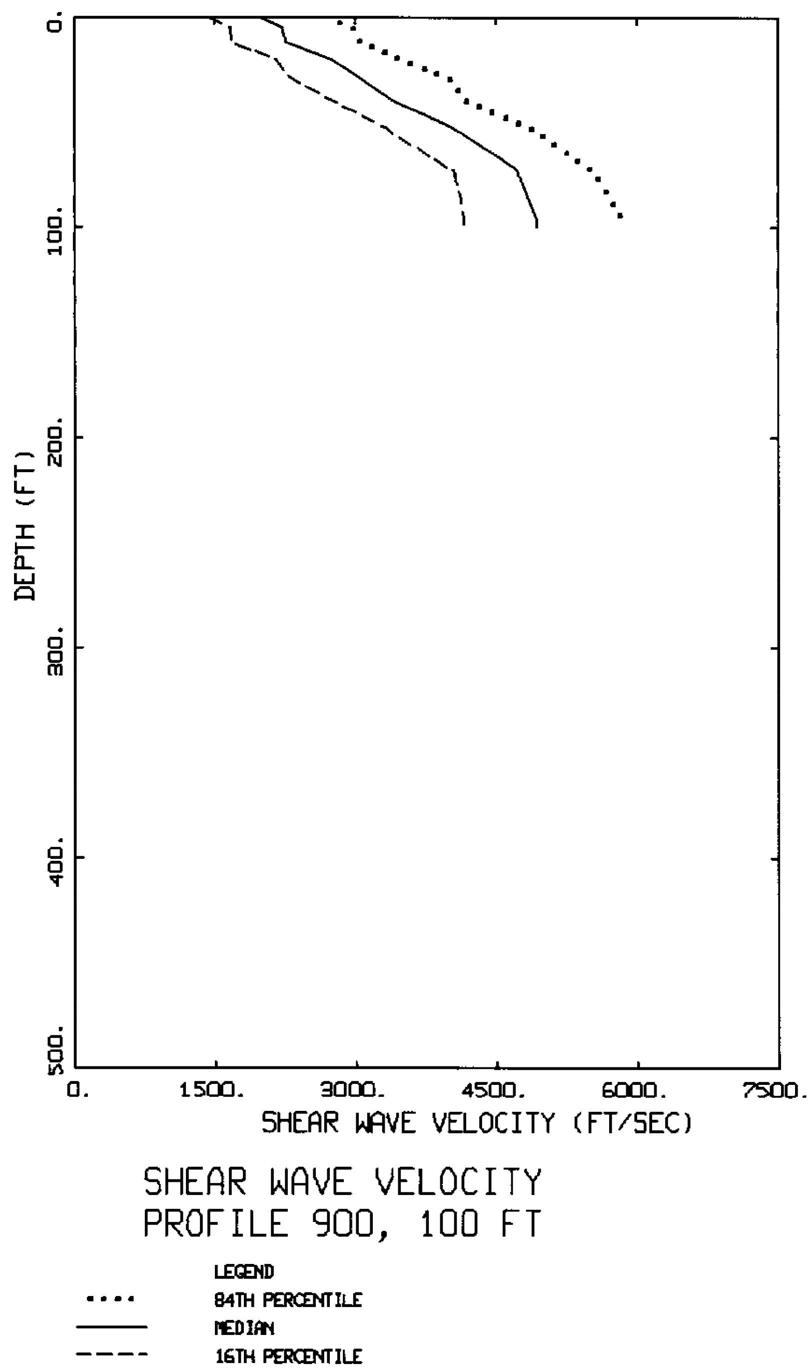


Figure 5.2-13 Strain Compatible Properties Computed for Profile 900 100 ft Depth to Bedrock (Sheet 1 of 4)

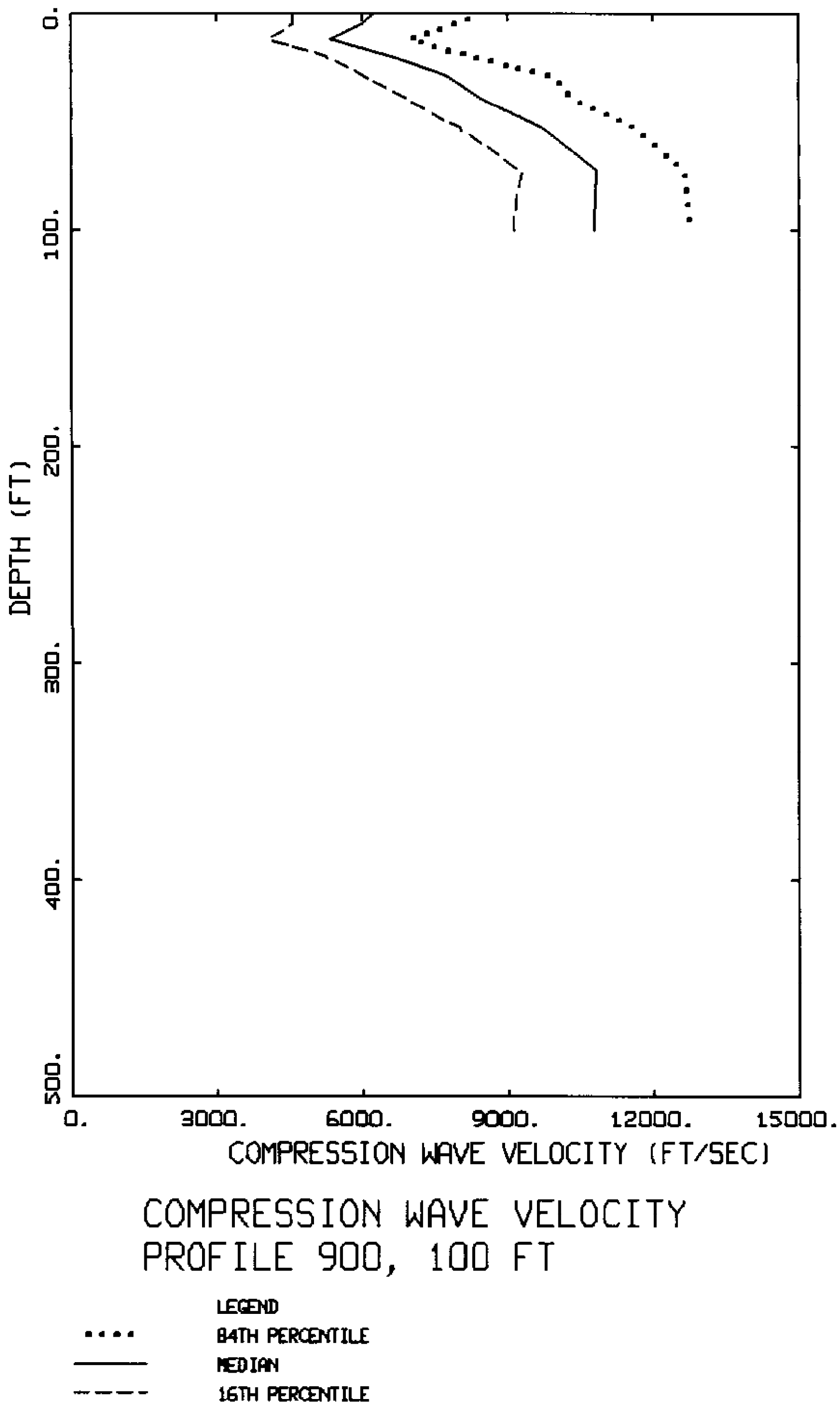


Figure 5.2-13 Strain Compatible Properties Computed for Profile 900 100 ft Depth to Bedrock (Sheet 2 of 4)

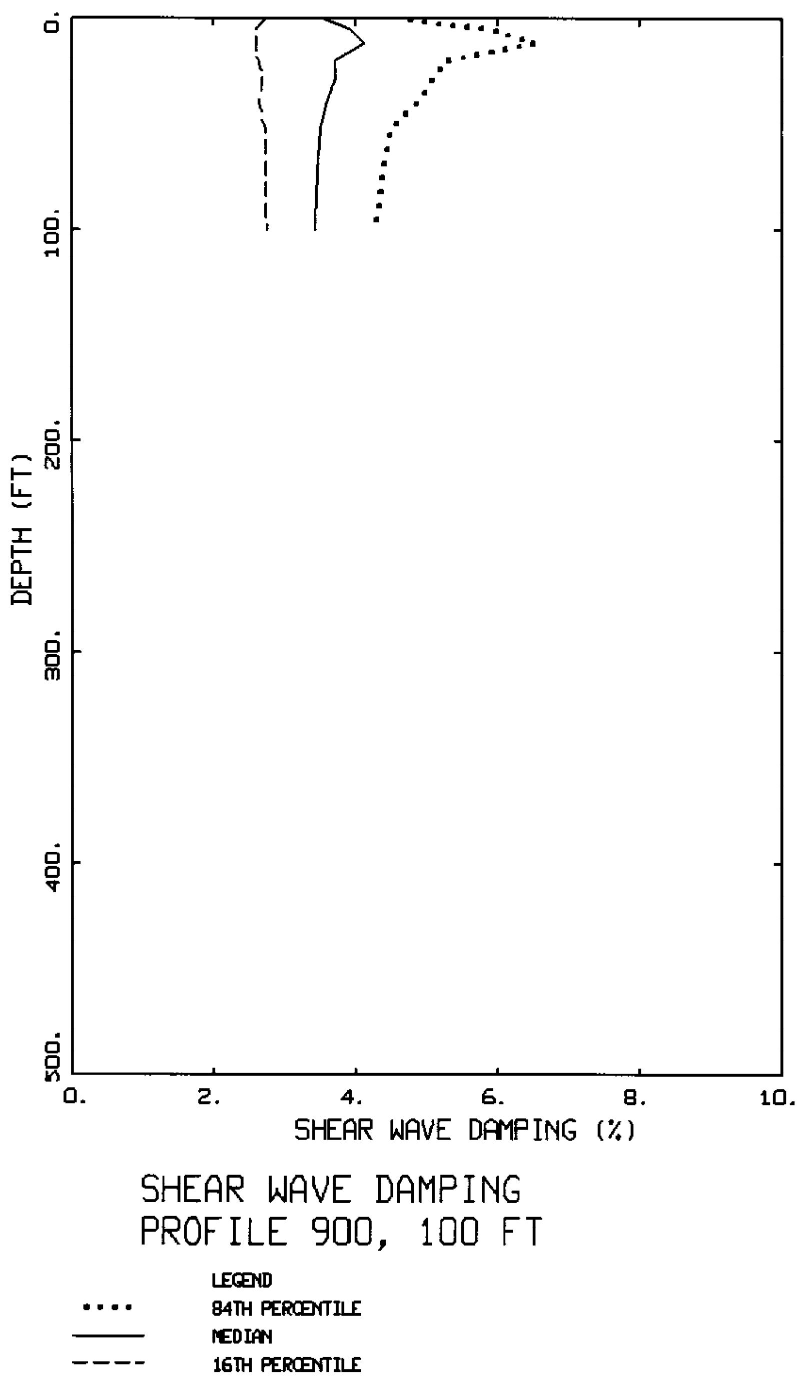


Figure 5.2-13 Strain Compatible Properties Computed for Profile 900 100 ft Depth to Bedrock (Sheet 3 of 4)

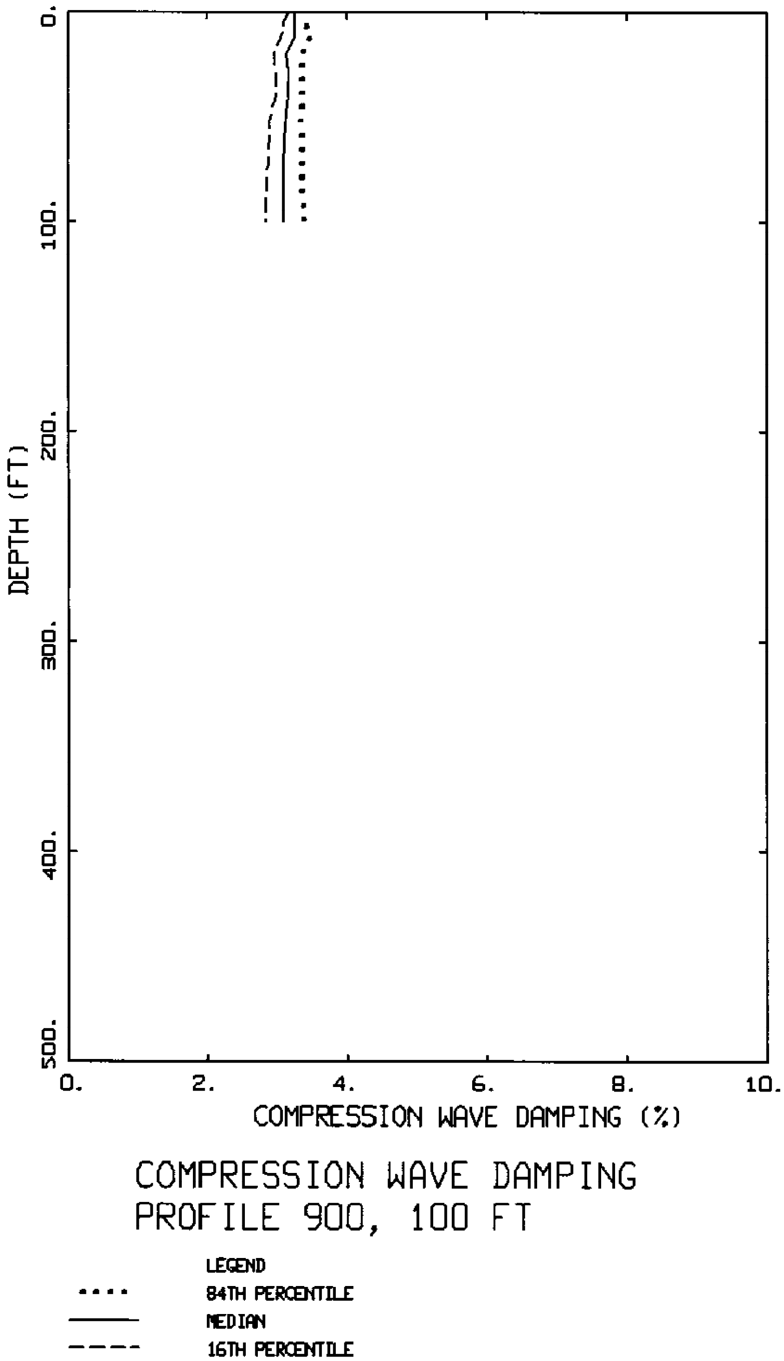


Figure 5.2-13 Strain Compatible Properties Computed for Profile 900 100 ft Depth to Bedrock (Sheet 4 of 4)

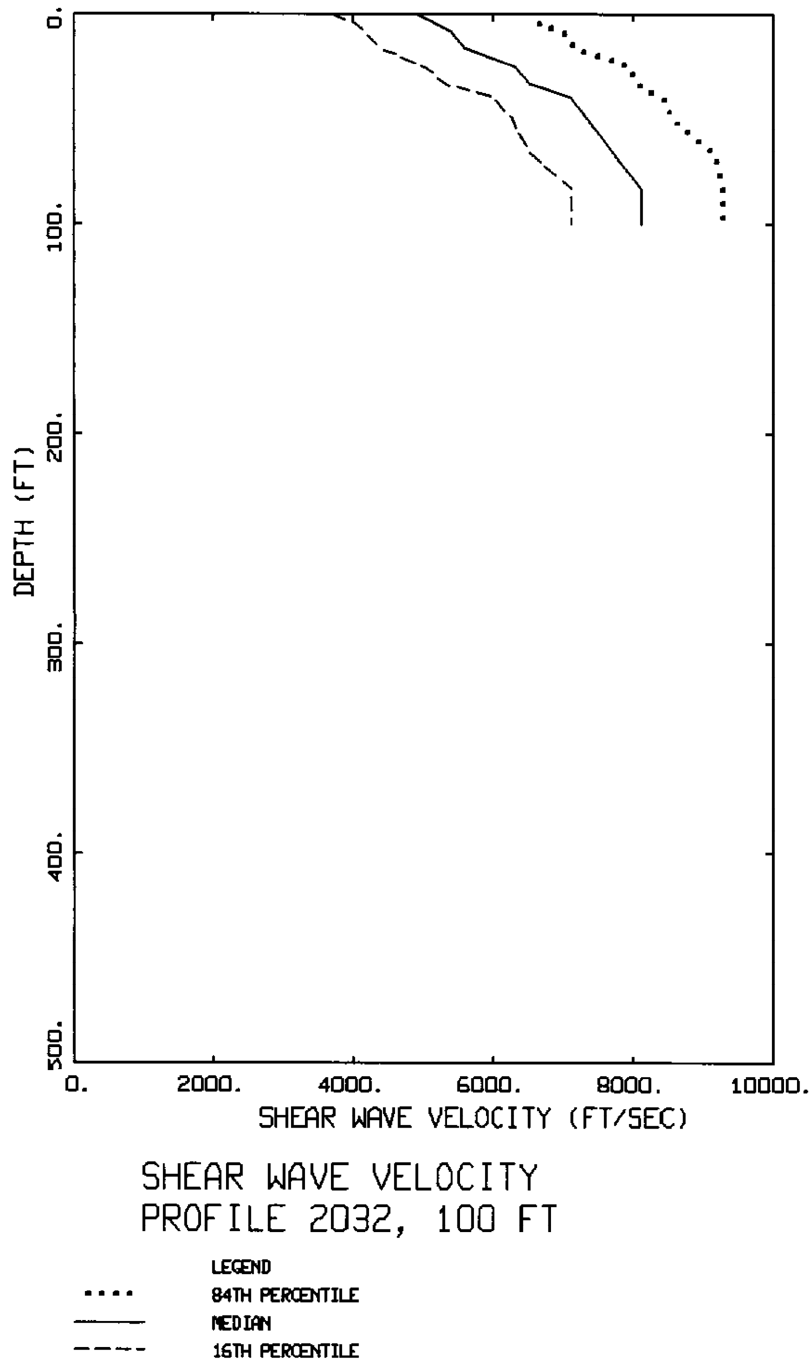


Figure 5.2-14 Strain Compatible Properties Computed for Profile 2032 100 ft Depth to Bedrock (Sheet 1 of 4)

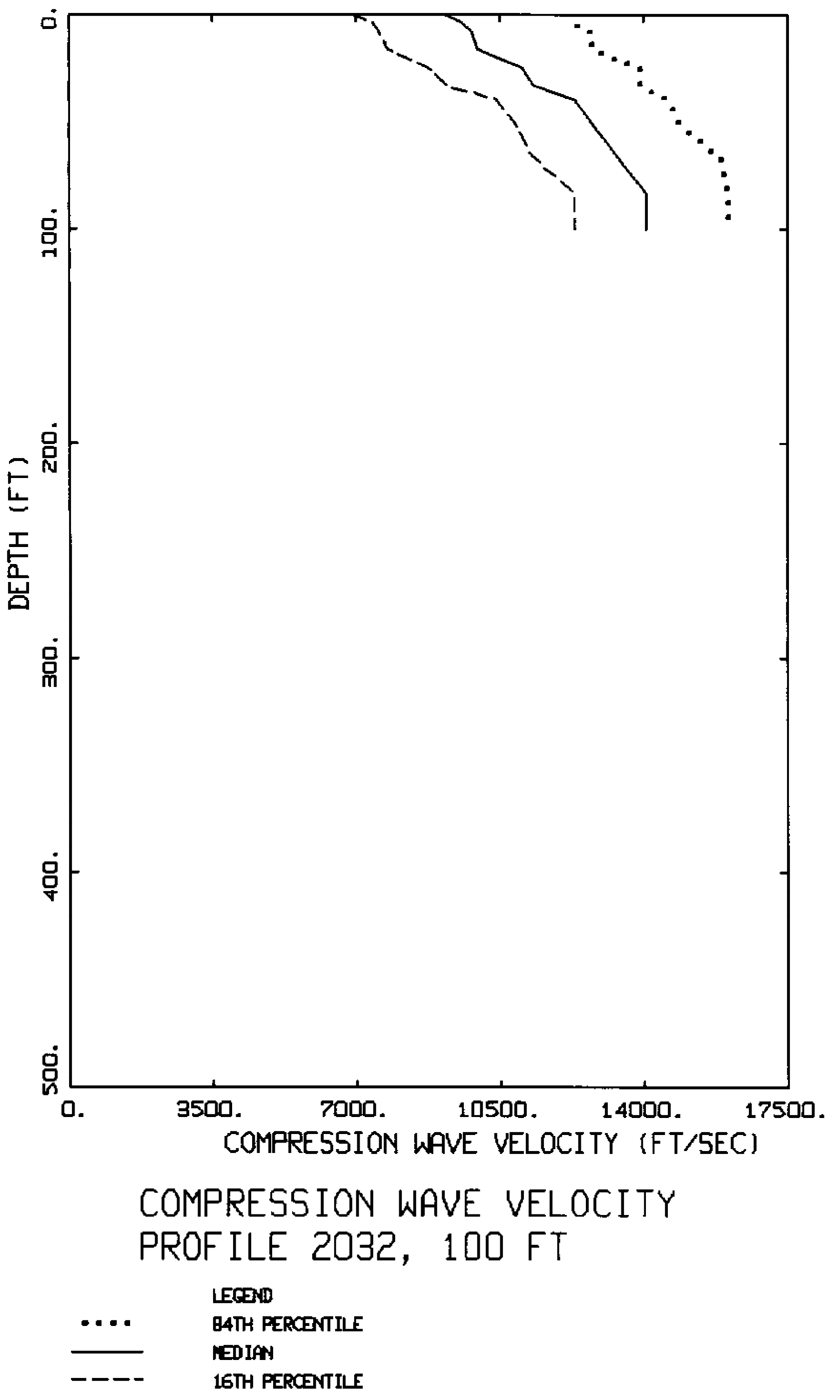


Figure 5.2-14 Strain Compatible Properties Computed for Profile 2032 100 ft Depth to Bedrock (Sheet 2 of 4)

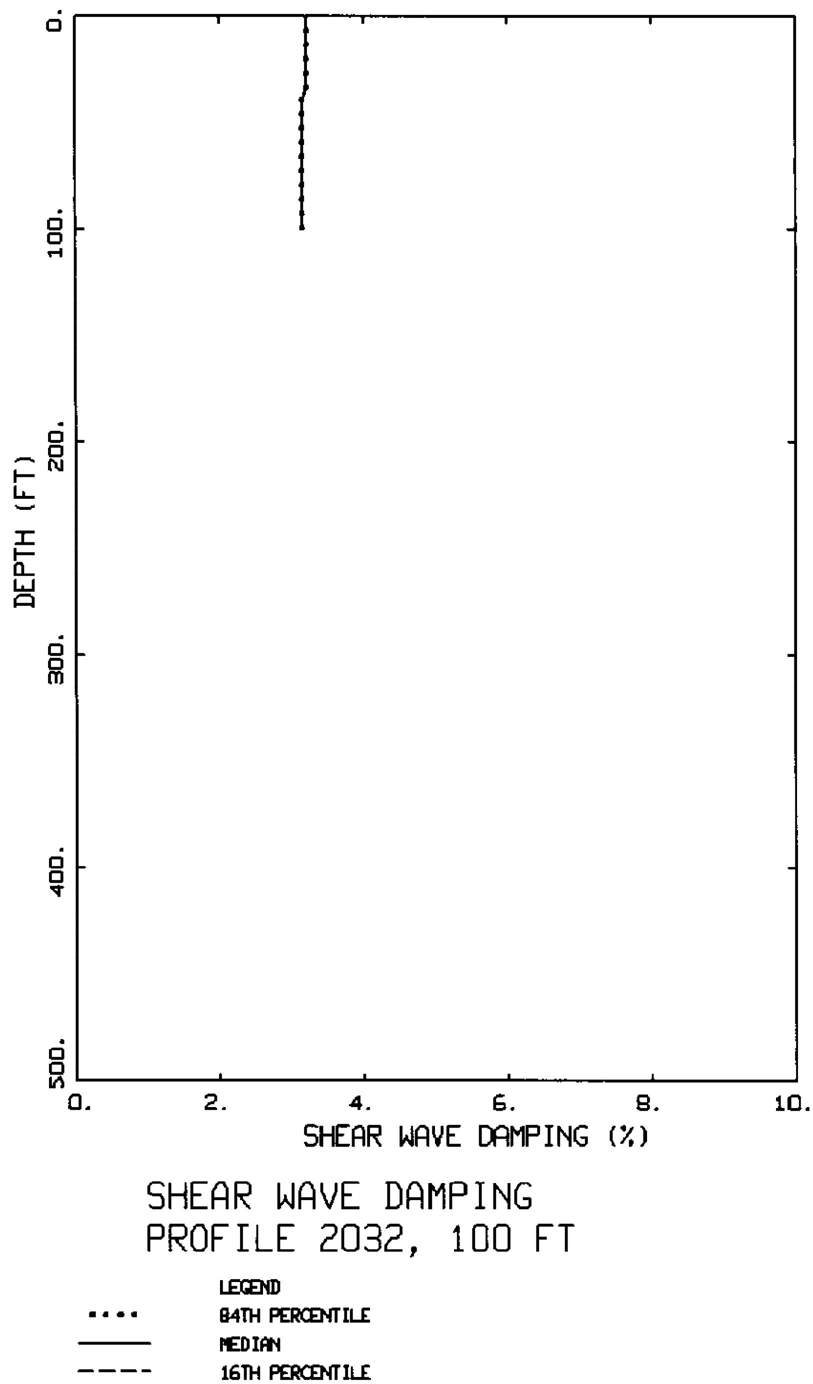


Figure 5.2-14 Strain Compatible Properties Computed for Profile 2032 100 ft Depth to Bedrock (Sheet 3 of 4)

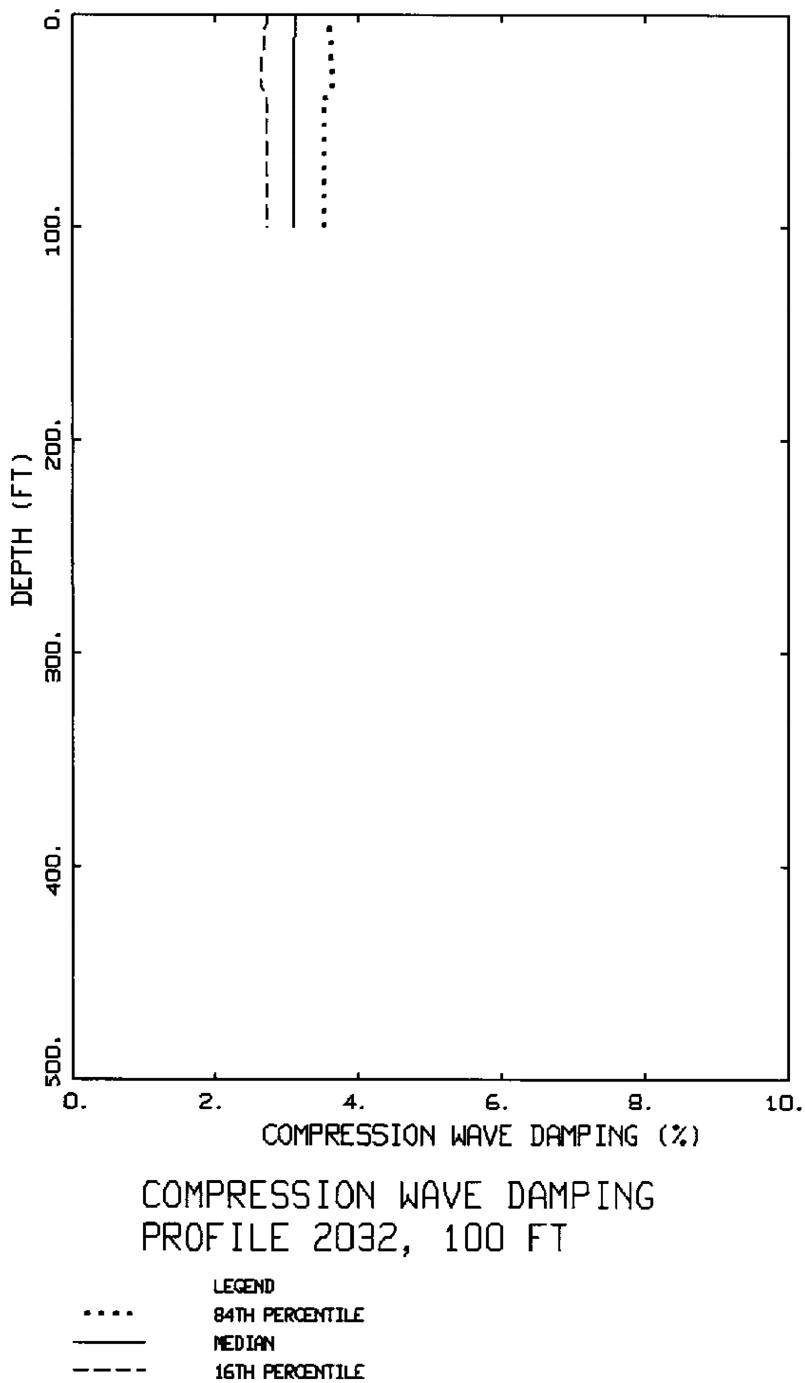


Figure 5.2-14 Strain Compatible Properties Computed for Profile 2032 100 ft Depth to Bedrock (Sheet 4 of 4)

5.3 Enhanced ACS SASSI Lumped-Mass-Stick Model of R/B Complex

5.3.1 R/B Complex Lumped-Mass-Stick Model

The US-APWR R/B complex consists of the R/B and FH/A, PCCV, CIS supported on a common reinforced concrete basemat. The lumped mass stick model of the R/B complex represents the dynamic characteristics (stiffness and mass inertia properties) of the R/B complex's structures.

Figure 5.3.1-1 and 5.3.1-2 presents the enhanced lumped mass stick model of the R/B complex.

5.3.1.1 SDOF Elements

The lumped mass stick model of the R/B complex is refined by including SDOF mass/spring elements to account for the flexibility of the slabs and walls within the R/B. A FE model identifies those slabs and walls that have a fundamental frequency less than 40 Hz along with their location, frequency, and effective mass, as shown in Tables 5.3.1-1 through 5.3.1-3. An equivalent spring constant is computed for each SDOF. The SDOF's location, mass, and equivalent spring constant are then connected with rigid beams to the lumped mass stick model.

Table 5.3.1-1 lists the 105 slabs that have frequencies below 40 Hz and their associated lumped mass node. Overall, the slab SDOF elements account for 27,731 kips.

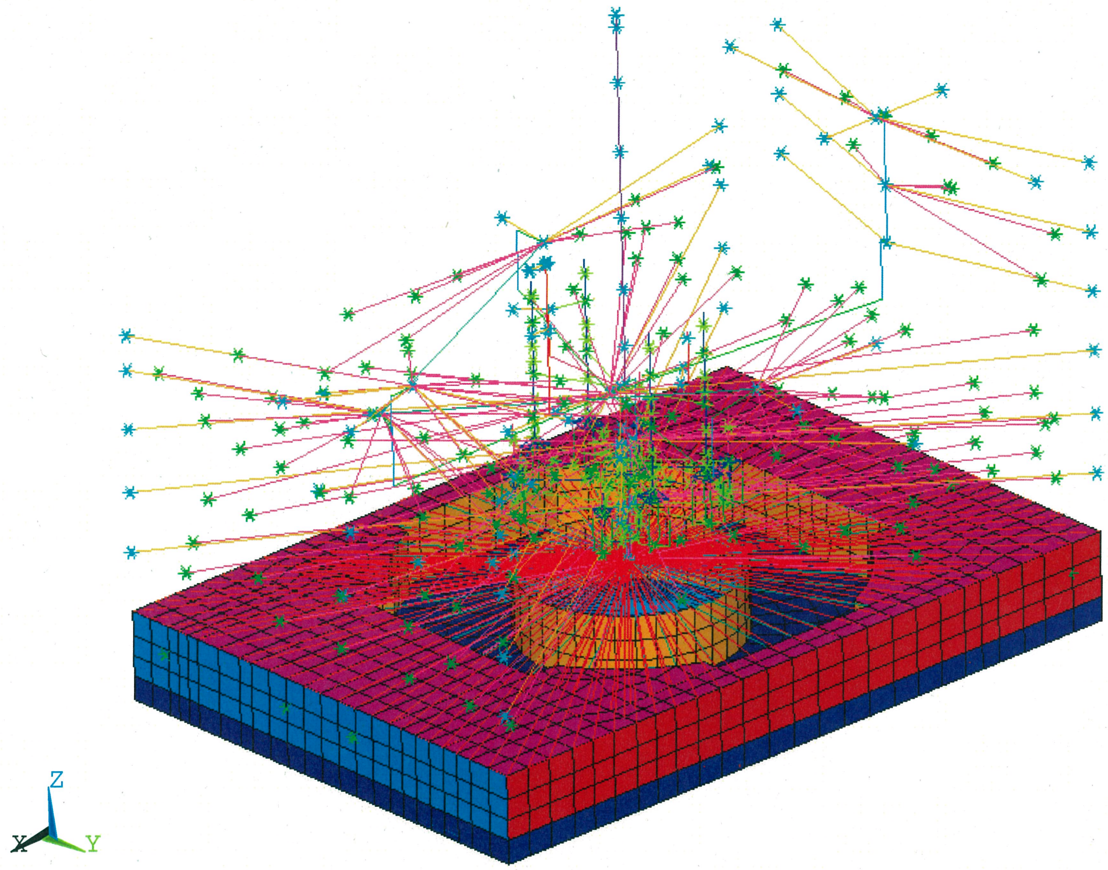


Figure 5.3.1-1 Enhanced Lumped-Mass-Stick Model of the R/B Complex

Table 5.3.1-1 Slab SDOF Properties (Cracked Concrete)
(Sheet 1 of 4)

Floor Mass ID	Slab ID#	x (ft)	y (ft)	z (ft)	Frequency (Hz)	Weight (Kips)	Spring Constant (kip/ft)
FH08	115_10a	-120.48	80.75	154.50	9.6	393	4.461E+04
	115_10b	-120.48	-39.42	154.50	9.7	537	6.211E+04
	115_10c	-120.48	-4.13	154.50	10.7	504	7.054E+04
	115_10d	-120.48	45.25	154.50	11.4	379	6.048E+04
	115_10e	-120.48	18.46	153.88	12.1	355	6.343E+04
	Full Floor Weight: 6250 kips			Total SDOF Weight:		2167 kips	35% of Total
RE05	115_30	94.67	70.50	122.33	13.3	224	4.818E+04
	115_30a	79.00	88.33	122.33	14.5	131	3.399E+04
	115_30b	82.35	54.42	122.33	14.5	131	3.399E+04
	115_30c	111.33	70.50	122.33	14.5	131	3.399E+04
	115_31	143.50	65.92	115.50	21.9	350	2.061E+05
	115_32	143.50	99.00	115.50	21.9	175	1.030E+05
	115_33a	94.67	19.42	115.50	17.8	678	2.620E+05
	115_33b	94.67	-19.42	115.50	17.8	678	2.620E+05
	115_33c	143.50	14.00	115.50	14.6	145	3.787E+04
	115_33d	143.50	-14.00	115.50	14.6	145	3.787E+04
	115_40	143.50	-62.71	115.50	21.8	497	2.891E+05
	Full Floor Weight: 19200 kips			Total SDOF Weight:		3286 kips	17% of Total
RE41	101_10a	-120.79	-80.17	101.00	13.4	140	3.076E+04
	101_10b	-79.00	-80.17	101.00	17.3	105	3.837E+04
	101_11	-43.17	-72.38	101.00	28.4	85	8.420E+04
	101_12b	-77.08	-53.75	101.00	39.9	74	1.452E+05
	101_40	39.00	-76.83	101.00	32.6	78	1.015E+05
	101_41a	68.33	-83.25	101.00	23.1	140	9.175E+04
	101_41b	68.33	-50.17	101.00	30.0	185	2.048E+05
	101_43a	110.50	-50.17	101.00	35.4	131	2.020E+05
	Full Floor Weight: 9450 kips			Total SDOF Weight:		939 kips	10% of Total

Table 5.3.1-1 Slab SDOF Properties (Cracked Concrete)
(Sheet 2 of 4)

Floor Mass ID	Slab ID#	x (ft)	y (ft)	z (ft)	Frequency (Hz)	Weight (Kips)	Spring Constant (kip/ft)
RE42	101_21	-57.79	40.54	112.00	10.0	308	3.748E+04
	101_22	-70.08	57.63	112.00	27.0	58	5.216E+04
	101_23	-56.58	79.63	112.00	12.8	291	5.818E+04
	101_23a	-56.58	79.63	112.00	27.0	58	5.216E+04
	101_24a	-56.58	99.08	112.00	29.1	23	2.439E+04
	Full Floor Weight: 7590 kips			Total SDOF Weight:		739 kips	10% of Total
RE04	101_30	42.50	73.75	101.00	34.2	123	1.765E+05
	101_30a	42.50	73.75	101.00	38.2	79	1.413E+05
	101_33a	110.50	81.58	101.00	30.3	136	1.523E+05
	Full Floor Weight: 16600 kips			Total SDOF Weight:		337 kips	2% of Total
RE03	86_14	-74.83	-81.08	88.42	29.1	123	1.276E+05
	86_16	-77.08	-54.67	85.25	33.4	131	1.795E+05
	86_17b	-82.21	-26.71	86.92	18.7	33	1.421E+04
	76_10a	-43.17	-76.83	76.50	31.8	139	1.722E+05
	76_10b	-78.83	-80.42	76.50	29.3	171	1.804E+05
	76_10c	-78.83	-54.00	76.50	34.9	207	3.092E+05
	76_11a	-100.42	-98.58	76.50	37.4	148	2.538E+05
	76_13	-81.83	1.67	76.50	27.9	64	6.119E+04
	76_20a	-58.33	76.71	76.50	37.6	337	5.830E+05
	76_21g	-142.63	76.71	76.50	27.0	209	1.858E+05
	76_30a	52.00	65.83	76.50	33.0	245	3.271E+05
	76_30a	52.00	65.83	76.50	37.4	148	2.538E+05
	76_30a	52.00	65.83	76.50	38.1	199	3.549E+05
	76_31b	87.67	19.42	76.50	39.8	229	4.449E+05
	76_33a	110.50	62.75	76.50	33.7	311	4.331E+05
	76_33b	143.50	62.75	76.50	17.8	1,622	6.287E+05
	76_40a	52.00	-65.50	76.50	31.7	161	1.979E+05
	76_41c	87.67	-19.42	76.50	39.8	244	4.744E+05
	76_43a	110.50	-62.71	76.50	28.8	320	3.260E+05
	76_43b	143.50	-62.71	76.50	18.0	1,570	6.202E+05
	Full Floor Weight: 67700 kips			Total SDOF Weight:		6611 kips	10% of Total

Table 5.3.1-1 Slab SDOF Properties (Cracked Concrete)
(Sheet 3 of 4)

Floor Mass ID	Slab ID#	x (ft)	y (ft)	z (ft)	Frequency (Hz)	Weight (Kips)	Spring Constant (kip/ft)
RE02	50_10b	-78.83	-65.75	50.17	37.8	589	1.031E+06
	50_20b	-78.83	75.88	50.17	29.1	208	2.165E+05
	50_21b	-132.42	98.58	50.17	22.3	74	4.520E+04
	50_21c	-142.88	75.88	50.17	22.3	74	4.520E+04
	50_21d	-116.88	75.88	50.17	22.3	74	4.520E+04
	50_21e	-132.42	52.88	50.17	22.3	74	4.520E+04
	50_22a	-87.46	20.83	50.17	32.0	175	2.202E+05
	50_30a	42.50	77.00	50.17	35.8	164	2.576E+05
	50_30b	71.83	82.67	50.17	34.8	128	1.897E+05
	50_32c	110.50	56.00	50.17	22.4	102	6.293E+04
	50_33d	143.50	59.88	50.17	26.4	167	1.429E+05
	50_34	127.00	19.42	50.17	22.4	920	5.664E+05
	50_40b	71.83	-81.08	50.17	34.0	106	1.501E+05
	50_42e	110.50	-54.42	50.17	22.4	102	6.293E+04
	50_43d	143.50	-58.29	50.17	26.3	161	1.369E+05
	50_44	127.00	-19.42	50.17	22.4	920	5.664E+05
	35_26	0.00	100.08	40.67	39.5	68	1.302E+05
	Full Floor Weight: 72400 kips			Total SDOF Weight:		4105 kips	6% of Total
RE01	25_20a	-121.50	29.73	25.25	27.4	307	2.830E+05
	25_20b	-132.42	52.88	25.25	21.8	85	4.947E+04
	25_20c	-104.92	59.67	25.25	39.1	314	5.891E+05
	25_20d	-142.88	75.88	25.25	21.8	85	4.947E+04
	25_20e	-119.71	75.88	25.25	21.8	85	4.947E+04
	25_20f	-132.42	98.58	25.25	21.8	85	4.947E+04
	25_22e	-78.83	75.88	25.25	36.9	143	2.388E+05
	25_23	-43.17	75.88	25.25	32.3	228	2.927E+05
	25_30b	42.50	77.00	25.25	33.0	210	2.814E+05
	25_33b	116.50	56.00	25.25	35.3	221	3.365E+05
	25_33d	143.50	56.00	25.25	21.0	485	2.613E+05
	25_34b	133.00	19.42	25.25	17.9	594	2.324E+05
	25_42d	139.50	-95.79	25.25	34.6	112	1.645E+05

Table 5.3.1-1 Slab SDOF Properties (Cracked Concrete)
(Sheet 4 of 4)

Floor Mass ID	Slab ID#	x (ft)	y (ft)	z (ft)	Frequency (Hz)	Weight (Kips)	Spring Constant (kip/ft)
	25_43d	143.50	-54.42	25.25	20.9	196	1.056E+05
	25_44b	133.00	-19.42	25.25	17.9	594	2.324E+05
	13_17	-127.04	-54.25	14.33	32.0	52	6.470E+04
	13_31	149.42	95.79	14.08	25.5	49	3.926E+04
	13_42	143.50	-95.79	14.08	21.3	72	4.025E+04
	Full Floor Weight: 68600 kips			Total SDOF Weight:		3918 kips	6% of Total
RE00	3_32a	133.00	54.42	3.58	27.4	1,593	1.461E+06
	3_32b	133.00	19.42	3.58	20.2	554	2.785E+05
	3_32c	133.00	-19.42	3.58	20.2	554	2.785E+05
	3_32d	133.00	-54.42	3.58	27.1	343	3.088E+05
	3_10a	-78.83	-75.88	3.58	30.4	314	3.547E+05
	3_20a	-78.83	76.88	3.58	29.3	315	3.323E+05
	3_15c	-127.92	-41.25	3.58	36.5	247	4.033E+05
	3_15d	-127.92	-23.29	3.58	36.5	247	4.033E+05
	3_15	-131.54	39.04	3.58	38.0	327	5.773E+05
	Full Floor Weight: 117000 kips			Total SDOF Weight:		4492 kips	4% of total
R/B Superstructure Weight: 393990 kips				Total SDOF Weight:		26593 kips	7% of total
BS01	n8_10a	-84.33	-70.83	-8.58	38.1	148	2.627E+05
	n8_11c	-100.42	-95.79	-8.58	33.2	76	1.027E+05
	n8_13	-127.04	-74.04	-8.58	29.4	121	1.281E+05
	n8_14b	-127.04	-40.42	-8.58	30.5	140	1.601E+05
	n8_16	-127.04	7.25	-8.58	33.9	111	1.568E+05
	n8_21c	-104.92	67.50	-8.58	30.0	113	1.249E+05
	n8_22a	-84.33	64.58	-8.58	39.2	129	2.424E+05
	n8_30a	84.67	64.58	-8.58	38.8	149	2.748E+05
	n8_40a	84.67	-70.83	-8.58	38.8	151	2.788E+05
	Full Floor Weight: 187000 kips			Total SDOF Weight:		1138 kips	1% of Total

Tables 5.3.1-2 and 5.3.1-3 list the 37 walls that have frequencies below 40 Hz (18 in the X direction and 19 in the Y), and their associated lumped mass properties. Overall, the wall SDOF elements account for 19,740 kips, or 5% of the reactor building's mass.

Table 5.3.1-2 Wall SDOF-X Properties

Floor Mass ID	Slab ID#	x (ft)	y (ft)	z (ft)	Frequency (Hz)	Weight (Kips)	Spring Constant (kip/ft)
FH07	W_N_1	-152.17	21.06	114.31	10.00	988	1.216E+05
	W_N_1	-152.17	-35.69	114.31	10.40	735	9.758E+04
	W_N_1	-152.17	79.81	114.31	10.70	359	5.033E+04
	W_N_1	-152.17	18.46	114.31	11.40	355	5.646E+04
RE04	W_S_3	161.67	-19.42	88.58	24.90	335	2.549E+05
	W_S_4	161.67	19.42	88.58	24.90	335	2.549E+05
	W_S_5	161.67	-61.88	94.29	12.80	984	1.980E+05
	W_S_6	161.67	61.88	94.29	13.00	1,004	2.078E+05
	W_P1n	127.00	61.88	92.63	26.10	714	5.971E+05
	W_P2n	127.00	-61.88	92.63	31.90	923	1.150E+06
RE03	W_S_9	161.67	-61.88	61.63	38.30	150	2.691E+05
	W_S_10	161.67	61.88	61.63	38.50	82	1.480E+05
RE02	W_N_3	-147.25	76.71	36.04	37.40	164	2.819E+05
	W_N_2	-147.25	-41.04	49.17	33.10	2,178	2.933E+06
RE00	W_S_21	161.67	-19.42	-11.38	37.20	192	3.251E+05
	W_S_22	161.67	19.42	-11.38	37.20	192	3.251E+05
	W_S_25	161.67	-88.33	-11.38	36.60	305	4.999E+05
	W_S_26	161.67	18.33	-11.38	36.60	305	4.999E+05
	Full Model Weight: 393990 kips			Total SDOF Weight:		10298 kips	3% of Total

Table 5.3.1-3 Wall SDOF-Y Properties

Floor Mass ID	Slab ID#	x (ft)	y (ft)	z (ft)	Frequency (Hz)	Weight (Kips)	Spring Constant (kip/ft)
FH07	W_E_1	-120.48	106.67	114.31	7.20	1,208	7.776E+04
RE42	W_E_2	-37.83	106.67	92.54	15.70	224	6.735E+04
	W_E_3	18.50	106.67	87.04	31.40	192	2.328E+05
RE41	W_W_2	-9.50	-106.67	83.96	23.00	140	9.079E+04
RE04	W_E_7	144.33	106.67	94.29	25.60	319	2.555E+05
	W_W_1	145.08	-106.67	94.29	34.60	314	4.596E+05
	W_P1e	144.33	84.92	92.63	15.40	965	2.794E+05
	W_P1w	144.33	38.83	92.63	15.40	965	2.794E+05
	W_P2e	144.33	-38.83	92.63	15.10	958	2.690E+05
	W_P2w	144.33	-84.92	92.63	15.10	958	2.690E+05
RE03	W_E_4	-44.40	106.67	61.63	31.40	192	2.328E+05
	W_E_4	-44.40	106.67	61.63	36.30	195	3.153E+05
	W_E_5	41.92	106.67	61.63	31.40	192	2.328E+05
	W_W_5	38.96	-106.67	61.63	28.80	195	1.986E+05
	W_W_6	-47.83	-106.67	61.63	28.80	195	1.986E+05
RE02	W_W_8	-65.17	-106.67	36.04	37.20	413	7.000E+05
	W_E_6	-44.40	106.67	36.04	36.30	195	3.153E+05
	W_P3e	-128.08	-13.92	47.53	22.70	1,584	9.990E+05
RE00	W_E_8	-131.54	106.67	-11.38	38.60	254	4.631E+05
	Full Model Weight: 393990 kips			Total SDOF Weight:		9658 kips	2% of Total

5.3.1.2 Lumped Mass Stick Model Properties

Figure 5.3.1-2 presents the lumped mass stick models of the R/B, PCCV, and the CIS developed following the methodology specified in DCD Subsection 3.7.2.3.2. The lumped mass models are developed on the basis of the building structural configuration and represent the centers of mass and the centers of rigidity. The complete model shown in Figure 5.3.1-1 is validated by comparing its dynamic characteristics with those obtained from detailed FE models of the R/B Complex structures. Tables 5.3.1-4 through 5.3.1-9 present the values of the lumped masses and the element properties of the connecting story stiffnesses such as the cross sectional areas, shear areas and moment of inertia. Additionally, Table 5.3.2-1 presents the material properties used to develop the story stiffnesses and the material damping of the structural elements. As shown in Figure 5.3.1-2 (sheets 1 of 2), the stiffness of the CIS below the operating floor at elevation 76'-5"is represented by a single stick element. Above this elevation, the CIS stiffness is represented by three stick elements located at the pressurizer, and the SG compartments. At the elevation of the pressurizer lower support, the internal structure's common floor is represented by spring elements connecting nodes IC07 and IC05. Table 5.3.1-10 presents the stiffness of these spring elements. Similarly, the R/B nodes RE41, RE42 and RE04 are connected by rigid beams representing the floor at elevation 101'-0". Figure 5.3.1-2 (Sheet 2 of 2) illustrates this configuration and Table 5.3.1-10 presents the spring connections and damping values.

Table 5.3.1-4 PCCV Model - Lumped Mass Inertia

Node	Description	Location			Lumped Mass & Inertia			
		X (ft)	Y (ft)	Z (ft)	Weight ($x10^3$ kip)	Jyy ($x10^6$ kip-ft^2)	Jxx ($x10^6$ kip-ft^2)	Jzz ($x10^6$ kip-ft^2)
CV11	Top of dome	0.00	0.00	230.17	0.887	0.0520	0.0520	0.101
CV10	7ft under dome top	0.00	0.00	225.00	4.1	2.88	2.88	5.63
CV09	El. At dome angle 40 deg.	0.00	0.00	201.67	7.81	14.5	14.5	28.2
CV08	El. At dome angle 15 deg.	0.00	0.00	173.08	8.49	23.4	23.4	45.8
CV07	Top of polar crane rail	0.00	0.00	145.58	11.9	35.6	35.6	70.1
CV06	Roof of MS/FW room	0.00	0.00	115.50	9.06	27.2	27.2	53.4
CV05	MS penetration	0.00	0.00	92.17	7.53	22.4	22.4	44.4
CV04	Operation floor level	0.00	0.00	76.42	4.64	13.8	13.8	27.4
CV03	FW penetration	0.00	0.00	68.25	4.43	13.1	13.1	26.1
CV02	R/B 3rd floor level	0.00	0.00	50.17	7.27	21.7	21.7	42.8
CV01	R/B 2nd floor level	0.00	0.00	25.25	8.23	24.7	24.7	48.5

subtotal:74.36 $\times 10^3$ kip

Table 5.3.1-5 CIS Model - Lumped Mass Inertia

Node	Description	Location			Lumped Mass & Inertia			
		X (ft)	Y (ft)	Z (ft)	Weight ($x10^3$ kip)	Jyy ($x10^6$ kip-1ft^2)	Jxx ($x10^6$ kip-ft^2)	Jzz ($x10^6$ kip-ft^2)
IC09	Upper level of P/R room	39.38	-0.03	139.50	0.716	0.0306	0.0553	0.0792
IC08	Change in P/R room wall thickness	39.64	0.02	112.33	2.08	0.163	0.235	0.230
IC18	P/R support	39.64	0.02	110.75	0.342	0.0133	0.0251	0.038
IC07	P/R room operation floor	36.25	0.12	76.42	1.07	0.0518	0.0889	0.118
IC71		8.11	-43.98	112.00	0.817	0.192	0.0622	0.253
IC72		7.29	44.03	112.00	1.04	0.243	0.0792	0.322
IC61	Top of SG wall	3.94	-37.73	96.58	2.16	0.510	0.168	0.671
IC62	Top of SG wall	3.88	37.65	96.58	2.2	0.518	0.171	0.681
IC05	Operation floor level	3.36	0.74	76.42	15.1	13.0	13.0	25.8
IC15	SG support level	3.36	0.74	59.17	0.22	0.178	0.178	0.355
IC04	R/B 3rd floor level	1.92	-0.61	50.17	14.9	12.1	12.1	24.0
IC14	SG support level	1.92	-0.61	45.67	0.353	0.284	0.284	0.568
IC03	Reactor vessel support	-2.28	0.13	35.88	8.84	5.97	5.97	11.9
IC02	R/B 2nd floor level	-2.02	0.23	25.25	17.4	23.0	23.0	45.8
IC01	Pressure header room	1.22	0.05	16.00	18.5	24.4	24.4	48.6

subtotal:85.70 $\times 10^3$ kip

Table 5.3.1-6 Mass of Stick Model for Buildings R/B and Basemat

(Sheet 1 of 2)

Node	Description	Location			Lumped Mass & Inertia			
		X (ft)	Y (ft)	Z (ft)	Weight ($x10^3$ kip)	Jyy ($x10^6$ kip-ft^2)	Jxx ($x10^6$ kip-ft^2)	Jzz ($x10^6$ kip-ft^2)
FH08	FH/A roof	-120.1	18.37	154.5	4.1	2.1	12.7	18.6
FH07	Top of FH/A crane rail	-120.1	18.37	125.67	4.5	1.2	11.8	9.1
FH06	Center building roof	-120.7	14.13	101	4.7	1.6	12.4	14.0
RE41	R/B 5th floor west roof	-28.58	-92.73	101	8.4	37.4	1.1	46.5
RE42	R/B 5th floor east roof	33.592	86.54	101	6.9	18.0	0.7	21.5
RE05	MS/FW room roof	127.8	6.84	115.5	15.9	7.3	64.6	82.0
RE04	R/B 5th floor level (MS/FW room)	124.98	4.28	101	16.3	6.5	60.2	53.9
RE03	R/B 4th floor operation floor	-5.733	-1.01	76.42	61.1	457.5	230.7	796.2
RE02	R/B 3rd floor	-5.342	-4.09	50.17	68.4	524.0	265.3	825.1
RE01	R/B 2nd floor	-0.033	-2.09	25.25	64.7	485.7	248.0	806.2

Table 5.3.1-6 Mass of Stick Model for Buildings R/B and Basemat
(Sheet 2 of 2)

Node	Location			Lumped Mass Inertia			
	X (ft)	Y (ft)	Z (ft)	Weight ($x10^3$ kip)	Jyy ($x10^6$ kip-ft^2)	Jxx ($x10^6$ kip-ft^2)	Jzz ($x10^6$ kip-ft^2)
CV00	0.00	0.00	1.92	3.94	11.7	11.7	23.2
RE00	1.24	-0.25	3.58	117	931	447	1375
IC00	1.22	0.05	1.92	21.8	28.9	28.9	57.5
BS01	2.43	0.75	-26.08	187	1500	722	2201
BB01	0.00	0.00	-36.25	-	-	-	-

subtotal:329.7 ×106lb

Total Weight:766.76 ×106lb

Table 5.3.1-7 PCCV Model – Stick Elements

Symbol	Height (ft)	Bottom Elevation (ft)	Eccentricity		Cross Sectional Properties						Shear Center (ft)	
			X (ft)	Y (ft)	Az (ft^2)	Ax (ft^2)	Ay (ft^2)	Iyy (ft^4)	Ixx (ft^4)	Izz (ft^4)	x_s NS	y_s EW
CV11	5.17	225.00	0.00	0.00	10.21	881.9	881.9	3.45E+05	3.45E+05	6.90E+05	0	0
CV10	23.33	201.67	0.00	0.00	116.7	881.9	881.9	2.02E+06	2.02E+06	4.04E+06	0	0
CV09	28.58	173.08	0.00	0.00	565.3	881.9	881.9	4.15E+06	4.15E+06	8.29E+06	0	0
CV08	27.50	145.58	0.00	0.00	2271	1000	1000	5.84E+06	5.84E+06	1.17E+07	0	0
CV07	30.08	115.50	0.00	0.00	2090	1042	1042	6.173E+06	6.173E+06	1.230E+07	0	0
CV06	23.33	92.17	0.00	0.00	2090	1042	1042	6.173E+06	6.173E+06	1.230E+07	0	0
CV05	15.75	76.42	0.00	0.00	2090	1042	1042	6.173E+06	6.173E+06	1.230E+07	0	0
CV04	8.17	68.25	0.00	0.00	2090	1042	1042	6.173E+06	6.173E+06	1.230E+07	0	0
CV03	18.08	50.17	0.00	0.00	2090	1042	1042	6.173E+06	6.173E+06	1.230E+07	0	0
CV02	24.92	25.25	0.00	0.00	2090	1042	1042	6.173E+06	6.173E+06	1.230E+07	0	0
CV01	23.33	1.92	0.00	0.00	2090	1042	1042	6.173E+06	6.173E+06	1.230E+07	0	0

Table 5.3.1-8 CIS Model – Stick Elements

Symbol	Height (ft)	Bottom Elevation (ft)	Eccentricity		Cross Sectional Properties						Shear Center (ft)	
			X (ft)	Y (ft)	Az (ft^2)	Ax (ft^2)	Ay (ft^2)	Iyy (ft^4)	Ixx (ft^4)	Izz (ft^4)	x_s NS	y_s EW
IC09	27.17	112.33	-39.29	0.00	285.4	82.6	143.1	2.069E+04	3.193E+04	3.347E+04	41.86	0.00
IC08	1.58	110.75	-39.24	0.00	379.2	97.2	152.1	2.532E+04	4.104E+04	3.627E+04	41.75	0.00
IC18	34.33	76.42	-39.24	0.00	379.2	97.2	152.1	2.532E+04	4.104E+04	3.627E+04	41.75	0.00
IC71			3.31	-40.33	370.8	133.3	118.8	2.397E+04	1.206E+04	1.268E+04	4.00	-39.44
IC72			3.31	40.33	370.8	133.3	118.8	2.397E+04	1.206E+04	1.268E+04	4.00	39.44
IC61	20.17	76.42	3.30	-39.79	770.8	361.1	191.7	5.401E+04	2.725E+04	1.673E+05	3.33	-36.52
IC62	20.17	76.42	3.30	39.79	770.8	361.1	191.7	5.401E+04	2.725E+04	1.673E+05	3.33	36.52
IC05	17.25	59.17	-0.61	-0.04	3035	1521	993.1	1.664E+06	1.307E+06	3.525E+06	-1.30	-0.23
IC15	9.00	50.17	-0.61	-0.04	3035	1521	993.1	1.664E+06	1.307E+06	3.525E+06	-1.30	-0.23
IC04	4.50	45.67	0.04	-0.43	2931	1465	1076	1.707E+06	1.379E+06	3.472E+06	-1.48	-0.24
IC14	10.06	35.60	0.04	-0.43	2931	1465	1076	1.707E+06	1.379E+06	3.472E+06	-1.48	-0.24
IC03	10.35	25.25	0.65	-0.39	3833	1833	1729	1.987E+06	1.239E+06	3.115E+06	-1.59	-0.07
IC02	9.25	16.00	-2.38	-0.18	7917	5257	5021	3.390E+06	1.770E+06	8.247E+06	-1.28	0.00
IC01	14.08	1.92	-3.68	-0.08	10347	8542	8333	3.530E+06	3.516E+06	8.825E+06	-0.87	0.00

Table 5.3.1-9 R/B-FH/A Model – Stick Elements

Symbol	Height (ft)	Bottom Elevation (ft)	Eccentricity		Cross Sectional Properties					
			X (ft)	Y (ft)	Az (ft^2)	Ax (ft^2)	Ay (ft^2)	Iyy (10^3 ft^4)	Ixx (10^3 ft^4)	Izz (10^6 ft^4)
FH08	28.83	125.67	-120.08	18.37	1,330	423	706	141	1,830	2.4
FH07	24.67	101.00	-120.08	18.37	1,330	423	706	141	1,830	3.7
FH06	24.58	76.42	-120.73	14.13	1,331	423	658	141	1,506	3.7
RE41	24.58	76.42	-28.58	-92.73	1,375	826	333	2,826	38	2.9
RE42	24.58	76.42	33.59	86.54	1,063	567	370	757	46	0.5
RE05	14.50	101.00	127.80	6.84	2,667	1,417	1,111	878	2,874	9.0
RE04	24.58	76.42	124.98	4.28	3,063	1,479	1,507	892	3,014	10.0
RE03	26.25	50.17	-5.73	-1.01	9,514	4,875	5,132	21,412	14,853	103.7
RE02	24.92	25.25	-5.34	-4.09	10,417	5,521	5,410	23,148	13,503	109.5
RE01	21.67	3.58	-0.03	-2.09	10,833	5,619	5,757	22,184	14,130	113.8

Table 5.3.1-10 CIS and R/B Spring Elements

	Location	Sort		Spring Value	Damping Value
CIS	Area at Lower Pressurizer Support IC07-JC05 (1)	NS	Horizontal	Infinity	h=5%
			Rotational	6.75×10^{12} lb·in/rad	
		EW	Horizontal	Infinity	
			Rotational	1.09×10^{13} lb·in/rad	
		Vertical		Infinity	
		Torsional		Infinity	
R/B	Roof Area 1 (2) (RE42-RE04)	NS	Horizontal	Infinity	h=7%
		EW	Horizontal	Infinity	
	Roof Area 2 (2) (RE41-RE04)	NS	Horizontal	Infinity	
		EW	Horizontal	Infinity	

Notes:

1. JC05 is a subordinate point of IC05 and located at the same coordinate as IC07. JC05 and IC07 are connected by the rotational spring elements shown in the above table.

2. RE41, RE42, and RE04 are linked by rigid translational springs. No link elements are set between RE41, RE 42 and FH06. See Figure 5.3.1-4 for the overall configuration of the R/B-PCCV-CIS lumped mass stick model.