ATTACHMENT XIII

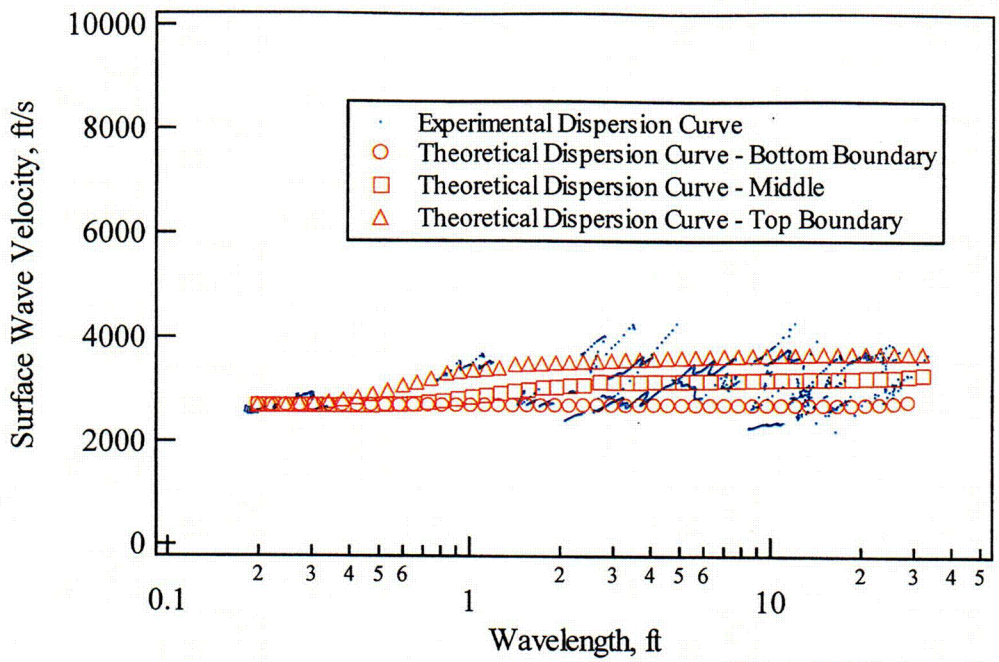
SASW VELOCITY PLOTS – ESF

ATTACHMENT XIII

SASW VELOCITY PLOTS – ESF

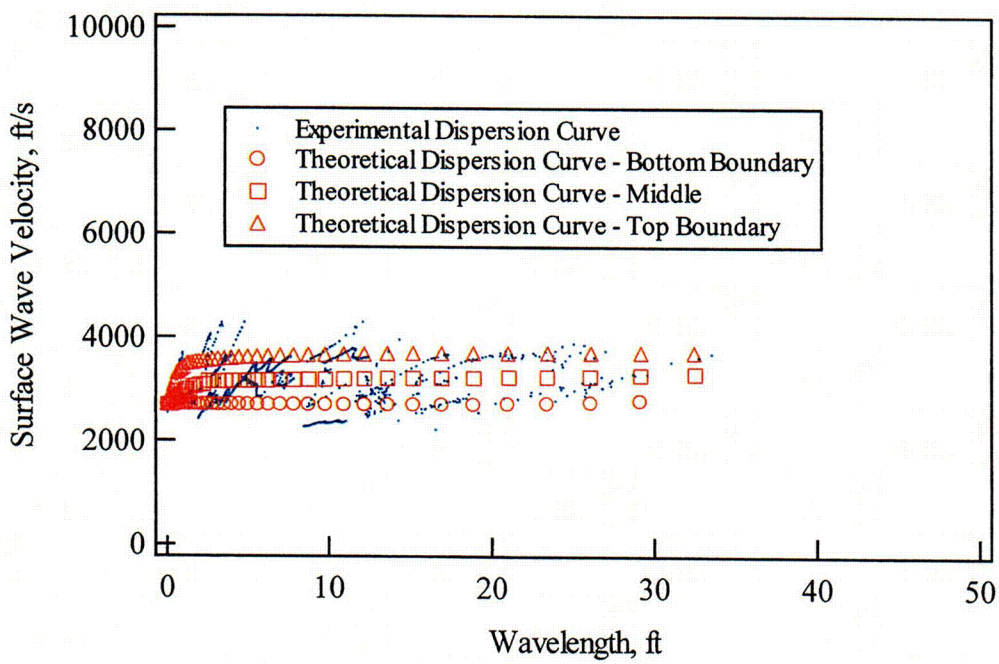
As discussed in Section 6.3.2, this attachment presents interpretive results of five SASW surveys performed in the Exploration Studies Facility (ESF). Each figure contains dispersion curves (both experimental and theoretical in linear and semi-log space) and the resulting shear-wave and compression-wave velocity profiles.

A detailed description of each analysis can be found in the associated appendix in scientific notebook SN-M&O-SCI-040-V1 (Wong 2002a).



(Wong, 2002e, Appendix 28)

a. SASW-T1 Dispersion Curves (Log Plot)

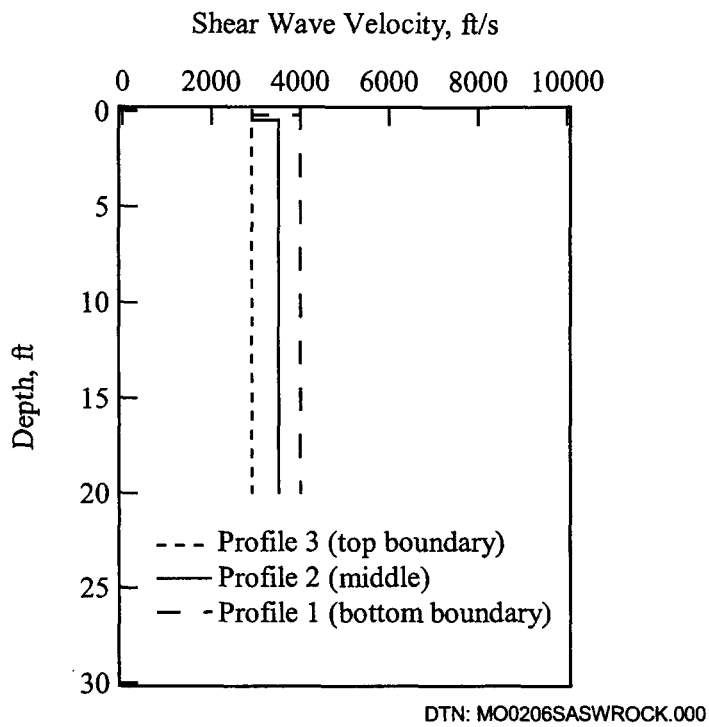


(Wong, 2002e, Appendix 28)

b. SASW-T1 Dispersion Curves (Linear Plot)

Figure XIII-1. SASW-T1 Results

C01



DTN: MO0206SASWROCK.000

c. SASW-T1 Shear Wave Velocity Profile

Location: SASW-T1 Profile 3

Layer No.	Thickness, ft	P-Wave Velocity, ft/s	S-Wave Velocity, ft/s	Poisson's Ratio*	Mass Density* pcf
1	20	5425	2900	0.25	145

Location: SASW-T1 Profile 2

Layer No.	Thickness, ft	P-Wave Velocity, ft/s	S-Wave Velocity, ft/s	Poisson's Ratio*	Mass Density* pcf
1	0.5	5425	2900	0.25	145
2	19.5	6548	3500	0.25	145

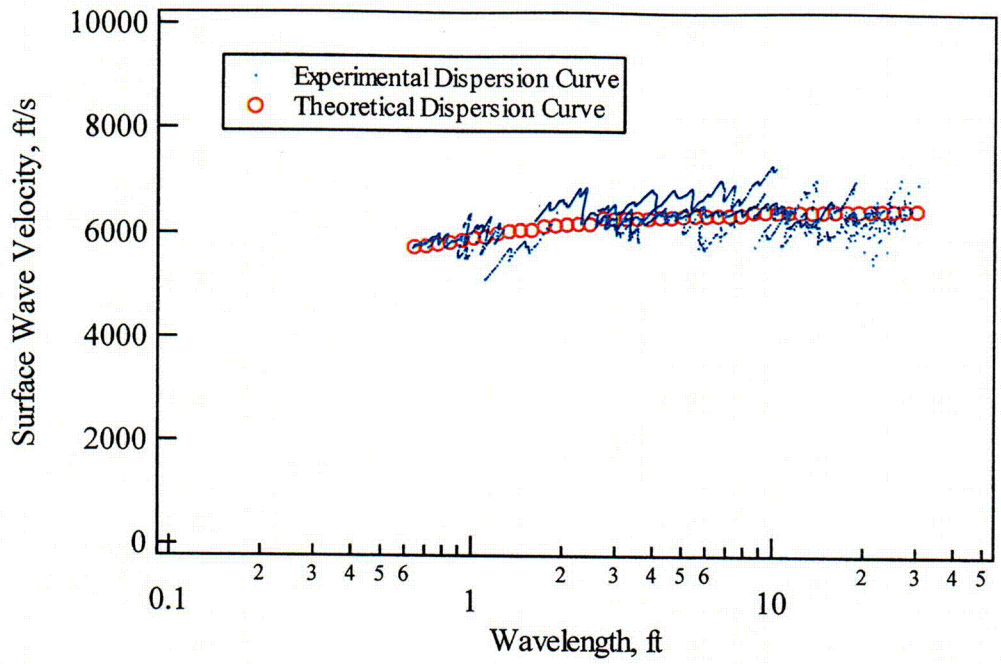
Location: SASW-T1 Profile 1

Layer No.	Thickness, ft	P-Wave Velocity, ft/s	S-Wave Velocity, ft/s	Poisson's Ratio*	Mass Density* pcf
1	0.3	5425	2900	0.25	145
2	19.7	7483	4000	0.25	145

DTN: MO0206SASWROCK.000

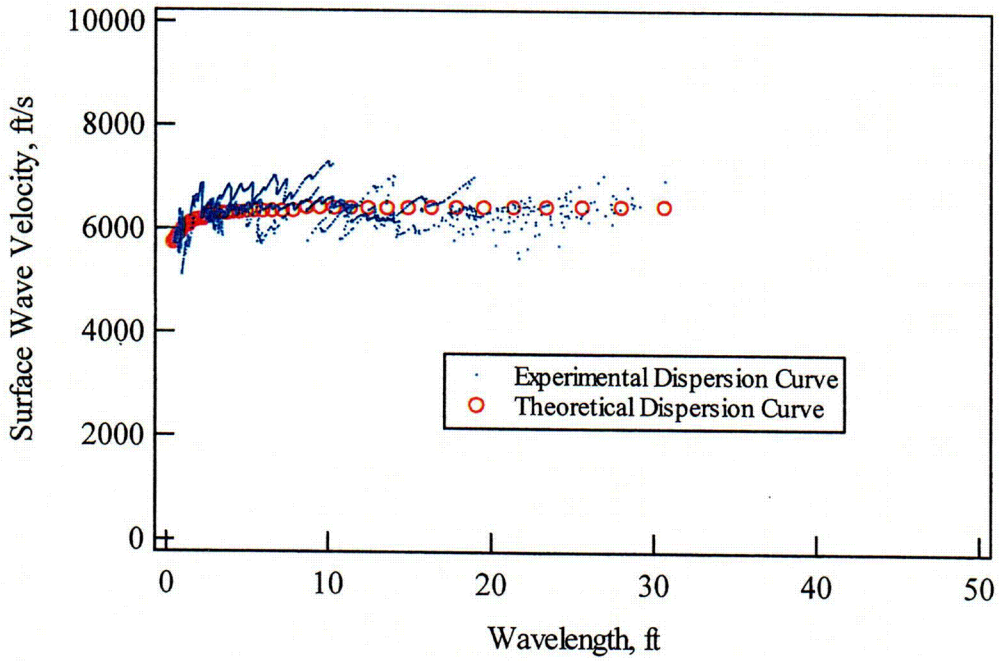
* Poisson's ratio and mass density from Wong (2002a, Appendix 28)

Figure XIII-1. SASW-T1 Results (continued)



(Wong, 2002e, Appendix 29)

a. SASW-T2 Dispersion Curves (Log Plot)

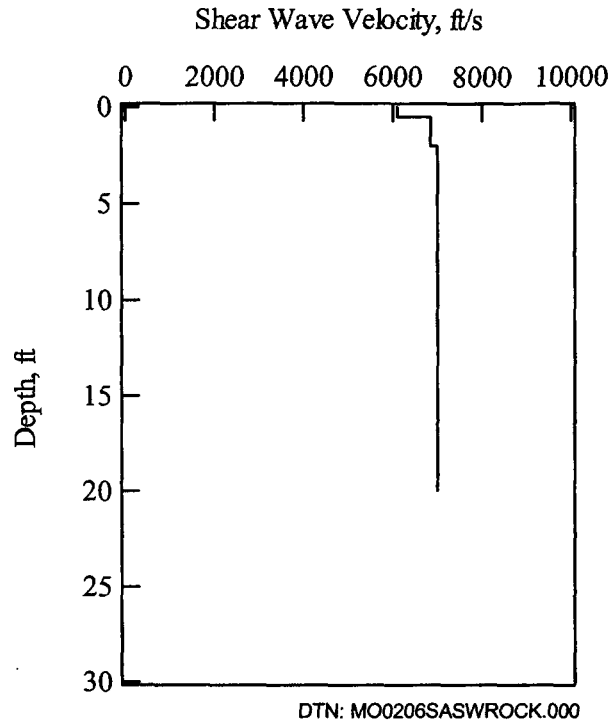


(Wong, 2002e, Appendix 29)

b. SASW-T2 Dispersion Curves (Linear Plot)

Figure XIII-2. SASW-T2 Results

C02



c. SASW-T2 Shear Wave Velocity Profile

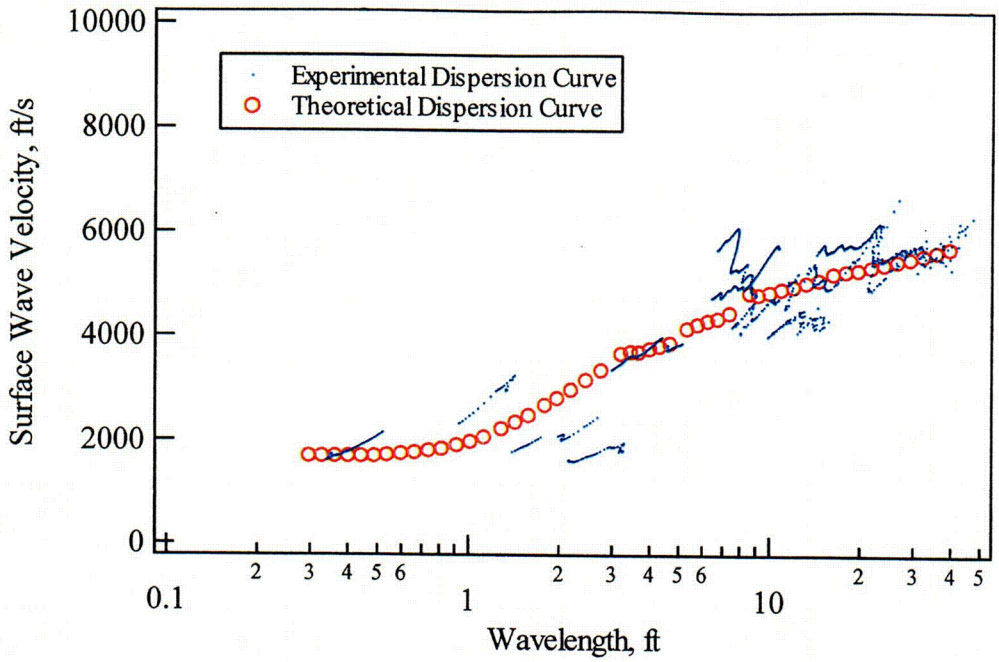
Location: SASW-T2

Layer No.	Thickness, ft	P-Wave Velocity, ft/s	S-Wave Velocity, ft/s	Poisson's Ratio*	Mass Density* pcf
1	0.5	11412	6100	0.25	145
2	1.5	12815	6850	0.25	145
3	18	13096	7000	0.25	145

DTN: MO0206SASWROCK.000

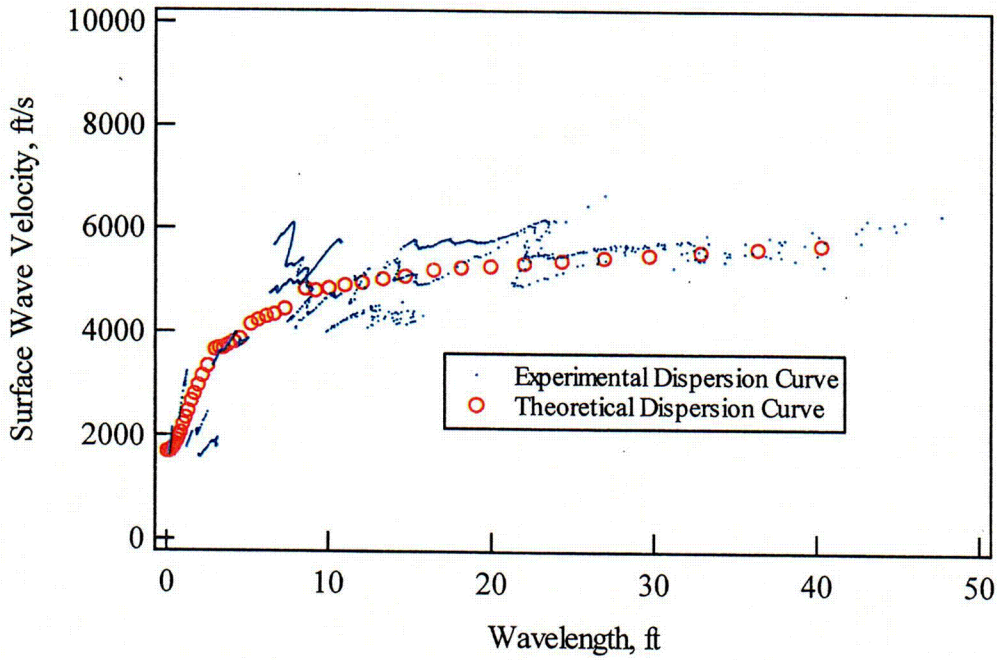
* Poisson's ratio and mass density from Wong (2002a, Appendix 29)

Figure XIII-2. SASW-T2 Results (continued)



(Wong, 2002e, Appendix 30)

a. SASW-T3 Dispersion Curves (Log Plot)

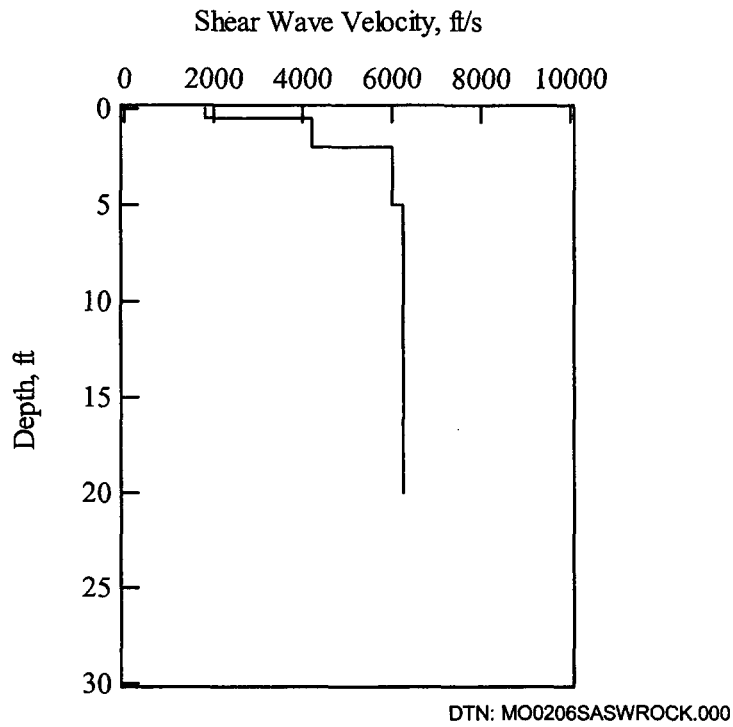


(Wong, 2002e, Appendix 30)

b. SASW-T3 Dispersion Curves (Linear Plot)

Figure XIII-3. SASW-T3 Results

C03



c. SASW-T3 Shear Wave Velocity Profile

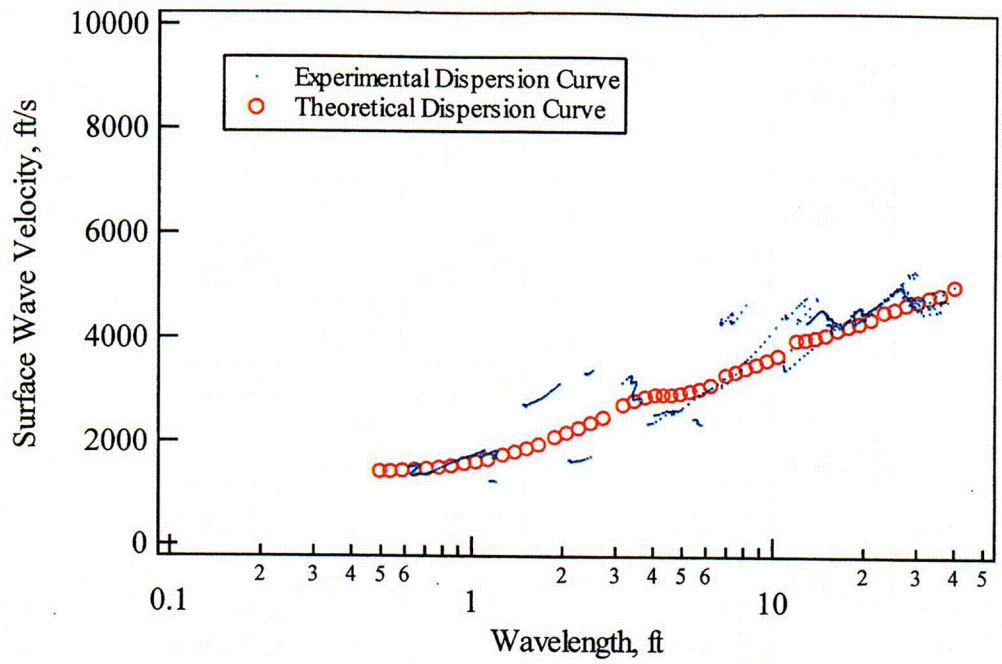
Location: SASW-T3

Layer No.	Thickness, ft	P-Wave Velocity, ft/s	S-Wave Velocity, ft/s	Poisson's Ratio*	Mass Density* pcf
1	0.5	3368	1800	0.25	145
2	1.5	7858	4200	0.25	145
3	3	11225	6000	0.25	145
4	15	11693	6250	0.25	145

DTN: MO0206SASWROCK.000

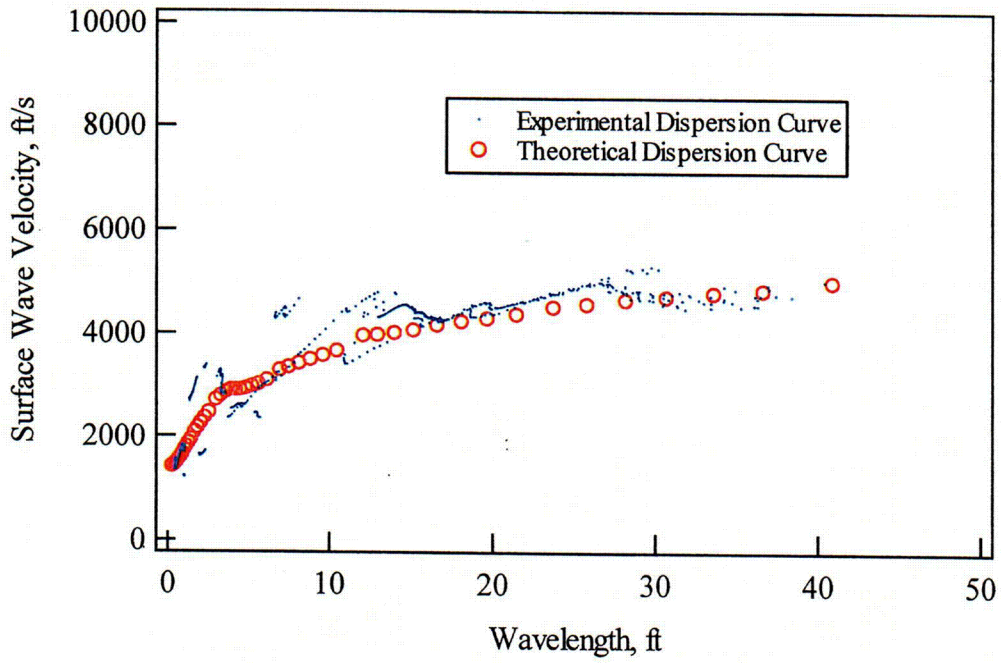
* Poisson's ratio and mass density from Wong (2002a, Appendix 30)

Figure XIII-3. SASW-T3 Results (continued)



(Wong, 2002e, Appendix 31)

a. SASW-T4 Dispersion Curves (Log Plot)

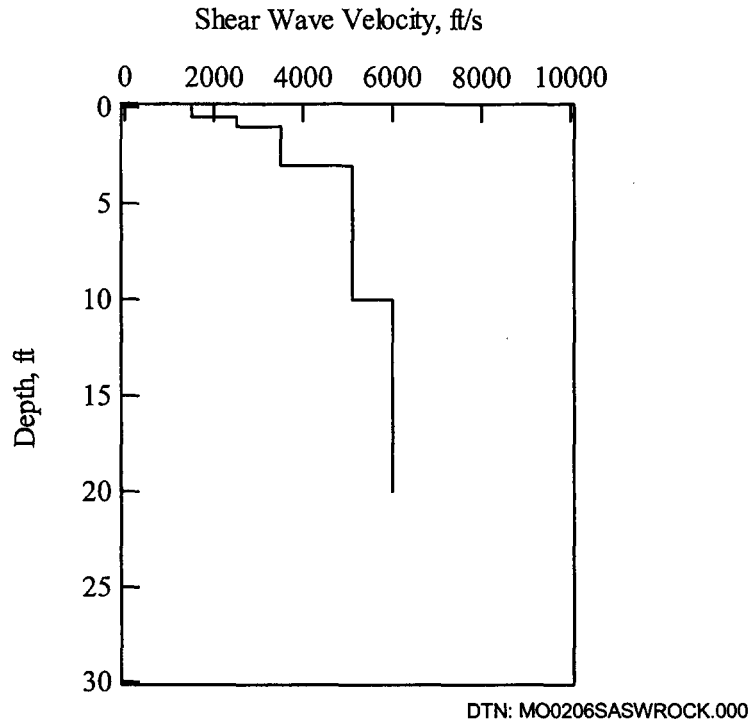


(Wong, 2002e, Appendix 31)

b. SASW-T4 Dispersion Curves (Linear Plot)

Figure XIII-4. SASW-T4 Results

C04



c. SASW-T4 Shear Wave Velocity Profile

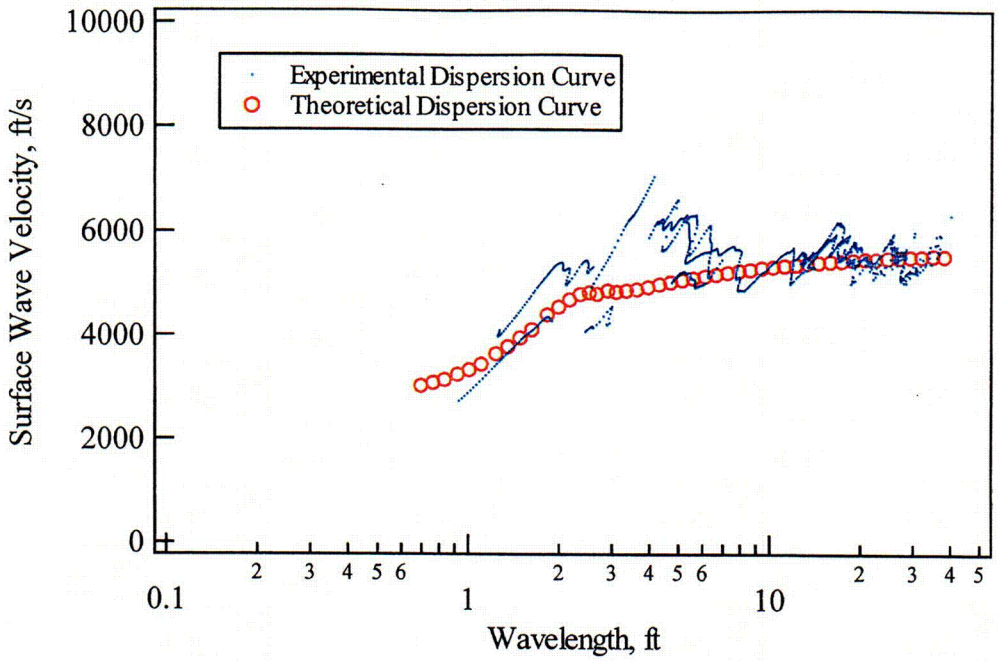
Location: SASW-T4

Layer No.	Thickness, ft	P-Wave Velocity, ft/s	S-Wave Velocity, ft/s	Poisson's Ratio*	Mass Density* pcf
1	0.5	2806	1500	0.25	145
2	0.5	4677	2500	0.25	145
3	2	6548	3500	0.25	145
4	7	9541	5100	0.25	145
5	10	11225	6000	0.25	145

DTN: MO0206SASWROCK.000

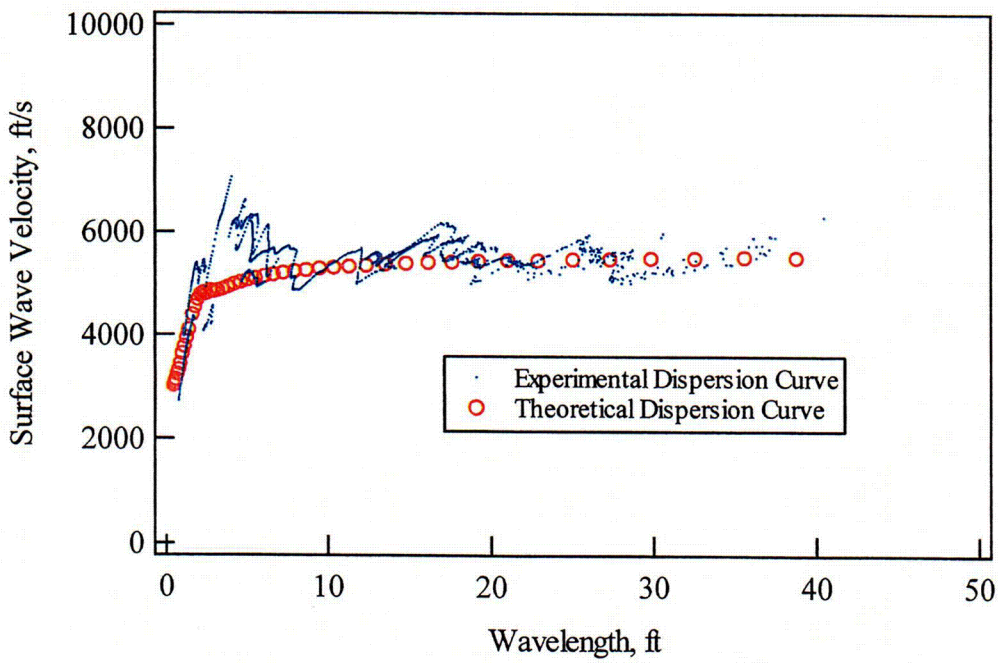
* Poisson's ratio and mass density from Wong (2002a, Appendix 31)

Figure XIII-4. SASW-T4 Results (continued)



(Wong, 2002e, Appendix 32)

a. SASW-T5 Dispersion Curves (Log Plot)

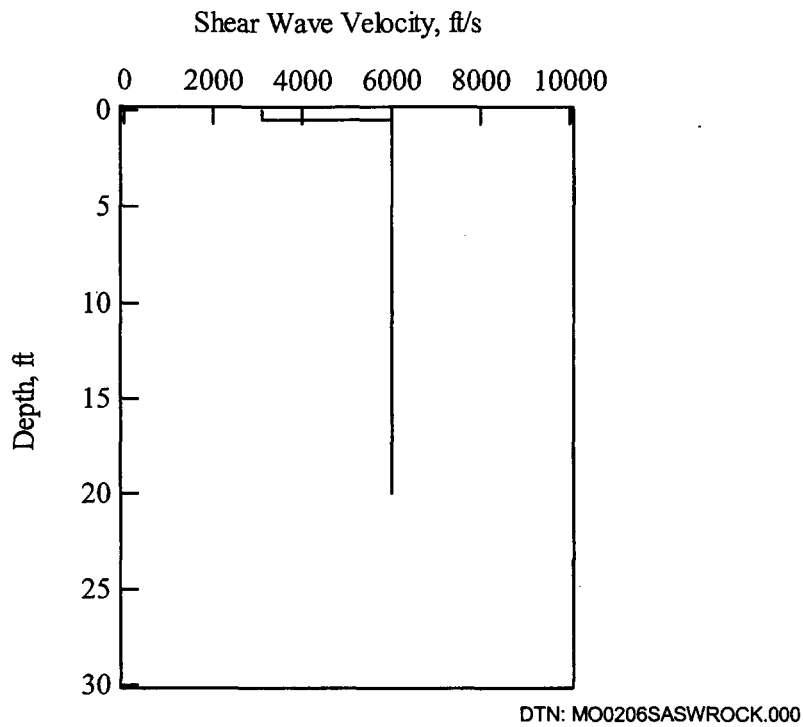


(Wong, 2002e, Appendix 32)

b. SASW-T5 Dispersion Curves (Linear Plot)

Figure XIII-5. SASW-T5 Results.

C05



c. SASW-T5 Shear Wave Velocity Profile

Location: SASW-T5

Layer No.	Thickness, ft	P-Wave Velocity, ft/s	S-Wave Velocity, ft/s	Poisson's Ratio*	Mass Density* pcf
1	0.5	5800	3100	0.25	145
2	19.5	11225	6000	0.25	145

DTN: MO0206SASWROCK.000

* Poisson's ratio and mass density from Wong (2002a, Appendix 32)

Figure XIII-5. SASW-T5 Results (continued)

ATTACHMENT XIV

GEOTECHNICAL LABORATORY DYNAMIC TESTING – ESF

As discussed in Section 6.3.3, this attachment presents the results of resonant column and torsional shear (RCTS) tests performed on samples taken by coring into the walls of the ESF North Ramp. Seven figures are followed by five tables. The data on these tables is found in DTN: MO0203DHRSSWHB.001.

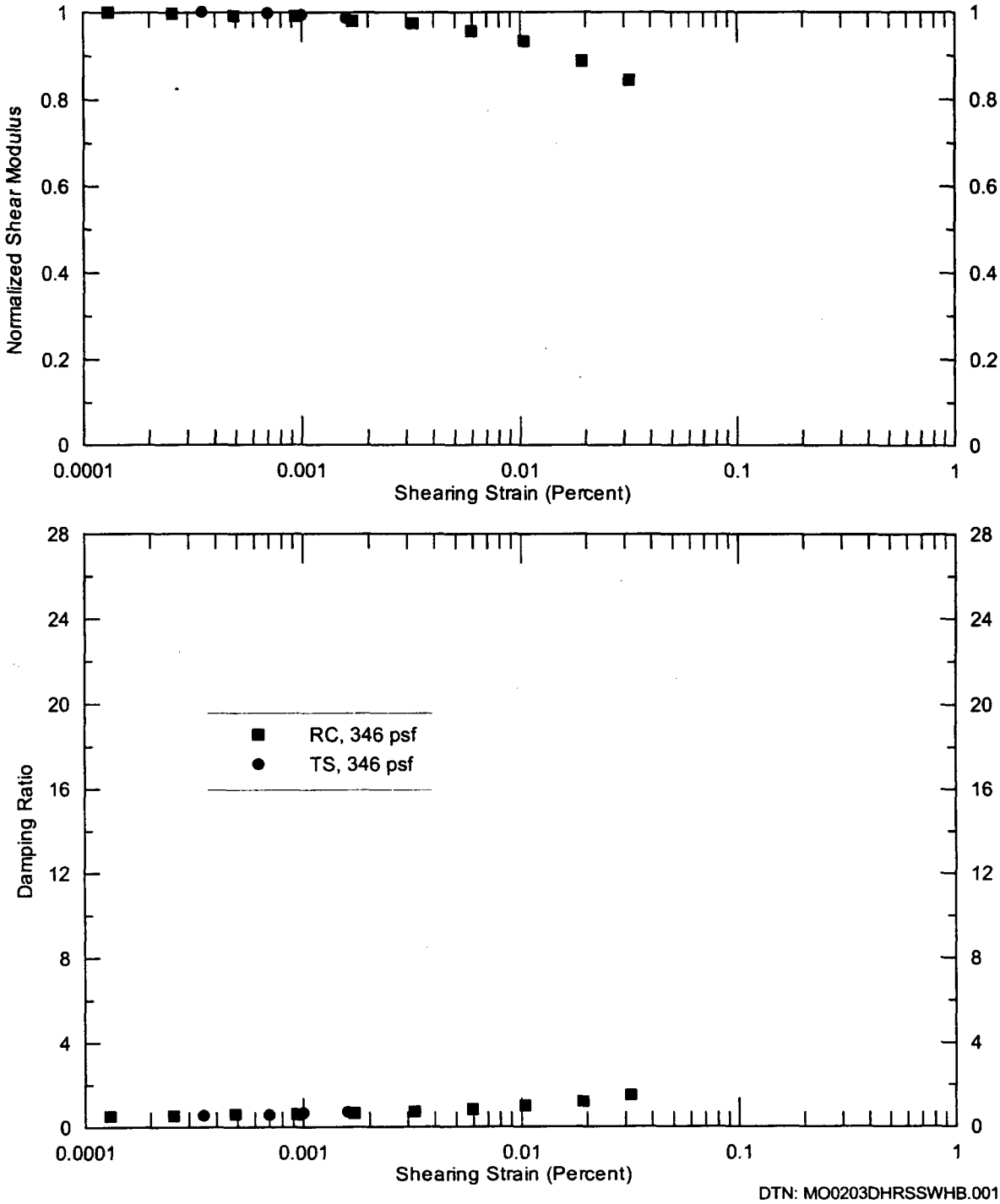


Figure XIV-1. Resonant Column and Torsional Shear Results for Specimen UTA-20-F

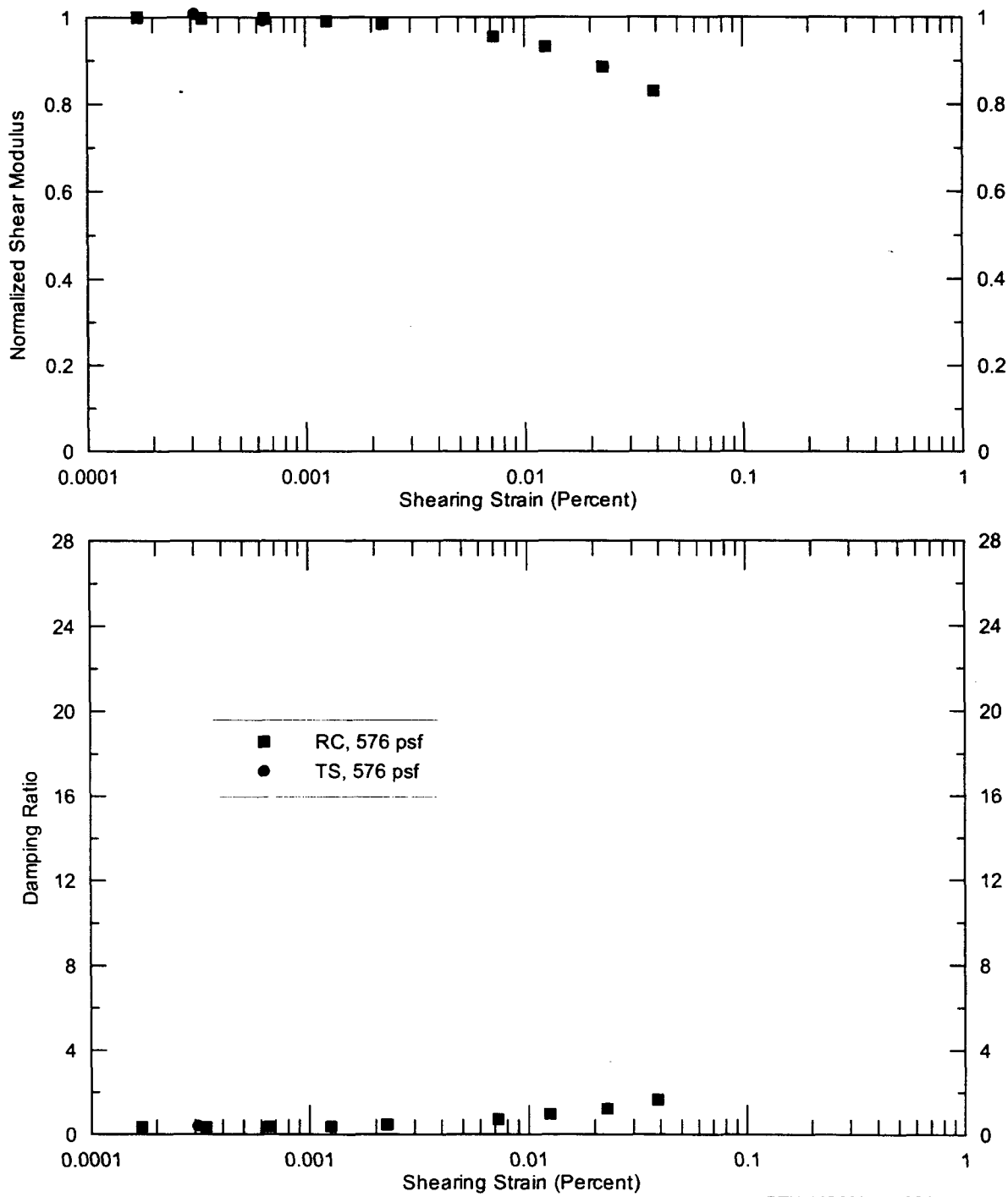


Figure XIV-2. Resonant Column and Torsional Shear Results for Specimen UTA-20-G

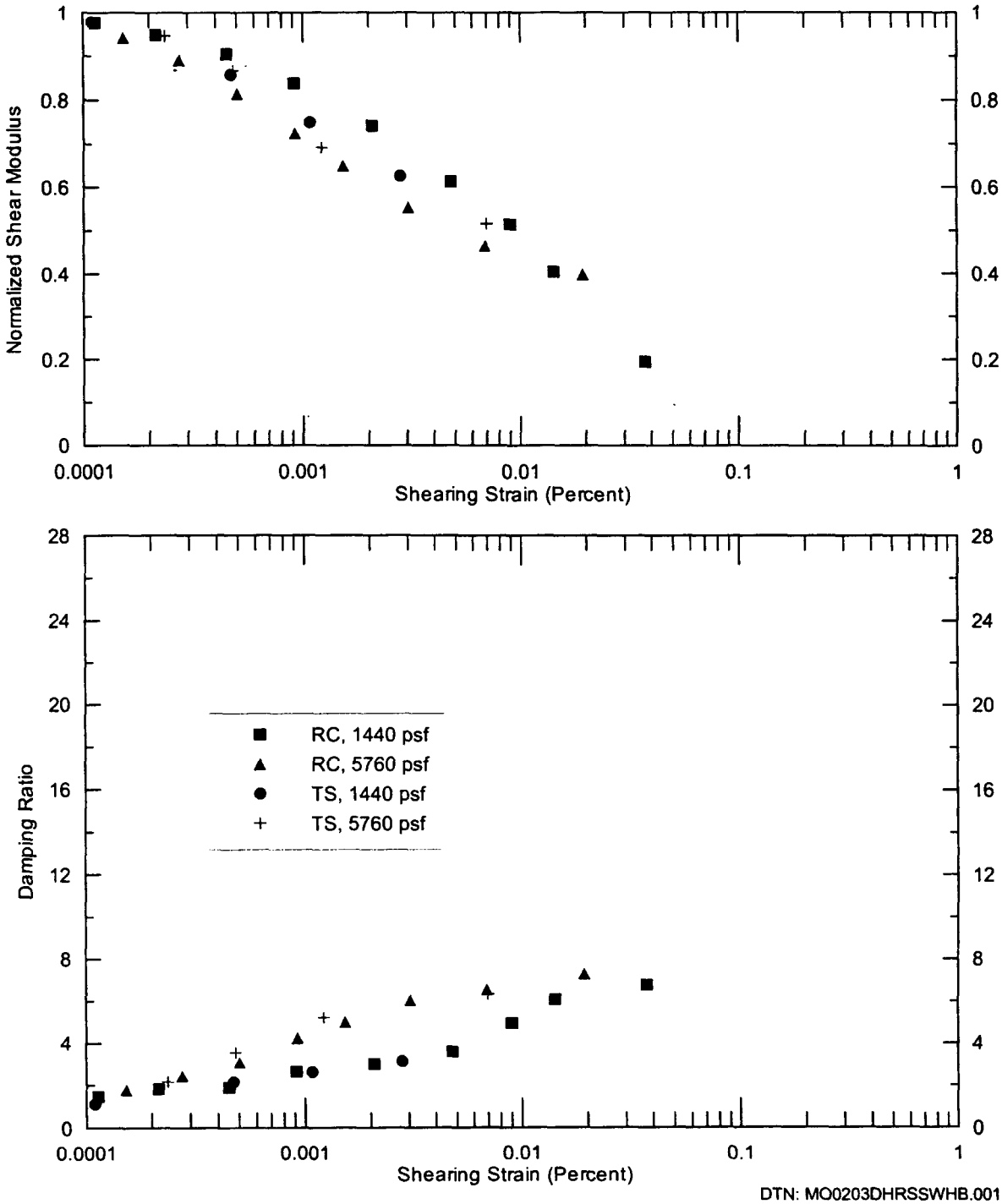
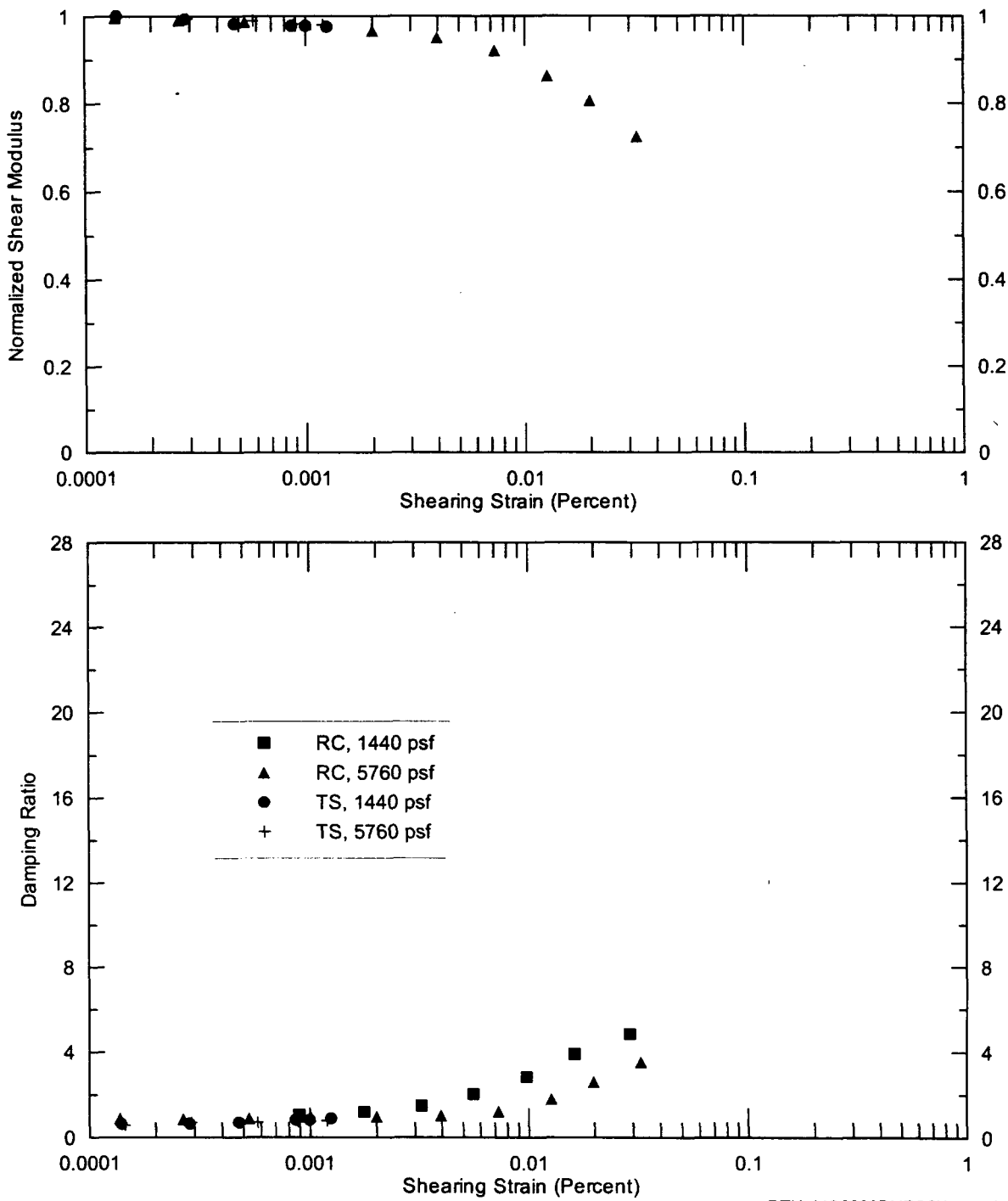


Figure XIV-3. Resonant Column and Torsional Shear Results for Specimen UTA-20-I



DTN: MO0203DHRSSWHB.001

Figure XIV-4. Resonant Column and Torsional Shear Results for Specimen UTA-20-J

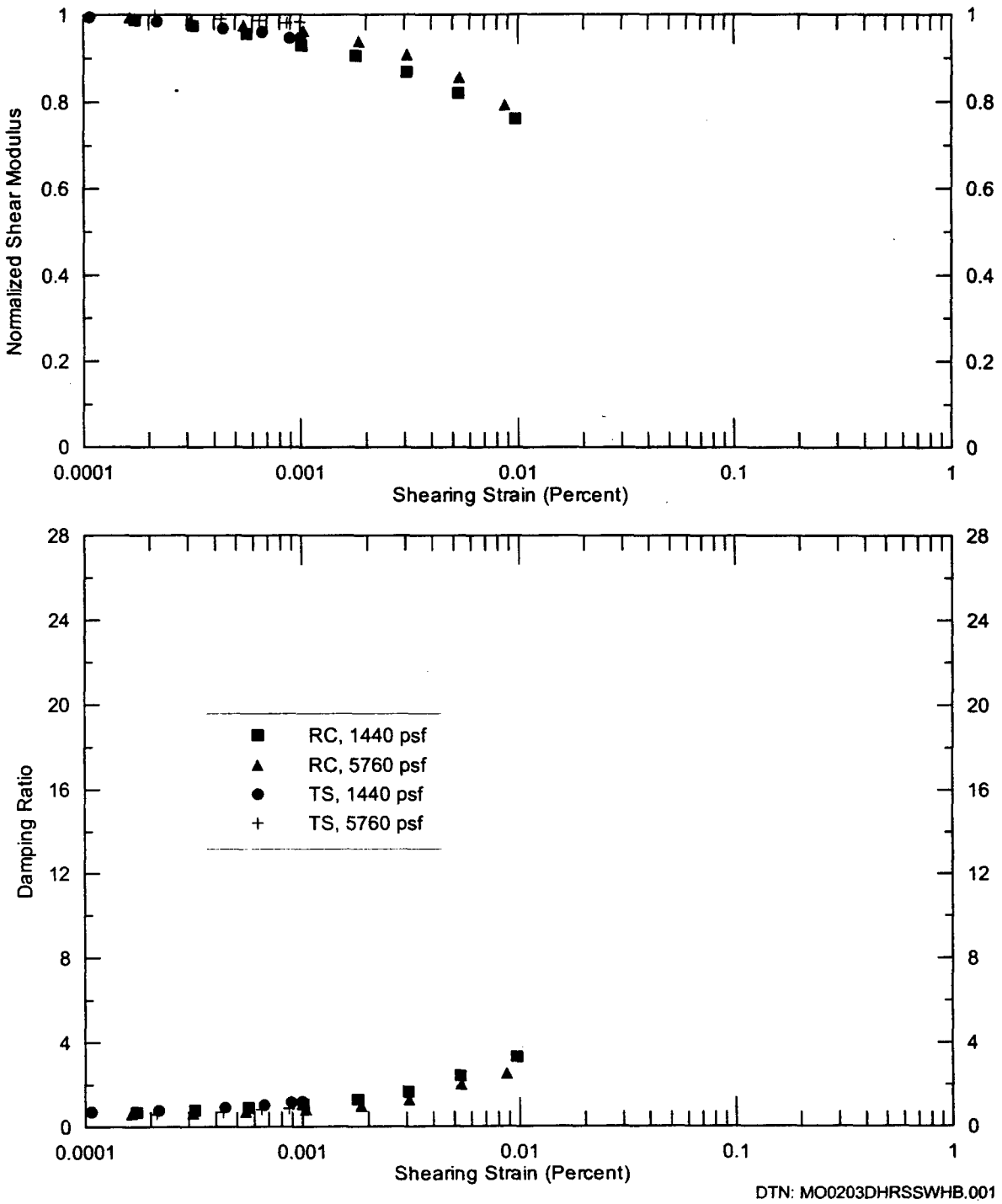
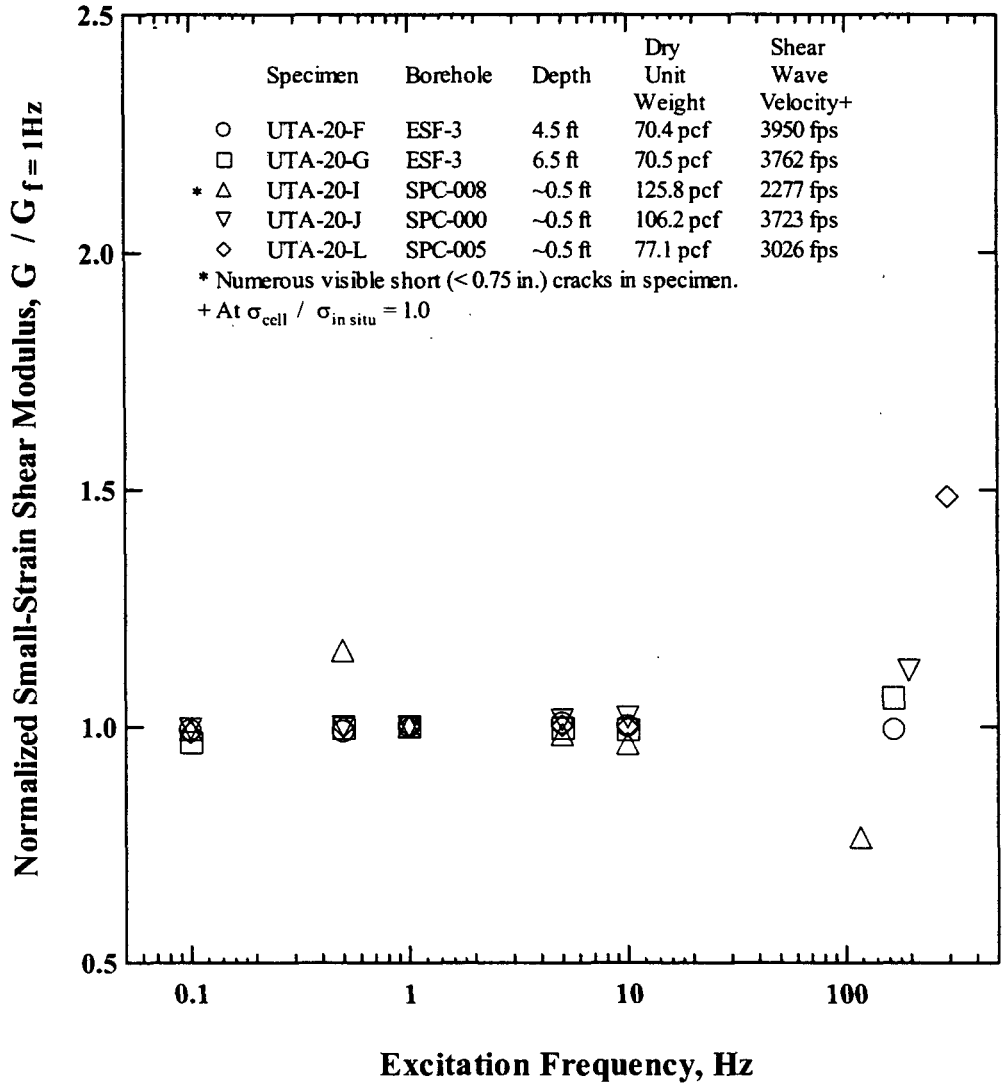
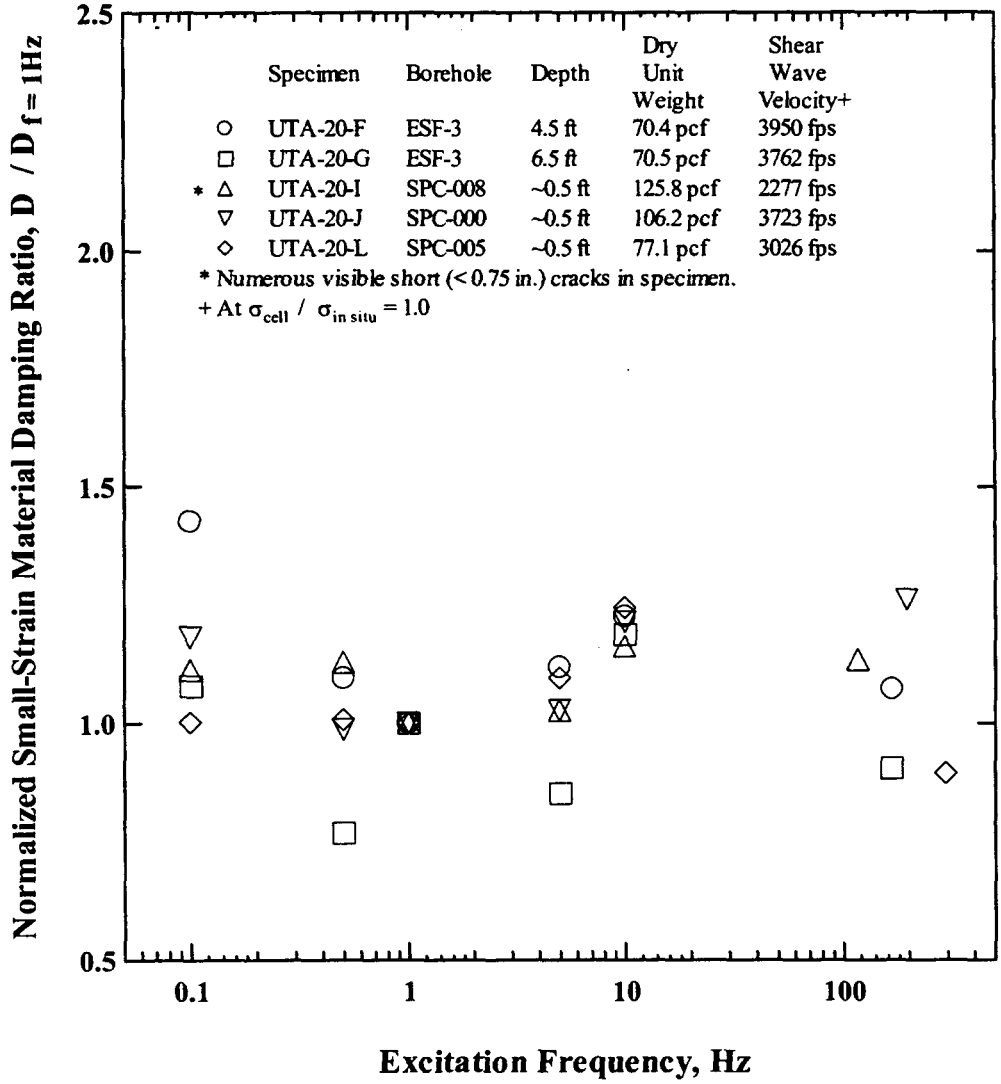


Figure XIV-5. Resonant Column and Torsional Shear Results for Specimen UTA-20-L



(Wong 2002e, Appendix 42, page 75)

Figure XIV-6. Variation in Normalized Small-Strain Shear Modulus with Excitation Frequency of Intact Tuff Specimens from the North Portal Area of the Access Tunnel



(Wong 2002e, Appendix 42, page 76)

Figure XIV-7. Variation in Normalized Small-Strain Material Damping Ratio with Excitation Frequency of Intact Tuff Specimens from the North Portal Area of the Access Tunnel

Table XIV-1a. Variation in Low-Amplitude Shear Wave Velocity, Low-Amplitude Shear Modulus, Low-Amplitude Material Damping Ratio and Void Ratio with Effective Isotropic Confining Pressure from RC Tests of Specimen UTA-20-F.

Effective Isotropic Confining Pressure, σ_o'			Low-Amplitude Shear Modulus, G_{max}		Low-Amplitude Shear Wave Velocity, V_s	Low-Amplitude Material Damping Ratio, Dmin, %
(psi)	(psf)	(kPa)	(ksf)	(MPa)	(fps)	
UNCONFINED	0	0	36000	1726	3931	0.85
0.6	86	4.1	36125	1732	3936	0.52
1.2	173	8.3	36173	1734	3938	0.51
2.4	346	16.6	36393	1745	3950	0.50

Table XIV-1b. Variation in Shear Modulus, Normalized Shear Modulus and Material Damping Ratio with Shearing Strain from RC Tests of Specimen UTA-20-F; Effective Confining Pressure, σ_o' = 2.4 psi (0.35 ksf = 17 kPa)

Peak Shearing Strain, %	Shear Modulus, G, ksf	Normalized Shear Modulus, G/G_{max}	Average[+] Shearing Strain, %	Material Damping Ratio[x], D, %
1.31E-04	36374	1.00	1.27E-04	0.51
2.55E-04	36290	1.00	2.47E-04	0.53
4.89E-04	36073	0.99	4.71E-04	0.60
9.35E-04	36071	0.99	8.96E-04	0.62
1.71E-03	35649	0.98	1.64E-03	0.66
3.24E-03	35438	0.97	3.10E-03	0.73
5.97E-03	34801	0.96	5.67E-03	0.82
1.04E-02	33967	0.93	9.82E-03	0.99
1.92E-02	32325	0.89	1.71E-02	1.20
3.18E-02	30726	0.84	2.91E-02	1.49

[+] Average Shearing Strain from the First Three Cycles of the Free Vibration Decay Curve

[x] Average Damping Ratio from the First Three Cycles of the Free Vibration Decay Curve

Table XIV-1c. Variation in Shear Modulus, Normalized Shear Modulus and Material Damping Ratio with Shearing Strain from TS Tests of Specimen UTA-20-F; Effective Confining Pressure, σ_o' = 2.4 psi (0.35 ksf = 17 kPa)

First Cycle				Tenth Cycle			
Peak Shearing Strain, %	Shear Modulus, G, ksf	Normalized Shear Modulus, G/G_{max}	Material Damping Ratio, D, %	Peak Shearing Strain, %	Shear Modulus, G, ksf	Normalized Shear Modulus, G/G_{max}	Material Damping Ratio, D, %
3.50E-04	36000	1.00	0.55	3.50E-04	35800	0.99	0.47
7.00E-04	35900	1.00	0.58	7.00E-04	35800	0.99	0.55
1.00E-03	35700	0.99	0.67	1.00E-03	35500	0.98	0.69
1.60E-03	35500	0.99	0.72	1.60E-03	35400	0.98	0.71

DTN: MO0203DHRSSWHB.001

Table XIV-2a. Variation in Low-Amplitude Shear Wave Velocity, Low-Amplitude Shear Modulus, Low-Amplitude Material Damping Ratio and Void Ratio with Effective Isotropic Confining Pressure from RC Tests of Specimen UTA-20-G.

Effective Isotropic Confining Pressure, σ_o'			Low-Amplitude Shear Modulus, G_{max}		Low-Amplitude Shear Wave Velocity, Vs	Low-Amplitude Material Damping Ratio, Dmin, %
(psi)	(psf)	(kPa)	(ksf)	(MPa)	(fps)	
UNCONFINED	0	0	35200	1687	3758	0.66
1	144	6.9	35208	1688	3759	0.38
2	288	13.8	35252	1690	3761	0.38
4	576	27.6	35263	1690	3762	0.35

Table XIV-2b. Variation in Shear Modulus, Normalized Shear Modulus and Material Damping Ratio with Shearing Strain from RC Tests of Specimen UTA-20-G; Effective Confining Pressure, σ_o' = 4 psi (0.58 ksf = kPa)

Peak Shearing Strain, %	Shear Modulus, G, ksf	Normalized Shear Modulus, G/G_{max}	Average[+] Shearing Strain, %	Material Damping Ratio[x], D, %
1.71E-04	35389	1.00	1.70E-04	0.35
8.66E-05	35396	1.00	8.48E-05	0.35
3.37E-04	35309	1.00	3.30E-04	0.34
6.51E-04	35312	1.00	6.37E-04	0.35
1.26E-03	35091	0.99	1.23E-03	0.36
2.26E-03	34840	0.98	2.19E-03	0.45
7.25E-03	33799	0.95	6.93E-03	0.72
1.25E-02	32971	0.93	1.18E-02	0.95
2.28E-02	31347	0.89	2.12E-02	1.21
3.89E-02	29383	0.83	3.52E-02	1.64

[+] Average Shearing Strain from the First Three Cycles of the Free Vibration Decay Curve

[x] Average Damping Ratio from the First Three Cycles of the Free Vibration Decay Curve

Table XIV-2c. Variation in Shear Modulus, Normalized Shear Modulus and Material Damping Ratio with Shearing Strain from TS Tests of Specimen UTA-20-G; Effective Confining Pressure, σ_o' = 4 psi (0.58 ksf = 28 kPa)

First Cycle				Tenth Cycle			
Peak Shearing Strain, %	Shear Modulus, G, ksf	Normalized Shear Modulus, G/G_{max}	Material Damping Ratio, D, %	Peak Shearing Strain, %	Shear Modulus, G, ksf	Normalized Shear Modulus, G/G_{max}	Material Damping Ratio, D, %
6.41E-04	32520	0.99	0.35	6.41E-04	32700	1.00	0.33
3.10E-04	33000	1.01	0.40	3.11E-04	33000	1.00	0.38

DTN: MO0203DHRSSWHB.001

Table XIV-3a. Variation in Low-Amplitude Shear Wave Velocity, Low-Amplitude Shear Modulus, Low-Amplitude Material Damping Ratio and Void Ratio with Effective Isotropic Confining Pressure from RC Tests of Specimen UTA-20-I.

Effective Isotropic Confining Pressure, σ_o'			Low-Amplitude Shear Modulus, G_{max}		Low-Amplitude Shear Wave Velocity, Vs	Low-Amplitude Material Damping Ratio, Dmin, %
(psi)	(psf)	(kPa)	(ksf)	(MPa)	(fps)	
UNCONFINED	0	0	18350	880	2155	2.82
3	360	17.3	18975	910	2192	2.46
5	720	34.5	20373	977	2272	2.00
10	1440	69.0	20468	981	2277	2.20
20	2880	138.1	7202	345	1351	2.64
40	5760	276.1	8113	389	1434	3.06
80	11520	552.3	19152	918	2203	2.58

Table XIV-3b. Variation in Shear Modulus, Normalized Shear Modulus and Material Damping Ratio with Shearing Strain from RC Tests of Specimen UTA-20-I; Effective Confining Pressure, σ_o' = 10 psi (1.4 ksf = 69 kPa)

Peak Shearing Strain, %	Shear Modulus, G, ksf	Normalized Shear Modulus, G/G_{max}	Average+ Shearing Strain, %	Material Damping Ratio^x, D, %
4.08E-05	21309	1.03	3.94E-05	1.39
1.14E-04	20211	0.98	1.04E-04	1.47
2.15E-04	19640	0.95	1.93E-04	1.82
4.49E-04	18706	0.90	4.01E-04	1.88
9.13E-04	17350	0.84	7.91E-04	2.64
2.08E-03	15340	0.74	1.75E-03	2.99
4.79E-03	12685	0.61	4.14E-03	3.56
8.99E-03	10626	0.51	6.80E-03	4.93
1.42E-02	8335	0.40	1.02E-02	6.06
3.72E-02	3996	0.19	2.58E-02	6.76

+ Average Shearing Strain from the First Three Cycles of the Free Vibration Decay Curve

x Average Damping Ratio from the First Three Cycles of the Free Vibration Decay Curve

DTN: MO0203DHRSSWHB.001

Table XIV-3c. Variation in Shear Modulus, Normalized Shear Modulus and Material Damping Ratio with Shearing Strain from TS Tests of Specimen UTA-20-I; Effective Confining Pressure, σ_o' = 10 psi (1.4 ksf = 69 kPa)

First Cycle				Tenth Cycle			
Peak Shearing Strain, %	Shear Modulus, G, ksf	Normalized Shear Modulus, G/G_{max}	Material Damping Ratio, D, %	Peak Shearing Strain, %	Shear Modulus, G, ksf	Normalized Shear Modulus, G/G_{max}	Material Damping Ratio, D, %
2.67E-05	31340	1.02	0.80	2.67E-05	31780	1.03	0.82
1.10E-04	29990	0.98	1.12	1.10E-04	30100	0.97	0.97
4.71E-04	26270	0.86	2.15	4.71E-04	25930	0.84	2.03
1.08E-03	22970	0.75	2.62	1.08E-03	22670	0.73	2.42
2.80E-03	19170	0.63	3.12	2.80E-03	19000	0.61	2.89

Table XIV-3d. Variation in Shear Modulus, Normalized Shear Modulus and Material Damping Ratio with Shearing Strain from RC Tests of Specimen UTA-20-I; Effective Confining Pressure, σ_o' = 40 psi (5.8 ksf = 276 kPa)

Peak Shearing Strain, %	Shear Modulus, G, ksf	Normalized Shear Modulus, G/G_{max}	Average[+] Shearing Strain, %	Material Damping Ratio[x], D, %
8.75E-05	9852	1.00	7.26E-05	1.81
1.53E-04	9282	0.94	1.38E-04	1.79
2.76E-04	8770	0.89	2.39E-04	2.44
5.03E-04	8029	0.81	4.19E-04	3.09
9.23E-04	7131	0.72	7.25E-04	4.22
1.53E-03	6391	0.65	1.16E-03	4.98
3.06E-03	5442	0.55	3.22E-03	6.02
6.89E-03	4569	0.46	7.28E-03	6.53
1.94E-02	3911	0.40	1.31E-02	7.28

[+] Average Shearing Strain from the First Three Cycles of the Free Vibration Decay Curve

[x] Average Damping Ratio from the First Three Cycles of the Free Vibration Decay Curve

Table XIV-3e. Variation in Shear Modulus, Normalized Shear Modulus and Material Damping Ratio with Shearing Strain from TS Tests of Specimen UTA-20-I; Effective Confining Pressure, σ_o' = 40 psi (5.8 ksf = 276 kPa)

First Cycle				Tenth Cycle			
Peak Shearing Strain, %	Shear Modulus, G, ksf	Normalized Shear Modulus, G/G_{max}	Material Damping Ratio, D, %	Peak Shearing Strain, %	Shear Modulus, G, ksf	Normalized Shear Modulus, G/G_{max}	Material Damping Ratio, D, %
5.43E-05	15640	1.05	2.25	5.43E-05	15210	1.04	2.25
2.37E-04	14040	0.95	2.16	2.37E-04	13940	0.96	2.23
4.83E-04	12860	0.87	3.54	4.83E-04	12600	0.86	3.45
1.22E-03	10250	0.69	5.19	1.22E-03	10060	0.69	4.92
7.00E-03	7647	0.52	6.31	7.00E-03	7624	0.52	5.93

DTN: MO0203DHRSSWHB.001

Table XIV-4a. Variation in Low-Amplitude Shear Wave Velocity, Low-Amplitude Shear Modulus, Low-Amplitude Material Damping Ratio and Void Ratio with Effective Isotropic Confining Pressure from RC Tests of Specimen UTA-20-J.

Effective Isotropic Confining Pressure, σ_o'			Low-Amplitude Shear Modulus, G_{max}		Low-Amplitude Shear Wave Velocity, Vs	Low-Amplitude Material Damping Ratio, Dmin, %
(psi)	(psf)	(kPa)	(ksf)	(MPa)	(fps)	
UNCONFINED	0	0	47200	2263	3703	1.19
3	360	17.3	47459	2275	3712	0.92
5	720	34.5	47788	2291	3725	0.95
10	1440	69.0	47735	2288	3723	0.90
20	2880	138.1	45281	2171	3625	0.88
40	5760	276.1	45428	2178	3631	0.85
80	11520	552.3	45955	2203	3652	0.80
160	23040	1104.5	45881	2200	3648	0.81

Table XIV-4b. Variation in Shear Modulus, Normalized Shear Modulus and Material Damping Ratio with Shearing S from RC Tests of Specimen UTA-20-J; Effective Confining Pressure, σ_o' = 10 psi (1.4 ksf = 69 kPa)

Peak Shearing Strain, %	Shear Modulus, G, ksf	Normalized Shear Modulus, G/G_{max}	Average[+] Shearing Strain, %	Material Damping Ratio[x], D, %
8.96E-04	47140	1.01	9.11E-04	1.05
1.76E-03	46668	0.99	1.79E-03	1.19
3.23E-03	45959	0.98	3.29E-03	1.48
5.58E-03	44555	0.95	5.68E-03	2.03
9.81E-03	42262	0.90	8.62E-03	2.83
1.62E-02	39150	0.83	1.37E-02	3.90
2.91E-02	35322	0.75	2.32E-02	4.85

[+] Average Shearing Strain from the First Three Cycles of the Free Vibration Decay Curve

[x] Average Damping Ratio from the First Three Cycles of the Free Vibration Decay Curve

DTN: MO0203DHRSSWHB.001

Table XIV-4c. Variation in Shear Modulus, Normalized Shear Modulus and Material Damping Ratio with Shearing Strain from TS Tests of Specimen UTA-20-J; Effective Confining Pressure, σ_o' = 10 psi (1.4 ksf = 69 kPa)

First Cycle				Tenth Cycle			
Peak Shearing Strain, %	Shear Modulus, G, ksf	Normalized Shear Modulus, G/G_{max}	Material Damping Ratio, D, %	Peak Shearing Strain, %	Shear Modulus, G, ksf	Normalized Shear Modulus, G/G_{max}	Material Damping Ratio, D, %
7.54E-05	43100	1.00	0.83	7.54E-05	43240	1.00	0.66
1.40E-04	43210	1.00	0.64	1.69E-04	42900	1.00	0.64
2.86E-04	42890	0.99	0.66	2.86E-04	42828	0.99	0.74
4.78E-04	42400	0.98	0.71	4.78E-04	42500	0.99	0.81
8.64E-04	42200	0.98	0.83	8.64E-04	42200	0.98	0.83
1.00E-03	42200	0.98	0.82	1.00E-03	42240	0.98	0.84
1.25E-03	42100	0.98	0.89	1.25E-03	42100	0.98	0.89

Table XIV-4d. Variation in Shear Modulus, Normalized Shear Modulus and Material Damping Ratio with Shearing Strain from RC Tests of Specimen UTA-20-J; Effective Confining Pressure, σ_o' = 40 psi (5.8 ksf = 276 kPa)

Peak Shearing Strain, %	Shear Modulus, G, ksf	Normalized Shear Modulus, G/G_{max}	Average[+] Shearing Strain, %	Material Damping Ratio[x], D, %
6.98E-05	45840	1.00	7.09E-05	0.85
1.38E-04	45740	1.00	1.31E-04	0.90
2.68E-04	45498	0.99	2.54E-04	0.87
5.31E-04	45272	0.99	5.03E-04	0.89
1.01E-03	45037	0.98	9.47E-04	1.00
2.01E-03	44337	0.97	1.89E-03	0.99
3.98E-03	43641	0.95	3.73E-03	1.03
7.30E-03	42273	0.92	6.77E-03	1.23
1.27E-02	39598	0.86	1.14E-02	1.80
1.99E-02	37012	0.81	1.70E-02	2.60
3.27E-02	33295	0.73	2.66E-02	3.54

[+] *Average Shearing Strain from the First Three Cycles of the Free Vibration Decay Curve*

[x] Average Damping Ratio from the First Three Cycles of the Free Vibration Decay Curve

Table XIV-4e. Variation in Shear Modulus, Normalized Shear Modulus and Material Damping Ratio with Shearing Strain from TS Tests of Specimen UTA-20-J; Effective Confining Pressure, σ_o' =40 psi (5.8 ksf = 276 kPa)

First Cycle				Tenth Cycle			
Peak Shearing Strain, %	Shear Modulus, G, ksf	Normalized Shear Modulus, G/G_{max}	Material Damping Ratio, D, %	Peak Shearing Strain, %	Shear Modulus, G, ksf	Normalized Shear Modulus, G/G_{max}	Material Damping Ratio, D, %
7.70E-05	42000	1.00	0.51	7.70E-05	42000	1.00	0.43
1.45E-04	41900	1.00	0.58	1.45E-04	42100	1.00	0.60
2.92E-04	41730	0.99	0.71	2.92E-04	41800	0.99	0.70
5.80E-04	41500	0.99	0.71	5.80E-04	41500	0.99	0.72
8.80E-04	41200	0.98	0.71	8.80E-04	41600	0.99	0.77
1.00E-03	41300	0.98	0.72	1.00E-03	41400	0.98	0.73
1.20E-03	41090	0.98	0.78	1.20E-03	41200	0.98	0.80

DTN: MO0203DHRSSWHB.001

Table XIV-5a. Variation in Low-Amplitude Shear Wave Velocity, Low-Amplitude Shear Modulus, Low-Amplitude Material Damping Ratio and Void Ratio with Effective Isotropic Confining Pressure from RC Tests of Specimen UTA-20-L.

Effective Isotropic Confining Pressure, σ_o'			Low-Amplitude Shear Modulus, G_{max}		Low-Amplitude Shear Wave Velocity, Vs	Low-Amplitude Material Damping Ratio,
(psi)	(psf)	(kPa)	(ksf)	(MPa)	(fps)	Dmin, %
UNCONFINED	0	0	21200	1016	2948	0.93
3	360	17.3	21454	1028	2967	0.71
5	720	34.5	21859	1048	2995	0.70
10	1440	69.0	22314	1070	3026	0.64
20	2880	138.1	23306	1117	3092	0.59
40	5760	276.1	24353	1167	3161	0.60
80	11520	552.3	25599	1227	3240	0.61
160	23040	1104.5	27508	1319	3357	0.59

Table XIV-5b. Variation in Shear Modulus, Normalized Shear Modulus and Material Damping Ratio with Shearing S from RC Tests of Specimen UTA-20-L; Effective Confining Pressure, σ_o' = 10 psi (1.4 ksf = 69 kPa)

Peak Shearing Strain, %	Shear Modulus, G, ksf	Normalized Shear Modulus, G/G_{max}	Average[+] Shearing Strain, %	Material Damping Ratio[x], D, %
2.36E-05	21868	1.00	2.26E-05	0.73
4.54E-05	21888	1.00	4.37E-05	0.62
9.00E-05	21723	0.99	8.65E-05	0.64
1.73E-04	21602	0.99	1.66E-04	0.68
3.21E-04	21320	0.97	3.06E-04	0.78
5.66E-04	20902	0.96	5.35E-04	0.91
1.01E-03	20327	0.93	9.49E-04	1.06
1.80E-03	19802	0.91	1.66E-03	1.29
3.08E-03	18995	0.87	2.79E-03	1.66
5.33E-03	17930	0.82	4.61E-03	2.41
9.71E-03	16663	0.76	8.27E-03	3.32

[+] Average Shearing Strain from the First Three Cycles of the Free Vibration Decay Curve

[x] Average Damping Ratio from the First Three Cycles of the Free Vibration Decay Curve

DTN: MO0203DHRSSWHB.001

Table XIV-5c. Variation in Shear Modulus, Normalized Shear Modulus and Material Damping Ratio with Shearing Strain from TS Tests of Specimen UTA-20-L; Effective Confining Pressure, σ_o' = 10psi (1.4ksf = 69kPa)

First Cycle				Tenth Cycle			
Peak Shearing Strain, %	Shear Modulus, G, ksf	Normalized Shear Modulus, G/G_{max}	Material Damping Ratio, D, %	Peak Shearing Strain, %	Shear Modulus, G, ksf	Normalized Shear Modulus, G/G_{max}	Material Damping Ratio, D, %
5.60E-05	14555	1.01	0.87	5.70E-05	14470	1.00	0.70
1.07E-04	14400	0.99	0.70	1.08E-04	14430	1.00	0.72
2.19E-04	14250	0.98	0.77	2.19E-04	14190	0.98	0.77
4.42E-04	14020	0.97	0.91	4.40E-04	14098	0.98	0.91
6.69E-04	13900	0.96	1.03	6.69E-04	13930	0.96	1.03
8.96E-04	13700	0.95	1.17	8.96E-04	13720	0.95	1.14
1.00E-03	13690	0.95	1.19	1.00E-03	13740	0.95	1.20

Table XIV-5d. Variation in Shear Modulus, Normalized Shear Modulus and Material Damping Ratio with Shearing Strain from RC Tests of Specimen UTA-20-L; Effective Confining Pressure, σ_o' = 40 psi (5.8 ksf = 276 kPa)

Peak Shearing Strain, %	Shear Modulus, G, ksf	Normalized Shear Modulus, G/G_{max}	Average[+] Shearing Strain, %	Material Damping Ratio[x], D, %
2.13E-05	23928	1.00	2.06E-05	0.58
4.18E-05	23930	1.00	4.03E-05	0.59
8.24E-05	23924	1.00	7.94E-05	0.59
1.64E-04	23776	0.99	1.58E-04	0.61
3.14E-04	23628	0.99	3.02E-04	0.64
5.49E-04	23330	0.97	5.20E-04	0.71
1.04E-03	23035	0.96	9.86E-04	0.83
1.87E-03	22454	0.94	1.76E-03	0.99
3.10E-03	21739	0.91	2.87E-03	1.29
5.39E-03	20480	0.86	4.62E-03	2.02
8.72E-03	18994	0.79	7.50E-03	2.54

[+] Average Shearing Strain from the First Three Cycles of the Free Vibration Decay Curve

[x] Average Damping Ratio from the First Three Cycles of the Free Vibration Decay Curve

Table XIV-5e. Variation in Shear Modulus, Normalized Shear Modulus and Material Damping Ratio with Shearing Strain from TS Tests of Specimen UTA-20-L; Effective Confining Pressure, σ_o' =40 psi (5.8 ksf = 276 kPa)

First Cycle				Tenth Cycle			
Peak Shearing Strain, %	Shear Modulus, G, ksf	Normalized Shear Modulus, G/G_{max}	Material Damping Ratio, D, %	Peak Shearing Strain, %	Shear Modulus, G, ksf	Normalized Shear Modulus, G/G_{max}	Material Damping Ratio, D, %
5.45E-05	14500	1.00	0.51	5.45E-05	14500	1.00	0.43
2.14E-04	14450	1.00	0.59	1.45E-04	14470	1.00	0.64
4.32E-04	14330	0.99	0.68	2.92E-04	14380	0.99	0.66
6.50E-04	14280	0.99	0.82	6.50E-04	14320	0.99	0.76
8.69E-04	14200	0.98	0.86	8.69E-04	14230	0.98	0.83
1.00E-03	14220	0.98	0.85	1.00E-03	14250	0.98	0.81

DTN: MO0203DHRSSWHB.001

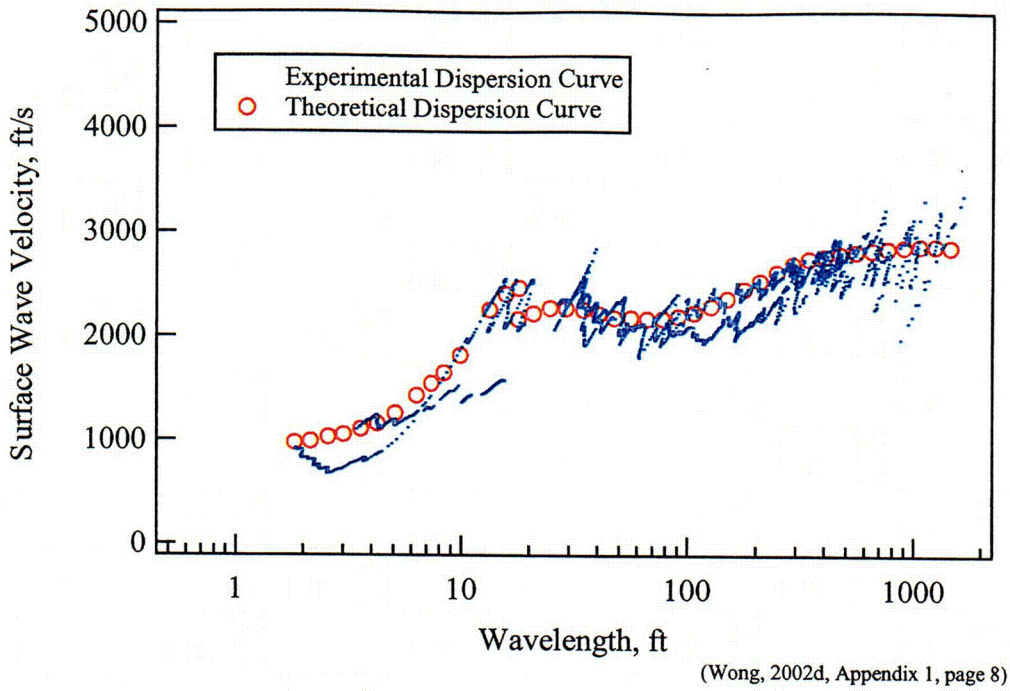
ATTACHMENT XV

SASW VELOCITY PLOTS – YUCCA MOUNTAIN CREST

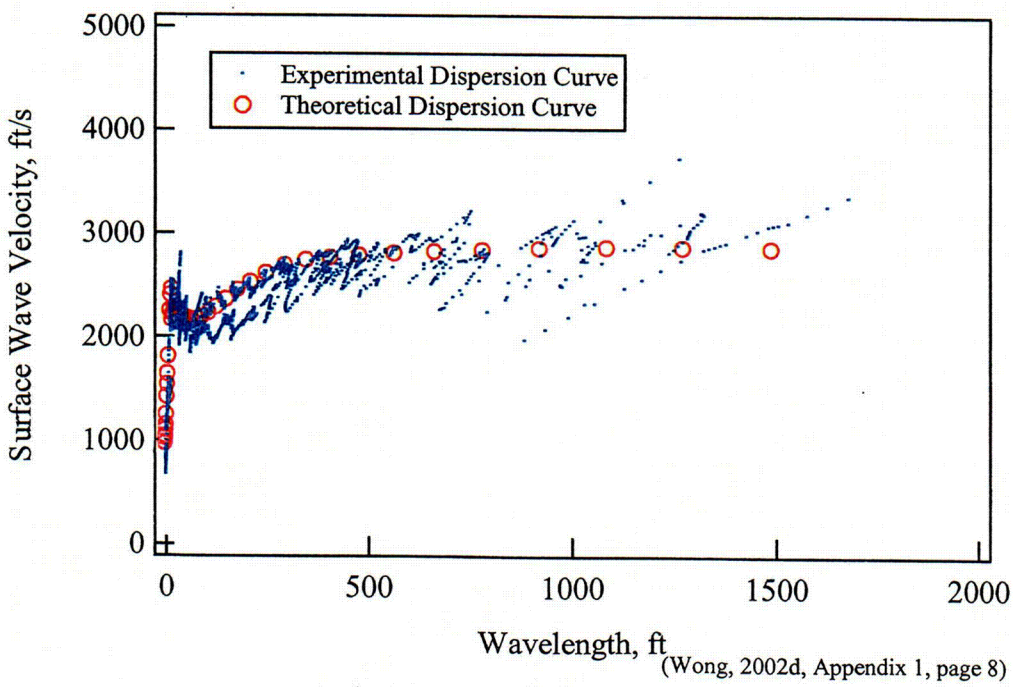
ATTACHMENT XV

SASW VELOCITY PLOTS – YUCCA MOUNTAIN CREST

As described in Section 6.4.2, this attachment contains 31 figures presenting detailed interpretive results for SASW surveys conducted at the crest of Yucca Mountain. Figures XV-1 through XV-7 are for the seven "C" sites, Figures XV-8 through XV-19 are for the twelve "S" sites, and Figures XV-20 through XV-31 are for the twelve "D" sites. Site D-12 is actually on Exile Hill. A detailed description of each analysis can be found in the associated appendix in SN-M&O-SCI-023-V1 (Wong 2002d) or SN-M&O-SCI-040-V1 (Wong 2002a).



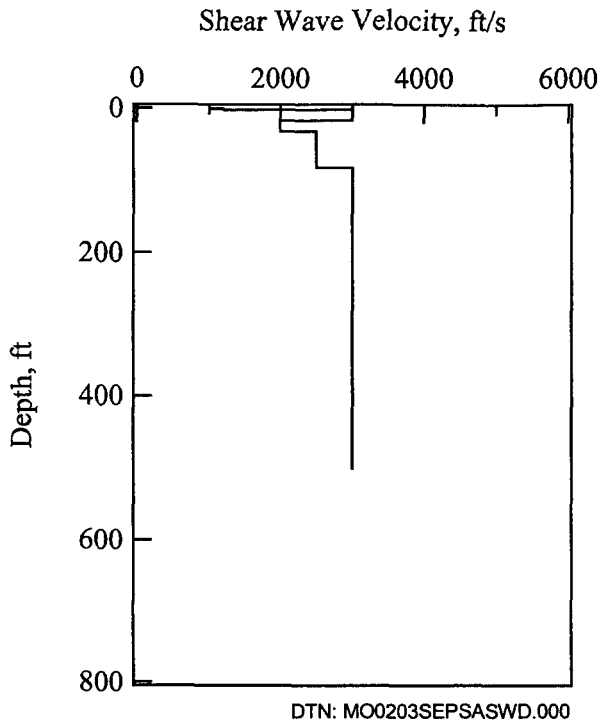
a. SASW C-1 Dispersion Curves (Log Plot)



b. SASW C-1 Dispersion Curves (Linear Plot)

Figure XV-1. SASW-C-1 Results

C06



c. SASW C-1 Shear Wave Velocity Profile

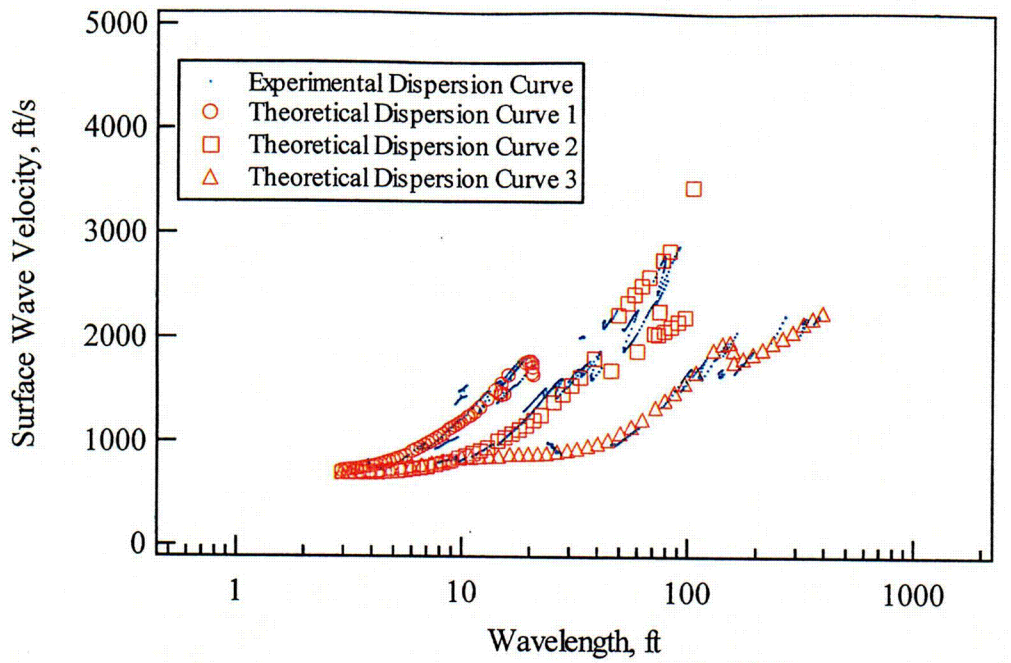
Location: SASW C-1

Layer No.	Thickness, ft	P-Wave Velocity, ft/s	S-Wave Velocity, ft/s	Poisson's Ratio*	Mass Density* pcf
1	1	1732	1000	0.25	145
2	1.5	2079	1200	0.25	145
3	15	5196	3000	0.25	145
4	15	3464	2000	0.25	145
5	50	4330	2500	0.25	145
6	420	5542	3200	0.25	145

DTN: MO0203SEPSASWD.000

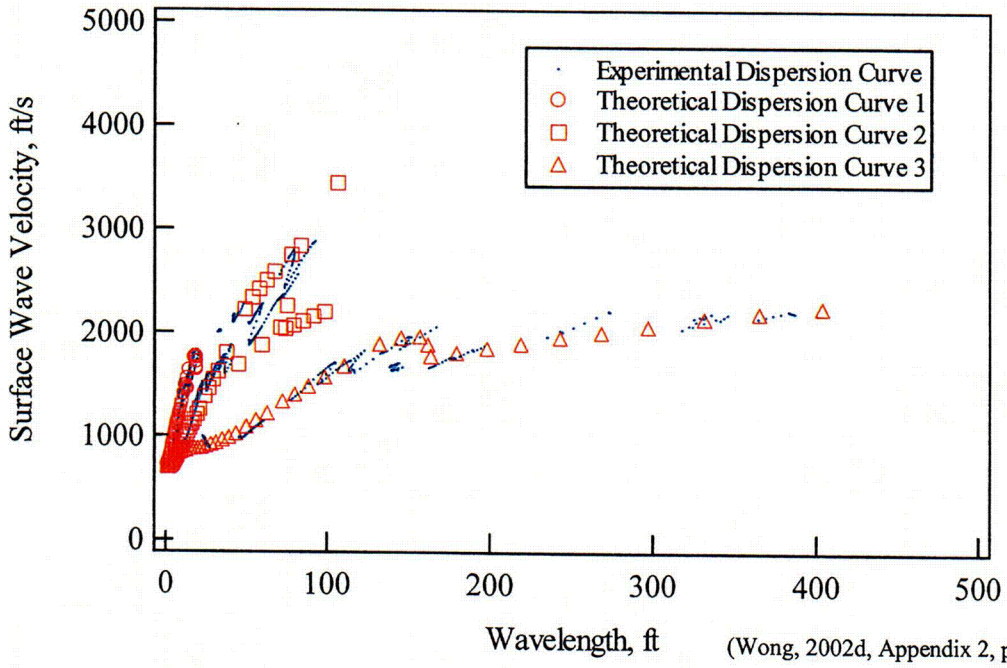
*Poisson's ratio and mass density from Wong (2002d, Appendix 1, page 9)

Figure XV-1. SASW-C1 Results (continued)



(Wong, 2002d, Appendix 2, page 17)

a. SASW C-2 Dispersion Curves (Log Plot)

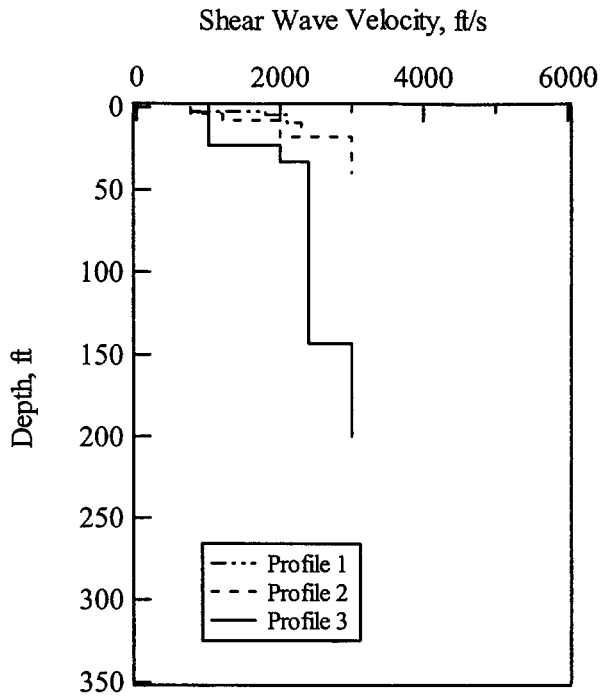


(Wong, 2002d, Appendix 2, page 17)

b. SASW C-2 Dispersion Curves (Linear Plot)

Figure XV-2. SASW-C2 Results

C07



DTN: MO0203SEPSASWD.000

c. SASW C-2 Shear Wave Velocity Profile

Location: SASW C-2-Profile 1

Layer No.	Thickness, ft	P-Wave Velocity, ft/s	S-Wave Velocity, ft/s	Poisson's Ratio*	Mass Density* pcf
1	2.5	1299	750	0.25	145
2	2	3118	1800	0.25	145
3	5	3637	2100	0.25	145
4	3	3984	2300	0.25	145

Location: SASW C-2-Profile 2

Layer No.	Thickness, ft	P-Wave Velocity, ft/s	S-Wave Velocity, ft/s	Poisson's Ratio*	Mass Density* pcf
1	4	1299	750	0.25	145
2	4	2078	1200	0.25	145
3	10	3464	2000	0.25	145
4	22	5196	3000	0.25	145

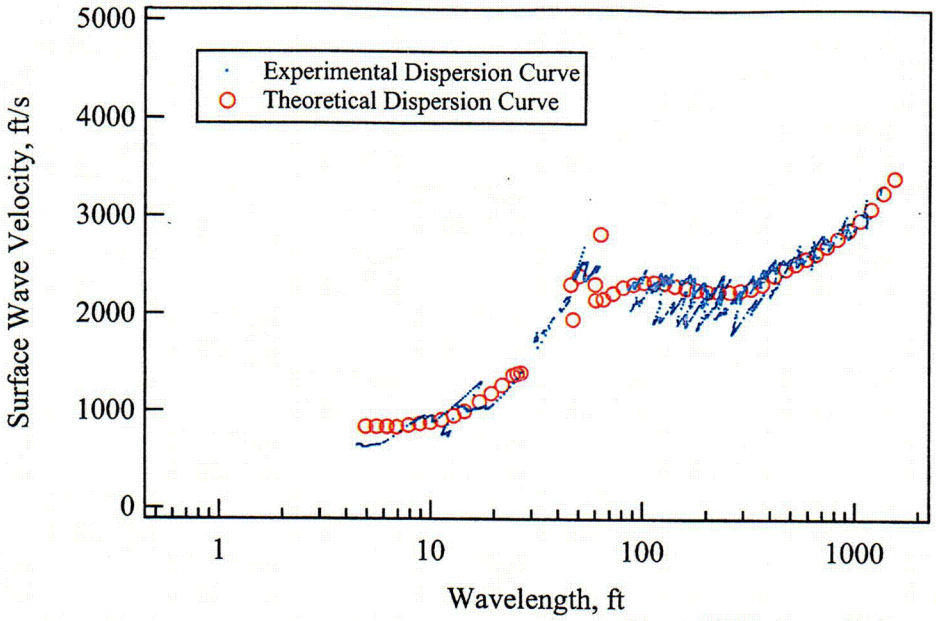
Location: SASW C-2-Profile 3

Layer No.	Thickness, ft	P-Wave Velocity, ft/s	S-Wave Velocity, ft/s	Poisson's Ratio*	Mass Density* pcf
1	3	1299	750	0.25	145
2	20	1732	1000	0.25	145
3	10	3464	2000	0.25	145
4	110	4156	2400	0.25	145
5	57	5196	3000	0.25	145

DTN: MO0203SEPSASWD.000

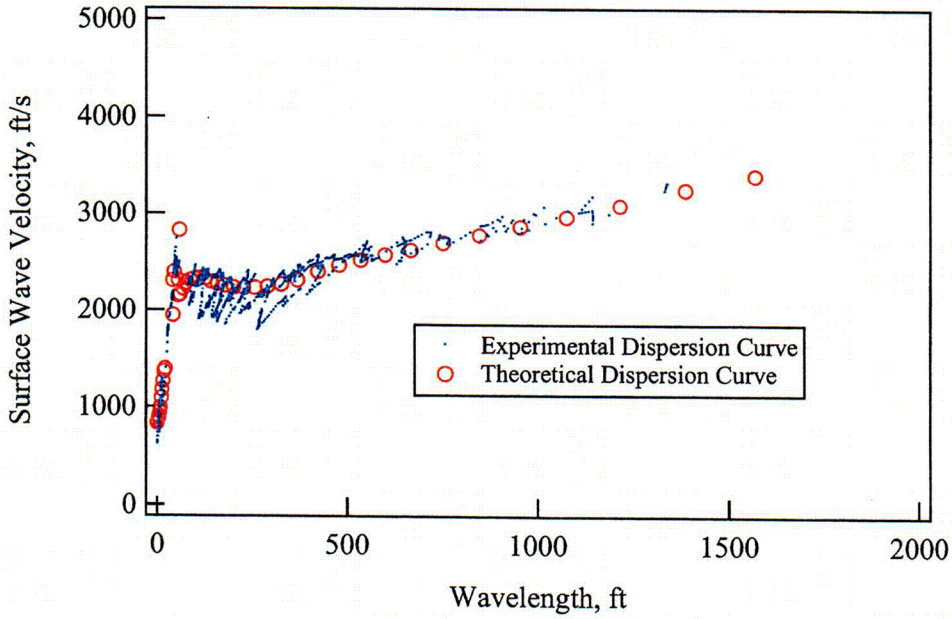
* Poisson's ratio and mass density from Wong (2002d, Appendix 2, page 19)

Figure XV-2. SASW-C2 Results (continued)



Wong, 2002d, Appendix 3, page 28)

a. SASW C-3 Dispersion Curves (Log Plot)

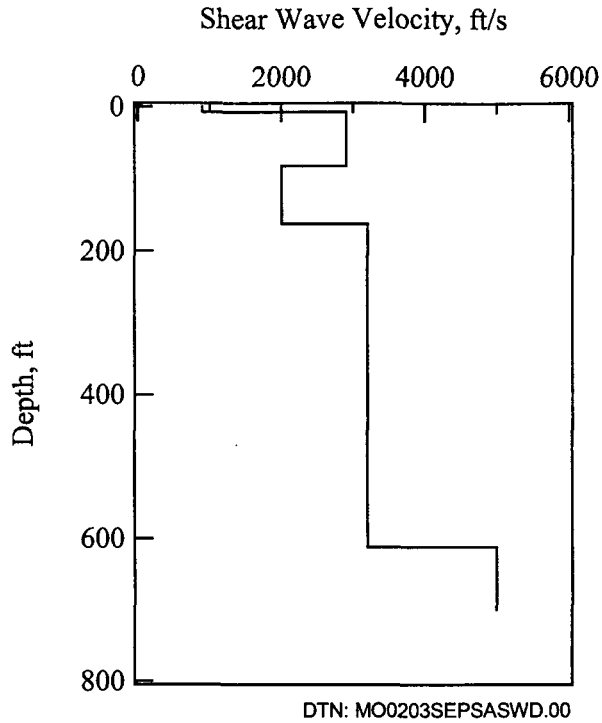


Wong, 2002d, Appendix 3, page 28)

b. SASW C-3 Dispersion Curves (Linear Plot)

Figure XV-3. SASW-C3 Results

C08



c. SASW C-3 Shear Wave Velocity Profile

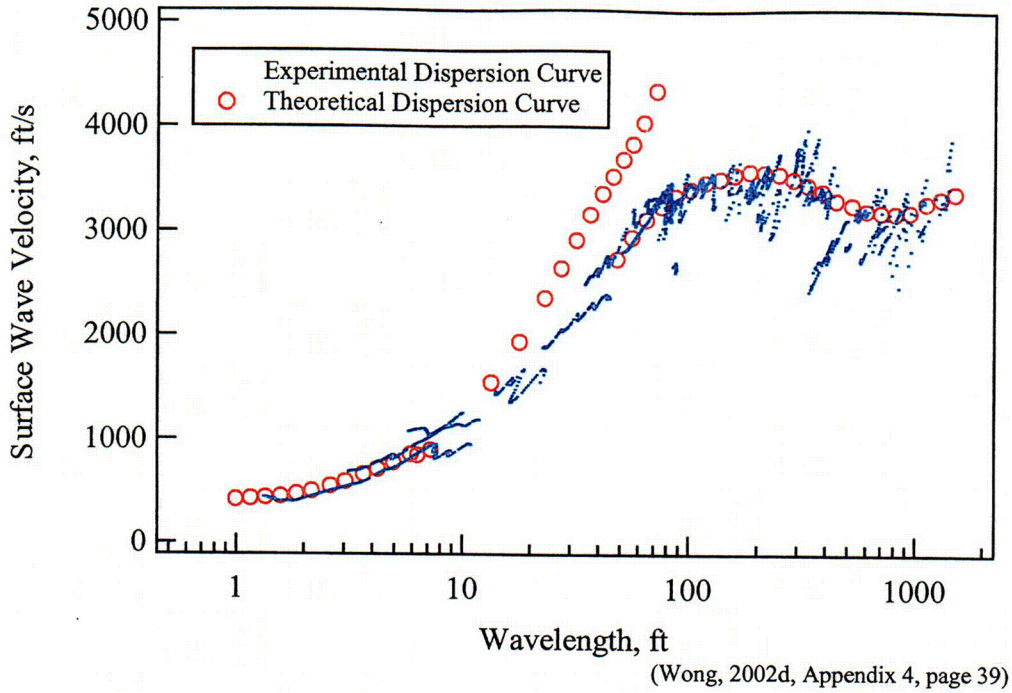
Location: SASW C-3

Layer No.	Thickness, ft	P-Wave Velocity, ft/s	S-Wave Velocity, ft/s	Poisson's Ratio*	Mass Density* pcf
1	7	1559	900	0.25	145
2	75	5022	2900	0.25	145
3	80	3464	2000	0.25	145
4	450	5542	3200	0.25	145
5	88	8660	5000	0.25	145

DTN: MO0203SEPSASWD.000

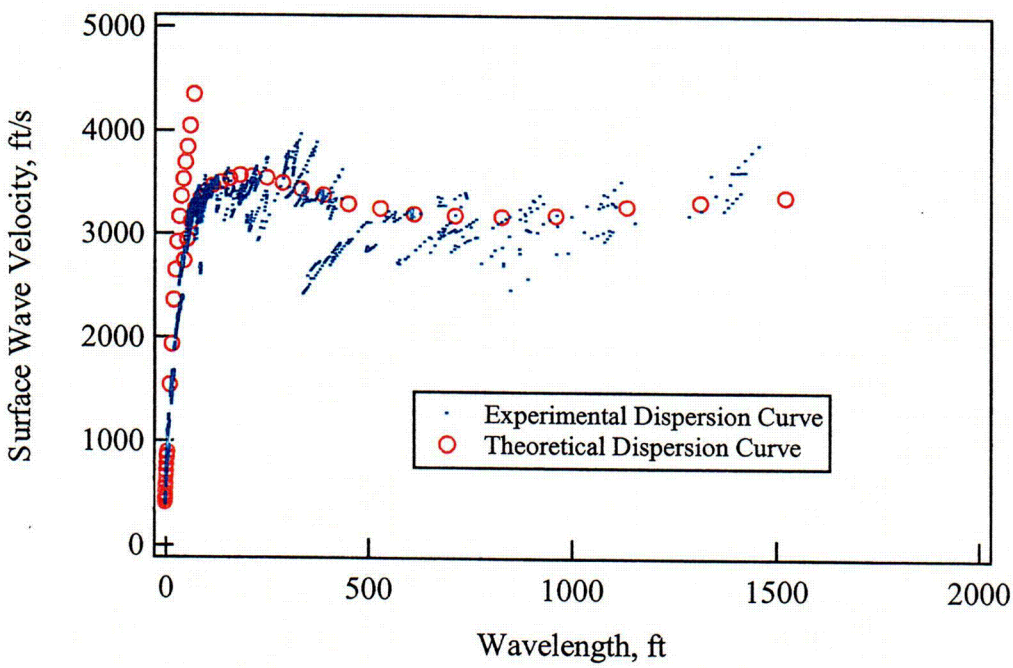
* Poisson's ratio and mass density from Wong (2002d, Appendix 3, page 30)

Figure XV-3. SASW-C3 Results (continued)



(Wong, 2002d, Appendix 4, page 39)

a. SASW C-4 Dispersion Curves (Log Plot)

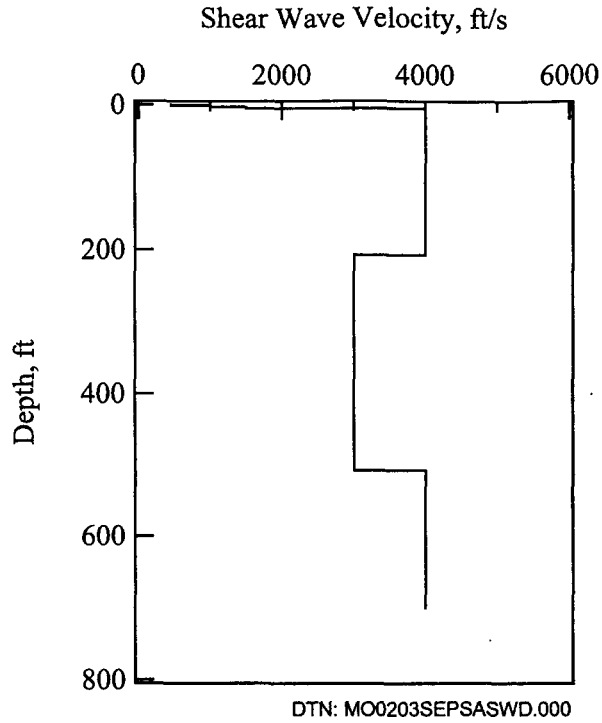


(Wong, 2002d, Appendix 4, page 39)

b. SASW C-4 Dispersion Curves (Linear Plot)

Figure XV-4. SASW-C4 Results

009



c. SASW C-4 Shear Wave Velocity Profile

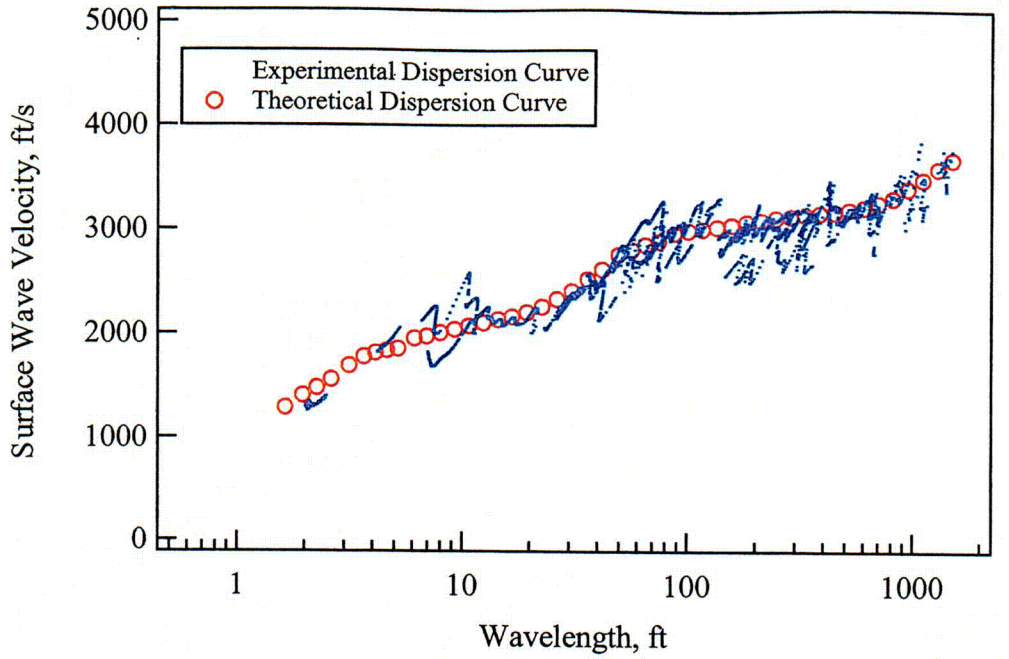
Location: SASW C-4

Layer No.	Thickness, ft	P-Wave Velocity, ft/s	S-Wave Velocity, ft/s	Poisson's Ratio*	Mass Density* pcf
1	1	779	450	0.25	145
2	2	1732	1000	0.25	145
3	2	2598	1500	0.25	145
4	200	6928	4000	0.25	145
5	300	5196	3000	0.25	145
6	200	6928	4000	0.25	145

DTN: MO0203SEPSASWD.000

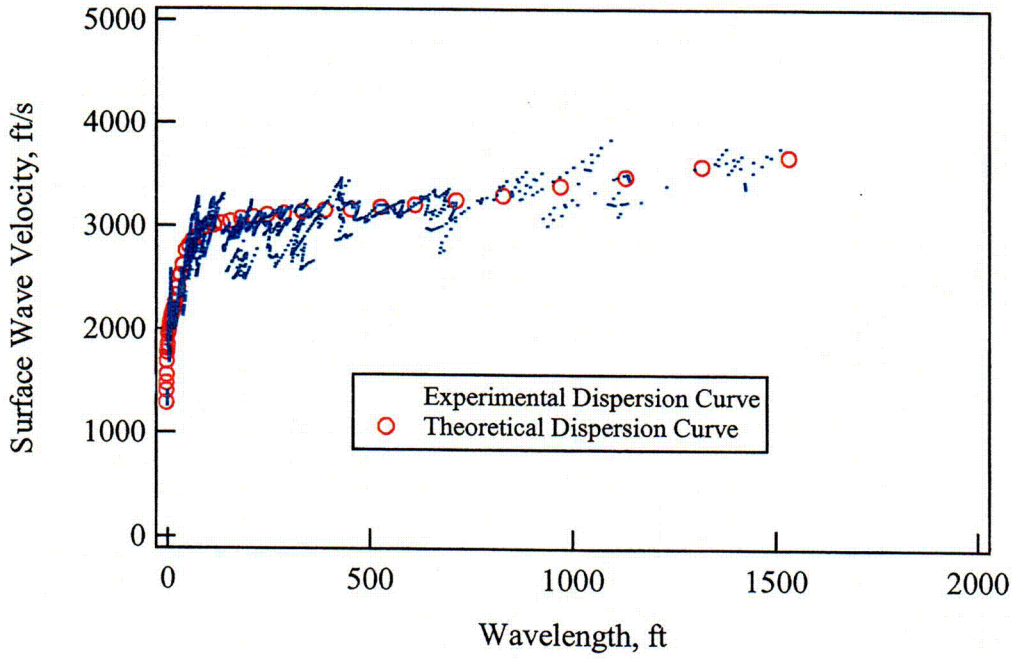
* Poisson's ratio and mass density from Wong (2002d, Appendix 4, page 41)

Figure XV-4. SASW-C4 Results (continued)



(Wong, 2002d, Appendix 5, page 49)

a. SASW C-5 Dispersion Curves (Log Plot)

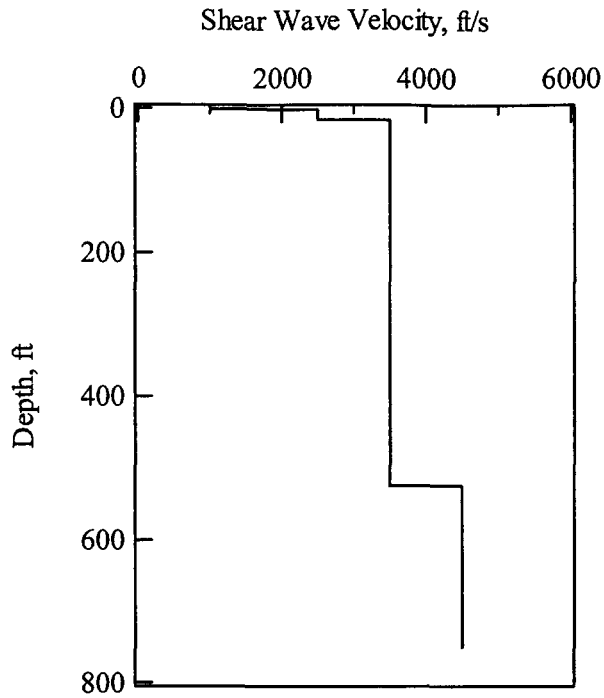


(Wong, 2002d, Appendix 5, page 49)

b. SASW C-5 Dispersion Curves (Linear Plot)

Figure XV-5. SASW-C5 Results

C10



DTN: MO0203SEPSASWD.000

c. SASW C-5 Shear Wave Velocity Profile

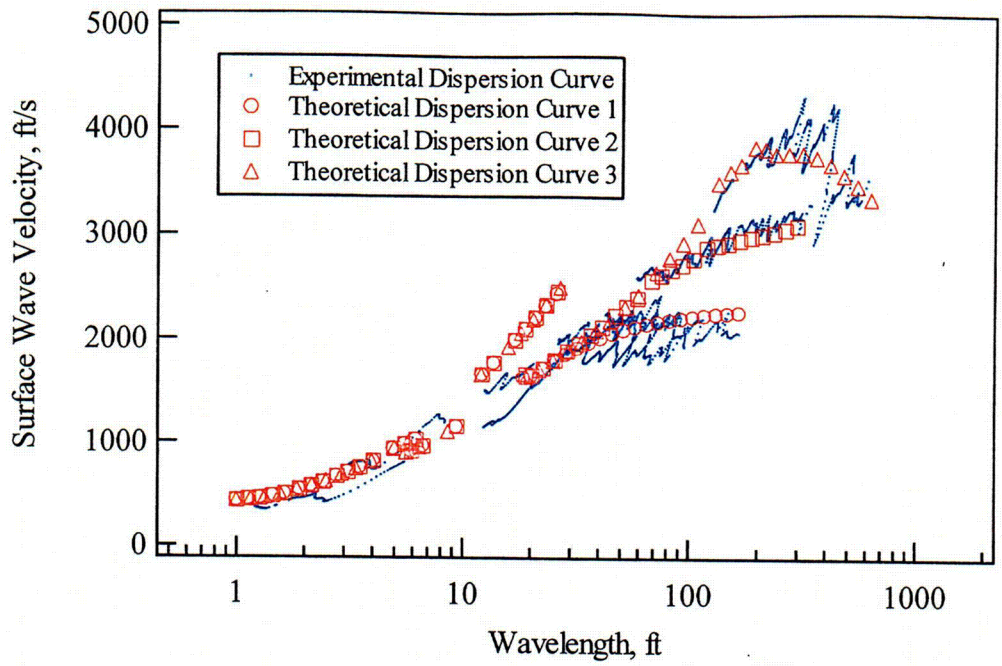
Location: SASW C-5

Layer No.	Thickness, ft	P-Wave Velocity, ft/s	S-Wave Velocity, ft/s	Poisson's Ratio*	Mass Density* pcf
1	0.5	1732	1000	0.25	145
2	1	3117	1800	0.25	145
3	14.5	4330	2500	0.25	145
4	508	6062	3500	0.25	145
5	226	7794	4500	0.25	145

DTN: MO0203SEPSASWD.000

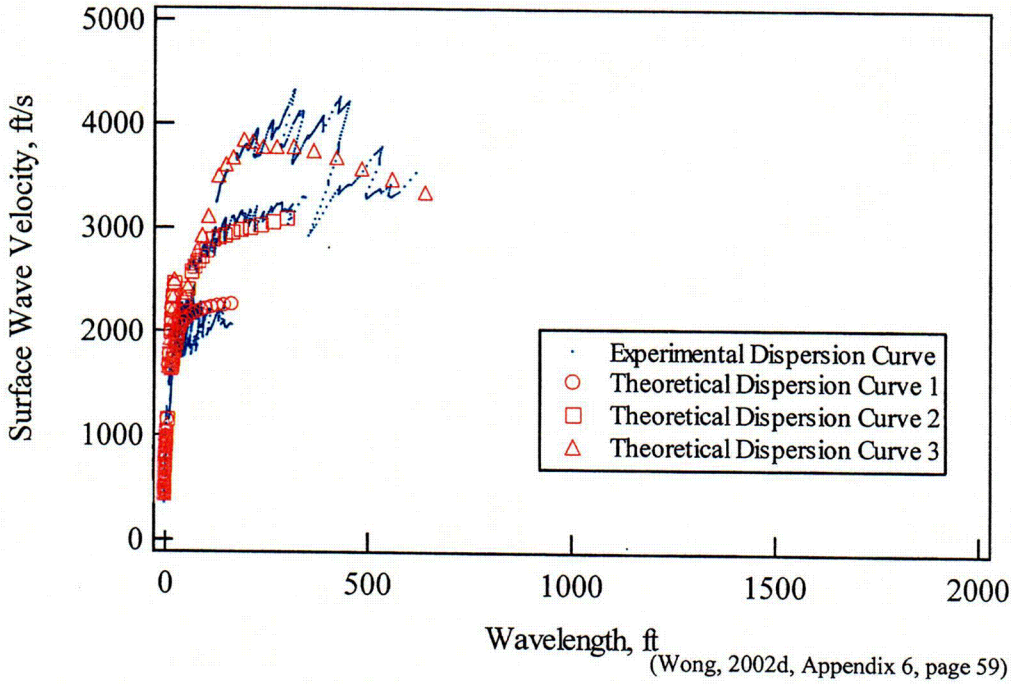
* Poisson's ratio and mass density from Wong (2002d, Appendix 5, page 51)

Figure XV-5. SASW-C5 Results (continued)



(Wong, 2002d, Appendix 6, page 59)

a. SASW C-6 Dispersion Curves (Log Plot)

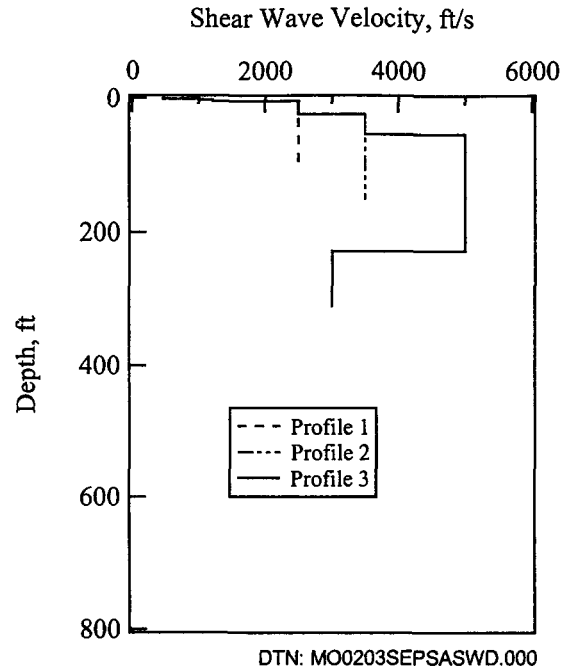


(Wong, 2002d, Appendix 6, page 59)

b. SASW C-6 Dispersion Curves (Linear Plot)

Figure XV-6. SASW-C6 Results

C11



c. SASW C-6 Shear Wave Velocity Profile

Location: SASW C-6 Profile 1

Layer No.	Thickness, ft	P-Wave Velocity, ft/s	S-Wave Velocity, ft/s	Poisson's Ratio*	Mass Density* pcf
1	0.75	779	450	0.25	145
2	1	1732	1000	0.25	145
3	2	2078	1200	0.25	145
4	96	4330	2500	0.25	145

Location: SASW C-6 Profile 2

Layer No.	Thickness, ft	P-Wave Velocity, ft/s	S-Wave Velocity, ft/s	Poisson's Ratio*	Mass Density* pcf
1	0.75	779	450	0.25	145
2	1	1732	1000	0.25	145
3	2	2078	1200	0.25	145
4	20	4330	2500	0.25	145
5	152	6062	3500	0.25	145

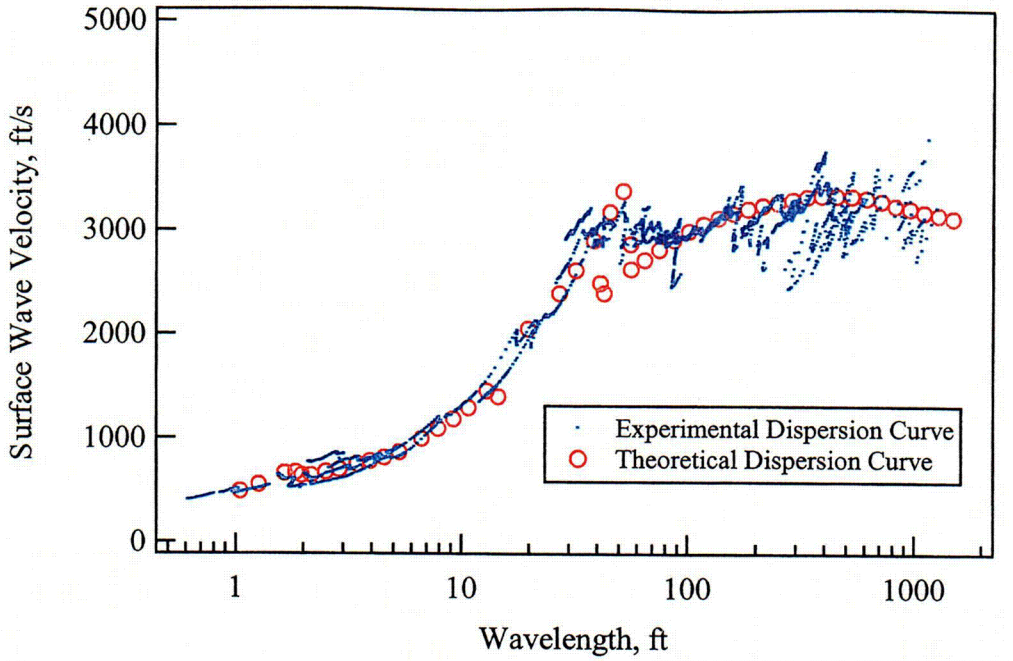
Location: SASW C-6 Profile 3

Layer No.	Thickness, ft	P-Wave Velocity, ft/s	S-Wave Velocity, ft/s	Poisson's Ratio*	Mass Density* pcf
1	0.75	779	450	0.25	145
2	1	1732	1000	0.25	145
3	2	2078	1200	0.25	145
4	20	4330	2500	0.25	145
5	30	6062	3500	0.25	145
6	175	8660	5000	0.25	145
7	70	5196	3000	0.25	145

DTN: MO0203SEPSASWD.000

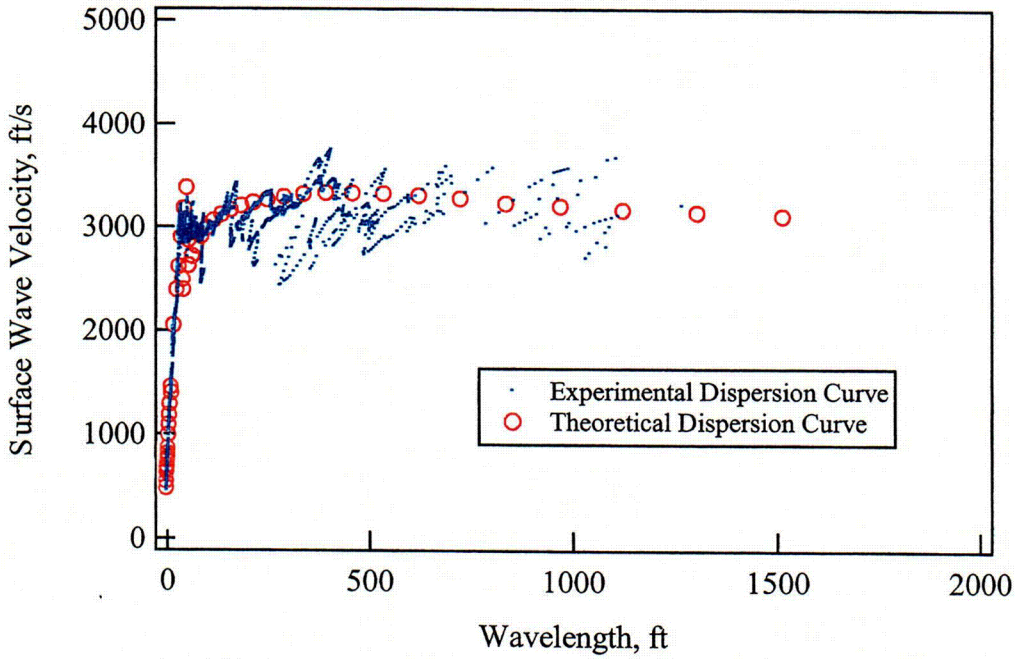
*Poisson's ratio and mass density from Wong (2002d, Appendix 6, page 61)

Figure XV-6. SASW-C6 Results (continued)



(Wong, 2002d, Appendix 7, page 70)

a. SASW C-7 Dispersion Curves (Log Plot)

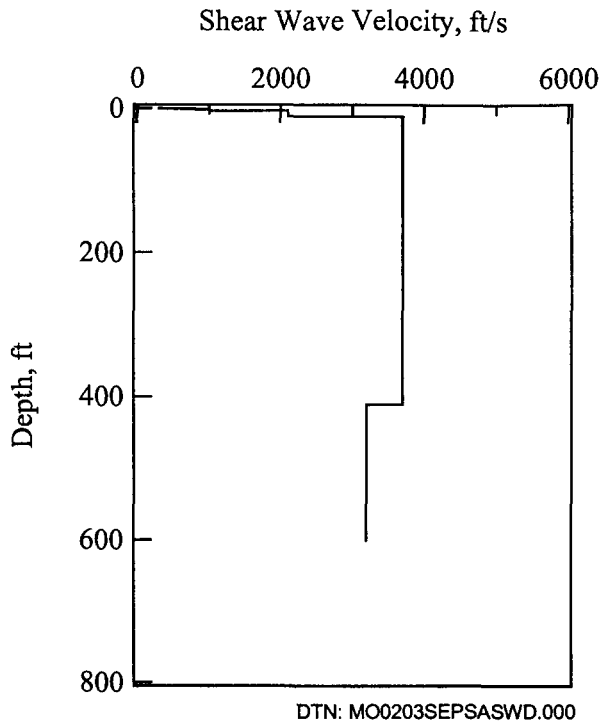


(Wong, 2002d, Appendix 7, page 70)

b. SASW C-7 Dispersion Curves (Linear Plot)

Figure XV-7. SASW-C7 Results

C12



c. SASW C-7 Shear Wave Velocity Profile

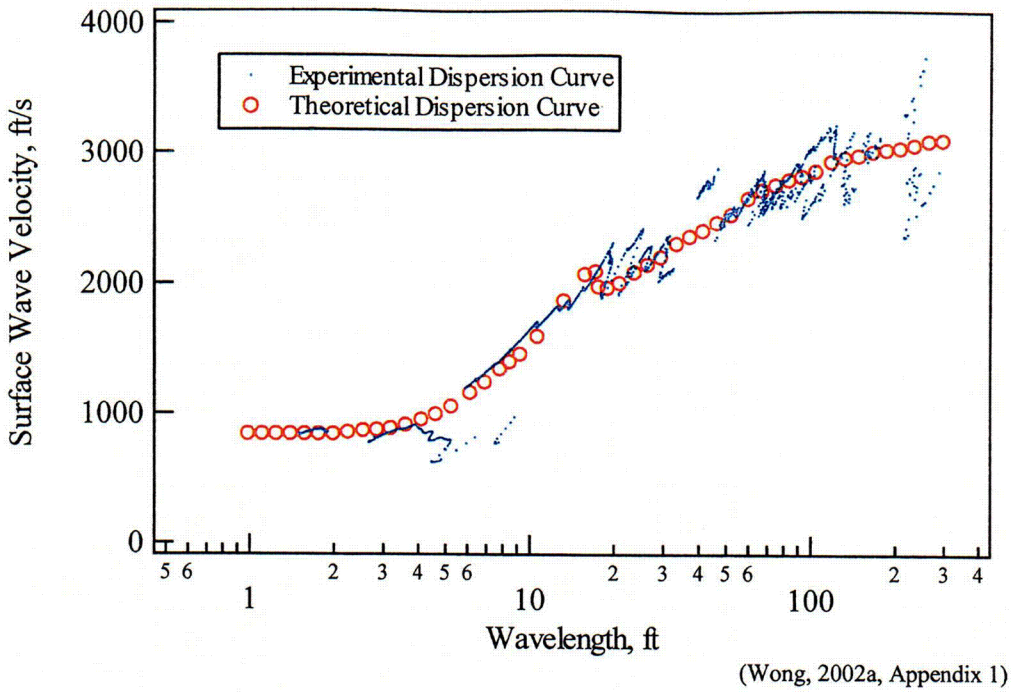
Location: SASW C-7

Layer No.	Thickness, ft	P-Wave Velocity, ft/s	S-Wave Velocity, ft/s	Poisson's Ratio*	Mass Density* pcf
1	0.25	519	300	0.25	145
2	1	1385	800	0.25	145
3	2	1732	1000	0.25	145
4	8	3637	2100	0.25	145
5	400	6409	3700	0.25	145
6	190	5542	3200	0.25	145

DTN: MO0203SEPSASWD.000

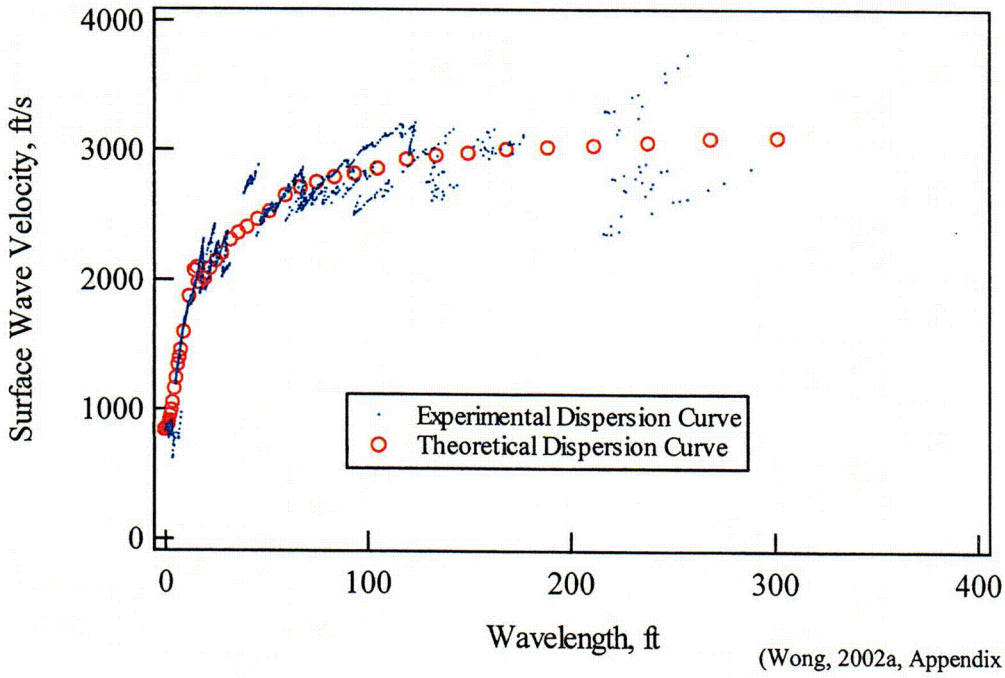
* Poisson's ratio and mass density from Wong (2002d, Appendix 7, page 72)

Figure XV-7. SASW-C7 Results (continued)



(Wong, 2002a, Appendix 1)

a. SASW-S1 Dispersion Curves (Log Plot)

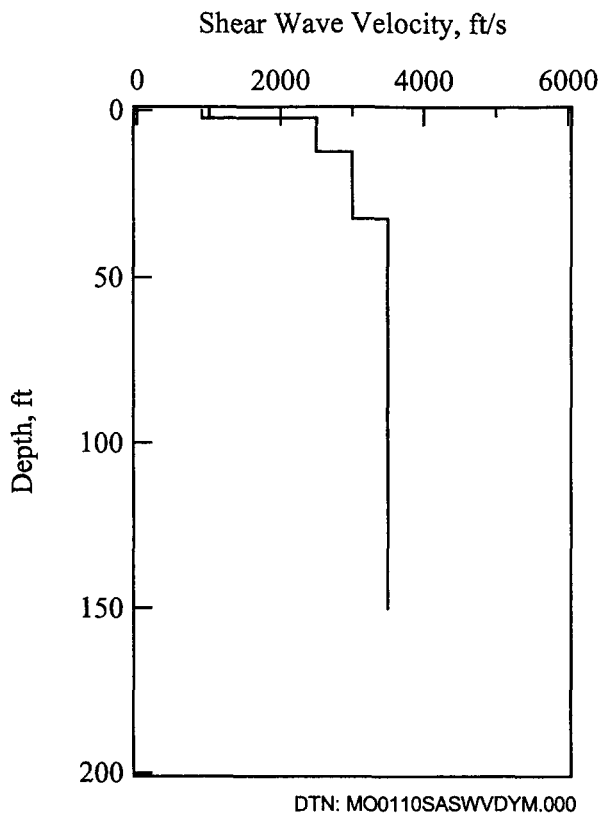


(Wong, 2002a, Appendix 1)

b. SASW-S1 Dispersion Curves (Linear Plot)

Figure XV-8. SASW-S1 Results

C13



c. SASW-S1 Shear Wave Velocity Profile

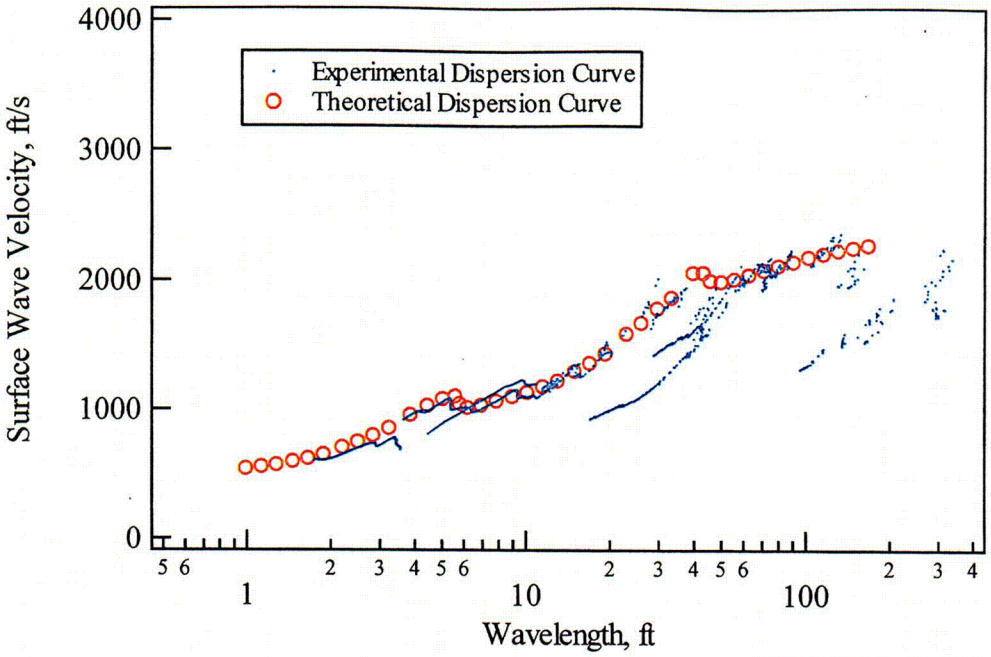
Location: SASW-S1

Layer No.	Thickness, ft	P-Wave Velocity, ft/s	S-Wave Velocity, ft/s	Poisson's Ratio*	Mass Density* pcf
1	2.25	1559	900	0.25	145
2	10	4330	2500	0.25	145
3	20	5196	3000	0.25	145
4	118	6062	3500	0.25	145

DTN: MO0110SASWVDYM.000

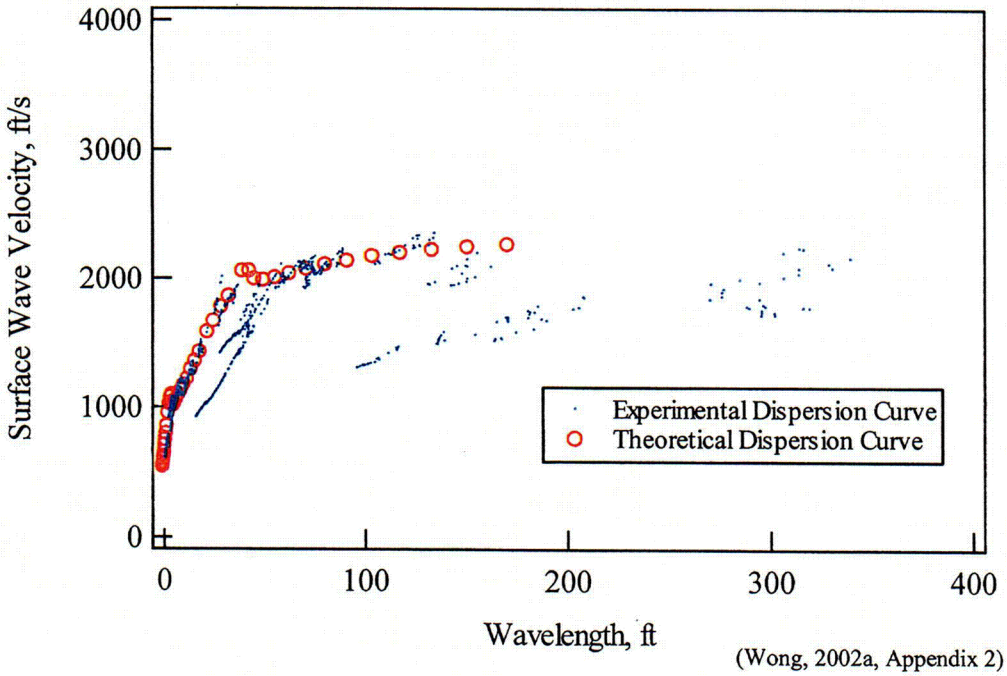
* Poisson's ratio and mass density from Wong (2002a, Appendix 1)

Figure XV-8. SASW-S1 Results (continued)



(Wong, 2002a, Appendix 2)

a. SASW-S2 Dispersion Curves (Log Plot)

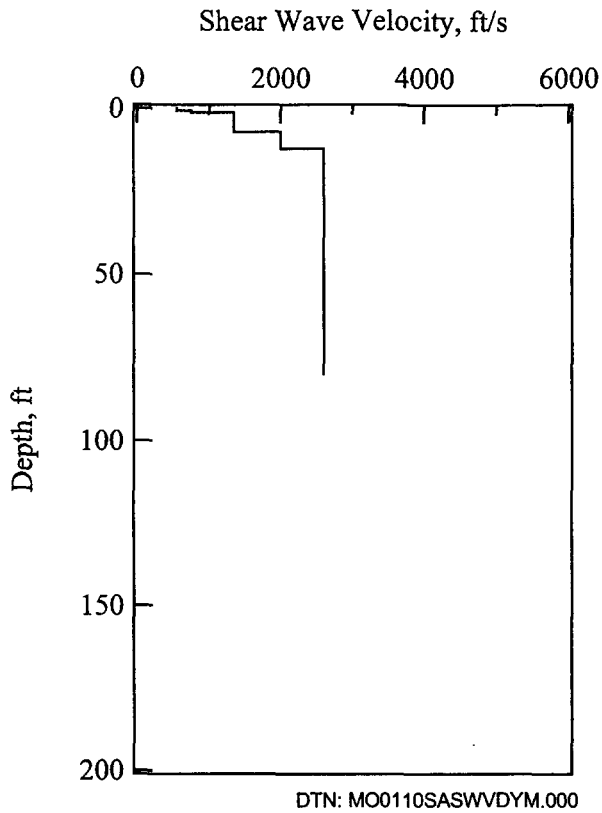


(Wong, 2002a, Appendix 2)

b. SASW-S2 Dispersion Curves (Linear Plot)

Figure XV-9. SASW-S2 Results

C14



c. SASW-S2 Shear Wave Velocity Profile

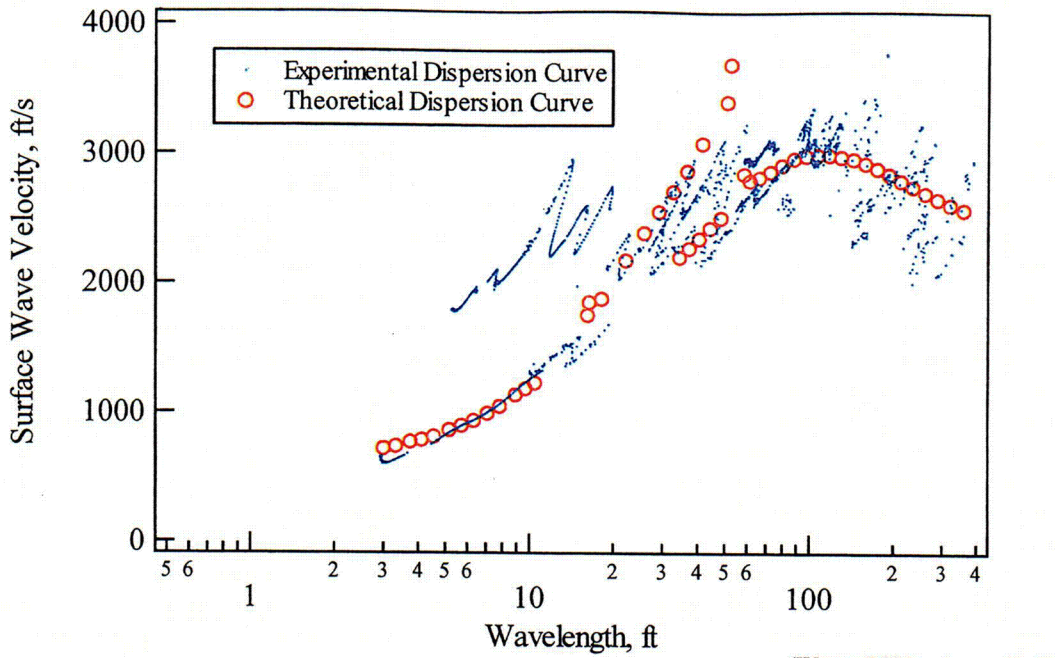
Location: SASW-S2

Layer No.	Thickness, ft	P-Wave Velocity, ft/s	S-Wave Velocity, ft/s	Poisson's Ratio*	Mass Density* pcf
1	0.6	953	550	0.25	145
2	0.5	1299	750	0.25	145
3	6	2338	1350	0.25	145
4	5	3464	2000	0.25	145
5	67	4503	2600	0.25	145

DTN: MO0110SASWVDYM.000

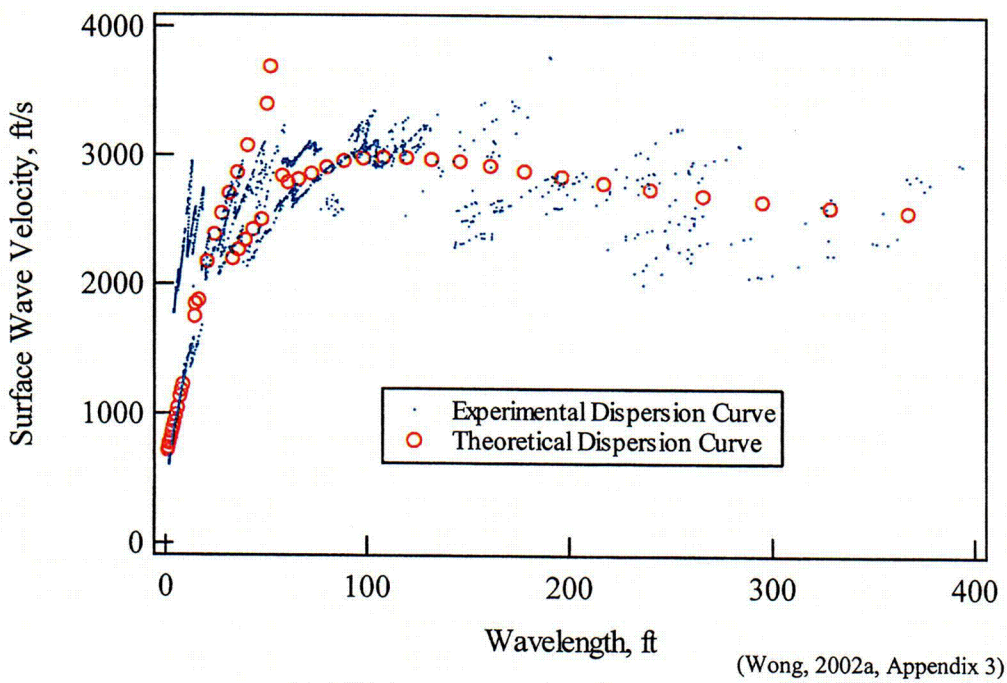
* Poisson's ratio and mass density from Wong (2002a, Appendix 2)

Figure XV-9. SASW-S2 Results (continued)



(Wong, 2002a, Appendix 3)

a. SASW-S3 Dispersion Curves (Log Plot)

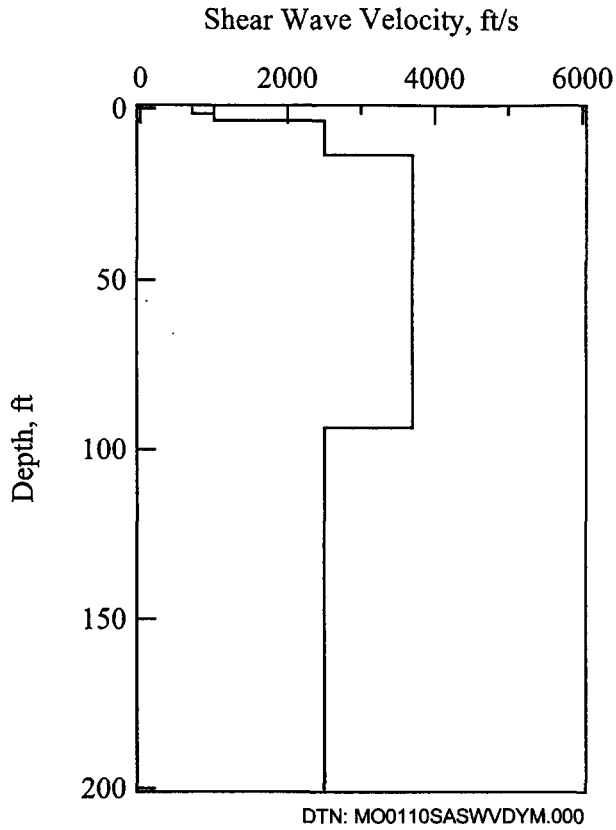


(Wong, 2002a, Appendix 3)

b. SASW-S3 Dispersion Curves (Linear Plot)

Figure XV-10. SASW-S3 Results

C15



c. SASW-S3 Shear Wave Velocity Profile

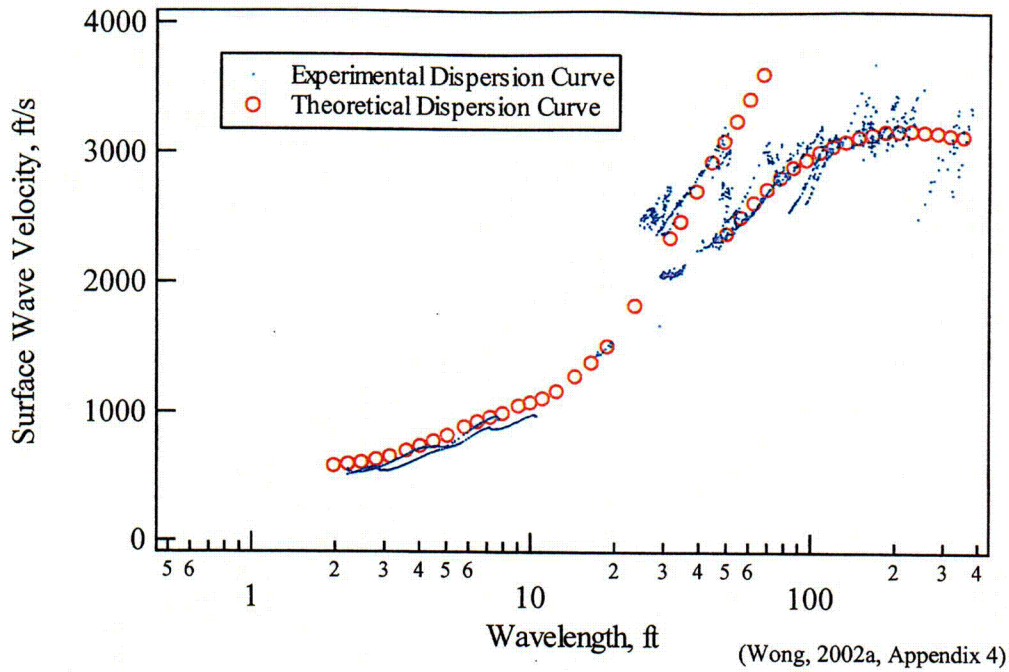
Location: SASW-S3

Layer No.	Thickness, ft	P-Wave Velocity, ft/s	S-Wave Velocity, ft/s	Poisson's Ratio*	Mass Density* pcf
1	1.5	1212	700	0.25	145
2	2	1732	1000	0.25	145
3	10	4330	2500	0.25	145
4	80	6409	3700	0.25	145
5	107	4330	2500	0.25	145

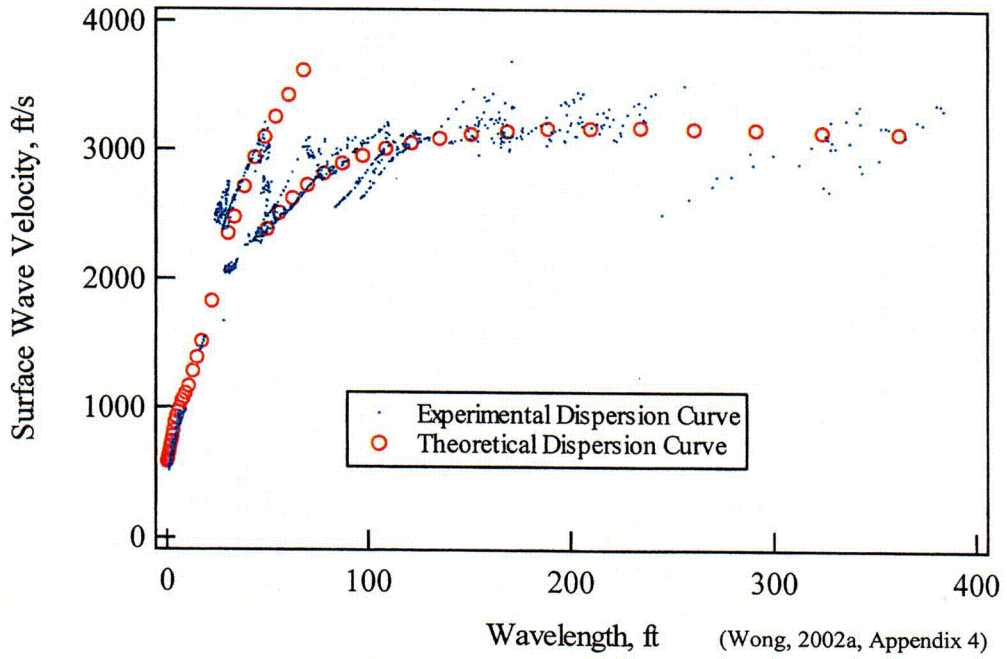
DTN: MO0110SASWVDYM.000

* Poisson's ratio and mass density from Wong (2002a, Appendix 3)

Figure XV-10. SASW-S3 Results (continued)



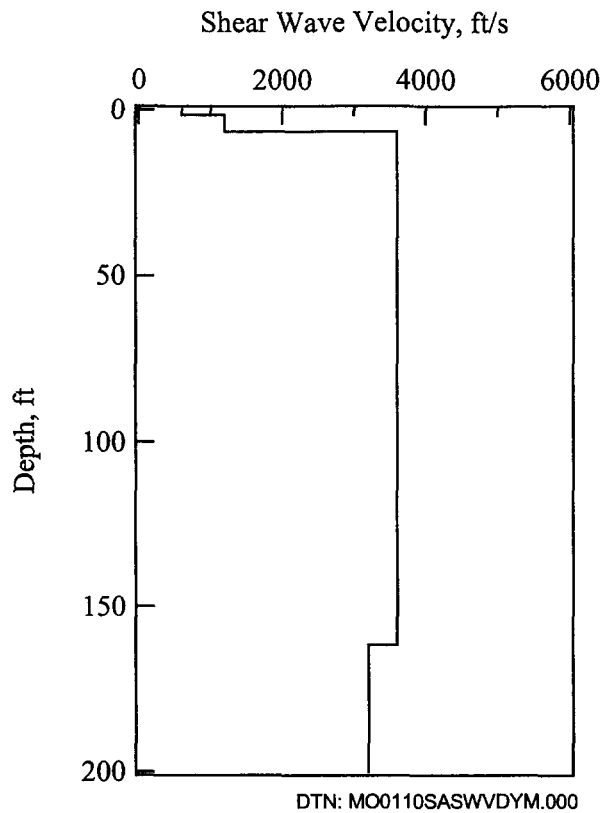
a. SASW-S4 Dispersion Curves (Log Plot)



b. SASW-S4 Dispersion Curves (Linear Plot)

Figure XV-11. SASW-S4 Results

C16



c. SASW-S4 Shear Wave Velocity Profile

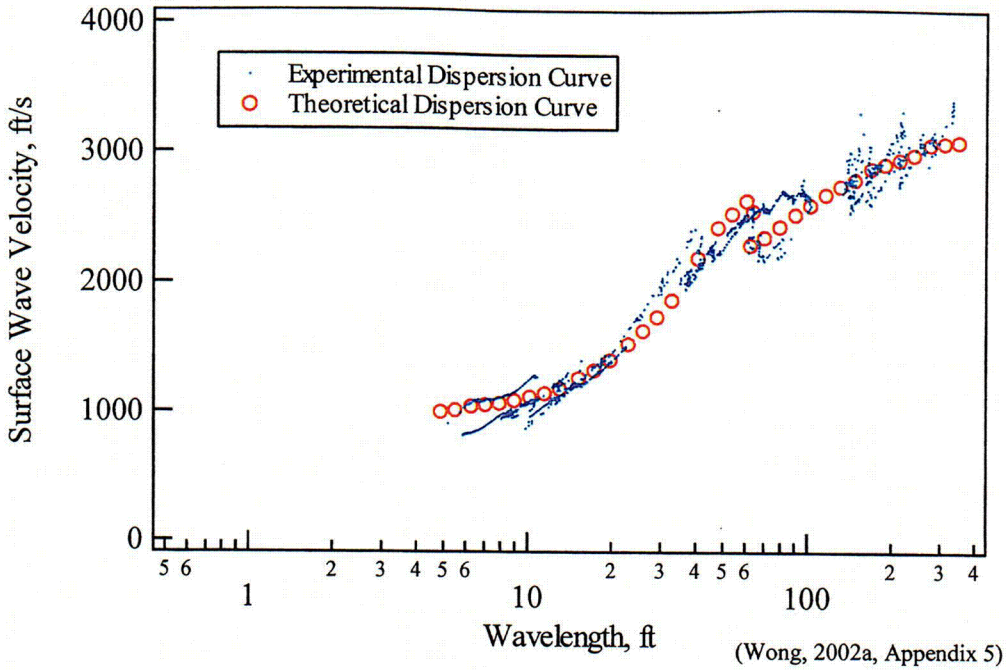
Location: SASW-S4

Layer No.	Thickness, ft	P-Wave Velocity, ft/s	S-Wave Velocity, ft/s	Poisson's Ratio*	Mass Density* pcf
1	1.5	1039	650	0.25	145
2	5	2079	1200	0.25	145
3	155	6235	3600	0.25	145
4	39	5543	3200	0.25	145

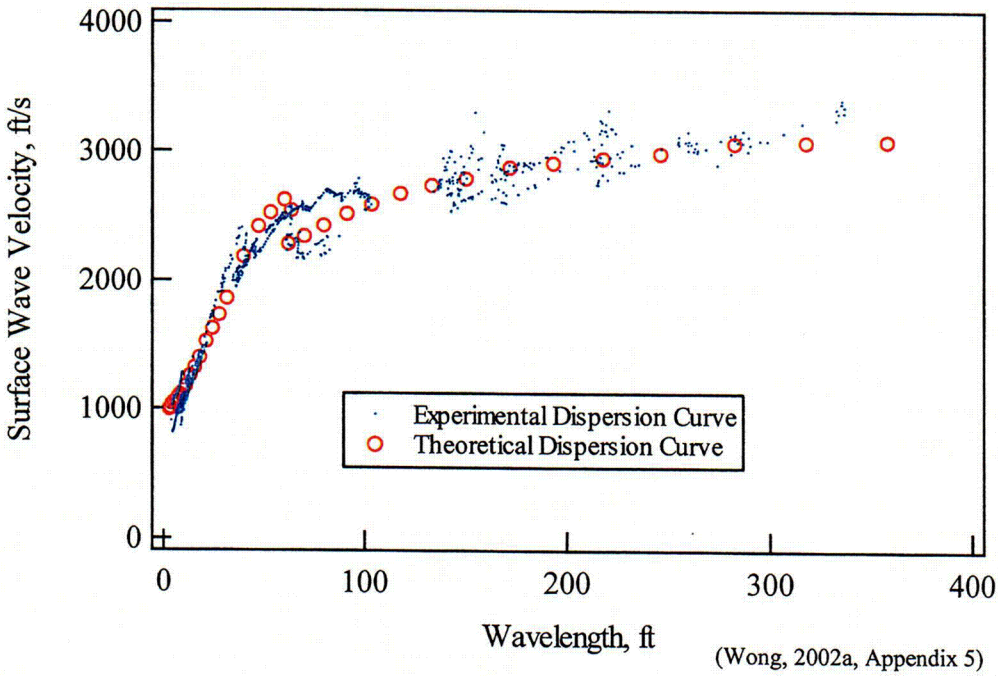
DTN: MO0110SASWVDYM.000

* Poisson's ratio and mass density from Wong (2002a, Appendix 4)

Figure XV-11. SASW-S4 Results (continued)



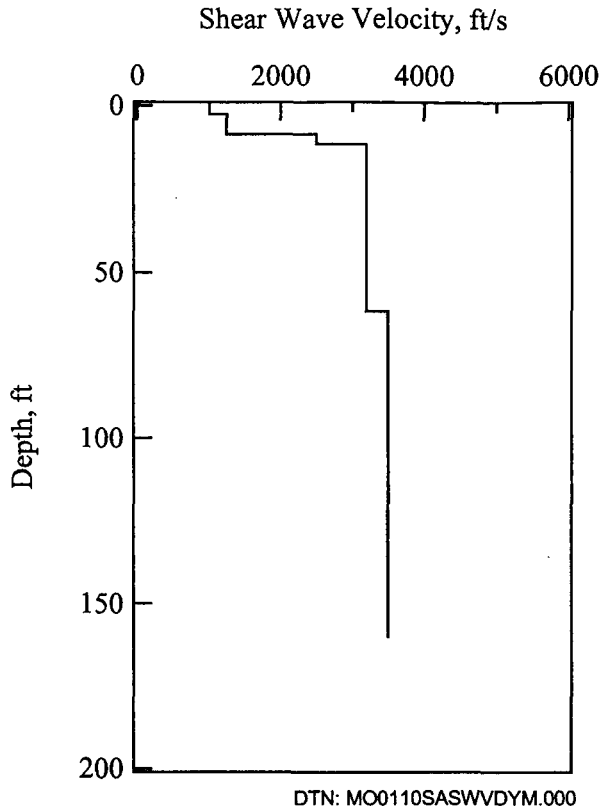
a. SASW-S5 Dispersion Curves (Log Plot)



b. SASW-S5 Dispersion Curves (Linear Plot)

Figure XV-12. SASW-S5 Results

C17



c. SASW-S5 Shear Wave Velocity Profile

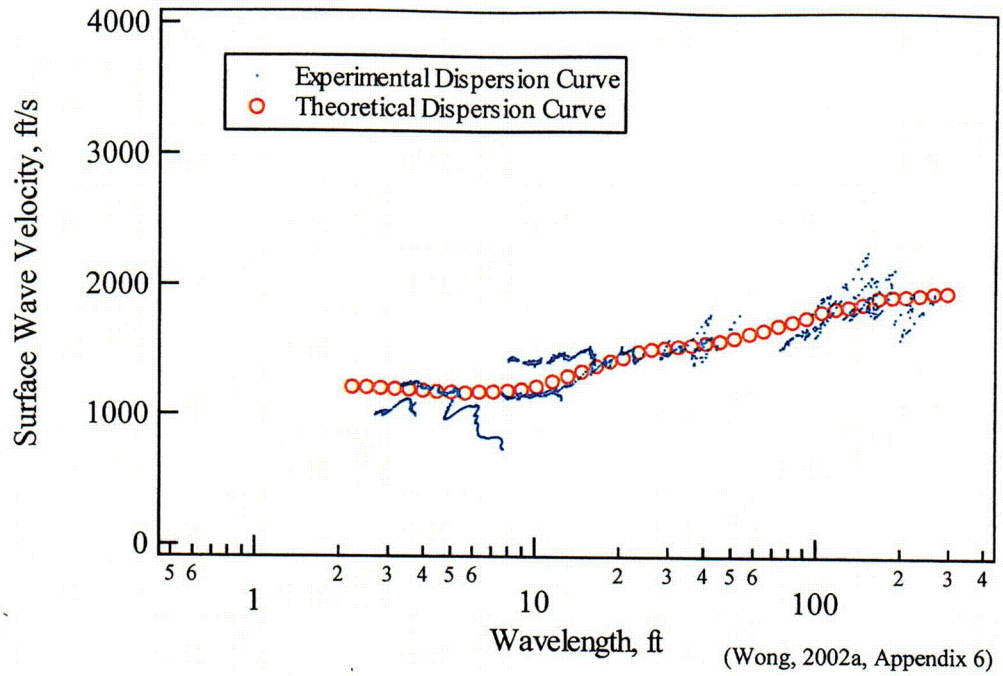
Location: SASW-S5

Layer No.	Thickness, ft	P-Wave Velocity, ft/s	S-Wave Velocity, ft/s	Poisson's Ratio*	Mass Density* pcf
1	2.5	1732	1000	0.25	145
2	6	2165	1250	0.25	145
3	3	4330	2500	0.25	145
4	50	5542	3200	0.25	145
5	98	6062	3500	0.25	145

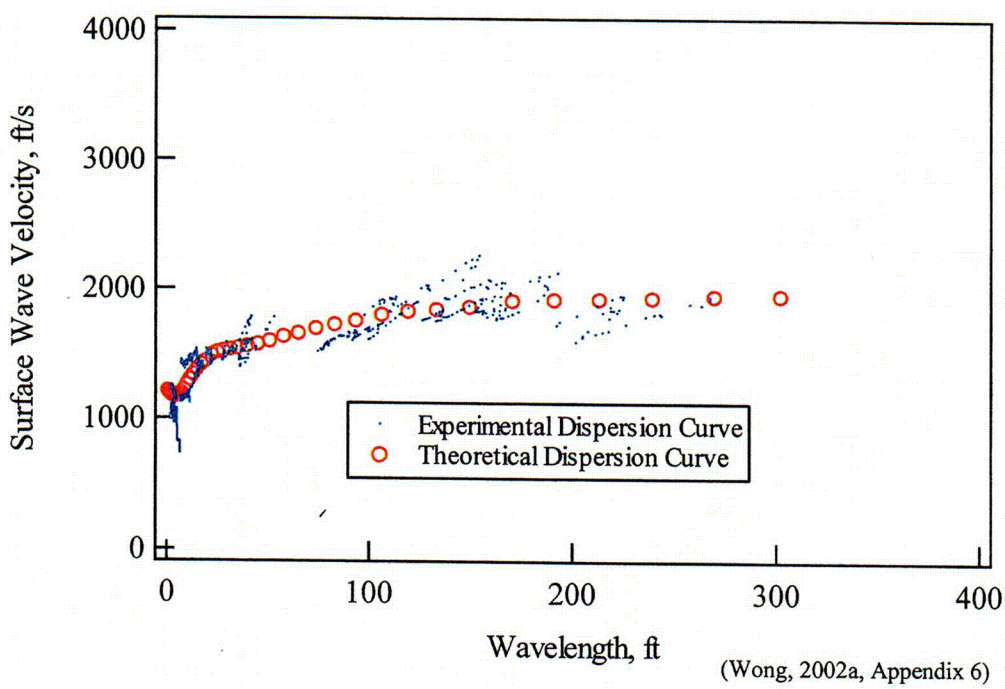
DTN: MO0110SASWVDYM.000

* Poisson's ratio and mass density from Wong (2002a, Appendix 5)

Figure XV-12. SASW-S5 Results (continued)



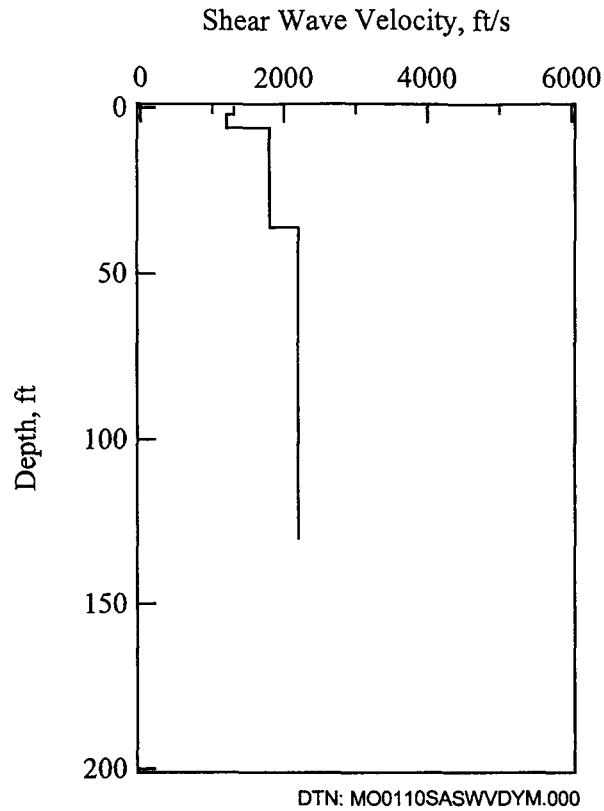
a. SASW-S6 Dispersion Curves (Log Plot)



b. SASW-S6 Dispersion Curves (Linear Plot)

Figure XV-13. SASW-S6 Results

C18



c. SASW-S6 Shear Wave Velocity Profile

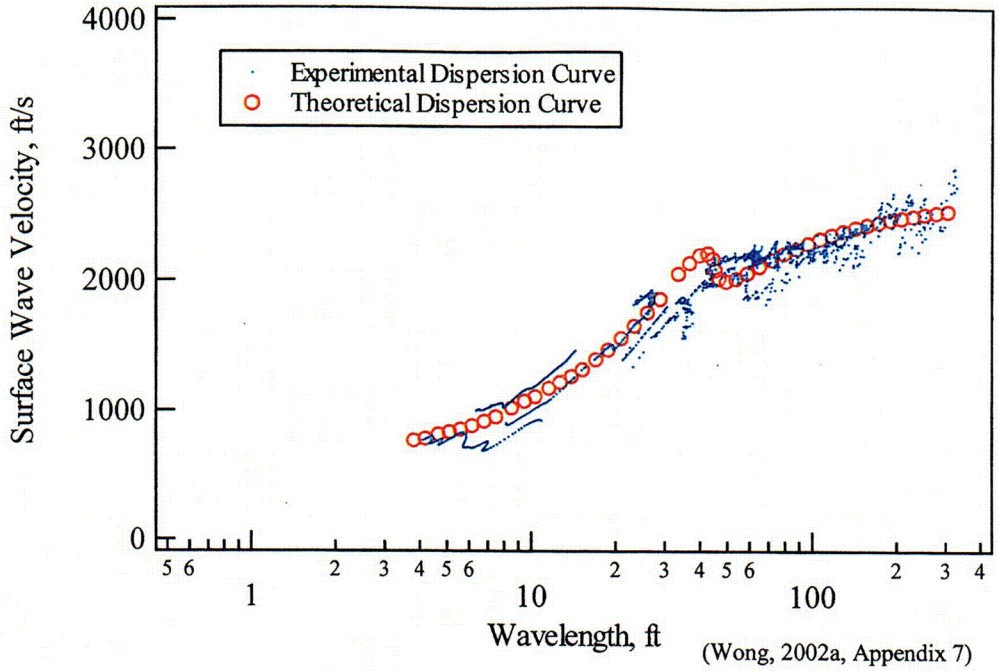
Location: SASW-S6

Layer No.	Thickness, ft	P-Wave Velocity, ft/s	S-Wave Velocity, ft/s	Poisson's Ratio*	Mass Density* pcf
1	2	2251	1300	0.25	145
2	4	2078	1200	0.25	145
3	30	3117	1800	0.25	145
4	96	3810	2200	0.25	145

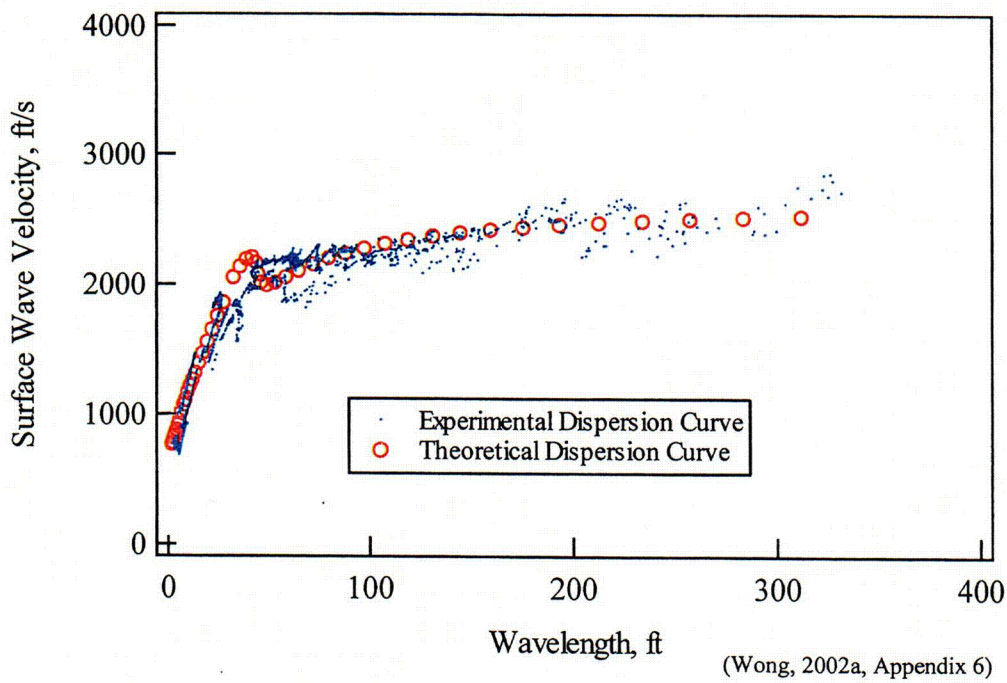
DTN: MO0110SASWVDYM.000

* Poisson's ratio and mass density from Wong (2002a, Appendix 6)

Figure XV-13. SASW-S6 Results (continued)



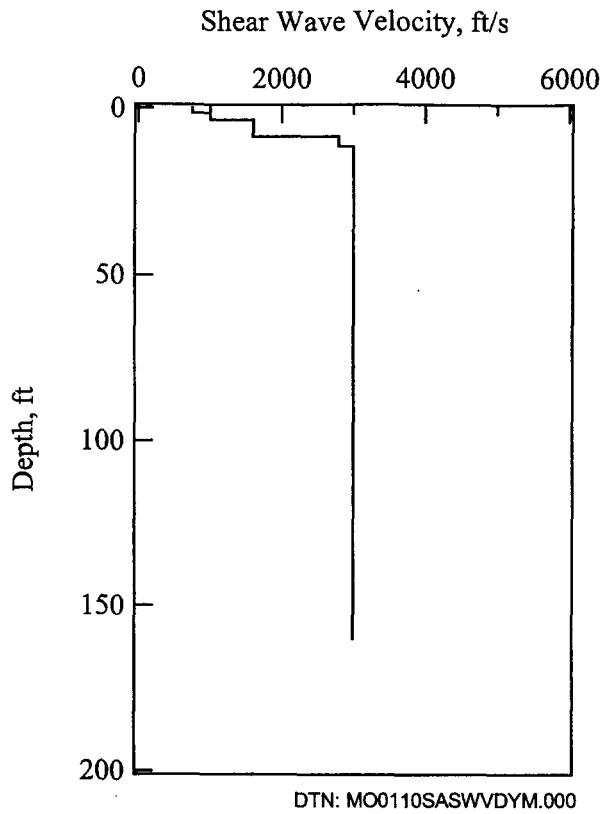
a. SASW-S7 Dispersion Curves (Log Plot)



b. SASW-S7 Dispersion Curves (Linear Plot)

Figure XV-14. SASW-S7 Results

C19



c. SASW-S7 Shear Wave Velocity Profile

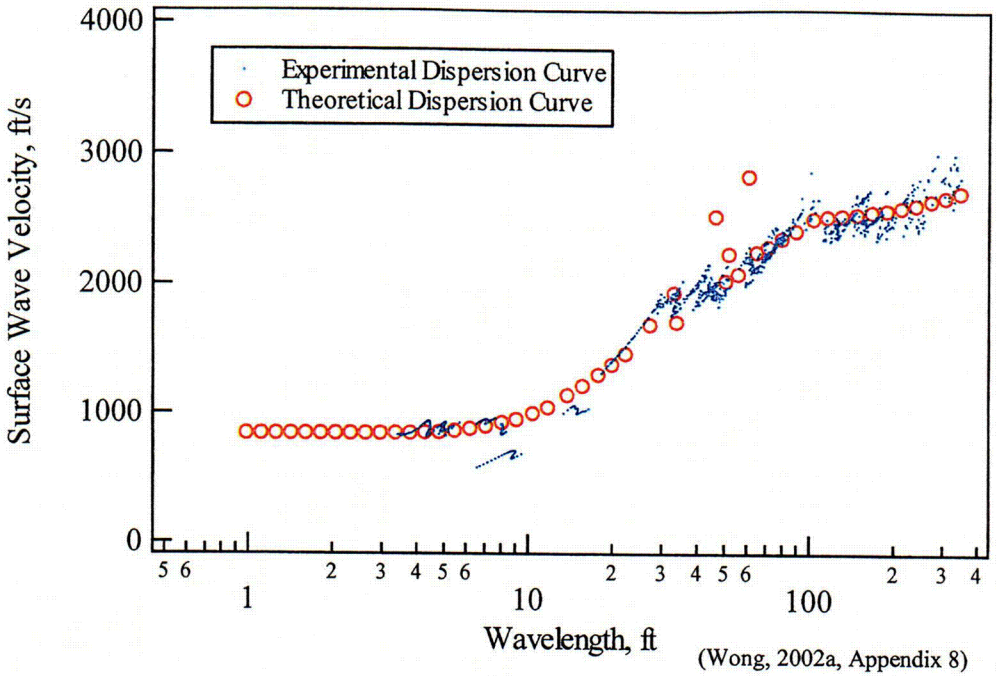
Location: SASW-S7

Layer No.	Thickness, ft	P-Wave Velocity, ft/s	S-Wave Velocity, ft/s	Poisson's Ratio*	Mass Density* pcf
1	1.5	1299	750	0.25	145
2	2	1732	1000	0.25	145
3	5	2771	1600	0.25	145
4	3	4850	2800	0.25	145
5	149	5196	3000	0.25	145

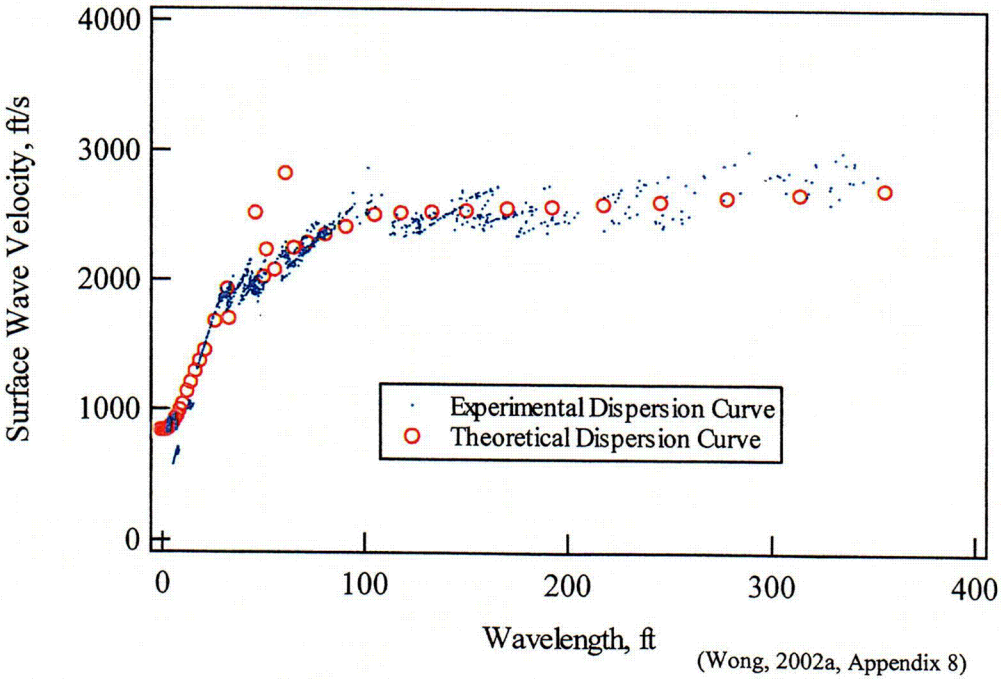
DTN: MO0110SASWVDYM.000

* Poisson's ratio and mass density from Wong (2002a, Appendix 7)

Figure XV-14. SASW-S7 Results (continued)



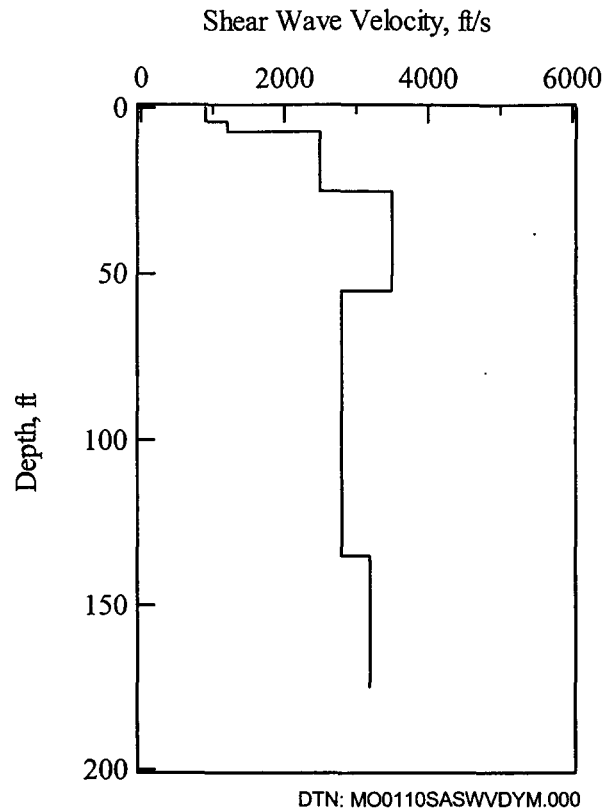
a. SASW-S8 Dispersion Curves (Log Plot)



b. SASW-S8 Dispersion Curves (Linear Plot)

Figure XV-15. SASW-S8 Results

C20



c. SASW-S8 Shear Wave Velocity Profile

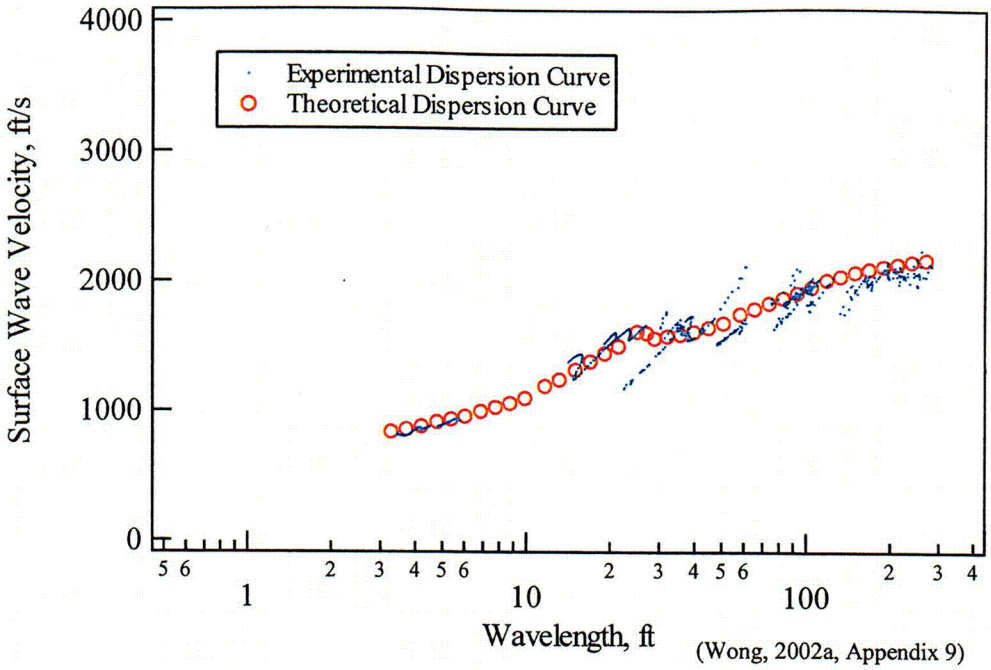
Location: SASW-S8

Layer No.	Thickness, ft	P-Wave Velocity, ft/s	S-Wave Velocity, ft/s	Poisson's Ratio*	Mass Density* pcf
1	4	1558	900	0.25	145
2	3	2078	1200	0.25	145
3	18	4330	2500	0.25	145
4	30	6062	3500	0.25	145
5	80	4849	2800	0.25	145
6	40	5542	3200	0.25	145

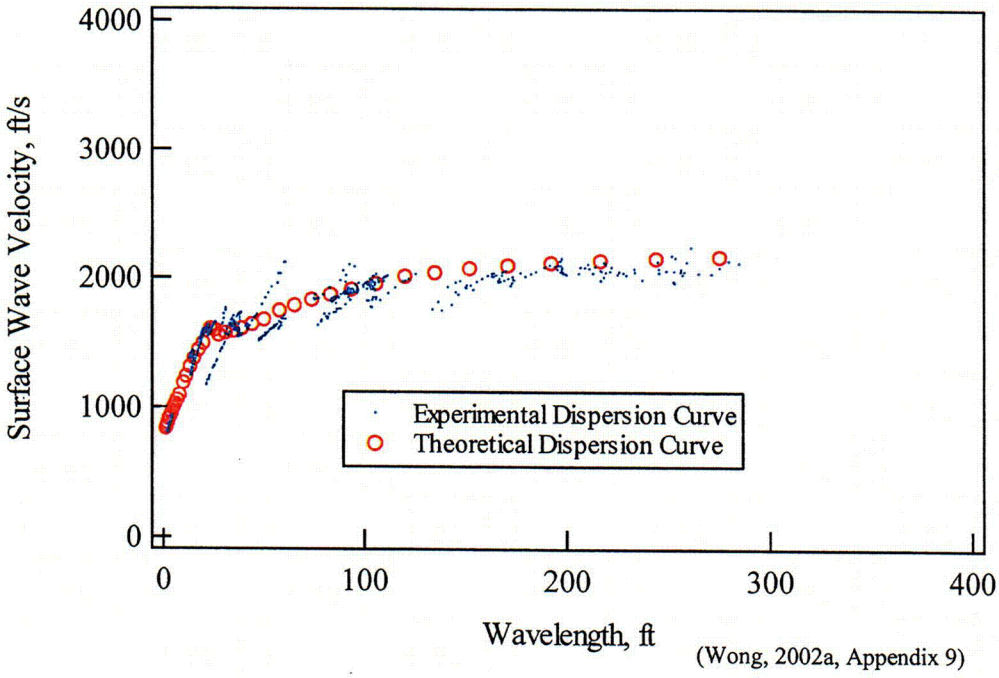
DTN: MO0110SASWVDYM.000

* Poisson's ratio and mass density from Wong (2002a, Appendix 8)

Figure XV-15. SASW-S8 Results (continued)



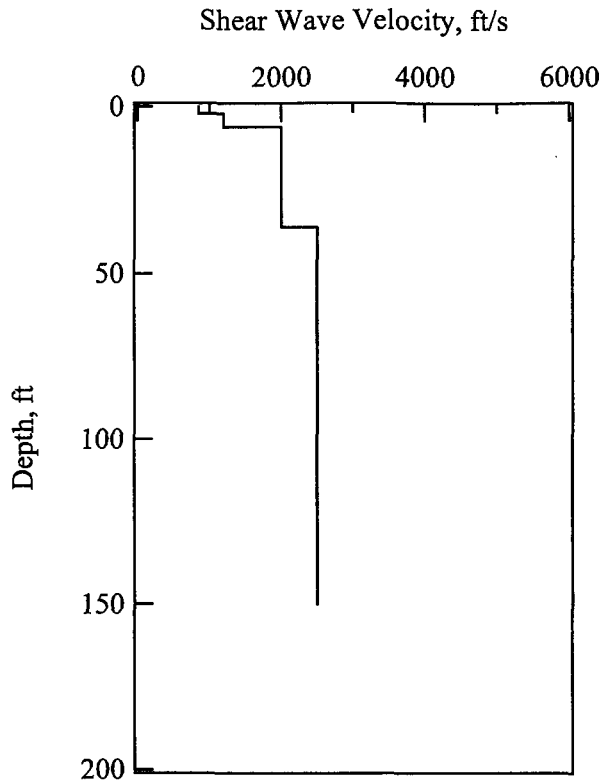
a. SASW-S9 Dispersion Curves (Log Plot)



b. SASW-S9 Dispersion Curves (Linear Plot)

Figure XV-16. SASW-S9 Results

C21



DTN: MO0110SASWVDYM.000

c. SASW-S9 Shear Wave Velocity Profile

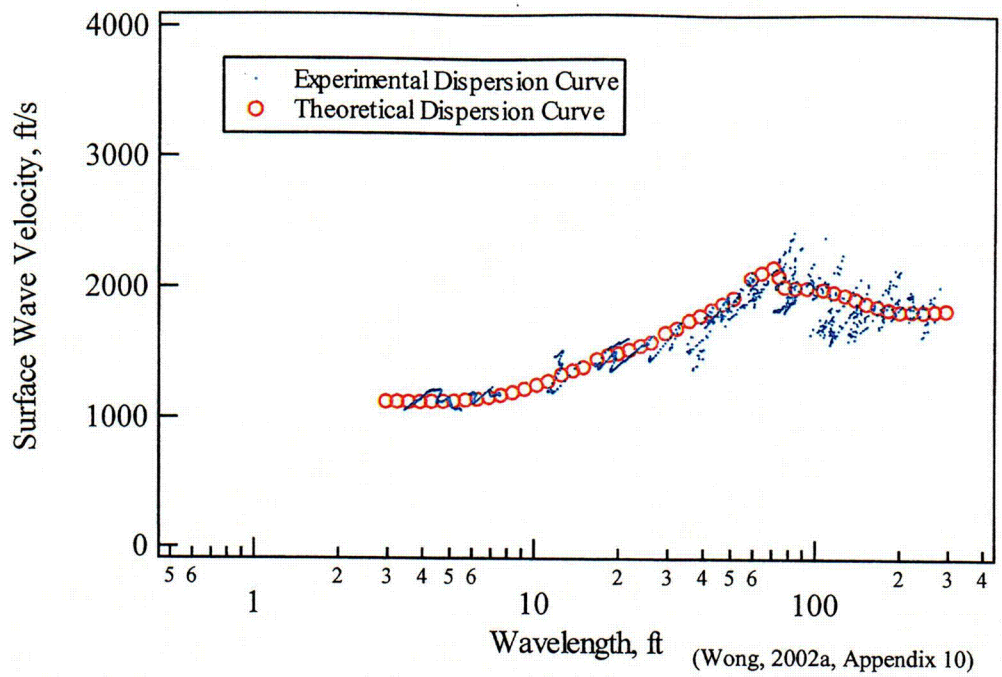
Location: SASW-S9

Layer No.	Thickness, ft	P-Wave Velocity, ft/s	S-Wave Velocity, ft/s	Poisson's Ratio*	Mass Density* pcf
1	2	1472	850	0.25	145
2	4	2078	1200	0.25	145
3	30	3464	2000	0.25	145
4	114	4330	2500	0.25	145

DTN: MO0110SASWVDYM.000

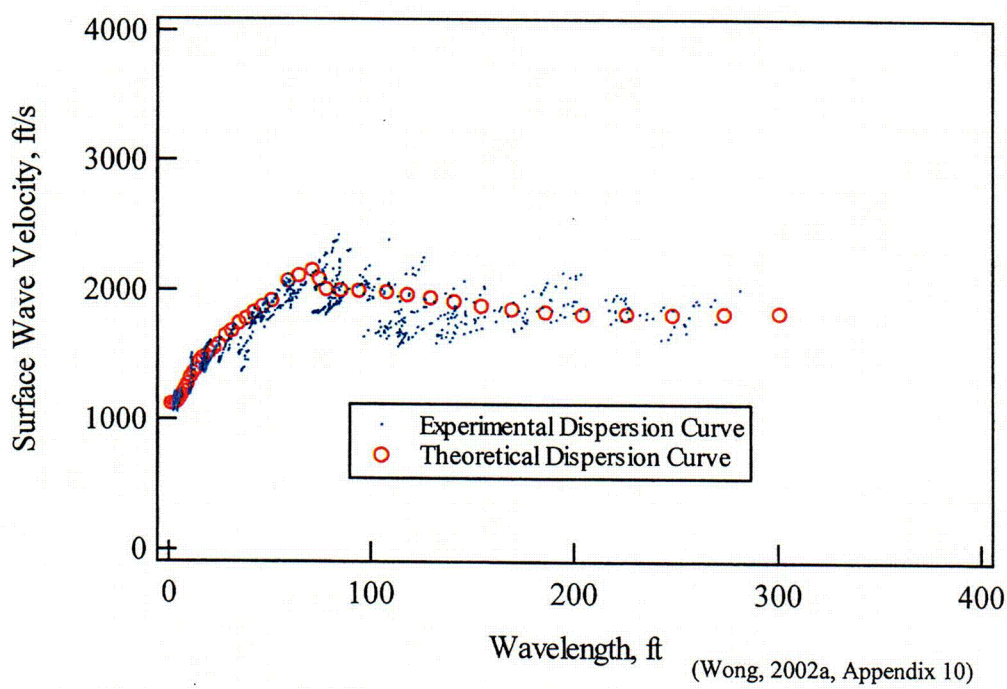
* Poisson's ratio and mass density from Wong (2002a, Appendix 9)

Figure XV-16. SASW-S9 Results (continued)



(Wong, 2002a, Appendix 10)

a. SASW-S10 Dispersion Curves (Log Plot)

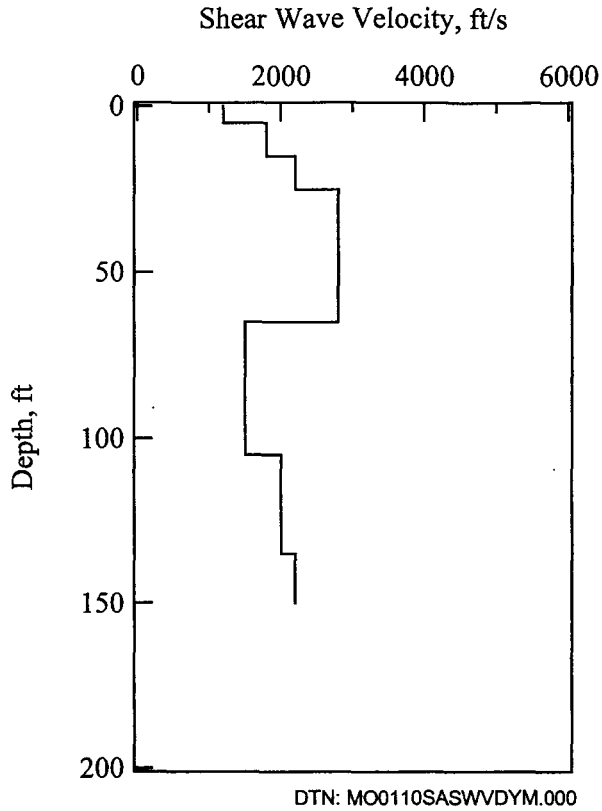


(Wong, 2002a, Appendix 10)

b. SASW-S10 Dispersion Curves (Linear Plot)

Figure XV-17. SASW-S10 Results

C22



c. SASW-S10 Shear Wave Velocity Profile

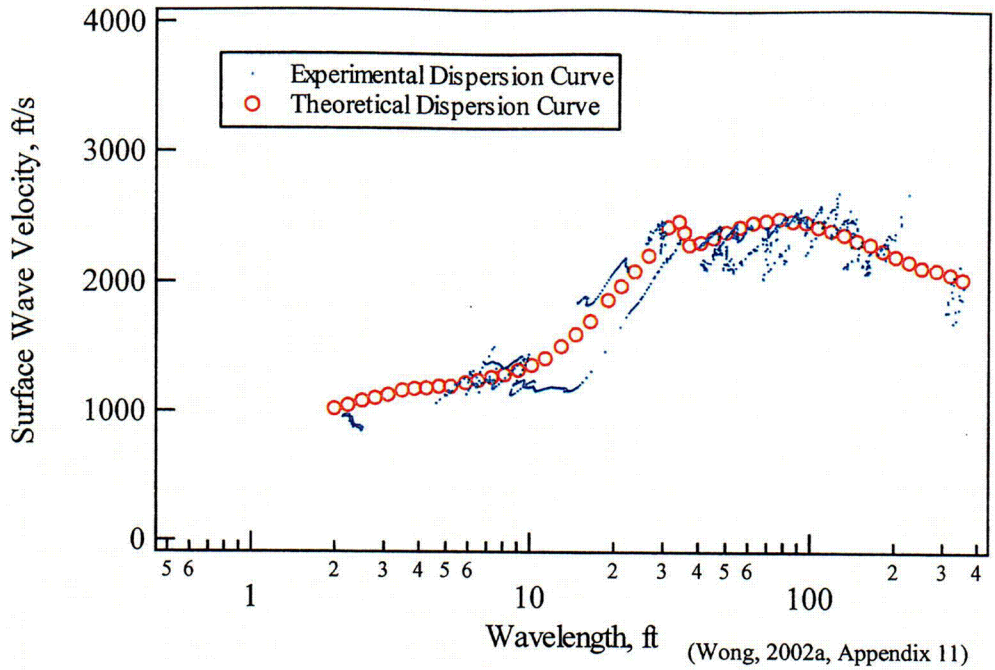
Location: SASW-S10

Layer No.	Thickness, ft	P-Wave Velocity, ft/s	S-Wave Velocity, ft/s	Poisson's Ratio*	Mass Density* pcf
1	5	2078	1200	0.25	145
2	10	3117	1800	0.25	145
3	10	3810	2200	0.25	145
4	40	4849	2800	0.25	145
5	40	2078	1500	0.25	145
6	30	3464	2000	0.25	145
7	15	3810	2200	0.25	145

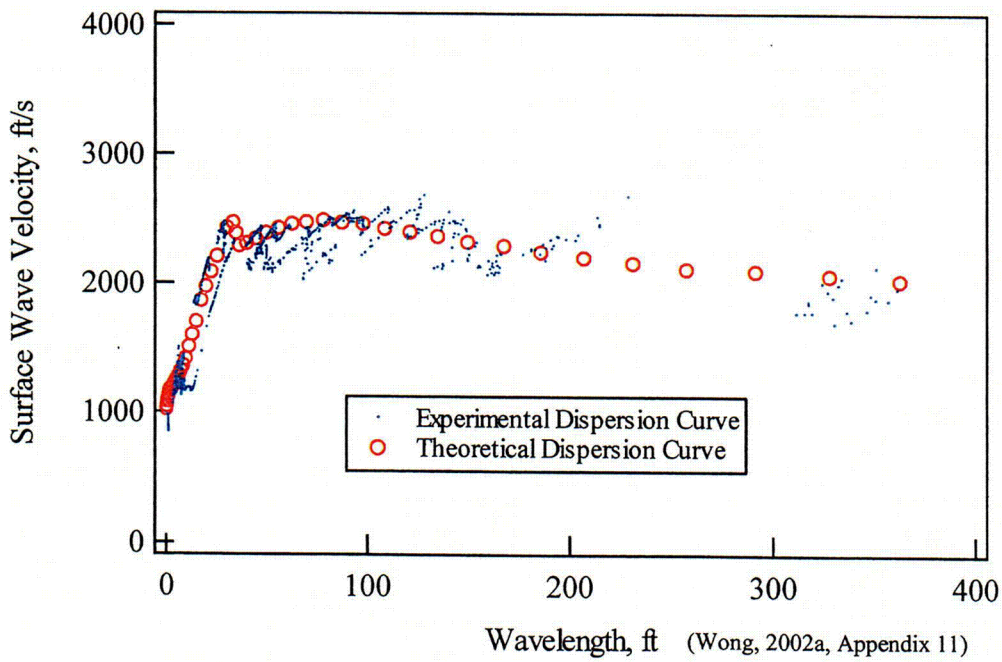
DTN: MO0110SASWVDYM.000

* Poisson's ratio and mass density from Wong (2002a, Appendix 10)

Figure XV-17. SASW-S10 Results (continued)



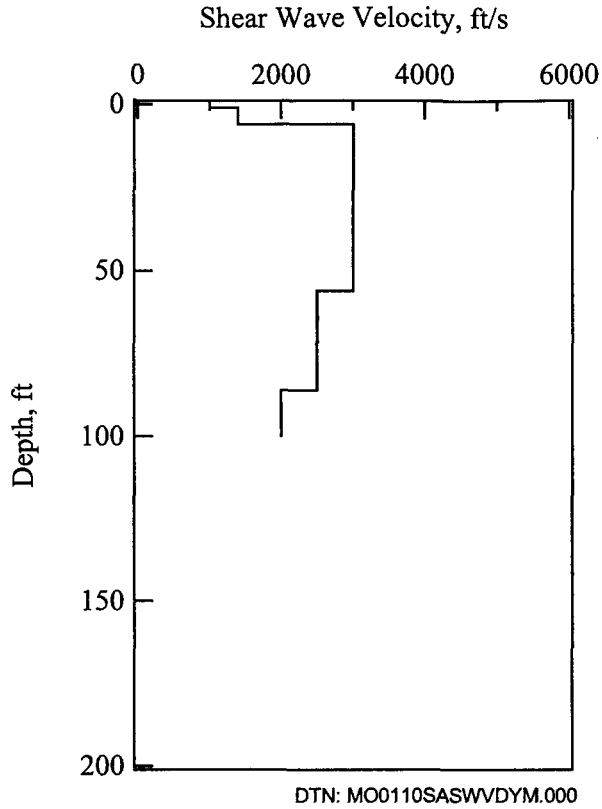
a. SASW-S11 Dispersion Curves (Log Plot)



b. SASW-S11 Dispersion Curves (Linear Plot)

Figure XV-18. SASW-S11 Results

C23



c. SASW-S11 Shear Wave Velocity Profile

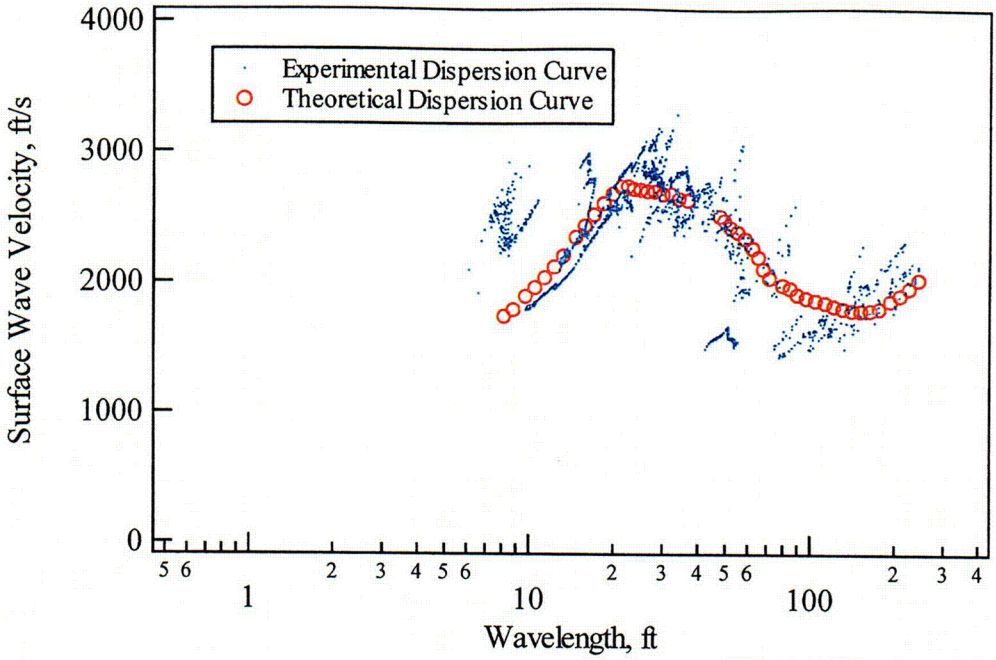
Location: SASW-S11

Layer No.	Thickness, ft	P-Wave Velocity, ft/s	S-Wave Velocity, ft/s	Poisson's Ratio*	Mass Density* pcf
1	1	1732	1000	0.25	145
2	5	2425	1400	0.25	145
3	50	5196	3000	0.25	145
4	30	4330	2500	0.25	145
5	14	3464	2000	0.25	145

DTN: MO0110SASWVDYM.000

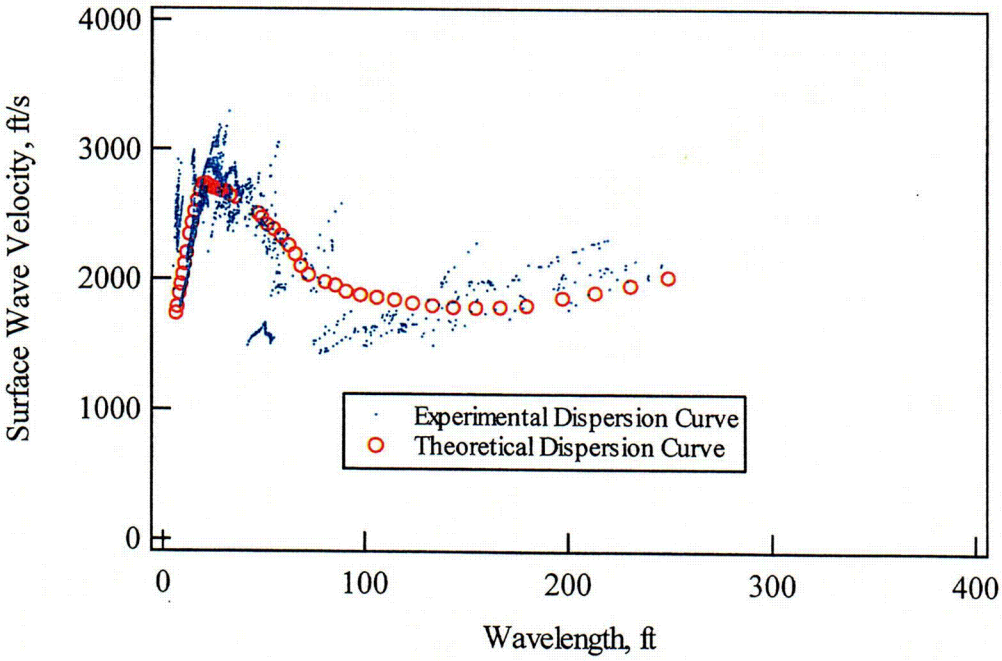
* Poisson's ratio and mass density from Wong (2002a, Appendix 11)

Figure XV-18. SASW-S11 Results (continued)



(Wong, 2002a, Appendix 12)

a. SASW-S12 Dispersion Curves (Log Plot)

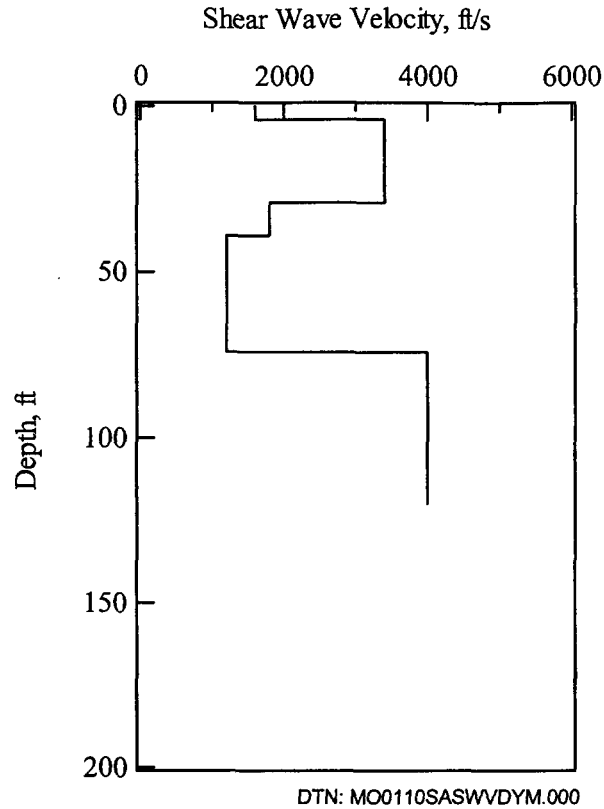


(Wong, 2002a, Appendix 12)

b. SASW-S12 Dispersion Curves (Linear Plot)

Figure XV-19. SASW-S12 Results

C24



c. SASW-S12 Shear Wave Velocity Profile

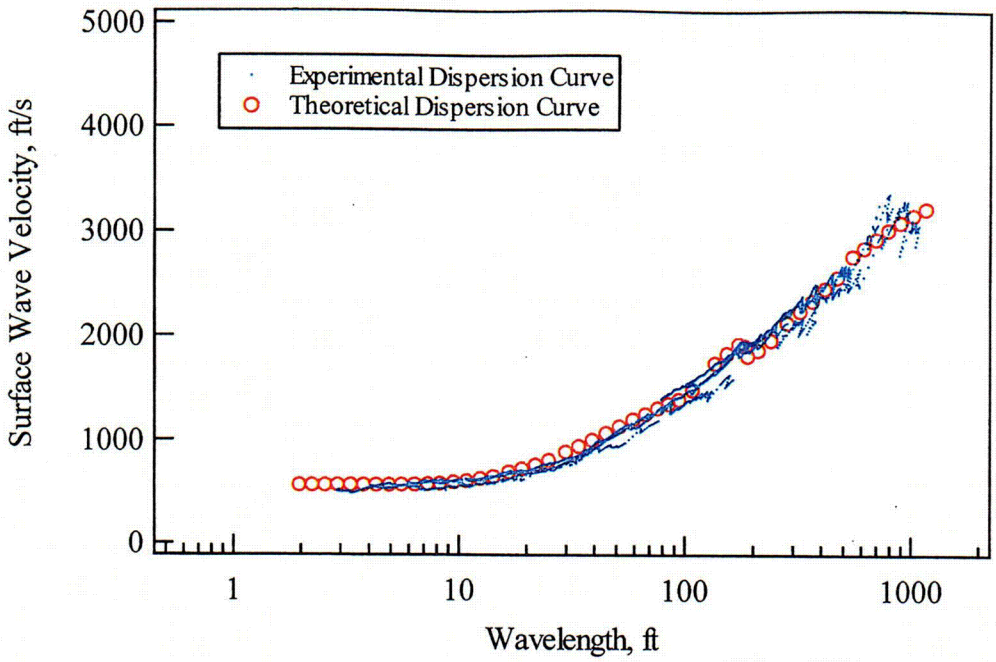
Location: SASW-S12

Layer No.	Thickness, ft	P-Wave Velocity, ft/s	S-Wave Velocity, ft/s	Poisson's Ratio*	Mass Density* pcf
1	4	2771	1600	0.25	145
2	25	5889	3400	0.25	145
3	10	3117	1800	0.25	145
4	35	2078	1200	0.25	145
5	46	6928	4000	0.25	145

DTN: MO0110SASWVDYM.000

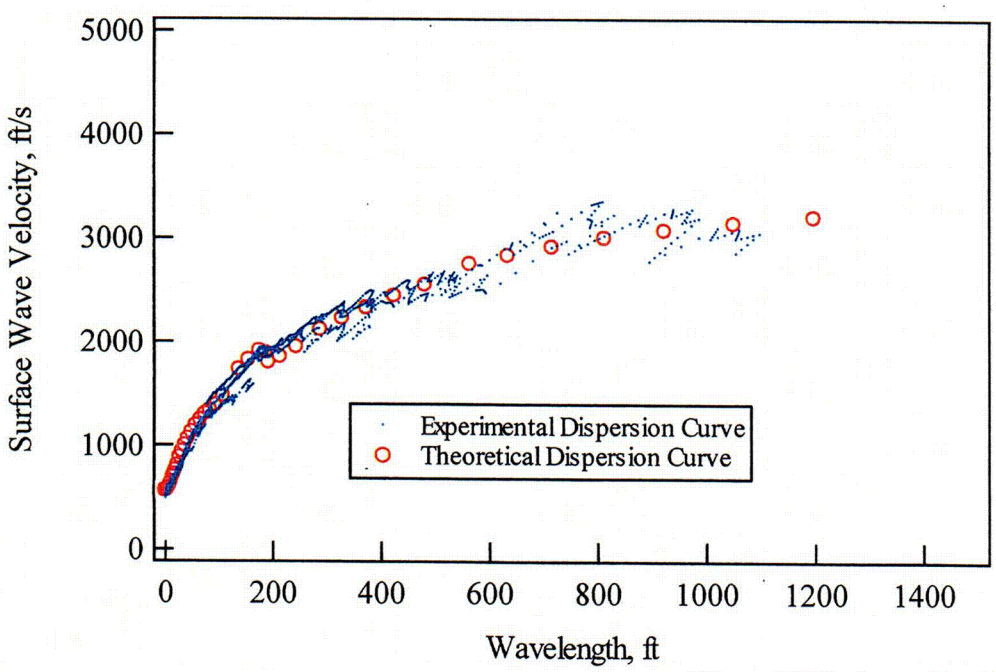
* Poisson's ratio and mass density from Wong (2002a, Appendix 12)

Figure XV-19. SASW-S12 Results (continued)



(Wong, 2002a, Appendix 15)

a. SASW-D1 Dispersion Curves (Log Plot)

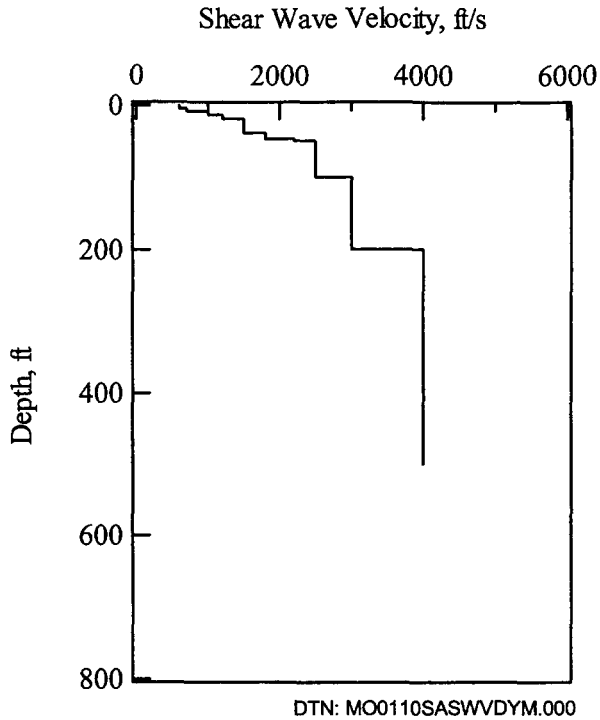


(Wong, 2002a, Appendix 15)

b. SASW-D1 Dispersion Curves (Linear Plot)

Figure XV-20. SASW-D1 Results

C25



c. SASW-D1 Shear Wave Velocity Profile

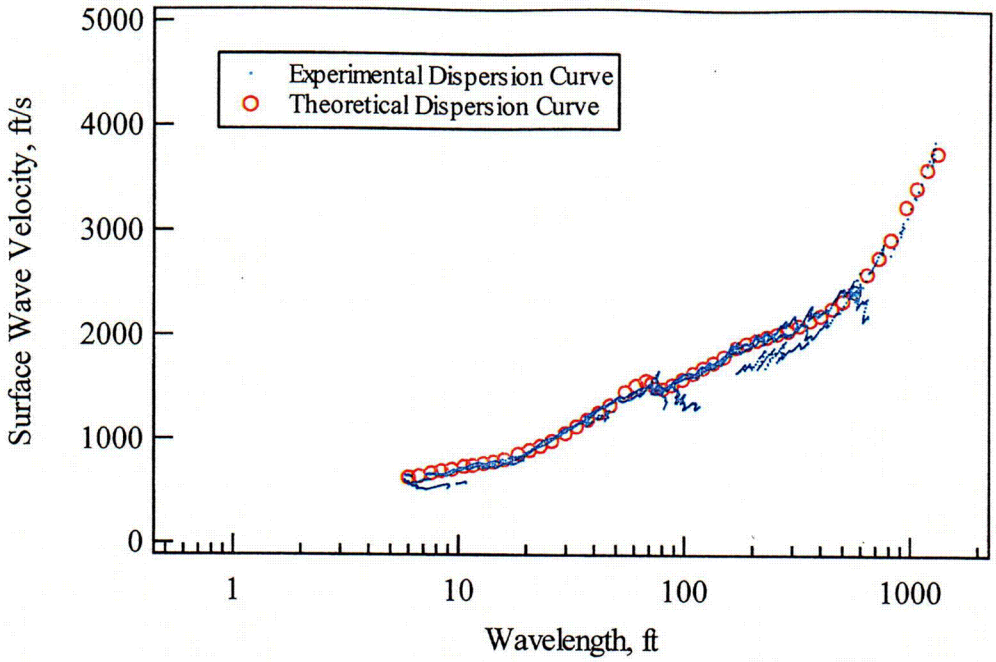
Location: SASW-D1

Layer No.	Thickness, ft	P-Wave Velocity, ft/s	S-Wave Velocity, ft/s	Poisson's Ratio*	Mass Density* pcf
1	5	1039	600	0.25	145
2	3	1212	700	0.25	145
3	5	1732	1000	0.25	145
4	5	2078	1200	0.25	145
5	20	2598	1500	0.25	145
6	8	3118	1800	0.25	145
7	3	3811	2200	0.25	145
8	50	4330	2500	0.25	145
9	100	5196	3000	0.25	145
10	300	6928	4000	0.25	145

DTN: MO0110SASWVDYM.000

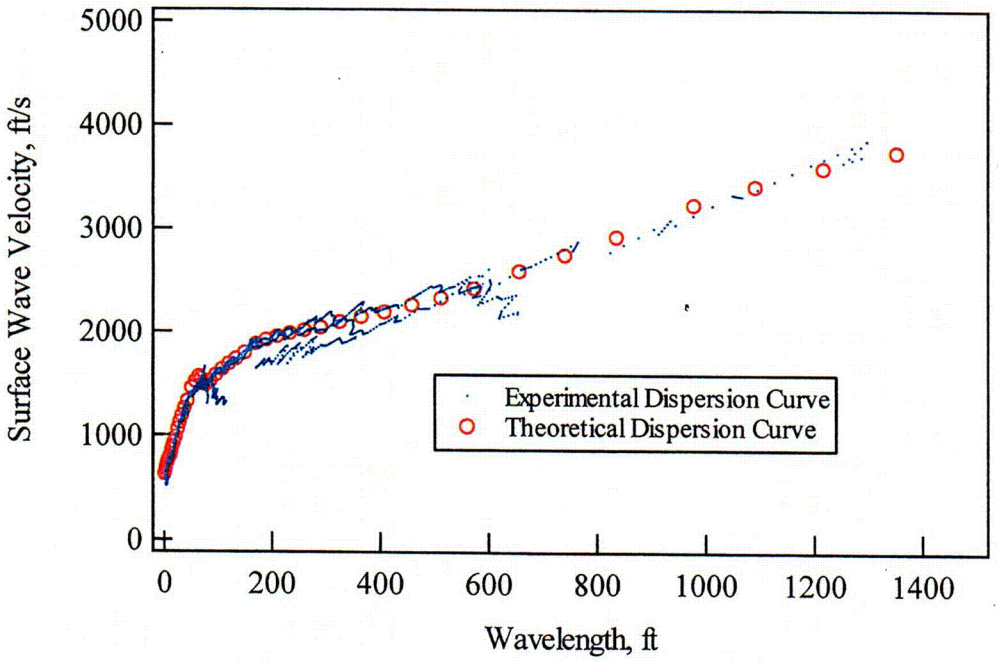
* Poisson's ratio and mass density from Wong (2002a, Appendix 15)

Figure XV-20. SASW-D1 Results (continued)



(Wong, 2002a, Appendix 16)

a. SASW-D2 Dispersion Curves (Log Plot)

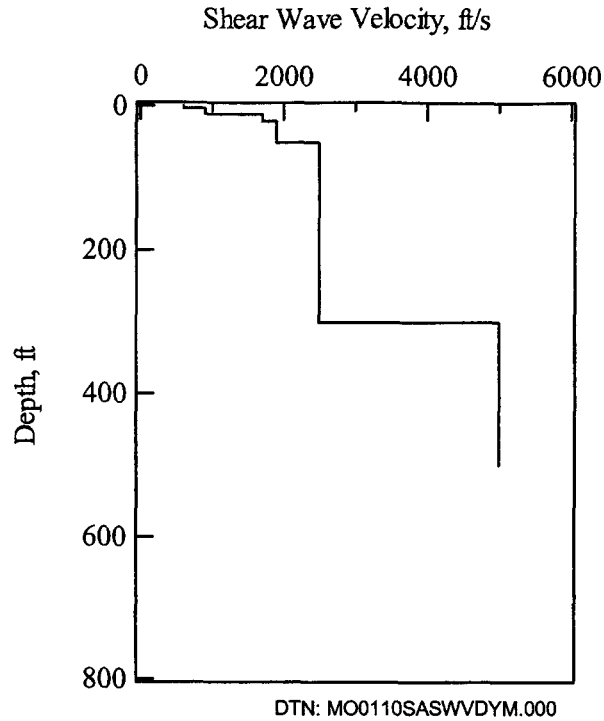


(Wong, 2002a, Appendix 16)

b. SASW-D2 Dispersion Curves (Linear Plot)

Figure XV-21. SASW-D2 Results

C26



c. SASW-D2 Shear Wave Velocity Profile

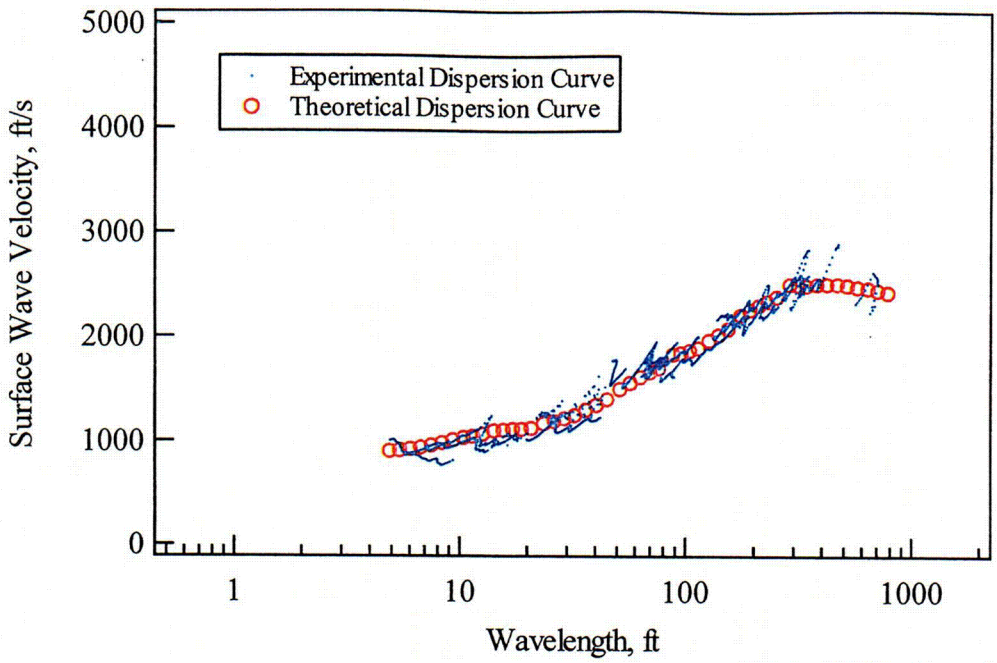
Location: SASW-D2

Layer No.	Thickness, ft	P-Wave Velocity, ft/s	S-Wave Velocity, ft/s	Poisson's Ratio*	Mass Density* pcf
1	3	1039	600	0.25	145
2	8	1559	900	0.25	145
3	10	2945	1700	0.25	145
4	30	3291	1900	0.25	145
5	250	4330	2500	0.25	145
6	200	8660	5000	0.25	145

DTN: MO0110SASWVDYM.000

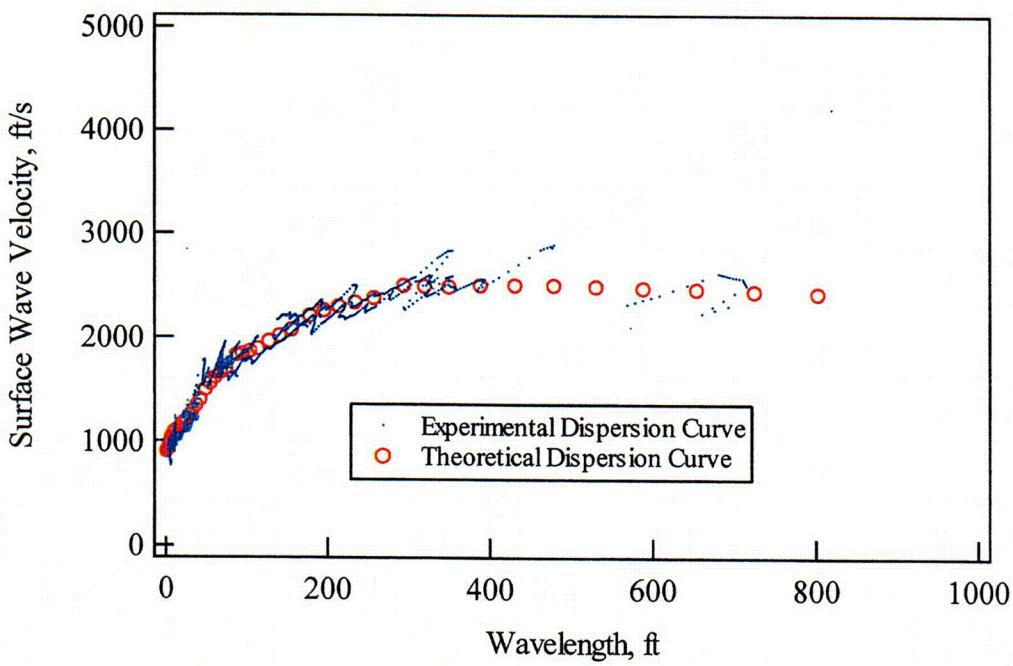
* Poisson's ratio and mass density from Wong (2002a, Appendix 16)

Figure XV-21. SASW-D2 Results (continued)



(Wong, 2002a, Appendix 17)

a. SASW-D3 Dispersion Curves (Log Plot)

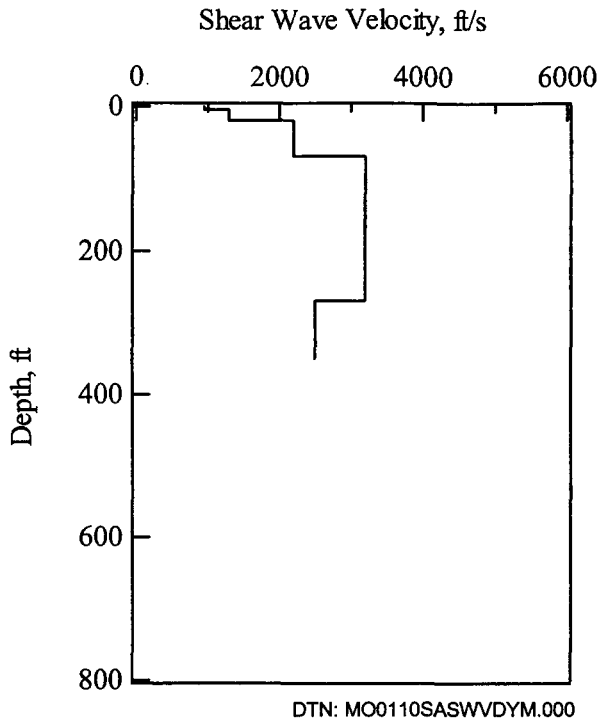


(Wong, 2002a, Appendix 17)

b. SASW-D3 Dispersion Curves (Linear Plot)

Figure XV-22. SASW-D3 Results

C27



c. SASW-D3 Shear Wave Velocity Profile

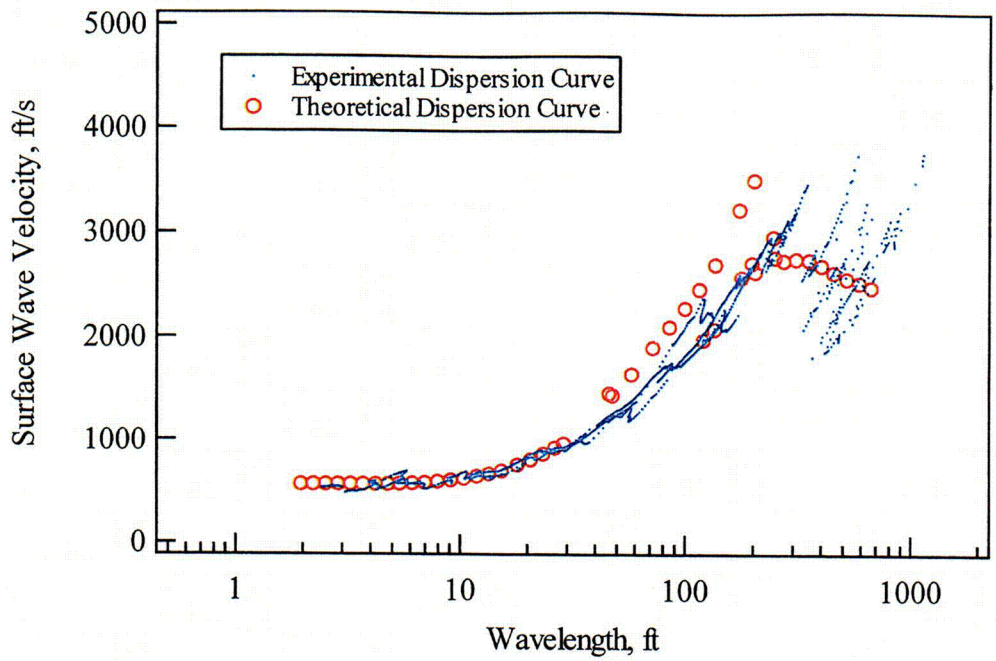
Location: SASW-D3

Layer No.	Thickness, ft	P-Wave Velocity, ft/s	S-Wave Velocity, ft/s	Poisson's Ratio*	Mass Density* pcf
1	4	1646	950	0.25	145
2	15	2252	1300	0.25	145
3	50	3811	2200	0.25	145
4	200	5543	3200	0.25	145
5	81	4330	2500	0.25	145

DTN: MO0110SASWVDYM.000

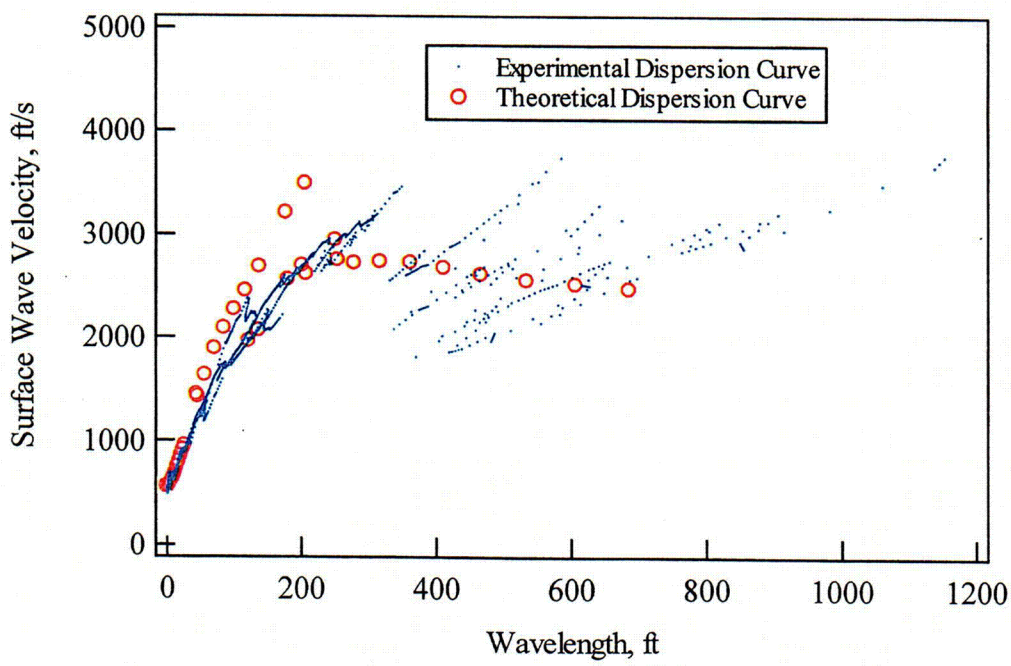
* Poisson's ratio and mass density from Wong (2002a, Appendix 17)

Figure XV-22. SASW-D3 Results (continued)



(Wong, 2002a, Appendix 18)

a. SASW-D4 Dispersion Curves (Log Plot)

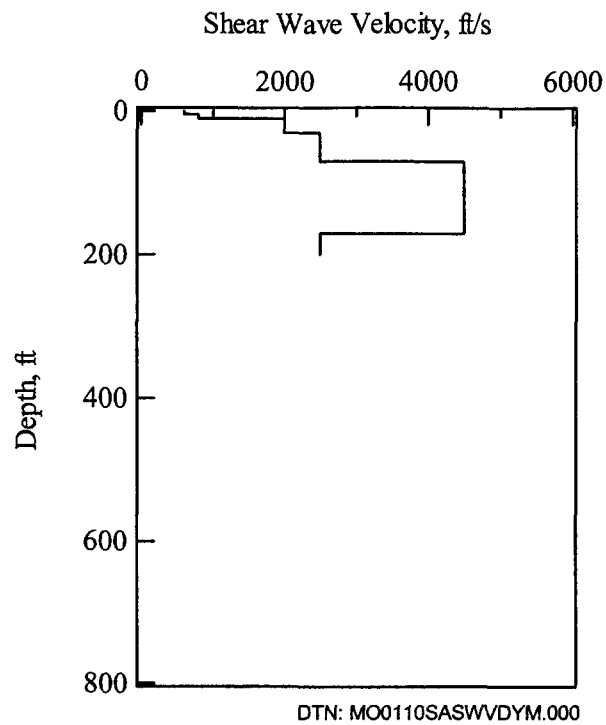


(Wong, 2002a, Appendix 18)

b. SASW-D4 Dispersion Curves (Linear Plot)

Figure XV-23. SASW-D4 Results

C28



c. SASW-D4 Shear Wave Velocity Profile

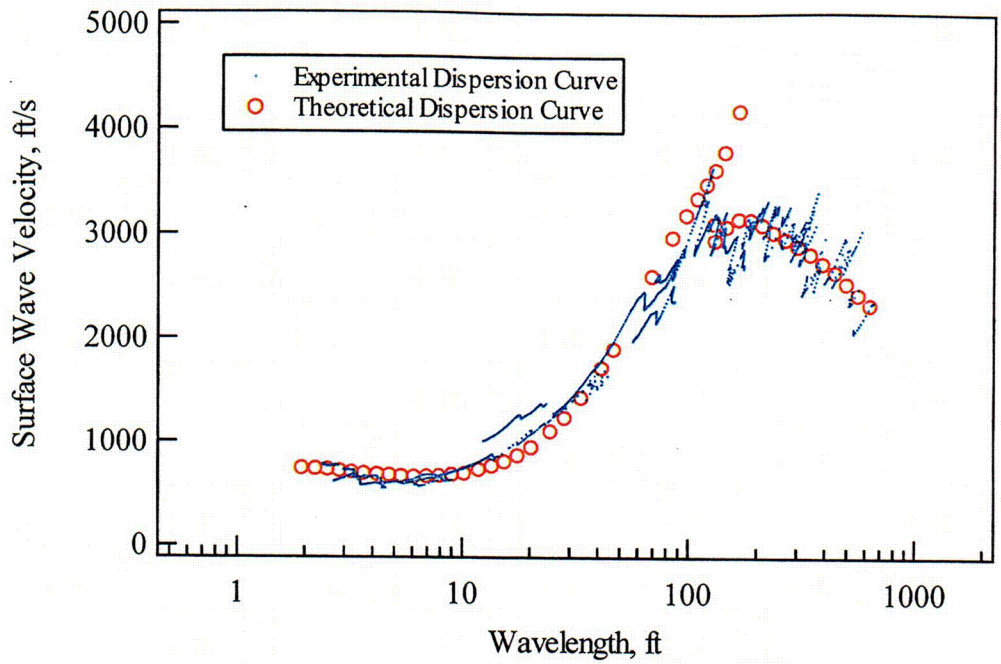
Location: SASW-D4

Layer No.	Thickness, ft	P-Wave Velocity, ft/s	S-Wave Velocity, ft/s	Poisson's Ratio*	Mass Density* pcf
1	5	1039	600	0.25	145
2	5	1386	800	0.25	145
3	20	3464	2000	0.25	145
4	40	4330	2500	0.25	145
5	100	7794	4500	0.25	145
6	30	4330	2500	0.25	145

DTN: MO0110SASWVDYM.000

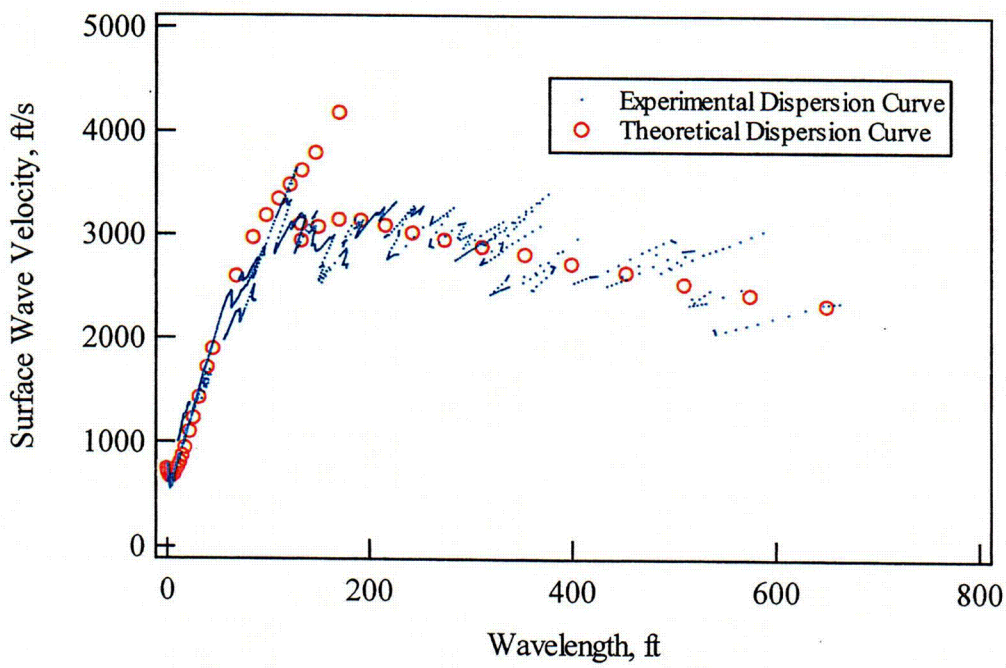
* Poisson's ratio and mass density from Wong (2002a, Appendix 18)

Figure XV-23. SASW-D4 Results (continued)



(Wong, 2002a, Appendix 19)

a. SASW-D5 Dispersion Curves (Log Plot)

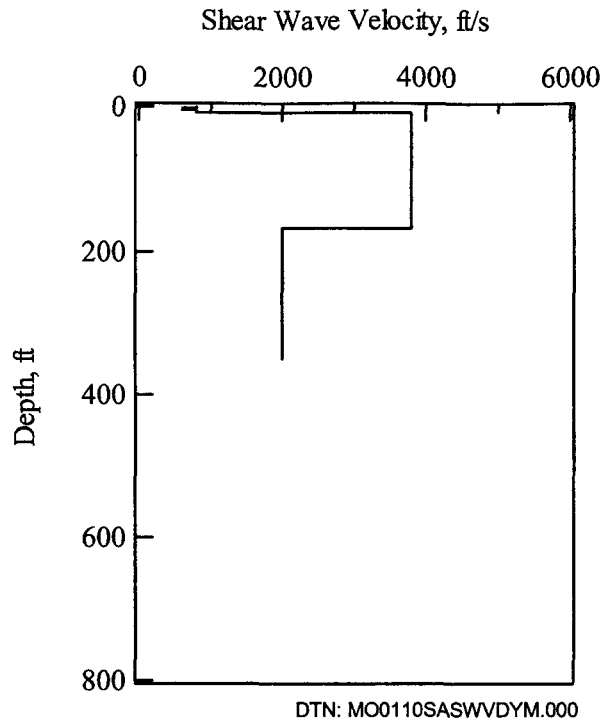


(Wong, 2002a, Appendix 19)

b. SASW-D5 Dispersion Curves (Linear Plot)

Figure XV-24. SASW-D5 Results

C29



c. SASW-D5 Shear Wave Velocity Profile

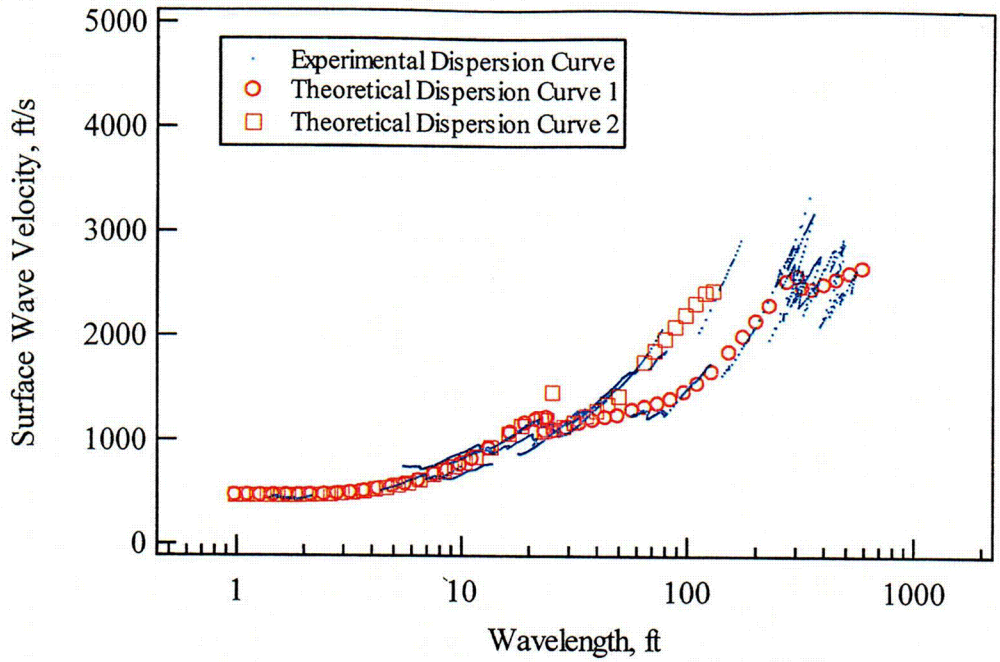
Location: SASW-D5

Layer No.	Thickness, ft	P-Wave Velocity, ft/s	S-Wave Velocity, ft/s	Poisson's Ratio*	Mass Density* pcf
1	2	1386	800	0.25	145
2	2	1039	600	0.25	145
3	4	1386	800	0.25	145
4	20	6582	3800	0.25	145
5	40	6582	3800	0.25	145
6	100	6582	3800	0.25	145
7	182	3464	2000	0.25	145

DTN: MO0110SASWVDYM.000

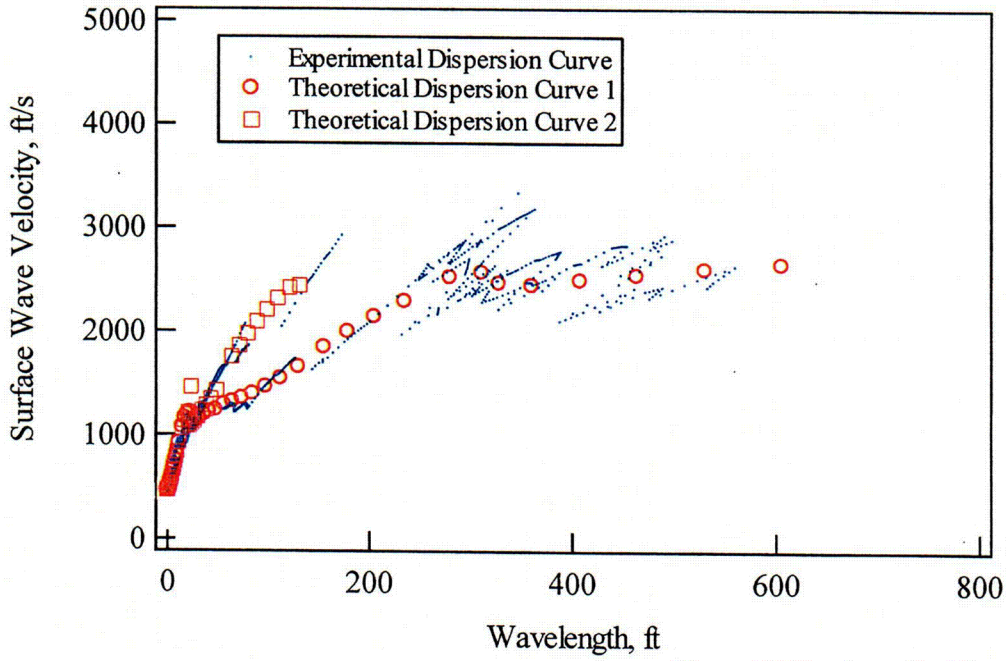
* Poisson's ratio and mass density from Wong (2002a, Appendix 19)

Figure XV-24. SASW-D5 Results (continued)



(Wong, 2002a, Appendix 20)

a. SASW-D6 Dispersion Curves (Log Plot)

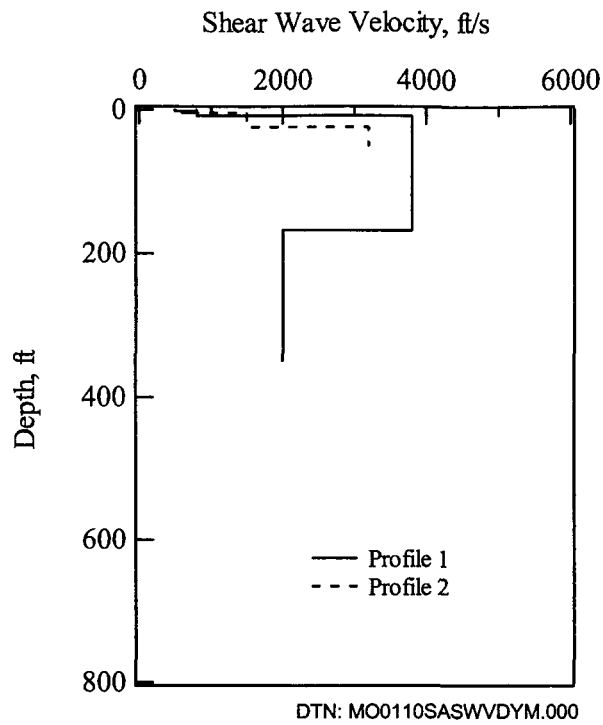


(Wong, 2002a, Appendix 20)

b. SASW-D6 Dispersion Curves (Linear Plot)

Figure XV-25. SASW-D6 Results

C30



c. SASW-D6 Shear Wave Velocity Profile

Location: SASW-D6 Profile 1

Layer No.	Thickness, ft	P-Wave Velocity, ft/s	S-Wave Velocity, ft/s	Poisson's Ratio*	Mass Density* pcf
1	2	1386	800	0.25	145
2	2	1039	600	0.25	145
3	4	1386	800	0.25	145
4	160	6582	3800	0.25	145
5	182	3464	2000	0.25	145

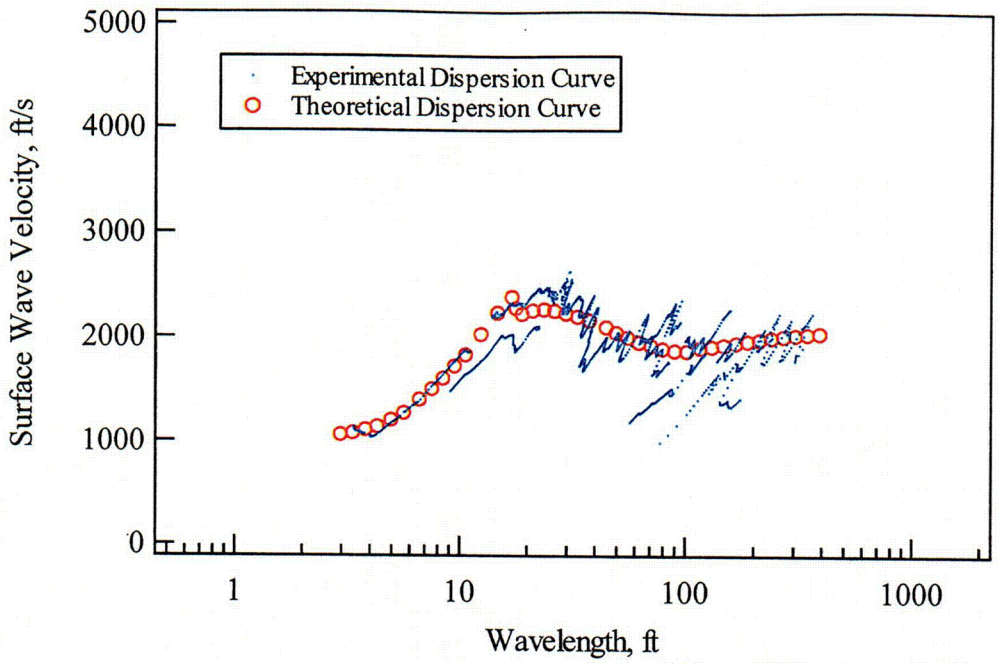
Location: SASW-D6 Profile 2

Layer No.	Thickness, ft	P-Wave Velocity, ft/s	S-Wave Velocity, ft/s	Poisson's Ratio*	Mass Density* pcf
1	2	866	500	0.25	145
2	2	1299	750	0.25	145
3	20	2598	1500	0.25	145
4	26	5542	3200	0.25	145

DTN: MO0110SASWVDYM.000

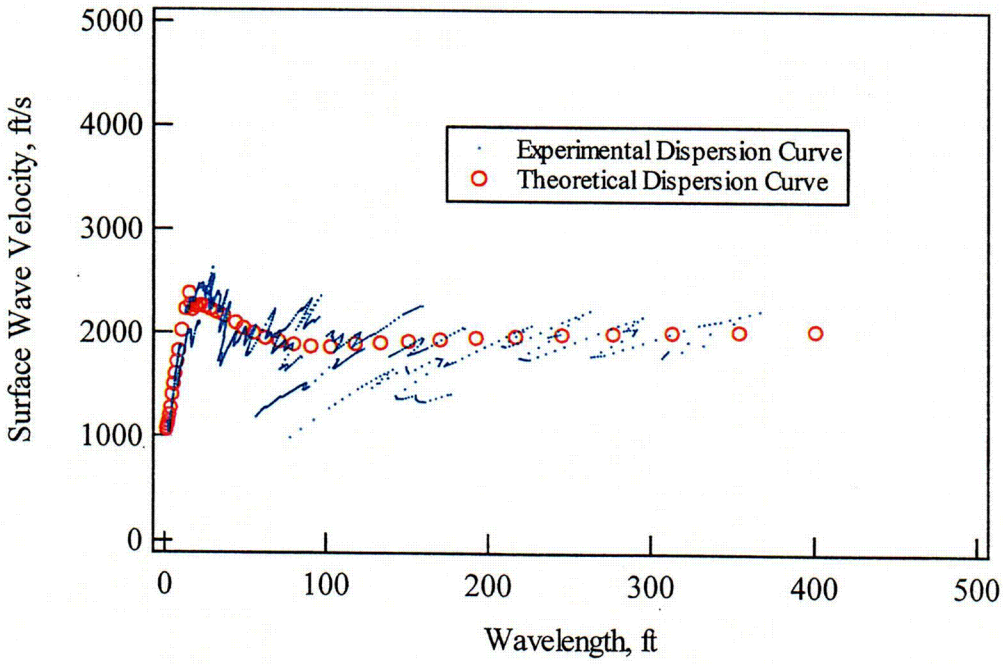
* Poisson's ratio and mass density from Wong (2002a, Appendix 20)

Figure XV-25. SASW-D6 Results (continued)



(Wong, 2002a, Appendix 21)

a. SASW-D7 Dispersion Curves (Log Plot)

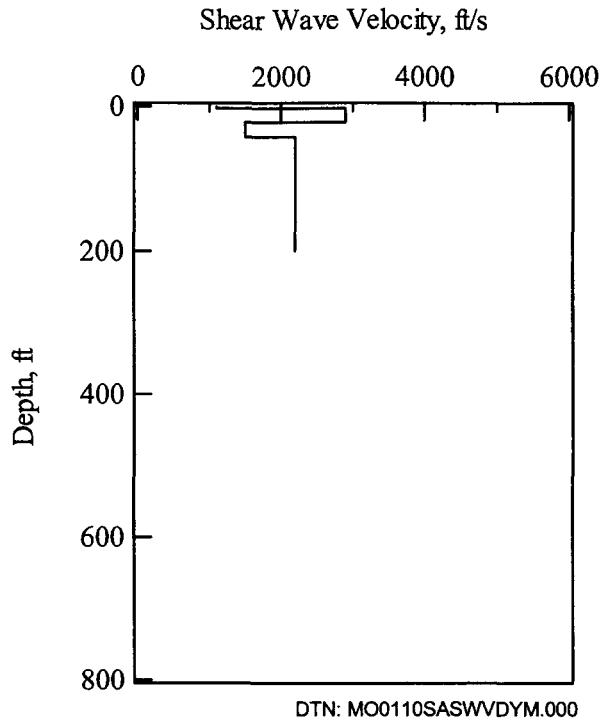


(Wong, 2002a, Appendix 21)

b. SASW-D7 Dispersion Curves (Linear Plot)

Figure XV-26. SASW-D7 Results

C31



c. SASW-D7 Shear Wave Velocity Profile

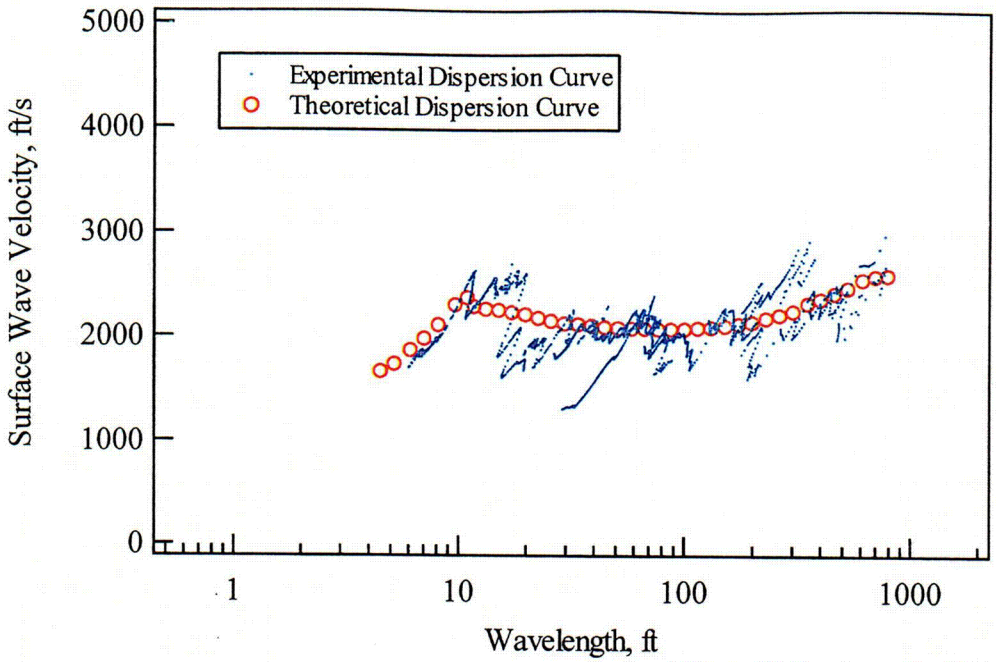
Location: SASW-D7

Layer No.	Thickness, ft	P-Wave Velocity, ft/s	S-Wave Velocity, ft/s	Poisson's Ratio*	Mass Density* pcf
1	2.5	1905	1100	0.25	145
2	20	5023	2900	0.25	145
3	20	2598	1500	0.25	145
4	158	3811	2200	0.25	145

DTN: MO0110SASWVDYM.000

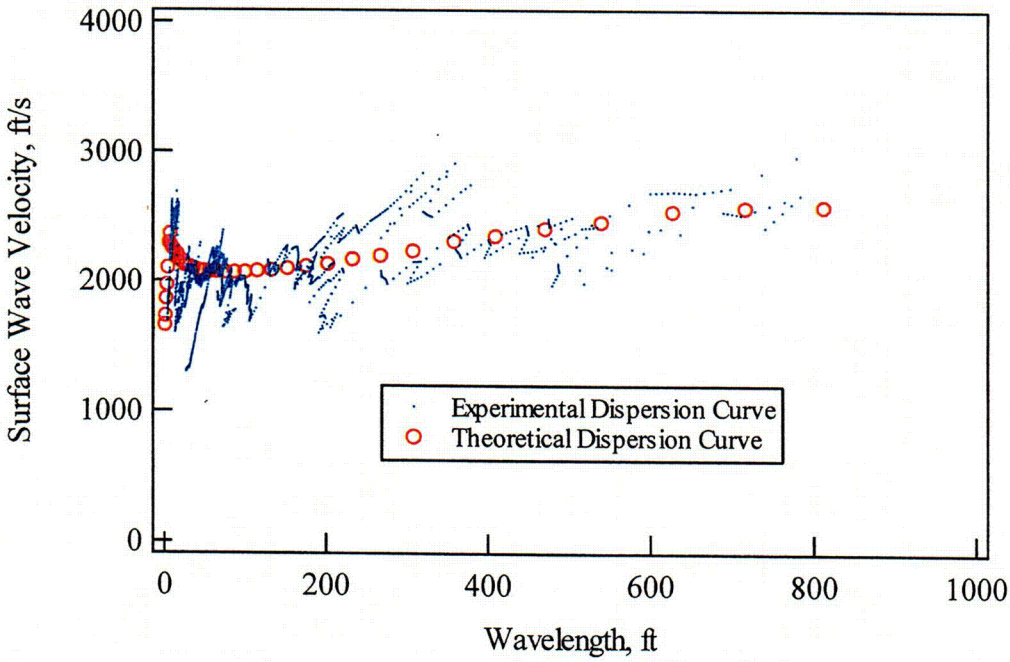
* Poisson's ratio and mass density from Wong (2002a, Appendix 21)

Figure XV-26. SASW-D7 Results (continued)



(Wong, 2002a, Appendix 22)

a. SASW-D8 Dispersion Curves (Log Plot)

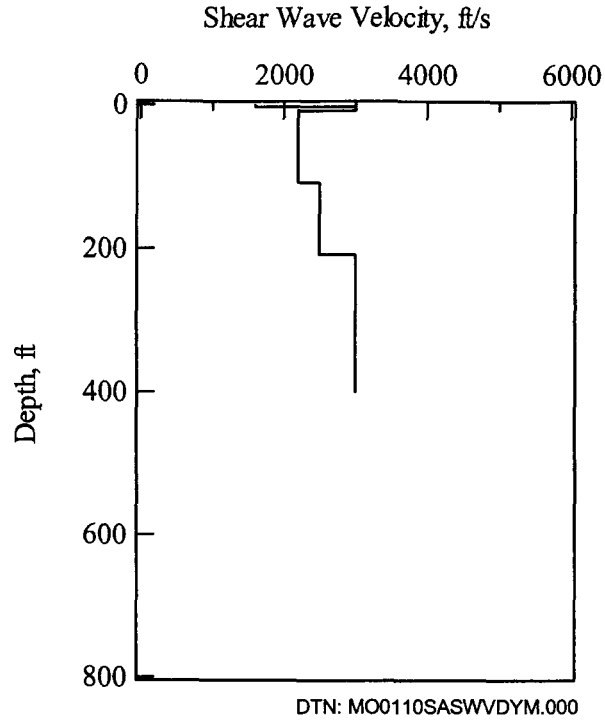


(Wong, 2002a, Appendix 22)

b. SASW-D8 Dispersion Curves (Linear Plot)

Figure XV-27. SASW-D8 Results

C32



c. SASW-D8 Shear Wave Velocity Profile

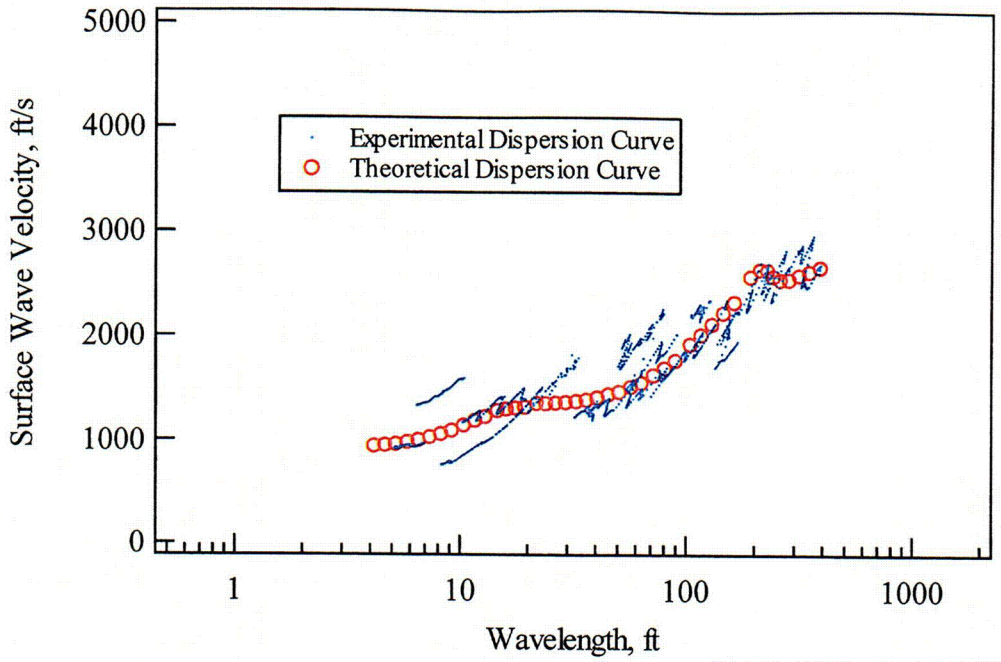
Location: SASW-D8

Layer No.	Thickness, ft	P-Wave Velocity, ft/s	S-Wave Velocity, ft/s	Poisson's Ratio*	Mass Density* pcf
1	2.5	2771	1600	0.25	145
2	6	5196	3000	0.25	145
3	100	3811	2200	0.25	145
4	100	4330	2500	0.25	145
5	192	5196	3000	0.25	145

DTN: MO0110SASWVDYM.000

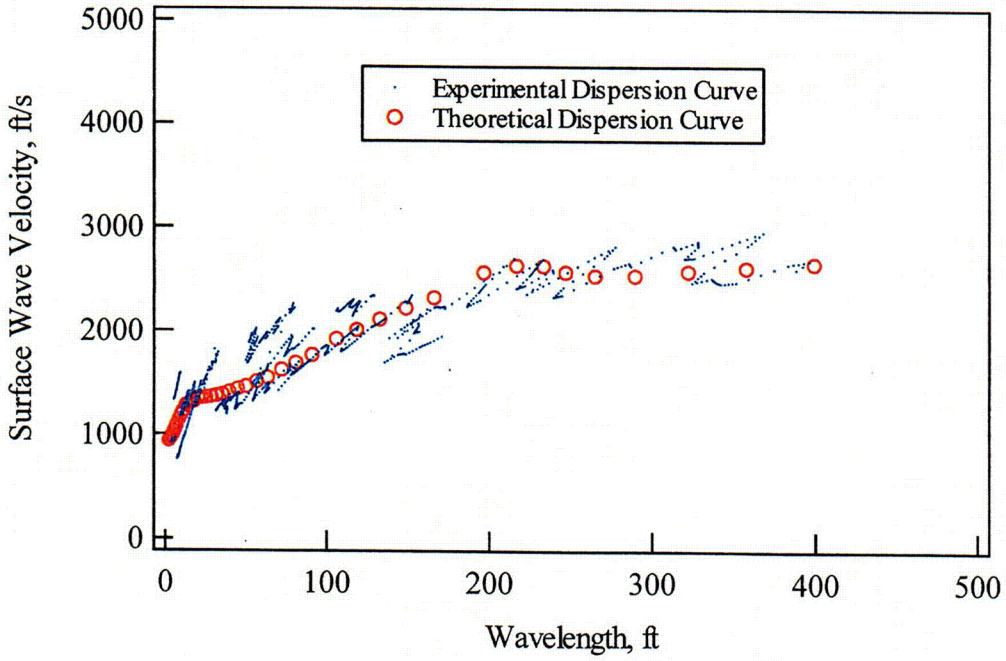
* Poisson's ratio and mass density from Wong (2002a, Appendix 22)

Figure XV-27. SASW-D8 Results (continued)



(Wong, 2002a, Appendix 23)

a. SASW-D9 Dispersion Curves (Log Plot)

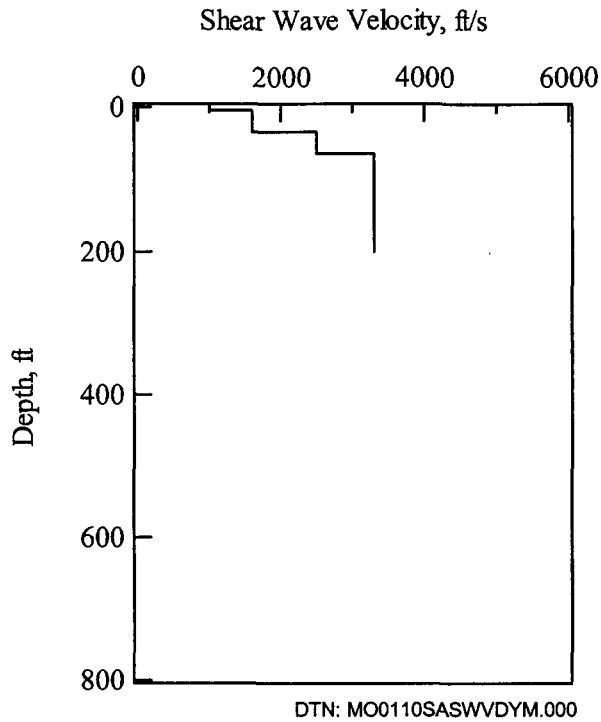


(Wong, 2002a, Appendix 23)

b. SASW-D9 Dispersion Curves (Linear Plot)

Figure XV-28. SASW-D9 Results

C33



c. SASW-D9 Shear Wave Velocity Profile

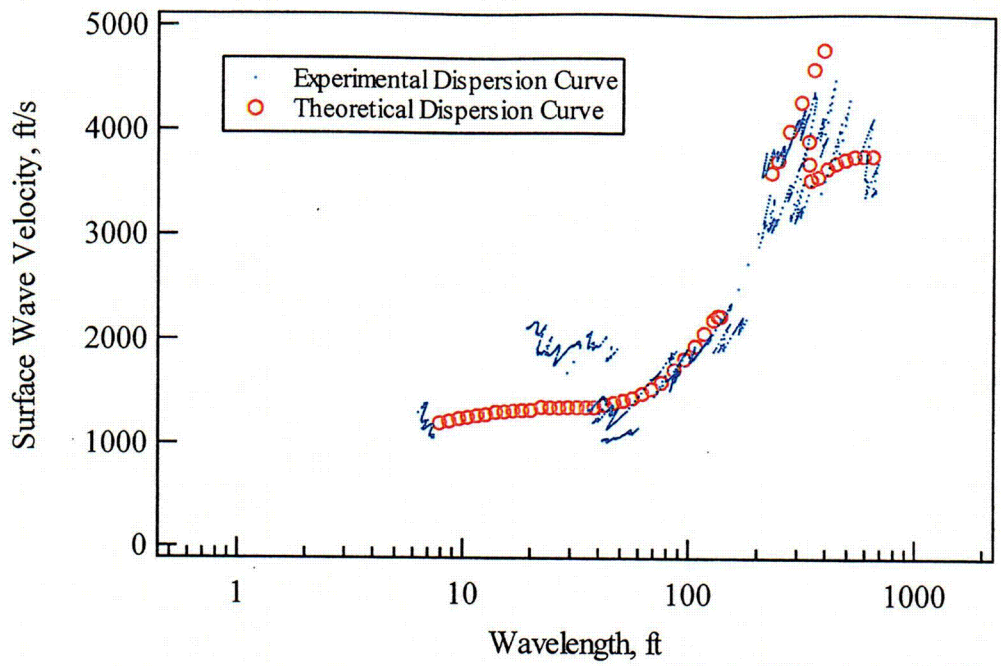
Location: SASW-D9

Layer No.	Thickness, ft	P-Wave Velocity, ft/s	S-Wave Velocity, ft/s	Poisson's Ratio*	Mass Density* pcf
1	4	1732	1000	0.25	145
2	30	2771	1600	0.25	145
3	30	4330	2500	0.25	145
4	136	5716	3300	0.25	145

DTN: MO0110SASWVDYM.000

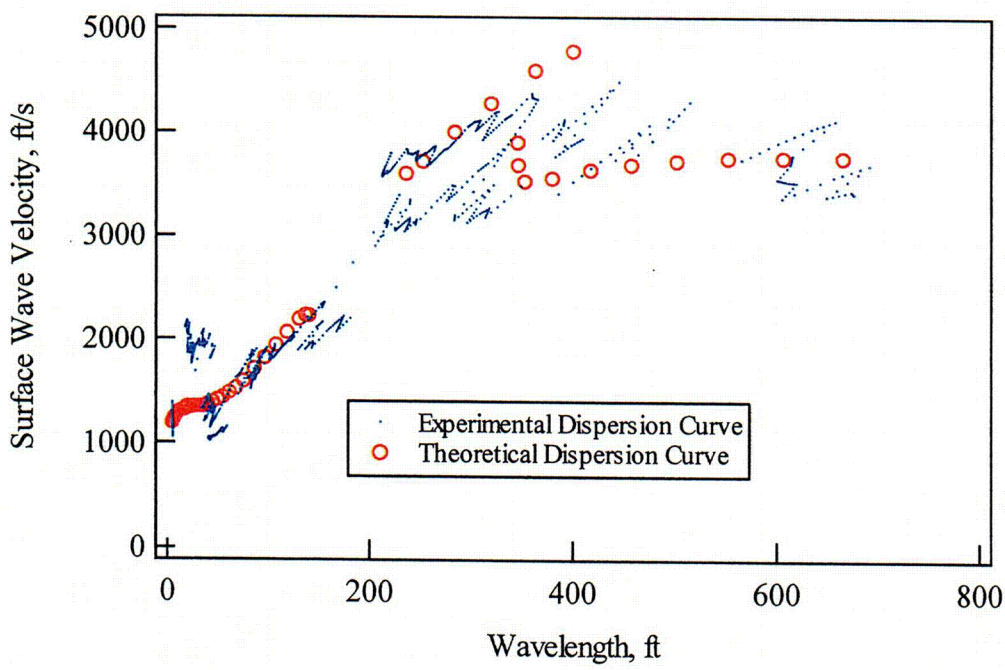
* Poisson's ratio and mass density from Wong (2002a, Appendix 23)

Figure XV-28. SASW-D9 Results (continued)



(Wong, 2002a, Appendix 24)

a. SASW-D10 Dispersion Curves (Log Plot)

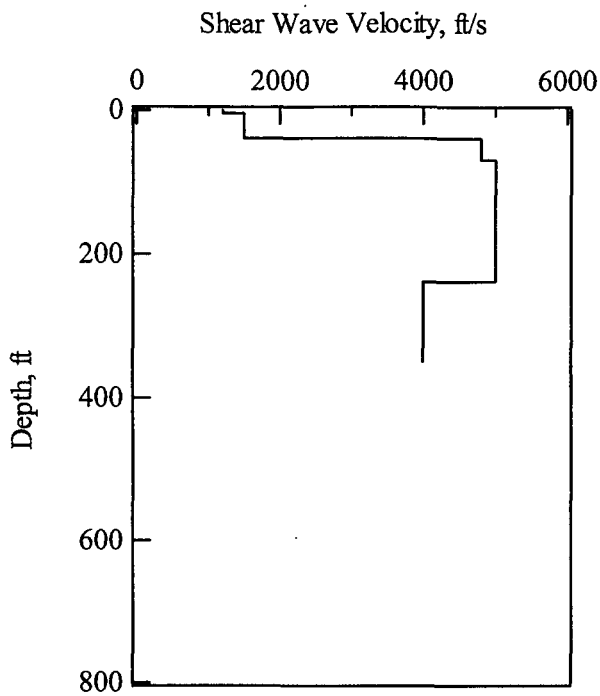


(Wong, 2002a, Appendix 24)

b. SASW-D10 Dispersion Curves (Linear Plot)

Figure XV-29. SASW-D10 Results

C34



DTN: MO0110SASWVDYM.000

c. SASW-D10 Shear Wave Velocity Profile

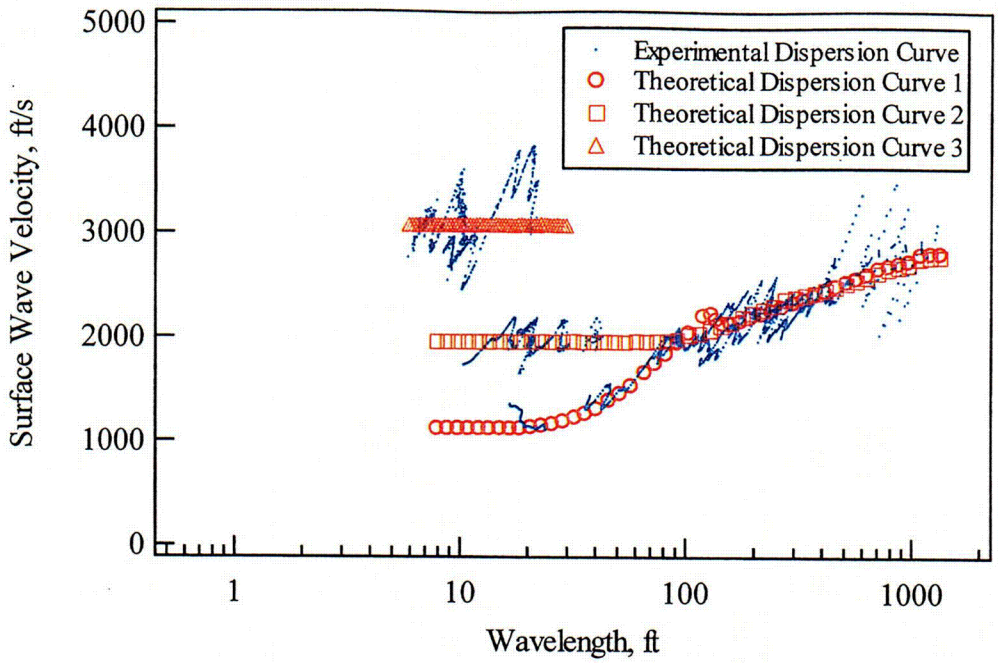
Location: SASW-D10

Layer No.	Thickness, ft	P-Wave Velocity, ft/s	S-Wave Velocity, ft/s	Poisson's Ratio*	Mass Density* pcf
1	4	2079	1200	0.25	145
2	35	2598	1500	0.25	145
3	30	8314	4800	0.25	145
4	170	8660	5000	0.25	145
5	110	6928	4000	0.25	145

DTN: MO0110SASWVDYM.000

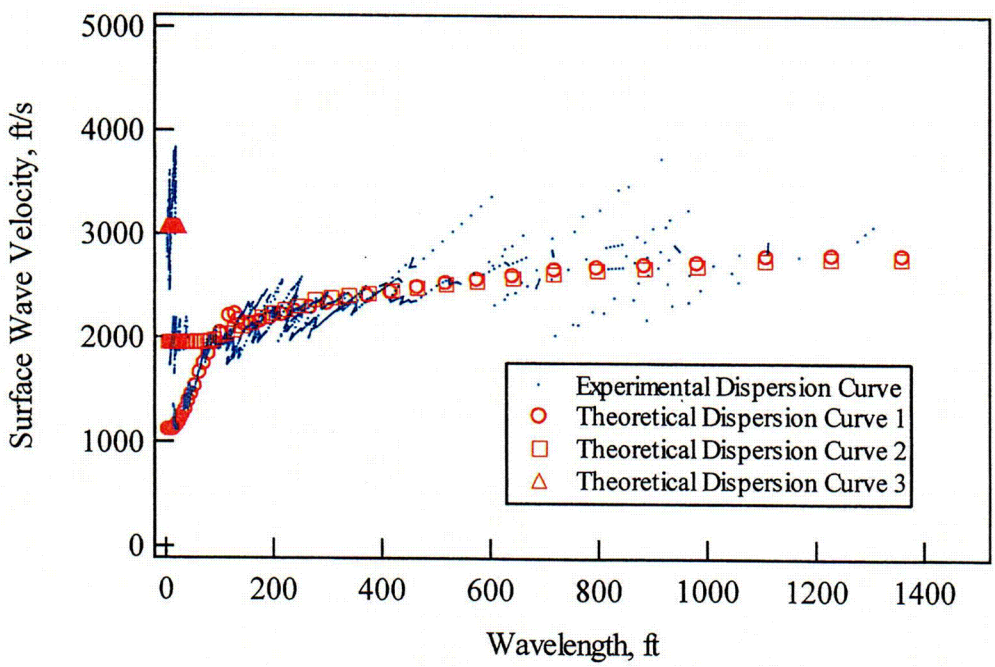
* Poisson's ratio and mass density from Wong (2002a, Appendix 24)

Figure XV-29. SASW-D10 Results (continued)



(Wong, 2002a, Appendix 25)

a. SASW-D11 Dispersion Curves (Log Plot)

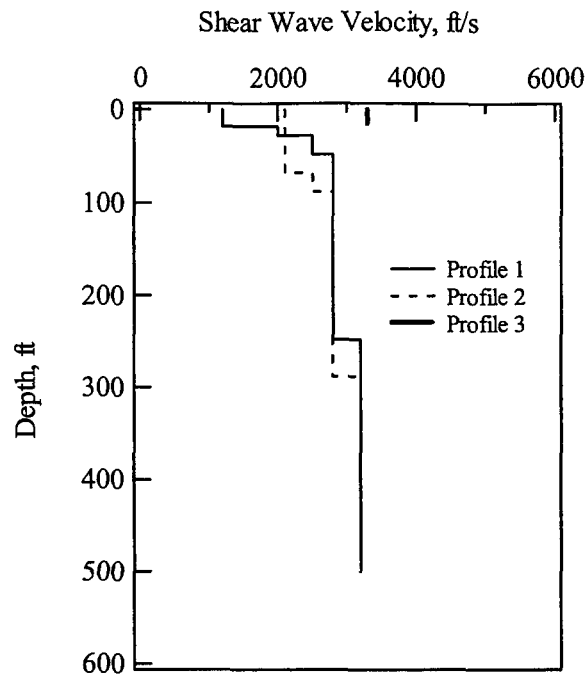


(Wong, 2002a, Appendix 25)

b. SASW-D11 Dispersion Curves (Linear Plot)

Figure XV-30. SASW-D11 Results

C35



DTN: MO0110SASWVDYM.000

c. SASW-D11 Shear Wave Velocity Profile

Location: SASW-D11 Profile 1

Layer No.	Thickness, ft	P-Wave Velocity, ft/s	S-Wave Velocity, ft/s	Poisson's Ratio*	Mass Density* pcf
1	18	2079	1200	0.25	145
2	10	3464	2000	0.25	145
3	20	4330	2500	0.25	145
4	200	4850	2800	0.25	145
5	252	5543	3200	0.25	145

Location: SASW-D11 Profile 2

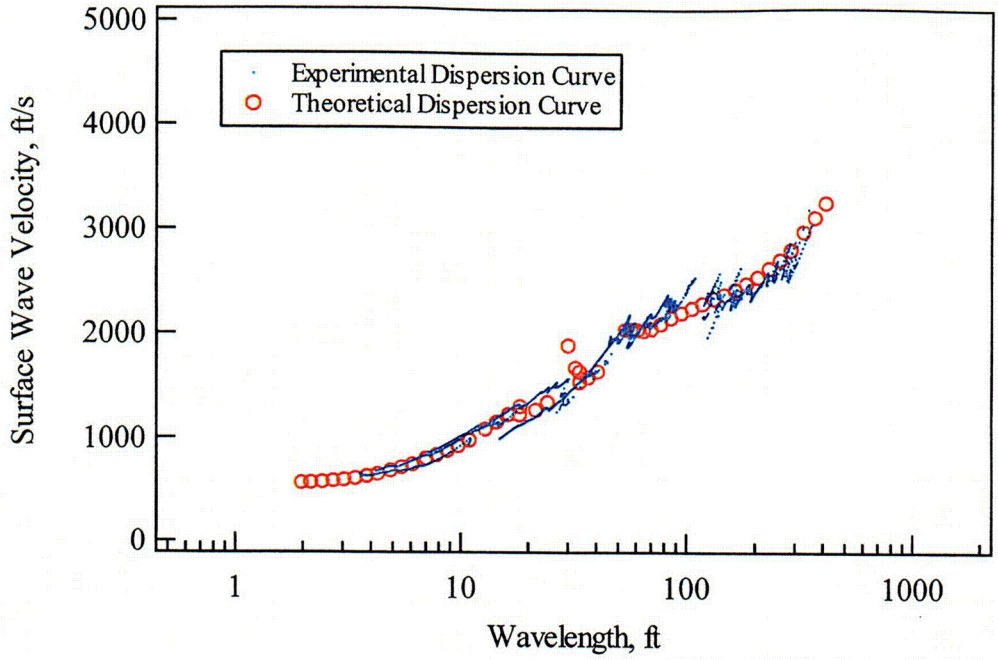
Layer No.	Thickness, ft	P-Wave Velocity, ft/s	S-Wave Velocity, ft/s	Poisson's Ratio*	Mass Density* pcf
1	68	3637	2100	0.25	145
2	20	4330	2500	0.25	145
3	200	4850	2800	0.25	145
4	212	5543	3200	0.25	145

Location: SASW-D11 Profile 3

Layer No.	Thickness, ft	P-Wave Velocity, ft/s	S-Wave Velocity, ft/s	Poisson's Ratio*	Mass Density* pcf
1	20	5716	3300	0.25	145

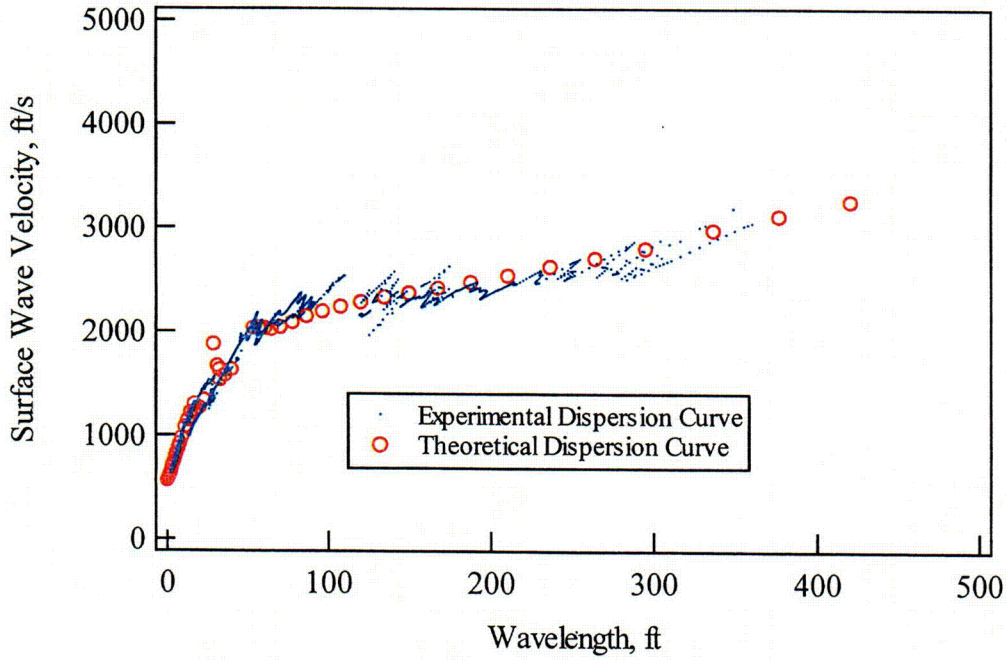
DTN: MO0110SASWVDYM.000

* Poisson's ratio and mass density from Wong (2002a, Appendix 25)



(Wong, 2002a, Appendix 26)

a. SASW-D12 Dispersion Curves (Log Plot)

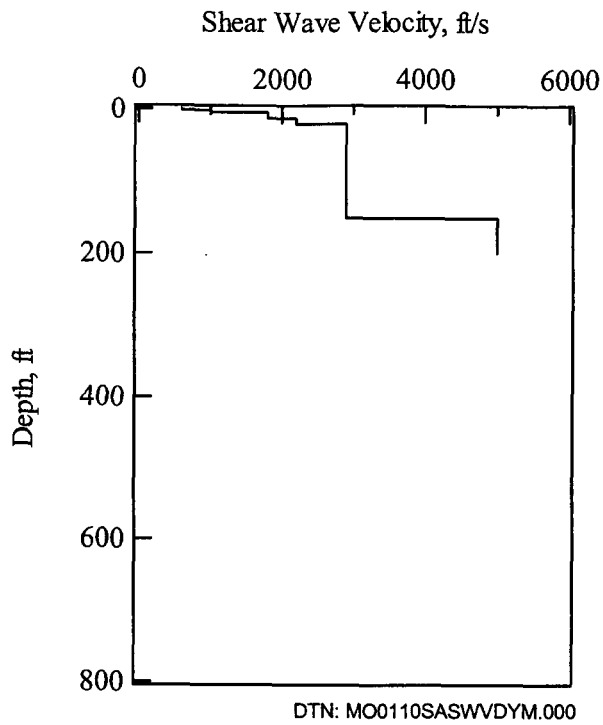


(Wong, 2002a, Appendix 26)

b. SASW-D12 Dispersion Curves (Linear Plot)

Figure XV-31. SASW-D12 Results

C36



c. SASW-D12 Shear Wave Velocity Profile

Location: SASW-D12

Layer No.	Thickness, ft	P-Wave Velocity, ft/s	S-Wave Velocity, ft/s	Poisson's Ratio*	Mass Density* pcf
1	2	1039	600	0.25	145
2	3	1732	1000	0.25	145
3	8	3118	1800	0.25	145
4	8	3811	2200	0.25	145
5	130	5023	2900	0.25	145
6	49	8660	5000	0.25	145

DTN: MO0110SASWVDYM.000

* Poisson's ratio and mass density from Wong (2002a, Appendix 26)

Figure XV-31. SASW-D12 Results (continued)

APPENDIX XVI

DOWNHOLE SEISMIC VELOCITY PLOTS – YUCCA MOUNTAIN CREST

ATTACHMENT XVI

DOWNHOLE SEISMIC VELOCITY PLOTS – YUCCA MOUNTAIN CREST

As discussed in Section 6.4.3, this attachment contains eight figures presenting the interpreted shear-wave and compression-wave velocity profiles from downhole seismic surveys conducted using eight boreholes that were installed in the past for other purposes. A detailed description of each analysis can be found in SN-M&O-SCI-039-V1 (Redpath 2002).

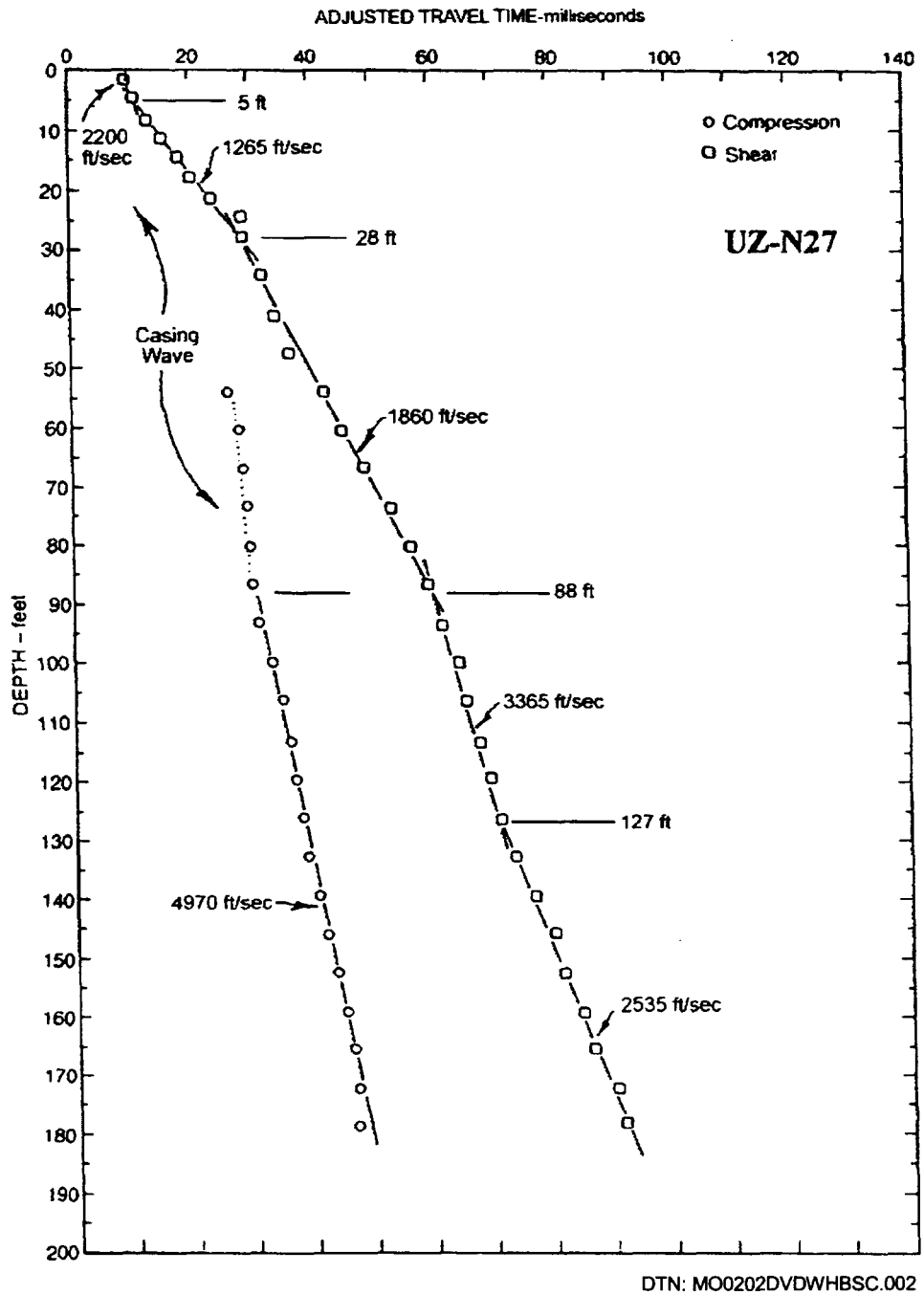


Figure XVI-1. UZ-N27 Downhole Travel Time Versus Depth Plots

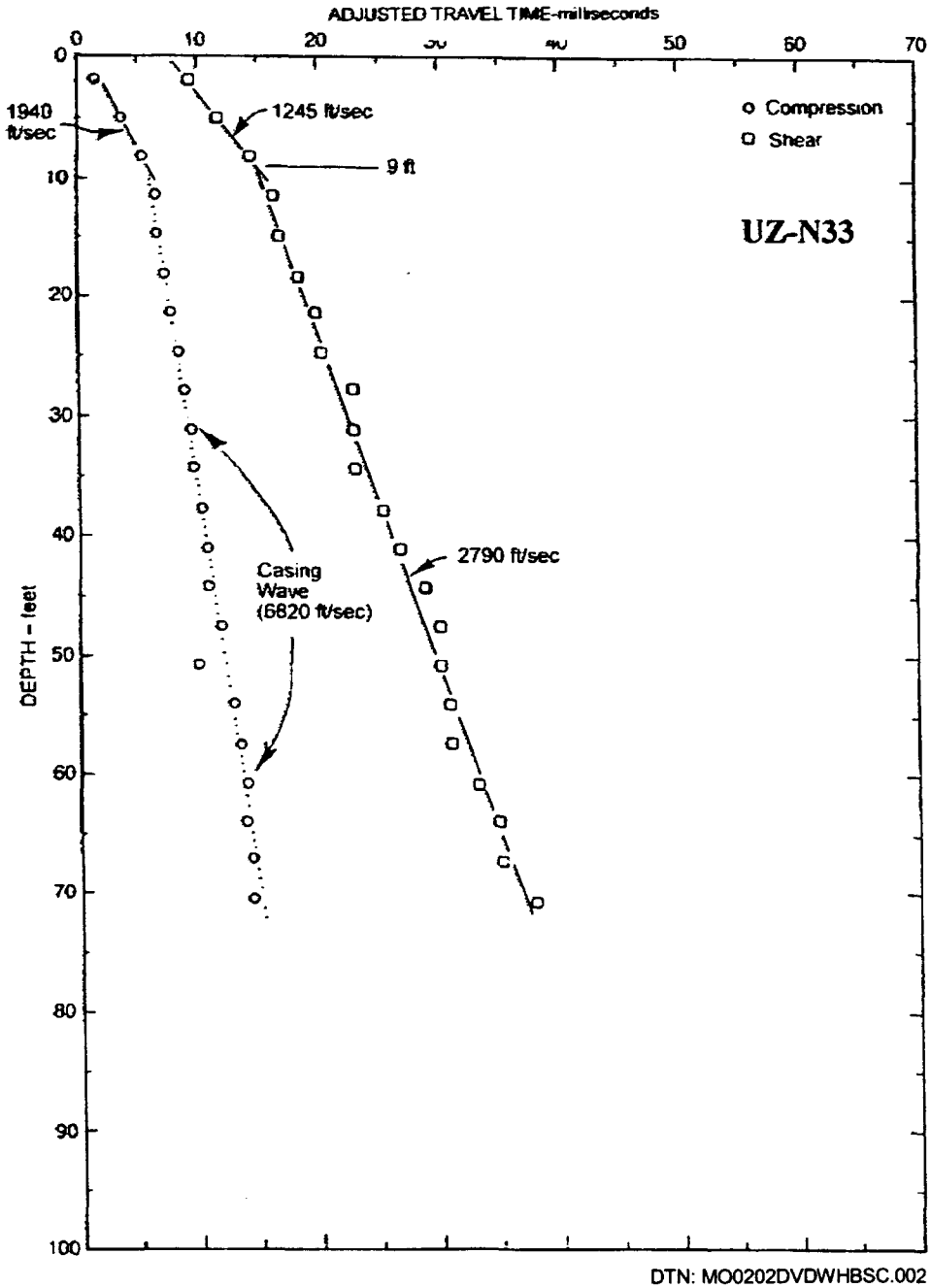


Figure XVI-2. UZ-N33 Downhole Travel Time Versus Depth Plots

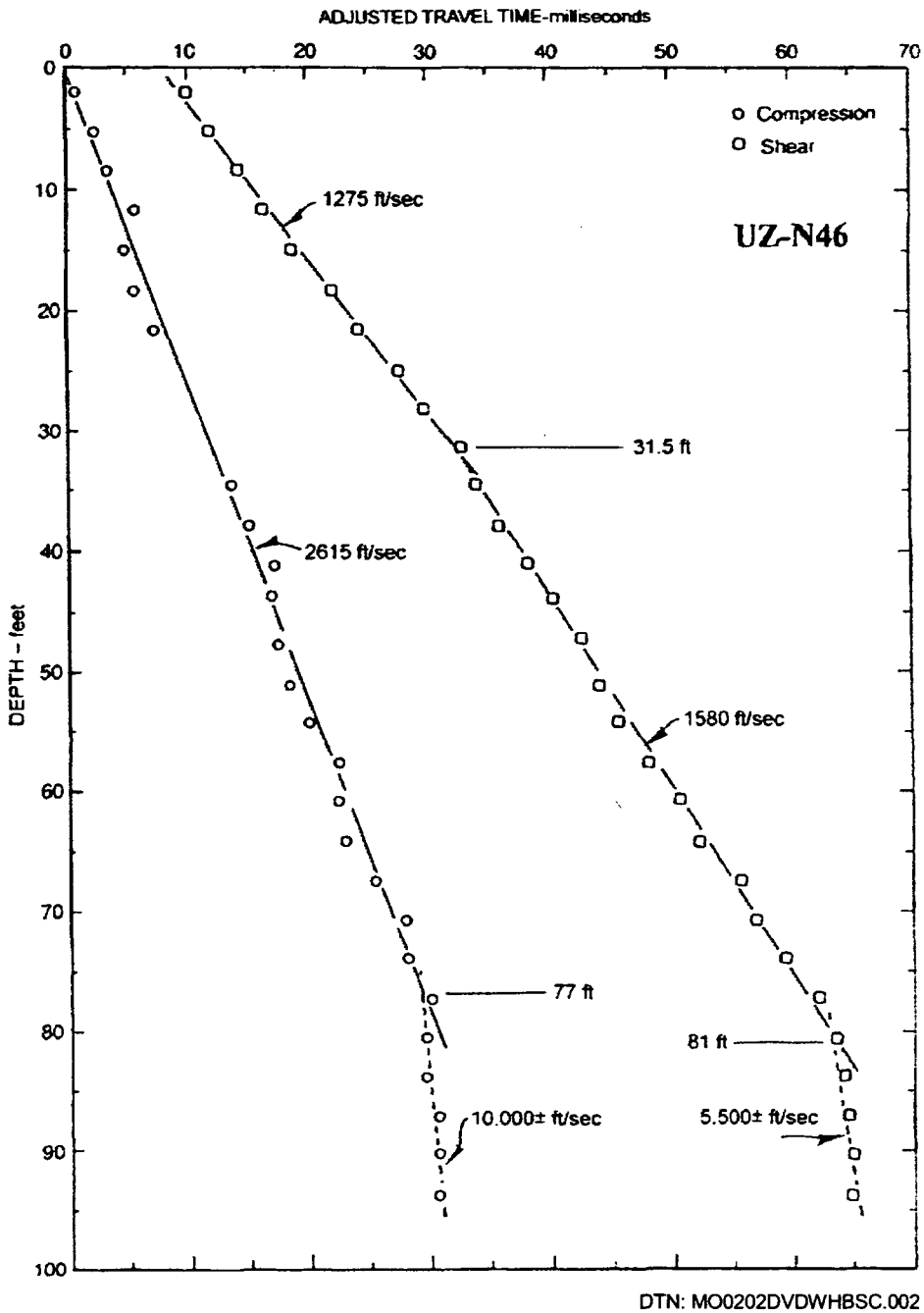
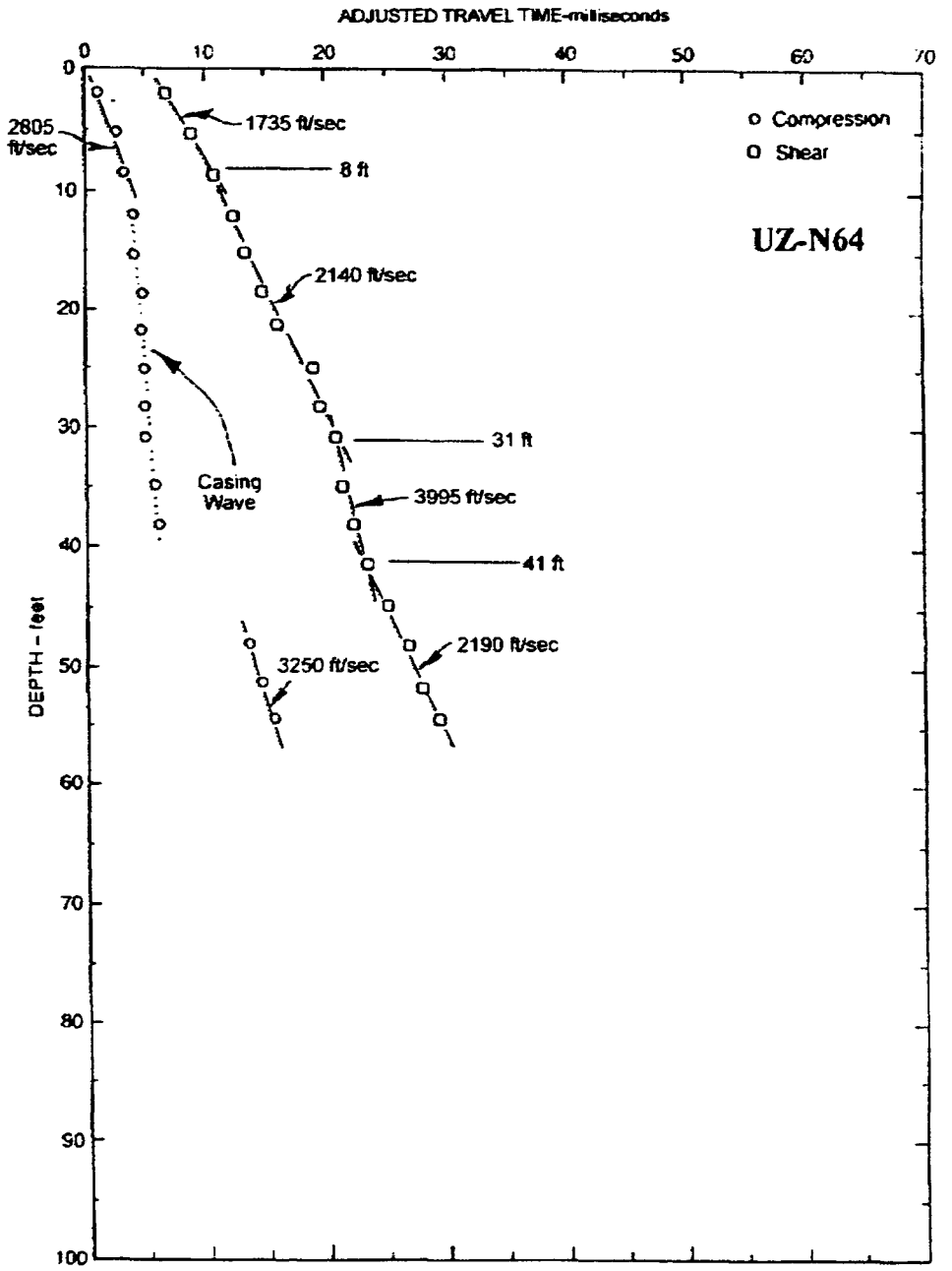


Figure XVI-3. UZ-N46 Downhole Travel Time Versus Depth Plots



DTN: MO0202DVDWHBSC.002

Figure XVI-4. UZ-N64 Downhole Travel Time Versus Depth Plots

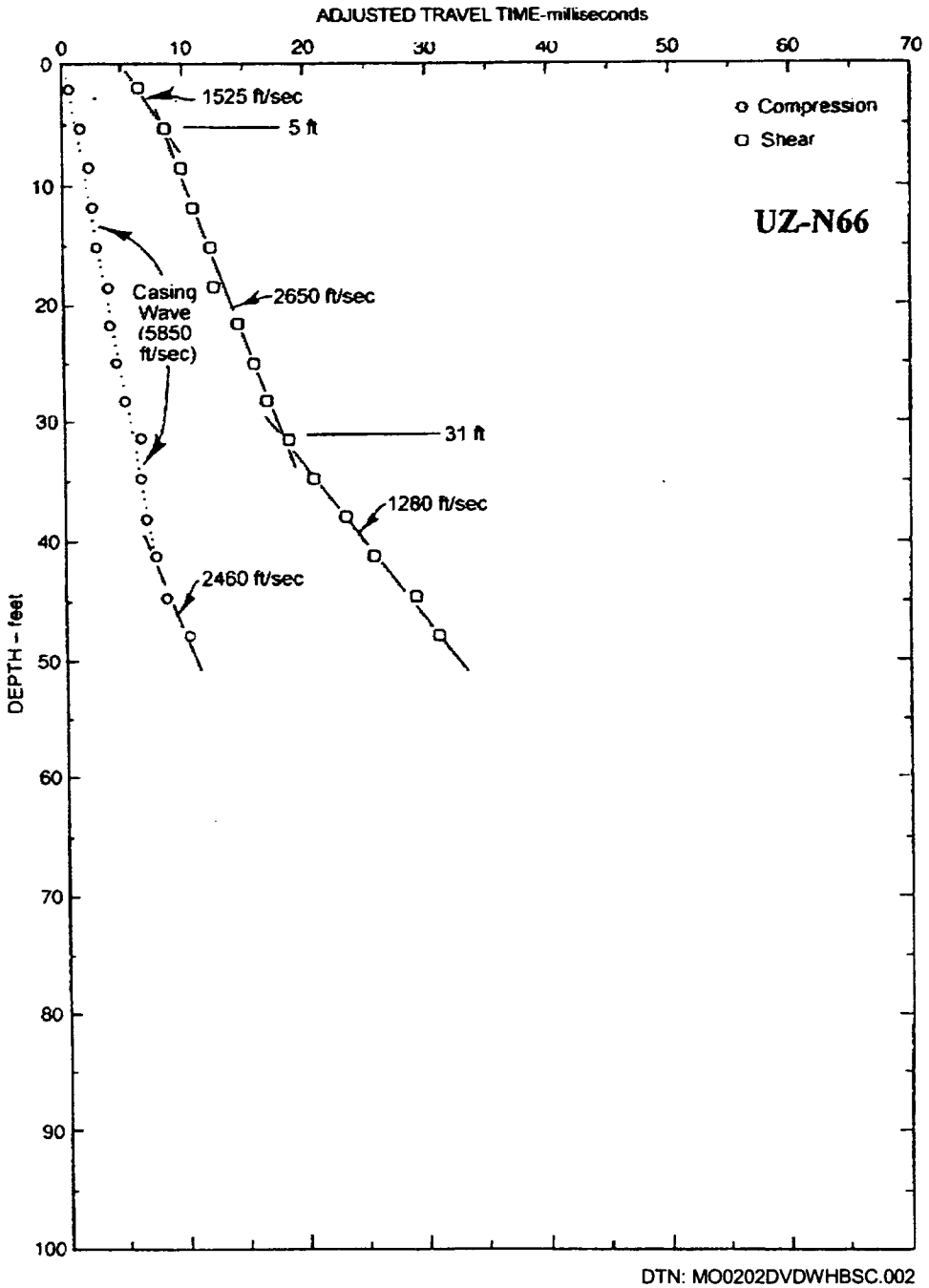


Figure XVI-5. UZ-N66 Downhole Travel Time Versus Depth Plots

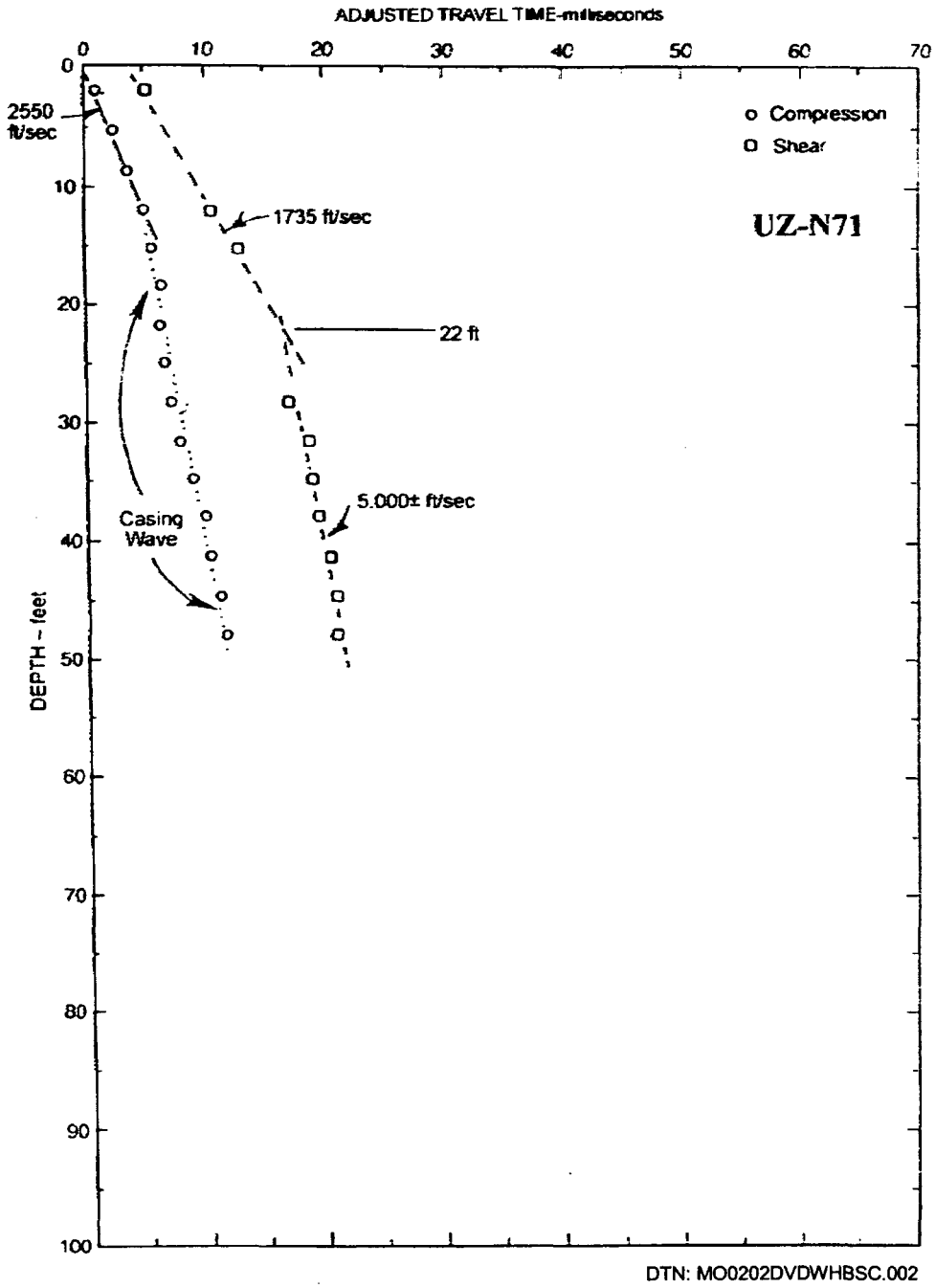


Figure XVI-6. UZ-N71 Downhole Travel Time Versus Depth Plots

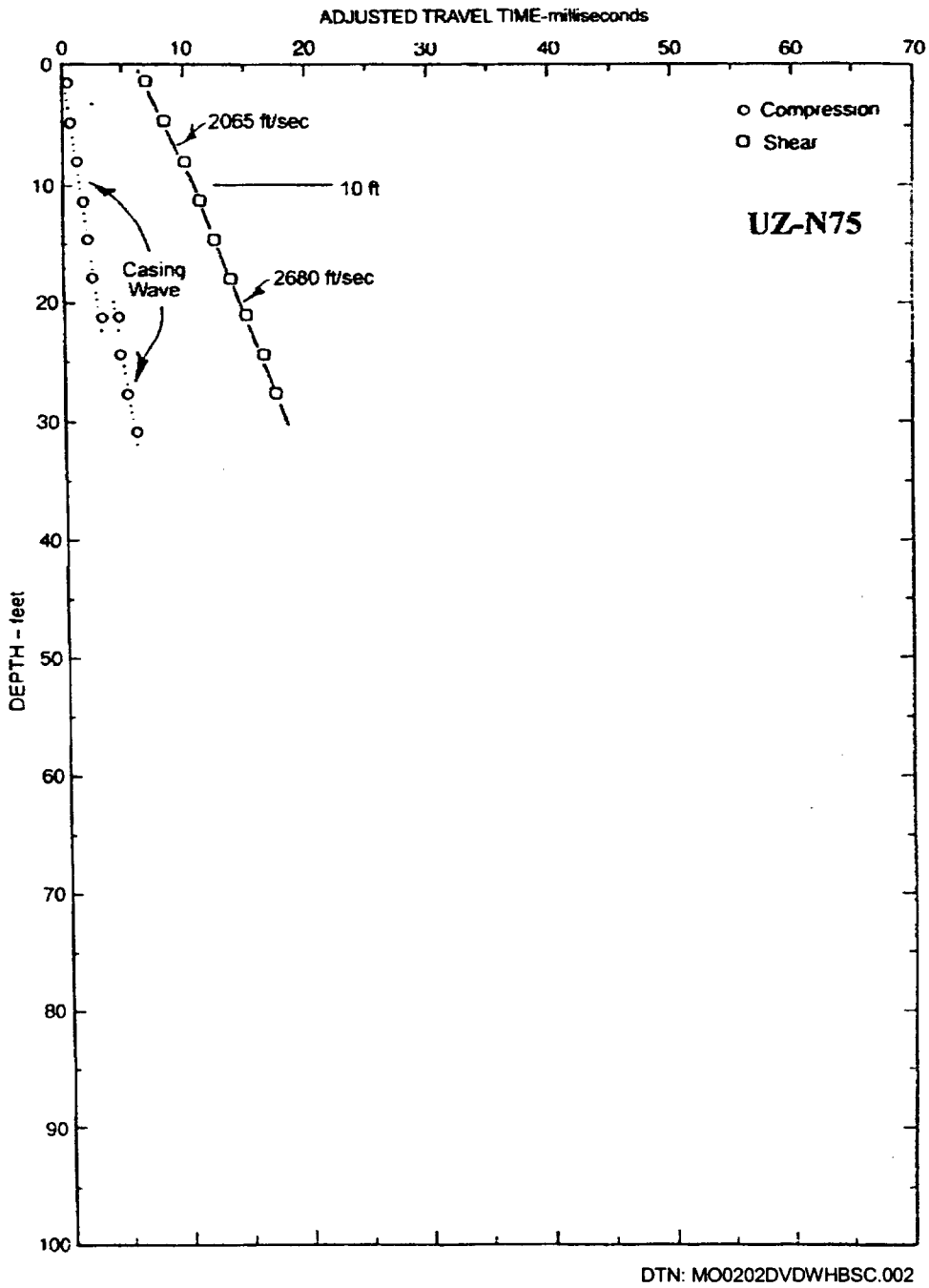


Figure XVI-7. UZ-N75 Downhole Travel Time Versus Depth Plots

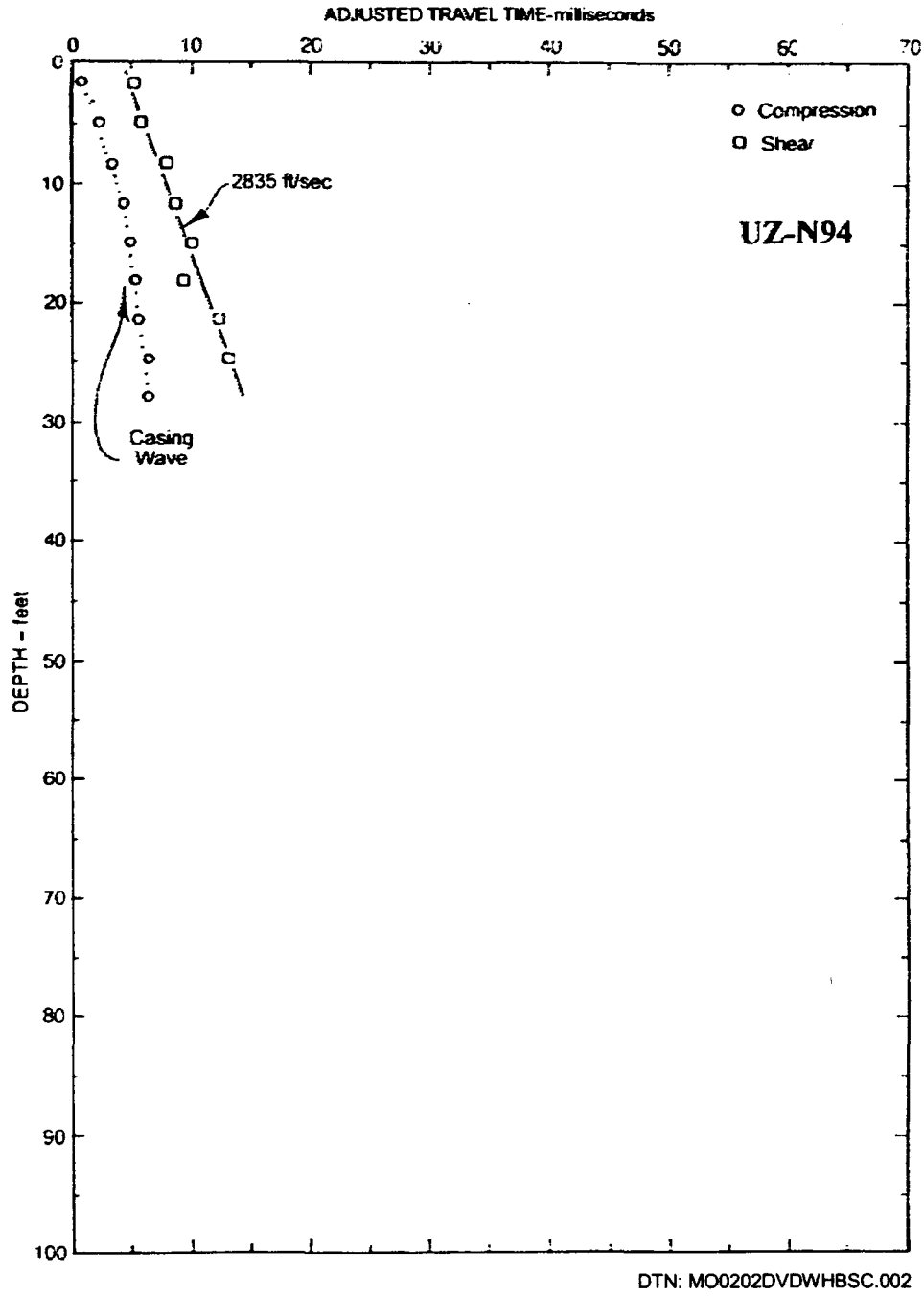


Figure XVI-8. UZ-N94 Downhole Travel Time Versus Depth Plots

ATTACHMENT XVII

GEOTECHNICAL LABORATORY DYNAMIC TESTING – FRAN RIDGE

ATTACHMENT XVII

GEOTECHNICAL LABORATORY DYNAMIC TESTING – FRAN RIDGE

As discussed in Section 6.5.3, this attachment presents the results of resonant column and torsional shear (RCTS) tests on compacted samples of material from the Fran Ridge Borrow Area, a potential borrow site to provide material for constructing an engineered fill at a potential WHB site. Twelve figures are followed by 10 tables. Each table spans two pages. The data on these tables is found in DTN: MO0203DHRSSWHB.001.

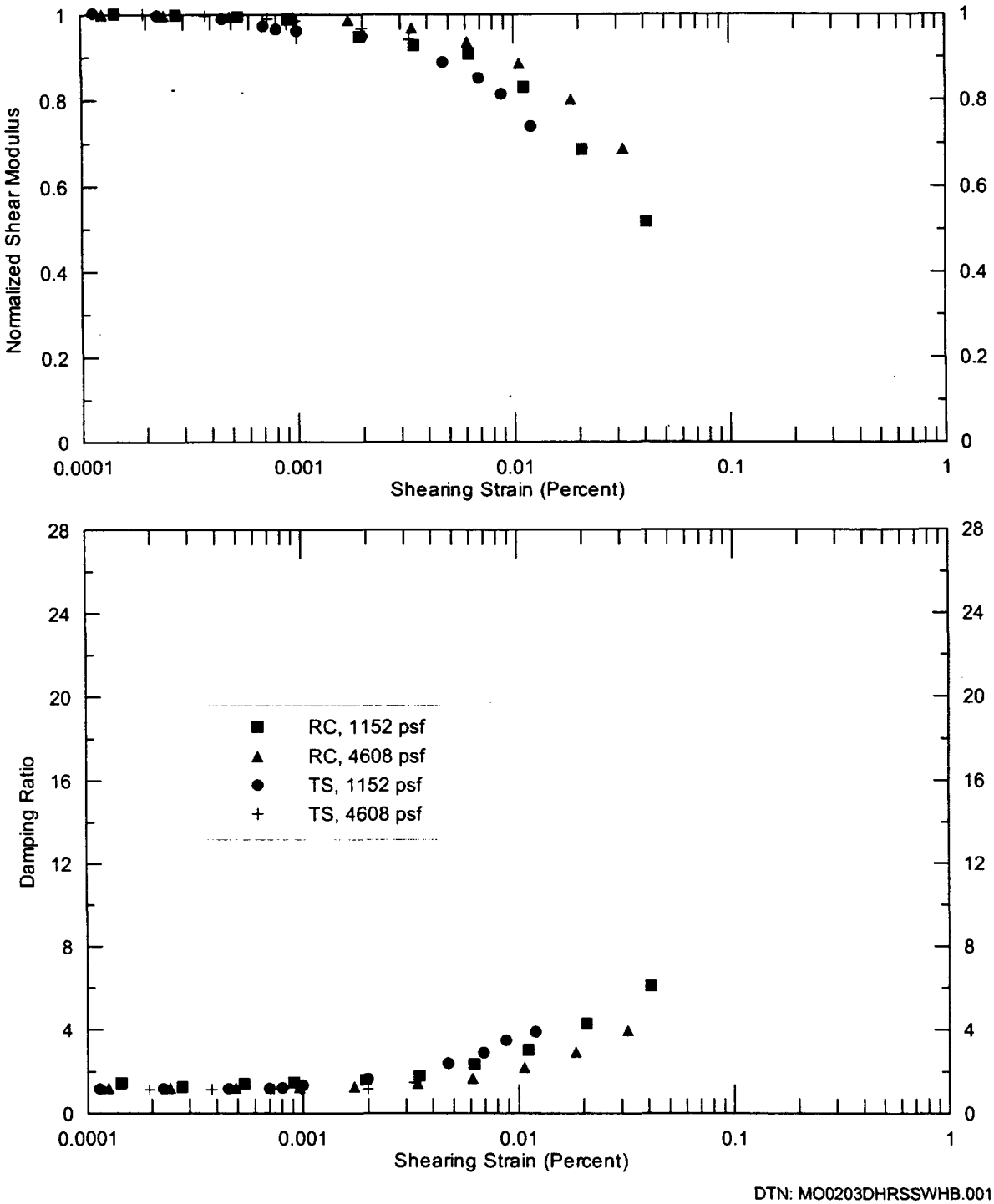


Figure XVII-1. Resonant Column and Torsional Shear Results for Specimen UTA-23-K

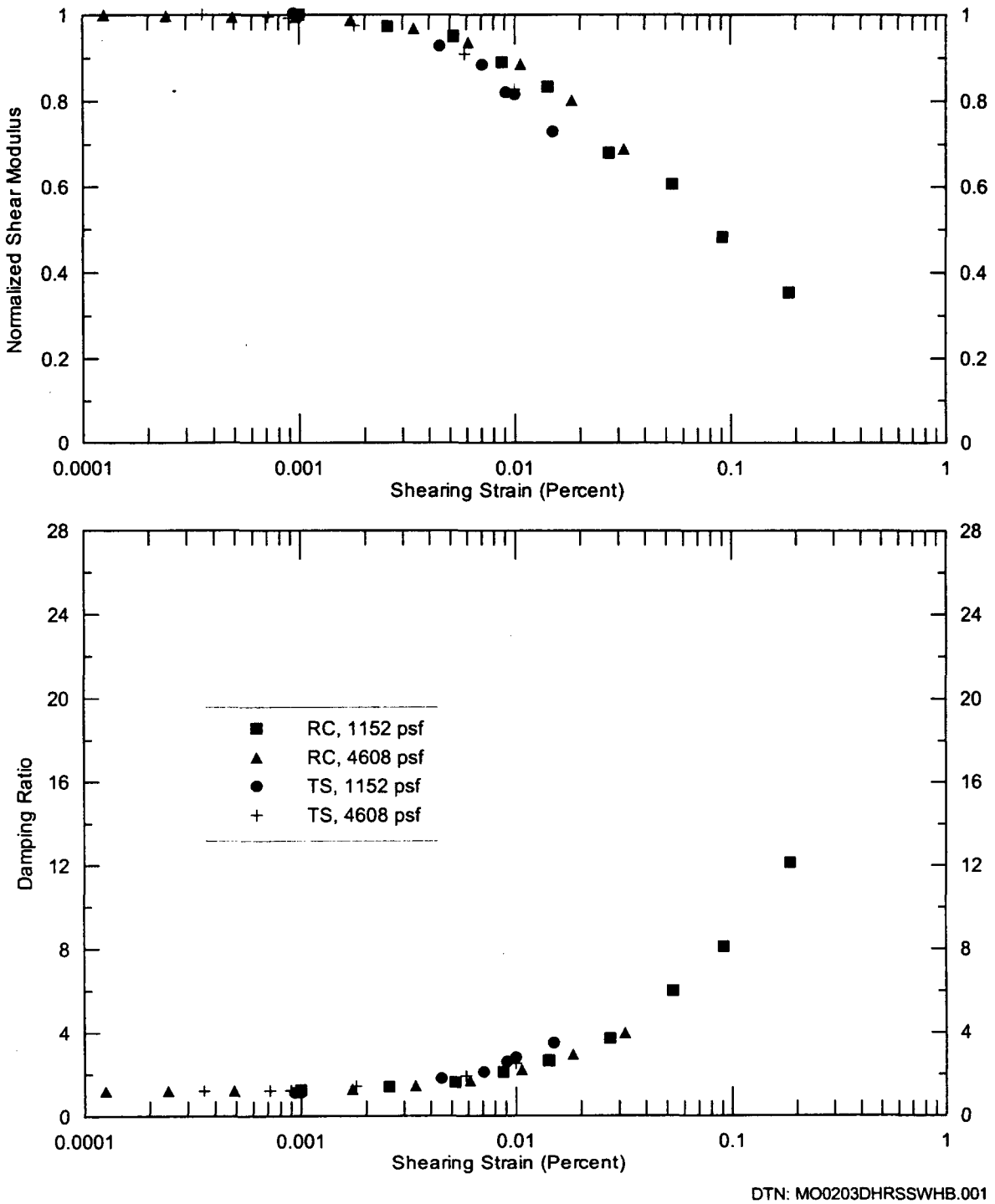
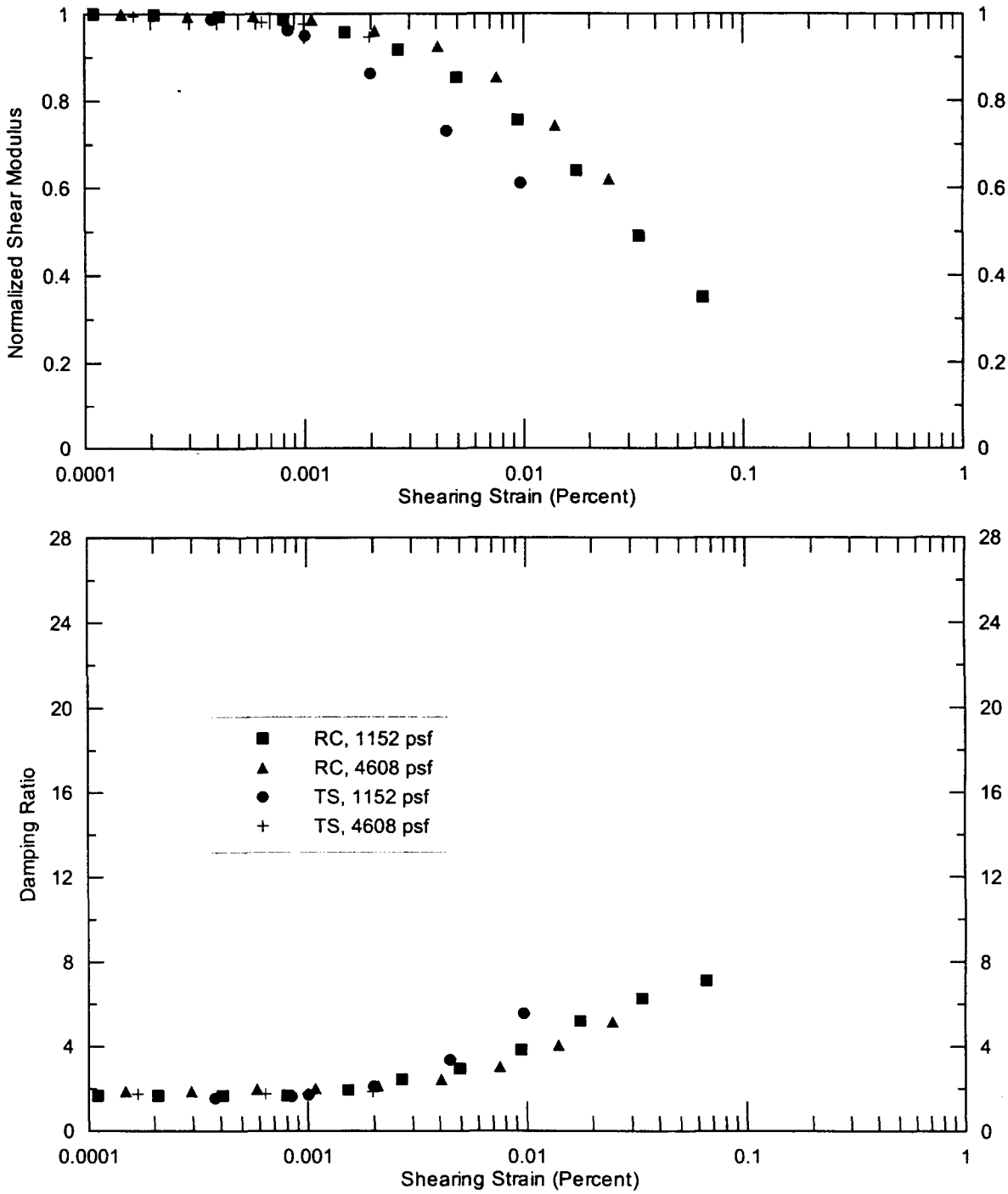


Figure XVII-2. Resonant Column and Torsional Shear Results for Specimen UTA-23-L



DTN: MO0203DHRSSWHB.001

Figure XVII-3. Resonant Column and Torsional Shear Results for Specimen UTA-23-M

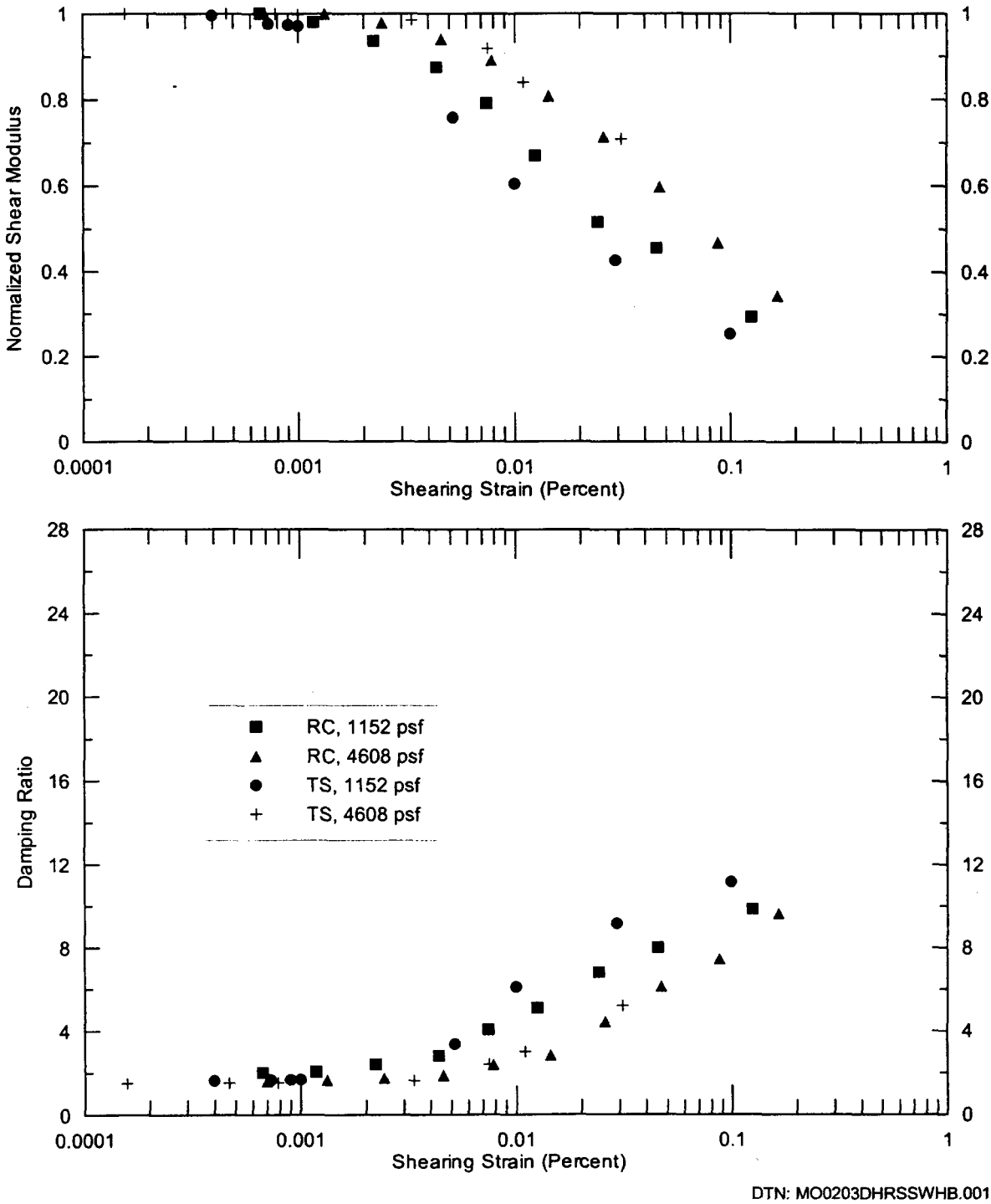
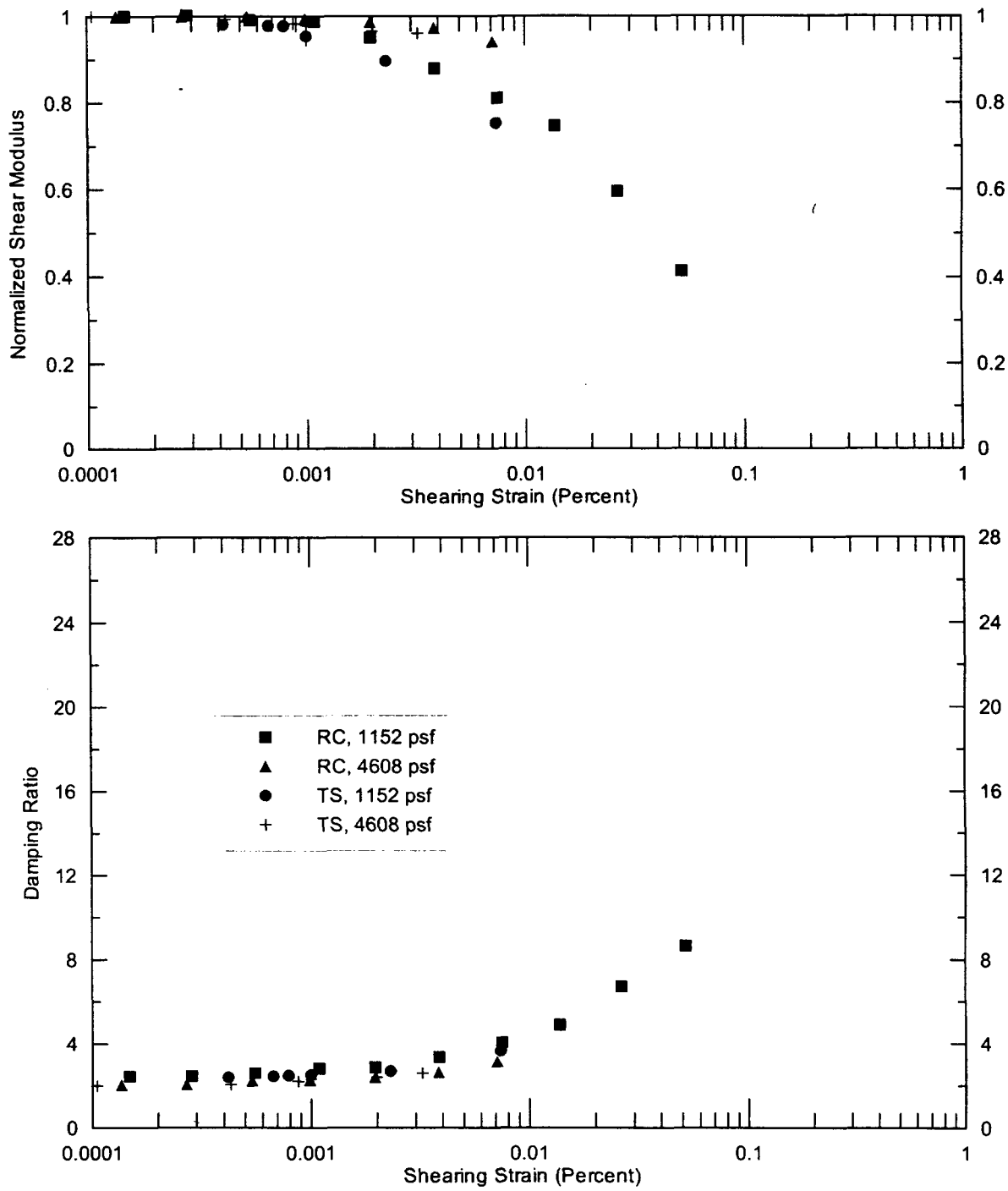


Figure XVII-4. Resonant Column and Torsional Shear Results for Specimen UTA-23-N



DTN: MO0203DHRSSWHB.001

Figure XVII-5. Resonant Column and Torsional Shear Results for Specimen UTA-23-O

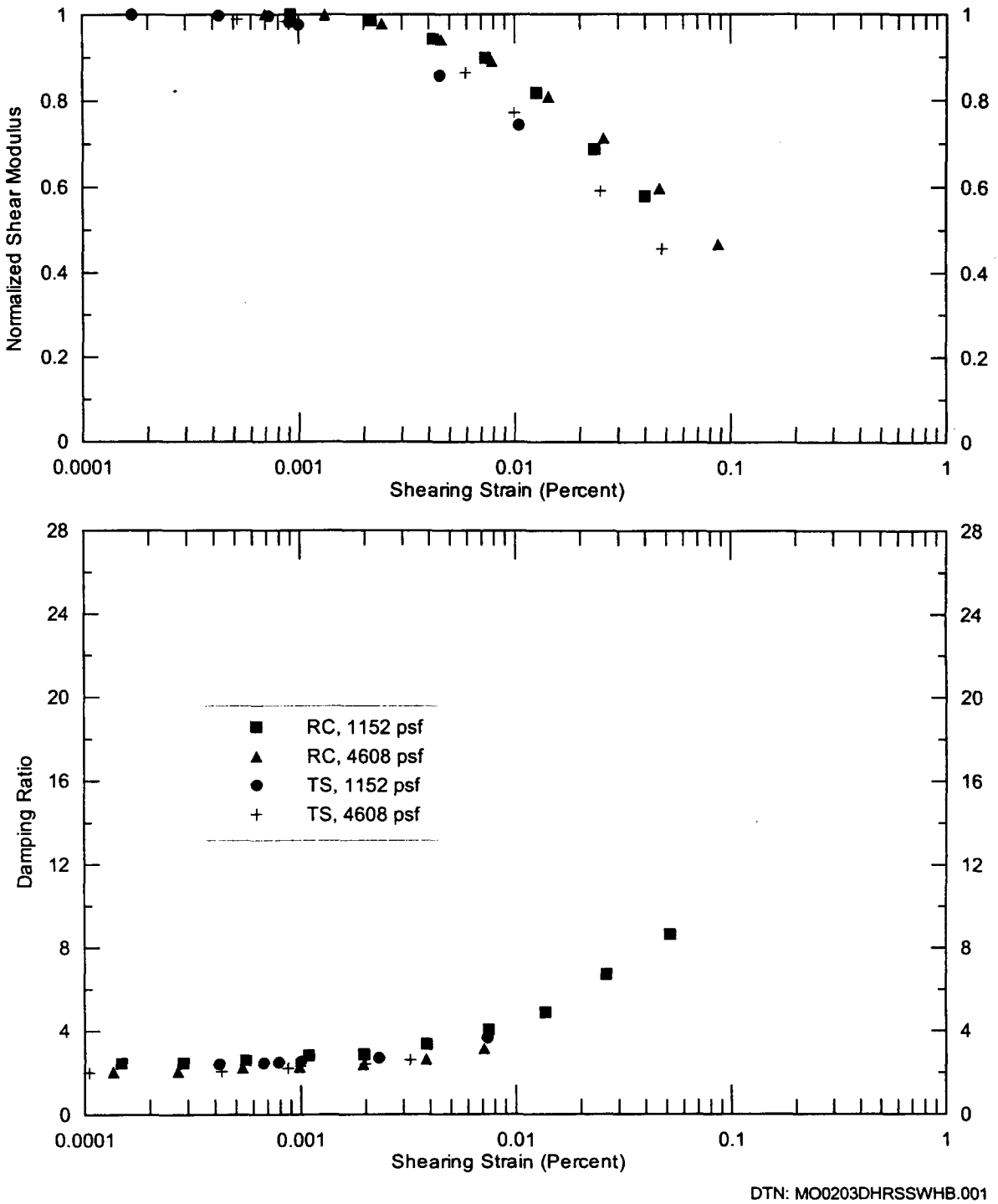


Figure XVII-6. Resonant Column and Torsional Shear Results for Specimen UTA-23-P

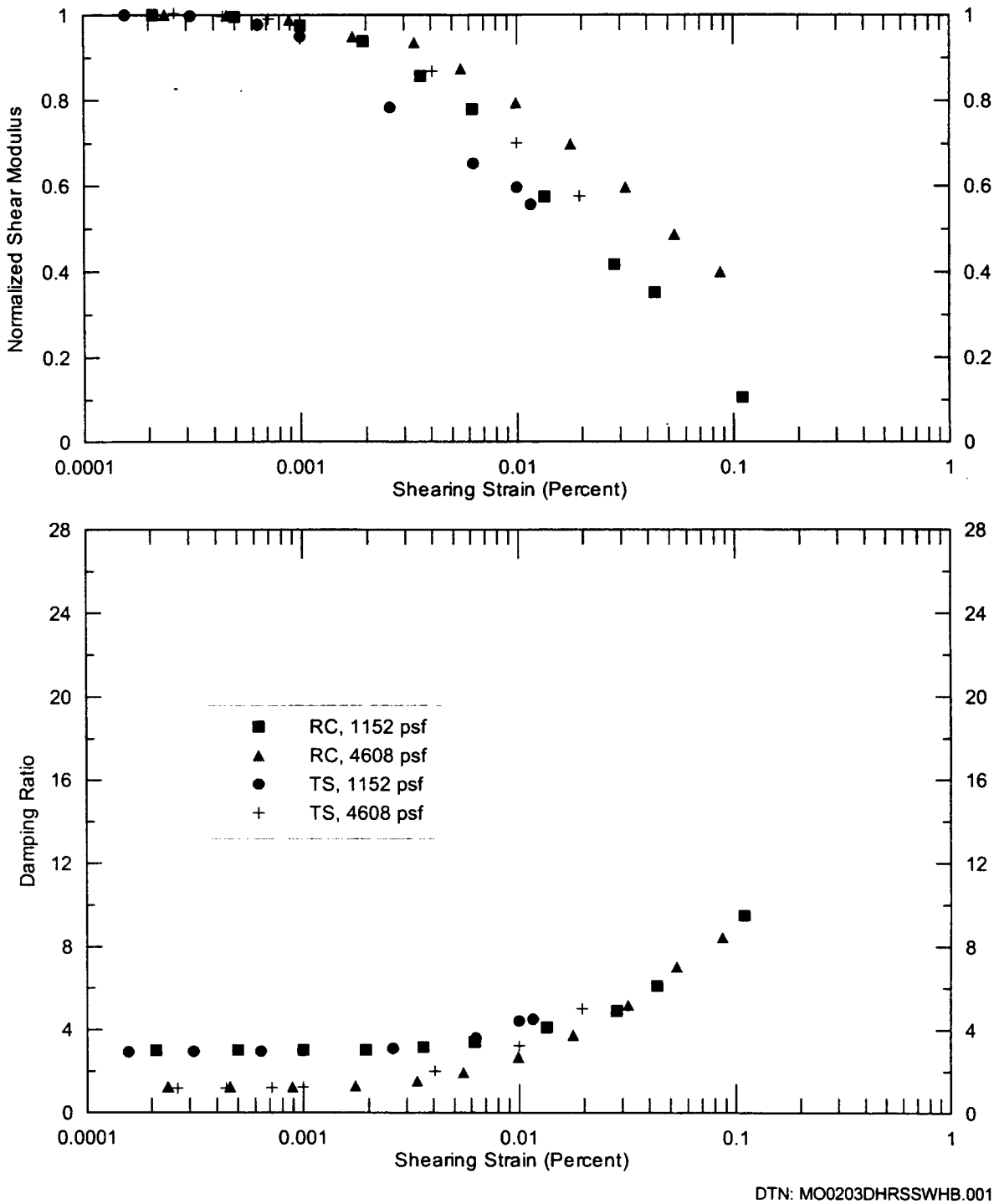


Figure XVII-7. Resonant Column and Torsional Shear Results for Specimen UTA-23-U

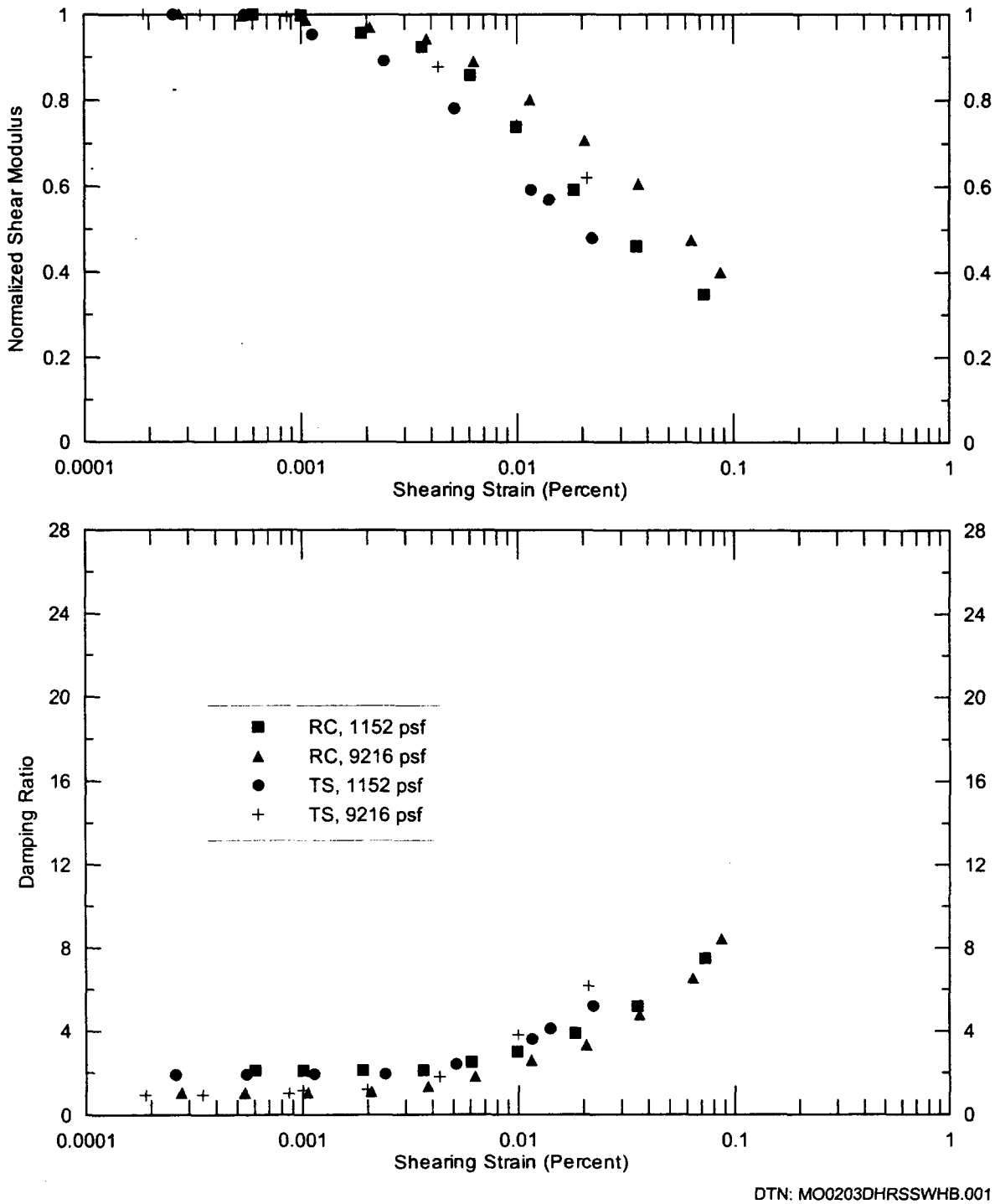
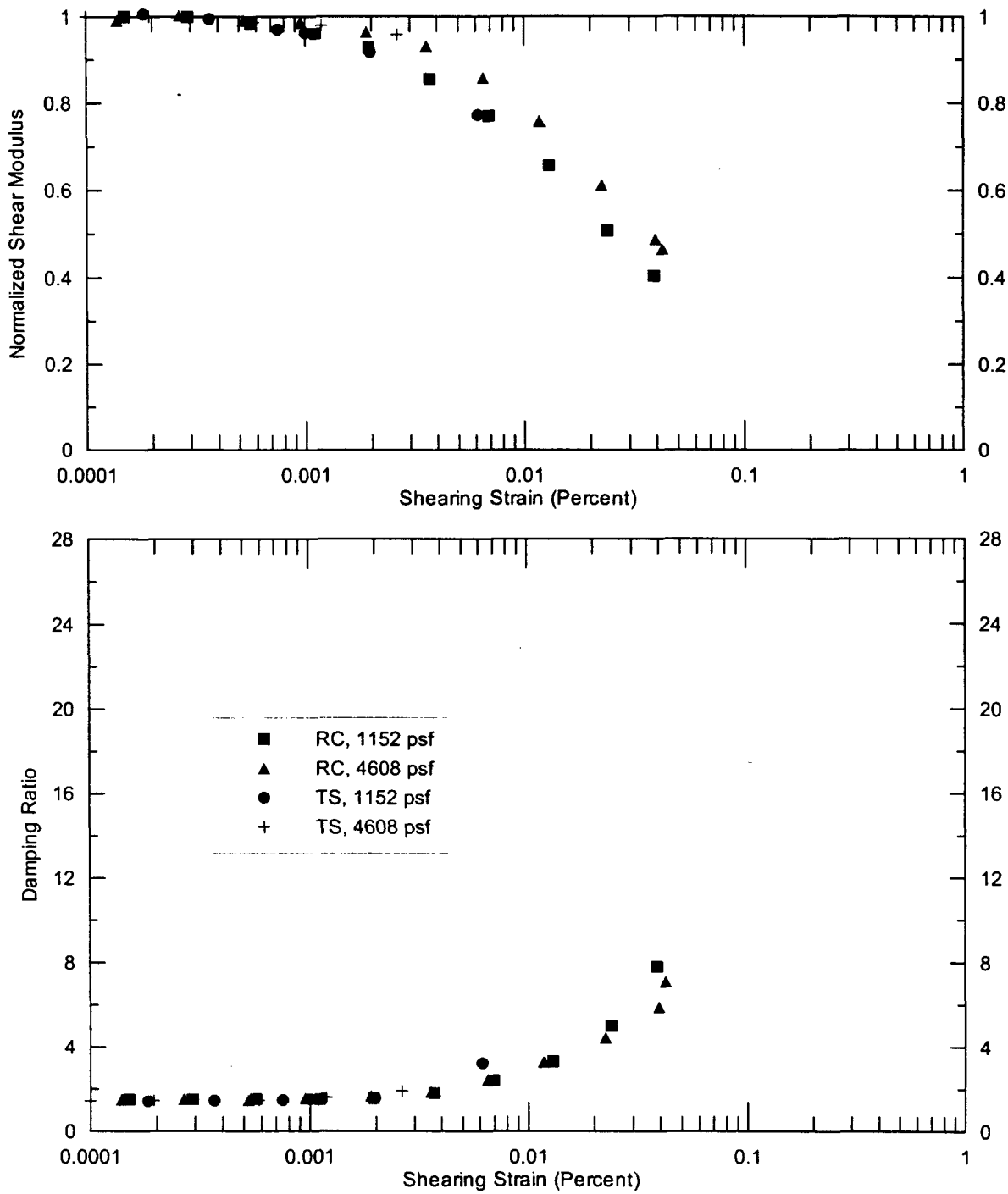


Figure XVII-8. Resonant Column and Torsional Shear Results for Specimen UTA-23-V



DTN: MO0203DHRSSWHB.001

Figure XVII-9. Resonant Column and Torsional Shear Results for Specimen UTA-23-W

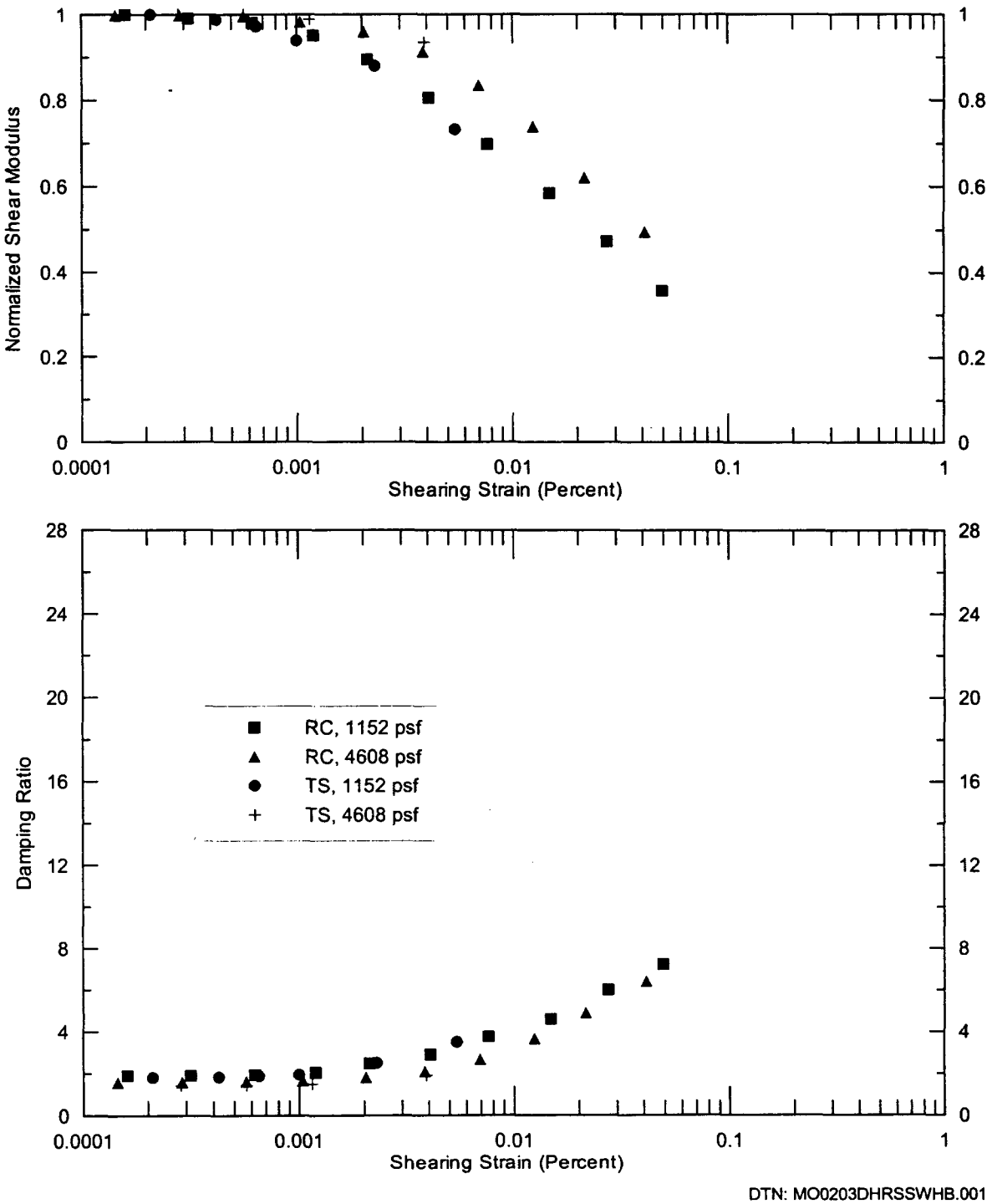
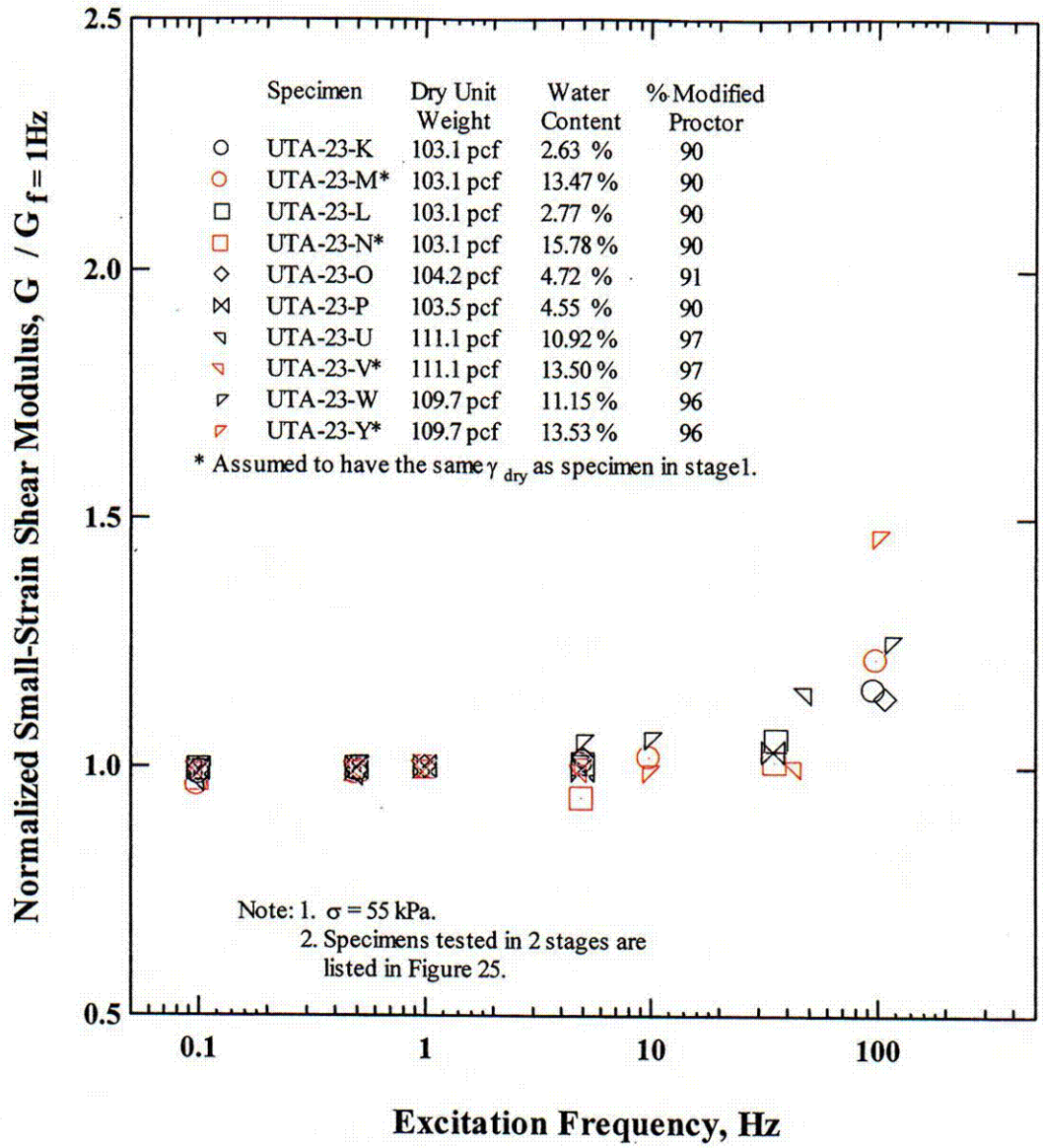


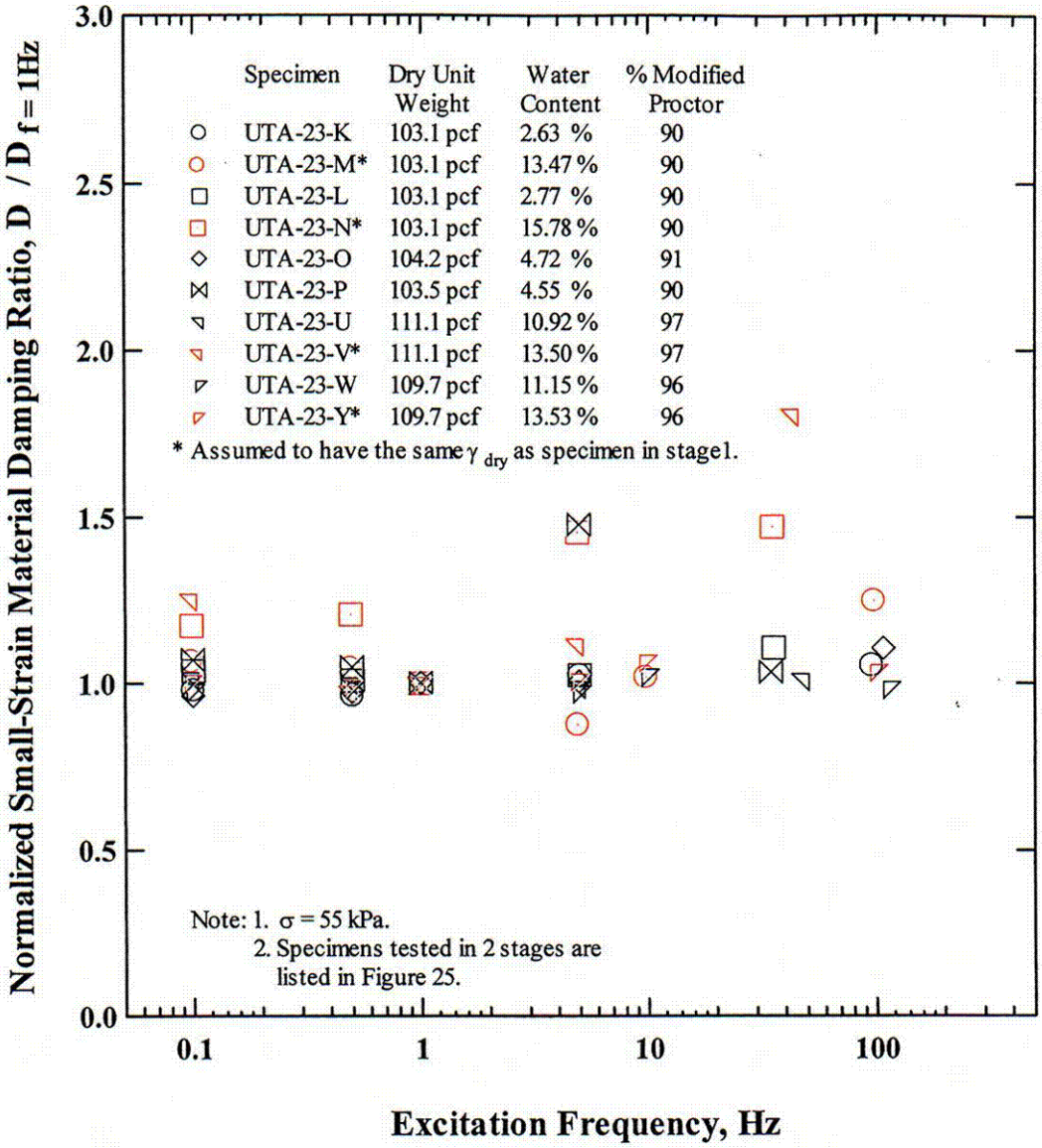
Figure XVII-10. Resonant Column and Torsional Shear Results for Specimen UTA-23-Y



(Modified fromWong, 2002e, Appendix 42, page 73)

Figure XVII-11. Variation in Small-Strain Shear Modulus with Excitation Frequency of Reconstituted Specimens of the Proposed Engineered Fill.

C37



(Modified fromWong, 2002e, Appendix 42, page 73)

Figure XVII-12. Variation in Normalized Small-Strain Material Damping Ratio with Excitation Frequency of Reconstituted Specimens of the Proposed Engineered Fill.

C38

Table XVII-1a. Variation in Low-Amplitude Shear-Wave Velocity, Low-Amplitude Shear Modulus, Low-Amplitude Material Damping Ratio and Void Ratio with Effective Isotropic Confining Pressure from RC Tests of Specimen UTA-23-K.

Effective Isotropic Confining Pressure, σ_o'			Low-Amplitude Shear Modulus, G_{max}		Low-Amplitude Shear-Wave Velocity, Vs	Low-Amplitude Material Damping Ratio, Dmin, %	Void Ratio, e
(psi)	(psf)	(kPa)	(ksf)	(MPa)	(fps)		
2	288	13.8	800	38	488	2.08	0.60
4	576	27.6	1037	50	555	1.64	0.60
8	1152	55.2	1422	68	657	1.64	0.60
16	2304	110.5	2841	136	925	1.42	0.59
32	4608	220.9	3689	177	1053	1.23	0.58

Table XVII-1b. Variation in Shear Modulus, Normalized Shear Modulus and Material Damping Ratio with Shearing Strain from RC Tests of Specimen UTA-23-K; Effective Confining Pressure, σ_o' = 8psi (1.2 ksf = 55 kPa)

Peak Shearing Strain, %	Shear Modulus, G, ksf	Normalized Shear Modulus, G/G_{max}	Average+ Shearing Strain, %	Material Damping Ratio×, D, %
1.44E-04	1505	1.00	1.32E-04	1.44
2.78E-04	1500	1.00	2.57E-04	1.26
5.36E-04	1495	1.00	4.92E-04	1.42
9.10E-04	1486	0.99	8.00E-04	1.48
1.95E-03	1425	0.95	1.77E-03	1.62
3.47E-03	1395	0.93	3.12E-03	1.79
6.23E-03	1365	0.91	5.41E-03	2.36
1.11E-02	1248	0.83	9.28E-03	3.03
2.07E-02	1031	0.69	1.62E-02	4.29
4.10E-02	778	0.52	2.93E-02	6.10

+ Average Shearing Strain from the First Three Cycles of the Free Vibration Decay Curve

× Average Damping Ratio from the First Three Cycles of the Free Vibration Decay Curve

Table XVII-1c. Variation in Shear Modulus, Normalized Shear Modulus and Material Damping Ratio with Shearing Strain from TS Tests of Specimen UTA-23-K; Effective Confining Pressure, σ_o' = 8psi (1.2 ksf = 55 kPa)

First Cycle				Tenth Cycle			
Peak Shearing Strain, %	Shear Modulus, G, ksf	Normalized Shear Modulus, G/G_{max}	Material Damping Ratio, D, %	Peak Shearing Strain, %	Shear Modulus, G, ksf	Normalized Shear Modulus, G/G_{max}	Material Damping Ratio, D, %
1.14E-04	1350	1.00	1.17	1.14E-04	1339	1.00	1.18
2.27E-04	1342	1.00	1.18	2.27E-04	1332	0.99	1.19
4.54E-04	1332	0.99	1.18	4.54E-04	1321	0.99	1.19
7.01E-04	1310	0.97	1.19	7.01E-04	1300	0.97	1.20
8.04E-04	1308	0.97	1.22	8.04E-04	1290	0.97	1.24
1.00E-03	1300	0.96	1.35	1.00E-03	1290	0.96	1.36
2.00E-03	1280	0.95	1.65	2.00E-03	1270	0.95	1.67
4.72E-03	1200	0.89	2.40	4.73E-03	1180	0.89	2.42
6.90E-03	1150	0.85	2.90	7.00E-03	1100	0.82	2.91
8.77E-03	1100	0.81	3.50	8.80E-03	1050	0.78	3.52
1.20E-02	1000	0.74	3.90	1.20E-02	970	0.72	3.95

DTN: MO0203DHRSSWHB.001

Table XVII-1d. Variation in Shear Modulus, Normalized Shear Modulus and Material Damping Ratio with Shearing Strain from RC Tests of Specimen UTA-23-K; Effective Confining Pressure, σ_o' =32psi (4.6 ksf = 221 kPa)

Peak Shearing Strain, %	Shear Modulus, G, ksf	Normalized Shear Modulus, G/G_{max}	Average[+] Shearing Strain, %	Material Damping Ratio[x], D, %
6.36E-05	3805	1.00	5.84E-05	1.21
1.25E-04	3805	1.00	1.16E-04	1.21
2.44E-04	3795	1.00	2.28E-04	1.21
4.91E-04	3785	0.99	4.56E-04	1.22
9.65E-04	3785	0.99	8.95E-04	1.24
1.73E-03	3760	0.99	1.60E-03	1.29
3.40E-03	3686	0.97	3.12E-03	1.44
6.12E-03	3564	0.94	5.53E-03	1.70
1.07E-02	3373	0.89	9.34E-03	2.21
1.84E-02	3052	0.80	1.55E-02	2.95
3.21E-02	2621	0.69	2.55E-02	3.97

[+] Average Shearing Strain from the First Three Cycles of the Free Vibration Decay Curve

[x] Average Damping Ratio from the First Three Cycles of the Free Vibration Decay Curve

Table XVII-1e. Variation in Shear Modulus, Normalized Shear Modulus and Material Damping Ratio with Shearing Strain from TS Tests of Specimen UTA-23-K; Effective Confining Pressure, σ_o' = 32psi (4.6 ksf = 221 kPa)

First Cycle				Tenth Cycle			
Peak Shearing Strain, %	Shear Modulus, G, ksf	Normalized Shear Modulus, G/G_{max}	Material Damping Ratio, D, %	Peak Shearing Strain, %	Shear Modulus, G, ksf	Normalized Shear Modulus, G/G_{max}	Material Damping Ratio, D, %
1.95E-04	3090	1.00	1.12	1.95E-04	3080	1.00	1.13
3.80E-04	3080	1.00	1.14	3.89E-04	3070	1.00	1.15
7.35E-04	3060	0.99	1.15	7.35E-04	3060	0.99	1.16
9.80E-04	3045	0.99	1.16	9.80E-04	3040	0.99	1.17
2.00E-03	2988	0.97	1.17	2.01E-03	2980	0.97	1.18
3.30E-03	2910	0.94	1.47	3.33E-03	2900	0.94	1.44

DTN: MO0203DHRSSWHB.001

Table XVII-2a. Variation in Low-Amplitude Shear-Wave Velocity, Low-Amplitude Shear Modulus, Low-Amplitude Material Damping Ratio and Void Ratio with Effective Isotropic Confining Pressure from RC Tests of Specimen UTA-23-L.

Effective Isotropic Confining Pressure, σ_o'			Low-Amplitude Shear Modulus, G_{max}		Low-Amplitude Shear-Wave Velocity, Vs	Low-Amplitude Material Damping Ratio, Dmin, %	Void Ratio, e
(psi)	(psf)	(kPa)	(ksf)	(MPa)	(fps)		
2	288	13.8	764	37	471	3.01	0.52
4	576	27.6	967	46	531	2.40	0.52
8	1152	55.2	1374	66	646	2.40	0.52
16	2304	110.5	2484	119	863	1.46	0.50
32	4608	220.9	3370	162	1004	1.42	0.50

Table XVII-2b. Variation in Shear Modulus, Normalized Shear Modulus and Material Damping Ratio with Shearing Strain from RC Tests of Specimen UTA-23-L; Effective Confining Pressure, σ_o' = 8psi (1.2 ksf = 55 kPa)

Peak Shearing Strain, %	Shear Modulus, G, ksf	Normalized Shear Modulus, G/G_{max}	Average* Shearing Strain, %	Material Damping Ratio^x, D, %
1.00E-03	1500	1.00	9.27E-04	1.24
2.57E-03	1460	0.97	2.36E-03	1.39
5.22E-03	1425	0.95	4.20E-03	1.60
8.75E-03	1327	0.89	7.17E-03	2.10
1.42E-02	1242	0.83	1.17E-02	2.65
2.73E-02	1020	0.68	2.26E-02	3.70
5.35E-02	910	0.61	4.45E-02	6.00
9.16E-02	719	0.48	5.98E-02	8.11
1.86E-01	526	0.35	1.04E-01	12.12

* Average Shearing Strain from the First Three Cycles of the Free Vibration Decay Curve

^x Average Damping Ratio from the First Three Cycles of the Free Vibration Decay Curve

Table XVII-2c. Variation in Shear Modulus, Normalized Shear Modulus and Material Damping Ratio with Shearing Strain from TS Tests of Specimen UTA-23-L; Effective Confining Pressure, σ_o' = 8psi (1.2 ksf = 55 kPa)

First Cycle				Tenth Cycle			
Peak Shearing Strain, %	Shear Modulus, G, ksf	Normalized Shear Modulus, G/G_{max}	Material Damping Ratio, D, %	Peak Shearing Strain, %	Shear Modulus, G, ksf	Normalized Shear Modulus, G/G_{max}	Material Damping Ratio, D, %
9.36E-04	1430	1.00	1.12	9.36E-04	1420	1.00	1.14
1.00E-03	1420	1.00	1.13	1.00E-03	1415	1.00	1.15
4.50E-03	1323	0.93	1.80	4.50E-03	1316	0.93	1.82
7.10E-03	1261	0.88	2.10	7.10E-03	1257	0.89	2.15
9.10E-03	1170	0.82	2.60	9.10E-03	1156	0.82	2.62
1.00E-02	1163	0.82	2.80	1.00E-02	1150	0.81	2.90
1.50E-02	1040	0.73	3.50	1.52E-02	1030	0.73	3.60

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Table XVII-2d. Variation in Shear Modulus, Normalized Shear Modulus and Material Damping Ratio with Shearing Strain from RC Tests of Specimen UTA-23-L; Effective Confining Pressure, σ_o' =32psi (4.6 ksf = 221 kPa)

Peak Shearing Strain, %	Shear Modulus, G, ksf	Normalized Shear Modulus, G/G_{max}	Average[+] Shearing Strain, %	Material Damping Ratio[x], D, %
6.36E-05	3805	1.00	5.84E-05	1.20
1.25E-04	3805	1.00	1.16E-04	1.20
2.44E-04	3795	1.00	2.28E-04	1.20
4.91E-04	3785	0.99	4.56E-04	1.22
9.65E-04	3785	0.99	8.95E-04	1.24
1.73E-03	3760	0.99	1.60E-03	1.29
3.40E-03	3686	0.97	3.12E-03	1.44
6.12E-03	3564	0.94	5.53E-03	1.70
1.07E-02	3373	0.89	9.34E-03	2.21
1.84E-02	3052	0.80	1.55E-02	2.95
3.21E-02	2621	0.69	2.55E-02	3.97

[+] Average Shearing Strain from the First Three Cycles of the Free Vibration Decay Curve

[x] Average Damping Ratio from the First Three Cycles of the Free Vibration Decay Curve

Table XVII-2e. Variation in Shear Modulus, Normalized Shear Modulus and Material Damping Ratio with Shearing Strain from TS Tests of Specimen UTA-23-L; Effective Confining Pressure, σ_o' = 32psi (4.6 ksf = 221 kPa)

First Cycle				Tenth Cycle			
Peak Shearing Strain, %	Shear Modulus, G, ksf	Normalized Shear Modulus, G/G_{max}	Material Damping Ratio, D, %	Peak Shearing Strain, %	Shear Modulus, G, ksf	Normalized Shear Modulus, G/G_{max}	Material Damping Ratio, D, %
3.57E-04	3393	1.00	1.20	3.57E-04	3390	1.00	1.21
7.17E-04	3361	1.00	1.21	7.17E-04	3350	0.99	1.22
9.00E-04	3350	0.99	1.22	9.00E-04	3340	0.99	1.23
1.00E-03	3334	0.99	1.23	1.00E-03	3320	0.99	1.24
1.80E-03	3290	0.97	1.42	1.83E-03	3280	0.97	1.45
5.88E-03	3070	0.91	1.90	5.89E-03	3060	0.91	1.91
1.00E-02	2812	0.83	2.50	1.00E-02	2812	0.83	2.52

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Table XVII-3a. Variation in Low-Amplitude Shear-Wave Velocity, Low-Amplitude Shear Modulus, Low-Amplitude Material Damping Ratio and Void Ratio with Effective Isotropic Confining Pressure from RC Tests of Specimen UTA-23-M.

Effective Isotropic Confining Pressure, σ_o'			Low-Amplitude Shear Modulus, G_{max}		Low-Amplitude Shear-Wave Velocity, Vs	Low-Amplitude Material Damping Ratio, Dmin, %	Void Ratio, e
(psi)	(psf)	(kPa)	(ksf)	(MPa)	(fps)		
2	288	13.8	884	42	493	2.33	0.52
4	576	27.6	1123	54	555	2.33	0.52
8	1152	55.2	1662	80	676	1.81	0.52
16	2304	110.5	2967	142	903	1.81	0.50
32	4608	220.9	4016	193	1050	1.50	0.50

Table XVII-3b. Variation in Shear Modulus, Normalized Shear Modulus and Material Damping Ratio with Shearing Strain from RC Tests of Specimen UTA-23-M; Effective Confining Pressure, σ_o' = 8psi (1.2 ksf = 55 kPa)

Peak Shearing Strain, %	Shear Modulus, G, ksf	Normalized Shear Modulus, G/G_{max}	Average+ Shearing Strain, %	Material Damping Ratio×, D, %
1.10E-04	1657	1.00	9.98E-05	1.66
2.09E-04	1647	1.00	1.88E-04	1.66
4.11E-04	1642	0.99	3.68E-04	1.67
8.05E-04	1632	0.99	7.19E-04	1.67
1.53E-03	1581	0.96	1.36E-03	1.92
2.68E-03	1517	0.92	2.31E-03	2.44
4.95E-03	1410	0.85	4.16E-03	2.94
9.45E-03	1249	0.76	7.57E-03	3.83
1.75E-02	1057	0.64	1.31E-02	5.19
3.34E-02	810	0.49	2.37E-02	6.26
6.55E-02	578	0.35	4.47E-02	7.13

+ Average Shearing Strain from the First Three Cycles of the Free Vibration Decay Curve

× Average Damping Ratio from the First Three Cycles of the Free Vibration Decay Curve

Table XVII-3c. Variation in Shear Modulus, Normalized Shear Modulus and Material Damping Ratio with Shearing Strain from TS Tests of Specimen UTA-23-M; Effective Confining Pressure, σ_o' = 8psi (1.2 ksf = 55 kPa)

First Cycle				Tenth Cycle			
Peak Shearing Strain, %	Shear Modulus, G, ksf	Normalized Shear Modulus, G/G_{max}	Material Damping Ratio, D, %	Peak Shearing Strain, %	Shear Modulus, G, ksf	Normalized Shear Modulus, G/G_{max}	Material Damping Ratio, D, %
9.39E-05	1600	1.00	1.52	9.40E-05	1584	1.00	1.54
3.80E-04	1560	0.99	1.54	3.80E-04	1550	0.99	1.55
8.45E-04	1540	0.96	1.62	8.45E-04	1520	0.96	1.64
1.01E-03	1520	0.95	1.70	1.01E-03	1510	0.95	1.73
2.00E-03	1380	0.86	2.10	2.03E-03	1340	0.85	2.12
4.47E-03	1156	0.73	3.36	4.53E-03	1148	0.73	3.40
9.70E-03	966	0.61	5.55	9.90E-03	957	0.61	5.59

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Table XVII-3d. Variation in Shear Modulus, Normalized Shear Modulus and Material Damping Ratio with Shearing Strain from RC Tests of Specimen UTA-23-M; Effective Confining Pressure, σ_o' =32psi (4.6 ksf = 221 kPa)

Peak Shearing Strain, %	Shear Modulus, G, ksf	Normalized Shear Modulus, G/G_{max}	Average[+] Shearing Strain, %	Material Damping Ratio[x], D, %
3.92E-05	4234	1.00	3.78E-05	1.85
7.52E-05	4234	1.00	6.72E-05	1.88
1.48E-04	4234	1.00	1.31E-04	1.87
2.96E-04	4210	0.99	2.64E-04	1.87
5.87E-04	4210	0.99	5.20E-04	1.98
1.08E-03	4177	0.99	9.59E-04	2.00
2.10E-03	4072	0.96	1.84E-03	2.14
4.08E-03	3920	0.93	3.53E-03	2.43
7.54E-03	3618	0.85	6.30E-03	3.04
1.40E-02	3148	0.74	1.11E-02	4.05
2.47E-02	2627	0.62	1.85E-02	5.17

[+] Average Shearing Strain from the First Three Cycles of the Free Vibration Decay Curve

[x] Average Damping Ratio from the First Three Cycles of the Free Vibration Decay Curve

Table XVII-3e. Variation in Shear Modulus, Normalized Shear Modulus and Material Damping Ratio with Shearing Strain from TS Tests of Specimen UTA-23-M; Effective Confining Pressure, σ_o' = 32psi (4.6 ksf = 221 kPa)

First Cycle				Tenth Cycle			
Peak Shearing Strain, %	Shear Modulus, G, ksf	Normalized Shear Modulus, G/G_{max}	Material Damping Ratio, D, %	Peak Shearing Strain, %	Shear Modulus, G, ksf	Normalized Shear Modulus, G/G_{max}	Material Damping Ratio, D, %
4.22E-05	3620	1.01	1.72	4.25E-05	3609	1.00	1.73
1.68E-04	3580	0.99	1.73	1.68E-04	3577	1.00	1.74
6.41E-04	3530	0.98	1.74	6.41E-04	3520	0.98	1.75
1.00E-03	3515	0.98	1.75	1.00E-03	3491	0.97	1.76
1.98E-03	3409	0.95	1.84	1.99E-03	3390	0.94	1.87

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Table XVII-4a. Variation in Low-Amplitude Shear-Wave Velocity, Low-Amplitude Shear Modulus, Low-Amplitude Material Damping Ratio and Void Ratio with Effective Isotropic Confining Pressure from RC Tests of Specimen UTA-23-N.

Effective Isotropic Confining Pressure, σ_o'			Low-Amplitude Shear Modulus, G_{max}		Low-Amplitude Shear-Wave Velocity, Vs	Low-Amplitude Material Damping Ratio, Dmin, %	Void Ratio, e
(psi)	(psf)	(kPa)	(ksf)	(MPa)	(fps)		
2	288	13.8	685	33	429	3.25	0.52
4	576	27.6	988	47	515	3.15	0.52
8	1152	55.2	1440	69	622	2.65	0.52
16	2304	110.5	2301	110	787	2.30	0.49
32	4608	220.9	3631	174	988	1.95	0.49

Table XVII-4b. Variation in Shear Modulus, Normalized Shear Modulus and Material Damping Ratio with Shearing Strain from RC Tests of Specimen UTA-23-N; Effective Confining Pressure, σ_o' = 8psi (1.2 ksf = 55 kPa)

Peak Shearing Strain, %	Shear Modulus, G, ksf	Normalized Shear Modulus, G/G_{max}	Average[+] Shearing Strain, %	Material Damping Ratio[x], D, %
6.68E-04	1563	1.00	6.00E-04	2.00
1.18E-03	1504	0.98	1.04E-03	2.05
2.22E-03	1436	0.94	1.91E-03	2.40
4.38E-03	1341	0.87	3.74E-03	2.80
7.45E-03	1214	0.79	5.90E-03	4.06
1.25E-02	1028	0.67	9.52E-03	5.10
2.42E-02	791	0.52	1.62E-02	6.80
4.54E-02	698	0.46	2.83E-02	8.00
1.25E-01	451	0.29	7.59E-02	9.85

[+] Average Shearing Strain from the First Three Cycles of the Free Vibration Decay Curve

[x] Average Damping Ratio from the First Three Cycles of the Free Vibration Decay Curve

Table XVII-4c. Variation in Shear Modulus, Normalized Shear Modulus and Material Damping Ratio with Shearing Strain from TS Tests of Specimen UTA-23-N; Effective Confining Pressure, σ_o' = 8psi (1.2 ksf = 55 kPa)

First Cycle				Tenth Cycle			
Peak Shearing Strain, %	Shear Modulus, G, ksf	Normalized Shear Modulus, G/G_{max}	Material Damping Ratio, D, %	Peak Shearing Strain, %	Shear Modulus, G, ksf	Normalized Shear Modulus, G/G_{max}	Material Damping Ratio, D, %
8.14E-05	1530	1.00	1.62	8.20E-05	1520	1.01	1.64
3.99E-04	1517	1.00	1.63	4.00E-04	1501	0.99	1.65
7.29E-04	1487	0.98	1.66	7.29E-04	1471	0.97	1.68
9.00E-04	1483	0.97	1.67	9.08E-04	1470	0.97	1.69
1.00E-03	1479	0.97	1.68	1.00E-03	1474	0.98	1.70
5.21E-03	1156	0.76	3.36	4.53E-03	1148	0.76	3.40
1.00E-02	922	0.61	6.10	1.00E-02	905	0.60	6.15
2.93E-02	650	0.43	9.15	3.03E-02	630	0.42	9.19
9.96E-02	386	0.25	11.17	1.00E-01	380	0.25	11.23

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Table XVII-4d. Variation in Shear Modulus, Normalized Shear Modulus and Material Damping Ratio with Shearing Strain from RC Tests of Specimen UTA-23-N; Effective Confining Pressure, σ_o' =32psi (4.6 ksf = 221 kPa)

Peak Shearing Strain, %	Shear Modulus, G, ksf	Normalized Shear Modulus, G/G_{max}	Average[+] Shearing Strain, %	Material Damping Ratio[x], D, %
7.01E-04	3824	1.00	6.56E-04	1.60
1.33E-03	3817	1.00	1.20E-03	1.66
2.44E-03	3739	0.98	2.22E-03	1.75
4.60E-03	3593	0.94	4.11E-03	1.87
7.86E-03	3405	0.89	6.82E-03	2.39
1.44E-02	3088	0.81	1.22E-02	2.82
2.58E-02	2726	0.71	2.01E-02	4.43
4.70E-02	2282	0.60	3.36E-02	6.12
8.79E-02	1786	0.47	5.90E-02	7.46
1.66E-01	1314	0.34	1.83E-01	9.65

[+] Average Shearing Strain from the First Three Cycles of the Free Vibration Decay Curve

[x] Average Damping Ratio from the First Three Cycles of the Free Vibration Decay Curve

Table XVII-4e. Variation in Shear Modulus, Normalized Shear Modulus and Material Damping Ratio with Shearing Strain from TS Tests of Specimen UTA-23-N; Effective Confining Pressure, σ_o' = 32psi (4.6 ksf = 221 kPa)

First Cycle				Tenth Cycle			
Peak Shearing Strain, %	Shear Modulus, G, ksf	Normalized Shear Modulus, G/G_{max}	Material Damping Ratio, D, %	Peak Shearing Strain, %	Shear Modulus, G, ksf	Normalized Shear Modulus, G/G_{max}	Material Damping Ratio, D, %
1.57E-04	3810	1.00	1.50	1.60E-04	3805	1.00	1.51
4.68E-04	3808	1.00	1.51	4.68E-04	3803	1.00	1.52
7.86E-04	3805	1.00	1.52	7.87E-04	3800	1.00	1.53
1.00E-03	3800	1.00	1.53	1.00E-03	3798	1.00	1.54
3.35E-03	3750	0.98	1.63	3.58E-03	3700	0.97	1.65
7.50E-03	3500	0.92	2.40	7.60E-03	3480	0.91	2.50
1.10E-02	3200	0.84	3.00	1.12E-02	3100	0.81	3.10
3.11E-02	2700	0.71	5.20	3.13E-02	2690	0.71	5.25

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Table XVII-5a. Variation in Low-Amplitude Shear-Wave Velocity, Low-Amplitude Shear Modulus, Low-Amplitude Material Damping Ratio and Void Ratio with Effective Isotropic Confining Pressure from RC Tests of Specimen UTA-23-O.

Effective Isotropic Confining Pressure, σ_o'			Low-Amplitude Shear Modulus, G_{max}		Low-Amplitude Shear-Wave Velocity, Vs	Low-Amplitude Material Damping Ratio, Dmin, %	Void Ratio, e
(psi)	(psf)	(kPa)	(ksf)	(MPa)	(fps)		
2	288	13.8	985	47	539	2.81	0.51
4	576	27.6	1274	61	637	2.51	0.51
8	1152	55.2	1698	81	707	2.70	0.51
16	2304	110.5	2570	123	870	2.25	0.50
32	4608	220.9	3827	183	1059	2.18	0.50

Table XVII-5b. Variation in Shear Modulus, Normalized Shear Modulus and Material Damping Ratio with Shearing Strain from RC Tests of Specimen UTA-23-O; Effective Confining Pressure, σ_o' = 8psi (1.2 ksf = 55 kPa)

Peak Shearing Strain, %	Shear Modulus, G, ksf	Normalized Shear Modulus, G/G_{max}	Average+ Shearing Strain, %	Material Damping Ratio[x], D, %
1.48E-04	1912	1.00	1.23E-04	2.43
2.86E-04	1923	1.00	2.47E-04	2.46
5.55E-04	1902	0.99	4.84E-04	2.60
1.09E-03	1894	0.99	9.21E-04	2.82
1.97E-03	1822	0.95	1.66E-03	2.86
3.85E-03	1685	0.88	3.17E-03	3.36
7.49E-03	1556	0.81	5.94E-03	4.05
1.37E-02	1432	0.75	1.04E-02	4.88
2.64E-02	1142	0.60	1.83E-02	6.71
5.17E-02	791	0.41	3.31E-02	8.64

+ Average Shearing Strain from the First Three Cycles of the Free Vibration Decay Curve

x Average Damping Ratio from the First Three Cycles of the Free Vibration Decay Curve

Table XVII-5c. Variation in Shear Modulus, Normalized Shear Modulus and Material Damping Ratio with Shearing Strain from TS Tests of Specimen UTA-23-O; Effective Confining Pressure, σ_o' = 8psi (1.2 ksf = 55 kPa)

First Cycle				Tenth Cycle			
Peak Shearing Strain, %	Shear Modulus, G, ksf	Normalized Shear Modulus, G/G_{max}	Material Damping Ratio, D, %	Peak Shearing Strain, %	Shear Modulus, G, ksf	Normalized Shear Modulus, G/G_{max}	Material Damping Ratio, D, %
4.44E-05	1729	1.00	2.30	4.53E-05	1712	1.00	2.31
4.20E-04	1666	0.98	2.40	4.29E-04	1665	0.99	2.45
6.73E-04	1661	0.98	2.45	6.73E-04	1653	0.98	2.46
7.90E-04	1660	0.98	2.48	8.00E-04	1650	0.98	2.49
1.00E-03	1650	0.95	2.52	1.00E-03	1648	0.96	2.53
2.31E-03	1550	0.90	2.69	2.33E-03	1540	0.90	2.70
7.40E-03	1279	0.75	3.66	7.50E-03	1269	0.75	3.69

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Table XVII-5d. Variation in Shear Modulus, Normalized Shear Modulus and Material Damping Ratio with Shearing Strain from RC Tests of Specimen UTA-23-O; Effective Confining Pressure, σ_o' =32psi (4.6 ksf = 221 kPa)

Peak Shearing Strain, %	Shear Modulus, G, ksf	Normalized Shear Modulus, G/G_{max}	Average[+] Shearing Strain, %	Material Damping Ratio[x], D, %
3.60E-05	4149	1.00	3.19E-05	1.98
6.87E-05	4155	1.00	6.09E-05	2.00
1.36E-04	4165	1.00	1.20E-04	2.02
2.71E-04	4165	1.00	2.39E-04	2.06
5.39E-04	4180	1.00	4.71E-04	2.23
9.87E-04	4126	0.99	8.62E-04	2.26
1.96E-03	4045	0.99	1.70E-03	2.38
3.84E-03	3938	0.97	3.29E-03	2.64
7.12E-03	3684	0.94	5.92E-03	3.15

[+] Average Shearing Strain from the First Three Cycles of the Free Vibration Decay Curve

[x] Average Damping Ratio from the First Three Cycles of the Free Vibration Decay Curve

Table XVII-5e. Variation in Shear Modulus, Normalized Shear Modulus and Material Damping Ratio with Shearing Strain from TS Tests of Specimen UTA-23-O; Effective Confining Pressure, σ_o' = 32psi (4.6 ksf = 221 kPa)

First Cycle				Tenth Cycle			
Peak Shearing Strain, %	Shear Modulus, G, ksf	Normalized Shear Modulus, G/G_{max}	Material Damping Ratio, D, %	Peak Shearing Strain, %	Shear Modulus, G, ksf	Normalized Shear Modulus, G/G_{max}	Material Damping Ratio, D, %
1.05E-04	3520	1.00	1.98	1.05E-04	3506	1.00	1.99
4.31E-04	3472	0.99	2.05	4.32E-04	3455	0.99	2.06
8.72E-04	3435	0.98	2.20	8.72E-04	3420	0.98	2.21
1.00E-03	3420	0.98	2.30	1.00E-03	3418	0.98	2.32
2.00E-03	3400	0.97	2.40	2.00E-03	3380	0.96	2.41
3.23E-03	3380	0.96	2.60	3.00E-03	3370	0.96	2.61

DTN: MO0203DHRSSWHB.001

Table XVII-6a. Variation in Low-Amplitude Shear-Wave Velocity, Low-Amplitude Shear Modulus, Low-Amplitude Material Damping Ratio and Void Ratio with Effective Isotropic Confining Pressure from RC Tests of Specimen UTA-23-P.

Effective Isotropic Confining Pressure, σ_o'			Low-Amplitude Shear Modulus, G_{max}		Low-Amplitude Shear-Wave Velocity, Vs	Low-Amplitude Material Damping Ratio, Dmin, %	Void Ratio, e
(psi)	(psf)	(kPa)	(ksf)	(MPa)	(fps)		
2	288	13.8	580	28	415	3.99	0.52
4	576	27.6	964	46	550	3.17	0.52
8	1152	55.2	1563	75	670	3.14	0.50
16	2304	110.5	1836	88	800	2.33	0.50
32	4608	220.9	3604	173	1028	1.95	0.48

Table XVII-6b. Variation in Shear Modulus, Normalized Shear Modulus and Material Damping Ratio with Shearing Strain from RC Tests of Specimen UTA-23-P; Effective Confining Pressure, σ_o' = 8psi (1.2 ksf = 55 kPa)

Peak Shearing Strain, %	Shear Modulus, G, ksf	Normalized Shear Modulus, G/G_{max}	Average+ Shearing Strain, %	Material Damping Ratio×, D, %
9.17E-04	1379	1.00	8.10E-04	1.50
2.17E-03	1360	0.99	1.98E-03	1.52
4.21E-03	1300	0.94	3.80E-03	1.80
7.31E-03	1225	0.90	6.33E-03	2.42
1.27E-02	1116	0.82	1.08E-02	3.00
2.33E-02	938	0.69	1.96E-02	4.00
4.00E-02	800	0.58	3.81E-02	6.00

+ Average Shearing Strain from the First Three Cycles of the Free Vibration Decay Curve

× Average Damping Ratio from the First Three Cycles of the Free Vibration Decay Curve

Table XVII-6c. Variation in Shear Modulus, Normalized Shear Modulus and Material Damping Ratio with Shearing Strain from TS Tests of Specimen UTA-23-P; Effective Confining Pressure, σ_o' = 8psi (1.2 ksf = 55 kPa)

First Cycle				Tenth Cycle			
Peak Shearing Strain, %	Shear Modulus, G, ksf	Normalized Shear Modulus, G/G_{max}	Material Damping Ratio, D, %	Peak Shearing Strain, %	Shear Modulus, G, ksf	Normalized Shear Modulus, G/G_{max}	Material Damping Ratio, D, %
1.70E-04	1347	1.00	1.42	1.70E-04	1340	1.00	1.44
4.29E-04	1340	1.00	1.43	4.29E-04	1335	1.00	1.45
7.29E-04	1338	1.00	1.45	7.29E-04	1321	0.99	1.46
9.08E-04	1320	0.98	1.48	9.08E-04	1319	0.98	1.49
1.00E-03	1315	0.98	1.52	1.00E-03	1311	0.98	1.53
4.53E-03	1156	0.86	2.30	4.53E-03	1148	0.86	2.31
1.05E-02	1000	0.74	3.00	1.05E-02	995	0.74	3.20

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Table XVII-6d. Variation in Shear Modulus, Normalized Shear Modulus and Material Damping Ratio with Shearing Strain from RC Tests of Specimen UTA-23-P; Effective Confining Pressure, σ_o' =32psi (4.6 ksf = 221 kPa)

Peak Shearing Strain, %	Shear Modulus, G, ksf	Normalized Shear Modulus, G/G_{max}	Average+ Shearing Strain, %	Material Damping Ratio×, D, %
7.01E-04	3864	1.00	6.21E-04	1.50
1.33E-03	3860	1.00	1.20E-03	1.52
2.44E-03	3779	0.98	2.22E-03	1.65
4.60E-03	3636	0.94	4.11E-03	1.87
7.86E-03	3442	0.89	6.82E-03	2.30
1.44E-02	3125	0.81	1.22E-02	3.50
2.58E-02	2759	0.71	2.01E-02	4.43
4.70E-02	2308	0.60	3.36E-02	6.12
8.79E-02	1806	0.47	5.90E-02	8.00
1.66E-01	1330	0.34	9.81E-02	10.45

+ Average Shearing Strain from the First Three Cycles of the Free Vibration Decay Curve

× Average Damping Ratio from the First Three Cycles of the Free Vibration Decay Curve

Table XVII-6e. Variation in Shear Modulus, Normalized Shear Modulus and Material Damping Ratio with Shearing Strain from TS Tests of Specimen UTA-23-P; Effective Confining Pressure, σ_o' = 32psi (4.6 ksf = 221 kPa)

First Cycle				Tenth Cycle			
Peak Shearing Strain, %	Shear Modulus, G, ksf	Normalized Shear Modulus, G/G_{max}	Material Damping Ratio, D, %	Peak Shearing Strain, %	Shear Modulus, G, ksf	Normalized Shear Modulus, G/G_{max}	Material Damping Ratio, D, %
1.72E-04	3522	1.00	1.42	1.72E-04	3500	1.00	1.43
5.21E-04	3444	0.99	1.43	5.21E-04	3420	0.99	1.44
8.72E-04	3427	0.98	1.45	8.72E-04	3411	0.99	1.47
1.00E-03	3403	0.98	1.47	1.00E-03	3400	0.98	1.48
5.94E-03	3011	0.86	2.30	5.96E-03	2990	0.86	2.35
1.00E-02	2690	0.77	3.20	1.00E-02	2678	0.77	3.30
2.50E-02	2060	0.59	5.70	2.50E-02	2050	0.59	5.73
4.80E-02	1590	0.46	7.30	4.80E-02	1575	0.45	7.32

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Table XVII-7a. Variation in Low-Amplitude Shear-Wave Velocity, Low-Amplitude Shear Modulus, Low-Amplitude Material Damping Ratio and Void Ratio with Effective Isotropic Confining Pressure from RC Tests of Specimen UTA-23-U.

Effective Isotropic Confining Pressure, σ_o'			Low-Amplitude Shear Modulus, G_{max}		Low-Amplitude Shear-Wave Velocity, Vs	Low-Amplitude Material Damping Ratio, Dmin, %	Void Ratio, e
(psi)	(psf)	(kPa)	(ksf)	(MPa)	(fps)		
2	288	13.8	1400	67	605	3.97	0.42
4	576	27.6	1767	85	687	3.55	0.41
8	1152	55.2	2709	130	841	3.28	0.41
16	2304	110.5	4431	212	1074	2.64	0.41
32	4608	220.9	5079	244	1149	1.63	0.40
64	9216	441.8	7598	364	1403	1.31	0.40

Table XVII-7b. Variation in Shear Modulus, Normalized Shear Modulus and Material Damping Ratio with Shearing Strain from RC Tests of Specimen UTA-23-U; Effective Confining Pressure, σ_o' = 8 psi (1.15 ksf = 55 kPa)

Peak Shearing Strain, %	Shear Modulus, G, ksf	Normalized Shear Modulus, G/G_{max}	Average[+] Shearing Strain, %	Material Damping Ratio[x], D, %
2.10E-04	2110	1.00	2.00E-04	3.00
5.00E-04	2100	1.00	4.87E-04	3.01
1.00E-03	2059	0.98	8.40E-04	3.02
1.94E-03	1983	0.94	1.46E-03	3.02
3.59E-03	1811	0.86	2.99E-03	3.15
6.22E-03	1647	0.78	4.89E-03	3.40
1.35E-02	1214	0.58	1.04E-02	4.10
2.83E-02	881	0.42	2.18E-02	4.90
4.34E-02	743	0.35	3.10E-02	6.11
1.10E-01	271	0.11	7.61E-02	9.50

[+] Average Shearing Strain from the First Three Cycles of the Free Vibration Decay Curve

[x] Average Damping Ratio from the First Three Cycles of the Free Vibration Decay Curve

Table XVII-7c. Variation in Shear Modulus, Normalized Shear Modulus and Material Damping Ratio with Shearing Strain from TS Tests of Specimen UTA-23-U; Effective Confining Pressure, σ_o' = 8 psi (1.15 ksf = 55 kPa)

First Cycle				Tenth Cycle			
Peak Shearing Strain, %	Shear Modulus, G, ksf	Normalized Shear Modulus, G/G_{max}	Material Damping Ratio, D, %	Peak Shearing Strain, %	Shear Modulus, G, ksf	Normalized Shear Modulus, G/G_{max}	Material Damping Ratio, D, %
1.56E-04	1912	1.00	2.92	1.56E-04	1908	1.00	2.93
3.13E-04	1899	1.00	2.95	3.14E-04	1881	1.00	2.96
6.39E-04	1841	0.98	2.96	6.40E-04	1883	0.98	2.97
1.00E-03	1762	0.95	2.98	1.00E-03	1760	0.95	3.04
2.60E-03	1500	0.78	3.10	2.62E-03	1497	0.78	3.20
6.30E-03	1250	0.65	3.60	6.10E-03	1240	0.65	3.65
1.00E-02	737	0.60	4.42	1.00E-02	728	0.60	4.43
1.16E-02	620	0.56	4.50	1.18E-02	610	0.56	4.51

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Table XVII-7d. Variation in Shear Modulus, Normalized Shear Modulus and Material Damping Ratio with Shearing Strain from RC Tests of Specimen UTA-23-U; Effective Confining Pressure, σ_o' = 32 psi (4.6 ksf = 220 kPa)

Peak Shearing Strain, %	Shear Modulus, G, ksf	Normalized Shear Modulus, G/G_{max}	Average[+] Shearing Strain, %	Material Damping Ratio[x], D, %
2.38E-04	5497	1.00	2.21E-04	1.24
4.61E-04	5485	1.00	4.27E-04	1.26
8.93E-04	5430	0.99	8.37E-04	1.25
1.74E-03	5223	0.95	1.61E-03	1.30
3.37E-03	5143	0.94	3.07E-03	1.53
5.52E-03	4809	0.88	4.91E-03	1.94
9.93E-03	4372	0.80	8.47E-03	2.68
1.78E-02	3839	0.70	1.43E-02	3.74
3.20E-02	3284	0.60	2.39E-02	5.18
5.36E-02	2679	0.49	3.67E-02	7.04
8.71E-02	2201	0.40	5.61E-02	8.45

[+] Average Shearing Strain from the First Three Cycles of the Free Vibration Decay Curve

[x] Average Damping Ratio from the First Three Cycles of the Free Vibration Decay Curve

Table XVII-7e. Variation in Shear Modulus, Normalized Shear Modulus and Material Damping Ratio with Shearing Strain from TS Tests of Specimen UTA-23-U; Effective Confining Pressure, σ_o' = 32 psi (4.6 ksf = 220 kPa)

First Cycle				Tenth Cycle			
Peak Shearing Strain, %	Shear Modulus, G, ksf	Normalized Shear Modulus, G/G_{max}	Material Damping Ratio, D, %	Peak Shearing Strain, %	Shear Modulus, G, ksf	Normalized Shear Modulus, G/G_{max}	Material Damping Ratio, D, %
2.64E-04	5234	1.00	1.16	2.64E-04	5230	1.00	1.17
4.41E-04	5195	1.00	1.18	4.41E-04	5194	1.00	1.19
7.16E-04	5163	0.99	1.20	7.16E-04	5143	0.99	1.22
1.00E-03	5090	0.98	1.23	1.00E-03	5083	0.98	1.24
4.07E-03	4534	0.87	2.00	4.07E-03	4514	0.87	2.10
1.00E-02	3658	0.70	3.23	1.00E-02	3649	0.70	3.25
1.96E-02	3007	0.58	5.00	1.96E-02	3004	0.58	5.20

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Table XVII-8a. Variation in Low-Amplitude Shear-Wave Velocity, Low-Amplitude Shear Modulus, Low-Amplitude Material Damping Ratio and Void Ratio with Effective Isotropic Confining Pressure from RC Tests of Specimen UTA-23-V.

Effective Isotropic Confining Pressure, σ_o'			Low-Amplitude Shear Modulus, G_{max}		Low-Amplitude Shear-Wave Velocity, Vs	Low-Amplitude Material Damping Ratio, Dmin, %	Void Ratio, e
(psi)	(psf)	(kPa)	(ksf)	(MPa)	(fps)		
2	288	13.8	681	33	417	3.83	0.42
4	576	27.6	1067	51	523	3.43	0.41
8	1152	55.2	1493	72	618	2.71	0.41
16	2304	110.5	2618	126	818	1.92	0.41
32	4608	220.9	4199	201	1036	1.43	0.41
64	9216	441.8	6421	308	1281	1.24	0.42

Table XVII-8b. Variation in Shear Modulus, Normalized Shear Modulus and Material Damping Ratio with Shearing Strain from RC Tests of Specimen UTA-23-V; Effective Confining Pressure, σ_o' = 8 psi (1.15 ksf = 55 kPa)

Peak Shearing Strain, %	Shear Modulus, G, ksf	Normalized Shear Modulus, G/G_{max}	Average[+] Shearing Strain, %	Material Damping Ratio[x], D, %
1.01E-03	1608	1.00	8.95E-04	2.10
6.03E-04	1610	1.00	5.96E-04	2.11
1.90E-03	1540	0.96	1.76E-03	2.11
3.63E-03	1488	0.92	3.19E-03	2.12
6.06E-03	1382	0.86	5.22E-03	2.49
9.91E-03	1190	0.74	7.04E-03	3.00
1.83E-02	955	0.59	1.46E-02	3.89
3.57E-02	743	0.46	2.67E-02	5.19
7.28E-02	560	0.35	5.59E-02	7.50

[+] Average Shearing Strain from the First Three Cycles of the Free Vibration Decay Curve

[x] Average Damping Ratio from the First Three Cycles of the Free Vibration Decay Curve

Table XVII-8c. Variation in Shear Modulus, Normalized Shear Modulus and Material Damping Ratio with Shearing Strain from TS Tests of Specimen UTA-23-V; Effective Confining Pressure, σ_o' = 8 psi (1.15 ksf = 55 kPa)

First Cycle				Tenth Cycle			
Peak Shearing Strain, %	Shear Modulus, G, ksf	Normalized Shear Modulus, G/G_{max}	Material Damping Ratio, D, %	Peak Shearing Strain, %	Shear Modulus, G, ksf	Normalized Shear Modulus, G/G_{max}	Material Damping Ratio, D, %
2.60E-04	1682	1.00	1.90	2.60E-04	1680	1.00	1.92
5.50E-04	1680	1.00	1.91	5.50E-04	1660	0.99	1.93
1.13E-03	1603	0.95	1.93	1.13E-03	1597	0.96	1.94
2.41E-03	1498	0.89	1.94	2.43E-03	1494	0.90	1.95
5.15E-03	1310	0.78	2.40	5.16E-03	1300	0.78	2.50
1.16E-02	990	0.59	3.60	1.18E-02	960	0.58	3.50
1.41E-02	950	0.57	4.10	1.42E-02	944	0.57	4.40
2.23E-02	797	0.48	5.20	2.25E-02	793	0.48	5.20

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Table XVII-8d. Variation in Shear Modulus, Normalized Shear Modulus and Material Damping Ratio with Shearing Strain from RC Tests of Specimen UTA-23-V; Effective Confining Pressure, σ_o' = 64 psi (9.2 ksf = 442 kPa)

Peak Shearing Strain, %	Shear Modulus, G, ksf	Normalized Shear Modulus, G/G_{max}	Average[+] Shearing Strain, %	Material Damping Ratio[x], D, %
5.41E-04	4334	1.00	5.08E-04	1.04
2.77E-04	4350	1.00	2.67E-04	1.05
1.06E-03	4286	0.99	9.82E-04	1.06
2.08E-03	4214	0.97	1.95E-03	1.10
3.81E-03	4097	0.94	3.51E-03	1.34
6.30E-03	3866	0.89	5.64E-03	1.82
1.15E-02	3483	0.80	9.85E-03	2.59
2.06E-02	3072	0.71	1.70E-02	3.33
3.64E-02	2637	0.61	2.78E-02	4.78
6.41E-02	2066	0.48	4.49E-02	6.55
1.03E-01	1819	0.42	6.50E-02	8.83

[+] Average Shearing Strain from the First Three Cycles of the Free Vibration Decay Curve

[x] Average Damping Ratio from the First Three Cycles of the Free Vibration Decay Curve

Table XVII-8e. Variation in Shear Modulus, Normalized Shear Modulus and Material Damping Ratio with Shearing Strain from TS Tests of Specimen UTA-23-V; Effective Confining Pressure, σ_o' = 64 psi (9.2 ksf = 442 kPa)

First Cycle				Tenth Cycle			
Peak Shearing Strain, %	Shear Modulus, G, ksf	Normalized Shear Modulus, G/G_{max}	Material Damping Ratio, D, %	Peak Shearing Strain, %	Shear Modulus, G, ksf	Normalized Shear Modulus, G/G_{max}	Material Damping Ratio, D, %
1.89E-04	4100	1.00	0.93	1.89E-04	4100	1.00	0.94
3.46E-04	4100	1.00	0.94	3.45E-04	4090	1.00	0.95
8.64E-04	4080	1.00	1.01	8.64E-04	4080	1.00	1.02
1.00E-03	4030	0.98	1.15	1.00E-03	4020	0.98	1.14
1.99E-03	3910	0.96	1.20	2.00E-03	3900	0.96	1.21
4.31E-03	3510	0.88	1.80	4.33E-03	3500	0.88	1.82
1.00E-02	2870	0.74	3.80	1.00E-02	2800	0.73	3.84
2.11E-02	2280	0.62	6.16	2.12E-02	2200	0.60	6.20

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Table XVII-9a. Variation in Low-Amplitude Shear-Wave Velocity, Low-Amplitude Shear Modulus, Low-Amplitude Material Damping Ratio and Void Ratio with Effective Isotropic Confining Pressure from RC Tests of Specimen UTA-23-W.

Effective Isotropic Confining Pressure, σ_o'			Low-Amplitude Shear Modulus, G_{max}		Low-Amplitude Shear-Wave Velocity, Vs	Low-Amplitude Material Damping Ratio, Dmin, %	Void Ratio, e
(psi)	(psf)	(kPa)	(ksf)	(MPa)	(fps)		
2	288	13.8	1180	57	558	2.21	0.43
4	576	27.6	1561	75	642	1.86	0.43
8	1152	55.2	2265	109	773	1.76	0.43
16	2304	110.5	3558	171	968	1.58	0.43
32	4608	220.9	5240	251	1174	1.53	0.43
64	9216	441.8	7774	373	1428	1.54	0.42

Table XVII-9b. Variation in Shear Modulus, Normalized Shear Modulus and Material Damping Ratio with Shearing Strain from RC Tests of Specimen UTA-23-W; Effective Confining Pressure, σ_o' = 8 psi (1.15 ksf = 55 kPa)

Peak Shearing Strain, %	Shear Modulus, G, ksf	Normalized Shear Modulus, G/G_{max}	Average[+] Shearing Strain, %	Material Damping Ratio[x], D, %
1.50E-04	2442	1.00	1.38E-04	1.50
2.92E-04	2440	1.00	2.68E-04	1.51
1.11E-03	2346	0.96	1.01E-03	1.52
1.95E-03	2265	0.93	1.77E-03	1.55
3.71E-03	2088	0.86	3.36E-03	1.80
6.93E-03	1881	0.77	6.25E-03	2.40
5.66E-04	2400	0.98	5.13E-04	1.52
1.30E-02	1603	0.66	1.01E-02	3.30
2.39E-02	1238	0.51	1.69E-02	5.00
3.88E-02	985	0.40	2.57E-02	7.80

[+] Average Shearing Strain from the First Three Cycles of the Free Vibration Decay Curve

[x] Average Damping Ratio from the First Three Cycles of the Free Vibration Decay Curve

Table XVII-9c. Variation in Shear Modulus, Normalized Shear Modulus and Material Damping Ratio with Shearing Strain from TS Tests of Specimen UTA-23-W; Effective Confining Pressure, σ_o' = 8 psi (1.15 ksf = 55 kPa)

First Cycle				Tenth Cycle			
Peak Shearing Strain, %	Shear Modulus, G, ksf	Normalized Shear Modulus, G/G_{max}	Material Damping Ratio, D, %	Peak Shearing Strain, %	Shear Modulus, G, ksf	Normalized Shear Modulus, G/G_{max}	Material Damping Ratio, D, %
1.83E-04	1970	1.01	1.42	1.83E-04	1970	1.01	1.43
3.67E-04	1950	0.99	1.44	3.67E-04	1950	0.99	1.45
7.53E-04	1910	0.97	1.47	7.53E-04	1900	0.97	1.48
1.00E-03	1890	0.96	1.52	1.00E-03	1880	0.96	1.54
1.98E-03	1800	0.92	1.57	1.99E-03	1790	0.91	1.58
6.18E-03	1520	0.77	3.22	6.20E-03	1500	0.77	3.12

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Table XVII-9d. Variation in Shear Modulus, Normalized Shear Modulus and Material Damping Ratio with Shearing Strain from RC Tests of Specimen UTA-23-W; Effective Confining Pressure, σ_o' = 32 psi (4.6 ksf = 220 kPa)

Peak Shearing Strain, %	Shear Modulus, G, ksf	Normalized Shear Modulus, G/G_{max}	Average[+] Shearing Strain, %	Material Damping Ratio[x], D, %
2.68E-04	5816	1.00	2.44E-04	1.52
1.39E-04	5752	0.99	1.27E-04	1.49
5.26E-04	5751	0.99	4.81E-04	1.46
9.53E-04	5721	0.99	8.67E-04	1.57
1.90E-03	5593	0.96	1.72E-03	1.67
3.58E-03	5404	0.93	3.20E-03	1.87
6.52E-03	4977	0.86	5.64E-03	2.44
1.18E-02	4398	0.76	9.74E-03	3.28
2.25E-02	3545	0.61	1.75E-02	4.44
3.95E-02	2829	0.49	3.01E-02	5.90
4.25E-02	2696	0.46	3.80E-02	7.10

[+] Average Shearing Strain from the First Three Cycles of the Free Vibration Decay Curve

[x] Average Damping Ratio from the First Three Cycles of the Free Vibration Decay Curve

Table XVII-9e. Variation in Shear Modulus, Normalized Shear Modulus and Material Damping Ratio with Shearing Strain from TS Tests of Specimen UTA-23-W; Effective Confining Pressure, σ_o' = 32 psi (4.6 ksf = 220 kPa)

First Cycle				Tenth Cycle			
Peak Shearing Strain, %	Shear Modulus, G, ksf	Normalized Shear Modulus, G/G_{max}	Material Damping Ratio, D, %	Peak Shearing Strain, %	Shear Modulus, G, ksf	Normalized Shear Modulus, G/G_{max}	Material Damping Ratio, D, %
1.00E-04	3750	1.00	1.43	1.01E-04	3740	1.00	1.44
1.94E-04	3750	1.00	1.44	1.95E-04	3760	1.00	1.45
5.85E-04	3700	0.99	1.45	5.87E-04	3700	0.99	1.46
1.19E-03	3680	0.98	1.60	1.20E-03	3670	0.98	1.61
2.64E-03	3600	0.96	1.90	2.65E-03	3580	0.95	1.91

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Table XVII-10a. Variation in Low-Amplitude Shear-Wave Velocity, Low-Amplitude Shear Modulus, Low-Amplitude Material Damping Ratio and Void Ratio with Effective Isotropic Confining Pressure from RC Tests of Specimen UTA-23-Y.

Effective Isotropic Confining Pressure, σ_o'			Low-Amplitude Shear Modulus, G_{max}		Low-Amplitude Shear-Wave Velocity, Vs	Low-Amplitude Material Damping Ratio, Dmin, %	Void Ratio, e
(psi)	(psf)	(kPa)	(ksf)	(MPa)	(fps)		
2	288	14	856	41	471	2.76	0.44
4	576	27.6	1332	64	587	2.23	0.44
8	1152	55.2	2055	99	729	1.88	0.43
16	2304	110.5	3263	156	918	1.66	0.43
32	4608	220.9	5000	240	1136	1.58	0.43
64	9216	441.8	7613	365	1401	1.51	0.43

Table XVII-10b. Variation in Shear Modulus, Normalized Shear Modulus and Material Damping Ratio with Shearing Strain from RC Tests of Specimen UTA-23-Y; Effective Confining Pressure, σ_o' = 8 psi (1.15 ksf = 55 kPa)

Peak Shearing Strain, %	Shear Modulus, G, ksf	Normalized Shear Modulus, G/G_{max}	Average+ Shearing Strain, %	Material Damping Ratio×, D, %
8.45E-05	1999	1.00	7.54E-05	1.90
1.61E-04	1997	1.00	1.43E-04	1.92
3.15E-04	1980	0.99	2.81E-04	1.92
6.24E-04	1960	0.98	5.55E-04	1.94
1.20E-03	1900	0.95	1.06E-03	2.04
2.13E-03	1788	0.89	1.83E-03	2.48
4.08E-03	1610	0.81	3.37E-03	2.90
7.65E-03	1395	0.70	5.97E-03	3.75
1.48E-02	1168	0.58	1.09E-02	4.60
2.75E-02	946	0.47	1.94E-02	6.00
4.95E-02	712	0.36	3.36E-02	7.22

+ Average Shearing Strain from the First Three Cycles of the Free Vibration Decay Curve

× Average Damping Ratio from the First Three Cycles of the Free Vibration Decay Curve

Table XVII-10c. Variation in Shear Modulus, Normalized Shear Modulus and Material Damping Ratio with Shearing Strain from TS Tests of Specimen UTA-23-Y; Effective Confining Pressure, σ_o' = 8 psi (1.15 ksf = 55 kPa)

First Cycle				Tenth Cycle			
Peak Shearing Strain, %	Shear Modulus, G, ksf	Normalized Shear Modulus, G/G_{max}	Material Damping Ratio, D, %	Peak Shearing Strain, %	Shear Modulus, G, ksf	Normalized Shear Modulus, G/G_{max}	Material Damping Ratio, D, %
2.11E-04	1705	1.00	1.82	2.11E-04	1704	1.00	1.83
4.25E-04	1684	0.99	1.84	4.25E-04	1683	0.99	1.84
6.52E-04	1657	0.97	1.88	6.52E-04	1652	0.97	1.89
1.00E-03	1601	0.94	1.95	1.00E-03	1600	0.94	1.96
2.30E-03	1500	0.88	2.50	2.30E-03	1490	0.87	2.52
5.43E-03	1250	0.73	3.50	5.45E-03	1239	0.73	3.54

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Table XVII-10d. Variation in Shear Modulus, Normalized Shear Modulus and Material Damping Ratio with Shearing Strain from RC Tests of Specimen UTA-23-Y; Effective Confining Pressure, σ_o' = 32 psi (4.6 ksf = 220 kPa)

Peak Shearing Strain, %	Shear Modulus, G, ksf	Normalized Shear Modulus, G/G_{max}	Average+ Shearing Strain, %	Material Damping Ratio^x, D, %
3.78E-05	5080	1.00	3.54E-05	1.55
7.25E-05	5060	1.00	6.59E-05	1.56
1.45E-04	5060	1.00	1.32E-04	1.58
2.88E-04	5060	1.00	2.61E-04	1.59
5.69E-04	5050	1.00	5.16E-04	1.62
1.04E-03	4980	0.98	9.39E-04	1.66
2.05E-03	4860	0.96	1.84E-03	1.82
3.85E-03	4630	0.91	3.39E-03	2.10
6.97E-03	4230	0.84	5.95E-03	2.67
1.25E-02	3750	0.74	1.01E-02	3.65
2.16E-02	3150	0.62	1.64E-02	4.90
4.13E-02	2510	0.50	2.91E-02	6.41

+ Average Shearing Strain from the First Three Cycles of the Free Vibration Decay Curve

x Average Damping Ratio from the First Three Cycles of the Free Vibration Decay Curve

Table XVII-10e. Variation in Shear Modulus, Normalized Shear Modulus and Material Damping Ratio with Shearing Strain from TS Tests of Specimen UTA-23-Y; Effective Confining Pressure, σ_o' = 32 psi (4.6 ksf = 220 kPa)

First Cycle				Tenth Cycle			
Peak Shearing Strain, %	Shear Modulus, G, ksf	Normalized Shear Modulus, G/G_{max}	Material Damping Ratio, D, %	Peak Shearing Strain, %	Shear Modulus, G, ksf	Normalized Shear Modulus, G/G_{max}	Material Damping Ratio, D, %
2.84E-04	4544	1.00	1.42	2.84E-04	4540	1.00	1.43
5.70E-04	4540	1.00	1.43	5.70E-04	4539	1.00	1.45
1.15E-03	4490	0.99	1.50	1.16E-03	4480	0.99	1.51
3.90E-03	4250	0.94	1.90	3.91E-03	4240	0.93	1.91

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ATTACHMENT XVIII

GLOSSARY

GLOSSARY

This glossary presents definitions for selected geologic and geotechnical terms as used in this Scientific Analysis Report. Alternative definitions may be used in other disciplines or in other contexts.

BEDDED TUFF	A rock unit composed of volcanic ejecta that was deposited in layers and that exhibits distinct planes of weakness (bedding planes) parallel to layering; deposited either by water or by compositional sorting by air fall.
BULK DENSITY	Synonym of density.
COEFFICIENT OF VARIATION	A statistical parameter providing a means for comparing the relative dispersion of more than one kind of data, computed as the standard deviation of a set of measurements divided by the mean value, expressed either as a decimal or percentage.
COMPRESSION-WAVE VELOCITY	Velocity of the compression (P) wave from a seismic energy source.
COUNT	In statistical analysis, the number of measurements in a data set.
DAMPING	The reduction in the amplitude of vibration of a body or system due to the dissipation of energy internally or by radiation.
DAMPING, MATERIAL	Damping that results from viscous, hysteric or other mechanisms except radiation.
DAMPING, RADIATION	Damping that results from spreading over a greater volume of material. Synonym: geometric damping.
DAMPING RATIO	For a system with viscous damping, the ratio of the actual damping coefficient to the critical damping coefficient.
DENSITY (OF SOIL OR ROCK), ρ (IN UNITS OF MASS PER LENGTH CUBED, E.G., POUND-MASS/FT^3 OR KG/M^3)	The total mass (solids plus liquid plus gas) per total volume.
DENSITY, DRY (OF SOIL OR ROCK), ρ_D (IN UNITS OF MASS PER LENGTH CUBED, E.G., POUND-MASS/FT^3 OR KG/M^3)	The mass of solid particles per the total volume of soil or rock.

DENSITY, SATURATED (OF SOIL OR ROCK), ρ_{SAT} (IN UNITS OF MASS PER LENGTH CUBED, E.G., POUND-MASS/FT^3 OR KG/M^3)	The total mass per total volume of completely saturated soil or rock.
DENSITY OF SOLID PARTICLES, ρ_S (IN UNIT OF MASS PER LENGTH CUBED, E.G., POUND-MASS/FT^3 OR KG/M^3	The mass of solid particles divided by the volume of solid particles.
DRY DENSITY	See density, dry.
DRY UNIT WEIGHT	See unit weight, dry.
ENGINEERED FILL	An artificial fill (i.e., a fill constructed by man) that meets several criteria, typically including: (1) the fill is designed to meet established criteria (e.g., bearing capacity, settlement) for a particular purpose (building, embankment, etc.); (2) criteria are established on drawings and in a written specification for the material placed in the fill; (3) the fill is placed in accordance with drawings and written specifications; (4) the fill placement operations are observed by a geotechnical engineer (usually a geotechnical technician working under the geotechnical engineer's supervision); (5) the material being placed in the fill is sufficiently tested to establish its geotechnical characteristics; (6) the degree of compaction of the fill is verified by either (a) in-situ density tests and compaction tests if relative compaction or relative density is specified, or (b) documenting adherence to a method specification, depending on which acceptance criteria is stipulated in the construction contract documents; (7) all fill material and all compacted fill that do not meet the contract requirements is either removed and replaced or reworked in an appropriate manner; (8) the geotechnical engineer prepares detailed written daily reports stating the geotechnical engineer's observations for the day, which are distributed on a daily basis; and (9) the geotechnical engineer writes and files a report at the conclusion of earthwork construction summarizing the geotechnical engineer's observations and testing made during construction and providing his opinion that the fill was or was not constructed in accordance with the specifications and is suited or not for its intended use.

EOLIAN	Borne, deposited, produced or eroded by wind
FINES CONTENT	The percent of a materials' particles, on a dry weight basis, that pass through a U.S. Standard No. 200 sieve.
GRABEN	A block bounded by faults that has been downthrown relative to the adjacent rock.
HOMOCLINAL	Pertaining to a group of beds having the same dip.
HORST	A block bounded by faults that has been uplifted relative to the adjacent rock.
KIP	a unit of force (weight) equal to one thousand pounds-force (1000 lbf).
LITHOPHYSAE	Hollow, bubble-like structures composed of concentric shells formed by the concentration of gasses during cooling of portions of a volcanic flow deposit.
LITHOPHYSAL	Containing lithophysae.
LOW-AMPLITUDE MATERIAL DAMPING RATIO	See material damping ratio, low-amplitude.
LOW-AMPLITUDE SHEAR MODULUS	See shear modulus, low-amplitude.
LOW-AMPLITUDE SHEAR-WAVE VELOCITY	See shear-wave velocity, low-amplitude.
MATERIAL DAMPING RATIO	The ratio of the energy dissipated to the energy input during one cycle of loading, computed on the basis of the area contained within the hysteresis loop, and the equivalent secant modulus. Symbol: D.
MATERIAL DAMPING RATIO, LOW-AMPLITUDE	The ratio of the energy dissipated to energy input during one cycle of loading at low strain values (< 0.001%). Symbol: D_{min}.
MOIST DENSITY	Synonym of density.
NON-ENGINEERED FILL	An artificial (man-made) fill that does not meet the definition of engineered fill.
NONWELDED TUFF	A volcanic rock consisting of fragments that were deposited with insufficient heat to have become fused.

PERCENT CORE RECOVERY	In a given cored interval, the ratio of the length of core recovered to the length of the interval, expressed as a percentage.
POISSON'S RATIO	In Hooke's Law for isotropic materials, for a material subjected to a stress in some direction, the ratio of the strain in the transverse direction to the strain in the direction of stress application.
POROSITY	The ratio, usually expressed as a percentage, of the volume of voids of a given soil or rock mass to the total volume of the soil or rock mass.
PUMICE	A type of volcanic ejecta consisting of air voids in a matrix of glassy lava, usually with the composition of rhyolite.
RELATIVE COMPACTION	The ratio, expressed as a percentage, of the dry unit weight of a soil mass to the reference maximum dry unit weight of the material as determined by a test, such as ASTM D1557-91 (1998), Standard Test Method for Laboratory Compaction Characteristics of Soil Using Modified Effort (56,000 ft-lbf/ft^3 (2,700 kN-m/m^3)).
RELATIVE DENSITY	The ratio of (1) the difference between the void ratio of a cohesionless soil in the loosest state and its actual void ratio, to (2) the difference between the void ratios in the loosest and in the densest states.
ROCK QUALITY DESIGNATION (ABBREVIATED RQD)	The ratio, expressed as a percentage, of the sum of the length of recovered of core pieces that have a length at least 100 mm to the total length of the core run.
SATURATED DENSITY	See density, saturated.
SEPARATION	Refers to the apparent relative displacement of a tabular body or surface across a fault. It is the distance between displaced parts measured in any specified direction. It is distinguished from slip, which refers to the actual relative displacement of the two walls of a fault. To classify a fault in terms of slip, it is necessary to know the direction and sense of translation. If the direction and sense of displacement is not known, then a fault can be classified in terms of separation.

SHEAR MODULUS	The stiffness factor for a material under shear stress, expressed by the relationship of the applied shear force to the change in position produced by this force, calculated as the product of the total mass density (total unit weight divided by gravity) and the square of the shear wave velocity. Symbol: G.
SHEAR MODULUS, LOW-AMPLITUDE	Shear modulus determined as the ratio of the shearing stress divided by the shearing strain at low strain values (< 0.001%). Symbol: G_{max}. Synonym: small-strain shear modulus.
SHEAR-WAVE VELOCITY	Velocity of the shear (S) wave from a seismic energy source.
SHEAR-WAVE VELOCITY, LOW-AMPLITUDE	the velocity of a seismic body wave propagating with a shearing motion that oscillates particles at right angles to the direction of propagation measured at low strain values (< 0.001%). Synonym: small-strain shear-wave velocity.
SMALL-STRAIN MATERIAL DAMPING RATIO	Synonym of low-amplitude material damping ratio.
SMALL-STRAIN SHEAR MODULUS	Synonym of low-amplitude shear modulus.
SMALL-STRAIN SHEAR-WAVE VELOCITY	Synonym of low-amplitude shear-wave velocity.
TOTAL DENSITY	Synonym of density.
TUBE WAVE	A pressure pulse that propagates nearly unattenuated down the fluid in a borehole at a velocity close to that of the shear wave in the surrounding material.
UNIT WEIGHT, γ (IN UNITS OF POUND-FORCE/FT^3 OR kN/M^3	The total weight (solids plus liquid plus gas) per total volume. This parameter is also commonly referred to as "moist unit weight," "wet unit weight," or "total unit weight."
UNIT WEIGHT, DRY, γ (IN UNITS OF POUND-FORCE/FT^3 OR kN/M^3	The total weight of solid particles per total volume.
VITRIC TUFF	An indurated deposit of volcanic ash composed mainly glassy fragments blown out during a volcanic eruption.

WATER CONTENT	The ratio of the mass of water contained in the pore spaces of soil or rock material, to the solid mass of particles in that material, expressed as a percentage (ASTM D 653-97, Standard Terminology Relating to Soil, Rock, and Contained Fluids). Also referred to as gravimetric water content. Note that adsorded water is not considered part of the water in the pore spaces but as water bound to the solid particles.
WELDED TUFF	A rock consisting of volcanic fragments that has been indurated by the heat retained by particles and the enveloping gases.
WHB AREA	The area delimited by the blue heptagon on Figure 1 (in Section 5), within which the Department of Energy has directed the M&O to assume, for the purposes of this report, the potential WHB will be located.

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