APPENDIX D

Results for Kleinfelder Specimen ID K2-13-003

- *Specimen Preparation Notes*
- *RCTS Testing Results*

SPECIMEN PREPARATION NOTES

Specimen No.: K2-13-003	**Project No :** 136473		**Page** 1 **of** 4	

Boring No.: B-728 **Date of Preparation..:** 10/12/13

Sample No..: 728-CS-04 **Depth..:** 53.7 - 54.2 feet

Disposition of Rock Core Sample

☒ No Apparent Disturbance ☐ Apparent Disturbance ☐ Apparent Slaking Due to Coring

☒ Other (Describe) Sample consisted of a Limestone of the Fort Thompson Formation with Small to Medium vugs

Specimen Preparation Notes

Trimming Method :	Rotary coring with water lubricant, 1.5-inch OD diameter core barrel		**Affixation to Platens :**	Epoxied to 2.8-inch diameter steel top cap and base pedestal	
Ave. Length (in.) :	4.0893	**Ave. Diameter (in.):**	1.449	**L/D**	2.8
Total Unit Weight . (pcf) :	144.3	**Moisture Content (%)**	7.7	**% Saturation (Assume SG = 2.70)**	80.7

Specimen Testing Comments

1) Sample 728-CS-04 was predominately a medium strong rock with small to medium sized vugs (see Photo D.1 to D.2). Due to the rock hardness, the sample could not be trimmed by hand and it was decided to core the nominally 2.5-inch diameter sample with a 1.5-inch outside diameter (OD), thin-walled diamond-impregnated core barrel.

2) Sample was trimmed to an approximate 6-inch length and grouted into an CMU block on 10/12/13. See Photos D.3 through D.4.

3) Sample was cored on 10/13/13. See Photo D.5. One approximately 1.45-inch diameter specimen resulted from the rotary coring. The specimen was of sufficient length for RCTS Testing and the sample ends were trimmed to the final length of about 4.1-inches.

4) Specimen was epoxied to the 2.8-inch diameter steel top cap and base pedestal on 12/11/13.

5) Testing commenced on 12/12/13, beginning with 5 psi pressure.

6) A membrane leak was detected during low-amplitude resonant column testing of Pressure Stage 4 (47 psi). Due to the leak, testing was terminated at Pressure Stage 4. Testing ended on 12/14/13.

☒ **See Attached Photographs**

SPECIMEN PREPARATION NOTES

Specimen No: K2-13-003

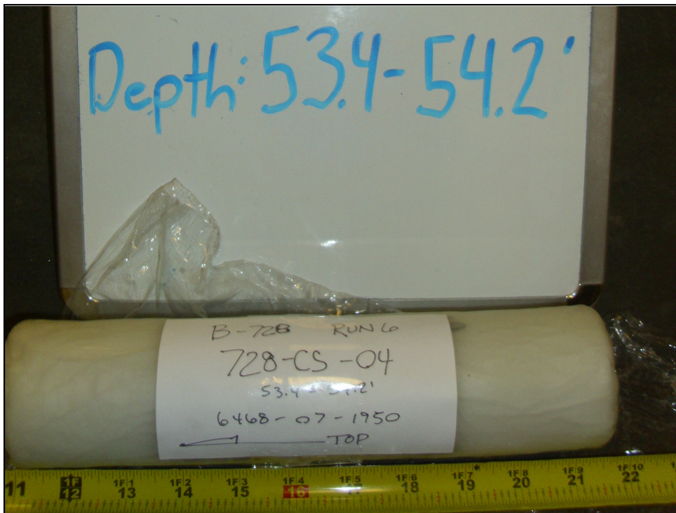


Photo D.1

Sample 728-CS-01 after removal from the protective transport container.

Photo D.2

Sample after removal from the wax casing and aluminum foil.

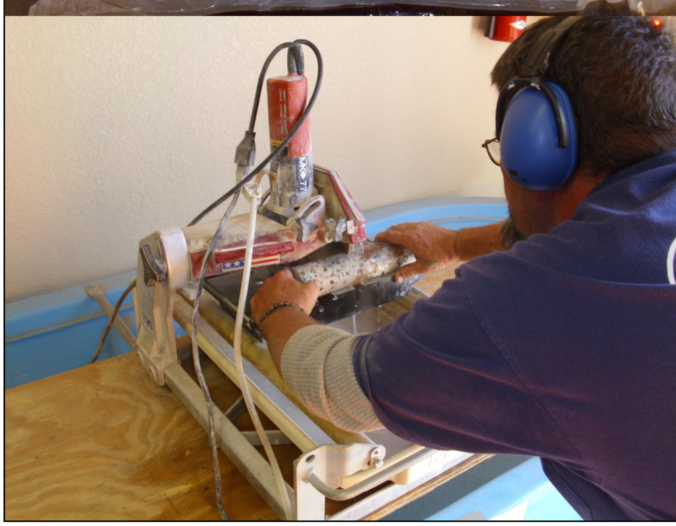


Photo C.3

Trimming the sample to an approximate 6-inch length as preparation for grouting in a CMU block. Note the modeling clay used to seal off natural vugs in sample to prevent grout infiltration.

SPECIMEN PREPARATION NOTES

Specimen No: K2-13-003

Photo D.4

Grouting sample in a CMU block as preparation for down coring the sample. Note the specimen number written on the side of the CMU block to maintain sample control.

Photo D.5

Rotary coring of specimen using the 1.5-inch OD core barrel.

Photo D.6

Specimen after down coring to an approximate 1.45-inch diameter.

SPECIMEN PREPARATION NOTES

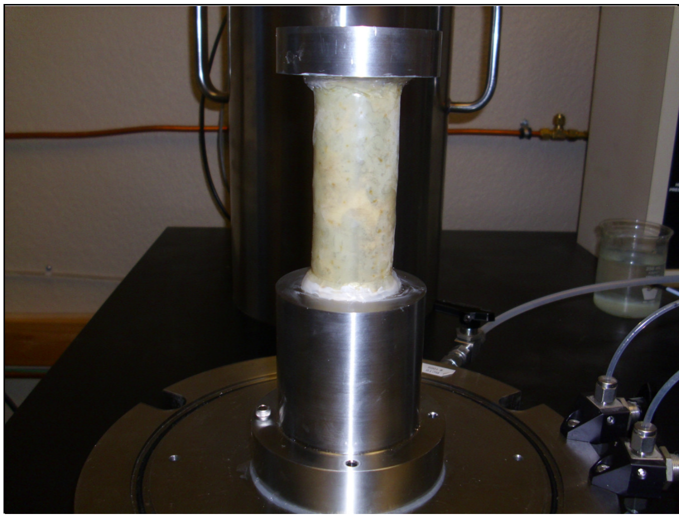


Photo D.7

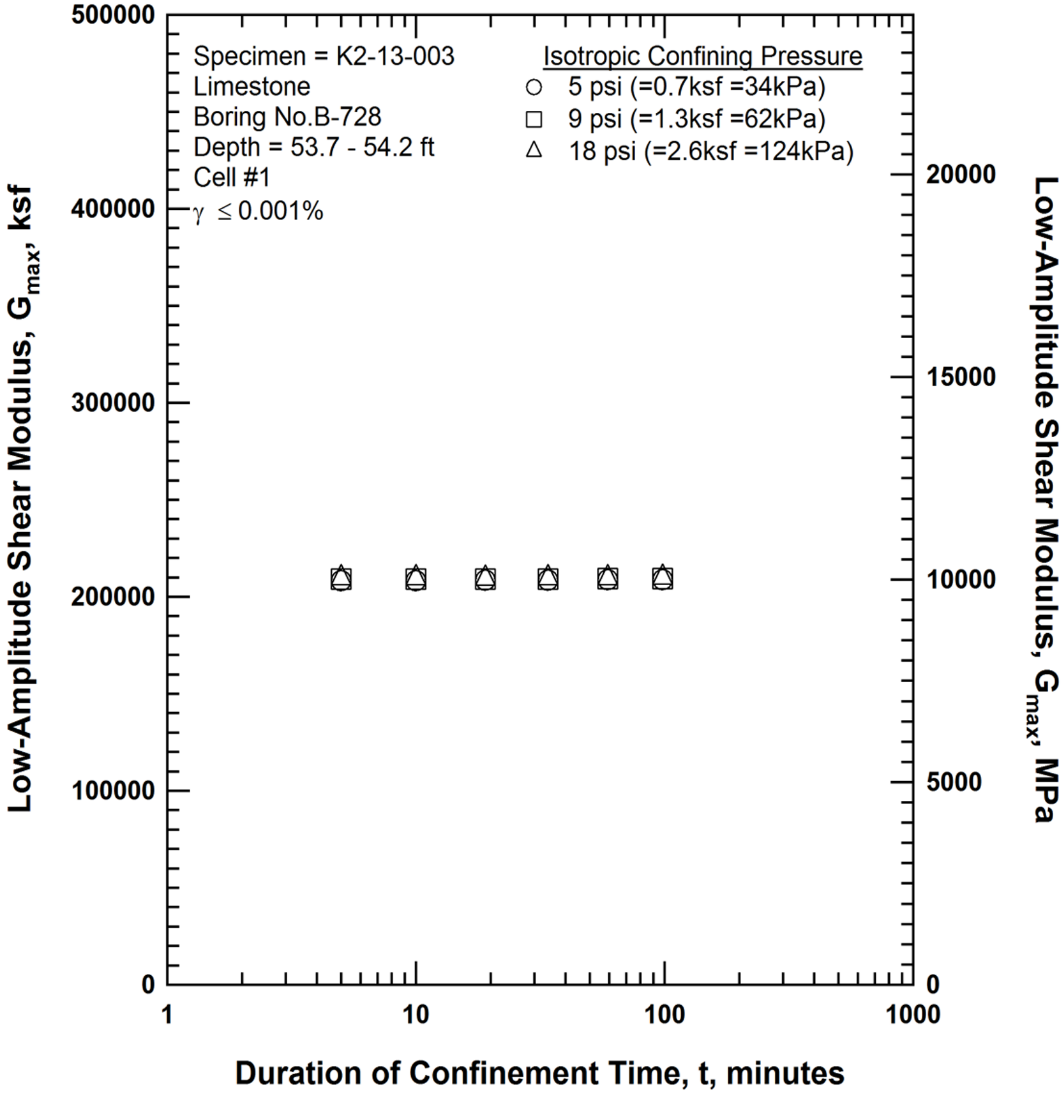
Specimen after affixation to the steal top cap and base pedestal using epoxy. Note modeling clay placed in natural vugs to prevent membrane puncture during testing.

Kleinfelder Specimen ID:

K2-13-003

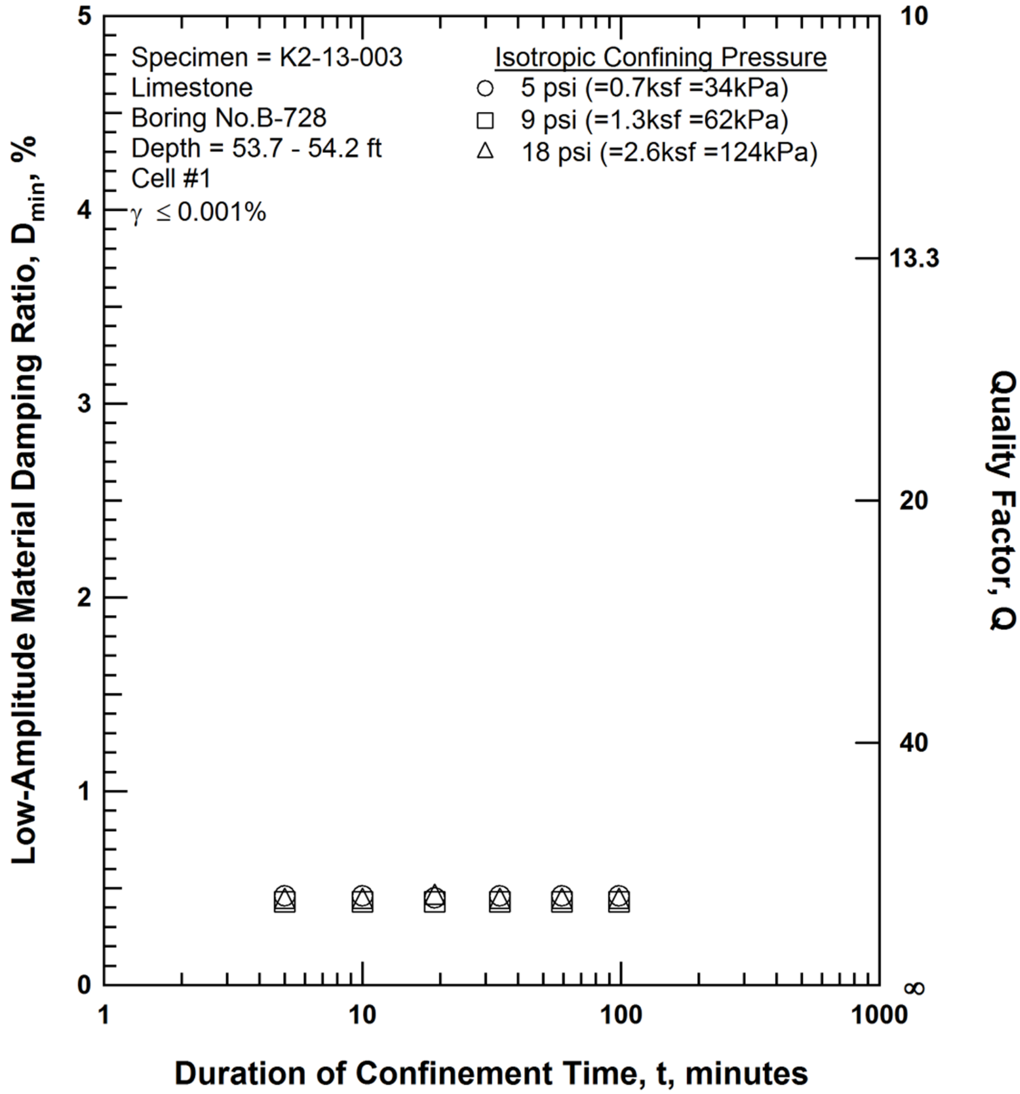
Boring No: B-728
Sample No: CS-04

Limestone (Fort Thompson Formation)
Depth = 53.7 ft – 54.2 ft (below existing ground surface)
Total Unit Weight = 144.3 lb/ft^3
Natural Moisture Content = 7.7%
Estimated In-Situ Mean Effective Stress = 18 psi



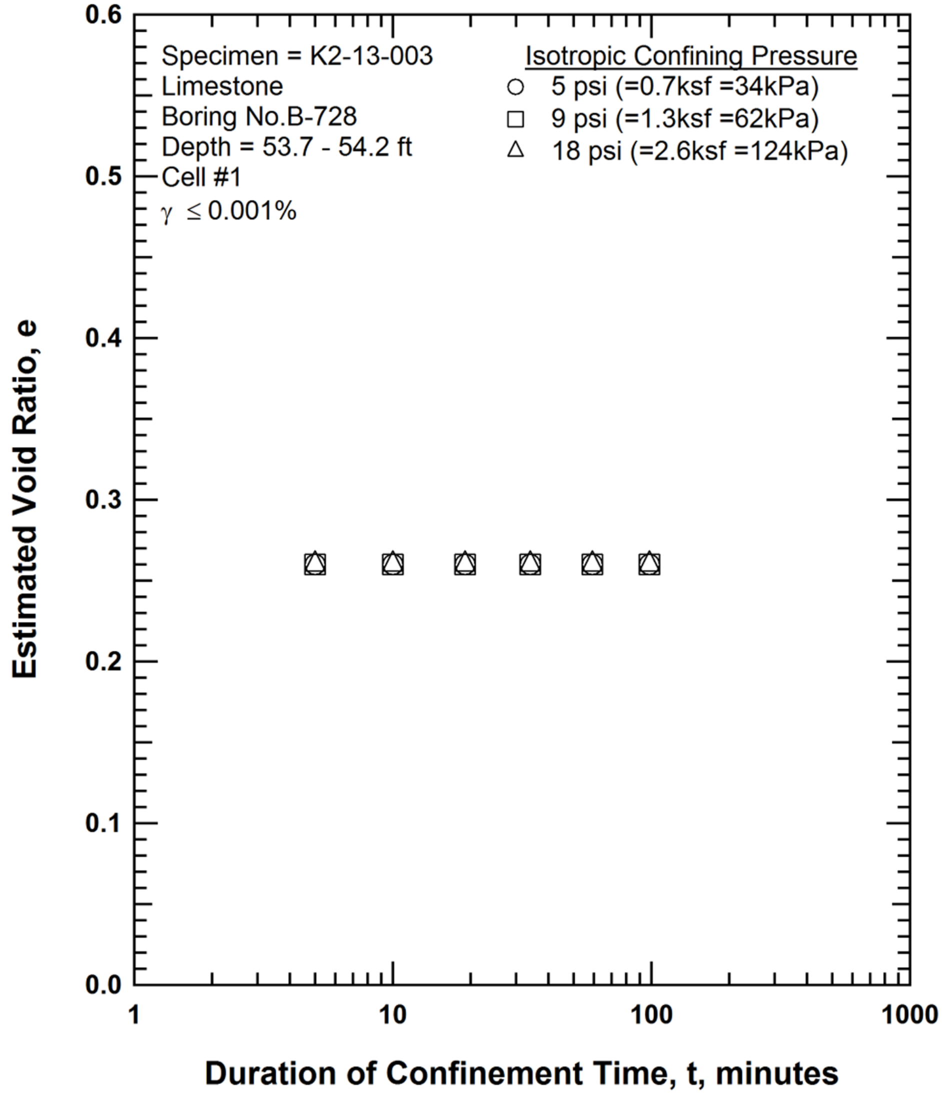
Note:
Membrane puncture at 47 psi prevented testing at higher confining pressures.

Figure D.1 Variation in Low-Amplitude Shear Modulus with Magnitude and Duration of Isotropic Confining Pressure from Resonant Column Tests of Specimen K2-13-003



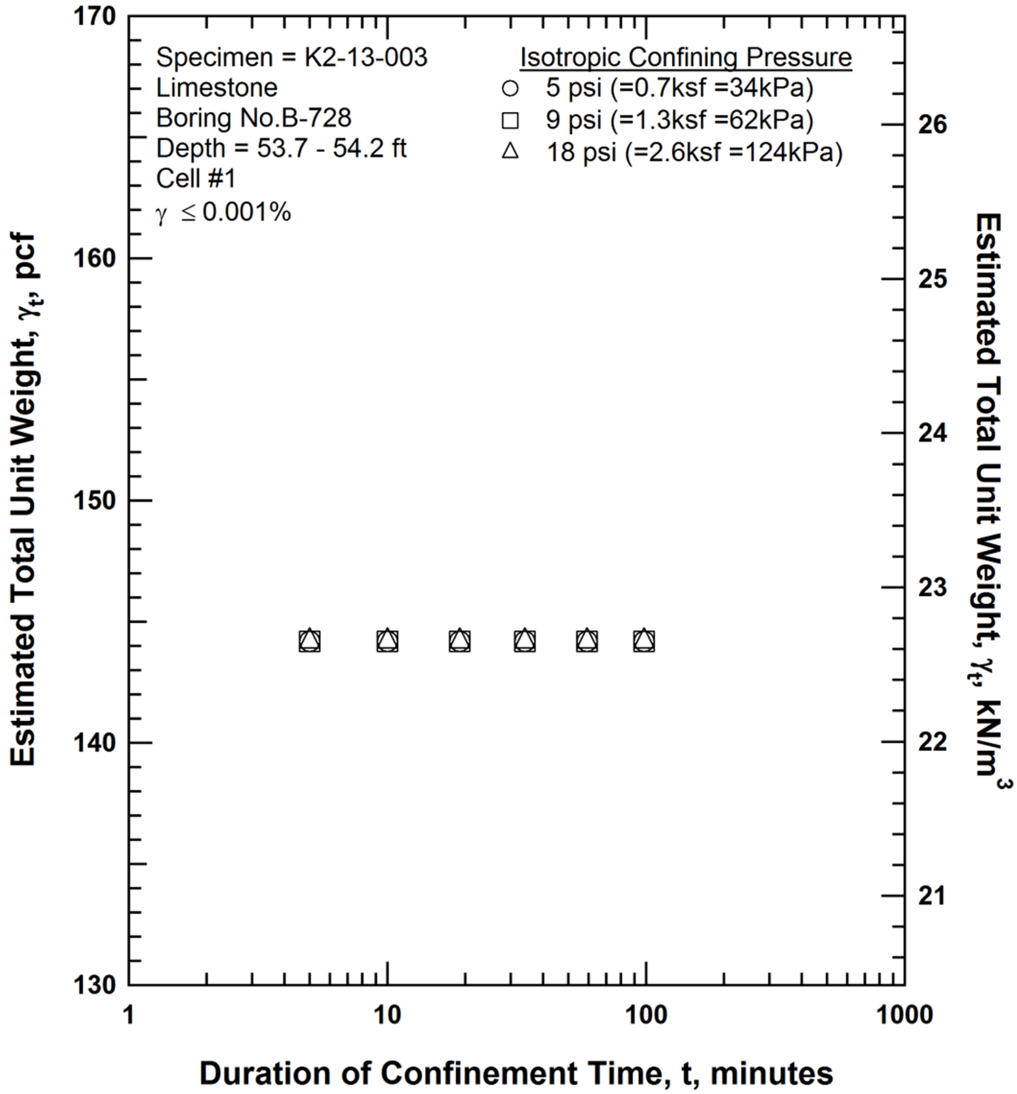
Note:
Membrane puncture at 47 psi prevented testing at higher confining pressures.

Figure D.2 Variation in Low-Amplitude Material Damping Ratio with Magnitude and Duration of Isotropic Confining Pressure from Resonant Column Tests of Specimen K2-13-003



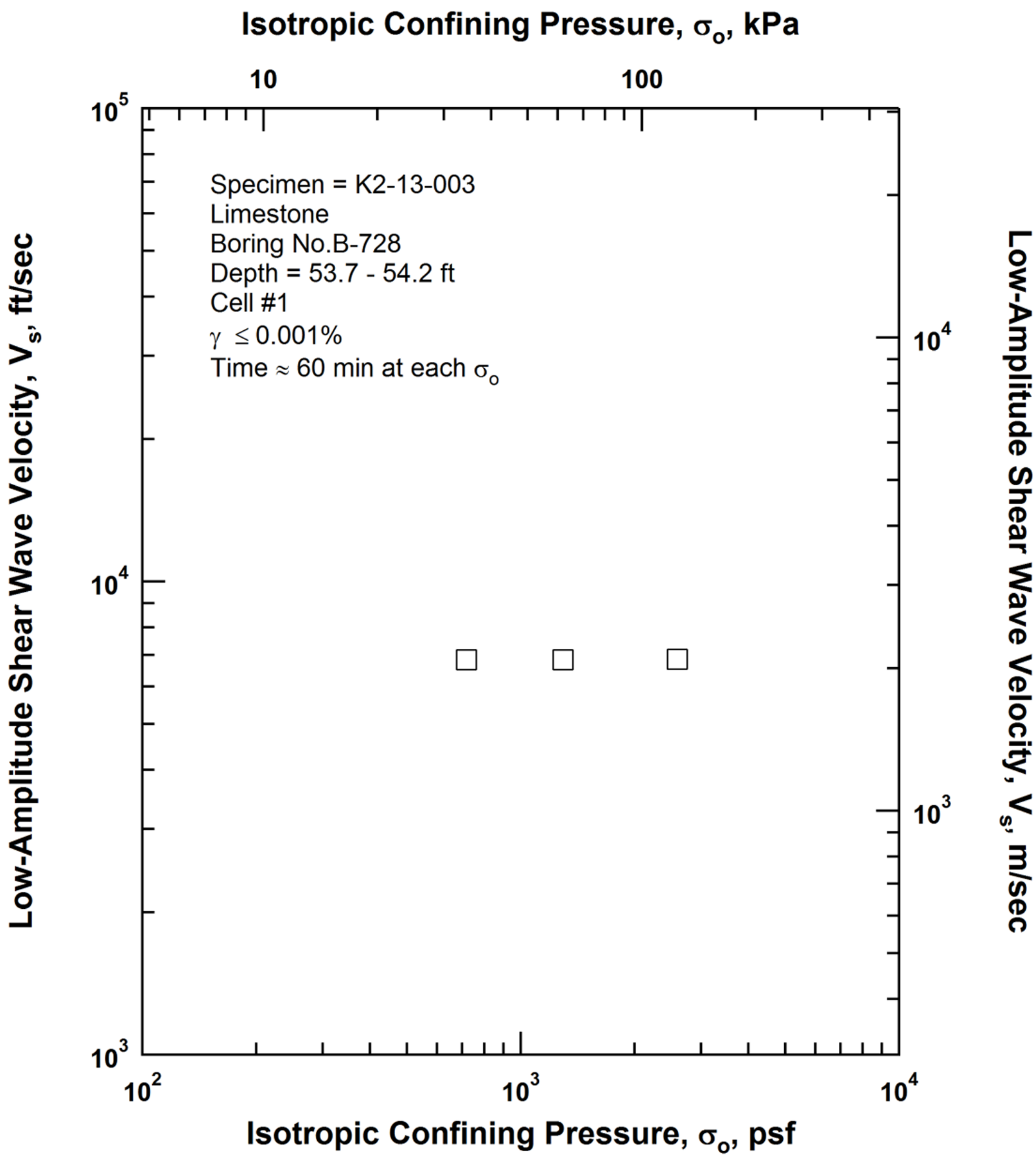
Note:
Membrane puncture at 47 psi prevented testing at higher confining pressures.

Figure D.3 Variation in Estimated Void Ratio with Magnitude and Duration of Isotropic Confining Pressure from Resonant Column Test of Specimen K2-13-003



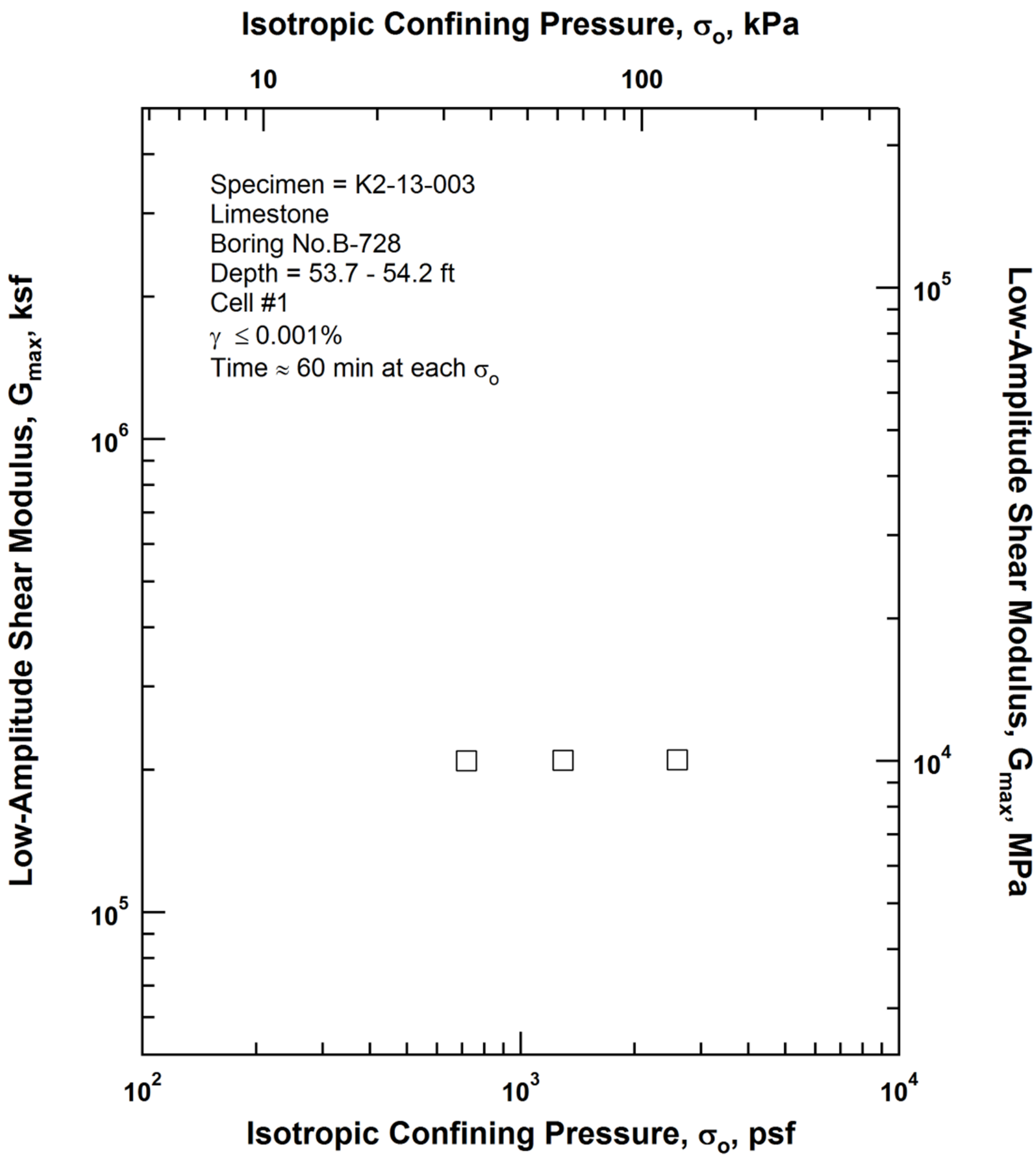
Note:
Membrane puncture at 47 psi prevented testing at higher confining pressures.

Figure D.4 Variation in Estimated Total Unit Weight with Magnitude and Duration of Isotropic Confining Pressure from Resonant Column Tests of Specimen K2-13-003



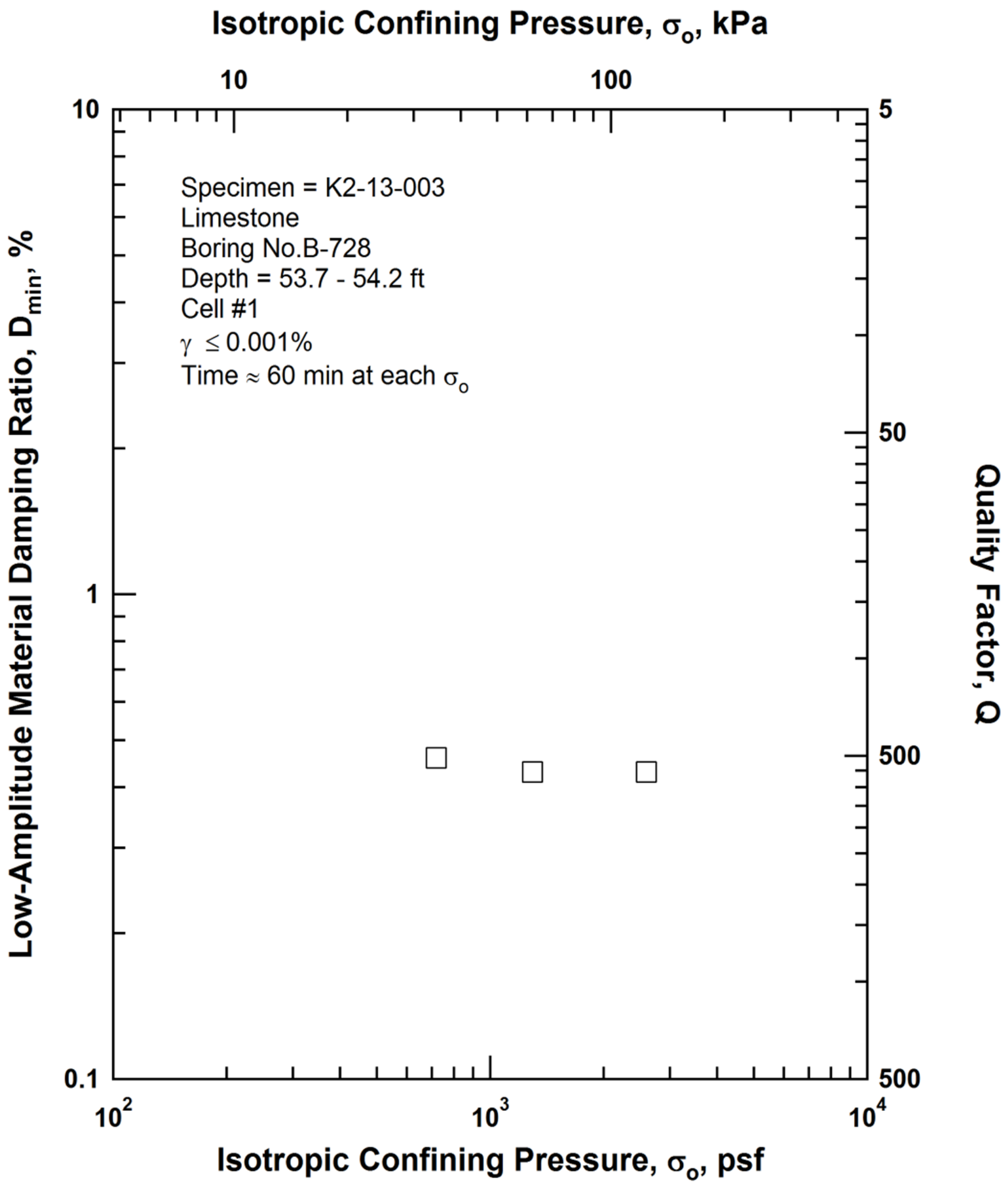
Note:
Membrane puncture at 47 psi prevented testing at higher confining pressures.

Figure D.5 Variation in Low-Amplitude Shear Wave Velocity with Isotropic Confining Pressure from Resonant Column Tests of Specimen K2-13-003



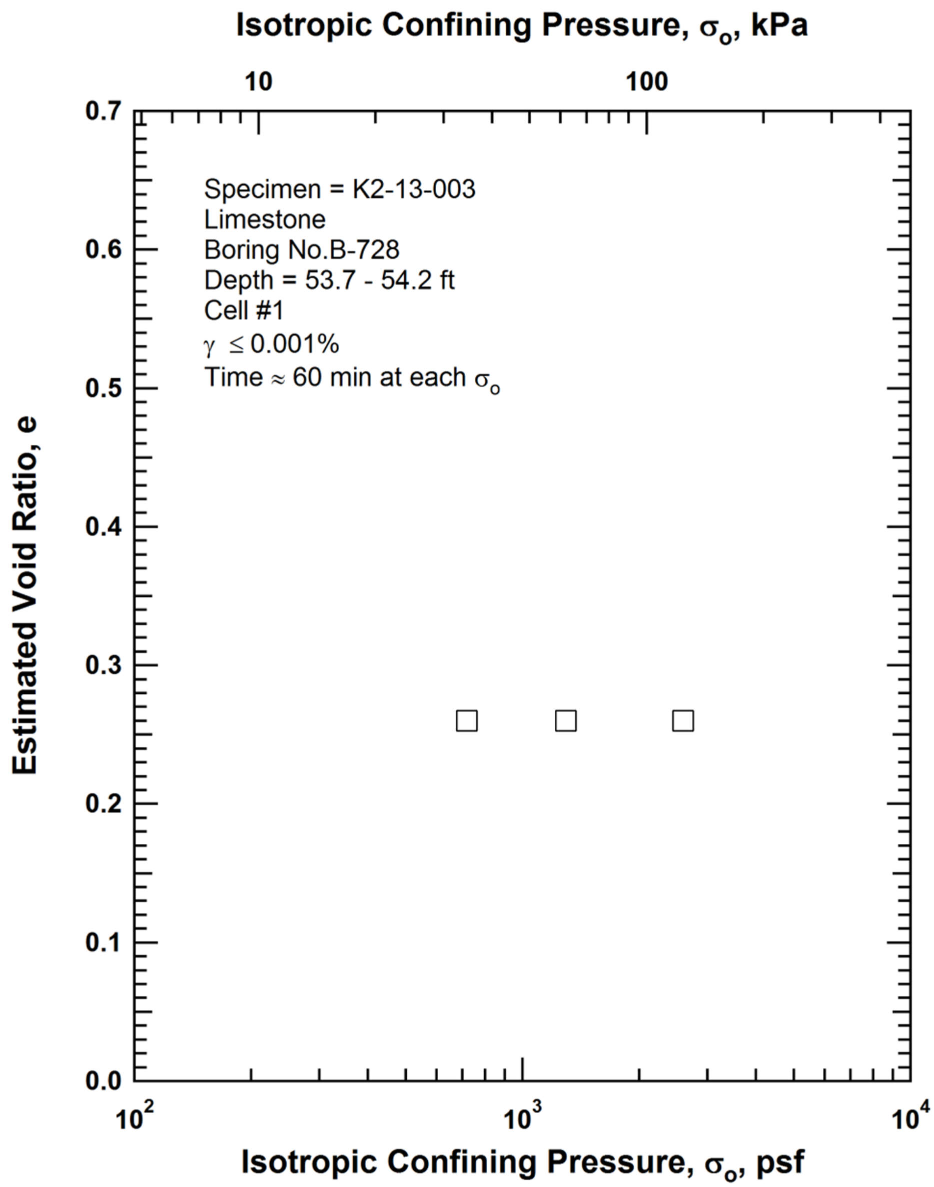
Note:
Membrane puncture at 47 psi prevented testing at higher confining pressures.

Figure D.6 Variation in Low-Amplitude Shear Modulus with Isotropic Confining Pressure from Resonant Column Test of Specimen K2-13-003



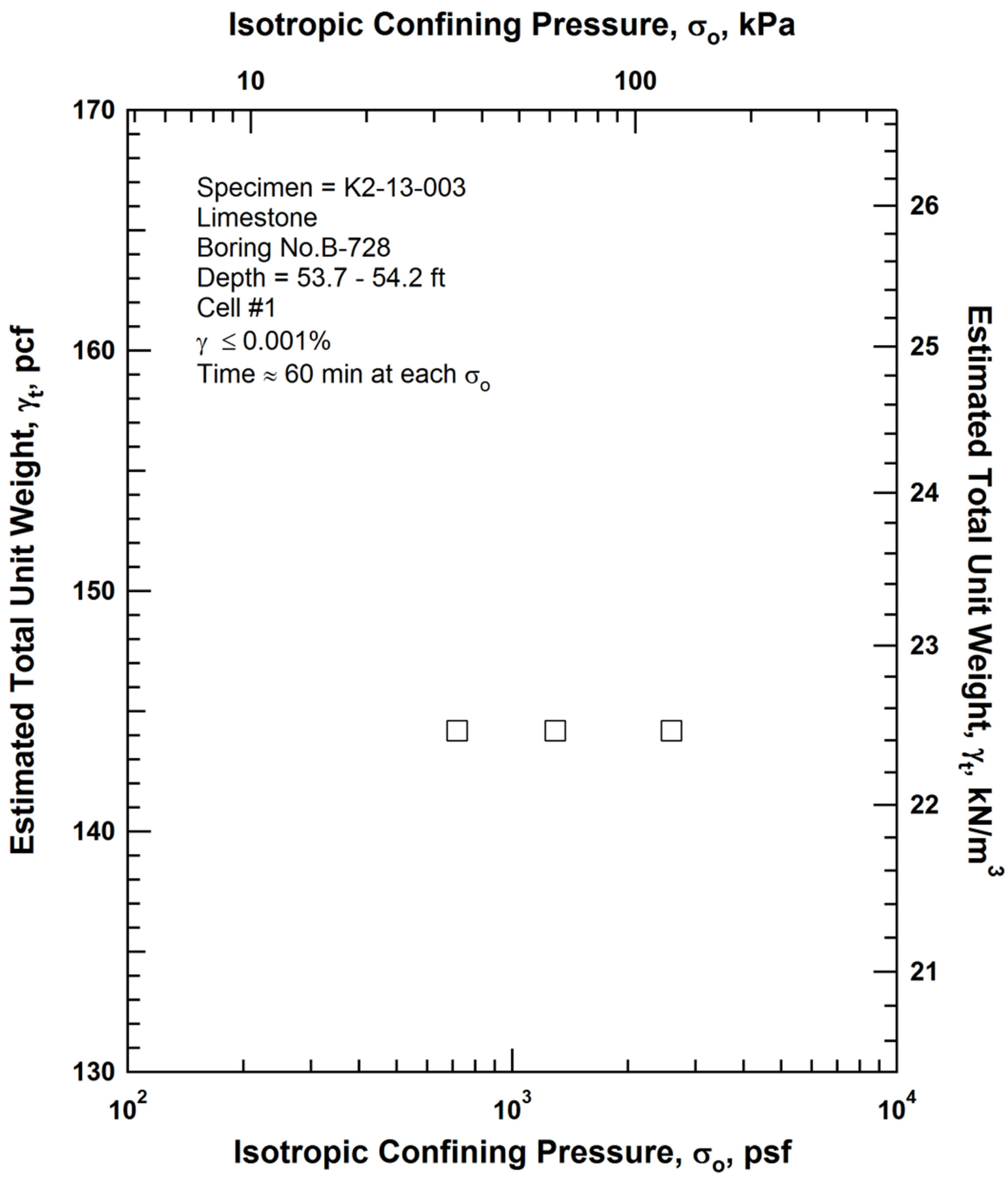
Note:
Membrane puncture at 47 psi prevented testing at higher confining pressures.

Figure D.7 Variation in Low-Amplitude Material Damping Ratio with Isotropic Confining Pressure from Resonant Column Tests of Specimen K2-13-003



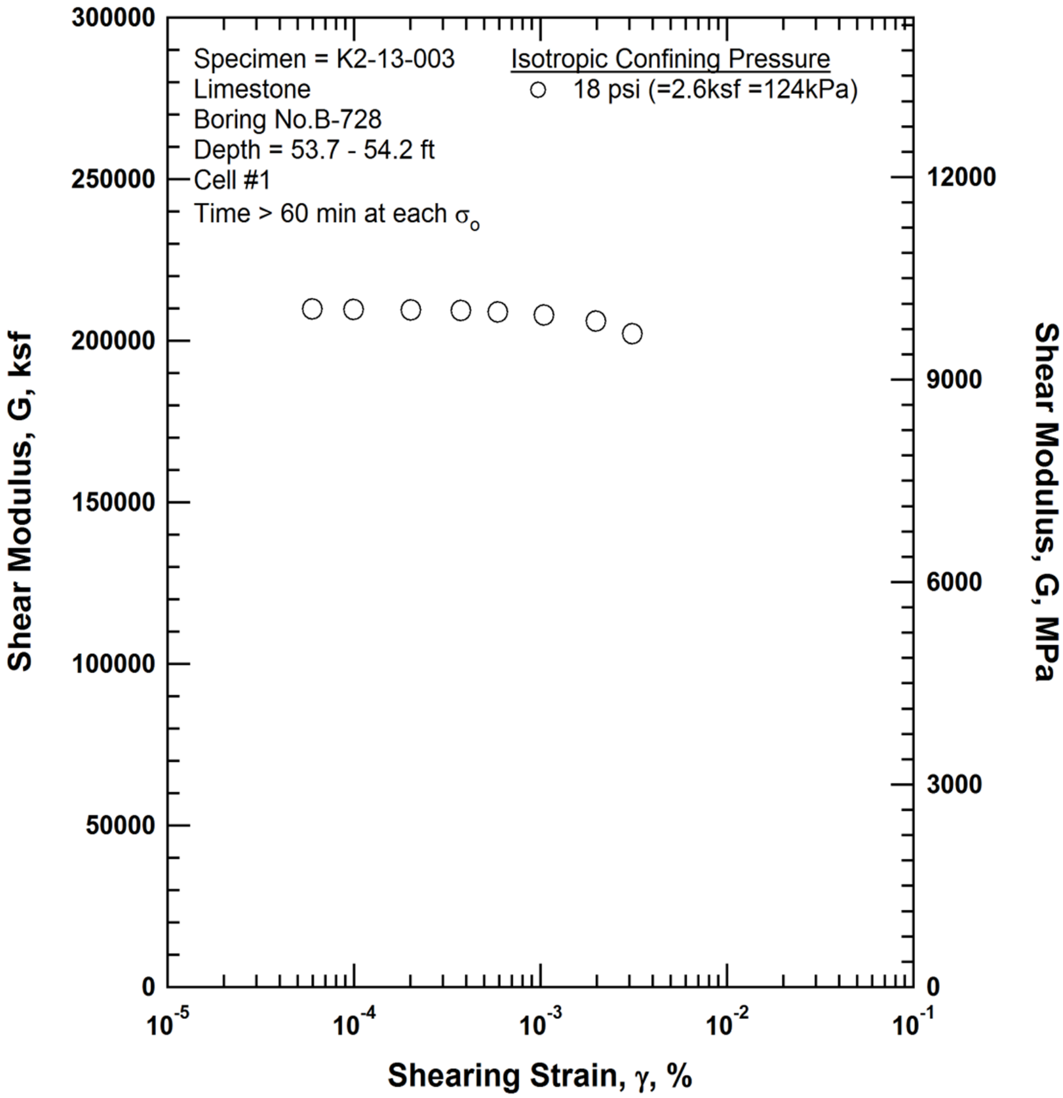
Note:
Membrane puncture at 47 psi prevented testing at higher confining pressures.

Figure D.8 Variation in Estimated Void Ratio with Isotropic Confining Pressure from Resonant Column Tests of Specimen K2-13-003



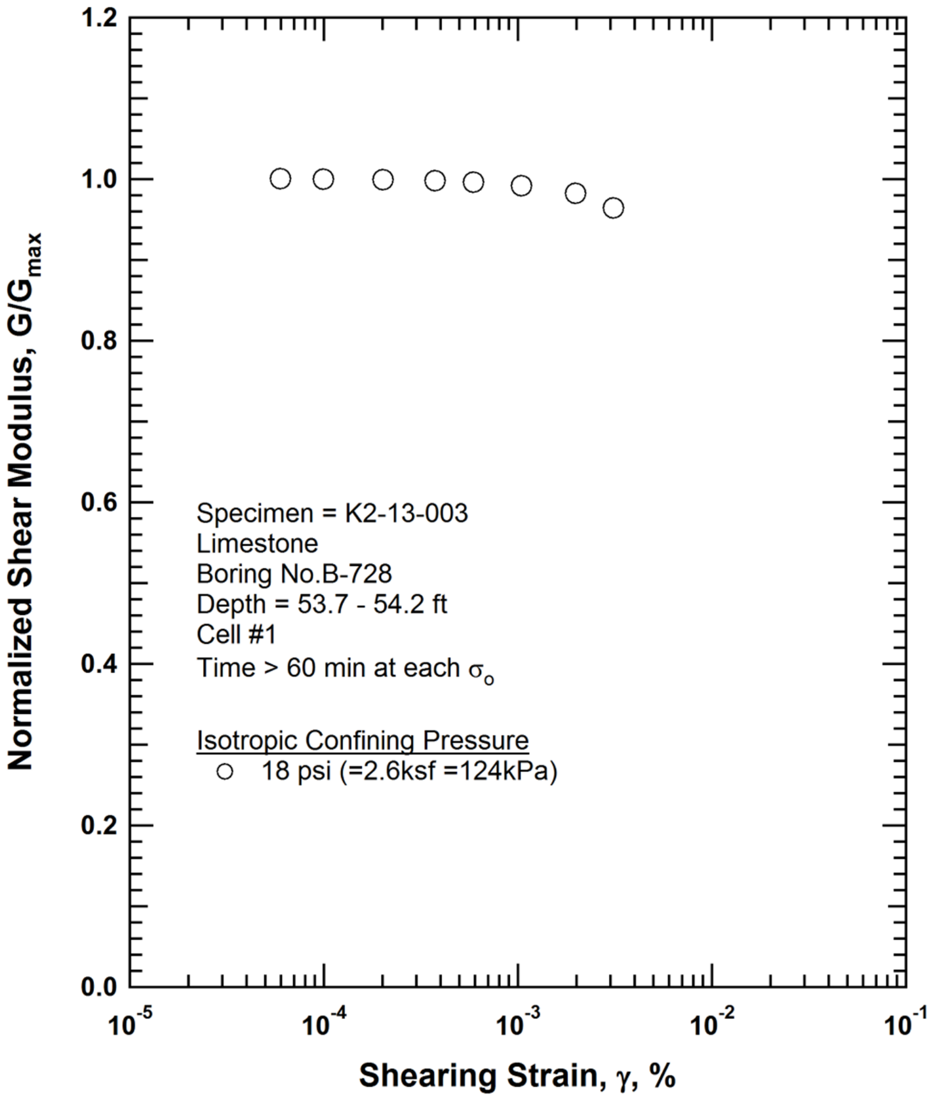
Note:
Membrane puncture at 47 psi prevented testing at higher confining pressures.

Figure D.9 Variation in Estimated Total Unit Weight with Isotropic Confining Pressure from Resonant Column Tests of Specimen K2-13-003



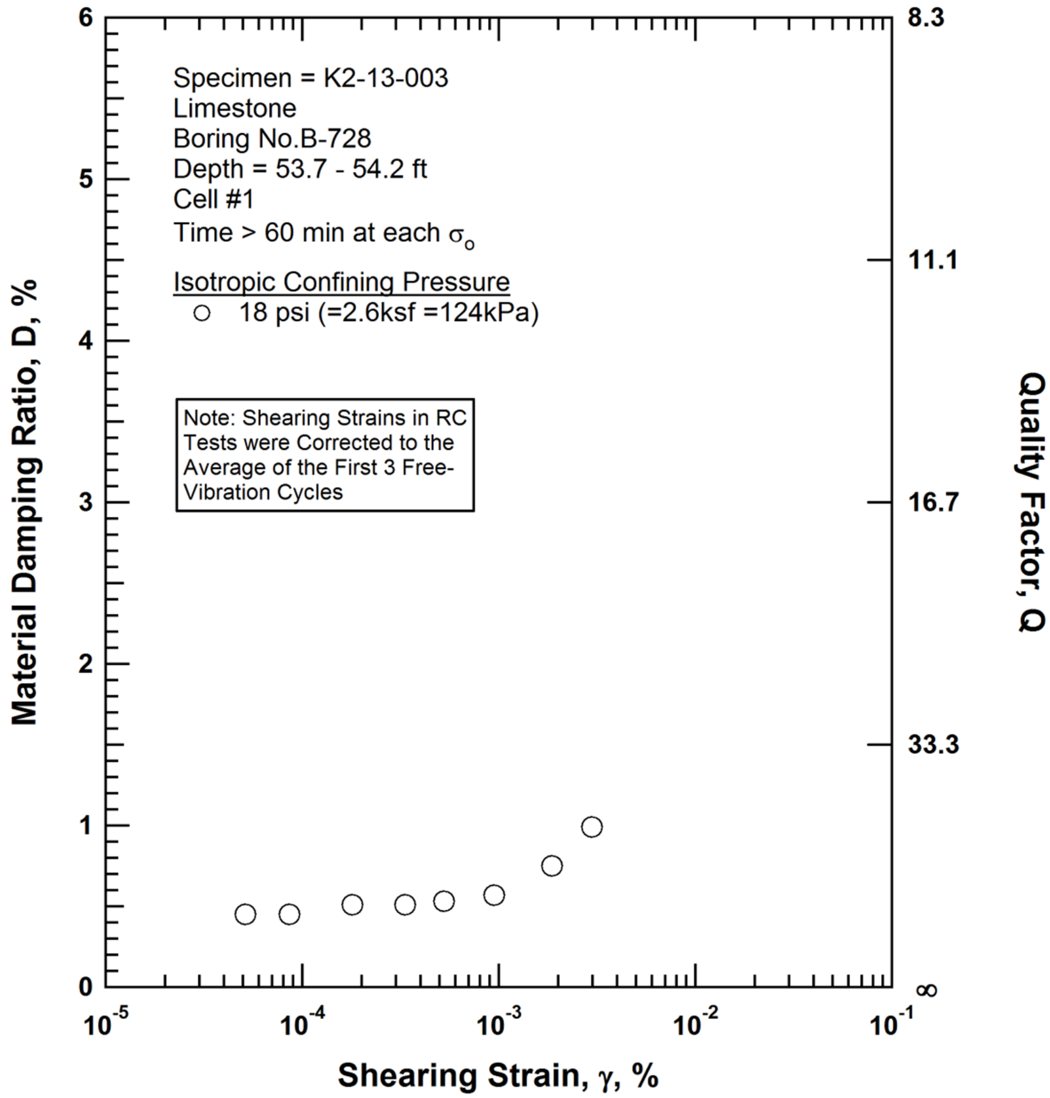
Note:
Membrane puncture at 47 psi prevented testing at higher confining pressures.

Figure D.10 Comparison of the Variation in Shear Modulus with Shearing Strain and Isotropic Confining Pressure from the Resonant Column Tests of Specimen K2-13-003



Note:
Membrane puncture at 47 psi prevented testing at higher confining pressures.

Figure D.11 Comparison of the Variation in Normalized Shear Modulus with Shearing Strain and Isotropic Confining Pressure from the Resonant Column Tests of Specimen K2-13-003



Note:
Membrane puncture at 47 psi prevented testing at higher confining pressures.

Figure D.12 Comparison of the Variation in Material Damping Ratio with Shearing Strain and Isotropic Confining Pressure from the Resonant Column Tests of Specimen K2-13-003

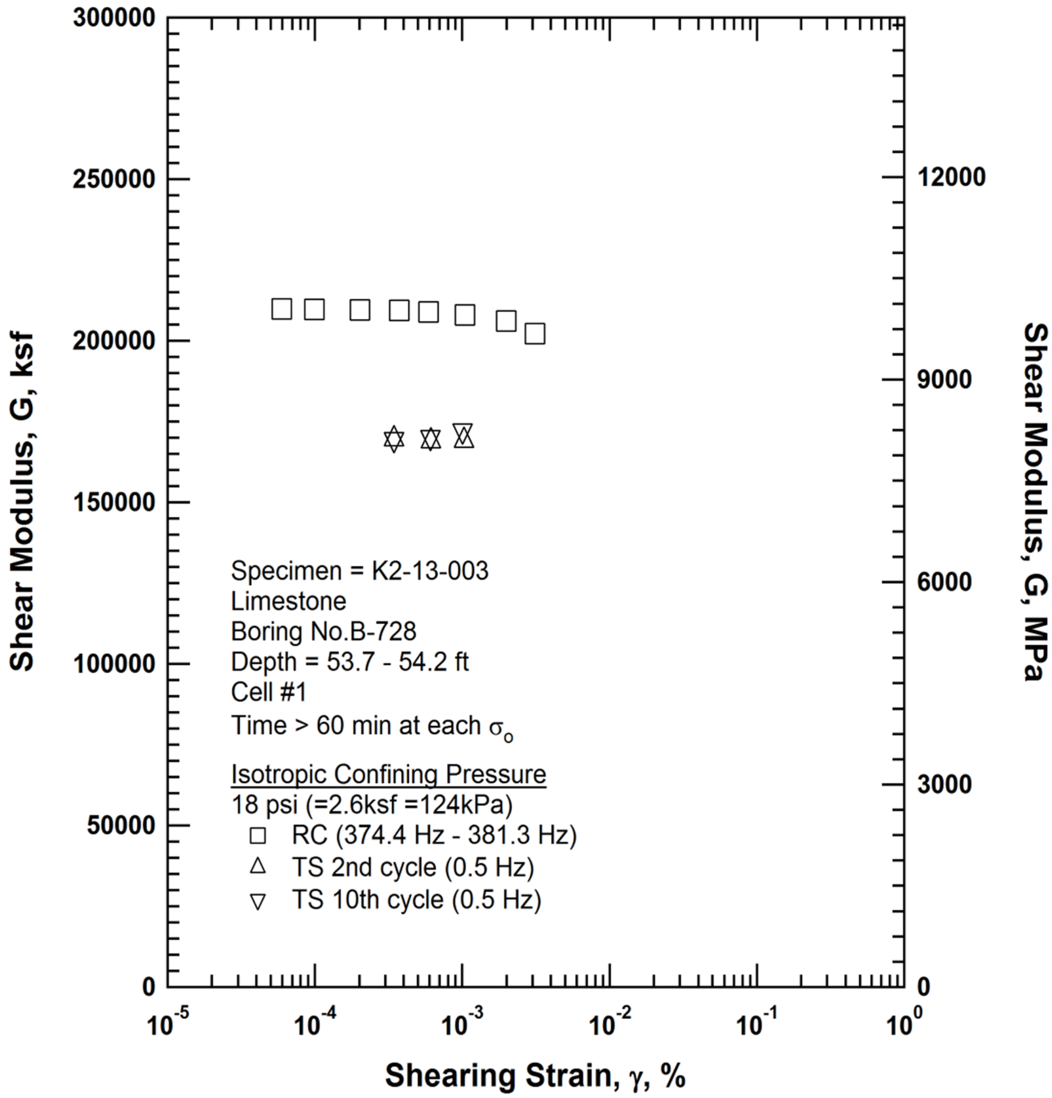


Figure D.13 Comparison of the Variation in Shear Modulus with Shearing Strain at an Isotropic Confining Pressure of 18 psi (=2.6ksf =124kPa) from the Combined RCTS Tests of Specimen K2-13-003

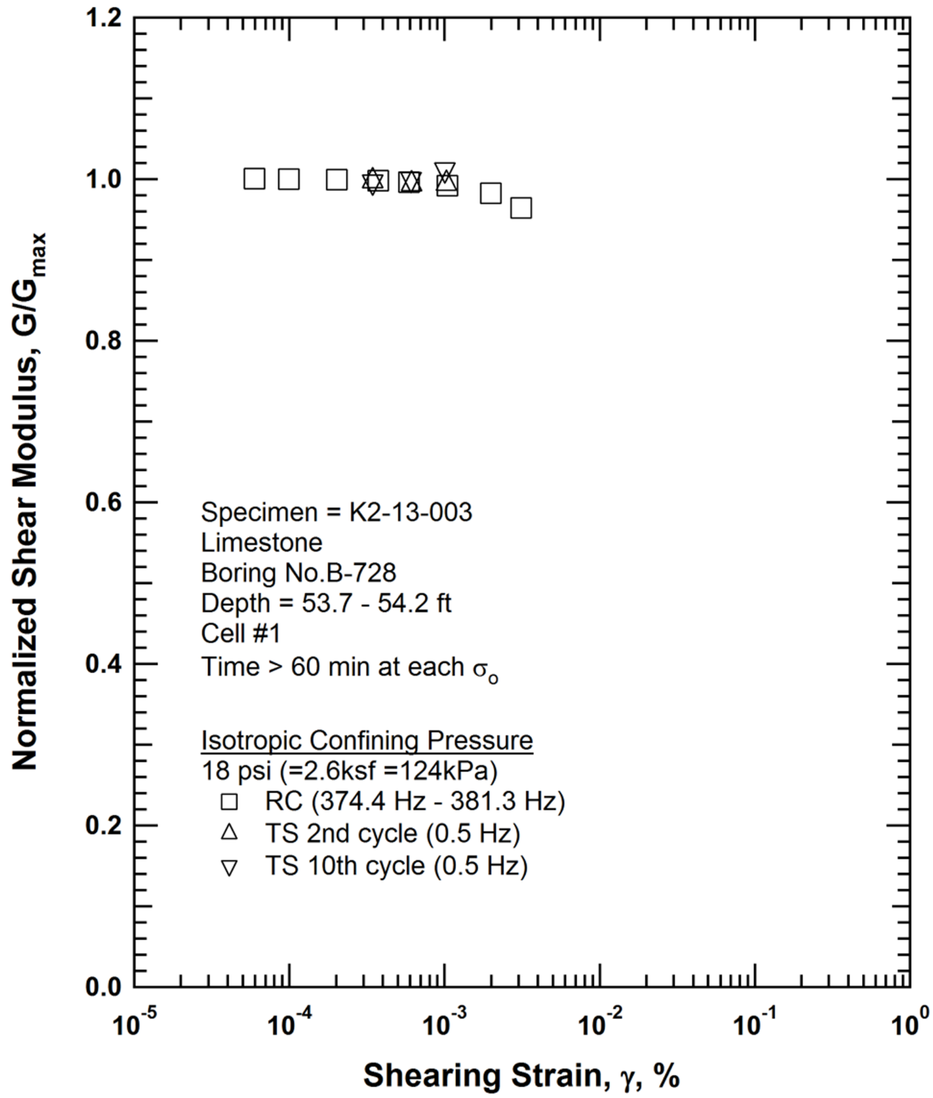
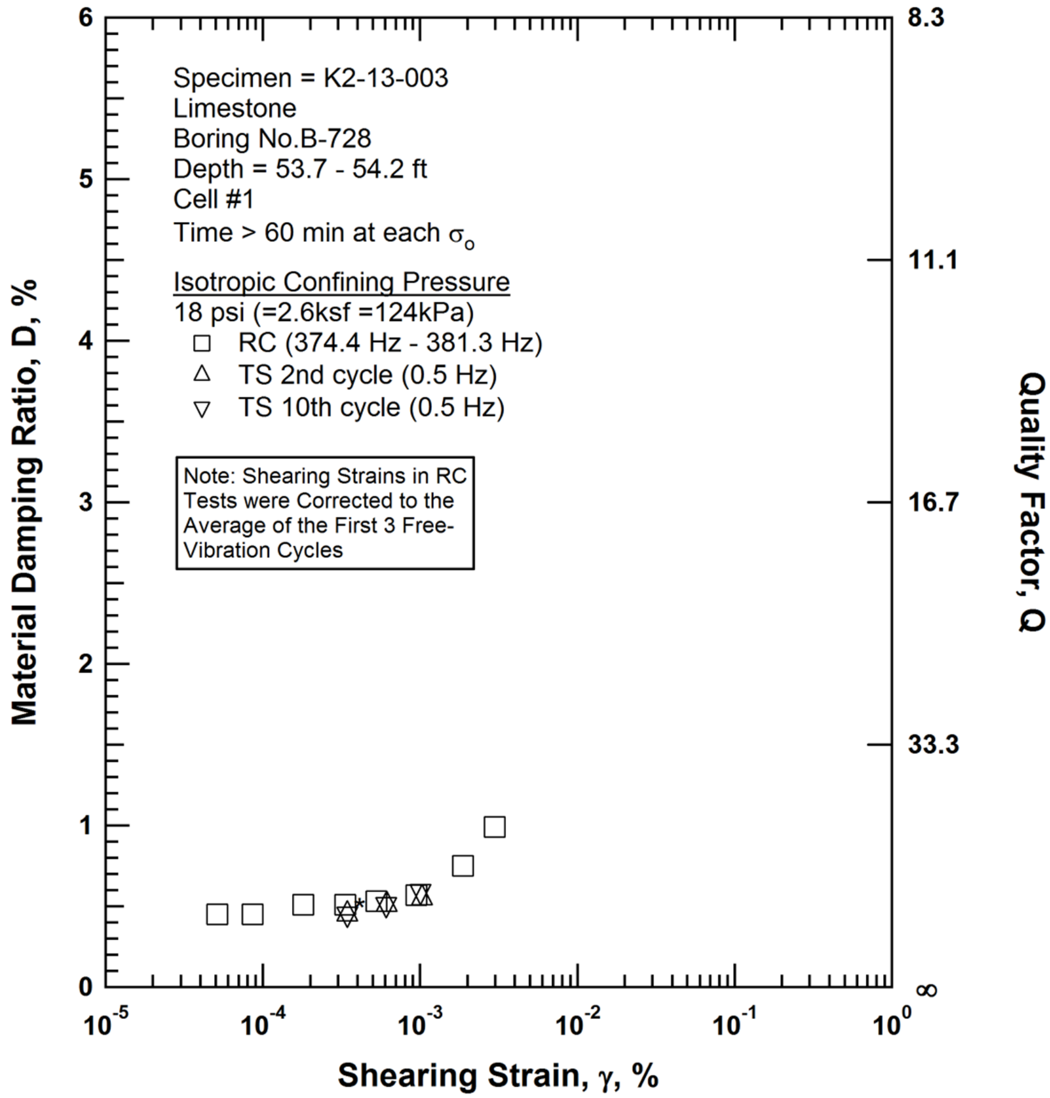


Figure D.14 Comparison of the Variation in Normalized Shear Modulus with Shearing Strain at an Isotropic Confining Pressure of 18 psi (=2.6ksf =124kPa) from the Combined RCTS Tests of Specimen K2-13-003



Note:
* Average result of first ten cycles.

Figure D.15 Comparison of the Variation in Material Damping Ratio with Shearing Strain at an Isotropic Confining Pressure of 18 psi (=2.6ksf =124kPa) from the Combined RCTS Tests of Specimen K2-13-003

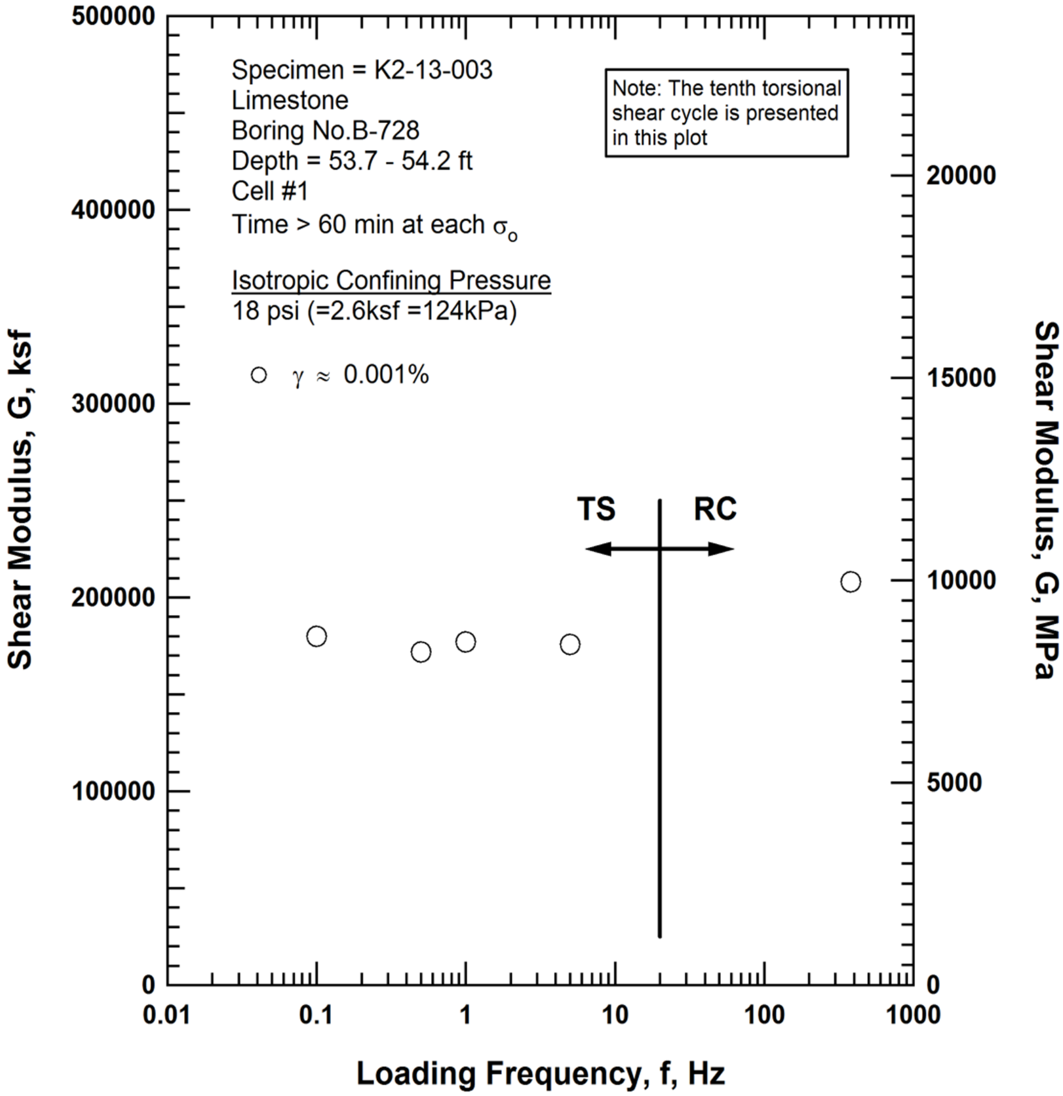


Figure D.16 Comparison of the Variation in Shear Modulus with Loading Frequency at an Isotropic Confining Pressure of 18 psi (=2.6ksf =124kPa) from the Combined RCTS Tests of Specimen K2-13-003

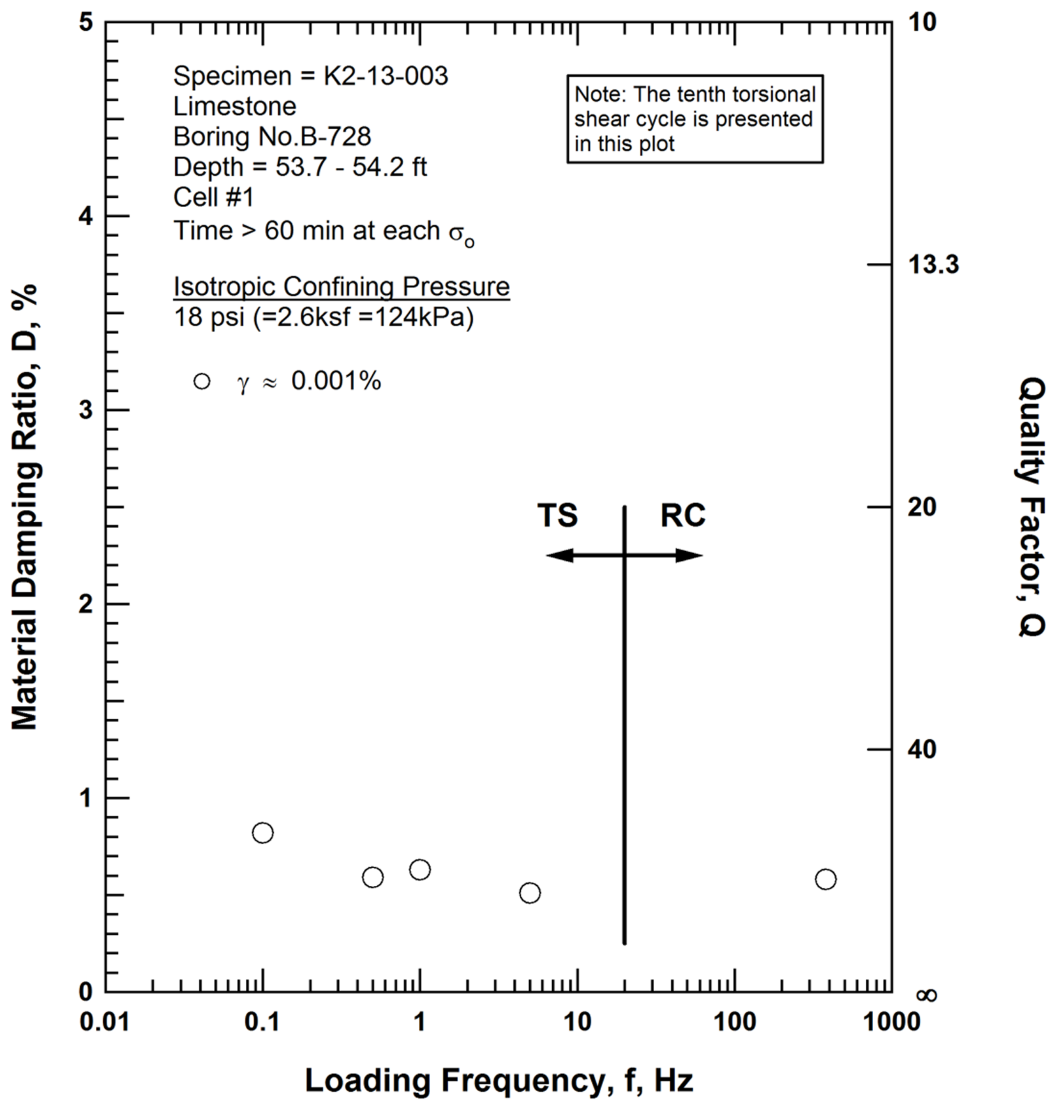


Figure D.17 Comparison of the Variation in Material Damping Ratio with Loading Frequency at an Isotropic Confining Pressure of 18 psi (=2.6ksf =124kPa) from the Combined RCTS Tests of Specimen K2-13-003

Table D.1 Variation in Low-Amplitude Shear Wave Velocity, Low-Amplitude Shear Modulus, Low-Amplitude Material Damping Ratio, Estimated Void Ratio, and Estimated Total Unit Weight with Isotropic Confining Pressure from RC Tests of Specimen K2-13-003

Isotropic Confining Pressure, σ_o [(1)]			Low-Amplitude Shear Modulus, G_{max}		Low-Amplitude Shear Wave Velocity, V_s	Low-Amplitude Material Damping Ratio, D_{min}	Estimated Void Ratio, e	Estimated Total Unit Weight, γ_t
(psi)	(psf)	(kPa)	(ksf)	(MPa)	(fps)	(%)	(Unitless)	(pcf)
5	720	34	208800	9999	6830	0.46	0.26	144.2
9	1296	62	209300	10020	6830	0.43	0.26	144.2
18	2592	124	209700	10040	6840	0.43	0.26	144.2

(1) Membrane puncture at 47 psi prevented testing at higher confining pressures

Table D.2 Variation in Shear Modulus, Normalized Shear Modulus and Material Damping Ratio with Shearing Strain from TS Tests of Specimen K2-13-003; Isotropic Confining Pressure σ_o = 18 psi (=2.6 ksf = 124 kPa)

Second Cycle				Tenth Cycle			
Peak Shearing Strain, γ, %	Shear Modulus, G, ksf	Normalized Shear Modulus, G/G_{max}	Material Damping Ratio, D, %	Peak Shearing Strain, γ, %	Shear Modulus, G, ksf	Normalized Shear Modulus, G/G_{max}	Material Damping Ratio, D, %
3.44E-04[(1)]	169500	1.00	0.45	3.45E-04[(1)]	169300	1.00	0.45
6.12E-04	168900	0.99	0.51	6.08E-04	169900	1.00	0.51
1.02E-03	169000	0.99	0.55	1.01E-03	172000	1.01	0.59

(1) Damping Results were Averaged for the First Ten Cycles at this Shearing Strain

Table D.3 Variation in Shear Modulus, Normalized Shear Modulus, and Material Damping with Shearing Strain from RC Tests of Specimen K2-13-003; Isotropic Confining Pressure σ_o = 18 psi (=2.6 ksf = 124 kPa)

Peak Shearing Strain, γ, %	Shear Modulus, G, ksf	Normalized Shear Modulus, G/G_{max}	Average Shearing Strain, %(1)	Material Damping Ratio, D, %(2)
5.97E-05	209800	1.00	5.14E-05	0.45
9.94E-05	209700	1.00	8.59E-05	0.45
2.02E-04	209500	1.00	1.80E-04	0.51
3.74E-04	209400	1.00	3.34E-04	0.51
5.91E-04	208900	1.00	5.27E-04	0.53
1.04E-03	208000	0.99	9.45E-04	0.57
1.98E-03	206100	0.98	1.87E-03	0.75
3.11E-03	202200	0.96	2.98E-03	0.99

(1) Average Shearing Strain from the First Three Cycle of the Free Vibration Decay Curve or from Half Power Damping for shearing strains less than 0.001%

(2) Average Damping Ratio from the First Three Cycle of the Free Vibration Decay Curve or from Half Power Damping for shearing strains less than 0.001%

Table D.4 Variation in Shear Modulus and Material Damping with Frequency from RC/TS Tests of Specimen K2-13-003; Isotropic Confining Pressure σ_o = 18 psi (=2.6 ksf = 124 kPa)

Approximate Shearing Strain, γ, %	Frequency, Hz	Shear Modulus, G, ksf	Material Damping Ratio, D, %
0.001	0.1	180000	0.82
	0.5	172000	0.59
	1.0	177100	0.63
	5.0	175700	0.51
	379.7	208000	0.58