SUPPLEMENTAL DATA REPORT NO. 1

DYNAMIC LABORATORY TESTING RESULTS

NORTH ANNA POWER STATION COL PROJECT

REV. 0
OCTOBER, 2007

MACTEC PROJECT NO. 6468-06-1472

DCN NACOL 253

SUPPLEMENTAL DATA REPORT No. 1, Rev. 0
DYNAMIC LABORATORY TESTING RESULTS

1.0 INTRODUCTION

This report is a supplement to the MACTEC Geotechnical Data Report issued as Rev. 0 on January 23, 2007. The Resonant Column/Torsional Shear laboratory testing was not complete when the Geotechnical Data Report Rev. 0 was issued. It was agreed by all parties that the test results would be issued as a supplemental report, not as a revision to the Geotechnical Data Report. The information in this supplemental data report is submitted for entry into the project document system and release for use.

2.0 SCOPE OF WORK

The attached test results were obtained from a laboratory study performed at Fugro Consultants (Fugro) laboratory in Houston, Texas. The dynamic properties of 3 intact soil samples from the North Anna site were evaluated. Combined resonant column and torsional shear (RCTS) equipment was used to perform the measurements. The dynamic characteristics evaluated with the RCTS equipment are the shear modulus (G), and the material damping ratio in shear (D). Dynamic testing of each specimen involved the evaluation of G and D over a range of isotropic confining pressures. Five isotropic confining pressures were used for each specimen, ranging from below to above the estimated in-situ mean effective stress.

Remaining material in the undisturbed sample tubes was used by Fugro to perform particle size distribution tests (ASTM D 422-63 (2002) and ASTM D 6913-04).

3.0 METHODOLOGY

3.1 Locations

Samples for testing were obtained from Borings B-901(1 sample) and B-911A (2 samples), both located within the Power Block area. The samples were undisturbed samples obtained using techniques of ASTM D 1587 -00. The undisturbed tubes were placed upright in protective boxes and transferred under chain of custody from the North Anna site to Fugro's laboratory following methods of ASTM D 4220-95 (2000) for Group C samples. The samples were received by Fugro personnel and set aside in climate controlled storage.

The samples to be tested were listed on a laboratory testing assignment issued by Bechtel. Twelve samples were assigned for testing. Bechtel later reduced the number of samples for testing to 4. Three samples were tested successfully; the testing on the fourth sample was problematic due to material changes in the sample, and Bechtel determined that testing on that sample was not to be completed.

3.2 Subcontractors

The RCTS testing was done by Fugro under subcontract to MACTEC. Dr. Ken Stokoe of the University of Texas Austin reviewed and approved the test reports prior to their issue by Fugro.

3.3 Technical Procedures

3.3.1 RCTS Tests

The RCTS testing was performed in accordance with "Test Procedures and Calibration Documentation Associated with the RCTS and URC Tests at the University of Texas at Austin, Geotechnical Engineering Report GR06-4, DCN: UTSD RCTS GR06-4 REV 0, dated April 25, 2006." A copy of the procedure is maintained in MACTEC project QA files.

3.3.2 Particle Size Distribution Tests

Brief descriptions of the particle size distribution tests assigned by Bechtel, performed by Fugro and contained in this Supplemental Report are given in the paragraphs below.

3.3.2.1 Particle Size Analysis

3.3.2.1.1 Sieve Analysis (ASTM D 6913-04) – The dried soil sample is separated into a series of fractions using a standard set of nested sieves. The sieving operation is conducted by means of a lateral and vertical motion of the nest of sieves, accompanied by jarring action to keep the sample moving continuously over the surface of the sieves. The weights retained on each of the set of nested sieves are used to calculate the percent of the sample passing each sieve size.

3.3.2.1.2 Combined sieve and hydrometer Analysis (ASTM D 422-63(2002)) – The sieve analysis is performed as described above. The portion of the soil sample passing the No. 200 (75 μm) sieve is soaked in water and dispersed using a dispersing agent. The solution is placed in a cylinder and stirred, and the density of the solution is monitored over time with a hydrometer to observe the settling out of suspended soil particles. Diameters corresponding to the readings of the hydrometer are then calculated using Stoke's law.

4.0 QUALITY ASSURANCE

4.1 Procurement

Fugro was procured for the work in accordance with the procedures in section QS-7 of the MACTEC Quality Assurance Project Document (QAPD).

4.2 Personnel

Fugro personnel were qualified and operated under the Fugro Quality Assurance plan. Qualifications for the RCTS reviewer, Dr. Ken Stokoe were reviewed and accepted by MACTEC in accordance with MACTEC Quality Assurance Procedure QAP 20-1 as included in the MACTEC QAPD. Qualifications information is maintained in MACTEC QA files.

4.3 Equipment Calibration

Equipment in the Fugro laboratory was calibrated in accordance with the Fugro Quality Assurance Program. Copies of the calibration records furnished by Fugro are maintained in MACTEC QA files.

4.4 Surveillances

MACTEC QA personnel conducted surveillances of the Fugro laboratory during the course of the RCTS testing. Records of the surveillances are maintained in MACTEC QA files.

5.0 RESULTS

The test results report from Fugro was reviewed and accepted by MACTEC. The report is attached.

MACTEC

DOCUMENTATION OF TECHNICAL REVIEW
SUBCONTRACTOR WORK PRODUCT

Project Name: North Anna COL

Project Number: 6468-06-1472

Project Manager: Steve Criscenzo

Project Principal: Al Tice

The test results described below have been prepared by the named subcontractor retained in accordance with the MACTEC QAPD. The test results have been technically reviewed by Dr. Ken Stokoe of the University of Texas Austin by agreement between Fugro and MACTEC. Comments on the work or report, if any, have been satisfactorily addressed by the subcontractor. The attached test results are approved in accordance with section QS-7 of MACTEC's QAPD

The information and data contained in the attached test results are hereby released by MACTEC for project use.

REPORT : RCTS Test Results for B-901-UD-1, B-911A-UD1 and B-911A-PB1 - Fugro report dated August 10, 2007 supplemented by revised tables and test reports dated September 27, 2007.

SUBCONTRACTOR: Fugro Consultants, Inc.

DATE OF ACCEPTANCE : 9-28-07

TECHNICAL REVIEWER: Dr. Ken Stokoe

PROJECT PRINCIPAL [signature] 9-28-07

DCN NACOL - 253

FUGRO CONSULTANTS, INC.

6100 Hillcroft (77081)
P.O. Box 740010
Houston, Texas 77274
Tel: 713-369-5400
Fax: 713-369-5518

August 10, 2007

Mr. Michael P. Sufnarski, P.E.
Principal Engineer/Project Manager
MACTEC Engineering and Consulting, Inc.
2801 Yorkmont Road | Charlotte, NC 28208

RE: Three (3) RCTS Reports For The North Anna Project

Dear Mr. Sufnarski:

Fugro has completed three (3) RCTS tests for the North Anna project. The final reports and the associated RCTS Test Approval by Dr. Kenneth Stokoe have been attached.

Please let us know if you have questions. Thanks.

Very truly yours,

Fugro Consultants, Inc.

Jiewu Meng, PhD, P.E.
Project Engineer

Bill DeGroff, P.E.
Laboratory Department Manager

Cc: Dr. Kenneth Stokoe

Enclosures

FUGRO CONSULTANTS, INC.

FUGRO

6100 Hillcroft (77081)
P.O. Box 740010
Houston, Texas 77274
Tel: 713-369-5400
Fax: 713-369-5518

September 27, 2007

Mr. J. Allan Tice, P. E.
Senior Principal Engineer/Assistant Vice President
MACTEC Engineering and Consulting, Inc.
3301 Atlantic Avenue
Raleigh, NC 27604

RE: Revised Tables, Particle Size Distribution Curves, and Clarification Letter of Transmittal August 10, 2007 for the North Anna Project

Dear Mr. Tice:

Per your request, Fugro has enclosed the above referenced items for the following specimens for the North Anna Project:

1. B901-UD1
2. B911A-UD1
3. B911A-PB1

Please let us know if you have questions. Thanks.

Very truly yours,

Fugro Consultants, Inc.

Jiewu Meng, PhD, P.E.
Project Engineer

Bill DeGroff, P.E.
Laboratory Department Manager

Enclosures

RCTS TEST APROVAL

PROJECT SITE/NAME	North Anna

Test ID	Sample ID	Depth B.S. (Ft)	Approved By (Initials)	Date
RCTS#A	B901-UD1	9.5	KHS	1 Aug '07
RCTS#B	B911A-UD1 *	11.7	KHS	1 Aug '07
RCTS#C	B911A-PB1 *	21.7	KHS	1 Aug '07
RCTS#				

The RCTS tests for the site referenced above were tested, and a report was prepared, by Fugro Consultants, Inc.

I have reviewed the data and associated results listed above and found them to be reasonable.

Approved By:

K. H. Stokoe

Dr. Kenneth Stokoe

Note: * minor changes suggested on some figures. These changes will only improve consistency between RC and TS data.

FUGRO CONSULTANTS, INC.

6100 Hillcroft (77081)
P.O. Box 740010
Houston, Texas 77274
Tel: 713-369-5400
Fax: 713-369-5518

September 27, 2007

Mr. J. Allan Tice, P. E.
Senior Principal Engineer/Assistant Vice President
MACTEC Engineering and Consulting, Inc.
3301 Atlantic Avenue
Raleigh, NC 27604

RE: Clarification of Three (3) RCTS Reports, Transmitted August 10, 2007, For The North Anna (NA) Project

Dear Mr. Tice:

Fugro has incorporated, as needed, Dr. Kenneth Stokoe's comments into the final reports, which were transmitted on August 10, 2007, of three (3) RCTS tests for the North Anna project.

Please let us know if you have questions. Thanks.

Very truly yours,

Fugro Consultants, Inc.

Jiewu Meng, PhD, P.E.
Project Engineer

Bill DeGroff, P.E.
Laboratory Department Manager

APPENDIX A

Specimen NA B901-UD1

Borehole B901
Sample UD1
Depth = 9.5 ft (2.9 m)
Total Unit Weight = 120.5 lb/ft^3
Water Content = 17.9 %
Estimated In-Situ Ko = 0.5
Estimated In-Situ Mean Effective
Stress = 4.3 psi

FUGRO JOB #: 0401-1662
Testing Station: RC5

NOTE: Visual classification, if not specifically stated otherwise, was practiced in determining the soil types.

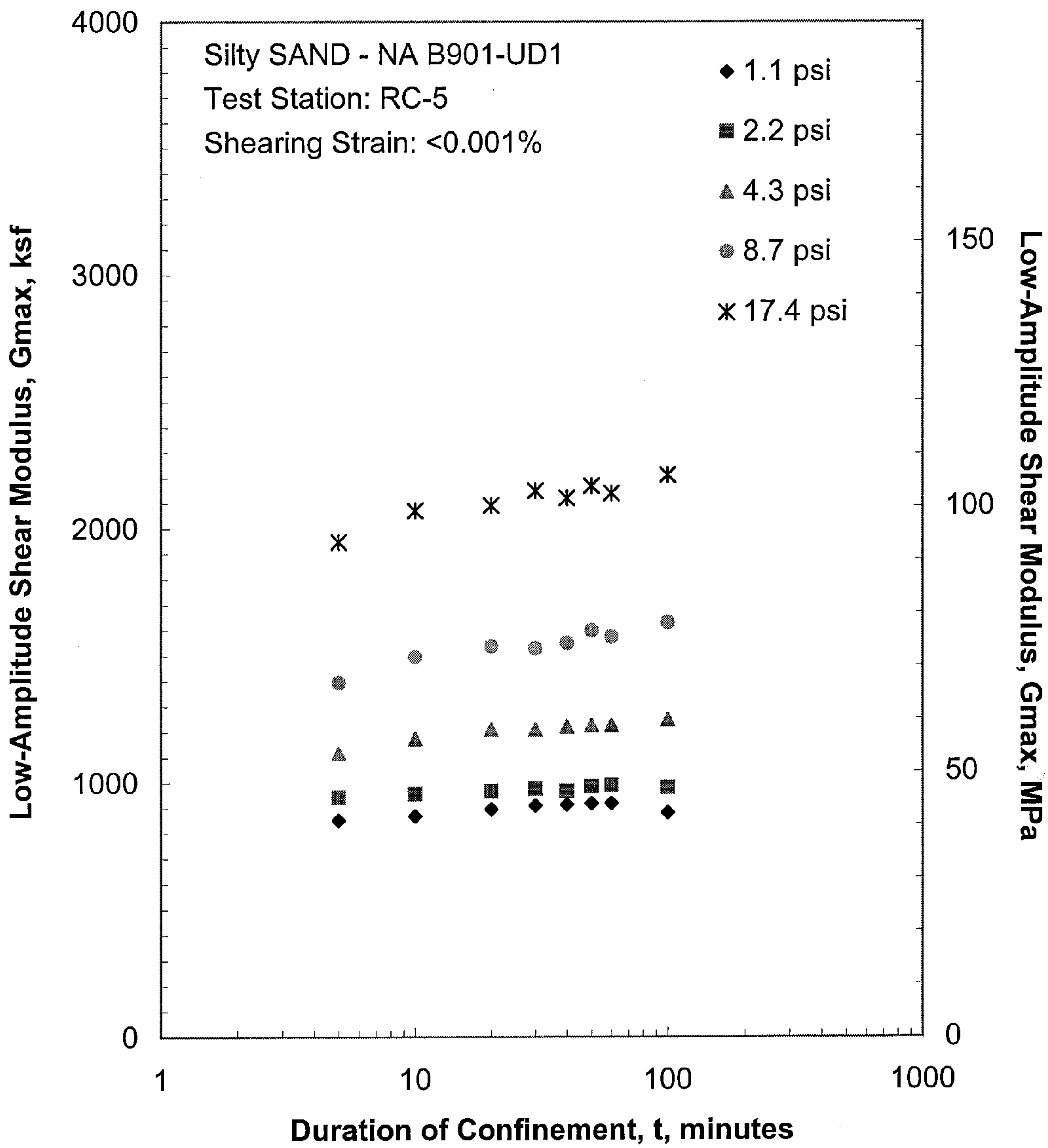


Figure A.1 Variation in Low-Amplitude Shear Modulus with Magnitude and Duration of Isotropic Confining Pressure from Resonant Column Tests

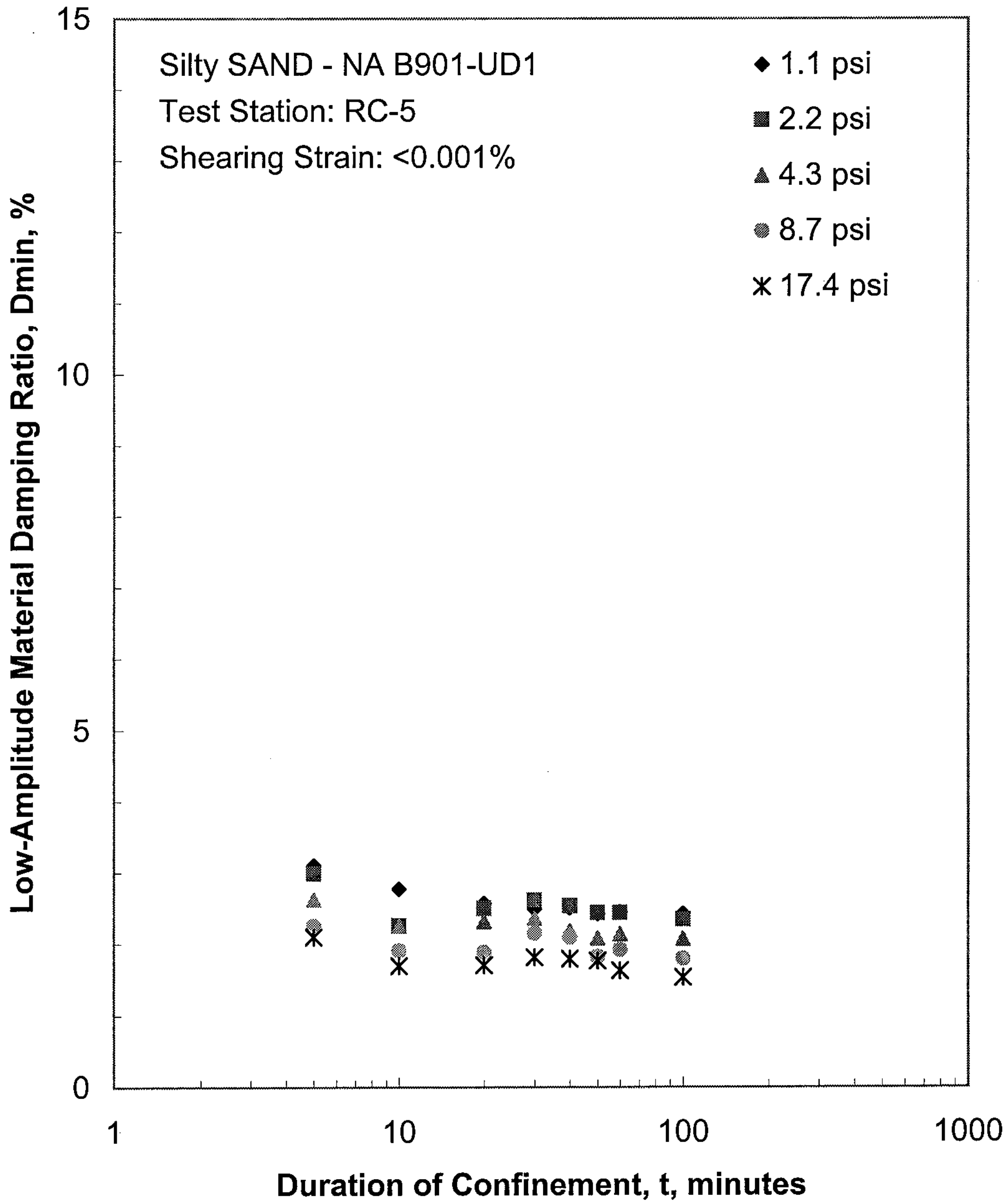


Figure A.2 Variation in Low-Amplitude Material Damping Ratio with Magnitude and Duration of Isotropic Confining Pressure from Resonant Column Tests

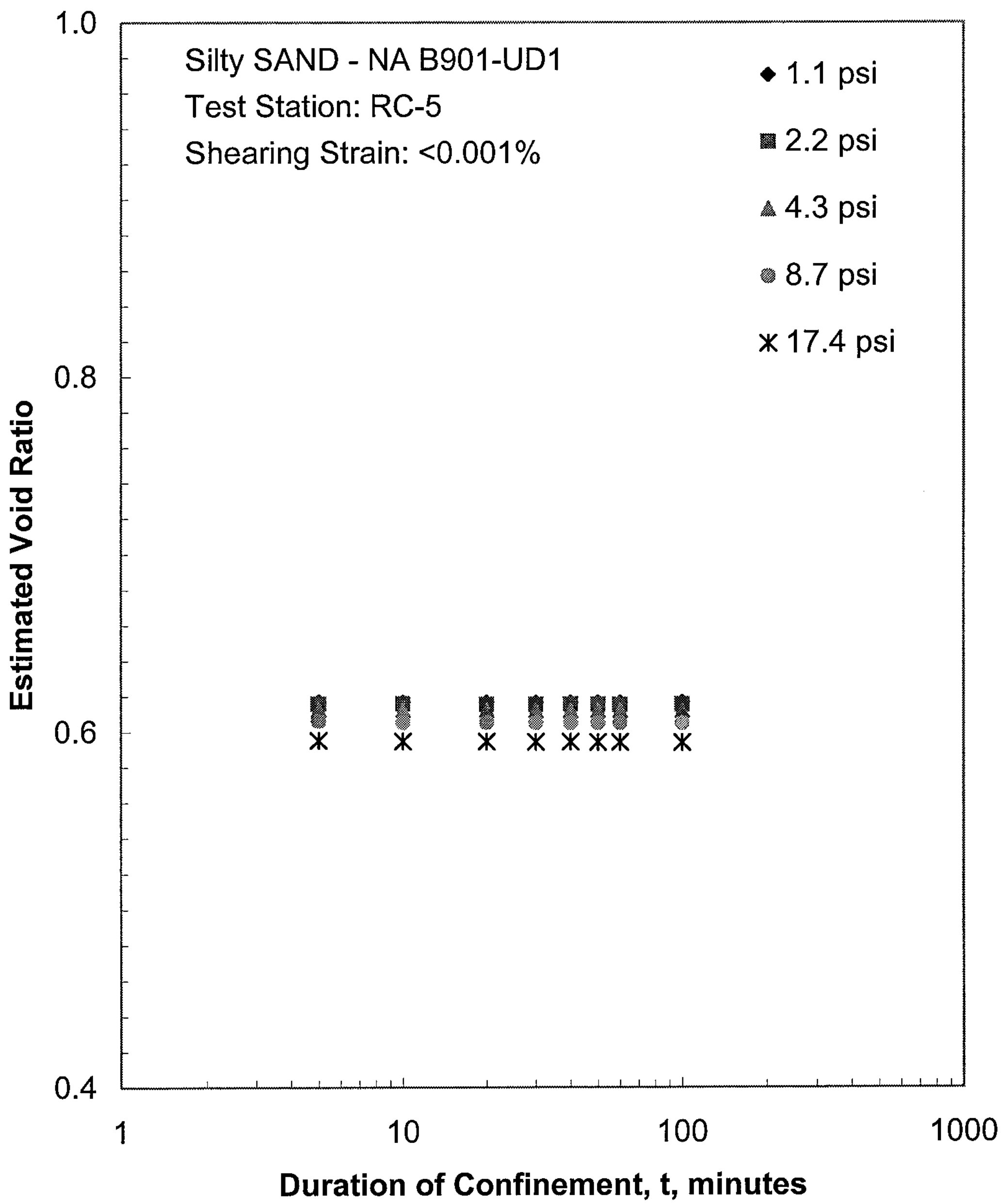


Figure A.3 Variation in Estimated Void Ratio with Magnitude and Duration of Isotropic Confining Pressure from Resonant Column Tests

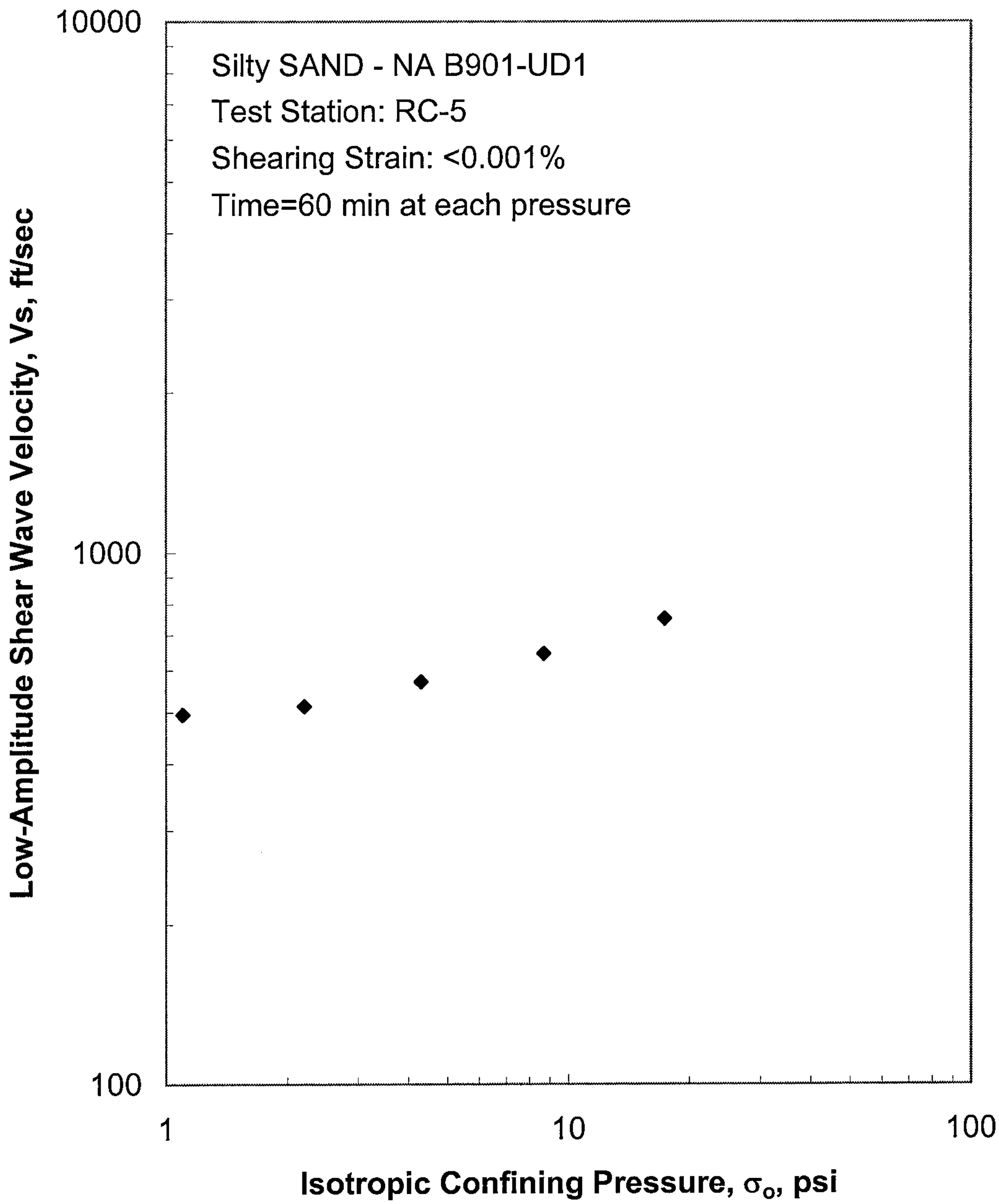


Figure A.4 Variation in Low-Amplitude Shear Wave Velocity with Isotropic Confining Pressure from Resonant Column Tests

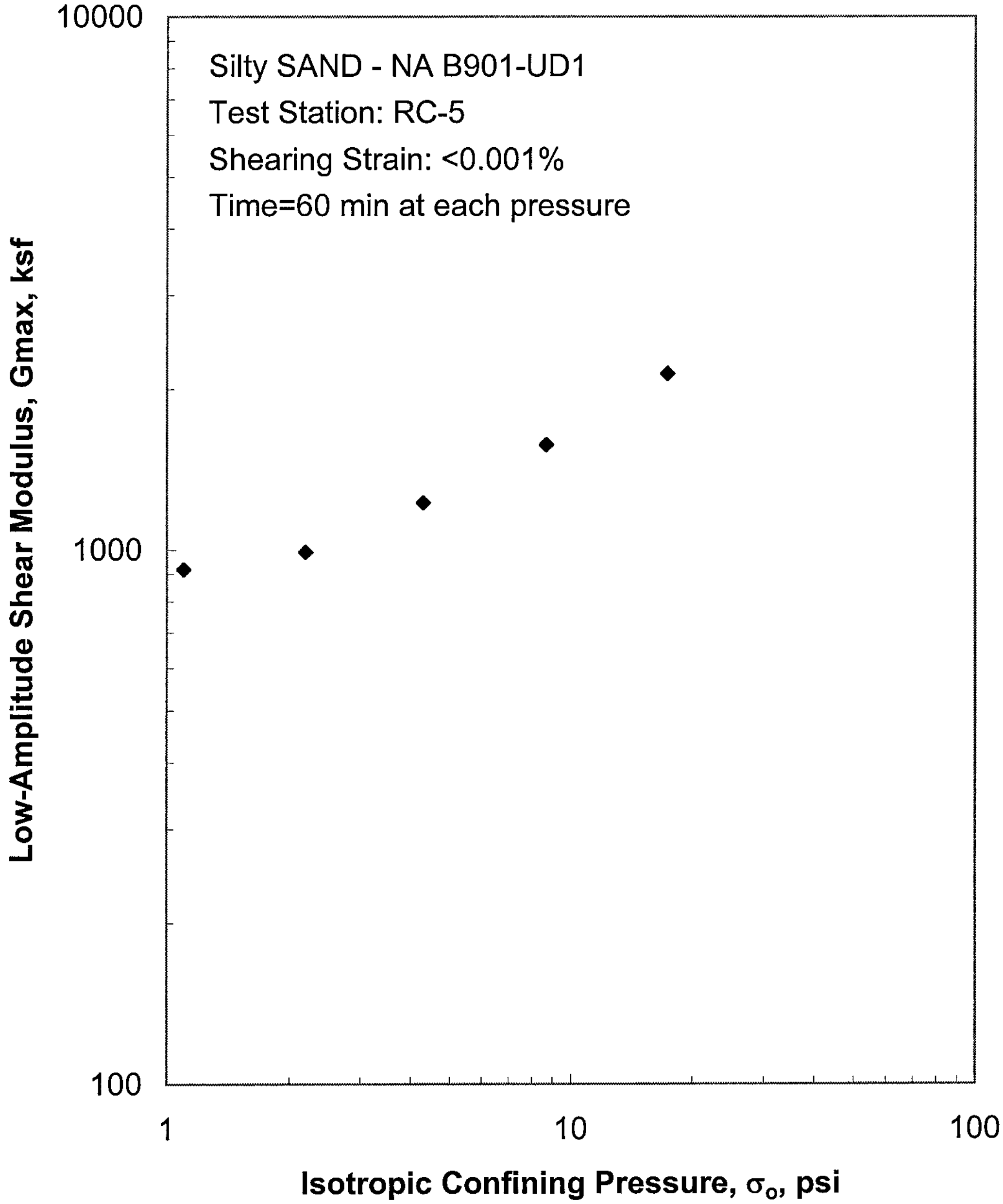


Figure A.5 Variation in Low-Amplitude Shear Modulus with Isotropic Confining Pressure from Resonant Column Tests

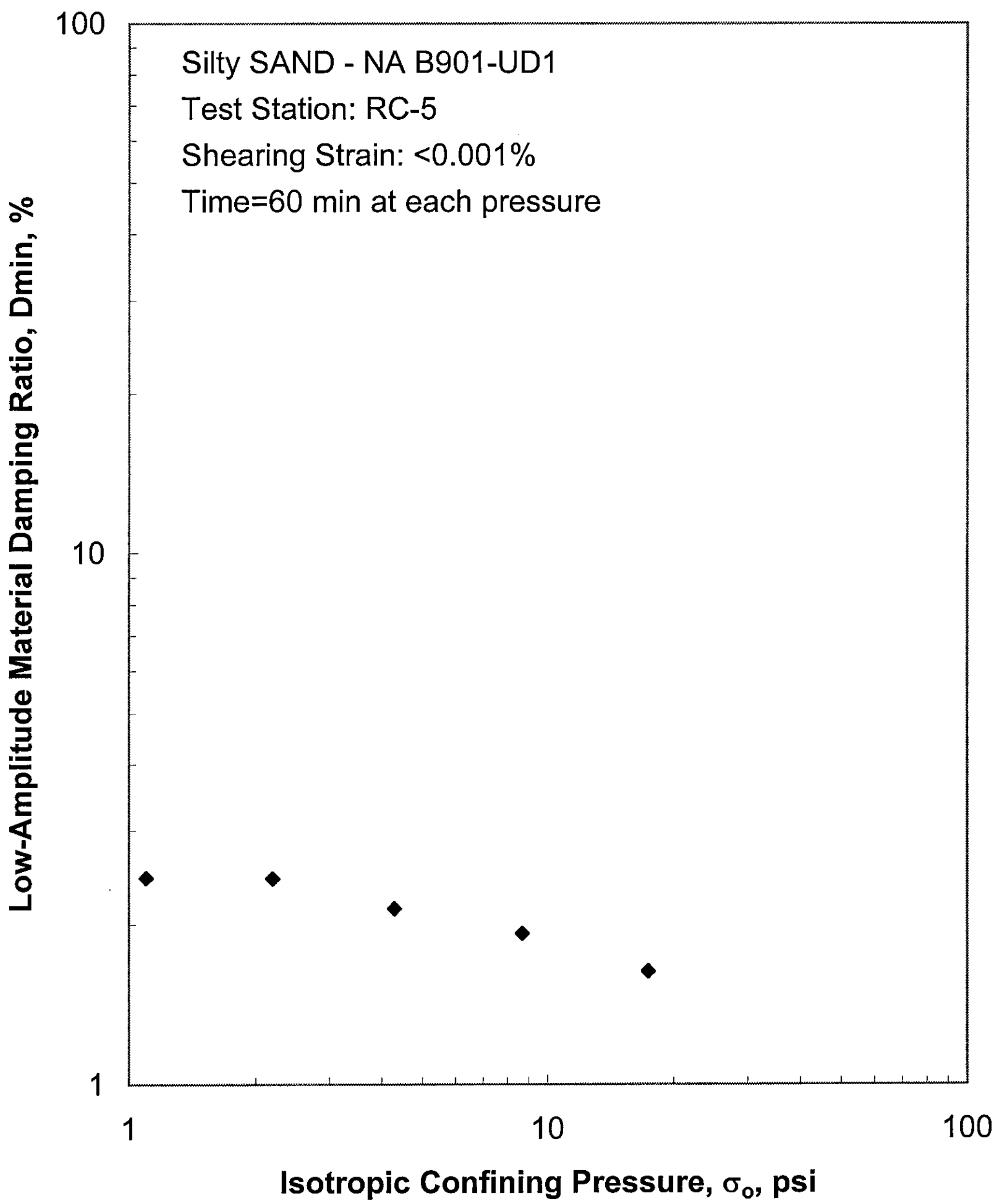


Figure A.6 Variation in Low-Amplitude Material Damping Ratio with Isotropic Confining Pressure from Resonant Column Tests

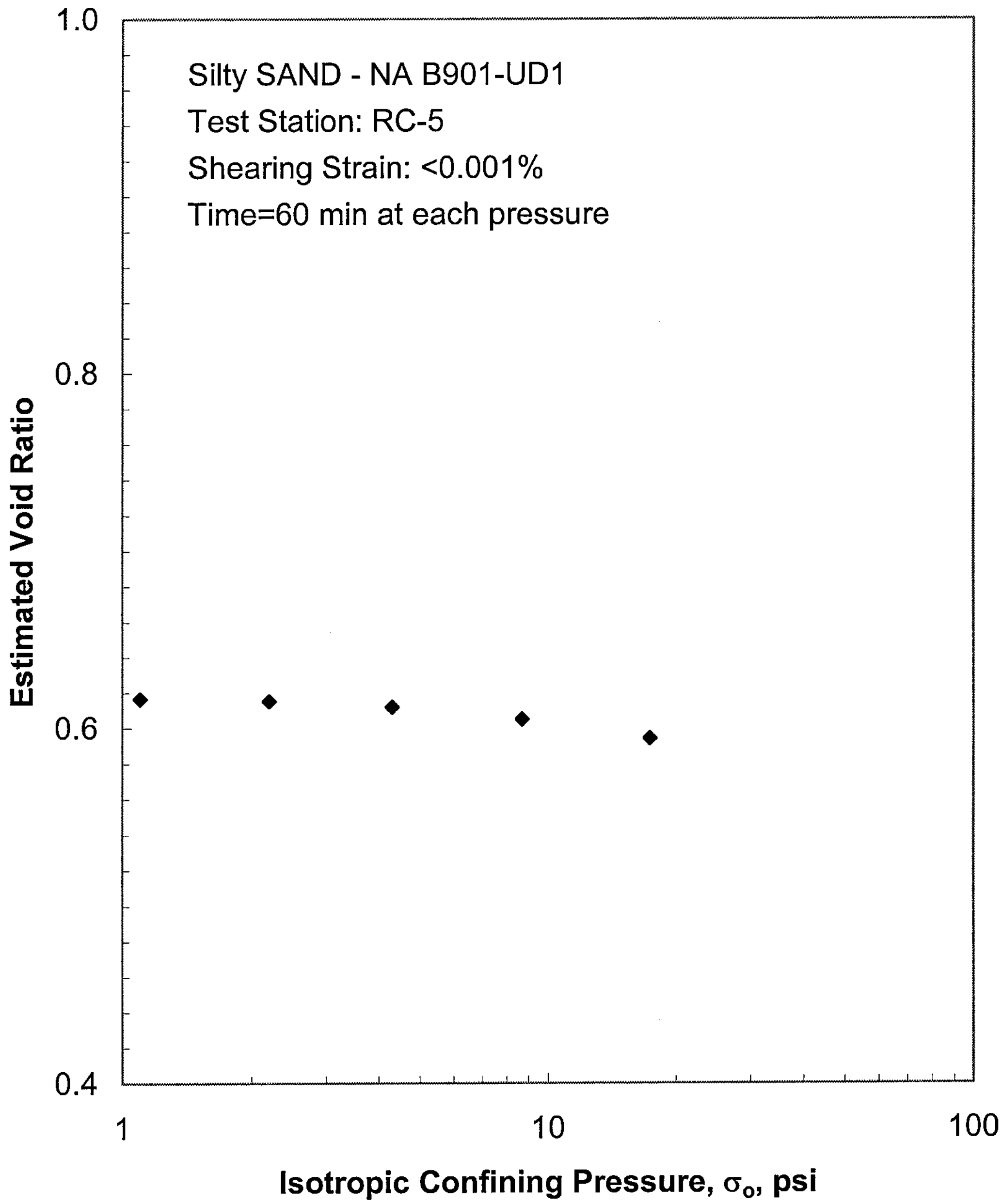


Figure A.7 Variation in Estimated Void Ratio with Isotropic Confining Pressure from Resonant Column Tests

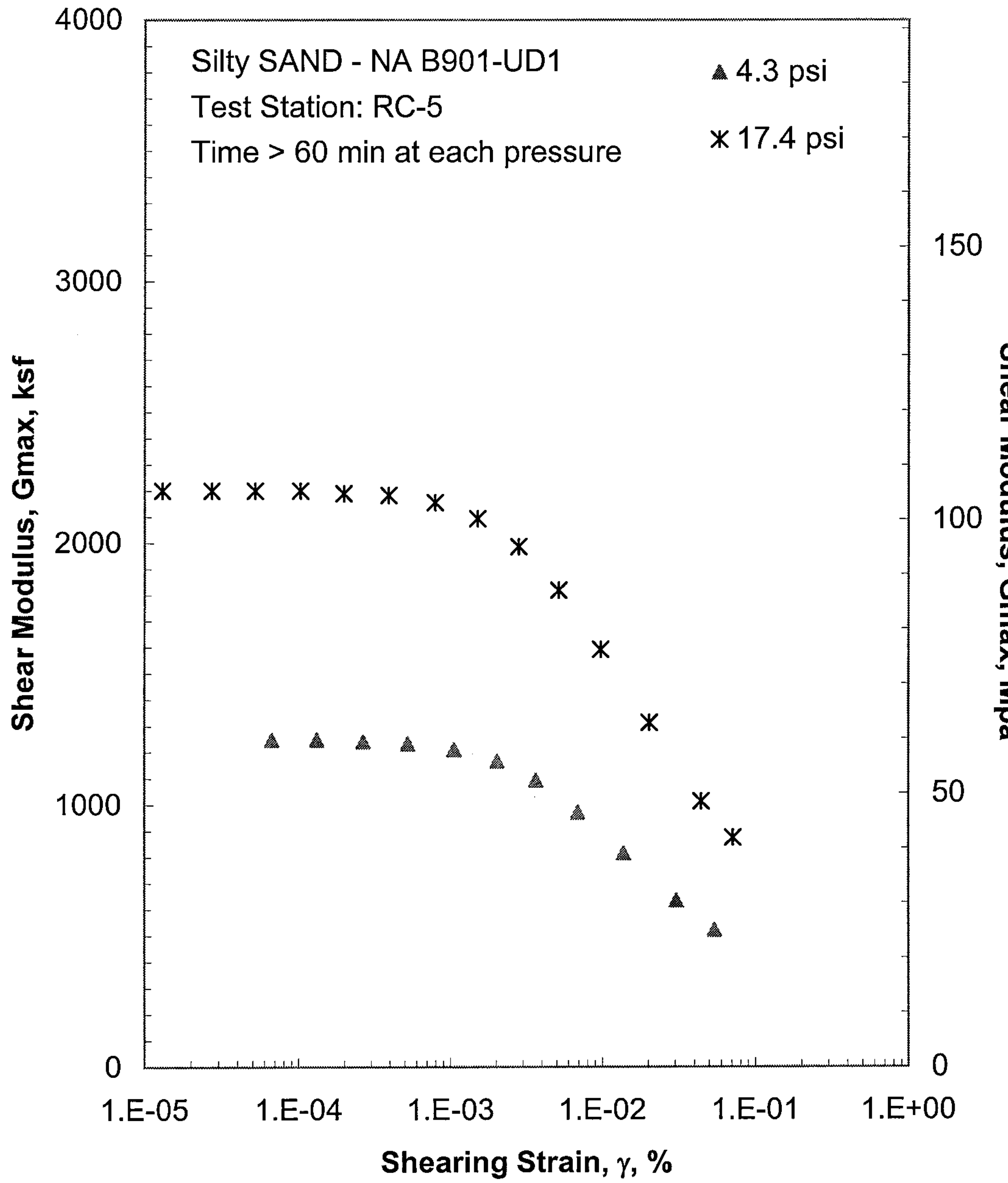


Figure A.8 Comparison of the Variation in Shear Modulus with Shearing Strain and Isotropic Confining Pressure from the Resonant Column Tests

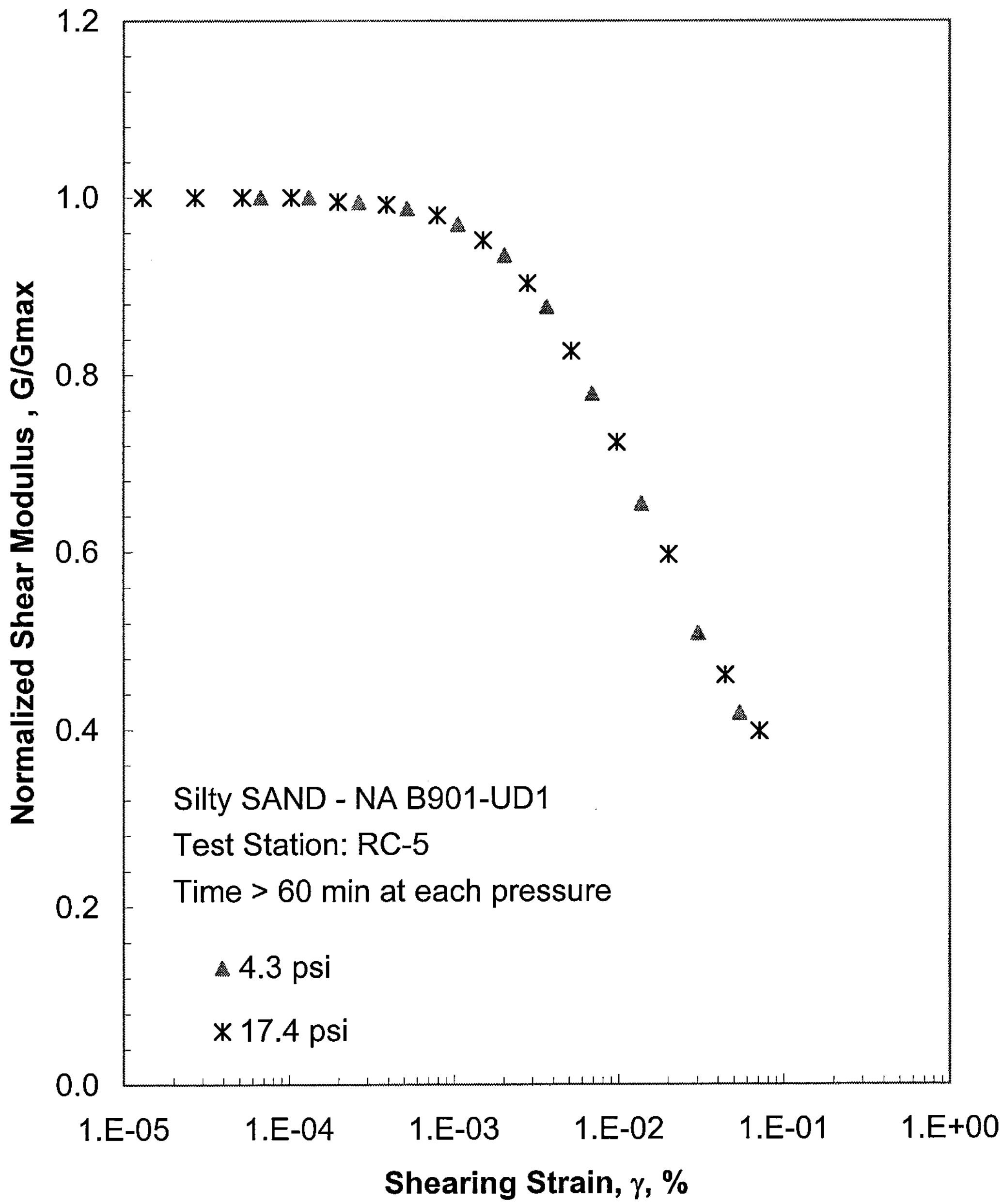


Figure A.9 Comparison of the Variation in Normalized Shear Modulus with Shearing Strain and Isotropic Confining Pressure from the Resonant Column Tests

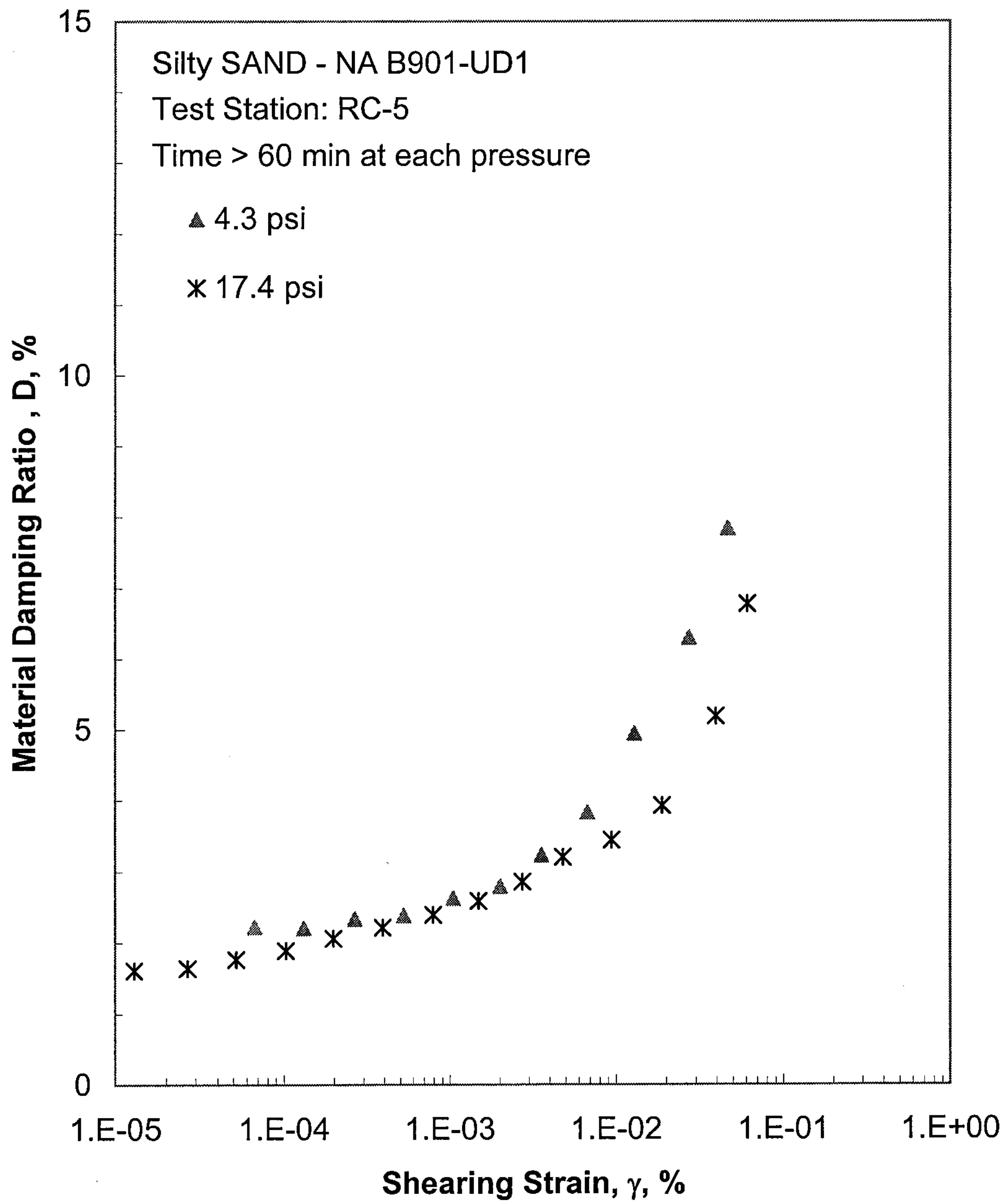


Figure A.10 Comparison of the Variation in Material Damping Ratio with Shearing Strain and Isotropic Confining Pressure from the Resonant Column Tests

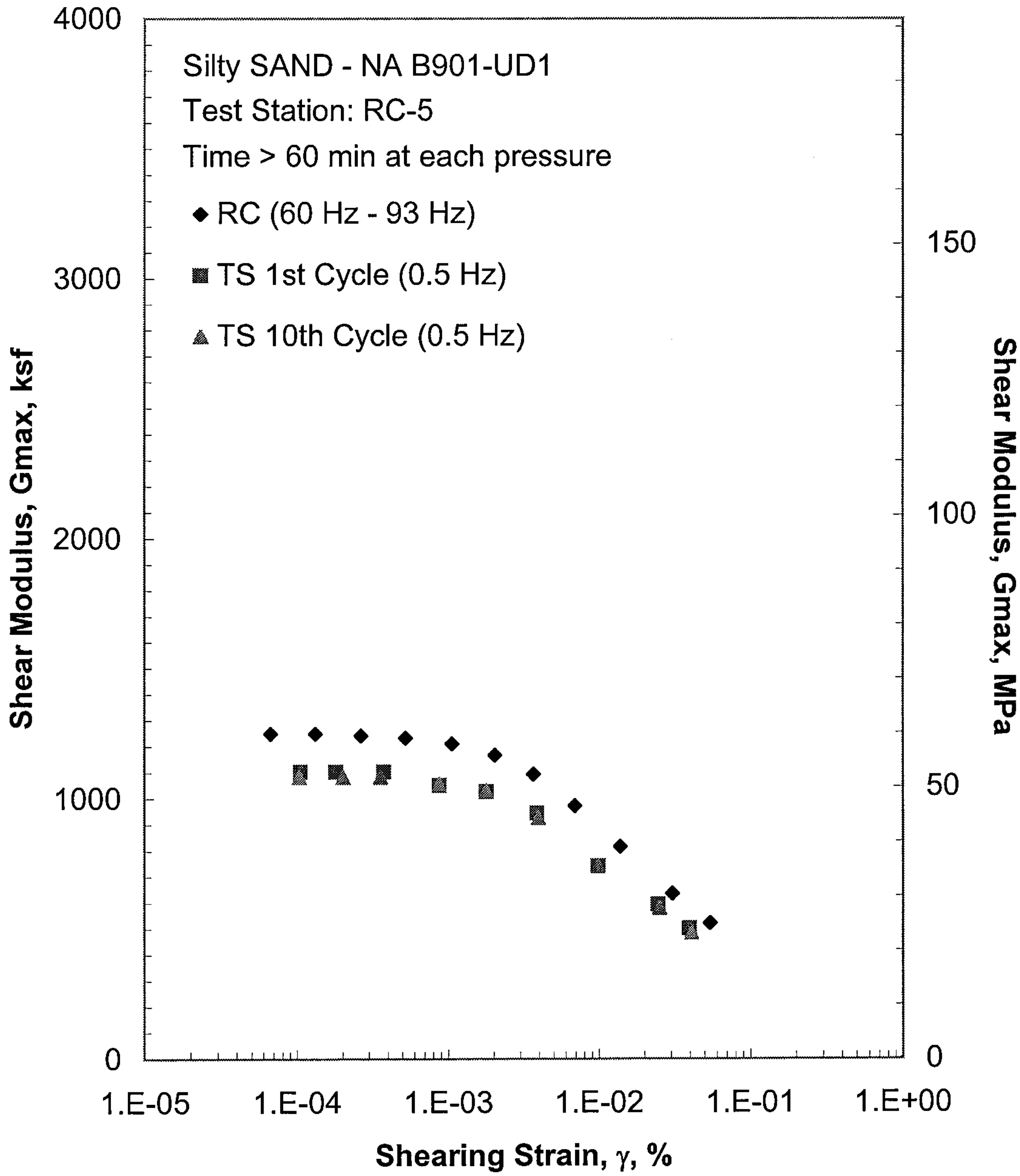


Figure A.11 Comparison of the Variation in Shear Modulus with Shearing Strain at an Isotropic Confining Pressure of 4.3 psi from the Combined RCTS Tests

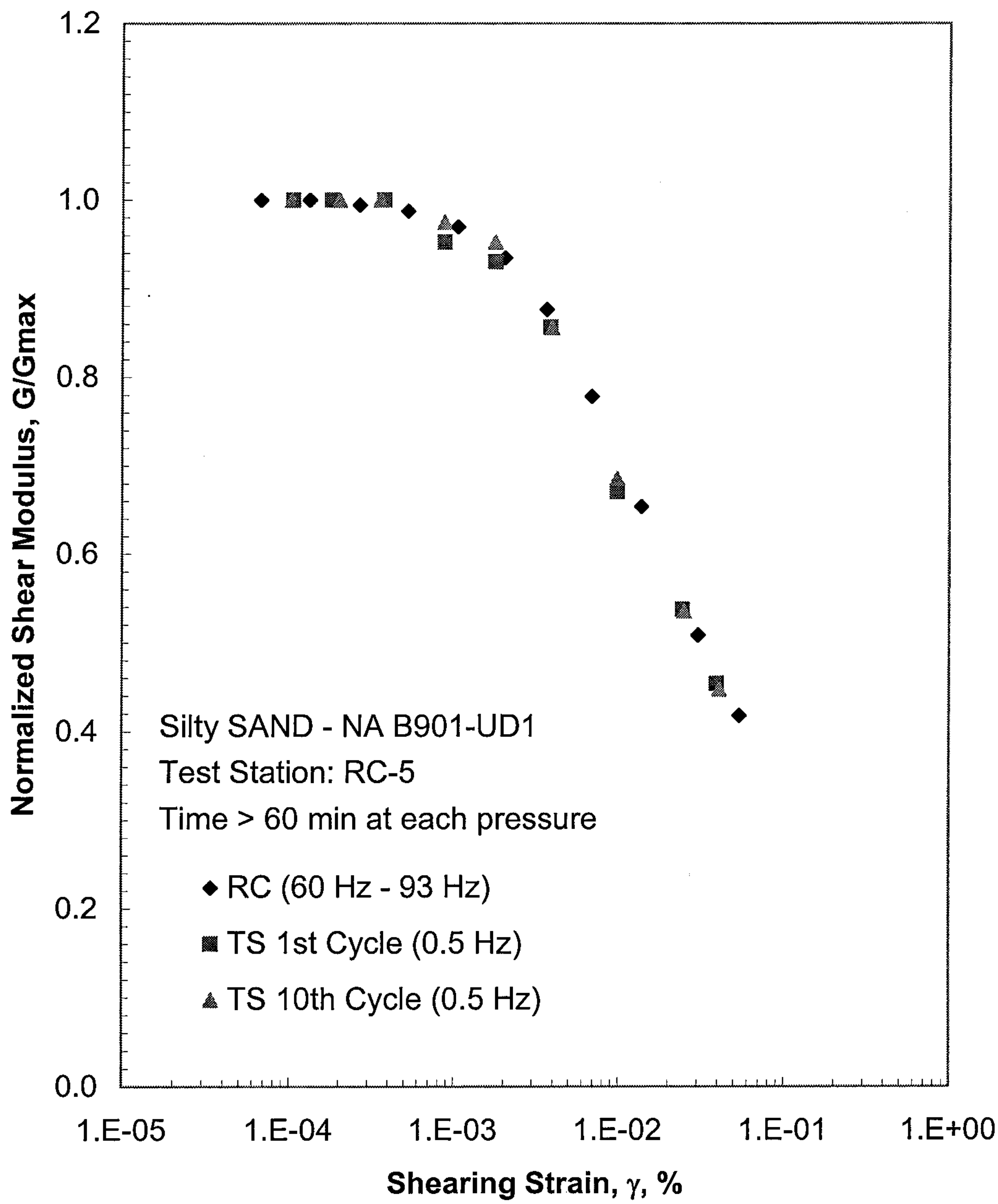


Figure A.12 Comparison of the Variation in Normalized Shear Modulus with Shearing Strain at an Isotropic Confining Pressure of 4.3 psi from the Combined RCTS Tests

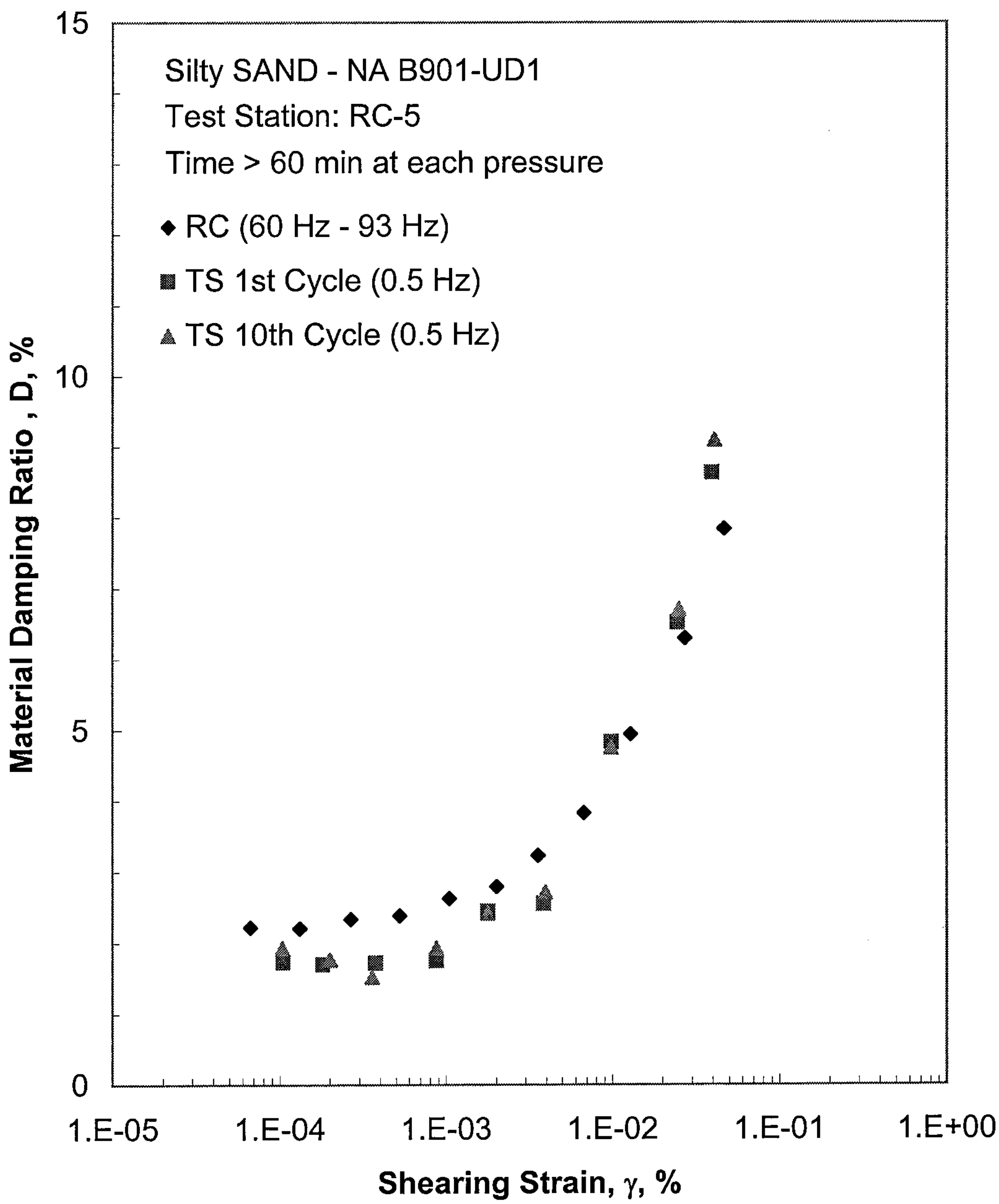


Figure A.13 Comparison of the Variation in Material Damping Ratio with Shearing Strain at an Isotropic Confining Pressure of 4.3 psi from the Combined RCTS Tests

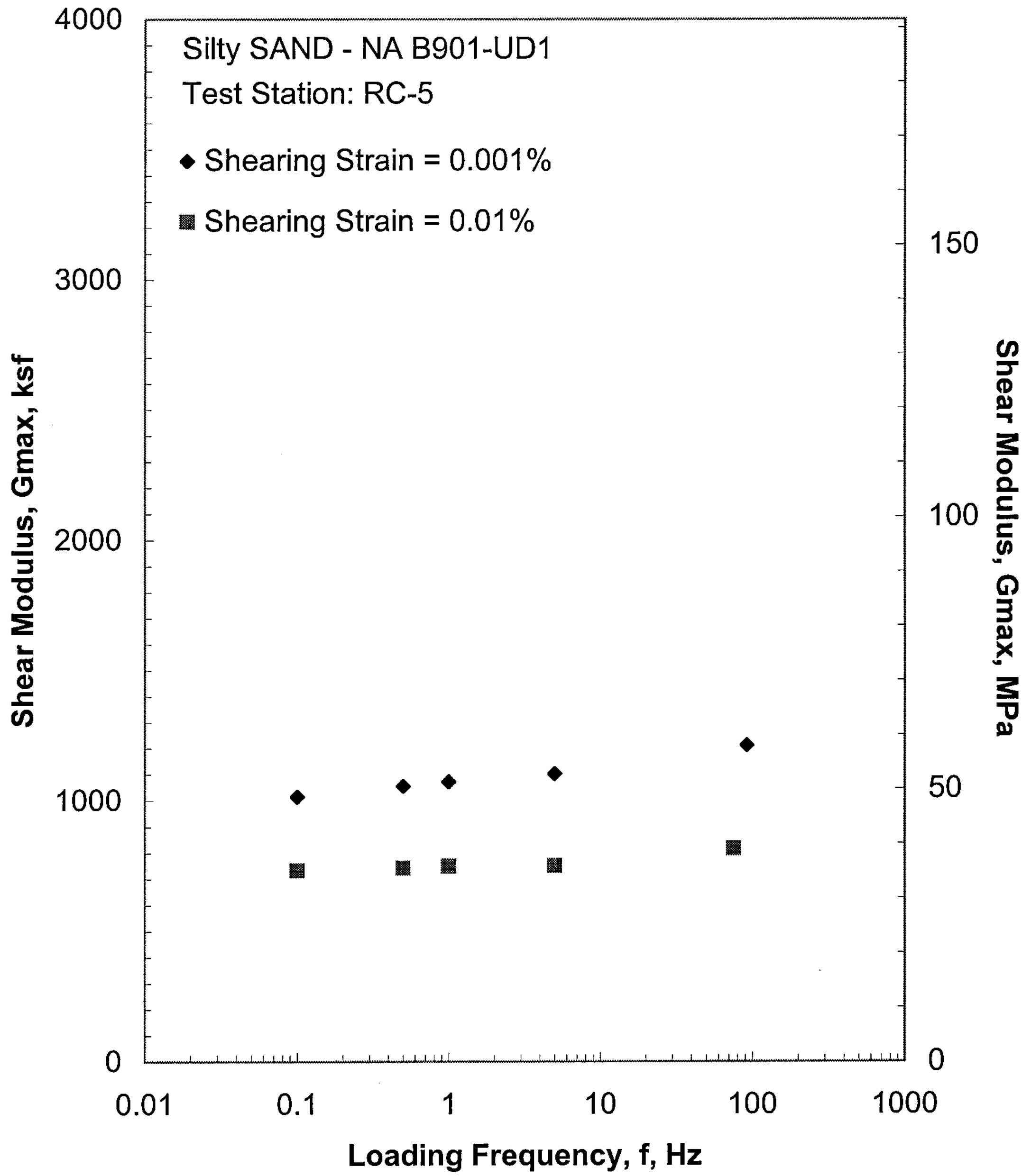


Figure A.14 Comparison of the Variation in Shear Modulus with Loading Frequency at an Isotropic Confining Pressure of 4.3 psi from the Combined RCTS Tests

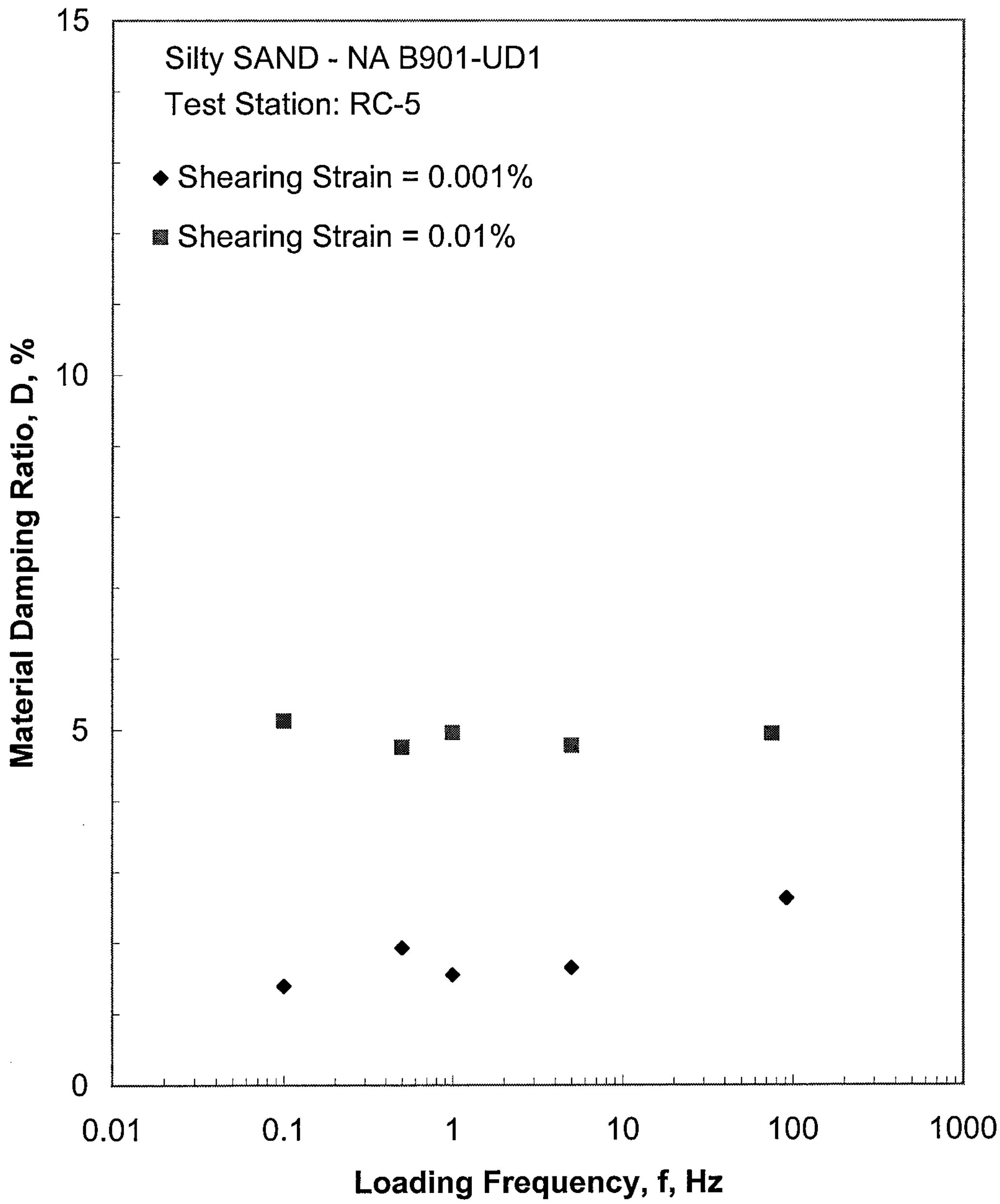


Figure A.15 Comparison of the Variation in Material Damping Ratio with Loading Frequency at an Isotropic Confining Pressure of 4.3 psi from the Combined RCTS Tests

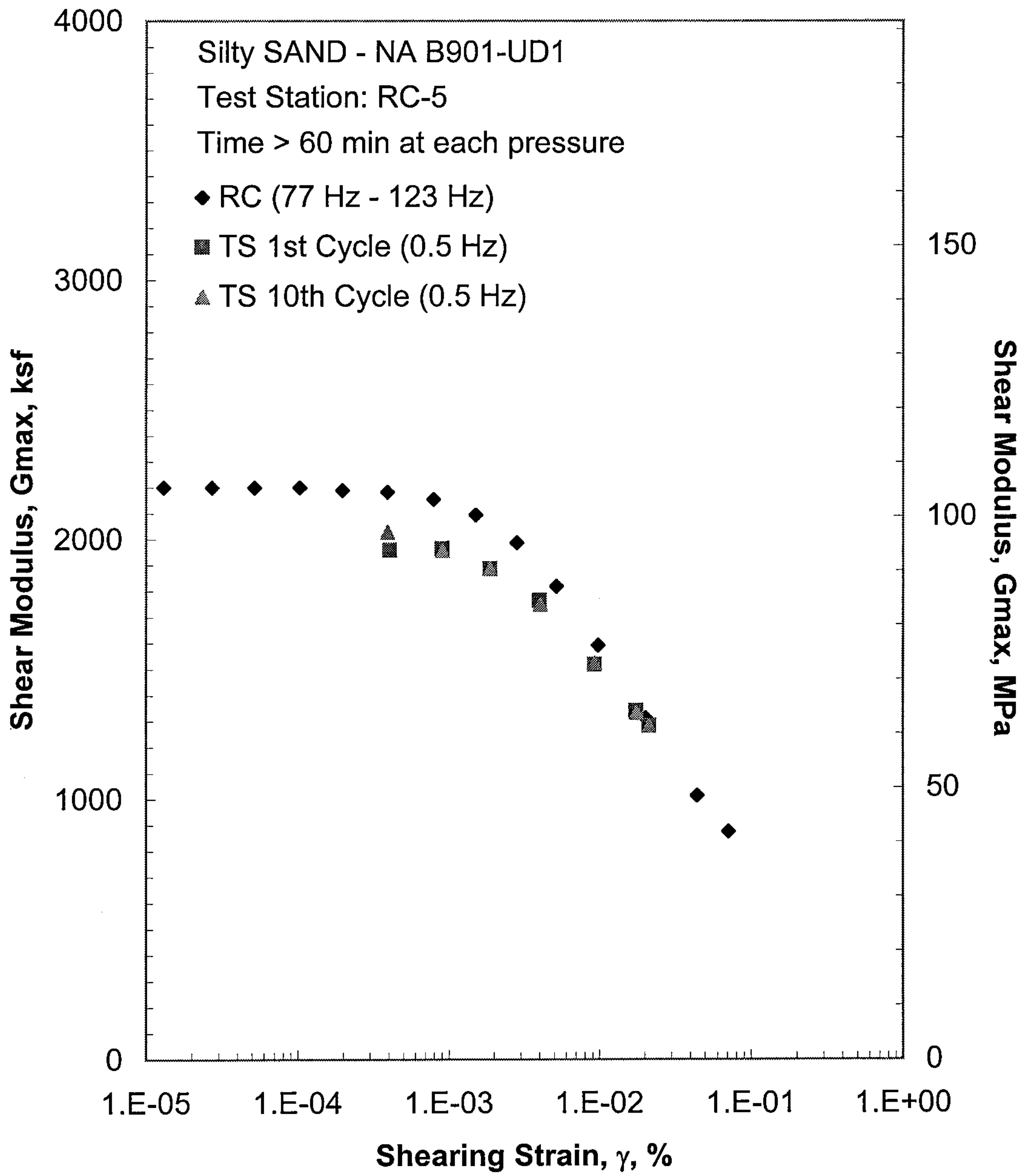


Figure A.16 Comparison of the Variation in Shear Modulus with Shearing Strain at an Isotropic Confining Pressure of 17.4 psi from the Combined RCTS Tests

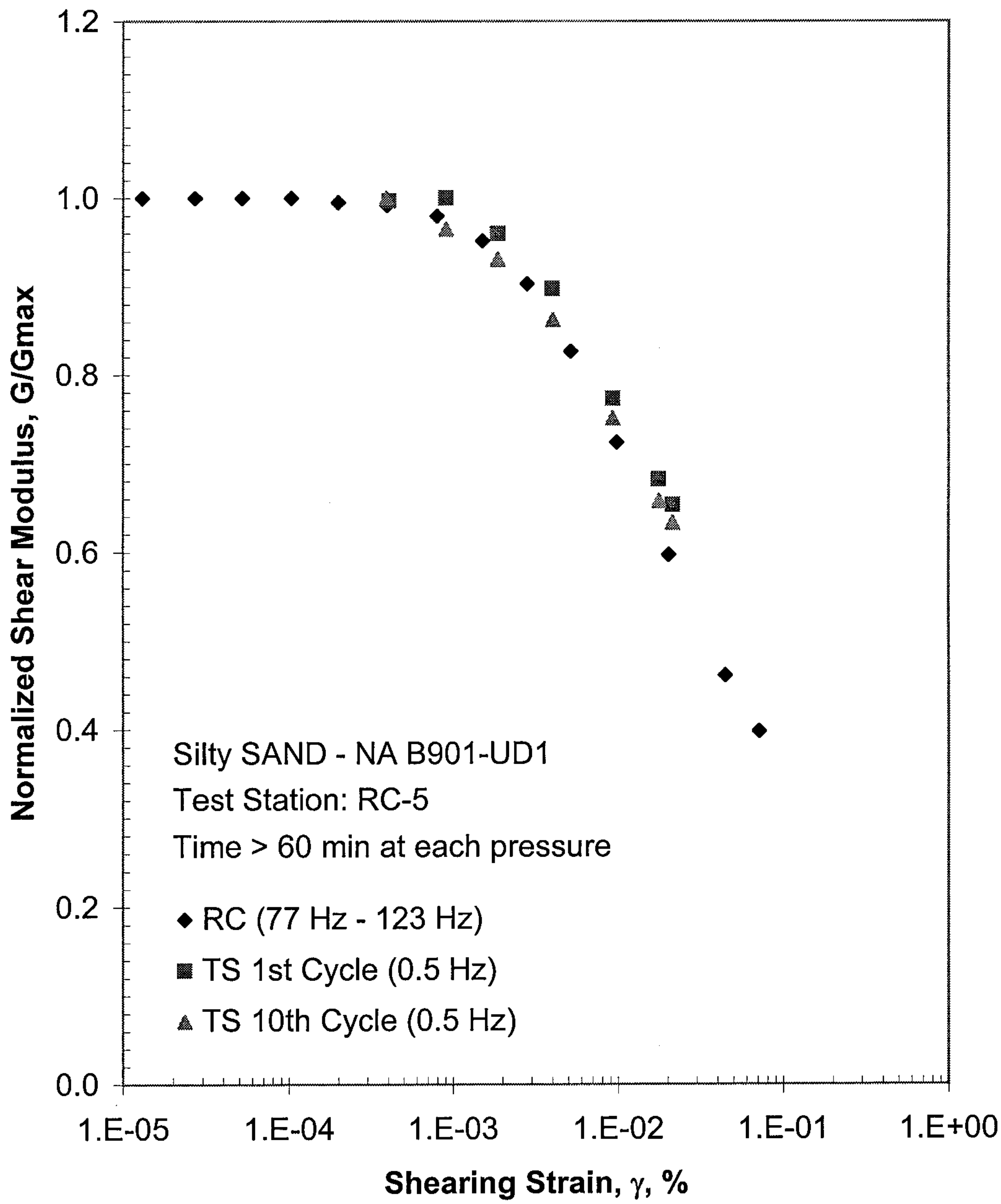


Figure A.17 Comparison of the Variation in Normalized Shear Modulus with Shearing Strain at an Isotropic Confining Pressure of 17.4 psi from the Combined RCTS Tests

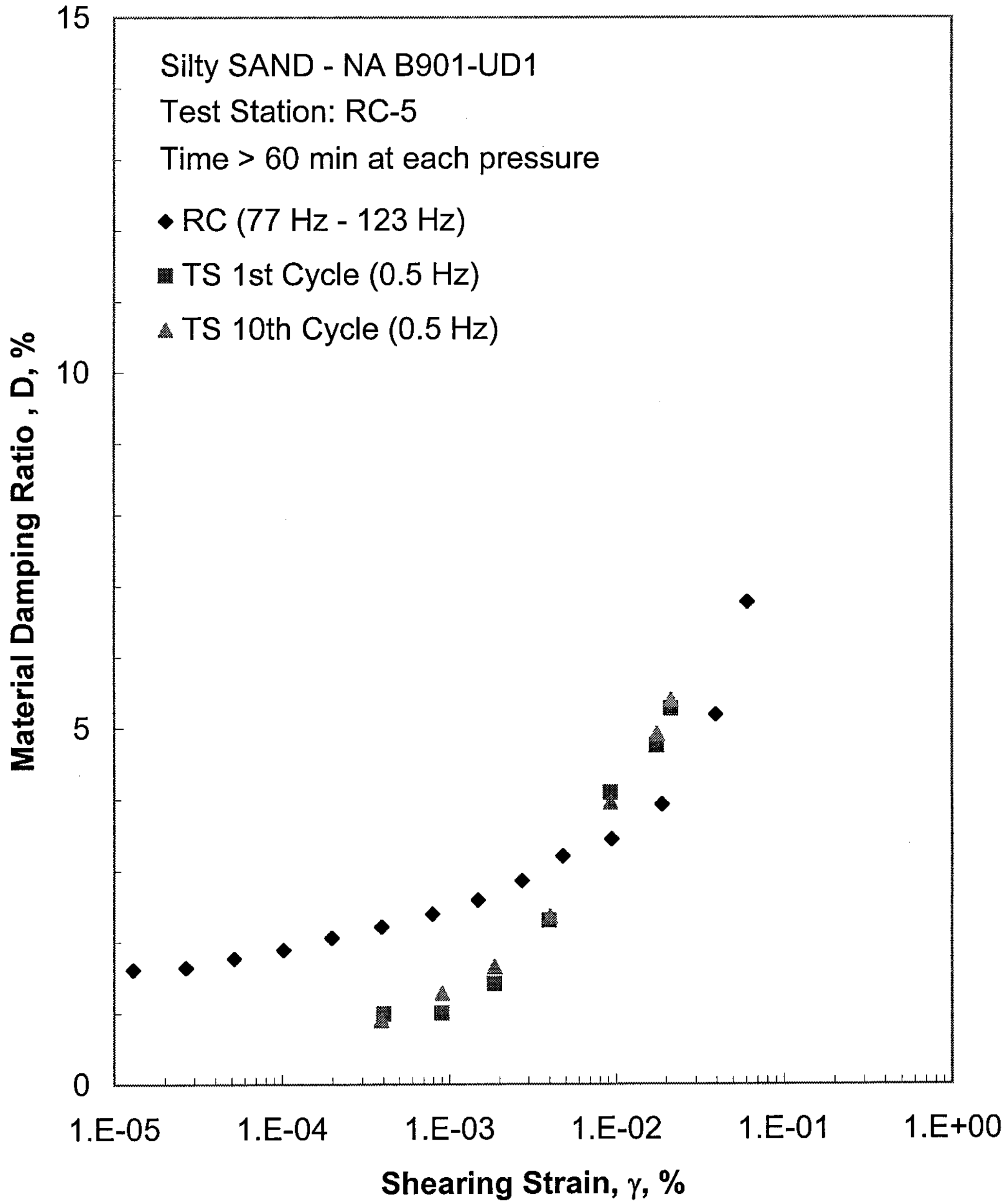


Figure A.18 Comparison of the Variation in Material Damping Ratio with Shearing Strain at an Isotropic Confining Pressure of 17.4 psi from the Combined RCTS Tests

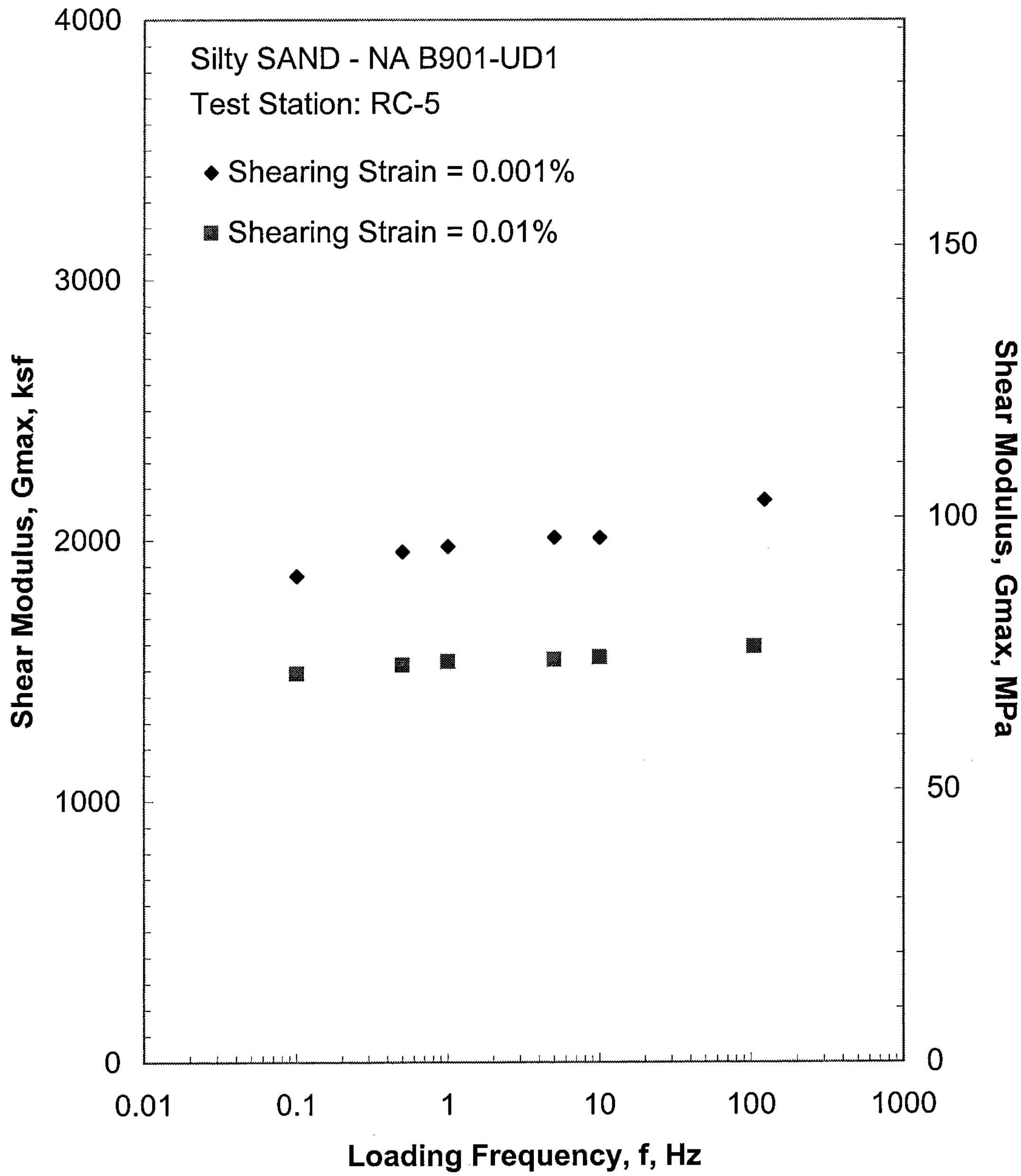


Figure A.19 Comparison of the Variation in Shear Modulus with Loading Frequency at an Isotropic Confining Pressure of 17.4 psi from the Combined RCTS Tests

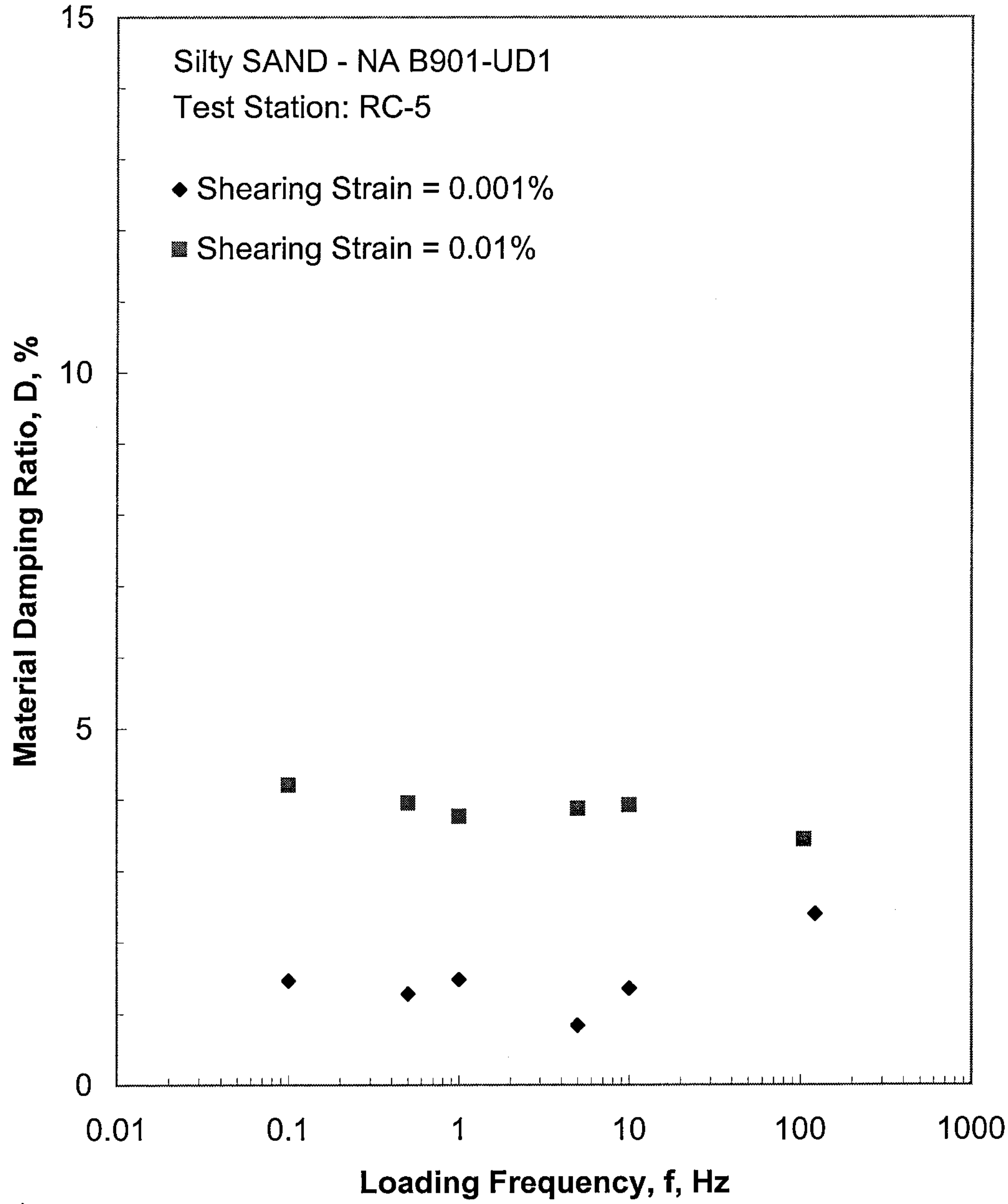


Figure A.20 Comparison of the Variation in Material Damping Ratio with Loading Frequency at an Isotropic Confining Pressure of 17.4 psi from the Combined RCTS Tests

Table A.1 Variation in Low-Amplitude Shear Wave Velocity, Low-Amplitude Shear Modulus, Low-Amplitude Material Damping Ratio and Estimated Void Ratio with Isotropic Confining Pressure from RC Tests of Specimen NA B901-UD1

Isotropic Confining Pressure, σ_o			Low-Amplitude Shear Modulus, G_{max}		Low-Amplitude Shear Wave Velocity, Vs	Low-Amplitude Material Damping Ratio, Dmin	Estimated Void Ratio, e
(psi)	(psf)	(kPa)	(ksf)	(MPa)	(fps)	(%)	
1.1	158	8	919	44	495	2.45	0.616
2.2	317	15	990	48	514	2.44	0.615
4.3	619	30	1226	59	571	2.14	0.612
8.7	1253	60	1574	76	646	1.92	0.605
17.4	2506	120	2140	103	750	1.63	0.594

Table A.2 Variation in Shear Modulus and Material Damping Ratio with Shearing Strain from RC Tests of Specimen NA B901-UD1; Isoptropic Confining Pressure, σ_o= 4.3 psi (0.6 ksf = 30 kPa)

Peak Shearing Strain, %	Shear Modulus, G, ksf	Normalized Shear Modulus, G/G_{max}	Average+ Shearing Strain, %	Material Damping Ratio^x, D, %
6.70E-05	1248	1.00	6.70E-05	2.22
1.32E-04	1248	1.00	1.32E-04	2.21
2.66E-04	1242	0.99	2.66E-04	2.34
5.24E-04	1233	0.99	5.24E-04	2.39
1.06E-03	1211	0.97	1.05E-03	2.63
2.03E-03	1167	0.93	2.01E-03	2.79
3.66E-03	1094	0.88	3.57E-03	3.23
6.90E-03	972	0.78	6.74E-03	3.83
1.38E-02	816	0.65	1.29E-02	4.94
3.05E-02	635	0.51	2.73E-02	6.29
5.42E-02	522	0.42	4.67E-02	7.84

+ 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 A.3 Variation in Shear Modulus, Normalized Shear Modulus and Material Damping Ratio with Shearing Strain from TS Tests of Specimen NA B901-UD1; Isotropic Confining Pressure, σ_o = 4.3 psi (0.6 ksf = 30 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	1103	1.00	1.73	1.03E-04	1083	1.00	1.93
1.81E-04	1103	1.00	1.70	2.01E-04	1083	1.00	1.77
3.76E-04	1103	1.00	1.72	3.58E-04	1083	1.00	1.52
8.76E-04	1050	0.95	1.75	8.74E-04	1056	0.97	1.93
1.79E-03	1026	0.93	2.44	1.78E-03	1031	0.95	2.42
3.87E-03	945	0.86	2.55	3.94E-03	927	0.86	2.71
9.86E-03	740	0.67	4.83	9.82E-03	743	0.69	4.75
2.46E-02	593	0.54	6.51	2.51E-02	580	0.54	6.70
3.96E-02	501	0.45	8.63	4.09E-02	485	0.45	9.10

Table A.4 Variation in Shear Modulus and Material Damping Ratio with Shearing Strain from RC Tests of Specimen NA B901-UD1; Isoptropic Confining Pressure, σ_o= 17.4 psi (2.5 ksf = 120 kPa)

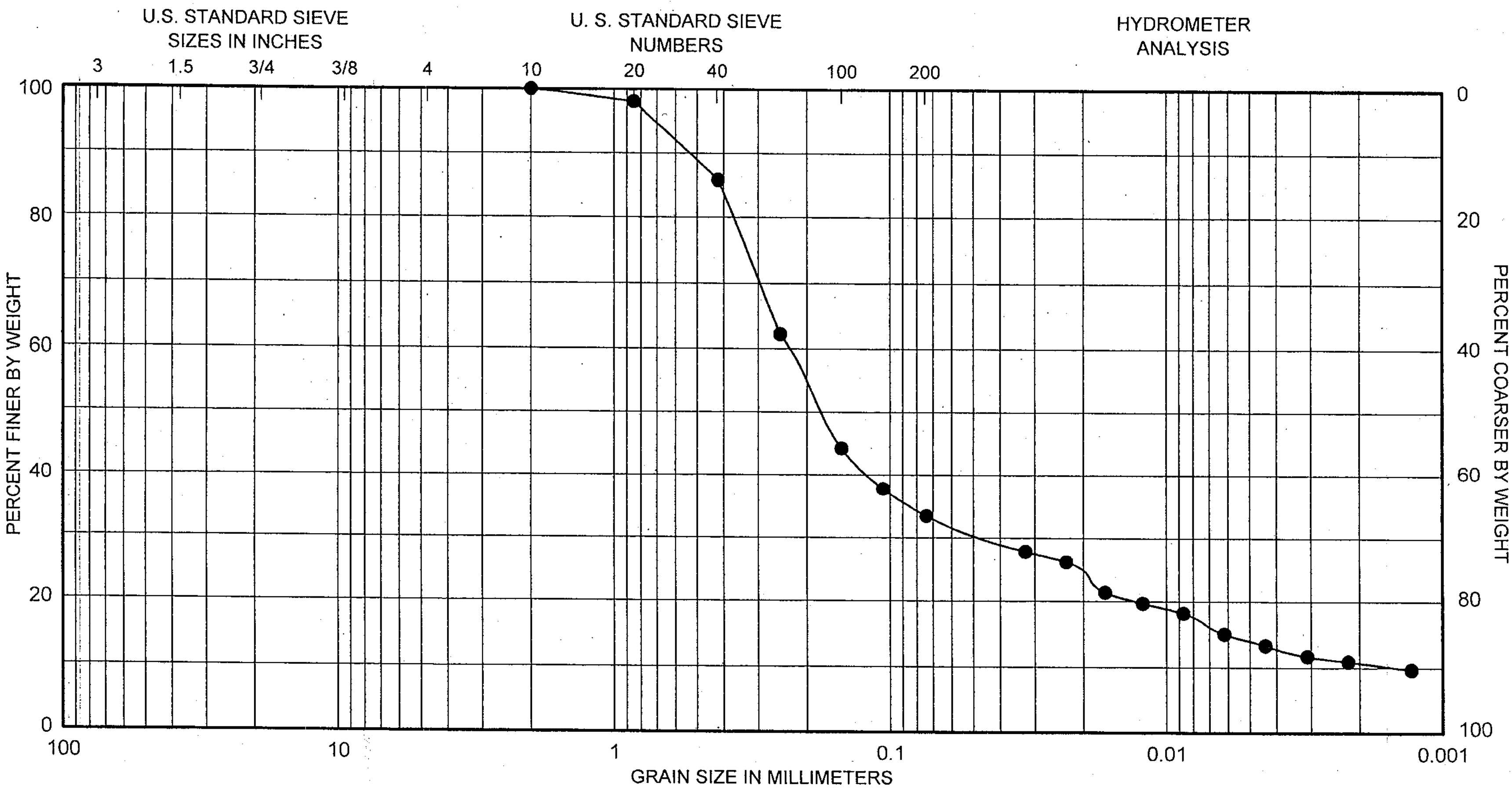
Peak Shearing Strain, %	Shear Modulus, G, ksf	Normalized Shear Modulus, G/G_{max}	Average^{+} Shearing Strain, %	Material Damping Ratio^{x}, D, %
1.30E-05	2200	1.00	1.30E-05	1.61
2.70E-05	2200	1.00	2.70E-05	1.64
5.20E-05	2200	1.00	5.20E-05	1.77
1.03E-04	2200	1.00	1.03E-04	1.89
1.98E-04	2189	1.00	1.98E-04	2.06
3.92E-04	2183	0.99	3.92E-04	2.21
7.93E-04	2155	0.98	7.93E-04	2.40
1.51E-03	2094	0.95	1.49E-03	2.59
2.81E-03	1987	0.90	2.74E-03	2.86
5.17E-03	1819	0.83	4.81E-03	3.20
9.78E-03	1592	0.72	9.42E-03	3.44
2.03E-02	1313	0.60	1.89E-02	3.93
4.44E-02	1015	0.46	3.96E-02	5.18
7.14E-02	875	0.40	6.10E-02	6.77

$^{+}$ 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 A.5 Variation in Shear Modulus, Normalized Shear Modulus and Material Damping Ratio with Shearing Strain from TS Tests of Specimen NA B901-UD1; Isotropic Confining Pressure, σ_o=17.40 psi (2.5 ksf = 120 kPa)

First Cycle				Tenth Cycle			
Peak Shearing Strain, %	Shear Modulus, G, ksf	Normalized Shear Modulus,	Material Damping Ratio, D,	Peak Shearing Strain, %	Shear Modulus, G, ksf	Normalized Shear Modulus,	Material Damping Ratio, D, %
4.04E-04	1959	1.00	0.99	3.91E-04	2028	1.00	0.90
9.01E-04	1965	1.00	1.00	9.05E-04	1956	0.96	1.28
1.87E-03	1886	0.96	1.41	1.87E-03	1887	0.93	1.65
3.99E-03	1764	0.90	2.30	4.03E-03	1749	0.86	2.36
9.28E-03	1519	0.77	4.09	9.26E-03	1523	0.75	3.95
1.75E-02	1340	0.68	4.75	1.76E-02	1333	0.66	4.92
2.14E-02	1283	0.65	5.27	2.14E-02	1283	0.63	5.39



GRAVEL		SAND			SILT or CLAY
Coarse	Fine	Coarse	Medium	Fine	

SYMBOL	BORING	DEPTH, FT	C_c	C_u	D_{50}	D_{90}	CLASSIFICATION
●	B-901-UD1	9.5	5.73	158.30	0.1766	0.53	Silty Fine Sand, tan

GRAIN SIZE CURVE

TEST METHOD ASTM D422-63 (2002)

APPENDIX B

Specimen NA B911A-UD1

Borehole B911A
Sample UD1
Depth = 11.7 ft (3.6 m)
Total Unit Weight = 121.9 lb/ft^3
Water Content = 16.6 %
Estimated In-Situ Ko = 0.5
Estimated In-Situ Mean Effective
Stress = 5.6 psi

FUGRO JOB #: 0401-1662
Testing Station: RC5

NOTE: Visual classification, if not specifically stated otherwise, was practiced in determining the soil types.

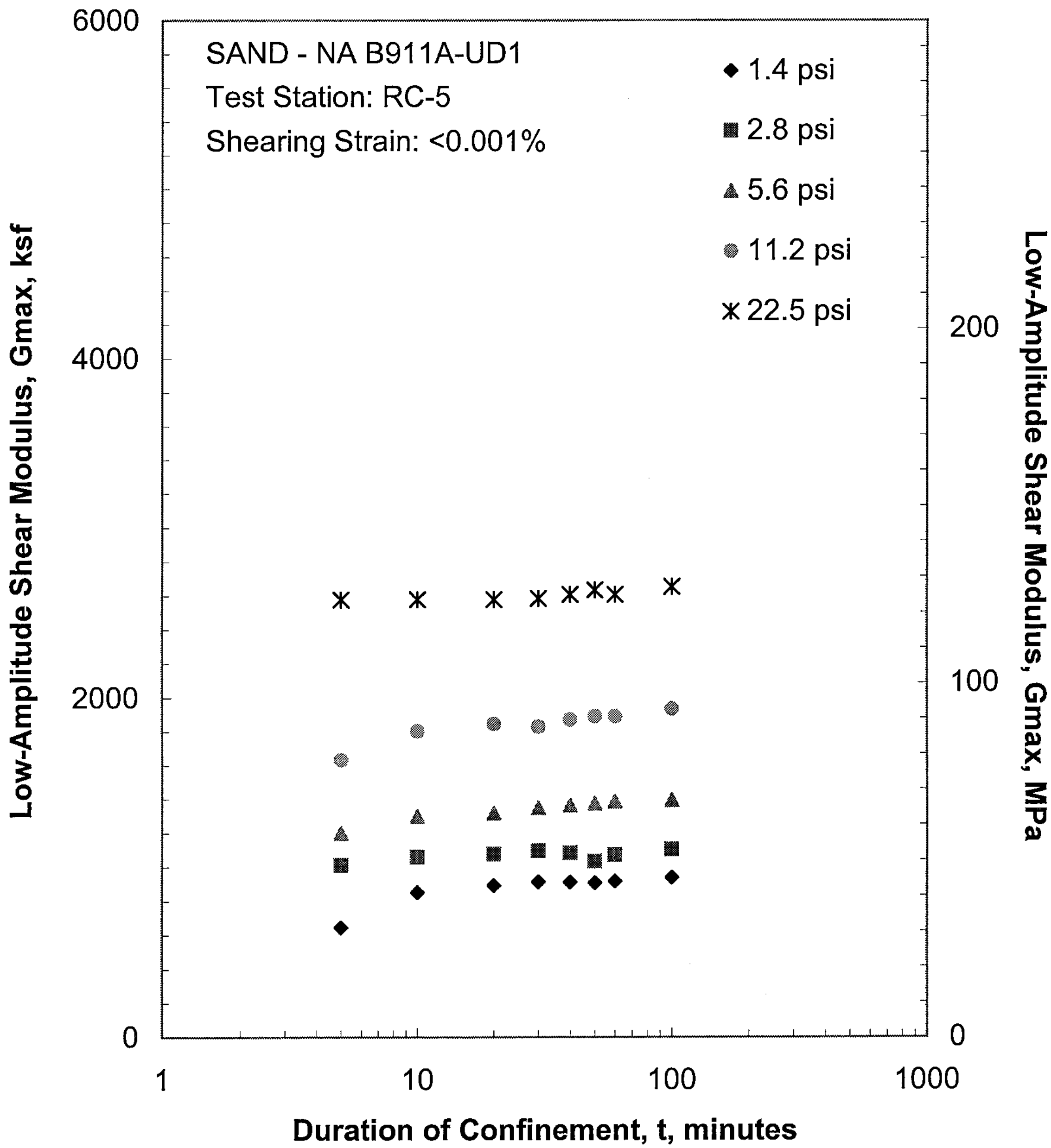


Figure B.1 Variation in Low-Amplitude Shear Modulus with Magnitude and Duration of Isotropic Confining Pressure from Resonant Column Tests

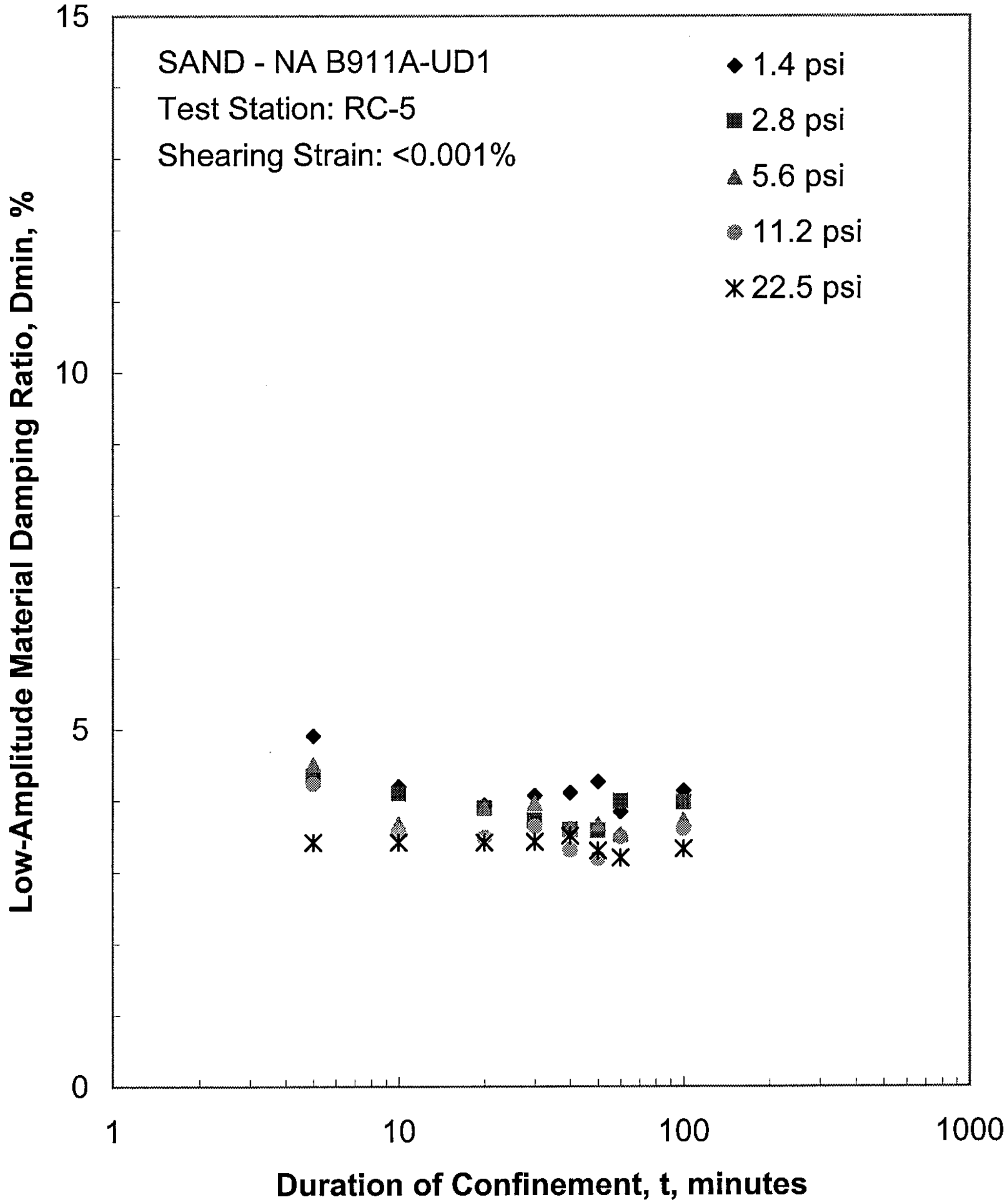


Figure B.2 Variation in Low-Amplitude Material Damping Ratio with Magnitude and Duration of Isotropic Confining Pressure from Resonant Column Tests

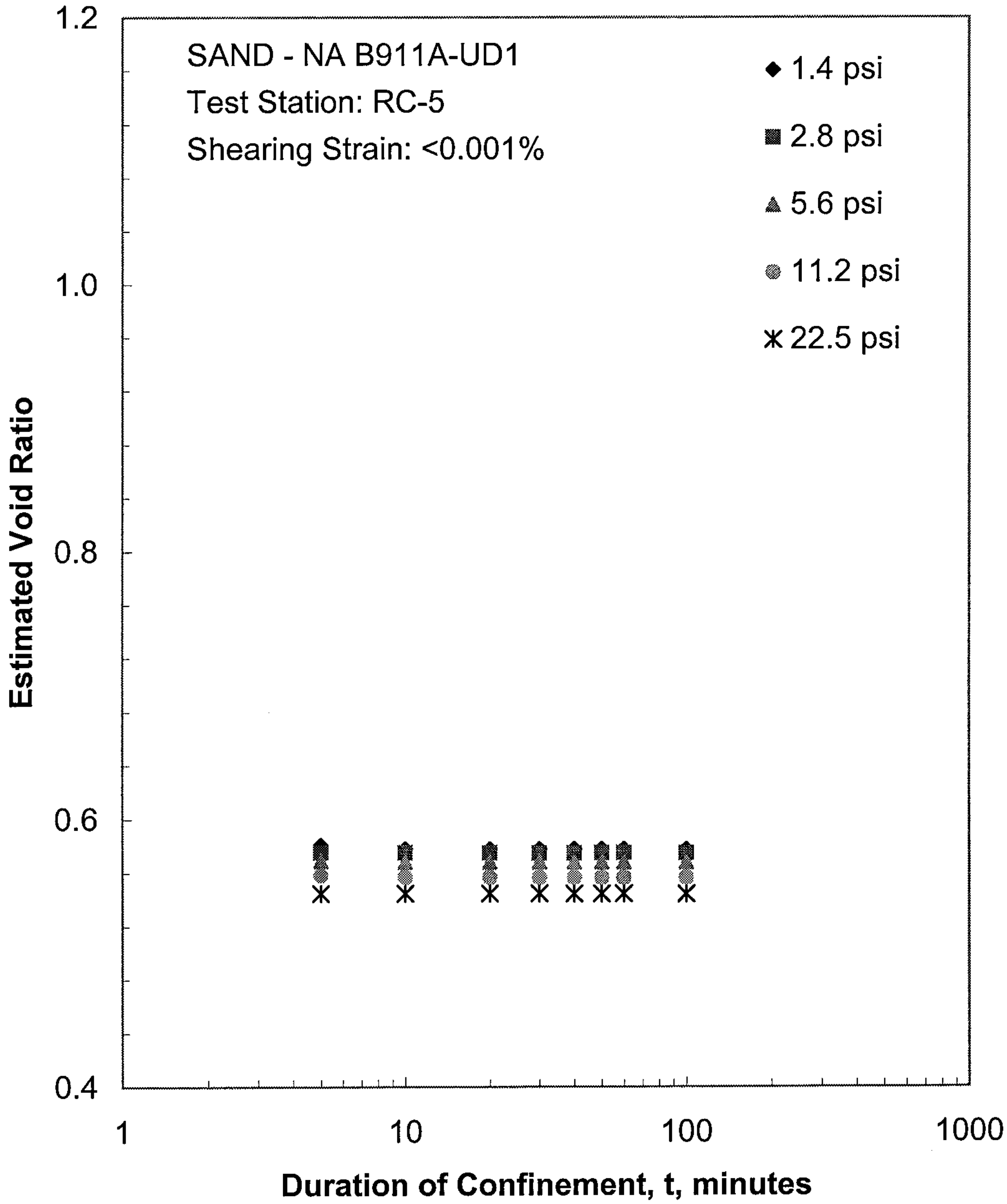


Figure B.3 Variation in Estimated Void Ratio with Magnitude and Duration of Isotropic Confining Pressure from Resonant Column Tests

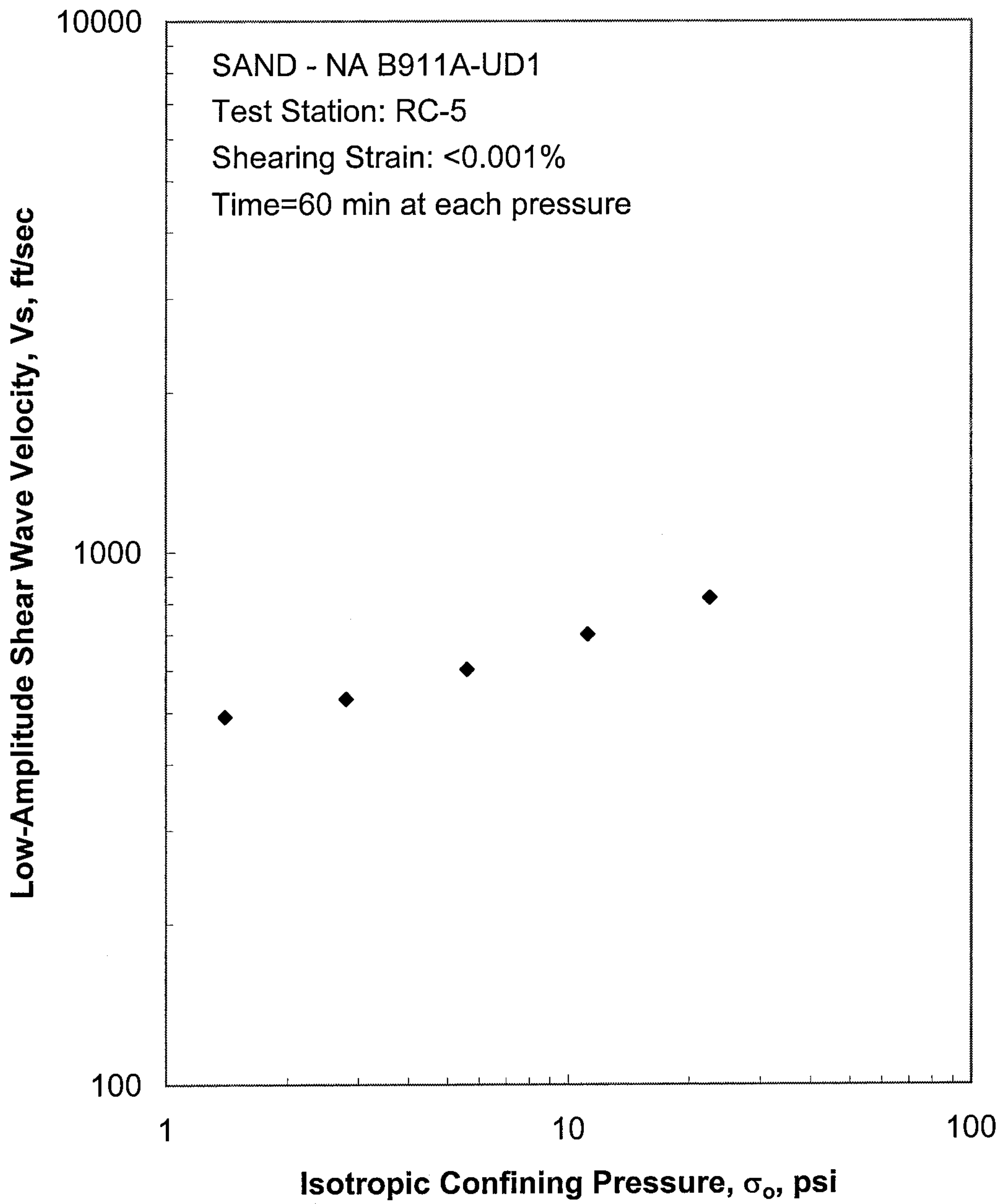


Figure B.4 Variation in Low-Amplitude Shear Wave Velocity with Isotropic Confining Pressure from Resonant Column Tests

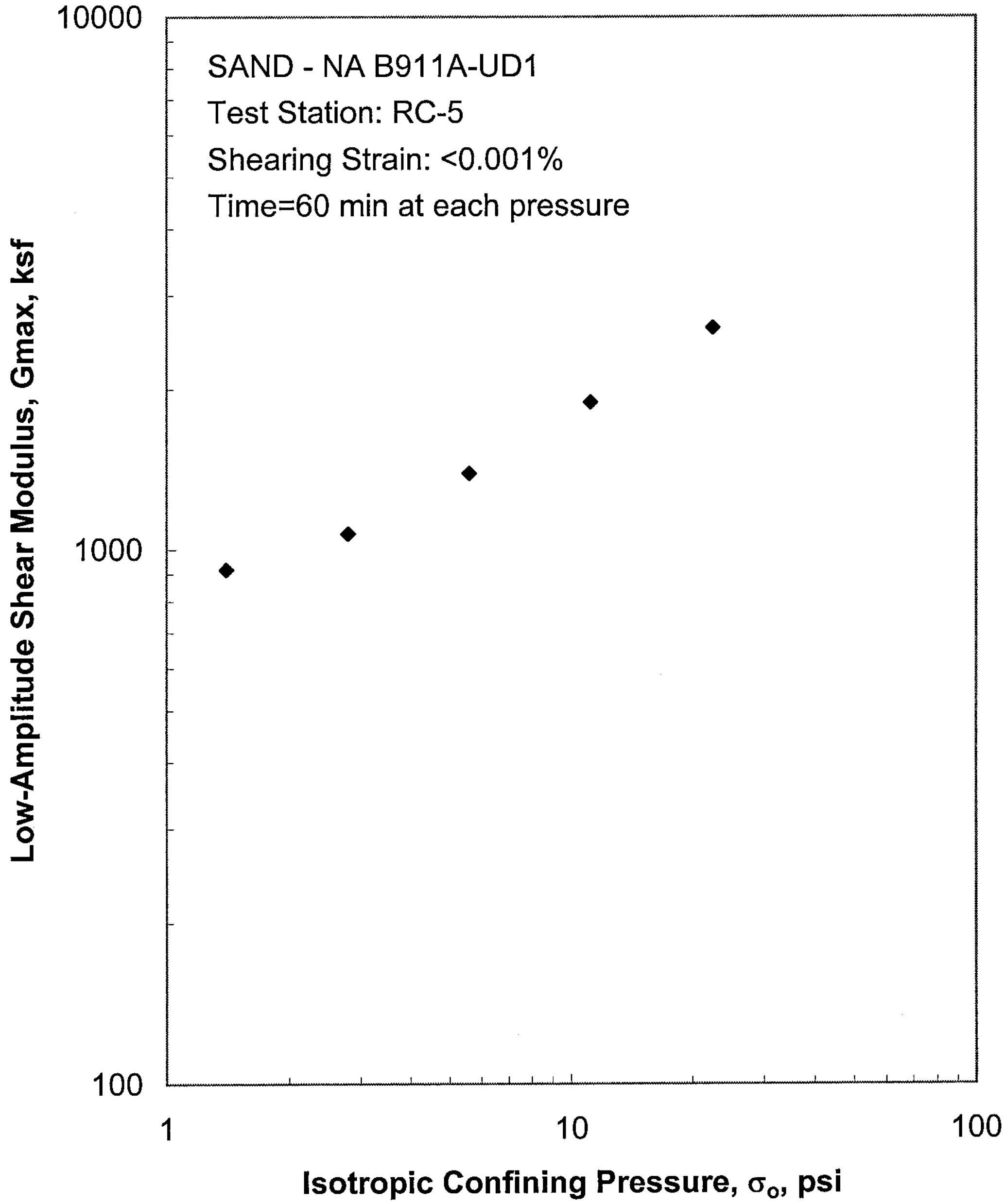


Figure B.5 Variation in Low-Amplitude Shear Modulus with Isotropic Confining Pressure from Resonant Column Tests

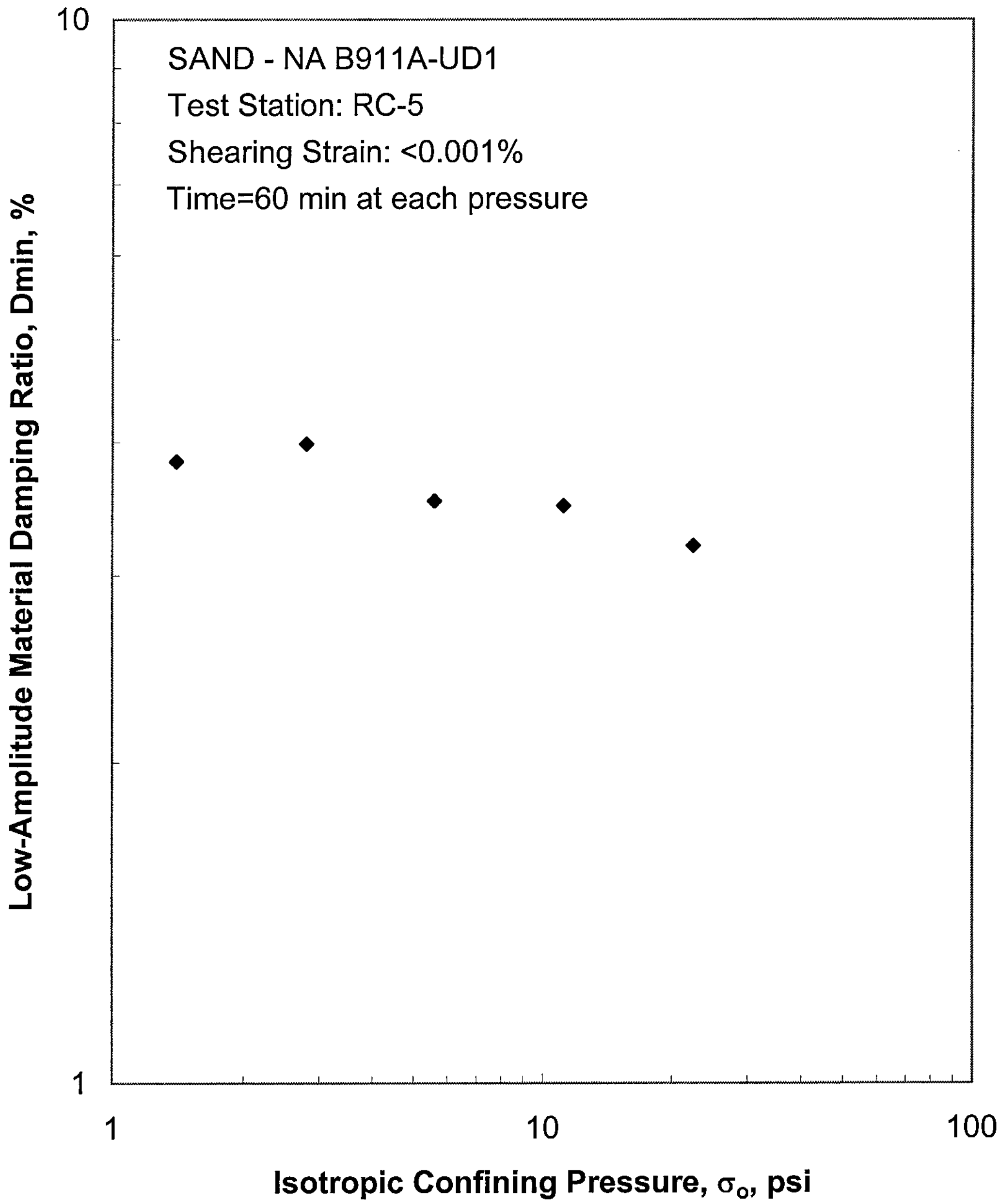


Figure B.6 Variation in Low-Amplitude Material Damping Ratio with Isotropic Confining Pressure from Resonant Column Tests

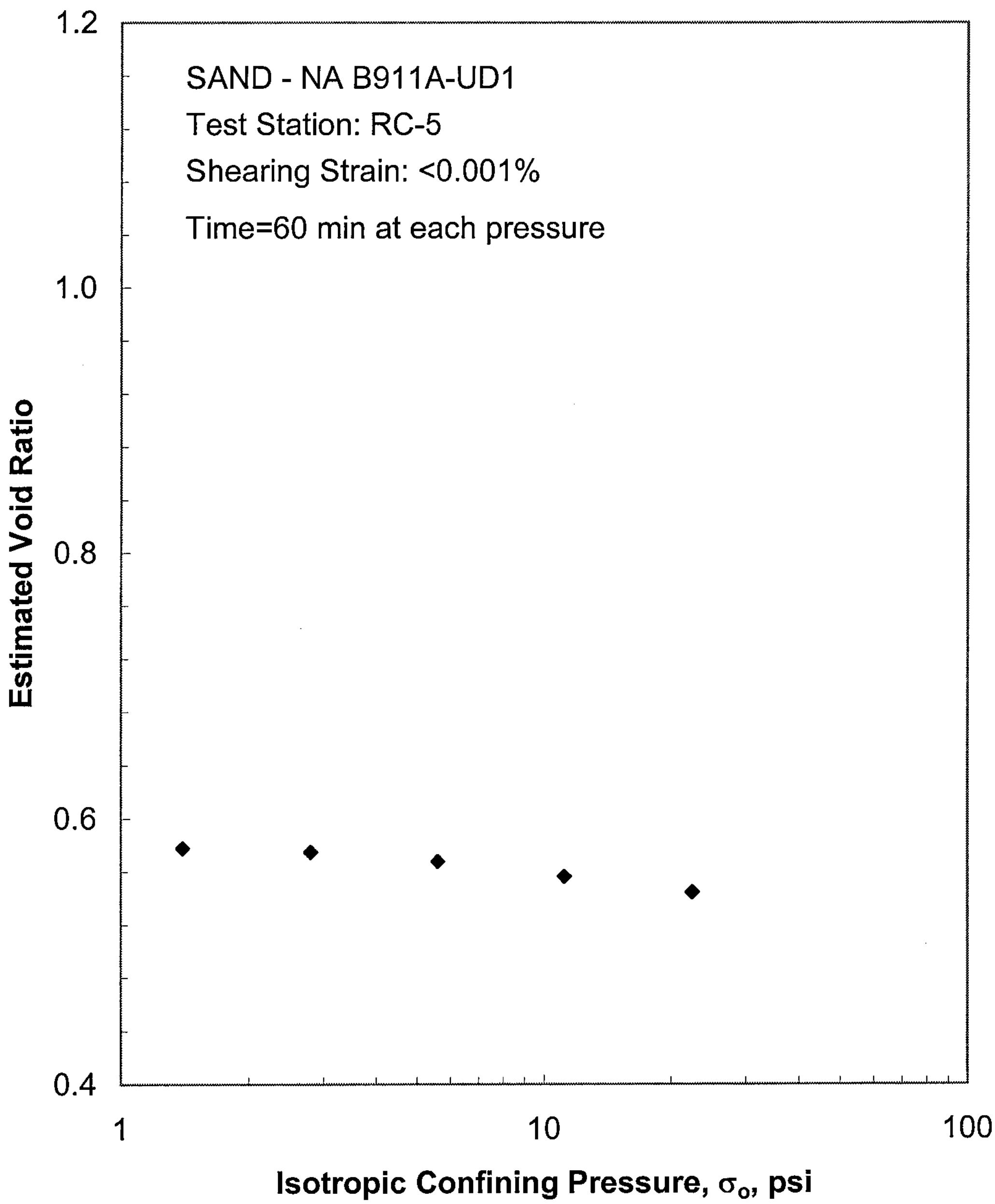


Figure B.7 Variation in Estimated Void Ratio with Isotropic Confining Pressure from Resonant Column Tests

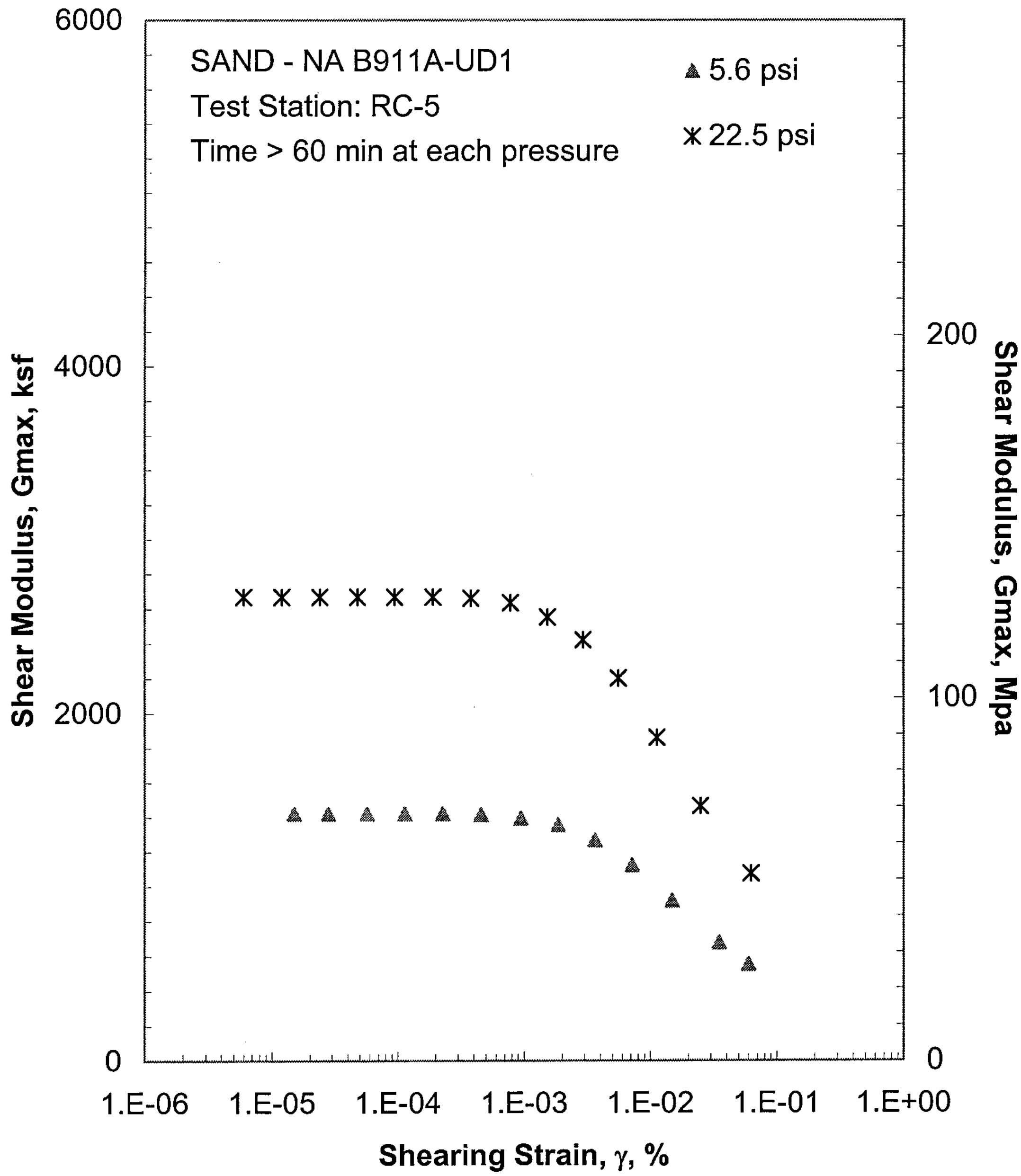


Figure B.8 Comparison of the Variation in Shear Modulus with Shearing Strain and Isotropic Confining Pressure from the Resonant Column Tests

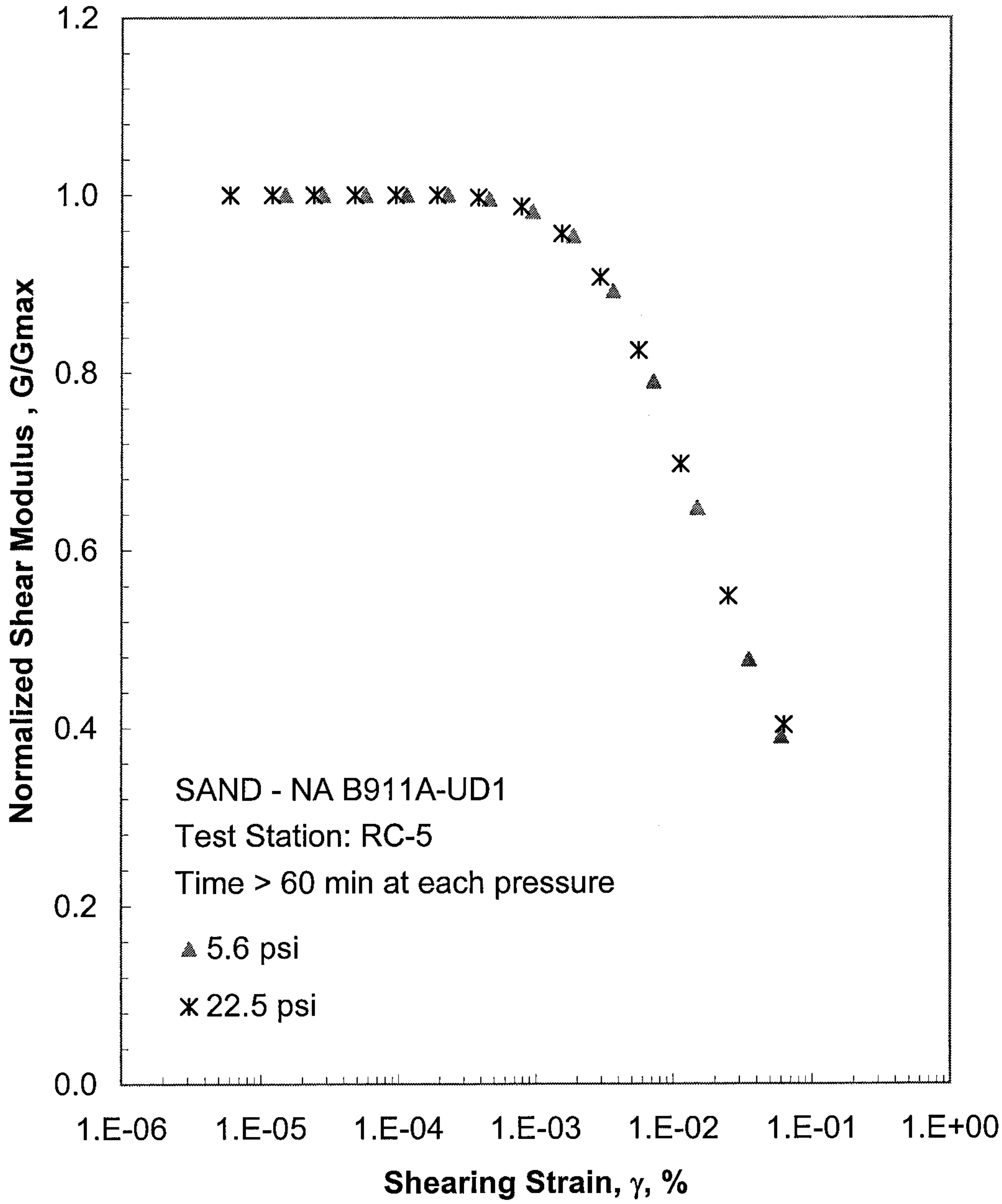


Figure B.9 Comparison of the Variation in Normalized Shear Modulus with Shearing Strain and Isotropic Confining Pressure from the Resonant Column Tests

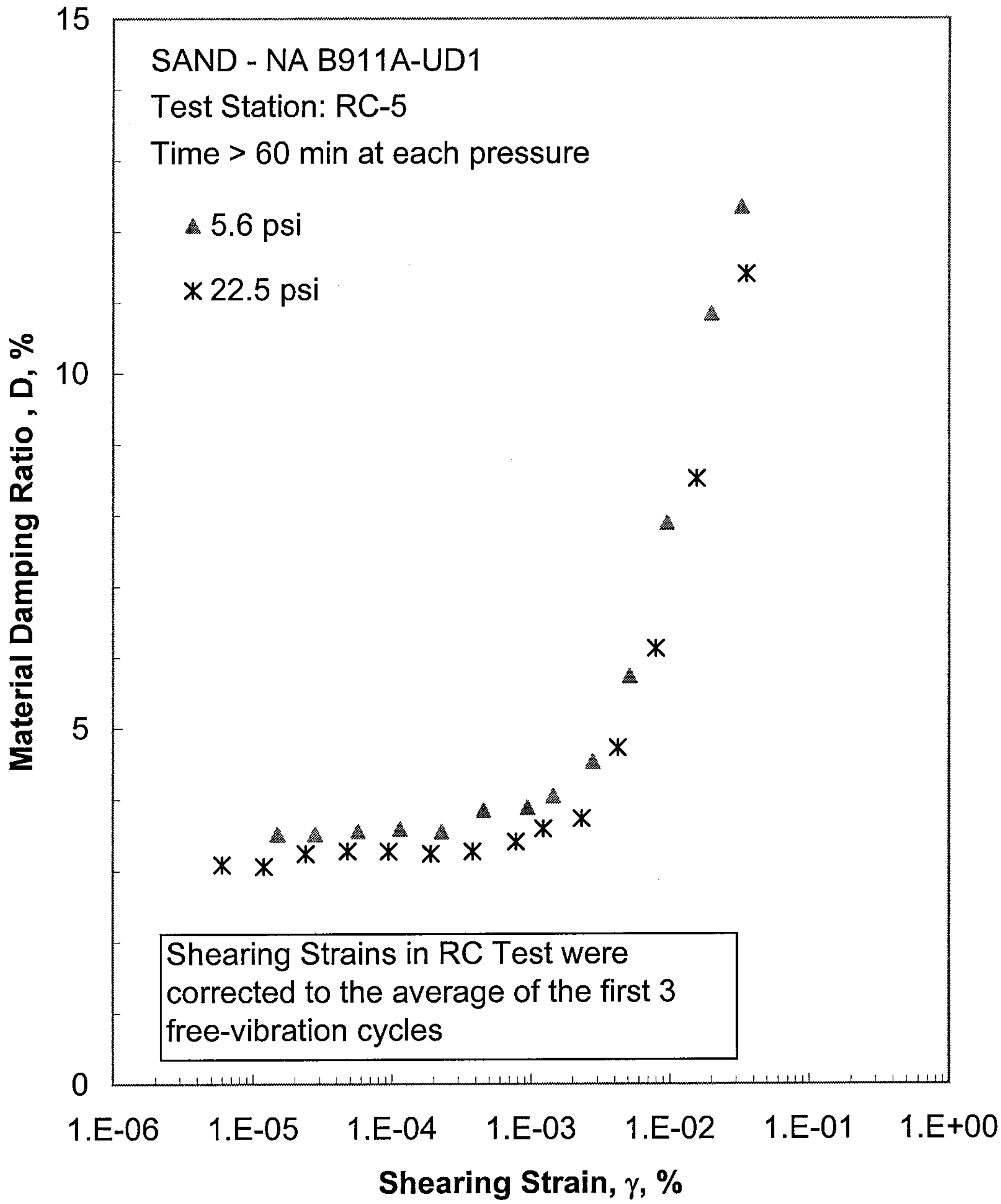


Figure B.10 Comparison of the Variation in Material Damping Ratio with Shearing Strain and Isotropic Confining Pressure from the Resonant Column Tests

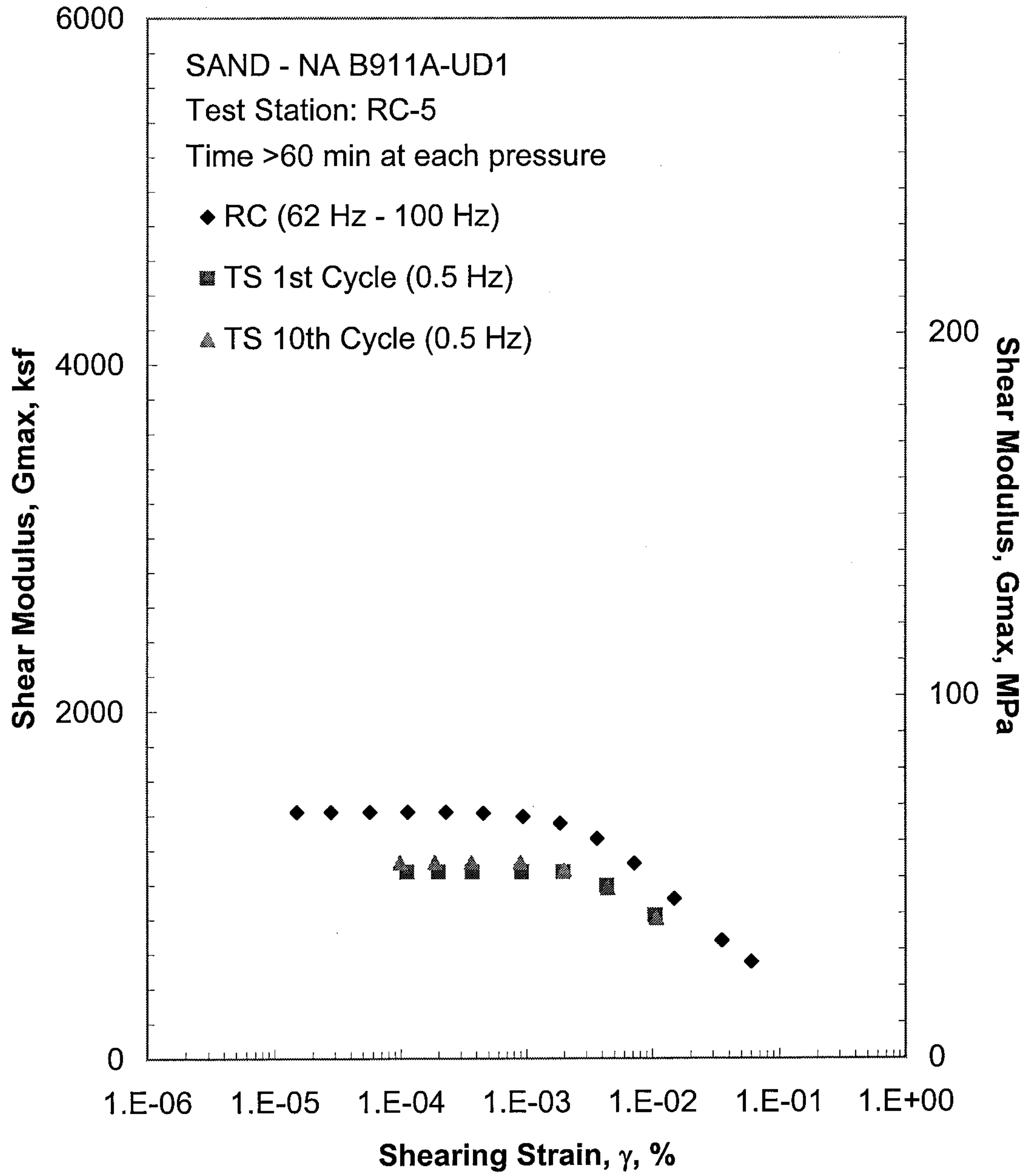


Figure B.11 Comparison of the Variation in Shear Modulus with Shearing Strain at an Isotropic Confining Pressure of 5.6 psi from the Combined RCTS Tests

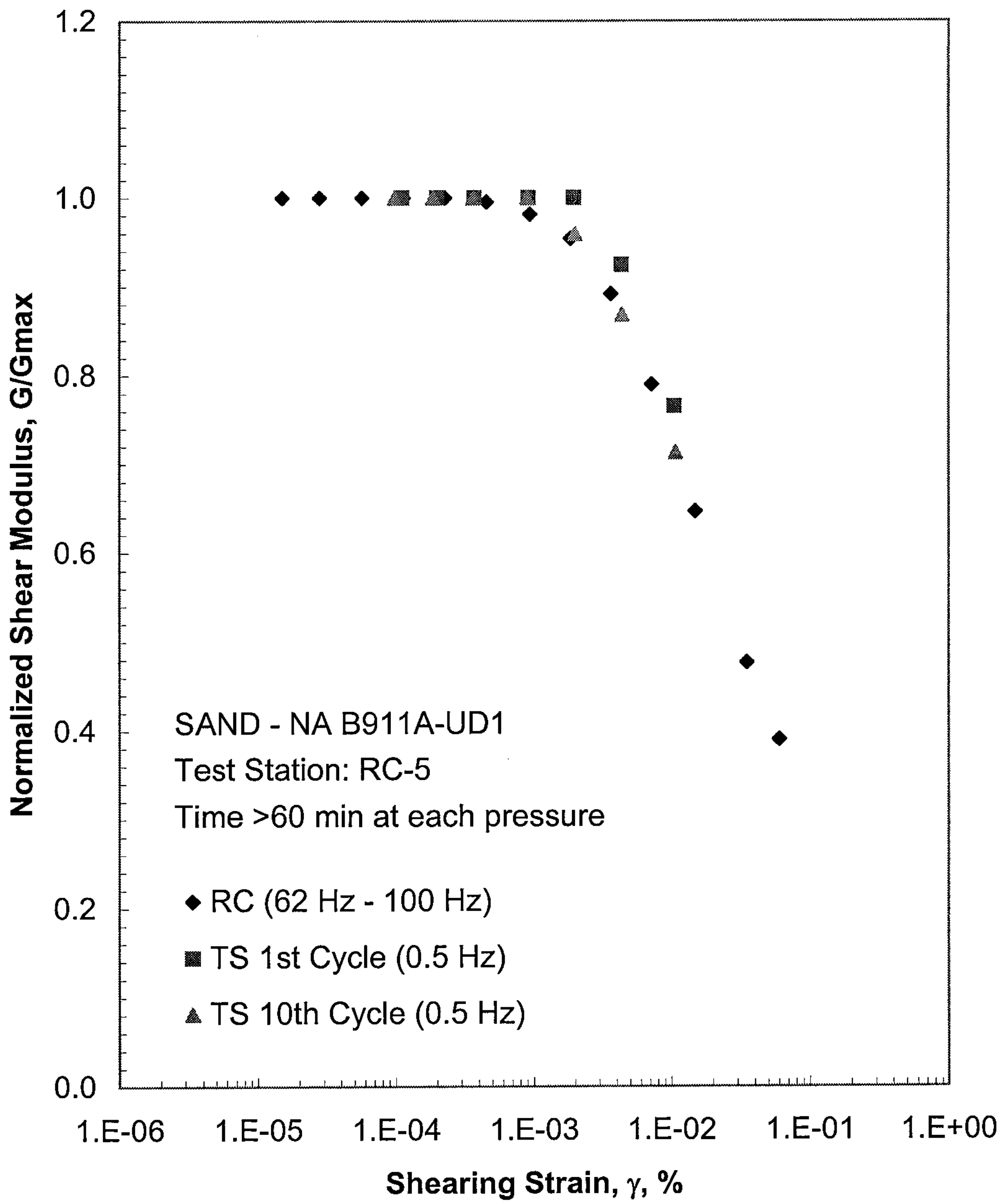


Figure B.12 Comparison of the Variation in Normalized Shear Modulus with Shearing Strain at an Isotropic Confining Pressure of 5.6 psi from the Combined RCTS Tests

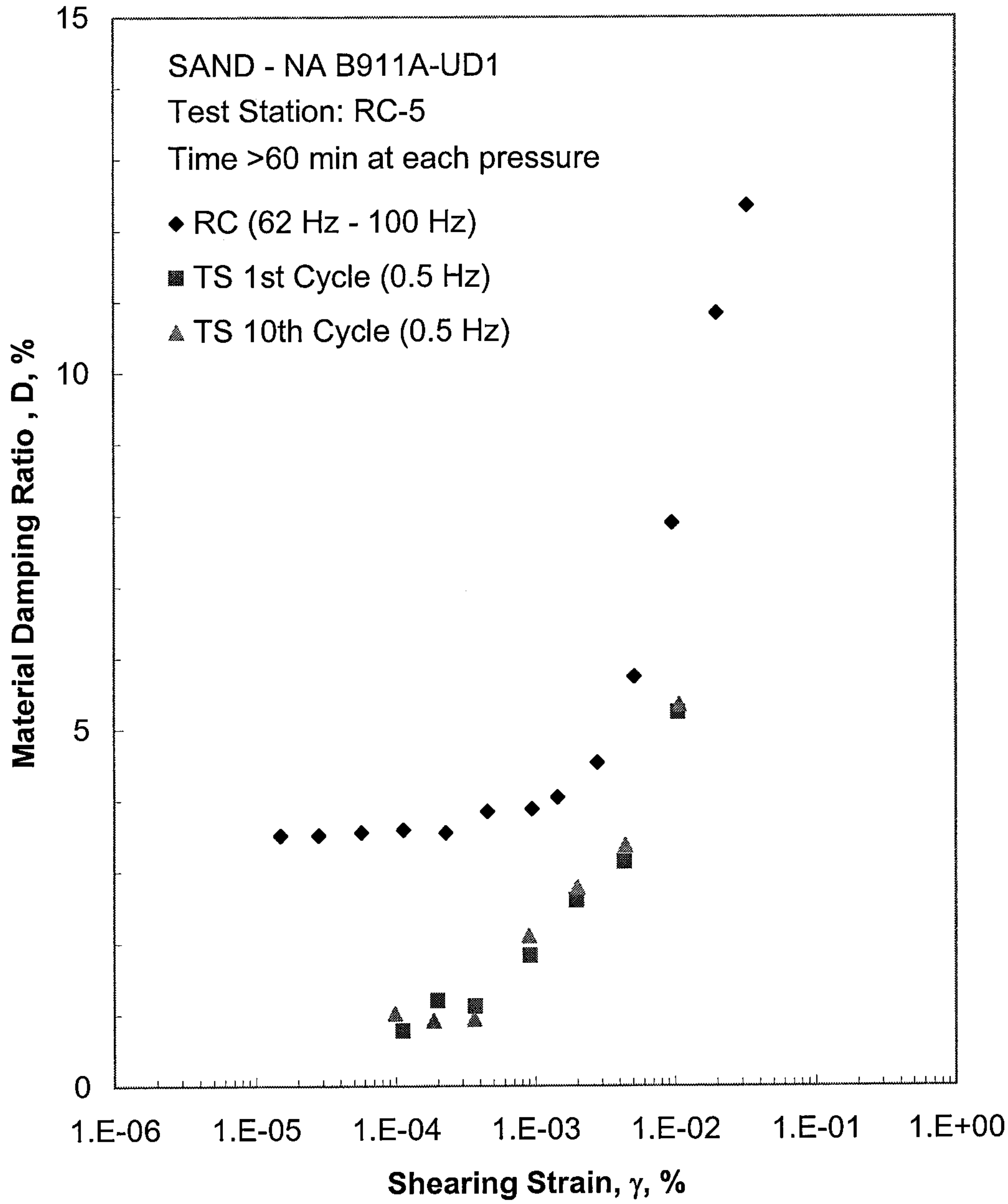


Figure B.13 Comparison of the Variation in Material Damping Ratio with Shearing Strain at an Isotropic Confining Pressure of 5.6 psi from the Combined RCTS Tests

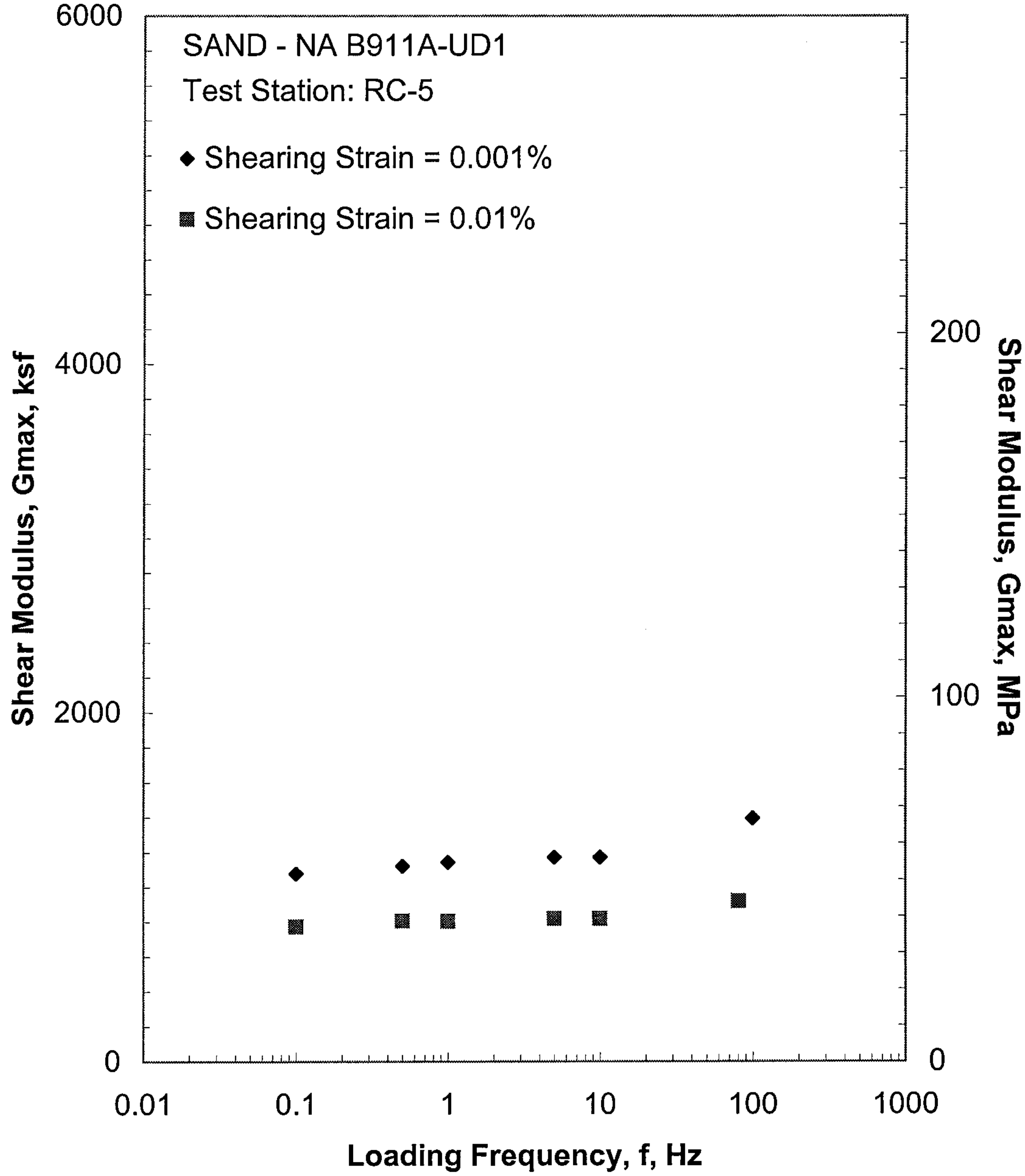


Figure B.14 Comparison of the Variation in Shear Modulus with Loading Frequency at an Isotropic Confining Pressure of 5.6 psi from the Combined RCTS Tests

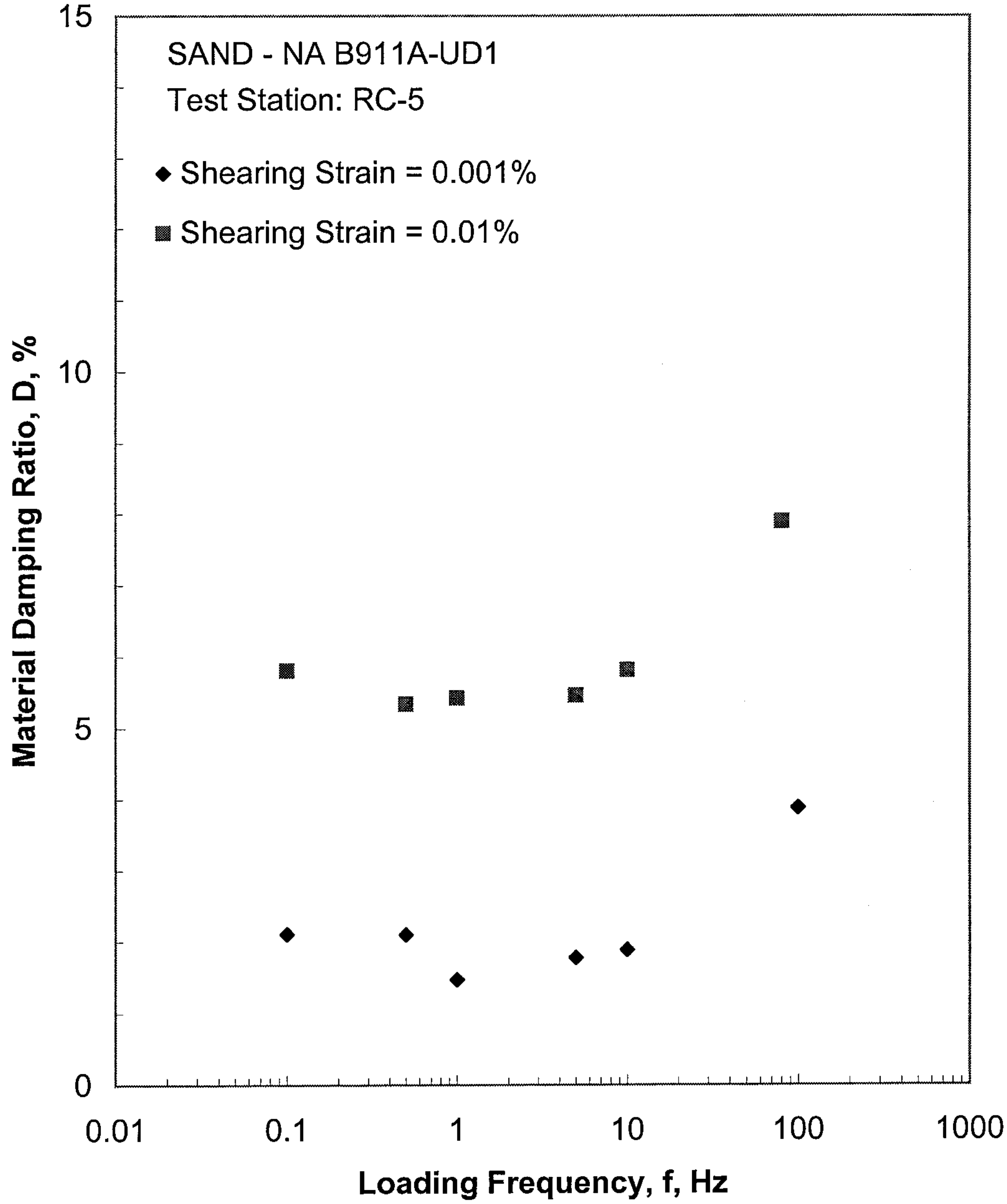


Figure B.15 Comparison of the Variation in Material Damping Ratio with Loading Frequency at an Isotropic Confining Pressure of 5.6 psi from the Combined RCTS Tests

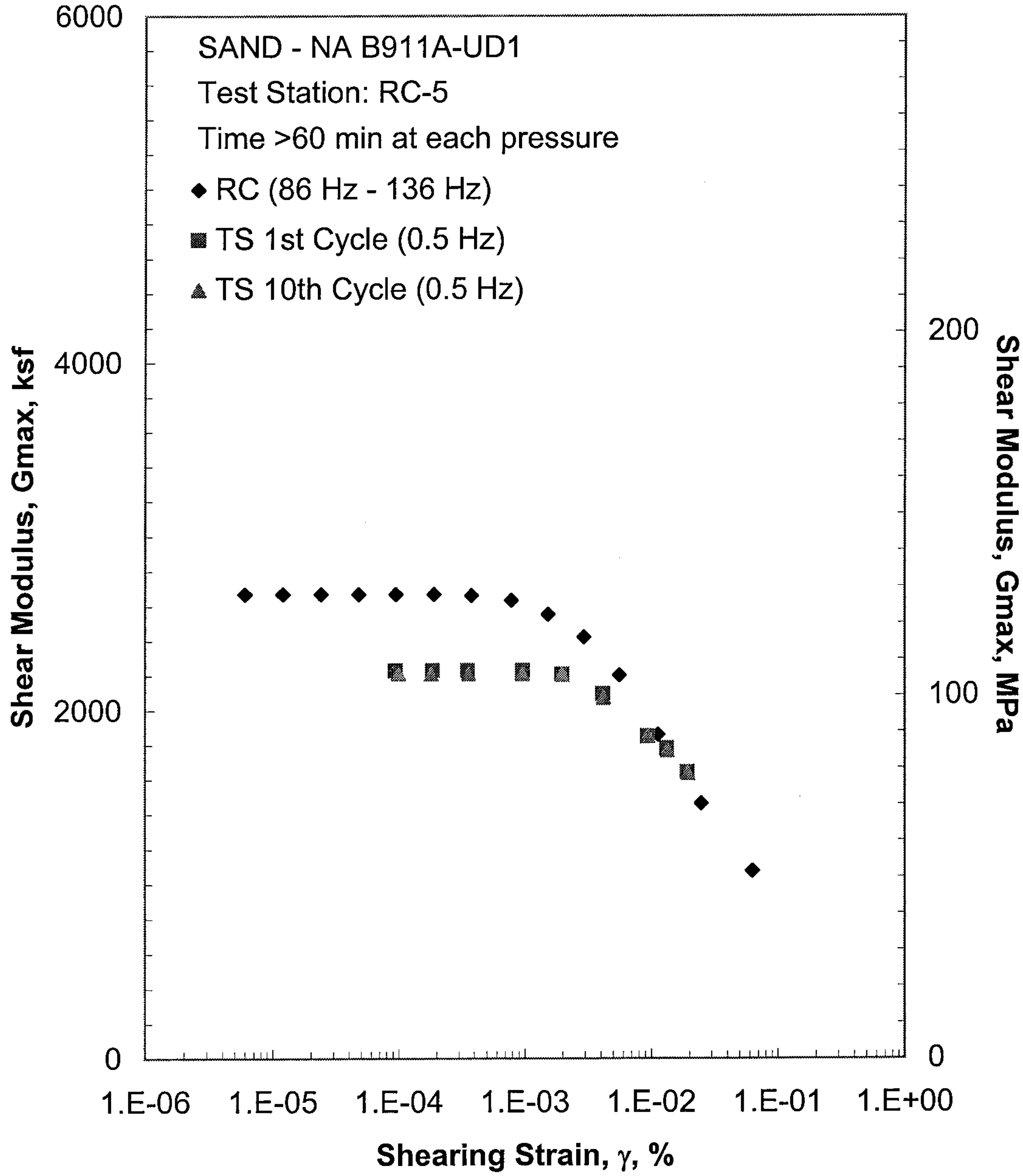


Figure B.16 Comparison of the Variation in Shear Modulus with Shearing Strain at an Isotropic Confining Pressure of 22.5 psi from the Combined RCTS Tests

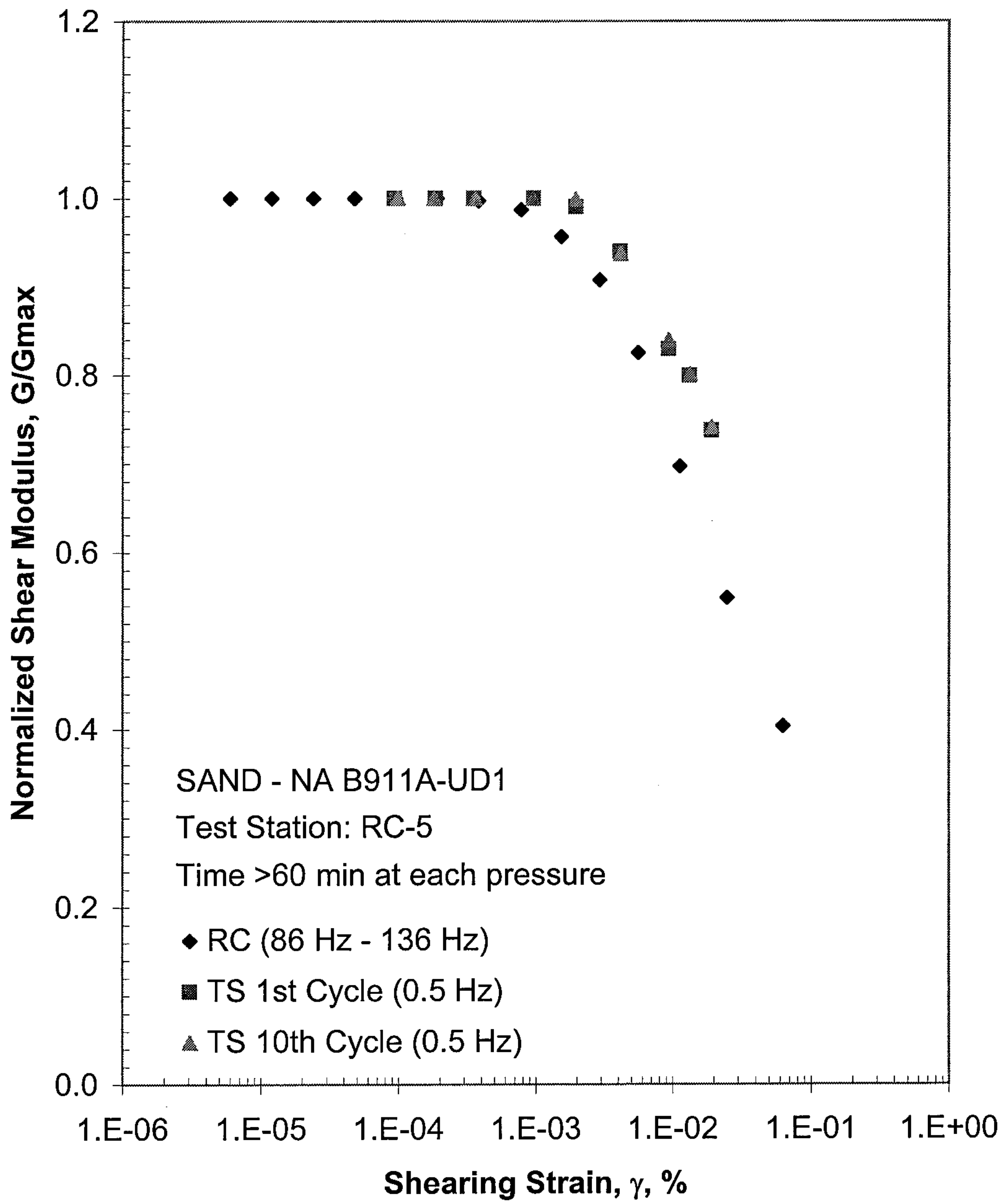


Figure B.17 Comparison of the Variation in Normalized Shear Modulus with Shearing Strain at an Isotropic Confining Pressure of 22.5 psi from the Combined RCTS Tests

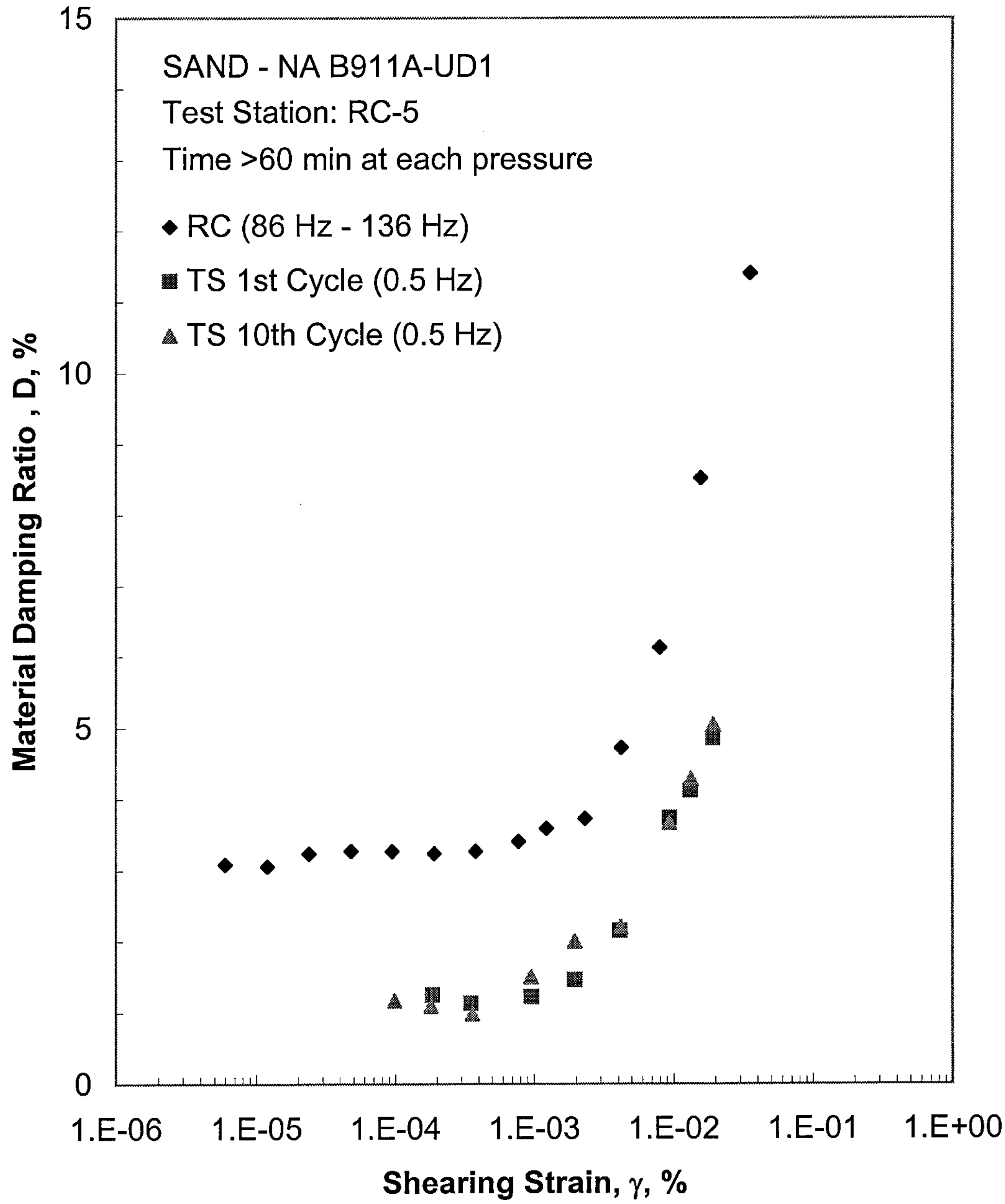


Figure B.18 Comparison of the Variation in Material Damping Ratio with Shearing Strain at an Isotropic Confining Pressure of 22.5 psi from the Combined RCTS Tests

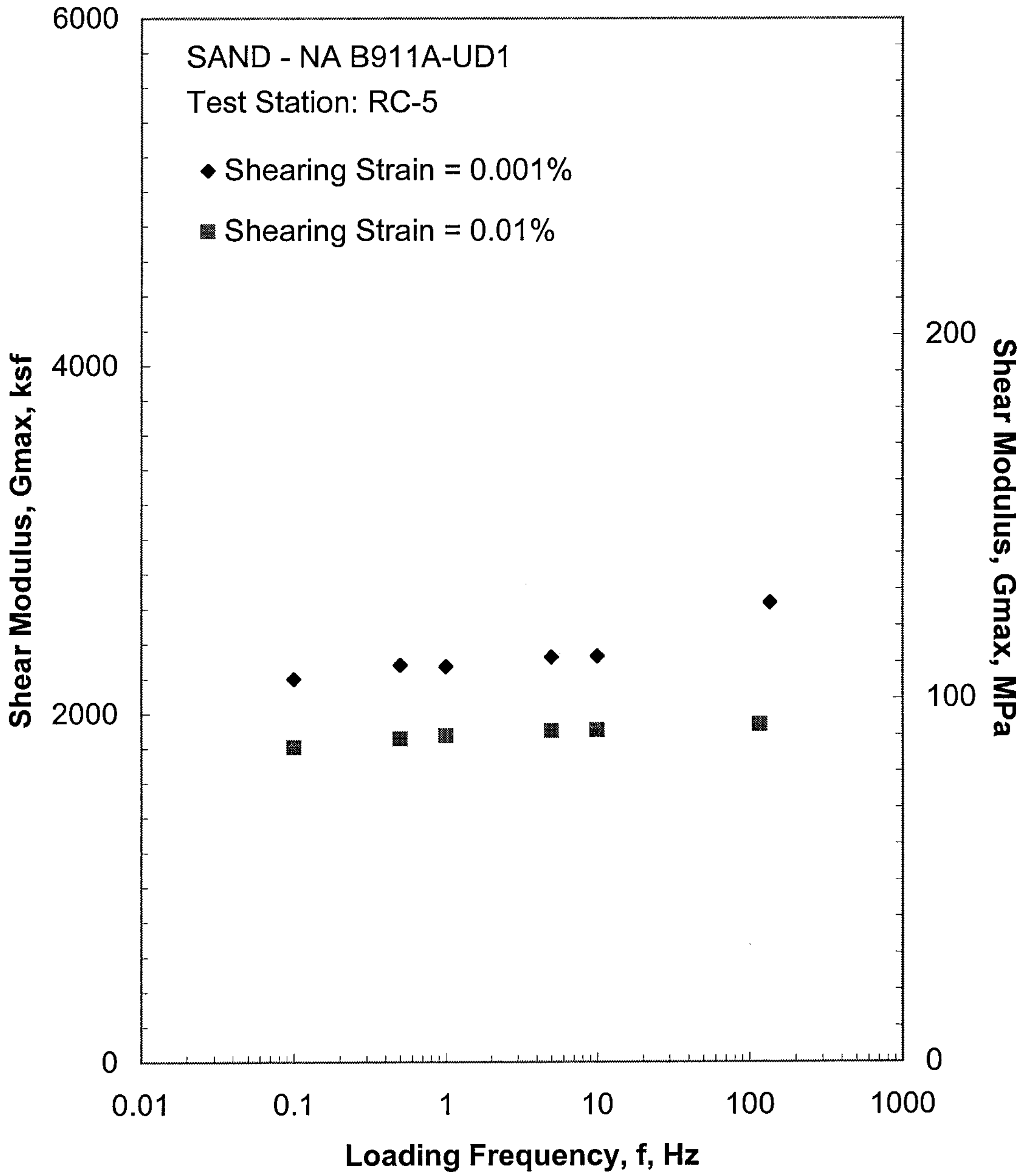


Figure B.19 Comparison of the Variation in Shear Modulus with Loading Frequency at an Isotropic Confining Pressure of 22.5 psi from the Combined RCTS Tests

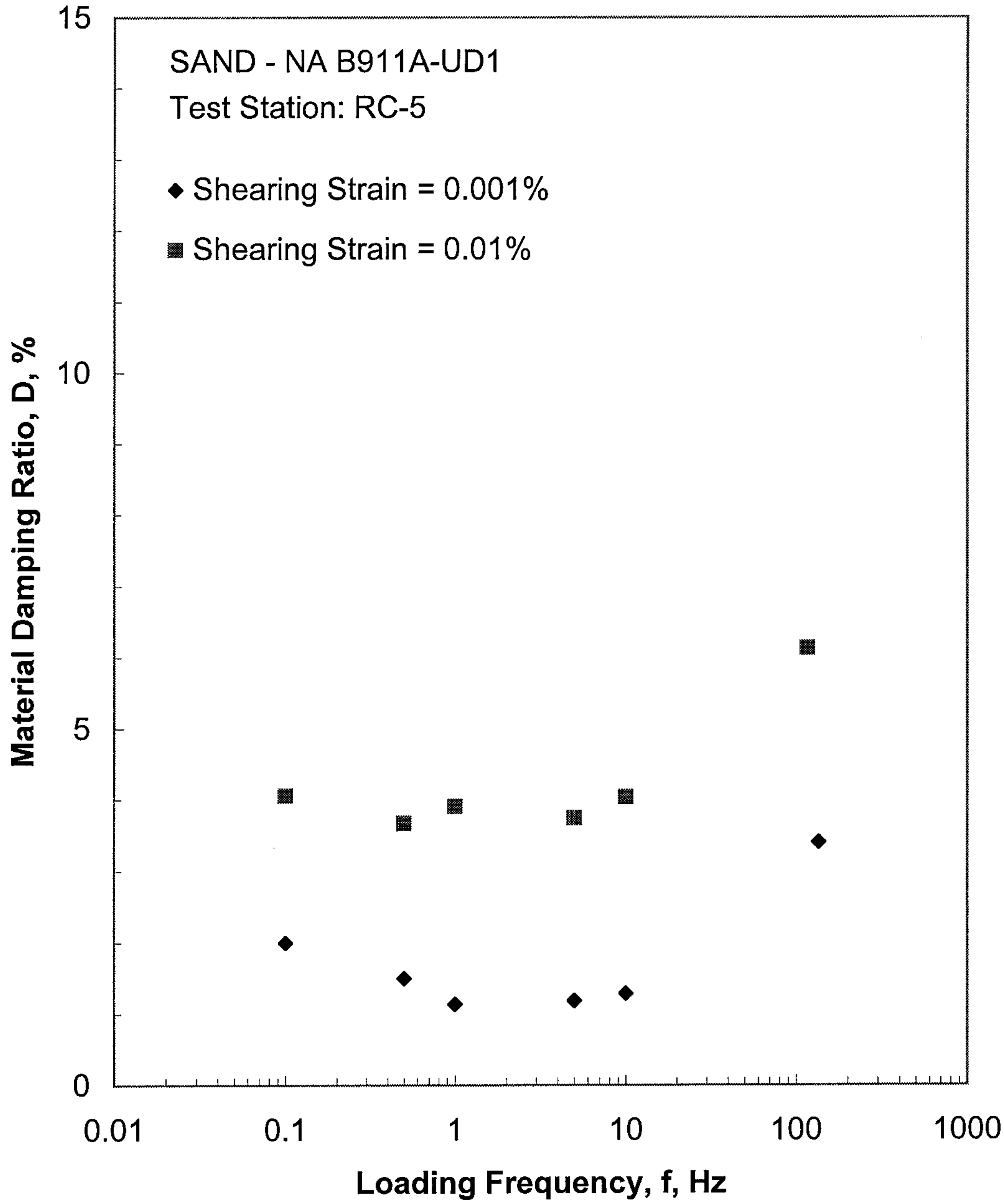


Figure B.20 Comparison of the Variation in Material Damping Ratio with Loading Frequency at an Isotropic Confining Pressure of 22.5 psi from the Combined RCTS Tests

Table B.1 Variation in Low-Amplitude Shear Wave Velocity, Low-Amplitude Shear Modulus, Low-Amplitude Material Damping Ratio and Estimated Void Ratio with Isotropic Confining Pressure from RC Tests of Specimen NA B911-UD1

Isotropic Confining Pressure, σ_o			Low-Amplitude Shear Modulus, G_{max}		Low-Amplitude Shear Wave Velocity, Vs	Low-Amplitude Material Damping Ratio, Dmin	Estimated Void Ratio, e
(psi)	(psf)	(kPa)	(ksf)	(MPa)	(fps)	(%)	
1.4	202	10	917	44	491	3.84	0.578
2.8	403	19	1071	51	530	3.99	0.575
5.6	806	39	1389	67	603	3.53	0.568
11.2	1613	77	1890	91	701	3.49	0.556
22.5	3240	155	2608	125	820	3.20	0.544

Table B.2 Variation in Shear Modulus and Material Damping Ratio with Shearing Strain from RC Tests of Specimen NA B911A-UD1; Isoptropic Confining Pressure, σ_o= 5.6 psi (0.8 ksf = 39 kPa)

Peak Shearing Strain, %	Shear Modulus, G, ksf	Normalized Shear Modulus, G/G_{max}	Average$^+$ Shearing Strain, %	Material Damping Ratio^x, D, %
1.50E-05	1422	1.00	1.50E-05	3.51
2.80E-05	1422	1.00	2.80E-05	3.51
5.70E-05	1422	1.00	5.70E-05	3.55
1.14E-04	1422	1.00	1.14E-04	3.59
2.29E-04	1422	1.00	2.29E-04	3.55
4.56E-04	1415	1.00	4.56E-04	3.84
9.44E-04	1396	0.98	9.44E-04	3.88
1.86E-03	1357	0.95	1.44E-03	4.04
3.65E-03	1268	0.89	2.78E-03	4.53
7.18E-03	1124	0.79	5.13E-03	5.74
1.49E-02	920	0.65	9.57E-03	7.89
3.51E-02	678	0.48	1.99E-02	10.84
6.00E-02	555	0.39	3.29E-02	12.35

$^+$ 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 B.3 Variation in Shear Modulus, Normalized Shear Modulus and Material Damping Ratio with Shearing Strain from TS Tests of Specimen NA B911A-UD1; Isotropic Confining Pressure, σ_o = 5.6 psi (0.8 ksf = 39 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, %
1.12E-04	1076	1.00	0.78	9.87E-05	1130	1.00	1.02
1.99E-04	1076	1.00	1.20	1.87E-04	1130	1.00	0.92
3.72E-04	1076	1.00	1.12	3.65E-04	1130	1.00	0.94
9.17E-04	1076	1.00	1.83	8.99E-04	1130	1.00	2.10
1.97E-03	1076	1.00	2.60	2.00E-03	1084	0.96	2.78
4.35E-03	994	0.92	3.14	4.41E-03	982	0.87	3.37
1.05E-02	823	0.77	5.23	1.07E-02	806	0.71	5.34

Table B.4 Variation in Shear Modulus and Material Damping Ratio with Shearing Strain from RC Tests of Specimen NA B911A-UD1; Isoptropic Confining Pressure, σ_o= 22.5 psi (3.2 ksf = 155 kPa)

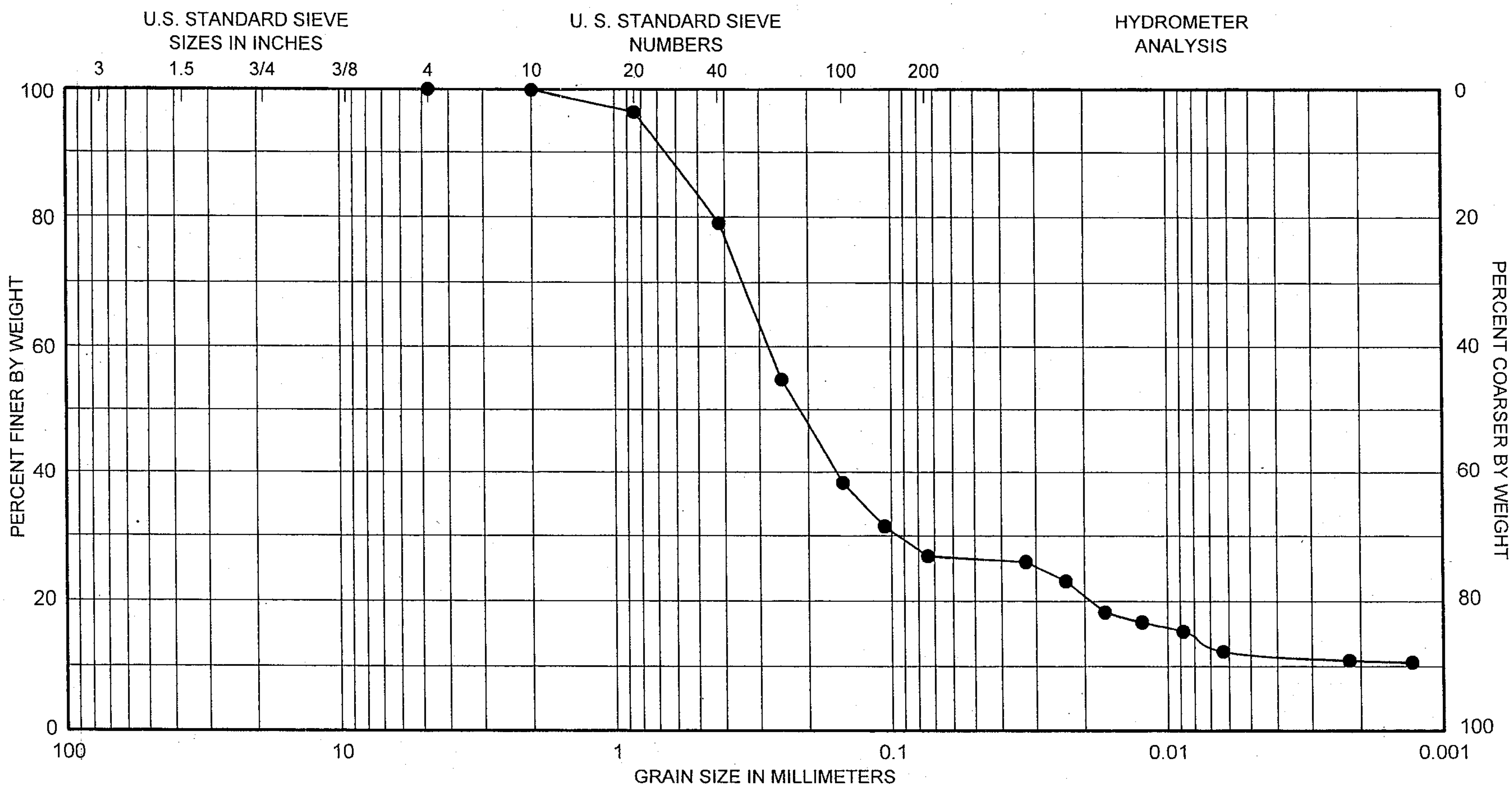
Peak Shearing Strain, %	Shear Modulus, G, ksf	Normalized Shear Modulus, G/G_{max}	Average$^+$ Shearing Strain, %	Material Damping Ratio^x, D, %
6.00E-06	2670	1.00	6.00E-06	3.09
1.20E-05	2670	1.00	1.20E-05	3.06
2.40E-05	2670	1.00	2.40E-05	3.24
4.80E-05	2670	1.00	4.80E-05	3.27
9.50E-05	2670	1.00	9.50E-05	3.27
1.91E-04	2670	1.00	1.91E-04	3.24
3.80E-04	2663	1.00	3.80E-04	3.27
7.81E-04	2636	0.99	7.81E-04	3.41
1.53E-03	2555	0.96	1.23E-03	3.59
2.93E-03	2423	0.91	2.32E-03	3.73
5.58E-03	2204	0.83	4.21E-03	4.72
1.13E-02	1860	0.70	7.94E-03	6.13
2.48E-02	1465	0.55	1.57E-02	8.52
6.29E-02	1077	0.40	3.55E-02	11.40

$^+$ 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 B.5 Variation in Shear Modulus, Normalized Shear Modulus and Material Damping Ratio with Shearing Strain from TS Tests of Specimen NA B911A-UD1; Isotropic Confining Pressure, σ_o=22.5 psi (3.2 ksf = 155 kPa)

First Cycle				Tenth Cycle			
Peak Shearing Strain, %	Shear Modulus, G, ksf	Normalized Shear Modulus,	Material Damping Ratio, D,	Peak Shearing Strain, %	Shear Modulus, G, ksf	Normalized Shear Modulus,	Material Damping Ratio, D, %
9.36E-05	2230	1.00	---	9.88E-05	2211	1.00	1.17
1.86E-04	2230	1.00	1.25	1.81E-04	2211	1.00	1.09
3.52E-04	2230	1.00	1.13	3.60E-04	2211	1.00	0.98
9.60E-04	2230	1.00	1.22	9.52E-04	2211	1.00	1.50
1.96E-03	2209	0.99	1.46	1.96E-03	2208	1.00	2.00
4.13E-03	2096	0.94	2.15	4.18E-03	2073	0.94	2.21
9.36E-03	1850	0.83	3.73	9.33E-03	1856	0.84	3.67
1.33E-02	1783	0.80	4.12	1.34E-02	1770	0.80	4.28
1.92E-02	1644	0.74	4.85	1.93E-02	1638	0.74	5.04



GRAVEL		SAND			SILT or CLAY
Coarse	Fine	Coarse	Medium	Fine	

SYMBOL	BORING	DEPTH, FT	C_c	C_u	D_{50}	D_{90}	CLASSIFICATION
●	B-911A-UD1	11.7			0.215	0.66	Sand, tan

GRAIN SIZE CURVE

TEST METHOD ASTM D422-63 (2002)

APPENDIX C

Specimen NA B911A-PB1

Borehole B911A
Sample PB1
Depth = 21.7 ft (6.6 m)
Total Unit Weight = 124.2 lb/ft^3
Water Content = 15.1 %
Estimated In-Situ Ko = 0.5
Estimated In-Situ Mean Effective
Stress = 11.4 psi

FUGRO JOB #: 0401-1662
Testing Station: RC5

NOTE: Visual classification, if not specifically stated otherwise, was practiced in determining the soil types.

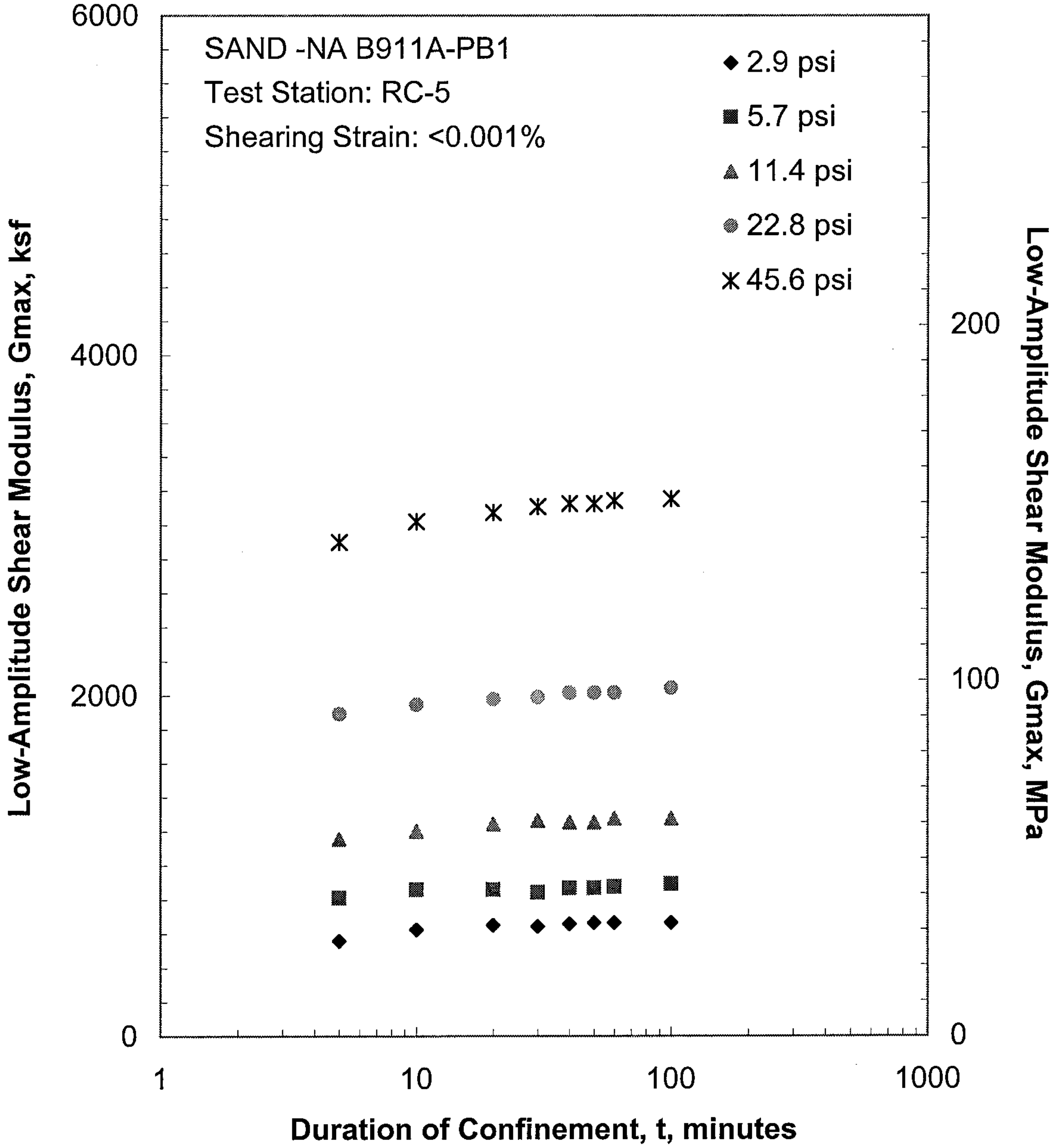


Figure C.1 Variation in Low-Amplitude Shear Modulus with Magnitude and Duration of Isotropic Confining Pressure from Resonant Column Tests

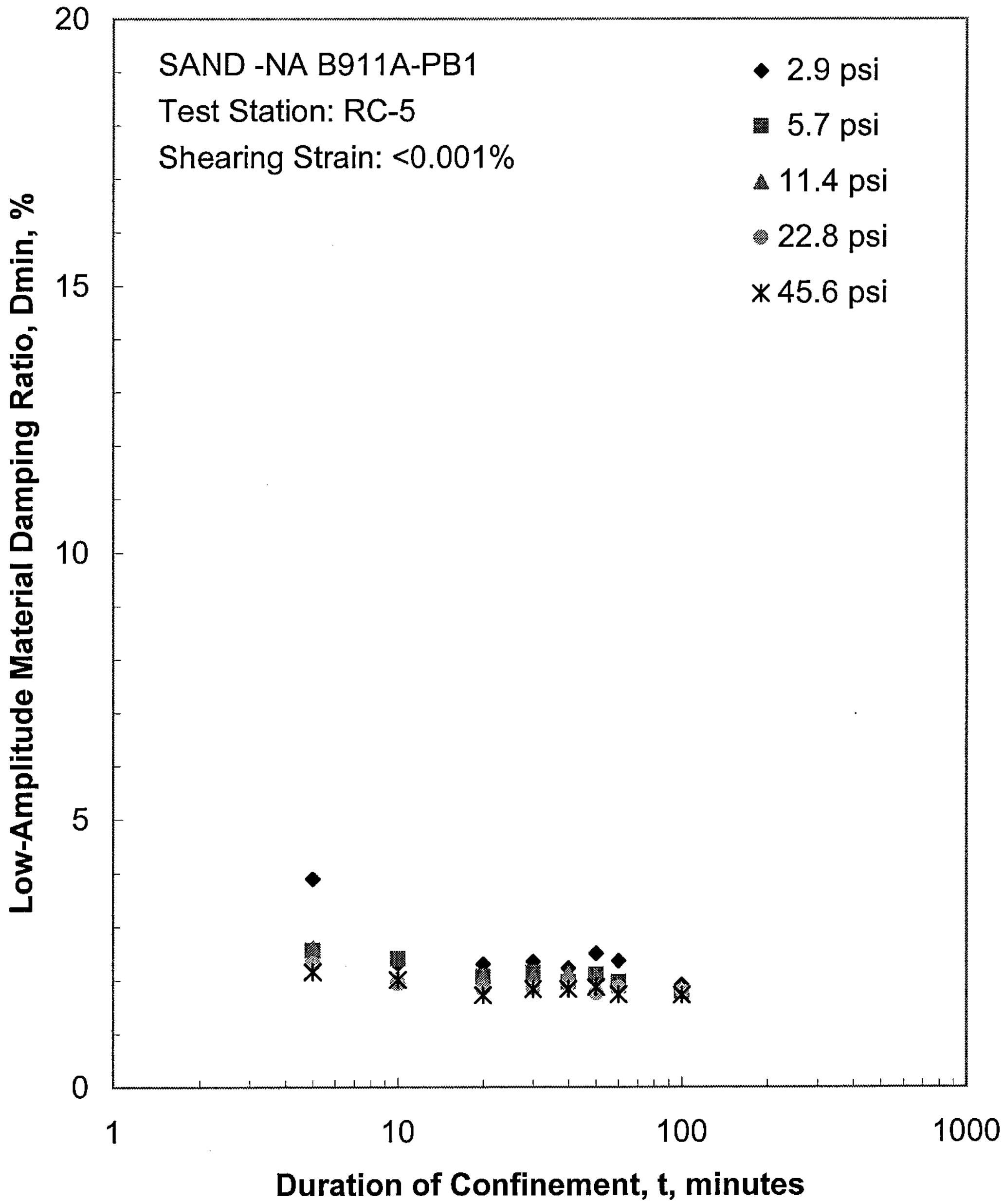


Figure C.2 Variation in Low-Amplitude Material Damping Ratio with Magnitude and Duration of Isotropic Confining Pressure from Resonant Column Tests

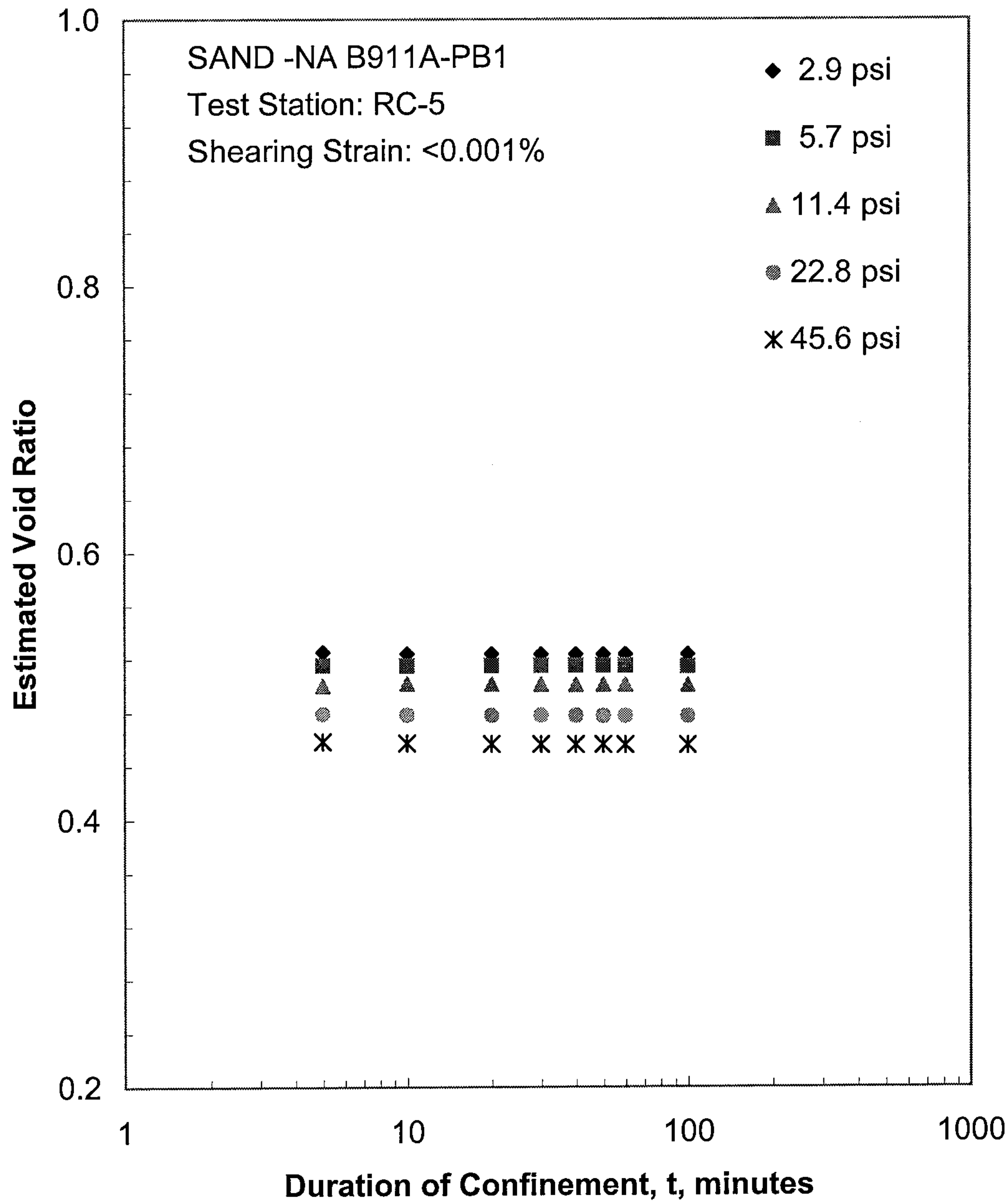


Figure C.3 Variation in Estimated Void Ratio with Magnitude and Duration of Isotropic Confining Pressure from Resonant Column Tests

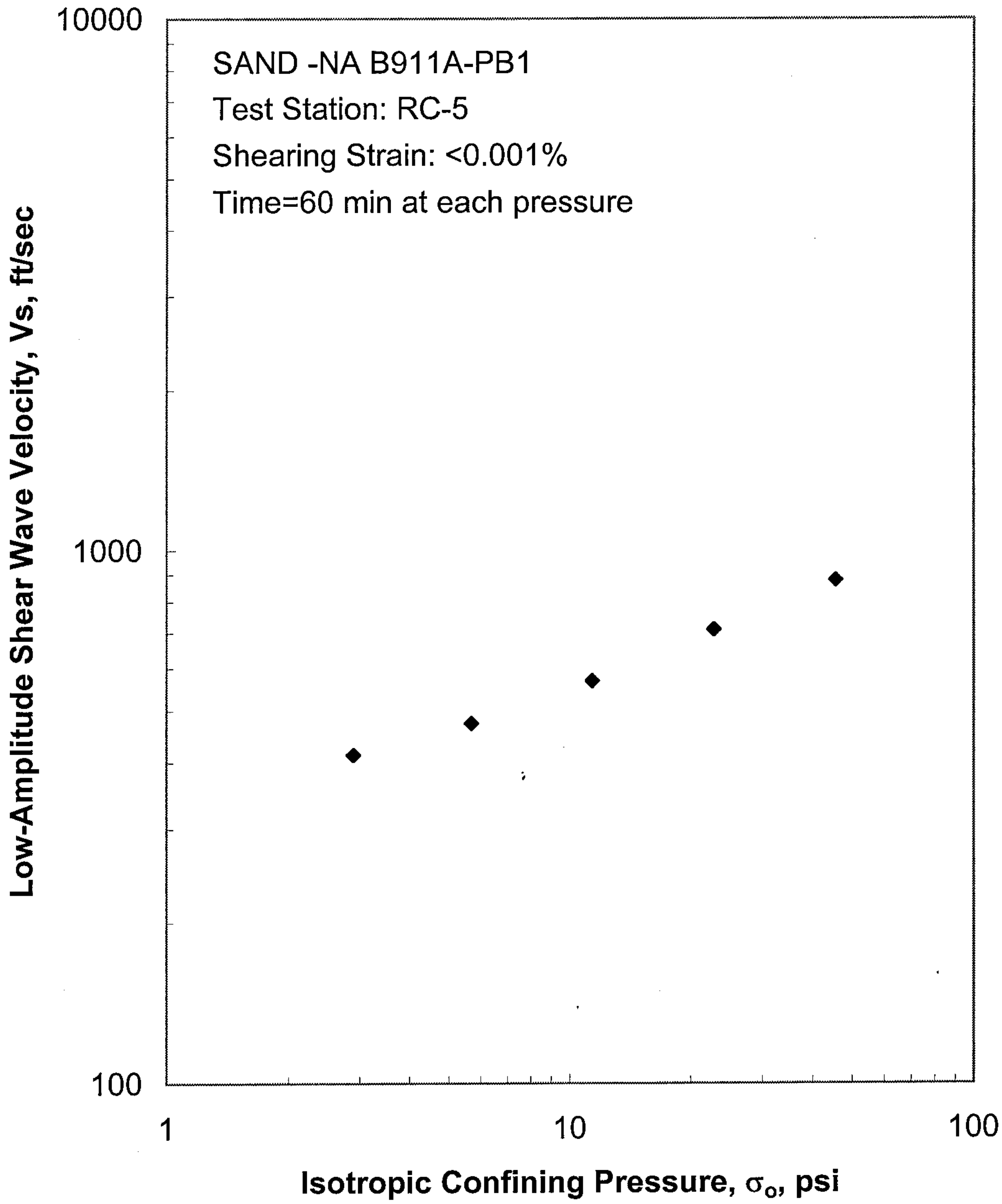


Figure C.4 Variation in Low-Amplitude Shear Wave Velocity with Isotropic Confining Pressure from Resonant Column Tests

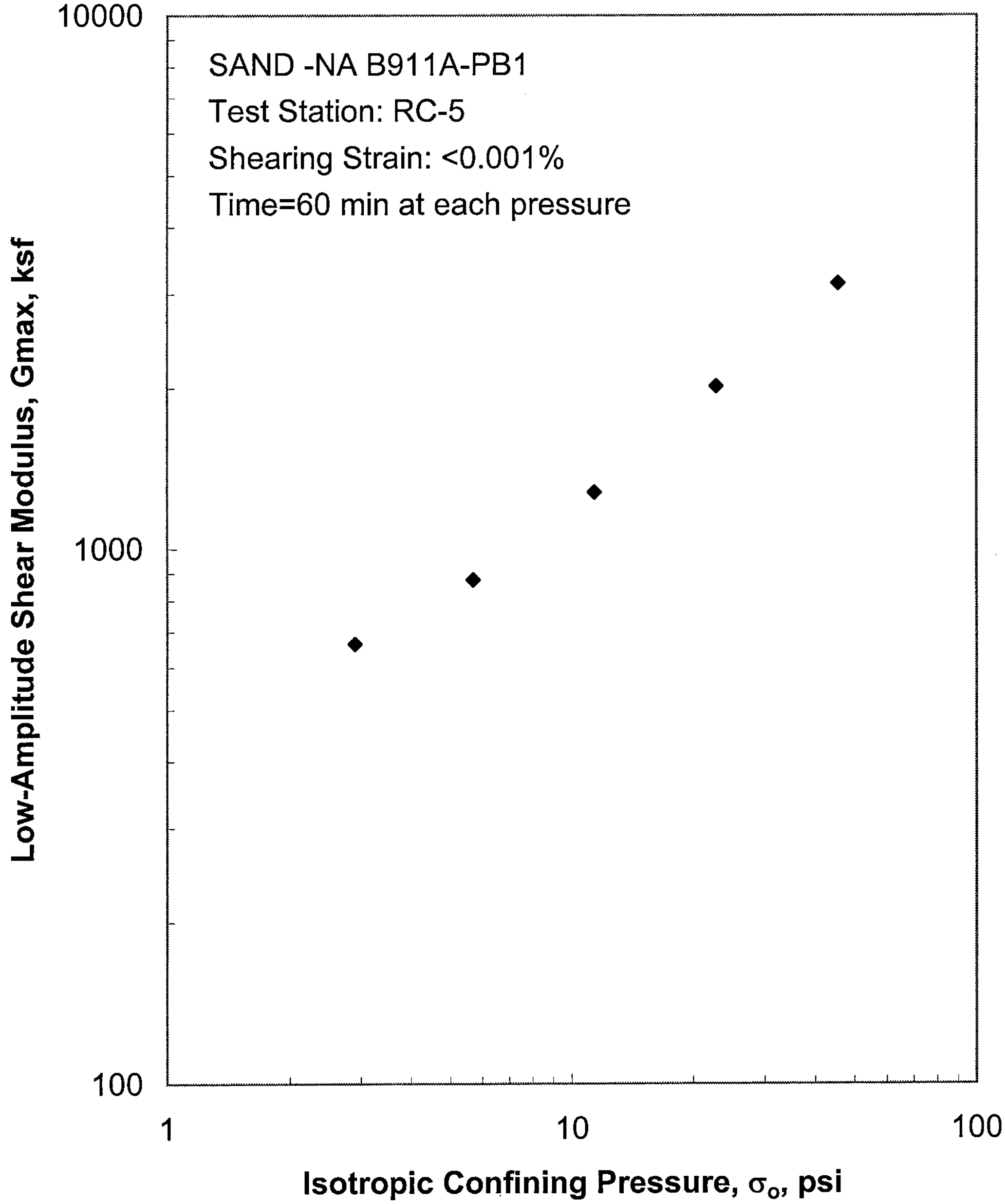


Figure C.5 Variation in Low-Amplitude Shear Modulus with Isotropic Confining Pressure from Resonant Column Tests

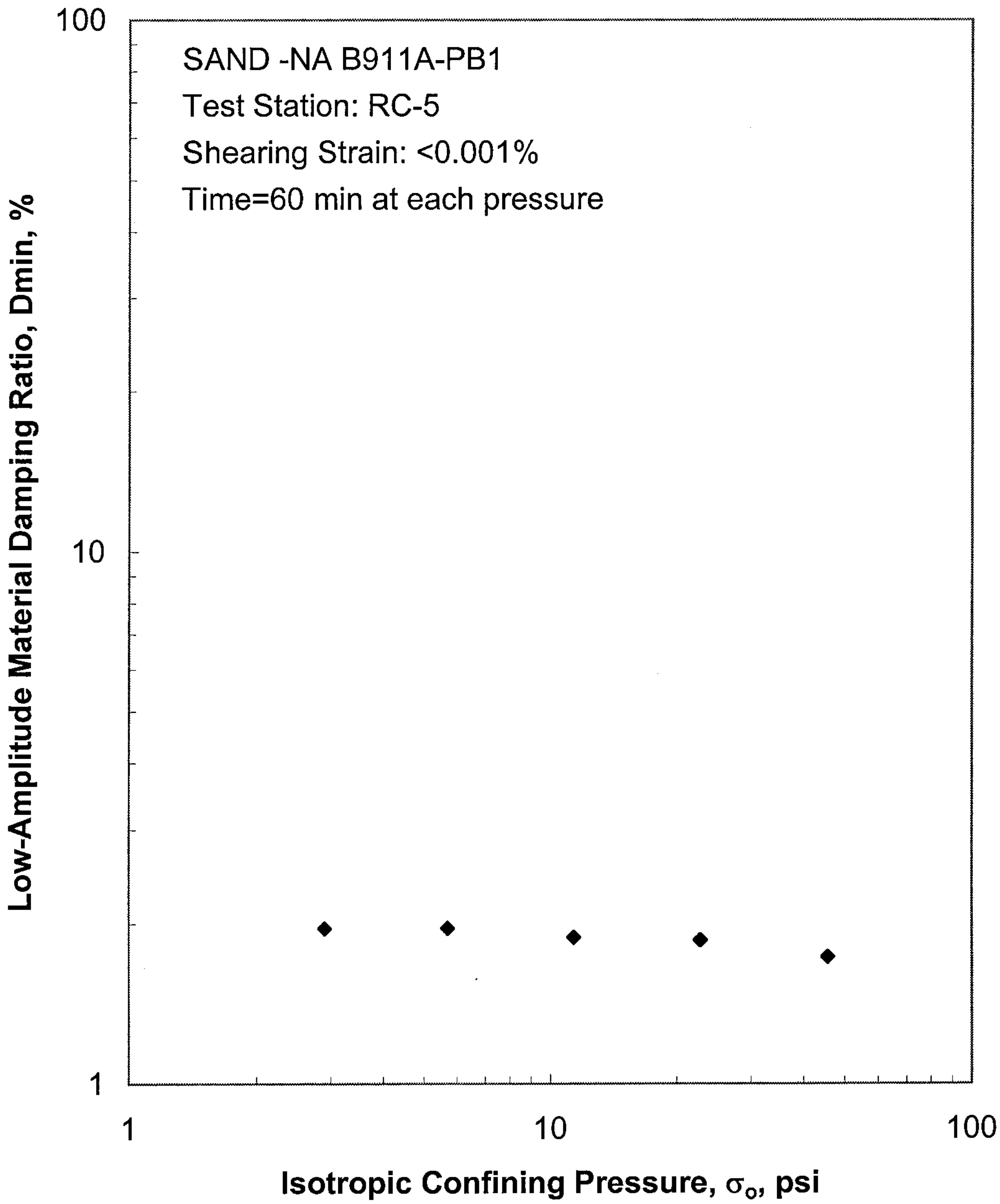


Figure C.6 Variation in Low-Amplitude Material Damping Ratio with Isotropic Confining Pressure from Resonant Column Tests

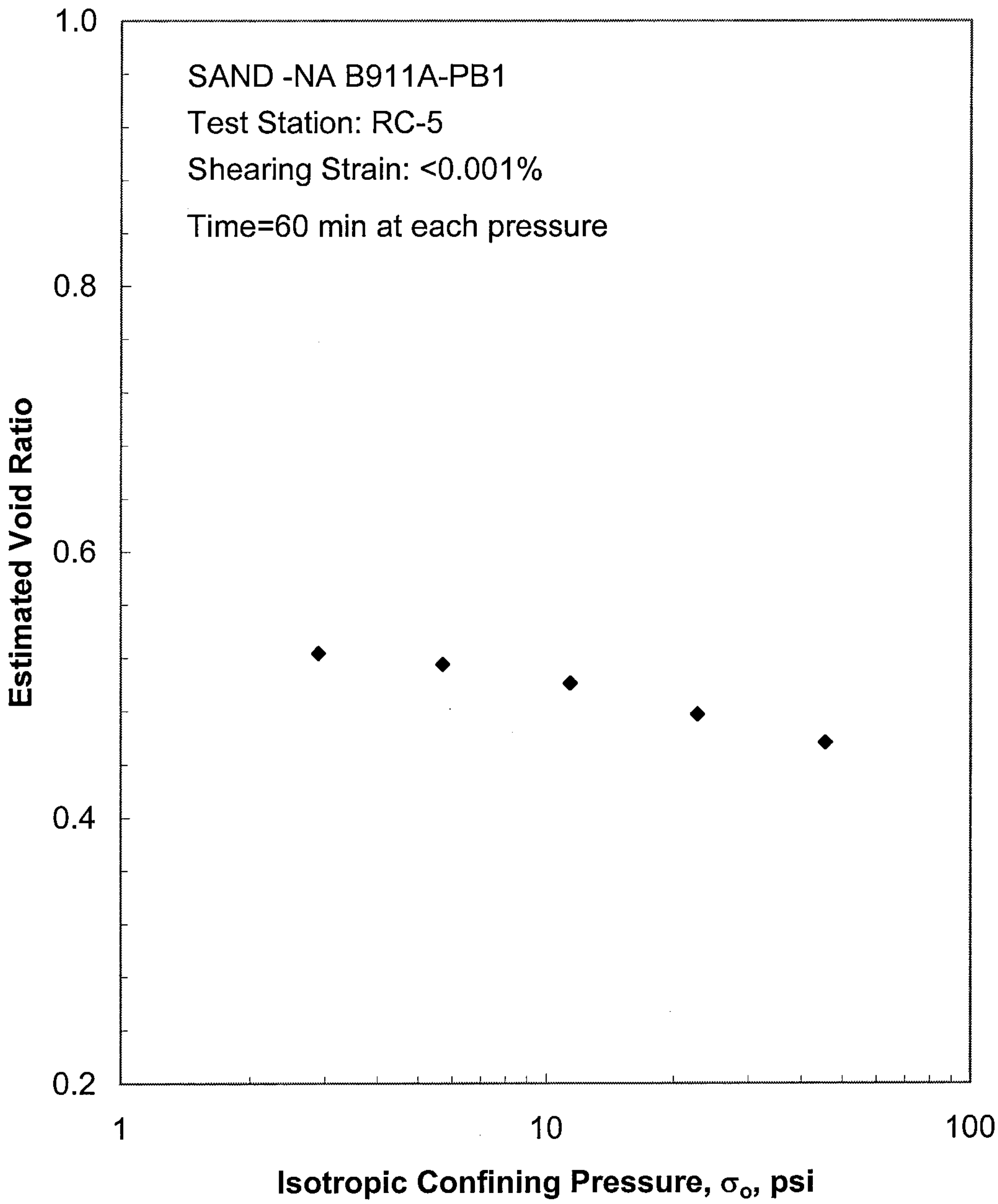


Figure C.7 Variation in Estimated Void Ratio with Isotropic Confining Pressure from Resonant Column Tests

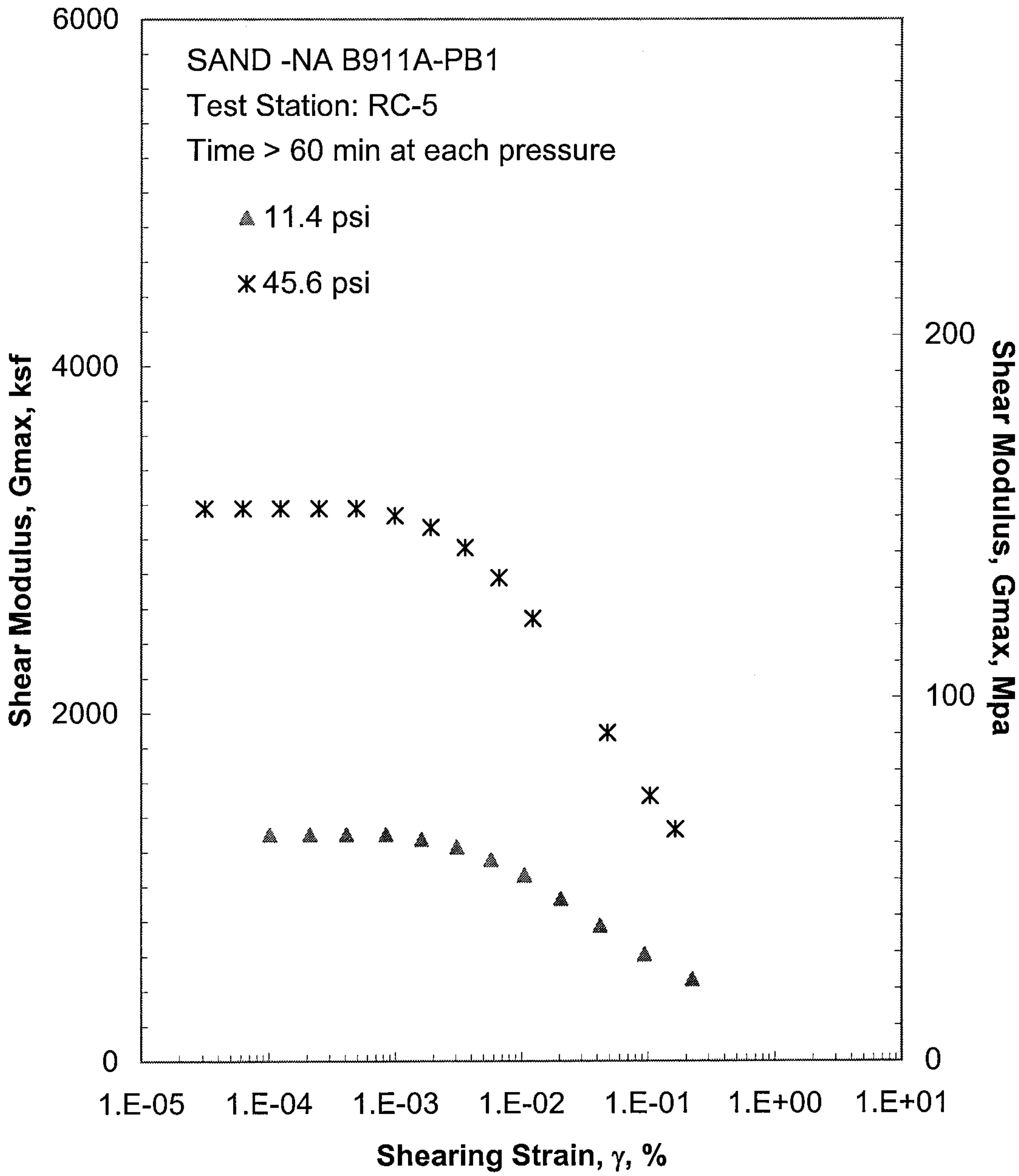


Figure C.8 Comparison of the Variation in Shear Modulus with Shearing Strain and Isotropic Confining Pressure from the Resonant Column Tests

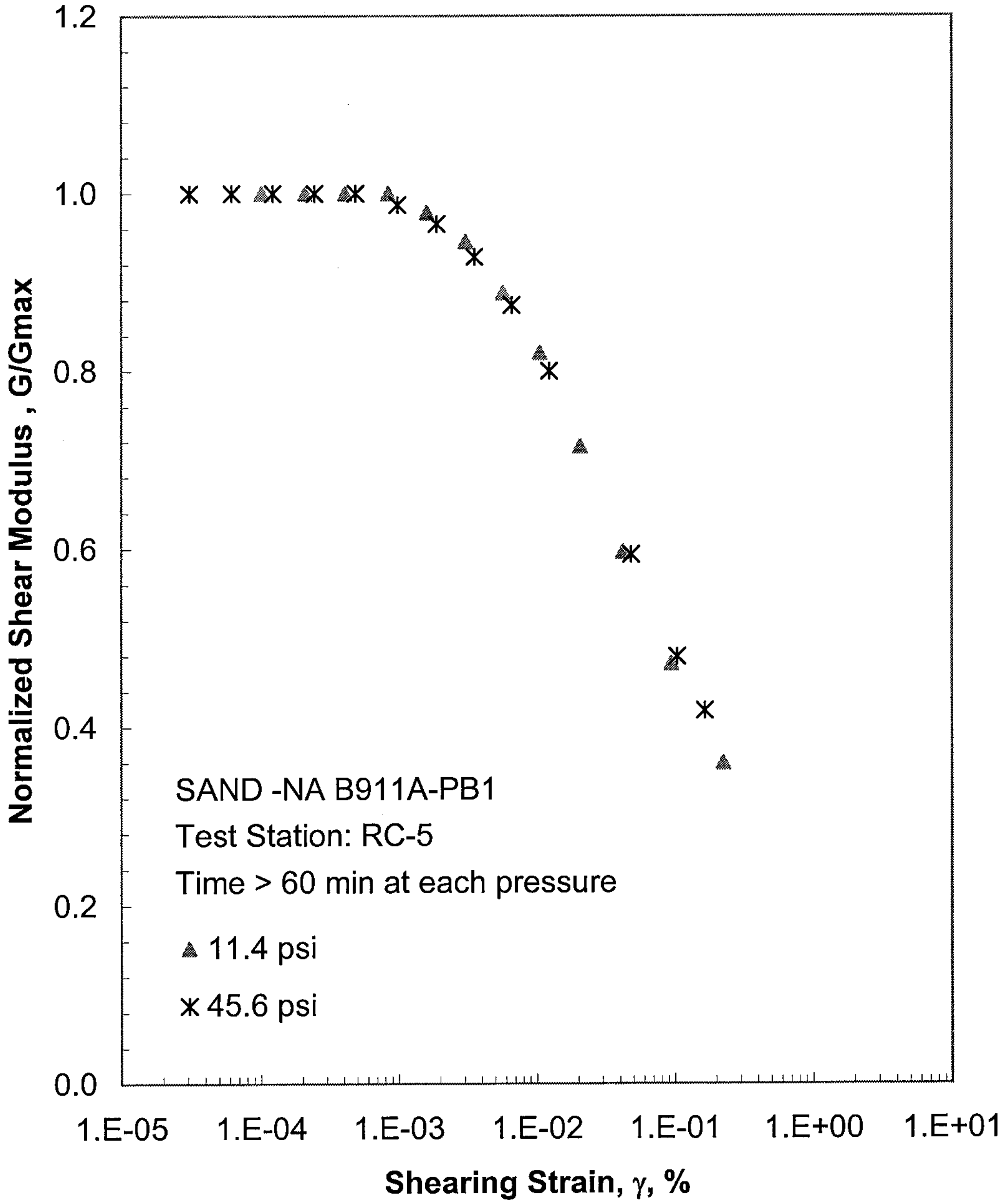


Figure C.9 Comparison of the Variation in Normalized Shear Modulus with Shearing Strain and Isotropic Confining Pressure from the Resonant Column Tests

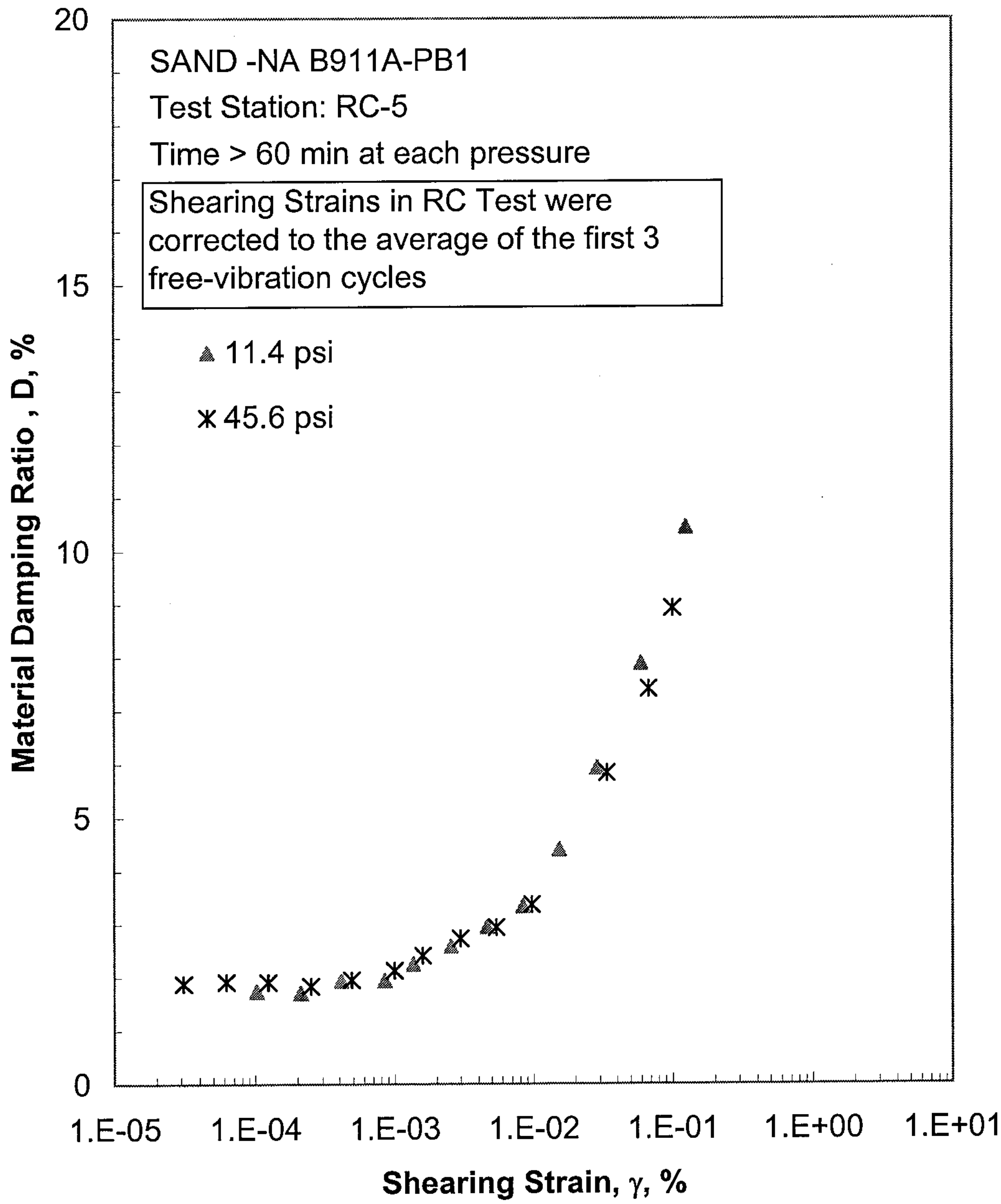


Figure C.10 Comparison of the Variation in Material Damping Ratio with Shearing Strain and Isotropic Confining Pressure from the Resonant Column Tests

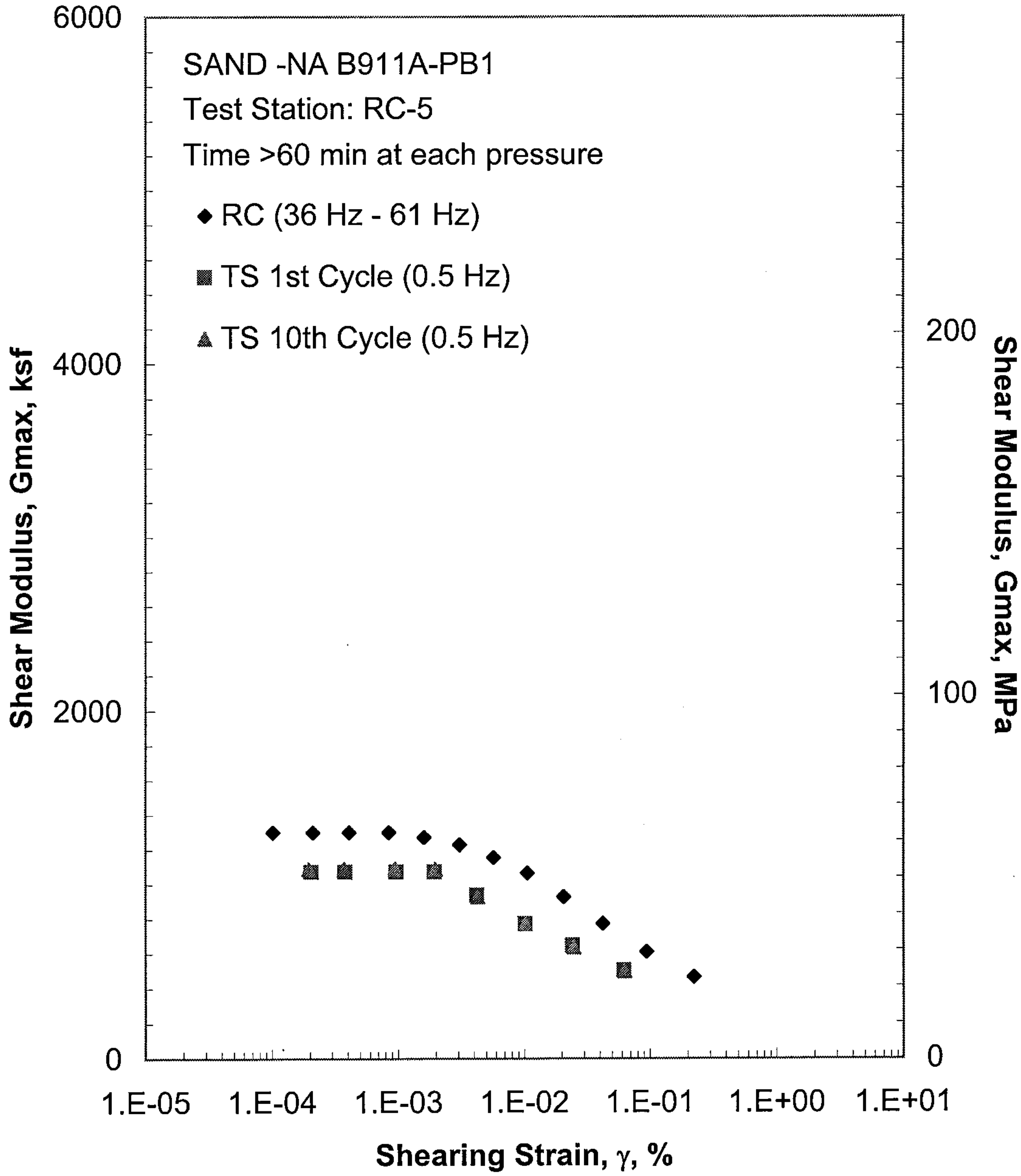


Figure C.11 Comparison of the Variation in Shear Modulus with Shearing Strain at an Isotropic Confining Pressure of 11.4 psi from the Combined RCTS Tests

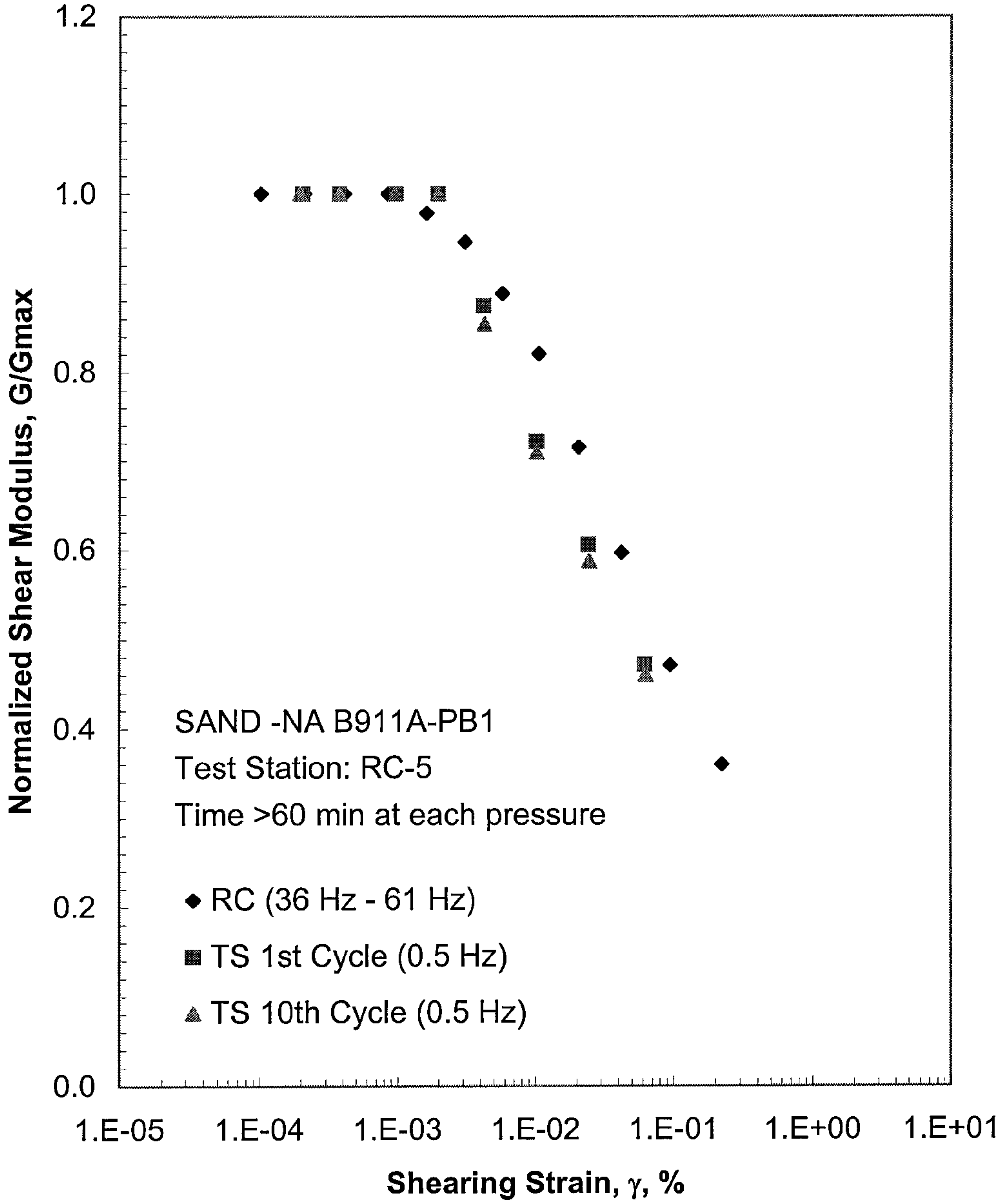


Figure C.12 Comparison of the Variation in Normalized Shear Modulus with Shearing Strain at an Isotropic Confining Pressure of 11.4 psi from the Combined RCTS Tests

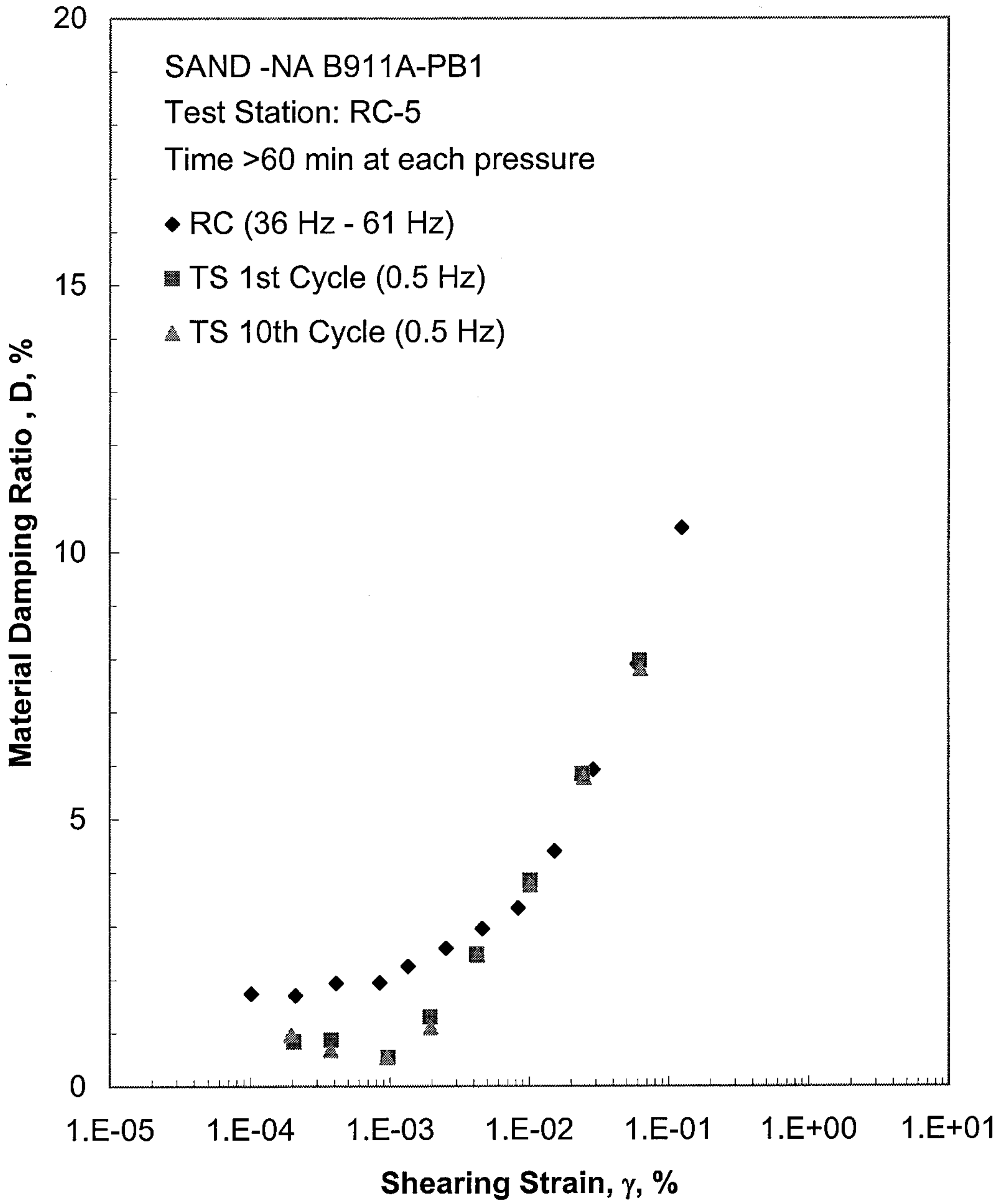


Figure C.13 Comparison of the Variation in Material Damping Ratio with Shearing Strain at an Isotropic Confining Pressure of 11.4 psi from the Combined RCTS Tests

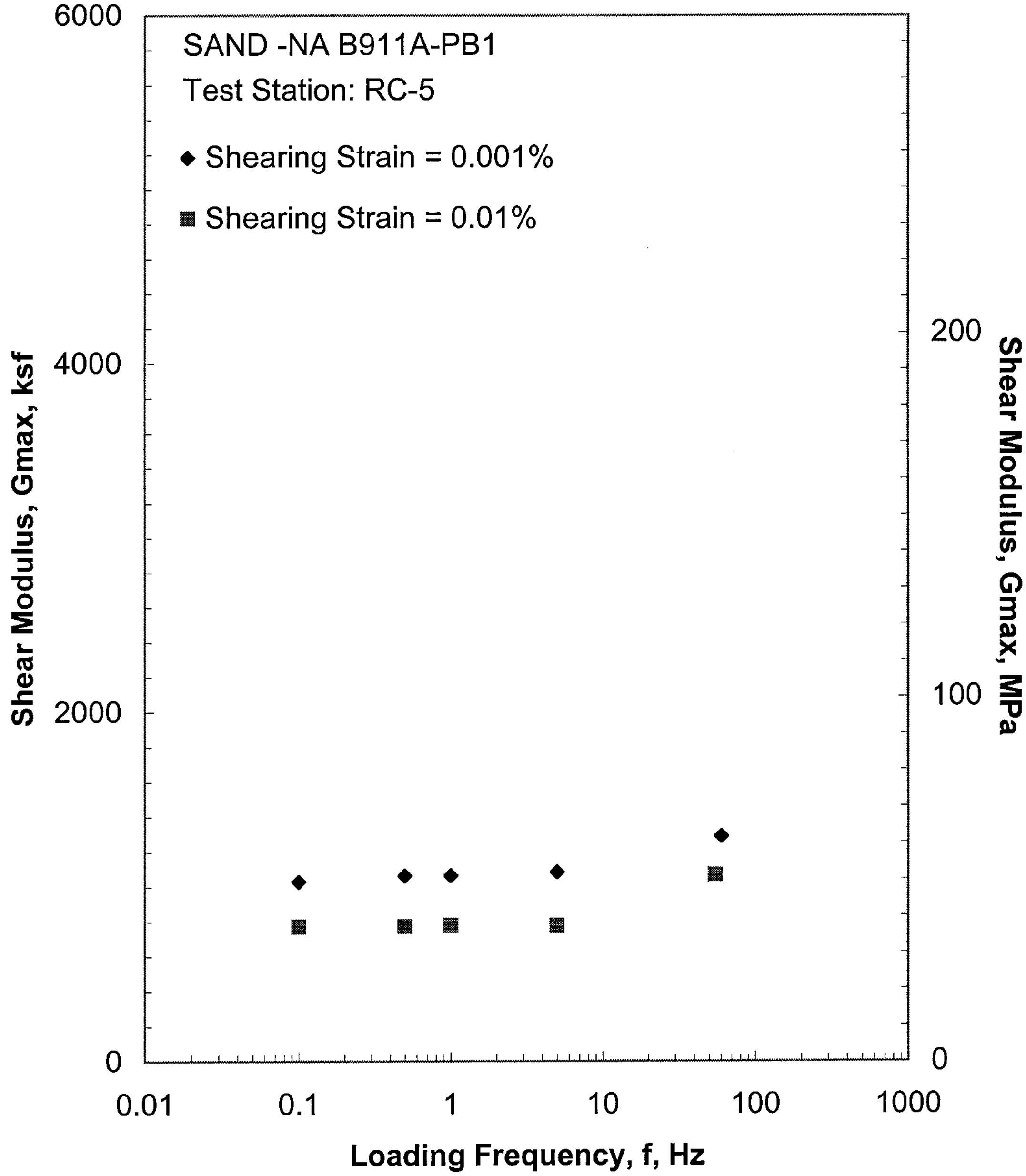


Figure C.14 Comparison of the Variation in Shear Modulus with Loading Frequency at an Isotropic Confining Pressure of 11.4 psi from the Combined RCTS Tests

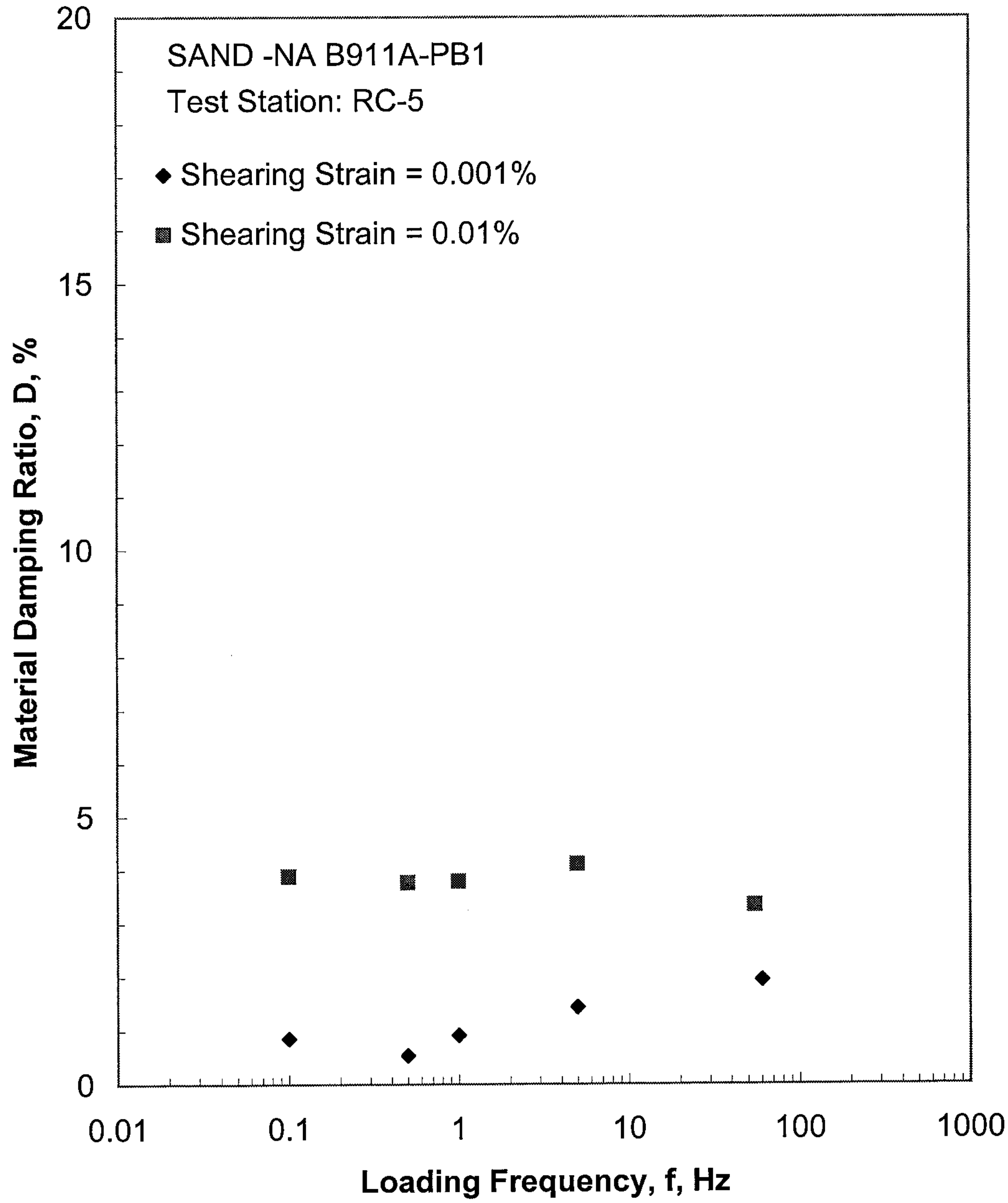


Figure C.15 Comparison of the Variation in Material Damping Ratio with Loading Frequency at an Isotropic Confining Pressure of 11.4 psi from the Combined RCTS Tests

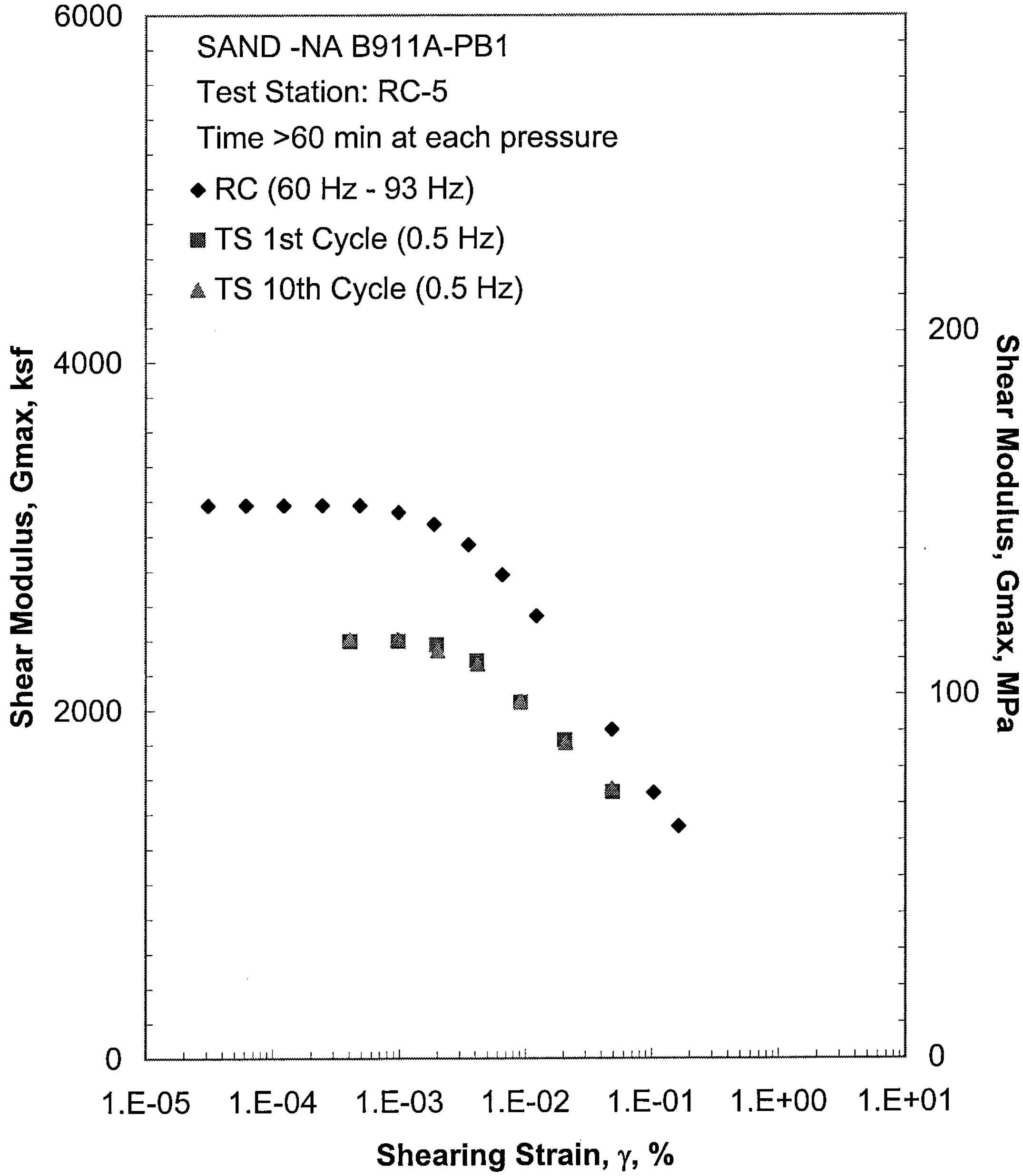


Figure C.16 Comparison of the Variation in Shear Modulus with Shearing Strain at an Isotropic Confining Pressure of 45.6 psi from the Combined RCTS Tests

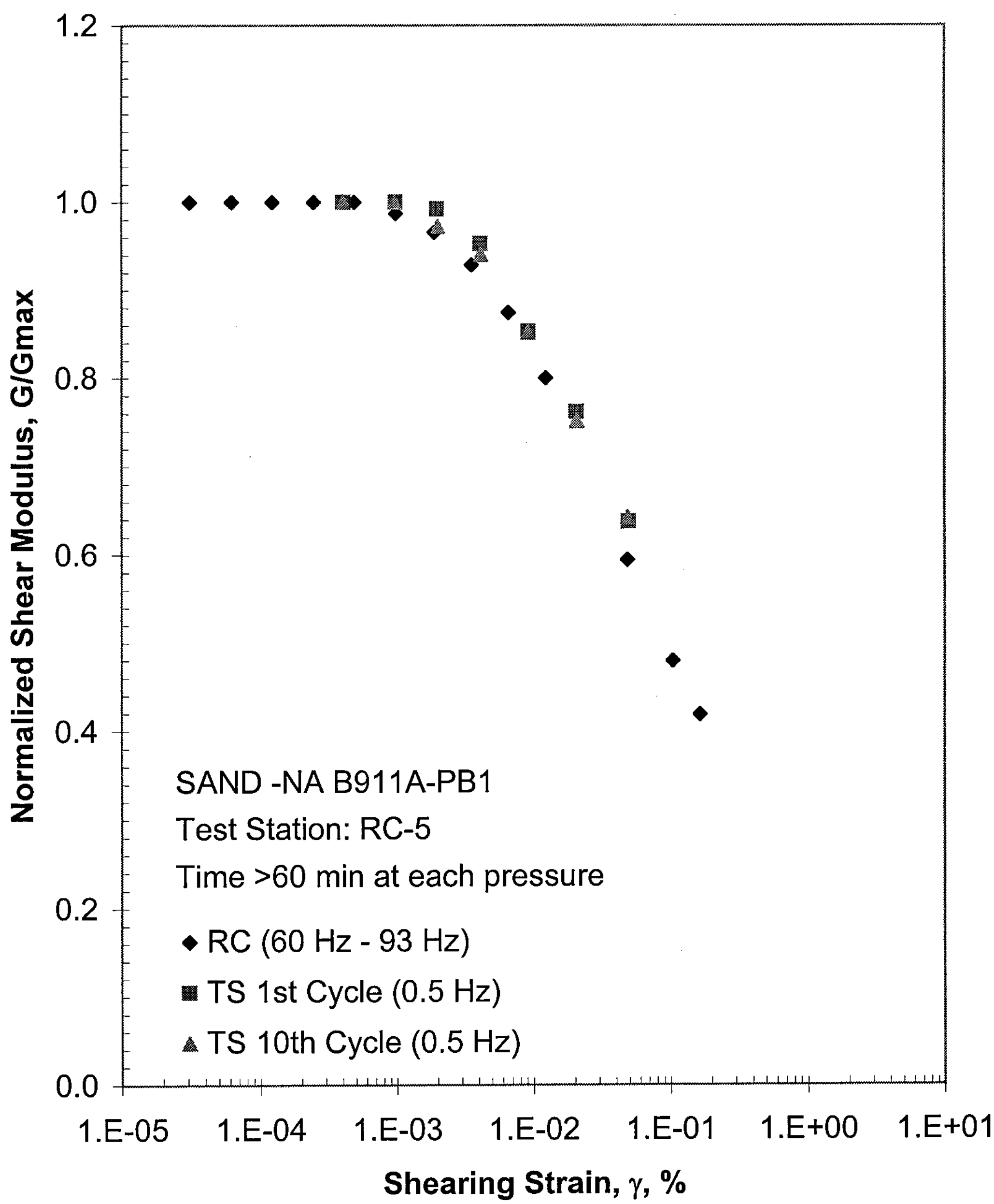


Figure C.17 Comparison of the Variation in Normalized Shear Modulus with Shearing Strain at an Isotropic Confining Pressure of 45.6 psi from the Combined RCTS Tests

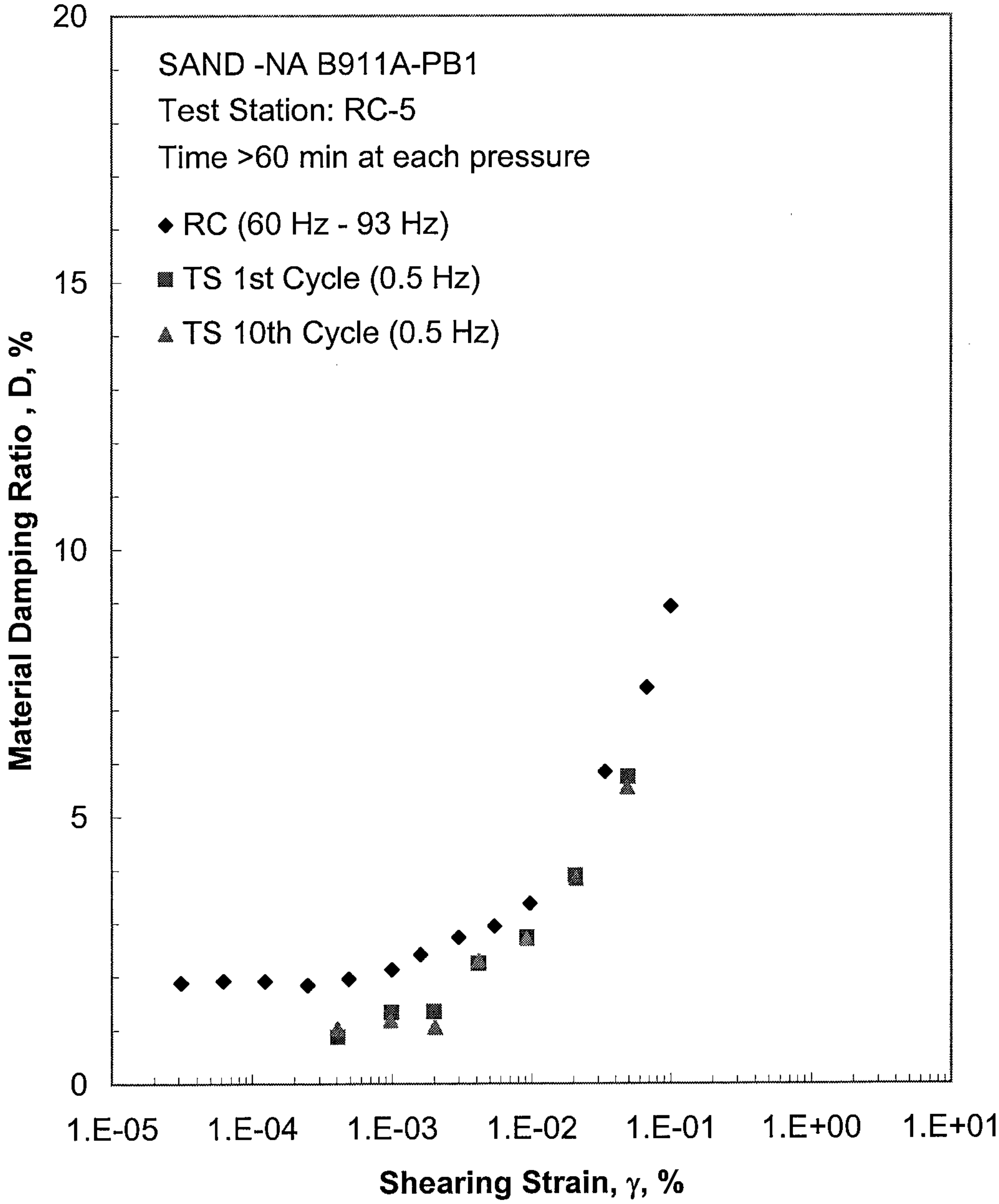


Figure C.18 Comparison of the Variation in Material Damping Ratio with Shearing Strain at an Isotropic Confining Pressure of 45.6 psi from the Combined RCTS Tests

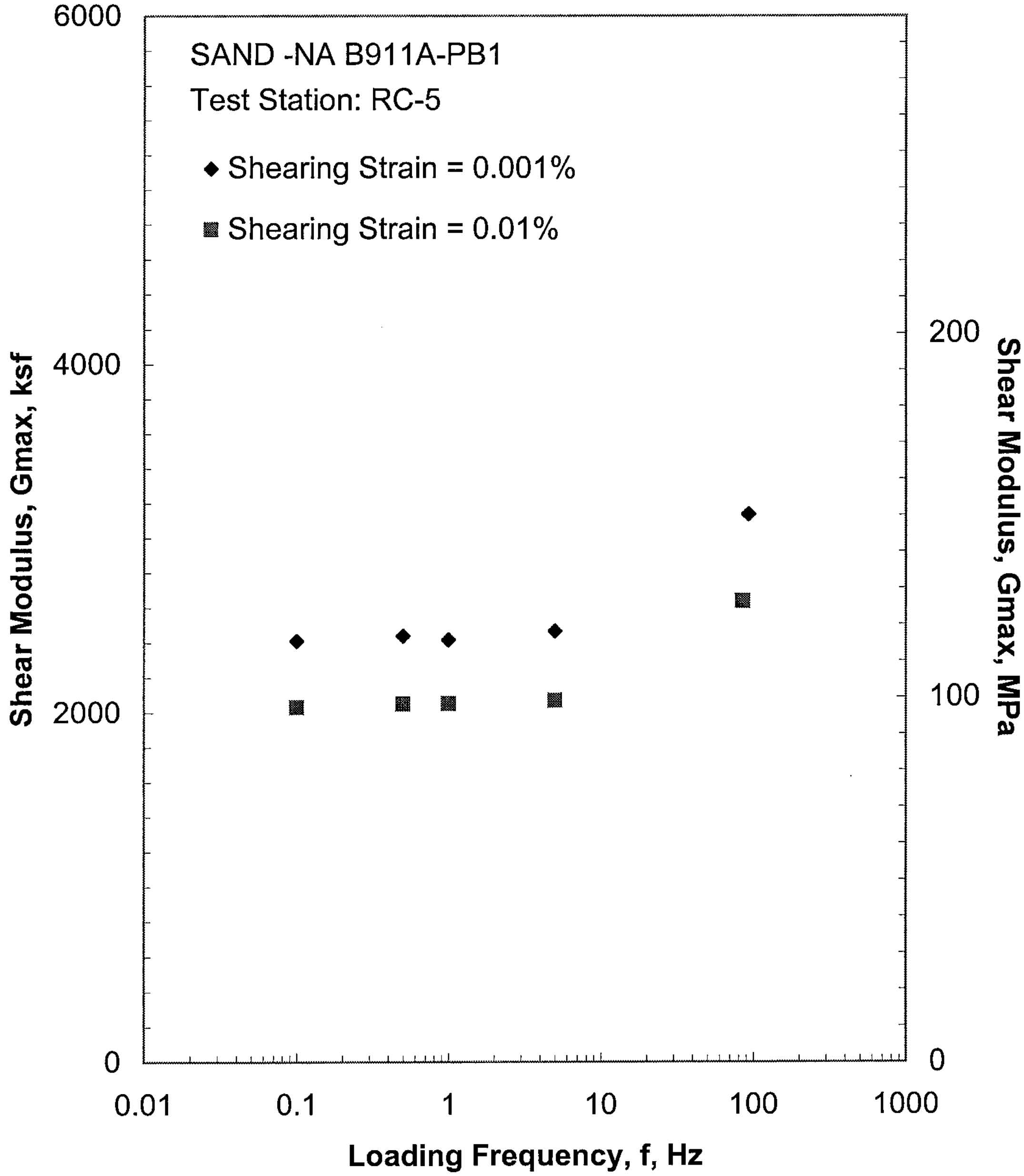


Figure C.19 Comparison of the Variation in Shear Modulus with Loading Frequency at an Isotropic Confining Pressure of 45.6 psi from the Combined RCTS Tests

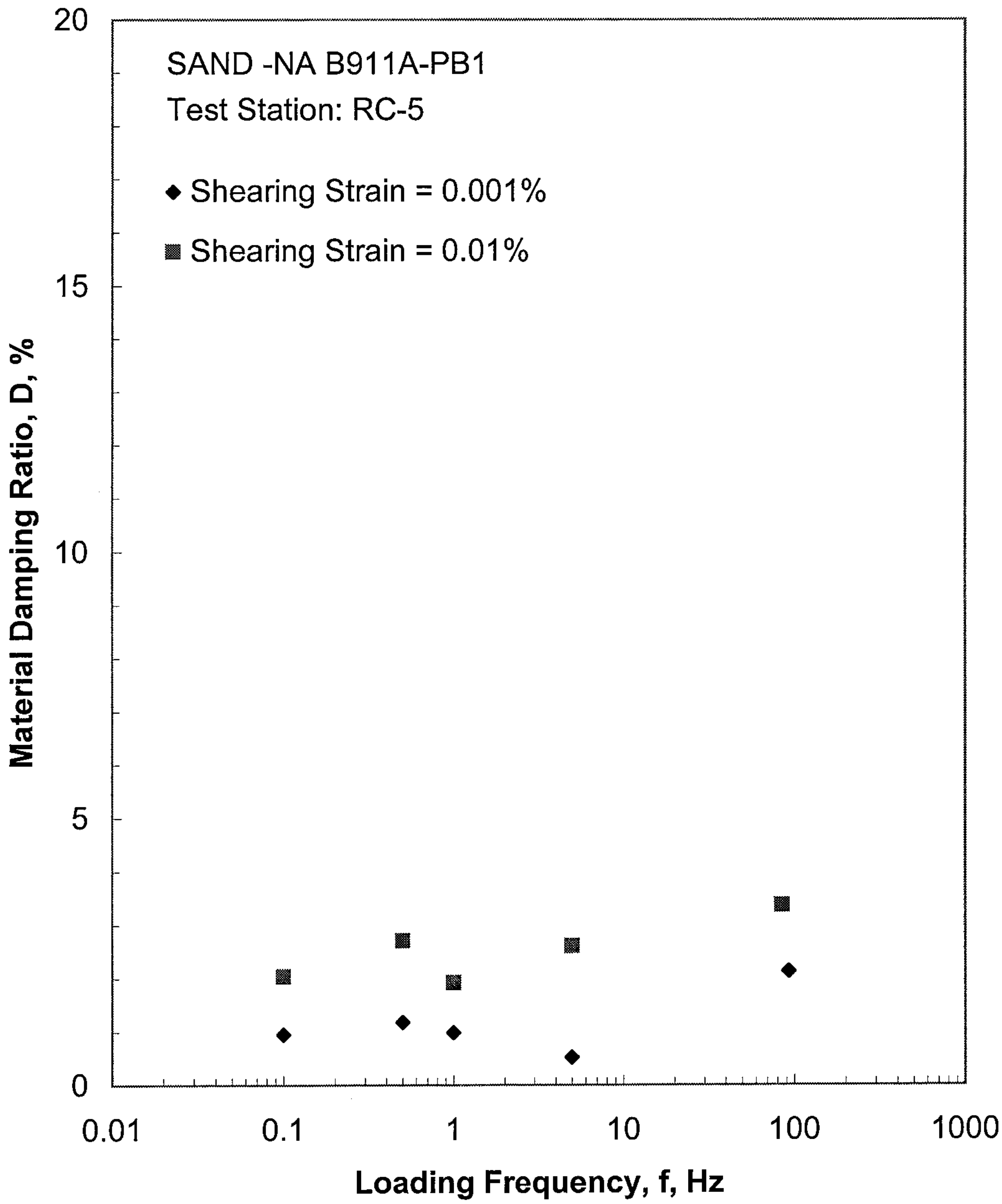


Figure C.20 Comparison of the Variation in Material Damping Ratio with Loading Frequency at an Isotropic Confining Pressure of 45.6 psi from the Combined RCTS Tests

Table C.1 Variation in Low-Amplitude Shear Wave Velocity, Low-Amplitude Shear Modulus, Low-Amplitude Material Damping Ratio and Estimated Void Ratio with Isotropic Confining Pressure from RC Tests of Specimen NA B911A-PB1

Isotropic Confining Pressure, σ_o			Low-Amplitude Shear Modulus, G_{max}		Low-Amplitude Shear Wave Velocity, Vs	Low-Amplitude Material Damping Ratio, Dmin	Estimated Void Ratio, e
(psi)	(psf)	(kPa)	(ksf)	(MPa)	(fps)	(%)	
2.9	418	20	665	32	414	2.36	0.524
5.7	821	39	876	42	474	1.96	0.515
11.4	1642	79	1276	61	569	1.88	0.501
22.8	3283	157	2017	97	710	1.86	0.478
45.6	6566	314	3142	151	879	1.73	0.456

Table C.2 Variation in Shear Modulus and Material Damping Ratio with Shearing Strain from RC Tests of Specimen NA B911A-PB1; Isoptropic Confining Pressure, σ_o= 11.4 psi (1.6 ksf = 79 kPa)

Peak Shearing Strain, %	Shear Modulus, G, ksf	Normalized Shear Modulus, G/G_{max}	Average$^+$ Shearing Strain, %	Material Damping Ratio^x, D, %
1.02E-04	1300	1.00	1.02E-04	1.74
2.10E-04	1300	1.00	2.10E-04	1.71
4.11E-04	1300	1.00	4.11E-04	1.94
8.46E-04	1300	1.00	8.46E-04	1.95
1.62E-03	1272	0.98	1.36E-03	2.25
3.07E-03	1230	0.95	2.55E-03	2.59
5.72E-03	1155	0.89	4.63E-03	2.95
1.06E-02	1067	0.82	8.36E-03	3.34
2.06E-02	930	0.72	1.53E-02	4.40
4.23E-02	776	0.60	2.87E-02	5.92
9.47E-02	613	0.47	5.96E-02	7.89
2.24E-01	468	0.36	1.25E-01	10.44

$^+$ 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 C.3 Variation in Shear Modulus, Normalized Shear Modulus and Material Damping Ratio with Shearing Strain from TS Tests of Specimen NA B911A-PB1; Isotropic Confining Pressure, σ_o = 11.4 psi (1.6 ksf = 79 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, %
2.05E-04	1073	1.00	0.84	1.96E-04	1089	1.00	0.97
3.80E-04	1073	1.00	0.87	3.75E-04	1089	1.00	0.68
9.71E-04	1073	1.00	0.54	9.50E-04	1089	1.00	0.54
1.95E-03	1073	1.00	1.30	1.97E-03	1089	1.00	1.11
4.22E-03	938	0.87	2.47	4.26E-03	930	0.85	2.46
1.02E-02	774	0.72	3.84	1.02E-02	773	0.71	3.77
2.42E-02	650	0.61	5.84	2.46E-02	640	0.59	5.77
6.22E-02	506	0.47	7.96	6.28E-02	501	0.46	7.80

Table C.4 Variation in Shear Modulus and Material Damping Ratio with Shearing Strain from RC Tests of Specimen NA B911A-PB1; Isoptropic Confining Pressure, σ_o= 45.6 psi (6.6 ksf = 314 kPa)

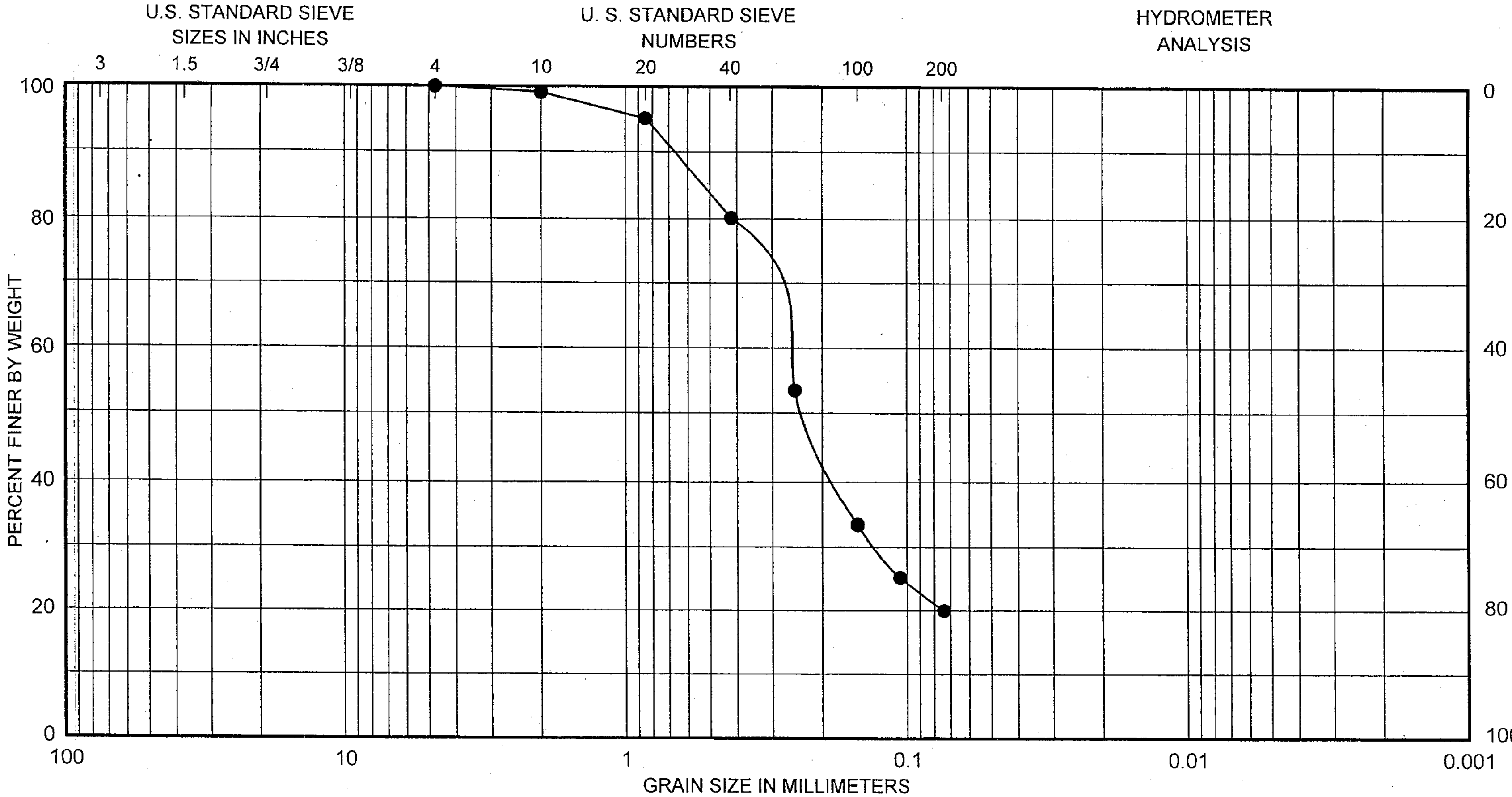
Peak Shearing Strain, %	Shear Modulus, G, ksf	Normalized Shear Modulus, G/G_{max}	Average+ Shearing Strain, %	Material Damping Ratio^x, D, %
3.10E-05	3178	1.00	3.10E-05	1.88
6.20E-05	3178	1.00	6.20E-05	1.92
1.23E-04	3178	1.00	1.23E-04	1.91
2.47E-04	3178	1.00	2.47E-04	1.84
4.89E-04	3178	1.00	4.89E-04	1.95
9.92E-04	3137	0.99	9.92E-04	2.13
1.90E-03	3069	0.97	1.60E-03	2.41
3.56E-03	2951	0.93	2.99E-03	2.73
6.60E-03	2779	0.87	5.41E-03	2.94
1.23E-02	2543	0.80	9.73E-03	3.37
4.84E-02	1887	0.59	3.39E-02	5.83
1.04E-01	1523	0.48	6.77E-02	7.41
1.65E-01	1330	0.42	1.01E-01	8.92

+ 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 C.5 Variation in Shear Modulus, Normalized Shear Modulus and Material Damping Ratio with Shearing Strain from TS Tests of Specimen NA B911A-PB1; Isotropic Confining Pressure, σ_o=45.6 psi (6.6 ksf = 314 kPa)

First Cycle				Tenth Cycle			
Peak Shearing Strain, %	Shear Modulus, G, ksf	Normalized Shear Modulus,	Material Damping Ratio, D,	Peak Shearing Strain, %	Shear Modulus, G, ksf	Normalized Shear Modulus,	Material Damping Ratio, D, %
4.07E-04	2396	1.00	0.87	4.06E-04	2409	1.00	1.03
9.86E-04	2396	1.00	1.33	9.75E-04	2409	1.00	1.18
1.99E-03	2378	0.99	1.34	2.02E-03	2342	0.97	1.05
4.13E-03	2283	0.95	2.24	4.16E-03	2265	0.94	2.29
9.22E-03	2044	0.85	2.73	9.18E-03	2051	0.85	2.71
2.06E-02	1825	0.76	3.89	2.08E-02	1810	0.75	3.83
4.94E-02	1527	0.64	5.74	4.88E-02	1547	0.64	5.54



Report No. 0401-1662

GRAVEL		SAND			SILT or CLAY
Coarse	Fine	Coarse	Medium	Fine	

SYMBOL	BORING	DEPTH, FT	C_c	C_u	D_{50}	D_{90}	CLASSIFICATION
●	B-911A-PB1	21.7			0.2285	0.67	Sand, tan

GRAIN SIZE CURVE

TEST METHOD ASTM D 6913-04

PLATE 1