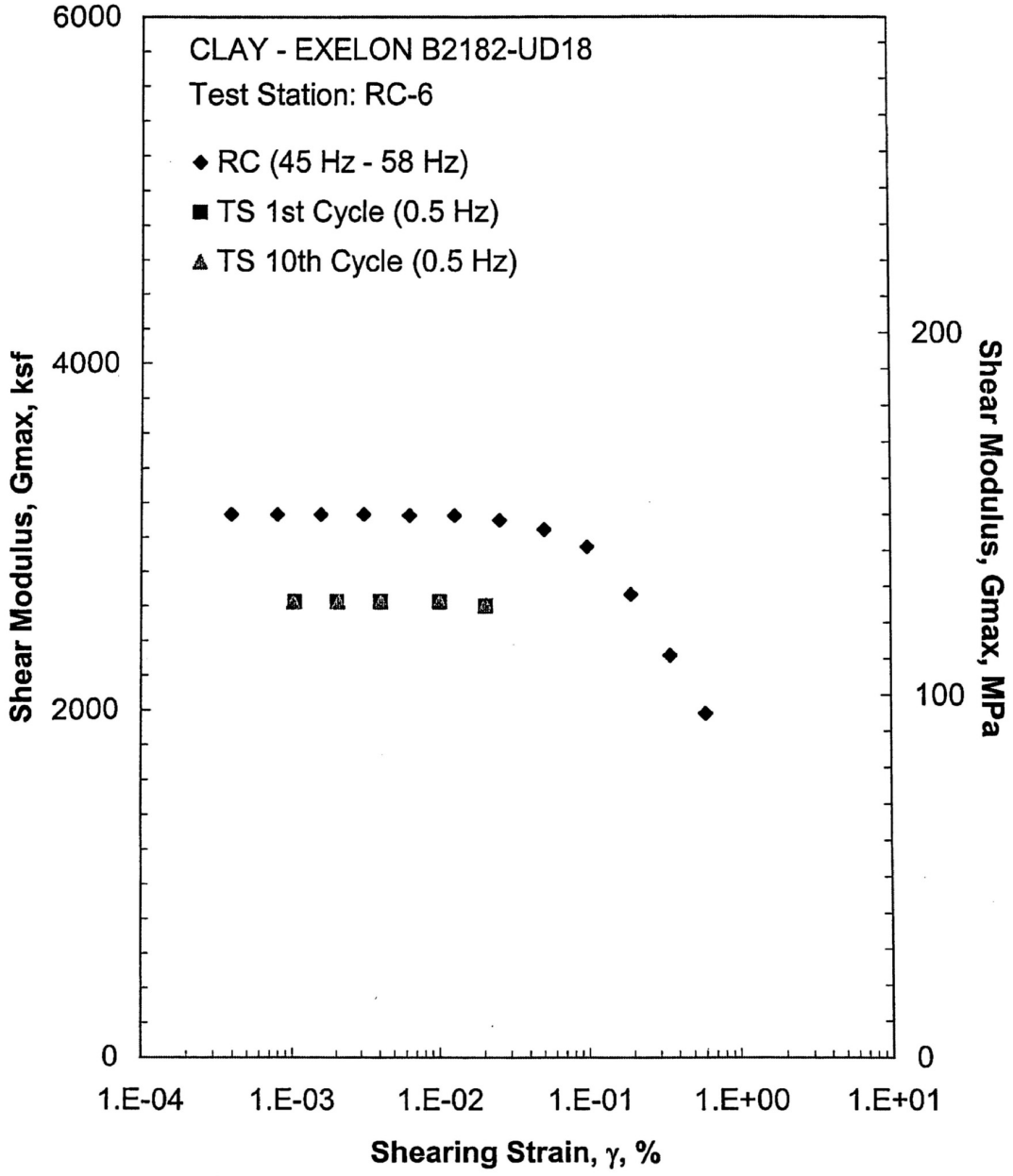


**Figure D.16 Comparison of the Variation in Shear Modulus with Shearing Strain at an Isotropic Confining Pressure of 310 psi from the Combined RCTS Tests**

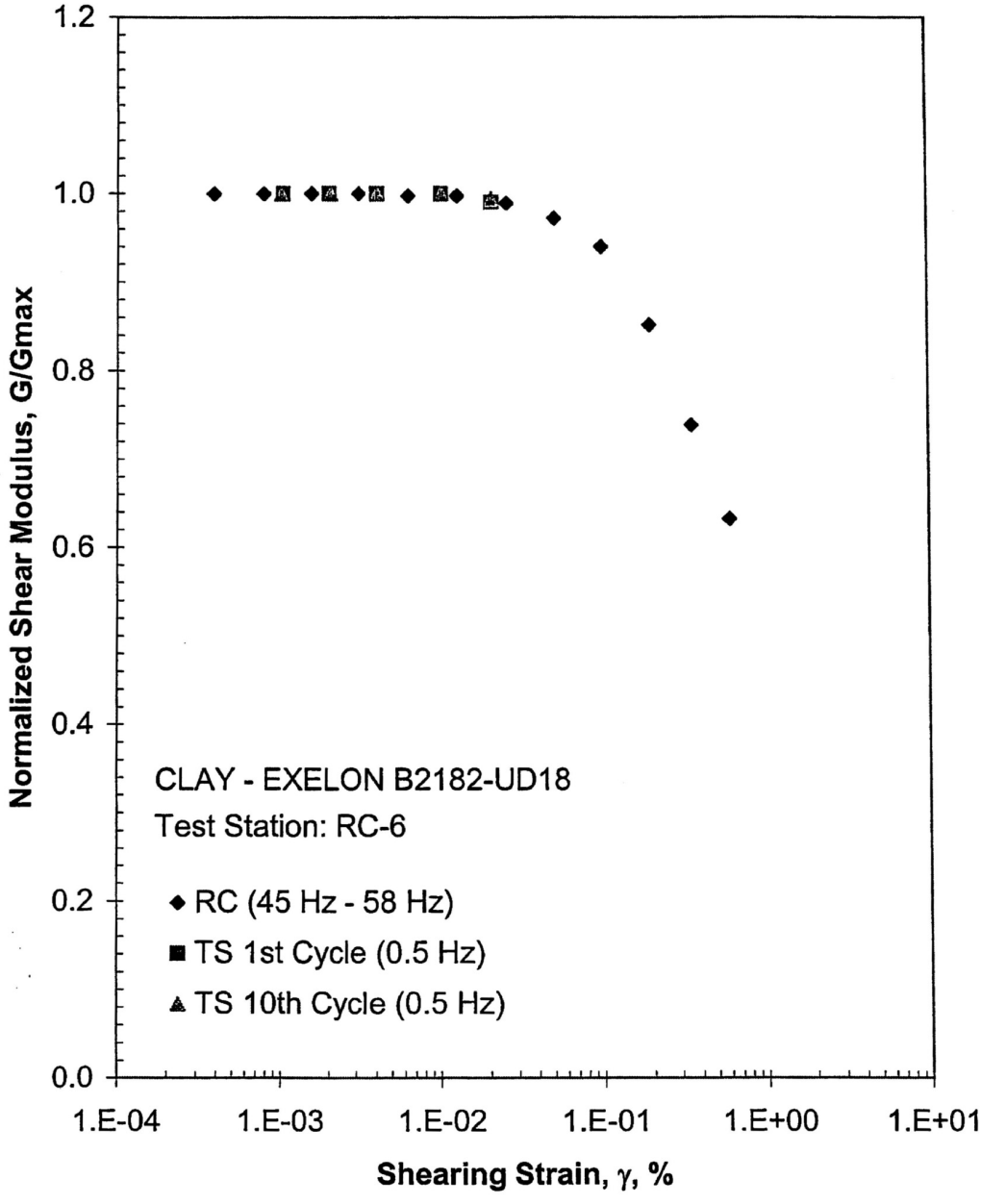


**Figure D.17 Comparison of the Variation in Normalized Shear Modulus with Shearing Strain at an Isotropic Confining Pressure of 310 psi from the Combined RCTS Tests**

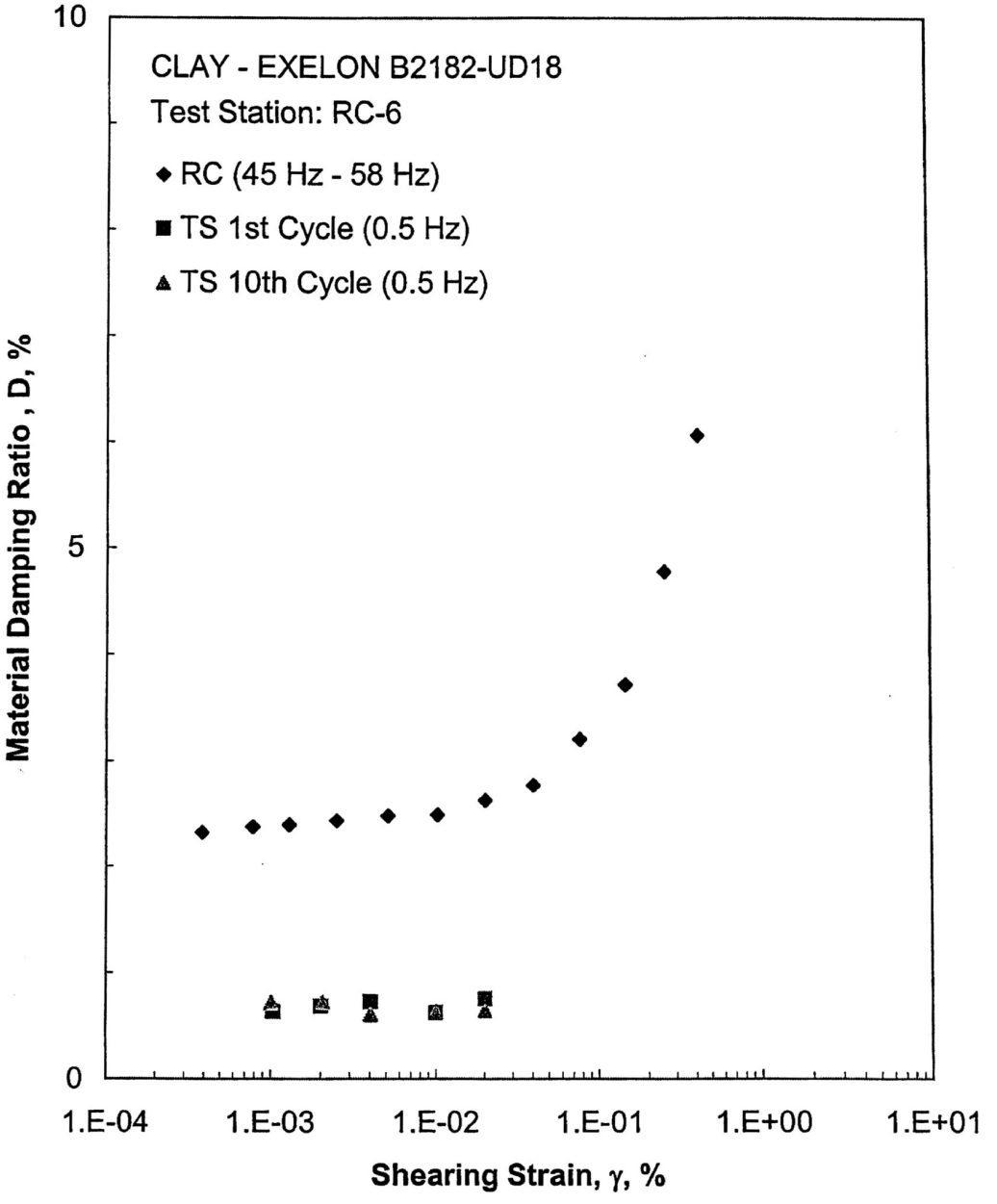


**Figure D.18 Comparison of the Variation in Material Damping Ratio with Shearing Strain at an Isotropic Confining Pressure of 310 psi from the Combined RCTS Tests**

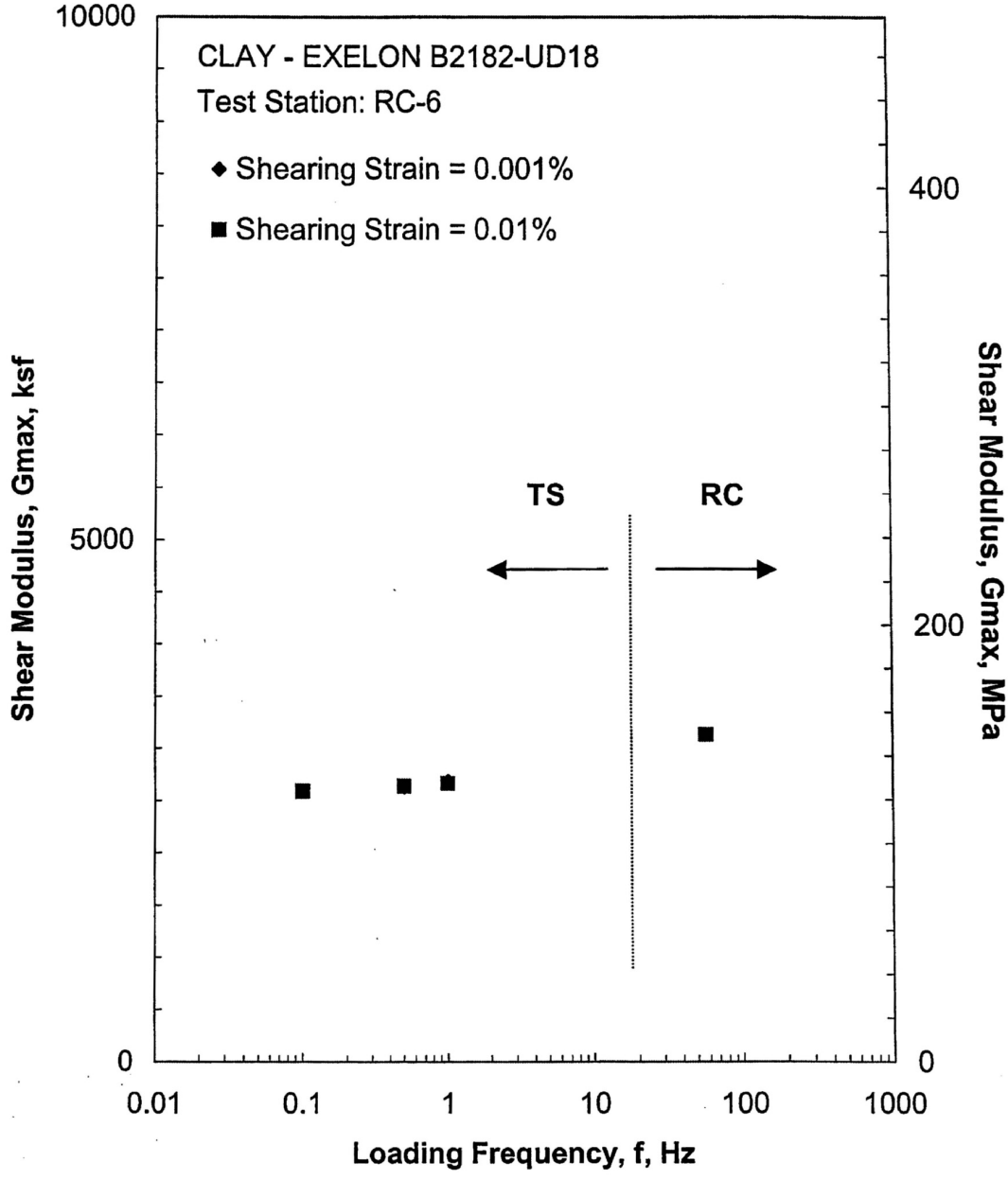


**Figure D.19 Comparison of the Variation in Shear Modulus with Loading Frequency at an Isotropic Confining Pressure of 310 psi from the Combined RCTS Tests**

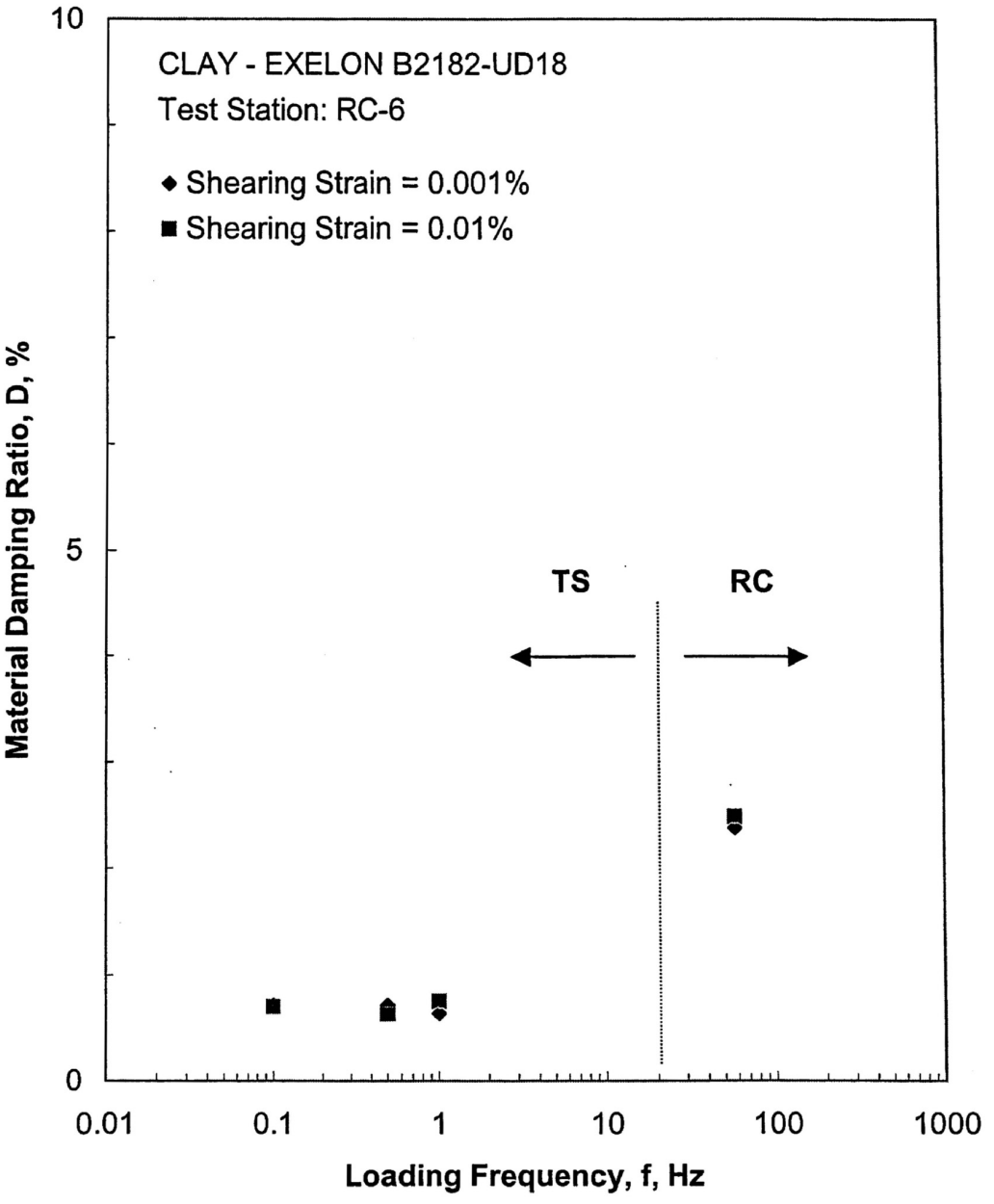


**Figure D.20 Comparison of the Variation in Material Damping Ratio with Loading Frequency at an Isotropic Confining Pressure of 310 psi from the Combined RCTS Tests**

Table D.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 EXELON B2182-UD18

| Isotropic Confining Pressure, $\sigma_o$ | | | 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) | (%) | |
| 19 | 2736 | 131 | 2002 | 96 | 746 | 2.81 | 1.01 |
| 39 | 5616 | 269 | 2138 | 103 | 770 | 2.64 | 1.00 |
| 78 | 11232 | 537 | 2238 | 107 | 785 | 2.48 | 0.98 |
| 155 | 22320 | 1068 | 2566 | 123 | 836 | 2.37 | 0.96 |
| 310 | 44640 | 2136 | 3002 | 144 | 887 | 2.28 | 0.89 |

Table D.2 Variation in Shear Modulus and Material Damping Ratio with Shearing Strain from RC Tests of Specimen EXELON B2182-UD18; Isoptropic Confining Pressure, $\sigma_o$=78 psi (11.2 ksf = 537 kPa)

| Peak Shearing Strain, % | Shear Modulus, G, ksf | Normalized Shear Modulus, $G/G_{max}$ | Average+ Shearing Strain, % | Material Damping Ratio^x, D, % |
|---|---|---|---|---|
| 2.66E-04 | 2272 | 1.00 | 2.66E-04 | 2.43 |
| 5.48E-04 | 2272 | 1.00 | 5.48E-04 | 2.46 |
| 1.08E-03 | 2260 | 0.99 | 1.08E-03 | 2.48 |
| 2.18E-03 | 2260 | 0.99 | 2.18E-03 | 2.56 |
| 4.39E-03 | 2260 | 0.99 | 3.51E-03 | 2.62 |
| 8.79E-03 | 2261 | 0.99 | 7.03E-03 | 2.74 |
| 1.76E-02 | 2238 | 0.99 | 1.46E-02 | 2.89 |
| 3.49E-02 | 2238 | 0.98 | 2.79E-02 | 3.13 |
| 6.95E-02 | 2154 | 0.95 | 5.35E-02 | 3.61 |
| 1.34E-01 | 1963 | 0.86 | 1.00E-01 | 4.21 |
| 2.31E-01 | 1734 | 0.76 | 1.64E-01 | 5.21 |
| 3.73E-01 | 1529 | 0.67 | 2.54E-01 | 6.38 |

+ 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 D.3 Variation in Shear Modulus, Normalized Shear Modulus and Material Damping Ratio with Shearing Strain from TS Tests of Specimen EXELON B2182-UD18; Isotropic Confining Pressure, $\sigma_o$= 78 psi (11.2 ksf =537 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, % |
| 1.01E-03 | 1854 | 1.00 | 0.56 | 1.00E-03 | 1851 | 1.00 | 0.46 |
| 2.02E-03 | 1854 | 1.00 | 0.61 | 2.04E-03 | 1851 | 1.00 | 0.50 |
| 3.97E-03 | 1854 | 1.00 | 0.59 | 4.00E-03 | 1851 | 1.00 | 0.60 |
| 1.02E-02 | 1854 | 1.00 | 0.70 | 1.02E-02 | 1851 | 1.00 | 0.79 |

Table D.4 Variation in Shear Modulus and Material Damping Ratio with Shearing Strain from RC Tests of Specimen EXELON B2182-UD18; Isoptropic Confining Pressure, $\sigma_o$= 310 psi (44.6 ksf = 2136 kPa)

| Peak Shearing Strain, % | Shear Modulus, G, ksf | Normalized Shear Modulus, $G/G_{max}$ | Average[+] Shearing Strain, % | Material Damping Ratio[x], D, % |
|---|---|---|---|---|
| 3.89E-04 | 3135 | 1.00 | 3.89E-04 | 2.32 |
| 7.88E-04 | 3135 | 1.00 | 7.88E-04 | 2.38 |
| 1.57E-03 | 3135 | 1.00 | 1.30E-03 | 2.40 |
| 3.10E-03 | 3135 | 1.00 | 2.51E-03 | 2.43 |
| 6.27E-03 | 3128 | 1.00 | 5.14E-03 | 2.48 |
| 1.25E-02 | 3128 | 1.00 | 1.03E-02 | 2.49 |
| 2.52E-02 | 3100 | 0.99 | 2.04E-02 | 2.63 |
| 5.02E-02 | 3046 | 0.97 | 4.06E-02 | 2.77 |
| 9.79E-02 | 2947 | 0.94 | 7.73E-02 | 3.20 |
| 1.93E-01 | 2669 | 0.85 | 1.47E-01 | 3.72 |
| 3.55E-01 | 2315 | 0.74 | 2.56E-01 | 4.78 |
| 6.03E-01 | 1982 | 0.63 | 4.22E-01 | 6.06 |

[+] 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 D.5 Variation in Shear Modulus, Normalized Shear Modulus and Material Damping Ratio with Shearing Strain from TS Tests of Specimen EXELON B2182-UD18; Isotropic Confining Pressure, $\sigma_o$=310 psi (44.6 ksf = 2136 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, % |
| 1.04E-03 | 2627 | 1.00 | 0.63 | 1.01E-03 | 2626 | 1.00 | 0.72 |
| 2.02E-03 | 2627 | 1.00 | 0.68 | 2.06E-03 | 2626 | 1.00 | 0.72 |
| 4.04E-03 | 2627 | 1.00 | 0.72 | 4.04E-03 | 2626 | 1.00 | 0.60 |
| 9.98E-03 | 2627 | 1.00 | 0.62 | 1.00E-02 | 2626 | 1.00 | 0.63 |
| 2.03E-02 | 2602 | 0.99 | 0.75 | 2.02E-02 | 2610 | 0.99 | 0.64 |

# APPENDIX E

Specimen B2182-UD9
(Index Properties Not Available)

Borehole B2182
Sample UD9
Depth = 85.8 ft (26.2)
Total Unit Weight = 115.0 lb/ft$^3$
Water Content = 35.1 %
Estimated In-Situ Ko = 0.5
Estimated In-Situ Mean Effective
Stress = 39 psi

FUGRO JOB #: 0401-1686
Testing Station: RC5

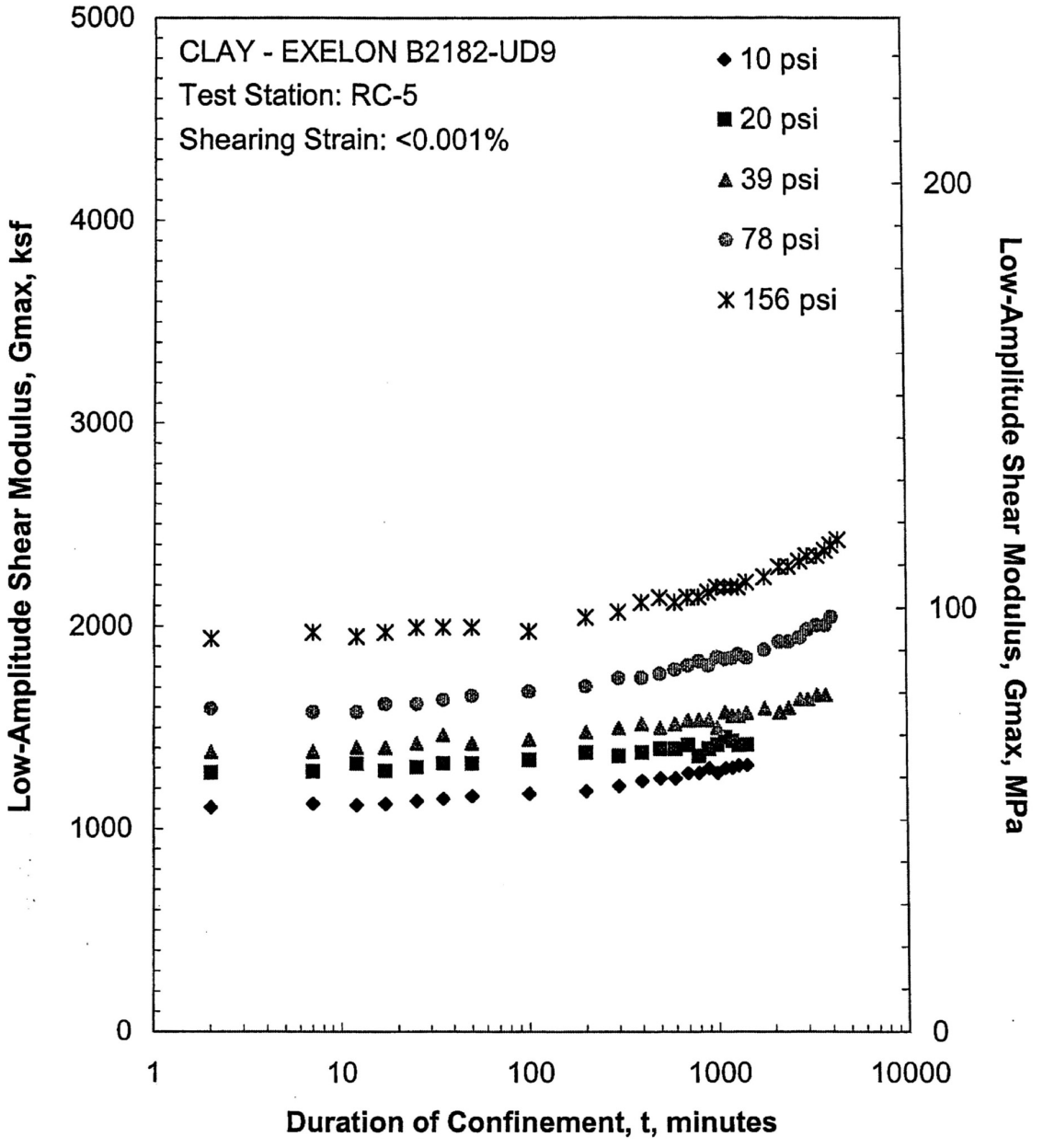


**Figure E.1 Variation in Low-Amplitude Shear Modulus with Magnitude and Duration of Isotropic Confining Pressure from Resonant Column Tests**

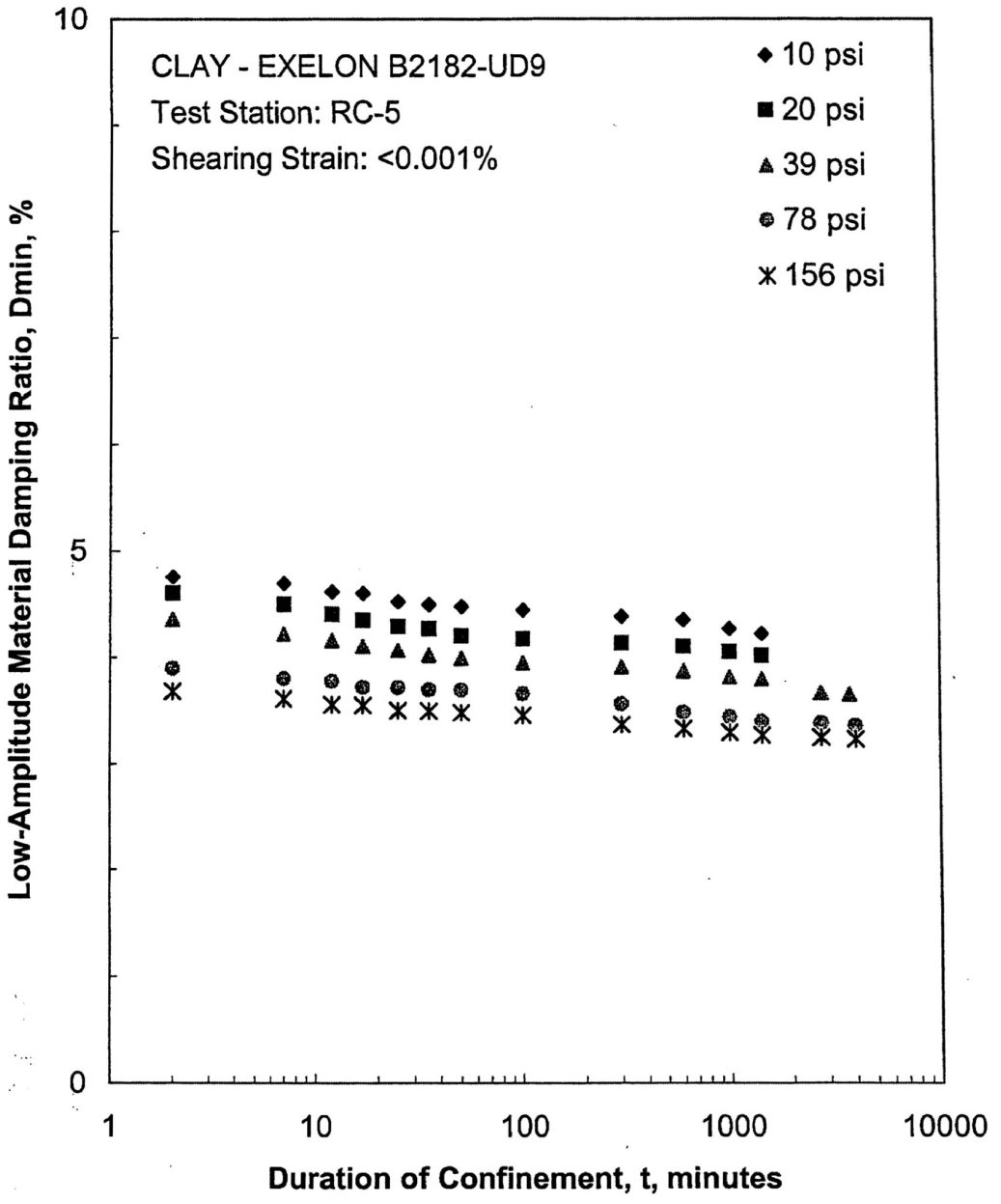


**Figure E.2 Variation in Low-Amplitude Material Damping Ratio with Magnitude and Duration of Isotropic Confining Pressure from Resonant Column Tests**

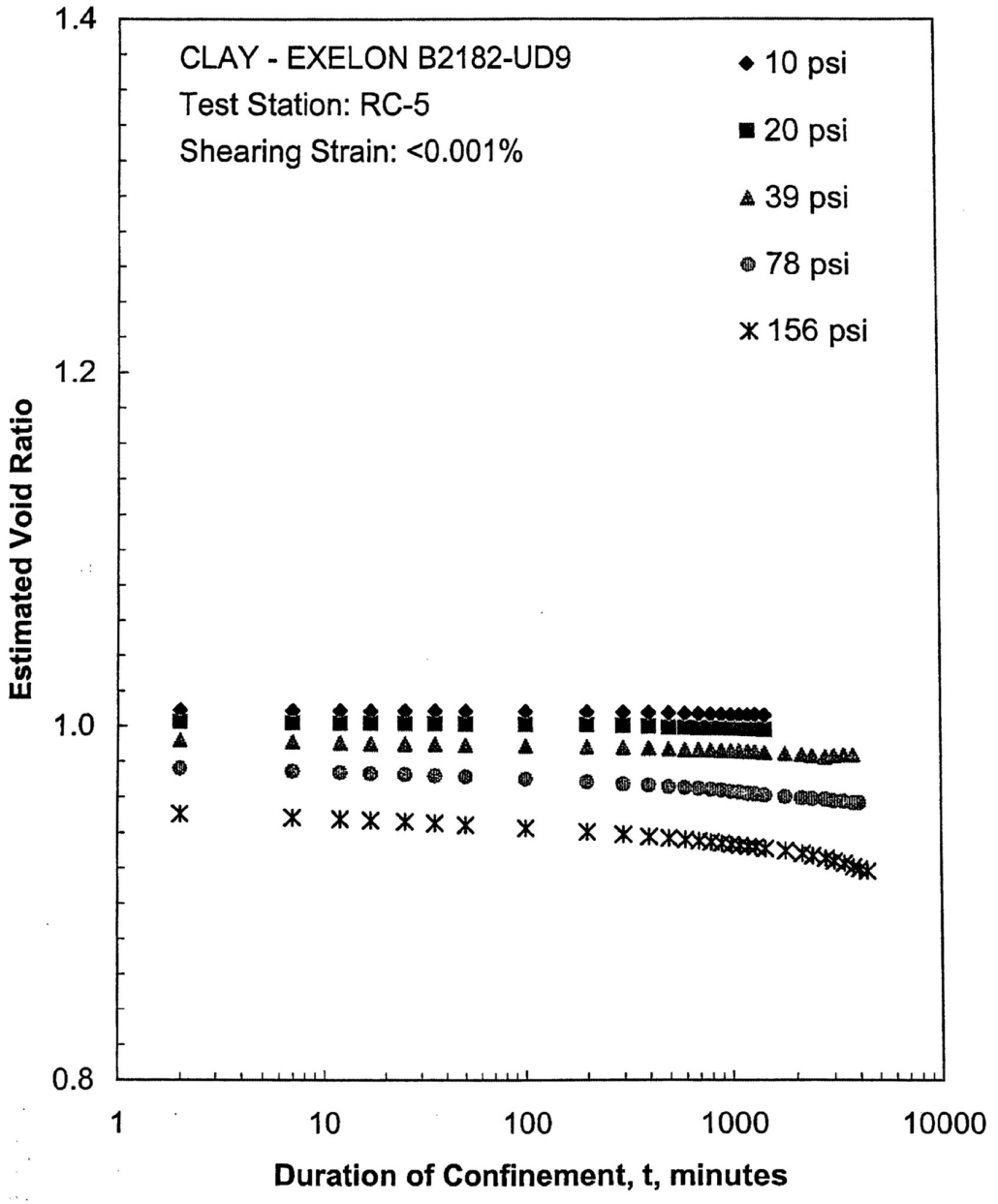


**Figure E.3 Variation in Estimated Void Ratio with Magnitude and Duration of Isotropic Confining Pressure from Resonant Column Tests**

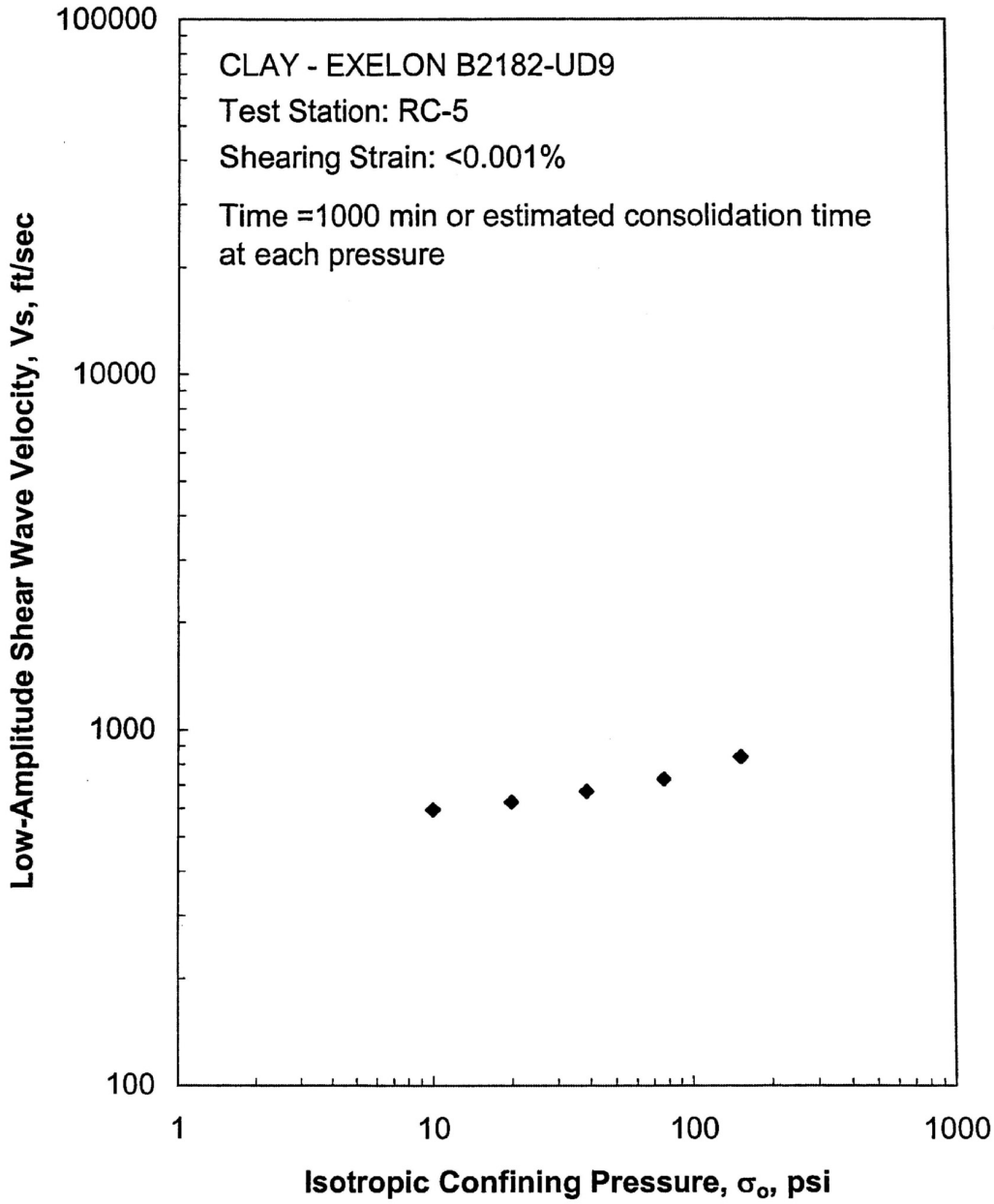


**Figure E.4 Variation in Low-Amplitude Shear Wave Velocity with Isotropic Confining Pressure from Resonant Column Tests**

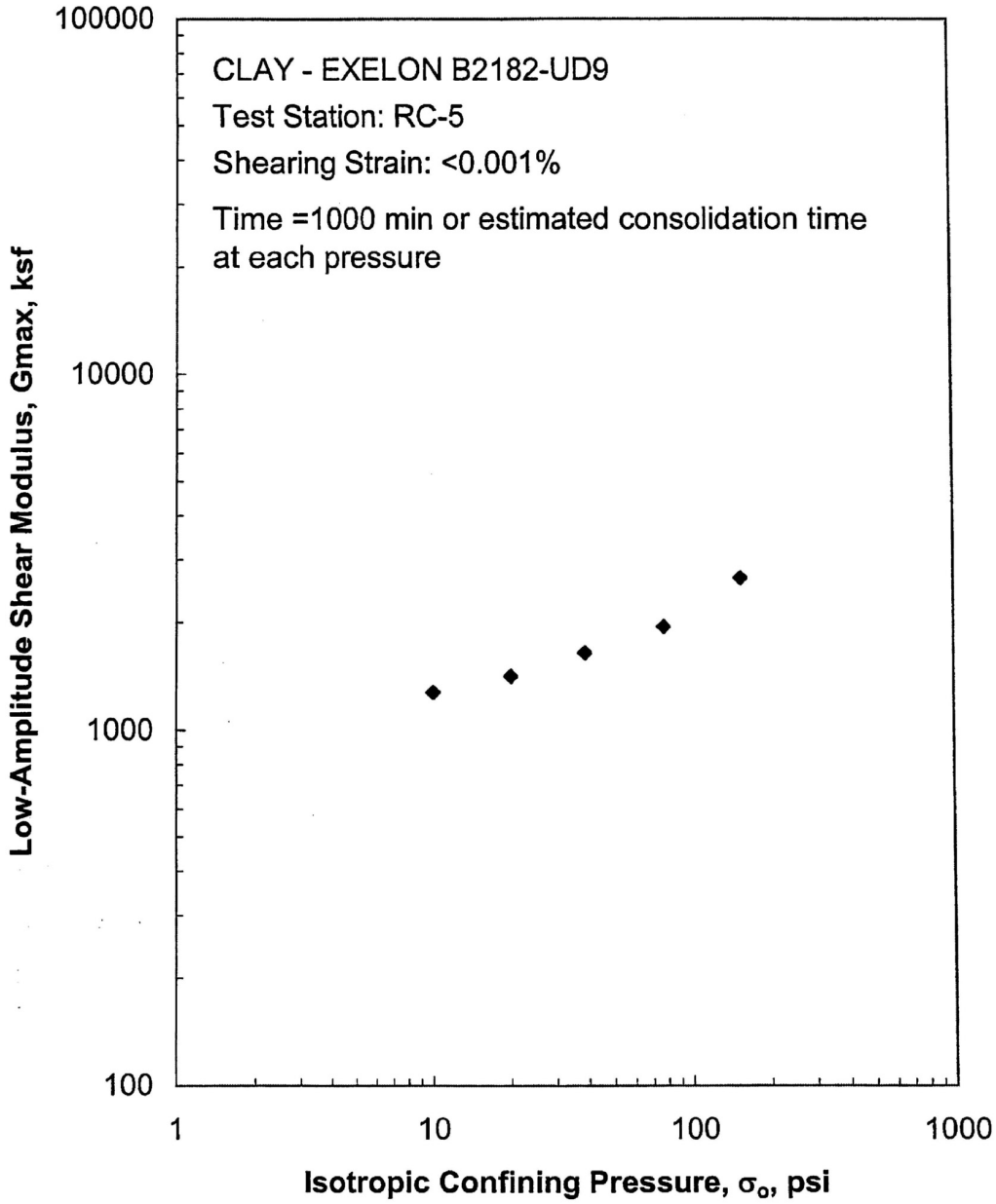


**Figure E.5 Variation in Low-Amplitude Shear Modulus with Isotropic Confining Pressure from Resonant Column Tests**

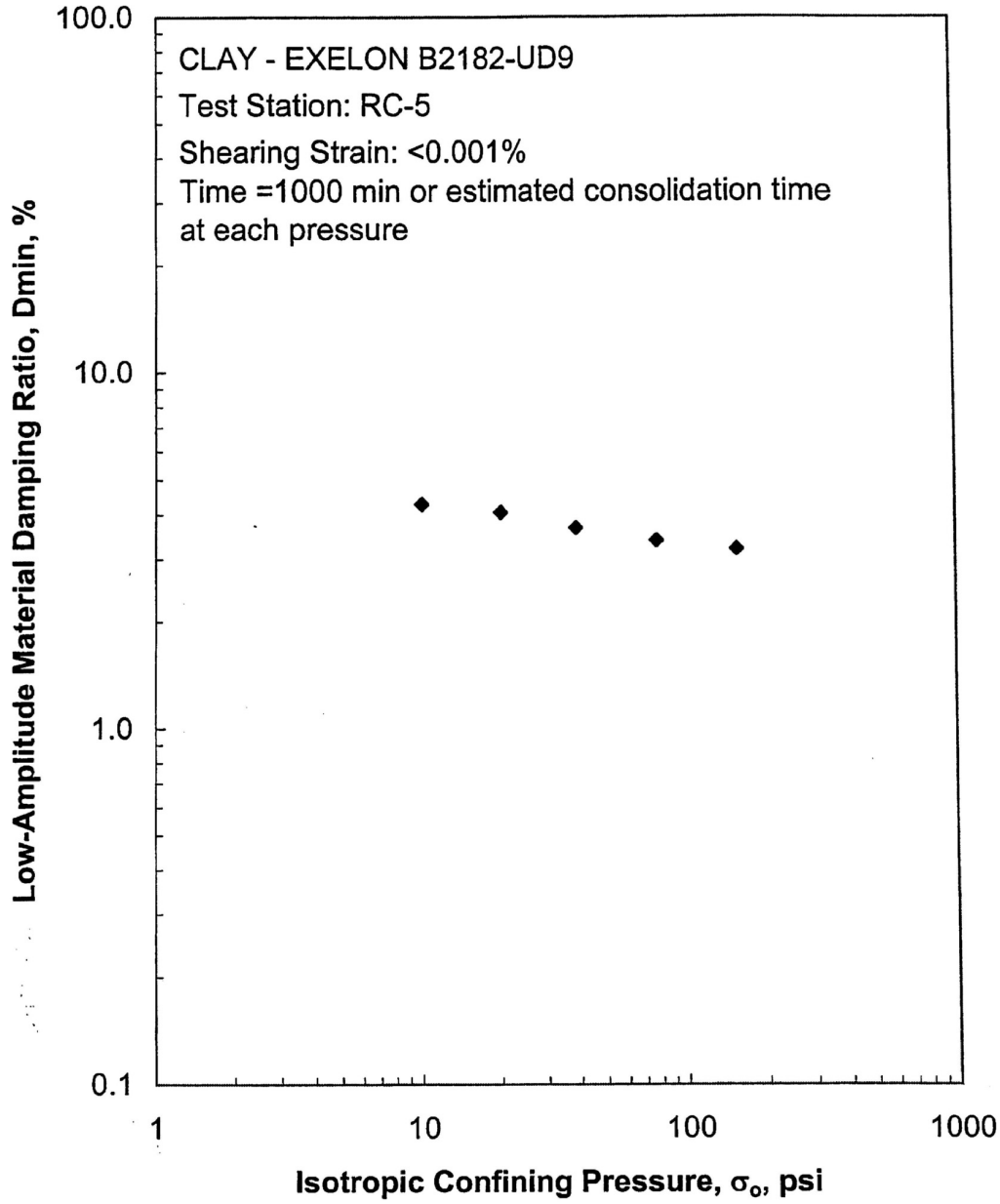


**Figure E.6 Variation in Low-Amplitude Material Damping Ratio with Isotropic Confining Pressure from Resonant Column Tests**

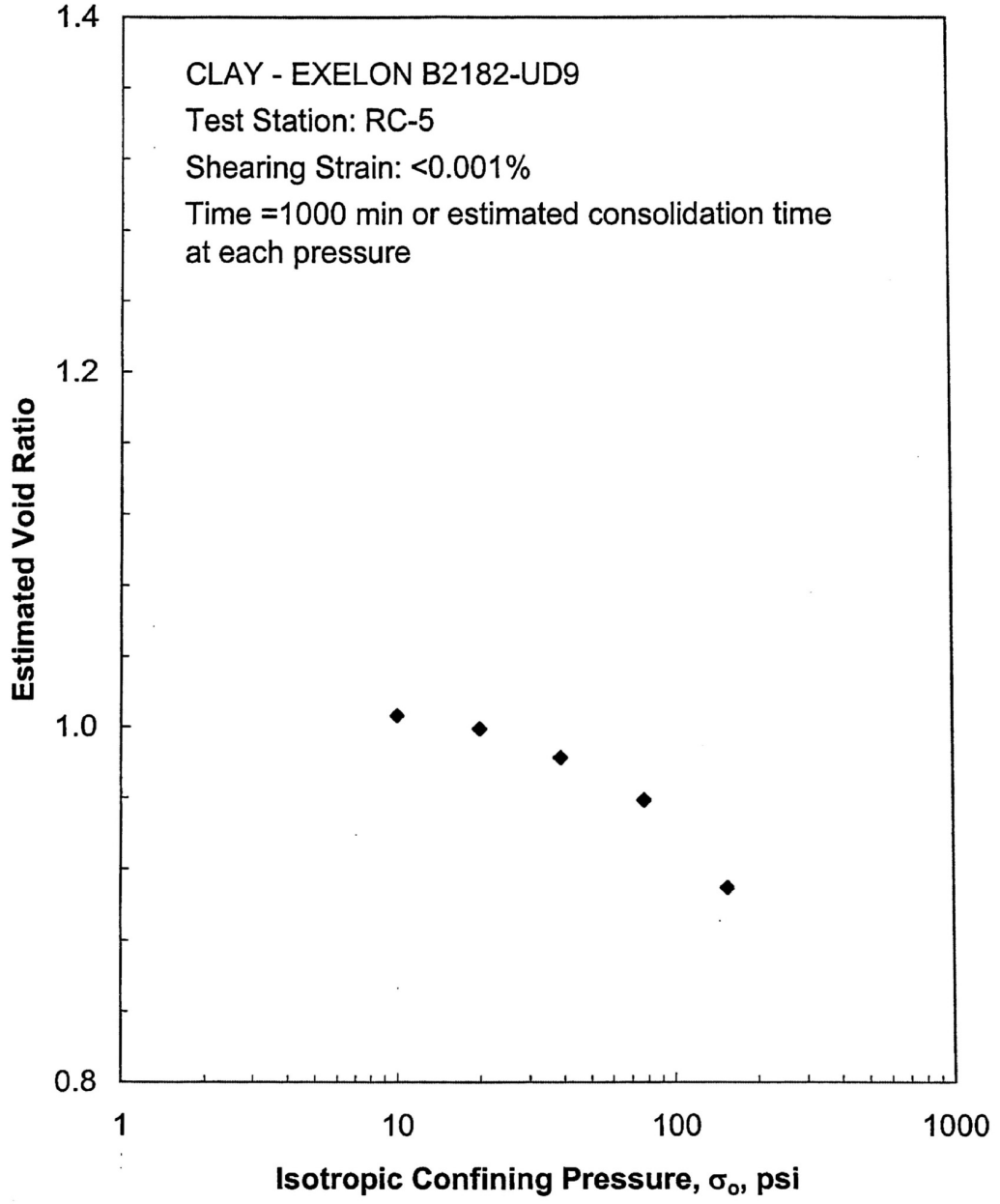


**Figure E.7 Variation in Estimated Void Ratio with Isotropic Confining Pressure from Resonant Column Tests**

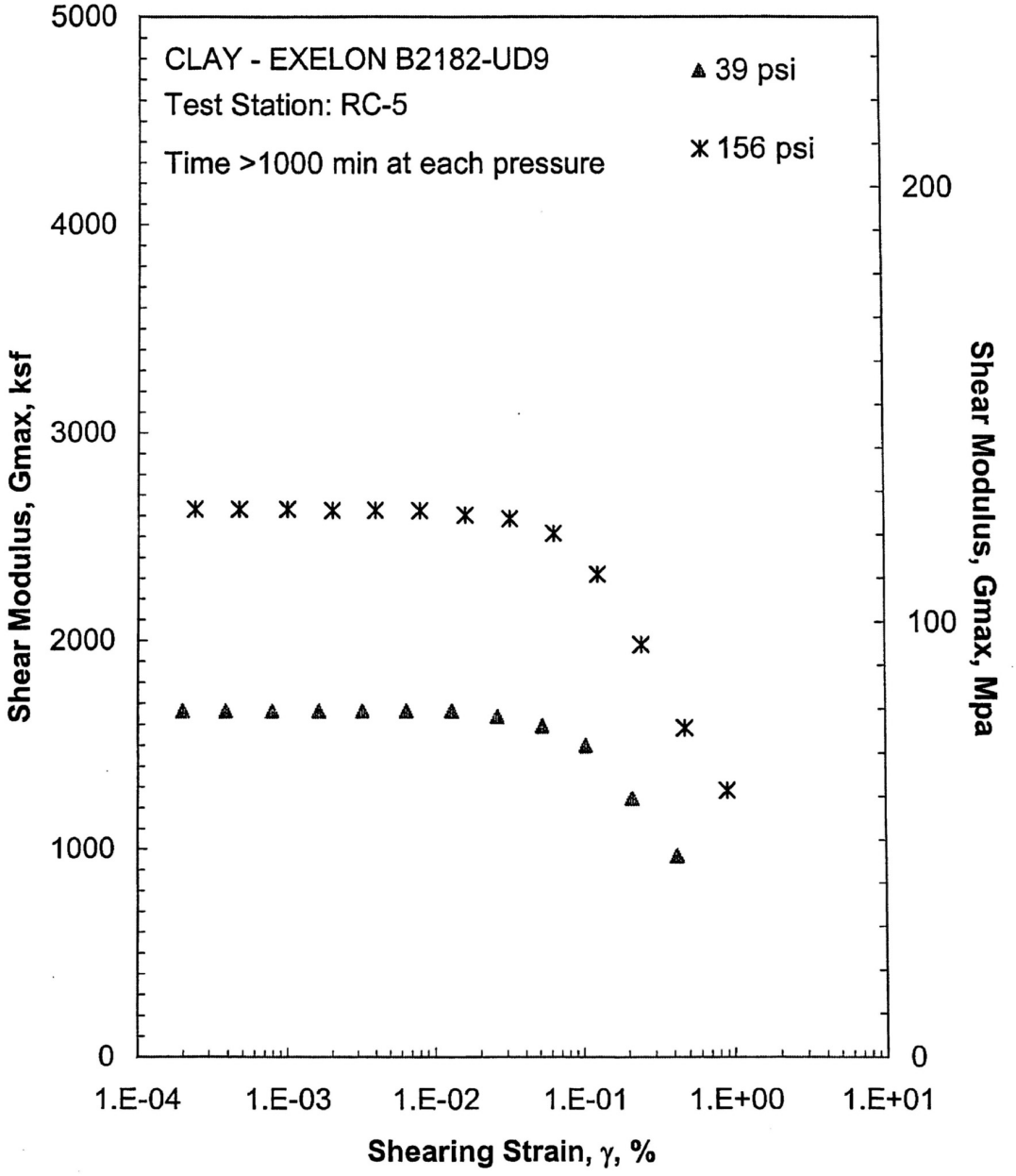


**Figure E.8 Comparison of the Variation in Shear Modulus with Shearing Strain and Isotropic Confining Pressure from the Resonant Column Tests**

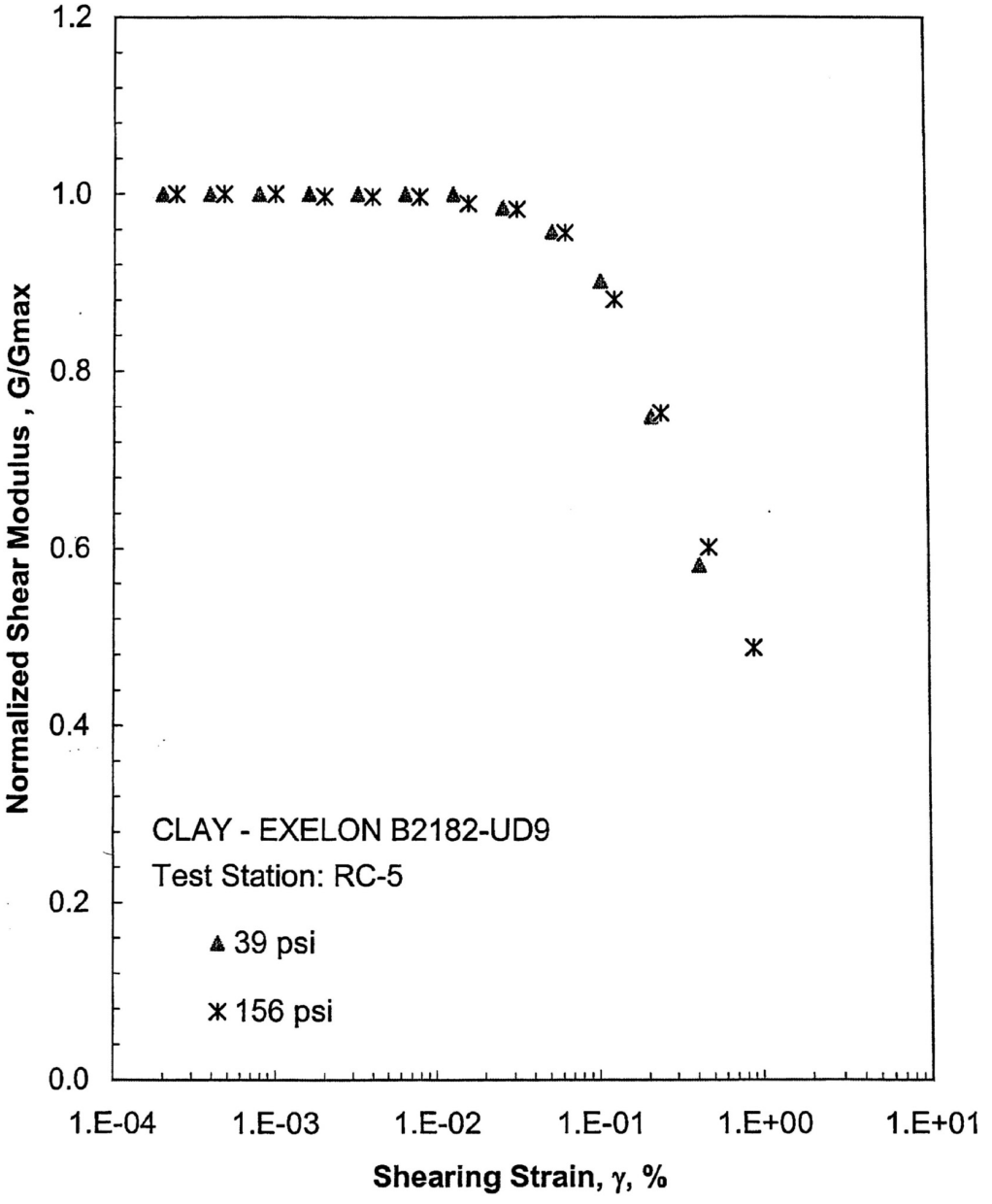


**Figure E.9 Comparison of the Variation in Normalized Shear Modulus with Shearing Strain and Isotropic Confining Pressure from the Resonant Column Tests**

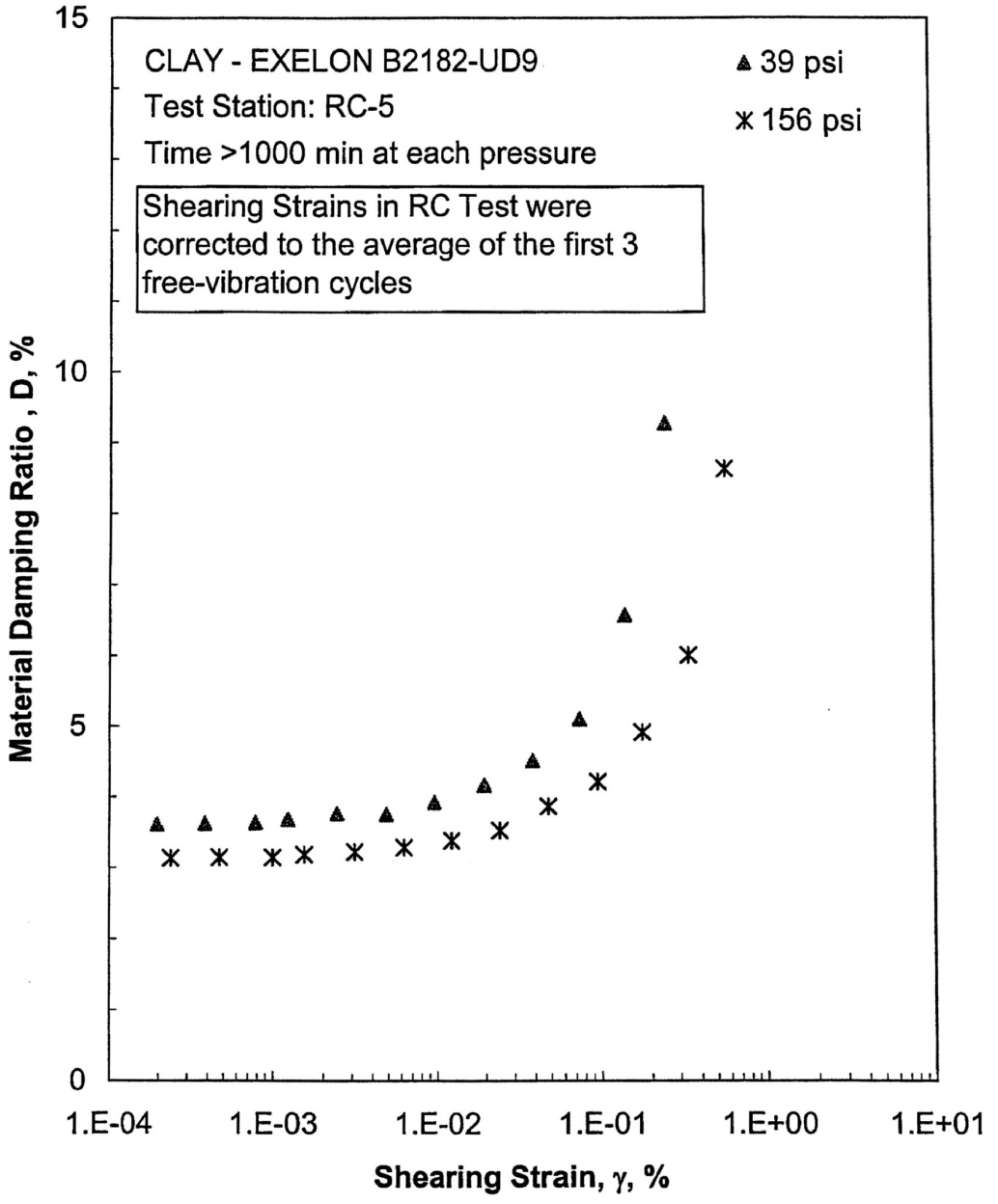


**Figure E.10 Comparison of the Variation in Material Damping Ratio with Shearing Strain and Isotropic Confining Pressure from the Resonant Column Tests**

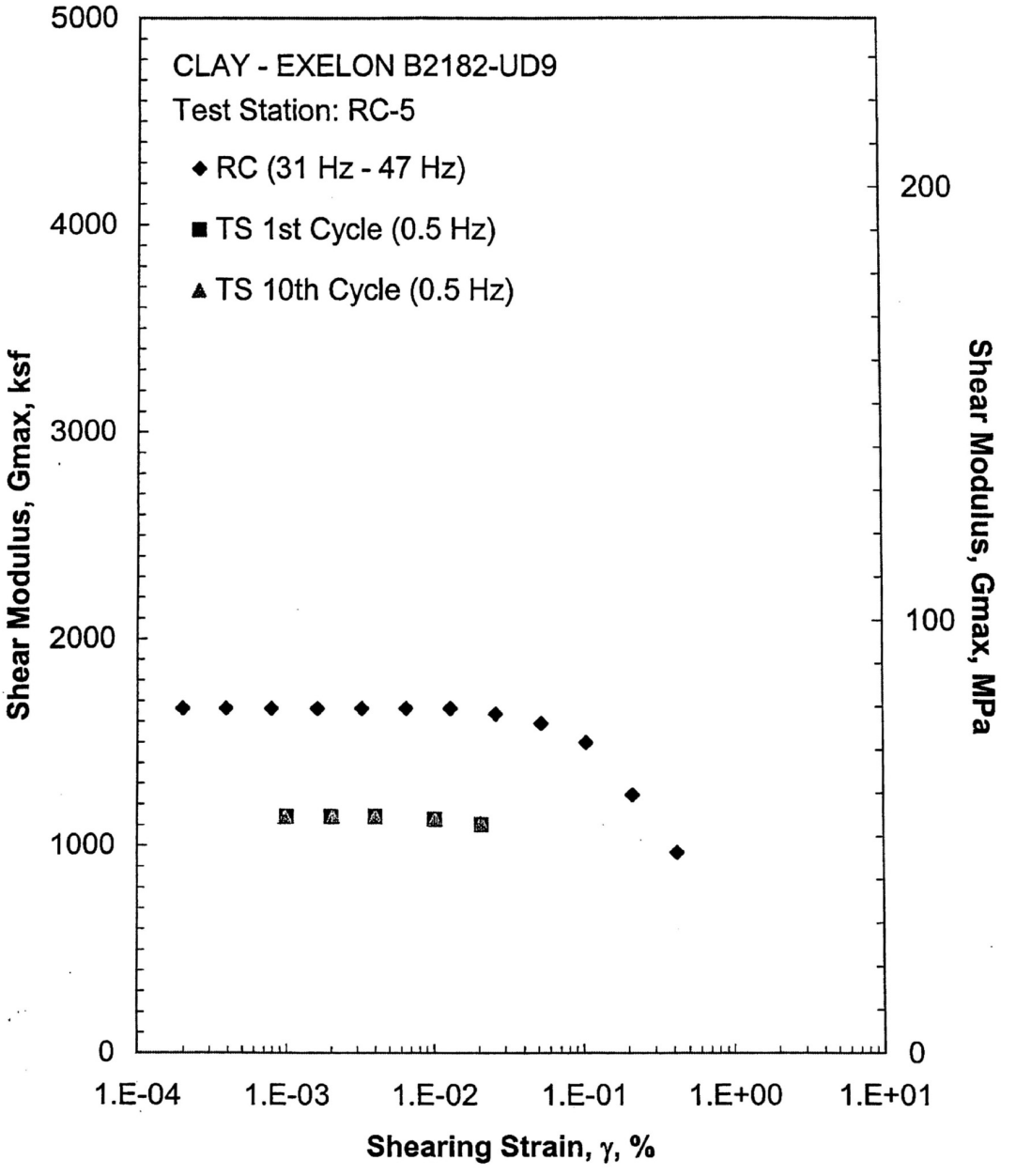


**Figure E.11 Comparison of the Variation in Shear Modulus with Shearing Strain at an Isotropic Confining Pressure of 39 psi from the Combined RCTS Tests**

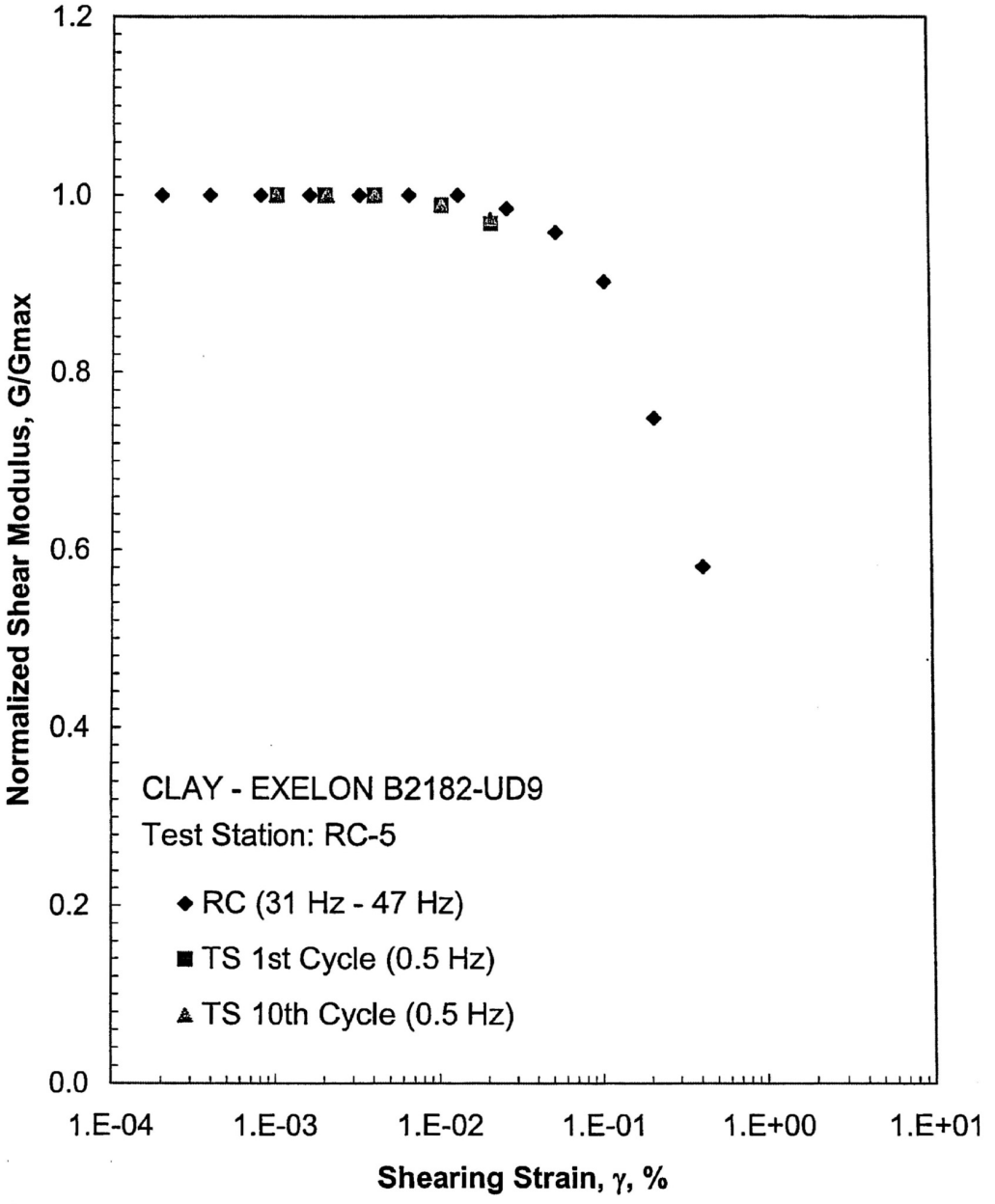


**Figure E.12 Comparison of the Variation in Normalized Shear Modulus with Shearing Strain at an Isotropic Confining Pressure of 39 psi from the Combined RCTS Tests**

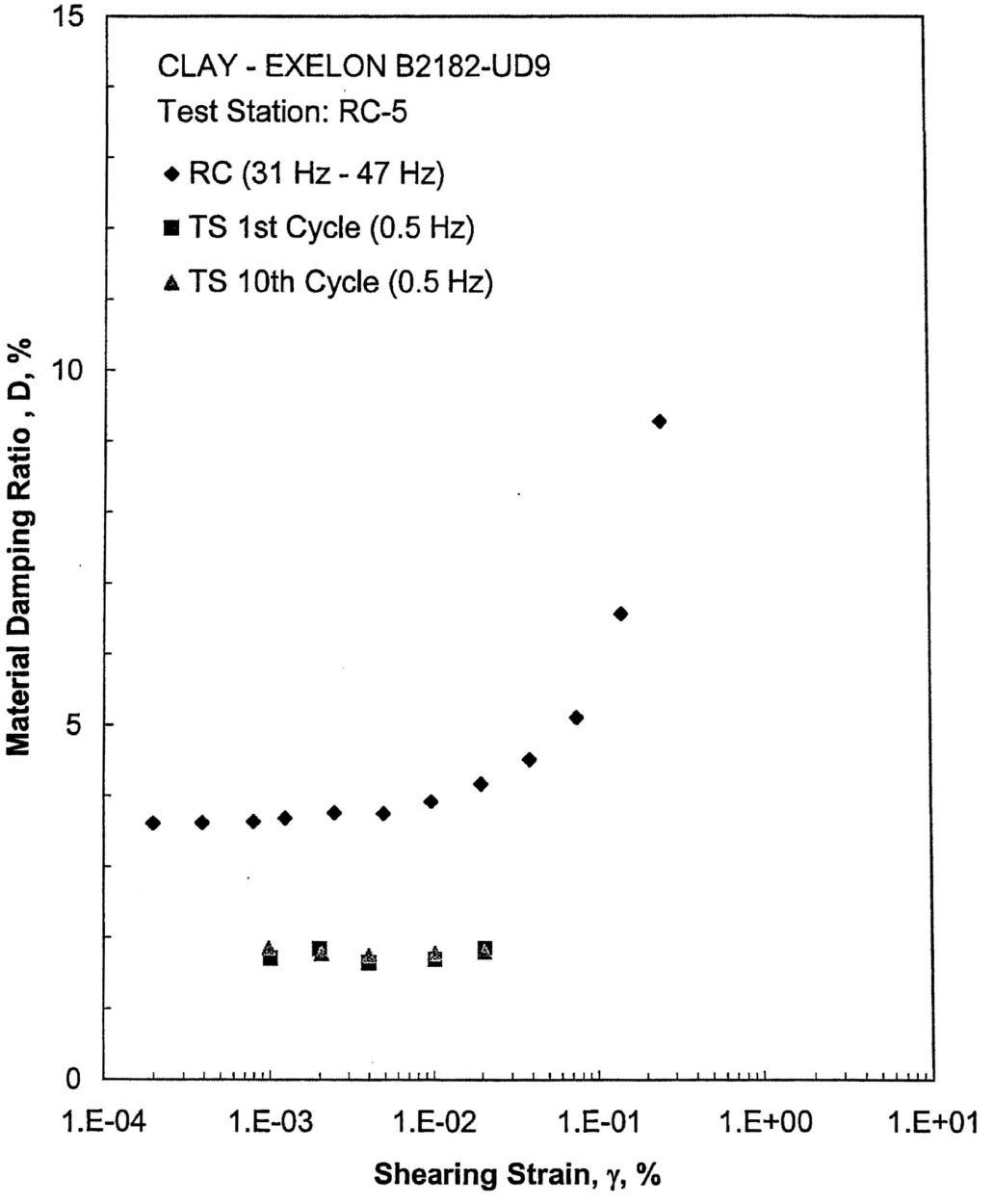


**Figure E.13 Comparison of the Variation in Material Damping Ratio with Shearing Strain at an Isotropic Confining Pressure of 39 psi from the Combined RCTS Tests**

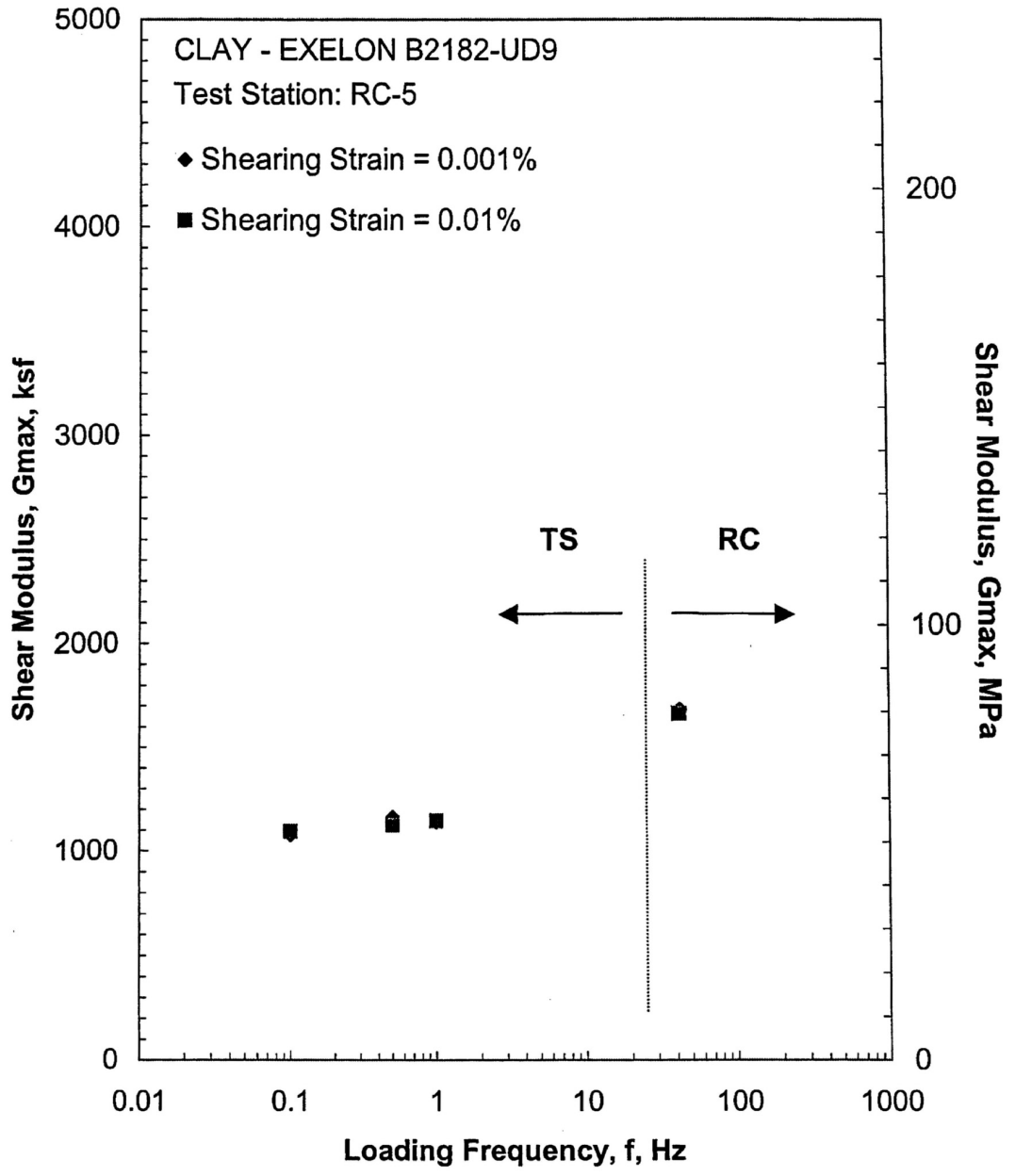


**Figure E.14 Comparison of the Variation in Shear Modulus with Loading Frequency at an Isotropic Confining Pressure of 39 psi from the Combined RCTS Tests**

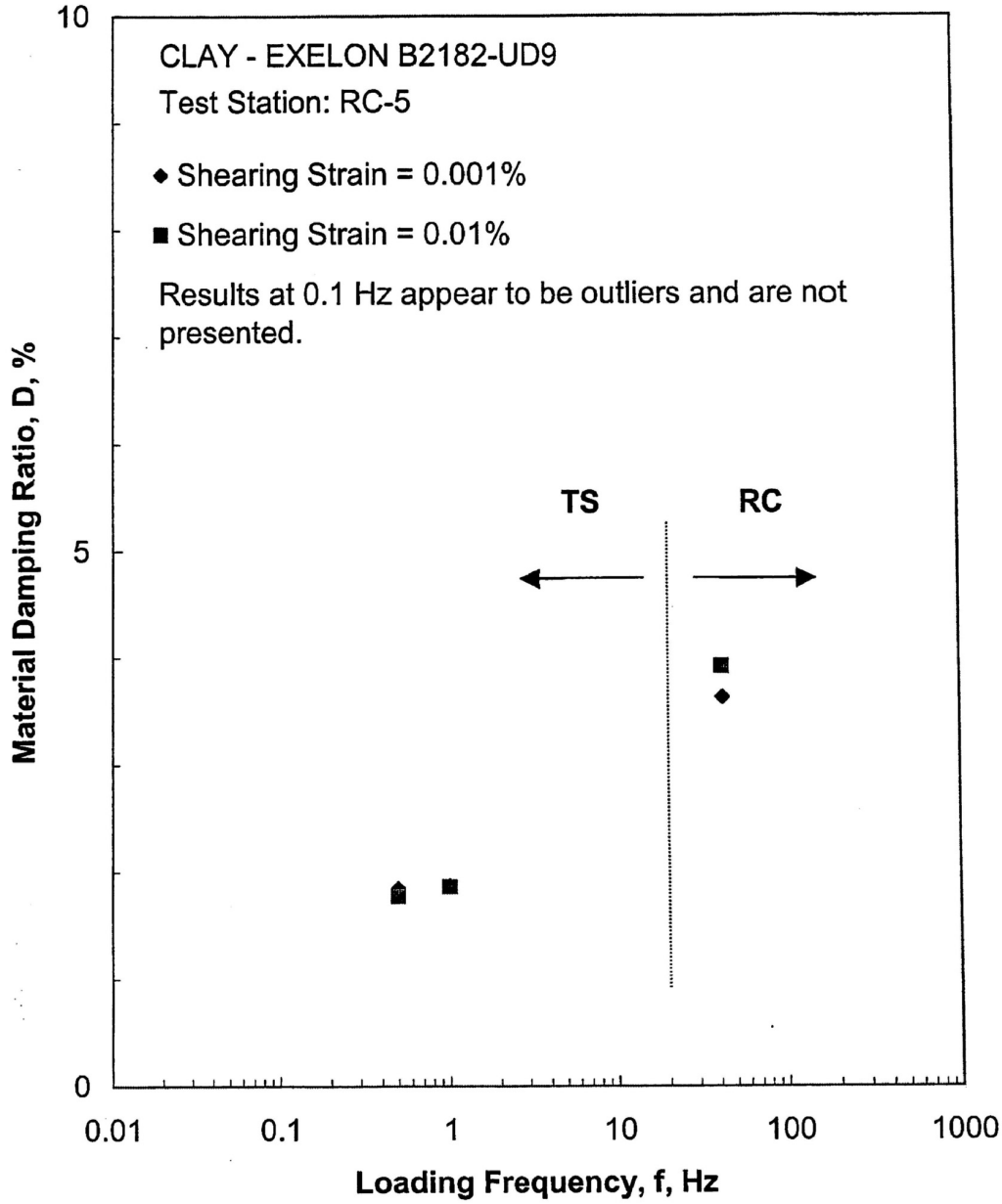


**Figure E.15 Comparison of the Variation in Material Damping Ratio with Loading Frequency at an Isotropic Confining Pressure of 39 psi from the Combined RCTS Tests**

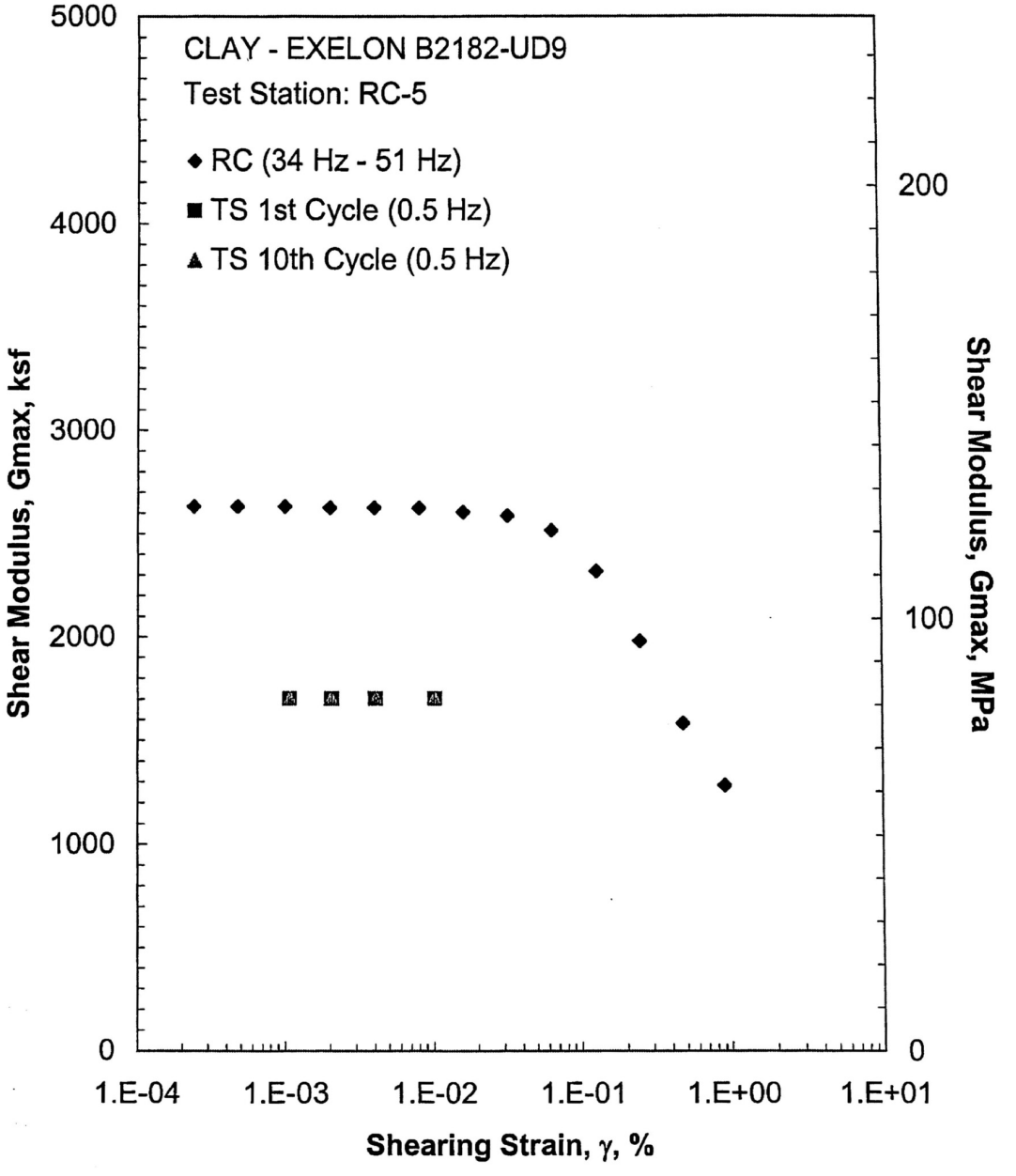


**Figure E.16 Comparison of the Variation in Shear Modulus with Shearing Strain at an Isotropic Confining Pressure of 156 psi from the Combined RCTS Tests**

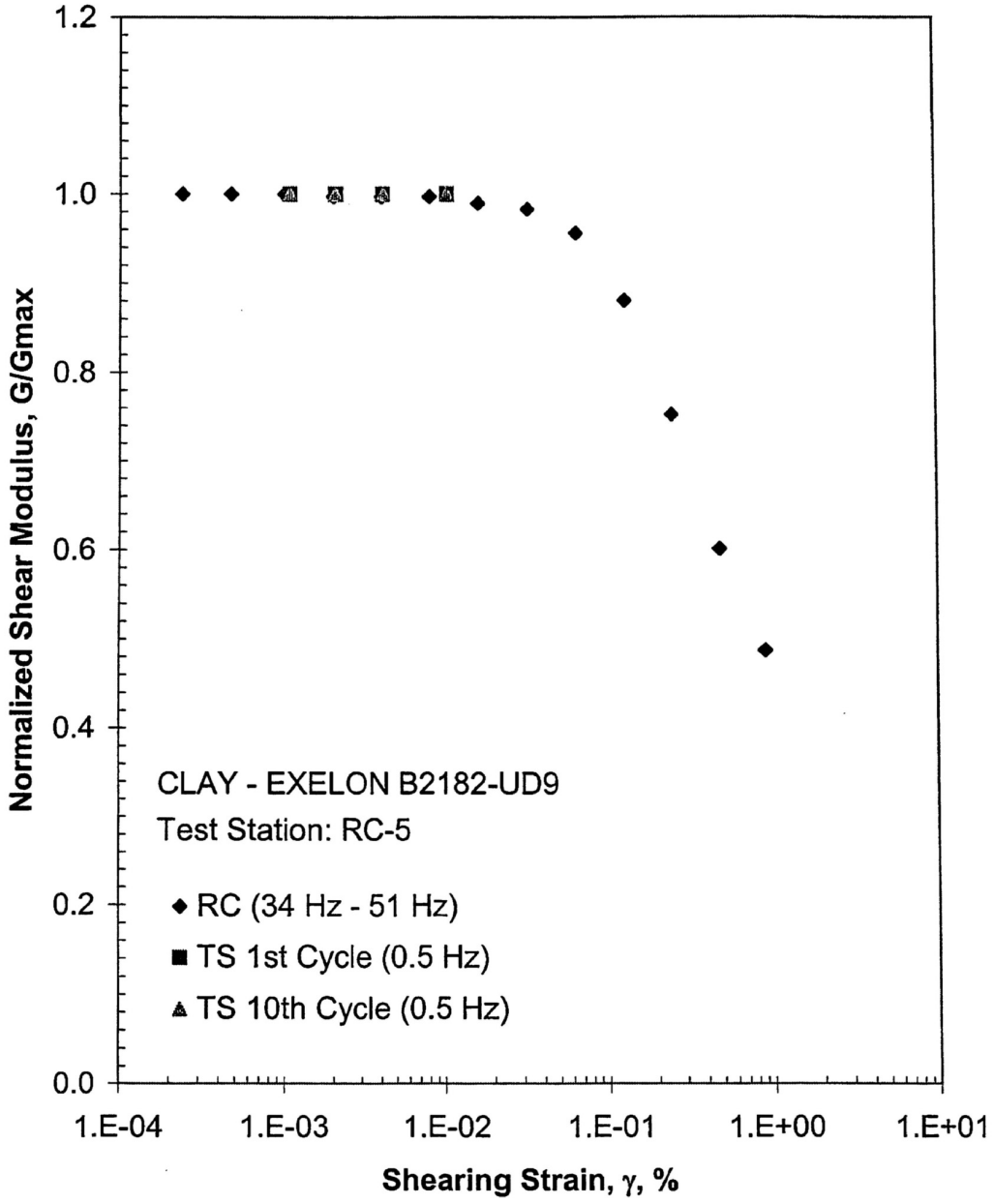


**Figure E.17 Comparison of the Variation in Normalized Shear Modulus with Shearing Strain at an Isotropic Confining Pressure of 156 psi from the Combined RCTS Tests**

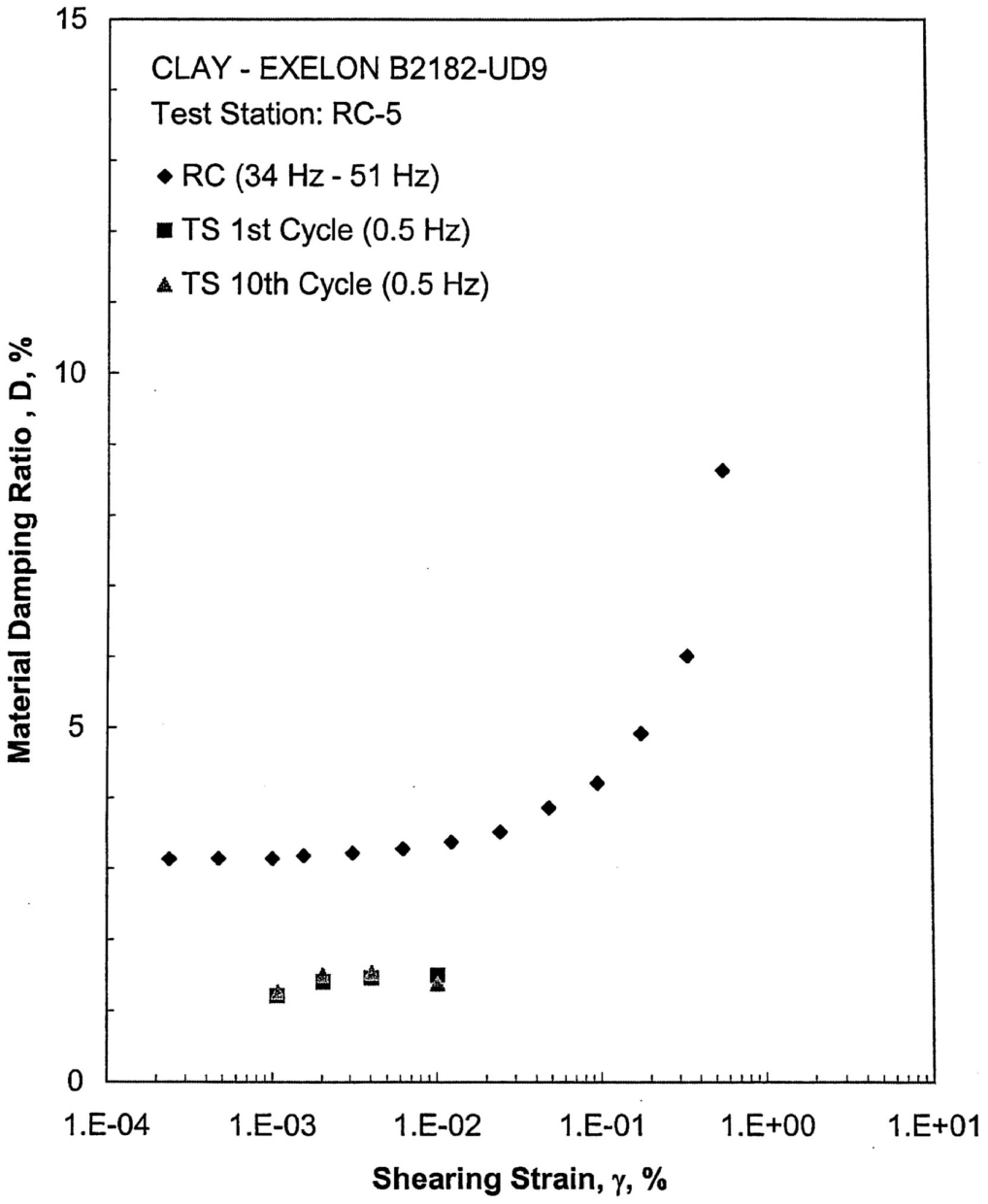


**Figure E.18 Comparison of the Variation in Material Damping Ratio with Shearing Strain at an Isotropic Confining Pressure of 156 psi from the Combined RCTS Tests**

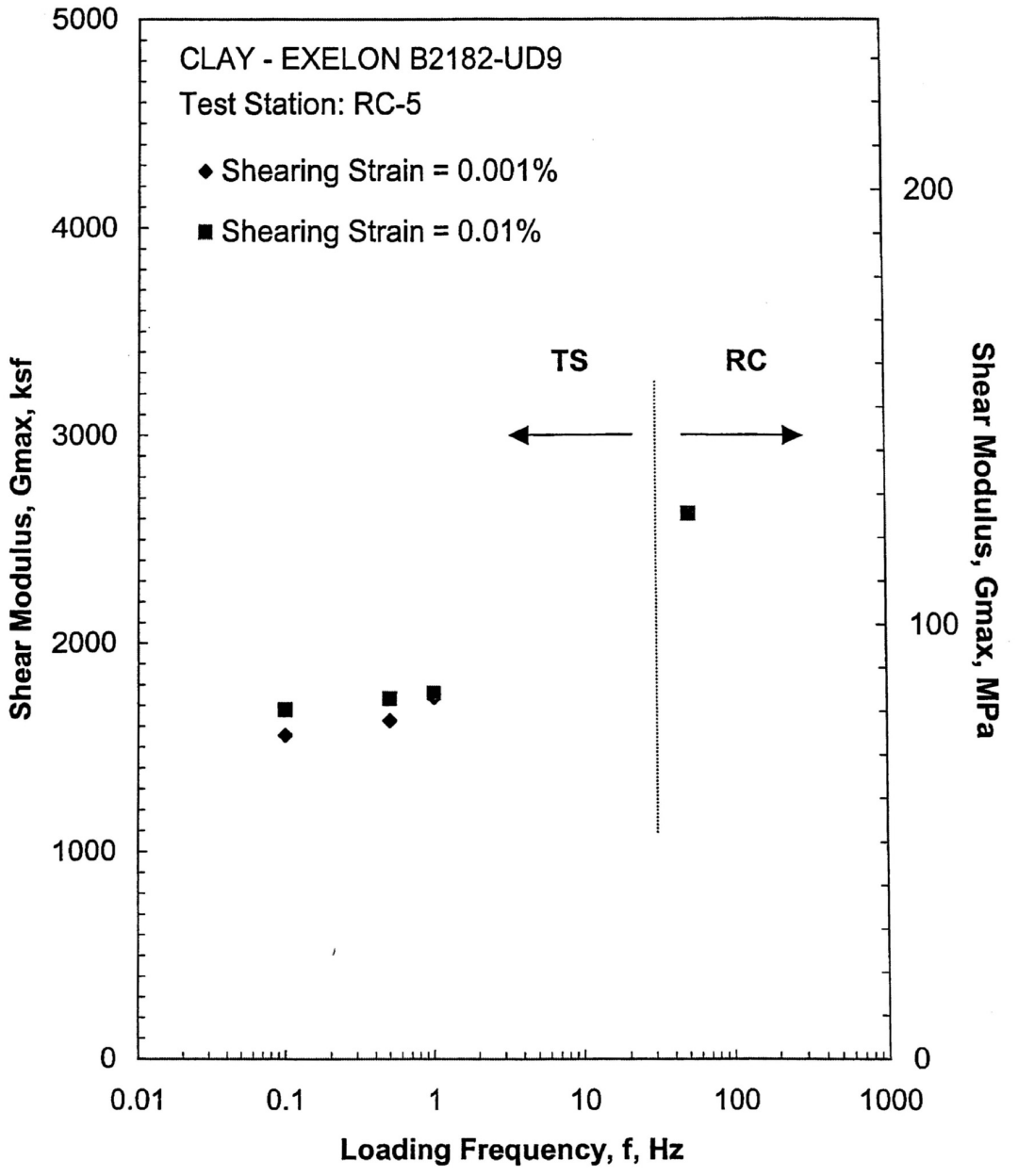


**Figure E.19 Comparison of the Variation in Shear Modulus with Loading Frequency at an Isotropic Confining Pressure of 156 psi from the Combined RCTS Tests**

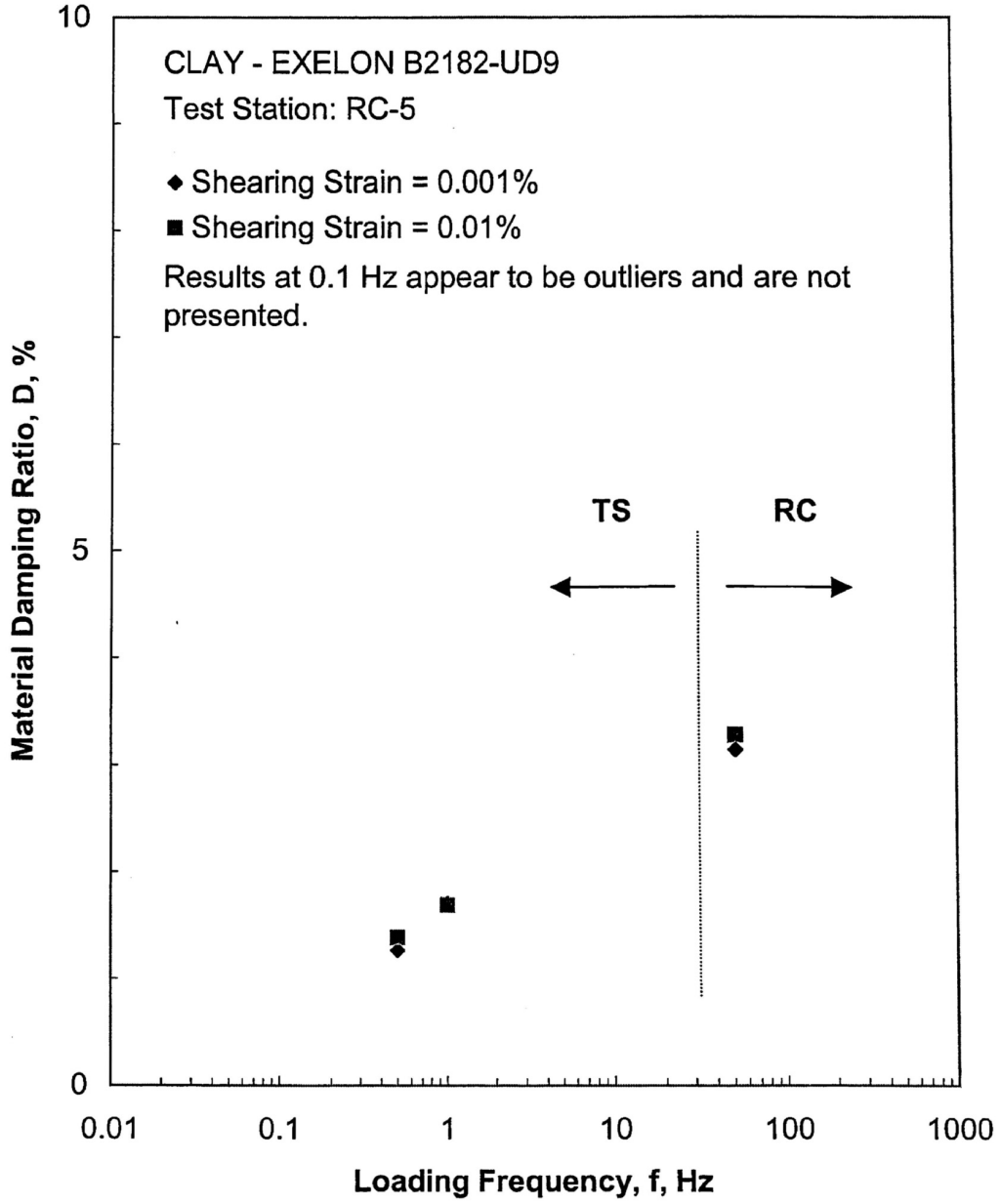


**Figure E.20 Comparison of the Variation in Material Damping Ratio with Loading Frequency at an Isotropic Confining Pressure of 156 psi from the Combined RCTS Tests**

Table E.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 B2182-UD9

| Isotropic Confining Pressure, $\sigma_o$ | | | 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) | (%) | |
| 10 | 1440 | 69 | 1276 | 61 | 596 | 4.27 | 1.01 |
| 20 | 2880 | 138 | 1416 | 68 | 627 | 4.05 | 1.00 |
| 39 | 5616 | 269 | 1642 | 79 | 672 | 3.67 | 0.98 |
| 78 | 11232 | 537 | 1944 | 93 | 727 | 3.38 | 0.96 |
| 156 | 22464 | 1075 | 2665 | 128 | 840 | 3.20 | 0.91 |

Table E.2 Variation in Shear Modulus and Material Damping Ratio with Shearing Strain from RC Tests of Specimen EXELON B2182-UD9; Isoptropic Confining Pressure, $\sigma_o$=39 psi (5.6 ksf = 269 kPa)

| Peak Shearing Strain, % | Shear Modulus, G, ksf | Normalized Shear Modulus, $G/G_{max}$ | Average[+] Shearing Strain, % | Material Damping Ratio[x], D, % |
|---|---|---|---|---|
| 1.97E-04 | 1663 | 1.00 | 1.97E-04 | 3.61 |
| 3.86E-04 | 1663 | 1.00 | 3.86E-04 | 3.62 |
| 7.87E-04 | 1663 | 1.00 | 7.87E-04 | 3.63 |
| 1.61E-03 | 1663 | 1.00 | 1.24E-03 | 3.68 |
| 3.22E-03 | 1663 | 1.00 | 2.44E-03 | 3.76 |
| 6.44E-03 | 1663 | 1.00 | 4.89E-03 | 3.75 |
| 1.28E-02 | 1663 | 1.00 | 9.63E-03 | 3.92 |
| 2.59E-02 | 1637 | 0.98 | 1.97E-02 | 4.17 |
| 5.25E-02 | 1592 | 0.96 | 3.88E-02 | 4.52 |
| 1.05E-01 | 1499 | 0.90 | 7.44E-02 | 5.11 |
| 2.14E-01 | 1245 | 0.75 | 1.41E-01 | 6.58 |
| 4.21E-01 | 966 | 0.58 | 2.49E-01 | 9.28 |

[+] 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 E.3 Variation in Shear Modulus, Normalized Shear Modulus and Material Damping Ratio with Shearing Strain from TS Tests of Specimen B2182-UD9; Isotropic Confining Pressure, $\sigma_o$= 39 psi (5.6 ksf =269 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, % |
| 1.01E-03 | 1140 | 1.00 | 1.71 | 9.82E-04 | 1139 | 1.00 | 1.85 |
| 1.99E-03 | 1140 | 1.00 | 1.85 | 2.05E-03 | 1139 | 1.00 | 1.77 |
| 3.99E-03 | 1140 | 1.00 | 1.65 | 3.99E-03 | 1139 | 1.00 | 1.75 |
| 1.02E-02 | 1127 | 0.99 | 1.69 | 1.02E-02 | 1126 | 0.99 | 1.78 |
| 2.07E-02 | 1103 | 0.97 | 1.85 | 2.07E-02 | 1108 | 0.97 | 1.80 |

Table E.4 Variation in Shear Modulus and Material Damping Ratio with Shearing Strain from RC Tests of Specimen B2182-UD9; Isoptropic Confining Pressure, $\sigma_o$= 156 psi (22.5 ksf = 1075 kPa)

| Peak Shearing Strain, % | Shear Modulus, G, ksf | Normalized Shear Modulus, $G/G_{max}$ | Average[+] Shearing Strain, % | Material Damping Ratio[x], D, % |
|---|---|---|---|---|
| 2.39E-04 | 2632 | 1.00 | 2.39E-04 | 3.14 |
| 4.74E-04 | 2632 | 1.00 | 4.74E-04 | 3.14 |
| 9.98E-04 | 2632 | 1.00 | 9.98E-04 | 3.14 |
| 1.99E-03 | 2625 | 1.00 | 1.55E-03 | 3.18 |
| 3.97E-03 | 2625 | 1.00 | 3.13E-03 | 3.22 |
| 7.92E-03 | 2625 | 1.00 | 6.26E-03 | 3.28 |
| 1.59E-02 | 2605 | 0.99 | 1.24E-02 | 3.38 |
| 3.17E-02 | 2587 | 0.98 | 2.44E-02 | 3.53 |
| 6.34E-02 | 2516 | 0.96 | 4.82E-02 | 3.86 |
| 1.28E-01 | 2318 | 0.88 | 9.58E-02 | 4.22 |
| 2.47E-01 | 1981 | 0.75 | 1.78E-01 | 4.92 |
| 4.81E-01 | 1583 | 0.60 | 3.42E-01 | 6.01 |
| 9.08E-01 | 1283 | 0.49 | 5.72E-01 | 8.63 |

[+] 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 E.5 Variation in Shear Modulus, Normalized Shear Modulus and Material Damping Ratio with Shearing Strain from TS Tests of Specimen B2182-UD9; Isotropic Confining Pressure, $\sigma_o$=156 psi (22.5 ksf = 1075 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, % |
| 1.07E-03 | 1702 | 1.00 | 1.21 | 1.08E-03 | 1703 | 1.00 | 1.26 |
| 2.04E-03 | 1702 | 1.00 | 1.40 | 2.03E-03 | 1703 | 1.00 | 1.50 |
| 4.04E-03 | 1702 | 1.00 | 1.46 | 4.06E-03 | 1703 | 1.00 | 1.53 |
| 1.02E-02 | 1702 | 1.00 | 1.50 | 1.01E-02 | 1703 | 1.00 | 1.38 |

# APPENDIX F

Specimen B2274-UD14
(Index Properties Not Available)

Borehole B2274
Sample UD14
Depth = 267.5 ft (81.5 m)
Total Unit Weight = 130.0 lb/ft$^3$
Water Content = 18.5 %
Estimated In-Situ Ko = 0.5
Estimated In-Situ Mean Effective
Stress = 91 psi

FUGRO JOB #: 0401-1686
Testing Station: RC5

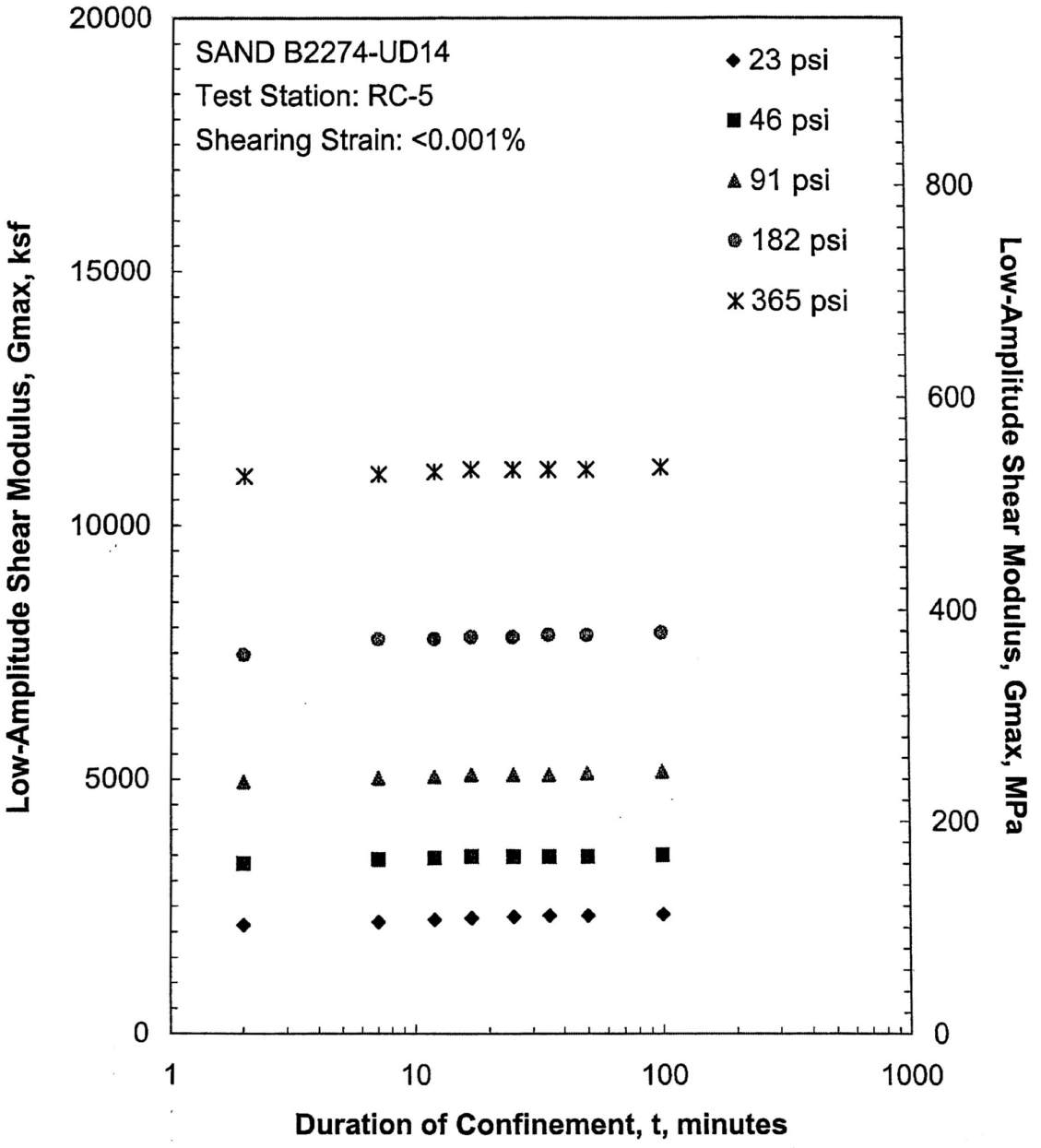


**Figure F.1 Variation in Low-Amplitude Shear Modulus with Magnitude and Duration of Isotropic Confining Pressure from Resonant Column Tests**

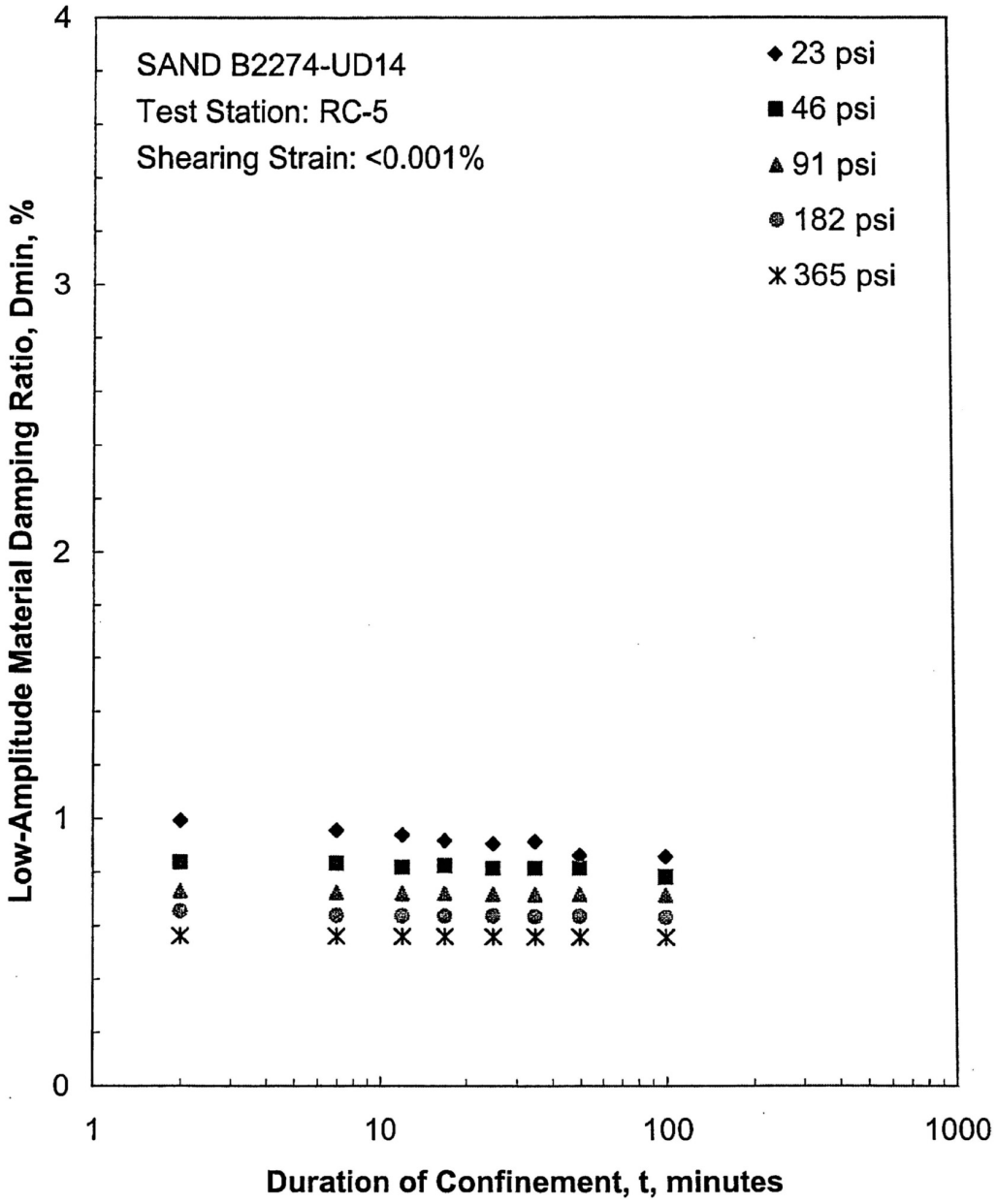


**Figure F.2 Variation in Low-Amplitude Material Damping Ratio with Magnitude and Duration of Isotropic Confining Pressure from Resonant Column Tests**

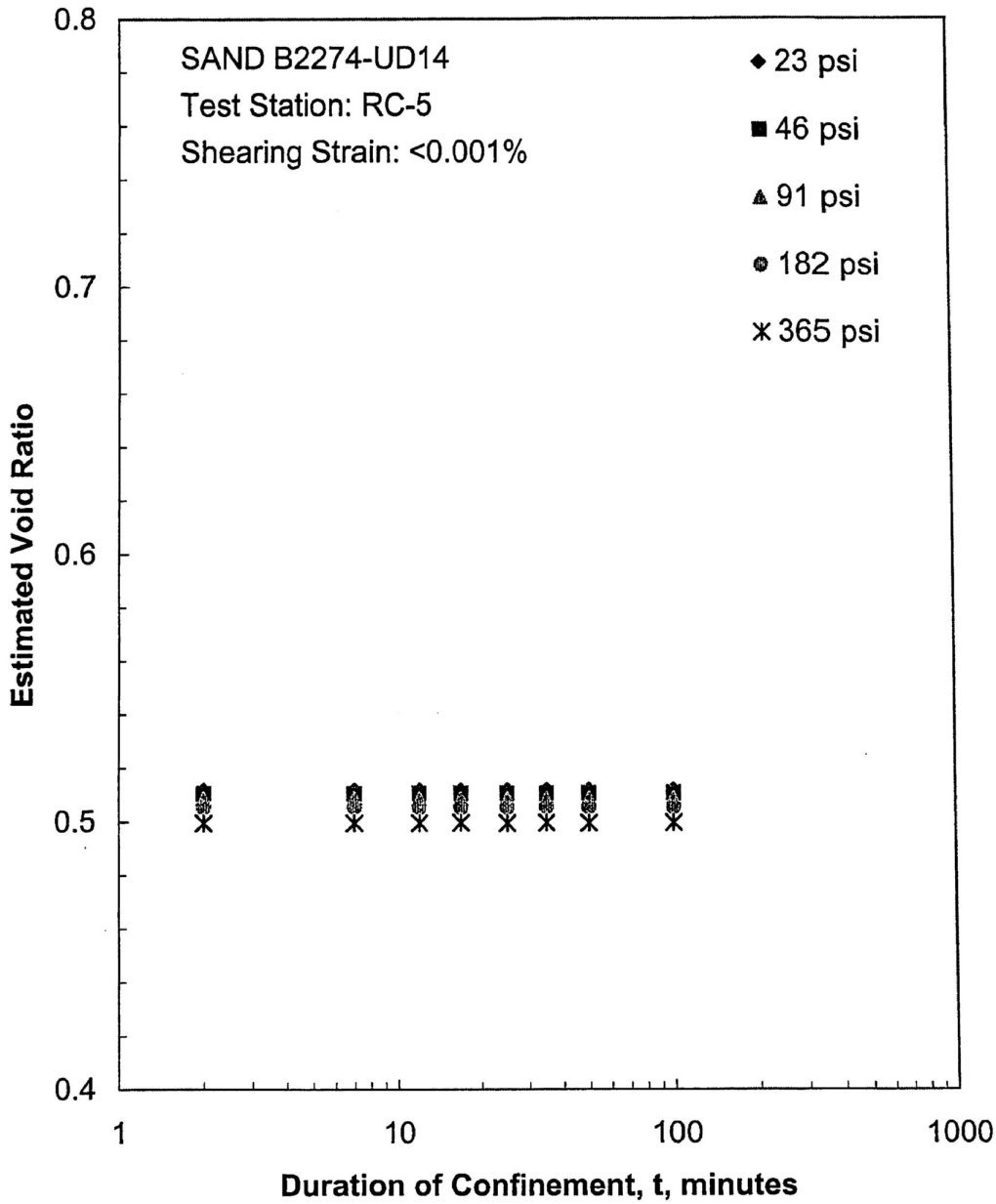


**Figure F.3 Variation in Estimated Void Ratio with Magnitude and Duration of Isotropic Confining Pressure from Resonant Column Tests**

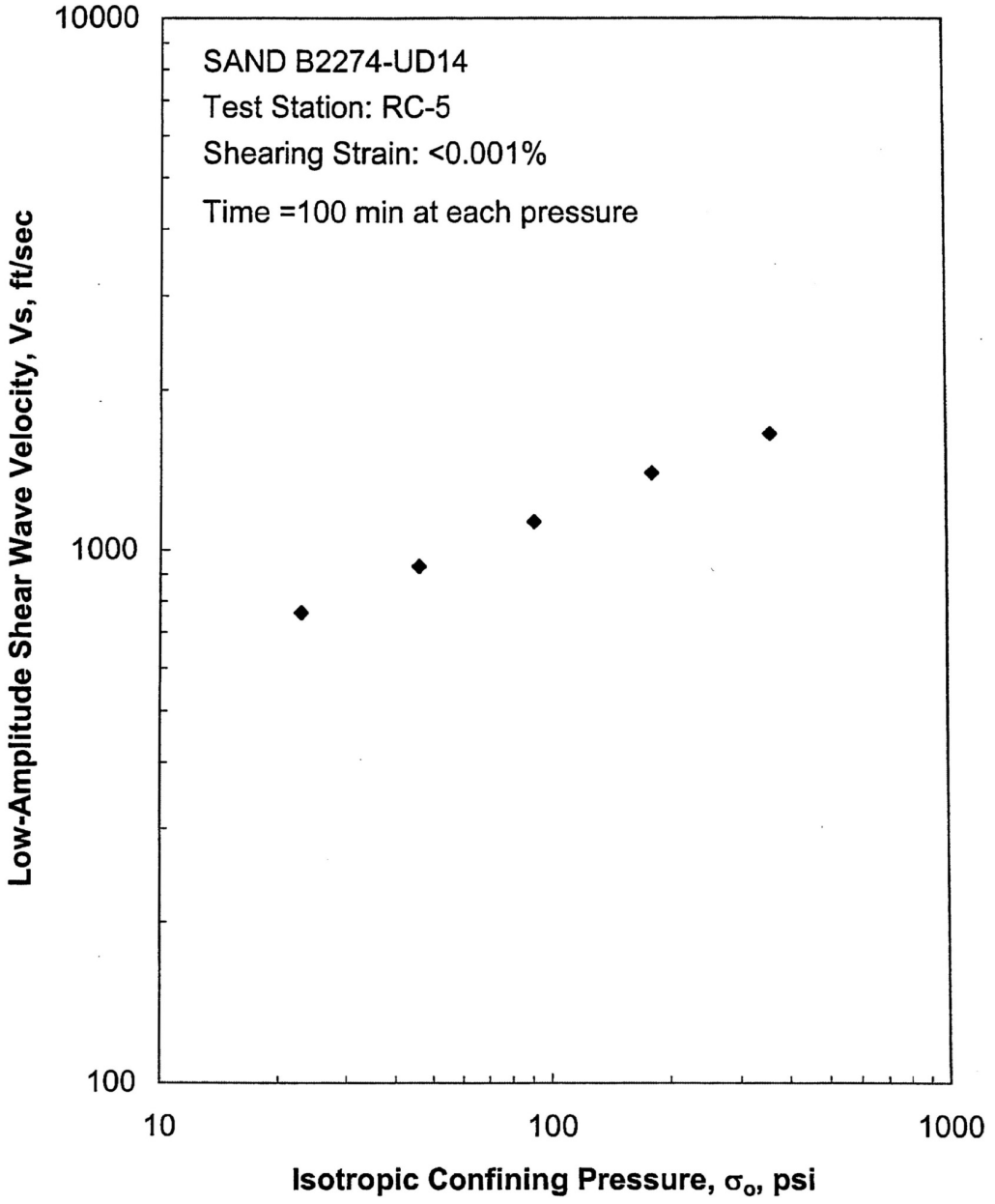


**Figure F.4 Variation in Low-Amplitude Shear Wave Velocity with Isotropic Confining Pressure from Resonant Column Tests**

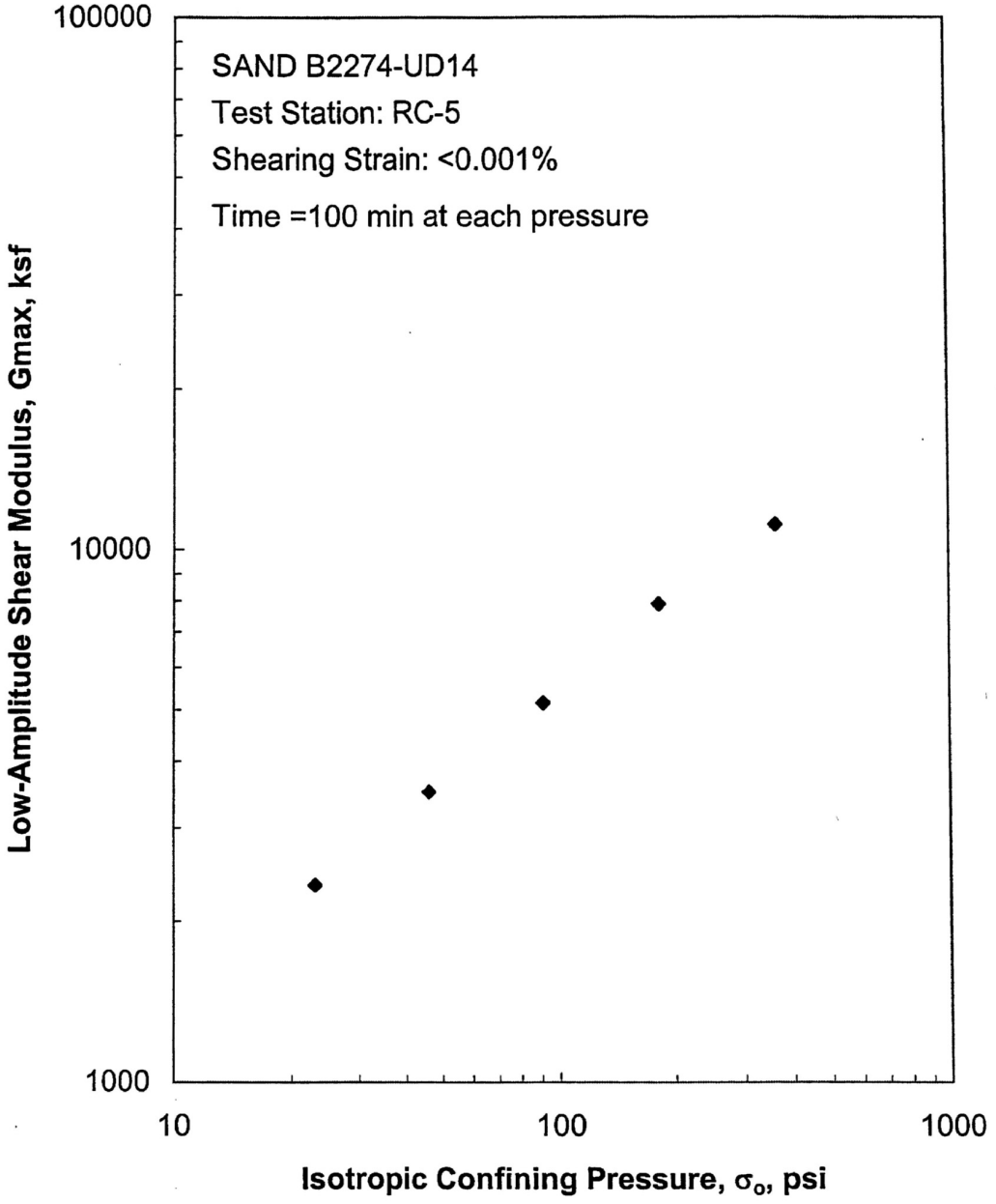


**Figure F.5 Variation in Low-Amplitude Shear Modulus with Isotropic Confining Pressure from Resonant Column Tests**

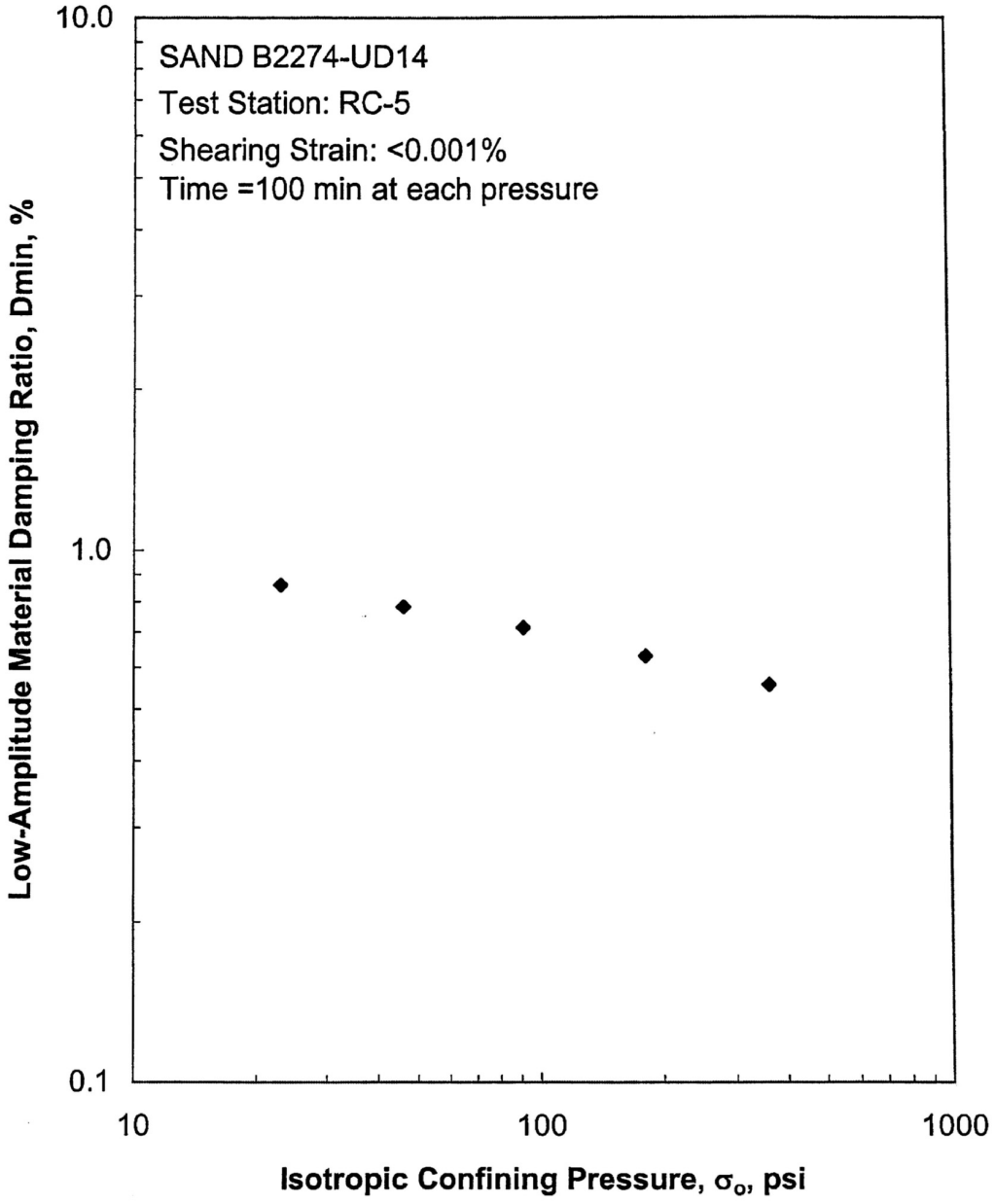


**Figure F.6 Variation in Low-Amplitude Material Damping Ratio with Isotropic Confining Pressure from Resonant Column Tests**

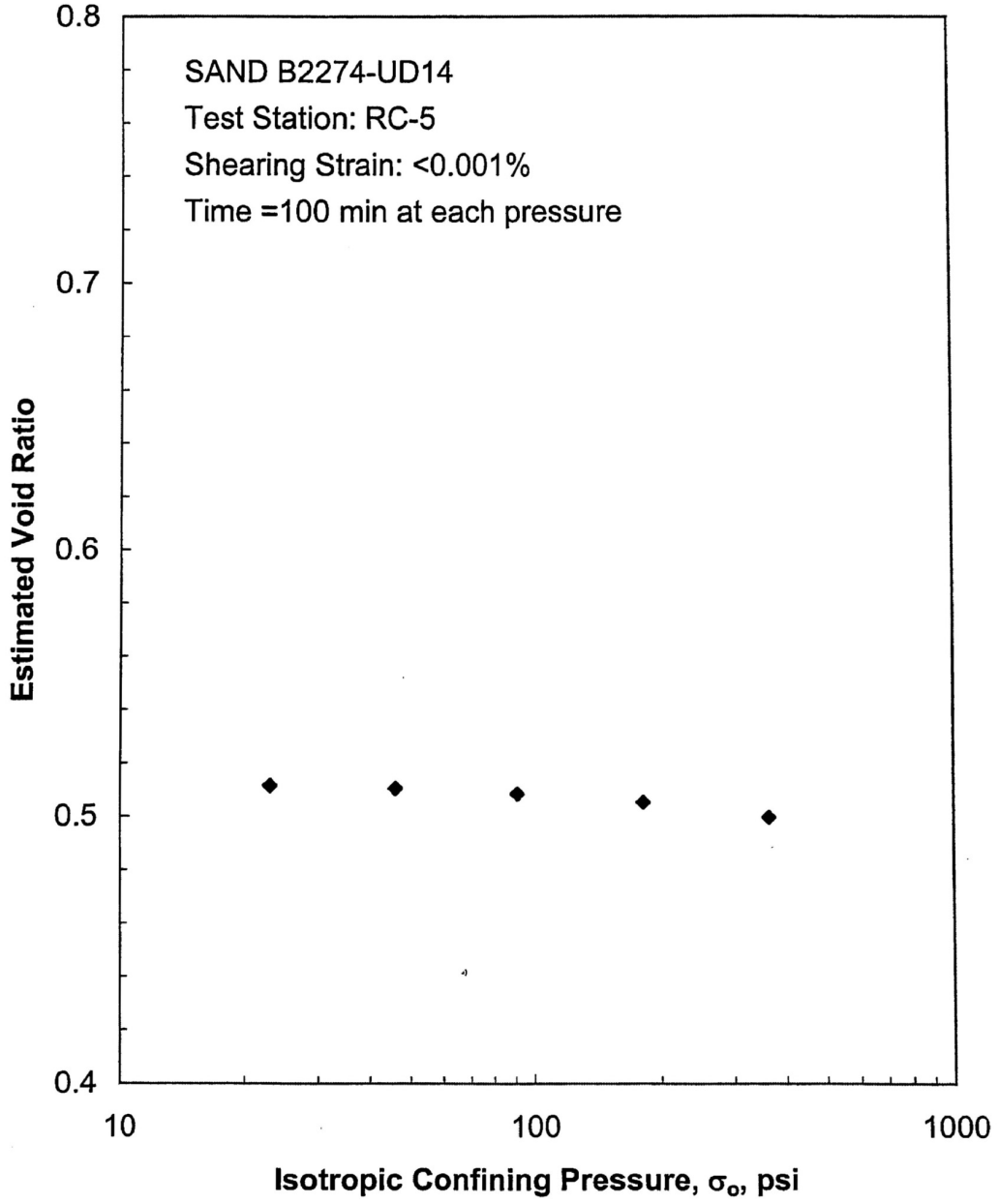


**Figure F.7 Variation in Estimated Void Ratio with Isotropic Confining Pressure from Resonant Column Tests**

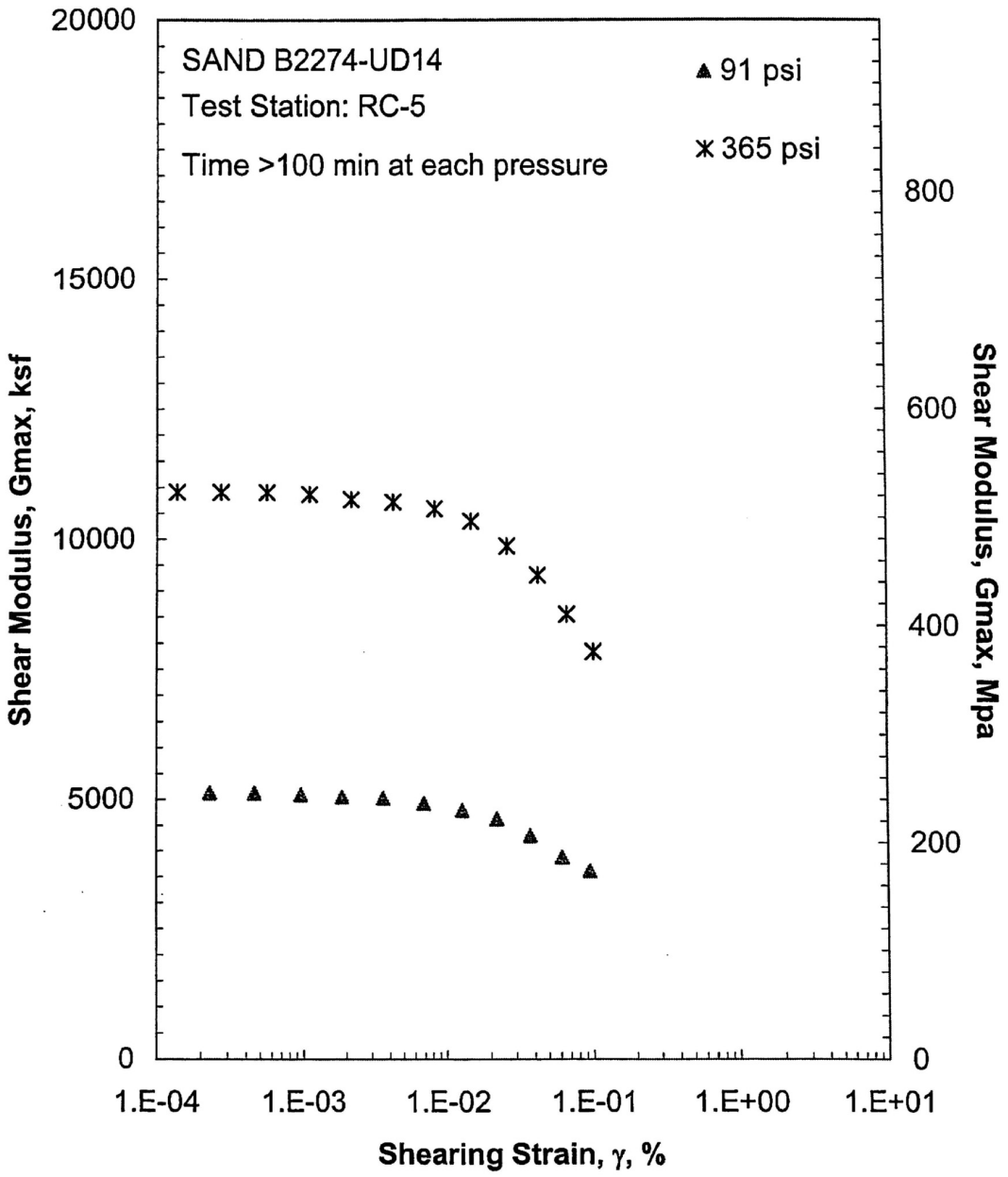


**Figure F.8 Comparison of the Variation in Shear Modulus with Shearing Strain and Isotropic Confining Pressure from the Resonant Column Tests**

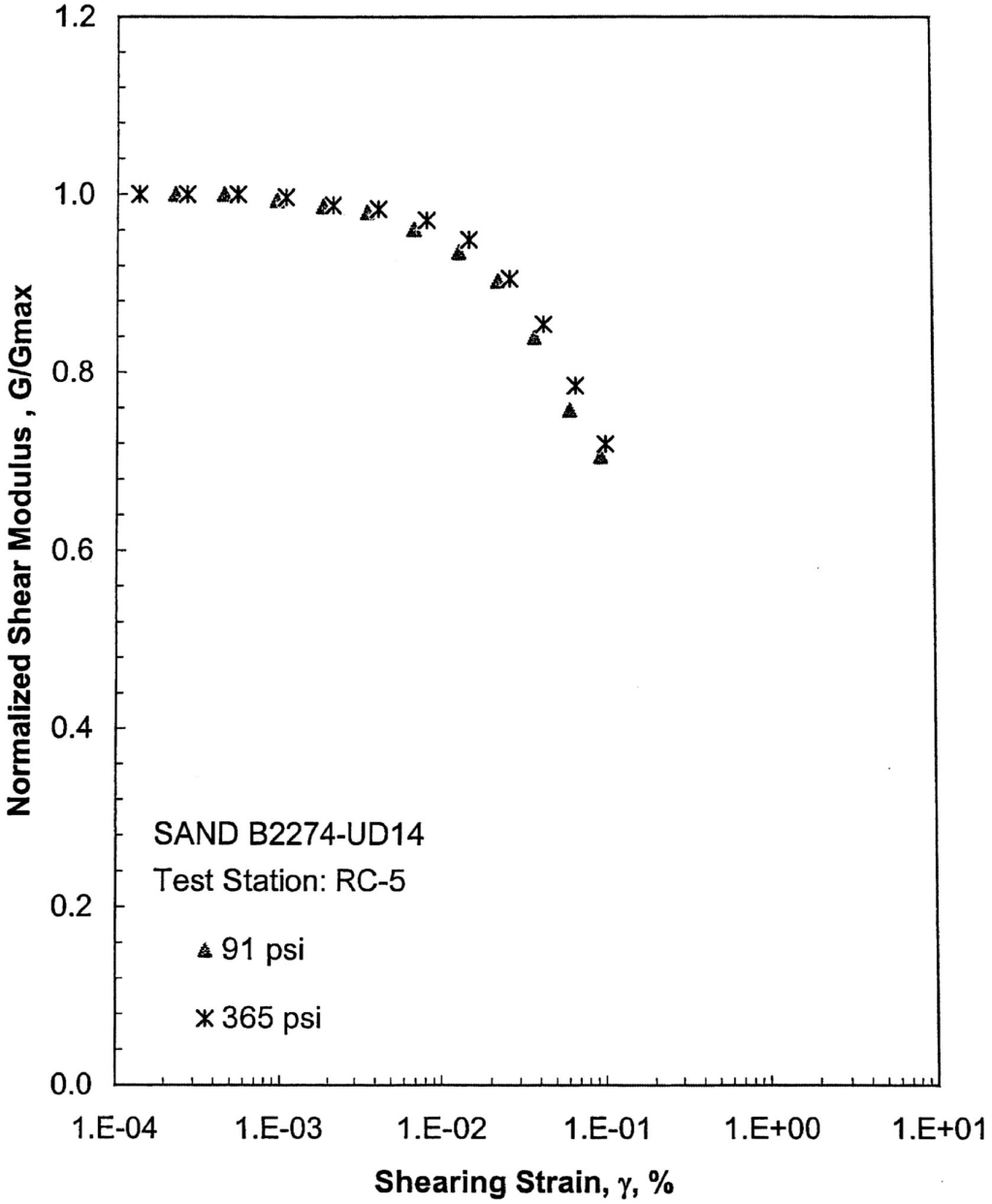


**Figure F.9 Comparison of the Variation in Normalized Shear Modulus with Shearing Strain and Isotropic Confining Pressure from the Resonant Column Tests**

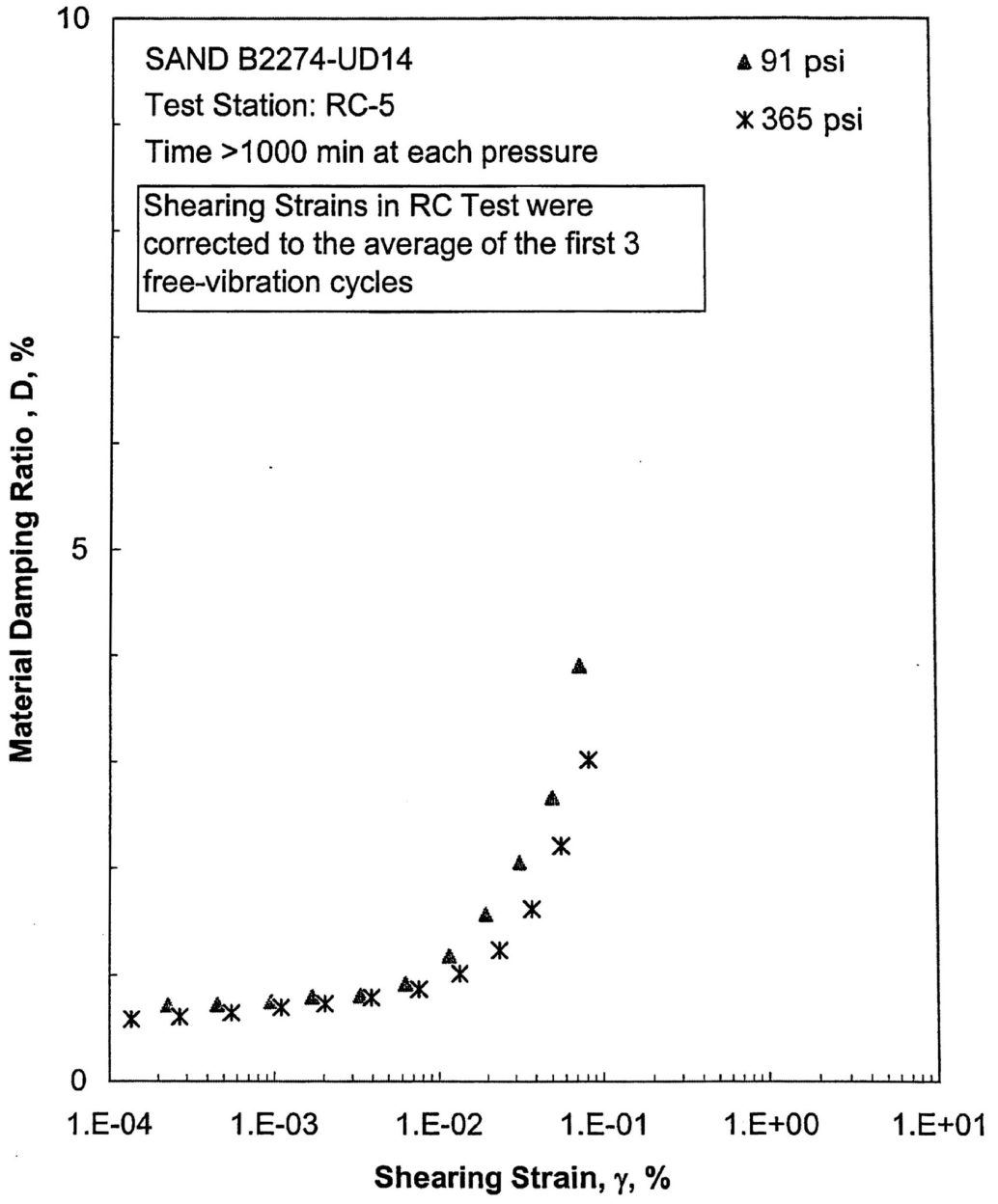


**Figure F.10 Comparison of the Variation in Material Damping Ratio with Shearing Strain and Isotropic Confining Pressure from the Resonant Column Tests**

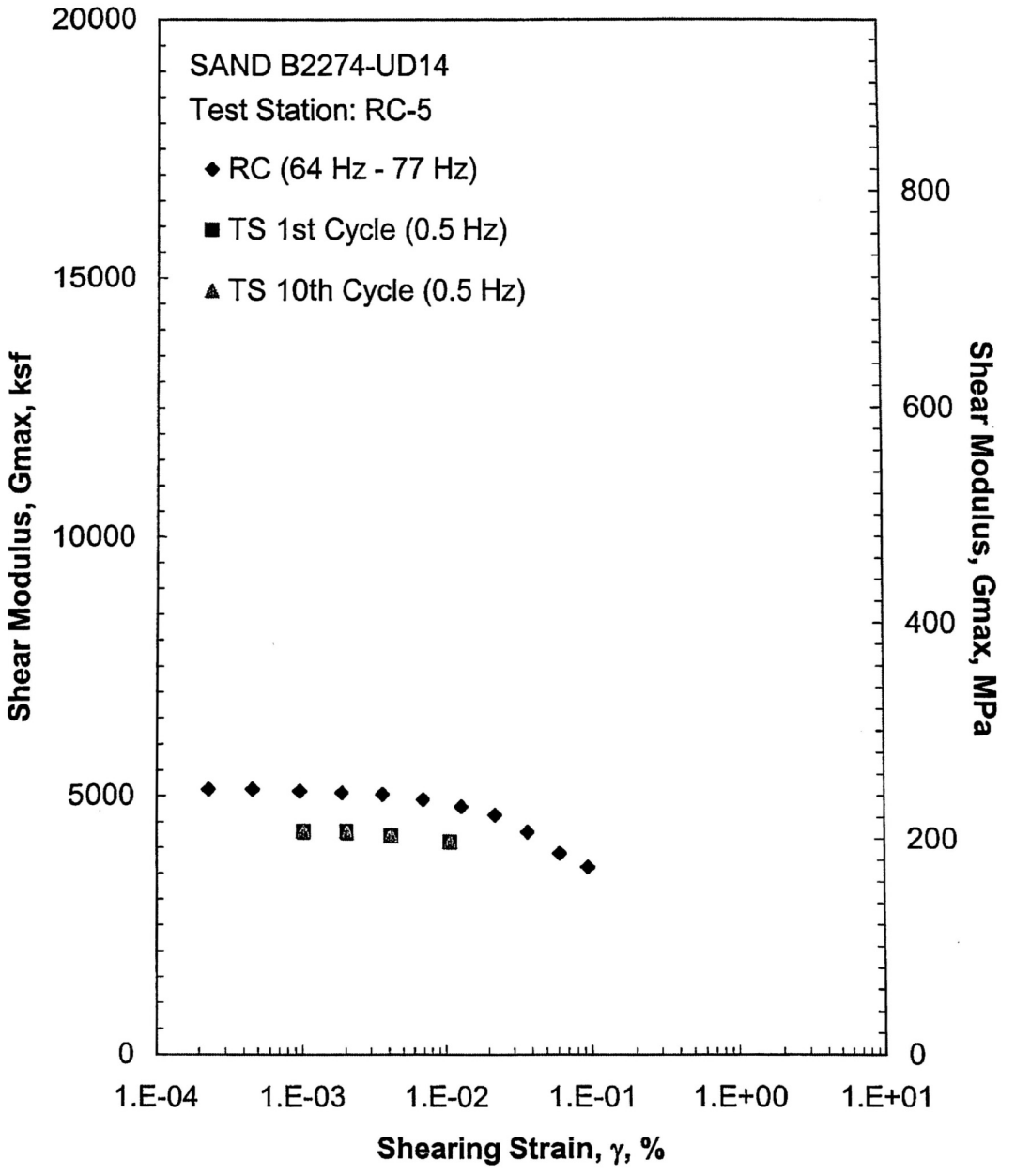


**Figure F.11 Comparison of the Variation in Shear Modulus with Shearing Strain at an Isotropic Confining Pressure of 91 psi from the Combined RCTS Tests**

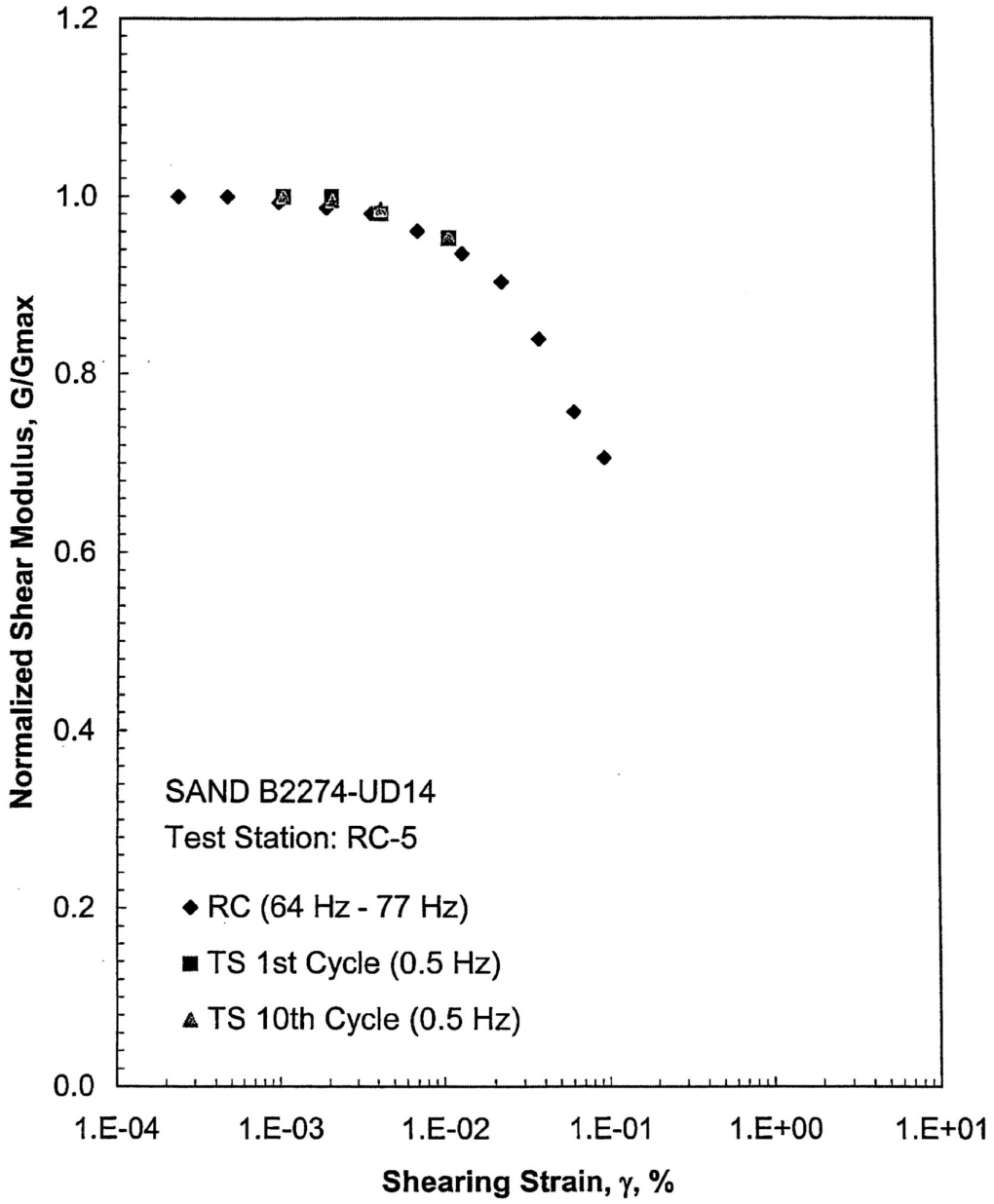


**Figure F.12 Comparison of the Variation in Normalized Shear Modulus with Shearing Strain at an Isotropic Confining Pressure of 91 psi from the Combined RCTS Tests**

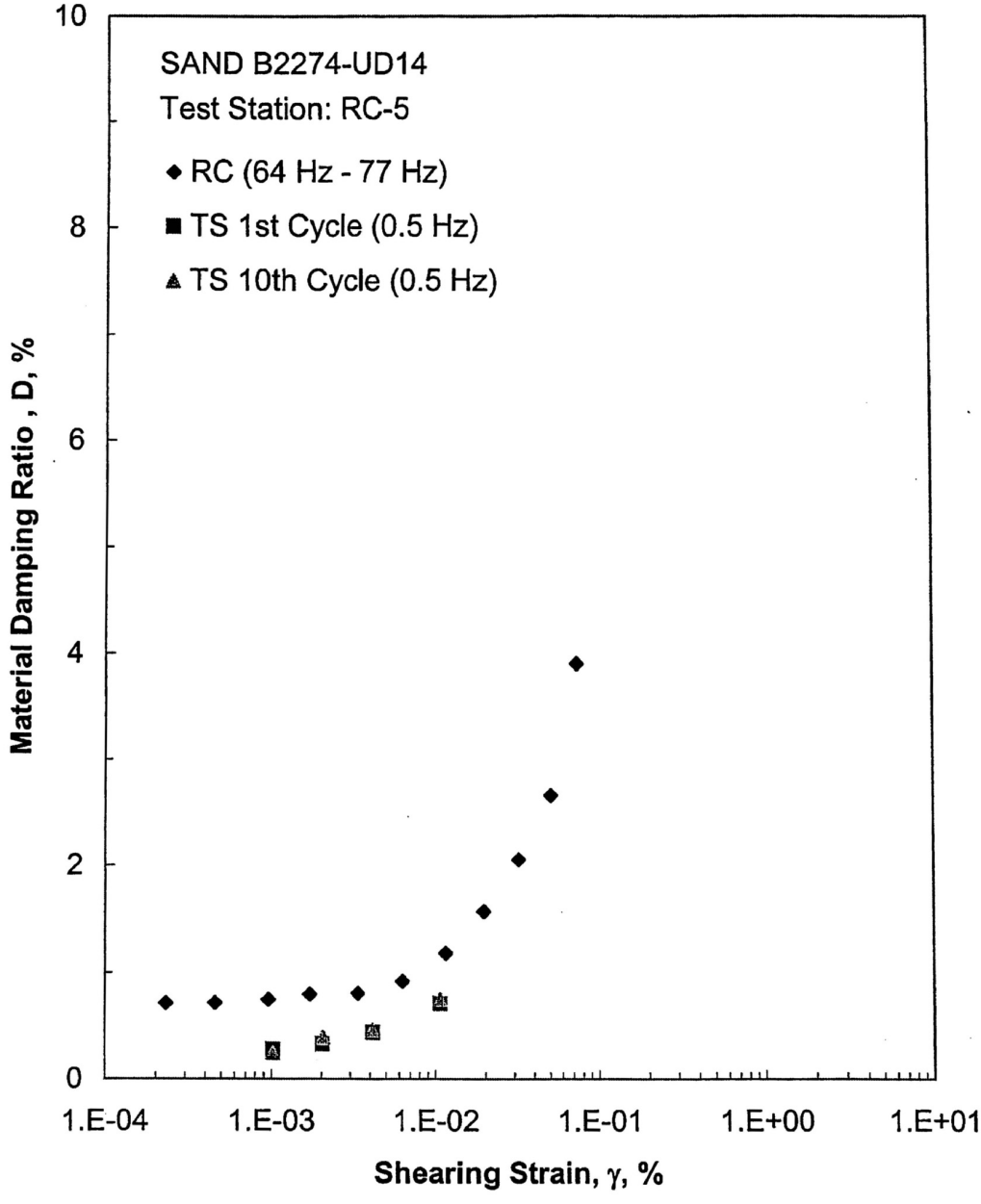


**Figure F.13 Comparison of the Variation in Material Damping Ratio with Shearing Strain at an Isotropic Confining Pressure of 91 psi from the Combined RCTS Tests**

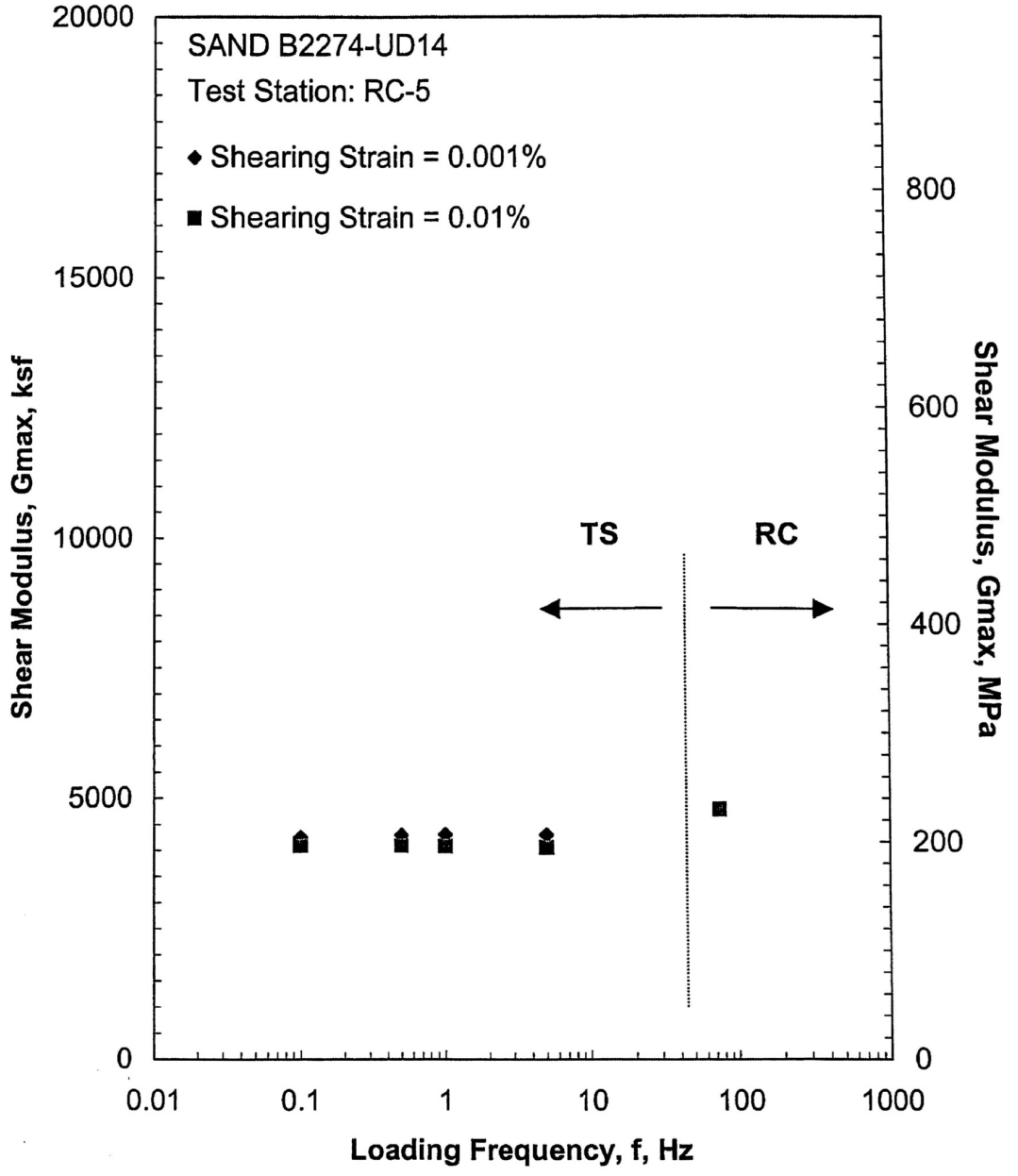


**Figure F.14 Comparison of the Variation in Shear Modulus with Loading Frequency at an Isotropic Confining Pressure of 91 psi from the Combined RCTS Tests**

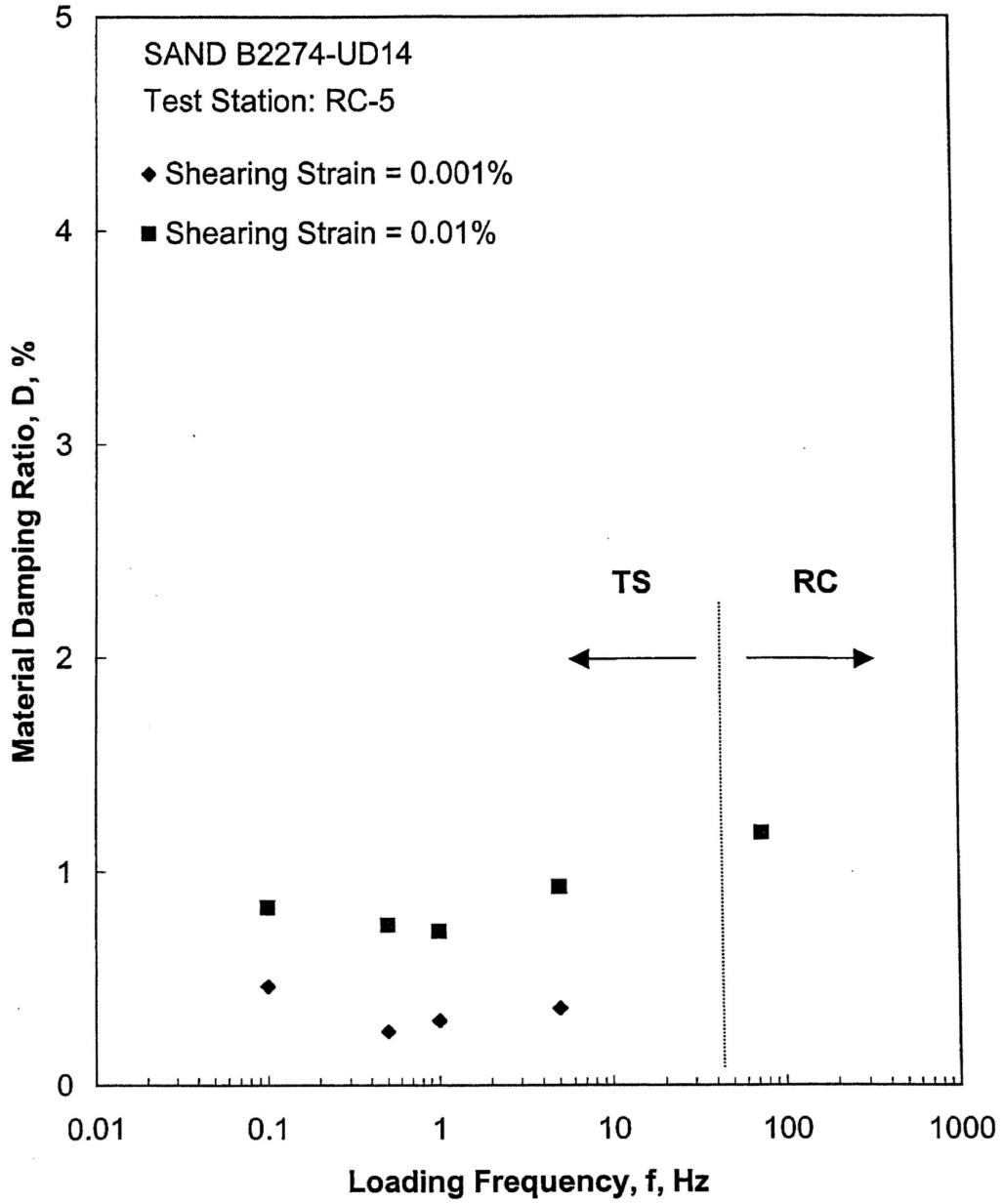


**Figure F.15 Comparison of the Variation in Material Damping Ratio with Loading Frequency at an Isotropic Confining Pressure of 91 psi from the Combined RCTS Tests**

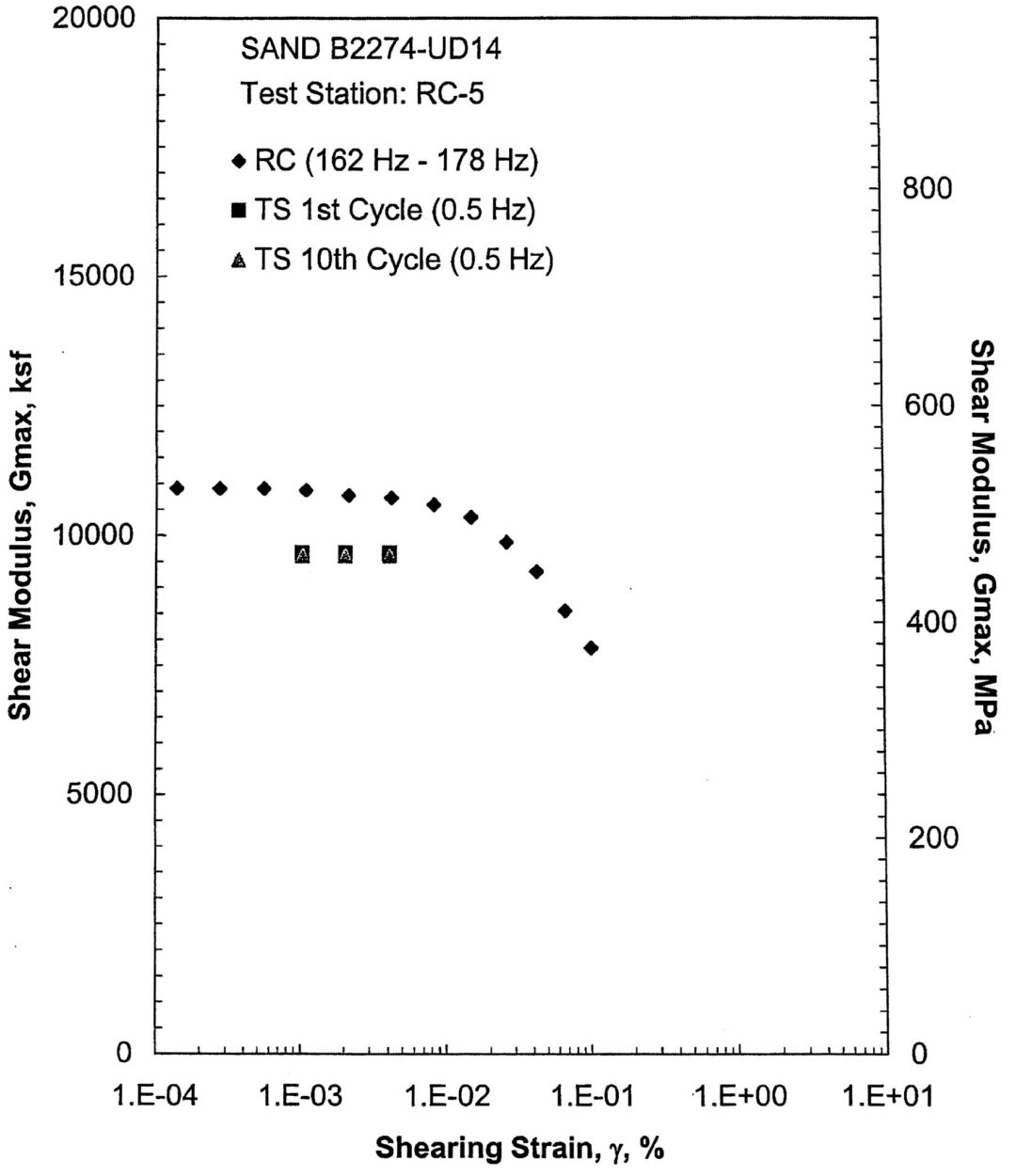


**Figure F.16 Comparison of the Variation in Shear Modulus with Shearing Strain at an Isotropic Confining Pressure of 365 psi from the Combined RCTS Tests**

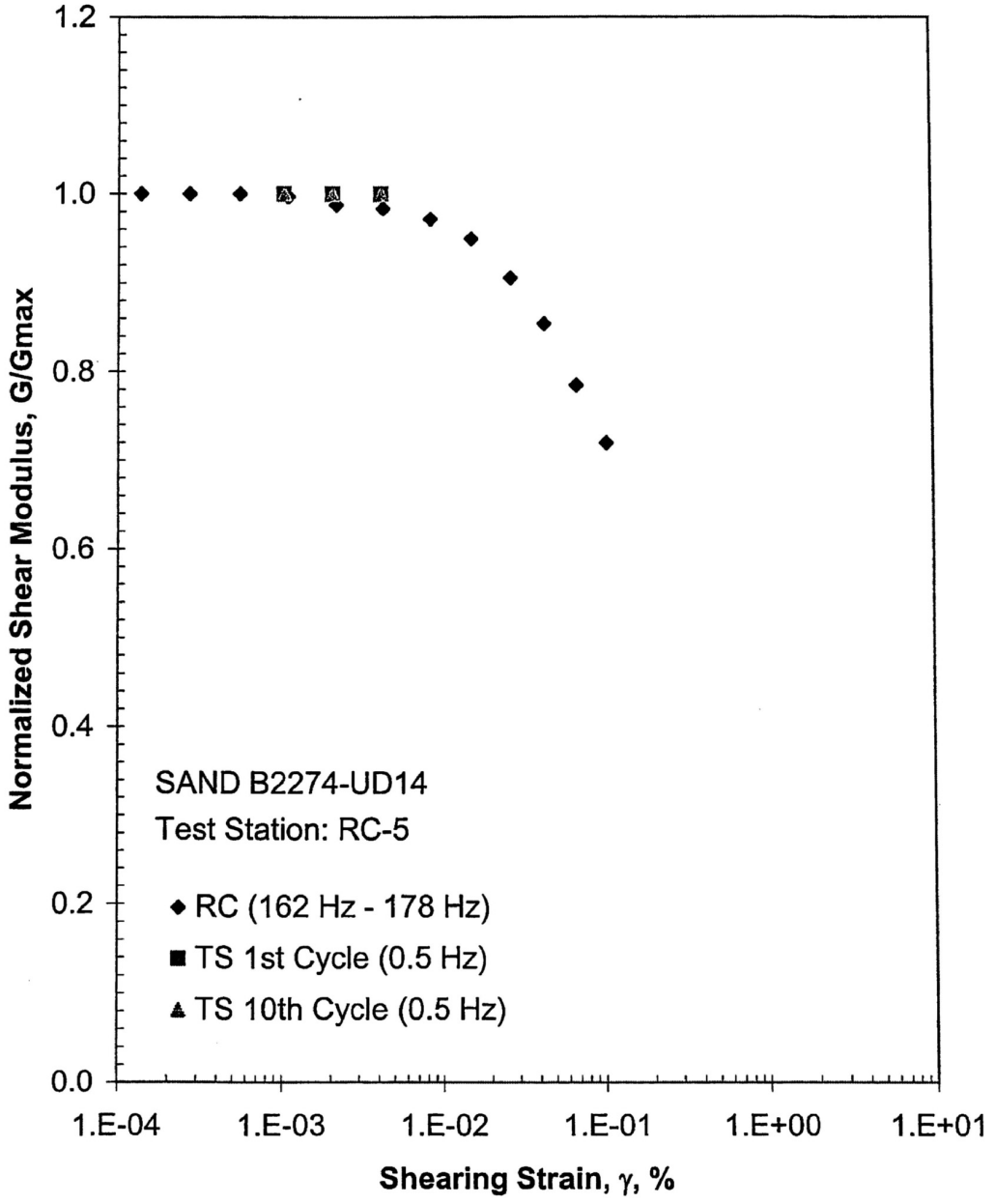


**Figure F.17 Comparison of the Variation in Normalized Shear Modulus with Shearing Strain at an Isotropic Confining Pressure of 365 psi from the Combined RCTS Tests**

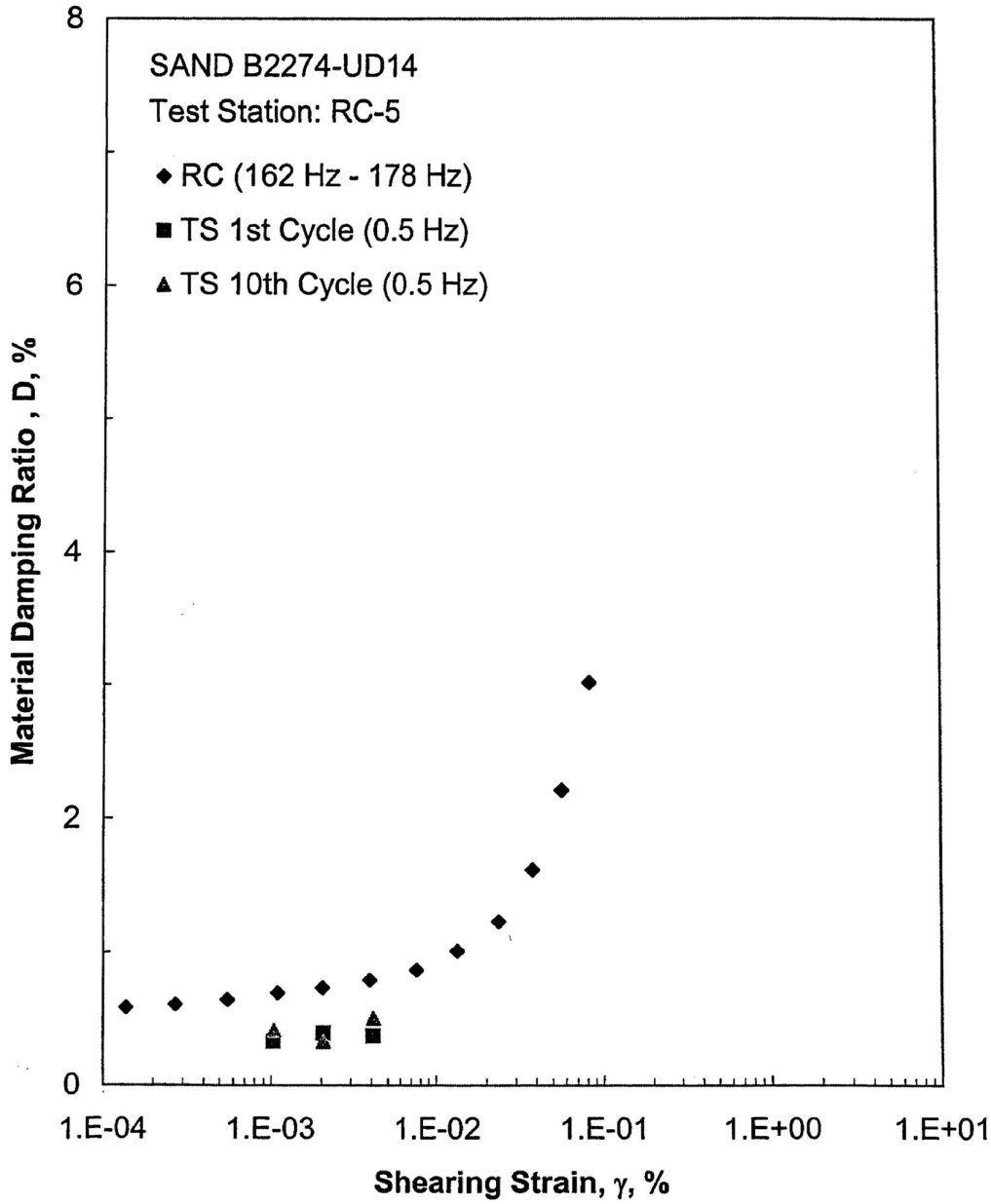


**Figure F.18 Comparison of the Variation in Material Damping Ratio with Shearing Strain at an Isotropic Confining Pressure of 365 psi from the Combined RCTS Tests**

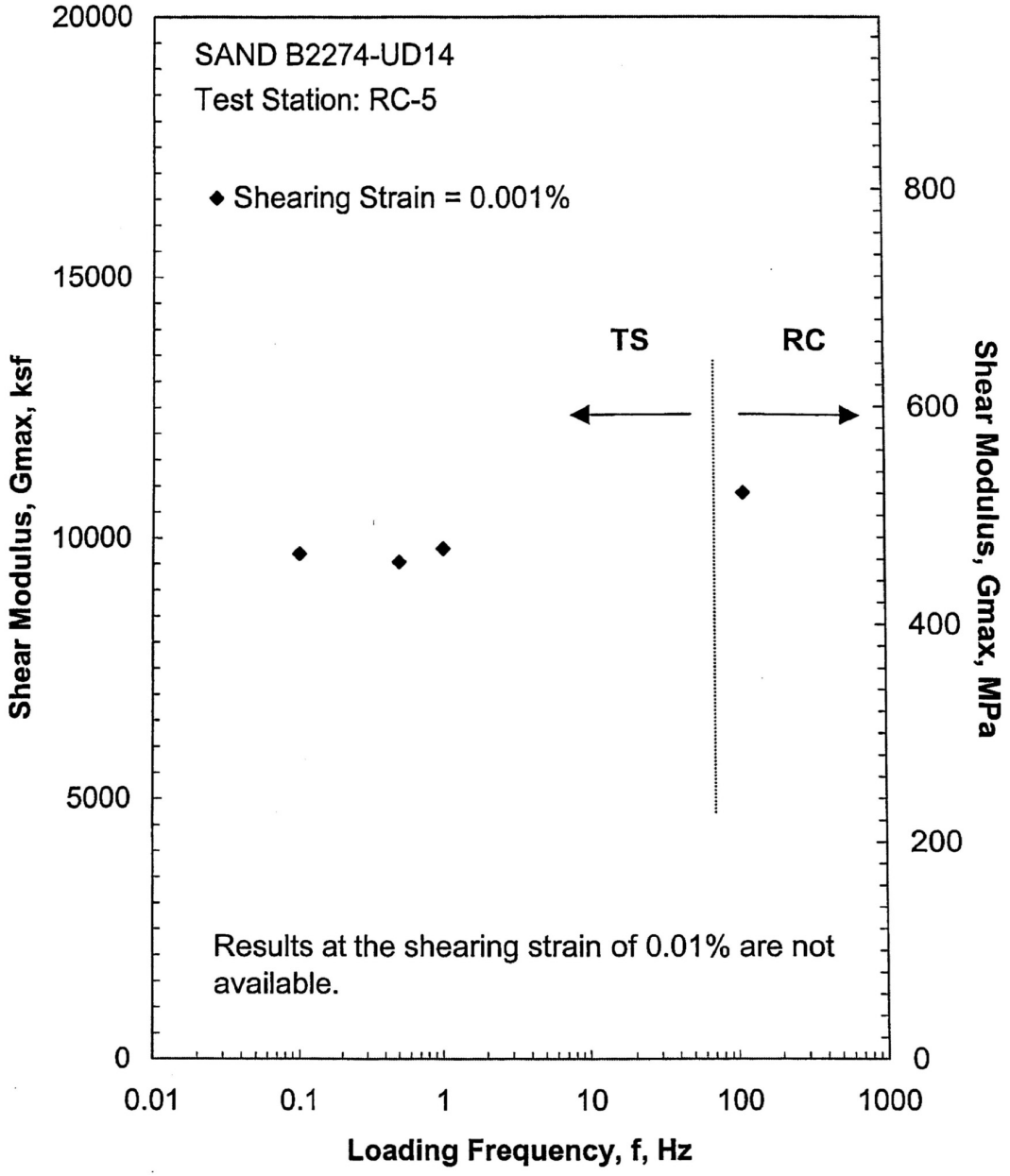


**Figure F.19 Comparison of the Variation in Shear Modulus with Loading Frequency at an Isotropic Confining Pressure of 365 psi from the Combined RCTS Tests**

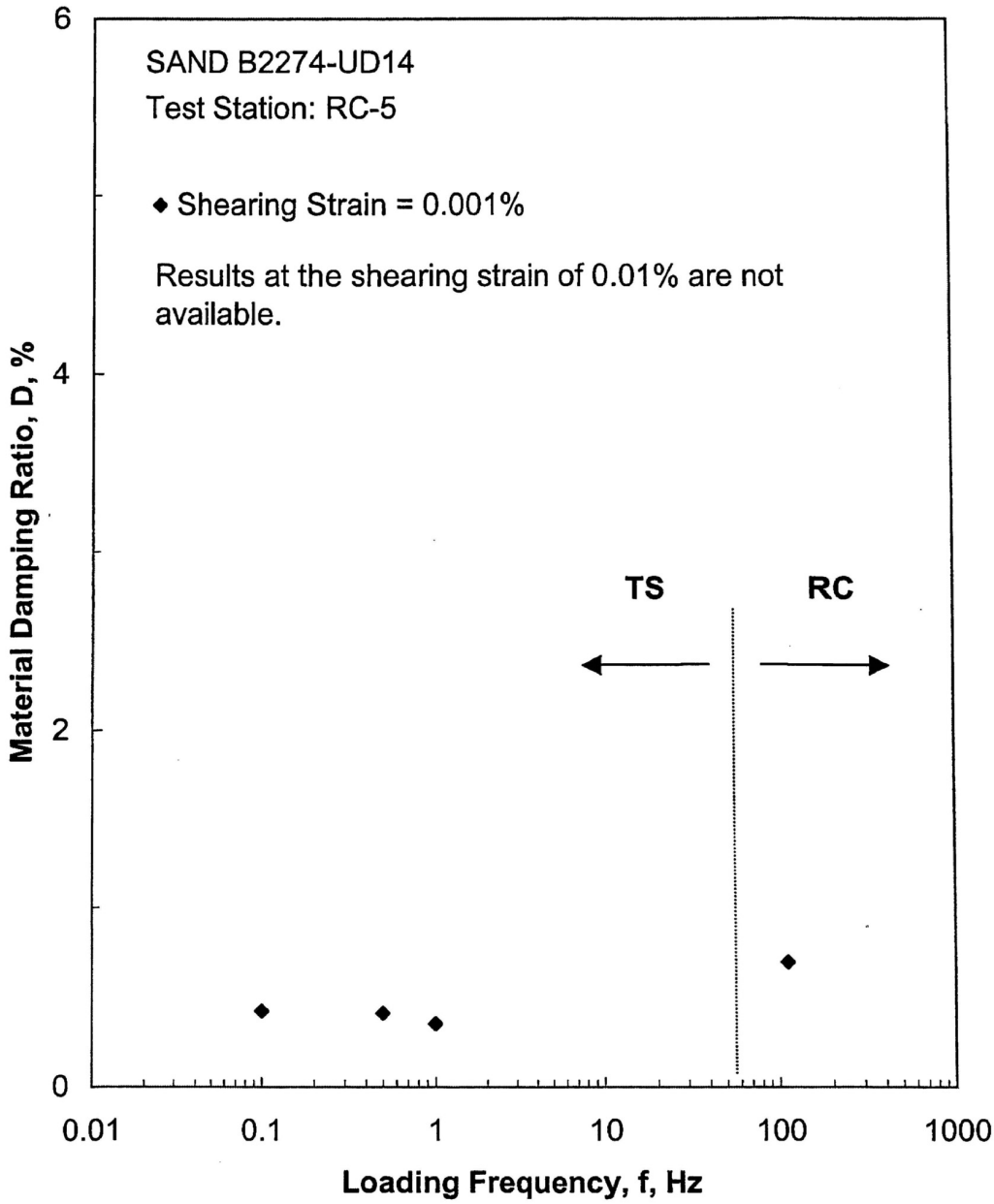


**Figure F.20 Comparison of the Variation in Material Damping Ratio with Loading Frequency at an Isotropic Confining Pressure of 365 psi from the Combined RCTS Tests**

Table F.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 B2274-UD14

| Isotropic Confining Pressure, $\sigma_o$ | | | 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) | (%) | |
| 23 | 3312 | 158 | 2341 | 112 | 762 | 0.86 | 0.51 |
| 46 | 6624 | 317 | 3505 | 168 | 932 | 0.78 | 0.51 |
| 91 | 13104 | 627 | 5158 | 248 | 1130 | 0.72 | 0.51 |
| 182 | 26208 | 1254 | 7898 | 379 | 1397 | 0.63 | 0.51 |
| 365 | 52560 | 2515 | 11145 | 535 | 1656 | 0.56 | 0.50 |

Table F.2 Variation in Shear Modulus and Material Damping Ratio with Shearing Strain from RC Tests of Specimen EXELON B2274-UD14; Isoptropic Confining Pressure, $\sigma_o$=91 psi (13.1 ksf = 627 kPa)

| Peak Shearing Strain, % | Shear Modulus, G, ksf | Normalized Shear Modulus, $G/G_{max}$ | Average[+] Shearing Strain, % | Material Damping Ratio[x], D, % |
|---|---|---|---|---|
| 2.30E-04 | 5127 | 1.00 | 2.30E-04 | 0.72 |
| 4.59E-04 | 5127 | 1.00 | 4.59E-04 | 0.72 |
| 9.58E-04 | 5093 | 0.99 | 9.58E-04 | 0.75 |
| 1.87E-03 | 5060 | 0.99 | 1.70E-03 | 0.80 |
| 3.61E-03 | 5026 | 0.98 | 3.35E-03 | 0.81 |
| 6.92E-03 | 4927 | 0.96 | 6.29E-03 | 0.92 |
| 1.28E-02 | 4795 | 0.94 | 1.16E-02 | 1.18 |
| 2.22E-02 | 4632 | 0.90 | 1.95E-02 | 1.57 |
| 3.75E-02 | 4303 | 0.84 | 3.19E-02 | 2.06 |
| 6.15E-02 | 3883 | 0.76 | 5.04E-02 | 2.66 |
| 9.52E-02 | 3619 | 0.71 | 7.33E-02 | 3.91 |

[+] 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 F.3 Variation in Shear Modulus, Normalized Shear Modulus and Material Damping Ratio with Shearing Strain from TS Tests of Specimen B2274-UD14; Isotropic Confining Pressure, $\sigma_o$= 91 psi (13.1 ksf =627 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, % |
| 1.02E-03 | 4314 | 1.00 | 0.28 | 1.02E-03 | 4305 | 1.00 | 0.25 |
| 2.03E-03 | 4314 | 1.00 | 0.33 | 2.05E-03 | 4285 | 1.00 | 0.39 |
| 4.15E-03 | 4229 | 0.98 | 0.44 | 4.14E-03 | 4241 | 0.99 | 0.46 |
| 1.07E-02 | 4110 | 0.95 | 0.71 | 1.07E-02 | 4102 | 0.95 | 0.75 |

Table F.4 Variation in Shear Modulus and Material Damping Ratio with Shearing Strain from RC Tests of Specimen B2274-UD14; Isoptropic Confining Pressure, $\sigma_o$= 365 psi (52.6 ksf = 2515 kPa)

| Peak Shearing Strain, % | Shear Modulus, G, ksf | Normalized Shear Modulus, $G/G_{max}$ | Average[+] Shearing Strain, % | Material Damping Ratio[x], D, % |
|---|---|---|---|---|
| 1.37E-04 | 10904 | 1.00 | 1.37E-04 | 0.58 |
| 2.71E-04 | 10904 | 1.00 | 2.71E-04 | 0.61 |
| 5.55E-04 | 10904 | 1.00 | 5.55E-04 | 0.64 |
| 1.10E-03 | 10871 | 1.00 | 1.10E-03 | 0.70 |
| 2.17E-03 | 10774 | 0.99 | 2.04E-03 | 0.73 |
| 4.22E-03 | 10725 | 0.98 | 3.92E-03 | 0.79 |
| 8.23E-03 | 10593 | 0.97 | 7.57E-03 | 0.87 |
| 1.48E-02 | 10351 | 0.95 | 1.35E-02 | 1.01 |
| 2.61E-02 | 9875 | 0.91 | 2.38E-02 | 1.23 |
| 4.26E-02 | 9312 | 0.85 | 3.79E-02 | 1.62 |
| 6.69E-02 | 8559 | 0.78 | 5.68E-02 | 2.21 |
| 1.02E-01 | 7844 | 0.72 | 8.28E-02 | 3.02 |

[+] 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 F.5 Variation in Shear Modulus, Normalized Shear Modulus and Material Damping Ratio with Shearing Strain from TS Tests of Specimen B2274-UD14; Isotropic Confining Pressure, $\sigma_o$=365 psi (52.6 ksf = 2515 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, % |
| 1.03E-03 | 9667 | 1.00 | 0.33 | 1.04E-03 | 9620 | 1.00 | 0.41 |
| 2.06E-03 | 9667 | 1.00 | 0.39 | 2.06E-03 | 9620 | 1.00 | 0.33 |
| 4.10E-03 | 9667 | 1.00 | 0.37 | 4.12E-03 | 9620 | 1.00 | 0.50 |

**FUGRO CONSULTANTS, INC.**

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

April 21, 2008

Ms. Siesta Williams
MACTEC
3301 Atlantic Avenue
Raleigh, NC 27604

**RE: Two (2) Reports For The EXELON COL Project**

Dear Ms. Williams:

Fugro has completed two (2) RCTS tests, which are B2274-UD23 and B2269-UD19, for the EXELON project. Fugro has incorporated, as needed, Dr. Kenneth Stokoe's comments into the final reports. The final reports and the associated RCTS Test Approvals 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

Enclosures

Cc: Kathryn White, in PDF

# RCTS TEST APROVAL

| PROJECT SITE/NAME | EXELON |
|---|---|

| Test ID | Sample ID | Depth B.S. (Ft) | Approved By (Initials) | Date |
|---|---|---|---|---|
| RCTS#G | B2274-UD23 | 422.5 | KHS | 12 Apr. 08 |
| RCTS#H | B2269-UD19 | 381.6 | KHS (+) | 12 Apr. 08 |

Two RCTS tests for the site referenced above were tested, and two reports were 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

(+) see notes on a couple figures

# APPENDIX G

Specimen B2274-UD23
(Index Properties Not Available)

Borehole B2274
Sample UD23
Depth = 422.5 (128.8 m)
Total Unit Weight = 134.4 lb/ft$^3$
Water Content = 15.5 %
Estimated In-Situ Ko = 0.5
Estimated In-Situ Mean Effective
Stress = 136 psi

FUGRO JOB #: 0411-08-1686
Testing Station: RC7

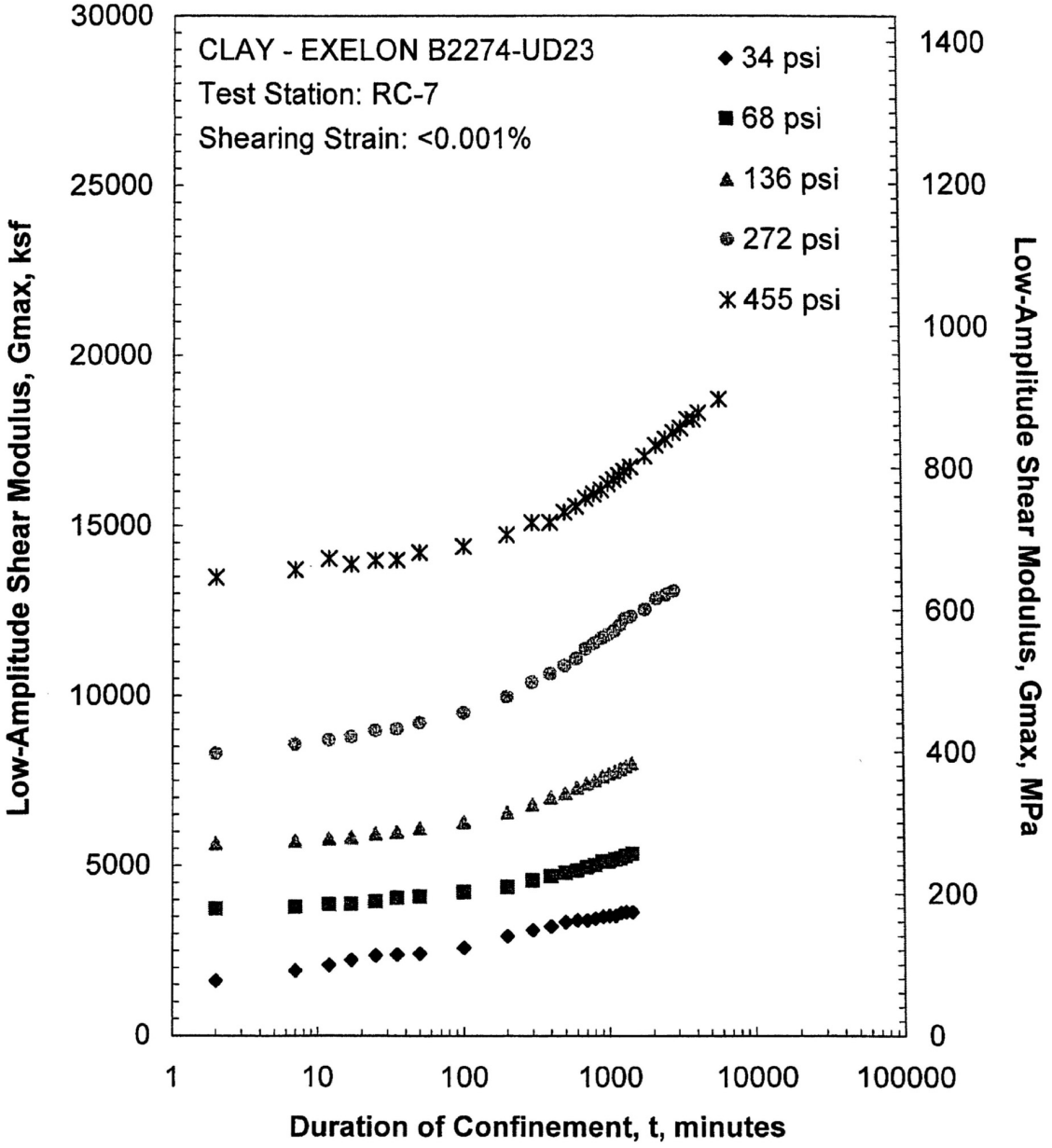


**Figure G.1 Variation in Low-Amplitude Shear Modulus with Magnitude and Duration of Isotropic Confining Pressure from Resonant Column Tests**

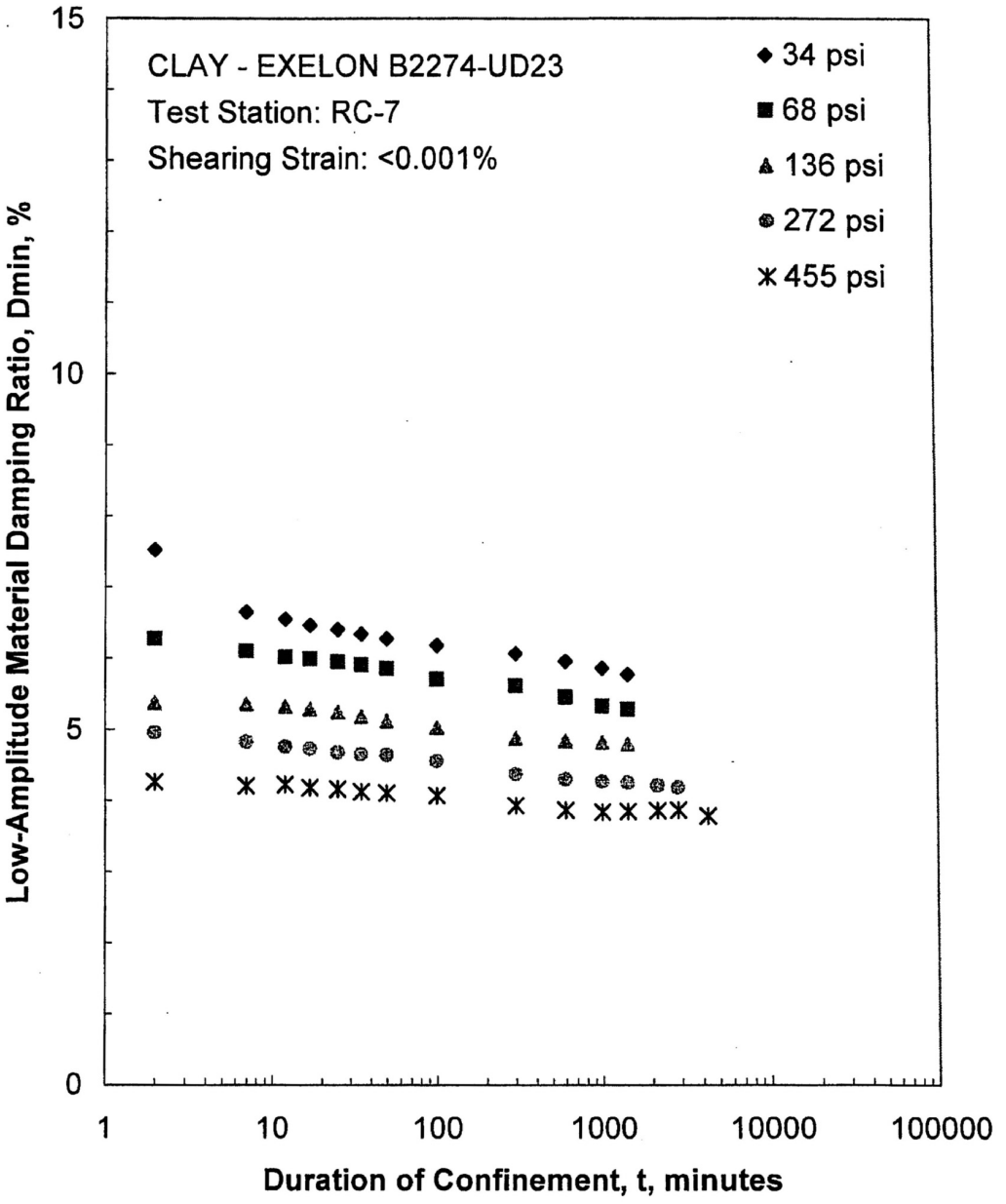


**Figure G.2 Variation in Low-Amplitude Material Damping Ratio with Magnitude and Duration of Isotropic Confining Pressure from Resonant Column Tests**

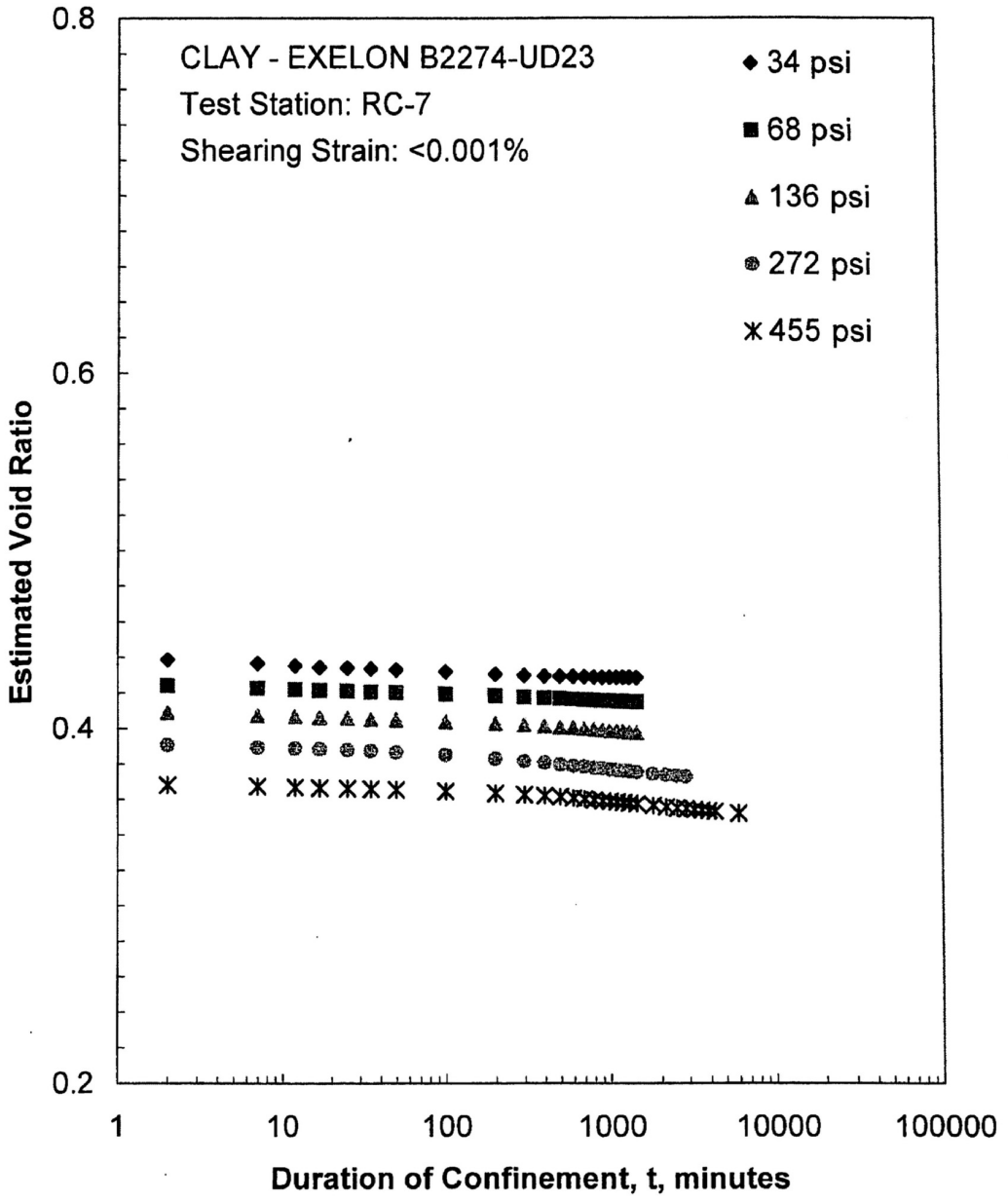


**Figure G.3 Variation in Estimated Void Ratio with Magnitude and Duration of Isotropic Confining Pressure from Resonant Column Tests**

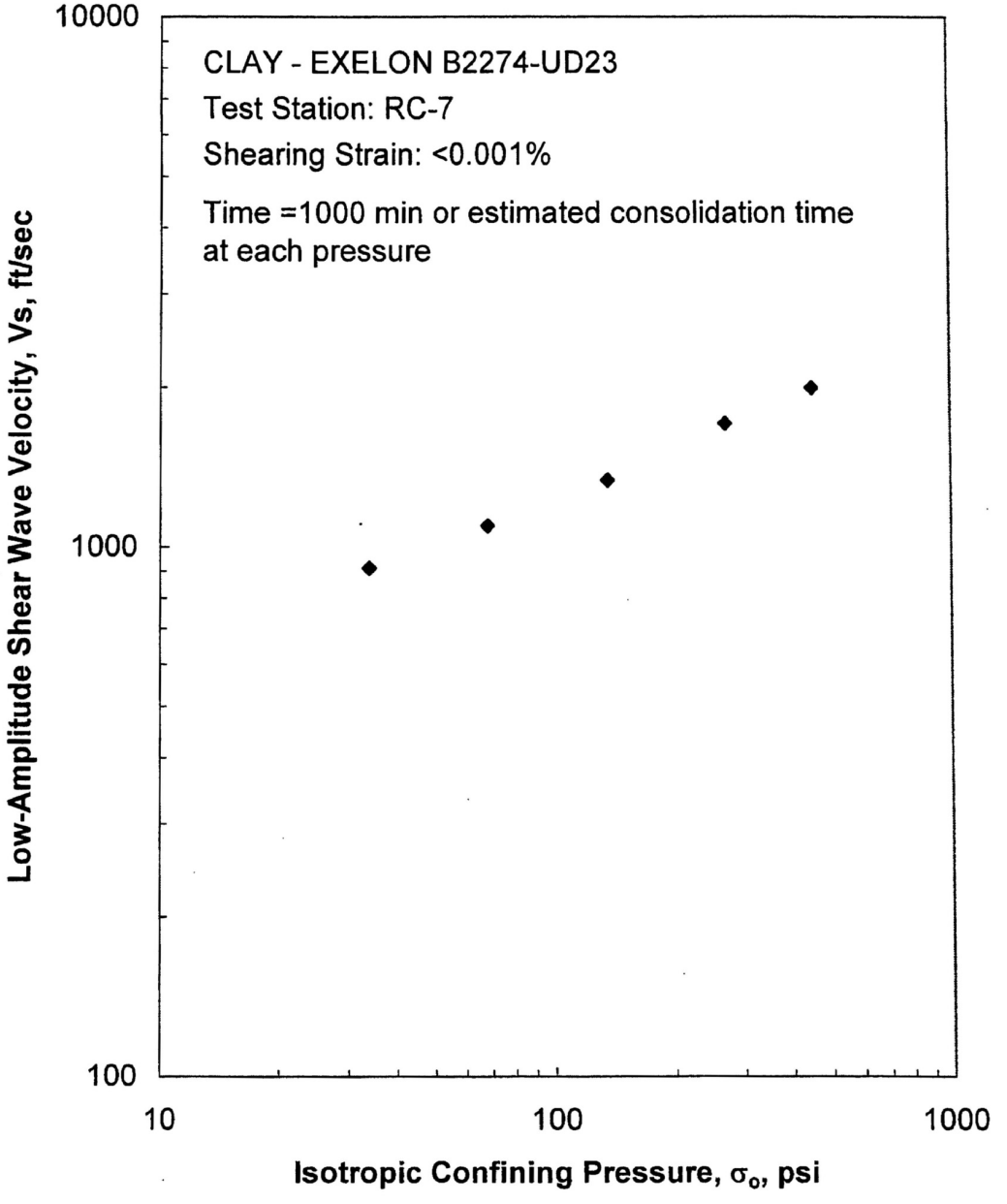


**Figure G.4 Variation in Low-Amplitude Shear Wave Velocity with Isotropic Confining Pressure from Resonant Column Tests**

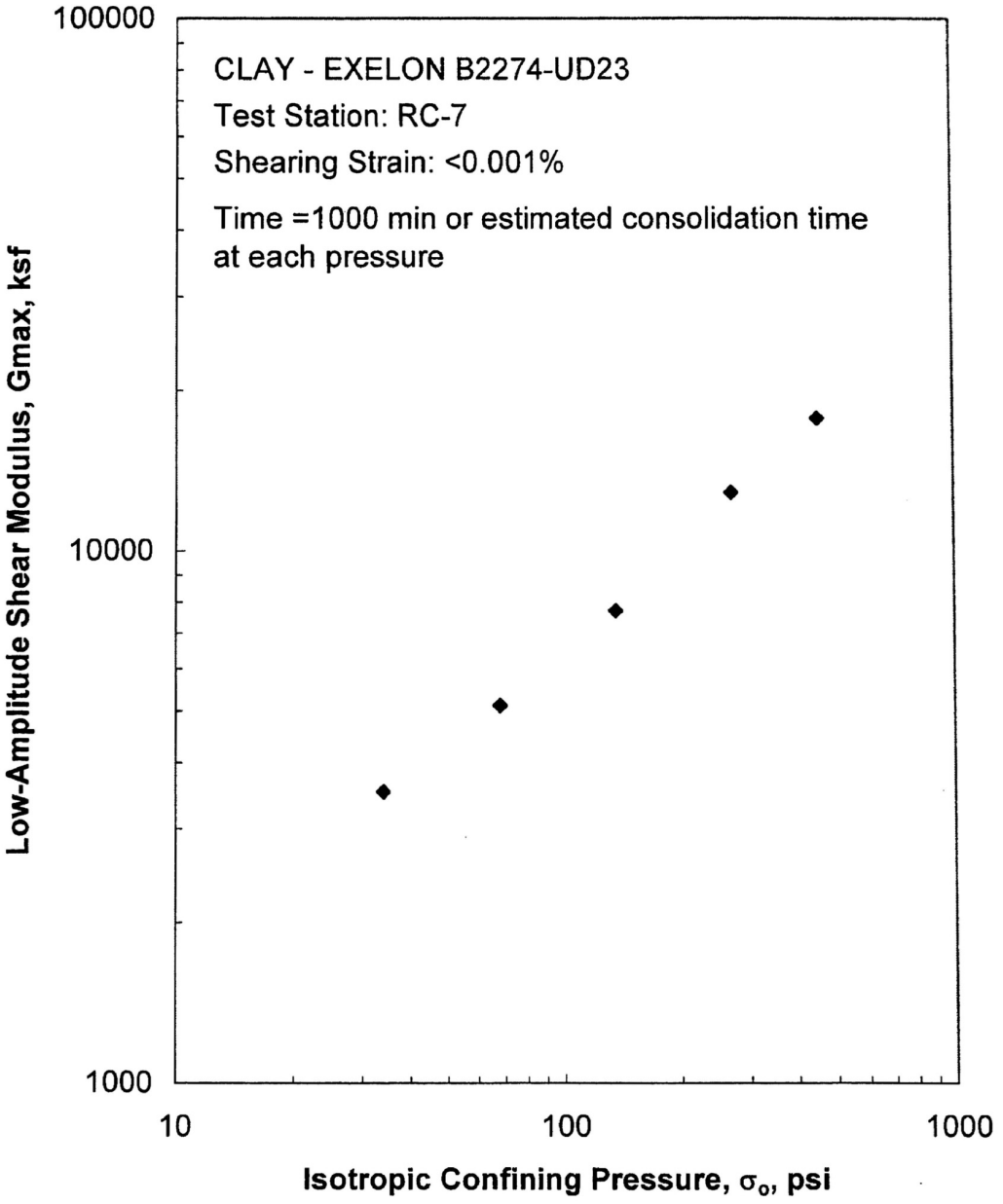


**Figure G.5 Variation in Low-Amplitude Shear Modulus with Isotropic Confining Pressure from Resonant Column Tests**

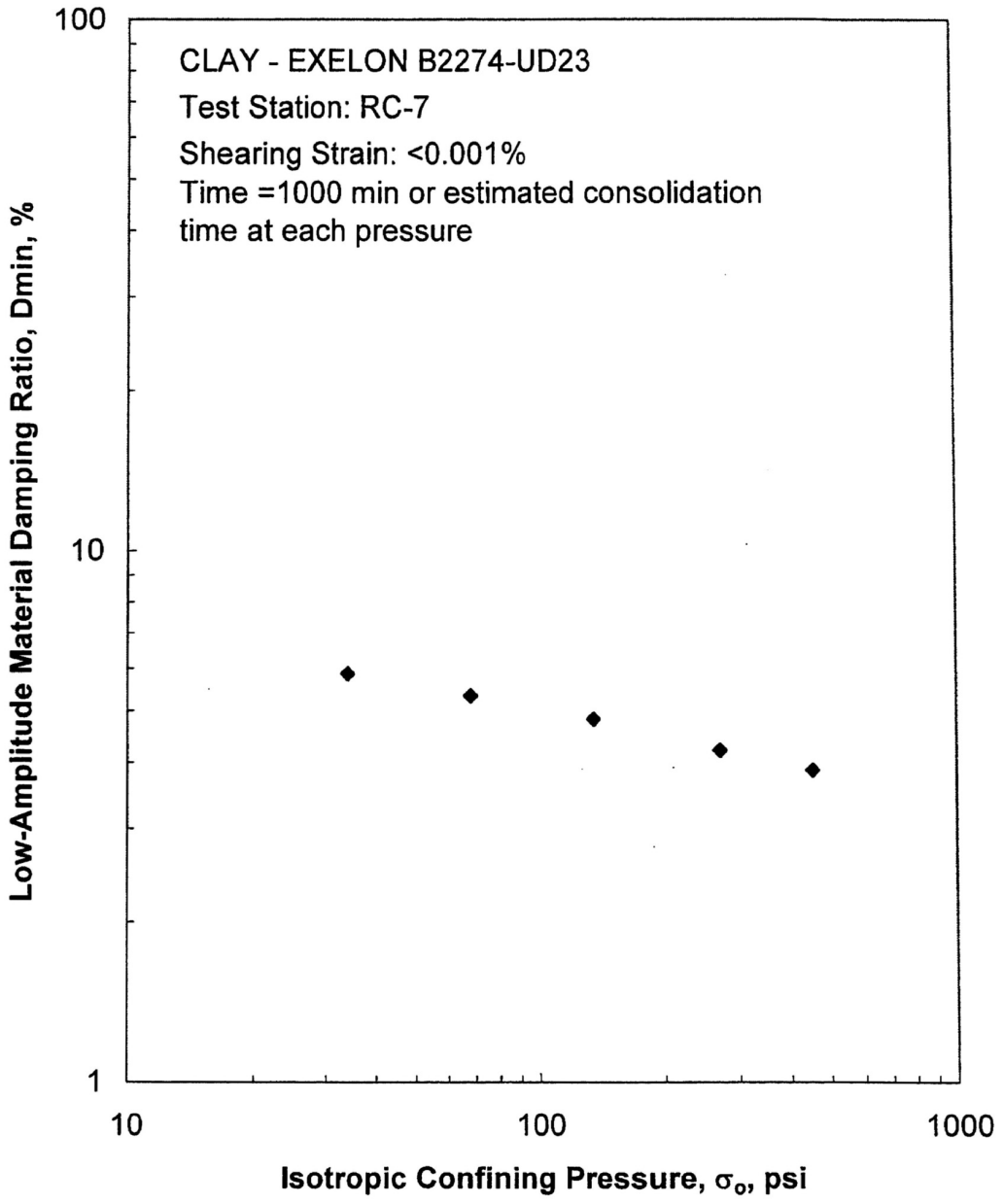


**Figure G.6 Variation in Low-Amplitude Material Damping Ratio with Isotropic Confining Pressure from Resonant Column Tests**

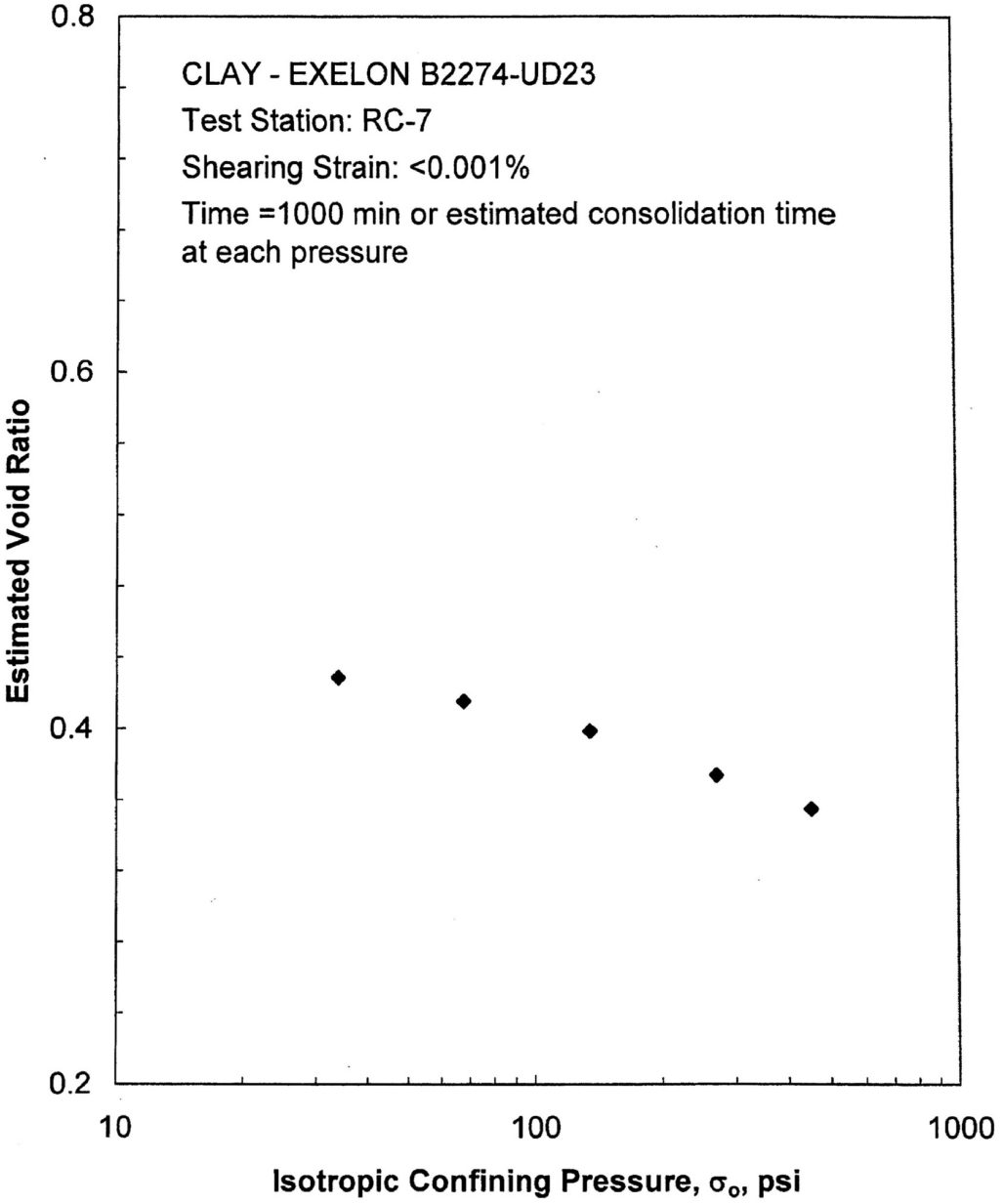


**Figure G.7 Variation in Estimated Void Ratio with Isotropic Confining Pressure from Resonant Column Tests**

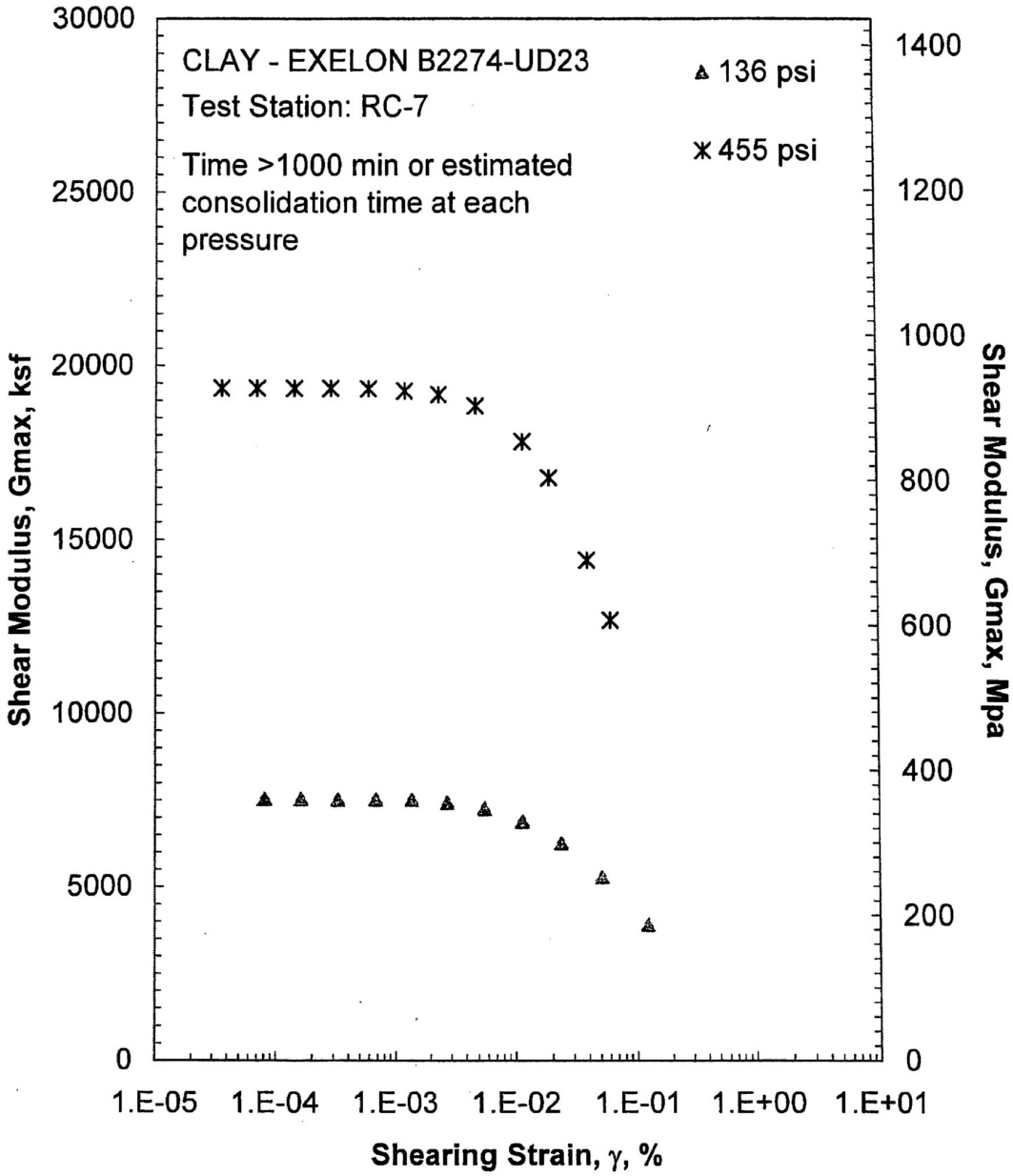


**Figure G.8 Comparison of the Variation in Shear Modulus with Shearing Strain and Isotropic Confining Pressure from the Resonant Column Tests**

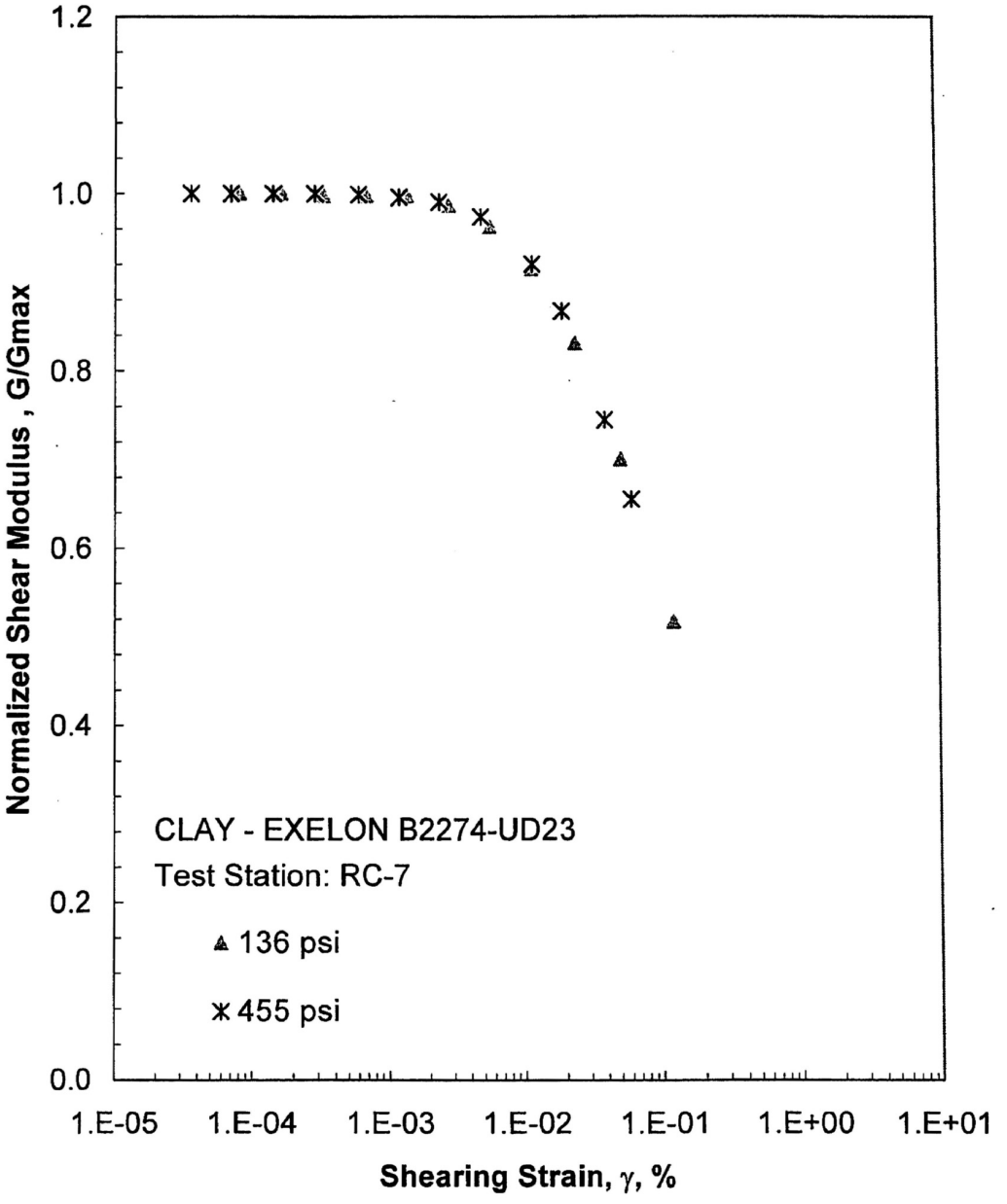


**Figure G.9 Comparison of the Variation in Normalized Shear Modulus with Shearing Strain and Isotropic Confining Pressure from the Resonant Column Tests**

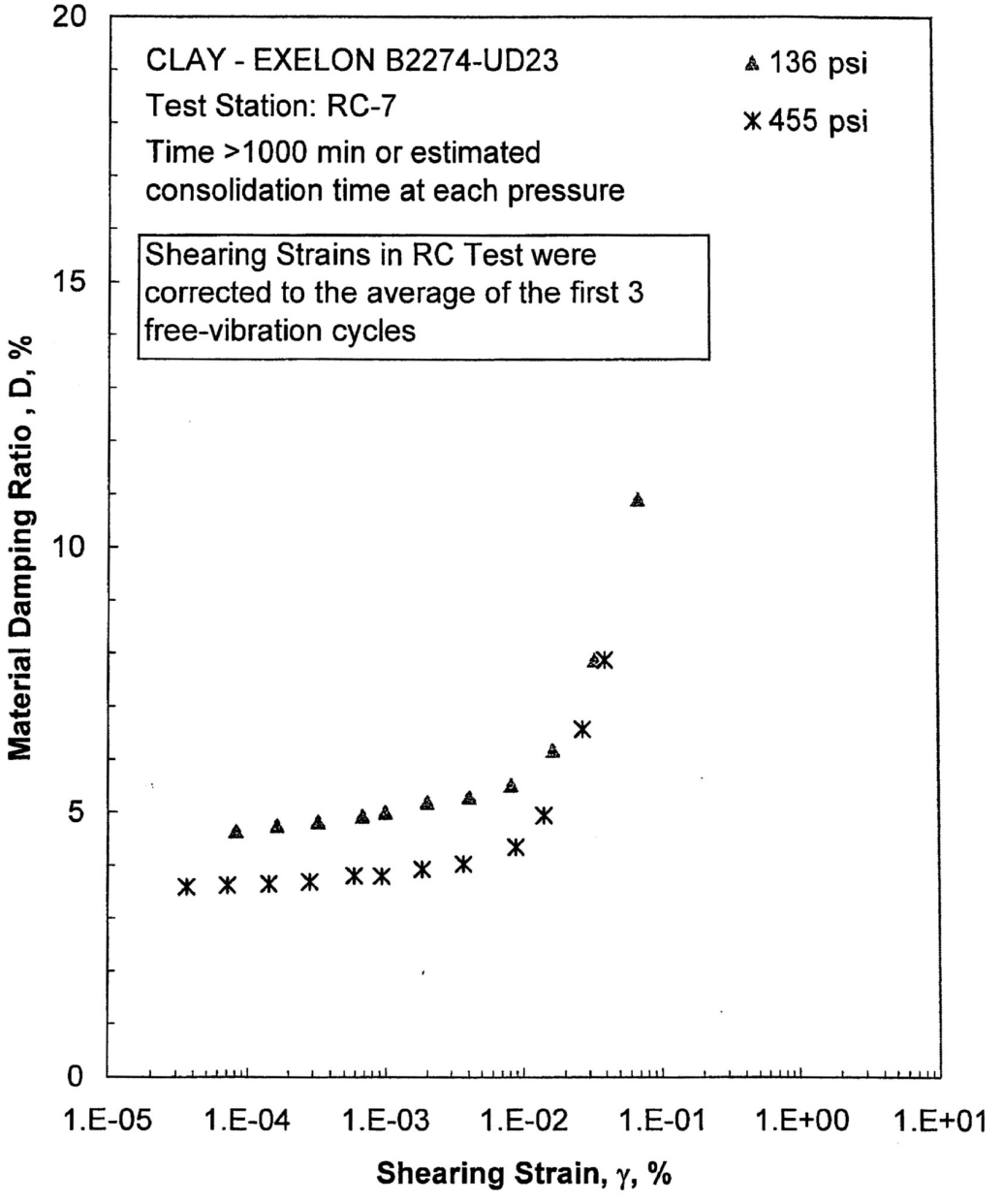


**Figure G.10 Comparison of the Variation in Material Damping Ratio with Shearing Strain and Isotropic Confining Pressure from the Resonant Column Tests**

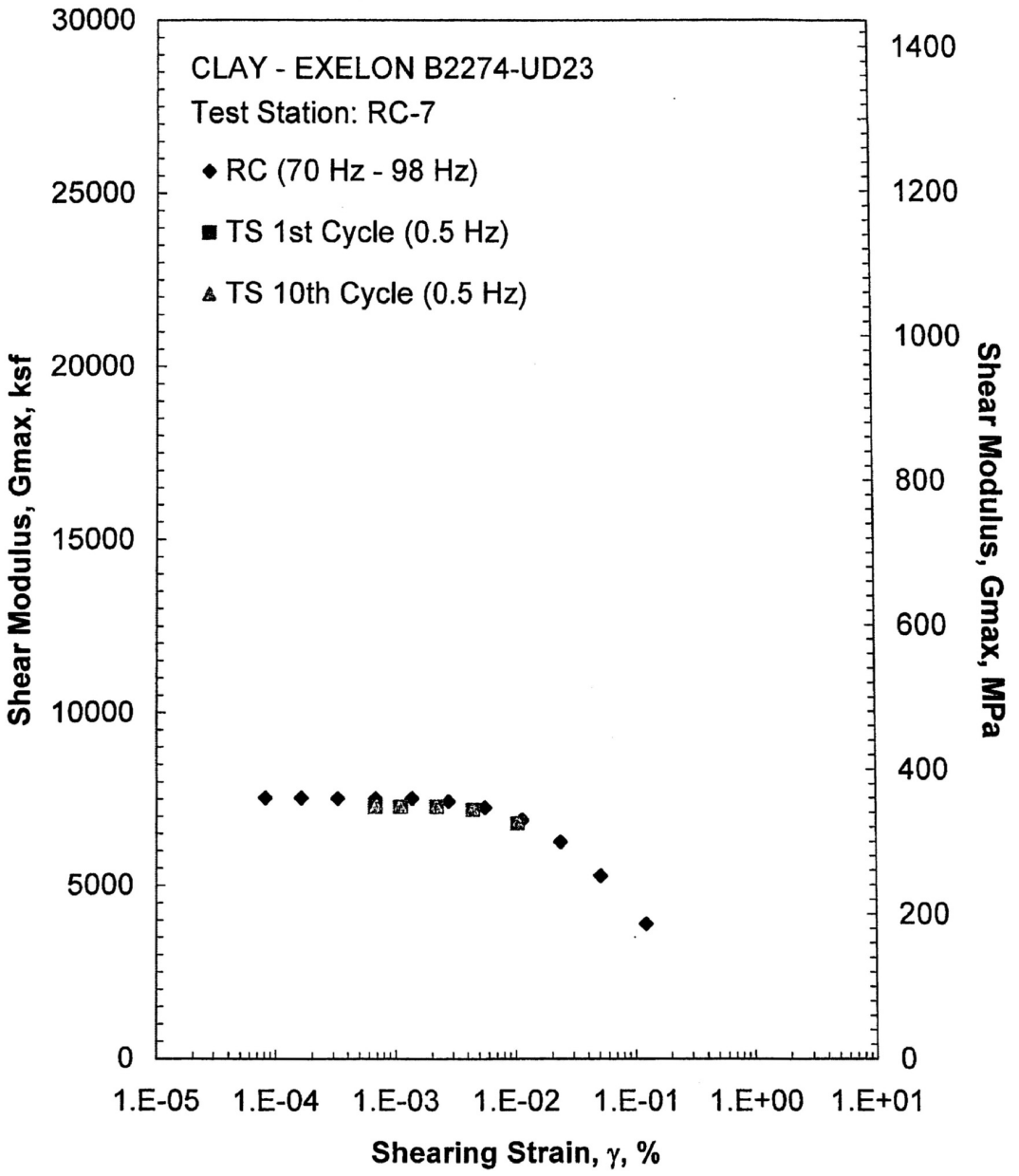


**Figure G.11 Comparison of the Variation in Shear Modulus with Shearing Strain at an Isotropic Confining Pressure of 136 psi from the Combined RCTS Tests**

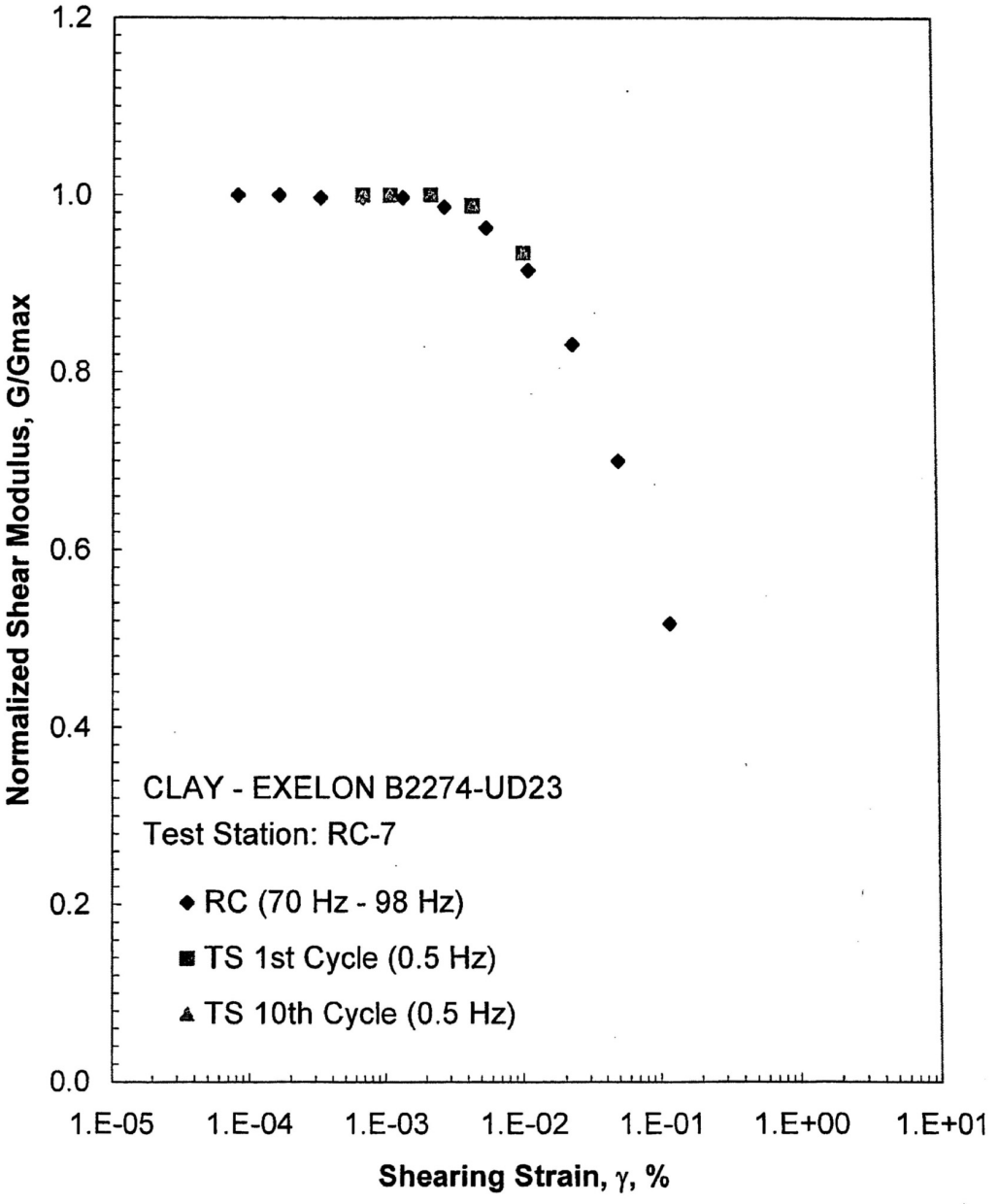


**Figure G.12 Comparison of the Variation in Normalized Shear Modulus with Shearing Strain at an Isotropic Confining Pressure of 136 psi from the Combined RCTS Tests**

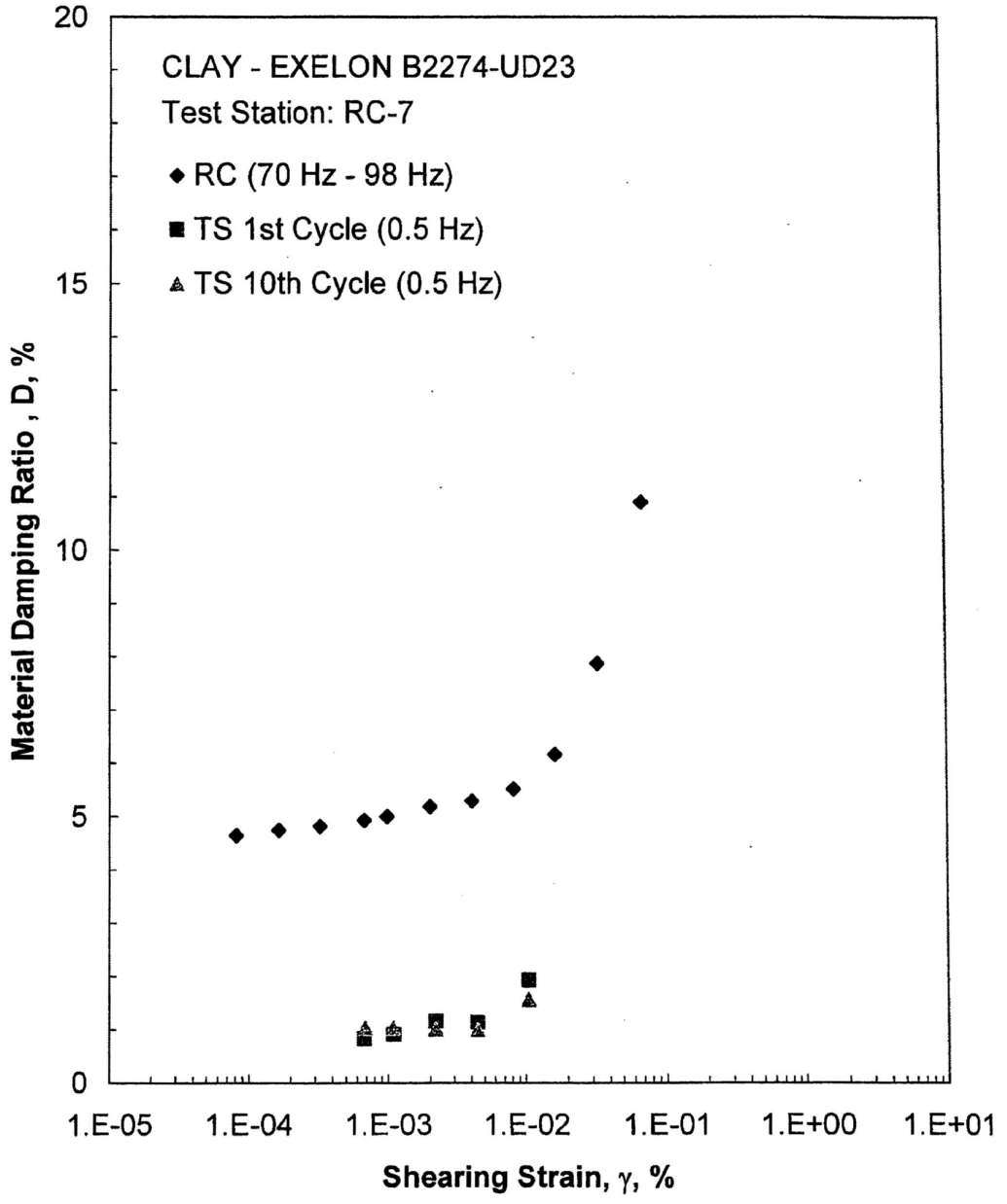


**Figure G.13 Comparison of the Variation in Material Damping Ratio with Shearing Strain at an Isotropic Confining Pressure of 136 psi from the Combined RCTS Tests**

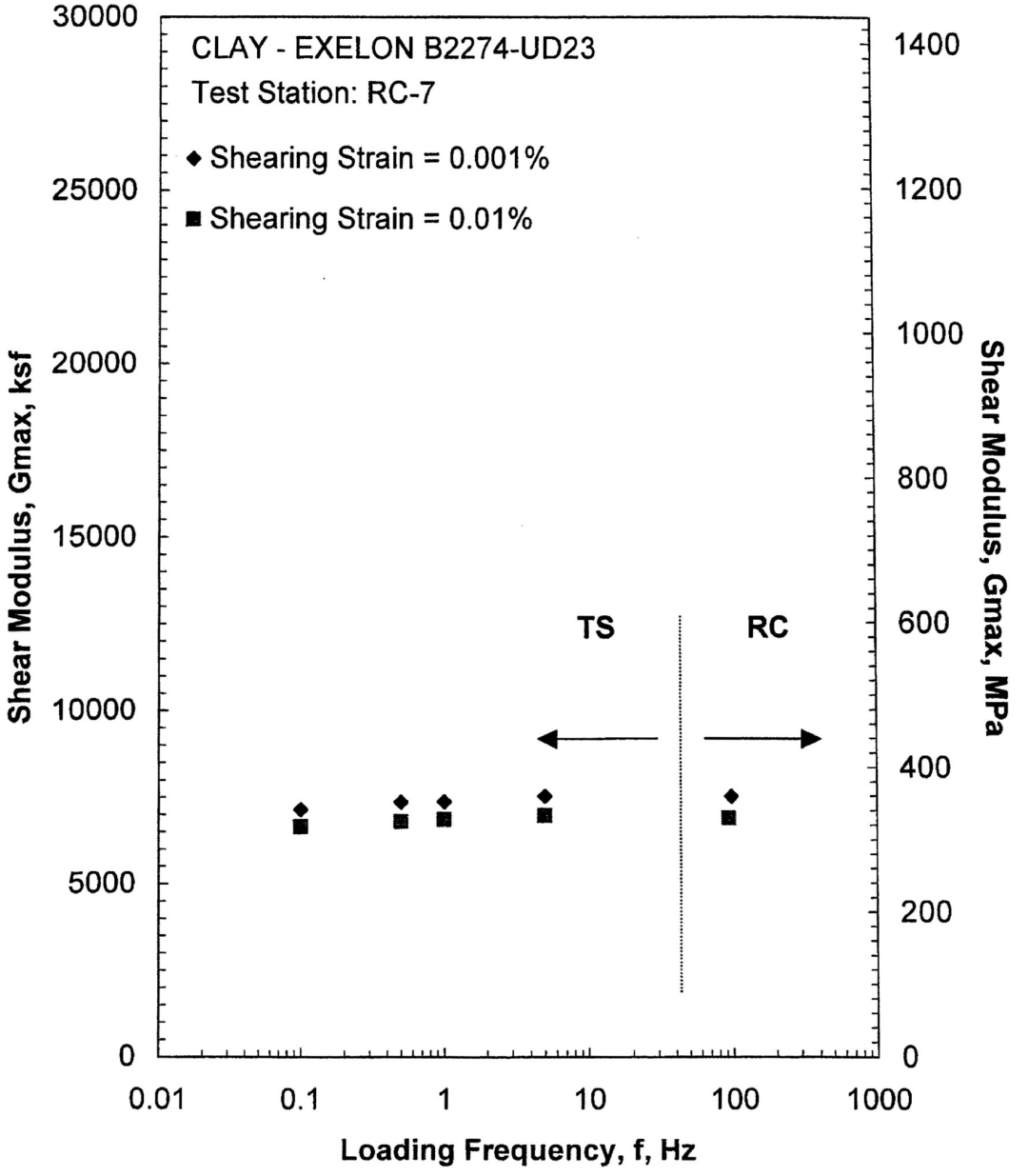


**Figure G.14 Comparison of the Variation in Shear Modulus with Loading Frequency at an Isotropic Confining Pressure of 136 psi from the Combined RCTS Tests**

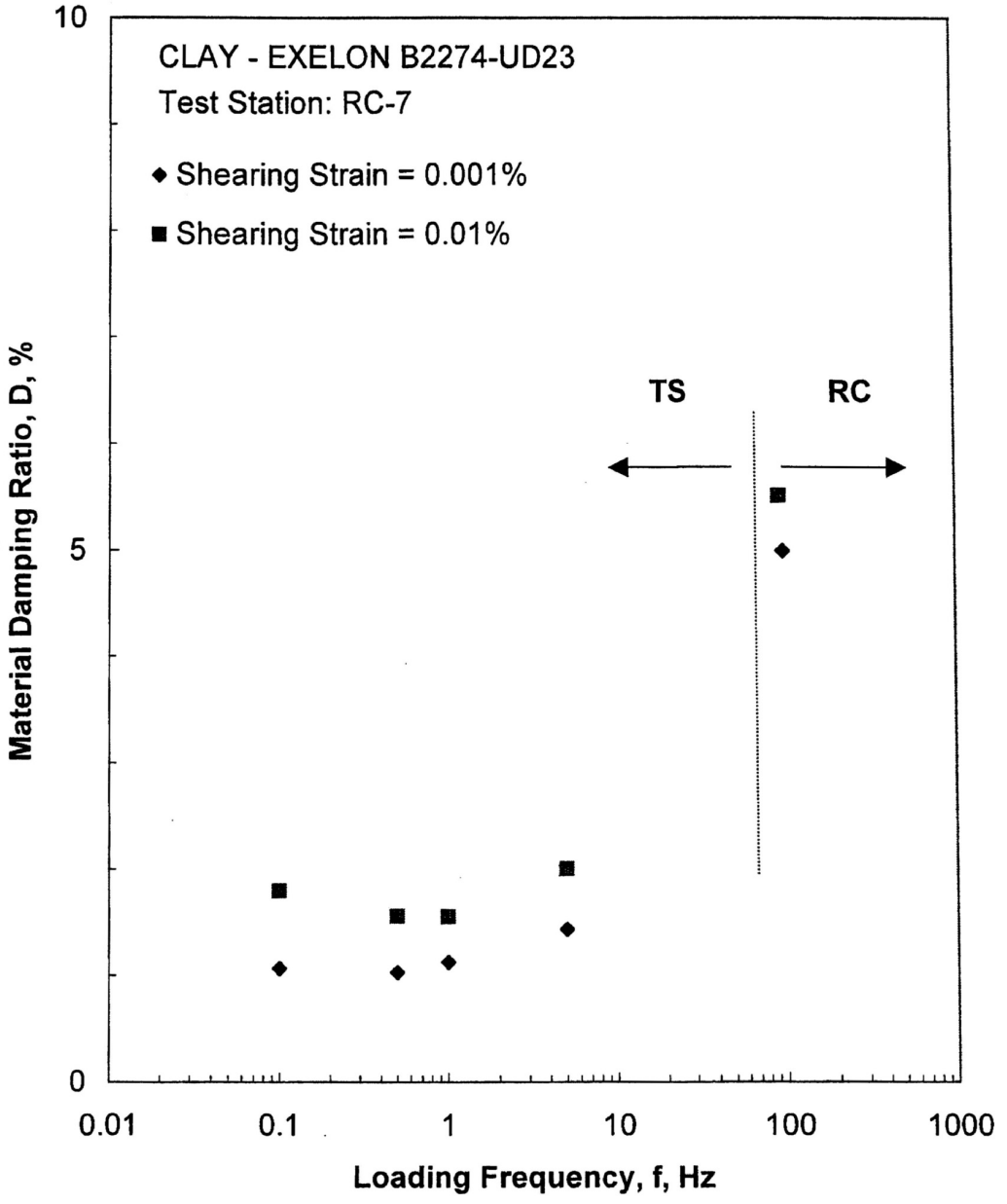


**Figure G.15 Comparison of the Variation in Material Damping Ratio with Loading Frequency at an Isotropic Confining Pressure of 136 psi from the Combined RCTS Tests**

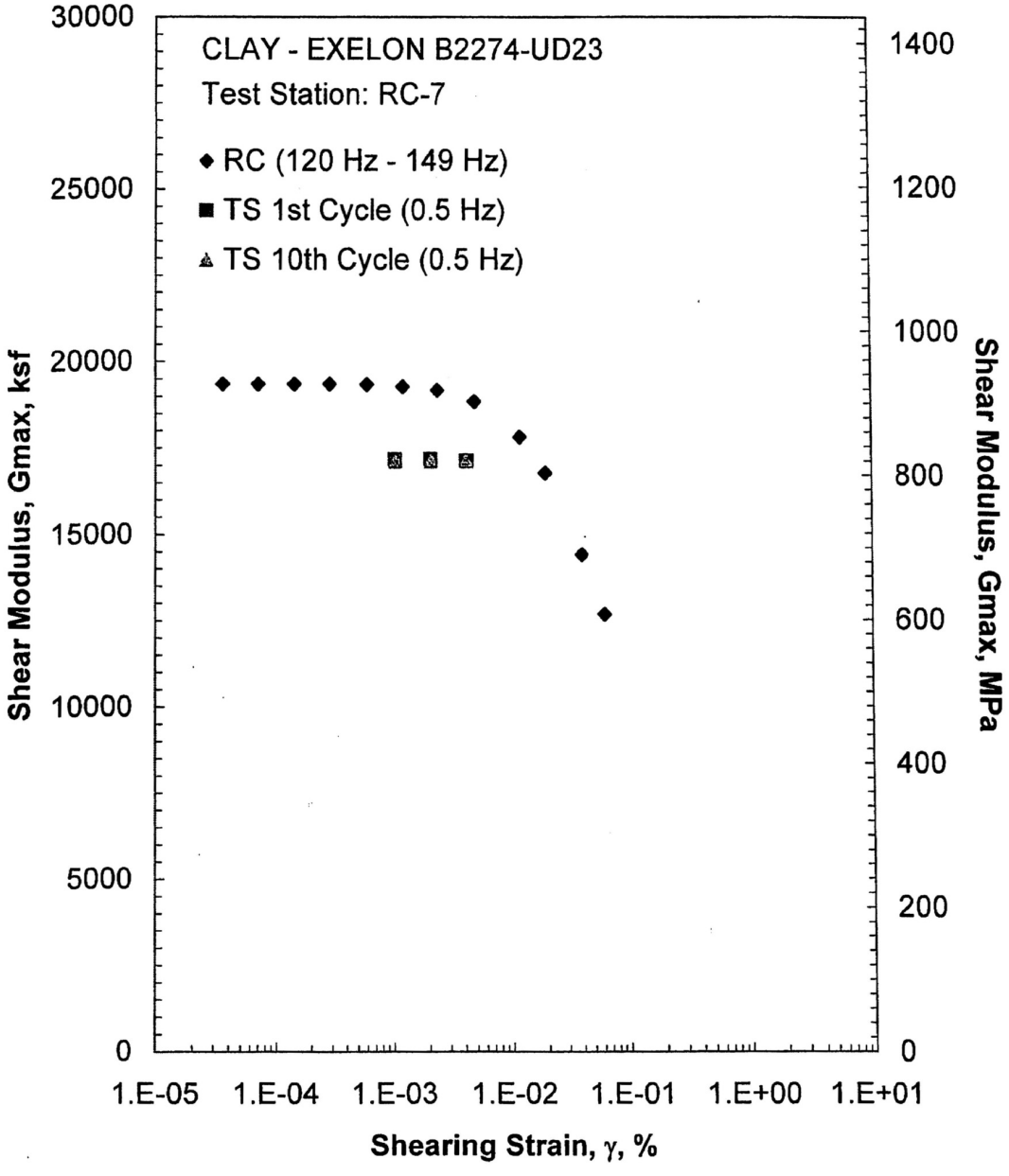


**Figure G.16 Comparison of the Variation in Shear Modulus with Shearing Strain at an Isotropic Confining Pressure of 455 psi from the Combined RCTS Tests**

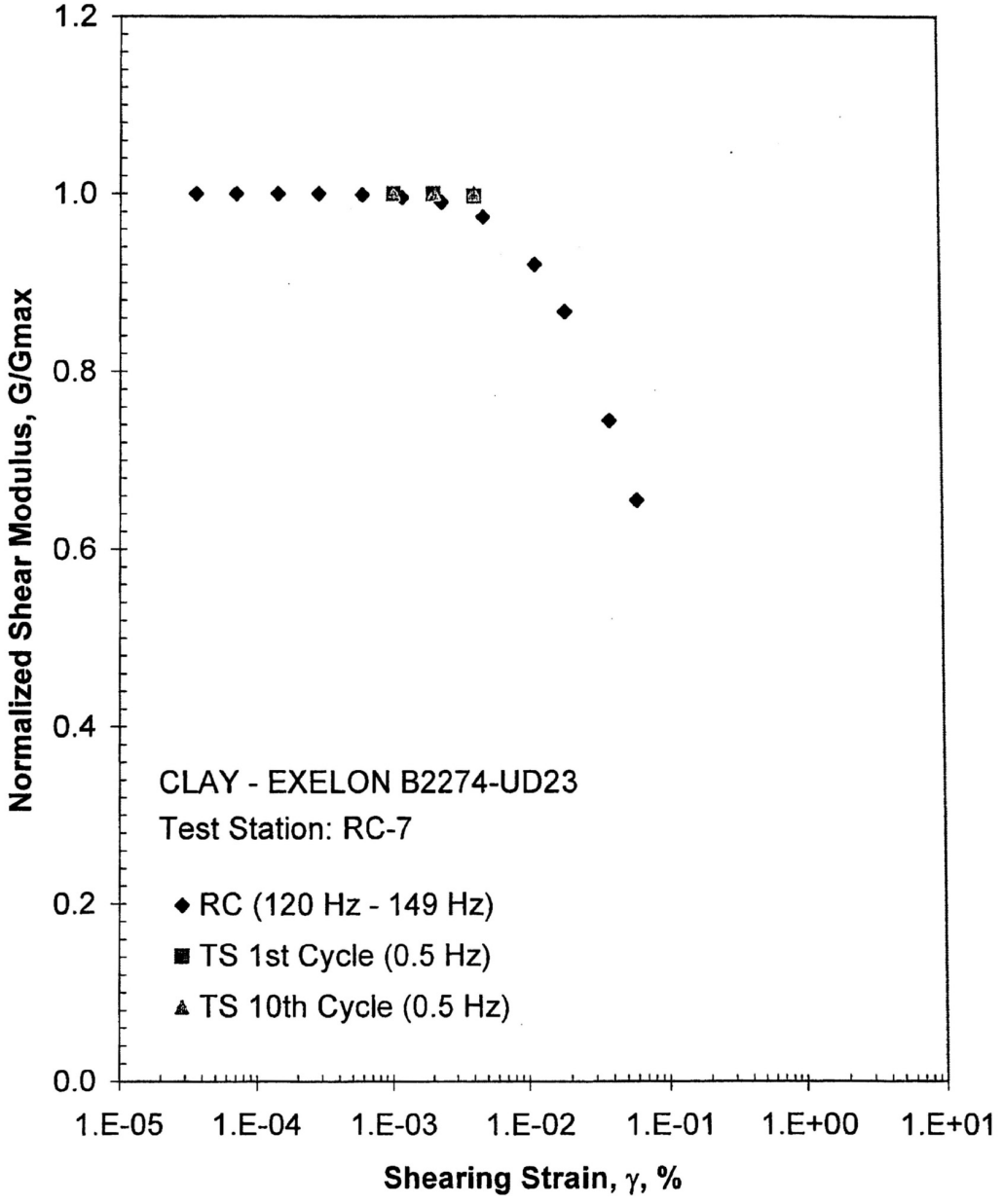


**Figure G.17 Comparison of the Variation in Normalized Shear Modulus with Shearing Strain at an Isotropic Confining Pressure of 455 psi from the Combined RCTS Tests**

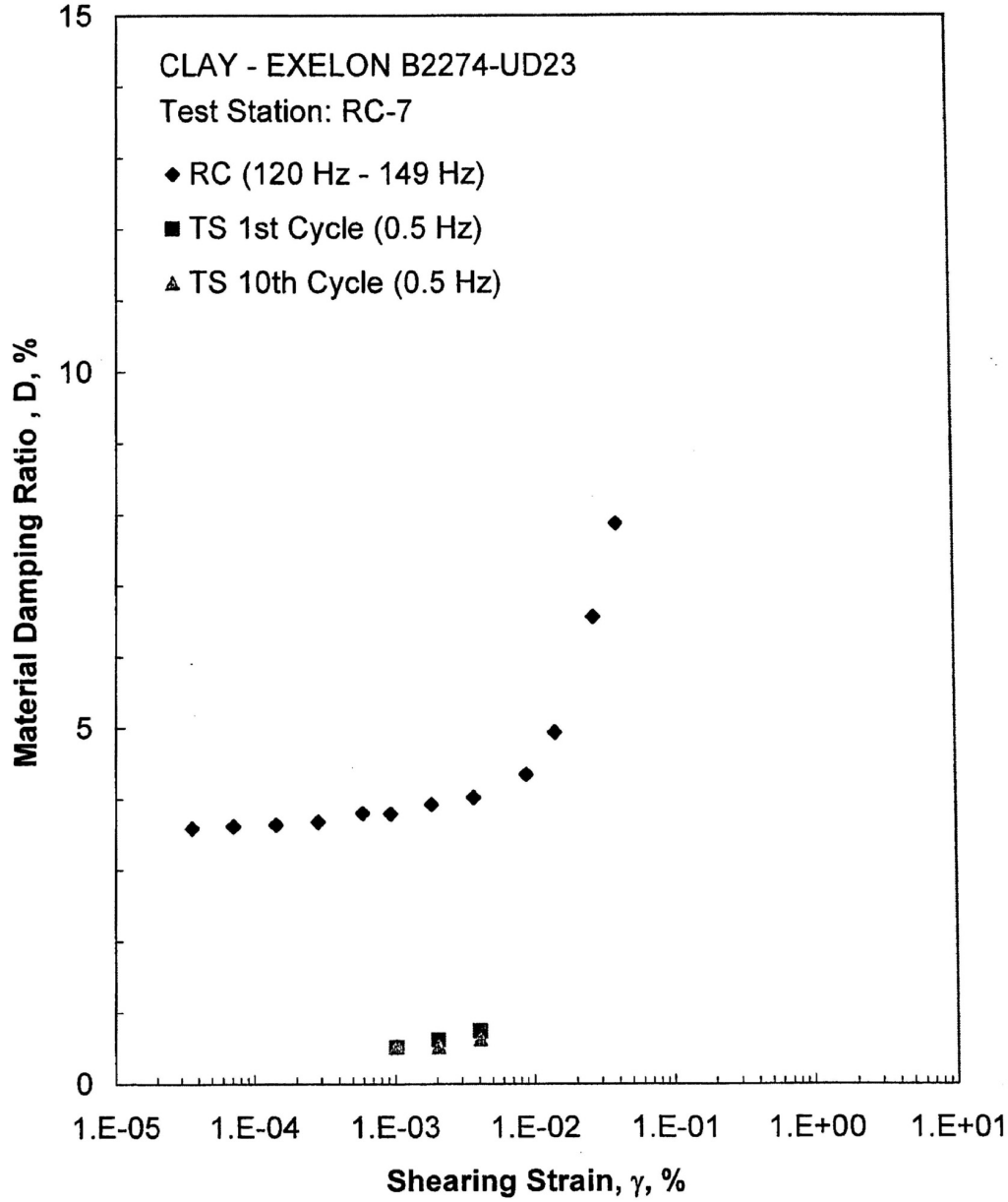


**Figure G.18 Comparison of the Variation in Material Damping Ratio with Shearing Strain at an Isotropic Confining Pressure of 455 psi from the Combined RCTS Tests**

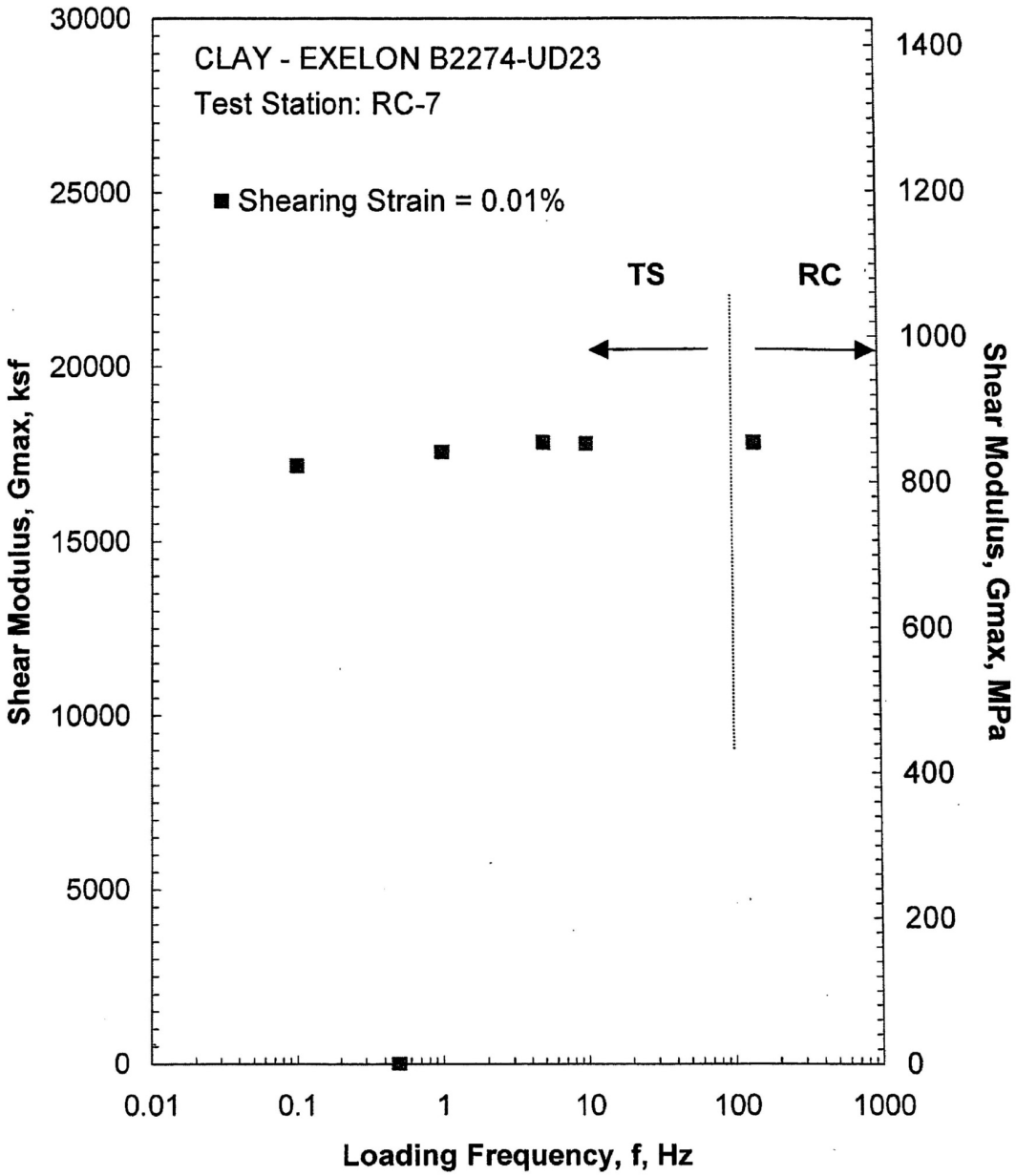


**Figure G.19 Comparison of the Variation in Shear Modulus with Loading Frequency at an Isotropic Confining Pressure of 455 psi from the Combined RCTS Tests**

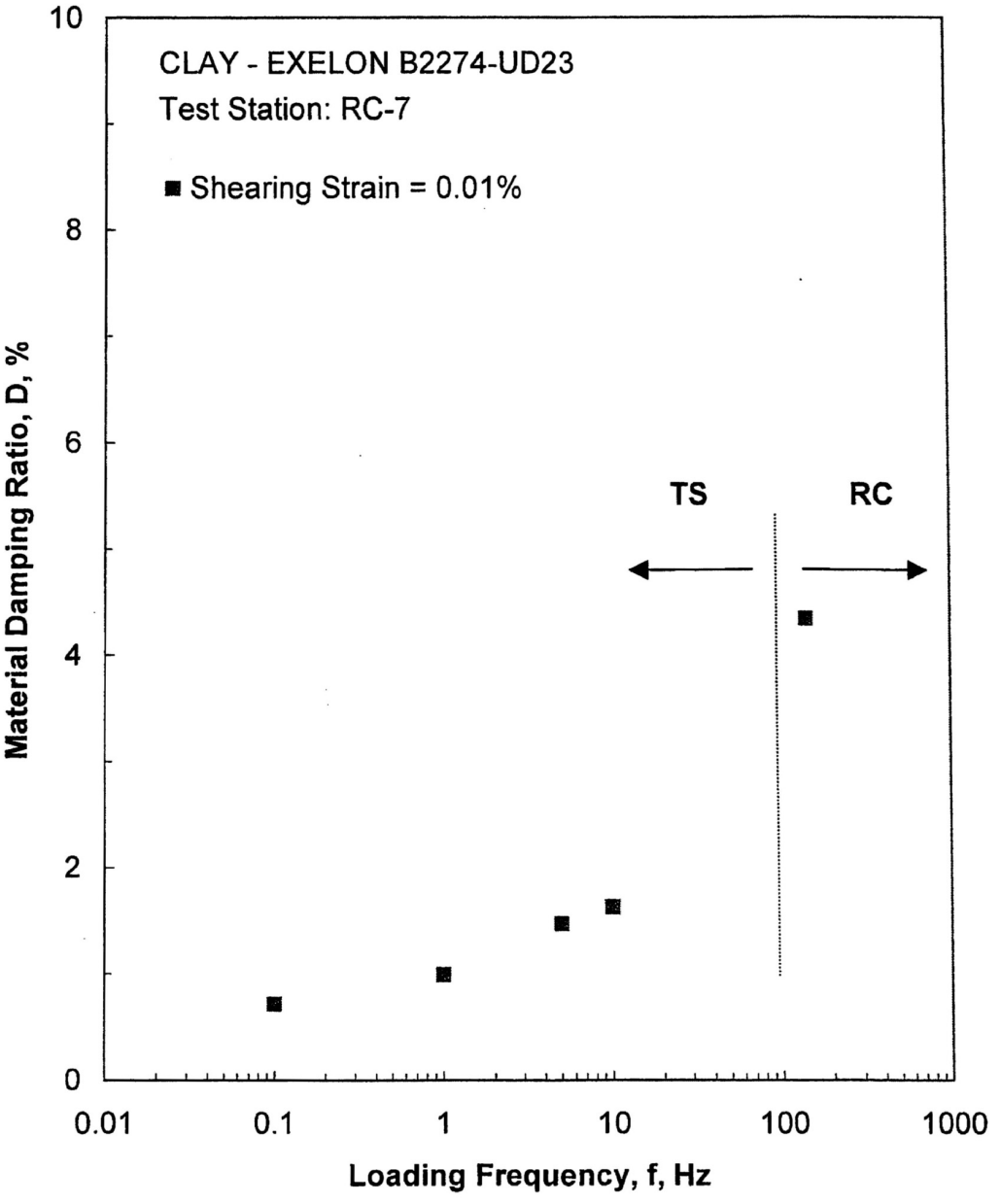


**Figure G.20 Comparison of the Variation in Material Damping Ratio with Loading Frequency at an Isotropic Confining Pressure of 455 psi from the Combined RCTS Tests**

Table G.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 B2274-UD23

| Isotropic Confining Pressure, $\sigma_o$ | | | 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) | (%) | |
| 34 | 4896 | 234 | 3525 | 169 | 912 | 5.86 | 0.43 |
| 68 | 9792 | 469 | 5117 | 246 | 1094 | 5.33 | 0.42 |
| 136 | 19584 | 937 | 7704 | 370 | 1335 | 4.82 | 0.40 |
| 272 | 39168 | 1874 | 12855 | 617 | 1708 | 4.21 | 0.37 |
| 455 | 65520 | 3135 | 17743 | 852 | 1993 | 3.86 | 0.35 |

Table G.2 Variation in Shear Modulus and Material Damping Ratio with Shearing Strain from RC Tests of Specimen B2274-UD23; Isoptropic Confining Pressure, $\sigma_o$=136 psi (19.6 ksf = 937 kPa)

| Peak Shearing Strain, % | Shear Modulus, G, ksf | Normalized Shear Modulus, $G/G_{max}$ | Average+ Shearing Strain, % | Material Damping Ratio^x, D, % |
|---|---|---|---|---|
| 8.20E-05 | 7525 | 1.00 | 8.20E-05 | 4.64 |
| 1.64E-04 | 7525 | 1.00 | 1.64E-04 | 4.74 |
| 3.28E-04 | 7504 | 1.00 | 3.28E-04 | 4.81 |
| 6.82E-04 | 7504 | 1.00 | 6.82E-04 | 4.92 |
| 1.36E-03 | 7504 | 1.00 | 9.94E-04 | 4.99 |
| 2.76E-03 | 7422 | 0.99 | 2.02E-03 | 5.18 |
| 5.60E-03 | 7242 | 0.96 | 4.09E-03 | 5.28 |
| 1.14E-02 | 6885 | 0.91 | 8.22E-03 | 5.51 |
| 2.36E-02 | 6253 | 0.83 | 1.65E-02 | 6.16 |
| 5.14E-02 | 5266 | 0.70 | 3.34E-02 | 7.86 |
| 1.23E-01 | 3888 | 0.52 | 7.00E-02 | 10.89 |

+ 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 G.3 Variation in Shear Modulus, Normalized Shear Modulus and Material Damping Ratio with Shearing Strain from TS Tests of Specimen B2274-UD23; Isotropic Confining Pressure, $\sigma_o$= 136 psi (19.6 ksf =937 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, % |
| 6.81E-04 | 7259 | 1.00 | 0.82 | 6.89E-04 | 7266 | 1.00 | 1.02 |
| 1.10E-03 | 7259 | 1.00 | 0.90 | 1.09E-03 | 7266 | 1.00 | 1.02 |
| 2.20E-03 | 7259 | 1.00 | 1.15 | 2.19E-03 | 7266 | 1.00 | 1.00 |
| 4.46E-03 | 7168 | 0.99 | 1.13 | 4.46E-03 | 7175 | 0.99 | 0.99 |

Table G.4 Variation in Shear Modulus and Material Damping Ratio with Shearing Strain from RC Tests of Specimen B2274-UD23; Isoptropic Confining Pressure, $\sigma_o$= 455 psi (65.5 ksf = 3135 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 | 19357 | 1.00 | 3.60E-05 | 3.59 |
| 7.10E-05 | 19357 | 1.00 | 7.10E-05 | 3.62 |
| 1.43E-04 | 19357 | 1.00 | 1.43E-04 | 3.64 |
| 2.86E-04 | 19357 | 1.00 | 2.86E-04 | 3.68 |
| 5.94E-04 | 19340 | 1.00 | 5.94E-04 | 3.80 |
| 1.19E-03 | 19275 | 1.00 | 9.39E-04 | 3.79 |
| 2.34E-03 | 19176 | 0.99 | 1.85E-03 | 3.92 |
| 4.77E-03 | 18850 | 0.97 | 3.72E-03 | 4.02 |
| 1.15E-02 | 17819 | 0.92 | 8.86E-03 | 4.34 |
| 1.90E-02 | 16782 | 0.87 | 1.43E-02 | 4.93 |
| 3.92E-02 | 14413 | 0.74 | 2.70E-02 | 6.56 |
| 6.12E-02 | 12678 | 0.65 | 3.98E-02 | 7.86 |

[+] 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 G.5 Variation in Shear Modulus, Normalized Shear Modulus and Material Damping Ratio with Shearing Strain from TS Tests of Specimen B2274-UD23; Isotropic Confining Pressure, $\sigma_o$=455 psi (65.5 ksf = 3135 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, % |
| 1.02E-03 | 17173 | 1.00 | 0.51 | 1.03E-03 | 17108 | 1.00 | 0.52 |
| 2.04E-03 | 17173 | 1.00 | 0.61 | 2.06E-03 | 17108 | 1.00 | 0.51 |
| 4.10E-03 | 17124 | 1.00 | 0.74 | 4.09E-03 | 17108 | 1.00 | 0.62 |

# APPENDIX H

Specimen B2269-UD19
(Index Properties Not Available)

Borehole B2269
Sample UD19
Depth = 381.6 (116.3 m)
Total Unit Weight = 114.6 lb/ft$^3$
Water Content = 33.0%
Estimated In-Situ Ko = 0.5
Estimated In-Situ Mean Effective
Stress = 125 psi

FUGRO JOB #: 0411-08-1686
Testing Station: RC8

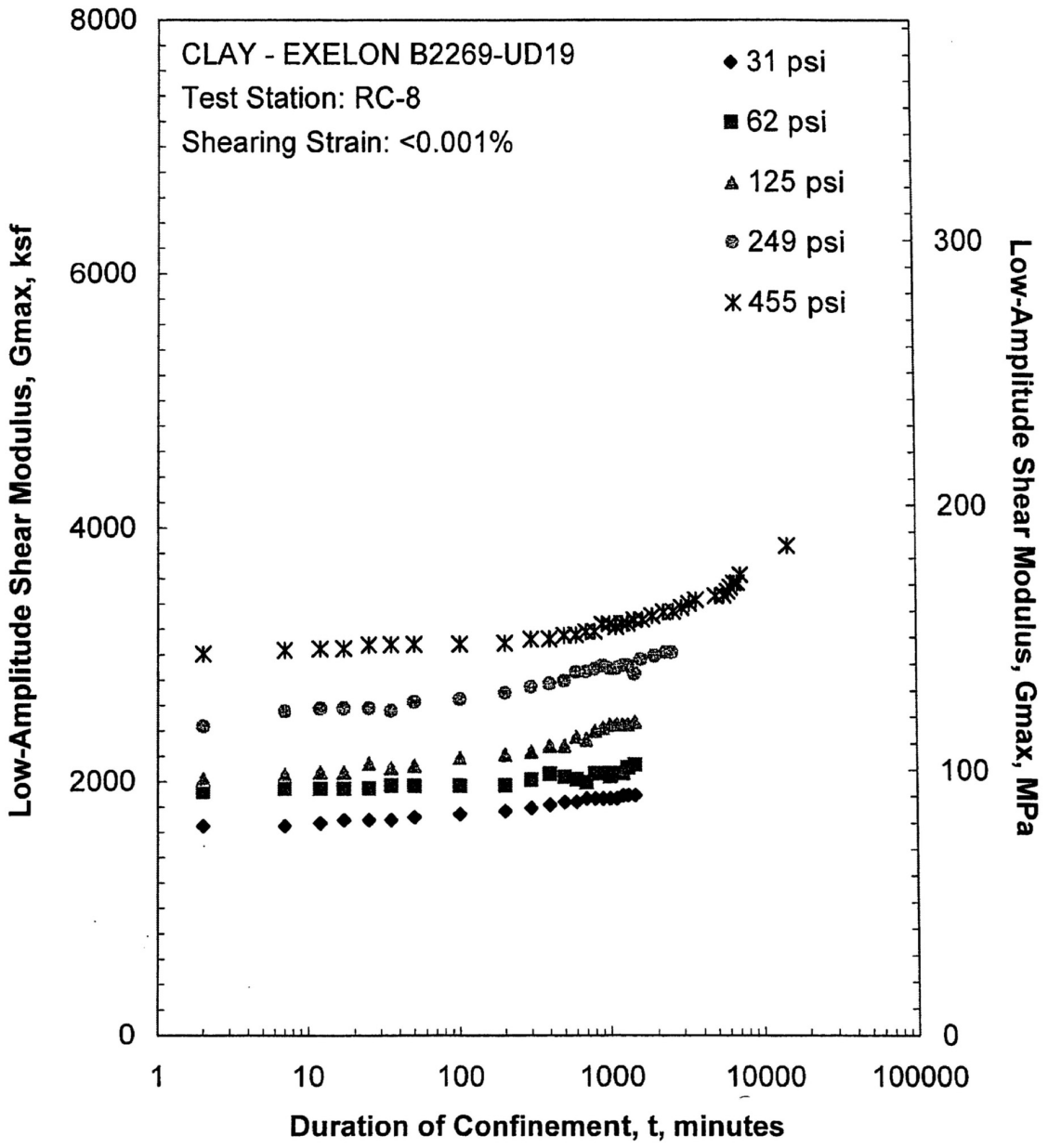


**Figure H.1 Variation in Low-Amplitude Shear Modulus with Magnitude and Duration of Isotropic Confining Pressure from Resonant Column Tests**

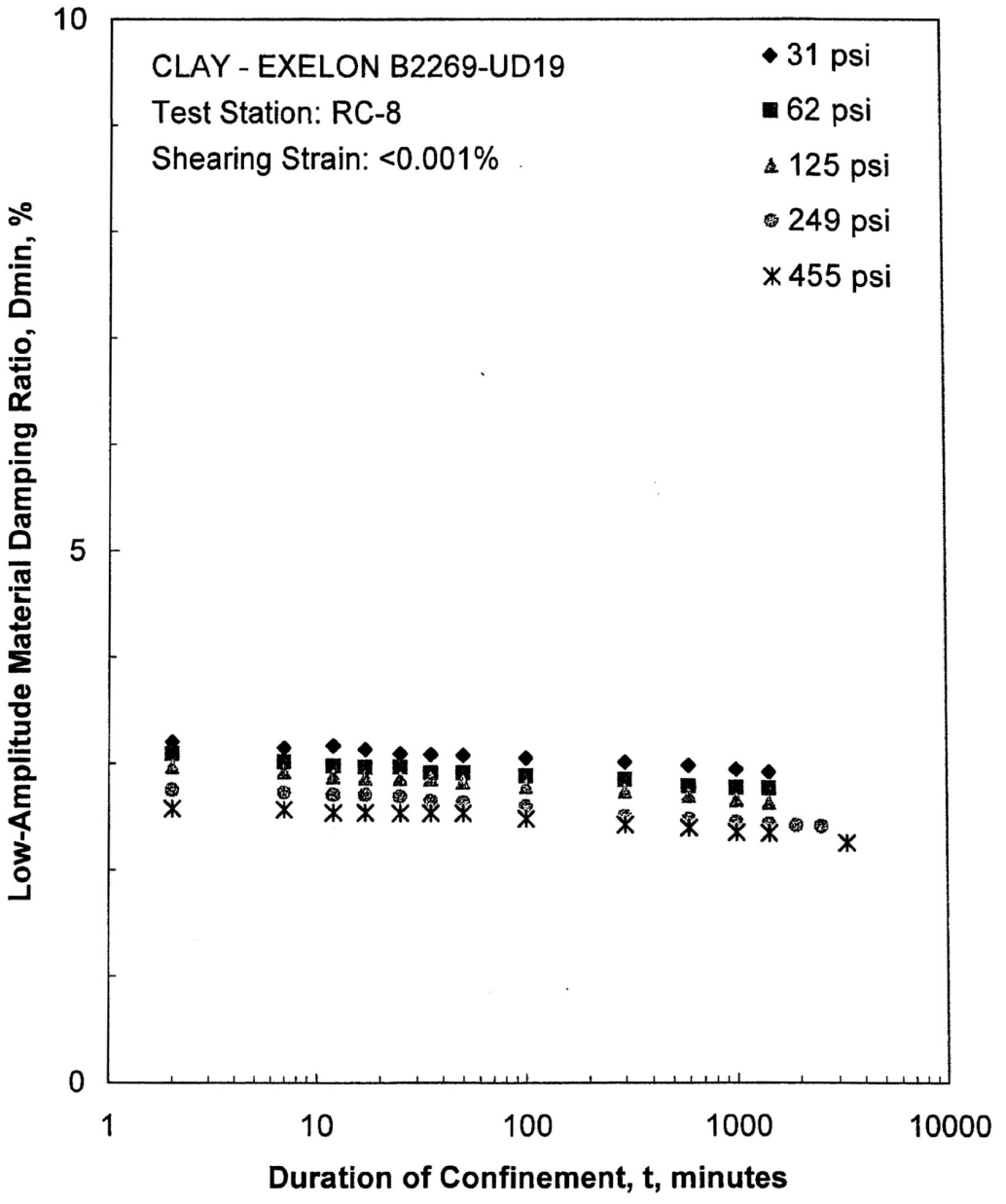


**Figure H.2 Variation in Low-Amplitude Material Damping Ratio with Magnitude and Duration of Isotropic Confining Pressure from Resonant Column Tests**

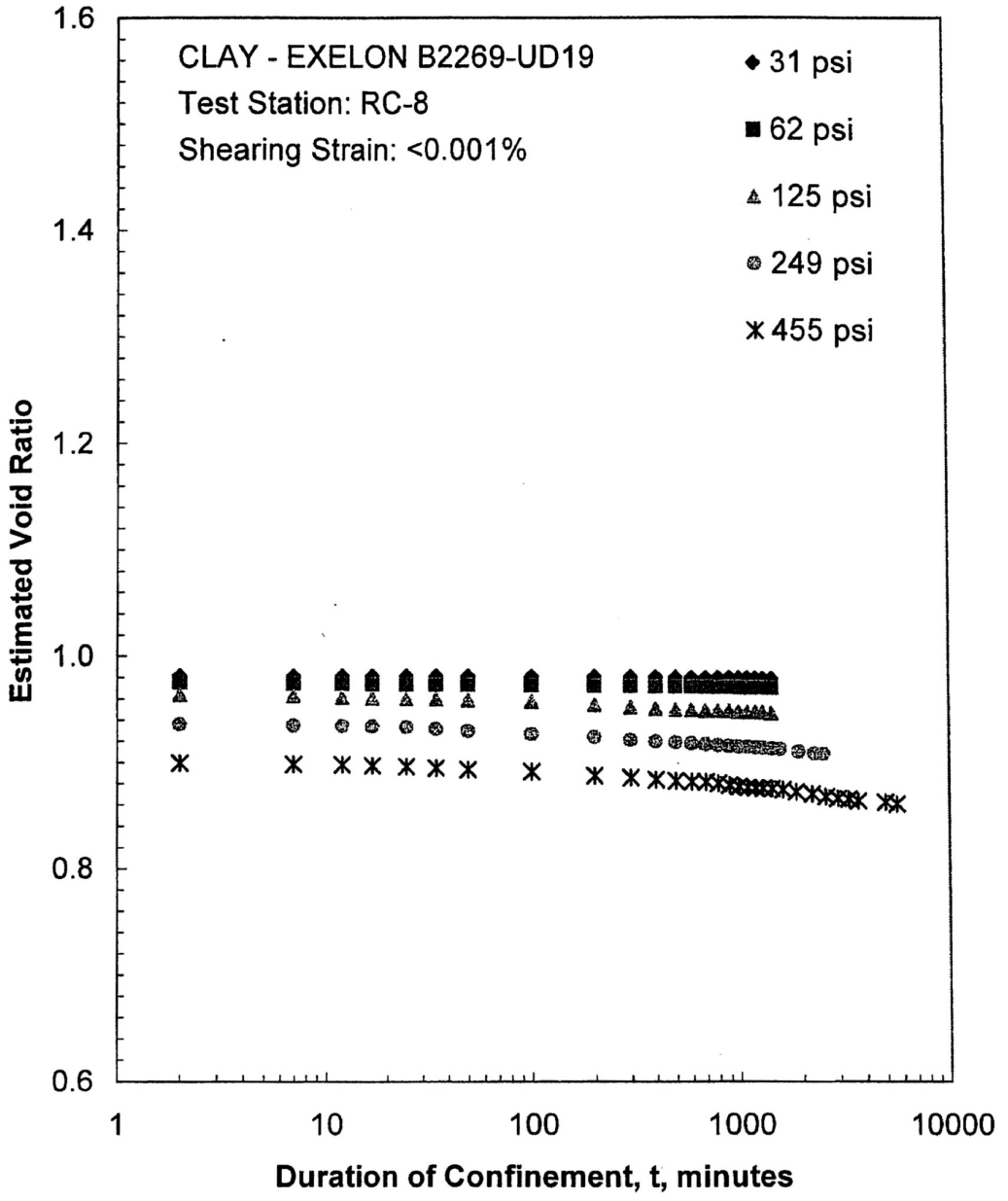


**Figure H.3 Variation in Estimated Void Ratio with Magnitude and Duration of Isotropic Confining Pressure from Resonant Column Tests**

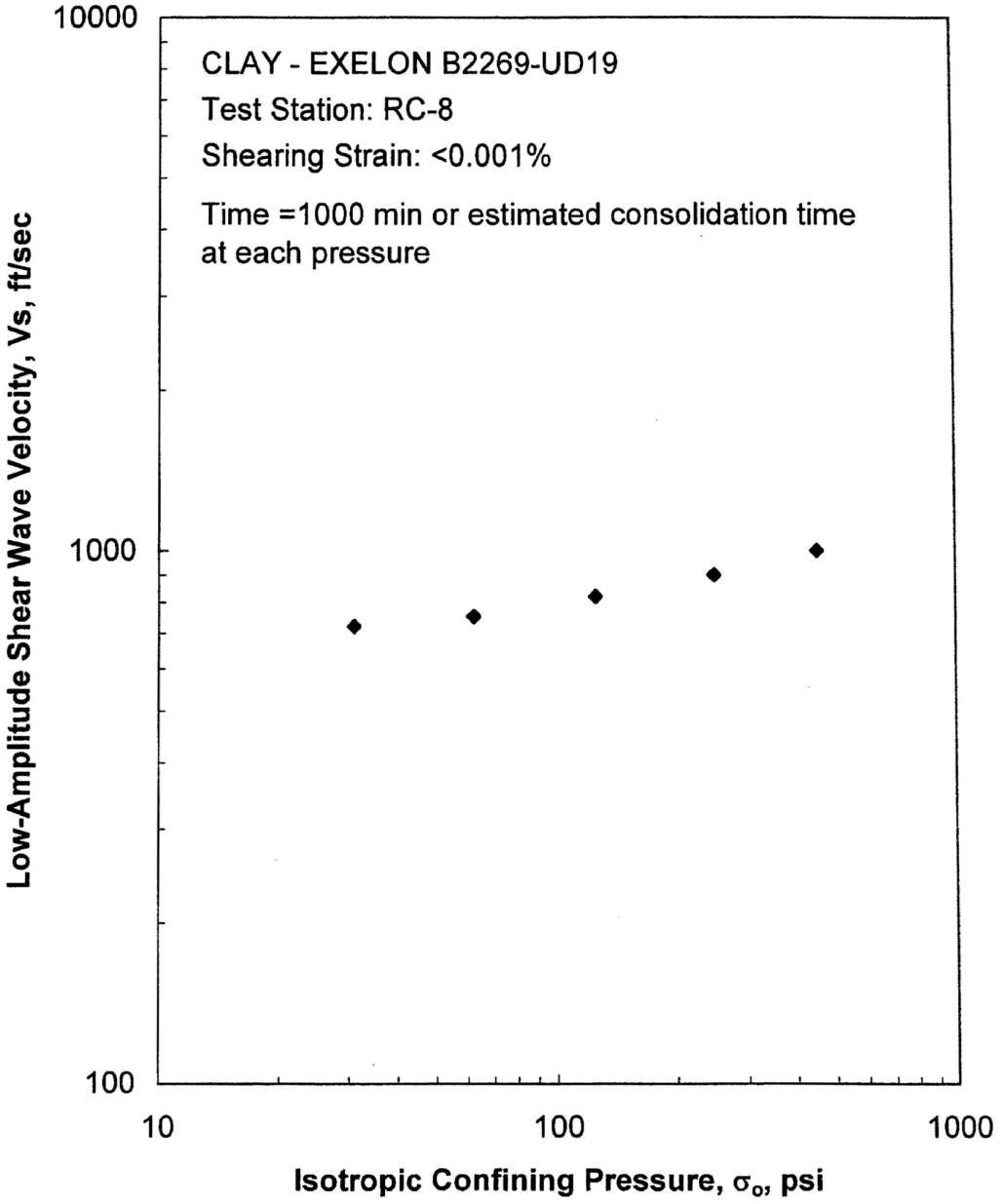


**Figure H.4 Variation in Low-Amplitude Shear Wave Velocity with Isotropic Confining Pressure from Resonant Column Tests**

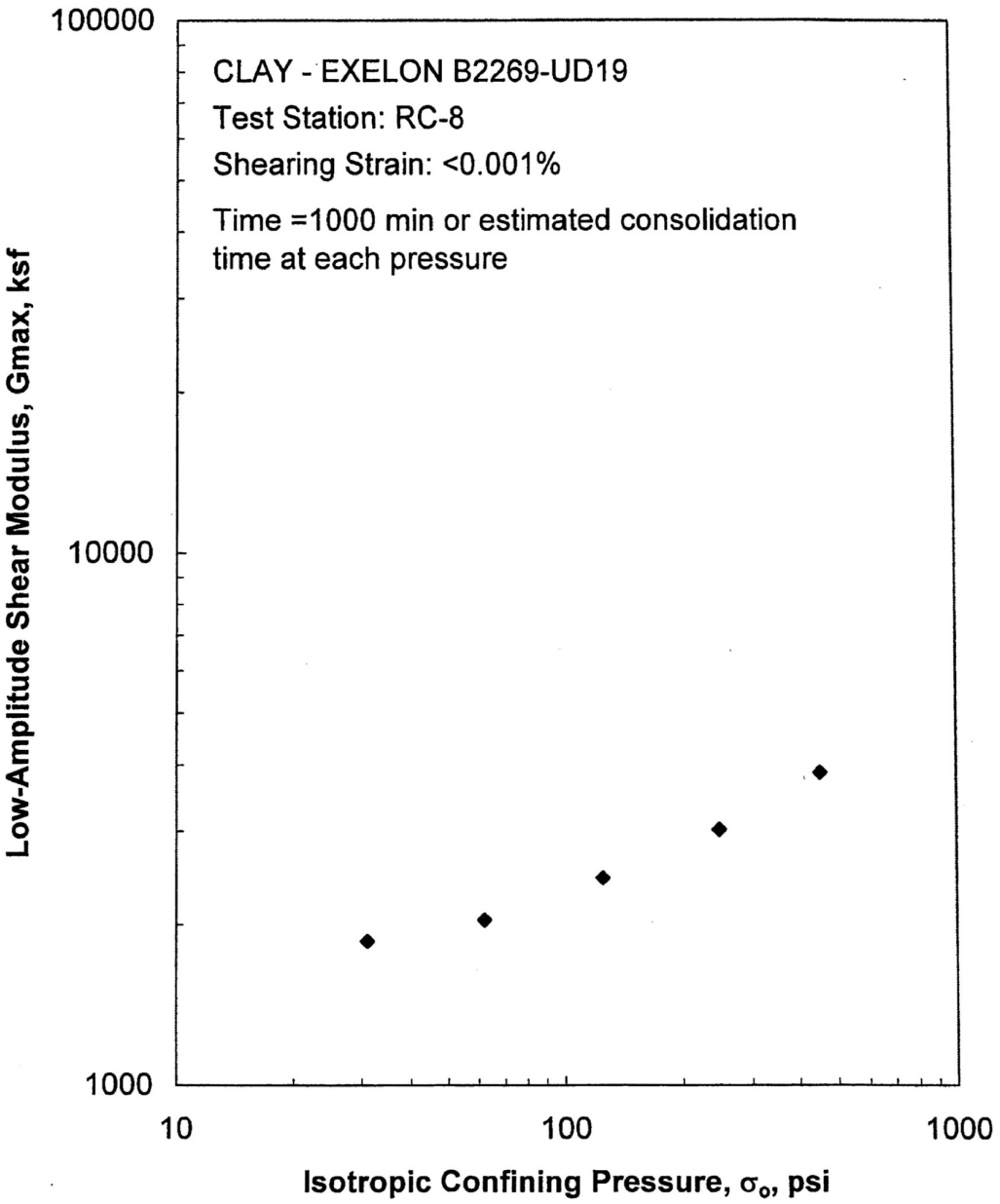


**Figure H.5 Variation in Low-Amplitude Shear Modulus with Isotropic Confining Pressure from Resonant Column Tests**

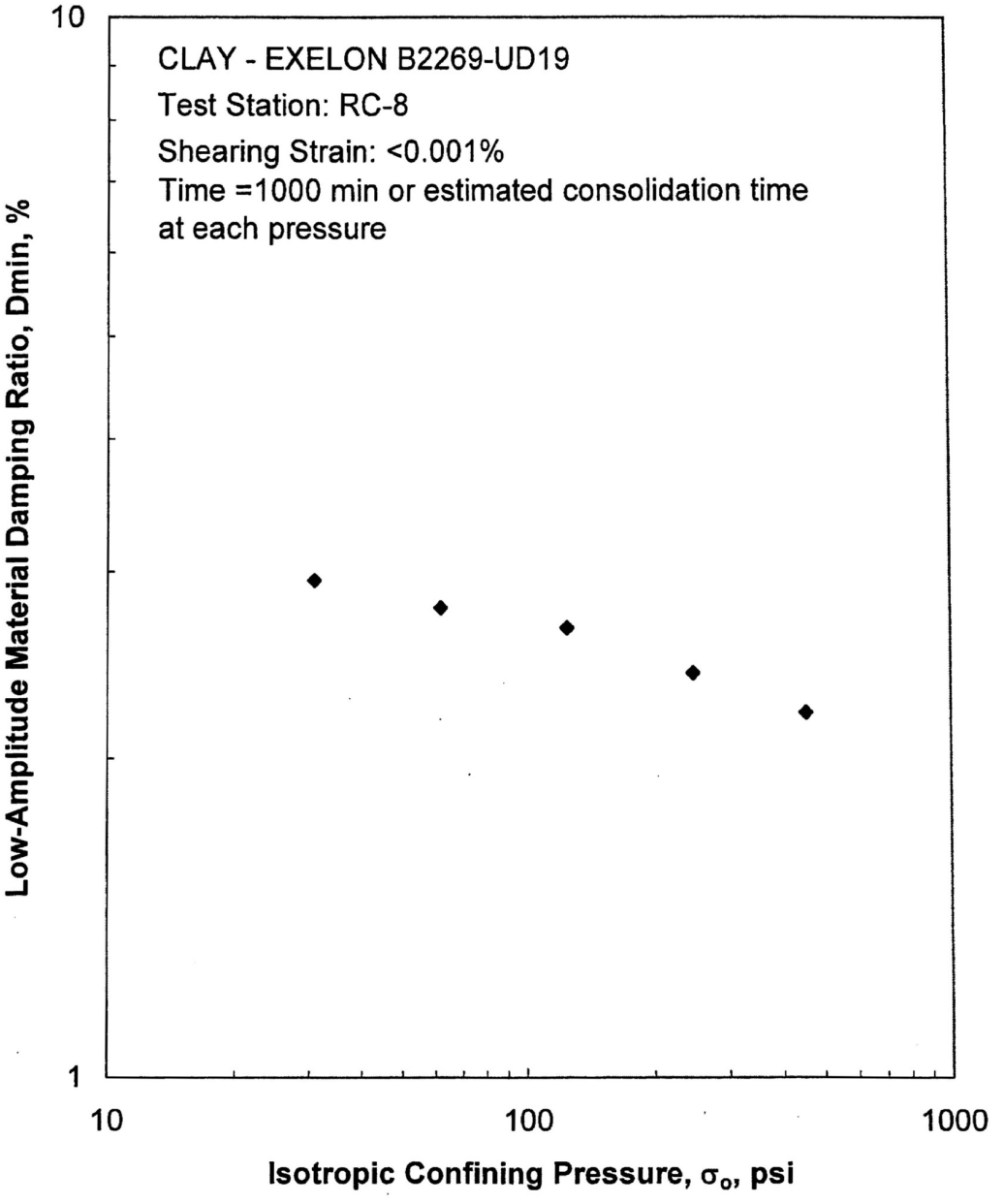


**Figure H.6 Variation in Low-Amplitude Material Damping Ratio with Isotropic Confining Pressure from Resonant Column Tests**

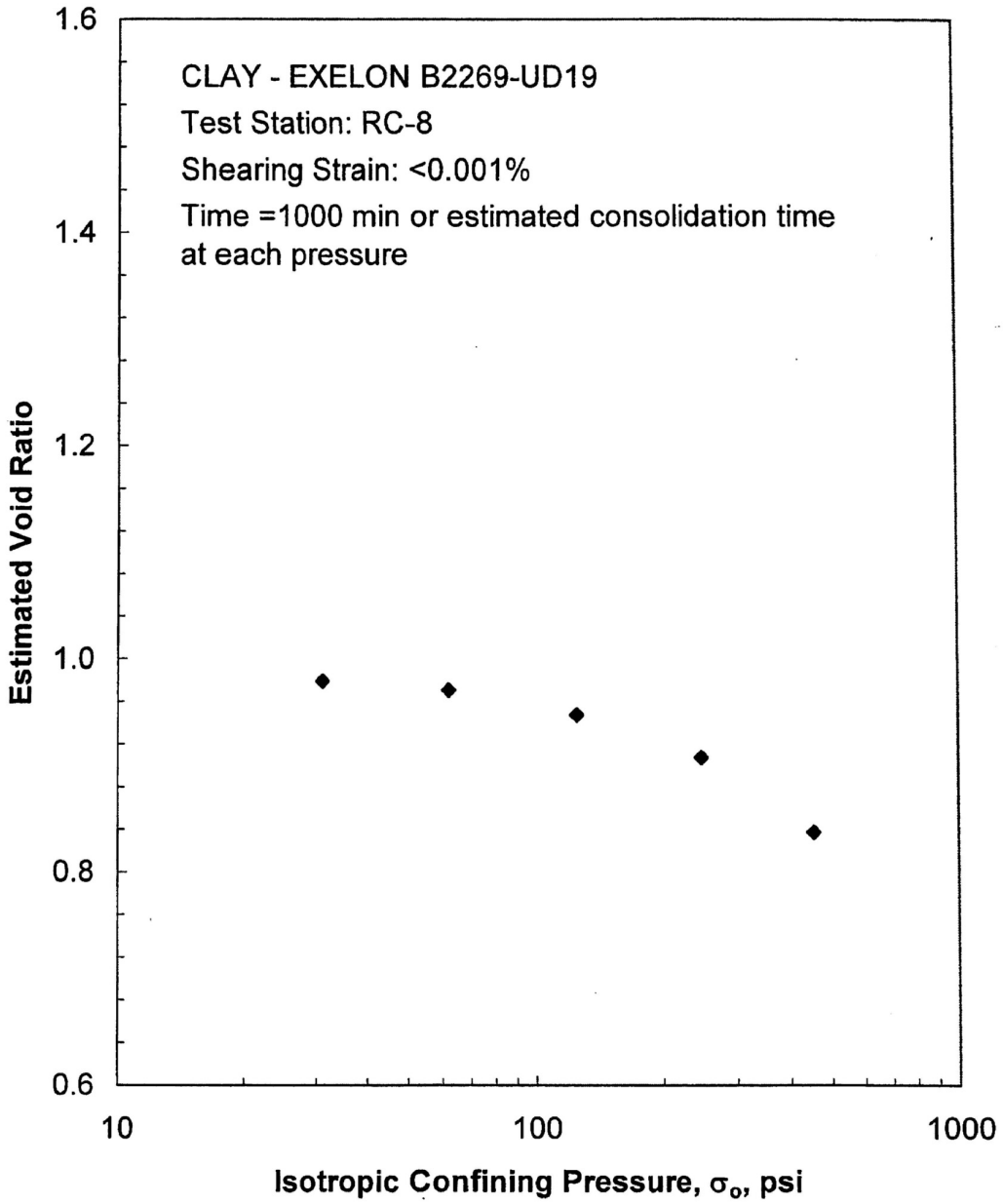


**Figure H.7 Variation in Estimated Void Ratio with Isotropic Confining Pressure from Resonant Column Tests**

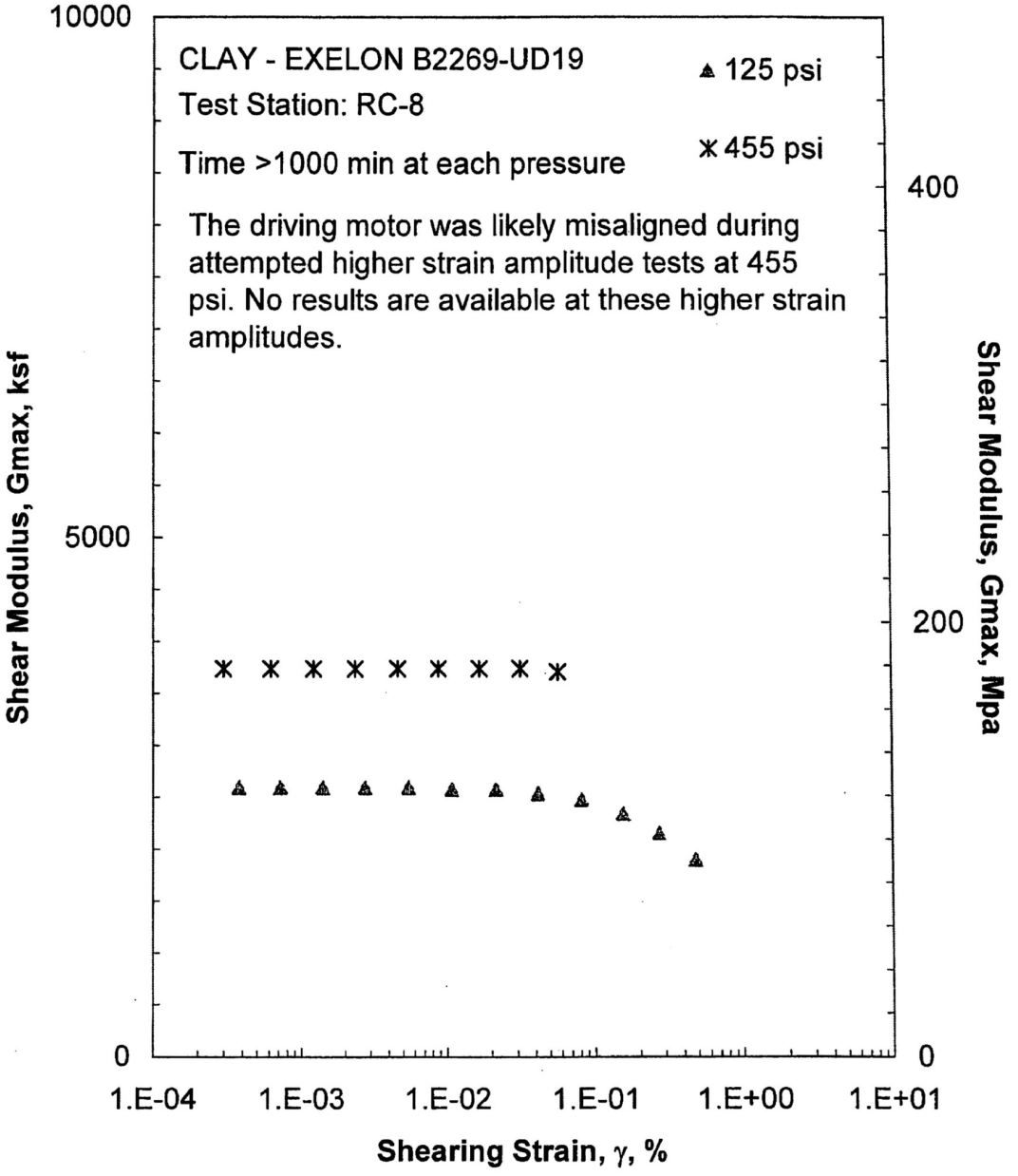


**Figure H.8 Comparison of the Variation in Shear Modulus with Shearing Strain and Isotropic Confining Pressure from the Resonant Column Tests**

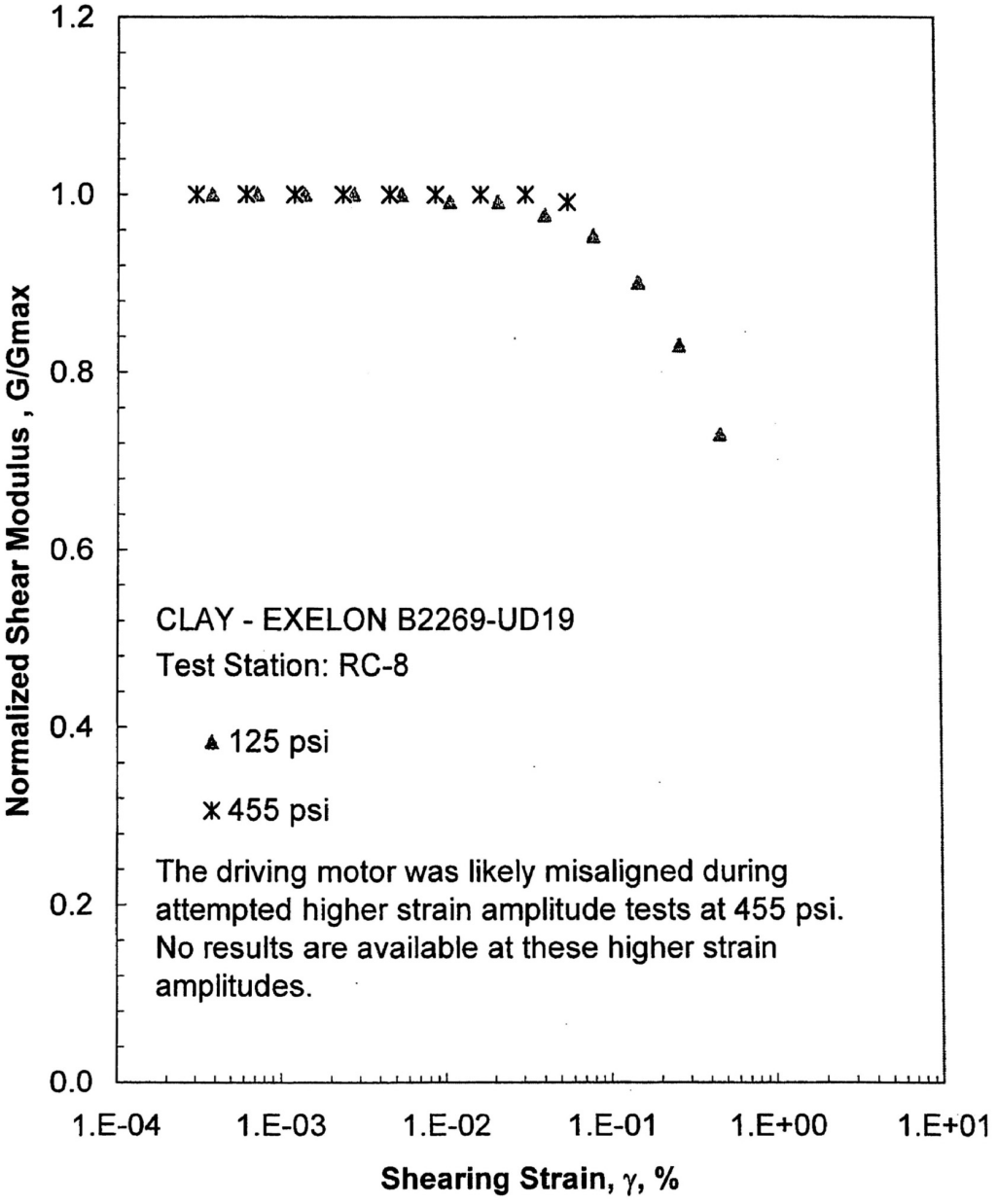


**Figure H.9 Comparison of the Variation in Normalized Shear Modulus with Shearing Strain and Isotropic Confining Pressure from the Resonant Column Tests**