DATA REPORT I

ROCK LABORATORY TEST DATA
(GeoTest Unlimited)

DIABLO CANYON ISFSI

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1.0 INTRODUCTION

Engineering rock testing was performed on selected samples of drill core taken from the DCPP ISFSI site during two phases of investigation. The first phase testing program was conducted in December 2000 on samples obtained from borings 00BA-1 and 00BA-2 (Attachment 1). The second phase testing program was conducted in April and May 2001 on samples obtained from borings 01-A through 01-I and 01CTF-A (Attachment 2). Locations of these borings and the ISFSI project features are shown on Figure I-1. The data on these borings is presented in Diablo Canyon ISFSI Data Report B. Laboratory testing was performed by GeoTest Unlimited (GTU), of Nevada City, California under the supervision of Dr. Anders Bro. Interpretation of the test results was jointly performed by Jeff Bachhuber of William Lettis & Associates (WLA) and Joseph Sun of PG&E, Geosciences Department, with geological input to the interpretation provided by Dr. William Page of PG&E, Geosciences Department. Independent technical review was performed by Robert White of PG&E, Geosciences Department.

The preparation of this data report was performed under the WLA Work Plan (Rev. 2) Dated November 28, 2000 using data collected under that Work Plan and a second WLA Work Plan (Rev. 1) dated September 19, 2001. The laboratory sampling and testing was performed under Geo Test Unlimited Work Plans (both Rev. 0 and both dated April 20, 2001) and the Geomatrix Work Plan (Rev. 2, dated December 8, 2000).

2.0 PURPOSE

The purpose of the tests was to determine the strengths, elastic properties at small strain levels, and bulk densities of intact rock cores, as well as contact strengths along rock discontinuities. Properties measured in the laboratory were used to characterize the strength and elastic properties of the rock mass for use in the evaluation of slope stability of the cut slope behind the ISFSI pads, the hillslope above the ISFSI, and the foundation stability of the ISFSI pads and CTF.

The testing program for strengths consisted of unconfined-compression (UC) tests, triaxial tests (including both single-stage and multi-stage tests, with and without pore pressure measurements), and direct-shear tests along discontinuities. Some small strain elastic property measurements were obtained as part of the UC and triaxial tests. In addition, bulk density was measured for each UC and triaxial test samples. The types and number of tests performed under each phase is summarized in Table I-1 shown below:

Table I-1 Summary of Rock Laboratory Tests Performed for ISFSI Site

Test Description	Number of tests performed in 2000	Number of tests performed in 2001	Total
Unconfined Compression	8	20	28
Small Strain Elastic Properties	--	24	24
Triaxial (single stage without pore pressure measurements)	4	--	4
Triaxial (multi-stage without pore pressure measurements)	4	5	9
Triaxial (multi-stage with pore pressure measurements)	--	4	4
Direct Shear	7	14	21

3.0 METHODOLOGY

The borings were made with truck mounted drill rigs and core samples were retrieved using HQ wire line triple core barrels (Diablo Canyon ISFSI Data Report B). Samples selected for testing were sealed in shrink-wrap plastic, placed in protective containers, and delivered to the testing facility in Nevada City. Most tests were performed within 1 to 2 weeks upon delivery at GTU. The number of tests performed on samples by boring is indicated in Table I-2 below; triaxial compression tests were performed without pore pressure measurements unless otherwise indicated.

Table I-2 Summary of Rock Laboratory Tests Performed in Borings

Boring Number	Unconfined Compression	Small Strain Elastic Properties	Triaxial Compression	Direct Shear
00BA-1	7	--	4 (ss)	7
00BA-2	1	--	4 (ms)	--
01-A	2	3	1 (ms)	--
01-B	2	2	--	1
01-C	1	1	1(ms, pwp)	2
01-D	2	3	1 (ms) 1(ms, pwp)	--
01-E	2	2	1(ms, pwp)	1
01-F	1	2	1 (ms)	2
01-G	2	2	--	--
01-H	2	3	1 (ms)	1
01-I	4	3	--	6
01-CTF-A	2	3	1 (ms) 1(ms, pwp)	1
Total	28	24	17	21

Notes: ss: single stage triaxial tests, ms: multi-stage triaxial tests, pwp: pore pressure measurements.

Unconfined Compression Tests

Unconfined compression tests were performed on the core samples to help estimate the unconfined compressive strength of intact hard dolomite and cemented sandstone. The measured strengths of the intact rock samples are used, in conjunction with other geological indices describing discontinuity properties of the rock mass, to develop the overall strength envelopes for jointed rock mass at the DCPP ISFSI using the Hoek-Brown semi-empirical approach (Hoek and Brown, 1988; Hoek, 2000). The tests were performed in general accordance with ASTM Test Method D-2938.

Small Strain Elastic Properties

Small strain values of Young's moduli and Poisson's ratios of intact rock cores were obtained from samples subjected to unconfined compressive tests and triaxial tests in the second phase of the laboratory testing program. These elastic properties were measured at the middle third of each core sample using local strain measurement devices under the unconfined stage of the tests. The lab-measured elastic properties, along with in-situ wave velocity based elastic properties, form the basis for selecting spring constants for use in ISFSI pad finite element load/displacement analyses.

Triaxial Compression Tests Without Pore Pressure Measurements

The undrained strengths of a number of friable (altered) sandstone samples were tested in a Hoek triaxial cell. This cell, which is not designed to measure pore pressures, is commonly used for testing of rock samples. Samples were tested under "as received" conditions without artificial saturation. Samples thus tested reflect their in-place strength under their current corresponding consolidation stresses. The strength envelope thus derived was interpreted as the unsaturated, unconsolidated, undrained (UUU) strength envelope. When possible, multi-stage procedures were used to test the strengths of the samples under increasing confining pressures. Since the samples were not saturated and thus no excess pore water pressure from consolidation was generated, only limited time was allowed for the sample to consolidate between stages. The tests were performed in general accordance with ASTM Test Method D-2664.

Consolidated-Undrained Triaxial Compression Tests With Pore Pressure Measurements

The effective and total strength parameters for friable (altered) sandstone were measured by performing consolidated-undrained triaxial compression tests in a modified triaxial cell that allowed pore pressure measurements. The samples were artificially saturated prior to testing. Multi-stage procedures were used to test the strengths of the samples under increasing confining pressures and sufficient time was allowed for samples to consolidate between stages. The tests were performed in general accordance with ASTM Test Method D-4767.

Direct Shear

Direct shear tests were performed to measure shear strengths along rock discontinuities. These discontinuities include joints, bedding planes, and clay seams or clay beds. Multi-stage tests were performed to define shear strength with increasing normal loads. After the initial peak strength for the final normal load was reached, the sample was unloaded to its lowest normal load and a second load cycle was performed to evaluate the post-peak strength properties. The tests were performed in general accordance with ASTM Test Method D-5607.

Density

Measurement of sample bulk densities was performed on UC and triaxial samples. These tests were conducted as part of the respective tests noted above.

4.0 RESULTS

Unconfined Compression Tests

A total of 28 UC tests were performed for the ISFSI site. Results are summarized in Table I-3. Some of the tests showed failure in shear along existing joints or discontinuities as indicated on the laboratory test data sheets, and these results do not represent the strength of intact rock mass. Tests on weakly cemented friable sandstone indicated that the cementation is so weak that material becomes friable upon test loading. Test results on these samples typically show unrealistically low unconfined compressive strengths. Unconfined compression test results thus measured do not reflect the in-place strength of this type of material whose strength will be dependent on confining pressures. This type of rock was subsequently tested using triaxial test procedures.

Triaxial Test Results

Single Stage Triaxial Tests without Pore Pressure Measurements

Single-stage, undrained triaxial tests were performed on four samples under confining pressures of between 40 and 80 psi and results are presented on Table I-4. Axial stresses at failure did not show a consistent strength increase with higher confining pressure and ranged from 3800 to 6800 psi. The average peak axial stress is about 5,000 psi for the four samples tested.

Multi-Stage Triaxial Tests without Pore Pressure Measurements

Multi-stage, undrained triaxial tests without pore pressure measurements were performed on nine samples. Each sample was tested under two to three different confining pressures, ranging from 10 to 296 psi and results are summarized on Table I-5. Upon application of the maximum confining stress to measure initial peak strength, the samples were unloaded to the initial confining stress and reloaded to measure the post-peak strength. Two samples (2B and 2C from boring 00BA-2) indicated a reduction in strength (hereafter referred to as the post-peak strength) with continued straining beyond the initial peak strengths. All other samples behaved in a more ductile strain-hardening manner, and no post-peak strengths were measured.

Multi-Stage Triaxial Tests with Pore Pressure Measurements

Multi-stage, undrained triaxial tests with pore pressure measurements were performed on four samples. Each sample was tested under two to three different confining pressures, ranging from 80 to 160 psi and results are summarized in Table I-6.

Small Strain Elastic Property Measurements

Lab-based small strain values of Young's modulus and Poisson's ratio were obtained from axial stress, axial strain, and radial strain measurements made in the second phase unconfined compression and triaxial tests by applying small amplitude axial loads on samples. The elastic properties were measured without applying the confining stresses on samples. Axial strains were measured with local strain measurement devices clamped to the middle third of the samples. The strains at which these elastic properties were measured are generally between 0.05% to 0.1%. Test results are summarized in Table I-7.

The lab measurement procedure is well suited for well-cemented material such as dolomite and dolomitic sandstone whose elastic properties are relatively insensitive to the confining pressure range of interest to this project. Young's moduli of the poorly cemented altered sandstone measured in a way similar to an unconfined compression test are very low and do not represent their in-place conditions as summarized in Table I-8.

Direct Shear Tests

Table I-9 summarizes the 21 direct shear tests performed in the 2000 and 2001 testing programs, samples tested included clean rock-to-rock contacts, clay-rock contacts or joints with clay coating, and clay seams or clay beds. Clay beds and clay seams typically are thicker than $^1/_4$ inch.

Failure envelopes for fractures with rock-rock contacts do not show significant differences, suggesting that the test results are fairly reliable and the in-situ variation of the strengths along clean rock discontinuities may not be significant. Many of the clay coatings in the clay coated joints tested were not visible when the sample was selected from the core box in the field, but were only visible after the tests when samples were taken apart to expose the joints. Four clay bed samples failed in compression when the normal loads were applied and the soil-like material was squeezed out of the rock shear box. The rock testing equipment and procedure used were not suitable for testing clay bed samples which produced inconsistent or unreasonable results. Strengths for clay beds were determined using a soil testing procedure as documented in Data Report G.

Unit Weight Tests

The unit weight of the rock ranges from 128.9 to 161.4 pounds per cubic foot (pcf) and results are presented on Table I-10. The samples do not show a consistent variation between rock units, with the exception of the two highest density values of 160.9 and 161.4 pcf, which were sandstone. The remaining samples typically fall within the range of 135 to 145 pcf.

5.0 REFERENCES

ASTM, 1998, Test D2216-98, Standard Test Method for Laboratory Determination of Water (Moisture) Content of Soil and Rock by Mass

ASTM, 1995, Test D2664-95a, Standard Test Method for Triaxial Compressive Strength of Undrained Rock Core Specimens without Pore Pressure Measurements

ASTM, 1995, Test D2938-95, Standard Test Method for Unconfined Compressive Strength of Intact Rock Core Specimens

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ASTM, 1995, Test D4767-95, Standard Test Method for Consolidated Undrained Triaxial Compression Test for Cohesive Soils.

ASTM, 1995, Test D5607-95, Standard Test Method for Performing Laboratory Direct Shear Strength Tests of Rock Specimens Under Constant Normal Force

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William Lettis & Associates Work Plan, Additional Exploratory Drilling and Geologic Mapping for the DCPP ISFSI Site, Rev. 1, signed by NQS on September 19, 2001.

Table I-3 Summary of Unconfined Compression Test Results (1 of 3)

Boring No.	Sample No.	Depth (ft)	DCPP ISFSI Data Report B Rock Unit[1]	Sample Lab Description[2]	Feature in Sample	Unit Wt. (pcf)	Failure Mode	Strength (psi)
00BA-1	1-8B	146.6 ~ 147.1	Tof_{b-1}	Brown fine grained dolomitic sandstone	No discernible noted	146.6	Shear	5133
00BA-1	1-9B	149.5 ~ 150.0	Tof_{b-1}	Gray to brown fine grained dolomitic sandstone	No discernible fractures	140.6	axial splitting	2625
00BA-1	1-10	12.2 ~ 12.7	Tof_{b-1}	Tan fine grained dolomitic sandstone	No discernible fractures	138.4	axial splitting and shear	5284
00BA-1	1-11	18.7 ~ 19.2	Tof_{b-1}	Tan fine grained dolomitic sandstone	No discernible fractures	142.4	axial splitting, shear, and bending	7190
00BA-1	1-12	22.6 ~ 23.1	Tof_{b-1}	Tan Fine grained dolomitic sandstone	No discernible fractures	134.5	axial splitting, shear, and bending	4523
00BA-1	1-13	40.9 ~ 41.4	Tof_{b-1}	Tan fine grained dolomitic sandstone	Healed and partially healed joints	128.9	Shear on existing joint	2079
00BA-1	1-14	49.1~49.6	Tof_{b-1}	Brown to tan dolomite	Bedding 80° from core axis; no apparent fractures	143.1	Axial splitting and bending	8649
00BA-2	2-E	50.9 ~ 51.4	Tof_{b-2}	Dolomite sandstone w/ slight porosity	Healed non-through going joints ~ 40° from core axis	160.9	Axial splitting and shear on existing joints	10921

Notes: [1]Rock unit description from William Lettis & Associates, Inc. (2001) Diablo Canyon ISFSI Data Report B. Sample lab description is not always consistent with the Data Report B descriptions that are more current and supercede the laboratory descriptions.

Tof_{b-1} – dolomite, clayey dolomite, dolomitic siltstone to fine-grained dolomitic sandstone, and limestone

Tof_{b-1a} – friable dolomite and dolomitic siltstone

Tof_{b-2} – fine- to coarse-grained dolomitic sandstone and sandstone

Tof_{b-2a} – friable sandstone

[2]Laboratory sample description from GTU.

Table I-3 Summary of Unconfined Compression Test Results (2 of 3)

Boring No.	Sample No.	Depth (ft)	DCPP ISFSI Data Report B Rock Unit[1]	Sample Lab Description[2]	Feature in Sample	Unit Wt. (pcf)	Failure Mode	Strength (psi)
01-A	1	19.5	Tof_{b-2}	Tan well cemented medium grained sandstone	Numerous healed fractures	161.4	Axial splitting	2888
01-A	2	24.5	Tof_{b-2}	Tan medium grained sandstone	No fractures noted	146.6	Axial splitting and crushing	1113
01-B	18	26.5	Tof_{b-2}/Tof_{b-2a}	Tan fine to medium grained dolomitic sandstone	No visible fractures	147.3	Shear	4778
01-B	19	38.0	Tof_{b-2}	Tan medium grained sandstone	Joint at one end	132.4	Shear (not on existing joint)	452
01-C	22	24.0	Tof_{b-2}	Tan fine grained dolomitic sandstone	Axial fracture	155.0	Axial splitting	4504
01-D	4	25.5	Tof_{b-2a}	Tan weak clayey medium grained sandstone	No features noted	142.3	splitting, shear	207
01-D	6	48.5	Tof_{b-1}/Tof_{b-2}	Tan fine to medium grained dolomitic sandstone	One joint about 32° from core axis and 1 axial fracture	147.1	Shear on existing joint	959
01-E	26	22.0	Tof_{b-1}	Tan fine grained dolomitic sandstone	Few healed shears	129.4	Shear on healed shears	437
01-E	28	49.0	Tof_{b-1}	Tan fine grained dolomitic sandstone	Healed fracture ~34° from core axis	135.8	Shear not on existing joint	2958
01-F	30	57.6	Tof_{b-2}	Light tan medium grained dolomite sandstone	Intact joint 60° from core axis	138.9	Shear not on existing joint	2543

Notes: [1]Rock unit description from William Lettis & Associates, Inc. (2001) Diablo Canyon ISFSI Data Report B. Sample lab description is not always consistent with the Data Report B descriptions that are more current and supercede the laboratory descriptions.

Tof_{b-1} – dolomite, clayey dolomite, dolomitic siltstone to fine-grained dolomitic sandstone, and limestone

Tof_{b-1a} – friable dolomite and dolomitic siltstone

Tof_{b-2} – fine- to coarse-grained dolomitic sandstone and sandstone

Tof_{b-2a} – friable sandstone

[2]Laboratory sample description from GTU.

Table I-3 Summary of Unconfined Compression Test Results (3 of 3)

Boring No.	Sample No.	Depth (ft)	DCPP ISFSI Data Report B Rock Unit[1]	Sample Lab Description[2]	Feature in Sample	Unit Wt. (pcf)	Failure Mode	Strength (psi)
01-G	9	28.8	Tof_{b-1}	Tan fine grained dolomitic sandstone	2 axial fractures	138.2	Axial splitting along existing fractures	3702
01-G	10	69.0	Tof_{b-2a}	Gray friable clayey medium grained sandstone	No features noted	130.7	Shear and Axial splitting	136
01-H	12	52.5	Tof_{b-2}	Tan fine grained dolomitic sandstone	No visible fractures	155.1	multiple shears	10252
01-H	11	11.0	Tof_{b-1}	Tan fine grained dolomitic sandstone	No apparent fractures	138.9	Shear	2434
01-I	38	159.5	Tof_{b-1}	Dark gray fine grained dolomitic sandstone	Healed joint 27° from core axis	144.2	Axial splitting	1834
01-I	39A	130.4	Tof_{b-1}	Tan fine to medium grained sandstone	Open joint 12° from core axis	140.3	Shear (not on existing joint)	505
01-I	40A	88.4	Tof_{b-1}	Tan thinly bedded fine grained dolomitic sandstone	Bedding at 69° from core axis	142.0	Axial splitting and bending	6373
01-I	42	44.0	Tof_{b-1}	Tan fine grained dolomitic sandstone	No features noted	141.5	Axial splitting and shear	3504
01-CTF-A	14	8.8	Tof_{b-2a}	Gray fine to medium grained soft sandstone	No features noted	128.8	Shear	29
01-CTF-A	15	13.5	Tof_{b-2}	Tan clayey friable medium grained sandstone	Possible healed joints	138.3	Shear	400

Notes: [1]Rock unit description from William Lettis & Associates, Inc. (2001) Diablo Canyon ISFSI Data Report B. Sample lab description is not always consistent with the Data Report B descriptions that are more current and supercede the laboratory descriptions.

Tof_{b-1} – dolomite, clayey dolomite, dolomitic siltstone to fine-grained dolomitic sandstone, and limestone
Tof_{b-1a} – friable dolomite and dolomitic siltstone
Tof_{b-2} – fine- to coarse-grained dolomitic sandstone and sandstone
Tof_{b-2a} – friable sandstone

[2]Laboratory sample description from GTU.

Table I-4 Summary of Single Stage Triaxial Tests without Pore Pressure Measurements

Boring No.	Sample I.D.	Depth (ft)	DCPP ISFSI Data Report B Rock Unit[1]	Sample Lab Description[2]	Unit Wt. (pcf)	Failure Mode	Con. Pressure (psi)	Peak Axial Stress (psi)	Strain (%)
00BA-1	1-5B	84.0 ~ 84.5	Tof_{b-1}	Tan fine grained dolomitic sandstone with brown oxidation stains	134.9	Axial splitting	40.2	5070	0.48
00BA-1	1-15	77.5 ~ 78.0	Tof_{b-1}	Tan fine grained sandstone to dolomite	140.3	Conical shear and splitting	80.6	6807	0.88
00BA-1	1-16	107.3 ~ 107.8	Tof_{b-1}	Tan fine grained dolomitic sandstone	132.8	Axial splitting	40.3	4483	0.6
00BA-1	1-17	116.4 ~ 116.9	Tof_{b-2}	Tan fine grained dolomitic sandstone	133.1	Shear	80.3	3787	0.4

Notes: [1]Rock unit description from William Lettis & Associates, Inc. (2001) Diablo Canyon ISFSI Data Report B. Sample lab description is not always consistent with the Data Report B descriptions that are more current and supercede the laboratory descriptions.

Tof_{b-1} – dolomite, clayey dolomite, dolomitic siltstone to fine-grained dolomitic sandstone, and limestone
Tof_{b-1a} – friable dolomite and dolomitic siltstone
Tof_{b-2} – fine- to coarse-grained dolomitic sandstone and sandstone
Tof_{b-2a} – friable sandstone

[2]Laboratory sample description from GTU.

Table I-5 Summary of Multi-Stage Triaxial Tests without Pore Pressure Measurements

Boring No.	Sample I.D.	Depth (ft)	DCPP ISFSI Data Report B Rock Unit[1]	Sample Lab Description [2]	Feature in Sample	Unit Wt. (pcf)	Cell. P. (psi)	Axial Stress (psi)
01-A	3	35.5	Tof_{b-2a}	Gray medium grained weak friable sandstone	one fracture	145.3	65	705
							98	870
							131	1020
01-D	5	28.0	Tof_{b-2a}	Tan medium grained clayey weak sandstone	Two healed axial fractures	144.5	58	693
							87	788
							116	844
01-H	13	57.0	Tof_{b-2a}	Gray medium grained clayey friable sandstone	none noted	131.7	87	472
							130	574
							174	664
01-F	32	117.7	Tof_{b-2a}	Gray fine to medium grained soft clayey friable sandstone	none noted	135.8	148	387
							222	475
							296	572
CTF-A	17	53.8	Tof_{b-2a}	Gray medium grained altered clayey friable sandstone	none noted	127.1	84	290
							126	348
							168	402
00BA-2	2-A	37.0 ~ 37.5	Tof_{b-2}	Tan fine to med. Grained dolomitic sandstone	none noted	130.1	20	87
							40	142
							80	183
00BA-2	2-B	37.5 ~ 38.0	Tof_{b-2}	Fine to med grained dolomitic sandstone	none noted	139.7	10	600
							20	600
							40	644
							10	187*
							20	270*
							40	398*
00BA-2	2-C	43.1 ~ 43.6	Tof_{b-2a}	gray, medium grained sandstone, friable	none noted	141.1	10	863
							20	887
							40	898
							10	170*
							20	242*
							40	385*
00BA-2	2-DB	46 .0 ~ 46.5	Tof_{b-2a}	gray fine to med. Grained clayey sandstone	Small tan sandstone zone	135.2	20	184
							40	283
							80	332

* Post-peak strength

Notes: [1]Rock unit description from William Lettis & Associates, Inc. (2001) Diablo Canyon ISFSI Data Report B. Sample lab description is not always consistent with the Data Report B descriptions that are more current and supercede the laboratory descriptions.

Tof_{b-1} – dolomite, clayey dolomite, dolomitic siltstone to fine-grained dolomitic sandstone, and limestone

Tof_{b-1a} – friable dolomite and dolomitic siltstone

Tof_{b-2} – fine- to coarse-grained dolomitic sandstone and sandstone

Tof_{b-2a} – friable sandstone

[2]Laboratory sample description from GTU.

Table I-6 Summary of Multi-Stage Triaxial Tests with Pore Pressure Measurements

Boring No.	Sample I.D.	Depth (ft)	DCPP ISFSI Data Report B Rock Unit[1]	Sample Lab Description[2]	Feature in Sample	Unit Wt. (pcf)	Cell. Press. (psi)	P.W.P. (psi)	Axial Stress (psi)	Strain (%)	c′ (psi)	ϕ′ (degrees)
01-D	7	55.5	Tof_{b-1}/ Tof_{b-2}	Tan clayey altered medium grained sandstone	Weak joint 57 deg from axis	-	80	50	200	5.30	25	25
							100	60	235	5.30		
01-CTF-A	16	48.8	Tof_{b-2a}	Tan friable clayey altered medium grained sandstone	-	133.2	85	73	378	1.87	95	22
							110	68	436	2.43		
							160	85	524	2.82		
01-C	21	9.5	Tof_{b-2a}	Gray friable weak medium grained sandstone	Partial plaster caps	132.5	80	57	239	4.70	41	24
							120	67	321	4.70		
01-E	25	7.0	Tof_{b-1a}	Tan fractured and sheared clayey altered weak fine grained dolomitic sandstone		135.8	80	59	231	3.40	12	44
							100	68	305	3.40		

Notes: [1]Rock unit description from William Lettis & Associates, Inc. (2001) Diablo Canyon ISFSI Data Report B. Sample lab description is not always consistent with the Data Report B descriptions that are more current and supercede the laboratory descriptions.

Tof_{b-1} – dolomite, clayey dolomite, dolomitic siltstone to fine-grained dolomitic sandstone, and limestone
Tof_{b-1a} – friable dolomite and dolomitic siltstone
Tof_{b-2} – fine- to coarse-grained dolomitic sandstone and sandstone
Tof_{b-2a} – friable sandstone

[2]Laboratory sample description from GTU.

Table I-7 Summary of Small Strain Elastic Property Measurements for Dolomite and Sandstone

Boring No.	Sample No.	Depth (ft)	DCPP ISFSI Data Report B Rock Unit[1]	Sample Lab Description[2]	Unit Weight (pcf)	Modulus (x 10^6 psi)	Poisson's Ratio
01-A	1	19.5	Tof_{b-2}	Tan well cemented medium grained sandstone	161.4	1.52	0.08*
01-A	2	24.5	Tof_{b-2}	Tan medium grained sandstone	146.6	0.65	0.55*
01-B	18	26.5	Tof_{b-2}	Tan fine to medium grained dolomitic sandstone	147.3	2.33	0.23
01-C	22	24.0	Tof_{b-2}	Tan fine grained dolomitic sandstone	155.0	4.92	0.23
01-D	6	48.5	Tof_{b-1} /Tof_{b-2}	Tan fine to medium grained dolomitic sandstone	147.1	0.63	0.30
01-E	26	22.0	Tof_{b-1}	Tan fine grained dolomitic sandstone	129.4	0.14	0.20
01-E	28	49.0	Tof_{b-1}	Tan fine grained dolomitic sandstone	135.8	0.85	0.15
01-G	9	28.8	Tof_{b-1}	Tan fine grained dolomitic sandstone	138.2	1.67	0.18
01-H	11	11.0	Tof_{b-1} to Tof_{b-2}	Tan fines grained dolomitic sandstone	138.9	1.09	0.13
01-H	12	52.5	Tof_{b-2}	Tan fine grained dolomitic sandstone	155.1	4.00	0.33
01-F	30	57.6	Tof_{b-2} to Tof_{b-2a}	Light tan medium grained sandstone	138.9	1.25	0.20
01-I	38	159.5	Tof_{b-1}	Dark gray fine grained dolomitic sandstone	144.2	0.79	0.30
01-I	40A	88.4	Tof_{b-1}	Tan thinly bedded fine grained dolomitic sandstone	142.0	2.14	0.17
01-I	42	44.0	Tof_{b-1}	Tan fine grained dolomitic sandstone	141.5	0.79	0.1*
01-CTF-A	15	13.5	Tof_{b-2}	Tan clayey friable medium grained sandstone	138.3	0.12	0.17
				Average	**144.0**	**1.53**	**0.22**

*Questionable values of Poisson's ratio not used in averages

Notes: [1]Rock unit description from William Lettis & Associates, Inc. (2001) Diablo Canyon ISFSI Data Report B. Sample lab description is not always consistent with the Data Report B descriptions that are more current and supercede the laboratory descriptions.

Tof_{b-1} – dolomite, clayey dolomite, dolomitic siltstone to fine-grained dolomitic sandstone, and limestone

Tof_{b-1a} – friable dolomite and dolomitic siltstone

Tof_{b-2} – fine- to coarse-grained dolomitic sandstone and sandstone

Tof_{b-2a} – friable sandstone

[2]Laboratory sample description from GTU..

Table I-8 Summary of Small Strain Elastic Property Measurements for Friable Sandstone

Boring No.	Sample No.	Depth (ft)	DCPP ISFSI Data Report B Rock Unit[1]	Sample Lab Description[2]	Unit Weight (pcf)	Modulus ($\times 10^6$ psi)	Poisson's Ratio
01-B	19	38.0	Tof_{b-2a}	Tan medium grained sandstone with claystone clasts	132.4	0.21	0.23
01-D	4	25.5	Tof_{b-2a}	Tan weak clayey medium grained sandstone	142.3	0.075*	0.15
01-G	10	69.0	Tof_{b-2a}	Gray friable clayey medium grained sandstone	130.7	0.015*	0.03**
01-CTF-A	14	8.8	Tof_{b-2a}	Gray fine to medium grained soft sandstone	128.8	0.004*	0.29
01-CTF-A	16	48.8	Tof_{b-2a}	Tan Clayey friable altered medium grained sandstone	133.2	0.061*	0.17
01-A	3	35.5	Tof_{b-2a}	Gray medium grained weak friable sandstone	145.3	0.033*	NA**
01-D	5	28.0	Tof_{b-2a}	Tan medium grained clayey weak sandstone	144.5	0.063*	0.06**
01-H	13	57.0	Tof_{b-2a}	Gray clayey friable medium grained sandstone	131.7	0.009*	0.16
01-F	32	117.7	Tof_{b-2a}	Gray clayey friable soft fine to medium grained sandstone	135.8	0.008*	0.32
				Representative Value	**134.9**	**0.21**	**0.23**

* Moduli measured in the unconfined compression test set up are too low to represent in-situ moduli for the confining pressure sensitive friable sandstone.

** Questionable values of Poisson's ratio

Notes: [1]Rock unit description from William Lettis & Associates, Inc. (2001) Diablo Canyon ISFSI Data Report B. Sample lab description is not always consistent with the Data Report B descriptions that are more current and supercede the laboratory descriptions.

Tof_{b-1} – dolomite, clayey dolomite, dolomitic siltstone to fine-grained dolomitic sandstone, and limestone

Tof_{b-1a} – friable dolomite and dolomitic siltstone

Tof_{b-2} – fine- to coarse-grained dolomitic sandstone and sandstone

Tof_{b-2a} – friable sandstone

[2]Laboratory sample description from GTU..

Table I-9 Summary of Direct Shear Test Results (1 of 4)

Boring No.	Sample I.D.	Depth (ft)	Discontinuity Inclination from horizontal (degrees)	DCPP ISFSI Data Report B Rock Unit[1]	Feature in Sample[2]	Normal Stress (psi)	Peak Shear Stress (psi)	Post Peak Shear Stress (psi)
01-B	20	48.8	50	Tof_{b-2}	Clay coated joint	13.0	11.8	--
						18.0	14.0	--
						25.0	17.0	--
						40.0	25.0	--
						55.0	30.5	--
						15.0	--	12.0
						20.0	--	14.0
						28.0	--	17.0
01-C	23	41.4	44	Tof_{b-2a}	Clay coated joint	20.2	4.5	--
						40.0	7.8	--
						62.3	11.7	--
						21.4	--	6.0
						41.3	--	9.0
						66.2	--	11.8
01-C	24	44.3	30	Tof_{b-2a}	Clay coated joint	20.8	4.5	--
						41.2	6.2	--
						61.0	7.8	--
						22.5	--	5.8
						45.2	--	7.3
						66.3	--	10.0
01-E	29	51.8	6	Tof_{b-1}	Rock-rock contact bedding joint	17.0	19.0	--
						30.0	30.2	--
						46.8	44.5	--
						17.5	--	16.0
						34.0	--	31.0
						50.2	--	45.0
01-F	31	117	15	Tof_{b-1a}/Tof_{b-2a}	Clay bed	12.5	4.0	--
						20.4	3.9	--
						38.7	3.4	--
						13.2	--	5.1
						21.6	--	4.7
						40.3	--	4.0
01-F	33	118.3	not reported in lab sheets	Tof_{b-2a}/Tof_{b-2}	Clay coated joint	18.5	8.0	--
						35.0	11.0	--
						72.0	20.0	--
						20.5	--	10.5
						40.0	--	14.0
						81.0	--	21.0
						174.0	--	36.0

Table I-9 Summary of Direct Shear Test Results (2 of 4)

Boring No.	Sample I.D.	Depth (ft)	Discontinuity Inclination from horizontal (degrees)	DCPP ISFSI Data Report B Rock Unit[1]	Feature in Sample[2]	Normal Stress (psi)	Peak Shear Stress (psi)	Post Peak Shear Stress (psi)
01-CTF-A	34	32.6	23	Tof_{b-2}	Clay coated joint	15.5	14.0	--
						31.5	24.2	--
						60.5	39.5	--
01-H	35	94.5	4	Tof_{b-2a}	Clay coated joint	14.0	2.6	--
						24.3	2.6	--
						47.2	3.5	--
						16.0	--	6.5
						29.0	--	6.5
						53.2	--	8.8
01-I	36	174	14	Tof_{b-1a}	Rock-rock contact bedding joint	86.0	76.0	--
						175.0	144.0	--
						352.0	264.0	--
						93.0	--	61.0
						190.0	--	121.0
						384.0	--	237.0
01-I	37	168.5	14	Tof_{b-1a}	Clay coated bedding joint	16.2	6.8	--
						27.5	9.6	--
						52.3	18.5	--
						16.5	--	7.9
						28.1	--	11.1
						54.5	--	20.0
01-I	39B	130.4	8	Tof_{b-1a}	Clay bed	13.1	4.8	--
						25.6	7.2	--
						47.8	10.6	--
						14.2	--	5.5
						28.1	--	7.3
						52.2	--	11.0
01-I	40B	88.8	16	Tof_{b-1}	Rock-rock contact bedding joint	47.0	42.0	--
						90.0	73.0	--
						178.0	133.0	--
						49.0	--	32.0
						96.0	--	59.0
						194.0	--	113.0
01-I	41A	45.6	17	Tof_{b-1}	Clay bed	9.5	8.0	--
						13.5	9.0	--
						26.5	14.0	--
						10.5	--	7.0
						16.5	--	9.0
						28.5	--	12.0

Table I-9 Summary of Direct Shear Test Results (3 of 4)

Boring No.	Sample I.D.	Depth (ft)	Discontinuity Inclination from horizontal (degrees)	DCPP ISFSI Data Report B Rock Unit[1]	Feature in Sample[2]	Normal Stress (psi)	Peak Shear Stress (psi)	Post Peak Shear Stress (psi)
01-I	41B	46.1	14	Tof_{b-1}	Rock-rock contact bedding joint	23.5	28.5	--
						48.0	54.5	--
						93.0	96.0	--
						25.5	--	20.0
						51.5	--	40.0
						100.0	--	75.0
00BA-1	1-1	18.2	30	Tof_{b-1}	Rock-rock poorly mated rough joints (Tof_{b-1})	10.6	13.0	--
						20.1	21.3	--
						41.2	35.3	--
						11.3	--	9.0
						21.4	--	16.6
						43.7	--	31.2
00BA-1	1-2	34.2	64	Tof_{b-1}	Rock-rock well mated joint	10.3	16.1	--
						20.1	25.6	--
						41.0	43.8	--
						10.0	--	9.0
						21.6	--	18.3
						44.1	--	33.0
00BA-1	1-3	37.1	12	Tof_{b-1}	Rock-rock bedding joint	10.1	8.0	--
						20.5	14.7	--
						41.3	27.5	--
						10.9	--	6.9
						22.2	--	12.4
						44.7	--	23.4
00BA-1	1-4	41.9	13	Tof_{b-1}	Rock-rock mechanical break along bedding	13.8	25.3	--
						24.0	31.0	--
						44.6	46.9	--
						15.8	--	10.8
						27.2	--	18.1
						50.5	--	31.7
00BA-1	1-6	88.8	21	Tof_{b-1}	Rock-rock moderately rough well mated joints	20.6	24.2	--
						40.1	42.4	--
						82.0	71.0	--
						24.2	--	13.3
						47.0	--	23.7
						96.2	--	45.0
00BA-1	1-7	142.0	55	Tof_{b-1}	Rock-rock poorly mated joint	20.5	21.8	--
						41.8	41.8	--
						83.0	76.8	--
						22.9	--	19.0
						46.7	--	37.0
						92.8	--	71.0

Table I-9 Summary of Direct Shear Test Results (4 of 4)

Boring No.	Sample I.D.	Depth (ft)	Discontinuity Inclination from horizontal (degrees)	DCPP ISFSI Data Report B Rock Unit[1]	Feature in Sample[2]	Normal Stress (psi)	Peak Shear Stress (psi)	Post Peak Shear Stress (psi)
00BA-1	1-18	56.5	15	Tof_{b-1}	Clay bed	5.8	7.8	--
						10.0	10.7	--
						20.2	15.2	--
						37.2	19.1	--
						6.5	--	4.9
						10.7	--	6.3
						21.9	--	9.4
						40.3	--	12.0

Notes: [1]Rock unit description from William Lettis & Associates, Inc. (2001) Diablo Canyon ISFSI Data Report B. Sample lab description is not always consistent with the Data Report B descriptions that are more current and supercede the laboratory descriptions.

Tof_{b-1} – dolomite, clayey dolomite, dolomitic siltstone to fine-grained dolomitic sandstone, and limestone

Tof_{b-1a} – friable dolomite and dolomitic siltstone

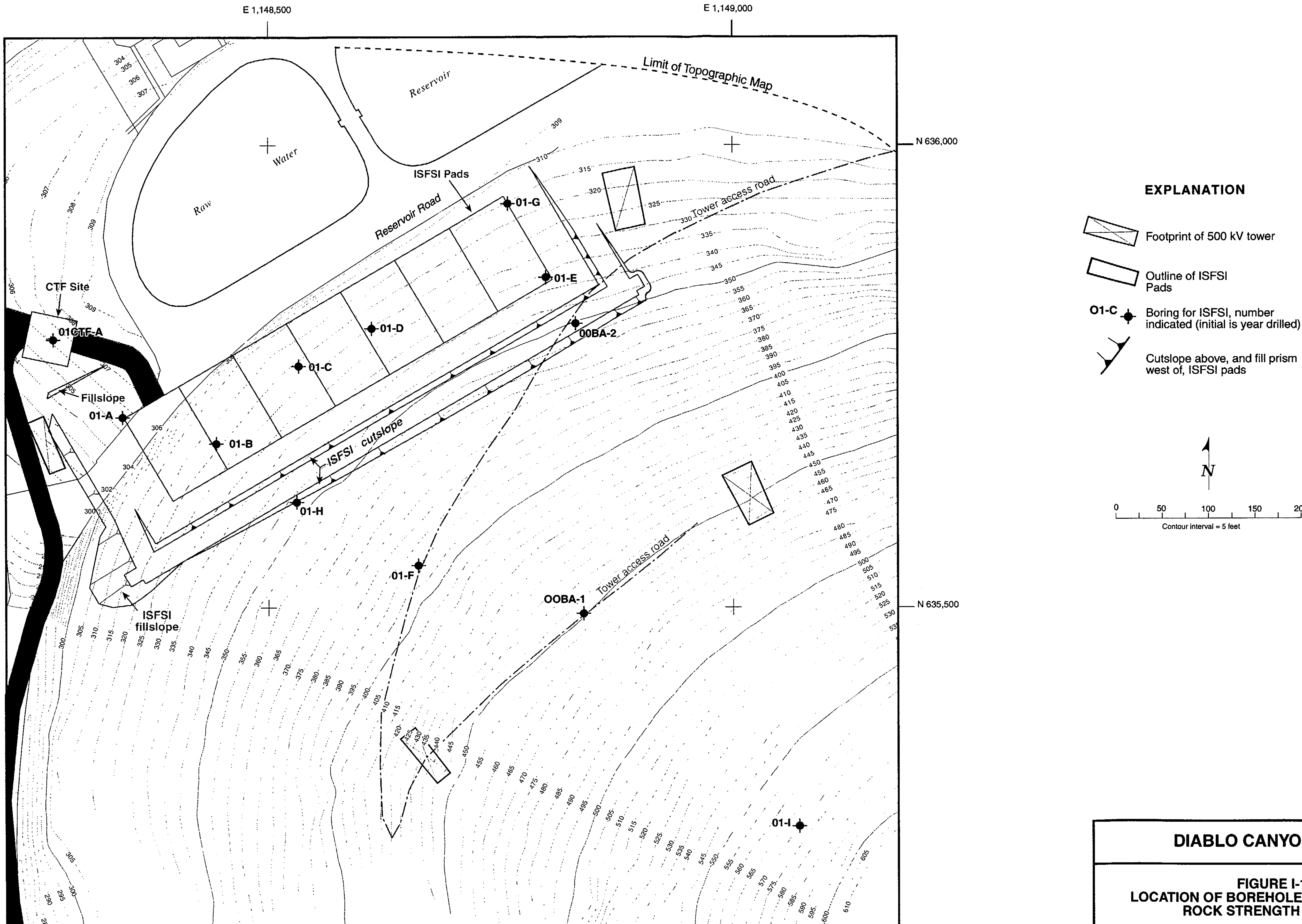
Tof_{b-2} – fine- to coarse-grained dolomitic sandstone and sandstone

Tof_{b-2a} – friable sandstone

[2]Sample description based on laboratory datasheets.

Table I-10 Summary of Unit Weight of Rock Core Samples

Boring	Sample	All	Dolomite	Sandstone
00BA-1	1-10	138.4	138.4	
00BA-1	1-11	142.4	142.4	
00BA-1	1-12	134.5	134.5	
00BA-1	1-13	128.9	128.9	
00BA-1	1-14	143.1	143.1	
00BA-1	1-8B	146.6	146.6	
00BA-1	1-9B	140.6	140.6	
00BA-2	2-E	160.9		160.9
00BA-1	1-5B	134.9	134.9	
00BA-1	1-15	140.3	140.3	
00BA-1	1-16	132.8	132.8	
00BA-1	1-17	133.1		133.1
00BA-2	2-A	130.1		130.1
00BA-2	2-B	139.7		139.7
00BA-2	2-C	141.1		141.1
00BA-2	2-DB	135.2		135.2
01-A	1	161.4		161.4
01-A	2	146.6		146.6
01-D	4	142.3		142.3
01-D	6	147.1		147.1
01-G	9	138.2	138.2	
01-G	10	130.7		130.7
01-H	11	138.9	138.9	
01-H	12	155.1		155.1
01-CTF-A	14	128.8		128.8
01-CTF-A	15	138.3		138.3
01-CTF-A	18	147.3		147.3
01-B	19	132.4		132.4
01-C	22	155		155
01-E	26	129.4	129.4	
01-E	28	135.8	135.8	
01-F	30	138.9		138.9
01-I	38	144.2	144.2	
01-I	39A	140.3	140.3	
01-I	40A	142	142	
01-I	42	141.5	141.5	
01-A	3	145.3		145.3
01-D	5	144.5		144.5
01-H	13	131.7		131.7
01-CTF-A	17	127.1		127.1
01-F	32	135.8		135.8
01-CTF-A	16	133.2		133.2
01-C	21	132.5		132.5
01-E	25	135.8	135.8	
		All Rock	**All Dolomite**	**All Sandstone**
	Average =	139.6	138.3	140.5
	Std. Dev.=	8.1	5.0	9.7



DIABLO CANYON ISFSI

FIGURE I-1
LOCATION OF BOREHOLES SAMPLED FOR ROCK STRENGTH TESTING

ATTACHMENT 1

LABORATORY ROCK TESTING REPORT

SAMPLES COLLECTED FROM BORINGS 00BA-1 AND 00BA-2, ANDERS BRO OF GEOTEST UNLIMITED

DECEMBER 30, 2000

Geo Test Unlimited (GTU)

Test Equipment Design & Fabrication
Laboratory & Field Testing
Consulting Services

Dr. Anders Bro

December 30, 2000

Jeff Bachhuber
William Lettis & Associates, Inc.
1777 Botelho Dr, Suite 262
Walnut Creek, CA 94596

Dear Jeff,

Thank you very much for using my rock testing lab for the Diablo Canyon Power Plant, ISFSI project. This letter report describes the tests performed and summarizes the test results along with observations which might have some bearing on interpreting the rock behavior.

A number of samples along with a schedule of the desired tests were obtained from your office on December 11, 2000. These samples were transported to GTU's facilities in Nevada City where they were prepared on December 14, 18 and 19. The tests were performed on December 17, 18 and 19.

The initial schedule of tests consisted of 16 unconfined compression tests and 7 direct shear tests. After discussions with you, the number of unconfined compression tests was reduced to 8, and 8 triaxial tests were added. 4 of the triaxial samples were selected from Boring OOBA-1. Since these were quite hard and would most likely behave in a brittle manner, they were tested using a single stage procedure. The remaining triaxial samples came from Boring OOBA-2 and were quite weak. It was thought that their weak ductile behavior would make them suitable candidates for multistage tests.

Schedule of Tests

Sample ID	Boring	Depth (ft)	Description	Test[1]
1-8B	OOBA-1	146.6-147.1	Brown dolomitic sandstone	UC
1-9B		149.5-150.0	Gray to light brown dolomitic sandstone	
1-10		12.2-12.7	Tan dolomitic sandstone	
1-11		18.7-19.2	Dark brown gray dolomitic sandstone	
1-12		22.6-23.1	Tan dolomitic sandstone	
1-13		40.9-41.35	Tan dolomitic sandstone	
1-14		49.1-49.6	Light brown to tan dolomitic siltstone	
2-E	OOBA-2	50.9-51.4	Tan dolomitic (siliceous?) sandstone	
1-5B	OOBA-1	84.0-84.5	Tan dolomitic sandstone	SSTX
1-15		77.5-78.0	Tan dolomitic sandstone	
1-16		107.3-107.8	Tan dolomitic sandstone	
1-17		116.4-116.9	Tan dolomitic sandstone	
2-A	OOBA-2	37.0-37.5	Tan weak, friable dolomitic sandstone	MSTX
2-B		37.5-38.0	Tan weak dolomitic sandstone	
2-C		43.1-43.6	Gray weak sandstone	
2-DB		46.0-46.5	Gray weak, friable sandstone	
1-1	OOBA-1	18.2	Poorly mated rough joint	DS
1-2		34.2	Well mated rough joint	
1-3		37.1	Bedding plane joint	
1-4		41.9	Mechanical break (along bedding?)	
1-6		88.8	Well mated rough joint with coating	
1-7		142.0	Poorly mated wavy joint.	
1-18		56.5	Rock/clay interface	

1. UC - Unconfined Compression Test
SSTX - Single-Stage Triaxial Test
MSTX - Multi-Stage Triaxial Test
DS - Direct Shear Test

27069 N. Bloomfield Rd., Nevada City, CA 95959 Tel/Fax (530)470-0583 email: abro@mindspring.com

The sample descriptions (both in the table above as well as on the data sheets and plots) may be misleading due to the difficulty in distinguishing between the dolomite, dolomitic sandstone, and limestone. A more thorough evaluation of these samples could be made to address these concerns if they had a bearing on the stability analyses. All of the tested samples have been returned to you in the event that such a reevaluation is required.

Calibration

Prior to testing, the transducer calibrations were checked. In the case of the 50 kip Interface load cell (used for the unconfined and triaxial compression tests) and the two 2 kip Lebow load cells (used for the direct shear tests), the linearity and accuracy of the cell readings were compared to the loads as measured by a 20 kip Morehouse proving ring. The calibration of the 200 psi Viatran pressure transducer (used to monitor and control the confining pressure of the triaxial tests) was checked with a high precision, 300 psi Heise pressure gauge. The calibration of the Schaevitz LVDTs with a 0.2 inch stroke were all checked with an electronic Mitutoyo precision micrometer head. Finally the calibration of the Transtek LVDT with a 1 inch stroke (used to measure the shear displacement of the shear box) was checked with a mechanical Mitutoyo micrometer head. Of these checks, only one load cell (the one used to measure the normal load in the shear box) resulted in a slight shift from the original calibration. For this 2000 lb load cell, a shift in the gain of about 25 lb (an error of 1.2%) was encountered. Before testing, the gain was adjusted to eliminate this error. Both of the Lebow cells appeared to have a 2 lb hysteresis (ie a 0.1% error) which developed during a loading/unloading cycle.

Test Procedures

The tests were all performed following the applicable ASTM procedures (ASTM 2938, ASTM 2664, and ASTM 5607). The specific procedures used at GTU are appended to this letter.

Test Results and Sample Behavior

The test results are presented in the appended test data sheets and plots. In the case of the unconfined compression and triaxial tests, the sample densities are calculated from the sample weights and their volumes. The stress strain curves are also plotted and the sample strengths are reported at the bottom of the plots. It should be noted that for these tests, the sample deformations include the platen interfaces, as well as the deformation of the load cell. Thus any modulus derived from these plots would be softer than the rock modulus.

The triaxial test plots present the axial stress and confining pressure vs. axial strain curves. The strength at each confining pressure is summarized at the bottom of these plots, and these confining pressure-strength pairs are used to develop the failure envelopes. In the case of the triaxial samples from boring OOBA-1, the natural variability of the sample strengths overshadowed any impact that the confining pressure may have had on the sample strengths. Therefore it was not possible to develop a reasonable failure envelope for these samples.

In the case of the triaxial samples from boring OOBA-2, two deformational behaviors were exhibited. One behavior for the slightly stronger rock (Samples 2-B and 2-C) was a fairly typical quasi-brittle behavior in which the samples exhibited significant weakening following a peak in the stress-strain curve. It was possible to obtain excellent "final" strength envelopes for these samples, although the initial weakening made it somewhat difficult to develop "initial" failure envelopes with a high degree of confidence.

The weaker two triaxial samples from boring OOBA-2 (Samples 2-A and 2-DB) behaved with a linear strain hardening manner. This behavior has been observed in many weak and ductile rocks. The construction of the failure envelopes follows a procedure developed for PG&E's Scott Dam testing program, in which the linear stress-strain curves are extrapolated and strengths at a single level of strain are derived for two confining pressures. (See the appended Technical Note.)

These two samples were unique in that they were so weak that mechanical breaks occurred in these samples during transport and in sample preparation. These breaks, which were perpendicular to the core axis, were well mated, and the samples were glued back together using cyanoacrylate glue. Due to the thin glue line, the weakness of the bond, and the orientation of the glued fractures, the sample repairs were thought to have little strengthening influence on the samples. During the testing of Sample 2-A, water appeared to have been squeezed out of the specimen (a behavior not uncommon for porous sandstone), indicating a significant pore pressure response in this soft rock. The hypothesis that pore pressures developed in the sample during the test was supported by the horizontal failure envelopes for these two samples. The shear strength of the rock appeared to be independent of the confining pressure, a condition reminiscent of an undrained clay. If an undrained test were performed in which pore pressures were measured, one would have expected to find a significant change in pore pressure during the test (most likely an increase, thereby maintaining the effective confining stress).

Of the 7 prioritized direct shear tests, the second one, Sample 2-DA, could not be tested. This sample consisted of an intact rock joint which did not appear to be through-going. An attempt was made to separate the sample into two halves, but the joint was so strong that the sample could not be split along this joint. Despite the strong nature of the intact joint, it was thought worthwhile to mount the sample in the shear box and test it anyway. As the sample was so strong, no string was used to hold the two sample halves together. The first half was potted in the plaster with no ill effects. The sample was then inverted and cast in the other half of the sample holder. After about 10 minutes, the sample was checked and the sample was found to have separated along the joint. Half of the sample was found submerged in the fresh potting plaster. This behavior indicated that the strength of the sandy, silty, clay rich rock was strongly influenced by the presence of water. The sample with a low water content was quite strong, and yet had a reduced strength when the water content increased. It was also apparent that this rock could absorb water fairly quickly. Although no test could be performed on this sample, its behavior during preparation might raise concerns regarding the strength of the rock mass as water is introduced into the joints.

Of the 7 direct shear samples which were tested, Sample 1-18 was unique in that it was a clay seam/rock interface. The positioning of the sample was not ideal in that when the sample was potted, the interface was on the same level as the casting plaster as opposed to being in the middle of the shear box gap. (The poor positioning of the sample was a result of the indistinct expression of the interface on the surface of the core.) Therefore the sample may not have been as free to shear as it might otherwise have been had it been properly positioned. On the other hand, an advantage of this positioning was that the soft clay was not permitted to squeeze sideways into the shear box gap, as it was completely confined by the casting plaster. Despite these concerns, the friction angle of this interface was still quite low, and was typical for plastic clays, in this case on the order of 12° for the final shear friction angle.

Sincerely,

Anders Bro

Anders Bro

Geo Test Unlimited (GTU)

DATA SHEET
Unconfined Compression Test of Rock (ASTM D2938)

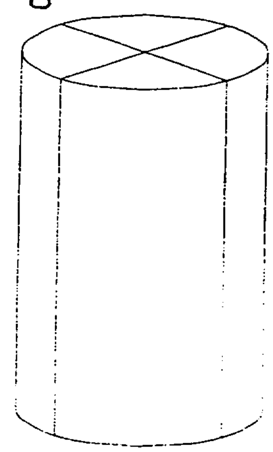
Date: 12-17-00
Technician: A. Bro

Client: W. Lettis & Assoc.
Job: #126-DCPP ISFSI
Sample ID: 1-8B
Sample Description: uniform fine grained grayish brown dolomitic siltstone.

Sample Depth: 146.6-147.1 Sample Condition: received & tested dry

d_1	d_2
2.392	2.397
2.390	2.393
2.390	2.390
2.393	2.394
2.397	2.399

l_1	l_2
+.0012	+.0005
+.0003	+.0003
±.0001	±.0002
-.0012	-.0005
-.0023	-.0011



Avg. diameter : 2.393
Sample area : 4.498
Sample volume(in³) : 25.042
Sample weight (g) : 964.0 g
Density : 38.49 g/in³ = 146.6 pcf (1 g/in³=3.8095 lb/ft³)

Avg. length : 5.568
l/d ratio : 2.33

Comments: note typical upward curved σ-ε ✓
quite ductile! strange "clunk" sound on failure.

Failed by shear

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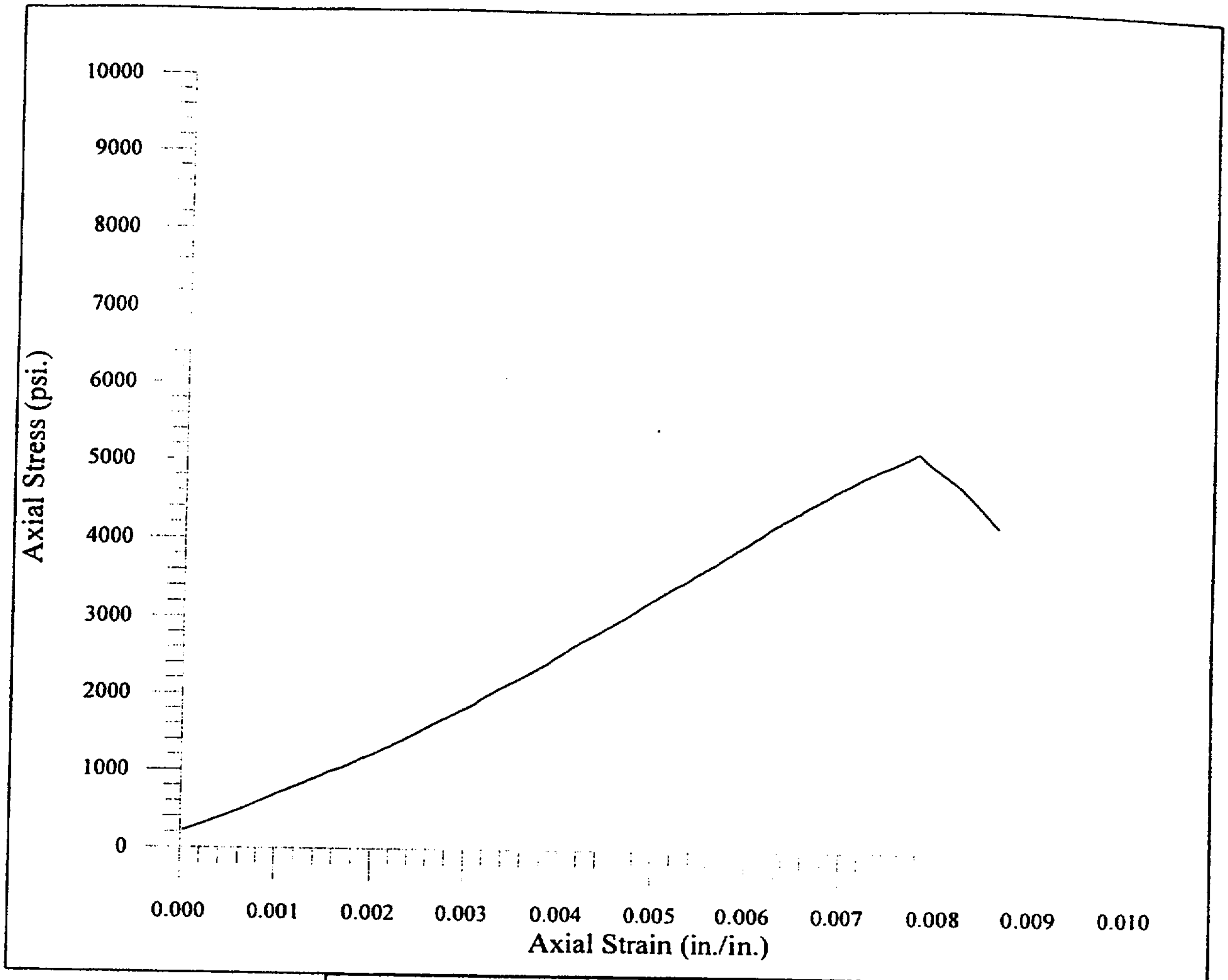


UNCONFINED COMPRESSION TEST
Axial Stress vs. Axial Strain

Boring: OOBA-1
Sample: 1-8B
Depth: 146.6-147.1'

DESCRIPTION
Fine grained grayish brown dolomitic sandstone, contains no discernable fractures.

Strength: 5133 psi
Density: 146.6 pcf

Geo Test Unlimited GTU
27069 N. Bloomfield Rd.
Nevada City, CA 95959

Client: William Lettis & Associates, Inc.
1777 Botelho Dr., Suite 262
Walnut Creek, CA 94596

Project: Diablo Canyon Power Plant ISFSI

Project Number: 1223-50

Test Date: December 17, 2000

Geo Test Unlimited (GTU)

DATA SHEET
Unconfined Compression Test of Rock (ASTM D2938)

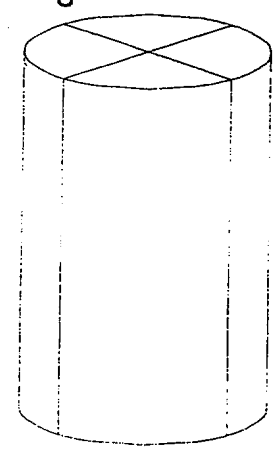
Date: 12-17-03
Technician: A.Bro

Client: W. Lettis & Assoc.
Job: #126-DCPP-ISFSI
Sample ID: 1-9B
Sample Description: Gray to light brown fine grained dolomitic sandstone, massive, no visible fractures.

Sample Depth: 149.5-150.0' Sample Condition: received & tested dry

d_1	d_2
2.394	2.390
2.394	2.386
2.400	2.394
2.399	2.397
2.400	2.400

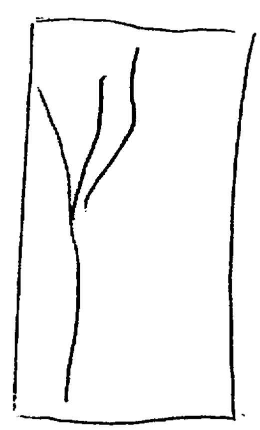
l_1	l_2
-.0023	-.0011
-.0010	-.0004
±.0001	±.0002
+.0009	+.0005
+.0017	+.0003



Avg. diameter : 2.396
Sample area : 4.509
Sample volume(in³) : 24.884
Sample weight (g) : 918.2g
Density : 36.90g/in³ = 140.6 pcf (1 g/in³=3.8095lb/ft³)

Avg. length : 5.519
l/d ratio : 2.30

Comments: very similar in behavior to sample 8B
initial failure by axial splitting



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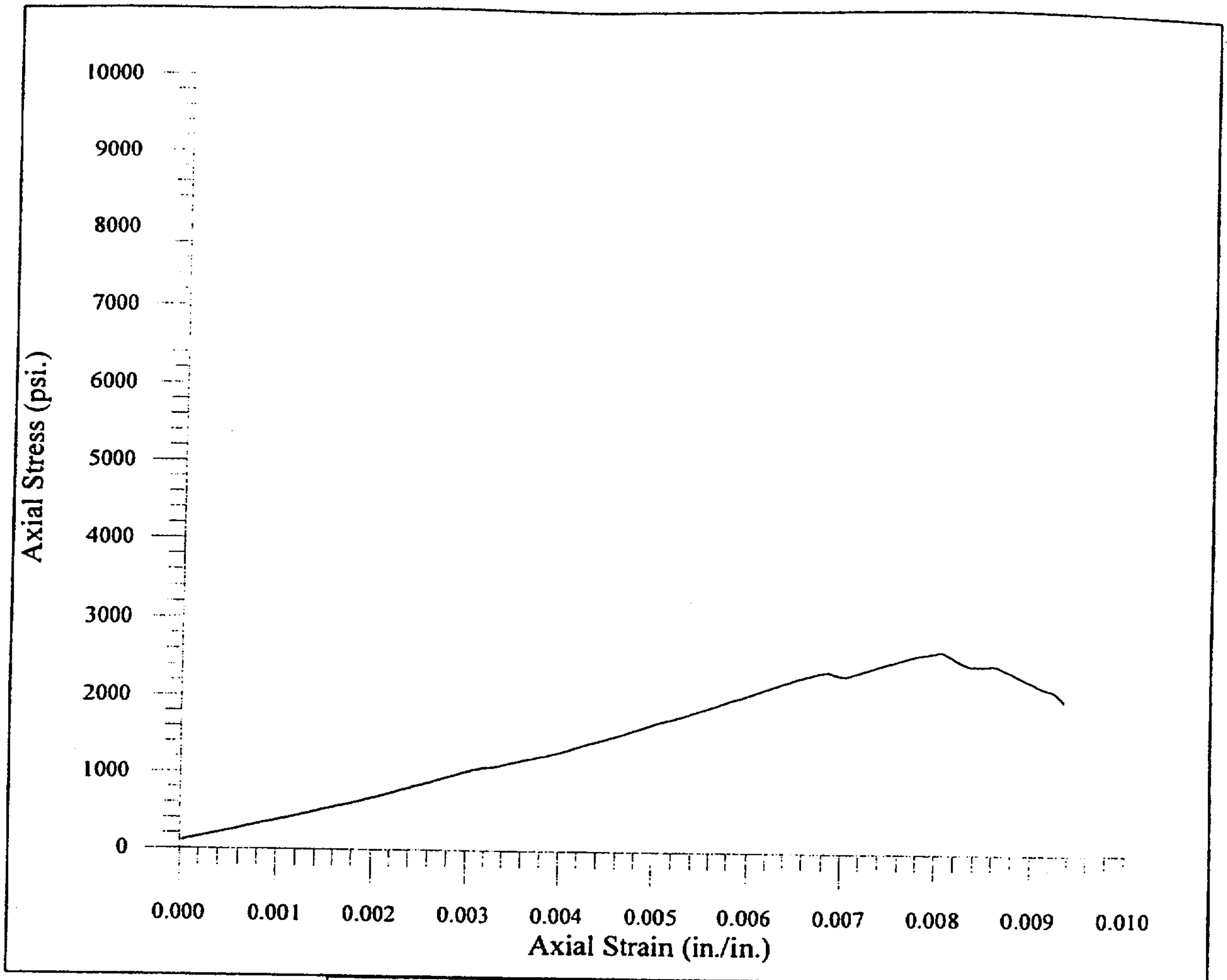


UNCONFINED COMPRESSION TEST
Axial Stress vs. Axial Strain

Boring: OOBA-1 **Sample:** 1-9B **Depth:** 149.5-150.0'	*Geo Test Unlimited* GTU 27069 N. Bloomfield Rd. Nevada City, CA 95959
DESCRIPTION Fine grained gray to light brown dolomitic sandstone, contains no discernable fractures.	**Client:** William Lettis & Associates, Inc. 1777 Botelho Dr., Suite 262 Walnut Creek, CA 94596
Strength: 2625 psi **Density:** 140.6 pcf	**Project:** Diablo Canyon Power Plant ISFSI **Project Number:** 1223-50
	Test Date: December 17, 2000

Geo Test Unlimited (GTU)

DATA SHEET
Unconfined Compression Test of Rock (ASTM D2938)

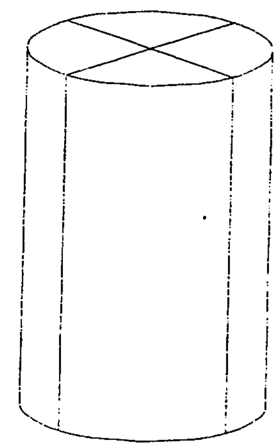
Date: 12-17-00
Technician: A.Bro

Client: W. Lettis & Assoc.
Job: #126-DCPP-ISFSI
Sample ID: 1-10
Sample Description: tan very fine grained dolomitic sandstone to dolomite, massive, with no apparent jointing.

Sample Depth: 12.2-12.7'   Sample Condition: ____

d_1	d_2
2.385	2.385
2.387	2.387
2.387	2.387
2.387	2.387
2.388	2.388

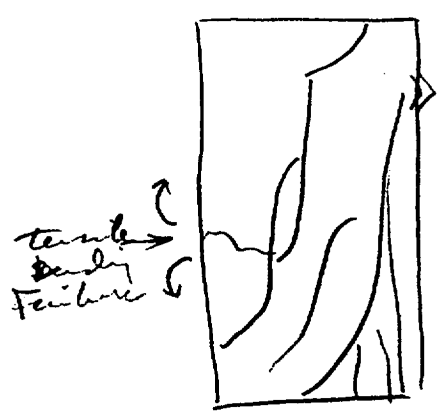
l_1	l_2
+.0013	+.0004
+.0006	+.0003
±.0001	±.0001
-.0007	-.0002
-.0014	-.0005



Avg. diameter : 2.387
Sample area : 4.475
Sample volume(in^3) : 24.630
Sample weight (g) : 894.98
Density : 36.33 g/in^3 = 138.4 pcf   (1 g/in^3=3.8095 lb/ft^3)

Avg. length : 5.504
l/d ratio : 2.31

Comments: Failed by axial splitting (?) & shear (?)



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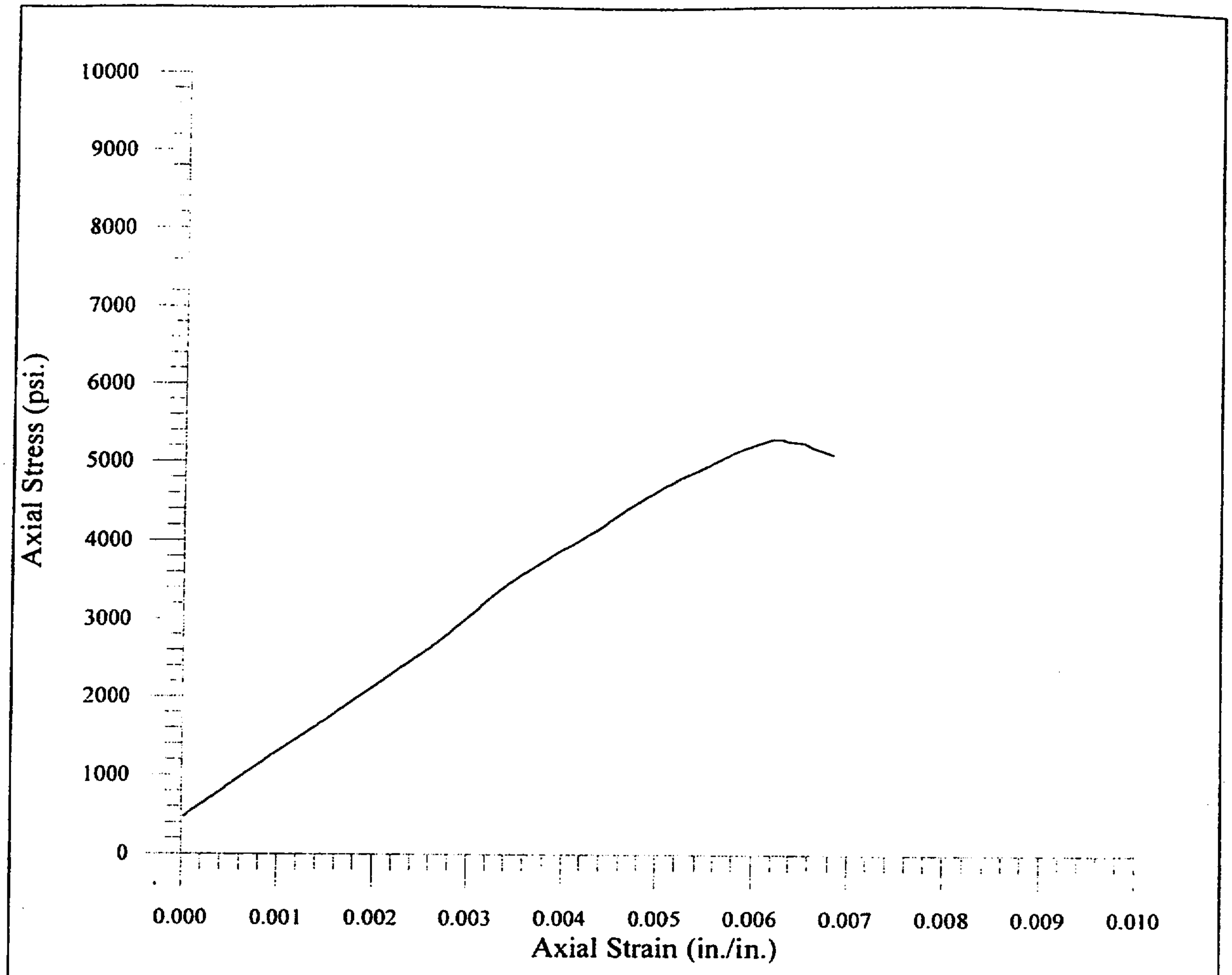


UNCONFINED COMPRESSION TEST
Axial Stress vs. Axial Strain

Boring: OOBA-1 **Sample:** 1-10 **Depth:** 12.2-12.7'	*Geo Test Unlimited* GTU **27069 N. Bloomfield Rd.** **Nevada City, CA 95959**
DESCRIPTION Very fine grained tan dolomitic sandstone, contains no discernable fractures.	**Client:** **William Lettis & Associates, Inc.** **1777 Botelho Dr., Suite 262** **Walnut Creek, CA 94596**
Strength: 5284 psi **Density:** 138.4 pcf	**Project:** **Diablo Canyon Power Plant ISFSI** **Project Number: 1223-50**
	Test Date: December 17, 2000

Geo Test Unlimited

DATA SHEET
Unconfined Compression Test of Rock (ASTM D2938)

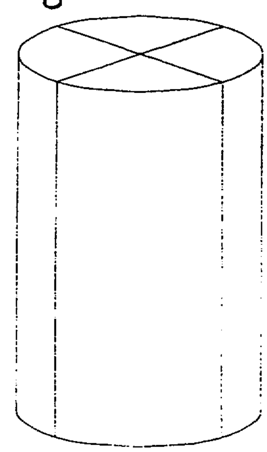
Date: 12-17-00
Technician: A. Bro

Client: W. Lettis & Assoc.
Job: #126-DCPP-ISFSI
Sample ID: 1-11
Sample Description: Dark brownish gray fine grained dolomitic sandstone to dolomite: massive with no visible fractures.

Sample Depth: 18.7 - 19.2 Sample Condition: received & tested dry

d_1	d_2
2.349	2.351
	2.350
	2.349
	2.350
	2.350

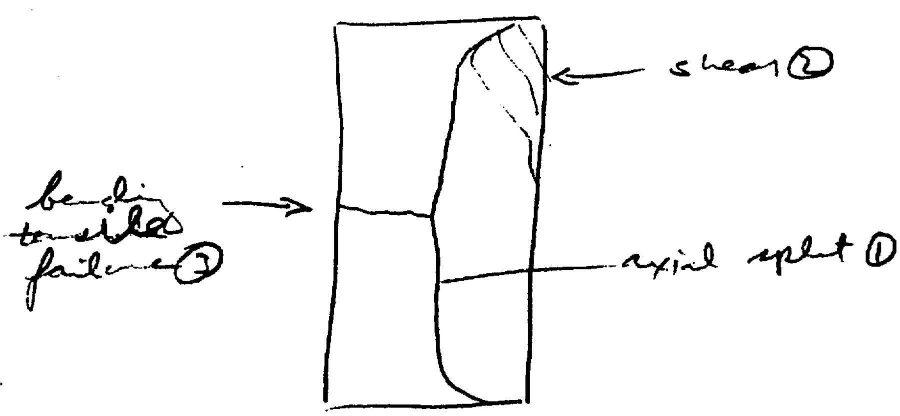
l_1	l_2
+.0005	+.0004
+.0003	+.0002
±.0001	±.0001
-.0003	-.0003
-.0006	-.0005

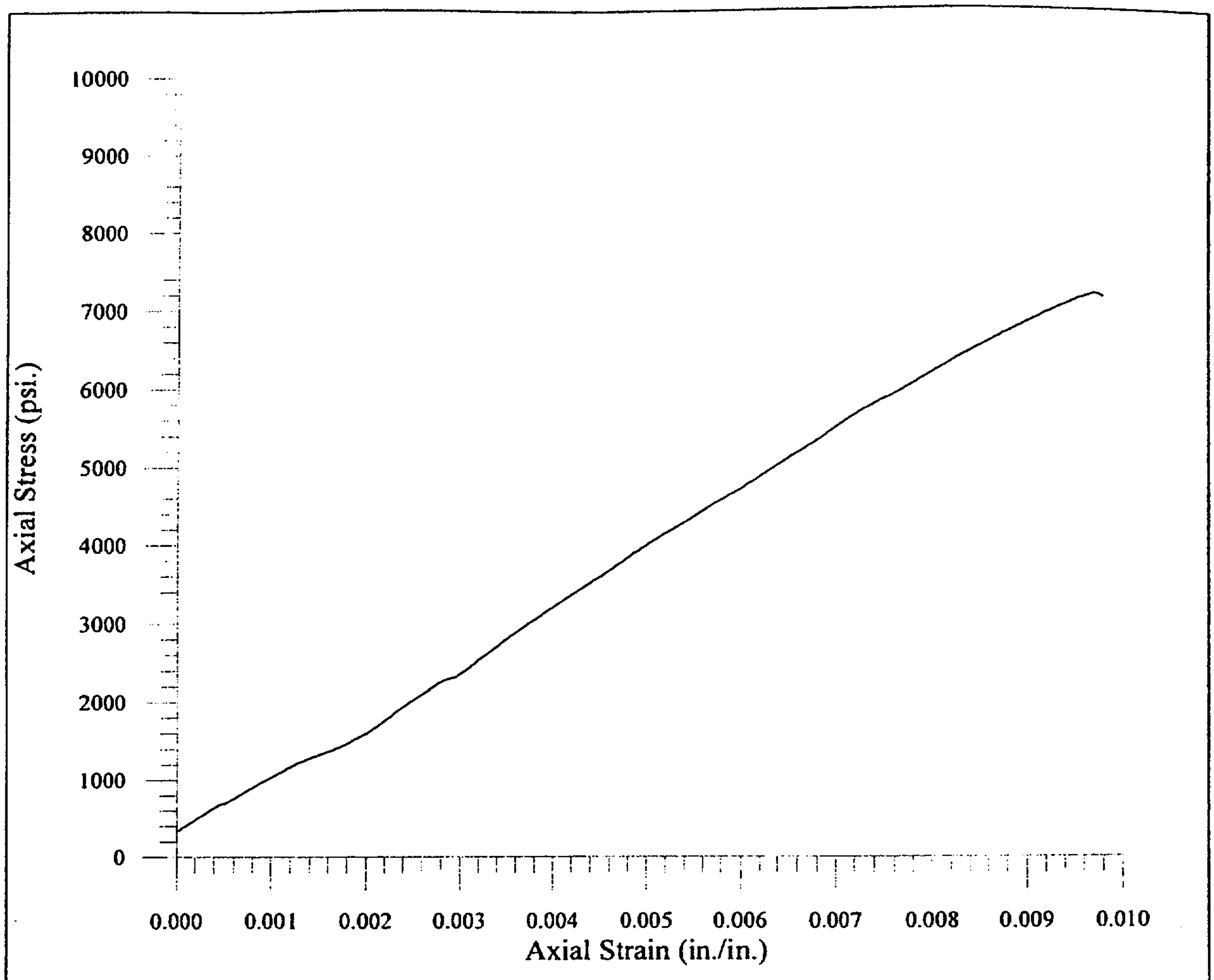


Avg. diameter : 2.349
Sample area : 4.334
Sample volume(in³) : 24.494
Sample weight (g) : 915.7 g
Density : 37.38 g/in³ = 142.4 pcF (1 g/in³=3.8095lb/ft³)

Avg. length : 5.652
l/d ratio : 2.41

Comments: quite a bit more ductile than the fan samples - similar to other dark gray/brown samples
Failed by axial splitting, shear & bending





UNCONFINED COMPRESSION TEST
Axial Stress vs. Axial Strain

Boring: OOBA-1
Sample: 1-11
Depth: 18.7-19.2'

DESCRIPTION
Fine grained dark grayish brown dolomitic sandstone to dolomite, contains no discernable fractures.

Strength: 7190 psi
Density: 142.4 pcf

Geo Test Unlimited
27069 N. Bloomfield Rd.
Nevada City, CA 95959

Client: **William Lettis & Associates, Inc.**
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Walnut Creek, CA 94596

Project: **Diablo Canyon Power Plant ISFSI**

Project Number: 1223-50

Test Date: December 17, 2000

Geo Test Unlimited

DATA SHEET
Unconfined Compression Test of Rock (ASTM D2938)

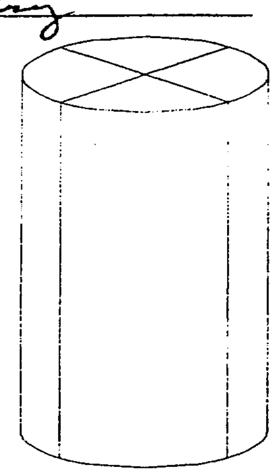
Date: 10-17-00
Technician: ABro

Client: W. Lettis & Assoc.
Job: #126-DCPP-ISFSI
Sample ID: 1-12
Sample Description: tan very fine grained dolomitic siltstone to dolomite, no apparent fractures, although slightly weaker at one end (chips easily)

Sample Depth: 22.6-23.1'   Sample Condition: received & tested dry

d_1	d_2
2.402	2.402
2.395	2.397
2.399	2.398
2.402	2.398
2.405	2.404

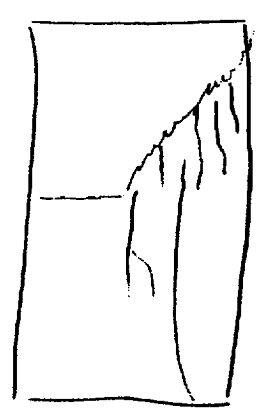
l_1	l_2
+.0011	+.0003
+.0007	+.0002
±.0001	±.0001
-.0005	-.0001
-.0010	-.0003



Avg. diameter : 2.400"   Avg. length : 5.523"
Sample area : 4.524   l/d ratio : 2.30
Sample volume(in³) : 24.985
Sample weight (g) : 881.9g
Density : 35.30 g/in³ = 134.5pcf   (1 g/in³=3.8095lb/ft³)

Comments: relatively large strain to failure, soft "thud" sounding failure.

Failed by axial splitting, shear & bending



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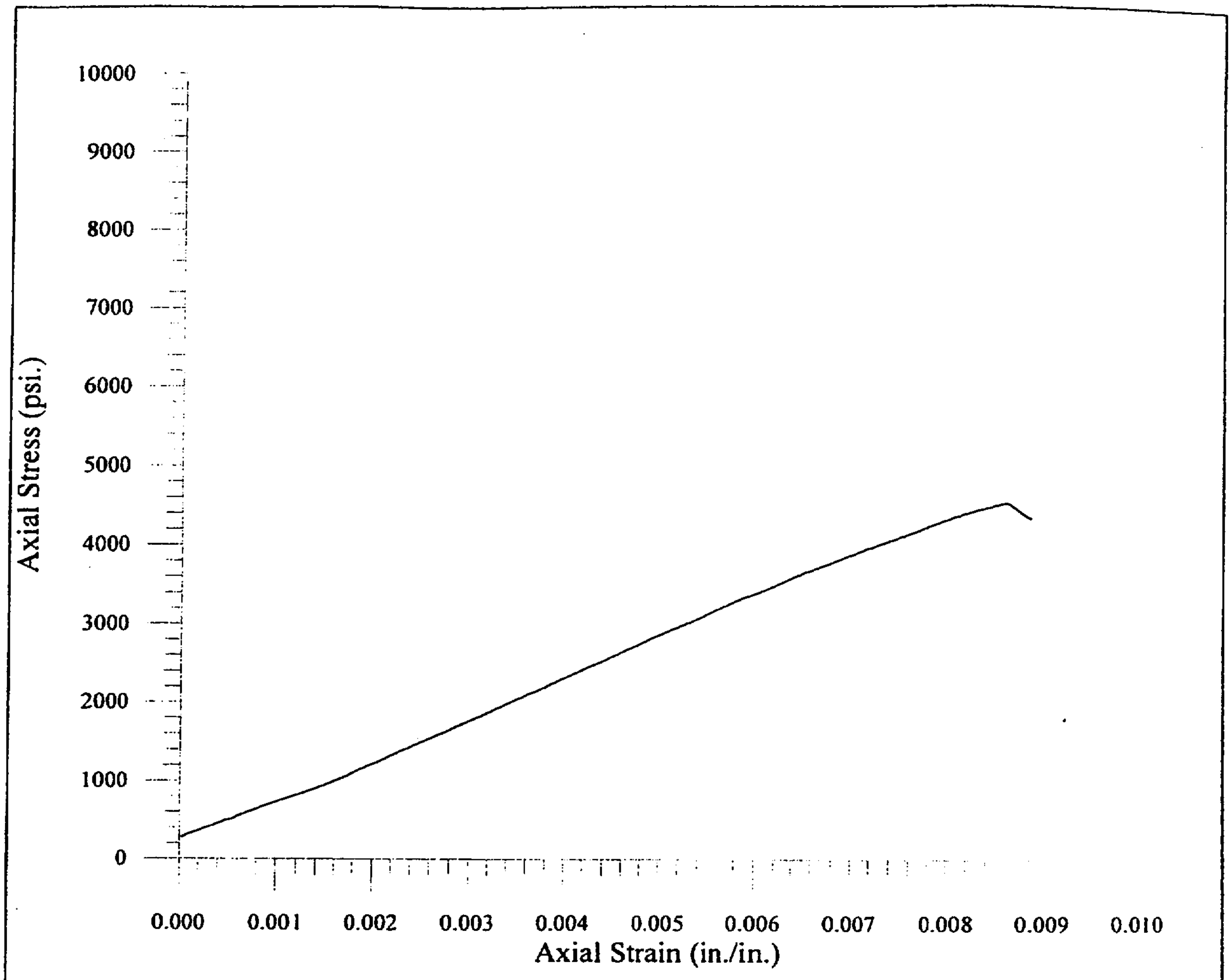

UNCONFINED COMPRESSION TEST
Axial Stress vs. Axial Strain

Boring: OOBA-1
Sample: 1-12
Depth: 22.6-23.1'

DESCRIPTION

Very fine grained tan dolomitic sandstone to dolomite, contains no discernable fractures, but appears weaker at one end.

Strength: 4523 psi
Density: 134.5 pcf

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Client: **William Lettis & Associates, Inc.**
1777 Botelho Dr., Suite 262
Walnut Creek, CA 94596

Project: **Diablo Canyon Power Plant ISFSI**

Project Number: 1223-50

Test Date: December 17, 2000

Geo Test Unlimited

DATA SHEET
Unconfined Compression Test of Rock (ASTM D2938)

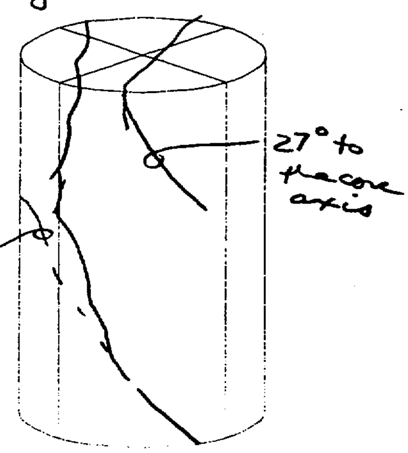
Date: 12-17-00
Technician: A.Bro

Client: W. Lettis & Assoc.
Job: #126-DCPP-ISFSI
Sample ID: 1-13
Sample Description: tan very fine grained dolomitic sandstone with a few healed and partially healed joints

Sample Depth: 40.9-41.35' Sample Condition: received & tested dry

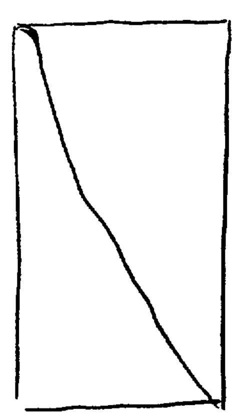
d_1	d_2
2.387	2.387
2.396	2.394
2.398	2.394
2.395	2.390
2.397	2.393

l_1	l_2
+.0006	-.0002
+.0004	0
±.0001	±.0001
-.0003	0
-.0008	-.0002



Avg. diameter : 2.393
Avg. length : 5.382
Sample area : 4.498
l/d ratio : 2.25
Sample volume(in^3) : 24.206
Sample weight (g) : 819.3g
Density : 33.85 g/in³ = 128.9 pcf (1 g/in³=3.8095lb/ft³)

Comments: failed by shear along existing joint



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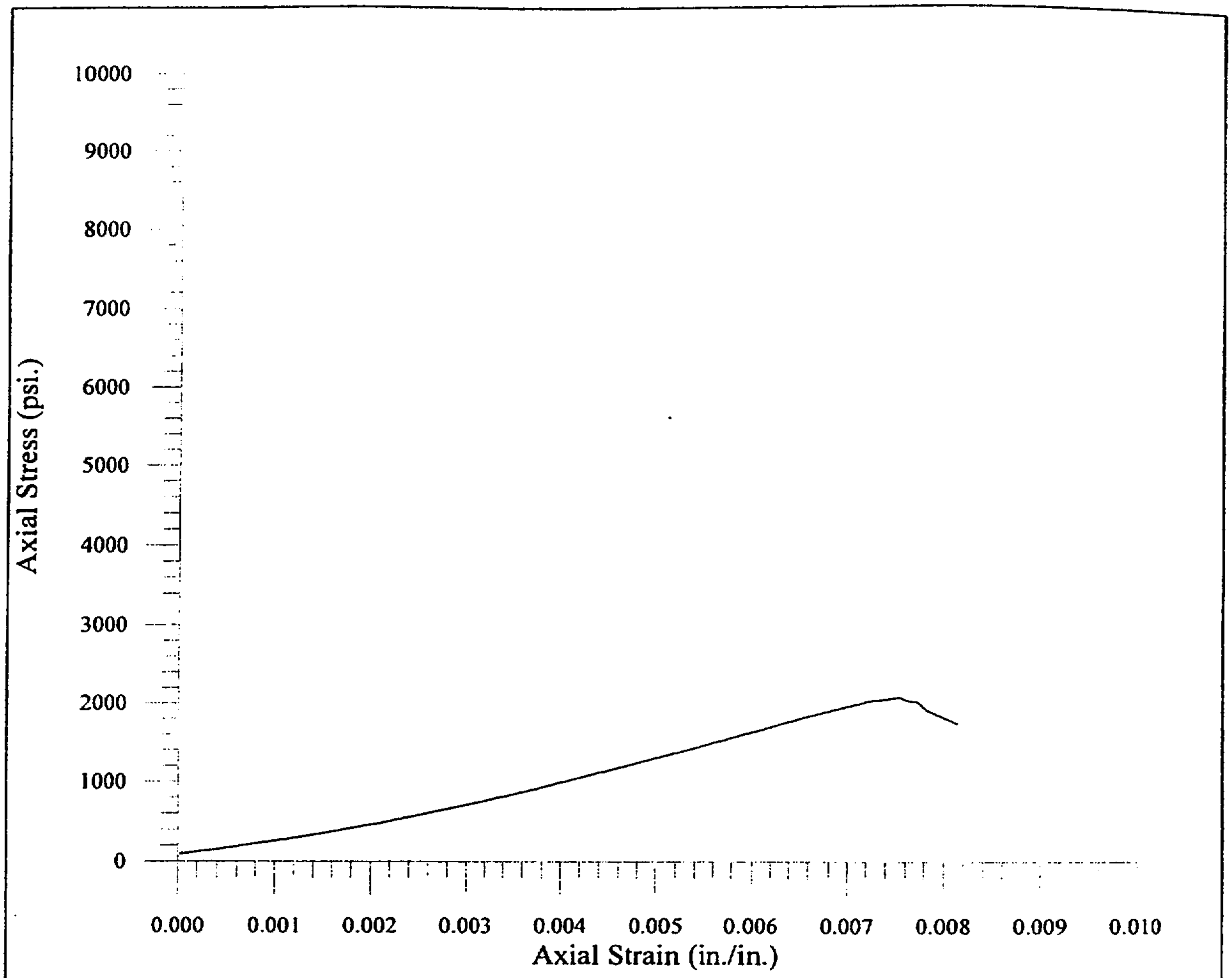


UNCONFINED COMPRESSION TEST
Axial Stress vs. Axial Strain

Boring: OOBA-1
Sample: 1-13
Depth: 40.9-41.35'

DESCRIPTION

Very fine grained tan dolomitic sandstone with a few healed and partially healed joints.

Strength: 2079 psi
Density: 128.9 pcf

Geo Test Unlimited GTU

27069 N. Bloomfield Rd.
Nevada City, CA 95959

Client: **William Lettis & Associates, Inc.**
1777 Botelho Dr., Suite 262
Walnut Creek, CA 94596

Project: **Diablo Canyon Power Plant ISFSI**

Project Number: 1223-50

Test Date: December 17, 2000

Geo Test Unlimited (GTU)

DATA SHEET
Unconfined Compression Test of Rock (ASTM D2938)

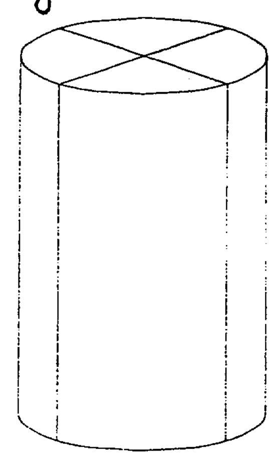
Date: 12-17-00
Technician: A. Bro

Client: W. Lettis & Assoc.
Job: #126-DCPP-ISFSI
Sample ID: 1-14
Sample Description: light brown to tan dolomitized siltstone to dolomite. Bedding (?) about 80° to the core axis. massive with no apparent fractures.

Sample Depth: 49.1-49.6 Sample Condition: received & tested dry

d_1	d_2
2.408	2.407
2.403	2.408
2.405	2.407
2.405	2.407
2.406	2.403

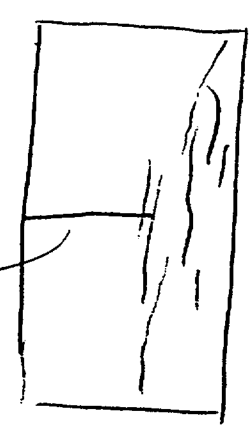
l_1	l_2
+.0013	+.0001
+.0007	
±.0001	±.0001
-.0004	
-.0009	-.0001



Avg. diameter : 2.406 Avg. length : 5.557
Sample area : 4.547 l/d ratio : 2.31
Sample volume(in^3) : 25.265
Sample weight (g) : 949.1 g
Density : 37.57 g/in³ = 143.1 pcf (1 g/in³=3.8095lb/ft³)

Comments: initial popping @ ~32 kips

Failed by axial splitting on one side & bending



this tensile failure is along bedding plane.

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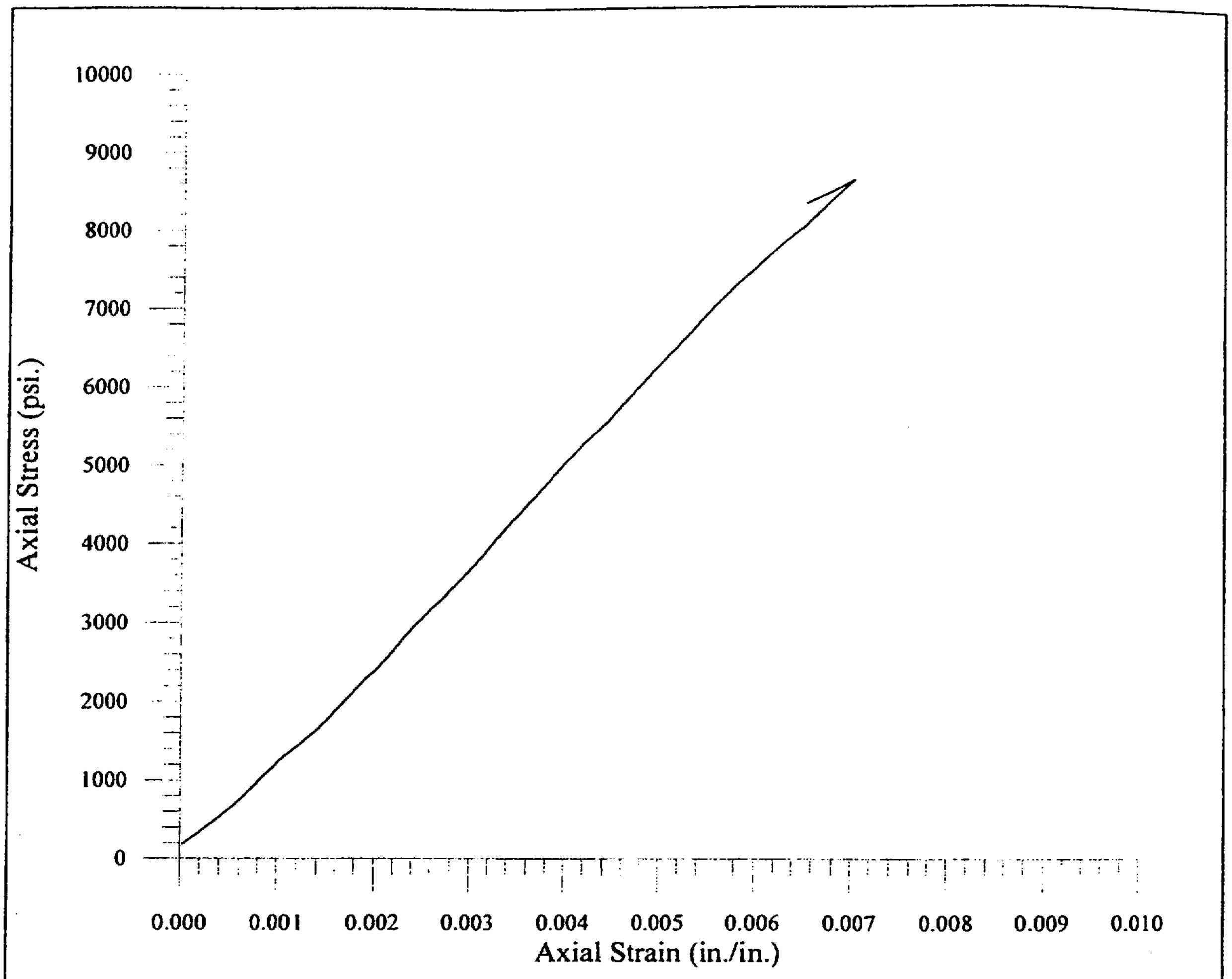


UNCONFINED COMPRESSION TEST
Axial Stress vs. Axial Strain

Boring: OOBA-1
Sample: 1-14
Depth: 49.1-49.6'

DESCRIPTION

Light brown to tan dolomitic siltstone to dolomite, with bedding (?) about 80 degrees to the core axis.

Strength: 8649 psi
Density: 143.1 pcf

Geo Test Unlimited GTU
27069 N. Bloomfield Rd.
Nevada City, CA 95959

Client: **William Lettis & Associates, Inc.**
1777 Botelho Dr., Suite 262
Walnut Creek, CA 94596

Project: **Diablo Canyon Power Plant ISFSI**

Project Number: 1223-50

Test Date: December 17, 2000

Geo Test Unlimited

DATA SHEET
Unconfined Compression Test of Rock (ASTM D2938)

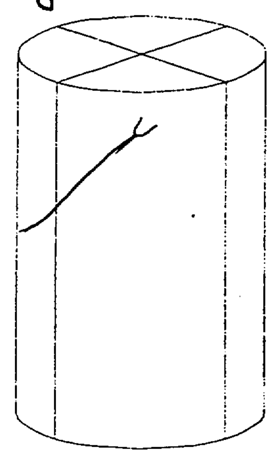
Date: 12-17-00
Technician: A. Bro

Client: W. Lettis & Assoc.
Job: #126-DCPP-ISFSI
Sample ID: 2-E
Sample Description: Fine to medium grained tan dolomitic sandstone with slight porosity. healed, non-through going joint ~40° to the core axis.

Sample Depth: 50.9'-51.4' Sample Condition: received & tested dry

d_1	d_2
2.406	2.404
2.404	2.404
2.403	2.400
2.404	2.403
2.400	2.402

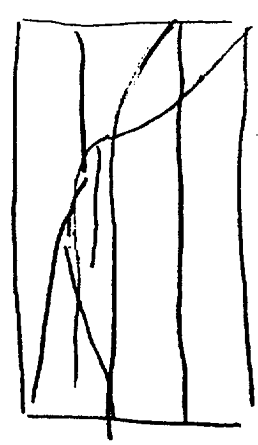
l_1	l_2
+.0008	0
+.0004	
±.0001	±.0001
-.0005	
-.0010	0



Avg. diameter : 2.403
Sample area : 4.535
Sample volume(in³) : 25.529
Sample weight (g) : 1078.0
Density : 42.23g/in³ = 160.9 pcf (1 g/in³=3.8095lb/ft³)

Avg. length : 5.629
l/d ratio : 2.34

Comments: Failed by axial splitting & shear (along existing joint)



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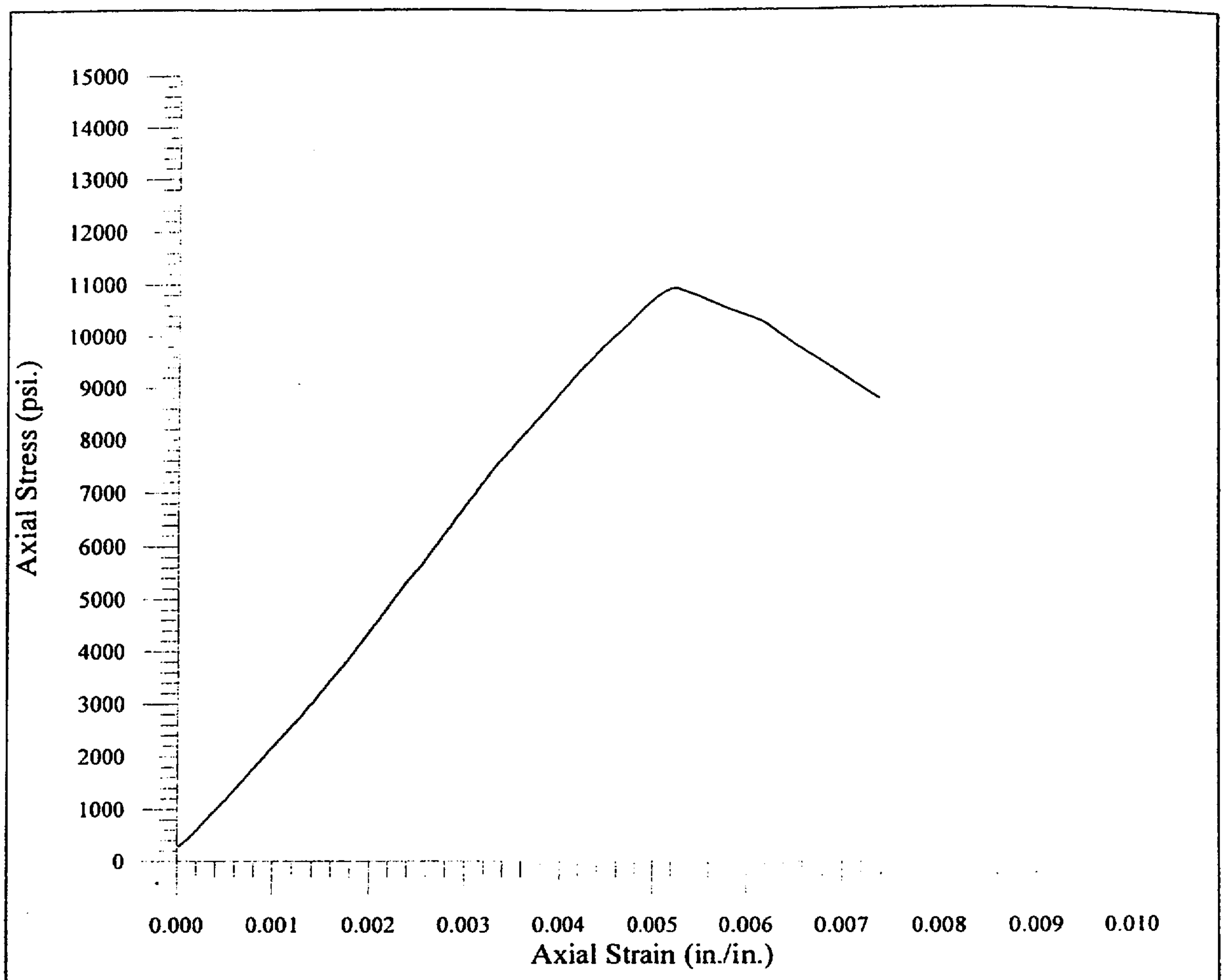

UNCONFINED COMPRESSION TEST
Axial Stress vs. Axial Strain

Boring: OOBA-2
Sample: 2-E
Depth: 50.9-51.4'

DESCRIPTION
Fine to medium grained tan dolomitic sandstone with slight porosity with a non-through-going joint about 40 degrees to the core axis.

Strength: 10,921 psi
Density: 160.9 pcf

Geo Test Unlimited GTU
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Nevada City, CA 95959

Client: William Lettis & Associates, Inc.
1777 Botelho Dr., Suite 262
Walnut Creek, CA 94596

Project: Diablo Canyon Power Plant ISFSI

Project Number: 1223-50

Test Date: December 17, 2000

Geo Test Unlimited

DATA SHEET
Triaxial Compression Test of Rock (ASTM D2664)

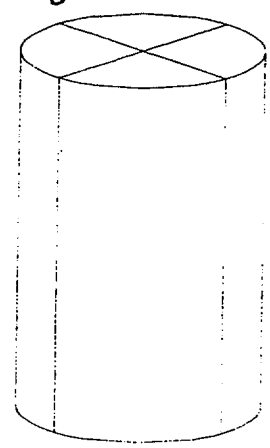
Date: 12-17-00
Technician: A. Bro

Client: W. Lettis & Assoc.
Job: #126-DCPP-ISFSI
Sample ID: 1-5B
Sample Description: Tan fine grained dolomitic sandstone, massive with no apparent fractures, small zones of brown oxide staining.

Sample Depth: 84.0 - 84.5' Sample Condition: received & tested dry

d_1	d_2
2.387	2.398
2.400	2.404
2.394	2.404
2.396	2.398
2.397	2.401

l_1	l_2
+.0012	+.0001
+.0007	0
±.0001	±.0001
-.0005	0
-.0010	0



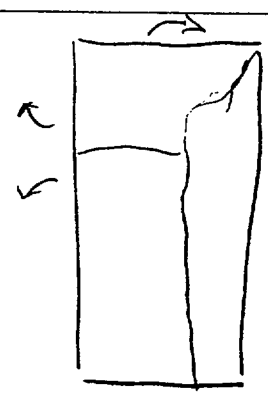
Avg. diameter: 2.398
Sample area: 4.516
Sample volume(in^3): 25.355
Sample weight (g): 897.98
Density: 35.41 g/in³ = 134.9 pcf (1 g/in³=3.8095 lb/ft³)

Avg. length: 5.614
l/d ratio: 2.34

Test Confining Pressures (psi)

40	~~800~~	

Comments: Failed by axial splitting



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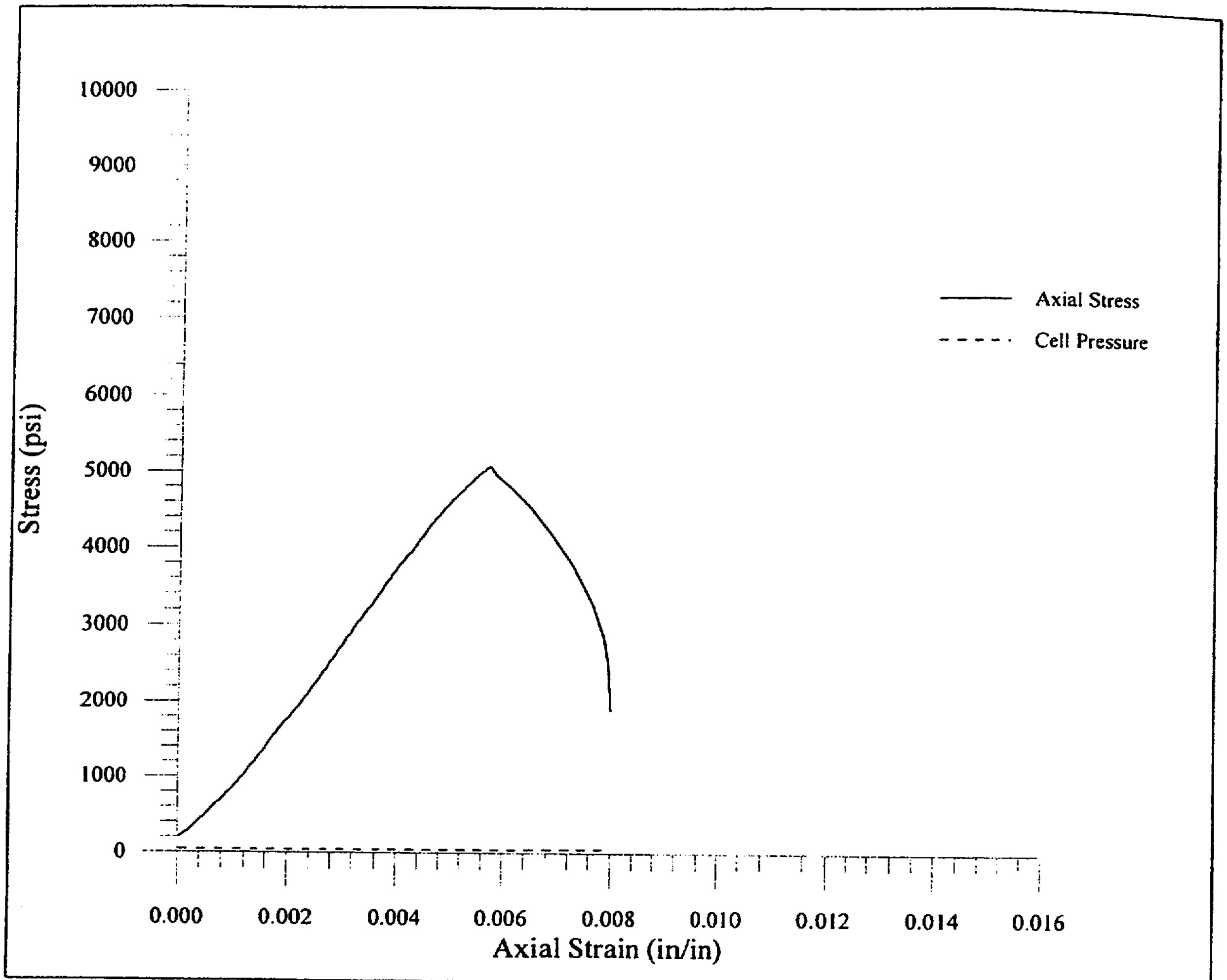


TRIAXIAL COMPRESSION TEST
Axial Stress and Confining Pressure vs. Strain

Boring: OOBA-1
Sample: 1-5B
Depth: 84.0-84.5'
Density: 134.9 pcf.

DESCRIPTION

Fine grained tan dolomitic sandstone, contains no discernabe fractures.

Conf. Pres. (psi)	Strength (psi)
40.2	5070

Geo Test Unlimited 27069 N. Bloomfield Rd. Nevada City, CA 95959

Client: **William Lettis & Associates, Inc.**
1777 Botelho Dr., Suite 262
Walnut Creek, CA 94596

Project: **Diablo Canyon Power Plant ISFSI**

Project Number: 1223-50

Test Date: December 17, 2000

Geo Test Unlimited

DATA SHEET
Triaxial Compression Test of Rock (ASTM D2664)

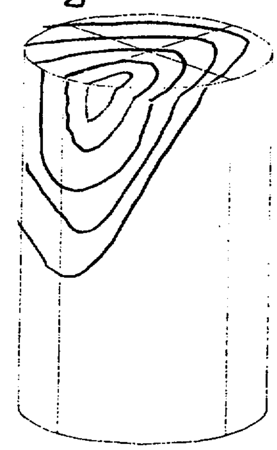
Date: 12-17-00
Technician: A. Bro

Client: W. Lettis & Assoc.
Job: #126-DCPP ISFSI
Sample ID: 1-15
Sample Description: very fine grained tan sandstone to dolomite. with bedding (?) about 85° to the core axis (planar zones of lighter rock) also highly curved solution front (...

Sample Depth: 77.5-78.0' Sample Condition: received & tested dry

d_1	d_2
2.390	2.391
2.384	2.383
2.384	2.390
2.390	2.388
2.385	2.385

l_1	l_2
+.0013	+.0001
+.0007	
±.0001	±.0001
-.0004	
-.0009	-.0001



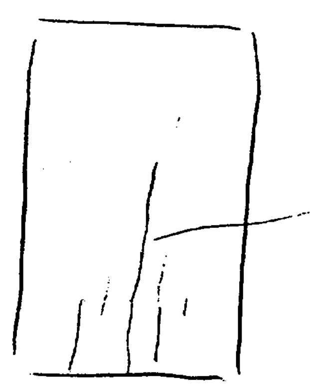
Avg. diameter : 2.387
Sample area : 4.475
Sample volume(in^3) : 25.002
Sample weight (g) : 921.1
Density : 36.84 g/in³ = 140.3 pcf (1 g/in³=3.8095 lb/ft³)

Avg. length : 5.587
l/d ratio : 2.34

Test Confining Pressures (psi)

80		

Comments: Failed by shear (conical?) & splitting



radial spreading splits

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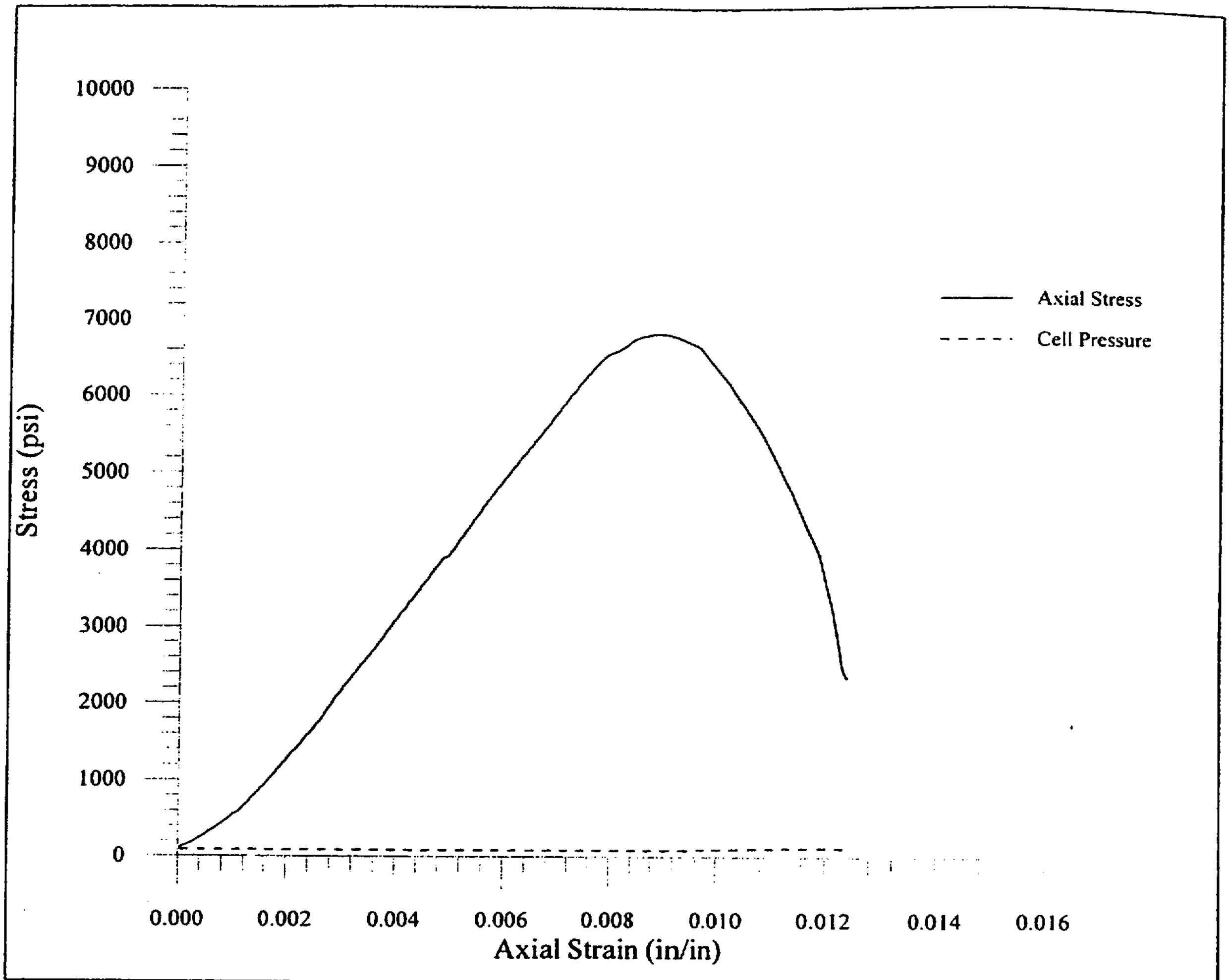

TRIAXIAL COMPRESSION TEST
Axial Stress and Confining Pressure vs. Strain

Boring: OOBA-1
Sample: 1-15
Depth: 77.5-78.0
Density: 140.3 pcf.

DESCRIPTION

Very fine grained tan dolomitic sandstone to dolomite, with bedding (?) about 85 degrees to the core axis.

Conf. Pres. (psi)	Strength (psi)
80.6	6807

Geo Test Unlimited GTU
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Nevada City, CA 95959

Client: William Lettis & Associates, Inc.
1777 Botelho Dr., Suite 262
Walnut Creek, CA 94596

Project: Diablo Canyon Power Plant ISFSI

Project Number: 1223-50

Test Date: December 17, 2000

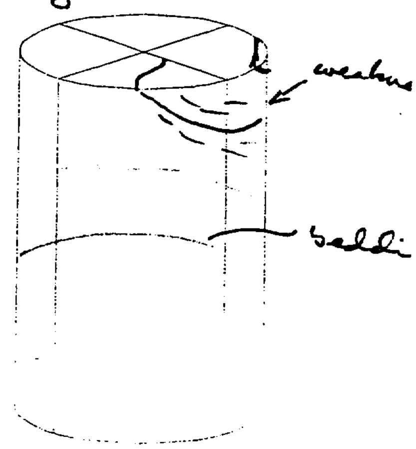
Geo Test Unlimited (GTU)

DATA SHEET
Triaxial Compression Test of Rock (ASTM D2664)

Date: 12-17-00
Technician: A. Bro

Client: W. Lettis & Assoc.
Job: #126 - DCPP - ISFSI
Sample ID: 1-16
Sample Description: Fine grained tan dolomitic sandstone with irregular bedding (?) about 65° to the core axis. One zone of weakness & joint near one end.

Sample Depth: 107.3 - 107.8' Sample Condition: received & tested dry



d_1	d_2
2.401	2.401
2.397	2.401
2.407	2.406
2.405	2.404
2.403	2.396

l_1	l_2
+.0011	+.0001
+.0004	
±.0001	±.0001
−.0005	
−.0012	−.0001

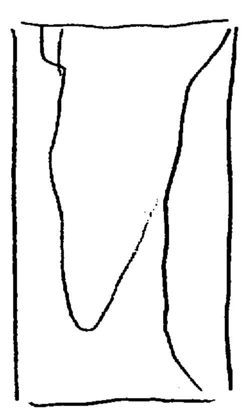
Avg. diameter : 2.402
Sample area : 4.531
Sample volume(in^3) : 24.909
Sample weight (g) : 868.2
Density : 34.85 g/in³ = 132.8 pcf (1 g/in³=3.8095 lb/ft³)

Avg. length : 5.497
l/d ratio : 2.29

Test Confining Pressures (psi)

40		

Comments: Failed by axial splitting



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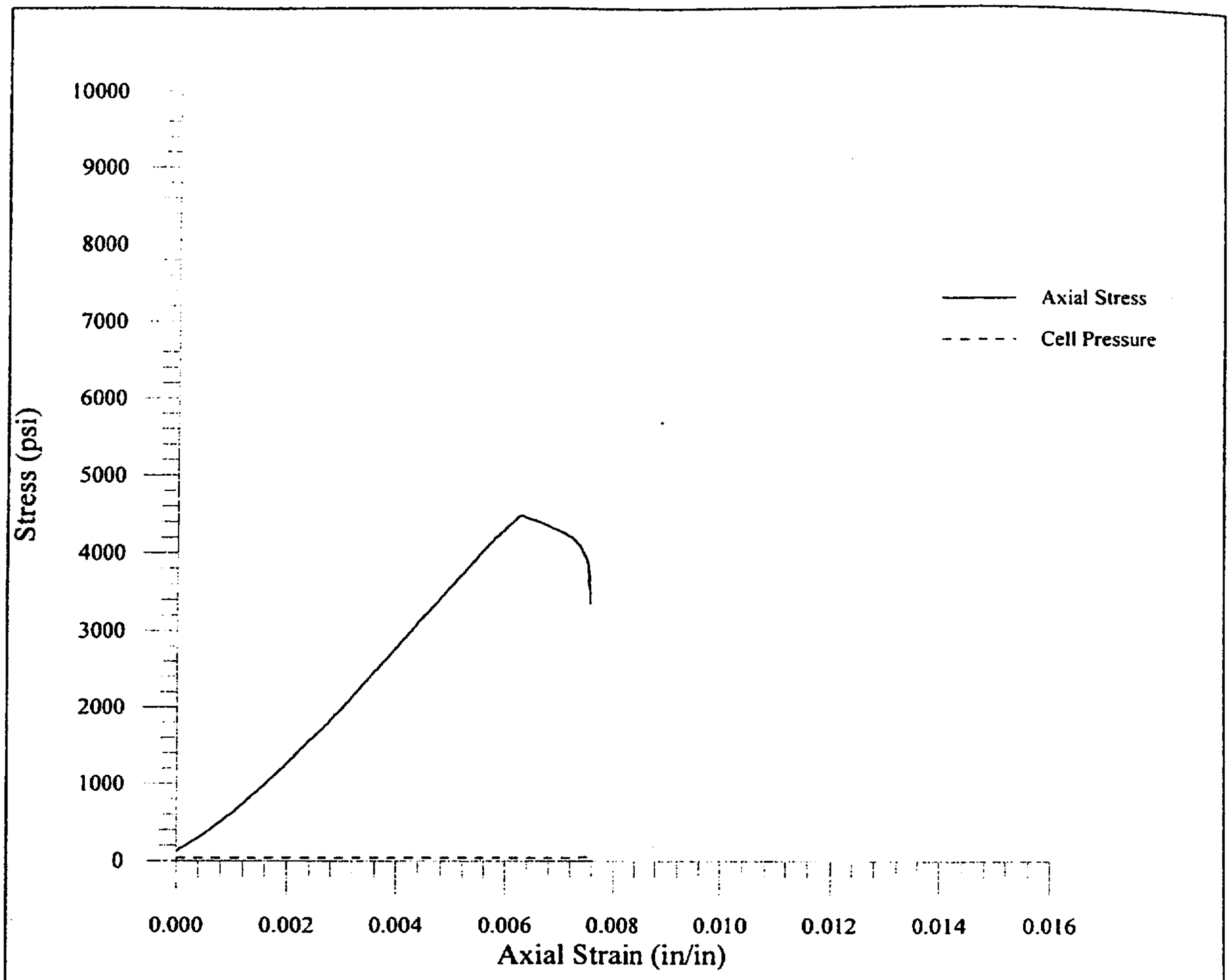

TRIAXIAL COMPRESSION TEST
Axial Stress and Confining Pressure vs. Strain

Boring: OOBA-1
Sample: 1-16
Depth: 107.3-107.8'
Density: 132.8 pcf.

DESCRIPTION

Fine grained tan dolomitic sandstone to dolomite, with bedding (?) about 65 degrees to the core axis. One zone of weakness and joint near one end.

Conf. Pres. (psi)	Strength (psi)
40.3	4483

Geo Test Unlimited GTU
27069 N. Bloomfield Rd.
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1777 Botelho Dr., Suite 262
Walnut Creek, CA 94596

Project: **Diablo Canyon Power Plant ISFSI**

Project Number: 1223-50

Test Date: December 17, 2000

Geo Test Unlimited

DATA SHEET
Triaxial Compression Test of Rock (ASTM D2664)

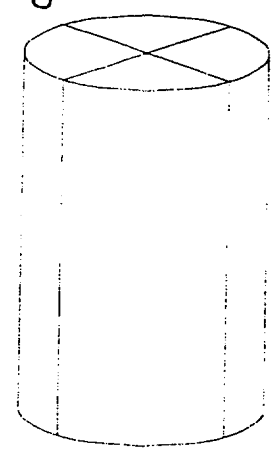
Date: 12-17-00
Technician: A. Bro

Client: W. Lettis & Assoc.
Job: #126-DCPP-ISFSI
Sample ID: 1-17
Sample Description: Fine grained tan dolomitic sandstone with a few slightly porous zones (possibly zones of weakness)

Sample Depth: 116.4-116.9' Sample Condition: received & tested dry

d_1	d_2
2.388	2.392
2.388	2.399
2.393	2.396
2.395	2.397
2.390	2.397

l_1	l_2
+.0010	+.0001
+.0005	
±.0001	±.0001
-.0005	
-.0011	-.0001



Avg. diameter : 2.393 Avg. length : 5.526
Sample area : 4.498 l/d ratio : 2.31
Sample volume(in^3) : 24.898
Sample weight (g) : 869.8g
Density : 34.93g/in^3 = 133.1 pcf (1 g/in^3=3.8095lb/ft^3)

Test Confining Pressures (psi)

80		

Comments: Failed by shear

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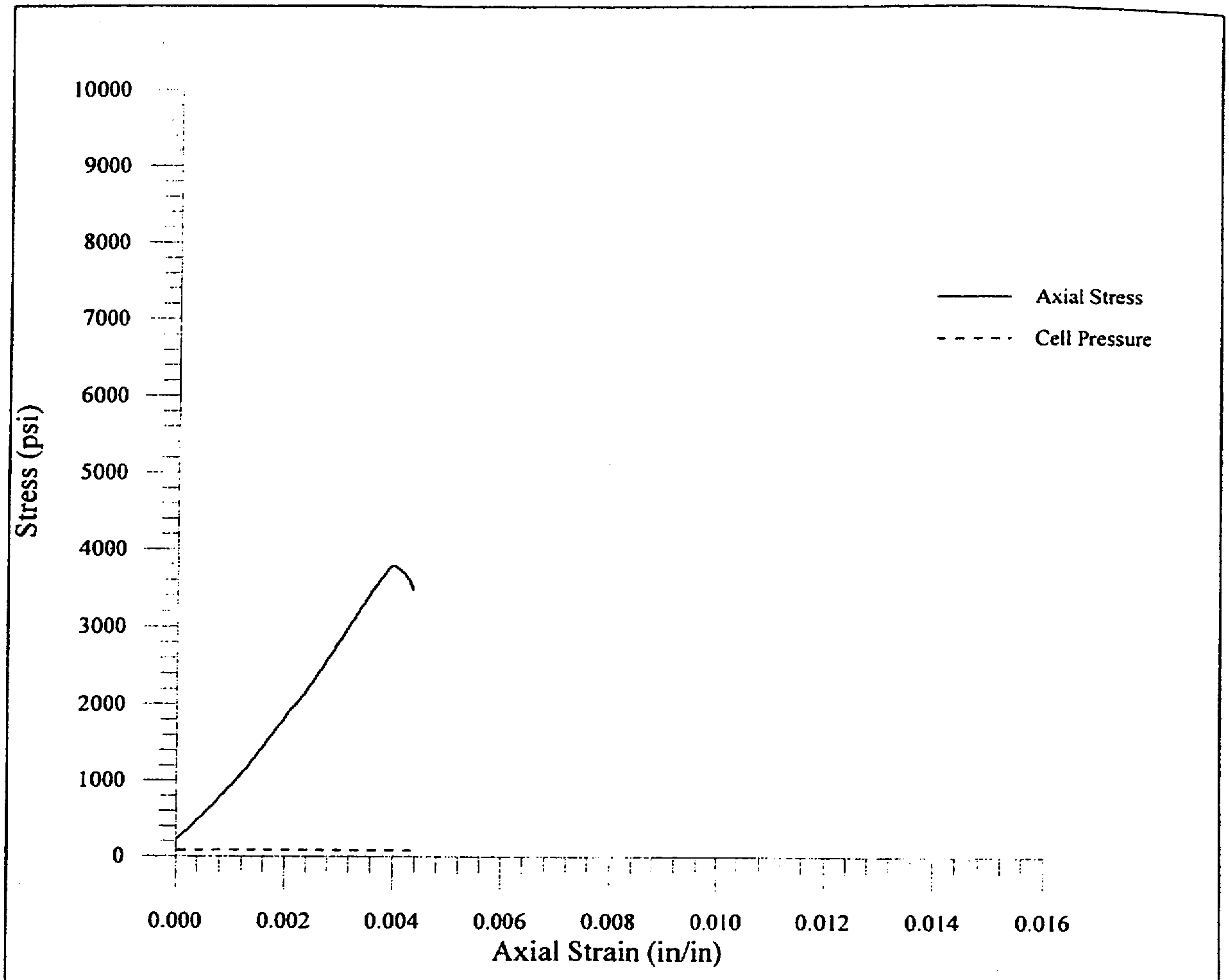

TRIAXIAL COMPRESSION TEST
Axial Stress and Confining Pressure vs. Strain

Boring: OOBA-1
Sample: 1-17
Depth: 116.4-116.9'
Density: 133.1 pcf.

DESCRIPTION

Fine grained tan dolomitic sandstone, with a few slightly porous zones.

Conf. Pres. (psi)	Strength (psi)
80.3	3787

Geo Test Unlimited GTU
27069 N. Bloomfield Rd.
Nevada City, CA 95959

Client: **William Lettis & Associates, Inc.**
1777 Botelho Dr., Suite 262
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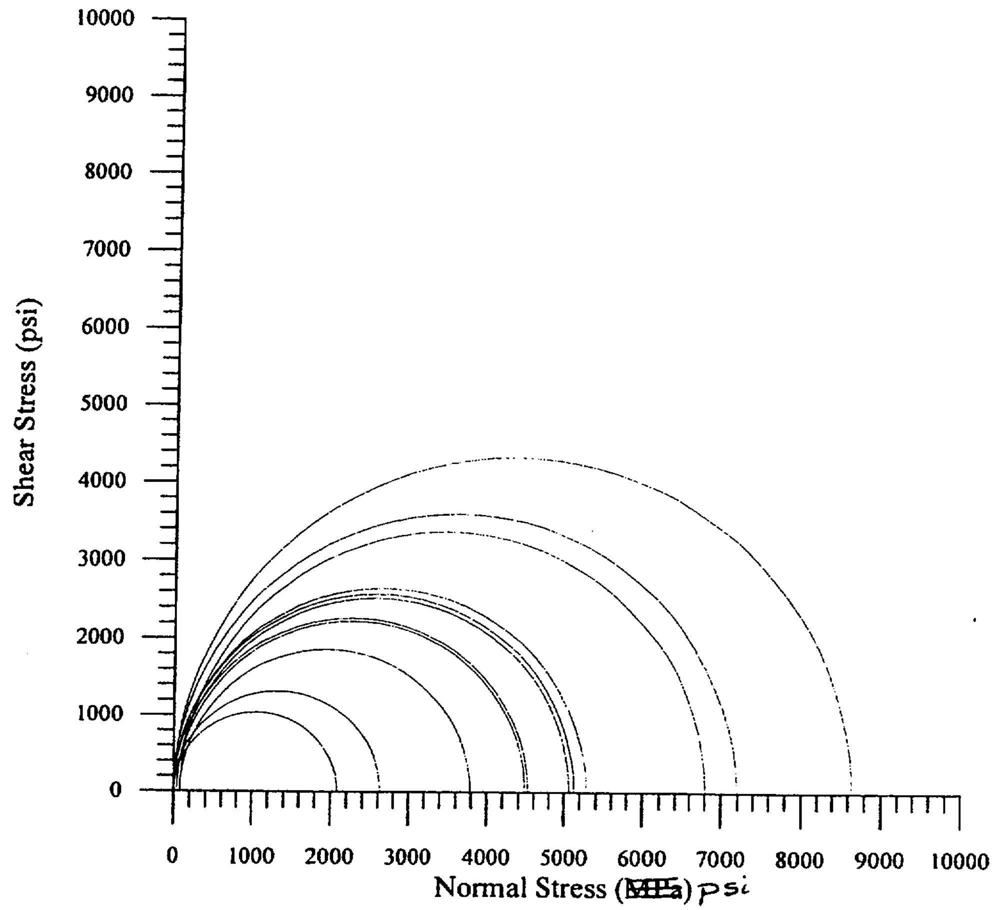
Project: **Diablo Canyon Power Plant ISFSI**

Project Number: 1223-50

Test Date: December 17, 2000



SUMMARY OF STRENGTH RESULTS
Mohr Failure Circles

Boring: OOBA-1 **DESCRIPTION** Fine to medium grained tan to brownish gray massive dolomitic sandstone.	*Geo Test Unlimited* GTU **27069 N. Bloomfield Rd.** **Nevada City, CA 95959** **Client:** **William Lettis & Associates** **1777 Botelho Dr., Suite 262** **Walnut Creek, CA 94596** **Project:** **Diablo Canyon Power Plant ISFSI** **Project Number: 1223-50** **Test Dates:** December 17, 2000

Geo Test Unlimited

DATA SHEET
Triaxial Compression Test of Rock (ASTM D2664)

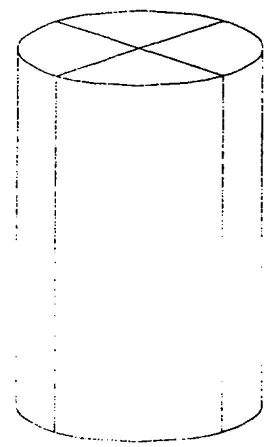
Date: 12-17-00
Technician: A. Bro

Client: W. Lettis & Assoc.
Job: #126-DCPP-ISFSI
Sample ID: 2-A
Sample Description: Fine to medium grained tan dolomitic sandstone quite weak - mechanical cracks (perp. to core axis) glued with cyanoacrylate glue.

Sample Depth: 37.0-37.5 Sample Condition: received & tested moist

d_1	d_2
2.393	2.418
2.406	2.420
2.404	2.390
2.404	2.409
2.415	2.409

l_1	l_2
+.0042	0
+.0023	+.0005
±.0005	±.0005
-.0020	-.0024
-.0062	-.0055



Avg. diameter: 2.407
Sample area: 4.550
Sample volume(in^3): 24.326
Sample weight (g): 830.6g
Density: 34.14g/in³ = 130.1 pcf (1 g/in³=3.8095lb/ft³)

Avg. length: 5.346
l/d ratio: 2.22

Test Confining Pressures (psi)

20	40	80

Comments: no apparent failure plane - assumed failure by barreling.
It seemed to exude some water at ends during test, indicating a pore water response.

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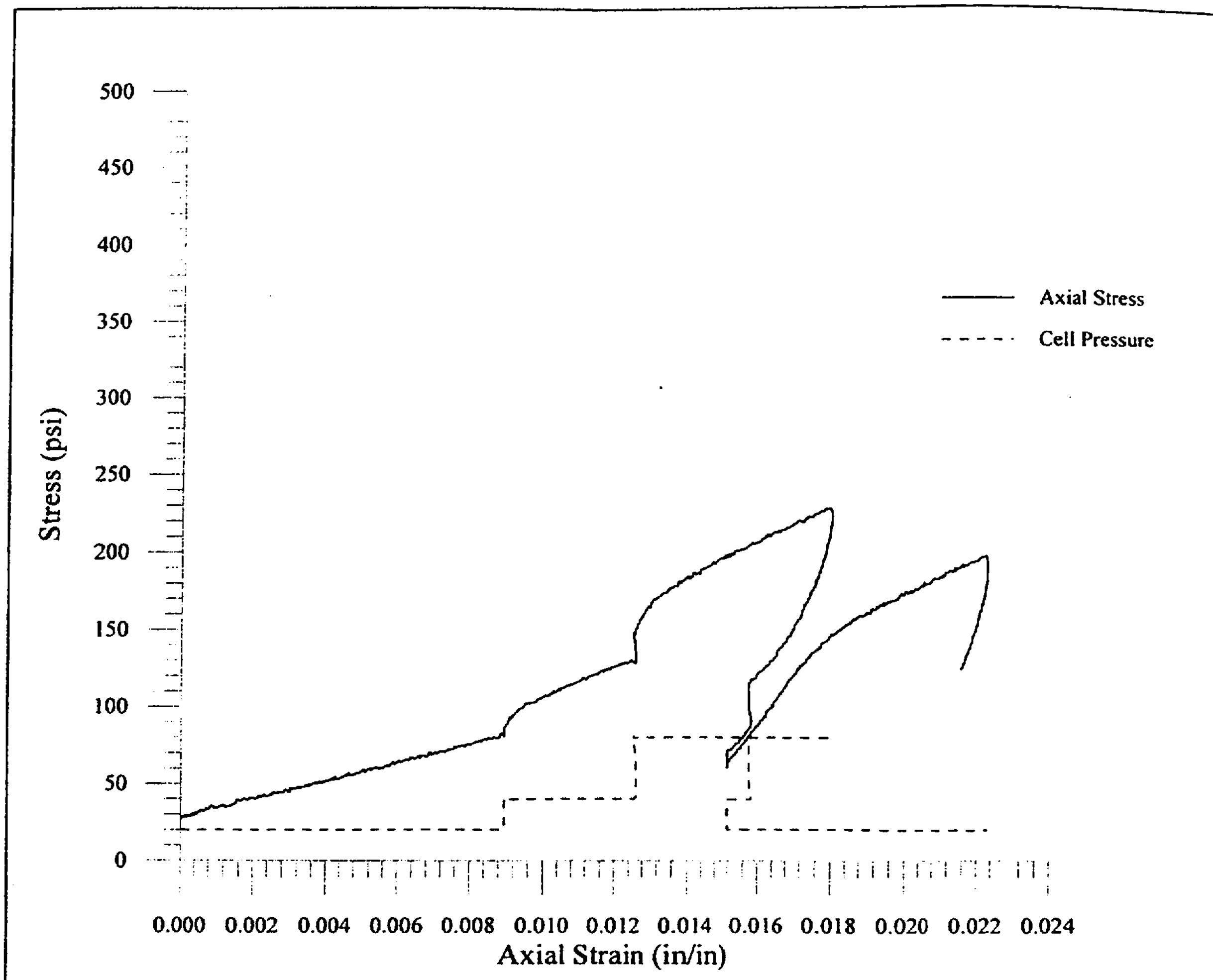

TRIAXIAL COMPRESSION TEST
Axial Stress and Confining Pressure vs. Strain

Boring: OOBA-2
Sample: 2-A
Depth: 37.0-37.5'
Density: 130.1 pcf.

DESCRIPTION

Fine to medium grained tan dolomitic sandstone, with glued mechnical breaks (perpendicular to the core axis).

Strain (in/in)	Conf. Pres. (psi)	Strength (psi)
0.010	20	87
	40	104
0.014	40	142
	80	183

Geo Test Unlimited
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Client: **William Lettis & Associates, Inc.**
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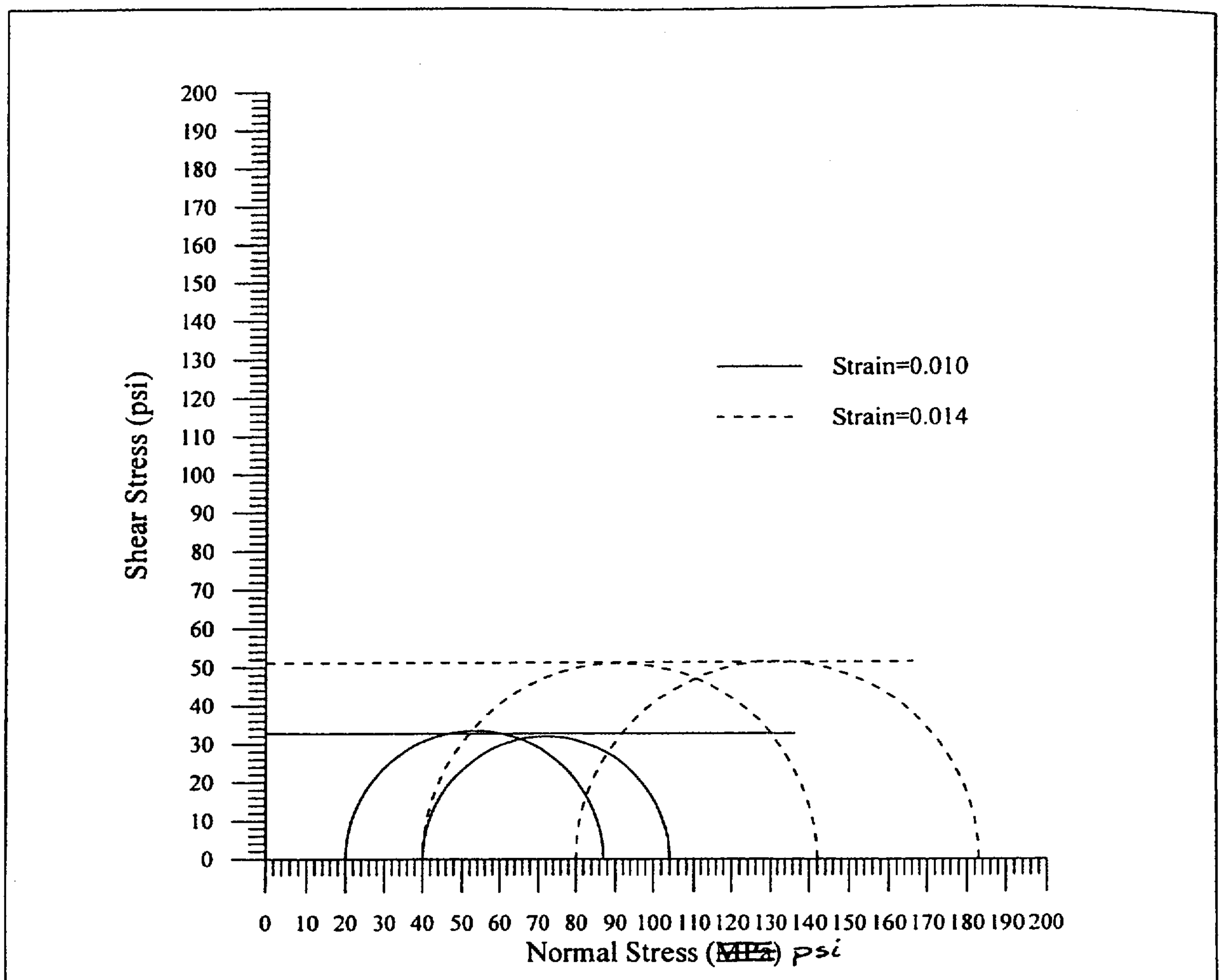
Walnut Creek, CA 94596

Project: **Diablo Canyon Power Plant ISFSI**

Project Number: 1223-50

Test Date: December 17, 2000



SUMMARY OF STRENGTH RESULTS
Mohr Failure Circles

Boring: OOBA-2
Sample: 2-A
Depth: 37.0-37.5'
Density: 130.1 pcf.

DESCRIPTION

Fine to medium grained tan dolomitic sandstone, with glued mechanical breaks (perpendicular to the core axis).

Strain (in/in)	C (psi)	ϕ
0.010	33	0
0.014	51	0

Geo Test Unlimited GTU
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Nevada City, CA 95959

Client: **William Lettis & Associates**
1777 Botelho Dr., Suite 262
Walnut Creek, CA 94596

Project: **Diablo Canyon Power Plant ISFSI**

Project Number: 1223-50

Test Dates: December 17, 2000

Geo Test Unlimited (GTU)

DATA SHEET
Triaxial Compression Test of Rock (ASTM D2664)

Date: 12-17-00
Technician: A.Bro

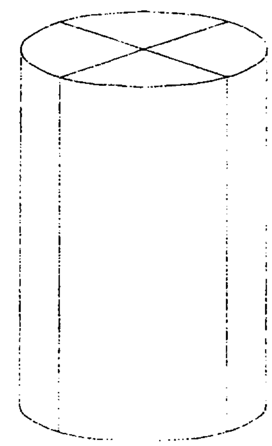
Client: W. Lettis & Assoc.
Job: #126-DCPP-ISFSI
Sample ID: 2-B
Sample Description: Fine to medium grained tan dolomitic sandstone (slightly clayey & weak)

Sample Depth: 37.5'-38'   Sample Condition: received & tested moist

*

d_1	d_2
2.416	2.414
2.417	2.411
2.414	2.412
2.415	2.416
2.415	2.409

l_1	l_2
+.0032	+.0022
+.0017	+.0011
±.0002	±.0002
-.0009	-.0004
-.0017	-.0007

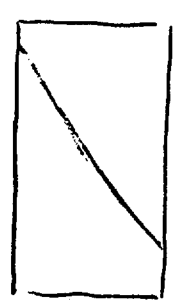


Avg. diameter : 2.414   Avg. length : 5.554
Sample area : 4.577   l/d ratio : 2.30
Sample volume(in³) : 25.420
Sample weight (g) : 932.2 g
Density : 36.67 g/in³ = 139.7 pcF   (1 g/in³=3.8095lb/ft³)

Test Confining Pressures (psi)

10	20	40

Comments: * some variation in diameter due to smeared drilling mud (clay)
Interesting to note that the immediate post peak strength (A) is lower than the large strain strength (B)
Failed by shear



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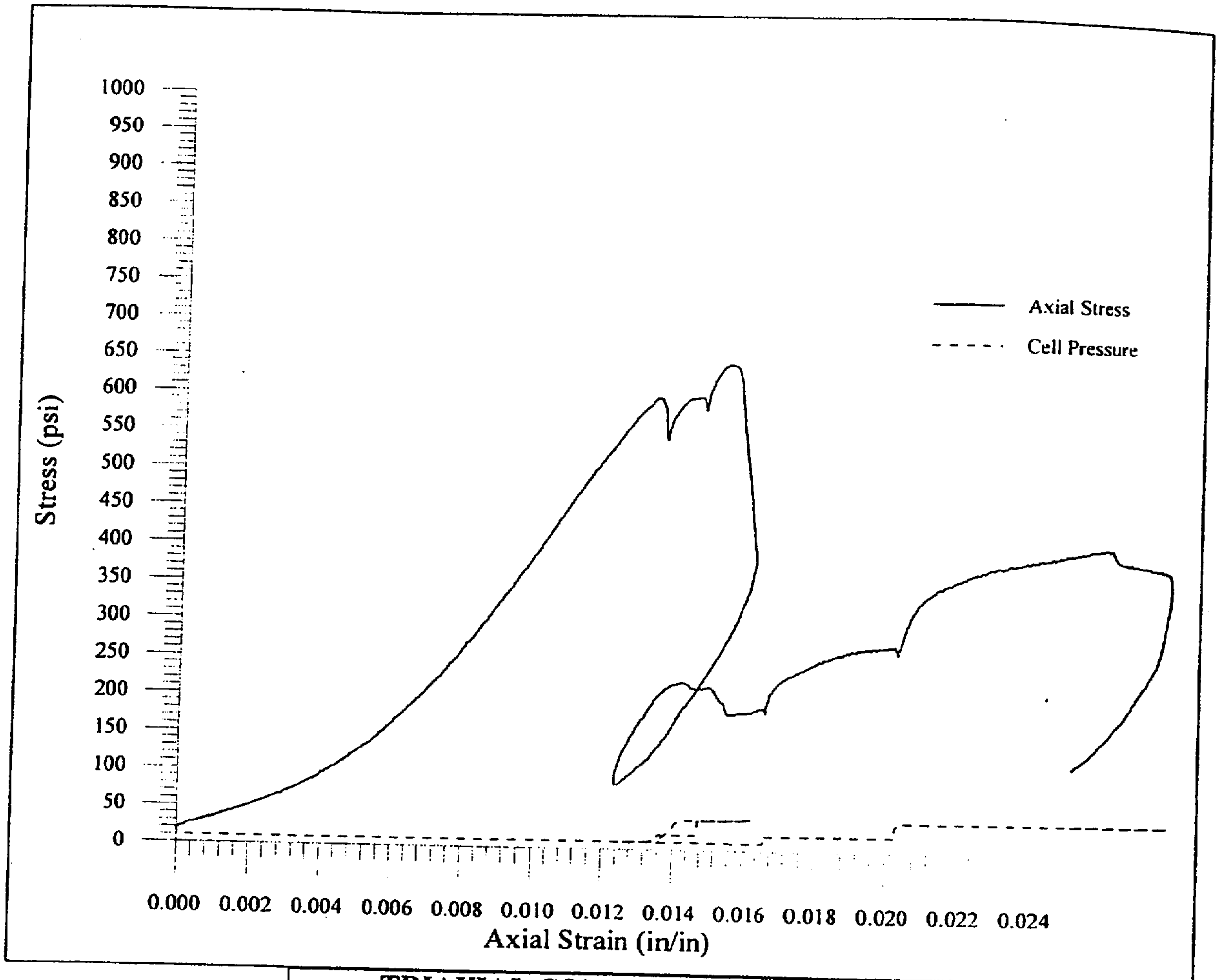

TRIAXIAL COMPRESSION TEST
Axial Stress and Confining Pressure vs. Strain

Boring: OOBA-2
Sample: 2-B
Depth: 37.5-38.0'
Density: 139.7 pcf.

DESCRIPTION

Fine to medium grained tan dolomitic sandstone.

	Conf. Pres. (psi)	Strength (psi)
peak initial	10	600
	20	600
	40	644
final	10	187
	20	270
	40	398

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Nevada City, CA 95959

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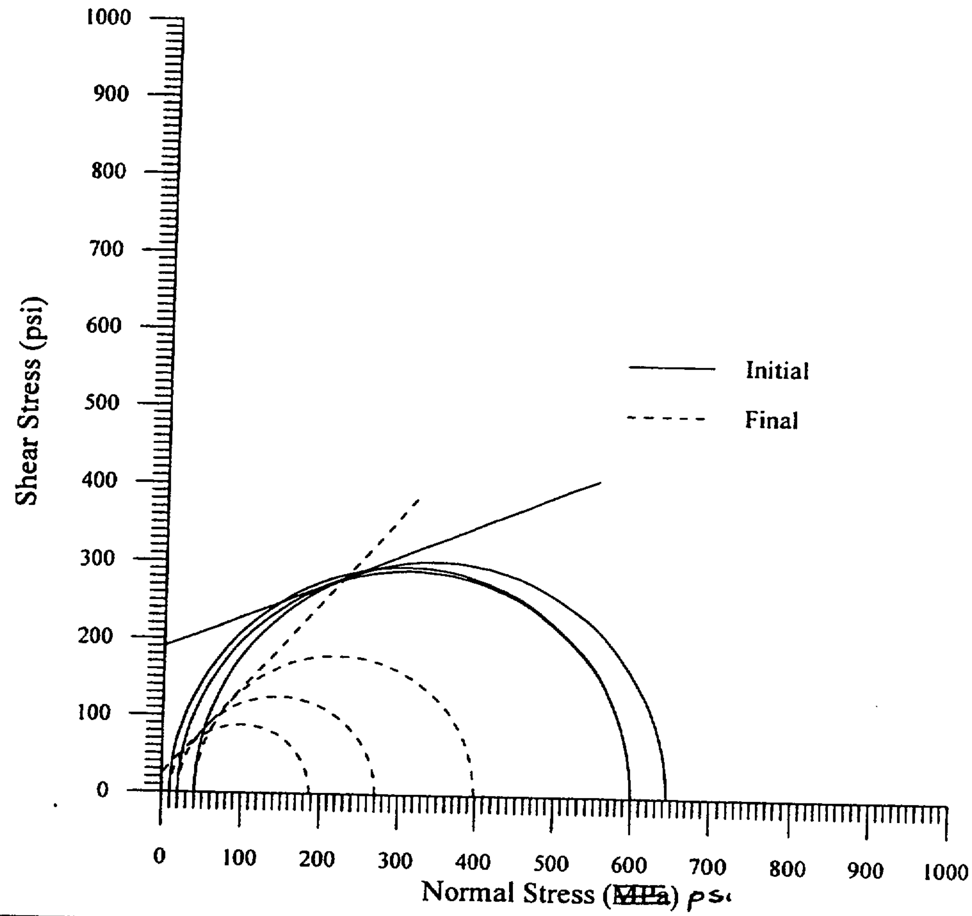
Project: **Diablo Canyon Power Plant ISFSI**

Project Number: 1223-50

Test Date: December 17, 2000



SUMMARY OF STRENGTH RESULTS
Mohr Failure Circles

Boring: OOBA-2
Sample: 2-B
Depth: 37.5-38.0'
Density: 139.7 pcf.

DESCRIPTION

Fine to medium grained tan dolomitic sandstone.

	C (psi)	ϕ
Initial	190(?)	21(?)
Final	25	48

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Nevada City, CA 95959

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Walnut Creek, CA 94596

Project: **Diablo Canyon Power Plant ISFSI**

Project Number: 1223-50

Test Dates: December 17, 2000

Geo Test Unlimited (GTU)

DATA SHEET

Triaxial Compression Test of Rock (ASTM D2664)

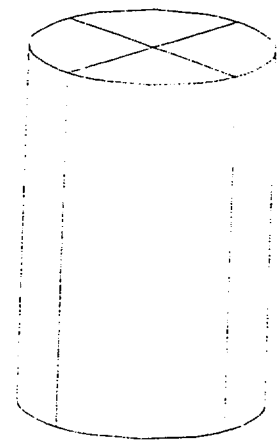
Date: 12-17-00
Technician: A.Bro

Client: W. Lettis & Assoc.
Job: #126- DCPP - ISFSI
Sample ID: 2-C
Sample Description: medium grained gray sandstone, fairly friable

Sample Depth: 43.1-43.6'   Sample Condition: received & tested moist

d_1	d_2
2.416	2.421
2.402	2.421
2.410	2.415
2.401	2.403
2.399	2.406

l_1	l_2
+.0040	+.0025
+.0020	+.0010
±.0005	±.0005
-.0002	-.0005
-.0005	+.0005



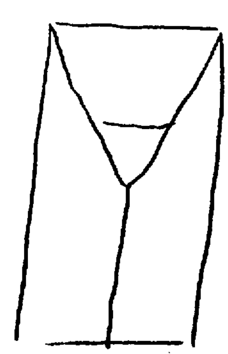
Avg. diameter : 2.409
Sample area : 4.558
Sample volume(in³) : 25.953
Sample weight (g) : 961.5 g
Density : 37.05 g/in³ = 141.1 pcf (1 g/in³=3.8095lb/ft³)

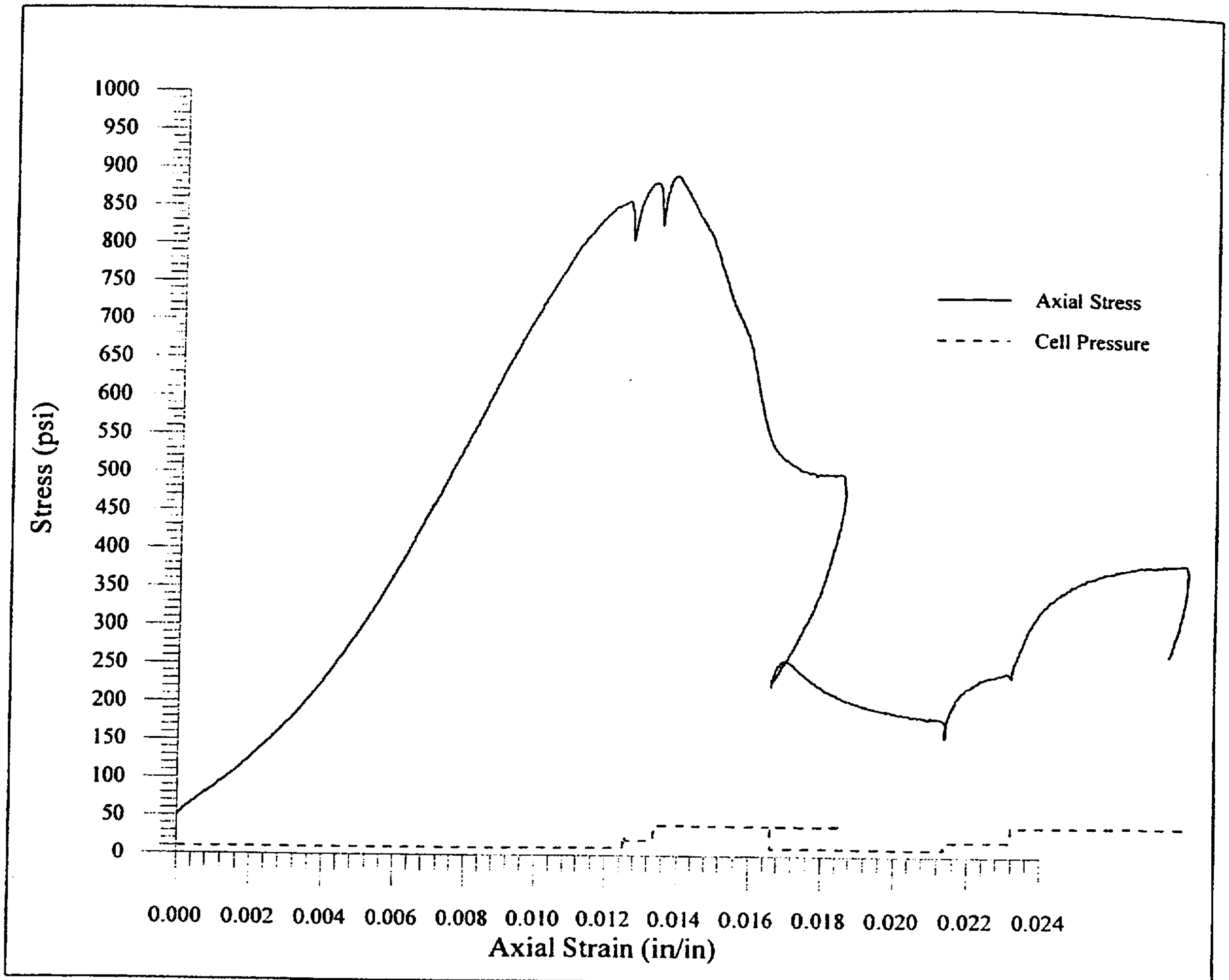
Avg. length : 5.694
l/d ratio : 2.36

Test Confining Pressures (psi)

10	20	40

Comments: Failed by shear & axial splitting





TRIAXIAL COMPRESSION TEST
Axial Stress and Confining Pressure vs. Strain

Boring: OOBA-2
Sample: 2-C
Depth: 43.1-43.6'
Density: 141.1 pcf.

DESCRIPTION

Medium grained gray sandstone.

	Conf. Pres. (psi)	Strength (psi)
initial	10	863
	20	887
	40	898
final	10	170
	20	242
	40	385

Geo Test Unlimited GTU
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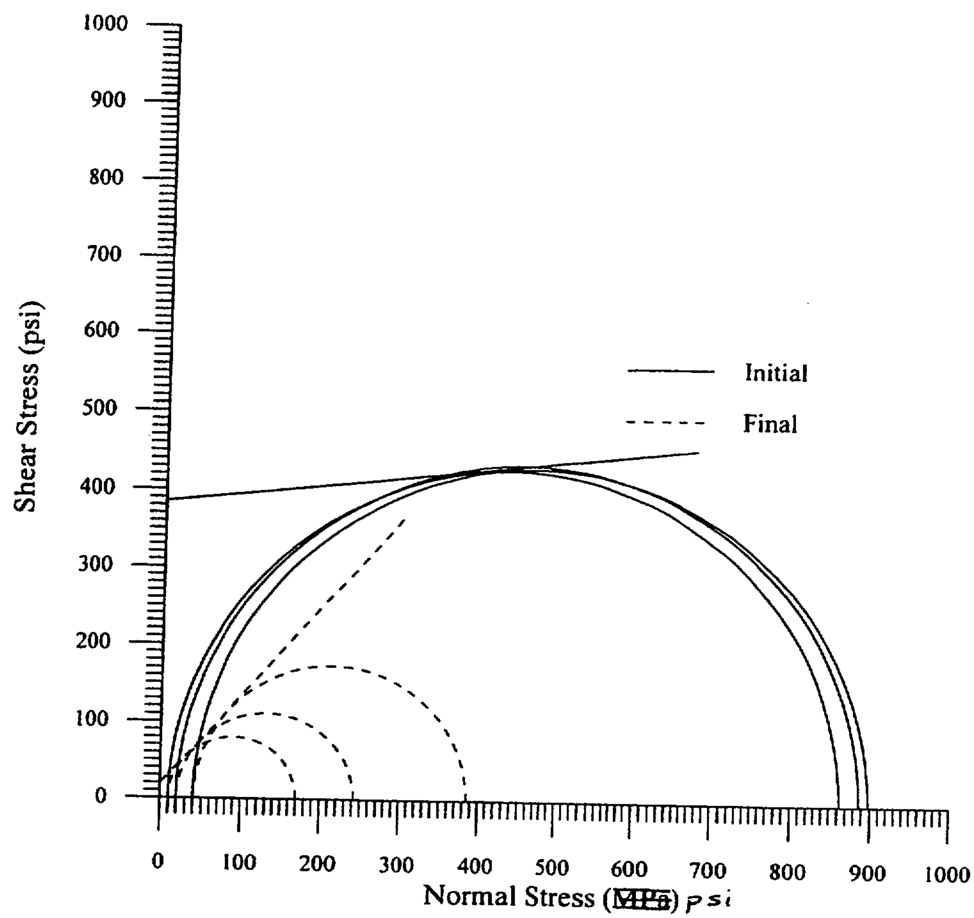
Project: **Diablo Canyon Power Plant ISFSI**

Project Number: 1223-50

Test Date: December 17, 2000



SUMMARY OF STRENGTH RESULTS
Mohr Failure Circles

Boring: OOBA-2
Sample: 2-C
Depth: 43.1-43.6'
Density: 141.1 pcf.

DESCRIPTION

Medium grained gray sandstone.

	C (psi)	ϕ
Initial	385(?)	6(?)
Final	20	49

Geo Test Unlimited GTU

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Nevada City, CA 95959

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Walnut Creek, CA 94596

Project: **Diablo Canyon Power Plant ISFSI**

Project Number: 1223-50

Test Dates: December 17, 2000

Geo Test Unlimited

DATA SHEET
Triaxial Compression Test of Rock (ASTM D2664)

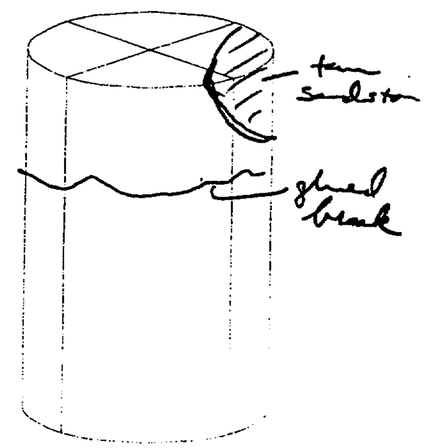
Date: 2-17-00
Technician: A. Bro

Client: W. Lettis & Assoc.
Job: #126-DCPP-ISFSI
Sample ID: 2-DB
Sample Description: Fine to medium grained gray clayey sandstone with a small tan sandstone zone. One mechanical break (perp. to core axis) glued with cyanoacrylate glue

Sample Depth: 46.0-46.5' Sample Condition: received & tested moist

d_1	d_2
2.432	2.418
2.428	2.390
2.418	2.400
2.424	2.403
2.420	2.411

l_1	l_2
+.0038	+.0018
+.0005	+.0013
±.0005	±.0005
-.0024	-.0020
-.0044	-.0055



Avg. diameter: 2.414
Sample area: 4.577
Sample volume(in^3): 23.909
Sample weight (g): 848.6g
Density: 35.49 g/in^3 = 135.2 pcf (1 g/in^3=3.8095 lb/ft^3)

Avg. length: 5.224
l/d ratio: 2.16

Test Confining Pressures (psi)

20	40	80

Comments: no discernable failure mode - possibly barrelling?

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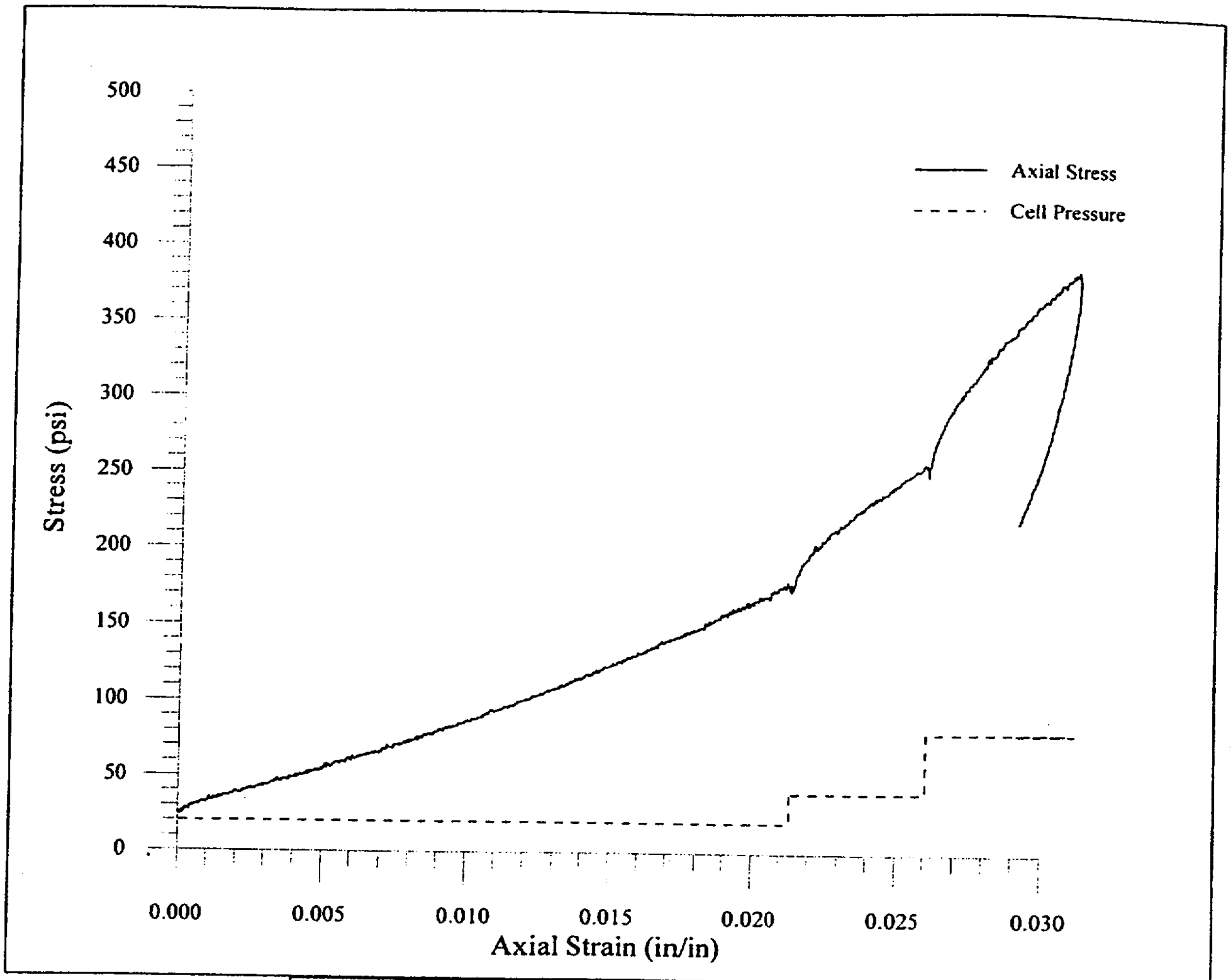

TRIAXIAL COMPRESSION TEST
Axial Stress and Confining Pressure vs. Strain

Boring: OOBA-2
Sample: 2-DB
Depth: 46.0-46.5'
Density: 135.2 pcf.

DESCRIPTION

Fine to medium grained gray clayey sandstone, with one glued mechnical break (perpendicular to the core axis).

Strain (in/in)	Conf. Pres. (psi)	Strength (psi)
0.022	20	184
	40	209
0.028	40	283
	80	332

Geo Test Unlimited GTU
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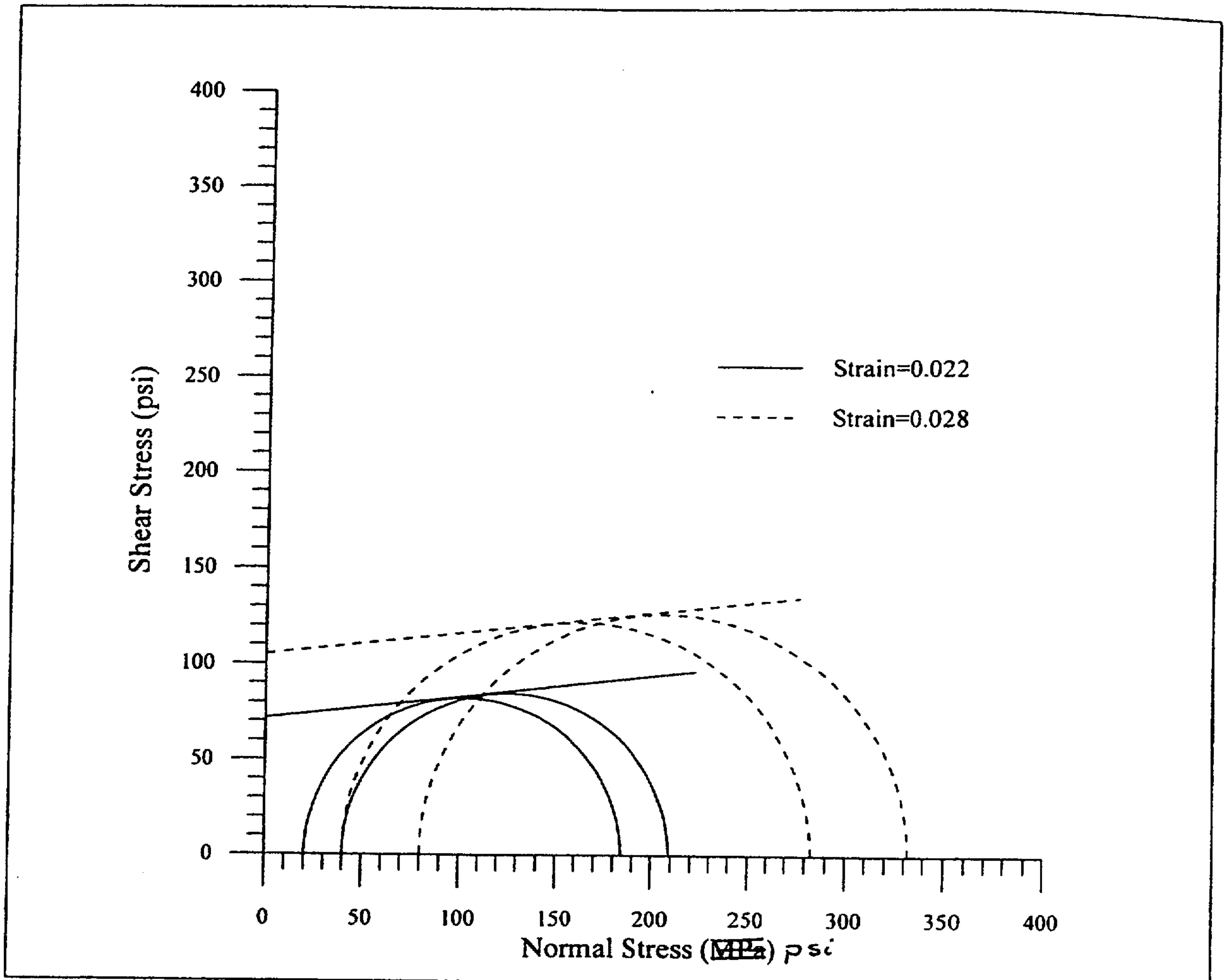
Project: **Diablo Canyon Power Plant ISFSI**

Project Number: 1223-50

Test Date: December 17, 2000



SUMMARY OF STRENGTH RESULTS
Mohr Failure Circles

Boring: OOBA-2
Sample: 2-DB
Depth: 46.0-46.5'
Density: 135.2 pcf.

DESCRIPTION

Fine to medium grained gray clayey sandstone, with one glued mechanical break (perpendicular to the core axis).

Strain (in/in)	C (psi)	ϕ
0.022	71	6
0.028	105	6

Geo Test Unlimited GTU

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1777 Botelho Dr., Suite 262
Walnut Creek, CA 94596

Project: **Diablo Canyon Power Plant ISFSI**

Project Number: 1223-50

Test Dates: December 17, 2000

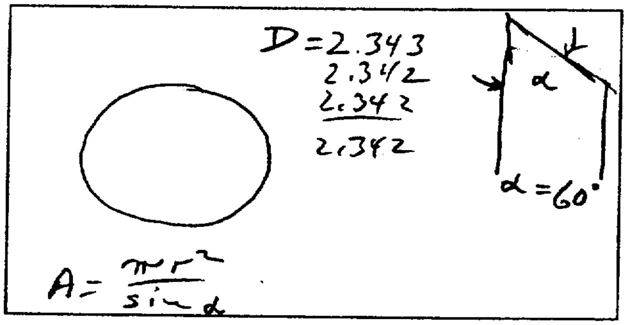
Geo Test Unlimited (GTU)

DATA SHEET
Direct Shear of Rock (ISRM)

Client: W. Lettis & Assoc. Date: 12-19-00
Job: #126-DCPP-ISFSI Tester: A. Bro
Sample ID: 1-1
SampleDescription: poorly mated somewhat rough joint in mottled tan and brown dolomite (?) with black oxide coating and light brown coating.

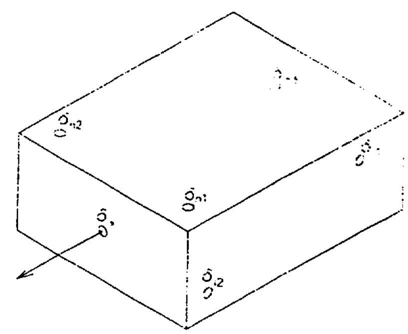
Sample Depth: 18.2' Sample Condition: received dry - tested soaked

Sketch of Shear Surface



Sample area : 4.974

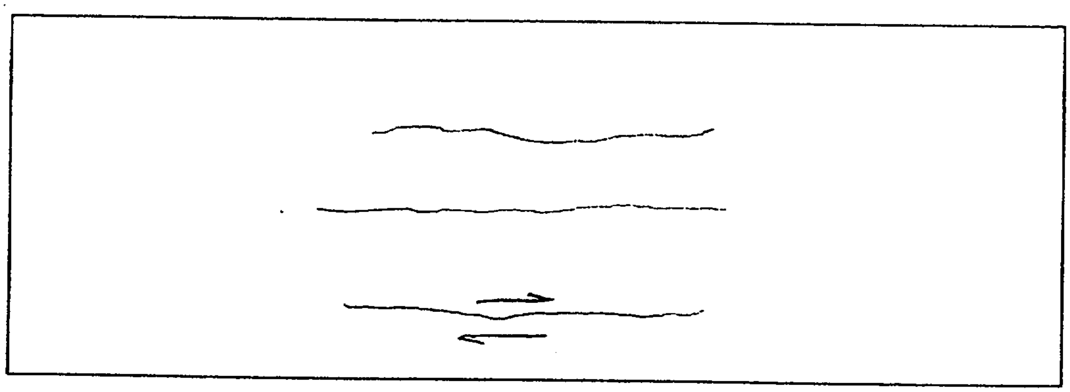
Location of LVDTs on top shear box



σ_n	10	20	40	psi
F_n	49.7	99.5	199.0	lb
F_n-W_b	34	84	184	lb

Estimated top box weight:
Measured top box weight: 14.9 lb

Joint Profiles



Comments:

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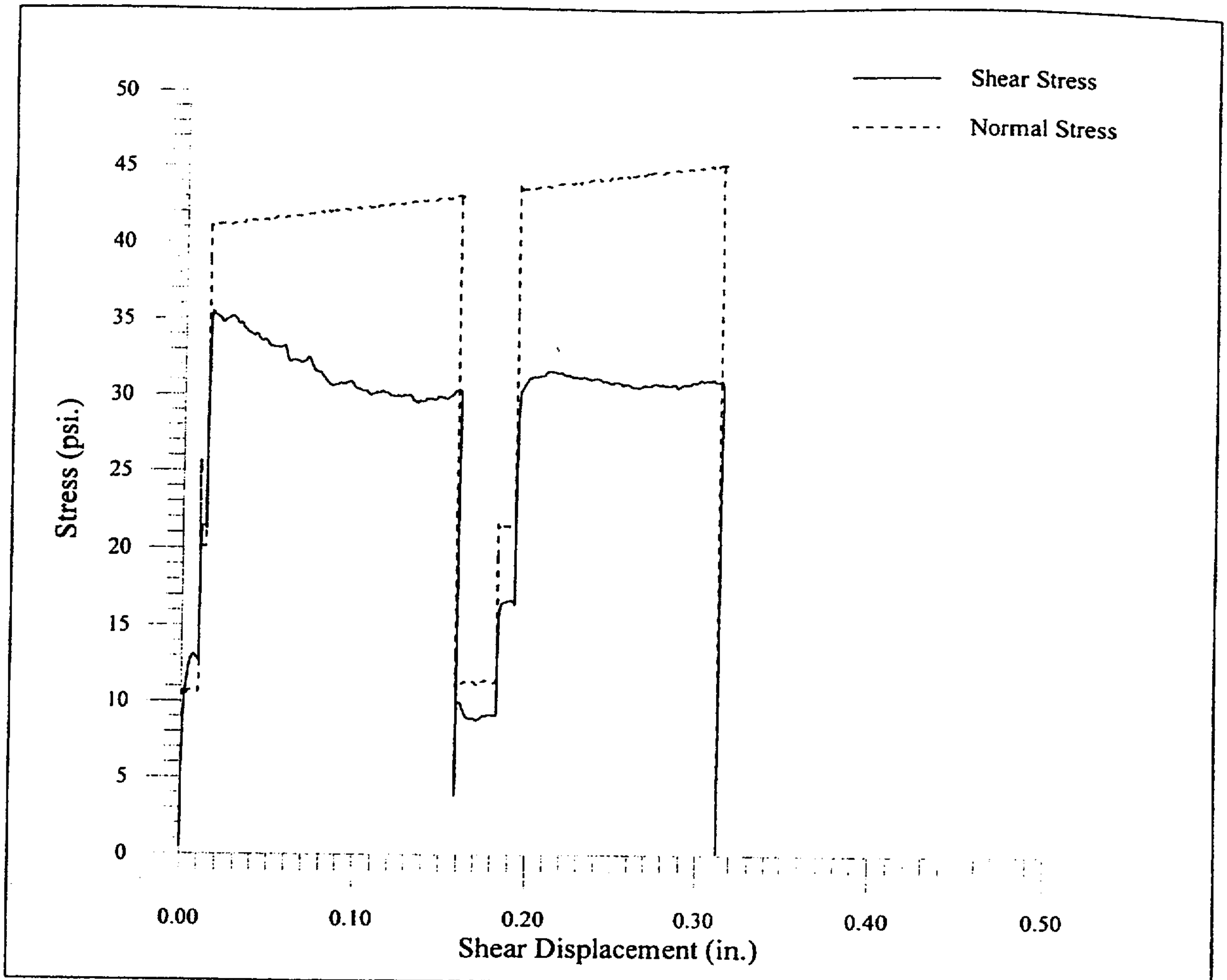

DIRECT SHEAR TEST
Shear and Normal Stress vs. Shear Displacement

Boring: OOBA-1
Sample: 1-1
Depth: 18.2'

DESCRIPTION

Poorly mated rough joint in mottled tan and brown dolomite(?) with black oxide and light brown coating.

	Normal Stress (psi)	Shear Stress (psi)
Initial	10.6	13.0
	20.1	21.3
	41.2	35.3
Final	11.3	9.0
	21.4	16.6
	43.7	31.2

Geo Test Unlimited
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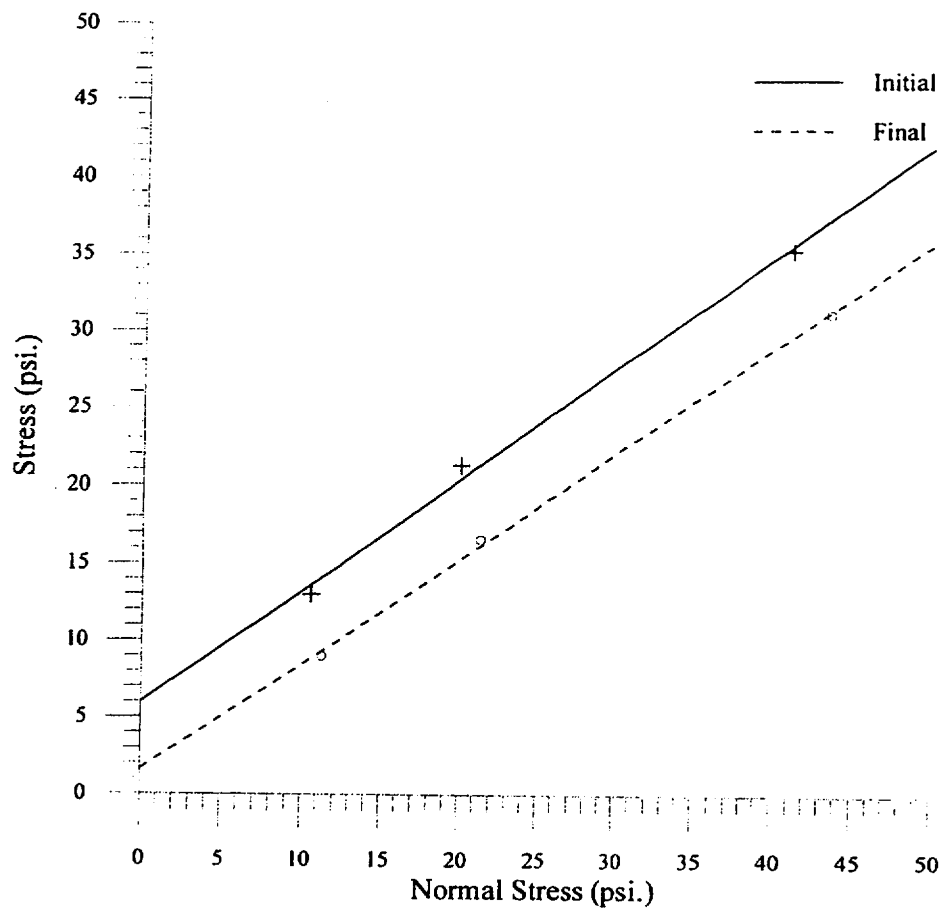
Client: **William Lettis & Associates, Inc.**
1777 Botelho Dr., Suite 262
Walnut Creek, CA 94596

Project: **Diablo Canyon Power Plant ISFSI**

Job Number: 1223-50

Test Date: December 19, 2000



DIRECT SHEAR TEST
Failure Envelope

Boring: OOBA-1
Sample: 1-1
Depth: 18.2'

DESCRIPTION

Poorly mated rough joint in mottled tan and brown dolomite(?) with black oxide and light brown coating.

	Shear Intercept (psi)	Friction Angle (degrees)
Initial	6.0	35.7
Final	1.6	34.2

Geo Test Unlimited GTU
27069 N. Bloomfield Rd.
Nevada City, CA 95959

Client: **William Lettis & Associates, Inc.**
1777 Botelho Dr., Suite 262
Walnut Creek, CA 94596

Project: **Diablo Canyon Power Plant ISFSI**

Job Number: 1223-50

Test Date: December 19, 2000

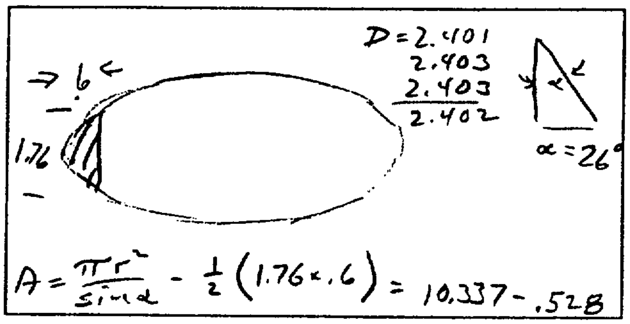
Geo Test Unlimited

DATA SHEET
Direct Shear of Rock (ISRM)

Client: W. Lettis & Assoc.
Date: 12-19-00
Job: #126-DCPP-ISFSI
Tester: A. Bro
Sample ID: 1-2
SampleDescription: Somewhat rough joint in tan dolomite (?) with black & brown oxide staining. Well mated.

Sample Depth: 34.2'
Sample Condition: received dry - tested soaked

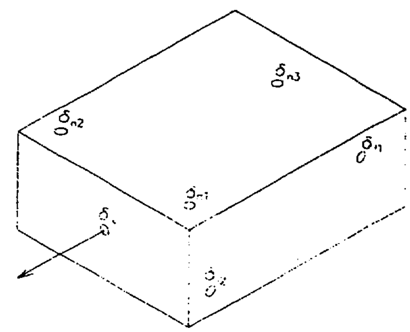
Sketch of Shear Surface



Sample area : 9.809 in²

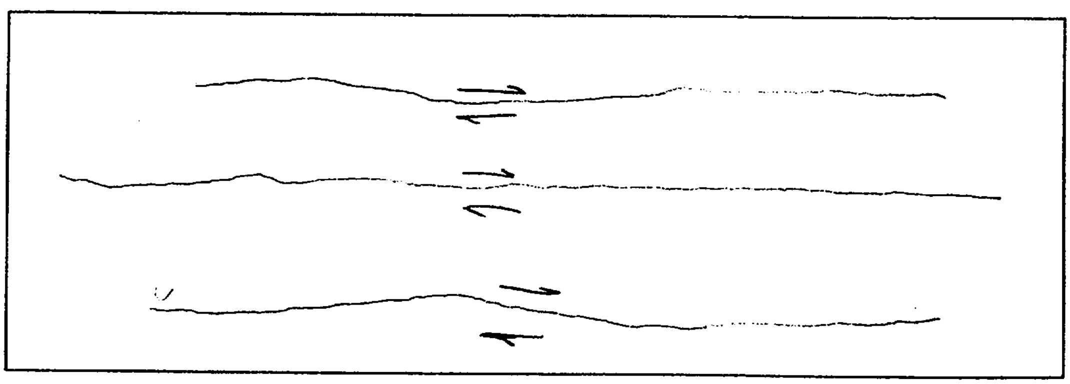
σ_n	10	20	40	psi
F_n	98.1	196.2	392.4	lb
F_n-W_b	82	180	376	lb

Location of LVDTs on top shear box



Estimated top box weight:
Measured top box weight: 15.6

Joint Profiles



Comments:

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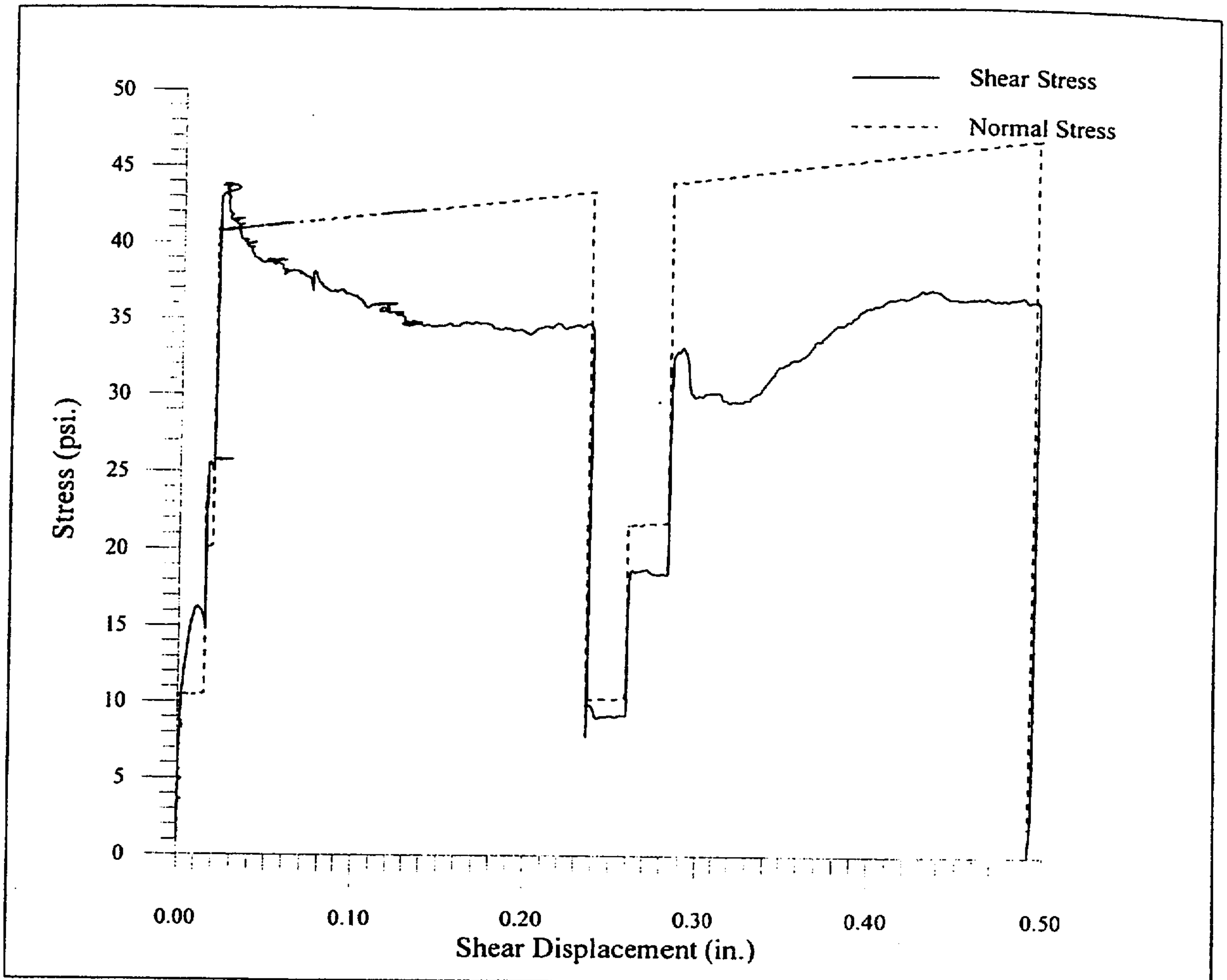

DIRECT SHEAR TEST
Shear and Normal Stress vs. Shear Displacement

Boring: OOBA-1
Sample: 1-2
Depth: 34.2'

DESCRIPTION

Rough, well mated joint in tan dolomite(?) with black and brown oxide staining.

	Normal Stress (psi)	Shear Stress (psi)
Initial	10.3	16.1
	20.1	25.6
	41.0	43.8
Final	10.0	9.0
	21.6	18.3
	44.1	33.0

Geo Test Unlimited GTU
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Nevada City, CA 95959

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1777 Botelho Dr., Suite 262
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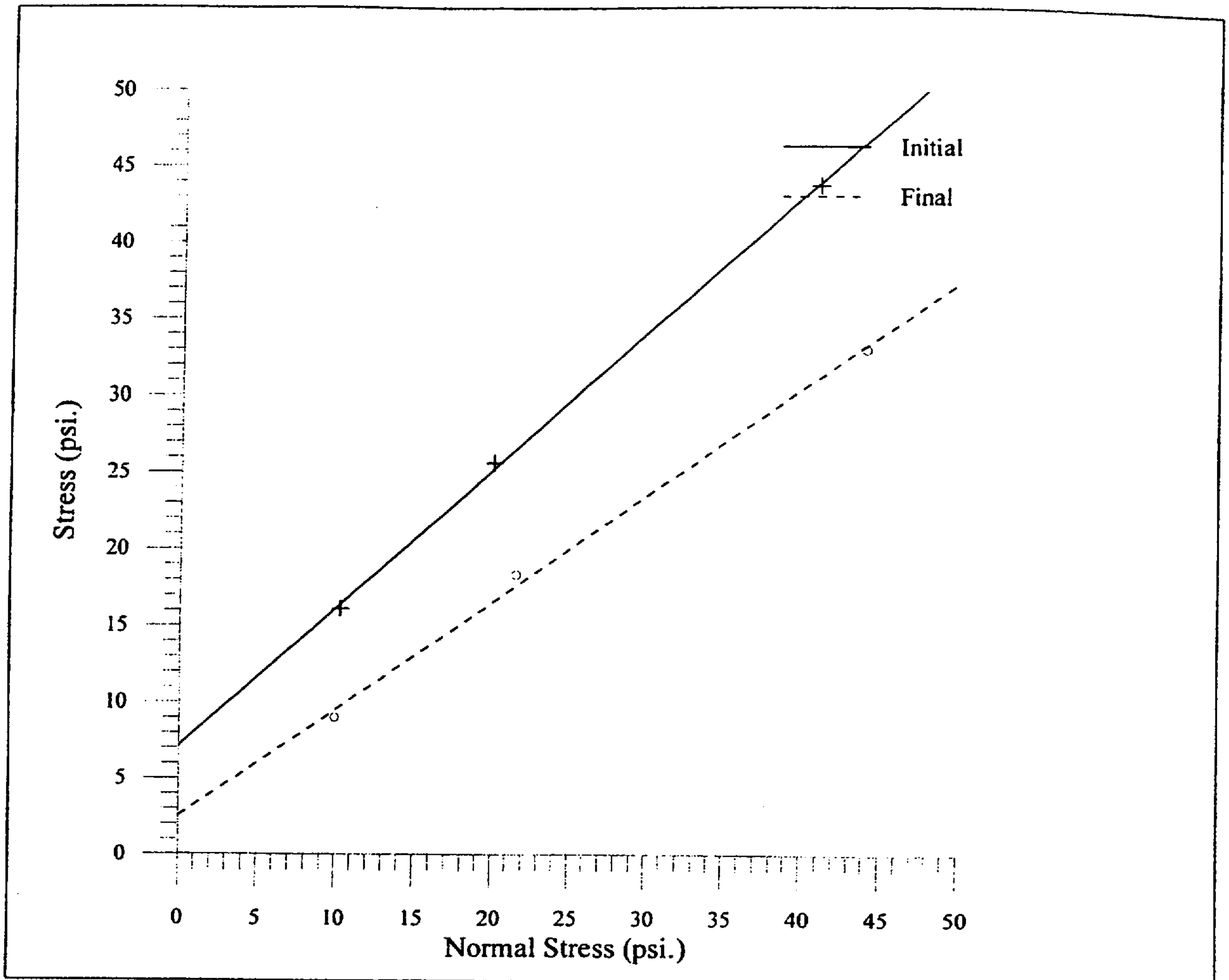
Project: **Diablo Canyon Power Plant ISFSI**

Job Number: 1223-50

Test Date: December 19, 2000



DIRECT SHEAR TEST
Failure Envelope

Boring: OOBA-1
Sample: 1-2
Depth: 34.2'

DESCRIPTION

Rough, well mated joint in tan dolomite(?) with black and brown oxide staining.

	Shear Intercept (psi)	Friction Angle (degrees)
Initial	7.1	41.9
Final	2.5	34.9

Geo Test Unlimited GTU
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Job Number: 1223-50

Test Date: December 19, 2000

Geo Test Unlimited

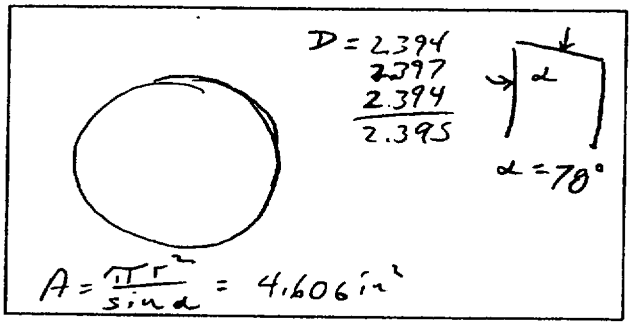
DATA SHEET
Direct Shear of Rock (ISRM)

Client: W. Lettis & Assoc.
Job: #126-DCPP-ISFSI
Sample ID: 1-3
SampleDescription: Bedding plane joint in dark brown dolomite (?).

Date: 12-18-00
Tester: A. Bro

Sample Depth: 37.1   Sample Condition: received dry tested soaked

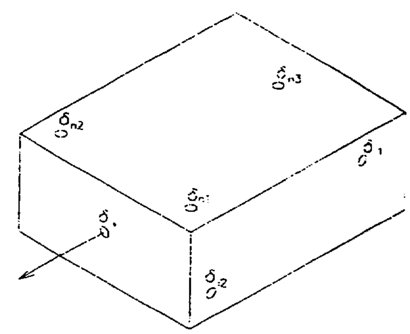
Sketch of Shear Surface



$A = \frac{\pi r^2}{\sin \alpha} = 4.606 \text{ in}^2$

Sample area : 4.606 in²

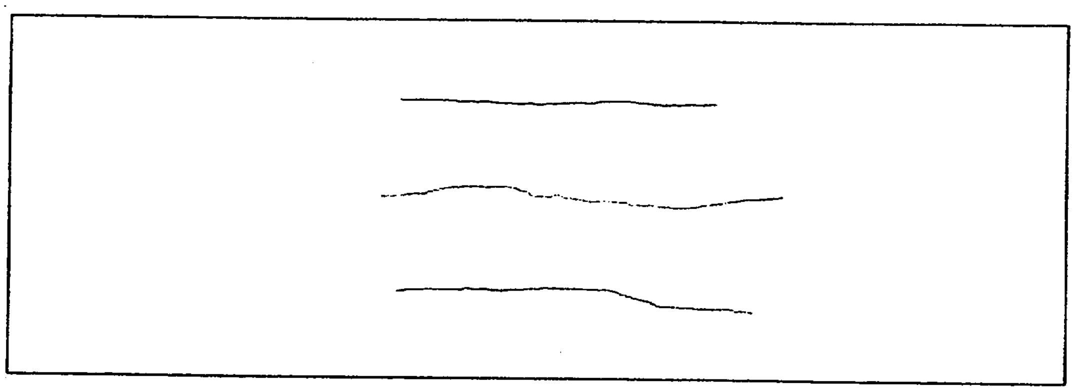
Location of LVDTs on top shear box



σ_n	10	20	40	psi
F_n	46.1	92.1	184	lb
F_n-W_b	31.	77	169	lb

Estimated top box weight:
Measured top box weight: 14.8 lb

Joint Profiles



Comments:

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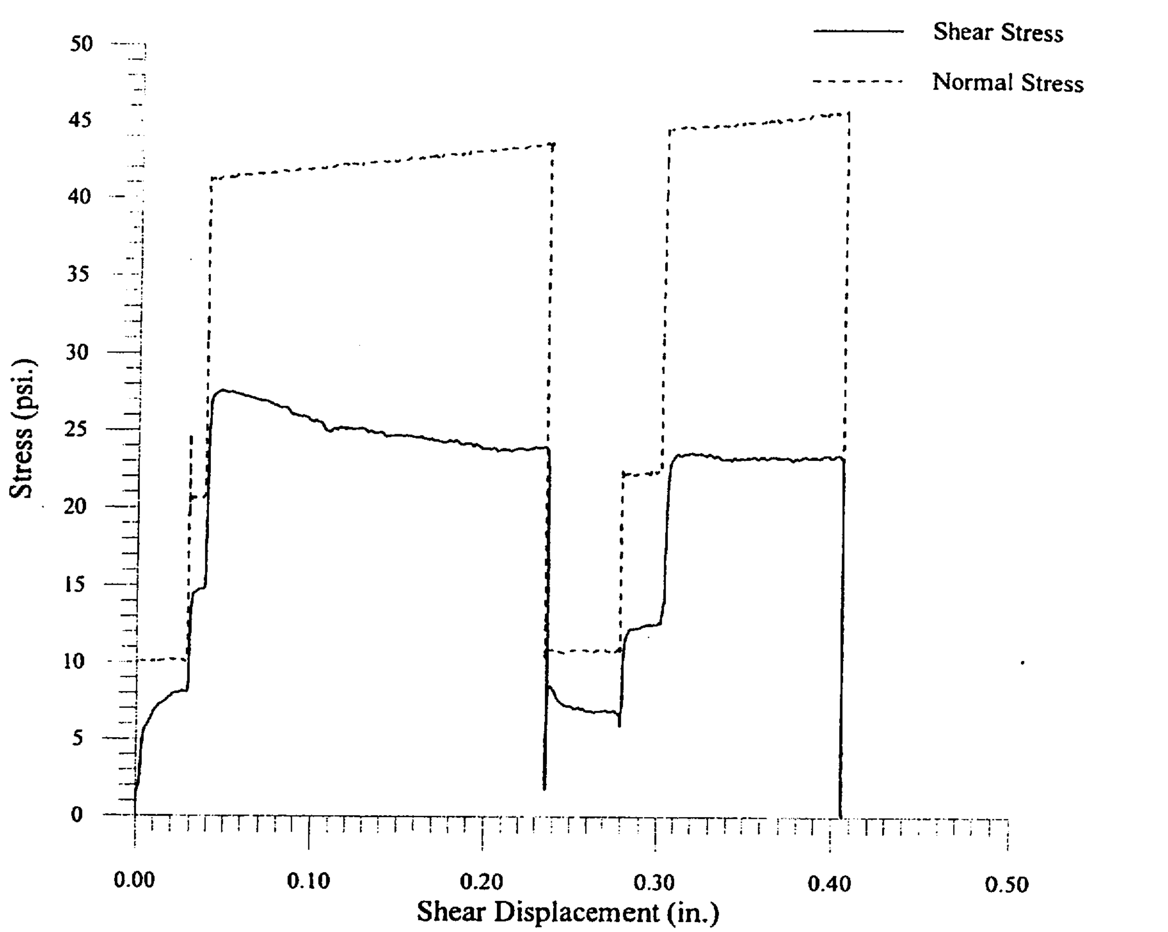

DIRECT SHEAR TEST
Shear and Normal Stress vs. Shear Displacement

Boring: OOBA-1
Sample: 1-3
Depth: 37.1'

DESCRIPTION

Bedding plane in dark brown dolomite(?)

	Normal Stress (psi)	Shear Stress (psi)
Initial	10.1	8.0
	20.5	14.7
	41.3	27.5
Final	10.9	6.9
	22.2	12.4
	44.7	23.4

Geo Test Unlimited
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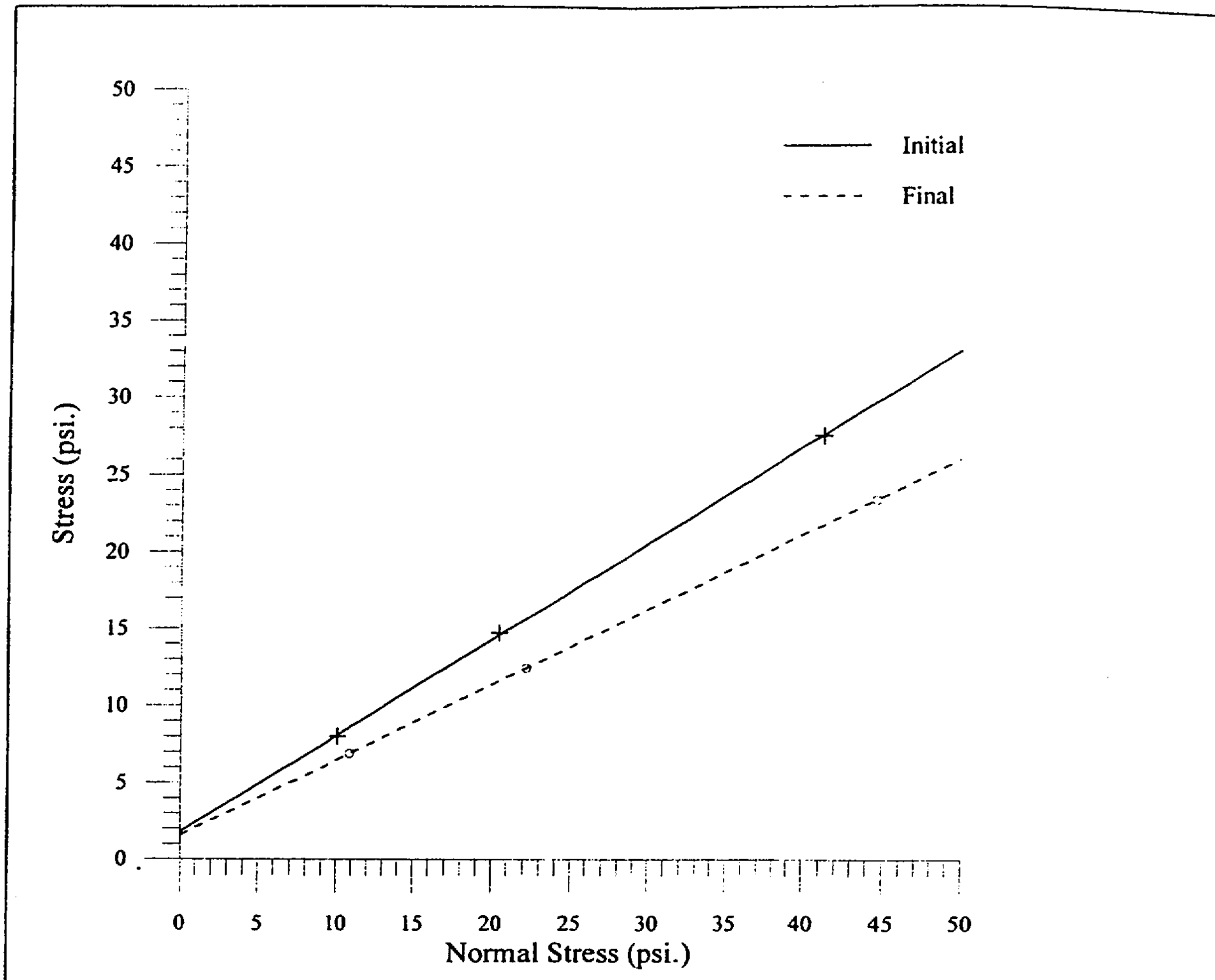
Client: **William Lettis & Associates, Inc.**
1777 Botelho Dr., Suite 262
Walnut Creek, CA 94596

Project: **Diablo Canyon Power Plant ISFSI**

Job Number: 1223-50

Test Date: December 18, 2000



DIRECT SHEAR TEST
Failure Envelope

Boring: OOBA-1
Sample:1-3
Depth: 37.1'

DESCRIPTION

Bedding plane in dark brown dolomite(?)

	Shear Intercept (psi)	Friction Angle (degrees)
Initial	1.8	31.9
Final	1.6	26.0

Geo Test Unlimited GTU
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Project: **Diablo Canyon Power Plant ISFSI**

Job Number: 1223-50

Test Date: December 18, 2000

Geo Test Unlimited (GTU)

DATA SHEET
Direct Shear of Rock (ISRM)

Client: W. Lettis & Assoc.

Job: #126-DCPP-ISFSI

Sample ID: 1-4

Date: 12-19-00

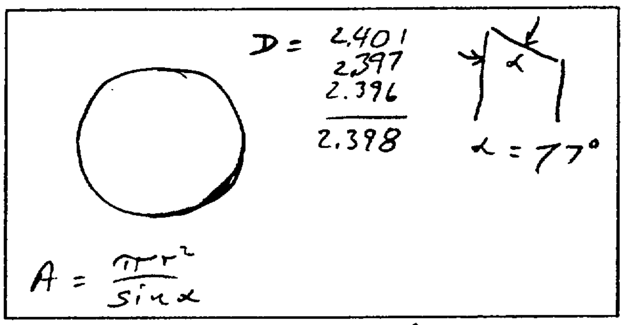
Tester: A. Bro

SampleDescription: mechanical break (possibly along bedding?) in tan dolomitic fine grained sandstone.

Sample Depth: 41.9'

Sample Condition: received dry. tested soaked

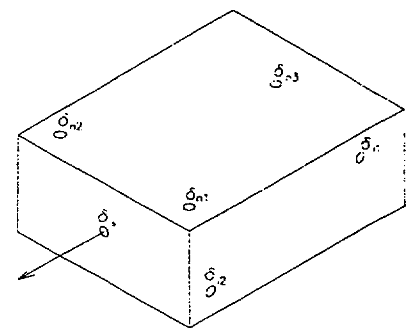
Sketch of Shear Surface



Sample area : 4.635 in²

σ_n	10	20	40	psi
F_n	46.4	92.7	185.4	lb
F_n-W_b	31	77	170	

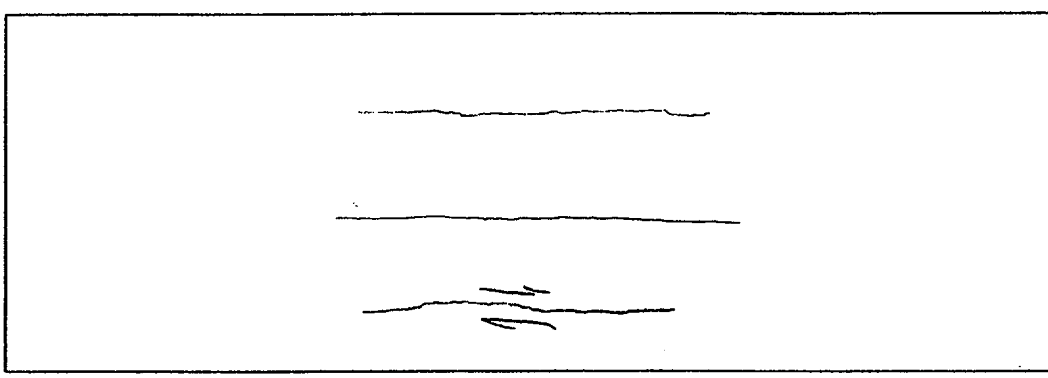
Location of LVDTs on top shear box



Estimated top box weight:

Measured top box weight: 15.4 lb

Joint Profiles



Comments: wedging in 1st stage of 1st suite

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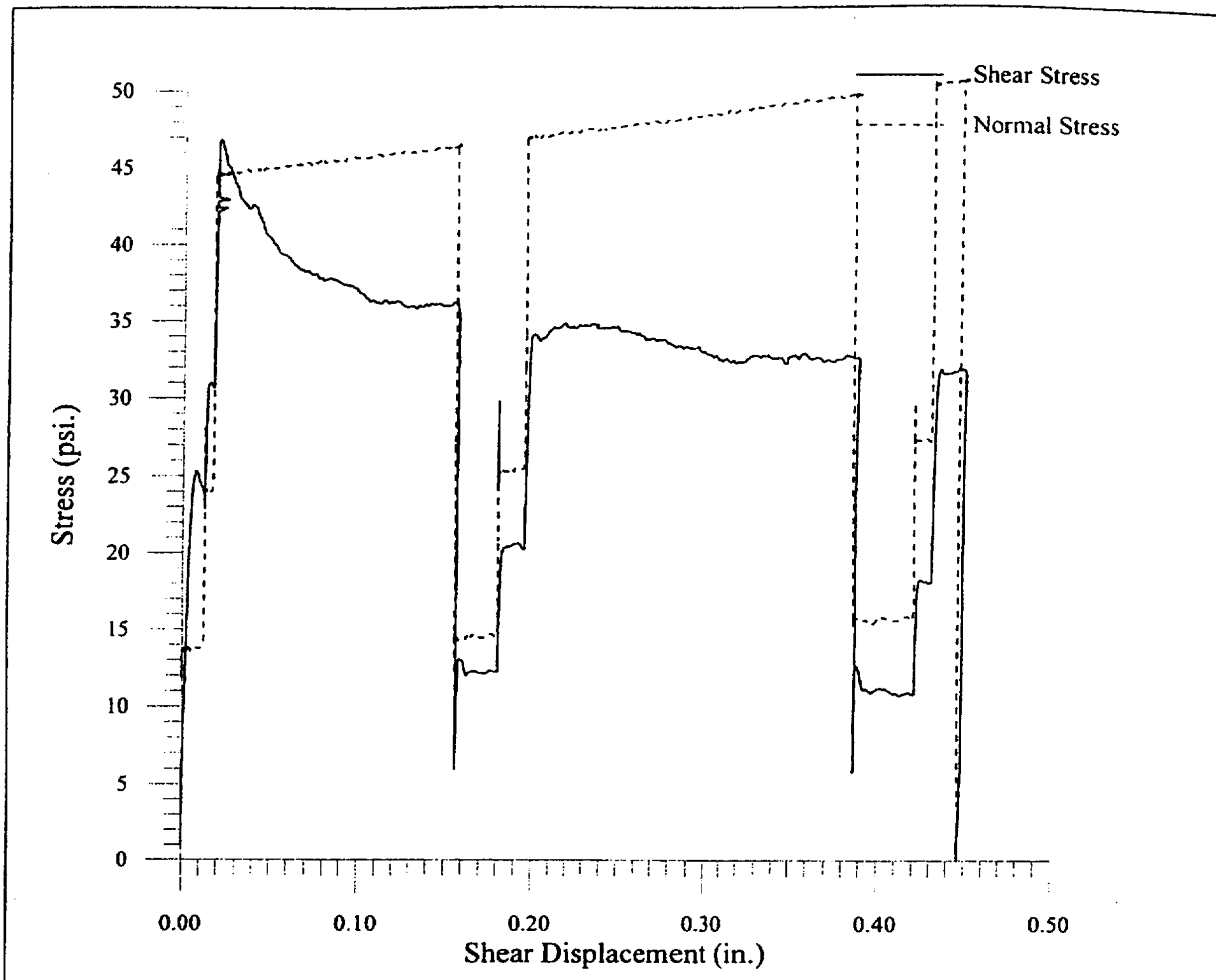

DIRECT SHEAR TEST
Shear and Normal Stress vs. Shear Displacement

Boring: OOBA-1
Sample: 1-4
Depth: 41.9'

DESCRIPTION

Mechanical break (possibly along bedding) in fine grained tan dolomitic sandstone.

	Normal Stress (psi)	Shear Stress (psi)
Initial	13.8	25.3
	24.0	31.0
	44.6	46.9
Final	15.8	10.8
	27.2	18.1
	50.5	31.7

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Client: **William Lettis & Associates, Inc.**
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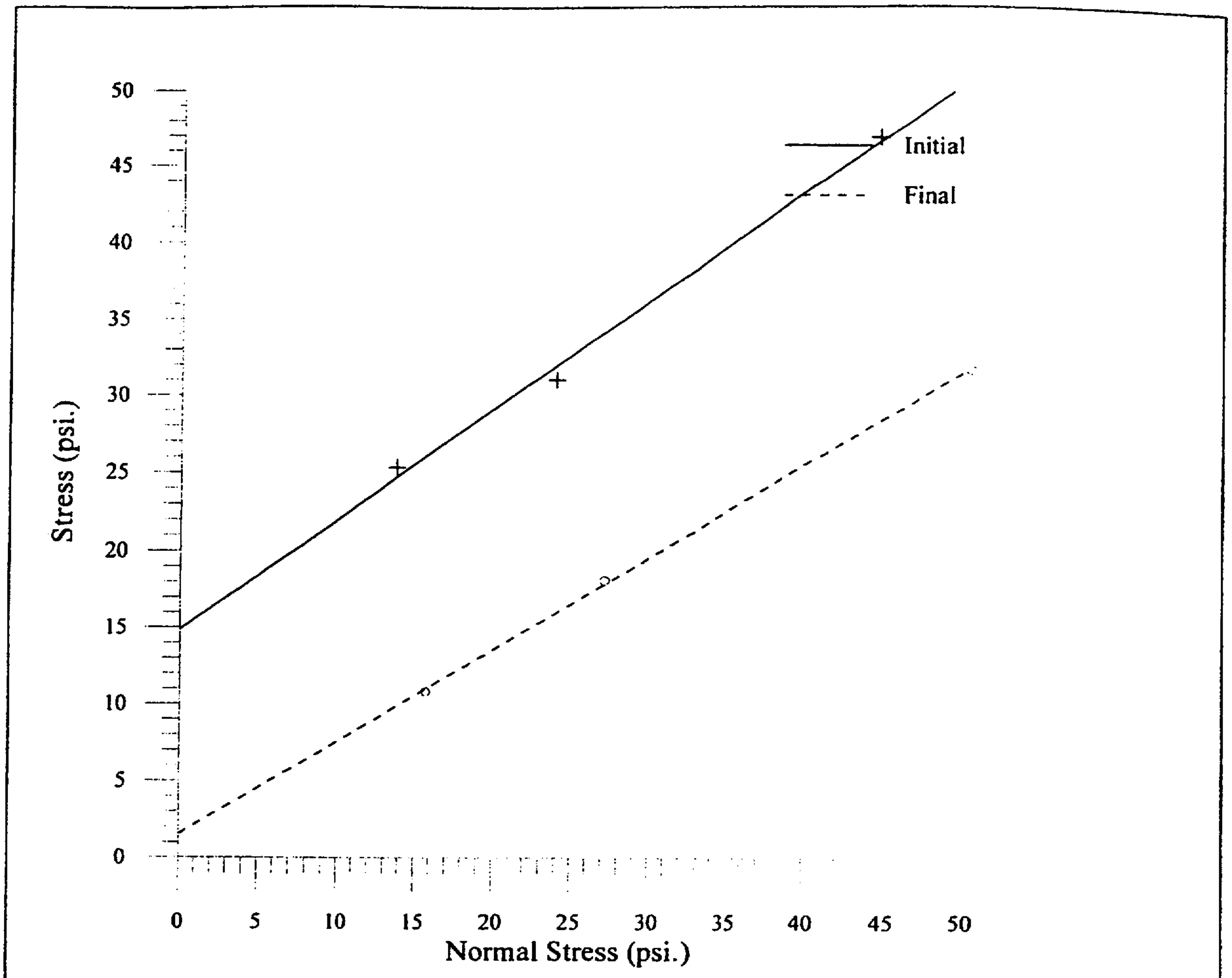
Project: **Diablo Canyon Power Plant ISFSI**

Job Number: 1223-50

Test Date: December 19, 2000



DIRECT SHEAR TEST
Failure Envelope

Boring: OOBA-1
Sample: 1-4
Depth: 41.9'

DESCRIPTION

Mechanical break (possibly along bedding) in fine grained tan dolomitic sandstone.

	Shear Intercept (psi)	Friction Angle (degrees)
Initial	14.9	35.4
Final	1.5	30.9

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Project: **Diablo Canyon Power Plant ISFSI**

Job Number: 1223-50

Test Date: December 19, 2000

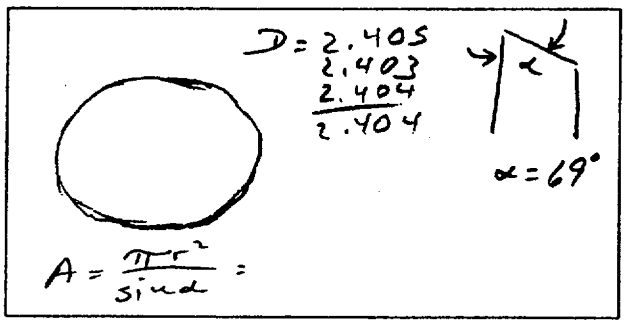
Geo Test Unlimited

DATA SHEET
Direct Shear of Rock (ISRM)

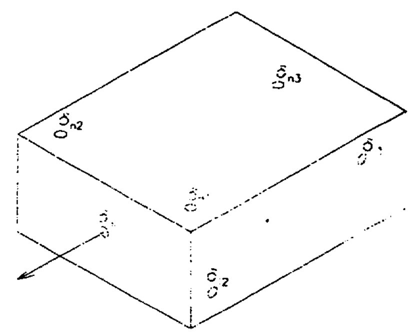
Client: W. Lettis & Assoc.
Job: #126-DCPP-ISFSI
Sample ID: 1-6
Date: 12-19-00
Tester: A. Bro
SampleDescription: somewhat rough joint with thin flakey coating (mineral deposit?) well mated - in tan dolomitic sandstone

Sample Depth: 88.8' Sample Condition: received dry, - tested soaked

Sketch of Shear Surface



Location of LVDTs on top shear box

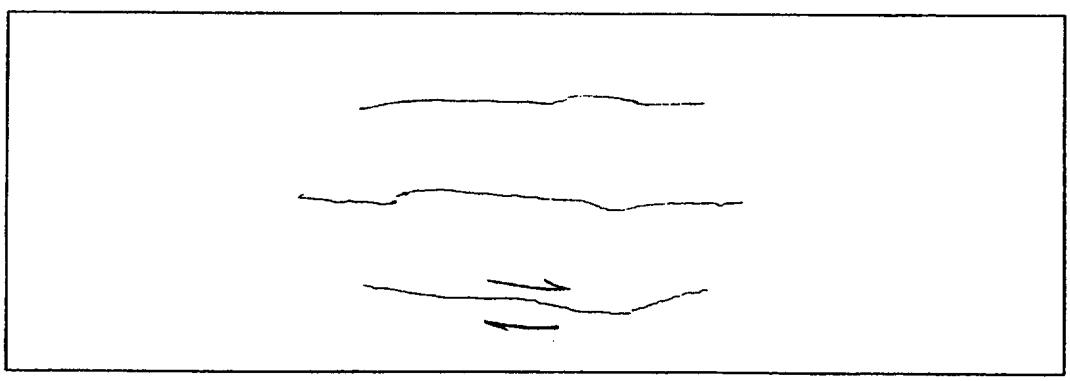


Sample area : 4.862

σ_n	20	40	80	psi
F_n	97.2	194.5	389.0	lb
F_n-W_b	82	179	374	lb

Estimated top box weight:
Measured top box weight: 14lb

Joint Profiles



Comments: 1st suite, 3rd stage, odd horizontal section probably due to joint locking up & mobilizing inside of the plate-like joint coatings. Probably due to less than ideal joint mating due to loss of coating flakes.

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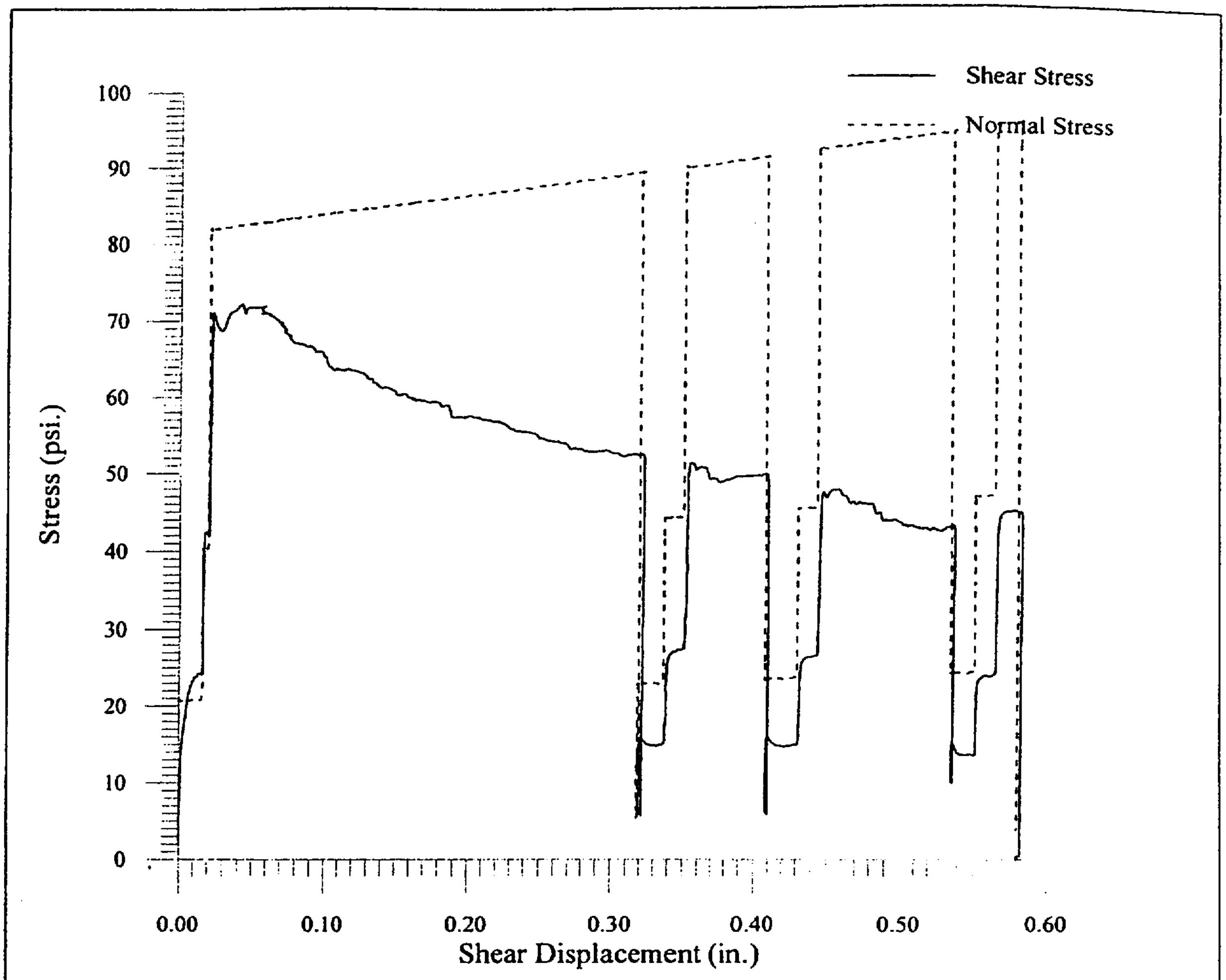

DIRECT SHEAR TEST
Shear and Normal Stress vs. Shear Displacement

Boring: OOBA-1
Sample: 1-6
Depth: 88.8'

DESCRIPTION

Moderately rough well mated joint with a thin flakey coating in tan dolomitic sandstone.

	Normal Stress (psi)	Shear Stress (psi)
Initial	20.6	24.2
	40.1	42.4
	82.0	71.0
Final	24.2	13.3
	47.0	23.7
	96.2	45.0

Geo Test Unlimited G T U
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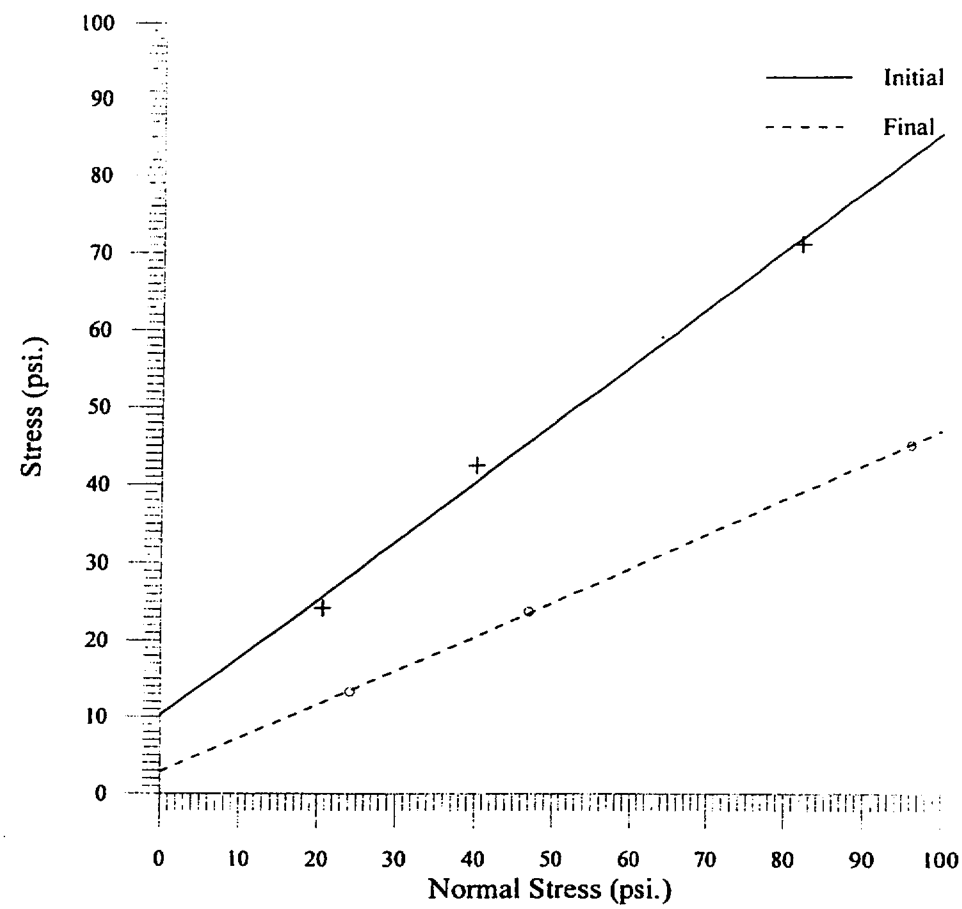
Walnut Creek, CA 94596

Project: **Diablo Canyon Power Plant ISFSI**

Job Number: 1223-50

Test Date: December 19, 2000



DIRECT SHEAR TEST
Failure Envelope

Boring: OOBA-1
Sample: 1-6
Depth: 88.8'

DESCRIPTION

Moderately rough well mated joint with a thin flakey coating in tan dolomitic sandstone.

	Shear Intercept (psi)	Friction Angle (degrees)
Initial	10.2	36.9
Final	2.8	23.7

Geo Test Unlimited GTU
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Client: **William Lettis & Associates, Inc.**
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Walnut Creek, CA 94596

Project: **Diablo Canyon Power Plant ISFSI**

Job Number: 1223-50

Test Date: December 19, 2000

Geo Test Unlimited

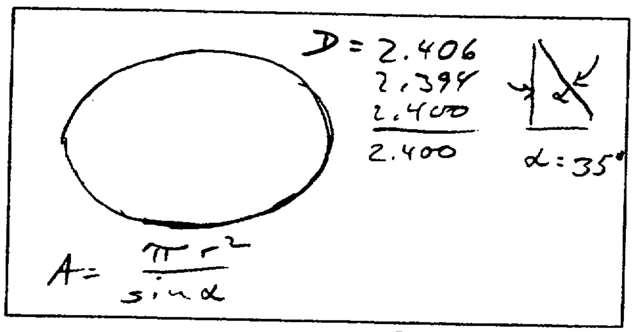
DATA SHEET
Direct Shear of Rock (ISRM)

Client: W. Lettis & Assoc.
Job: #126 - CDPP - ISFSI
Sample ID: S 1-7
Date: 12-19-00
Tester: A. Bro

SampleDescription: Somewhat wavy joint in tan dolomitic sandstone with black oxide coating and a yellow and tan flakey filling (probably clay) poorly mated

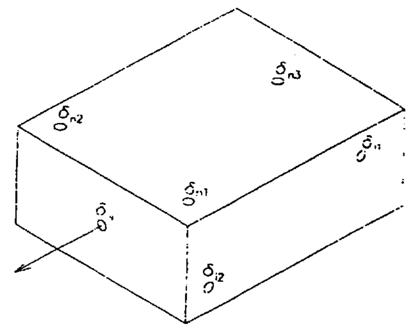
Sample Depth: 142.0'   Sample Condition: received dry - tested soaked

Sketch of Shear Surface



Sample area : 7.887 in²

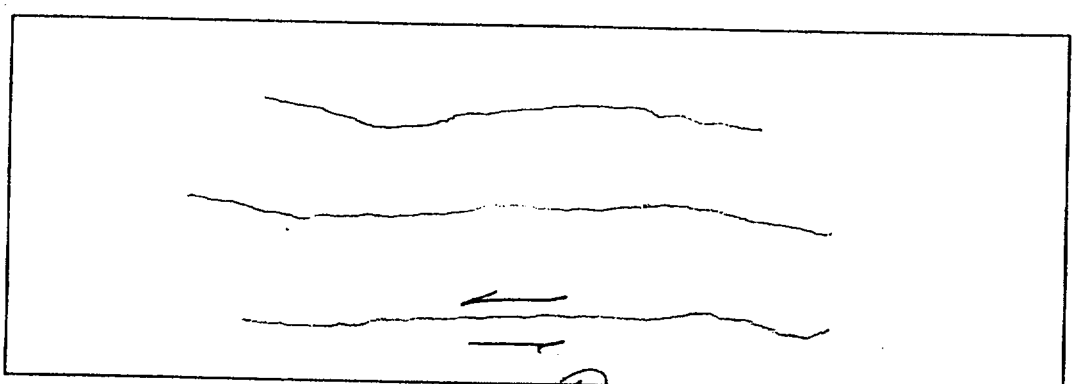
Location of LVDTs on top shear box



σ_n	20	40	80
F_n	157.7	315.5	631.0
F_n-W_b	142	300	616

Estimated top box weight: .
Measured top box weight: 14.9 lb

Joint Profiles



Comments: 1st similar 3rd stage!! P probably due to either lock-up or asperities grinding through clay coating. Therefore I unloaded & repeated the multistage since

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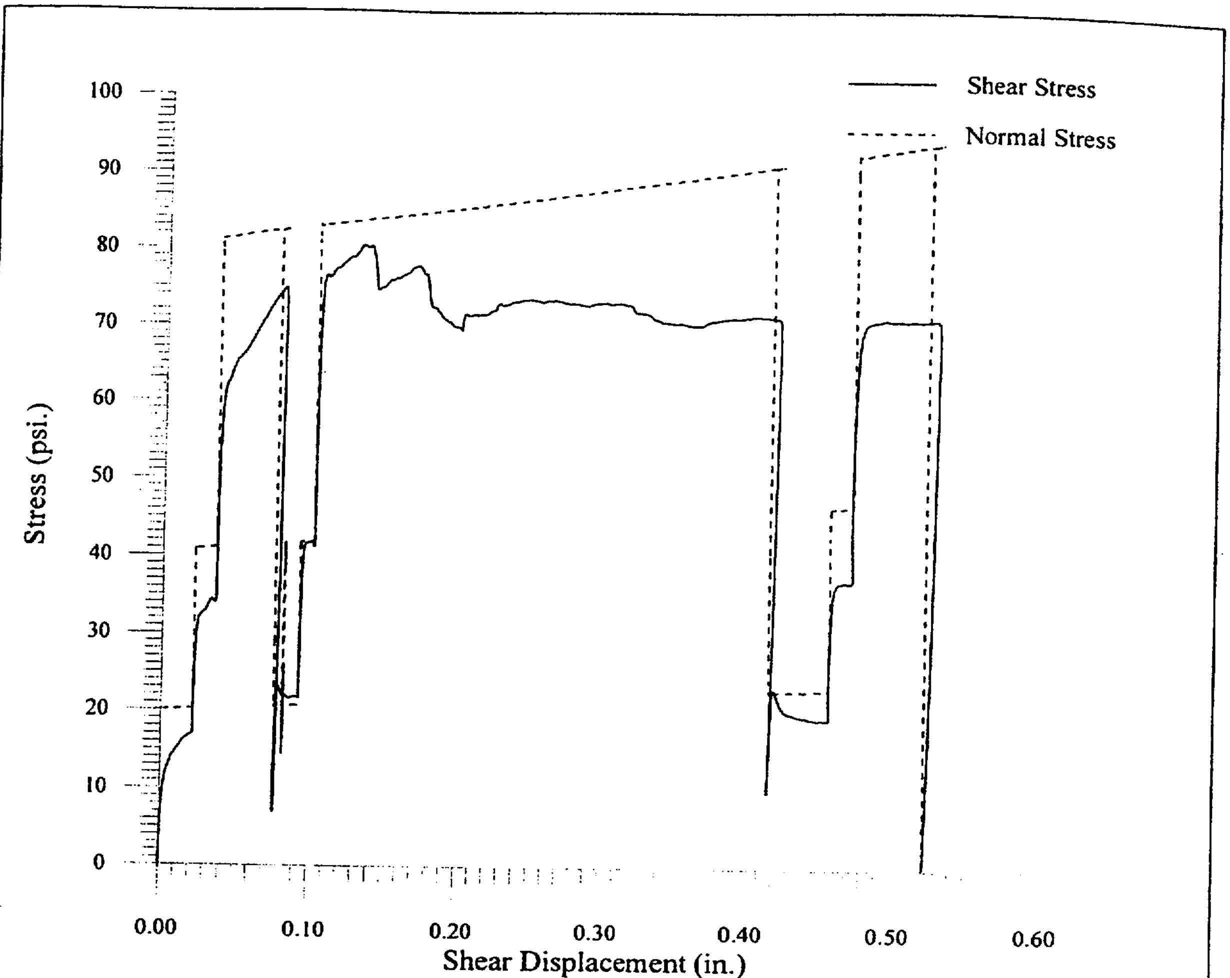

DIRECT SHEAR TEST
Shear and Normal Stress vs. Shear Displacement

Boring: OOBA-1
Sample: 1-7
Depth: 142.0'

DESCRIPTION

Wavy poorly mated joint with a black oxide coating and tan flakey coating (probably clay) in tan dolomitic sandstone.

	Normal Stress (psi)	Shear Stress (psi)
Initial	20.5	21.8
	41.8	41.8
	83.0	76.8
Final	22.9	19.0
	46.7	37.0
	92.8	71.0

Geo Test Unlimited (GTU)
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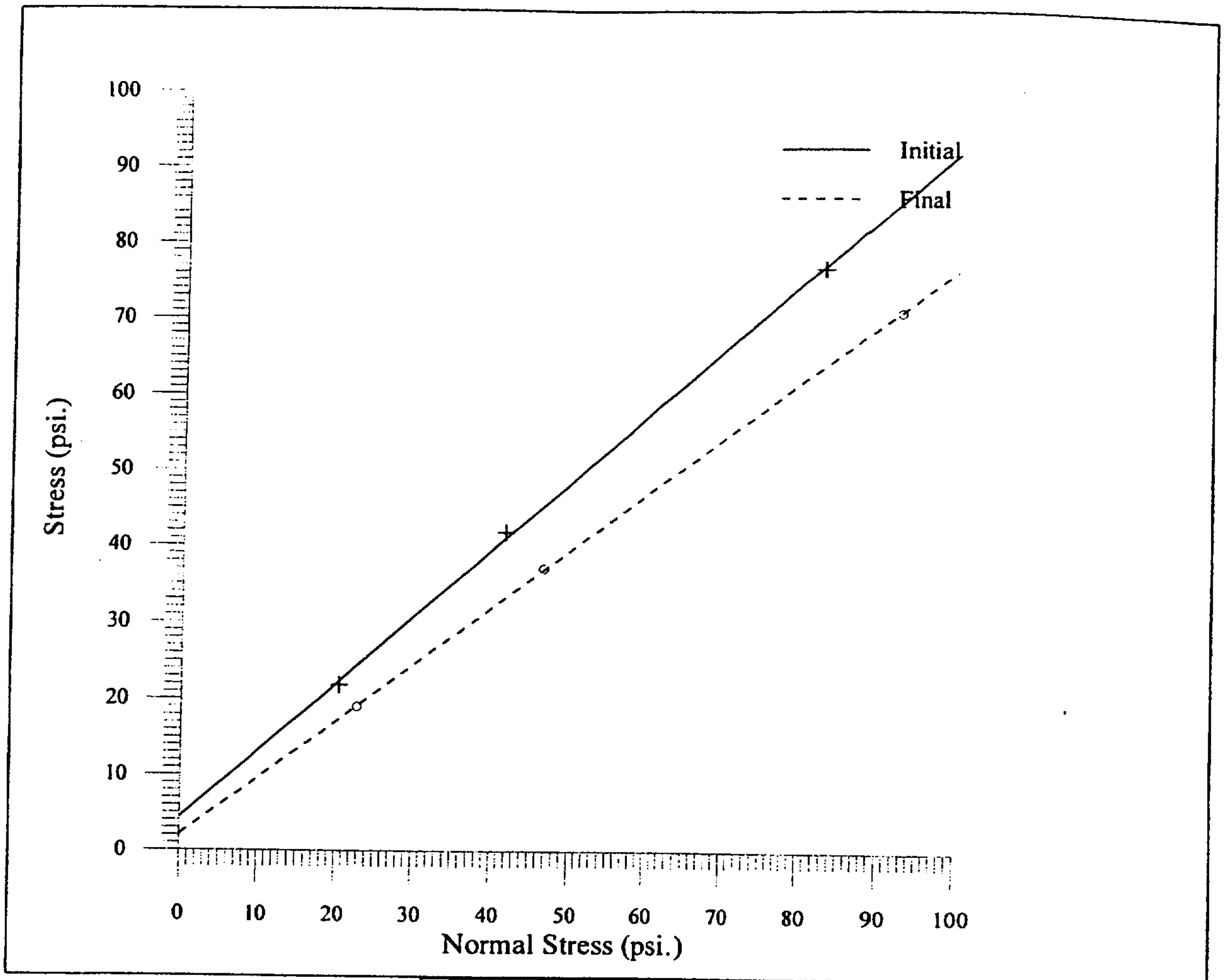
1777 Botelho Dr., Suite 262
Walnut Creek, CA 94596

Project: Diablo Canyon Power Plant ISFSI

Job Number: 1223-50

Test Date: December 19, 2000



DIRECT SHEAR TEST
Failure Envelope

Boring: OOBA-1
Sample: 1-7
Depth: 142.0'

DESCRIPTION

Wavy poorly mated joint with a black oxide coating and tan flakey coating (probably clay) in tan dolomitic sandstone.

	Shear Intercept (psi)	Friction Angle (degrees)
Initial	4.4	41.2
Final	2.1	36.6

Geo Test Unlimited GTU
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Project: **Diablo Canyon Power Plant ISFSI**

Job Number: 1223-50

Test Date: December 19, 2000

Geo Test Unlimited

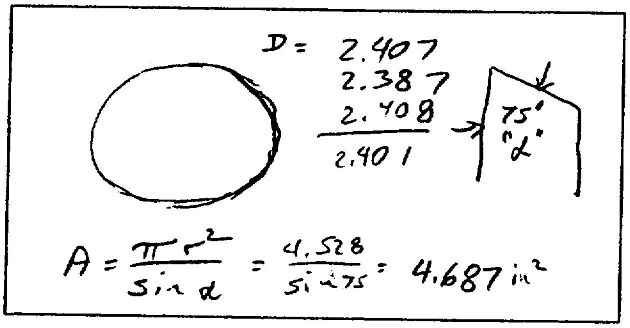
DATA SHEET
Direct Shear of Rock (ISRM)

Client: W. Lettis & Assoc.
Job: #126-DCPP-ISFSI
Sample ID: S1-18
Date: 12-18-00
Tester: A.Bro

SampleDescription: tan rock/clay seam interface darker brown staining on interface.

Sample Depth: 56.5'
Sample Condition: received & tested moist

Sketch of Shear Surface



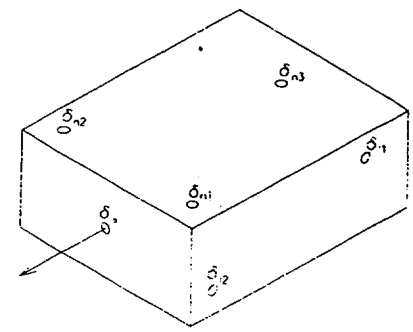
$$A = \frac{\pi r^2}{\sin \alpha} = \frac{4.528}{\sin 75} = 4.687\ in^2$$

Sample area: 4.687 in²

? may be too small load

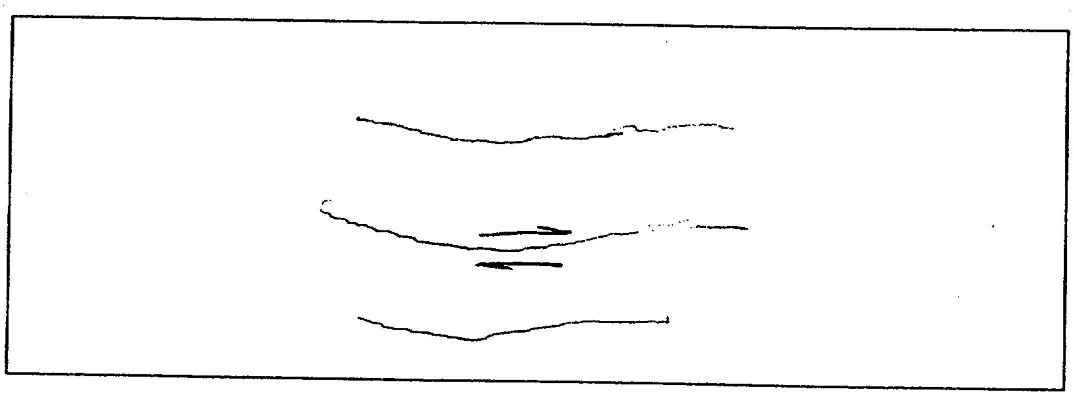
σ_n	5	10	20	40	psi
F_n	23.4	46.9	93.7	187.5	
F_n-W_b	8.4	31.9	78.7	172.5	

Location of LVDTs on top shear box



Estimated top box weight: 15 lb
Measured top box weight: 14.8 lb

Joint Profiles



Comments: during start of "final" stage 12 lb F_N, load ram not centered. Test stopped load button centered, and test resumed.
(negative δ_{ni} means dilation) δ_{n1}, δ_{n2} reset @ $\delta_s \approx .29$" & at .395"

Failed with multiple shears, one through the rock & another within the clay. It may be that the strengthening in the 2nd load level, 2nd set was due to the initiation of rock shearing

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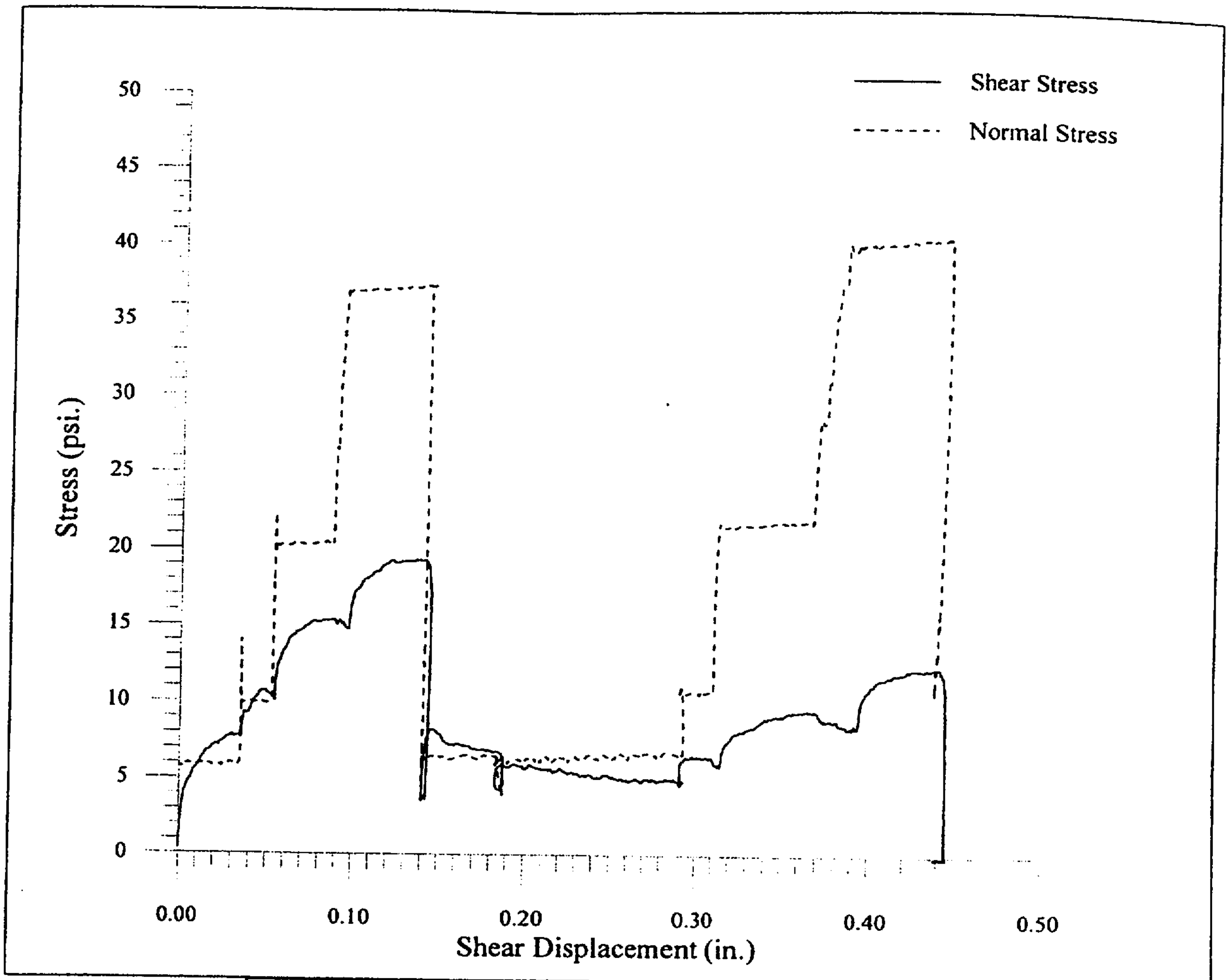

DIRECT SHEAR TEST
Shear and Normal Stress vs. Shear Displacement

Boring: OOBA-1
Sample: 1-18
Depth: 56.5'

DESCRIPTION

Tan rock/clay seam interface with a dark brown staining in the vicinity of the interface.

	Normal Stress (psi)	Shear Stress (psi)
Initial	5.8	7.8
	10.0	10.7
	20.2	15.2
	37.2	19.1
Final	6.5	4.9
	10.7	6.3
	21.9	9.4
	40.3	12.0

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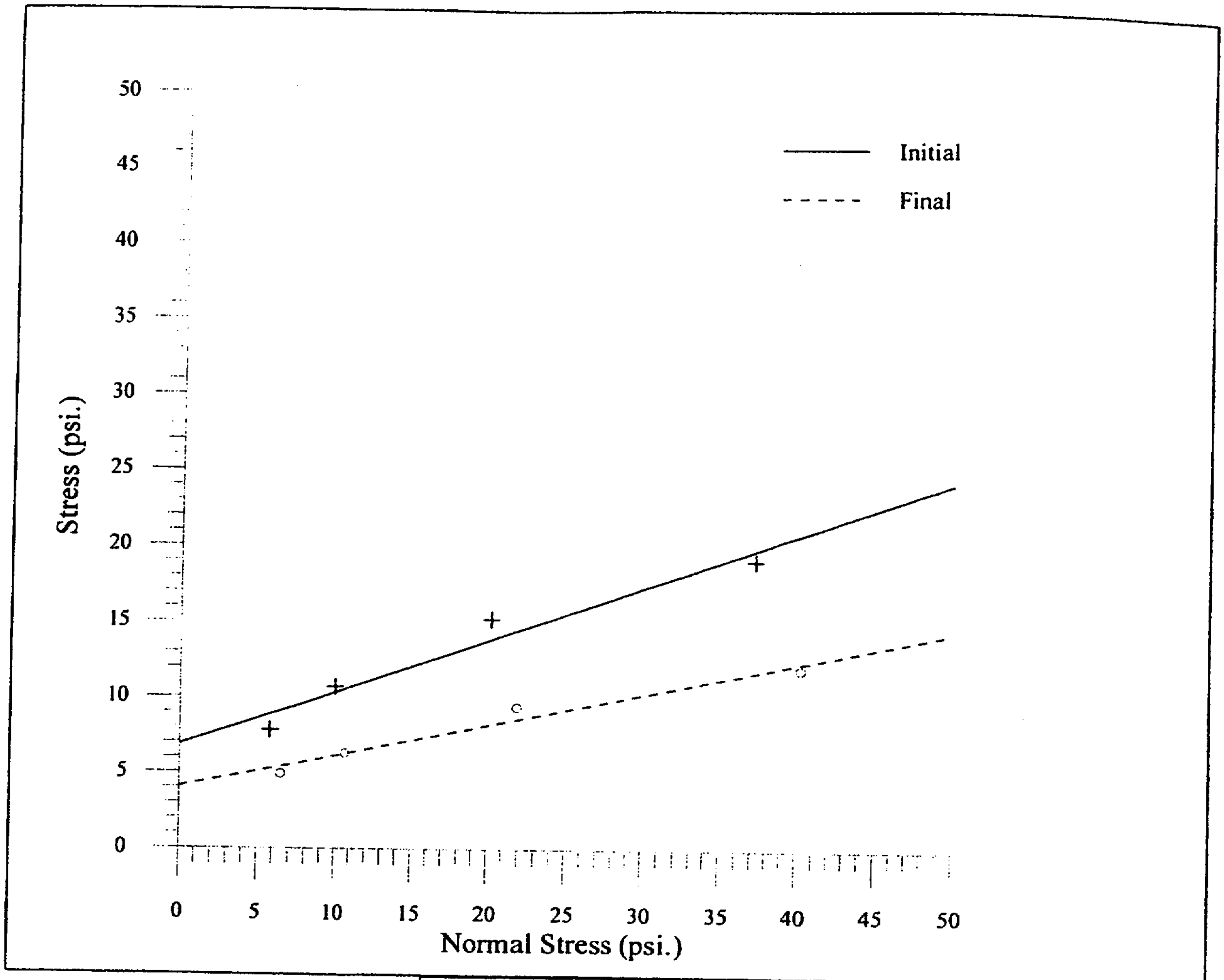

DIRECT SHEAR TEST
Failure Envelope

Boring: OOBA-1
Sample: 1-18
Depth: 56.5'

DESCRIPTION

Tan rock/clay seam interface with a dark brown staining in the vicinity of the interface.

	Shear Intercept (psi)	Friction Angle (degrees)
Initial	6.8	19.2
Final	4.0	11.7

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Project: **Diablo Canyon Power Plant ISFSI**

Job Number: 1223-50

Test Date: December 18, 2000

Geo Test Unlimited

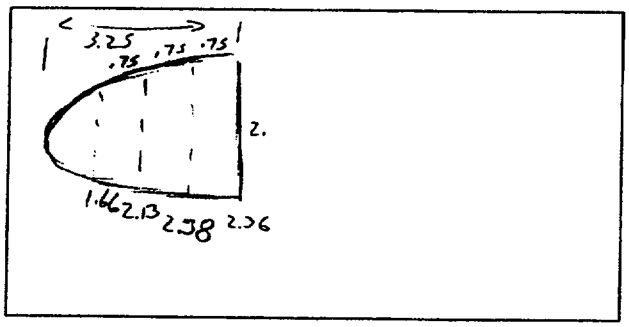
DATA SHEET
Direct Shear of Rock (ISRM)

Client: W. Lettis & Assoc.
Job: #126 - DCPP - ISFSI
Sample ID: 2 - DA
SampleDescription: gray sandstone, non-through-going joint

Date: ______
Tester: ABro

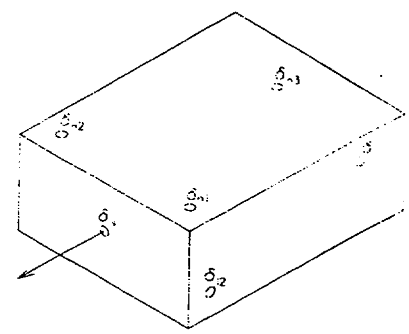
Sample Depth: 46.6' Sample Condition: received & tested moist

Sketch of Shear Surface



Sample area : ______

Location of LVDTs on top shear box



σ_n	10	20	40	psi
F_n				
F_n-W_b				

Estimated top box weight: ______
Measured top box weight: ______

Joint Profiles

Comments: Could not be tested. The moisture from the casting plaster loosened the joint & it fell apart.

27069 N. Bloomfield Rd., Nevada City, CA 95959 Tel/Fax (707)455-7684 email: abro@mindspring.com

ATTACHMENT 2

LABORATORY ROCK TESTING REPORT

SAMPLES COLLECTED FROM BORINGS 01-A THROUGH 01-I AND 01-CTF-A, ANDERS BRO OF GEOTEST UNLIMITED

MAY 23, 2001

Geo Test Unlimited (GTU)

Test Equipment Design & Fabrication
Laboratory & Field Testing
Consulting Services

Dr. Anders Bro

May 23, 2001

Jeff Bachhuber
William Lettis & Associates, Inc.
1777 Botelho Dr, Suite 262
Walnut Creek, CA 94596

Dear Jeff,

Thank you very much for using my rock testing lab for this second set of tests for the Diablo Canyon Power Plant, ISFSI project. This letter report describes the tests performed and summarizes the test results along with observations which might have some bearing on interpreting the rock behavior.

The samples were obtained during two visits to the Diablo Canyon power plant, the first visit on April 20 and a second visit on April 23&24. In addition a few samples were delivered to GTU's facilities by Joseph Sun on May 7. All of the tested samples and the cut off remains were returned in person to the offices of William Lettis & Associates on May 18. The samples were prepared and tested between April 25 and May 17, 2001. A total of 20 unconfined compression tests, 25 modulus tests, 5 conventional triaxial tests, 4 triaxial tests with pore pressure measurements, and 14 direct shear tests were performed.

Calibration

During the previous testing program for the Diablo Canyon power plant (November 2000), the transducers were recalibrated in-house and the new calibrations checked against the prior calibrations prior to testing. In the case of the 50 kip Interface load cell (used for the unconfined and triaxial compression tests) and the two 2 kip Lebow load cells (used for the direct shear tests), the linearity and accuracy of the cell readings were compared to the loads as measured by a 20 kip Morehouse proving ring. The calibration of the 200 psi Viatran pressure transducer (used to monitor and control the confining pressure of the triaxial tests) was checked with a high precision, 300 psi Heise pressure gauge. The calibration of the Schaevitz LVDTs with a 0.2 inch stroke were all checked with an electronic Mitutoyo precision micrometer head. Finally the calibration of the Transtek LVDT with a 1 inch stroke (used to measure the shear displacement of the shear box) was checked with a mechanical Mitutoyo micrometer head. Of these checks, only one load cell (the one used to measure the normal load in the shear box) resulted in a slight shift from the original calibration. For this 2000 lb load cell, a shift in the gain of about 25 lb (an error of 1.2%) was encountered. Before testing, the gain was adjusted to eliminate this error. Both of the Lebow cells appeared to have a 2 lb hysteresis (ie a 0.1% error) which developed during a loading/unloading cycle. The calibration sheets are appended to this letter report.

Test Procedures

The tests were all performed following the applicable ASTM procedures (ASTM 2938, ASTM 2664, a modified version of ASTM 4767, and ASTM 5607). The specific procedures used at GTU are appended to this letter.

Test Results

The results of the testing program are summarized below. With the exception of the unconfined compressive strengths, all of the values require some interpretation of the plotted test results. The derived values presented in the summary tables below express one interpretation. Alternative approaches for deriving the rock properties are possible. The plots appended to this letter report should be referred to in evaluating the properties selected for these summary tables. In the case of the unconfined and triaxial test samples, the densities have been calculated from the measured sample dimensions and weights.

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Unconfined Compression Test Result Summary

Sample Number	Boring (Depth)	Description	Density (pcf)	E ($x10^3$psi)	ν	σ_{uc} (psi)
1	01-A (19.5')	Tan well cemented medium grained sandstone.	161.4	1,520	NR? (.08)	2888
2	01-A (24.5')	Tan medium grained sandstone	146.6	649	NR (.55)	1113
4	01-D (25.5')	Tan weak clayey medium grained sandstone.	142.3	75.8	.15	207
6	01-D (48.5')	Tan fine to medium grained dolomitic sandstone.	147.1	630	.30	959
9	01-G (28.8')	Tan fine grained dolomitic sandstone.	138.2	1,670	.18	3702
10	01-G (69.0')	Gray friable clayey medium grained sandstone.	130.7	15.2	NR (.03)	136
11	01-H (11.0')	Tan fine grained dolomitic sandstone.	138.9	1,090	.13	2434
12	01-H (52.5')	Tan fine grained dolomitic sandstone.	155.1	4,000	.33	10,252
14	01-CTF-A (8.8')	Gray fine to medium grained soft sandstone	128.8	3.5	.29	28.9
15	01-CTF-A (13.5')	Tan clayey friable medium grained sandstone.	138.3	119	.17	400
18	01-B (26.5')	Tan fine to medium grained (dolomitic?) sandstone.	147.3	2,330	.23	4778
19	01-B (38.0')	Tan medium grained sandstone.	132.4	206	.23	452
22	01-C (24.0')	Tan fine grained (dolomitic?) sandstone.	155.0	4,920	.23	4504
26	01-E (22.0')	Tan fine grained (dolomitic?) sandstone.	129.4	143	.20	437
28	01-E (49.0')	Tan fine grained (dolomitic?) sandstone.	135.8	850	.15	2958
30	01-F (57.6')	Light tan medium grained sandstone.	138.9	1,250	.20	2543
38	01-I (159.5')	Dark gray fine grained dolomitic sandstone.	144.2	794	.30	1834
39A	01-I (130.4')	Tan fine to medium grained sandstone.	140.3	NP	NP	505
40A	01-I (88.4')	Tan thinly bedded fine grained dolomitic sandstone.	142.0	2,140	.17	6373
42	01-I (44.0')	Tan fine grained dolomitic sandstone.	141.5	794	NR? (.10)	3504

Abbreviations:

NR - The values do not appear to be reasonable.

NP - The sample was so weak that the modulus test was not performed.

Triaxial Test Result Summary (conventional hard rock test procedure)

Sample Number	Boring (Depth)	Description	Density (pcf)	E ($x10^3$psi)	ν	C (psi)	ϕ (deg.)
3	01-A (35.5')	Gray medium grained weak friable sandstone.	145.3	33	NR	100	40
5	01-D (28.0')	Tan medium grained clayey weak sandstone.	144.5	63	NR? (.06)	170	26
13	01-H (57.0')	Gray clayey friable medium grained sandstone.	131.7	8.7	.16	95	22
17	01-CTF-A (53.8')	Gray clayey friable medium grained altered sandstone.	127.1	NP	NP	78	8
32	01-F (117.7')	Gray clayey friable soft fine to medium grained sandstone.	135.8	8.3	.32	90	6

Abbreviations:

NR - The values do not appear to be reasonable, or it was not possible to measure a value.
NP - The sample was so weak that the modulus test was not performed.

Notes:

Sample #27, Boring 01-E (41.2'), was too weak to perform a modulus test and it fell apart on trying to load the sample into the triaxial cell. Therefore there is no entry in this table for the sample.

Triaxial Test Result Summary (weak rock test procedure w/ pore pressure)

Sample Number	Boring (Depth)	Description	Density (pcf)	E ($x10^3$psi)	ν	C' (psi)	ϕ' (deg.)
7	01-D (55.5')	Tan clayey altered medium grained sandstone.	NM	NP	NP	17[1] 25	25 25
16	01-CTF-A (48.8')	Tan clayey friable altered medium grained sandstone.	133.2	60.6	.17	95	22
21	01-C (9.5')	Gray clayey friable medium grained sandstone.	132.5	NP	NP	26[2] 41	8 24
25	01-E (7.0')	Tan fractured and sheared weak clayey altered fine grained dolomitic sandstone.	135.8	NP	NP	22[3] 12	30 44

Abbreviations:

NP - The sample was so weak that the modulus test was not performed.
NM - The weight was not measured as the sample was too weak.

Notes:

1. The first set of c,ϕ values are at a strain of 3.0% and the second set of values are assessed at 5.3% strain.
2. The first set of c,ϕ values are at a strain of 2.8% and the second set of values are assessed at 4.7% strain.
3. The first set of c,ϕ values are at a strain of 1.7% and the second set of values are assessed at 3.4% strain.

Direct Shear Test Result Summary

Sample Number	Boring (Depth)	Description	S_j (psi)	ϕ (deg.)
20	01-B (48.8')	Slightly wavy contact between hard dolomite and soft clayey altered dolomite.	5.9 (i) 6.3 (f)	24.5 (i) 21.0 (f)
23	01-C (41.4')	Very thin gray clay coated slickensided joint in gray medium grained sandstone.	1.0 (i) 3.4 (f)	9.7 (i) 7.3 (f)
24	01-C (44.3')	Wavy lightly bonded joint with a thin tan clay coating in tan medium grained sandstone.	2.8 (i) 3.4 (f)	4.7 (i) 5.5 (f)
29	01-E (51.8')	Planar well mated bedding joint in tan fine to medium grained sandstone.	4.5 (i) 0.6 (f)	40.5 (i) 41.6 (f)
31	01-F (117.0')	Tan sandy soft clay seam (0.5-1.0" thick) in tan clayey fine to medium grained sandstone.	3.9 (i)[1] 4.7 (f)	0 (i) 0 (f)
33	01-F (118.3')	Gray clay seam (<0.05" thick) in gray weak clayey medium grained sandstone.	3.5 (i) 7.3 (f)	12.8 (i) 9.4 (f)
34	01-CTF-A (32.6')	Contact between tan sandy clay and tan clayey fine to medium grained sandstone.	5.8 (i)	29.3 (i)
35	01-H (94.5')	Dark gray clay filled irregular joint (0.1-0.4" thick) in gray clayey medium grained sandstone.	2.1 (i) 5.1 (f)	1.7 (i) 3.8 (f)
36	01-I (174.0')	Planar bedding joint in tan thinly bedded very fine grained dolomitic sandstone.	17.8 (i) 5.4 (f)	35.1 (i) 31.1 (f)
37	01-I (168.5')	Bedding plane joint in tan fine grained dolomitic sandstone, with a thin lamination and clay coating.	1.1 (i) 2.4 (f)	18.3(i) 17.8 (f)
39B	01-I (130.4')	Tan clay seam (0.1-0.2" thick) in tan fine grained dolomitic sandstone.	2.8 (i) 3.3 (f)	9.4 (i) 8.3 (f)
40B	01-I (88.8')	Planar bedding joint in tan fine grained dolomitic sandstone.	9.9 (i) 5.0 (f)	34.7 (i) 29.1 (f)
41A	01-I (45.6')	Tan clay seam about ¾ inch thick in tan fine grained sandstone.	4.4 (i) 4.3 (f)	19.8 (i) 15.3 (f)
41B	01-I (46.1')	Planar bedding joint in tan fine grained dolomitic sandstone.	6.7 (i) 1.6 (f)	44.0 (i) 36.4 (f)

Abbreviations:

i - Initial strength parameters.

f - Final strength parameters.

Notes:

1. - The sample strength actually decreased slightly with increasing normal stress.

Unconfined Compression Test Results

The strengths of these samples spanned a large range, from 28.9 psi to 10,252 psi. This range truly represents the large variation of sample competencies found in these samples, from weak plastic clayey altered sandstone to quite competent fine grained dolomitic sandstone. The sample strengths can somewhat arbitrarily be broken down into sub-categories as follows:

Number of Samples	Range of Strength (psi)	Moduli ($x10^3$ psi)	Poisson's Ratios
3	28.9-207	3.5, 15.2, 75.8	NR(.03), .15, .29
4	400-505	NP, 119, 143, 206	NP, .17, .20, .23
3	959-1834	630, 649, 794	.29, .30, .30
6	2434-3702	794, 850, 1090, 1250, 1520, 1670	NR(.08), NR(.10), .13, .15, .18, .20
2	4504-4778	2330, 4920	.23, .23
1	6373	2140	.17
1	10,252	4000	.33

It should be noted that this distribution of strengths may be skewed toward the high end due to sampling bias. Much of the core observed in the core boxes was quite fractured and clayey and often was highly disturbed. It was often difficult, if not impossible, to obtain representative samples of these weaker materials. On the other hand there were also quite a few lengths of competent core obtained from the drilling program which were overlooked for testing as they were not thought to be critical for slope stability design.

Conventional Triaxial Test Results

The samples selected for the conventional triaxial tests generally consisted of weaker rock. These samples were weak enough to exhibit quite plastic behavior. The range of moduli were well within the range of the range of those measured in the weakest grouping of the unconfined compression test results, indicating that the unconfined strengths were likely quite low. These soft samples generally exhibited strain hardening behavior. Except for Sample 5 which failed at a fairly low strain of about 1.5%, the other samples reached their peak strengths between about 3-6%. It may be that the strengths measured at these large strains are not appropriate for design as any structure supported on such a mass might not be able to sustain such large strains. In light of these considerations, the strength values reported in the summary table may need to be reduced.

Triaxial Test Results (weak rock procedure with pore pressure measurements)

These samples were generally the weakest of all of the samples. As such, great care was required to load the samples into the triaxial cell. Sample disturbance which would have been incurred by performing the modulus tests on these samples was thought to be so great that modulus testing was only performed on one of the four samples. It is interesting to note that the samples which was strong enough to allow modulus testing was also the only sample which exhibited quite standard stress-strain behavior with peak strengths being attained between 1.9 and 2.8% strain, with little strain hardening behavior. The other three samples exhibited prominent strain hardening behavior.

The strain hardening behavior made it difficult to establish any definitive strength for the samples, as no peak strengths were achieved. For these samples, a strain based failure analysis was performed. This analysis was developed for another PG&E project, Scott Dam, and a technical note detailing the approach is appended to this letter report.

The samples generally exhibited significant pore pressure increases during the tests. These pressures increased quite rapidly during the initial loading phase of each stage, and once the constant slope, strain hardening phase was entered, the pore pressure remained quite constant, although they did appear to decline slowly as the samples continued to strain harden.

The first strength measured for Sample 16 occurred unexpectedly soon, and as a result, the sample weakened slightly before the sample could be unloaded in preparation for the next stage. Therefore the two strengths in the subsequent stages are likely less than what one might measure on an undisturbed sample. Consequently, the later two Mohr circles for this sample may be a bit too small to represent the undisturbed strength of this sample. The true cohesion may be a little smaller, and the true friction angle may be a little bit higher than reported in the summary table.

The analysis of the Sample 21 test result presented a dilemma in that the last stage was characterized by a quite nonlinear hardening curve. This behavior is quite unusual and made it difficult to chose an appropriate linearization to represent the hardening during this stage. One choice has been made and the circles drawn accordingly. The change in c and ϕ, from one strain to another is quite extreme and is likely a consequence of this choice. One has a great deal of freedom in analyzing this test result, and this result may wish to be revised.

Direct Shear Test Results

These test results appear to fall into three categories. The clean bedding plane joints, Samples 29, 36, 40B, and 41B, all had quite high friction angles in the range of 34.7- 44.0° for initial values and 29.1-41.6° for final values. A group of four samples, Sample 20, 34, 37, and 41A, generally contained a fair amount of clay and had friction angles ranging from 18.3-29.3° for initial values and 15.3-21.0° for final values. The third category of samples had very low friction angles ranging from 0-2.8° for initial values to 0-9.4° for final values. All of these weakest joints were also coated with clay. The very low friction angles (three of the samples had friction angles less than 5.5°) were likely a result of the clay coatings being sheared in an undrained condition.

The most interesting test was that of Sample 31. This thick clay filled joint actually exhibited a "negative" friction angle. As the normal load was increased, the shear strength actually decreased. This decrease was not a manifestation of strain softening, as the test was repeated and the behavior was duplicated. Instead it is likely that the initial normal load was high enough to take the clay filling into a near plastic state. Under these lower normal loads, the clay could sustain some shear load. At higher normal loads, the clay likely became plastic and even a relatively small shear load was sufficient to result in plastic shear flow. It should be noted that following the test the clay in this joint was heavily deformed and for the most part had squeezed out of the joint.

The stress-displacement curve for Sample 34 is quite unusual. This irregular shape is not a real indication of the sample shear displacements, but is rather a manifestation of extreme shear box rotation and the positioning of the shear displacement transducer. The shear and normal stresses however are unaffected by the box rotations and they can still be used to derive the initial failure envelope.

Sincerely,

Anders Bro

Pergamon

Int. J. Rock Mech. Min. Sci. & Geomech. Abstr. Vol. 00, No. 0, pp. 000–000, 1996

0148-9062/96 $15.00 + 0.00

S0142-9062(96)00043-5

Technical Note

Analysis of Multistage Triaxial Test Results for a Strain-Hardening Rock

A. BRO†

INTRODUCTION

Some weak rocks appear to behave quite differently from conventional rocks in that failure is characterized by a significant amount of strain hardening. This behavior creates a problem if the results are to be interpreted using a conventional peak strength approach. An analysis is presented here which incorporates strain in the failure envelope. The final result of the data reduction is a relation between cohesion and strain, and friction angle and strain.

WEAK ROCK BEHAVIOR IN MULTISTAGE TRIAXIAL COMPRESSION

The procedure for performing a multistage test is to apply the first confining pressure, and then to steadily increase the axial load until the sample deforms plastically. The confining pressure is then increased and axial loading is resumed until the sample fails a second time. This procedure is repeated for as many stages as desired.

A typical stress–strain curve (Fig. 1) starts with a steep recoverable loading period (Section A). At some point, nonrecoverable deformations begin (Kinkpoint B) and the loading curve continues at a decreased, but fairly linear slope (Section C). The increase in the confining pressure occurs at Point D, after which the next loading cycle begins.

The initial slopes of the recoverable loading sections (e.g. Section A) appear to be fairly constant from one confining pressure to the next. On the other hand, the slopes of the post-kink stress–strain curves (e.g. Section C) appear to increase as the confining pressure increases. In addition, the post-kink slope appears to be fairly linear for the range of strains involved in these tests (< 5%). However, if a sample is taken to very large strain (10–20%) the slope tends to decrease and ultimately becomes horizontal.

In light of the strain dependent strength and the large strains required to reach ultimate strength, conventional data reduction techniques may be unsuitable for these test results. Instead, a method of reducing the data is proposed which accounts for the strain hardening. With this analysis in hand, an engineer has a rational approach for determining the material strength.

DEVELOPING A STRAIN HARDENING FAILURE ENVELOPE

The steep sections of the stress–strain curve are treated as elastic, and the post-kink sections (e.g. Section C) represent strain hardening failure. To develop a failure envelope for a strain hardening material, one needs to evaluate the material strength when subjected to two different confining pressures, but at the same strain. This requirement is not physically possible. Instead, a small extrapolation is used to arrive at the desired information. In numerous tests, the post-kink slope continues in a nearly linear manner for a large range of strains. Thus, it is not unreasonable to make a small extrapolation of Section C outward to a strain greater than the kink-point of the next test stage (e.g. to Point E). A vertical line can then be drawn which intersects the second stage results (Point F) and the first stage results (Point G). These two points represent the strength of the material at this one strain, but at two different confining pressures. Thus, one can develop a pair of Mohr circles (the solid circles in Fig. 2) and develop a C and ϕ for this one strain. One repeats the process, extending the stress–strain curve for the second stage to past the third stage kink-point strain, and develops another pair of Mohr circles (the dashed circles in Fig. 2) and a failure envelope which is representative of this larger strain. Finally, the resulting cohesions and friction angles are plotted as a function of strain (Fig. 3).

The accuracy of this analysis can be checked by recovering the original stress–strain curve from the C and ϕ vs strain plot. Two back calculated strengths have been plotted in Fig. 1 as heavy crosses. These strengths are obtained by: (1) determining the cohesion and friction angle for the desired strain; (2) calculating the effective axial stress at failure using the equation:

$$\sigma_1 = 2C\tan\left(45 + \frac{\phi}{2}\right) + \sigma_3\tan^2\left(45 + \frac{\phi}{2}\right)$$

†GeoTest Unlimited, 800 Peralta Avenue, San Leandro, CA 94577,

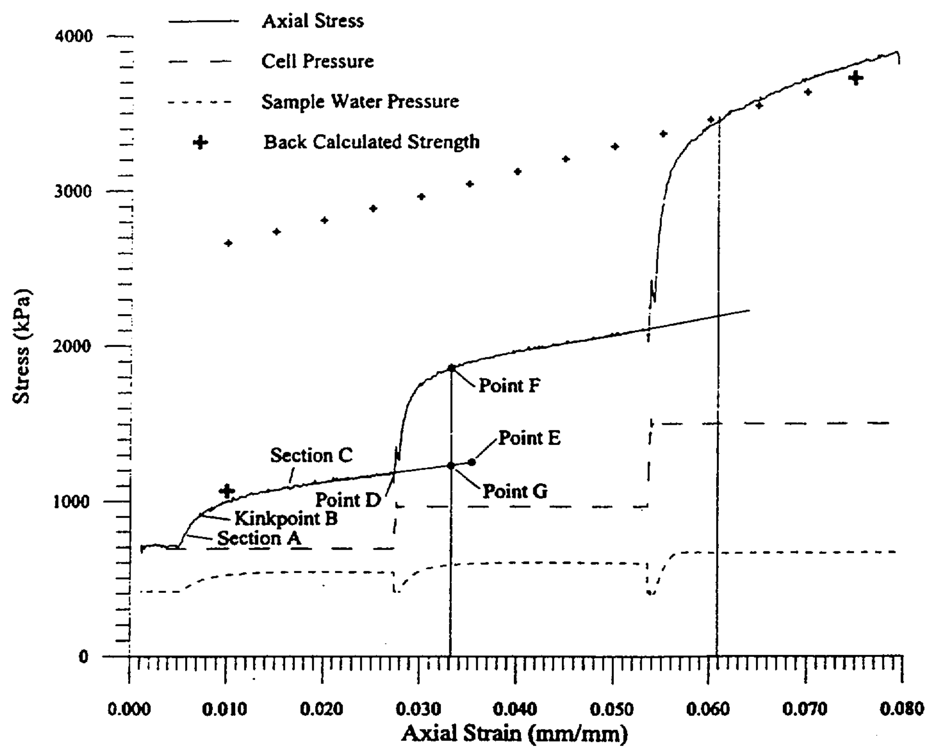
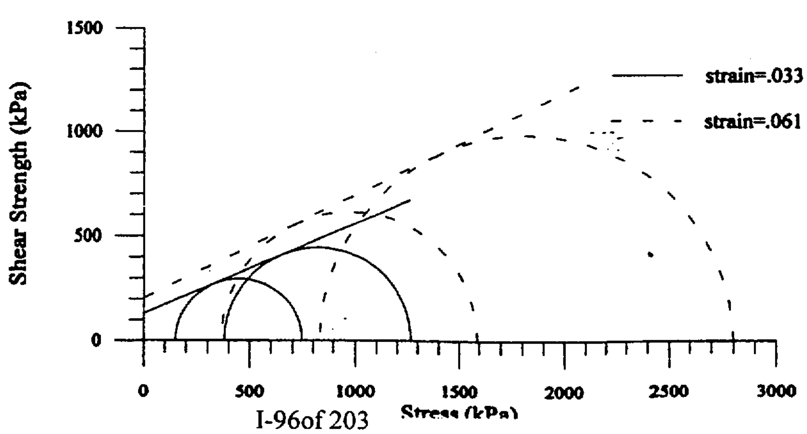


Fig. 1. Typical triaxial test result—axial stress, cell pressure and sample water pressure vs axial strain.

in which the confining pressure is the effective confining pressure; (3) adding the sample water pressure to arrive at the axial strengths as plotted in Fig. 1.

So, is the analysis any good? The two back calculated bold points appear to be somewhat representative of the sample strengths at two different confining pressures. But there seems to be a problem when the strength of the sample subjected to the highest confining pressure is projected backward to smaller strains (the small crosses in Fig. 1). This curve has a slight upward concavity, which is contrary to the expected behavior. One would expect the slope of the stress–strain to decrease with increasing strain. Despite these small inconsistencies, the results are quite reasonable considering that the analysis is based on only four points extracted from the stress–strain curve. The deviations from the measured strengths are likely due to the linear approximation of the strain hardening process. In fact, these post-kink slopes gradually decrease with strain. It should be possible to more accurately account for these nonlinearities using a four stage test. A second order relation could then be developed between the cohesion and strain, and the friction angle and strain using the strengths measured at three different strains. This refinement would increase the accuracy of the analysis, but make it more complicated and unwieldy. (Also, such refinements might not be warranted in light of the highly variable nature of these weak rocks.)



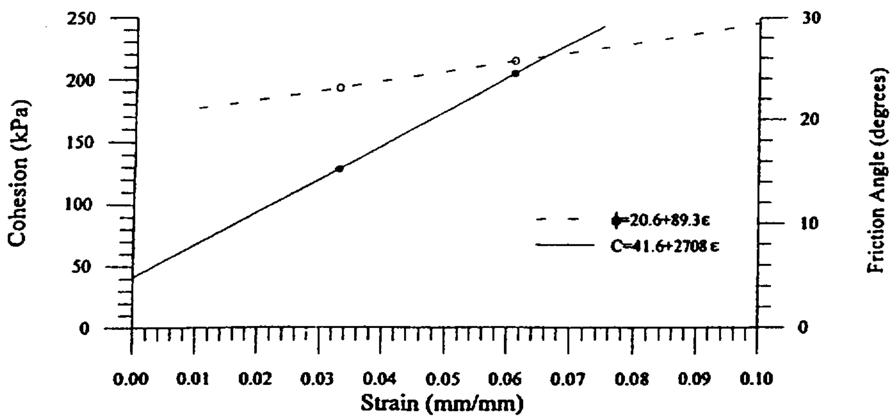


Fig. 3. Cohesion and friction angle as functions of strain.

POSSIBLE EXPLANATION FOR THE SAMPLE BEHAVIOR

Whereas homogeneous rocks tend to result in either elastic–plastic or elastic–brittle behavior, these strain hardening rocks consist of a highly heterogeneous mixture of weak and strong components. The weak rock could be thought of as a hard skeleton (comprised of relatively hard rock chips, layers and rounded aggregate) surrounded by a weak clayey matrix. As the sample begins to be loaded, the stiffer skeleton sustains the majority of the load, and the sample behaves in an elastic manner. As the load increases further, the contacts between the skeleton members exceed their shear strength and tend to slide, resulting in the start of plastic deformation. As sliding develops on the contacts, the skeleton is constrained by the weak matrix. The weak matrix starts to become stressed and the contacts come to a new state of equilibrium. As the sample is loaded further, the skeletal contacts are remobilized. As a larger proportion of the weak matrix constrains the contacts, the strengths of the skeletal contacts increase, thus resulting in a strain hardening behavior. After a large amount of strain, all of the matrix is mobilized to a fully plastic state, and can no longer constrain the skeleton. Subsequently, the sample becomes perfectly plastic, or possibly weakens as it starts to break apart.

One of the implications of this hypothetical mechanism of deformation is that it may be difficult to develop a model material with strain hardening behavior which would be suitable for performing parametric laboratory studies. If this model of weak rock is valid, the structure of the strong skeleton may prove to be just as important as the relative proportion of the weak and strong components. The difficulty may come in trying to replicate this skeletal structure.

USING A STRAIN HARDENING ENVELOPE FOR THE ANALYSIS OF STRUCTURES

Conventional limit analyses are generally based on the ultimate strength of the rock. For materials such as those discussed here, such an approach would be inappropriate. A structure would likely fail before the foundation materials could reach the large strains which accompany their ultimate strength. Thus, some strength less than the ultimate strength would be more suitable for design. The question is what should that strength be? Another, possibly more tractable approach is to ask the question of how much strain can be accommodated by the structure, and consequently the maximum strain which the ground can be allowed to sustain. Once this assessment is made, the rock strength parameters can be determined. One advantage of this approach is that the analysis could be confirmed directly with field measurements of displacement (as opposed to inferred stress measurements) as the structure is being constructed and after it is in-service.

Acknowledgements—I would like to thank Richard E. Goodman, as well as Bob McManus and those in his group at Pacific Gas & Electric for their friendly help and discussions during the testing program when some of these ideas were developed.

Accepted for publication 14 July 1996

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Geo Test Unlimited

Date: 12-15-00
Technician: A. Bro
Temperature: 22°C

LOAD CELL CALIBRATION SHEET
(in-system calibration)

Load Cell Mfg: Lebow Capacity: 2000 (lb) Model #: 3169 Serial #: 4657 (NORMAL LOAD)
Signal Conditioner Mfg: Daytronics Model #: 9187A Serial #: –
Data Acquisition System Mfg: Computer Boards, Inc. Model #: CIO-DAS 1600 Serial #: none
Input Range: Bipolar 5V Software Calibration Factor: 400 (lb/V)
Shunt Calibration Resistor: ______ (ohms) Equivalent Load: 1513 (lb) old NEW: 1493 lb
Reference Proving Ring Mfg: Morehouse Range: 20,000 lb Series #: S100 Serial #: 892
Reference Calibration Date: August 3, 1995 Reference "ASTM Uncertainty" (2.4xStd. Dev.): 7.17lb

Proving Ring Deflection: $D = -0.1184 + 0.01786L + 1.451x10^{-8}L^2$
Proving Ring Temp. Correction: $D_{23} = D_t - 0.00027(T-23)D_t$

Load Cell Readings ±.5 lb (lb)	Proving Ring Reading ±.1 (divisions)	Proving Ring Deflection (measured/corrected) (divisions)	Proving Ring Load (lb)	Error (lb)
0	6.7	0	0	0
213	10.3	3.6	208	+5
409	13.9	7.2	410	-1
602	17.3	10.6	600	+2
802	20.8	14.1	796	+6
1001	24.2	17.5	986	+15
1201	27.8	21.1	1187	+14
1401	31.3	24.6	1382	+19
1599	34.8	28.1	1578	+21
1799	38.3	31.6	1773	+26
1974	41.4	34.7	1946	+28
1799	38.3	31.6	1773	+26
1601	34.9	28.2	1583	+28
1398	31.4	24.7	1388	+10
1198	27.8	21.1	1187	+11
990	24.1	17.4	980	+10
798	20.8	14.1	796	+2
602	17.3	10.6	600	+2
399	13.8	7.1	404	-5
199	10.3	3.6	208	-9
0	6.8	.1	6	-6

shunt range

Comments:
note that .1 div. is difficult to discern on the proving ring so there is really a confidence of ± 6 lb or 12 lb total uncertainty. However the trend in the error is consistant and the amplifier gain should be reduced so that with the shunt calibration should read about 20 lb less, or 1493 lb

27069 N. Bloomfield Rd., Nevada City, CA 95959 Tel/Fax (530)470-0583 email: abro@mindspring.com

Geo Test Unlimited

Date: 12-15-00
Technician: A.Bro
Temperature: 22°C

LOAD CELL CALIBRATION SHEET
(in-system calibration)

Load Cell Mfg: Lebow Capacity: 2000 (lb) Model #: 3169 Serial #: 4661 (SHEAR LOAD)
Signal Conditioner Mfg: Daytronics Model #: 9187A Serial #: —
Data Acquisition System Mfg: Computer Boards, Inc. Model #: CIO-DAS 1600 Serial #: none
Input Range: Bipolar 5V Software Calibration Factor: 400 (lb/V)
Shunt Calibration Resistor: — (ohms) Equivalent Load: 1473 (lb)
Reference Proving Ring Mfg: Morehouse Range: 20,000 lb Series #: S100 Serial #: 892
Reference Calibration Date: August 3, 1995 Reference "ASTM Uncertainty" (2.4xStd. Dev.): 7.17lb

Proving Ring Deflection: $D = -0.1184 + 0.01786L + 1.451x10^{-8} L^2$
Proving Ring Temp. Correction: $D_{23} = D_t - 0.00027(T-23)D_t$

Load Cell Readings ±.5lb (lb)	Proving Ring Reading ±.1 (divisions)	Proving Ring Deflection (measured/corrected) (divisions)	Proving Ring Load (lb)	Error (lb)
0	6.8	0	0	0
203	10.4	3.6	208	-5
401	14.0	7.2	410	-9
608	17.6	10.8	611	-3
802	21	14.2	801	+1
999	24.7	17.9	997	+2
1197	28.1	21.3	1198	-1
1407	31.9	25.1	1410	-3
1600	35.4	28.6	1606	-6
1800	39.0	32.2	1807	-7
1980	42.2	35.4	1985	-5
1800	39.0	32.2	1807	-7
1598	35.4	28.6	1606	-8
1394	31.8	25.0	1404	-10
1199	28.2	21.4	1203	-4
989	24.5	17.7	997	-8
795	21.0	14.2	801	-6
597	17.5	10.7	605	-8
399	14.0	7.2	410	-11
190	10.2	3.4	197	-7
0	6.8	0	0	

Comments:
3 load cycles prior to calib run.
Amplifier gain is OK.

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Geo Test Unlimited

Date: 12-15-00
Technician: A. Bro
Temperature: 24°C

LOAD CELL CALIBRATION SHEET
(in-system calibration)

Load Cell Mfg: InterFace Capacity: 10,000 (lb) Model #: 1210A0-10K Serial #: 68854
Signal Conditioner Mfg: Daytronics Model #: 9187A Serial #: —
Data Acquisition System Mfg: Computer Boards, Inc. Model #: CIO-DAS 1600 Serial #: none
Input Range: Bipolar 5V Software Calibration Factor: 2000 (lb/V)
Shunt Calibration Resistor: — (ohms) Equivalent Load: 3572 (lb)
Reference Proving Ring Mfg: Morehouse Range: 20,000 lb Series #: S100 Serial #: 892
Reference Calibration Date: August 3, 1995 Reference "ASTM Uncertainty" (2.4xStd. Dev.): 7.17lb

Proving Ring Deflection: $D = -0.1184 + 0.01786L + 1.451x10^{-8} L^2$
Proving Ring Temp. Correction: $D_{23} = D_t - 0.00027(T-23)D_t$ (max. correction = .04 ∴ not used)

Load Cell Readings ±2lb (lb)	Proving Ring Reading ±.1 (divisions)	Proving Ring Deflection (measured/corrected) (divisions)	Proving Ring Load (lb)	Error (lb)
0	6.8	0	0	0
1010	24.8	18	1014	-4
2000	42.7	35.9	2013	-13
3012	60.7	53.9	3017	-5
4026	79.0	72.2	4036	-10
5025	97.0	90.2	5036	-11
6028	114.9	108.1	6030	-2
7008	132.6	125.8	7010	-2
8030	151.0	144.2	8028	+2
9017	168.9	162.1	9017	0
7931	149.1	142.3	7923	+8
6992	132.2	125.4	6988	+4
5997	114.2	107.4	5991	+6
5008	96.5	89.7	5009	-1
4012	78.5	71.7	4008	+4
2968	59.9	53.1	2972	-4
2000	42.6	35.8	2008	-8
997	24.6	17.8	1002	-5
0	6.9	.1	6	-6

Comments:
cal. after 2 load cycles
Amplifier gain is OK

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Geo Test Unlimited

Date: 12/15/00
Technician: A.Bro
Temperature: 75°F = 24°C

LOAD CELL CALIBRATION SHEET
(in-system calibration)

Load Cell Mfg: Interface Capacity: 50,000 (lb) Model #: 1221A0 Serial #: 59767
Signal Conditioner Mfg: Daytronics Model #: 9187A Serial #: –
Data Acquisition System Mfg: Computer Boards, Inc. Model #: CIO-DAS 1600 Serial #: none
Input Range: Bipolar 5V Software Calibration Factor: 10,000 (lb/V)
Shunt Calibration Resistor:________(ohms) Equivalent Load: 17695 (lb)
Reference Proving Ring Mfg: Morehouse Range: 20,000 lb Series #: S100 Serial #: 892
Reference Calibration Date: August 3, 1995 Reference "ASTM Uncertainty" (2.4xStd. Dev.): 7.17lb

Proving Ring Deflection: $D = -0.1184 + 0.01786L + 1.451x10^{-8}\,L^2$
Proving Ring Temp. Correction: $D_{23} = D_t - 0.00027(T-23)D_t$

Load Cell Readings ± 10lb (lb)	Proving Ring Reading (divisions)	Proving Ring Deflection (measured/corrected) (divisions)	Proving Ring Load (lb)	Error (lb)
0	7.3	0	0	0
2000	43	35.7	2002	-2
4030	79.5	72.2	4036	-6
6000	114.7	107.4	5991	+9
8000	150.6	143.3	7978	+22
10,020	187.4	180.1	10009	+11
12,050	224.4	217.1	12044	+6
14,020	260.2	252.9	14007	+13
16,010	296.8	289.5	16007	+3
18,030	333.7	326.4	18018	+12
19,040	352.5	345.2	19040	0
17,930	332.1	324.8	17931	-1
16,010	296.8	289.5	16007	+3
14,000	259.8	252.5	13985	+15
12,000	223.2	215.9	11978	+22
9990	186.7	179.4	9970	+20
8020	151.1	143.8	8006	+14
5930	113.3	106.0	5913	+17
4030	79.3	72.0	4025	+5
2010	43.1	35.8	2008	+2
0	7.2	-.1	-6	+6

Comments:
3 load cycles to 19 kips before cal. run
Amplifier gain is Fine

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Geo Test Unlimited

Date: 12-16-00
Technician: A. Bro
Temperature: 21°C

PRESSURE TRANSDUCER CALIBRATION SHEET
(in-system calibration)

Transducer Mfg: Victran Capacity: 200 (psi) Model #: 104 Serial #: 211544
Signal Conditioner Mfg: Daytronics Model #: 9187A Serial #: —
Data Acquisition System Mfg: Computer Boards, Inc. Model #: CIO-DAS 1600 Serial #: none
Input Range: Bipolar 5V Software Calibration Factor: 40 (psi/V)
Shunt Calibration Resistor: — (ohms) Equivalent Load: — (psi)
Reference Gauge Mfg: Heise Range: 300 psi Model #: 12" Serial #: C-56764
Reference Calibration Date: 6-19-95

Transducer Reading ±.2 (psi)	Reference Reading ±.2 (psi)	Error (psi)
0	0.5	
20.0	20.0	
40.1	40.0	
67.0	67.0	
79.7	79.5	
104	104.0	
121.9	121.9	
142.3	142.3	
160.9	160.8	
180.2	180.4	
160.5	160.5	
141.0	141.0	
120.0	120.0	
100.5	100.5	
79.6	79.5	
61.1	61.0	
40.5	40.5	
19.9	19.9	
0	0.5	

Comments:

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Geo Test Unlimited

Date: 5/4/01
Technician: A. Bro
Temperature: 16°C

PRESSURE TRANSDUCER CALIBRATION SHEET
(in-system calibration)

Transducer Mfg: Viatran Capacity: 500 (psi) Model #: 104 Serial #: 211543
Signal Conditioner Mfg: Daytronics Model #: 9187A Serial #:
Data Acquisition System Mfg: Computer Boards, Inc. Model #: CIO-DAS 1600 Serial #: none
Input Range: Bipolar 5V Software Calibration Factor: 100 (psi/V)
Shunt Calibration Resistor: — (ohms) Equivalent Load: — (psi)
Reference Gauge Mfg: Heise Range: 300 psi Model #: 12" Serial #: C 56764
Reference Calibration Date: 6-19-96

elect. noise → ±.2 psi

Transducer Reading, ±.2 psi (psi)	Reference Reading (psi)	Error (psi)
0	0	0
290.1	290	+.1
252.2	252	+.2
203.3	203	+.3
151.4	151	+.4
101.0	100.7	+.3
50.3	50.3	0
0	0	0

Comments:

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Geo Test Unlimited

Date: 12-16-00
Technician: A. Bro
Temperature: 19°C

LVDT CALIBRATATION SHEET
(in-system calibration)

LVDT Mfg: Schaevitz Model #: PCA-220-100 Serial #: 7449
Signal Conditioner Mfg: Daytronics Model #: 9130 Serial #: —
Data Acquisition System Mfg: Computer Boards, Inc. Model #: CIO-DAS 1600
Serial#: none
Input Range: Bipolar 5V Software Calibration Factor: 1 (in/V)
Micrometer: Mitutoyo Model #: 350-711-10 Serial #: 109105
Precision: 0.00005 inches Calibration Date: none

Micrometer Readings (in.)	LVDT Readings (Volts)	Linearized Reading (in)	Error (in)
0	-5.000		
.02	-3.958		
.04	-2.926		
.06	-1.893		
.08	-.855		
.10	+.186		
.12	+1.224		
.14	2.259		
.16	3.291		
.18	4.329		
.192	4.958		
.18	4.326		
.16	3.290		
.14	2.256		
.12	1.223		
.10	+.184		
.08	-.857		
.06	-1.896		
.04	-2.929		
.02	-3.957		

0 -5.000

Comments

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Geo Test Unlimited (GTU)

Date: 12-16-00
Technician: A. Bro
Temperature: 18°c

LVDT CALIBRATATION SHEET
(in-system calibration)

LVDT Mfg: Schaevitz   Model #: PCA-220-100   Serial #: 7429
Signal Conditioner Mfg: Daytronics   Model #: 9130   Serial #: —
Data Acquisition System Mfg: Computer Boards, Inc.   Model #: CIO-DAS 1600
Serial#: none
Input Range: Bipolar 5V   Software Calibration Factor: 1 (in/V)
Micrometer: Mitutoyo   Model #: 350-711-10   Serial #: 109105
Precision: 0.00005 inches   Calibration Date: none

Micrometer Readings (in.)	LVDT Readings (Volts)	Linearized Reading (in)	Error (in)
0	-4.993		
.02	-4.042		
.04	-3.060		
.06	-2.050		
.08	-1.023		
.10000	-.014		
.12	+1.030		
.14	+2.045		
.16	3.049		
.18	4.039		
.19900	4.969		
.18	4.037		
.16	3.045		
.14	2.043		
.12	1.028		
.10	+.014		
.08	-1.023		
.06	-2.052		
.04	-3.060		
.02	-4.041		
0	-4.991		

Comments

electronics reconfigured (adjusted) after initial cal. run. The readings above are taken after the adjustment.

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Geo Test Unlimited

Date: 12-16-00
Technician: A. Bro
Temperature: 18°C

LVDT CALIBRATATION SHEET
(in-system calibration)

LVDT Mfg: Schaevitz Model #: PCA-220-100 Serial #: 7471
Signal Conditioner Mfg: Daytronics Model #: 9130 Serial #: —
Data Acquisition System Mfg: Computer Boards, Inc. Model #: CIO-DAS 1600
Serial#: none
Input Range: Bipolar 5V Software Calibration Factor: 1 (in/V)
Micrometer: Mitutoyo Model #: 350-711-10 Serial #: 109105
Precision: 0.00005 inches Calibration Date: none

Micrometer Readings (in.)	LVDT Readings (Volts)	Linearized Reading (in)	Error (in)
0	-4.996		
.02	-3.984		
.04	-2.980		
.06	-1.972		
.08	-.959		
.10000	+.058		
.12	+1.067		
.14	2.071		
.16	3.078		
.18	4.084		
.197	4.958		
.18	4.082		
.16	3.075		
.14	2.071		
.12	1.064		
.10	+.057		
.08	-.960		
.06	-1.973		
.04	-2.981		
.02	-3.984		
0	-4.995		

Comments

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Geo Test Unlimited (GTU)

Date: 12-16-00
Technician: A. Bro
Temperature: 18°C

LVDT CALIBRATATION SHEET
(in-system calibration)

LVDT Mfg: Schaevitz Model #: PCA-220-100 Serial #: 7443
Signal Conditioner Mfg: Daytronics Model #: 9130 Serial #: —
Data Acquisition System Mfg: Computer Boards, Inc. Model #: CIO-DAS 1600
Serial#: none
Input Range: Bipolar 5V Software Calibration Factor: 1 (in/V)
Micrometer: Mitutoyo Model #: 350-711-10 Serial #: 109105
Precision: 0.00005 inches Calibration Date: none

Micrometer Readings (in.)	LVDT Readings (Volts)	Linearized Reading (in)	Error (in)
0	-4.997		
.02	-3.978		
.04	-2.978		
.06	-1.978		
.08	-0.976		
.10000	+ .033		
.12	1.035		
.14	2.038		
.16	3.040		
.18	4.043		
.195	4.801		
.18	4.039		
.16	3.036		
.14	2.037		
.12	1.034		
.10	.029		
* .08	-1.008		
.06	-2.013		
.04	-3.010		
.02	-4.010		

.00065 - 4.991

Comments

* put down LVDT - slight shift in position of body relative to micrometer

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Geo Test Unlimited GTU

Date: 12-16-00
Technician: A.Bro
Temperature: 17°C

LVDT CALIBRATATION SHEET
(in-system calibration)

LVDT Mfg: Schaevitz Model #: PCA-220-100 Serial #: 7421
Signal Conditioner Mfg: Daytronics Model #: 9130 Serial #: —
Data Acquisition System Mfg: Computer Boards, Inc. Model #: CIO-DAS 1600
Serial#: none
Input Range: Bipolar 5V Software Calibration Factor: 1 (in/V)
Micrometer: Mitutoyo Model #: 350-711-10 Serial #: 109105
Precision: 0.00005 inches Calibration Date: none

Micrometer Readings (in.)	LVDT Readings (Volts)	Linearized Reading (in)	Error (in)
0	-4.999		
.02000	-3.992		
.04	-2.994		
.06	-1.994		
.08	-.985		
.10000	+.025		
.12	1.033		
.14	2.039		
.16	3.038		
.18	4.037		
.19900	4.998		
.18	4.035		
.16	3.035		
.14	2.035		
.12	1.030		
.10	.027		
.08	-.987		
.06	-1.994		
.04	-2.993		
.02	-3.987		
0	-4.990		

Comments

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Geo Test Unlimited

Date: 12-15-00
Technician: A. Bro
Temperature: 22°C

LVDT CALIBRATATION SHEET
(in-system calibration)

LVDT Mfg: Schaevitz   Model #: LBB 375-TA-1001   Serial #: — load frame LVDT
Signal Conditioner Mfg: Daytronics   Model #: 9130   Serial #: —
Data Acquisition System Mfg: Computer Boards, Inc.   Model #: CIO-DAS 1600
Serial#: none
Input Range: Bipolar 5V   Software Calibration Factor: 1 (in/V)
Micrometer: Mitutoyo   Model #: 350-711-10   Serial #: 109105
Precision: 0.00005 inches   Calibration Date: none

Micrometer Readings (in.)	LVDT Readings (Volts)	Linearized Reading (in)	Error (in)
.0	4.988		
.02	3.992		
.04	2.992		
.06	1.984		
.08	0.984		
.10	+.002		
.12	-.987		
.14	-1.987		
.16	-2.994		
.18	-3.994		
.20	-4.983		
.18	-3.994		
.16	-2.991		
.14	-1.985		
.12	-.986		
.10	-.004		
.08	+.984		
.06	+1.982		
.04	2.989		
.02	3.991		
0	4.985		

Comments

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Geo Test Unlimited

Date: 12-15-00
Technician: A. Bro
Temperature: 22°C

LVDT CALIBRATATION SHEET
(in-system calibration)

LVDT Mfg: TransTek Model #: 303-000 Serial #: L-2B
Signal Conditioner Mfg: Daytronics Model #: 9130 Serial #: —
Data Acquisition System Mfg: Computer Boards, Inc. Model #: CIO-DAS 1600
Serial#: none
Input Range: Bipolar 5V Software Calibration Factor: 1 (in/V)
Micrometer: Mitutoyo Micrometer Head
Precision: 0.0001 inches Calibration Date: none

Micrometer Readings (in.)	LVDT Readings (Volts)	Linearized Reading (in)	Error (in)
1.0000	-4.962		
.9000	-3.974		
.8	-2.988		
.7	-1.993		
.6	-0.985		
.5	+0.029		
.4	1.040		
.3	2.046		
.2	3.044		
.1	4.034		
.005	4.975		
.1	4.037		
.2	3.047		
.3	2.051		
.4	1.045		
.5	+0.034		
.6	-0.981		
.7	-1.989		
.8	-2.984		
.9	-3.974		
1.0000	-4.965		

Comments

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Geo Test Unlimited

DATA SHEET
Unconfined Compression Test of Rock (ASTM D2938)

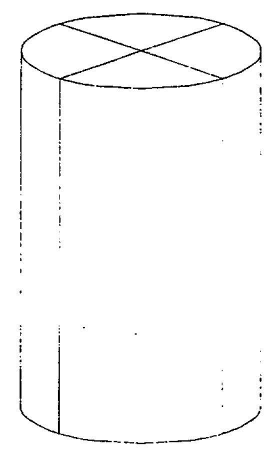
Date: 4/29/01
Technician: A.Bro

Client: W. Lettis & Assoc.
Job: #131- DCPP/ISFSI
Sample ID: #1- Boring 101-A
Sample Description: Tan, well cemented medium grained sandstone with numerous dolomite (?) healed fractures

Sample Depth: 19.5'   Sample Condition: received & tested moist

d_1	d_2
2.373	2.377
2.372	2.377
2.371	2.375
2.370	2.376
2.369	2.379

l_1	l_2
+.0013	+.0002
+.0006	
±.0001	±.0002
+.0010	
+.0017	-.0002

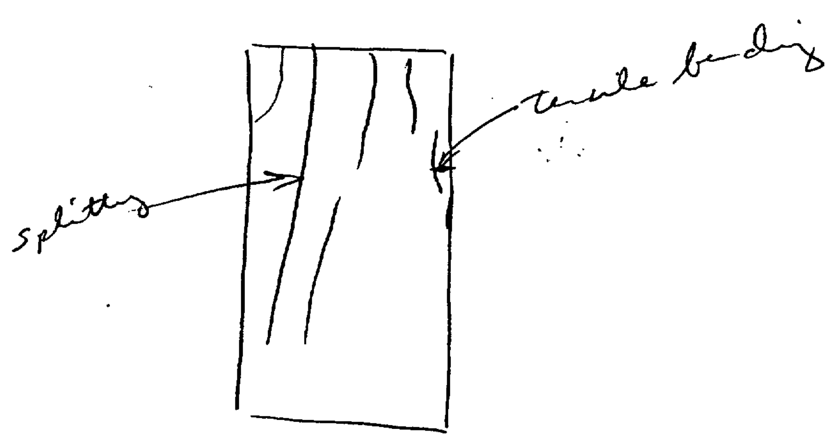


Avg. diameter : 2.374
Sample area : 4.426
Sample volume(in^3) : 23.177
Sample weight (g) : 981.98
Density : 42.37 g/in³ = 161.4 pcf   (1 g/in³=3.8095lb/ft³)
Gauge Length: 2.000 in

Avg. length : 5.236
l/d ratio : 2.21

Comments: During E test, the radius became smaller ≥ 3 micro-in! in 1 dimension during "elastic" loading - likely due to internal rock structure.

UC = Failed by axial splitting



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Geo Test Unlimited

DATA SHEET
Unconfined Compression Test of Rock (ASTM D2938)

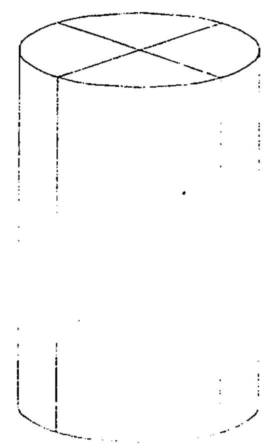
Date: 5/12 & 13/01
Technician: A. Bro

Client: W. Lettis & Assoc.
Job: #131- DCPP/ISFSI
Sample ID: # 2 Boring 01-A
Sample Description: Tan medium grained massive sandstone.

Sample Depth: 24.5' Sample Condition: received & tested moist

d_1	d_2
2.379	2.371
2.378	2.370
2.375	2.368
2.374	2.368
2.374	2.374

l_1	l_2
+.0002	+.0020
+.0001	+.0006
±.0001	±.0002
-.0001	-.0005
-.0003	-.0008



Avg. diameter : 2.373 Avg. length : 5.365
Sample area : 4.422 l/d ratio : 2.26
Sample volume(in³) : 23.728
Sample weight (g) : 913.38
Density : 38.49 g/in³ = 146.6 pcf (1 g/in³=3.8095lb/ft³)
gage length : 2.000"

Comments: mod test $\epsilon_{r_2} \approx 3 \times \epsilon_{r_1}$ (plastic strain)
Failed by axial splitting & crushing at one end

Crushed

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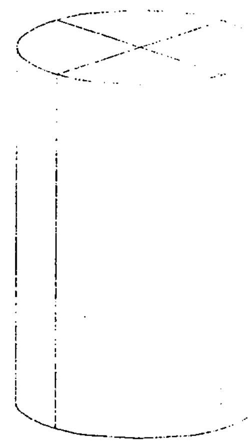
Geo Test Unlimited (GTU)

DATA SHEET
Unconfined Compression Test of Rock (ASTM D2938)

Date: 5/12 & 13/01
Technician: A. Bro

Client: W. Lettis & Assoc.
Job: #131 - DCPP/ISFSI
Sample ID: #4 Boring: 01-D
Sample Description: Tan medium grained sandstone (weak clayey)

Sample Depth: 25.5'   Sample Condition: received & tested moist

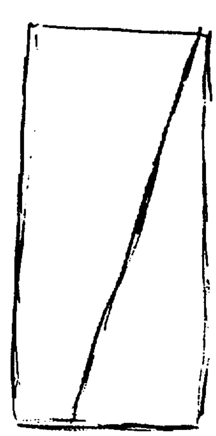


d_1	d_2
2.247	2.232
2.252	2.238
2.248	2.242
2.251	2.249
2.250	2.248

l_1	l_2
+.0025	+.0018
+.0012	+.0007
±.0002	±.0001
-.0006	-.0002
-.0012	-.0004

Avg. diameter : 2.246   Avg. length : 5.446"
Sample area : 3.962   l/d ratio : 2.42
Sample volume(in^3) : 21.577
Sample weight (g) : 806.2 g
Density : 37.36 g/in^3 = 142.3 pcf   (1 g/in^3=3.8095 lb/ft^3)
gauge length: 2.000"

Comments: mod $E_{a_1} \approx 2\times E_{a_2}$ 1st cycle ... 1st part of unloading cycle?
note creep on 3rd unloading cycle
1st Failure by axial split/shear



Geo Test Unlimited

DATA SHEET
Unconfined Compression Test of Rock (ASTM D2938)

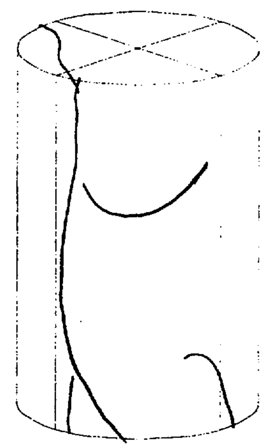
Date: 4/29/01
Technician: A. Bro

Client: W. Lettis & Assoc.
Job: #131- DCPP/ISFSI
Sample ID: #6- Boring: 01-D
Sample Description: Tan Fine to medium grained dolomitic sandstone with one axial fracture and one diagonal joint ~ 32° to the core axis.

Sample Depth: 48.5' Sample Condition: received & tested moist

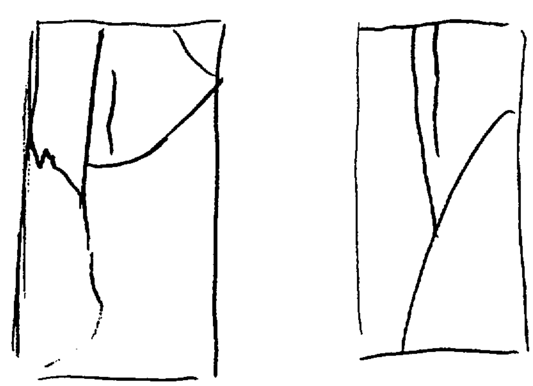
d_1	d_2
2.349	2.351
2.353	2.353
2.355	2.356
2.354	2.355
2.352	2.353

l_1	l_2
+.0003	+.0007
+.0002	+.0002
±.0001	±.0002
-.0002	-.0004
-.0006	-.0008



Avg. diameter : 2.353 Avg. length : 5.352
Sample area : 4.348 l/d ratio :
Sample volume(in^3) : 23.273 i^3
Sample weight (g) : 898.4g
Density : 38.60g/in³ = 147.1pcF (1 g/in³=3.8095lb/ft³)
Gauge Length (modulus): 2.000 in

Comments: Failed by shear on existing joints



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Geo Test Unlimited (GTU)

DATA SHEET
Unconfined Compression Test of Rock (ASTM D2938)

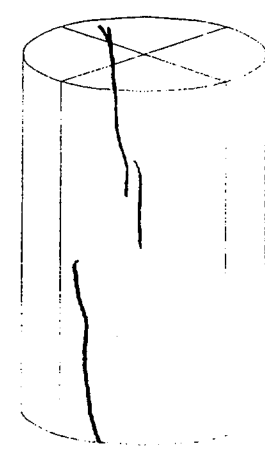
Date: 4/29/01
Technician: A. Bro

Client: W. Lettis & Assoc.
Job: #131- DCPP/ISFSI
Sample ID: #9 Boring: 01-G
Sample Description: Tan finegrained dolomitic sandstone with two axial fractures.

Sample Depth: 28.8'   Sample Condition: received & tested moist

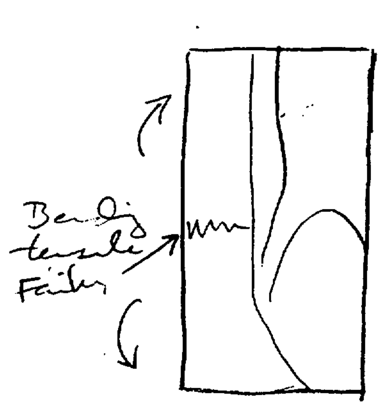
d_1	d_2
2.395	2.394
2.396	2.398
2.390	2.393
2.393	2.398
2.400	2.401

l_1	l_2
+.0009	0
+.0004	0
±.0001	±.0001
-.0002	0
-.0005	0



Avg. diameter: 2.396   Avg. length: 5.056
Sample area: 4.509   l/d ratio: 2.11
Sample volume(in³): 22.797
Sample weight (g): 826.98
Density: 36.27 g/in³ = 138.2 pcf (1 g/in³=3.8095lb/ft³)
Gauge Length (modulus): 2.000 in.

Comments: initial unloading* in mod. probably due to gauge
Failed by axial splitting along existing axial fractures



Petroleum smell: note slightly darkened vertical joint ...? petroleum ?

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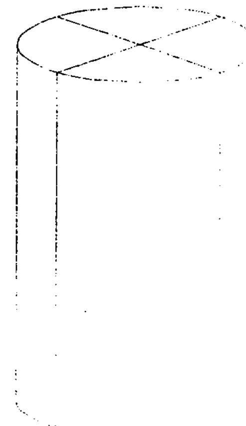
Geo Test Unlimited

DATA SHEET
Unconfined Compression Test of Rock (ASTM D2938)

Date: 5/12-13/01
Technician: A. Bro

Client: W. Letts & Assoc.
Job: #131-DCPP/ISFSI
Sample ID: #10 Boring 01-G
Sample Description: Grey, Friable clayey medium grained sandstone.

Sample Depth: 69.0'   Sample Condition: received & tested moist



d_1	d_2
2.464	2.456
2.448	2.438
2.450	2.440
2.436	2.445
2.439	2.440

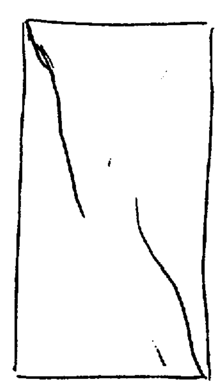
l_1	l_2
0	+.0015
	+.0010
±.0005	±.0005
	-.0010
0	-.0025

Avg. diameter : 2.446
Sample area : 4.699
Sample volume(in^3) : 25.680
Sample weight (g) : 881.3g
Density : 34.32 g/in³ = 130.7 pcf (1 g/in³=3.8095lb/ft³)

Avg. length : 5.465
l/d ratio : 2.23

gauge length: 2.000"

Comments: HUGE strain to failure!
Failed by shear/axial splitting



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DATA SHEET
Unconfined Compression Test of Rock (ASTM D2938)

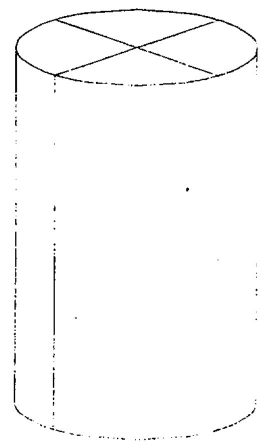
Date: 5/13/01
Technician: A. Bro

Client: W. Letts & Assoc.
Job: #131 - DCPP/ISFSI
Sample ID: #11 Boring: 01-H
Sample Description: Tan fine grained dolomitic sandstone

Sample Depth: 11.0'   Sample Condition: received & tested - moist

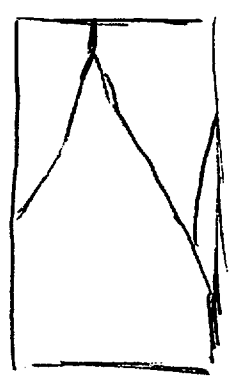
d_1	d_2
2.300	2.304
2.316	2.320
2.322	2.324
2.361	2.364
2.378	2.368

l_1	l_2
+.0008	+.0004
+.0003	+.0002
±.0003	±.0003
-.0002	-.0002
-.0004	-.0004



Avg. diameter: 2.336   Avg. length: 5.310
Sample area: 4.286   l/d ratio: 2.27
Sample volume(in^3): 22.758
Sample weight (g): 829.58
Density: 36.45 g/in³ = 138.9 pcf (1 g/in^3=3.8095lb/ft^3)
gauge length: 2.000 in

Comments: Failed by shear



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DATA SHEET
Unconfined Compression Test of Rock (ASTM D2938)

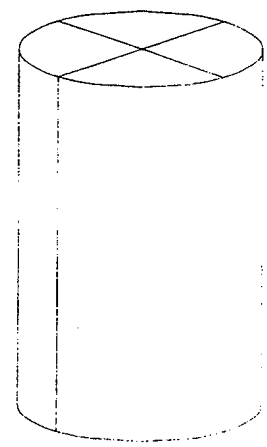
Date: 4/29/01
Technician: A. Bro

Client: W. Lettis & Assoc.
Job: #131-DCPP/ISFSI
Sample ID: #12 - Boring: 01-H
Sample Description: Tan fine grained dolomitic sandstone or dolomite with no visible fractures.

Sample Depth: 52.5'   Sample Condition: received & tested moist

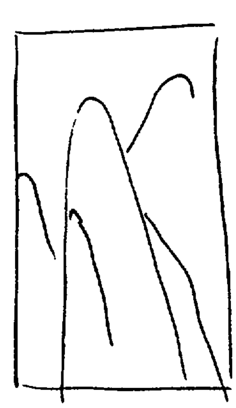
d_1	d_2
2.388	2.395
2.394	2.394
2.385	2.394
2.387	2.388
2.389	2.388

l_1	l_2
+.0005	+.0004
+.0002	+.0002
±.0001	±.0002
-.0002	-.0002
-.0005	-.0005



Avg. diameter : 2.390   Avg. length : 5.307"
Sample area : 4.486   l/d ratio : 2.22
Sample volume(in^3) : 23.809
Sample weight (g) : 969.1 g
Density : 40.70 g/in³ = 155.1 pcf   (1 g/in^3=3.8095lb/ft^3)
Gauge Length (modulus): 2.000 in

Comments: Failed with multiple shears (brittle failure)



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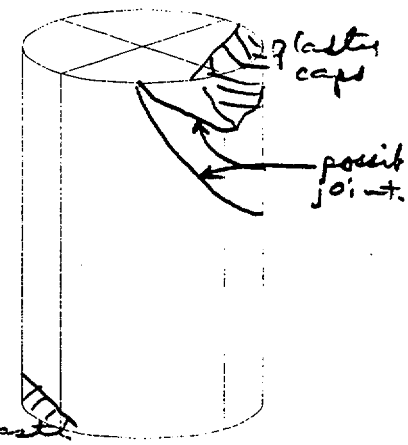
DATA SHEET
Unconfined Compression Test of Rock (ASTM D2938)

Date: 4/29/01
Technician: A. Bro

Client: W. Lettis & Assoc.
Job: #131- DCPP/ISFSI
Sample ID: # 14 Boring 01-CTF-A
Sample Description: Gray Fine to medium grained soft sandstone with partial caps of plaster on ends

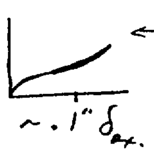
Sample Depth: 8.8' Sample Condition: received & tested moist



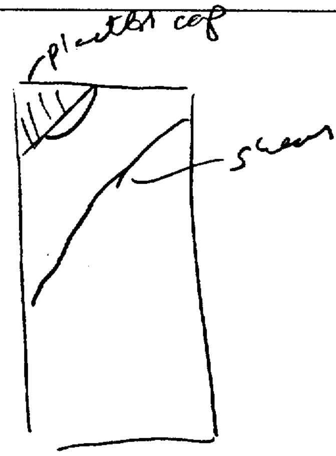
d_1	d_2
2.507	—
2.488	2.484
2.497	2.468
2.470	2.475
2.464	2.468

l_1	l_2
+.0158	+.00[illegible]
+.0060	+.0020
±.0005	±.0005
+.0020	+.0050
+.0040	+.0075

Avg. diameter : 2.480 Avg. length : 5.612
Sample area : 4.831 l/d ratio : 2.26
Sample volume(in^3) : 27.109
Sample weight (g) : 916.7g
Density : 33.82 g/in^3 = 128.8 pcf (1 g/in^3=3.8095lb/ft^3)
Gauge Length (modulus): 2.000 in.



Comments: very soft nature results in uneven ends
mod: hard to get E due to low max load ~40 lb.
uc: very plastic, ε hardening behavior. Shape of σ-ε like a
sandstone but at LARGE strains!
Shear failure developing @ ~124 lb



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Geo Test Unlimited (GTU)

DATA SHEET
Unconfined Compression Test of Rock (ASTM D2938)

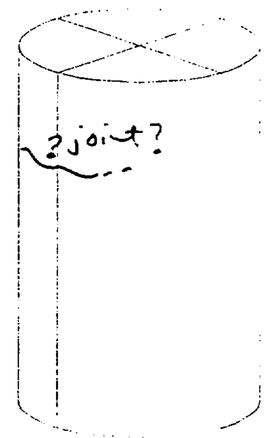
Date: 5/13/01
Technician: A. Bro

Client: W. Lettis & Assoc.
Job: #131- DCPP/ISFSI
Sample ID: #15 - Boring: 01-CTF-A
Sample Description: Tan medium grained clayey friable sandstone possibly with healed joint.

Sample Depth: 13.5'   Sample Condition: received & tested moist

d_1	d_2
2.371	2.368
2.369	2.369
2.379	2.380
2.384	2.380
2.391	2.386

l_1	l_2
+.0027	+.0018
+.0012	+.0011
±.0002	±.0003
-.0012	-.0003
-.0025	-.0010



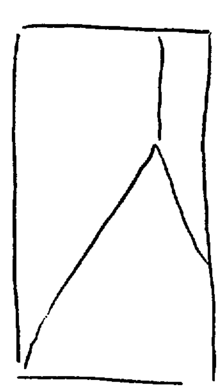
Avg. diameter : 2.378   Avg. length : 5.583
Sample area : 4.441   l/d ratio : 2.35
Sample volume(in³) : 24.796
Sample weight (g) : 900.4g
Density : 36.3 g/in³ = 138.3 pcf (1 g/in³=3.8095lb/ft³)

gauge length: 2.000"

Comments: mod: note creep of Ea, this gauge may span a healed joint

high strain to peak load

Failed by shear



Geo Test Unlimited

DATA SHEET
Unconfined Compression Test of Rock (ASTM D2938)

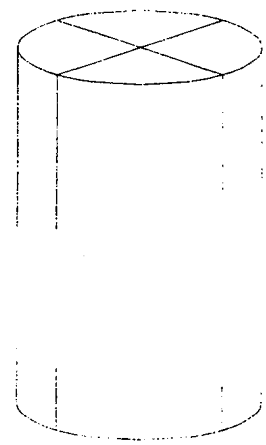
Date: 4/29/01
Technician: A. Bro

Client: W. Lettis & Assoc.
Job: #131-DCPP/ISFSI
Sample ID: #18- Boring: 01-B
Sample Description: Tan medium to fine grained (dolomitic?) sandstone with no visible fractures.

Sample Depth: 26.5'
Sample Condition: received & tested moist

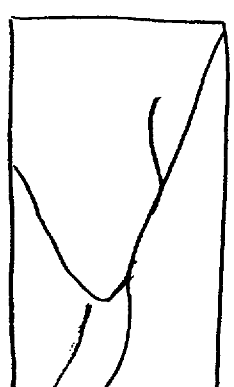
d_1	d_2
2.380	2.379
2.380	2.377
2.380	2.377
2.379	2.377
2.380	2.376

l_1	l_2
+.0010	0
+.0004	0
±.0001	±.0002
-.0003	0
-.0008	0



Avg. diameter : 2.379
Sample area : 4.445
Sample volume(in^3) : 23.763
Sample weight (g) : 918.9g
Density : 38.67g/in^3 = 147.3 pcf (1 g/in^3=3.8095lb/ft^3)
Avg. length : 5.346
l/d ratio : 2.25
Gauge Length (modulus): 2.000 in

Comments: Failed by shear



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Geo Test Unlimited

DATA SHEET
Unconfined Compression Test of Rock (ASTM D2938)

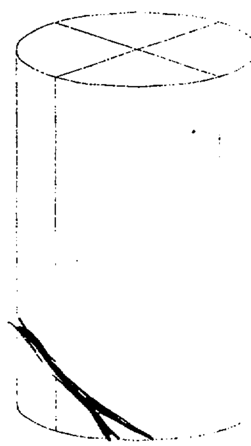
Date: 5/13/01
Technician: A. Bro

Client: W. Lettis & Assoc
Job: #131-DCPP/ISFSI
Sample ID: #19 Boring 01-B
Sample Description: Tan medium grained sandstone with a few rounded gray claystone clasts with a joint on one end

Sample Depth: 38.0' Sample Condition: received & tested moist

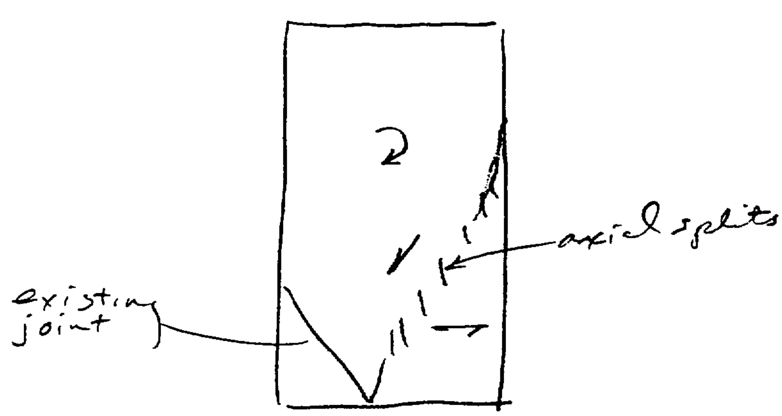
d_1	d_2
2.363	2.356
2.364	2.356
2.364	2.356
2.364	2.359
2.374	2.366

l_1	l_2
+.0024	+.0025
+.0012	+.0012
±.0003	±.0003
-.0014	-.0013
-.0027	-.0019



Avg. diameter : 2.362 Avg. length : 5.427"
Sample area : 4.382 l/d ratio : 2.30
Sample volume(in^3) : 23.780
Sample weight (g) : 826.38
Density : 34.75g/in^3 = 132.4 pcF (1 g/in^3=3.8095lb/ft^3)
gauge length: 2.000"

Comments: Failed by "shear" actually it was an axial splitting along [illegible] "shear" plane accompanied by a sample rotation & sideways movement



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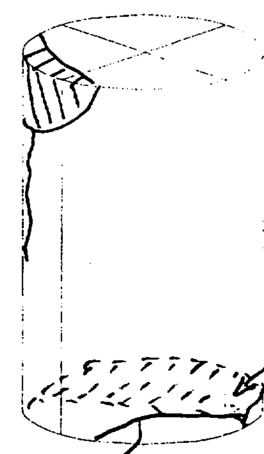
Geo Test Unlimited (GTU)

DATA SHEET
Unconfined Compression Test of Rock (ASTM D2938)

Date: 4/29/01
Technician: A. Bro

Client: W. Lettis & Assoc.
Job: #131 - DCPP/ISFSI
Sample ID: #22 Boring 01-C
Sample Description: Tan Fine grained (dolomitic?) sandstone with partial plaster caps, Contains an axial fracture

Sample Depth: 24.0' Sample Condition: received & tested moist

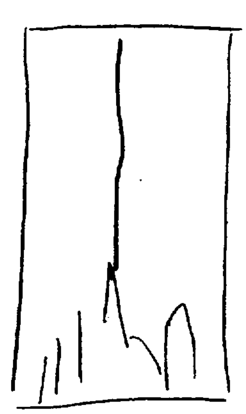


d_1	d_2
2.380	2.377
2.372	2.378
2.377	2.378
2.374	2.378
—	2.377

l_1	l_2
+.0004	+.0012
+.0002	+.0007
±.0001	±.0001
−.0001	−.0004
−.0001	−.0006

Avg. diameter : 2.377 Avg. length : 5.519"
Sample area : 4.438 l/d ratio : 2.32
Sample volume(in^3) : 24.491
Sample weight (g) : 996.7 g
Density : 40.70 g/in³ = 155.0 pcf (1 g/in³=3.8095lb/ft³)
Gauge Length (modulus) : 2.000 in

Comments: Failed by axial splitting through intact rock as well as along existing axial fracture.



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Geo Test Unlimited

DATA SHEET
Unconfined Compression Test of Rock (ASTM D2938)

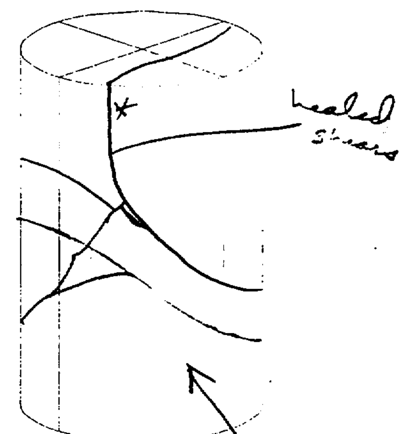
Date: 5/13/01
Technician: A. Bro

Client: W. Lettis & Assoc.
Job: #131- DCPP/ISFSI
Sample ID: #26 Boring 01-E
Sample Description: Tan fine grained (dolomitic?) sandstone with a few healed shears

Sample Depth: 22.0' Sample Condition: received & tested moist

d_1	d_2
2.394	2.372
2.391	2.380
2.386	2.382
2.397	2.376
2.395	2.393

l_1	l_2
+.0019	+.0015
+.0009	+.0005
±.0002	±.0003
−.0002	−.0003
−.0008	−.0009



Avg. diameter : 2.387   Avg. length : 5.353
Sample area : 4.475   l/d ratio : 2.24
Sample volume(in^3) : 23.955
Sample weight (g) : 813.8 g
Density : 33.97 g/in³ = 129.4 pcF   (1 g/in³=3.8095lb/ft³)
gauge length: 2.000"

Comments: Failed by shear along the healed shear*

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Geo Test Unlimited

DATA SHEET
Unconfined Compression Test of Rock (ASTM D2938)

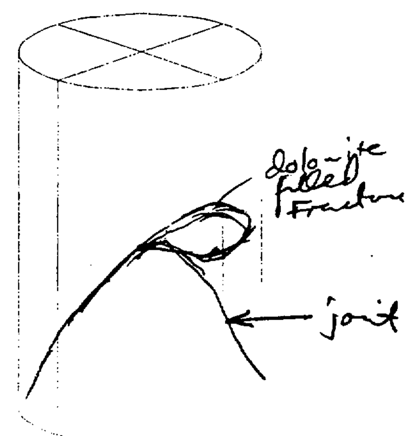
Date: 4/29/01
Technician: A. Bro

Client: W. Lettis & Assoc.
Job: #131- DCPP/ ISFSI
Sample ID: #28 - Boring: 01-E
Sample Description: Tan Fine grained (dolomitic?) sandstone with a dolomite (?) healed fracture ~34° to the core axis

Sample Depth: 49.0'   Sample Condition: received & tested moist

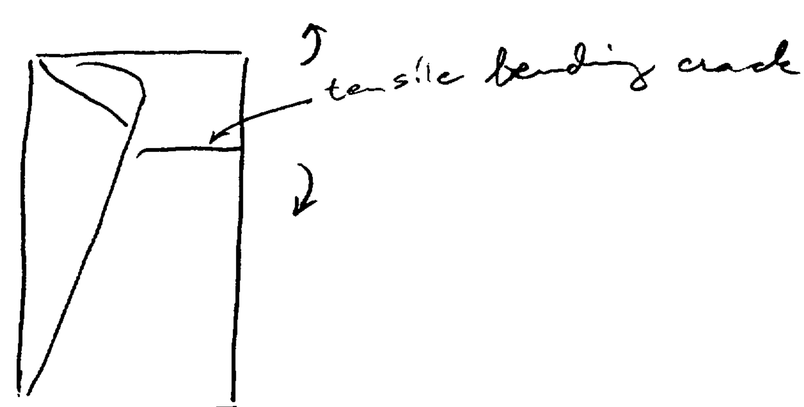
d_1	d_2
2.397	2.398
2.398	2.397
2.398	2.397
2.400	2.399
2.400	2.398

l_1	l_2
+.0009	0
+.0004	0
±.0001	±.0002
-.0004	0
-.0007	0



Avg. diameter : 2.398   Avg. length : 5.395"
Sample area : 4.516   l/d ratio : 2.25
Sample volume(in^3) : 24.366
Sample weight (g) : 868.3g
Density : 35.64g/in³ = 135.8pcf (1 g/in³=3.8095lb/ft³)
Gauge Length (modulus) : 2.000 in.

Comments: Failed by shear - not along the joint noted above



Geo Test Unlimited

DATA SHEET
Unconfined Compression Test of Rock (ASTM D2938)

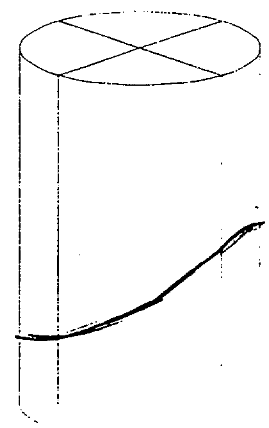
Date: 5/13/01
Technician: A Bro

Client: W. Lettis & Assoc.
Job: #131-DCPP/ISFSI
Sample ID: #30 - Boring 01-F
Sample Description: light tan (oxide stained gray?) medium grained sandstone with an oxide stained joint about 60° to the core axis. intact

Sample Depth: 57.6'   Sample Condition: received & tested moist

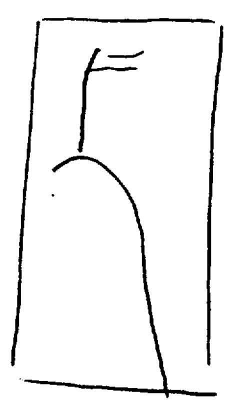
d_1	d_2
2.407	2.399
2.407	2.406
2.407	2.409
2.407	2.405
2.401	2.403

l_1	l_2
+.0009	0
+.0005	0
±.0002	±.0002
-.0004	0
-.0007	0



Avg. diameter : 2.405   Avg. length : 5.430
Sample area : 4.543   l/d ratio : 2.26
Sample volume(in^3) : 24.667
Sample weight (g) : 899.4 g
Density : 36.46 g/in³ = 138.9 pcf (1 g/in³=3.8095lb/ft³)
gauge length: 2.000"

Comments: Failed by shear - not along intact joint



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DATA SHEET
Unconfined Compression Test of Rock (ASTM D2938)

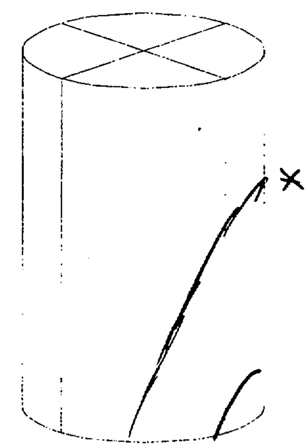
Date: 5/13/01
Technician: A.Bro

Client: W. Lettis & Assoc.
Job: #131-DCPP/ISFSI
Sample ID: #38 Boring: 01-I
Sample Description: Dark gray fine grained dolomitic siltstone with healed joint at 27° to the core axis. (soft white healing mineral)

Sample Depth: 159.5'   Sample Condition: received & tested moist

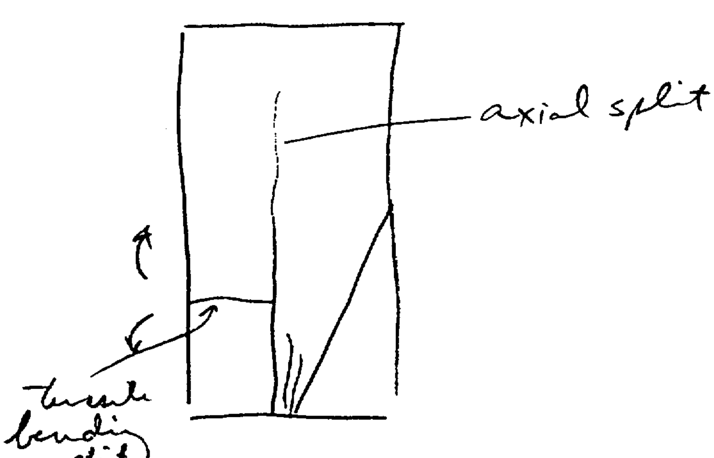
d_1	d_2
2.403	2.404
2.403	2.405
2.403	2.401
2.397	2.402
2.402	2.403

l_1	l_2
+.0009	+.0021
+.0003	+.0012
±.0001	±.0002
-.0003	-.0013
-.0006	-.0027



Avg. diameter: 2.403   Avg. length: 5.436
Sample area: 4.535   l/d ratio: 2.26
Sample volume(in^3): 24.653
Sample weight (g): 933.5g
Density: 37.868/in^3= 144.2 pcf   (1 g/in^3=3.8095lb/ft^3)
gauge length: 2.000"

Comments: slight hydrocarbon odor upon cutting
1st drop in σ-ε curve (UC) due to opening of joint*
otherwise failed by axial splitting



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Geo Test Unlimited (GTU)

DATA SHEET
Unconfined Compression Test of Rock (ASTM D2938)

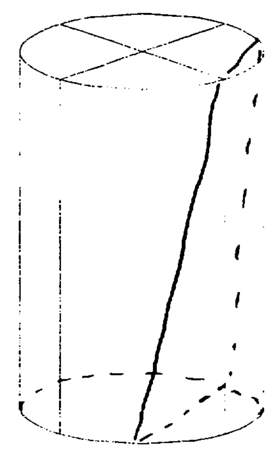
Date: 5/13/01
Technician: A. Bro

Client: W. Lettis & Assoc.
Job: #131 - DCPP/ISFSI
Sample ID: #39A - Boring 01-I
Sample Description: Tan fine to medium grained sandstone with an open filled joint ~12° to the core axis (weak white filling)

Sample Depth: 130.4'   Sample Condition: received & tested moist

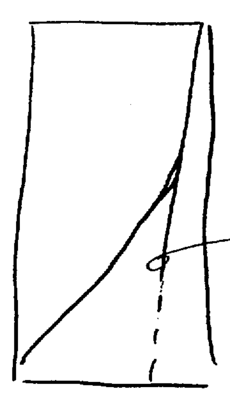
d_1	d_2
2.407	2.408
2.407	2.404
2.403	2.406
2.405	2.404
2.403	2.401

l_1	l_2
+.0041	+.0008
+.0017	+.0003
±.0003	±.0003
-.0015	-.0002
-.0045	-.0004



Avg. diameter : 2.405   Avg. length : 5.362
Sample area : 4.543   l/d ratio : 2.23
Sample volume(in^3) : 24.358
Sample weight (g) : 897.1
Density : 36.83 g/in³ = 140.3 pcf   (1 g/in³=3.8095lb/ft³)

Comments: strong hydrocarbon odor on cutting
No modulus due to axial fracture.
Failed by shear



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Geo Test Unlimited

DATA SHEET
Unconfined Compression Test of Rock (ASTM D2938)

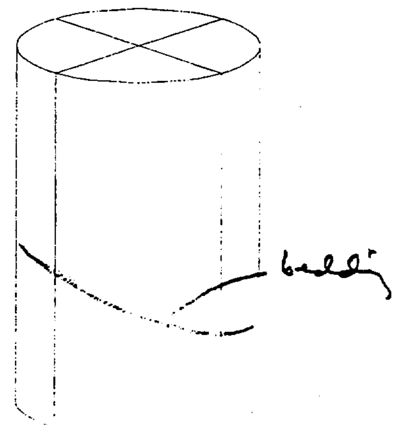
Date: 5/13/01
Technician: A. Bro

Client: W. Lettis & Assoc.
Job: #131-DCPP/ISFSI
Sample ID: #40A-Boring:01-I
Sample Description: Tan thinly bedded fine grained dolomitic sandstone with bedding about 69° to the core axis. Possibly on weaker bedding plane joint

Sample Depth: 88.4'   Sample Condition: received & tested moist

d_1	d_2
2.406	2.402
2.403	2.404
2.406	2.407
2.404	2.404
2.405	2.404

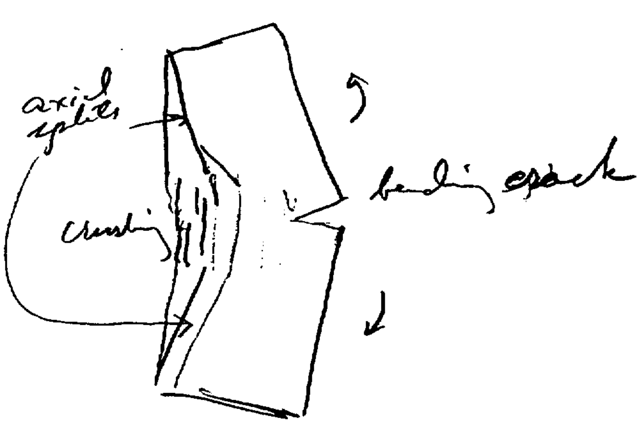
l_1	l_2
+.0010	+.0003
+.0005	+.0001
±.0002	±.0002
-.0002	-.0001
-.0006	-.0003



Avg. diameter : 2.405   Avg. length : 5.178
Sample area : 4.543   l/d ratio : 2.15
Sample volume(in^3) : 23.522
Sample weight (g) : 876.5g
Density : 37.26 g/in³ = 142.0 pcF   (1 g/in³=3.8095lb/ft³)
gauge length: 2.000"

Comments: moderate hydrocarbon odor during cutting

Failed by axial splitting, crushing & bending



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Geo Test Unlimited (GTU)

DATA SHEET
Unconfined Compression Test of Rock (ASTM D2938)

Date: 5/13/01
Technician: A. Bro

Client: W. Lettis & Assoc.
Job: #131-DCPP/ISFSI
Sample ID: #42- Boring: 01-I
Sample Description: Tan (~~thinly bedded~~) fine grained dolomitic sandstone.

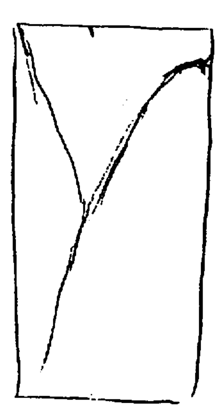
Sample Depth: 44.0'   Sample Condition: received & tested moist

d_1	d_2
2.408	2.410
2.399	2.408
2.406	2.405
2.402	2.408
2.404	2.406

l_1	l_2
+.0013	0
+.0008	0
±.0001	±.0002
-.0007	0
-.0012	0

Avg. diameter: 2.406   Avg. length: 5.404
Sample area: 4.547   l/d ratio: 2.25
Sample volume(in³): 24.570
Sample weight (g): 912.4 g
Density: 37.14 g/in³ = 141.5 pcF   (1 g/in³=3.8095lb/ft³)
gauge length: 2.000"

Comments: Failed by axial splitting and shear
strong HC odor on failure



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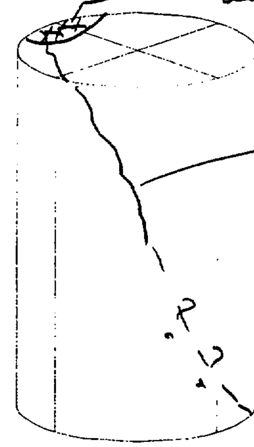
Geo Test Unlimited (GTU)

DATA SHEET
Triaxial Compression Test of Rock (ASTM D2664)

Date: 4/29 & 5/4/01
Technician: A. Bro

Client: W. Lettis Assoc.
Job: #131-DCPP/ISFSI
Sample ID: #3 - Boring: 01-A
Sample Description: Gray medium grained weak friable sandstone with one, possibly through-going, fracture.

Sample Depth: 35.5'   Sample Condition: received & tested moist



d_1	d_2
2.414	2.427
2.429	2.408
2.399	2.401
2.398	2.387
2.403	2.396

l_1	l_2
+.0042	-.0010
+.0010	+.0012
±.0005	±.0005
-.0010	-.0010
-.0025	-.0019

Avg. diameter : 2.406   Avg. length : 5.088
Sample area : 4.547   l/d ratio : 2.11
Sample volume(in³) : 23.133
Sample weight (g) : 882.5
Density : 38.15 g/in³ = 145.3 pcf (1 g/in³=3.8095lb/ft³)

Test Confining Pressures (psi)

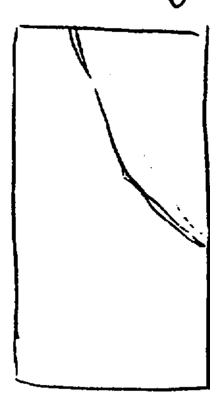
65.5	98.25	131
298 lb	447 lb	596 lb

= axial load for $\sigma_d = 0$

Comments: end roughness due to friable nature of sample
[illegible] test: very weak rock - can get E but not [illegible] due to limited elastic strain prior to large plastic deformations.
Pause after 2nd stage - resulted in load drop
reset LVDT near end of 5th stage

δ_{r_1} expand
δ_{r_2} contracted
$\delta_{a_1} \sim 4 \times \delta_{a2}$

The outside of the sample was quite wet after testing ie the pore water was forced to the outer surface



Failed by shear along partially open fracture

Geo Test Unlimited

DATA SHEET
Triaxial Compression Test of Rock (ASTM D2664)

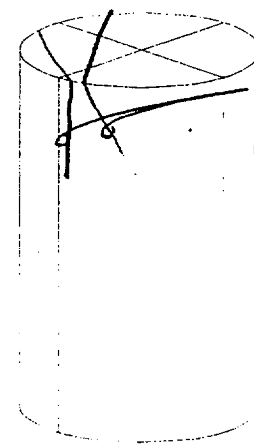
Date: 4/29 & 5/4/01
Technician: A. Bro

Client: W. Lettis Assoc.
Job: #131-DCPP/ISFSI
Sample ID: #5 - Boring: 01-D
Sample Description: Tan clayey medium grained weak sandstone with ~~no visible fractures~~ & 2 healed axial fractures (white healing mineral)

Sample Depth: 28.0' Sample Condition: received & tested moist

d_1	d_2
2.332	2.344
2.329	2.344
2.330	2.345
2.333	2.344
2.307	2.341

l_1	l_2
+.0015	+.0032
+.0007	+.0017
±.0002	±.0005
−.0007	−.0007
−.0014	−.0014



healed fractures

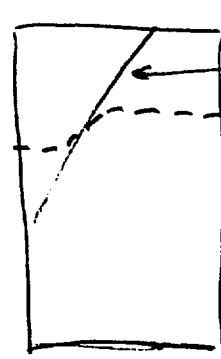
Avg. diameter : 2.335 Avg. length : 5.393"
Sample area : 4.282 l/d ratio : 2.31
Sample volume(in³) : 23.094
Sample weight (g) : 876.2
Density : 37.94 g/in³ - 144.5 pcf (1 g/in³=3.8095lb/ft³)

Test Confining Pressures (psi)

58	87	116
248	372	496 lb

F_{ax} for $\sigma_d = 0$

Comments: ~~mod test~~ : $\epsilon_{a_1} \approx 2\epsilon_{a_2}$ - slight sample creep at start of unloading
TX test just managed to catch the peak on 3rd stage.



Failed in shear

mechanical break which developed on removing the sample

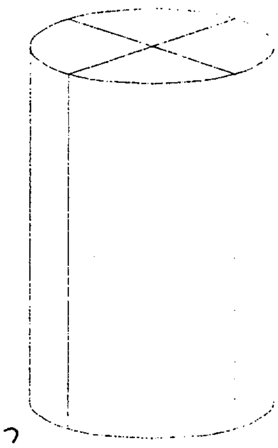
Geo Test Unlimited

DATA SHEET
Triaxial Compression Test of Rock (ASTM D2664)

Date: 4/29 & 5/4/01
Technician: A. Bro

Client: W. Lettis & Assoc.
Job: #131 - DCPP/ISFSI
Sample ID: # 13 - Boring 01-H
Sample Description: Gray medium grained clayey friable sandstone

Sample Depth: 57.0'
Sample Condition: received & tested moist



d_1	d_2
2.447	2.471
2.450	2.467
2.473	2.434
2.453	2.470
2.472	2.413

l_1	l_2
+.0022	+.0031
+.0009	+.0018
±.0005	±.0005
-.0019	-.0008
-.0025	-.0026

Avg. diameter : 2.455
Avg. length : 5.503
Sample area : 4.734
l/d ratio : 2.24
Sample volume(in³) : 26.049
Sample weight (g) : 900.88
Density : 34.58 g/in³ = 131.7 pcf (1 g/in³=3.8095lb/ft³)

just noise!...? possibly noise on all channels?

Test Confining Pressures (psi)

87	130.5	174
411	617	822 lb

indicate that the def. irregularity is not just occurring, ...

Comments: mod test: very interesting shape in both σ-ε curves
TX test: reset LVDT during 1st stage

2nd cycle

3rd cycle

NO discernable mode of failure
likely it is a barrelling mode

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DATA SHEET
Triaxial Compression Test of Rock (ASTM D2664)

Date: 5/2/01
Technician: A. Bro

Client: W. Lettis & Assoc
Job: #131 - DCPP/ISFSI
Sample ID: #17 - Boring: 01-CTF-A
Sample Description: Gray medium grained, altered, clayey, friable sandstone.

Sample Depth: 53.8'   Sample Condition: received & tested moist

d_1	d_2
2.413	2.423
2.397	2.410
2.406	2.403
2.386	2.390
2.392	2.395

l_1	l_2
+.0050	+.0040
+.0070	+.0015
±.0010	±.0010
-.0020	-.0050
-.0050	-.0100

Avg. diameter : 2.402   Avg. length : 5.463"
Sample area : 4.531   l/d ratio : 2.27
Sample volume(in³) : 24.755
Sample weight (g) : 826.0
Density : 33.37 g/in³ = 127.1 pcf (1 g/in³=3.8095lb/ft³)

Test Confining Pressures (psi)

83.8	125.7	167.6
380	570	760

Comments: NO MODULUS! Too weak
reset LVDT part-way through 1st stage
" " after 1st stage
LOTS of water squeezed out of sample ~1 teaspoon
Failed by shear & possibly barrelling

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DATA SHEET
Triaxial Compression Test of Rock (ASTM D2664)

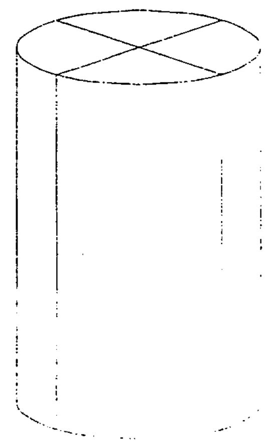
Date: 5/4/01
Technician: A. Bro

Client: W. Lettis & Assoc.
Job: #131 - DCPP/ISFSI
Sample ID: #27 - Boring 01-E
Sample Description: Tan Fine grained, soft friable clayey altered dolomitic sandstone. Contains numerous fractures - capped with hydrostone on both ends.

Sample Depth: 41.2'   Sample Condition: received & tested moist

d_1	d_2
2.320	2.391
2.268	2.460
2.251	2.409

l_1	l_2
+.0058	+.0135
+.0035	+.0070
±.0005	±.0005
-.0045	-.0064
-.0097	-.0135



Avg. diameter : 2.350   Avg. length : 5.205
Sample area : 4.337   l/d ratio : 2.21
Sample volume(in^3) : 22.576
Sample weight (g) : 710.1 g
Density : 31.45 g/in^3 = 119.8 pcF (1 g/in^3=3.8095lb/ft^3)

Test Confining Pressures (psi)

71.2	106.8	142.4
309	463	618

Comments: sample somewhat "chewed up" & soft. - NO MODULUS TEST

SAMPLE fell apart on loading the triaxial cell

NO Test

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Geo Test Unlimited

DATA SHEET
Triaxial Compression Test of Rock (ASTM D2664)

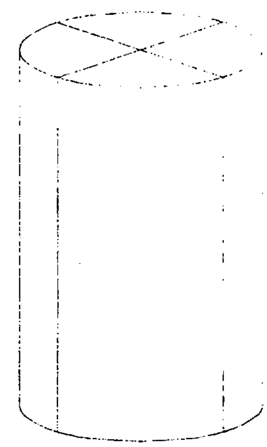
Date: 4/29 & 5/4/01
Technician: A.Bro

Client: W. Lettis & Assoc.
Job: #131- DCPP/ISFSI
Sample ID: #32- Boring: 01-F
Sample Description: Gray fine to medium grained soft clayey friable sandstone

Sample Depth: 117.7'   Sample Condition: received & tested moist

d_1	d_2
2.457	2.550
2.446	2.528
2.483	2.552
2.470	2.548
2.508	2.510

l_1	l_2
+.0033	+.0042
+.0012	+.0023
±.0005	±.0005
-.0023	-.0007
-.0040	-.0006



Avg. diameter : 2.505
Sample area : 4.928
Sample volume(in^3) : 26.796
Sample weight (g) : 955.2 g
Avg. length : 5.437"
l/d ratio : 2.17
Density : 35.65 g/in³ = 135.8 pcf (1 g/in³=3.8095lb/ft³)

Test Confining Pressures (psi)

147.7	221.6	295.4
728	1092	1456

Comments: needed to trim off a few bumps to fit in the triax cell
reset LVDT near end of 1st stage
Some sample damage on removal
Failed in shear, possibly with barrelling

mechanical breaks on removal

Load 2000
σ_3 40
δ_{axial} .02
σ_3 ...

Geo Test Unlimited (GTU)

DATA SHEET

Triaxial Compression Test of Rock w/ Pore Pressure Measurement

(A procedure developed at GTU following the guidelines of ASTM D4767)

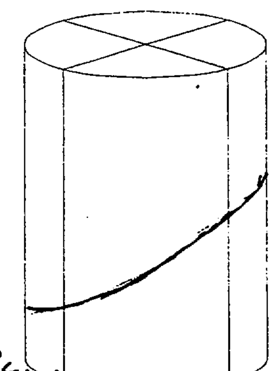
Date: 5/15/01
Technician: A.Bro

Client: W. Letts & Assoc.
Job: #131 DCPP/ISFSI
Sample ID: #7 Boring 01-D
Sample Description: Tan clayey altered medium grained sandstone. with preexisting joint ~ 57° to the core axis

Sample Depth: 55.5' Sample Condition: received & tested moist

d_1	d_2
2.280	2.317
2.306	2.351

l_1	l_2



Avg. diameter : 2.314
Sample area : 4.205
Sample volume(in^3) :
Sample weight (g) : — too weak to take off plastic - no weight measured
Density : ———

Avg. length : 5.386
l/d ratio : 2.33
(1 g/in^3=3.8095lb/ft^3)

Initial Cell Pressure (psi) σ_{ci}	Final Cell Pressure (psi) σ_{cf}	Inititial Eff. Confining Pressure (psi) σ'_{ci}	Final Eff. Confining Pressure (psi) σ'_{cf}	$1-\frac{\Delta\sigma'_c}{\Delta\sigma_c}$ B
54.1	64.7	15.1	14.6	.95

$\frac{.5}{10.6}$

.5/10.6 = .05

Comments: σ_3 = 30, 40, 60 psi
Too weak → No modulus.
use u = 40 psi ⇒ σ_3 = 70, 80, 100 psi
reset LVDT after 1st stage & 2nd stage

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Geo Test Unlimited

DATA SHEET

Triaxial Compression Test of Rock w/ Pore Pressure Measurement
(A procedure developed at GTU following the guidelines of ASTM D4767)

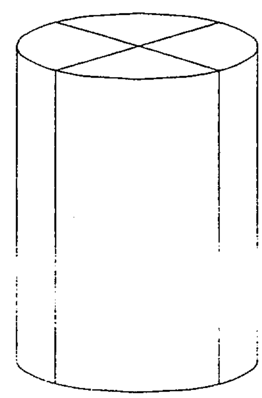
Date: 5/13&16/01
Technician: A.Bro

Client: W. Lettis & Assoc.
Job: #131- DCPP/ISFSI
Sample ID: #16 Boring: 01-CTF-A
Sample Description: Tan friable clayey altered medium grained sandstone

Sample Depth: 48.8'   Sample Condition: received & tested moist

d_1	d_2
2.370	2.369
2.359	2.368
2.358	2.367
2.352	2.353
2.353	2.346

l_1	l_2
+.0024	+.0025
+.0011	+.0008
±.0005	±.0005
+.0030	-.0005
-.0005	-.0012



Avg. diameter : 2.360   Avg. length : 5.293
Sample area : 4.374   l/d ratio : 2.24
Sample volume(in^3) : 23.153
Sample weight (g) : 809.8 g
Density : 34.98 g/in^3 = 133.2 pcf   (1 g/in^3=3.8095lb/ft^3)
gauge length : 2.000 in.

Initial Cell Pressure (psi) σ_{ci}	Final Cell Pressure (psi) σ_{cf}	Inititial Eff. Confining Pressure (psi) σ'_{ci}	Final Eff. Confining Pressure (psi) σ'_{cf}	$1-\frac{\Delta\sigma'_c}{\Delta\sigma_c}$ B
50.0	61.1	10.0	10.8	.93
70.0	80.4	10.0	10.2	.98

$\frac{.8}{11.1}$ = .07
$\frac{.2}{10.4}$ = .02

Comments: σ_3' = 25, 50, 100 psi   use back press. = 60 psi
σ_3 = 85 110 160 psi
went a bit past peak on 1st stage

Geo Test Unlimited (GTU)

DATA SHEET

Triaxial Compression Test of Rock w/ Pore Pressure Measurement
(A procedure developed at GTU following the guidelines of ASTM D4767)

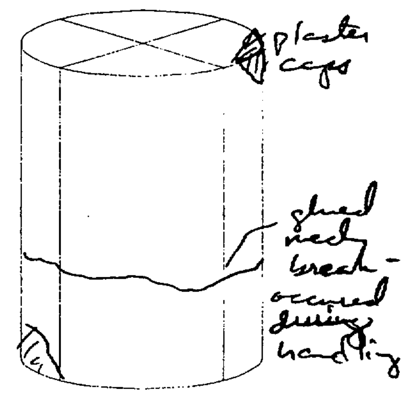
Date: 5/16/01
Technician: A. Bro

Client: W. Lettis & Assoc.
Job: #131- DCPP/ISFSI
Sample ID: #21 Boring 01-C
Sample Description: Grey clayey friable weak medium sandstone with partial plaster caps

Sample Depth: 9.5'   Sample Condition: received & tested moist

d_1	d_2
2.370	2.333
2.297	2.327
2.275	2.217
2.219	2.235
2.314	2.295

l_1	l_2



Avg. diameter : 2.288   Avg. length : 5.392
Sample area : 4.112   l/d ratio : 2.36
Sample volume(in^3) : 22.169
Sample weight (g) : 771.1 g
Density : 34.78 g/in³ = 132.5 pcF (1 g/in³=3.8095lb/ft³)

Initial Cell Pressure (psi) σ_{ci}	Final Cell Pressure (psi) σ_{cf}	Inititial Eff. Confining Pressure (psi) σ'_{ci}	Final Eff. Confining Pressure (psi) σ'_{cf}	$1-\frac{\Delta\sigma'_c}{\Delta\sigma_c}$ B
49.9	67.6	10.0	10.6	.97

$\frac{.6}{17.7} = .03$

Comments: $\sigma_3' = 20, 40, 80$ psi
Too weak to evaluate modulus.
use 40 psi back pressure
$\sigma_3 = 60, 80, 120$ psi
reset LVDT after 1st stage & just before 3rd stage

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Geo Test Unlimited (GTU)

DATA SHEET

Triaxial Compression Test of Rock w/ Pore Pressure Measurement
(A procedure developed at GTU following the guidelines of ASTM D4767)

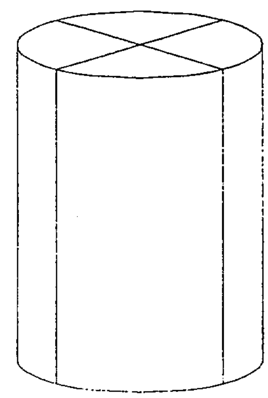
Date: 5/17/01
Technician: A. Bro

Client: W. Lettis & Assoc.
Job: #131-DCPP/ISFSI
Sample ID: #25 Boring 01-E
Sample Description: Tan fractured and sheared clayey altered weak dolomite/fine grained dolomitic sandstone

Sample Depth: 7.0'   Sample Condition: received & tested moist

d_1	d_2
2.196	2.455
2.370	2.456
2.398	2.459
2.198	2.420
2.142	2.483

l_1	l_2



Avg. diameter : 2.358   Avg. length : 5.983
Sample area : 4.367   l/d ratio : 2.54
Sample volume(in^3) : 26.127
Sample weight (g) : 931.10
Density : 35.64 g/in³ = 135.8 pcf   (1 g/in³=3.8095lb/ft³)

Initial Cell Pressure (psi) σ_{ci}	Final Cell Pressure (psi) σ_{cf}	Inititial Eff. Confining Pressure (psi) σ'_{ci}	Final Eff. Confining Pressure (psi) σ'_{cf}	$1-\frac{\Delta\sigma'_c}{\Delta\sigma_c}$ B
70.0	84.7	9.9	10.5	.96

$\frac{.6}{14.7}$ .04

Comments: σ_3' = 10, 20, 40 psi
No Modulus - sample is too irregular to interpret results
use 60 psi for back pressure
70, 80, 100 psi = σ_3
reset LVDT just after 2nd stage unloading
(ended 2nd stage at full throw of LVDT)

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Geo Test Unlimited ($G_T U$)

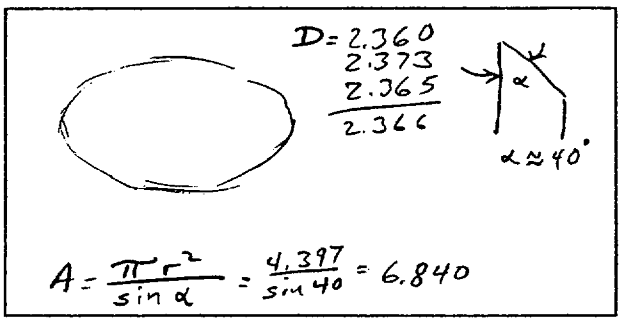
DATA SHEET
Direct Shear of Rock (ISRM)

Client: W. Lettis & Assoc
Job: #131 - DCPP/ISFSI
Sample ID: #20 Boring: 01-B
SampleDescription: Contact between hard dolomite and soft clayey altered Dolomite - distinct contact, slightly wavy, intact

Date: 5/7/01
Tester: A. Bro

Sample Depth: 48.8 Sample Condition: received & tested moist

Sketch of Shear Surface



A_s $\sin\alpha \cdot \frac{A_c}{A_s}$

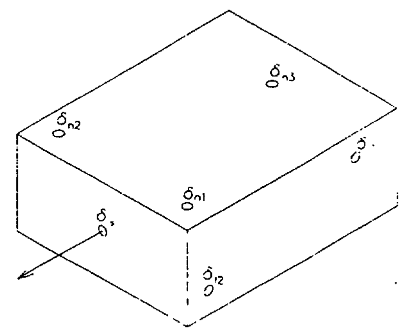
D = 2.360
2.373
2.365
2.366

$\alpha \approx 40°$

$A = \frac{\pi r^2}{\sin\alpha} = \frac{4.397}{\sin 40} = 6.840$

Sample area : 6.840 in²

Location of LVDTs on top shear box



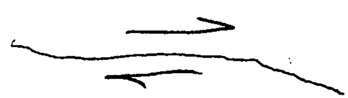
1.82

σ_n	30	45	60	psi
F_n	205	308	410	lb
F_n-W_b	190	293	395	lb*
	75	110	150	

Estimated top box weight: 15.5 lb
Measured top box weight: 14.6 lb

Joint Profiles

NA - sheared on soft slickensided surface



Comments: * 150 lb F_n resulted in normal displ. creep so the normal loads were reduced
@ δ_s = .29" reset δ_{n3}
δ_s = .36 reset δ_{n2}

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Geo Test Unlimited

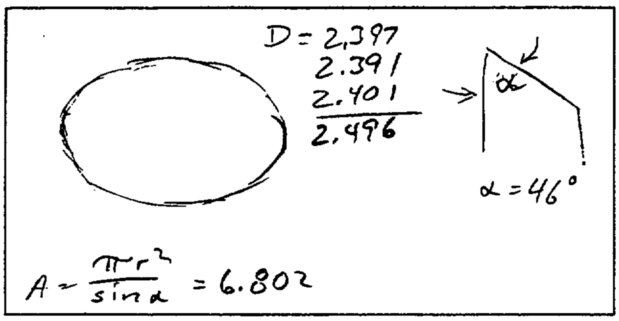
DATA SHEET
Direct Shear of Rock (ISRM)

Client: W. Lettis & Assoc.
Job: #121 - DCPP/ISFSI
Sample ID: #23 - Boring 101-C
SampleDescription: Very thin gray clay coated joint in gray medium grained sandstone
slickensided

Date: 5/7/01
Tester: A. Bro

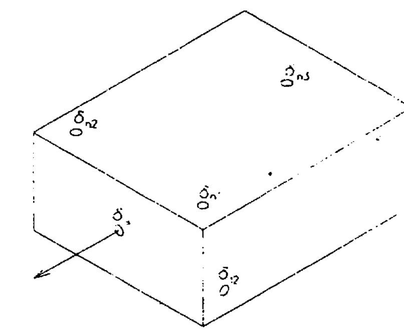
Sample Depth: 41.4'   Sample Condition: received & tested moist

Sketch of Shear Surface



Sample area : 6.802 in²

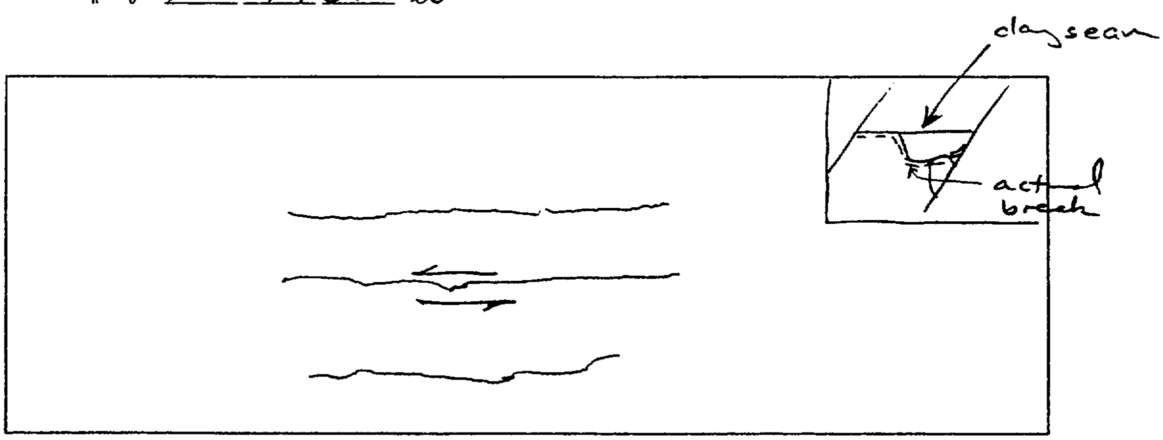
Location of LVDTs on top shear box



σ_n	20	40	60	psi
F_n	136	272	408	lb
F_n-W_b	121	257	393	lb

Estimated top box weight: 15.5 lb
Measured top box weight: 14.9 lb

Joint Profiles



Comments: needed to repot sample in shear box, and in doing so, slightly disturbed the joint

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DATA SHEET
Direct Shear of Rock (ISRM)

Client: W. Lettis & Assoc.

Job: #131- DCPP/ISFSI

Sample ID: #24 - Boring: 01-C

SampleDescription: Wavy, partly bonded joint in tan medium grained sandstone (~~pitting~~ with thin clay coating?)

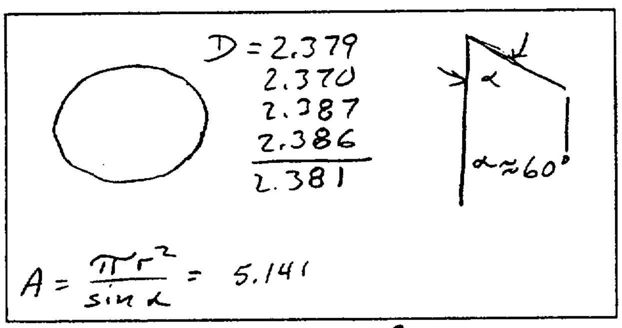
Date: 5-7-01

Tester: A. Bro

Sample Depth: 44.3'

Sample Condition: received & tested moist

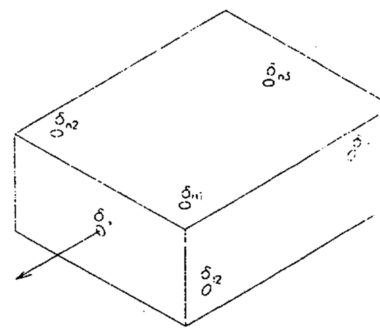
Sketch of Shear Surface



Sample area : 5.141 in^2

σ_n	20	40	60	psi
F_n	103	206	309	lb
F_n-W_b	88	191	294	lb

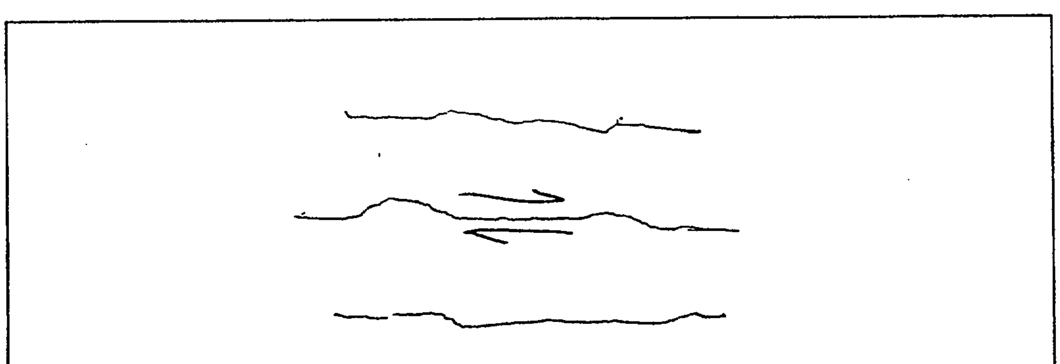
Location of LVDTs on top shear box



Estimated top box weight: 15.5 lb

Measured top box weight: 14.7 lb

Joint Profiles



Comments: very thin tan clay coating resulted in very low friction angle.

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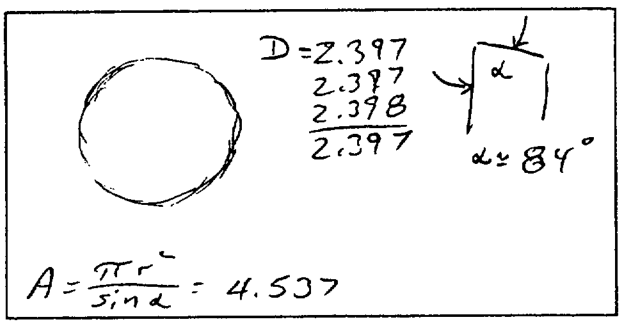
DATA SHEET
Direct Shear of Rock (ISRM)

Client: W. Lettis & Assoc.
Job: #131 - DCPP/ISFSI
Sample ID: #29 - Boring: 01-E
SampleDescription: Planar well mated joint (bedding ?) in fine to medium grained sandstone.

Date: 5/8/01
Tester: A. Bro

Sample Depth: 51.8' Sample Condition: received & tested moist

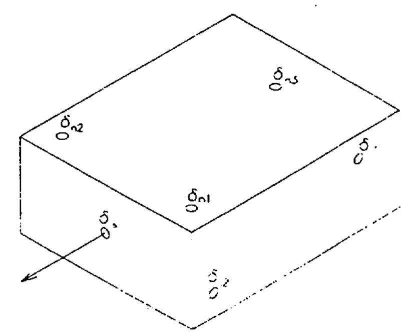
Sketch of Shear Surface



Sample area : 4.537 in²

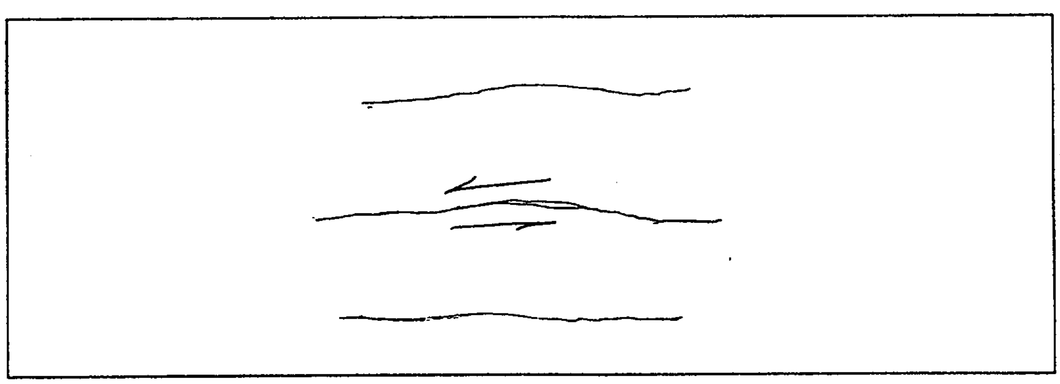
σ_n	15	30	45	psi
F_n	68	136	204	
F_n-W_b	53	121	189	

Location of LVDTs on top shear box



Estimated top box weight: 15 lb
Measured top box weight: 14.8 lb

Joint Profiles



Comments: moist joint

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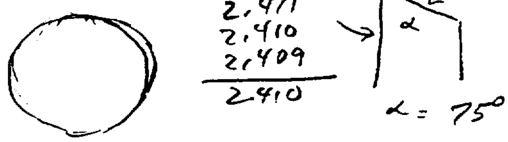
DATA SHEET
Direct Shear of Rock (ISRM)

Client: W. Lettis & Assoc. Date: 5/8/01
Job: #131- DCPP/ISFSI Tester: A. Bro
Sample ID: #31 - Boring :01- F
SampleDescription: Tan-stiff clay seam (1/2"-1" thick) in top fine to medium grained clayey sandstone

Sample Depth: 117.0' Sample Condition: received & tested moist

Sketch of Shear Surface



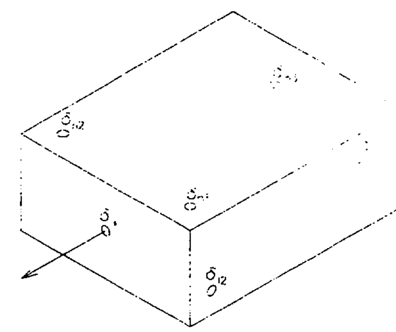
D = ~~2.460~~
2.411
2.410
2.409
2.410

$\alpha = 75^\circ$

$A = \frac{\pi r^2}{\sin\alpha} = 4.723$

Sample area : 4.723 in²

Location of LVDTs on top shear box

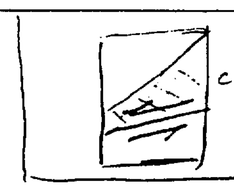


Estimated top box weight: 15 lb
Measured top box weight: 14.9

σ_n	60	120	240	psi
F_n	283	567	1134	lb
F_n-W_b	268	552	1119	lb
	40	80	160	

Joint Profiles

NA - the separation surface is not the shear surface - the shear surface "stuck together" too well. Lots of slicks within the clay mass. Sample extruded sideways - see photos



clay seam

Comments: soft clay probably won't support σ_n of 240 psi ∴ start ~~test~~ lower - Large normal displacements due to F_N = 160 lb.
Strange τ_s-σ_n behavior as σ_n increases τ_s decreases! tried waiting @ F_N = 160 lb for ~15 min then shearing*
Likely the normal stress puts the clay into plasticity, and any increase in shear just increases the plastic rate, [illegible] no increase in strength.
* only slight strength increase.

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Geo Test Unlimited (GTU)

DATA SHEET
Direct Shear of Rock (ISRM)

Client: W. Lettis & Assoc.

Job: #131-DCPP/ISFSI

Date: 5/8/01

Tester: A. Bro

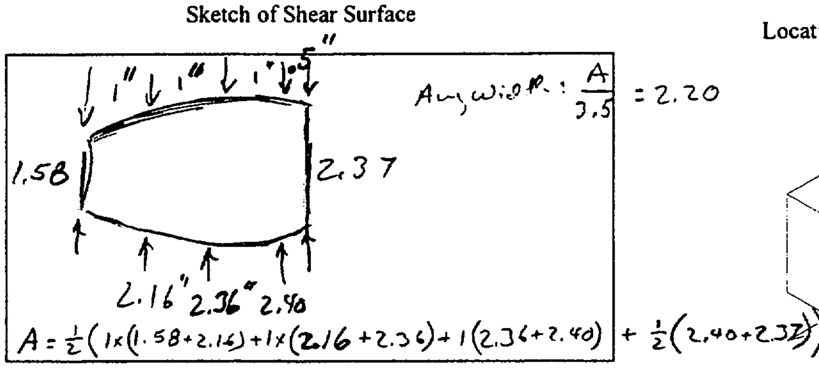
Sample ID: #33 - Boring: 01-F

SampleDescription: Gray clay seam (0-.05" thick) in gray medium grained sandstone (weak & clayey) ~70° dip

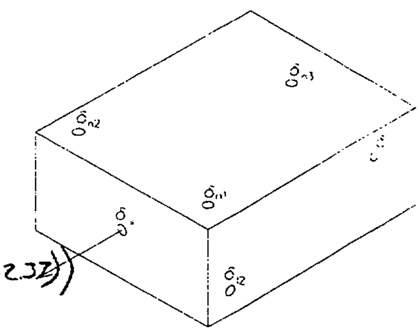
Sample Depth: 118.3'

Sample Condition: received & tested moist

Sketch of Shear Surface



Location of LVDTs on top shear box



Sample area: 7.703 in²

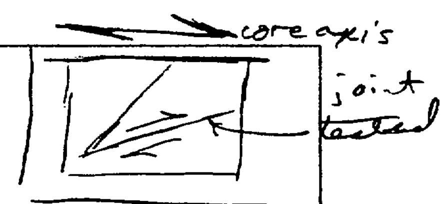
σ_n	60	120	240	psi
F_n	462	924	1849	lb
F_n-W_b	447	909	1834	lb
	125	250	500	

Estimated top box weight: 15 lb

Measured top box weight: 14.8 lb

Joint Profiles

NA - pulled apart through cleaved up "rock," not along a discrete plane.



Comments: probably too high σ_n due to clay - start w/ lower σ_n

seam appears to become plastic between 400-500 psi F_N

possibly asperities pushing through clay to result in

higher φ @ 500 psi

May not have sheared along thin clay seam

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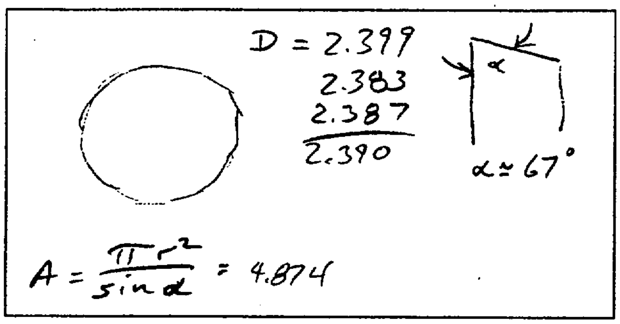
DATA SHEET
Direct Shear of Rock (ISRM)

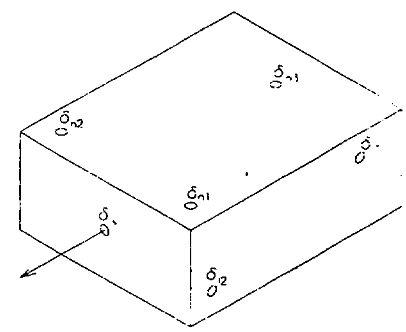
Client: W. Lettis & Assoc.   Date: 5/9/01
Job: #131 - DCPP/ISFSI   Tester: A. Bro
Sample ID: #34 - Boring: 01-CTF-A
SampleDescription: Contact between tan sandy clay and tan clayey fine to medium grained sandstone.

Sample Depth: 22.6'   Sample Condition: received & tested moist

Sketch of Shear Surface



Location of LVDTs on top shear box



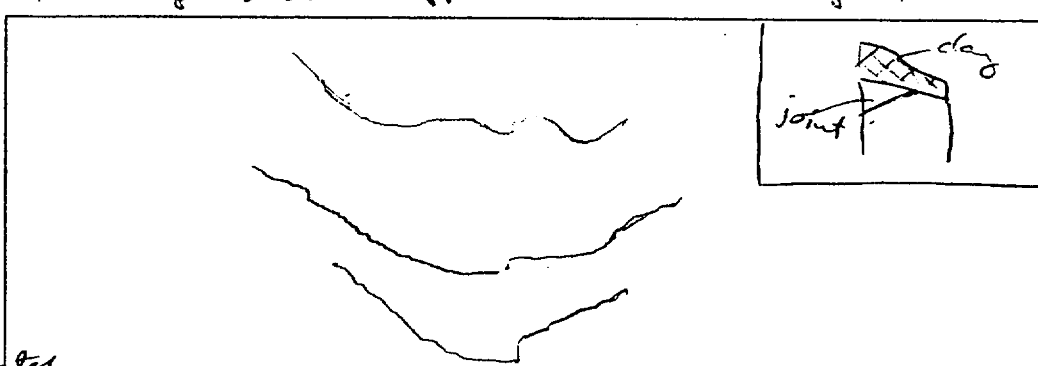
Sample area : 4.874

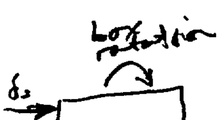
σ_n	15	30	60 psi
F_n	73	146	292 lb
F_n-W_b	58	131	277 lb

Estimated top box weight: 15 lb
Measured top box weight: 14.6

The sample did not appear to shear through the clay

Joint Profiles





as box rotates, the δ_s moves in a negative direction.

Comments: all δ's reset before 3rd stage - rear of sample collapsed. Large sample rotations result in very odd F_s-δ_s curves*
It is still possible to use the strengths for the envelope.
Note: GTU recommended that this sample not be tested due to limited ability to hold on to the sample.

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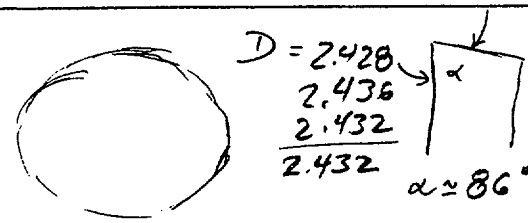
DATA SHEET
Direct Shear of Rock (ISRM)

Client: W. Lettis & Assoc. Date: 5/9/01
Job: #131-DCPP/ISFSI Tester: A. Bro
Sample ID: #35 - Boring: 01-H
Sample Description: Irregular dark gray clay filled joint (1/2 - 4" thick) in gray clayey medium grained sandstone.

Sample Depth: 94.5 Sample Condition: received & tested moist

Sketch of Shear Surface



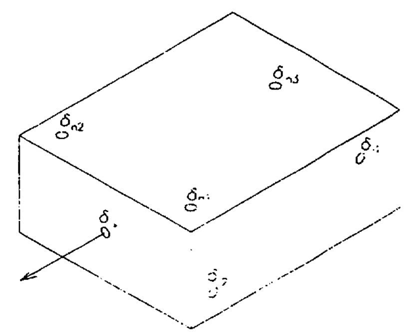
D = 2.428
2.436
2.432
2.432

$\alpha \simeq 86°$

$A = \frac{\pi r^2}{\sin \alpha} = 4.657$

Sample area: $4.657\ in^2$

Location of LVDTs on top shear box



σ_n	50	100	200	psi
F_n	232	464	928	lb
F_n-W_b	217	449	913	lb
~~5~~ 1st	50	100	200	lb

Estimated top box weight: 15 lb
Measured top box weight: 14.6

Joint Profiles

NA - smeared clay layer

Comments: δ_n reset @ $\delta_s \approx .23$. During 1st 3 stages the sample "compressed" about .1". By the end of the test, there was steel-to-steel contact which developed on 2nd stage of 2nd set of normal loads.

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Geo Test Unlimited

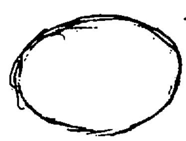
DATA SHEET
Direct Shear of Rock (ISRM)

Client: W. Lettis & Assoc.
Job: #131-DCPP/ISFSI
Sample ID: #36 Boring: 01-I
SampleDescription: Planar bedding joint in tan thinly bedded very fine grained "dolomitic sandstone".

Date: 5/10/01
Tester: A.Bro

Sample Depth: 174'
Sample Condition: received & tested moist

Sketch of Shear Surface



D = 2.400
2.398
2.391
2.396

$\alpha = 76°$

$A = \frac{\pi r^2}{\sin \alpha} = 4.647$

Location of LVDTs on top shear box

Sample area : 4.647

σ_n	87	174	348	psi
F_n	404	808	1617	lb
F_n-W_b	389	793	1602	lb

Estimated top box weight: 15 lb
Measured top box weight: 15.0 lb

Joint Profiles

Comments: hydrocarbon odor during cutting - also there is a leaf fossil on the joint. dark brown

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Geo Test Unlimited (GTU)

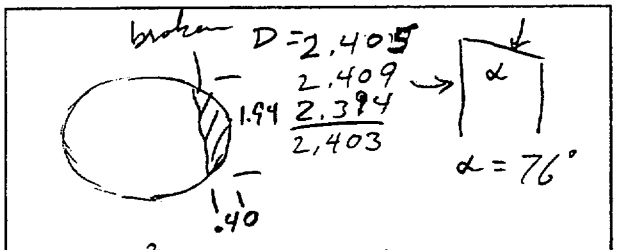
DATA SHEET
Direct Shear of Rock (ISRM)

Client: W. Letts & Assoc.
Job: #131- DCPP/ISFSI
Sample ID: #37- Boring: 01-I
SampleDescription: Bedding plane joint with a thin lamination and clay coating. The lamination is somewhat broken.

Date: 5-10-01
Tester: A.Bro

Sample Depth: 168.5' Sample Condition: received & tested moist

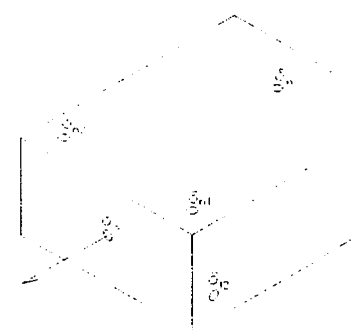
Sketch of Shear Surface



$A = \frac{\pi r^2}{\sin \alpha} - \frac{1}{2}(.40 \times 1.94) = 4.674 - .388$

Sample area : 4.286

Location of LVDTs on top shear box



Estimated top box weight: 15 lb
Measured top box weight: 14.8 lb

σ_n	84	168	336	psi
F_n	360	720	1440	lb
$F_n - W_b$	345	705	1425	lb ?

Joint Profiles

τ_n 100 200 400 ?
50 100 200

NA - consists of chips of rock and smeared clay

Comments: @ 200 lb, a fair amount of sample rotation is developing - don't take to highest stress
The increase in shear strength @ 200 = F_n may be due to joint sides grinding into contact through the clay.

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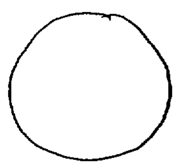
Geo Test Unlimited (GTU)

DATA SHEET
Direct Shear of Rock (ISRM)

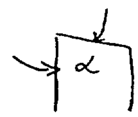
Client: W. Lettis & Assoc. | Date: 5/10/01
Job: #131-DCPP/ISFSI | Tester: A. Bro
Sample ID: #39B-Boring:01-I
SampleDescription: Tan clay seam (.1-.2" thick) in tan fine grained dolomitic sandstone

Sample Depth: 1304' Sample Condition: received & tested moist

Sketch of Shear Surface



D = 2.410
2.413
2.425
2.416



$\alpha \approx 82°$

$A = \frac{\pi r^2}{\sin\alpha} = 4.629$

Sample area : 4.629

Location of LVDTs on top shear box

Estimated top box weight: 15 lb
Measured top box weight: 14.8

σ_n	65	130	260	psi
F_n	301	602	1204	lb
F_n-W_b	286	587	1189	lb
use	50	100	200	lb

Joint Profiles

NA

Comments: strong hydrocarbon odor on cutting
sliding on soft clay with broken chips of rock on shear surface

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Geo Test Unlimited

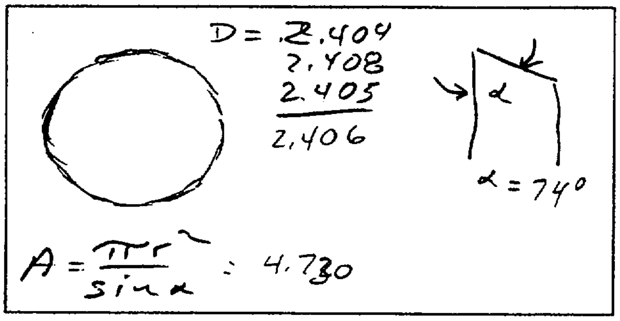
DATA SHEET
Direct Shear of Rock (ISRM)

Client: W. Lettis & Assoc
Job: #131-DCPP/ISFSI
Sample ID: #40B- Boring:01-I
SampleDescription: Planar bedding joint in tan fine grained dolomitic sandstone.

Date: 5/10/01
Tester: A.Bro

Sample Depth: 88.8'
Sample Condition: received & tested moist

Sketch of Shear Surface



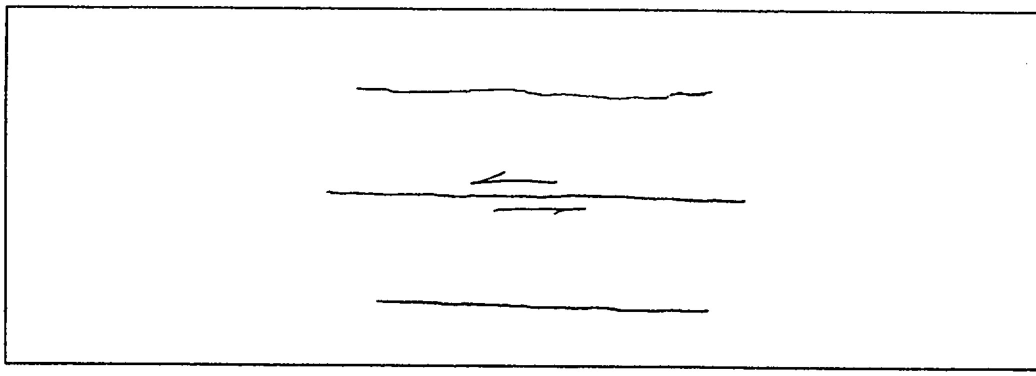
Location of LVDTs on top shear box

Sample area : 4.730

σ_n	44	88	176 psi
F_n	208	416	832 lb
F_n-W_b	193	401	817 lb

Estimated top box weight: 15 lb
Measured top box weight: 15.0 lb

Joint Profiles



Comments: moderate hydro carbon odor on cutting

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Geo **GTU** ***Test*** ***Unlimited***

DATA SHEET
Direct Shear of Rock (ISRM)

Client: W. Lettis & Assoc. Date: 5/11/01
Job: #131- DCPP/ISFSI Tester: A. Bro
Sample ID: # 41A - Boring: 01-I
SampleDescription: Tan thick clay seam (~3/4" thick) in fine grained tan sandstone.

Sample Depth: 45.6' Sample Condition: received & tested moist

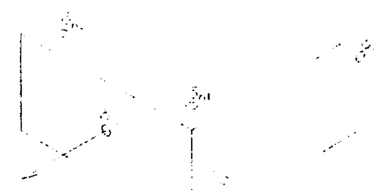
Sketch of Shear Surface

$D = 2.388$
2.395
2.365
$\overline{2.383}$

$\alpha = 73^\circ$

$A = \dfrac{\pi r^2}{\sin\alpha} = 4.664$

Location of LVDTs on top shear box



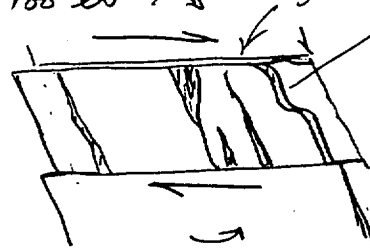
Sample area : 4.664

σ_n	22	45	90 psi
F_n	103	210	420 lb
F_n-W_b	88	195	405 lb

Estimated top box weight: 15 lb
Measured top box weight: 14.4 lb

~~Joint Profiles~~ side view after testing

τ_n 50 100 150 lb
→ 25 50 100 lb



Comments: moderate hydrocarbon odor on cutting

* on 3rd stage, second set increase in σ_n results in significant vertical sample displacement & rocking*
F_s slightly dependent on shear displ. rate. As rate increases F_s increases, when rate decreases F_s decreases - ~1/12

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DATA SHEET
Direct Shear of Rock (ISRM)

Client: W. Lettis & Assoc. Date: 5/10/01

Job: #131 - DCPP/ISFSI Tester: A. Bro

Sample ID: #41B - Boring 01-I

SampleDescription: planar bedding joint in tan fine grained dolomitic sandstone

Sample Depth: 46.1' Sample Condition: received & tested moist

Sketch of Shear Surface

D = 2.407
2.408
2.407
2.407

$\alpha = 76°$

$A = \frac{\pi r^2}{\sin \alpha} = 4.690$

Location of LVDTs on top shear box

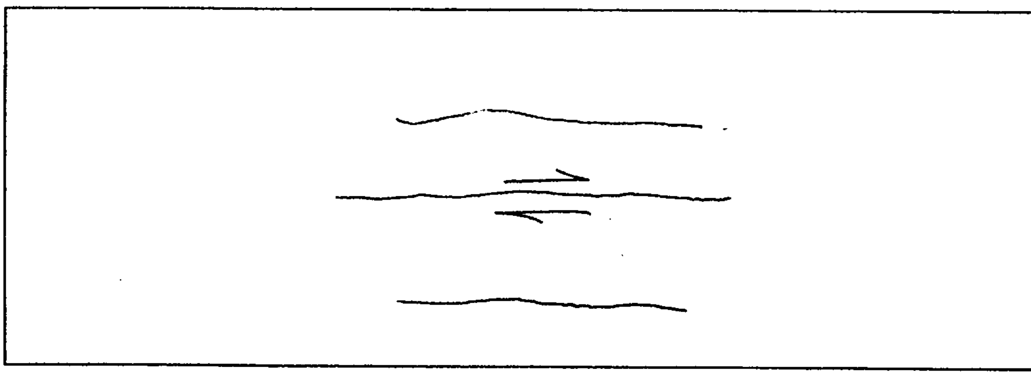
Sample area : 4.690

σ_n	23	46	92	psi
F_n	108	216	431	
F_n-W_b	93	201	416	

Estimated top box weight: 15 lb

Measured top box weight: 14.9 lb

Joint Profiles



Comments: moderate hydrocarbon odor on cutting @ ~.19 = δ_s reset all δ_n due to large block rotations.

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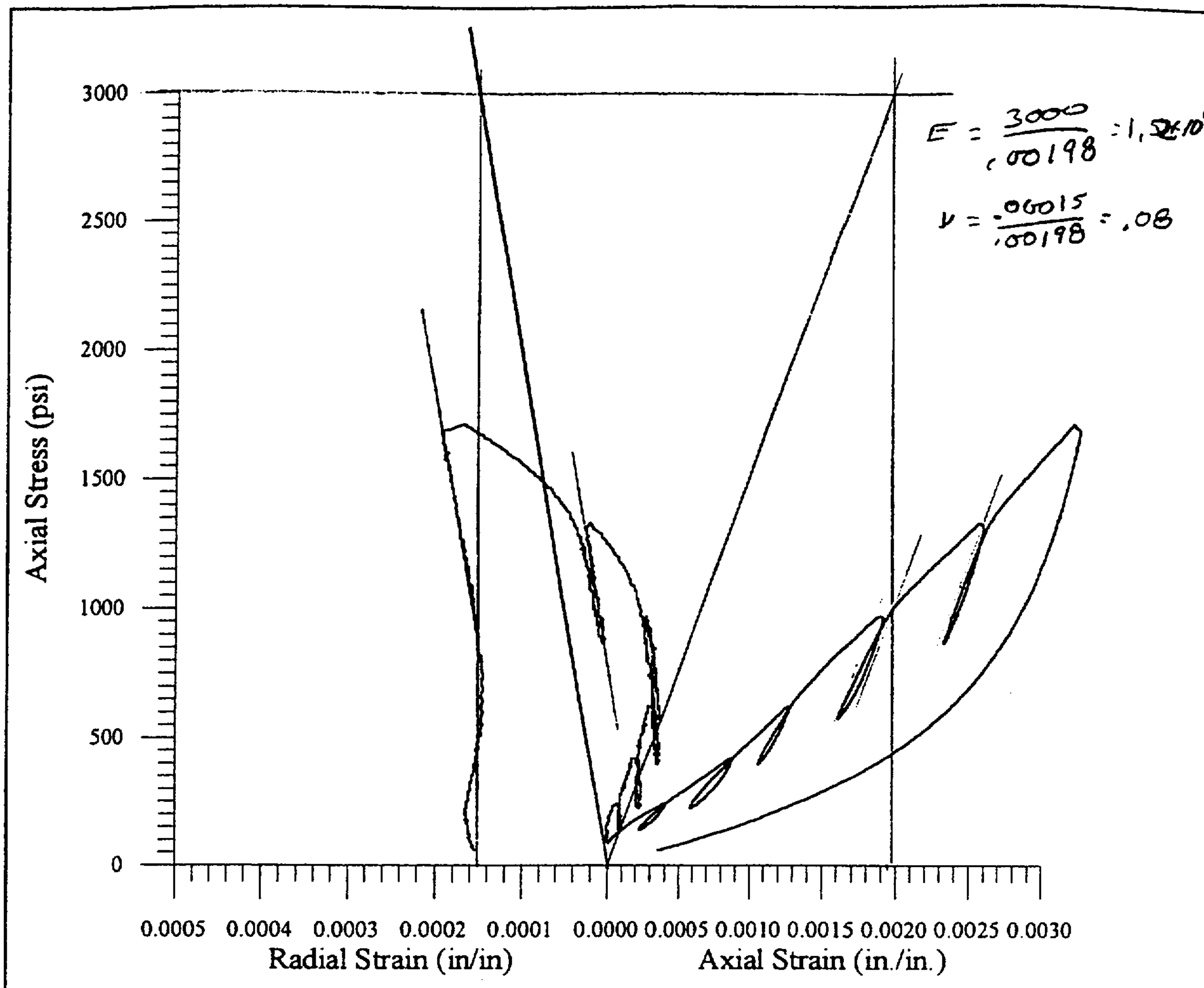

ELASTIC MODULUS TEST
Axial Stress vs. Axial & Radial Strain

Boring: 01-A
Sample: #1
Depth: 19.5'

DESCRIPTION

Tan well cemented medium grained sandstone with numerous dolomite(?) healed fractures.

Modulus:	~~**4,030,000**~~ **psi**
Poisson's ratio:	~~**.26**~~
Density:	**161.4 pcf**

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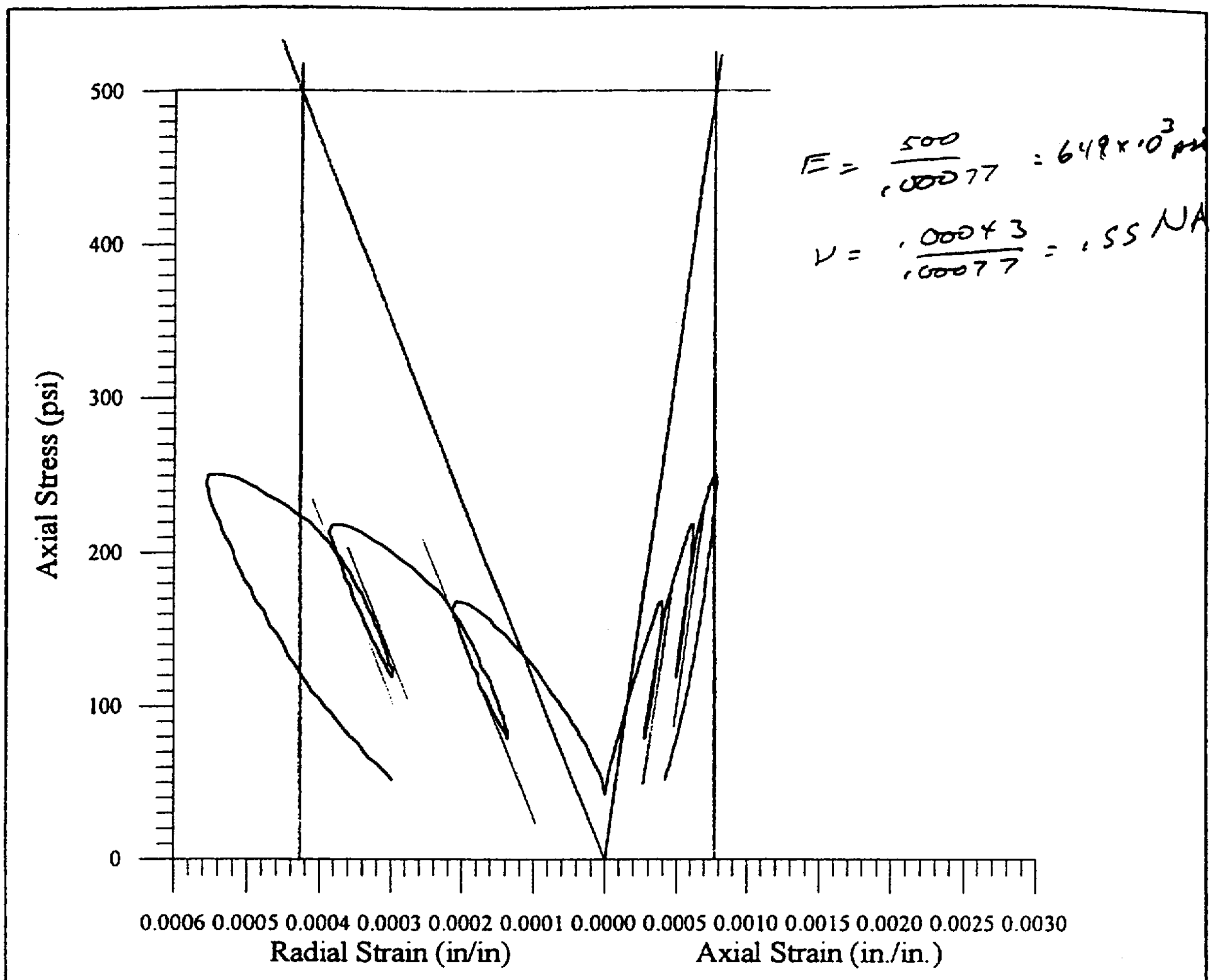
Nevada City, CA 95959

Client: **William Lettis & Associates, Inc.**
1777 Botelho Dr., Suite 262
Walnut Creek, CA 94596

Project: **Diablo Canyon Power Plant ISFSI**

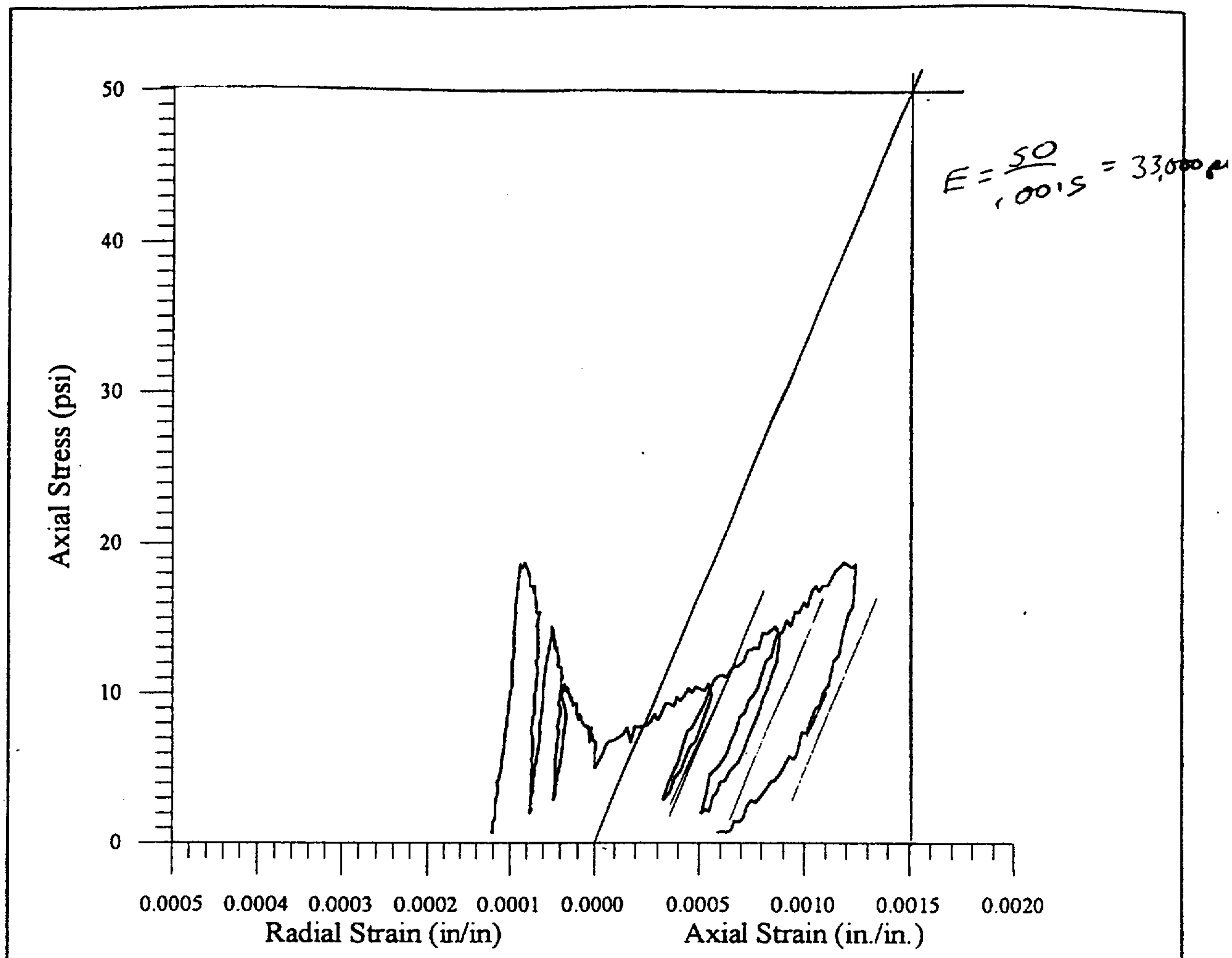
Project Number: 1223-~~50~~ 60 ?

Test Date: April 29, 2001



ELASTIC MODULUS TEST
Axial Stress vs. Axial & Radial Strain

Boring: 01-A **Sample: #2** **Depth: 24.5'** **DESCRIPTION** Tan medium grained sandstone. **Modulus:** ~~60,600~~ psi **Poisson's ratio:** ~~.17~~ **Density:** ~~133.2~~ pcf	*Geo Test Unlimited* GTU **27069 N. Bloomfield Rd.** **Nevada City, CA 95959** **Client:** **William Lettis & Associates, Inc.** **1777 Botelho Dr., Suite 262** **Walnut Creek, CA 94596** **Project:** **Diablo Canyon Power Plant ISFSI** **Project Number: 1223-60** **Test Date:** May 12, 2001



ELASTIC MODULUS TEST
Axial Stress vs. Axial & Radial Strain

Boring: 01-A
Sample: #3
Depth: 35.5'

DESCRIPTION

Gray medium grained weak friable sandstone with one, possibly through-going, fracture.

Modulus:	~~850,000 psi~~
Poisson's ratio:	~~.15~~
Density:	~~135.8 pcf~~

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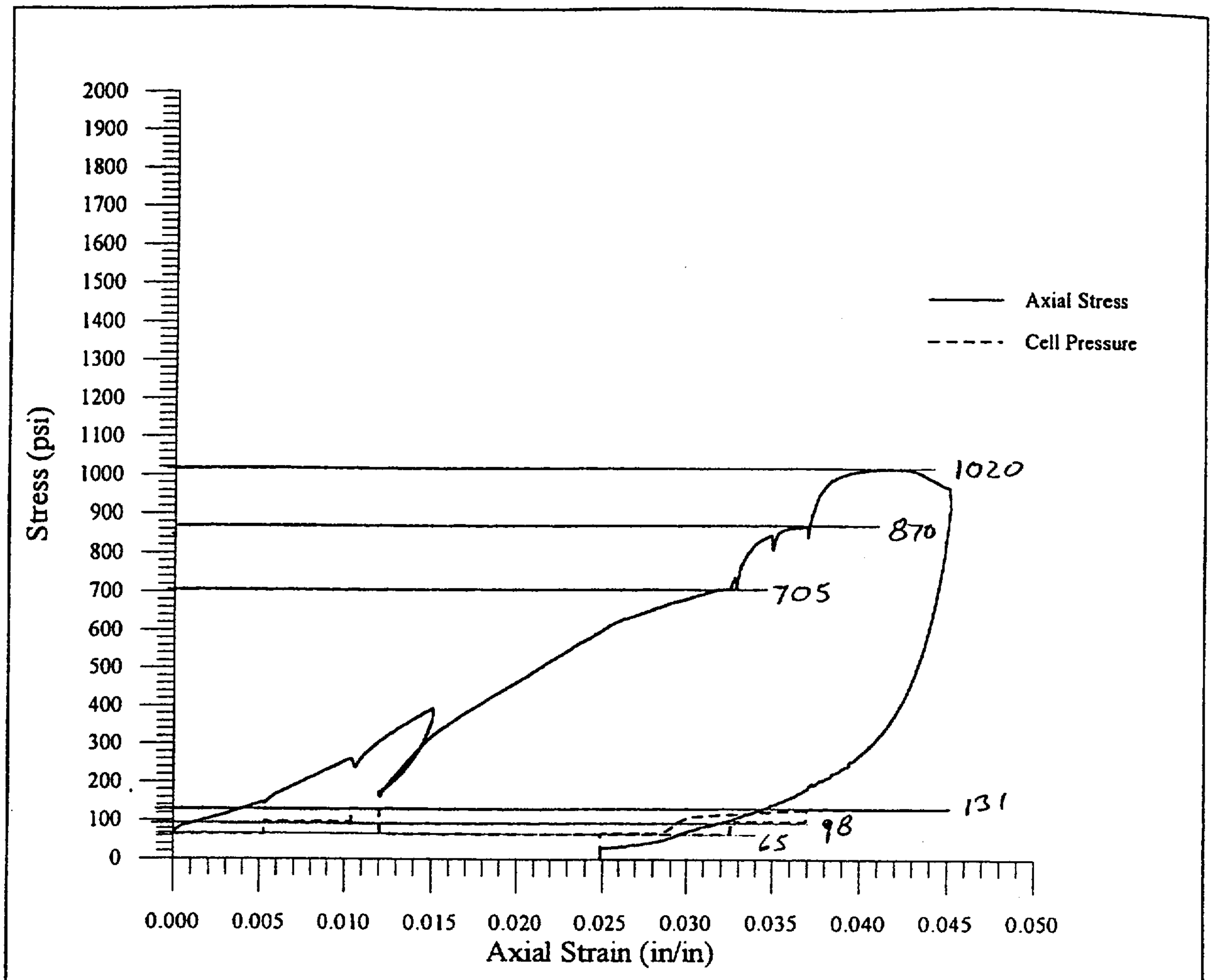
Nevada City, CA 95959

Client: William Lettis & Associates, Inc.
1777 Botelho Dr., Suite 262
Walnut Creek, CA 94596

Project: Diablo Canyon Power Plant ISFSI

Project Number: 1223-~~50~~ 60

Test Date: April 29, 2001



TRIAXIAL COMPRESSION TEST
Axial Stress and Confining Pressure vs. Strain

Boring: O1-A
Sample: 3
Depth: 35.5'
Density: 145.3 pcf.

DESCRIPTION

Gray medium grained weak fraible sandstone with one fracture, possibly through-going.

Conf. Pres. (psi)	Strength (psi)
80.6	6807

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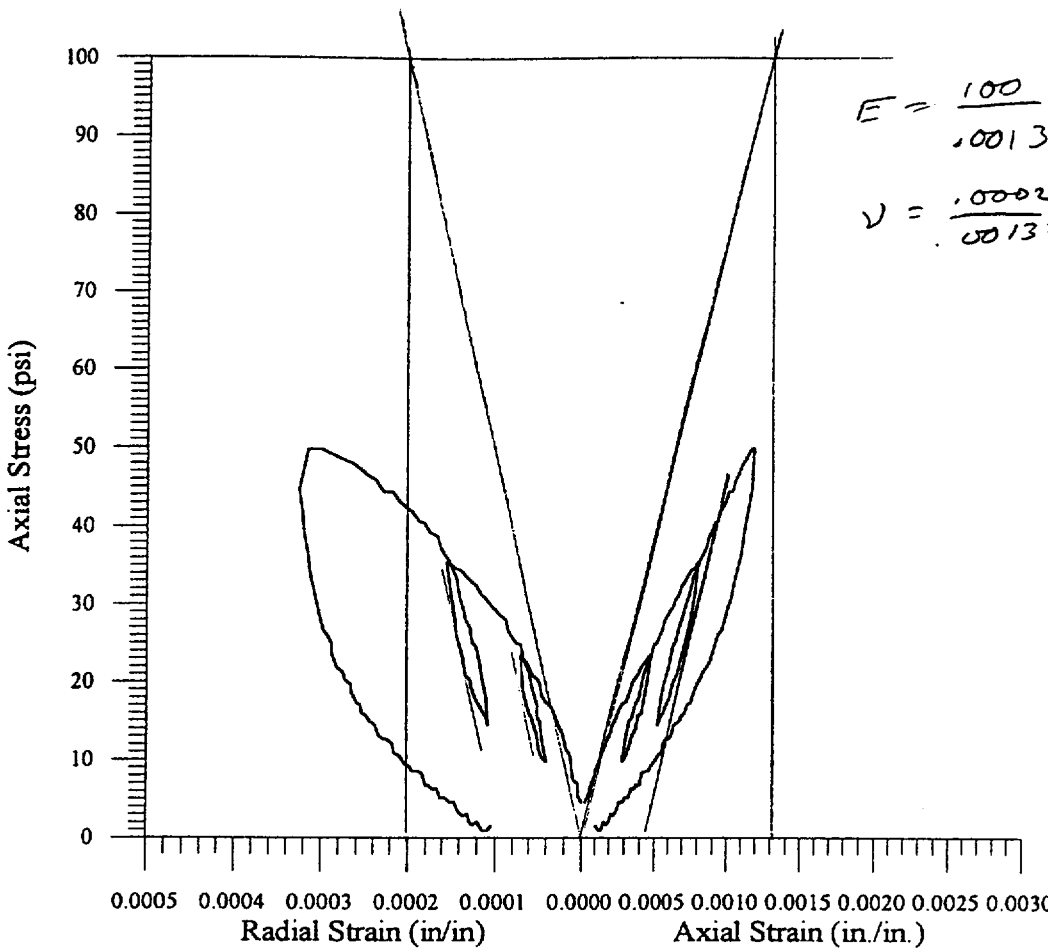
Client: William Lettis & Associates, Inc.
1777 Botelho Dr., Suite 262
Walnut Creek, CA 94596

Project: Diablo Canyon Power Plant ISFSI

Project Number: 1223-60

Test Date: May 4, 2001

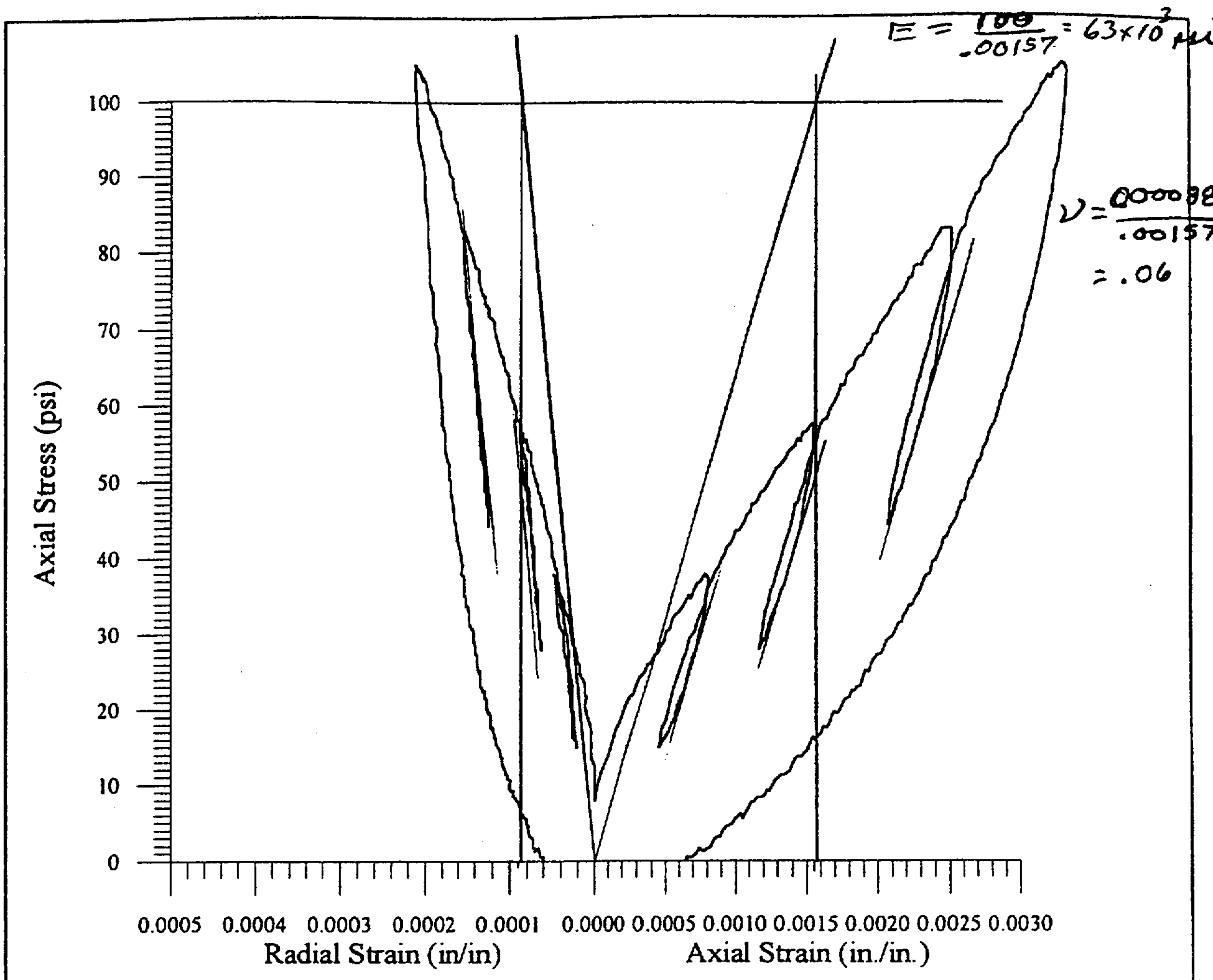


$E = \frac{100}{.00132} = 75.8 \times 10^3$ p

$\nu = \frac{.0002}{.00132} = .15$

ELASTIC MODULUS TEST
Axial Stress vs. Axial & Radial Strain

Boring: 01-D **Sample: #4** **Depth: 25.5'**	**Geo Test Unlimited** (GTU) **27069 N. Bloomfield Rd.** **Nevada City, CA 95959**
DESCRIPTION Tan weak clayey medium grained sandstone.	**Client:** **William Lettis & Associates, Inc.** **1777 Botelho Dr., Suite 262** **Walnut Creek, CA 94596** **Project:** **Diablo Canyon Power Plant ISFSI** **Project Number: 1223-60**
Modulus: ~~**649,000 psi**~~ **Poisson's ratio:** ~~**NA (.55)**~~ **Density:** ~~**146.6 pcf**~~	**Test Date:** May 12, 2001



ELASTIC MODULUS TEST
Axial Stress vs. Axial & Radial Strain

Boring: 01-D
Sample: #5
Depth: 28.0'

DESCRIPTION

Tan medium grained clayey weak sandstone with two healed axial fractures.

Modulus:	~~33,000 psi~~
Poisson's ratio:	~~NA~~
Density:	145.3 pcf

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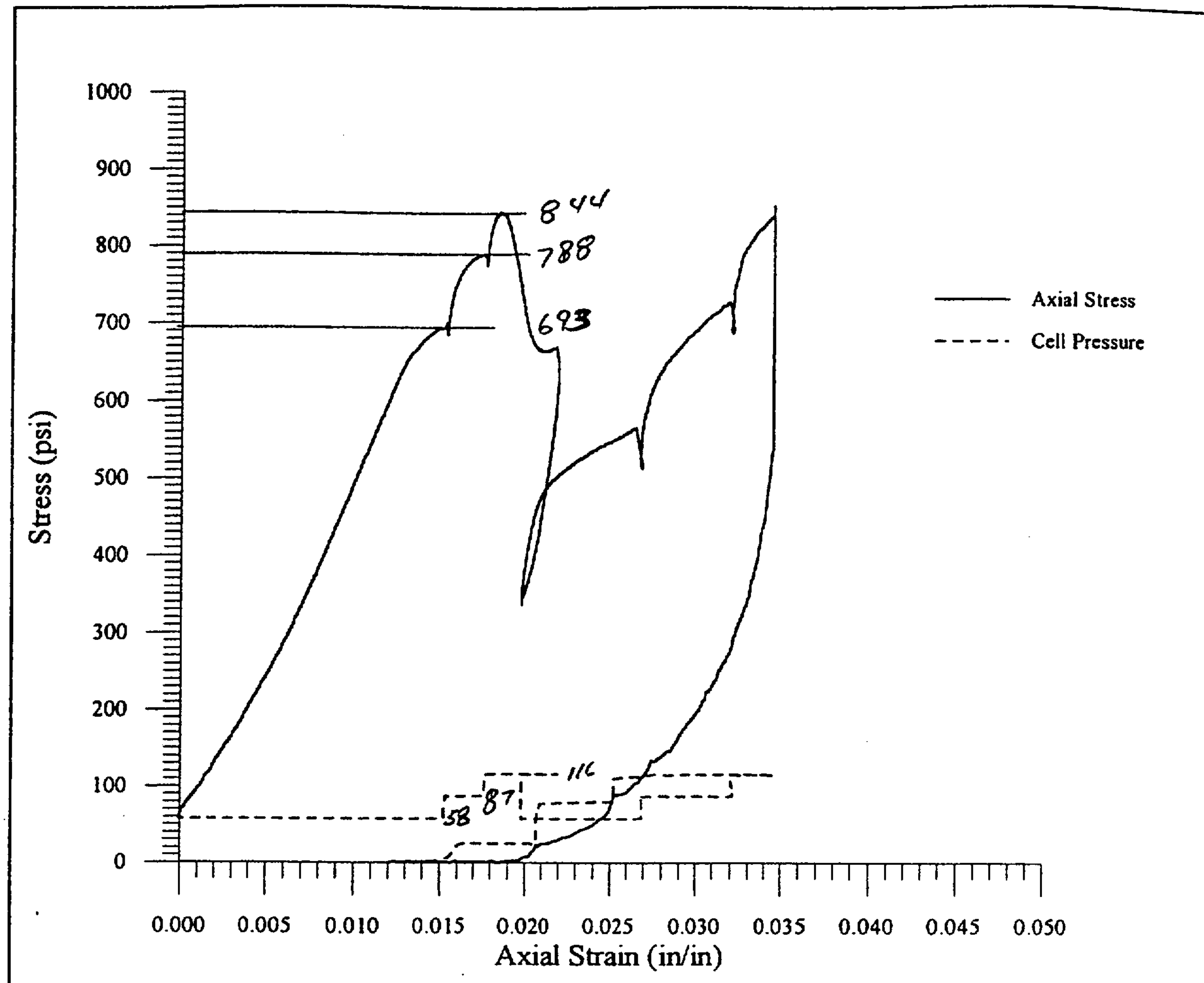
Nevada City, CA 95959

Client: **William Lettis & Associates, Inc.**
1777 Botelho Dr., Suite 262
Walnut Creek, CA 94596

Project: **Diablo Canyon Power Plant ISFSI**

Project Number: 1223-~~50~~ 60

Test Date: April 29, 2001



TRIAXIAL COMPRESSION TEST
Axial Stress and Confining Pressure vs. Strain

Boring: O1-D
Sample: 5
Depth: 28.0'
Density: 144.5 pcf.

DESCRIPTION

Tan medium grained clayey weak sandstone with two healed axial fractures.

Conf. Pres. (psi)	Strength (psi)
65	705
98	870
131	1020

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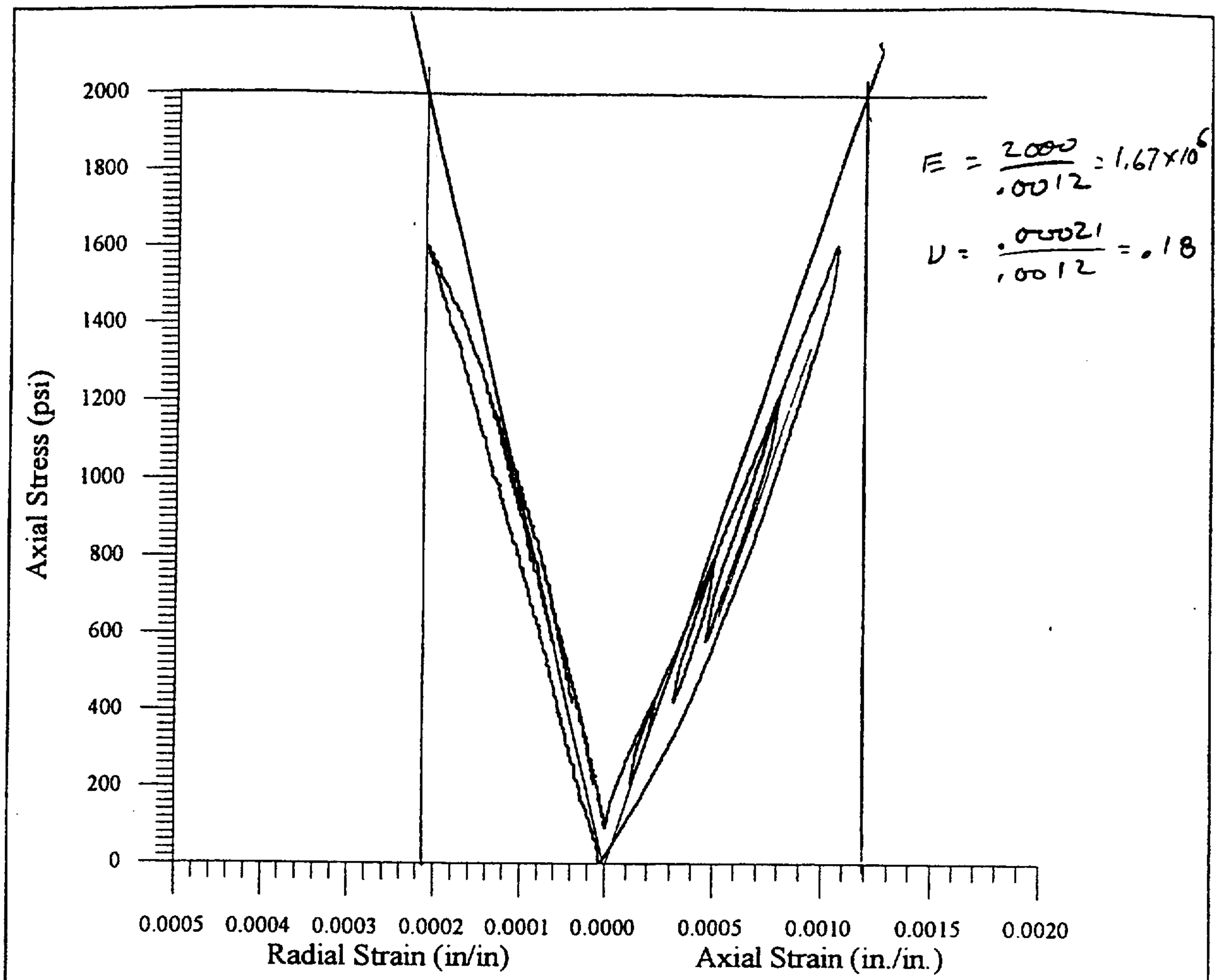
Client: **William Lettis & Associates, Inc.**
1777 Botelho Dr., Suite 262
Walnut Creek, CA 94596

Project: **Diablo Canyon Power Plant ISFSI**

Project Number: 1223-60

Test Date: May 4, 2001



ELASTIC MODULUS TEST
Axial Stress vs. Axial & Radial Strain

Boring: 01-G
Sample: #9
Depth: 28.8'

DESCRIPTION

Tan fine grained dolomitic sandstone with two dark brown axial fractures. This sample had a hydrocarbon odor after testing.

Modulus:	~~**1,850,000 psi**~~
Poisson's ratio:	? ~~**.22**~~
Density:	~~**138.2 pcf**~~

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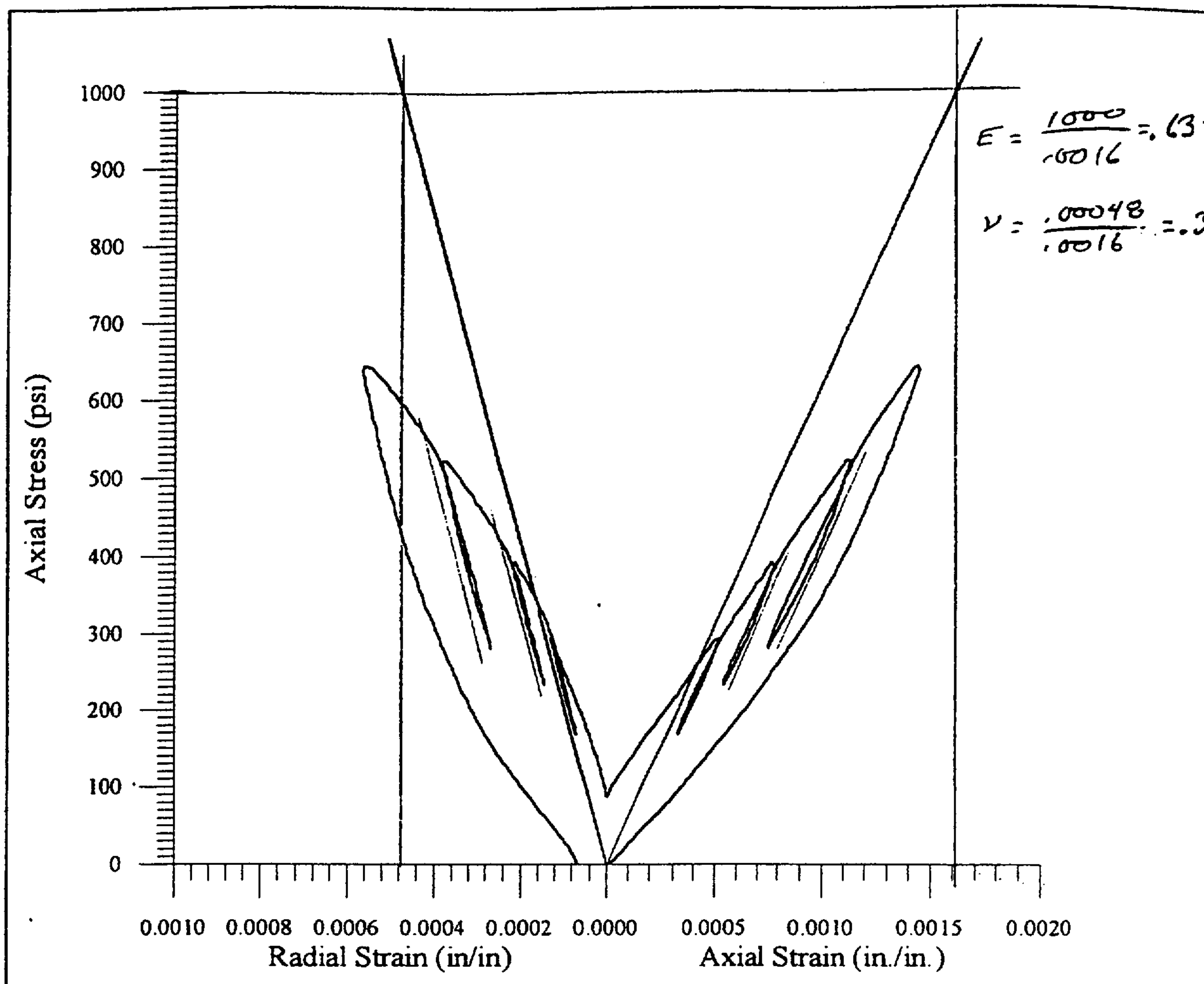
Nevada City, CA 95959

Client: William Lettis & Associates, Inc.
1777 Botelho Dr., Suite 262
Walnut Creek, CA 94596

Project: Diablo Canyon Power Plant ISFSI

Project Number: 1223-~~50~~ 60

Test Date: April 29, 2001



ELASTIC MODULUS TEST
Axial Stress vs. Axial & Radial Strain

Boring: 01-D
Sample: #6
Depth: 48.5'

DESCRIPTION

Tan fine to medium grained dolomitic sandstone with one axial fracture and one diagonal joint about 32 degrees to the core axis.

Modulus:	~~**1,520,000 psi**~~
Poisson's ratio:	~~**.08**~~
Density:	~~**161.4 pcf**~~

Geo Test Unlimited GTU
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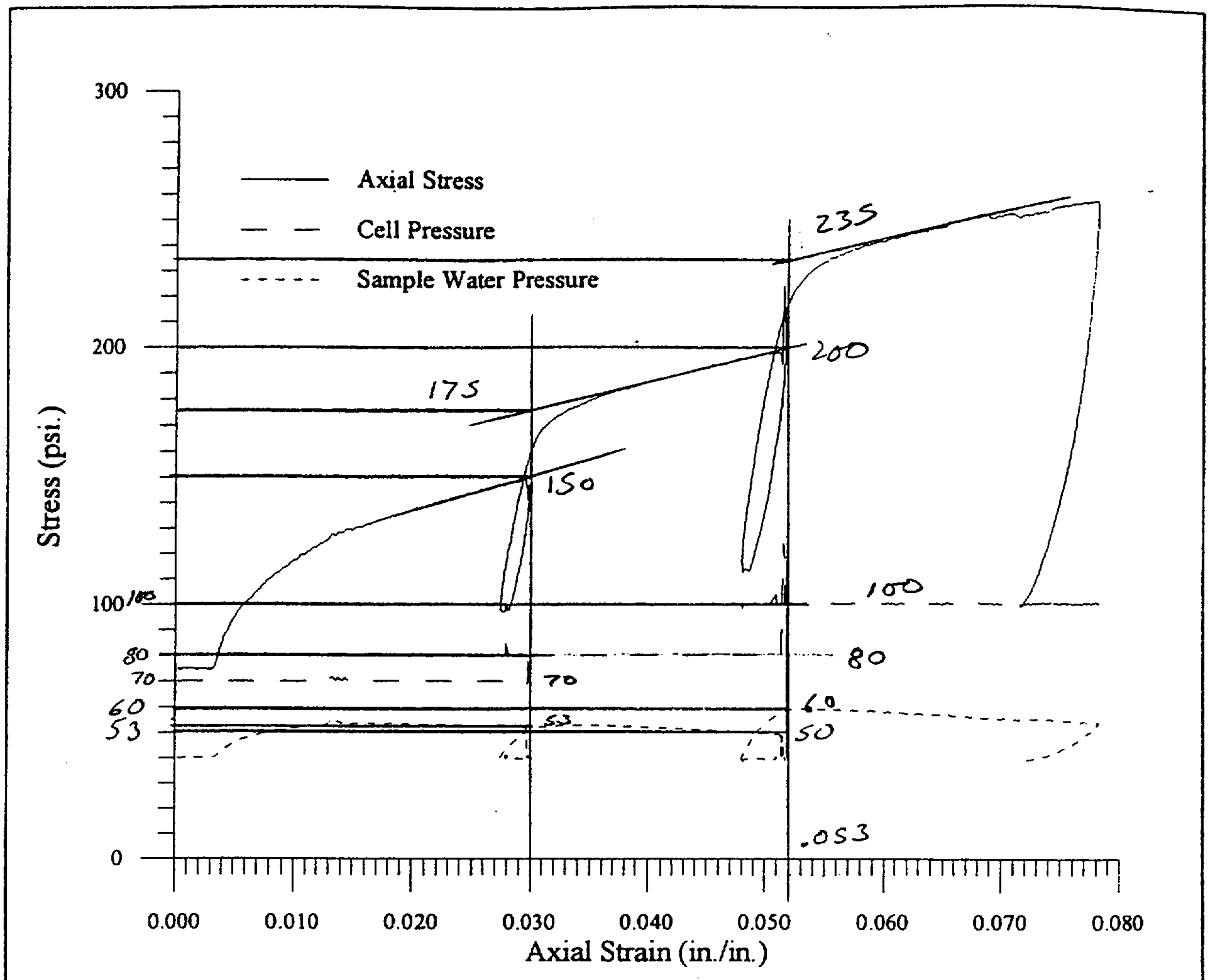
Nevada City, CA 95959

Client: **William Lettis & Associates, Inc.**
1777 Botelho Dr., Suite 262
Walnut Creek, CA 94596

Project: **Diablo Canyon Power Plant ISFSI**

Project Number: 1223-~~50~~ 60 ?

Test Date: April 29, 2001



TRIAXIAL COMPRESSION TEST
Axial Stress, Cell Pressure & Sample Pressure vs. Axial Strain

Boring: 01-D
Sample: #7
Depth: 55.5'

DESCRIPTION

Tan clayey altered medium grained sandstone with a weak joint about 57 degrees to the core axis.

STRENGTH SUMMARY

Cell Pressure (psi)	Sample Pressure (psi)	Axial Strength (psi)
100	75	132
141	97	209
219	116	358

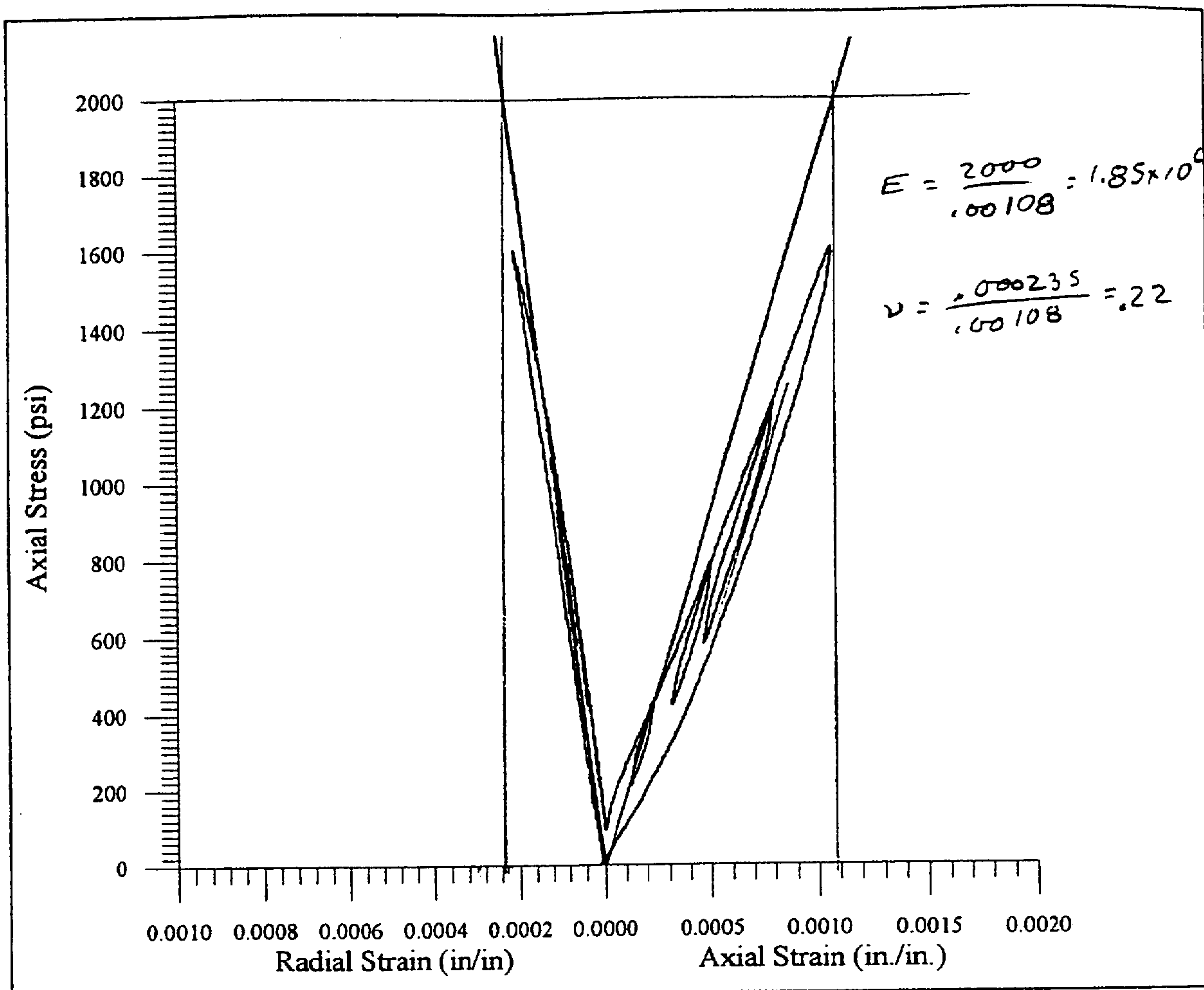
Geo Test Unlimited (GTU)
800 Peralta Ave
San Leandro, CA 94577

Client: William Lettis & Associates, Inc.
1777 Botelho Dr., Suite 262
Walnut Creek, CA 94596

Project: Diablo Canyon Power Plant ISFSI

Project Number: 1223-60

Test Date: May 15, 2001

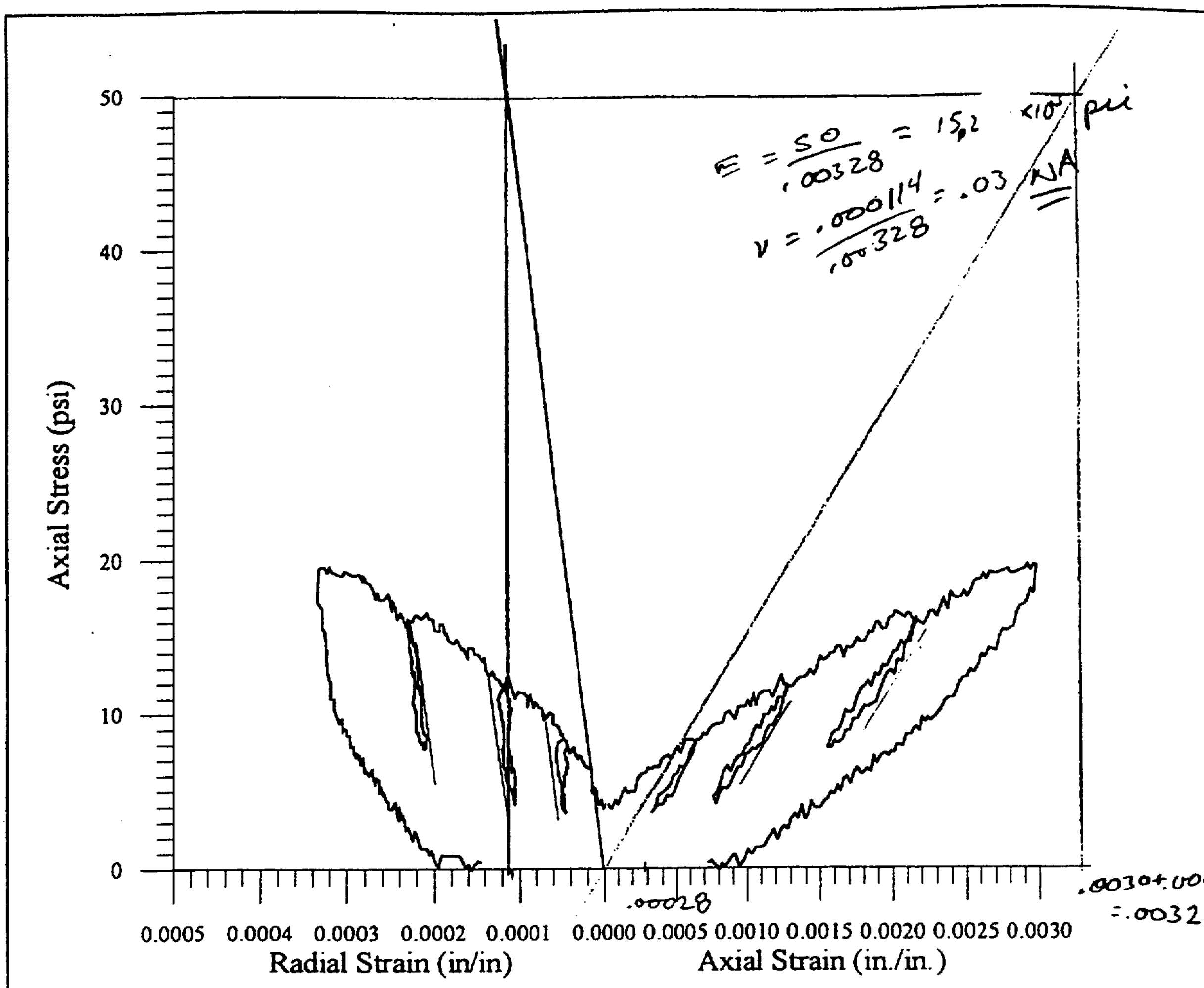


$E = \frac{2000}{.00108} = 1.85 \times 10^6$ psi

$\nu = \frac{.000235}{.00108} = .22$

ELASTIC MODULUS TEST
Axial Stress vs. Axial & Radial Strain

Boring: 01-G **Sample: #9** **Depth: 28.8'**	Geo Test Unlimited 27069 N. Bloomfield Rd. Nevada City, CA 95959
DESCRIPTION Tan fine grained dolomitic sandstone with two axial fractures.	**Client:** William Lettis & Associates, Inc. 1777 Botelho Dr., Suite 262 Walnut Creek, CA 94596
Modulus: ~~630,000~~ psi **Poisson's ratio:** ~~.30~~ **Density:** ~~147.1~~ pcf	**Project:** Diablo Canyon Power Plant ISFSI **Project Number:** 1223-~~50~~ 60
	Test Date: April 29, 2001



ELASTIC MODULUS TEST
Axial Stress vs. Axial & Radial Strain

Boring: 01-G
Sample: #10
Depth: 69.0'

DESCRIPTION

Gray friable clayey medium grained sandstone.

Modulus:	~~75,800~~ psi
Poisson's ratio:	~~.15~~
Density:	~~142.3~~ pcf

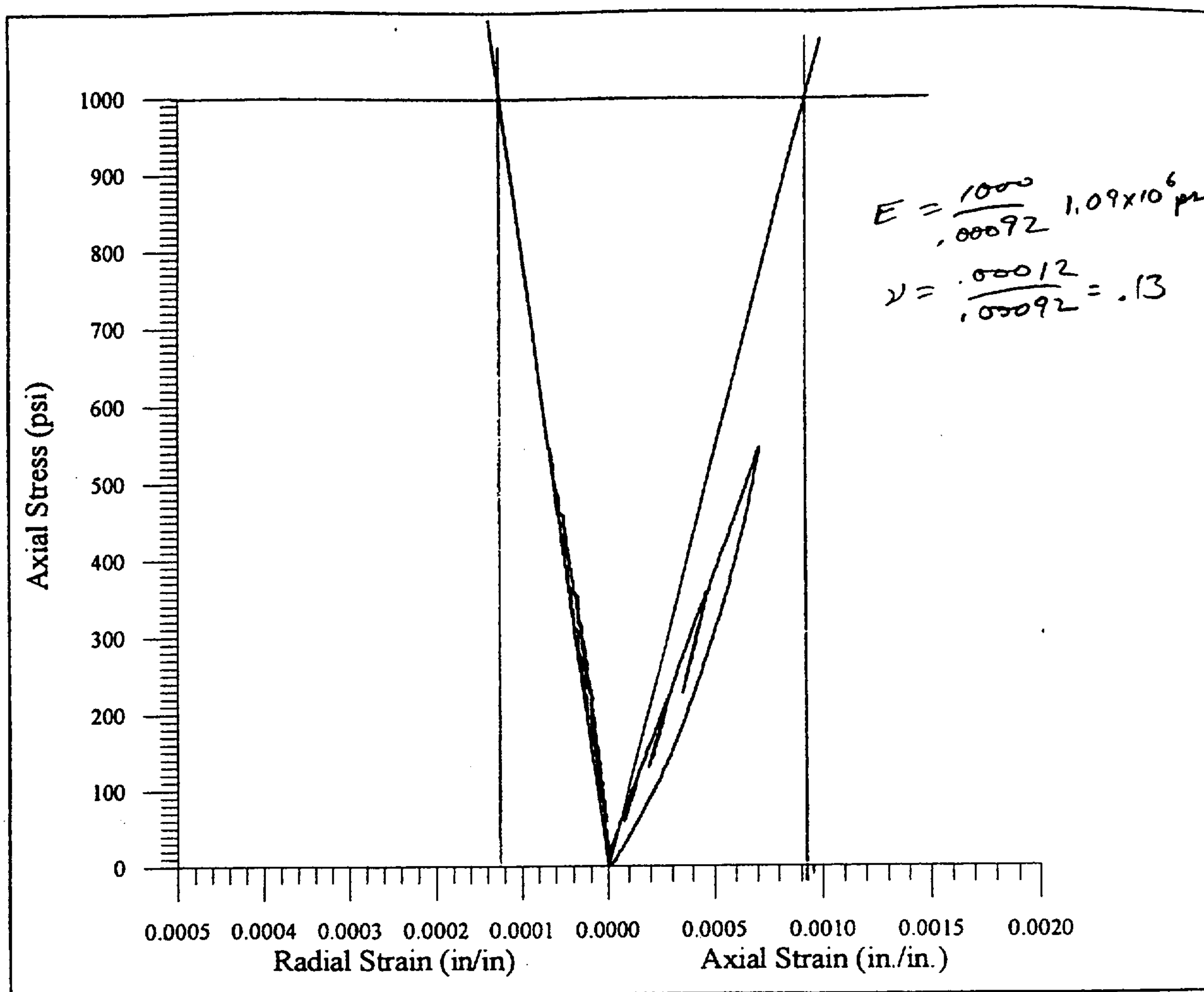
Geo Test Unlimited GTU
27069 N. Bloomfield Rd.
Nevada City, CA 95959

Client: **William Lettis & Associates, Inc.**
1777 Botelho Dr., Suite 262
Walnut Creek, CA 94596

Project: **Diablo Canyon Power Plant ISFSI**

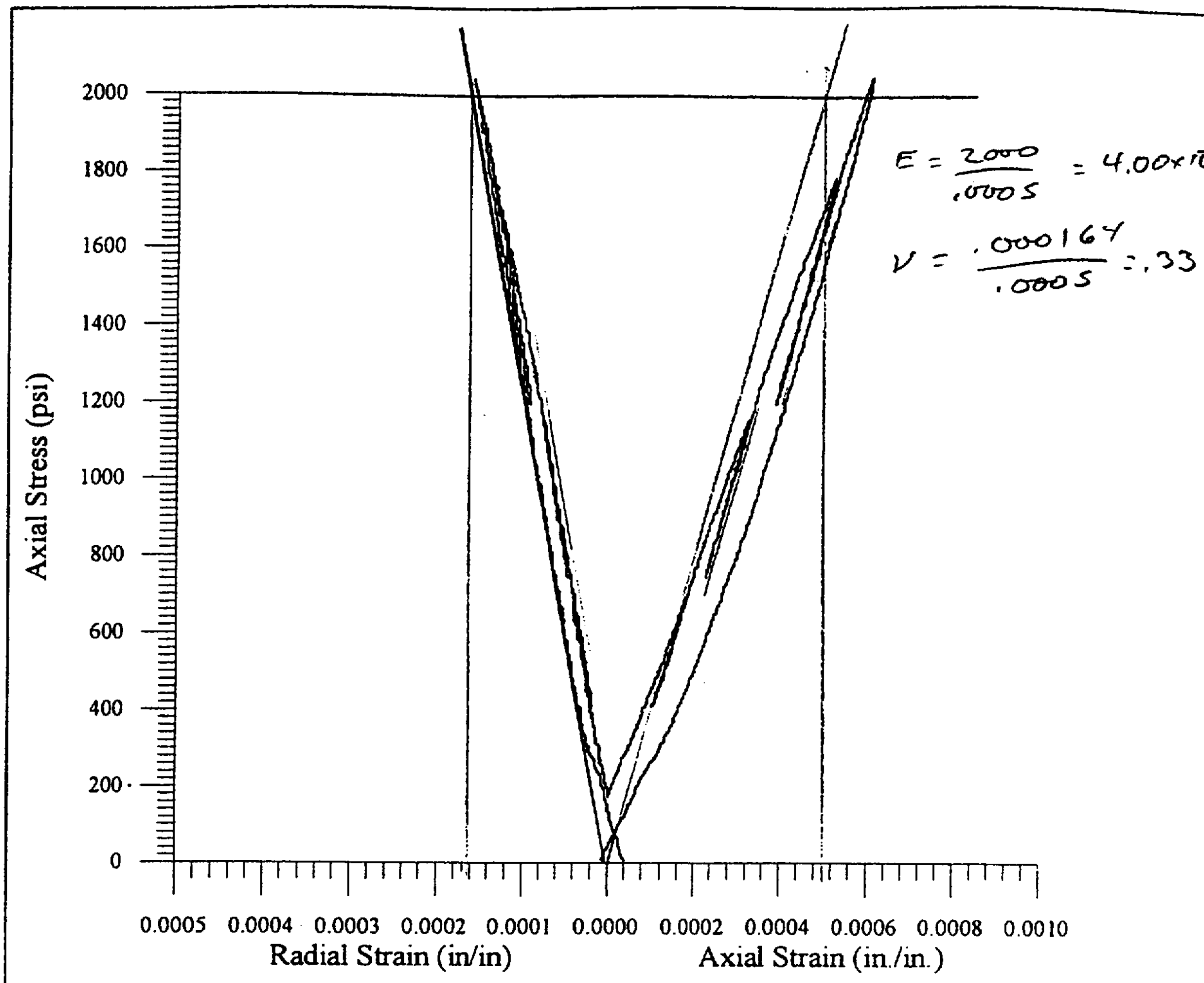
Project Number: 1223-60

Test Date: May 12, 2001



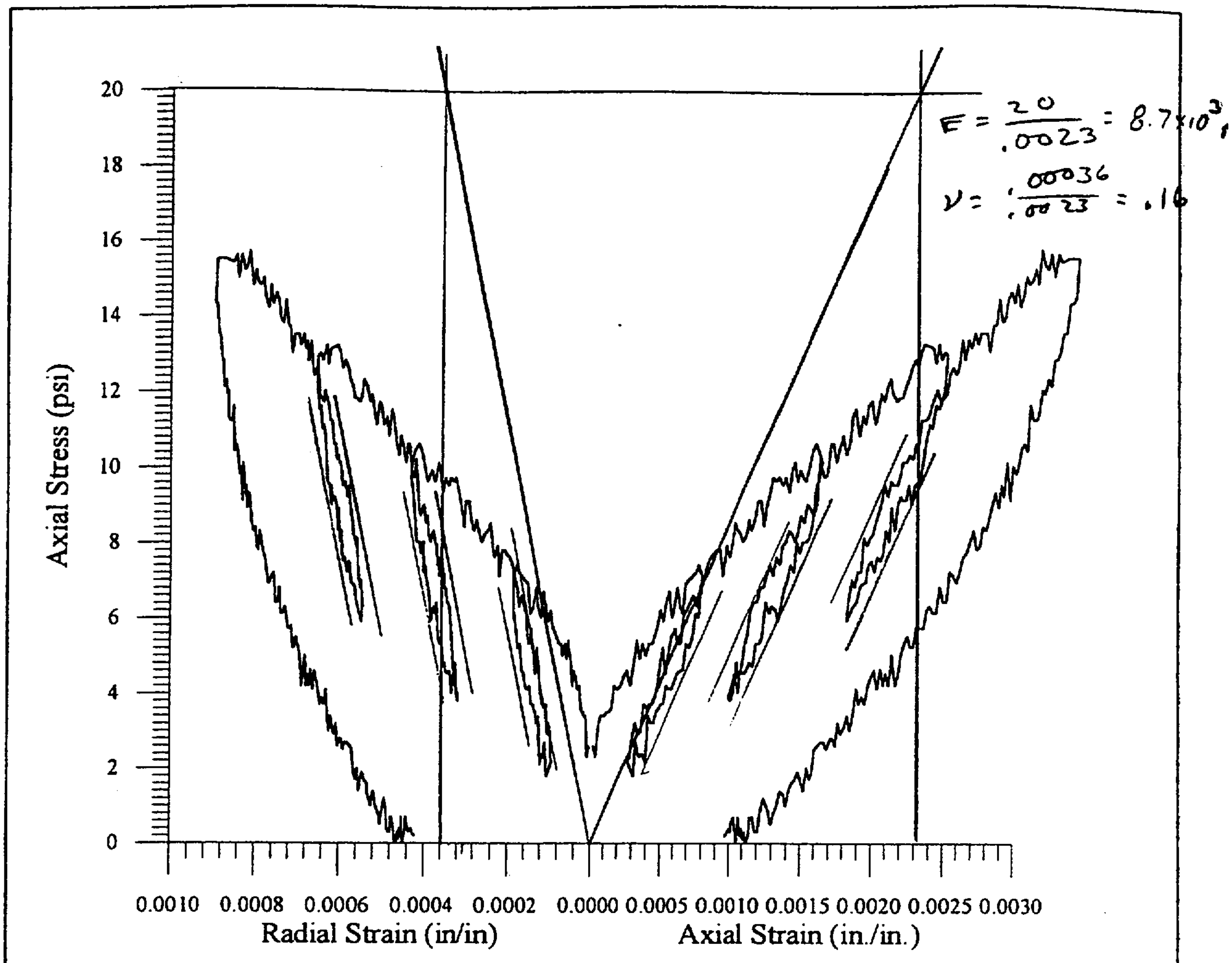
ELASTIC MODULUS TEST
Axial Stress vs. Axial & Radial Strain

Boring: 01-H **Sample: #11** **Depth: 11.0'**	**Geo Test Unlimited** GTU **27069 N. Bloomfield Rd.** **Nevada City, CA 95959**
DESCRIPTION Tan fine grained dolomitic sandstone.	**Client:** **William Lettis & Associates, Inc.** **1777 Botelho Dr., Suite 262** **Walnut Creek, CA 94596**
Modulus: ~~15,200~~ psi **Poisson's ratio:** ~~NA~~ (.03) **Density:** 130.7 pcf	**Project:** **Diablo Canyon Power Plant ISFSI** **Project Number: 1223-60**
	Test Date: May 13, 2001



ELASTIC MODULUS TEST
Axial Stress vs. Axial & Radial Strain

Boring: 01-H **Sample: #12** **Depth: 52.5'** **DESCRIPTION** Tan fine grained dolomitic sandstone (or dolomite) with no visible fractures. **Modulus:** ~~1,670,000 psi~~ **Poisson's ratio:** ~~.18~~ **Density:** ~~138.2 pcf~~	***Geo Test Unlimited*** (GTU) **27069 N. Bloomfield Rd.** **Nevada City, CA 95959** **Client:** **William Lettis & Associates, Inc.** **1777 Botelho Dr., Suite 262** **Walnut Creek, CA 94596** **Project:** **Diablo Canyon Power Plant ISFSI** **Project Number: 1223-~~50~~** 60 **Test Date:** April 29, 2001



ELASTIC MODULUS TEST
Axial Stress vs. Axial & Radial Strain

Boring: 01-H
Sample: #13
Depth: 57.0'

DESCRIPTION

Gray medium grained clayey friable sandstone with no visible fractures.

Modulus:	~~63,000~~ psi
Poisson's ratio:	~~.06 (?)~~
Density:	~~144.5~~ pcf

Geo Test Unlimited (GTU)
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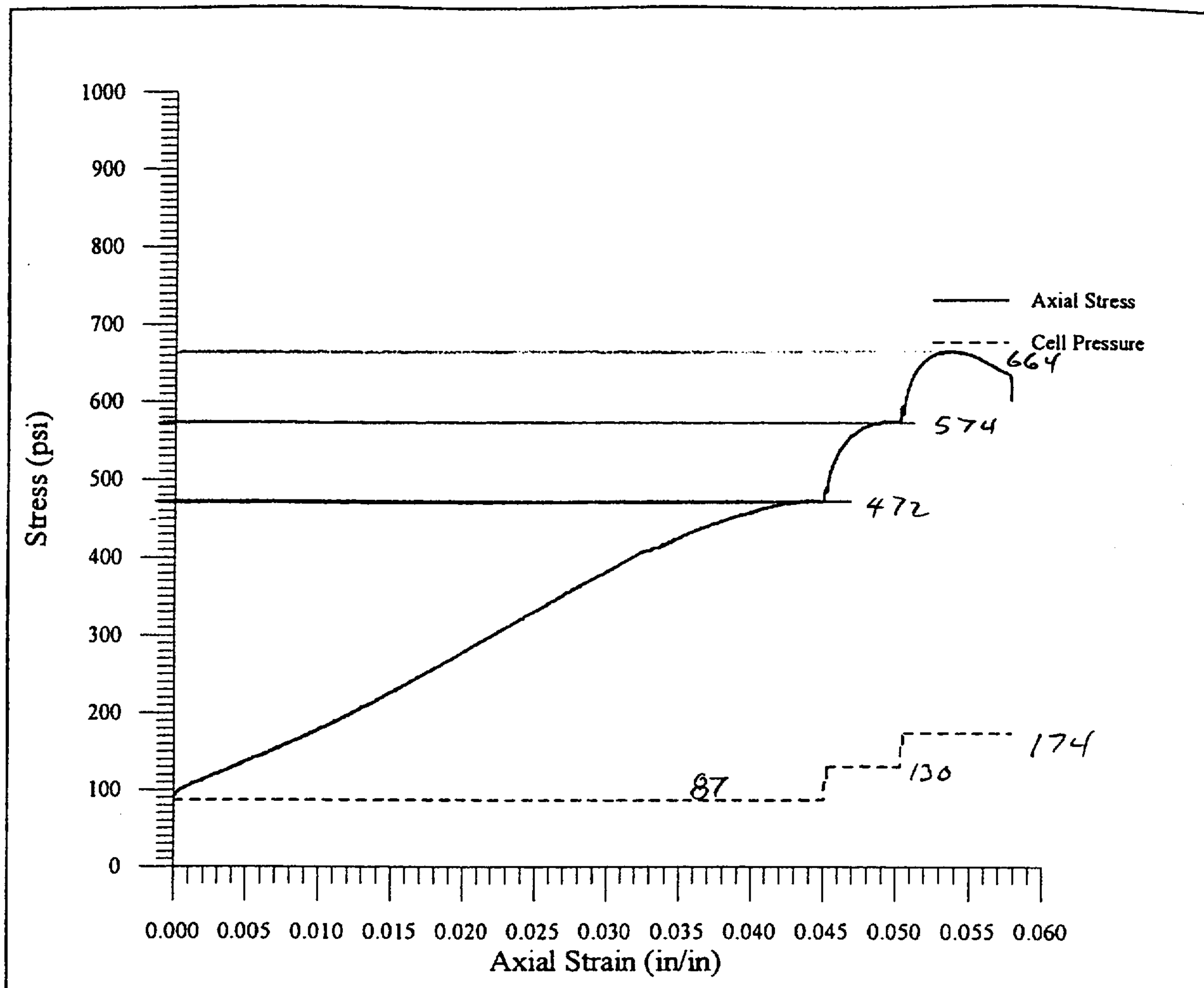
Nevada City, CA 95959

Client: William Lettis & Associates, Inc.
1777 Botelho Dr., Suite 262
Walnut Creek, CA 94596

Project: Diablo Canyon Power Plant ISFSI

Project Number: 1223-~~50~~ 60

Test Date: April 29, 2001



TRIAXIAL COMPRESSION TEST
Axial Stress and Confining Pressure vs. Strain

Boring: O1-H
Sample: 13
Depth: 57.0'
Density: 131.7 pcf.

DESCRIPTION

Gray medium grained clayey friable sandstone with no visible fractures.

Conf. Pres. (psi)	Strength (psi)
~~58~~	~~693~~
~~87~~	~~788~~
~~116~~	~~844~~

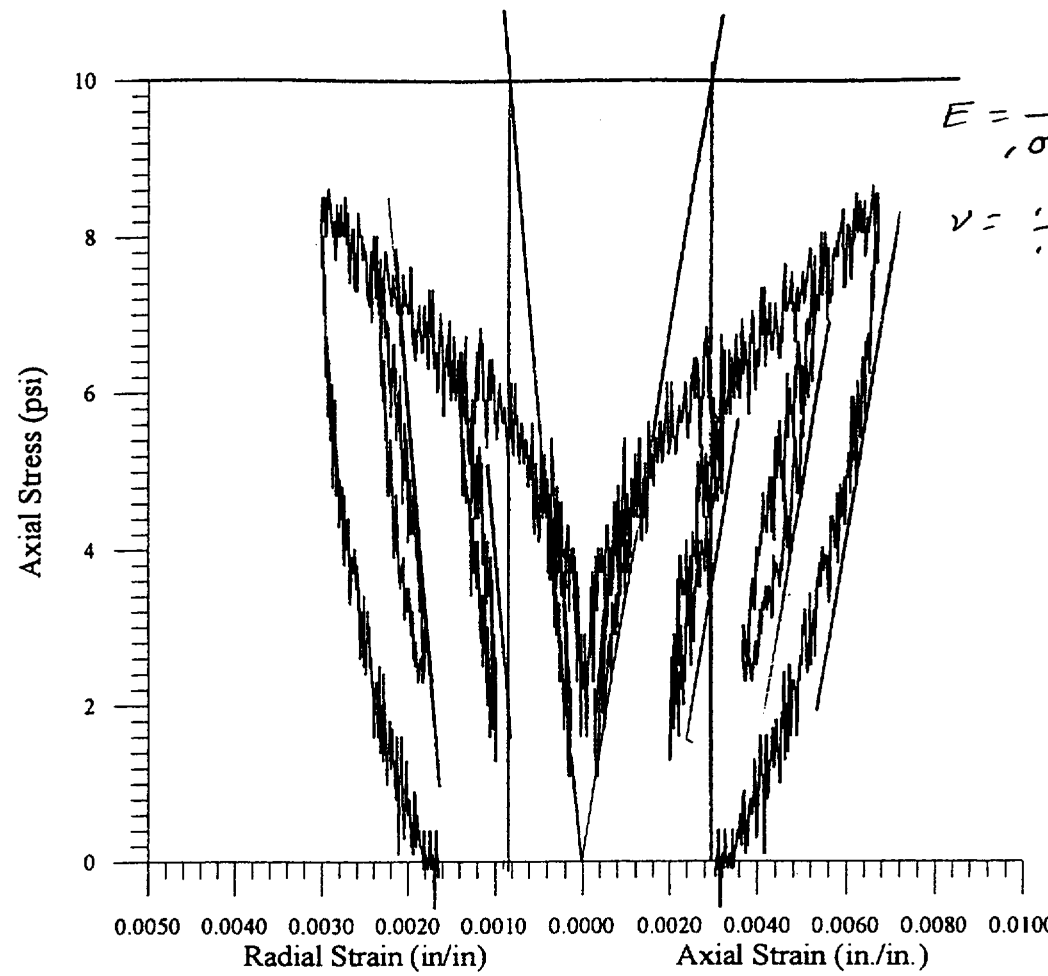
Geo Test Unlimited GTU
27069 N. Bloomfield Rd.
Nevada City, CA 95959

Client: **William Lettis & Associates, Inc.**
1777 Botelho Dr., Suite 262
Walnut Creek, CA 94596

Project: **Diablo Canyon Power Plant ISFSI**

Project Number: 1223-60

Test Date: May 4, 2001



$E = \frac{10}{.0029} = 3.5 \times 1$

$\nu = \frac{.00085}{.0029} = .29$

ELASTIC MODULUS TEST
Axial Stress vs. Axial & Radial Strain

Boring: 01-CTF-A
Sample: #14
Depth: 8.8'

DESCRIPTION

Gray fine to medium grained soft sandstone with partial plaster caps on both ends.

Modulus:	~~4,000,000 psi~~
Poisson's ratio:	~~.33~~
Density:	~~155.1 pcf~~

Geo Test Unlimited GTU
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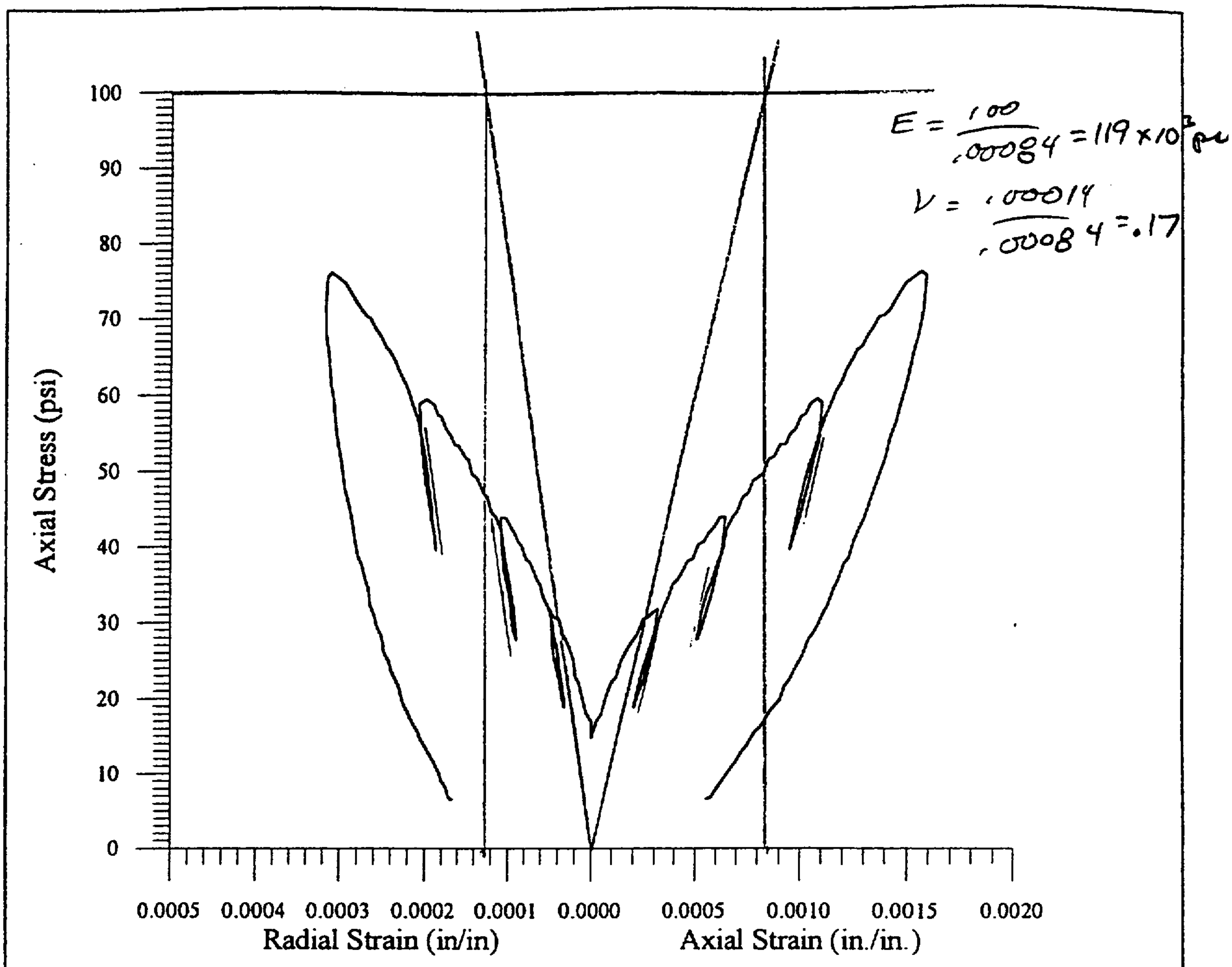
Nevada City, CA 95959

Client: William Lettis & Associates, Inc.
1777 Botelho Dr., Suite 262
Walnut Creek, CA 94596

Project: Diablo Canyon Power Plant ISFSI

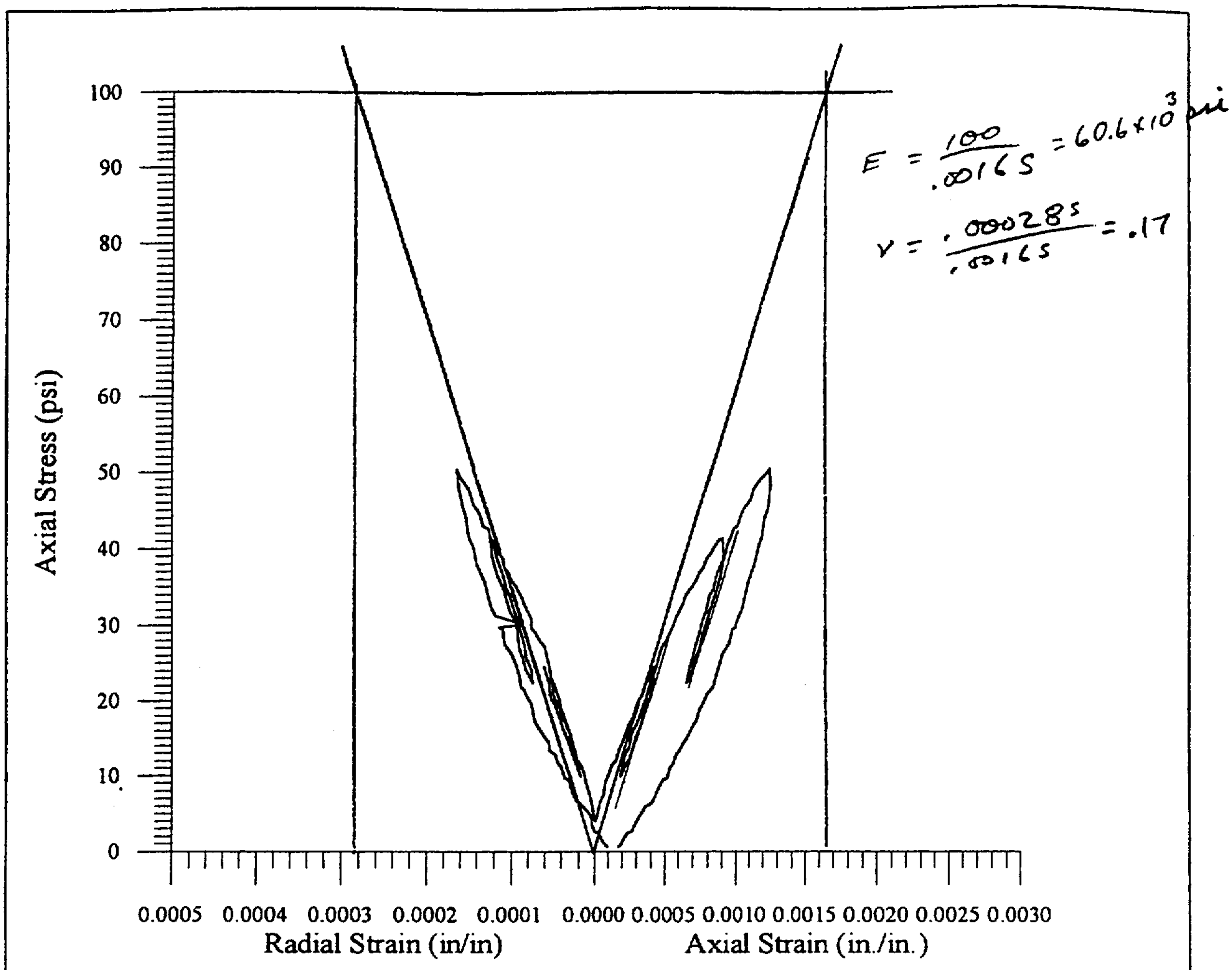
Project Number: 1223-~~50~~ 60

Test Date: April 29, 2001



ELASTIC MODULUS TEST
Axial Stress vs. Axial & Radial Strain

Boring: 01-CTF-A **Sample: #15** **Depth: 13.5'**	*Geo Test Unlimited* (GTU) 27069 N. Bloomfield Rd. Nevada City, CA 95959
DESCRIPTION Tan clayey friable medium grained sandstone.	**Client:** William Lettis & Associates, Inc. 1777 Botelho Dr., Suite 262 Walnut Creek, CA 94596
Modulus: 1,090,000 psi **Poisson's ratio:** .13 **Density:** 138.9 pcf	**Project:** Diablo Canyon Power Plant ISFSI **Project Number: 1223-60**
	Test Date: May 13, 2001



ELASTIC MODULUS TEST
Axial Stress vs. Axial & Radial Strain

Boring: 01-CTF-A
Sample: #16
Depth: 48.8'

DESCRIPTION
Tan friable clayey altered medium grained sandstone.

Modulus: ~~63,000 psi~~
Poisson's ratio: ~~.06 (?)~~
Density: ~~144.5 pcf~~

Geo Test Unlimited G T U
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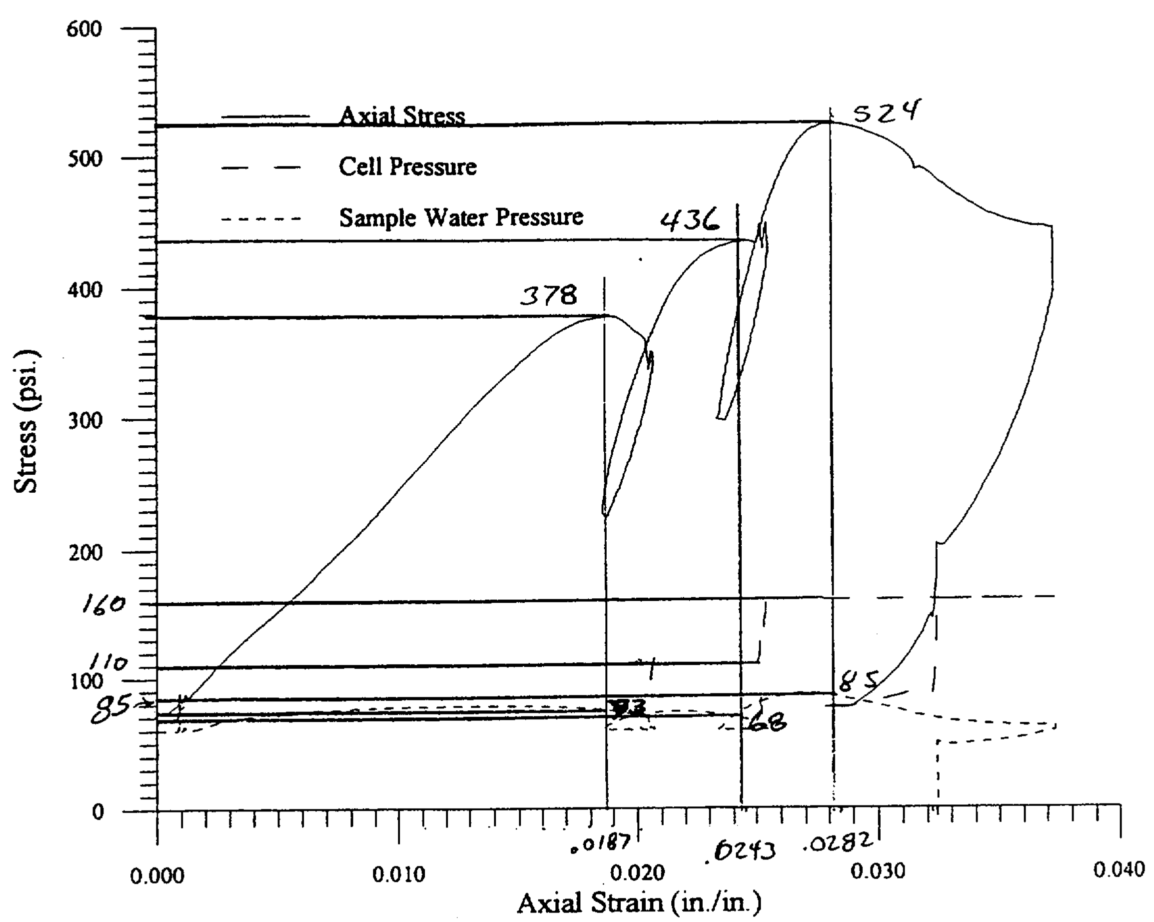
Nevada City, CA 95959

Client: **William Lettis & Associates, Inc.**
1777 Botelho Dr., Suite 262
Walnut Creek, CA 94596

Project: **Diablo Canyon Power Plant ISFSI**

Project Number: 1223-60

Test Date: May 13, 2001



TRIAXIAL COMPRESSION TEST
Axial Stress, Cell Pressure & Sample Pressure vs. Axial Strain

Boring: 01-CTF-A
Sample: #16
Depth: 48.8'

DESCRIPTION
Tan friable clayey altered medium grained sandstone.

STRENGTH SUMMARY

Strain (in./in.)	Cell Pressure (psi)	Sample Pressure (psi)	Axial Strength (psi)
.030	~~70~~	53	~~150~~
	80	~~53~~	175
.053	~~80~~	50	200
	100	~~60~~	235

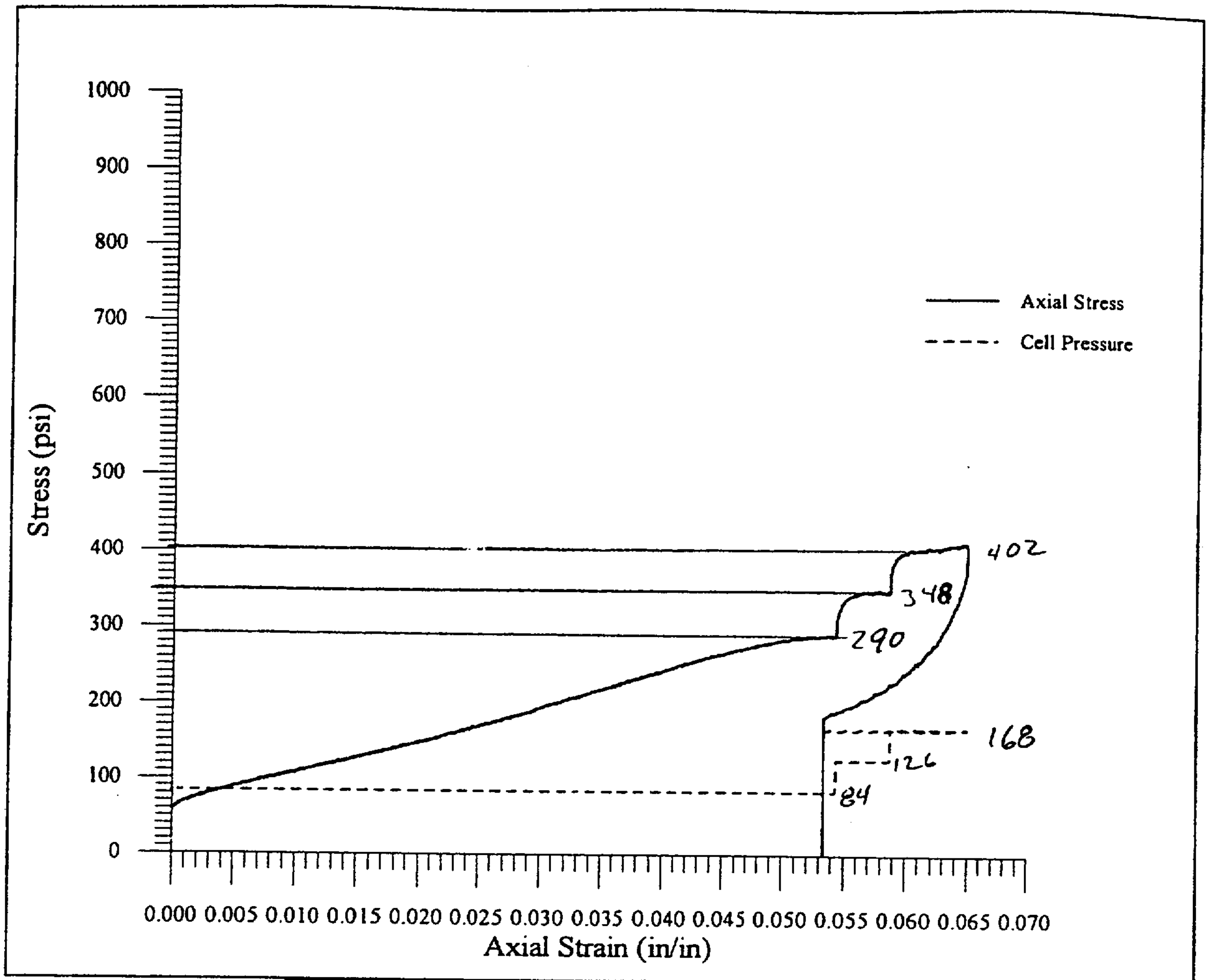
Geo Test Unlimited 800 Peralta Ave San Leandro, CA 94577

Client: William Lettis & Associates, Inc. 1777 Botelho Dr., Suite 262 Walnut Creek, CA 94596

Project: Diablo Canyon Power Plant ISFSI

Project Number: 1223-60

Test Date: May 16, 2001



TRIAXIAL COMPRESSION TEST
Axial Stress and Confining Pressure vs. Strain

Boring: O1-CTF-A
Sample: 17
Depth: 53.8'
Density: 127.1 pcf.

DESCRIPTION

Gray medium grained altered clayey friable sandstone.

Conf. Pres. (psi)	Strength (psi)
87	472
130	574
174	664

Geo Test Unlimited
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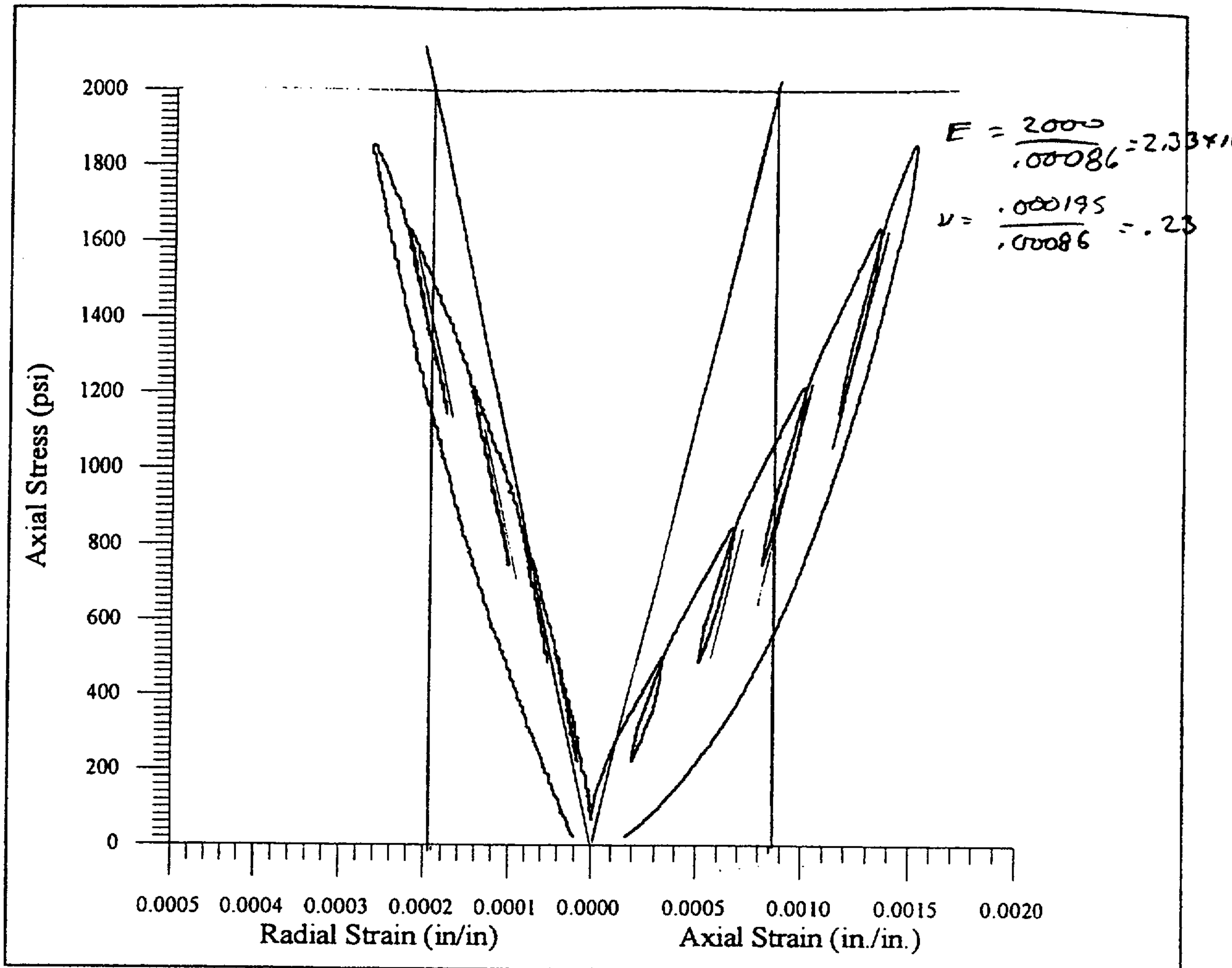
Nevada City, CA 95959

Client: William Lettis & Associates, Inc.
1777 Botelho Dr., Suite 262
Walnut Creek, CA 94596

Project: Diablo Canyon Power Plant ISFSI

Project Number: 1223-60

Test Date: May 4, 2001



ELASTIC MODULUS TEST
Axial Stress vs. Axial & Radial Strain

Boring: 01-B
Sample: #18
Depth: 26.5'

DESCRIPTION

Tan fine to medium grained (dolomitic?) sandstone with no visible fractures.

Modulus:	~~**4,000,000 psi**~~
Poisson's ratio:	~~**.33**~~
Density:	~~**155.1 pcf**~~

Geo Test Unlimited GTU
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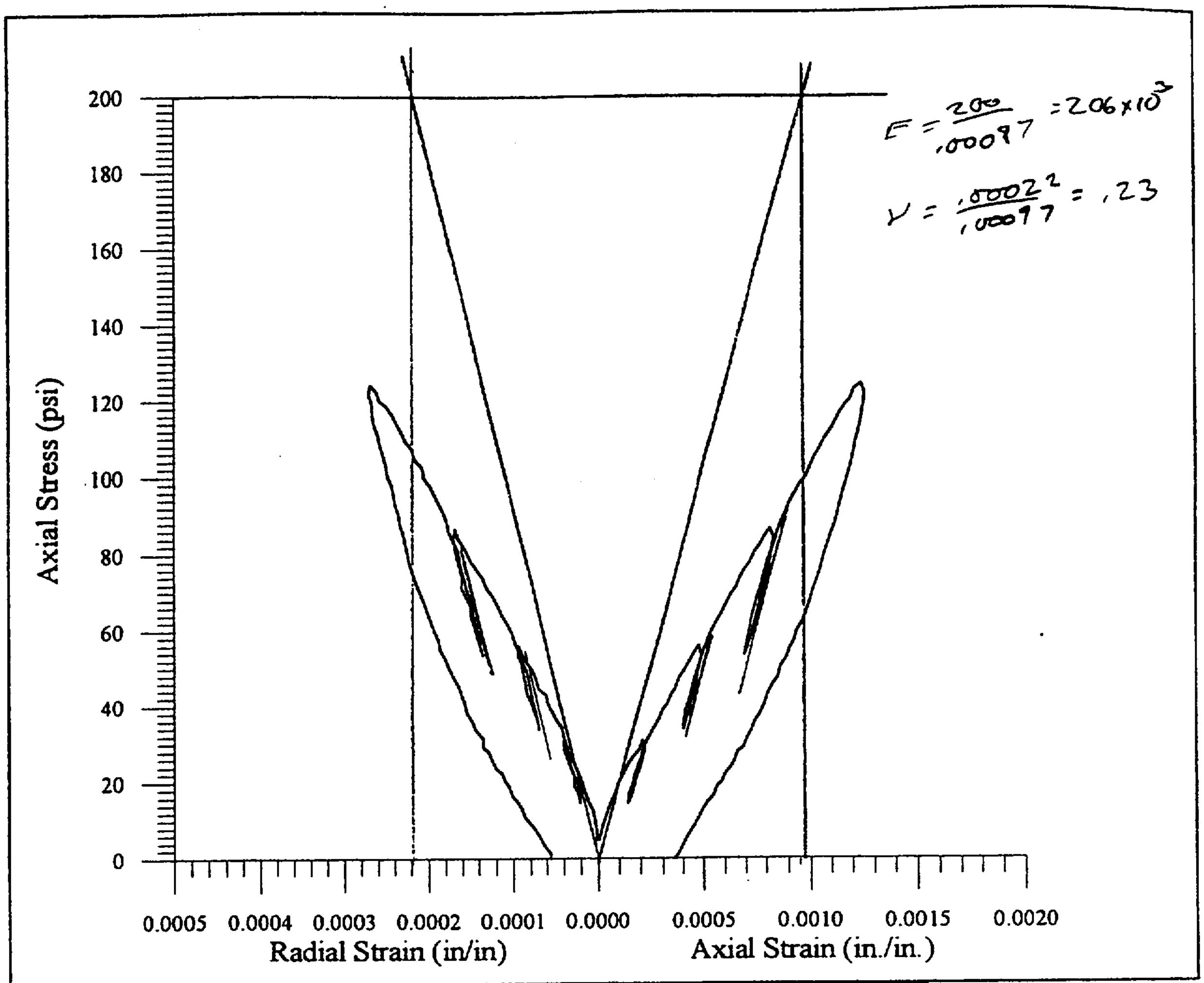
Nevada City, CA 95959

Client: **William Lettis & Associates, Inc.**
1777 Botelho Dr., Suite 262
Walnut Creek, CA 94596

Project: **Diablo Canyon Power Plant ISFSI**

Project Number: 1223-~~50~~ 60

Test Date: April 29, 2001



ELASTIC MODULUS TEST
Axial Stress vs. Axial & Radial Strain

Boring: 01-B
Sample: #19
Depth: 38.0'

DESCRIPTION

Tan medium grained sandstone with a few rounded gray claystone clasts and a joint at one end.

Modulus:	**119,000 psi**
Poisson's ratio:	**.17**
Density:	**138.3 pcf**

Geo Test Unlimited GTU
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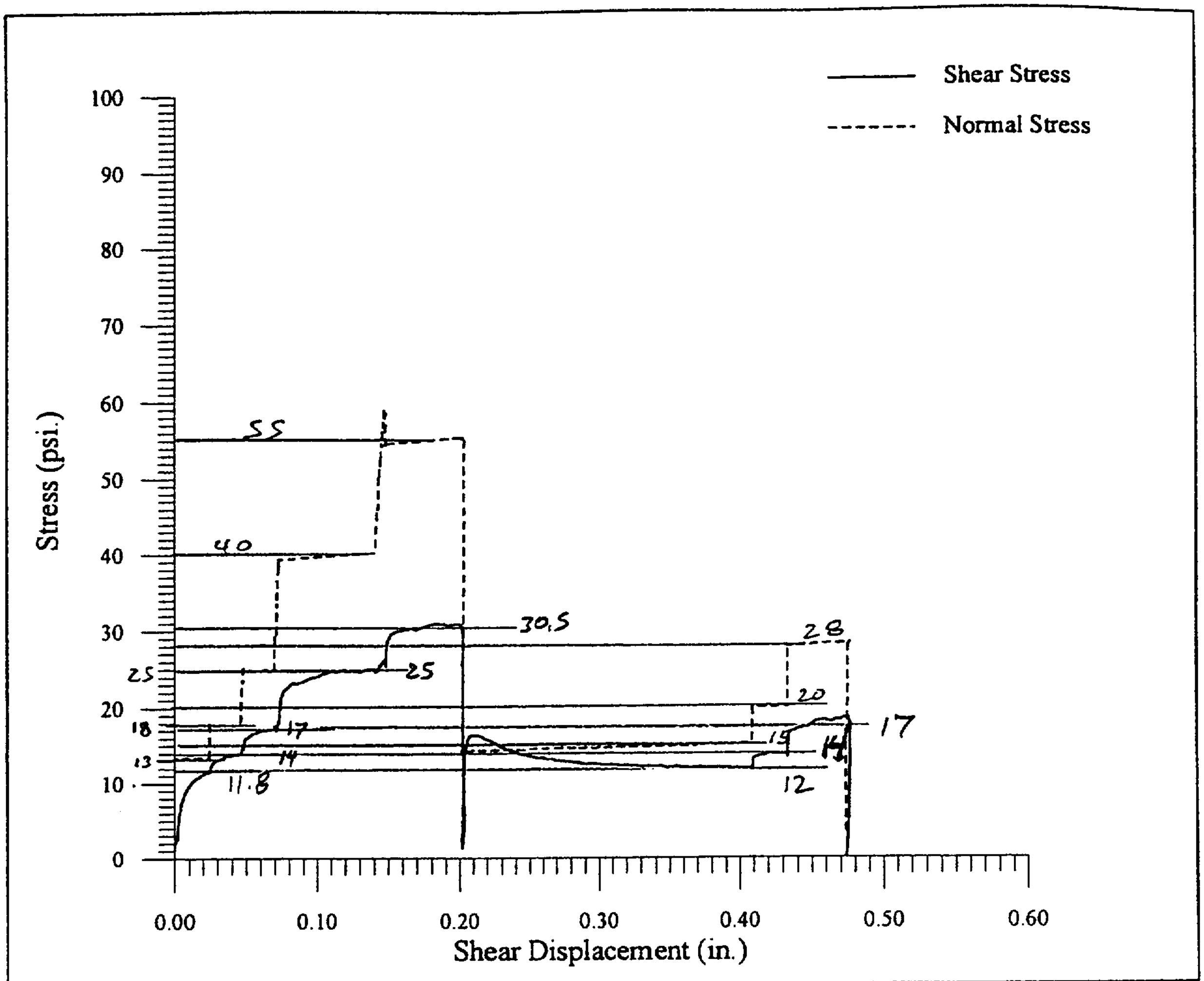
Nevada City, CA 95959

Client: **William Lettis & Associates, Inc.**
1777 Botelho Dr., Suite 262
Walnut Creek, CA 94596

Project: **Diablo Canyon Power Plant ISFSI**

Project Number: 1223-60

Test Date: May 13, 2001



DIRECT SHEAR TEST
Shear and Normal Stress vs. Shear Displacement

Boring: O1-B
Sample: 20
Depth: 48.8'

DESCRIPTION

Slightly wavy intact contact between hard dolomite and soft clayey altered dolomite.

	Normal Stress (psi)	Shear Stress (psi)
Initial	20.5	21.8
	41.8	41.8
	83.0	76.8
Final	22.9	19.0
	46.7	37.0
	92.8	71.0

Geo Test Unlimited G T U
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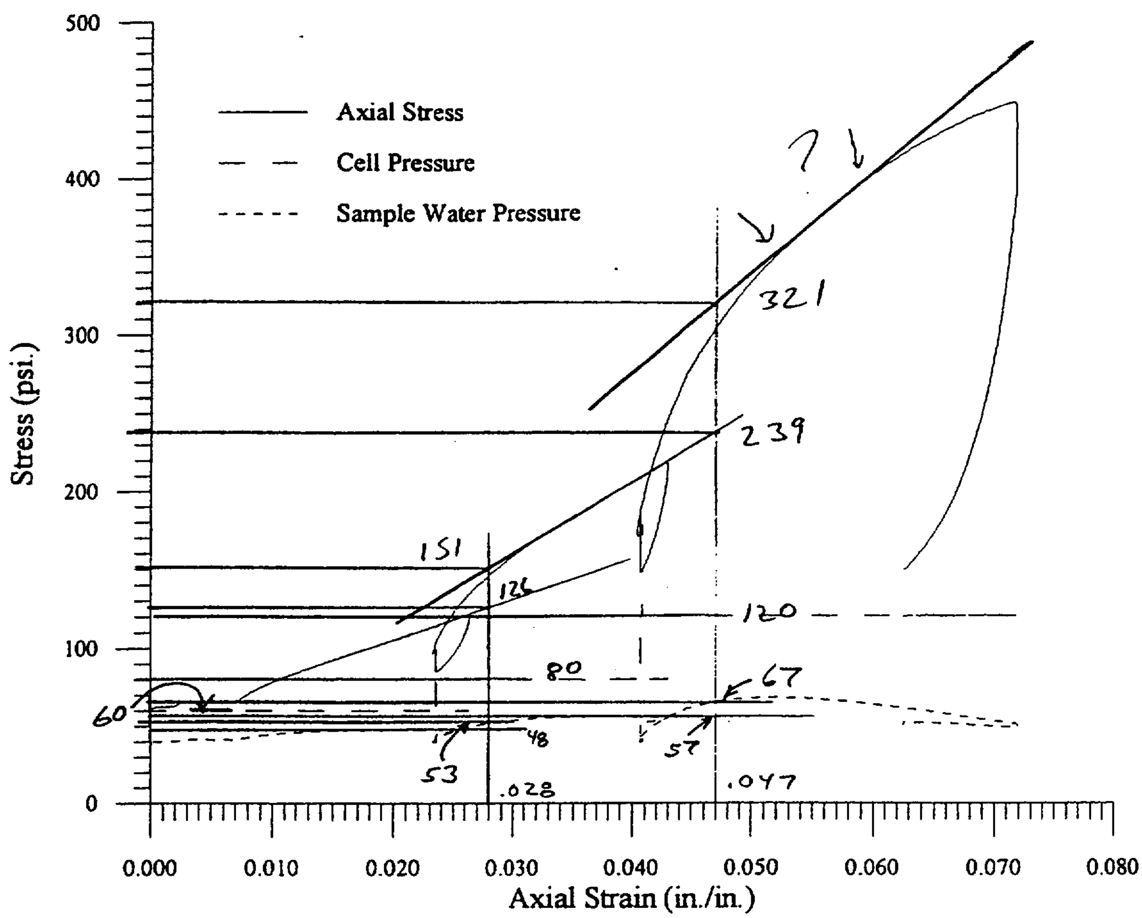
Nevada City, CA 95959

Client: **William Lettis & Associates, Inc.**
1777 Botelho Dr., Suite 262
Walnut Creek, CA 94596

Project: **Diablo Canyon Power Plant ISFSI**

Job Number: 1223-60

Test Date: May 7, 2001



TRIAXIAL COMPRESSION TEST
Axial Stress, Cell Pressure & Sample Pressure vs. Axial Strain

Boring: 01-C
Sample: #21
Depth: 9.5'

DESCRIPTION

Gray friable clayey weak medium sandstone with partial plaster caps.

STRENGTH SUMMARY

Strain (in./in.)	Cell Pressure (psi)	Sample Pressure (psi)	Axial Strength (psi)
.0187	85	73	378
.0243	110	68	436
.0282	160	~~85~~	524

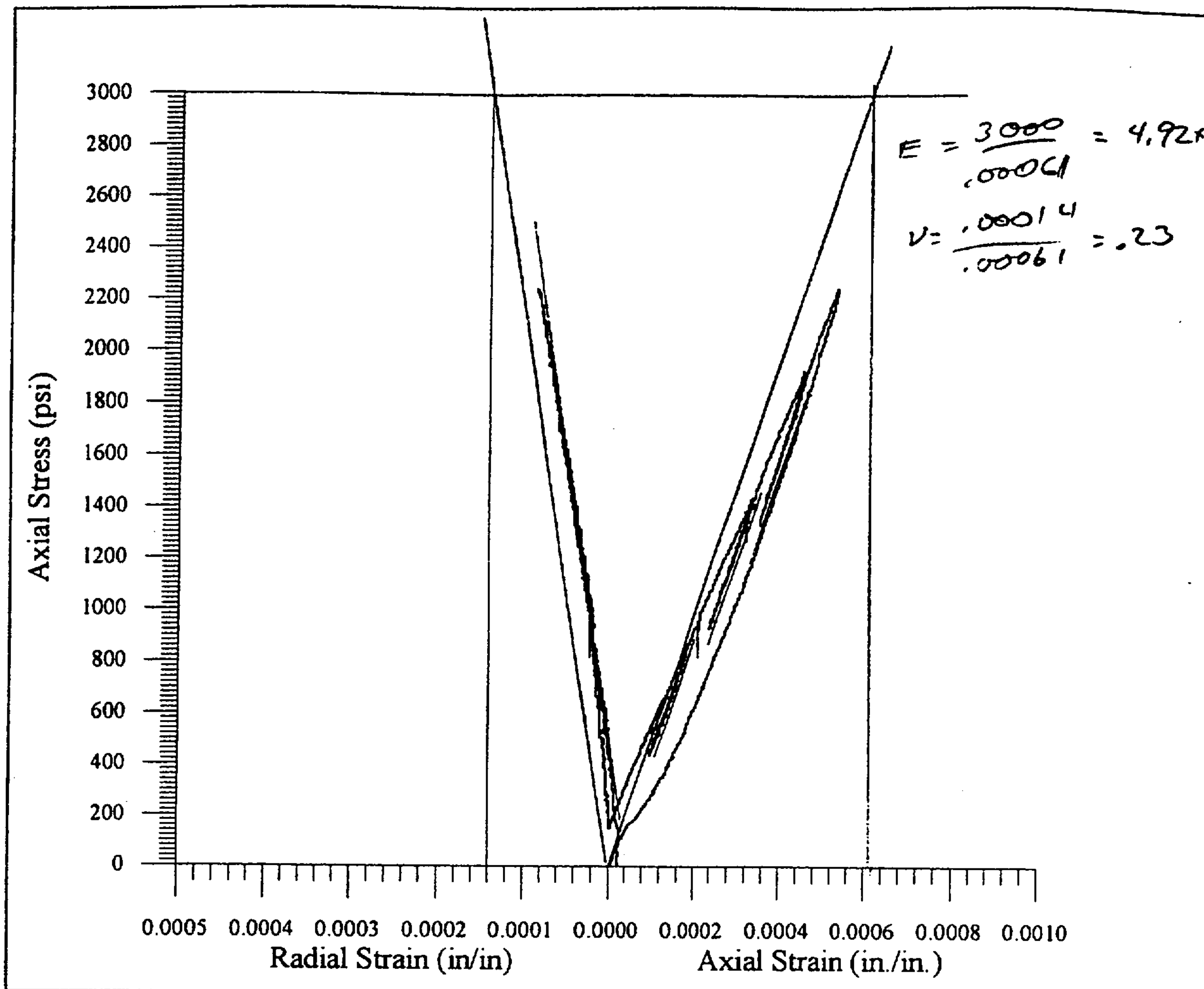
Geo Test Unlimited
800 Peralta Ave
San Leandro, CA 94577

Client: William Lettis & Associates, Inc.
1777 Botelho Dr., Suite 262
Walnut Creek, CA 94596

Project: Diablo Canyon Power Plant ISFSI

Project Number: 1223-60

Test Date: May 16, 2001



ELASTIC MODULUS TEST
Axial Stress vs. Axial & Radial Strain

Boring: 01-C
Sample: #22
Depth: 24.0'

DESCRIPTION

Tan fine grained (dolomitic?) sandstone with an axial fracture and partial plaster caps on both ends.

Modulus:	**2,330,000 psi**
Poisson's ratio:	**.23**
Density:	**147.3 pcf**

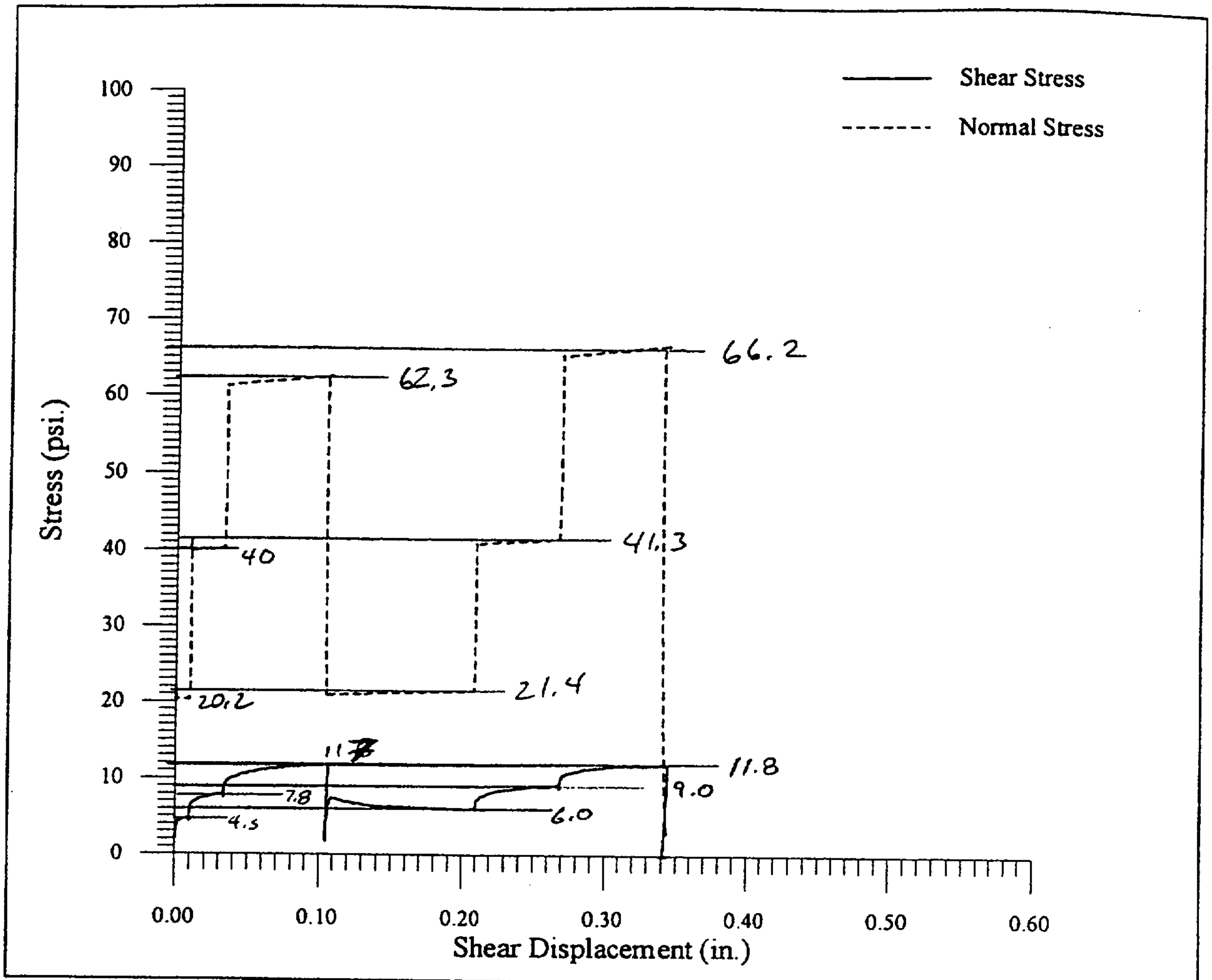
Geo Test Unlimited GTU
27069 N. Bloomfield Rd.
Nevada City, CA 95959

Client: **William Lettis & Associates, Inc.**
1777 Botelho Dr., Suite 262
Walnut Creek, CA 94596

Project: **Diablo Canyon Power Plant ISFSI**

Project Number: 1223-~~50~~ 60

Test Date: April 29, 2001



DIRECT SHEAR TEST
Shear and Normal Stress vs. Shear Displacement

Boring: O1-C
Sample: 23
Depth: 41.4'

DESCRIPTION

Very thin gray clay coated slickensided joint in gray medium grained sandstone.

	Normal Stress (psi)	Shear Stress (psi)
Initial	20.5	21.8
	41.8	41.8
	83.0	76.8
Final	22.9	19.0
	46.7	37.0
	92.8	71.0

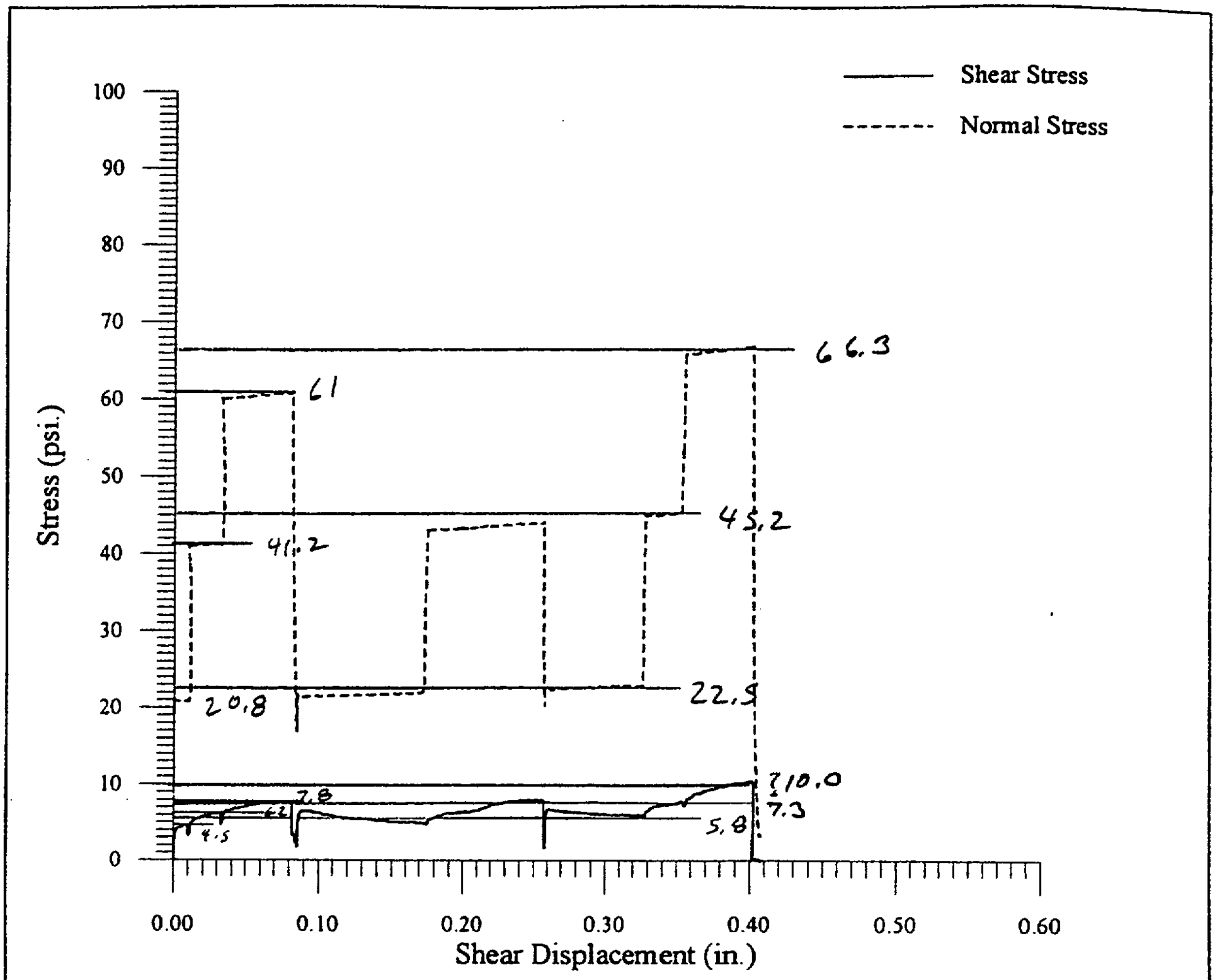
Geo Test Unlimited (GTU)
27069 N. Bloomfield Rd.
Nevada City, CA 95959

Client: **William Lettis & Associates, Inc.**
1777 Botelho Dr., Suite 262
Walnut Creek, CA 94596

Project: **Diablo Canyon Power Plant ISFSI**

Job Number: 1223-60

Test Date: May 7, 200~~0~~1



DIRECT SHEAR TEST
Shear and Normal Stress vs. Shear Displacement

Boring: O1-C
Sample: 24
Depth: 44.3'

DESCRIPTION

Wavy lightly bonded joint with thin clay coating in tan medium grained sandstone.

	Normal Stress (psi)	Shear Stress (psi)
Initial	20.2	4.5
	40.0	7.8
	62.3	11.7
Final	21.4	6.0
	41.3	9.0
	66.2	11.8

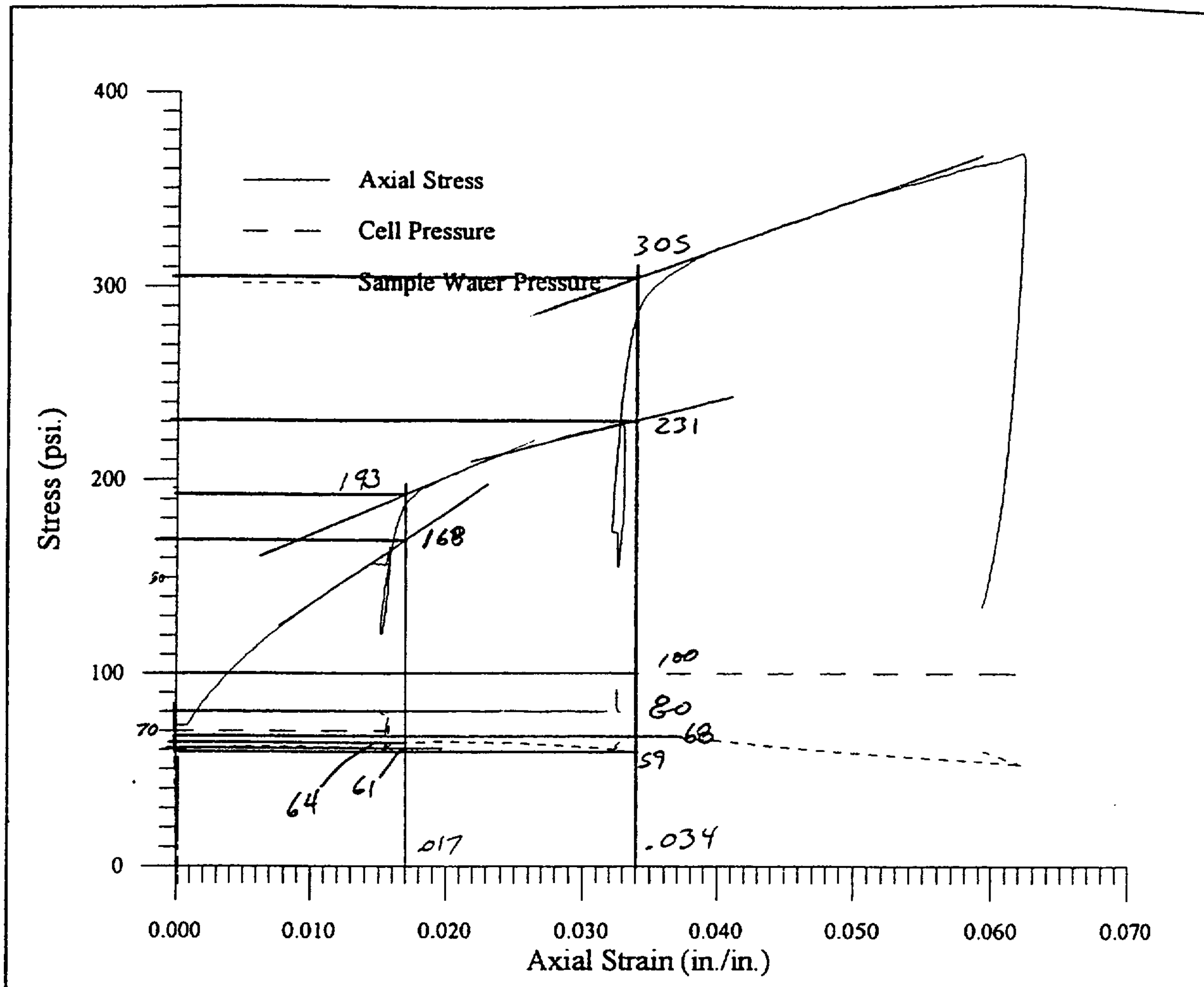
Geo Test Unlimited GTU
27069 N. Bloomfield Rd.
Nevada City, CA 95959

Client: **William Lettis & Associates, Inc.**
1777 Botelho Dr., Suite 262
Walnut Creek, CA 94596

Project: **Diablo Canyon Power Plant ISFSI**

Job Number: 1223-60

Test Date: May 7, 2000



TRIAXIAL COMPRESSION TEST
Axial Stress, Cell Pressure & Sample Pressure vs. Axial Strain

Boring: 01-E
Sample: #25
Depth: 7.0'

DESCRIPTION

Tan fractured and sheared clayey altered weak fine grained dolomitic sandstone.

STRENGTH SUMMARY

Strain (in./in.)	Cell Pressure (psi)	Sample Pressure (psi)	Axial Strength (psi)
.028	60	48	126
	80	53	151
.047	80	57	239
	120	67	321 (?)

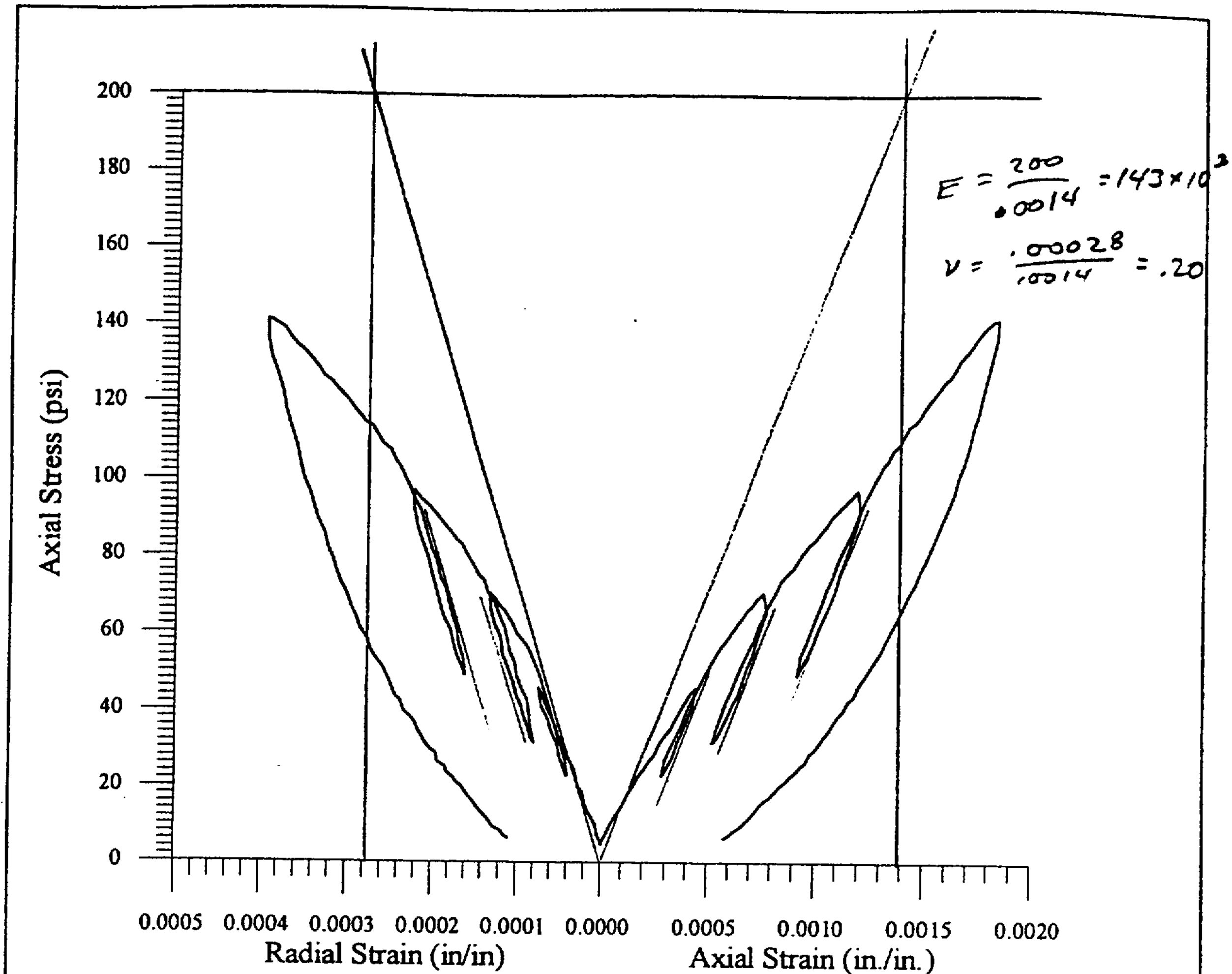
Geo Test Unlimited GTU
800 Peralta Ave
San Leandro, CA 94577

Client: William Lettis & Associates, Inc.
1777 Botelho Dr., Suite 262
Walnut Creek, CA 94596

Project: Diablo Canyon Power Plant ISFSI

Project Number: 1223-60

Test Date: May 17, 2001



ELASTIC MODULUS TEST
Axial Stress vs. Axial & Radial Strain

Boring: 01-E
Sample: #26
Depth: 22.0'

DESCRIPTION

Tan fine grained (dolomitic?) sandstone with a few healed shears.

Modulus:	~~**206,000 psi**~~
Poisson's ratio:	~~**.23**~~
Density:	**132.4 pcf**

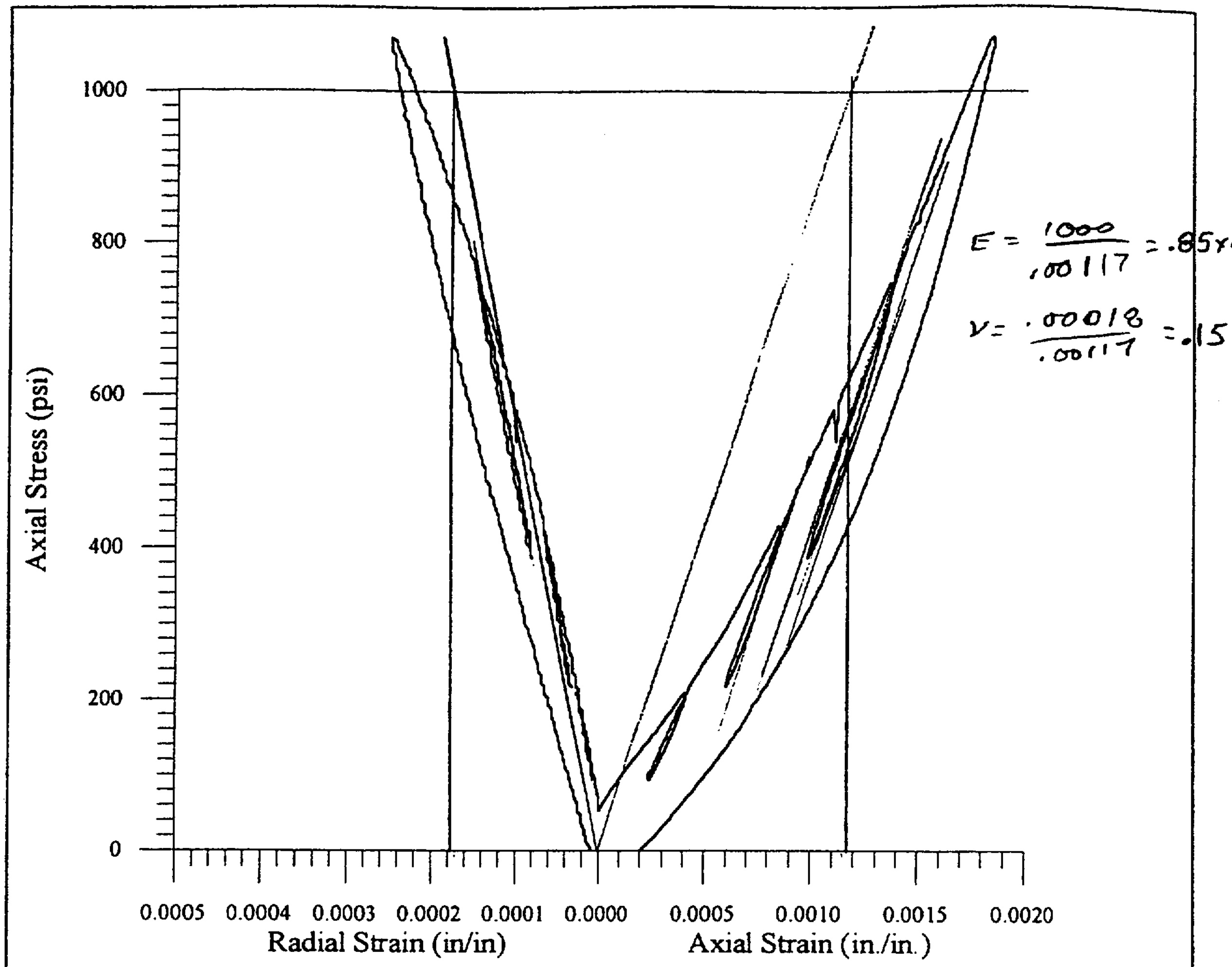
Geo Test Unlimited G T U
27069 N. Bloomfield Rd.
Nevada City, CA 95959

Client: **William Lettis & Associates, Inc.**
1777 Botelho Dr., Suite 262
Walnut Creek, CA 94596

Project: **Diablo Canyon Power Plant ISFSI**

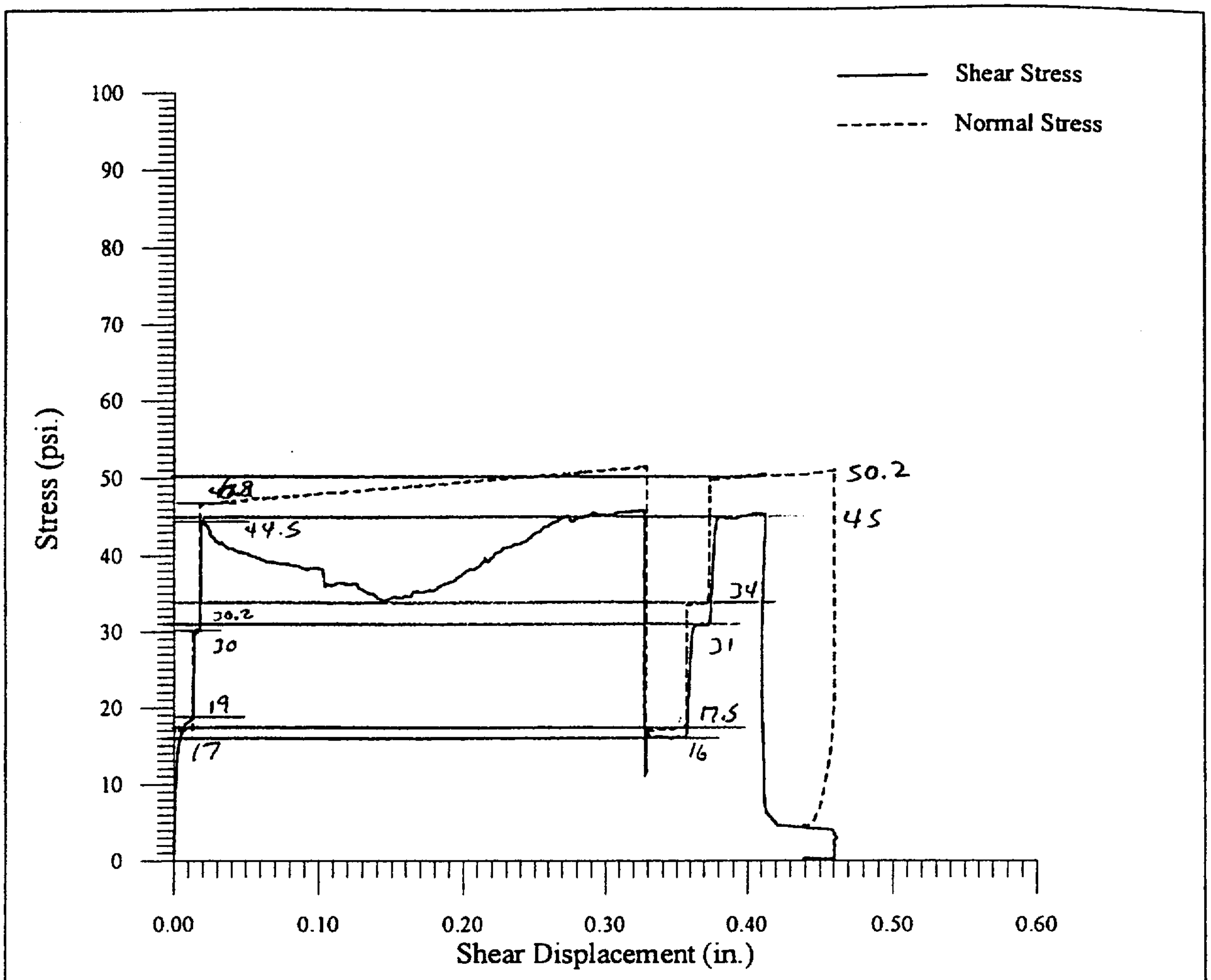
Project Number: 1223-60

Test Date: May 13, 2001



ELASTIC MODULUS TEST
Axial Stress vs. Axial & Radial Strain

Boring: 01-E **Sample: #28** **Depth: 49.0'** **DESCRIPTION** Tan fine grained (dolomitic?) sandstone with dolomite(?) healed fracture about 34 degrees to the core axis. **Modulus:** ~~4,920,000 psi~~ **Poisson's ratio:** ~~.23~~ **Density:** ~~155.0 pcf~~	***Geo Test Unlimited*** GTU **27069 N. Bloomfield Rd.** **Nevada City, CA 95959** **Client:** **William Lettis & Associates, Inc.** **1777 Botelho Dr., Suite 262** **Walnut Creek, CA 94596** **Project:** **Diablo Canyon Power Plant ISFSI** **Project Number: 1223-~~50~~** 60 **Test Date:** April 29, 2001



DIRECT SHEAR TEST
Shear and Normal Stress vs. Shear Displacement

Boring: O1-E
Sample: 29
Depth: 51.8'

DESCRIPTION

Planar well mated bedding joint in tan fine to medium grainedf sandstone.

	Normal Stress (psi)	Shear Stress (psi)
Initial	20.8	4.5
	41.2	6.2
	61.0	7.8
Final	22.5	5.8
	45.2	7.3
	66.3	10.0

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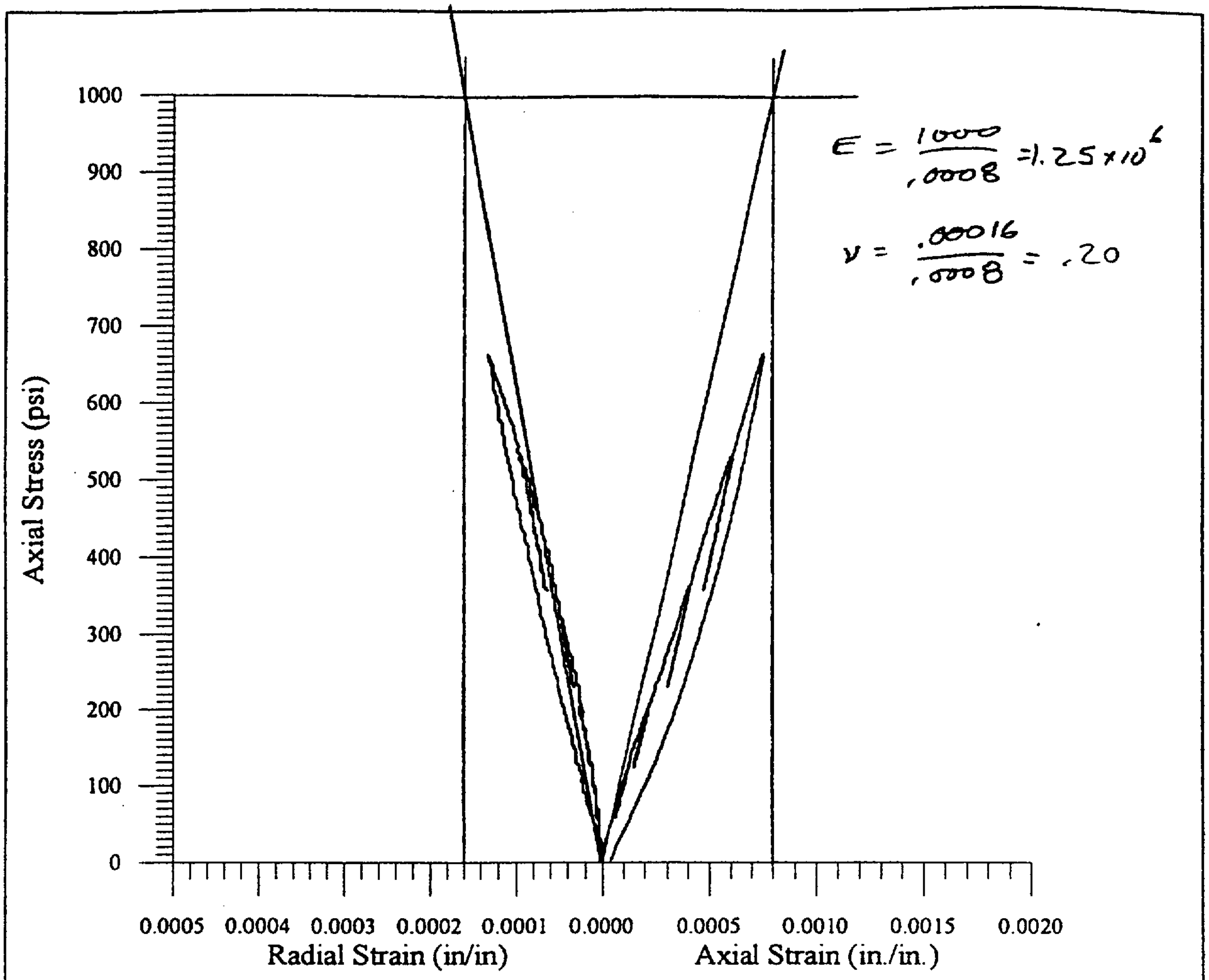
Client: **William Lettis & Associates, Inc.**
1777 Botelho Dr., Suite 262
Walnut Creek, CA 94596

Project: **Diablo Canyon Power Plant ISFSI**

Job Number: 1223-60

Test Date: May 8, 2000



ELASTIC MODULUS TEST
Axial Stress vs. Axial & Radial Strain

Boring: 01-F
Sample: #30
Depth: 57.6'

DESCRIPTION
Light tan medium grained sandstone.

Modulus:	**143,000 psi**
Poisson's ratio:	**.20**
Density:	**129.4 pcf**

Geo Test Unlimited GTU
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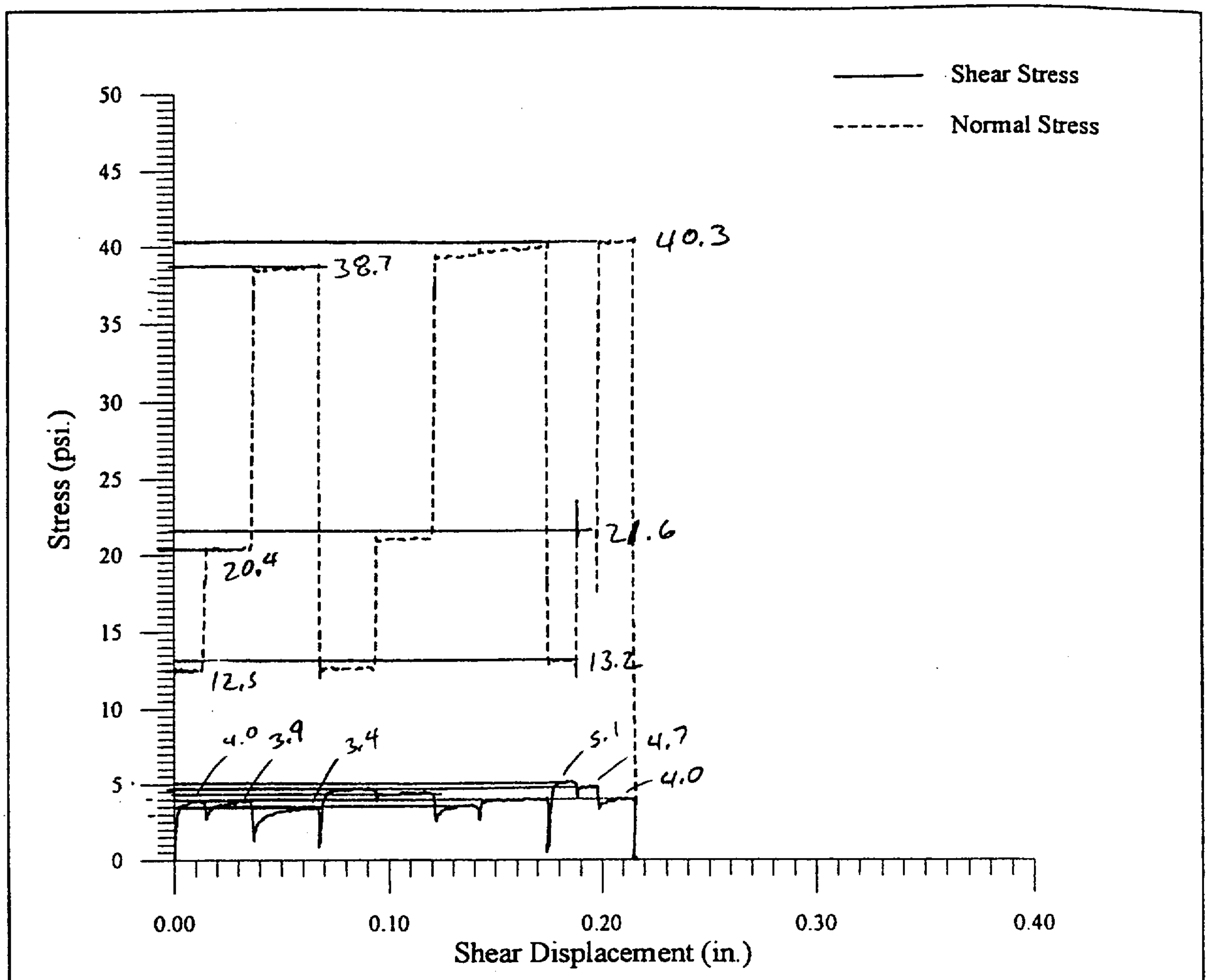
Nevada City, CA 95959

Client: **William Lettis & Associates, Inc.**
1777 Botelho Dr., Suite 262
Walnut Creek, CA 94596

Project: **Diablo Canyon Power Plant ISFSI**

Project Number: 1223-60

Test Date: May 13, 2001



DIRECT SHEAR TEST
Shear and Normal Stress vs. Shear Displacement

Boring: O1-F
Sample: 31
Depth: 117.0'

DESCRIPTION

Tan sandy clay seam (.5-1" thick) in tan fine to medium grained clayey sandstone.

	Normal Stress (psi)	Shear Stress (psi)
Initial	17.0	19.0
	30.0	30.2
	46.8	44.5
Final	17.5	16.0
	34.0	31.0
	50.2	45.0

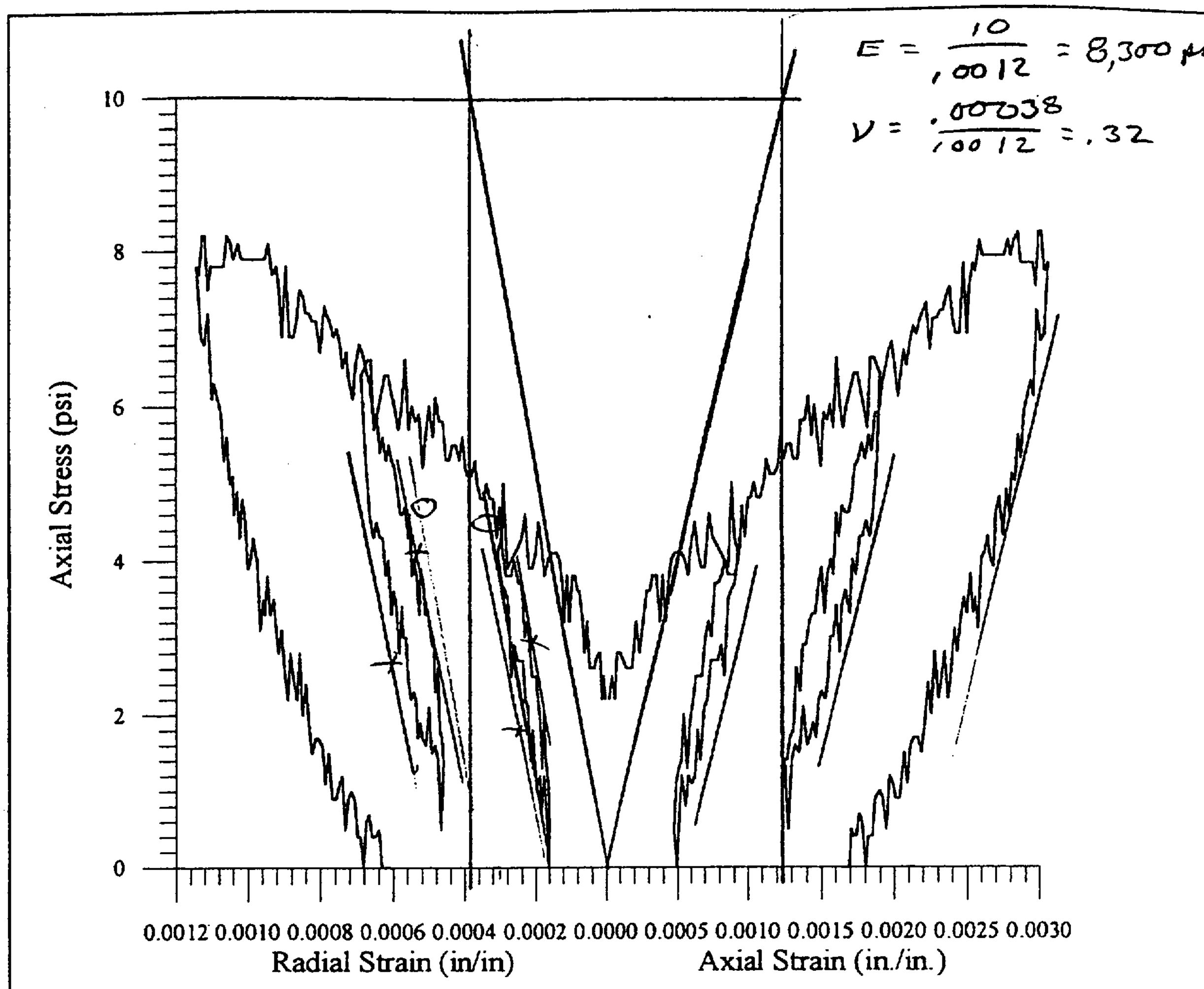
Geo Test Unlimited (GTU)
27069 N. Bloomfield Rd.
Nevada City, CA 95959

Client: **William Lettis & Associates, Inc.**
1777 Botelho Dr., Suite 262
Walnut Creek, CA 94596

Project: **Diablo Canyon Power Plant ISFSI**

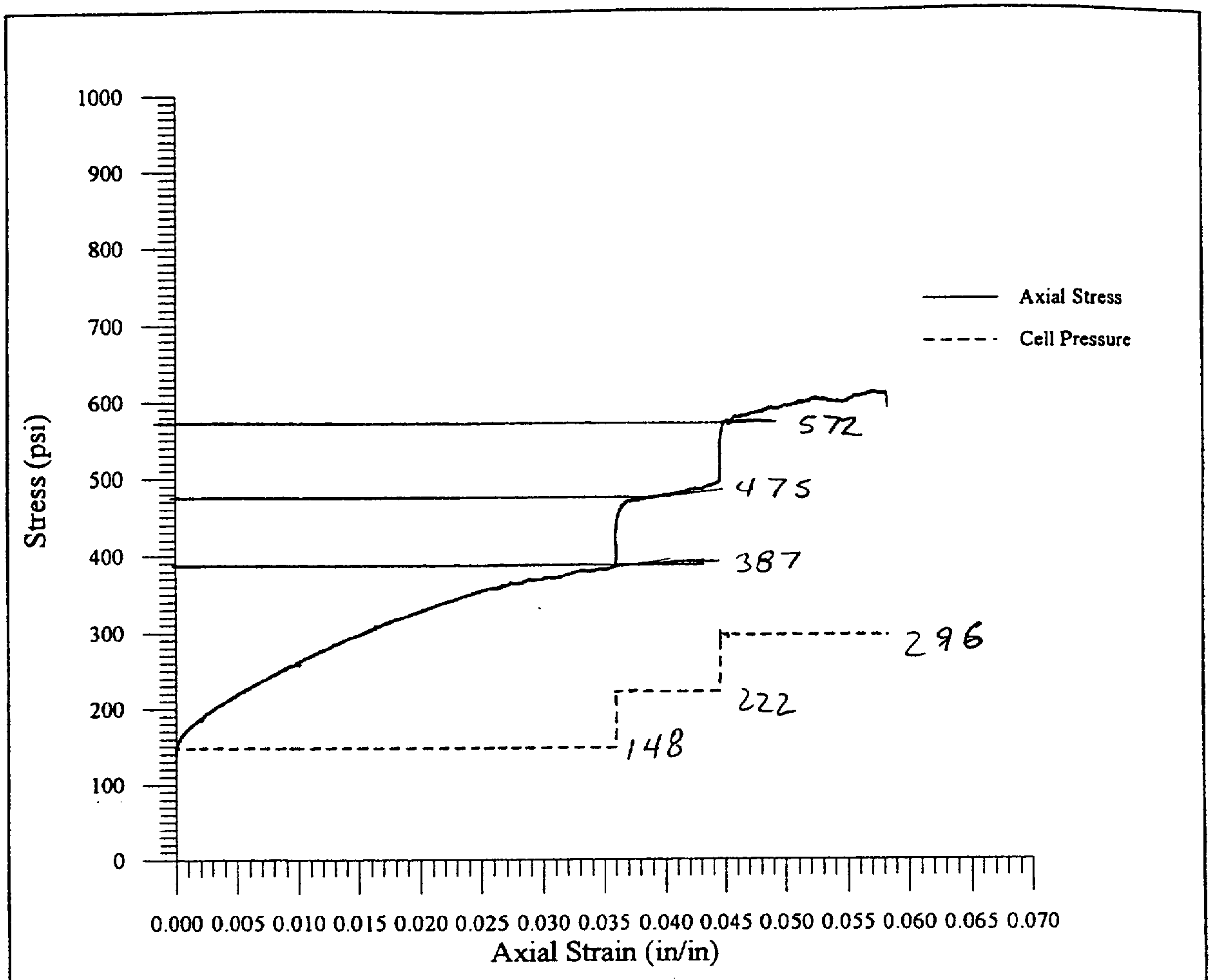
Job Number: 1223-60

Test Date: May 8, 200~~0~~1



ELASTIC MODULUS TEST
Axial Stress vs. Axial & Radial Strain

Boring: 01-F **Sample: #32** **Depth: 117.7'**	***Geo Test Unlimited*** (GTU) **27069 N. Bloomfield Rd.** **Nevada City, CA 95959**
DESCRIPTION Gray fine to medium grained soft clayey friable sandstone with no visible fractures.	**Client:** **William Lettis & Associates, Inc.** **1777 Botelho Dr., Suite 262** **Walnut Creek, CA 94596**
Modulus: ~~8,700 psi~~ **Poisson's ratio:** ~~.16~~ **Density:** ~~131.7 pcf~~	**Project:** **Diablo Canyon Power Plant ISFSI** **Project Number: 1223-~~50~~** 60
	Test Date: April 29, 2001



TRIAXIAL COMPRESSION TEST
Axial Stress and Confining Pressure vs. Strain

Boring: O1-F
Sample: 32
Depth: 117.7'
Density: 135.8 pcf.

DESCRIPTION

Gray fine to medium grained soft clayey friable sandstone with no visible fractures.

Conf. Pres. (psi)	Strength (psi)
~~84~~	~~290~~
~~126~~	~~348~~
~~168~~	~~402~~

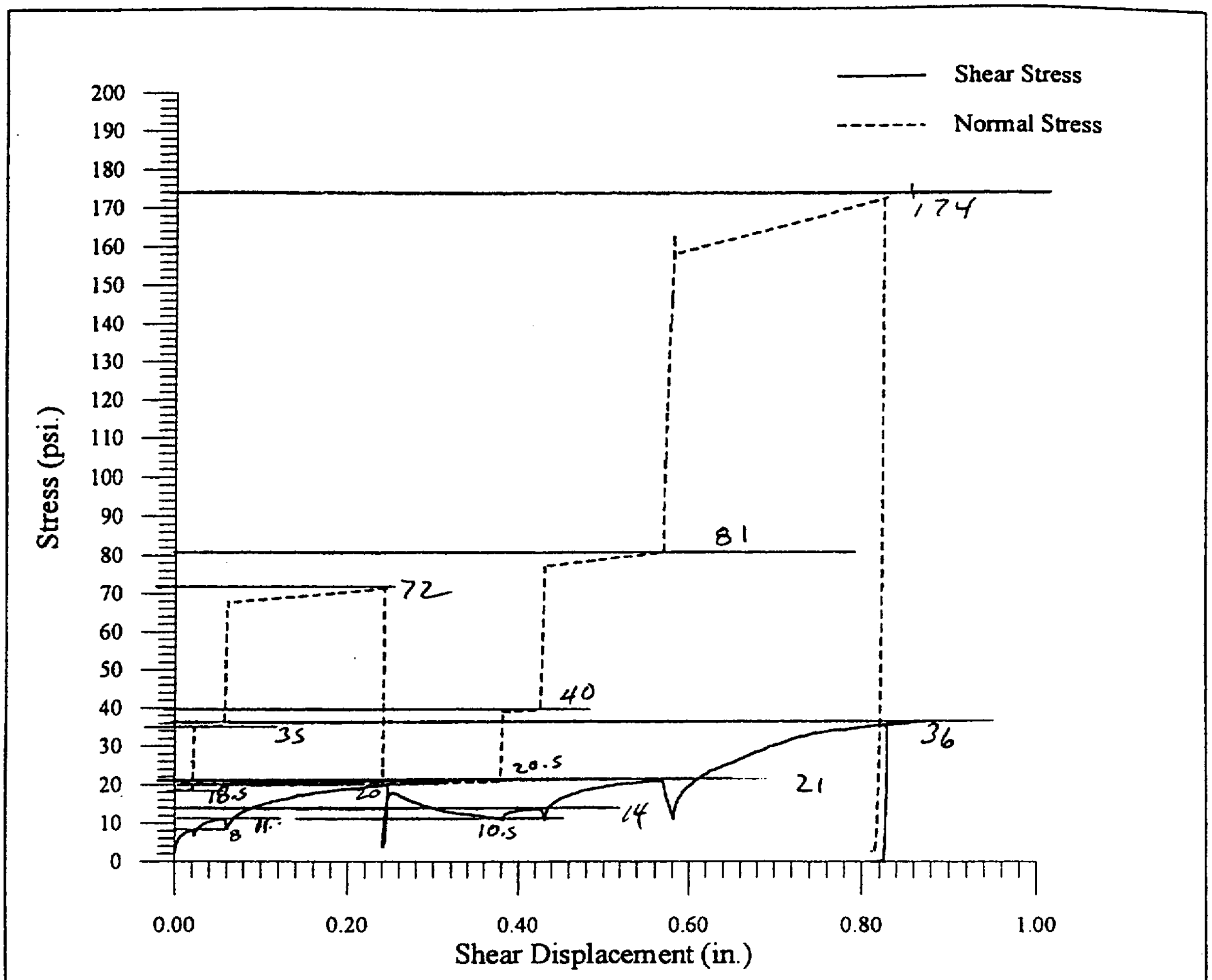
Geo Test Unlimited GTU
27069 N. Bloomfield Rd.
Nevada City, CA 95959

Client: **William Lettis & Associates, Inc.**
1777 Botelho Dr., Suite 262
Walnut Creek, CA 94596

Project: **Diablo Canyon Power Plant ISFSI**

Project Number: 1223-60

Test Date: May 4, 2001



DIRECT SHEAR TEST
Shear and Normal Stress vs. Shear Displacement

Boring: O1-F
Sample: 33
Depth: 118.3'

DESCRIPTION

Gray clay seam (0-.05" thick) in gray medium grained weak clayey sandstone.

	Normal Stress (psi)	Shear Stress (psi)
Initial	12.5	4.0
	20.4	3.9
	38.7	3.4
Final	13.2	5.1
	21.6	4.7
	40.1	4.0

Geo Test Unlimited
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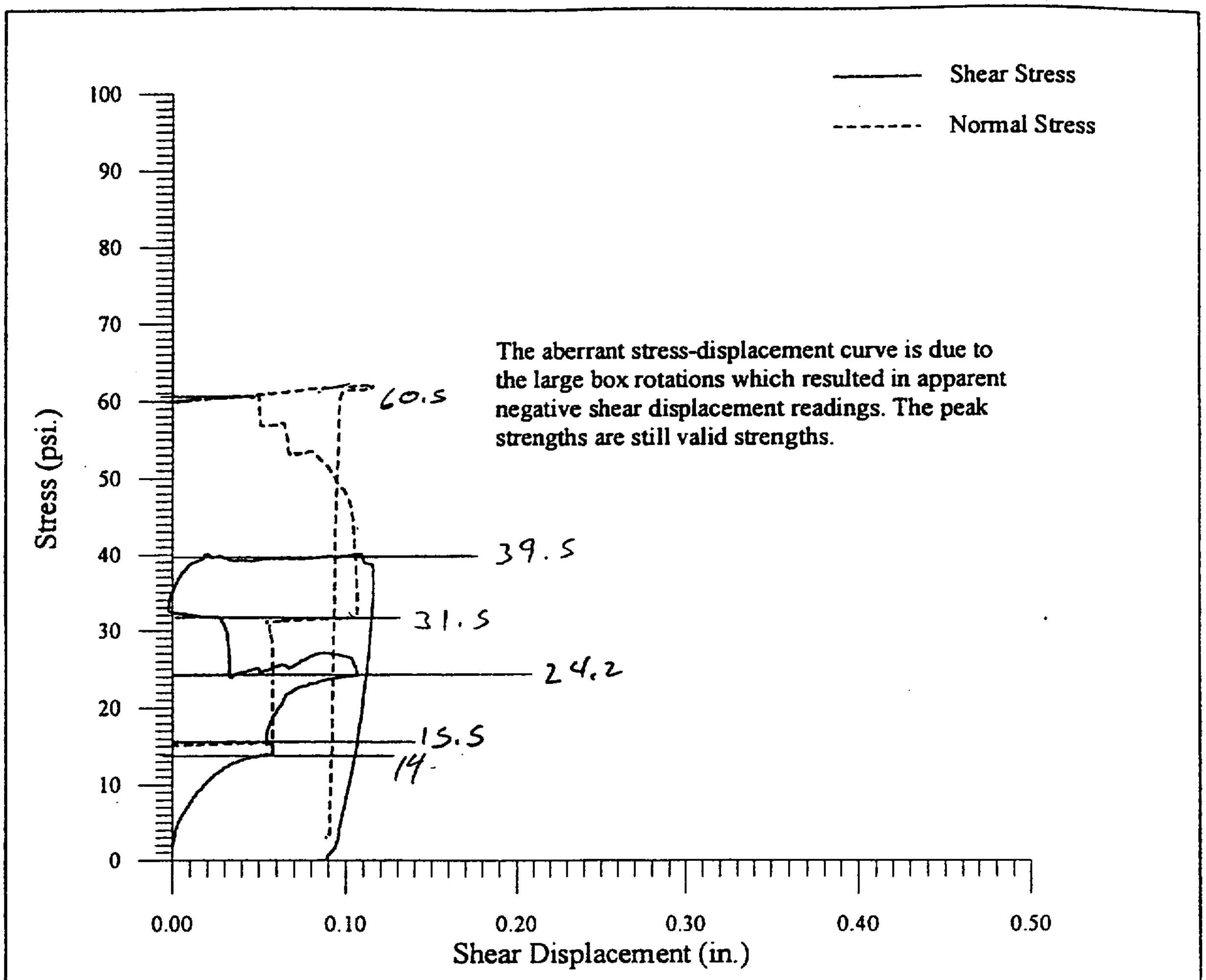
Nevada City, CA 95959

Client: **William Lettis & Associates, Inc.**
1777 Botelho Dr., Suite 262
Walnut Creek, CA 94596

Project: **Diablo Canyon Power Plant ISFSI**

Job Number: 1223-60

Test Date: May 8, 200~~0~~1



DIRECT SHEAR TEST
Shear and Normal Stress vs. Shear Displacement

Boring: O1-CTF-A
Sample: 34
Depth: 32.6'

DESCRIPTION

Contadct between tan snady clay and tan clayey fine to medium grained sandstone.

	Normal Stress (psi)	Shear Stress (psi)
Initial	18.5	8
	35	11
	72	20
Final	20.5	10.5
	40	14
	81	21
	174	36

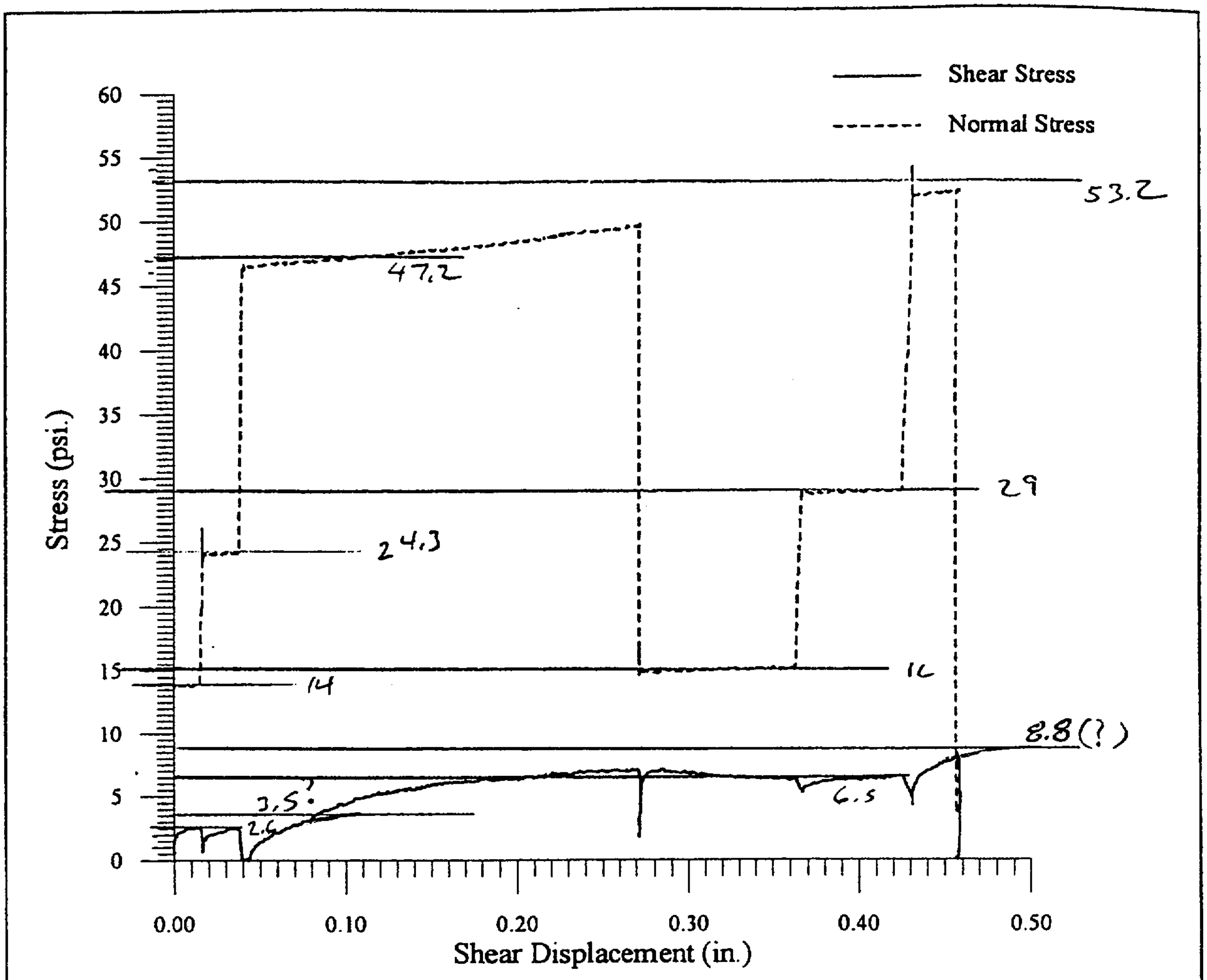
Geo Test Unlimited GTU
27069 N. Bloomfield Rd.
Nevada City, CA 95959

Client: **William Lettis & Associates, Inc.**
1777 Botelho Dr., Suite 262
Walnut Creek, CA 94596

Project: **Diablo Canyon Power Plant ISFSI**

Job Number: 1223-60

Test Date: May 9, 2000



DIRECT SHEAR TEST
Shear and Normal Stress vs. Shear Displacement

Boring: O1-H
Sample: 35
Depth: 94.5'

DESCRIPTION

Irregular dark gray clay filled joint (.1-.4" thick) in gray clayey medium grained sandstone.

	Normal Stress (psi)	Shear Stress (psi)
Initial	12.5	4.0
	20.4	3.9
	38.7	3.4
Final	13.2	5.1
	21.6	4.7
	40.3	4.0

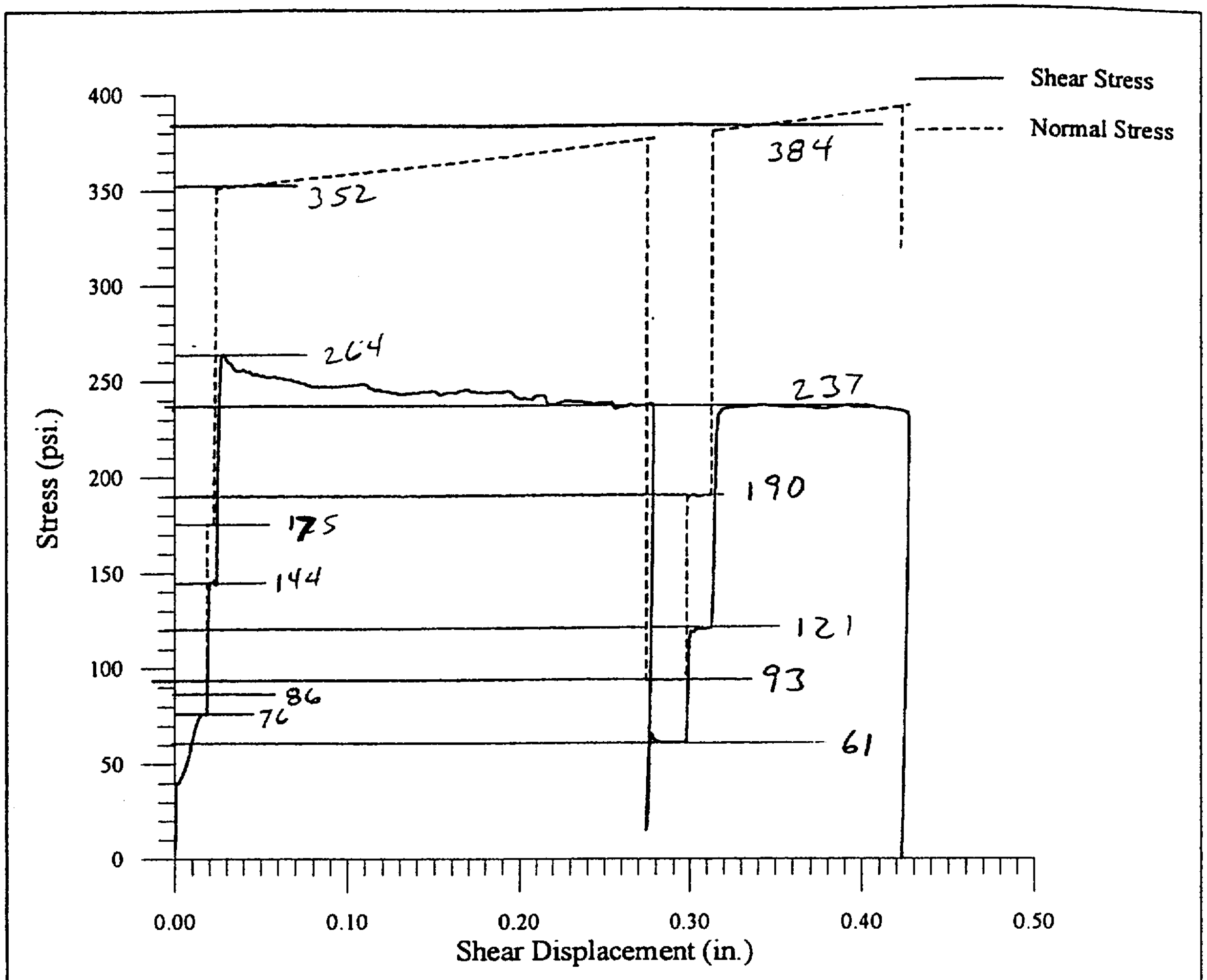
Geo Test Unlimited GTU
27069 N. Bloomfield Rd.
Nevada City, CA 95959

Client: **William Lettis & Associates, Inc.**
1777 Botelho Dr., Suite 262
Walnut Creek, CA 94596

Project: **Diablo Canyon Power Plant ISFSI**

Job Number: 1223-60

Test Date: May 9, 2001



DIRECT SHEAR TEST
Shear and Normal Stress vs. Shear Displacement

Boring: O1-I
Sample: 36
Depth: 174'

DESCRIPTION

Planar bedding joint in tan thinly bedded very fine grained dolomitic sandstone.

	Normal Stress (psi)	Shear Stress (psi)
Initial	14.0	2.6
	24.3	2.6
	47.2	3.5 (?)
Final	16.0	6.5
	29.0	6.5
	53.2	8.8 (?)

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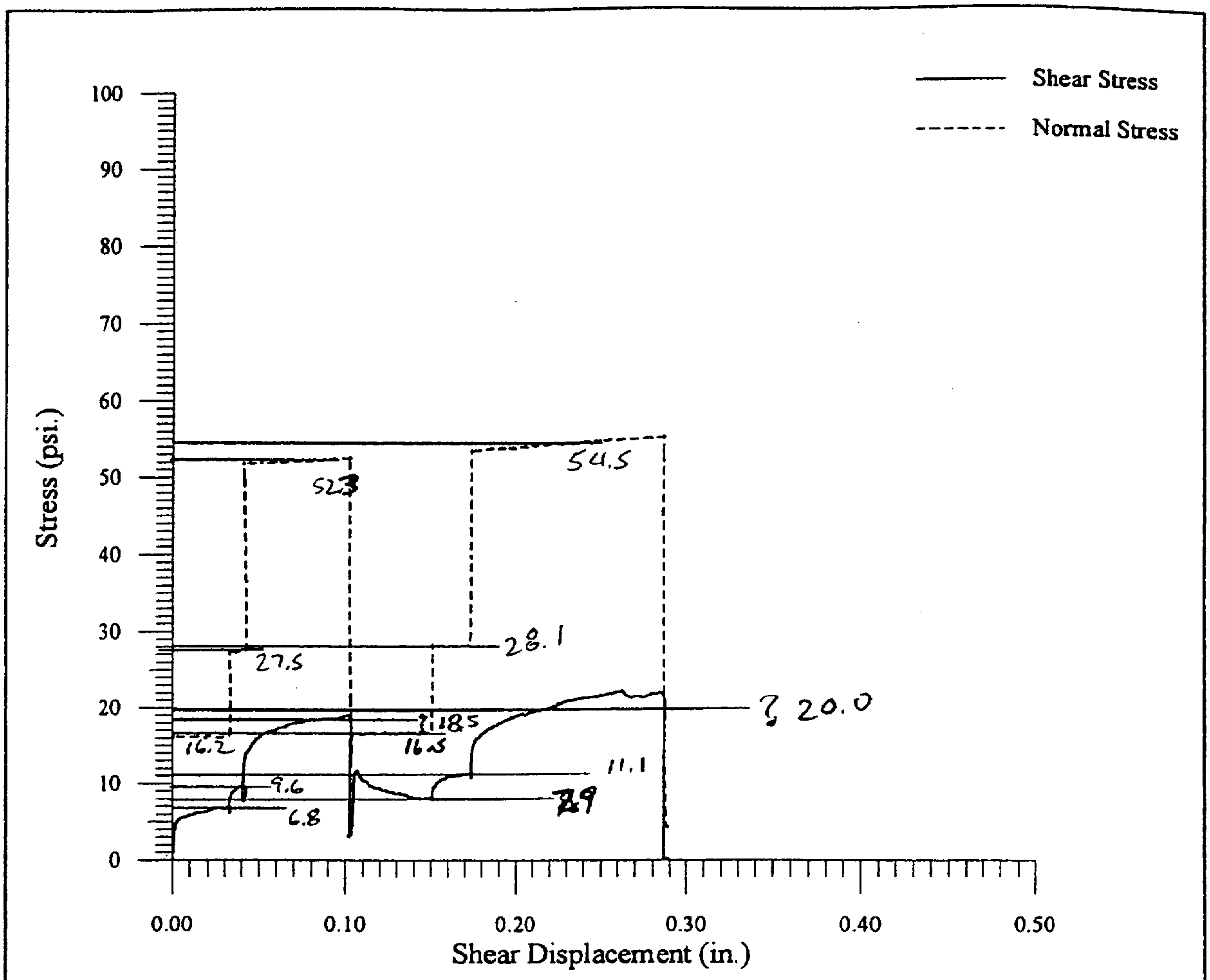
Nevada City, CA 95959

Client: William Lettis & Associates, Inc.
1777 Botelho Dr., Suite 262
Walnut Creek, CA 94596

Project: Diablo Canyon Power Plant ISFSI

Job Number: 1223-60

Test Date: May 10, 2001



DIRECT SHEAR TEST
Shear and Normal Stress vs. Shear Displacement

Boring: O1-I
Sample: 37
Depth: 168.5'

DESCRIPTION

Bedding plane joint in tan fine grained dolomitic sandstone with a thin lamination and clay coating.

	Normal Stress (psi)	Shear Stress (psi)
Initial	86	76
	175	144
	352	264
Final	93	61
	190	121
	384	237

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1777 Botelho Dr., Suite 262
Walnut Creek, CA 94596

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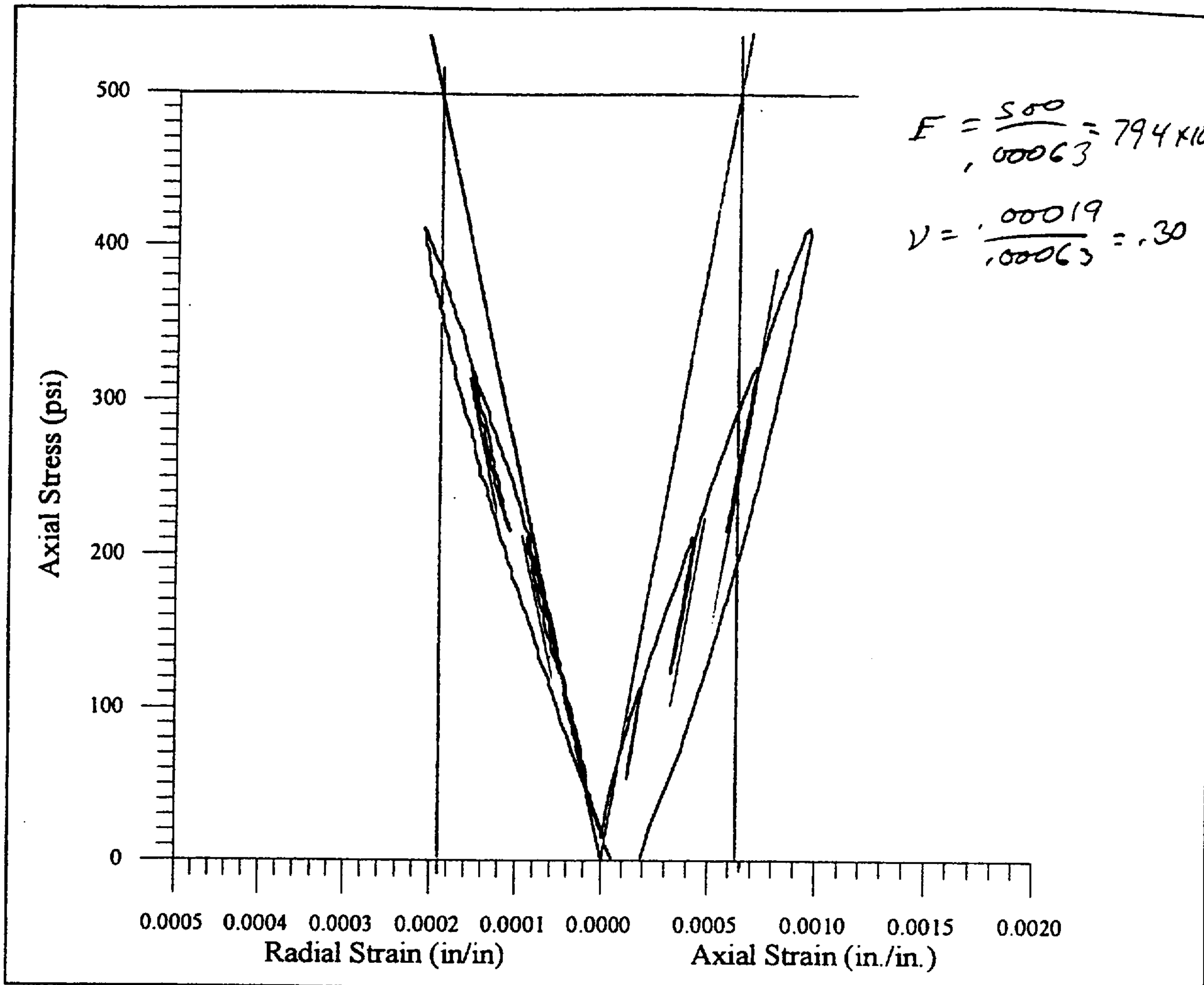
Job Number: 1223-60

Test Date: May 10, 2001



ELASTIC MODULUS TEST
Axial Stress vs. Axial & Radial Strain

Boring: 01-I
Sample: #38
Depth: 159.5'

DESCRIPTION

Dark gray fine grained dolomitic sandstone with two healed joints about 27 degrees to the core axis, healed with a soft white mineral.

Modulus:	1,250,000 psi
Poisson's ratio:	.20
Density:	138.9 pcf

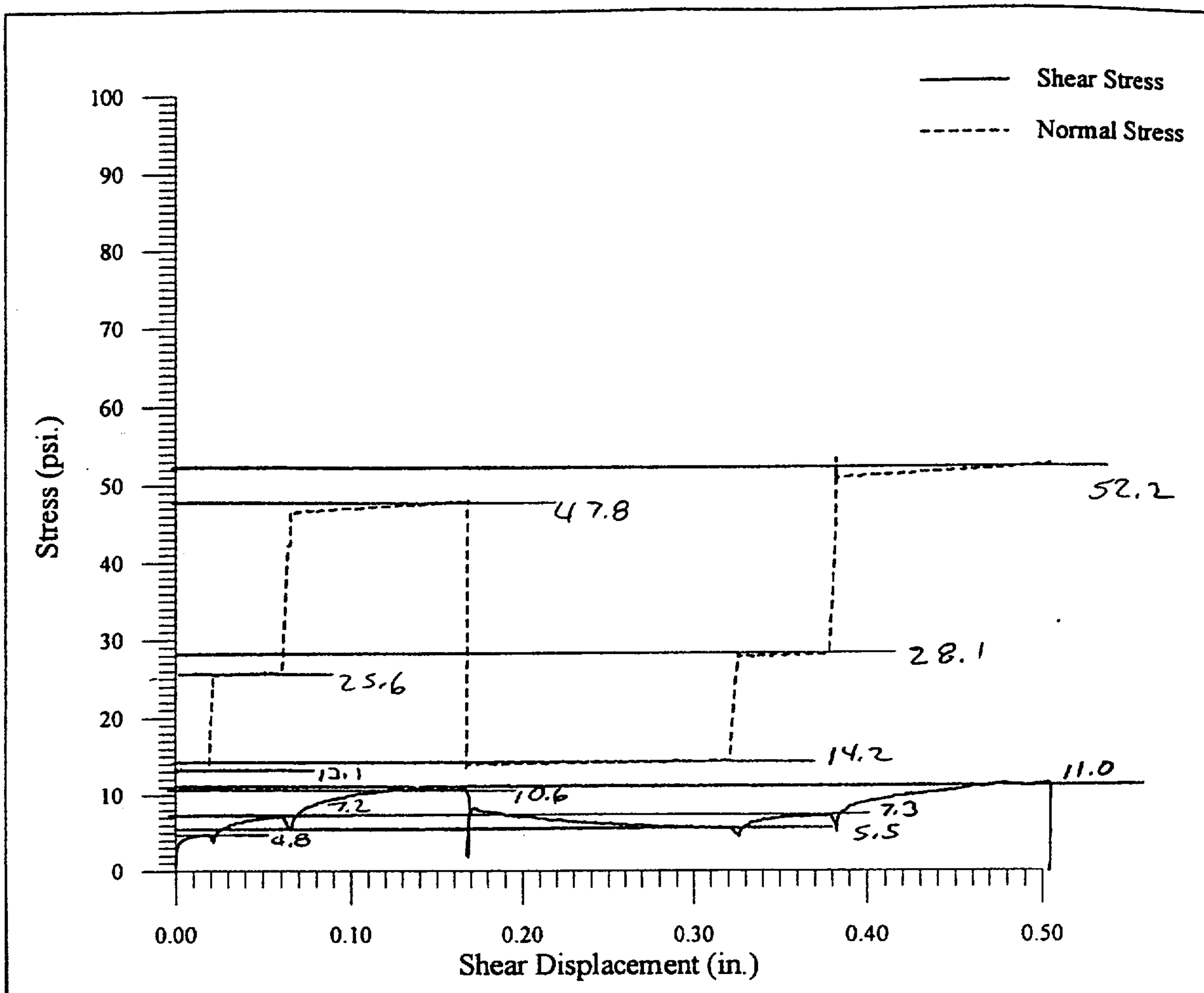
Geo Test Unlimited GTU
27069 N. Bloomfield Rd.
Nevada City, CA 95959

Client: William Lettis & Associates, Inc.
1777 Botelho Dr., Suite 262
Walnut Creek, CA 94596

Project: Diablo Canyon Power Plant ISFSI

Project Number: 1223-60

Test Date: May 13, 2001



DIRECT SHEAR TEST
Shear and Normal Stress vs. Shear Displacement

Boring: O1-I
Sample: 39B
Depth: 130.4'

DESCRIPTION

Tan clay seam (.1-.2" thick) in tan fine grained dolomitic sandstone.

	Normal Stress (psi)	Shear Stress (psi)
Initial	~~16.2~~	~~6.8~~
	~~27.5~~	~~9.6~~
	~~52.3~~	~~18.5~~
Final	~~16.5~~	~~7.9~~
	~~28.1~~	~~11.1~~
	~~54.5~~	~~20.0~~

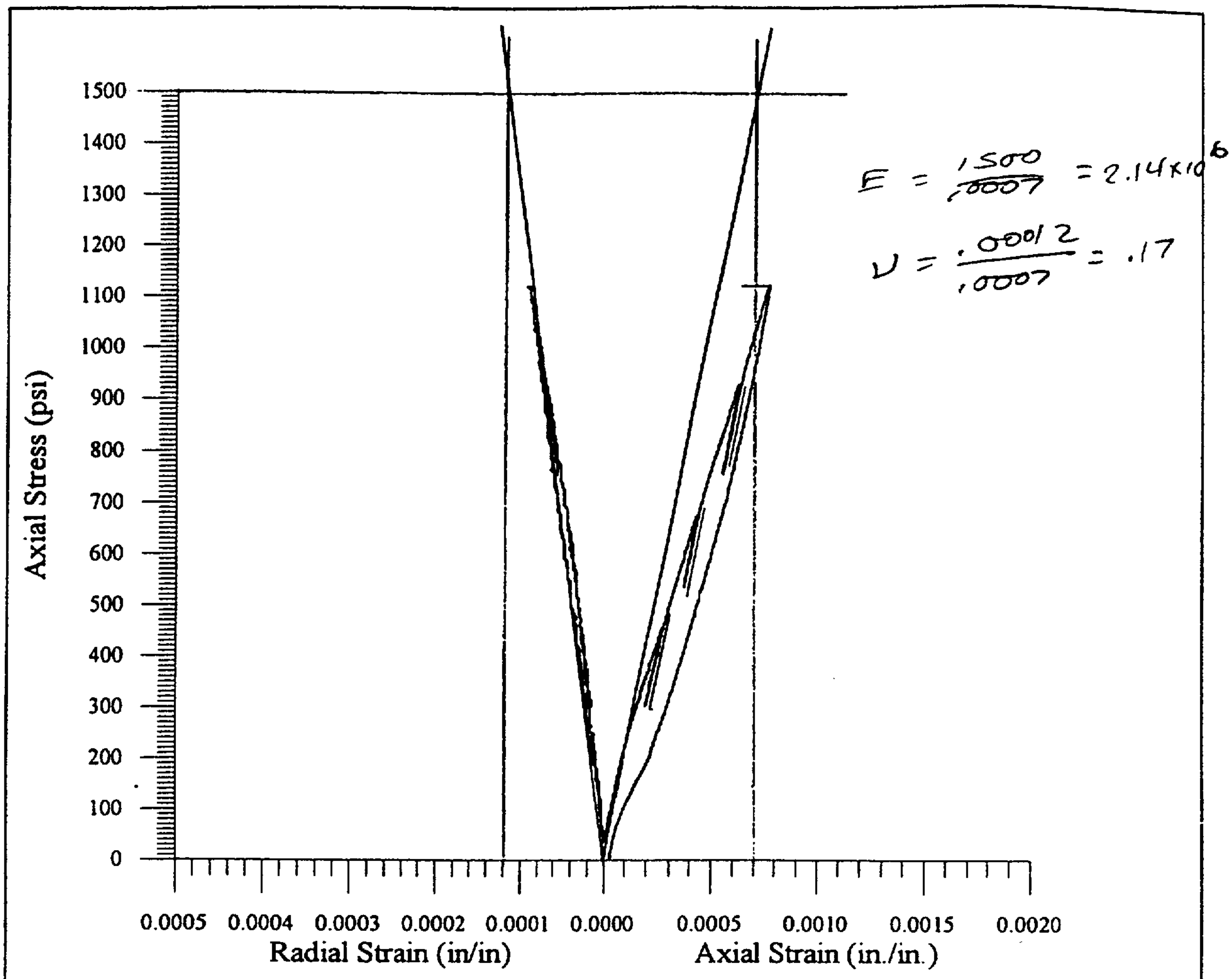
Geo Test Unlimited (GTU)
27069 N. Bloomfield Rd.
Nevada City, CA 95959

Client: **William Lettis & Associates, Inc.**
1777 Botelho Dr., Suite 262
Walnut Creek, CA 94596

Project: **Diablo Canyon Power Plant ISFSI**

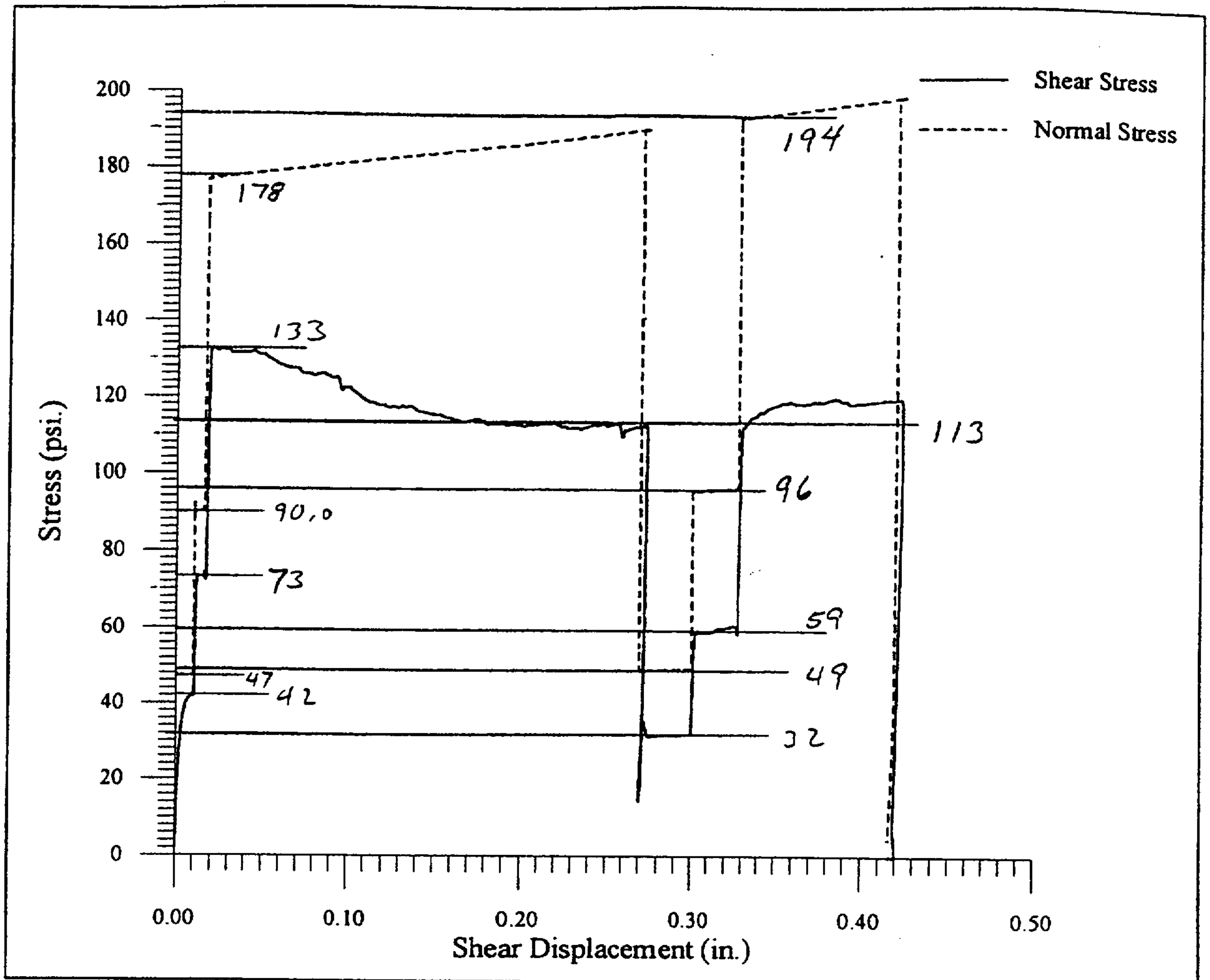
Job Number: 1223-60

Test Date: May 10, 2001



ELASTIC MODULUS TEST
Axial Stress vs. Axial & Radial Strain

Boring: 01-I **Sample: #40A** **Depth: 88.4'**	*Geo Test Unlimited* GTU **27069 N. Bloomfield Rd.** **Nevada City, CA 95959**
DESCRIPTION Tan thinly bedded fine grained dolomitic sandstone with bedding about 69 degrees to the core axis.	**Client:** **William Lettis & Associates, Inc.** **1777 Botelho Dr., Suite 262** **Walnut Creek, CA 94596**
Modulus: ~~794,000~~ psi **Poisson's ratio:** ~~.30~~ **Density:** ~~144.2~~ pcf	**Project:** **Diablo Canyon Power Plant ISFSI** **Project Number: 1223-60** **Test Date:** May 13, 2001



DIRECT SHEAR TEST
Shear and Normal Stress vs. Shear Displacement

Boring: O1-I
Sample: 40B
Depth: 88.8'

DESCRIPTION

Planar bedding joint in tan fine grained dolomitic sandstone.

	Normal Stress (psi)	Shear Stress (psi)
Initial	13.1	4.8
	25.6	7.2
	47.8	10.6
Final	14.2	5.5
	28.1	7.3
	52.2	11.0

Geo Test Unlimited GTU

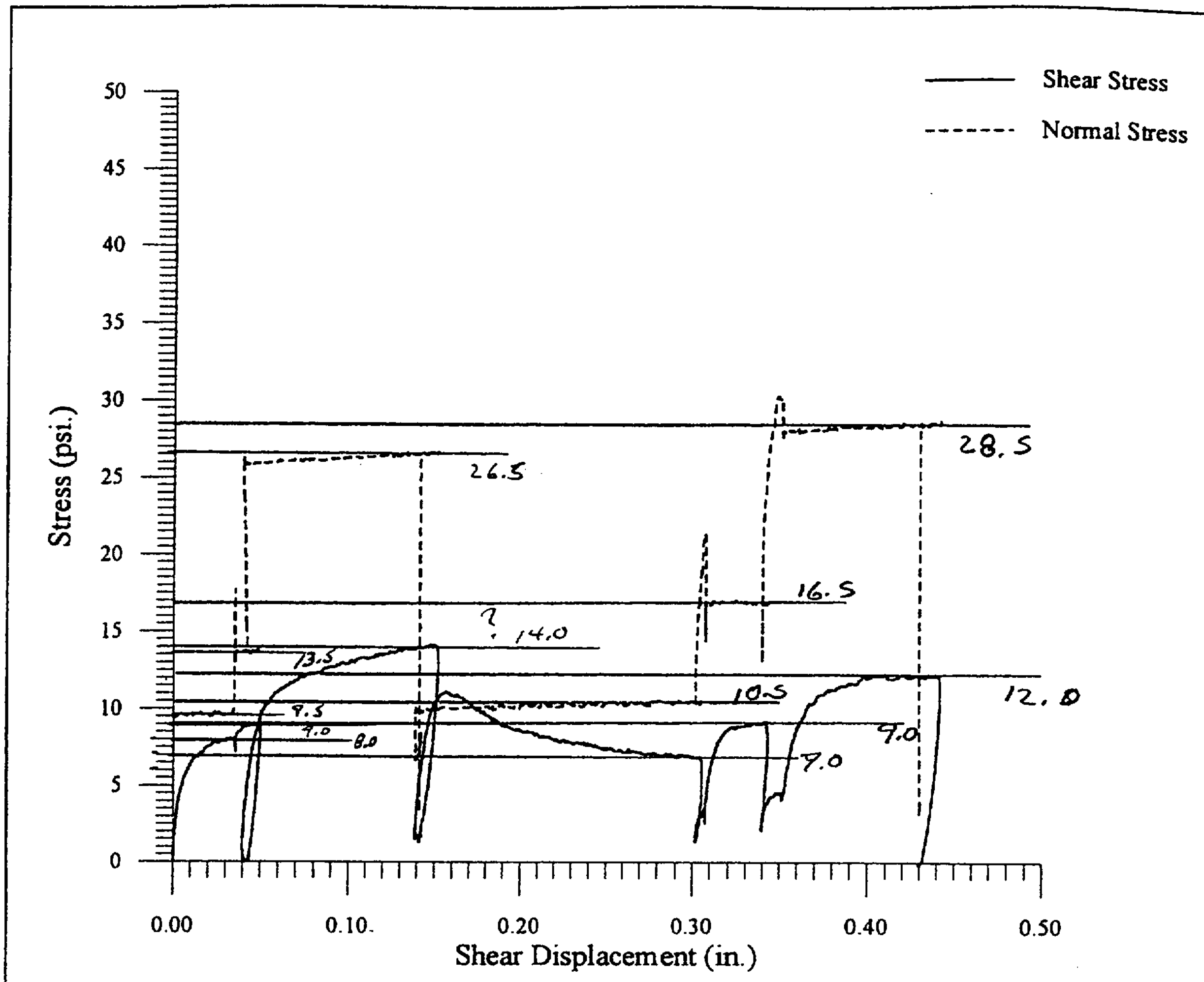
27069 N. Bloomfield Rd.
Nevada City, CA 95959

Client: **William Lettis & Associates, Inc.**
1777 Botelho Dr., Suite 262
Walnut Creek, CA 94596

Project: **Diablo Canyon Power Plant ISFSI**

Job Number: 1223-60

Test Date: May 10, 2001



DIRECT SHEAR TEST
Shear and Normal Stress vs. Shear Displacement

Boring: O1-I
Sample: 41A
Depth: 45.6'

DESCRIPTION

Tan clay seam about 3/4" thick in tan fine grained sandstone.

	Normal Stress (psi)	Shear Stress (psi)
Initial	47	42
	90	73
	178	133
Final	49	32
	96	59
	194	113

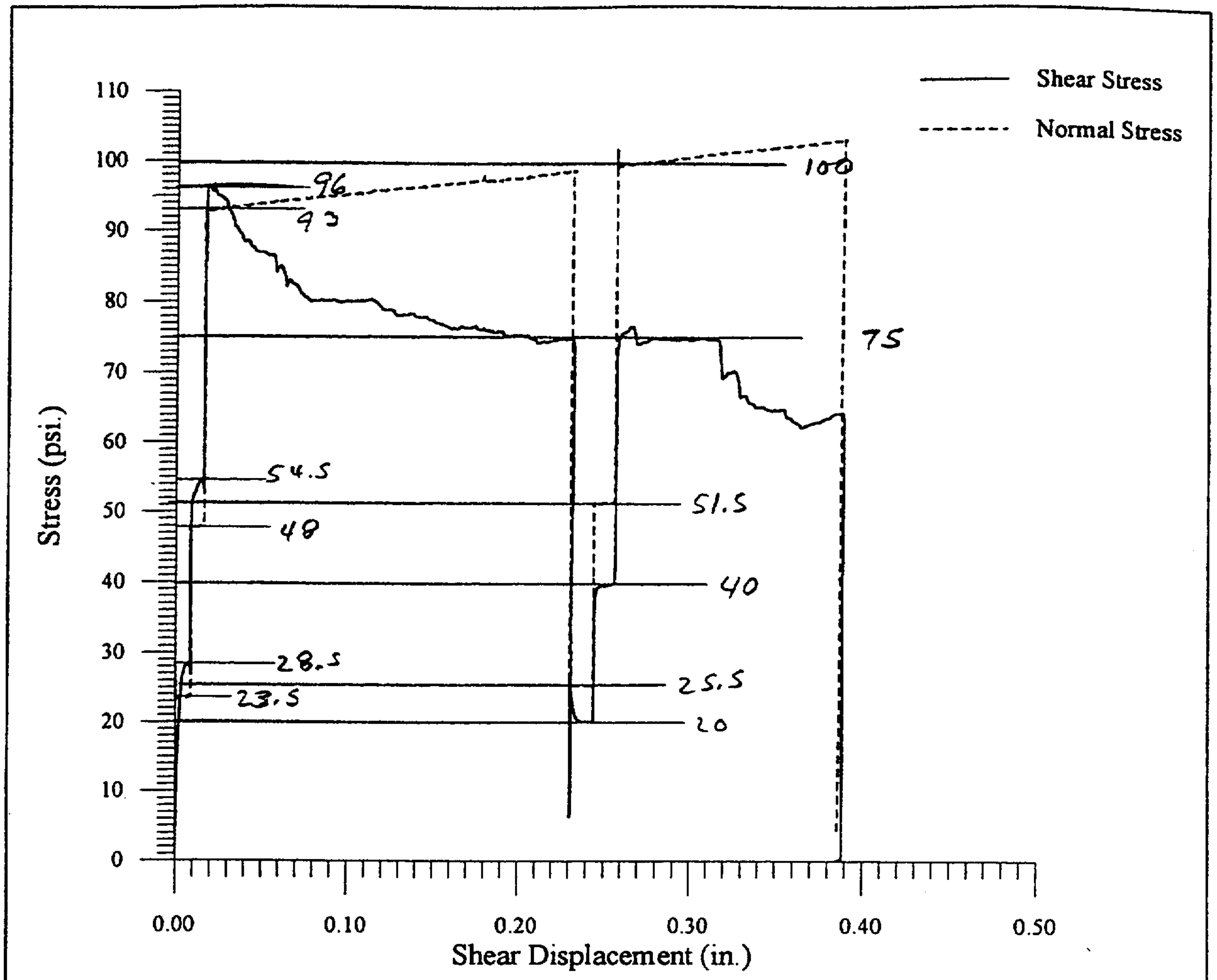
Geo Test Unlimited GTU
27069 N. Bloomfield Rd.
Nevada City, CA 95959

Client: **William Lettis & Associates, Inc.**
1777 Botelho Dr., Suite 262
Walnut Creek, CA 94596

Project: **Diablo Canyon Power Plant ISFSI**

Job Number: 1223-60

Test Date: May 11, 2001



DIRECT SHEAR TEST
Shear and Normal Stress vs. Shear Displacement

Boring: O1-I
Sample: 41B
Depth: 46.1'

DESCRIPTION

Planar bedding joint in tan fine grained dolomitic sandstone.

	Normal Stress (psi)	Shear Stress (psi)
Initial	9.5	8.0
	13.5	9.0
	26.5	14.0 (?)
Final	10.5	7.0
	16.5	9.0
	28.5	12.0

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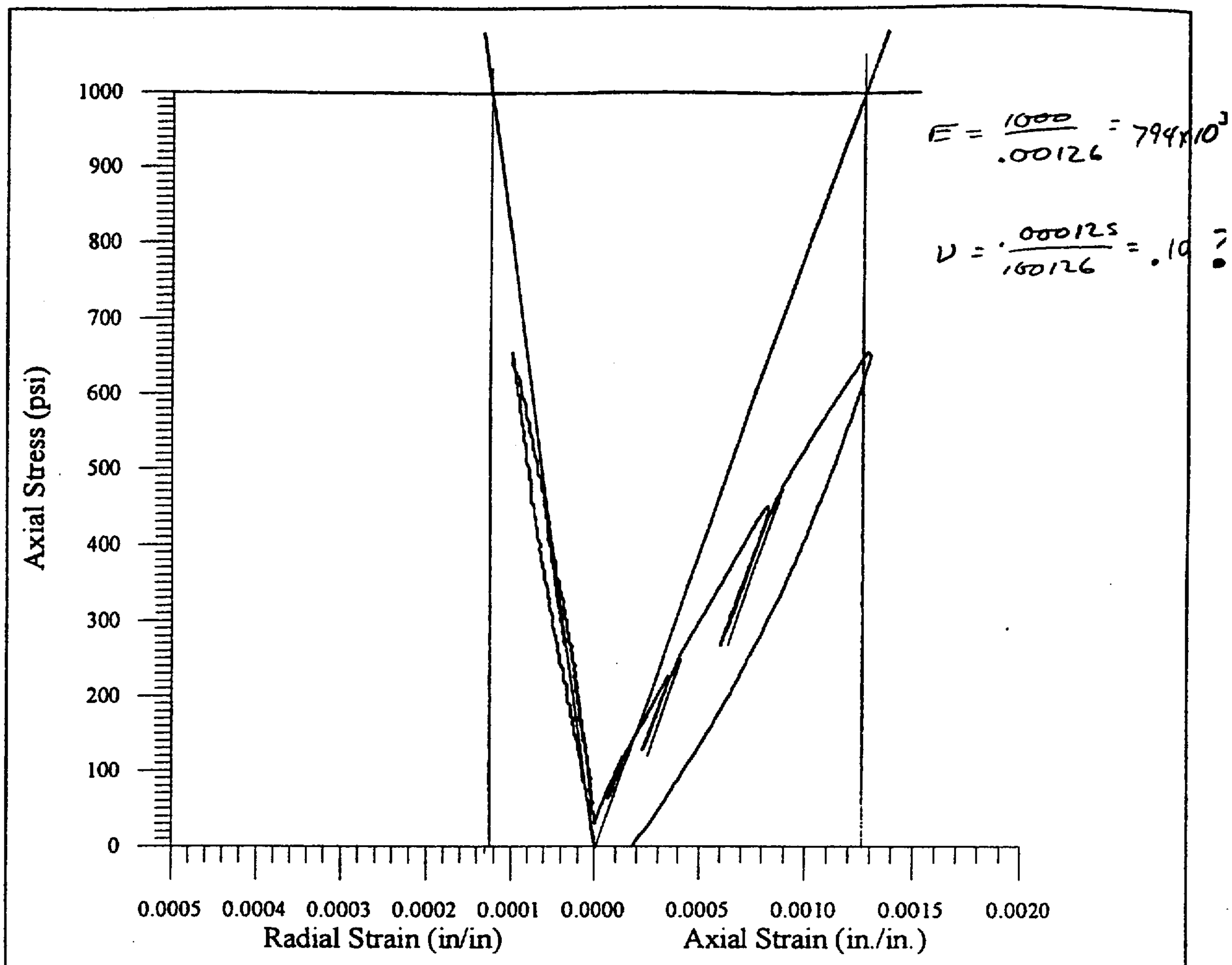
Nevada City, CA 95959

Client: **William Lettis & Associates, Inc.**
1777 Botelho Dr., Suite 262
Walnut Creek, CA 94596

Project: **Diablo Canyon Power Plant ISFSI**

Job Number: 1223-60

Test Date: May 10, 2001



ELASTIC MODULUS TEST
Axial Stress vs. Axial & Radial Strain

Boring: 01-I
Sample: #42
Depth: 44.0'

DESCRIPTION
Tan fine grained dolomitic sandstone.

Modulus:	**~~2,140,000 psi~~**
Poisson's ratio:	**~~.17~~**
Density:	**~~142.0 pcf~~**

Geo Test Unlimited GTU
27069 N. Bloomfield Rd.
Nevada City, CA 95959

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1777 Botelho Dr., Suite 262
Walnut Creek, CA 94596

Project: **Diablo Canyon Power Plant ISFSI**

Project Number: 1223-60

Test Date: May 13, 2001