



**Earth  
Mechanics**



**Fugro - Earth Mechanics**  
A JOINT VENTURE

**SUBCONTRACTOR REPORTS  
FINAL GEOTECHNICAL  
SITE CHARACTERIZATION**

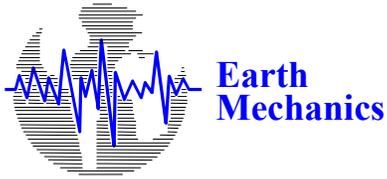
**SAN FRANCISCO-OAKLAND BAY BRIDGE  
EAST SPAN SEISMIC SAFETY PROJECT**

**VOLUME 2 OF 3  
(GeoTest Unlimited)**



**Prepared for  
CALIFORNIA DEPARTMENT OF TRANSPORTATION**

**March 2001**



**Earth  
Mechanics**



**Fugro - Earth Mechanics**  
A JOINT VENTURE

March 5, 2001  
Project No. 98-42-0054

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Attention: Mr. Mark Willian  
Contract Manager

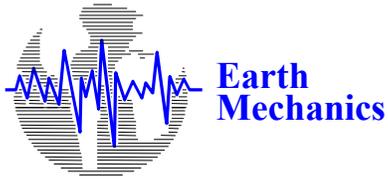
**Subcontractor Reports**  
**Final Geotechnical Site Characterization**  
**SFOBB East Span Seismic Safety Project**

Dear Mr. Willian:

The geologic and geotechnical studies for the San Francisco-Oakland Bay Bridge (SFOBB) East Span Seismic Safety are being conducted by Fugro-Earth Mechanics (a joint venture of Fugro West, Inc., and Earth Mechanics, Inc.) under California Department of Transportation (Caltrans) Contract 59A0053. Phase 2 of the studies included 30 marine borings drilled from September through November 1998 per the requirements of Task Order No. 5 of the referenced contract. The borings included extensive in situ testing, soil sampling, rock coring, and downhole geophysical logging. Extensive laboratory testing programs were conducted on the soil samples and rock cores recovered from the borings.

As part of the execution of the final geotechnical site investigations, services were obtained from several subcontractors who have submitted reports to Fugro-Earth Mechanics documenting the data they collected. Those reports are reproduced in a set of three volumes that include the following subcontractor reports:

Volume	Subcontractor	Report Subject
1	<ul style="list-style-type: none"><li>• Geovision</li><li>• Welenco, Inc.</li></ul>	<ul style="list-style-type: none"><li>• Borehole Geophysics</li><li>• Borehole Televiewer Logs</li></ul>
2	<ul style="list-style-type: none"><li>• GeoTest Unlimited</li></ul>	<ul style="list-style-type: none"><li>• Laboratory Rock Testing Program</li></ul>
3	<ul style="list-style-type: none"><li>• Fugro West, Inc.</li></ul>	<ul style="list-style-type: none"><li>• Tethered Seascout Soundings</li></ul>



**Earth  
Mechanics**

California Department of Transportation  
March 5, 2001 (98-42-0054)



**Fugro - Earth Mechanics**  
A JOINT VENTURE

On behalf of the project team, we appreciate the opportunity to contribute to the Caltrans' design of the new bridge to replace the existing SFOBB East Span. Please call if we can answer any questions relative to the information presented in the enclosed report.

Sincerely,

FUGRO-EARTH MECHANICS, A Joint Venture

Thomas W. McNeilan, C.E., G.E.  
Vice President

TWM:cab

Attachment

Copies Submitted: Mr. Mark Willian, Caltrans  
Mr. Saba Mohan, Caltrans  
Mr. Robert Price, Caltrans  
Dr. Brian Maroney, Caltrans  
Ms. Sharon Naramore, Caltrans  
Mr. Gerry Houlahan, TY Lin/M&N  
Mr. Sajid Abbas, TY Lin/M&N  
Mr. Al Ely, TY Lin/M&N

**SAN FRANCISCO-OAKLAND BAY BRIDGE  
EAST SPAN SEISMIC SAFETY PROJECT  
CALTRANS CONTRACT 59A0053**

**SUBCONTRACTOR REPORTS  
FINAL GEOTECHNICAL  
SITE CHARACTERIZATION**

**VOLUME 2 OF 3  
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Prepared For:

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Prepared By:

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November 9, 1998

Mr. Craig Prentice  
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Letter Report  
San Francisco Oakland Bay Bridge  
East Span Replacement Project  
Rock Testing Program

This report details an extensive suite of unconfined compression, and direct shear tests. The samples were received from Rick Smith (Fugro), within the period of October 12 and October 19, 1998. The samples were prepared and tested at GTU's facilities in San Leandro, CA. The samples were tested between October 14 and October 30, 1998.

The sample preparation and testing procedures followed the ASTM Standards and ISRM Suggested Methods.

This letter report presents the test results and highlights any behavior exhibited during the tests which might have some bearing on interpreting the test results.

This report is accompanied by a set of data sheets and plots. The standard test procedures used by GTU are appended to this report. The sample photographs and ZIP drive with all of the test data and GRAPHER files are also included with this report.

### Sample Description

All of the samples consisted of either sandstone or siltstone.

The sandstone was generally gray and quite strong in its unfractured state. This rock has also been called a graywacke by many geologists, and contains small chips of claystone. The color of this rock can also be tan or brown and weaker as the degree of weathering increases. Generally the sandstone grains were quite fine. The sandstone was generally fractured and the fractures were more often than not healed with calcite (and possibly quartz) and quite thin. Sometimes they were so thin that they were not readily visible to the naked eye, but could be exposed by wetting the samples and letting them partially dry. They would then be highlighted as thin lines of moisture, indicating that these joints were only partially healed. Larger calcite healed seams were also common. The sandstone joints were quite planar, with a small scale roughness on the scale of the particle size.

Many of the siltstone samples could also be considered to be claystones due to their high clay contents. These samples are commonly called shale by the geologists in the Bay Area. This black or dark gray claystone was found either as thin interbeds in the

sandstone or as more massive somewhat fissile bedded rock. The partings were generally polished and calcite coated, and when no major fractures passed through the samples, a fine network of fractures could be easily seen if the surface of the wet samples were slightly dried. Some of the major fractures in this rock also contained a few pyrite crystals. These joints were generally quite planar and smooth. Large scale undulations were also common.

## **Sample Preparation**

The samples were prepared using the procedures presented in the appendices. In a few cases, the unconfined samples were quite weak due to a high degree of jointing. These samples were first wrapped with heat shrink wrap, and the wrap heated to confine the samples. Then they were cut and surfaced in the regular manner. The wrap was removed just prior to testing. In one case (Boring 98-24, Sample 14a), the end of the sample was so weak and broken that it had to be capped with hydrostone before it could be cut to length and ground.

All of the samples were stored in a high humidity environment (The humidity was high enough to keep the sample surfaces wet.) from the time they were received until they were tested.

## **Test Procedures**

### *Elastic Modulus Test Procedure*

No deviations from the appended test procedure were required for these tests. A 222 kN (50 kip) load cell was used to measure the loads in these tests.

The objective of the modulus tests was only to load the samples in the elastic region. In a few cases, the samples clearly deformed in a plastic manner, and may have failed at very low stresses during the modulus test.

### *Unconfined Compression Test Procedure*

No deviations from the appended test procedure were required for these tests. A 890 kN (200 kip) load cell was used for these tests.

### *Direct Shear Test Procedure*

No deviations from the appended test procedure were required for these tests. For these tests, the shear box was configured with the smaller sample holder, and the normal loads were applied using a pneumatic cylinder. 8.9 kN (2 kip) load cells were used to measure the normal and shear loads. Generally, two sets of three stage tests were performed on each sample. One set was performed at very small shear displacements, in an attempt to capture the initial unsheared failure strength of the joint. The second set was performed at relatively large displacements to obtain a measure of the joint strength in an unmated configuration.

## Test Results

### Modulus and Unconfined Compression Tests

#### Boring 98-21

Sample ID	Depth (ft)	Description	Density (kN/m <sup>3</sup> ) (pcf)	UC Strength (Mpa) (psi)	Modulus (Gpa) (x10 <sup>6</sup> psi)	Poisson's Ratio
26a	72.5	Medium gray sandstone with small claystone chips creating a bedded appearance with bedding about 45 degrees to the core axis.	27.28 (167.3)	78.78 (11,426)	47.84 (6.94)	.27
29a	83	Dark gray claystone with a few irregular sandstone lenses. Contains many calcite healed hairline fractures parallel to the bedding about 53 degrees to the core axis.	26.47 (168.5)	26.11 (3787)	28.75 (4.17)	.35
31a	97	In one sample half, dark gray fine sandy siltstone and siltstone interbedded with claystone. The other half consists of claystone. Bedding about 25 degrees to the core axis.	26.36 (167.8)	36.10 (5236)	44.20 (6.41)	.29
32a	106.5	Medium gray bedded sandstone with a long claystone flake and two calcite healed bedding plane fractures, and many calcite healed fractures perpendicular to the bedding (50 degrees to the core axis).	26.30 (167.4)	60.38 (8757)	49.99 (7.25)	.22
34a	122.5	Medium gray sandstone with a calcite healed hairline fracture about 32 degrees to the core axis.	26.50 (168.7)	81.30 (11,791)	44.75 (6.49)	.32
35a	130	Medium dark gray fine sandy siltstone to sandstone with a few claystone inclusions and one non-continuous calcite healed joint, about 24 degrees to the core axis.	26.55 (169.0)	93.63 (13,580)	53.85 (7.81)	.32

#### Boring 98-22

Sample ID	Depth (ft)	Description	Density (kN/m <sup>3</sup> ) (pcf)	UC Strength (Mpa) (psi)	Modulus (Gpa) (x10 <sup>6</sup> psi)	Poisson's Ratio
16a	35	Tan weathered massive sandstone	25.81 (164.3)	35.97 (5217)	19.17 (2.78)	.31
17a	38.5	Olive gray sandy siltstone with a few yellowish tan fine sandstone inclusions and a few partially healed fractures.	25.53 (162.5)	21.45 (3111)	15.44 (2.24)	.20
18a	48	Medium gray sandstone with calcite healed fractures, 0, 32, and 53 degrees to the core axis.	26.39 (168.0)	82.28 (11,934)	52.26 (7.58)	.25

20a	59	Medium gray massive sandy siltstone with a few small claystone inclusions	26.44 (168.3)	76.44 (11,087)	33.78 (4.90)	.34
21a	70	Medium gray sandstone with a few axial fractures partially healed with calcite.	26.31 (167.5)	20.89 (3030)	37.09 (5.38)	.25
21a(b)	70.5	Medium gray sandstone with a few calcite healed fractures, 27 and 32 degrees to the core axis.	26.34 (167.7)	72.69 (10,543)	53.02 (7.69)	.21
21a(c)	71	Medium gray sandstone with a few calcite healed hairline fractures, about 20 degrees to the core axis.	26.42 (168.2)	67.20 (9746)	45.99 (6.67)	.22
25a	85	Medium gray sandstone with a few calcite healed joints and hairline fractures, 33 and 39 degrees to the core axis, with a few small claystone inclusions.	26.59 (169.3)	135.90 (19,710)	57.43 (8.33)	.29
27a	98.5	Finely interbedded medium gray sandstone and claystone, bedding about 60 degrees to the core axis, with claystone on one end and a calcite healed fracture about 37 degrees to the core axis.	26.45 (168.4)	60.67 (8799)	39.64 (5.75)	.31
29a	112	Medium gray massive sandstone with one calcite healed hairline fracture about 45 degrees to the core axis.	26.55 (169.0)	140.75 (20,414)	68.95 (10.00)	.38
31a	124	Dark gray claystone interbedded with sandy siltstone, with many hairline fractures parallel to the bedding (60 degrees to the core axis) and one calcite healed axial fracture.	26.31 (167.5)	35.45 (5141)	24.34 (3.53)	.31
32a	130	Medium gray massive sandy siltstone with two calcite healed fractures, 0 and 50 degrees to the core axis.	26.42 (168.2)	122.78 (17,808)	45.99 (6.67)	.27
35a	149	Medium gray massive sandstone with many calcite healed axial hairline fractures.	26.55 (169.0)	54.90 (7962)	63.78 (9.25)	.30

### Boring 98-23

Sample ID	Depth (ft)	Description	Density (kN/m <sup>3</sup> ) (pcf)	UC Strength (Mpa) (psi)	Modulus (Gpa) (x10 <sup>6</sup> psi)	Poisson's Ratio
6a	14.5	Light brown massive sandstone with an open fracture near the core end, 32 degrees to the core axis, and a calcite coating on one side.	25.43 (161.9)	19.00 (2756)	12.20 (1.77)	.30
11a	34	Medium gray sandstone with a few calcite healed hairline fractures, 0, 20, 28, and 67 degrees to the core axis.	26.55 (169.0)	119.49 (17,330)	62.67 (9.09)	.21
14a	46.5	Medium gray sandstone with two calcite healed hairline fractures, 33 degrees to the core axis.	26.66 (169.7)	90.38 (13,109)	80.19 (11.63)	.26

17a	57.5	Dark gray fine sandy siltstone with claystone inclusions and many calcite healed hairline fractures, 30 and 50 degrees to the core axis.	26.45 (168.4)	37.22 (5398)	35.92 (5.21)	.36
18a	63	Dark gray sandstone to fine sandy siltstone with two calcite healed hairline fractures, 41 degrees to the core axis.	26.39 (168.0)	56.87 (8249)	39.64 (5.75)	.33
20a	74	Medium gray sandstone finely interbedded with claystone and siltstone in one sample half, claystone and siltstone in the other half, separated by a calcite healed joint 63 degrees to the core axis.	26.27 (167.2)	11.57 (1678)	23.30 (3.38)	NA? .19
20b	74.5	Dark gray claystone and siltstone with numerous calcite healed hairline fractures parallel to the bedding, 62 degrees to the core axis.	26.28 (167.3)	17.94 (2602)	14.75 (2.14)	.33
21a	78	Medium gray sandstone finely interbedded with dark gray siltstone and claystone, with bedding about 65 degrees to the core axis. Also contains a few calcite healed axial hairline fractures.	26.36 (167.8)	28.80 (4177)	34.47 (5.00)	NA .19
22a	85	Medium gray sandstone with a few calcite healed hairline fractures, 27 degrees to the core axis.	26.64 (169.6)	138.86 (20,140)	57.43 (8.33)	.24
27a	106.5	Dark gray fine sandy siltstone, with two minor calcite healed hairline fractures.	26.55 (169.0)	59.80 (8673)	65.02 (9.43)	.36
28a	114	Dark interbedded claystone, siltstone and sandstone, bedded about 70 degrees to the core axis.	26.41 (168.1)	19.15 (2778)	19.86 (2.88)	.14
29a	120.5	Medium gray fine sandy siltstone to sandstone with several calcite healed hairline fractures about 15 to 25 degrees to the core axis.	26.63 (169.5)	16.63 (2412)	37.78 (5.48)	.21
30b	128.5	Medium gray sandstone with a calcite healed hairline fracture.	26.74 (170.2)	114.31 (16,579)	57.43 (8.33)	.25
31a	135	Medium gray sandstone alternating with fine sandy siltstone. Contains numerous calcite healed hairline fractures about 24 to 37 degrees to the core axis, and one healed axial fracture.	26.74 (170.2)	38.00 (5512)	47.85 (6.94)	.22
32a	142.8	Medium gray sandstone with an end zone of contorted dark gray to olive gray claystone and many calcite healed hairline fractures.	26.53 (168.9)	44.46 (6449)	37.09 (5.38)	.24

### Boring 98-24

Sample ID	Depth (ft)	Description	Density (kN/m <sup>3</sup> ) (pcf)	UC Strength (Mpa) (psi)	Modulus (Gpa) (x10 <sup>6</sup> psi)	Poisson's Ratio
12a	38.5	Medium gray sandstone with a small swarm of calcite healed hairline axial fractures	26.39 (168.0)	24.27 (3521)	38.27 (5.55)	.31
13a	45	Medium gray sandstone with partially healed and calcite healed fractures, 13, 27, and 57 degrees to the core axis.	26.34 (167.7)	24.26 (3519)	34.47 (5.00)	.37
14a	52	Dark gray siltstone and claystone with many hairline fractures and two calcite healed fractures, 0 and 59 degrees to the core axis.	26.03 (165.7)	14.60 (2118)	14.24 (2.08)	.31
15a	54	Medium gray sandstone with many calcite healed fractures (hairline to 3/16 inch wide), 0 to 45 degrees to the core axis.	26.47 (168.5)	31.78 (4610)	26.96 (3.91)	.36
16a	59.5	Medium gray sandstone with a small claystone inclusion and a calcite healed hairline fracture about 10 degrees to the core axis.	26.58 (169.2)	51.37 (7451)	55.57 (8.06)	.32
20a	75.5	Medium gray sandstone with partially healed and calcite healed fractures, generally 25 degrees to the core axis and one 50 degrees to the core axis.	26.47 (168.5)	49.19 (7134)	42.06 (6.10)	.37
21a	79	Dark gray siltstone with sandstone layers. The siltstone contains many hairline fractures parallel to the bedding, about 65 degrees to the core axis.	26.39 (168.0)	19.49 (2827)	28.27 (4.10)	.35
22a	87.5	Medium gray sandstone with several calcite healed hairline fractures, 12 and 62 degrees to the core axis.	26.63 (169.5)	45.24 (6562)	65.02 (9.43)	.31
24a	98	Medium gray sandstone with partially healed and calcite healed fractures about 40 degrees to the core axis.	26.66 (169.7)	75.24 (10,912)	66.33 (9.62)	.30
25a	105	Medium gray massive sandstone	26.67 (169.8)	136.76 (19,835)	68.95 (10.00)	.35

### Boring 98-24a

Sample ID	Depth (ft)	Description	Density (kN/m <sup>3</sup> ) (pcf)	UC Strength (Mpa) (psi)	Modulus (Gpa) (x10 <sup>6</sup> psi)	Poisson's Ratio
6a	33	Massive tan sandstone with an unhealed fracture about 672 degrees to the core axis.	26.27 (167.2)	54.48 (7901)	NA? 11.65 (1.69)	NA .07
7a	38	Medium dark gray fine sandy siltstone with a calcite healed hairline fracture about 15 degrees to the core axis.	26.53 (168.9)	106.30 (15,417)	45.99 (6.67)	.33
8a	48	Dark gray massive fine sandy siltstone with no visible fractures.	26.48 (168.6)	113.86 (16,514)	48.54 (7.04)	.31

### Direct Shear Tests

#### Boring 98-21

Sample ID	Depth (ft)	Description	Initial Joint Strength		Final Joint Strength	
			Sj (Kpa) (psi)	φj (degrees)	Sj (Kpa) (psi)	φj (degrees)
20a	45	Planar bedding joint in dark gray claystone.	6.9 (1.0)	23.8	13.8 (2.0)	23.7
31b	98	Planar parting between gray sandstone and dark gray fine sandy siltstone.	42.1 (6.1)	33.3	24.8 (3.6)	32.1
34b	123.5	Planar calcite coated joint in medium dark gray fine sandy siltstone.	49.0 (7.1)	36.8	29.0 (4.2)	38.1
36a	133	Planar bedding plane joint in dark gray claystone.	53.8 (7.8)	28.6	20.0 (2.9)	24.5
36b	135.5	Planar bedding plane joint in a thin dark gray claystone bed.	7.6 (1.1)	27.0	28.3 (4.1)	23.9

#### Boring 98-22

Sample ID	Depth (ft)	Description	Initial Joint Strength		Final Joint Strength	
			Sj (Kpa) (psi)	φj (degrees)	Sj (Kpa) (psi)	φj (degrees)
19a	51	Slightly rough, oxide coated joint in medium gray sandstone.	84.1 (12.2)	38.5	13.8 (2.0)	30.1
19b	55	Irregular Vee shaped joint in dark gray siltstone with a slight oxide coating.	26.2 (3.8)	36.7	33.8 (4.9)	27.2
25b	86	Planar calcite coated bedding plane joint in dark gray claystone.	53.8 (7.8)	35.6	31.0 (4.5)	30.1
25c	91.5	Planar calcite coated bedding plane joint in dark gray claystone adjacent to a claystone/siltstone contact.	1.4 (0.2)	20.3	24.1 (3.5)	22.9

### Boring 98-23

Sample ID	Depth (ft)	Description	Initial Joint Strength		Final Joint Strength	
			Sj (Kpa) (psi)	$\phi_j$ (degrees)	Sj (Kpa) (psi)	$\phi_j$ (degrees)
7a	17.5	Slightly rough joint in tan sandstone with a light tan clay or silt coating.	24.1 (3.5)	33.2	33.8 (4.9)	29.2
7b	17.7	Slightly rough joint in tan sandstone.	60.0 (8.7)	41.9	47.6 (6.9)	26.6
17b	58	Planar calcite coated joint in dark gray claystone.	15.2 (2.2)	29.6	30.3 (4.4)	27.9
24a	96.5	Planar calcite coated joint in dark gray claystone/siltstone.	182.0 (26.4)	35.4	37.9 (5.5)	28.5
26a	103.5	Planar calcite coated bedding joint between dark gray claystone and siltstone.	35.9 (5.2)	31.6	19.3 (2.8)	28.6
26b	104.5	Undulating calcite coated joint in dark gray claystone.	85.5 (12.4)	26.9	96.5 (14.0)	21.0
30a	128	Slightly wavy joint in medium dark gray fine sandy siltstone.	87.6 (12.7)	31.1	47.6 (6.9)	23.8

### Boring 98-24

Sample ID	Depth (ft)	Description	Initial Joint Strength		Final Joint Strength	
			Sj (Kpa) (psi)	$\phi_j$ (degrees)	Sj (Kpa) (psi)	$\phi_j$ (degrees)
21b	79	Planar bedding plane joint in dark gray claystone at a claystone/siltstone interface.	2.8 (0.4)	24.4	23.4 (3.4)	23.2
21c	80	Planar bedding plane joint in dark gray claystone.	9.0 (1.3)	23.8	15.2 (2.2)	24.1

### Sample Behavior and Test Interpretation

#### *Unconfined Compression Tests*

A large range of strengths were measured in this suite of tests. The sandstone samples appeared to result in the largest variation of strengths, ranging from 19.00 Mpa (2256 psi) to 140.75 Mpa (20,414 psi). The sandstone samples were decidedly stronger than the other samples, with the exception of the fine sandy siltstones which could also be quite strong. The claystones and clayey siltstones were significantly weaker than the sandstones, with strengths ranging from 11.57 Mpa (1678 psi) to 37.22 Mpa (5398 psi).

Within each category of rock, the strengths were highly dependent on the extent of jointing, the degree of healing on the joints, the number of joints, and the orientation of the joints. Often joints which appeared to be well healed with calcite were only partially healed and were the weak link in the rock. A few samples failed along joints which were so fine that they were not visible on initial inspection. Thus the condition, orientation,

and number of joints made it quite difficult to guess the sample strength from the sample appearance. Some samples which appeared to be weak due to the large number of healed joints were surprisingly strong, and conversely, samples which looked strong and intact were significantly weakened by a very fine joint.

There appeared to be a trend between the width of the healed joints and the sample strengths. Those samples which contained wide calcite healed joints appeared to be stronger than those samples containing thin hairline healed joints. The narrower joints generally appeared to be less well healed, with a poorly crystallized binder, whereas in the wider healed joints, the calcite was more well developed, with fewer voids, and better binding between the two sides of the healed joint.

The degree of weathering also significantly impacted the strength of the sandstone. The weakest sandstone sample was a brown weathered sample, whereas the strongest sample, with an order of magnitude greater strength, was a gray unweathered specimen.

One question which arose during this testing program was, "What spatial correlation is there between samples strengths?" A few pieces of core were supplied from which a number of samples could be cut. Since only one sample was asked from each length of core, the questions naturally arose, "Does it matter from which section of the core the sample is taken?" and "What might the strength variation be?"

In an effort to shed some light on these questions, three samples were cut from one intact piece of core. Boring 98-22, Samples 21a, 21a(b) and 21a(c) were cut from an 18" length of core and were therefore immediately adjacent to each other in this run of core. The rock appeared to be quite similar from sample to sample, and it was expected that the strengths would be similar as well. The first sample (21a) which was initially chosen to perform the requested test, was significantly weaker, with a strength of 20.89 Mpa (3030 psi) than the other two samples 7269 Mpa (10,543 psi) and 67.20 Mpa (9746 psi). This variation in strength highlights the problems with estimating the strength of a rock mass from a limited number of tests. Clearly, even in this spatially limited grouping of samples, the strength variation was quite high, even though the rock looked quite similar from sample to sample. This insight indicates that a probabilistic analysis might be more suitable than a deterministic one.

#### *Elastic Modulus Tests*

The moduli measured in this suite of tests seemed to correlate well with the unconfined compressive strength. The high strength samples had high moduli (e.g. Boring 98-22 Sample 29a had a strength of 140.75 Kpa (20,414 psi) and had a modulus of 68.95 Gpa ( $10 \times 10^6$  psi)) and the low strength samples had low moduli (e.g. Boring 98-23 Sample 20b had a strength of 17.94 Kpa (2602 psi) and a modulus of 14.75 Gpa ( $2.14 \times 10^6$  psi)).

The Poisson's ratios generally ranged from about .21 to .36, with a few values exceeding this range. The variation of the Poisson's ratios may well be due to the anisotropic and nonhomogeneous nature of the samples. This anisotropy was clearly evident when the measurements from the two axial deformation gauges were compared to each other. It was unusual for these two gauges to have the same load-displacement slope. Often tests had to be repeated, after repositioning the axial gauges to result in the

measurement of more comparable axial strains. Since these two measurements were averaged together for the stress-strain plots, this measure of sample anisotropy was hidden, but could be seen in the raw data files.

A few of the Poisson's ratios may be misleading (Not Applicable - NA - in the tables above) due to the heterogeneity of the samples. In the case of Boring 98-23, Sample 20a, the sample consisted of two distinct rock types. The axial gauge monitored the deformations of one rock type, whereas the radial gauge was mounted on the other rock type. Unfortunately, no other gauge arrangement was possible, and the Poisson's ratio derived from this test is most likely incorrect.

#### *Direct Shear Tests*

For the most part, this suite of tests demonstrated that the sandstone joints had higher friction angles than the siltstone or claystone joints. Joints in neither rock type had significant shear strength intercepts. The sandstone (or sandy siltstone) friction angles ranged from 26.6 to 38.1 degrees with an average of 31.2 degrees, whereas the siltstone and claystone sample friction angles ranged from 21.0 to 30.1 degrees with an average friction angle of 25.3 degrees. (All are final joint strengths.)

In all but a few cases, the shear strength (as measured by the friction angle) decreased with shear displacement from the initial to the final strengths. Those samples which strengthened slightly may have been poorly mated at the start of the test and the slight strengthening may have been due to the sample halves grinding together, improving the mating as the samples sheared.

#### **Conclusion**

This testing program clearly highlighted the large variability in rock strength which is primarily attributable to the pervasive jointing found in this rock mass. This jointing implies that the rock mass strength and the mode of failure depends strongly on the orientation of the loads relative to the joints and the orientation of the joints with respect to any free surfaces into which block masses can move. Strengths measured in the unconfined tests are suitable for vertical loadings. Other load orientations may result in a weaker or stronger rock mass.

The hairline fractures appeared to be the weakest feature of these rocks. These joints were often quite difficult to see, and yet significantly weakened the rock, resulting in failure along these nearly invisible joints.

The claystone was generally weaker than the sandstone. Since the claystone often occurred in thin bedding planes within the sandstone, it might be prudent to account for the claystone strengths rather than relying on the sandstone strengths in any engineering analysis. If the claystone interbeds are present, failure would be more likely to occur on these surfaces than on similarly oriented sandstone joints.

A small set of unconfined tests at a depth of 70-71 feet in Boring 98-22 in intact sandstone demonstrated the inherent variability of the rock strength, even in samples with similar appearance and taken immediately adjacent to each other. This observation

indicated that a probabilistic approach might be suitable for analyzing the rock mass, and that the high strength values should not be relied upon for the support purposes, although they need to be accounted for when considering the effort needed to create an excavation.

for GeoTest Unlimited



Dr. Anders Bro



## **Modulus Determination of Rock Core (in accordance with ASTM D3148)**

### **Test Equipment**

The samples are cut to length using an MK saw with a 14 inch diameter continuous rim diamond blade. The ends of the samples are ground flat and parallel to each other using a Norton surface grinder and a diamond wheel. The samples are held in a cylindrical sample holder which in turn is clamped in a Vee block and held to the grinding table. This arrangement precisely orients the sample so that the end surfaces are ground flat and parallel to each other (within a tolerance of 0.0005 inches across an HQ size sample).

An 8-inch digital Mitutoyo caliper (with a resolution of 0.0005 inches) is used to measure the sample diameters. A Starrett height gauge (with a resolution of 0.001 inches) standing on a flat granite plate is used to measure the sample heights and a Federal dial gauge (with 0.0001 inch gradations) is used to determine the planarity of the sample ends.

A stiff, 4-post, 200 kip press fabricated by GTU is used to load the specimens. The loading platens consist of one fixed platen and one spherical seat (both made by GTU). The platens have the same diameter as the nominal core diameter.

The pressure is applied to the loading ram using a computer controlled loading system fabricated by GTU. The load is monitored with a suitably sized load cell. Four load cells can be incorporated into the system, a 200 kip cell, a 50 kip cell, a 10 kip cell and a 2 kip cell. The three highest capacity cells are shear web cells made by Interface, Inc. and the 2 kip cell is a shear web cell fabricated by Lebow.

The axial displacements are measured using a pair of clip gauges (fabricated by GTU) with a gauge length of 2 inches. The change in sample diameter is measured with a pair of LVDTs mounted perpendicular to the core axis on a floating ring. These two LVDTs are mounted 90° apart, thus measuring two orthogonal diameter changes. These gauges devices employ Schaevitz  $\pm$  0.02 inch stroke LVDTs to measure the displacements.

The time, axial load and axial and circumferential displacements are monitored using a Computer Boards, Inc. Data Acquisition System (CIO-DAS1600/16) which has a 16 bit resolution and can monitor up to 16 single ended channels. The LVDTs are conditioned using Sensotec Model SA-AC LVDT conditioners. The load cell is conditioned with a Pacific Instruments Model 8650, F2 strain gauge conditioner.

### **Test Procedure**

A representative section of core is identified for testing. It is cut to length (with a length to diameter ratio of a little more than 2:1) and the ends are ground flat and parallel. If the sample is very weak, special techniques need to be used to prepare the sample ends with plaster or capping compound. The sample diameter and lengths are measured to

determine the sample area and to evaluate the planarity and parallelness of the surfaced ends.

Power is applied to the data acquisition system and signal conditioners at least one hour prior to testing to permit the electronics to reach thermal equilibrium. Once stabilized, the load cell conditioning system is adjusted with the help of a shunt calibration resistor. The LVDT conditioners are also adjusted (the excitation, phase, zero and gain) with the help of a Mitutoyo digital micrometer, LVDT holding jig and a Hewlett Packard Model 3455A Digital Voltmeter.

The sample is installed in the loading frame, along with the loading platens. The two axial clip gauges and the radial gauges are attached to the sample and properly adjusted. The loading piston is then extended until a small load is applied to the sample.

The data acquisition system is directed to start acquiring data and the loading ram is slowly advanced under computer control. Loading continues until an indication of reaching the nonelastic region is seen (by a departure from linearity in the load-displacement curve) or until a clearly linear trend has been established.

All of the data are recorded in a computer data file which includes a title block identifying the client, job, sample and sample dimensions. The data block includes data legends and units along with columns of time, axial load, axial displacement, and change in circumference. These files are used to calculate the sample stresses and strains and develop computer generated plots of the sample behavior.

## **Unconfined Compression Test of Rock Core (in accordance with ASTM D2938)**

### **Test Equipment**

The samples are cut to length using an MK saw with a 14 inch diameter continuous rim diamond blade. The ends of the samples are ground flat and parallel to each other using a Norton surface grinder with a diamond grinding wheel.

A Starrett height gauge standing on a flat granite plate is used to measure the sample heights and a Starrett dial gauge mounted to the height gauge is used to determine the planarity of the sample ends. An 8-inch Mitutoyo caliper is used to measure the sample diameters.

GTU's 200 kip loading frame is used to load the specimens. The loading platens consist of one fixed platen and one spherical seat (both made by GTU). The platens have the same diameter as the nominal core diameter.

The pressure is applied to the loading ram using a computer controlled loading system fabricated by GTU. The load is monitored with a suitably sized load cell. Four load cells can be incorporated into the system, a 200 kip cell, a 50 kip cell, a 10 kip cell and a 2 kip cell. The three highest capacity cells are shear web cells made by Interface, Inc. and the 2 kip cell is a shear web cell fabricated by Lebow.

The axial displacement is monitored using a  $\pm 0.1$  inch stroke Schaevitz LVDT measuring the displacement between the fixed pedestal just above the load cell and the bottom loading platen immediately adjacent to the specimen. Thus the measured axial displacement includes the deformation of the load cell.

The time, axial load and axial displacements are monitored using a Computer Boards, Inc. Data Acquisition System (CIO-DAS1600/16) which has a 16 bit resolution and can monitor up to 16 channels. The LVDT is conditioned using a Daytronics Model 9130 LVDT conditioner. The load cell is conditioned with a Pacific Instruments Model 8650,F2 strain gauge conditioner.

### **Test Procedure**

A representative section of core is identified for testing. It is cut to length (with a length to diameter ratio of a little more than 2:1) and the ends are ground flat and parallel. If the sample is very weak, special techniques need to be used to prepare the sample ends with plaster or capping compound (many innovative procedures are required to prepare a weak rock sample). The sample diameter and lengths are measured for determining the sample area and to evaluate the planarity and parallelness of the surfaced ends.

Power is applied to the data acquisition system and signal conditioners at least one hour prior to testing to permit the electronics to reach thermal equilibrium. Once stabilized, the load cell conditioning system is adjusted with the help of a shunt calibration resistor. The LVDT conditioner is also adjusted (the null, zero, span and symmetry) with the help of a Mitutoyo digital micrometer and LVDT holding jig.

The sample is installed in the loading frame, along with the loading platens and the LVDT is properly positioned to maximize its travel during the test. The loading piston is extended until a small load is applied to the sample.

The acquisition is directed to start acquiring data and the loading ram is slowly advanced under computer control. If failure is catastrophic, the test is terminated immediately after failure. If the failure is plastic, the test continues until a post-peak plateau develops.

The loads and displacements are printed on the computer screen along with a plot of axial load vs displacement. Thus one has a clear image of the sample behavior at any stage of the test.

All of the data are recorded in a computer data file which includes a title block identifying the client, job, sample and sample dimensions. The data block includes data legends and units along with columns of time, axial load and axial displacement. These files are used to develop computer generated plots of the sample behavior.

**Direct Shear Test of Rock Core  
(in accordance with the ISRM Suggested Method)**

**Test Equipment**

The samples are cut to size using an MK Model 2001 "Brick Saw" using a 14 inch diameter continuous rim diamond blade.

A Mitutoyo caliper is used to measure the dimensions of the sample. A carpenter's profile gauge is used to transfer the joint surface profile to the data sheet.

The shear box (see accompanying figure) is one designed and fabricated by GTU. It consists of a tall reaction A-frame which applies the normal force to the sample. A column pivots at the top of the A-frame and bears against the sample at the bottom of the A-frame. Thus there is little resistance to shear (which develops in roller bearing systems). A separate shear yoke is hung in balance at the level of the shear plane. Thus the shear yoke does not contribute to the normal load on the sample. The normal and shear loads are applied with hydraulic pistons. Either of two sized boxes can fit into the loading frame, one for smaller core samples and another suited for large block samples.

The loads are monitored with load cells. (2, 10, and 50 kip cells can be used depending on the level of loads encountered in the test.) One LVDT with a + 0.5 inch stroke is used to measure the shear displacement. Three + 0.1 inch stroke LVDTs are used to monitor the normal displacement of the sample. Two  $\pm 0.1$  inch stroke LVDTs are used to monitor the sideways movement of the sample.

The pressure is applied to the loading rams using a computer controlled loading system fabricated by GTU. The normal load is measured by the data acquisition system and compared to the desired load. Two normal loading systems can be used. For normal loads less than 2000 lb, a pneumatic system is used for finer control of the load. For loads above this range, a hydraulic system is used. The control system outputs a signal to the pneumatic or hydraulic system to increase or decrease the normal load toward the desired value. The shear load is applied by injecting hydraulic oil into the shear loading system at a constant rate.

The time, shear load, normal load, and six displacements are monitored using a Computer Boards, Inc. Data Acquisition System (CIO-DAS1600/16) which has a 16 bit resolution and can monitor up to 16 channels. The LVDTs are conditioned using Daytronics Model 9130 LVDT conditioners. The load cells are conditioned with Vishay Model 2120 strain gauge conditioners.

**Test Procedure**

The sample is trimmed to a suitable size to fit the chosen shear box. If the sample is an open joint which can be taken apart without changing the properties of the joint, three joint profiles are taken from the sample using a profile gauge. Otherwise, these profiles are taken after testing the sample. The dimensions of the shear surface are measured using a caliper. These measurements are used to estimate the sample area and thus the required normal loads during the test.

If required, the sample is tied together using tape, thread or string to maintain the sample integrity. The sample is positioned in one shear box half so that the shear surface extends 1/4 inch above and parallel to the lip of the shear box half. Positioned thus, hydrostone (a strong plaster) is poured into the box to pot the sample in the box half. Once the plaster has set, the box half is inverted and placed on the second box half. 1/2

inch spacers are used to separate the box halves. Hydrostone is then used to pot the second half of the sample. Once the plaster has hardened, the sample is installed in the shear loading frame and any tape, thread or string which is holding the sample halves together is cut.

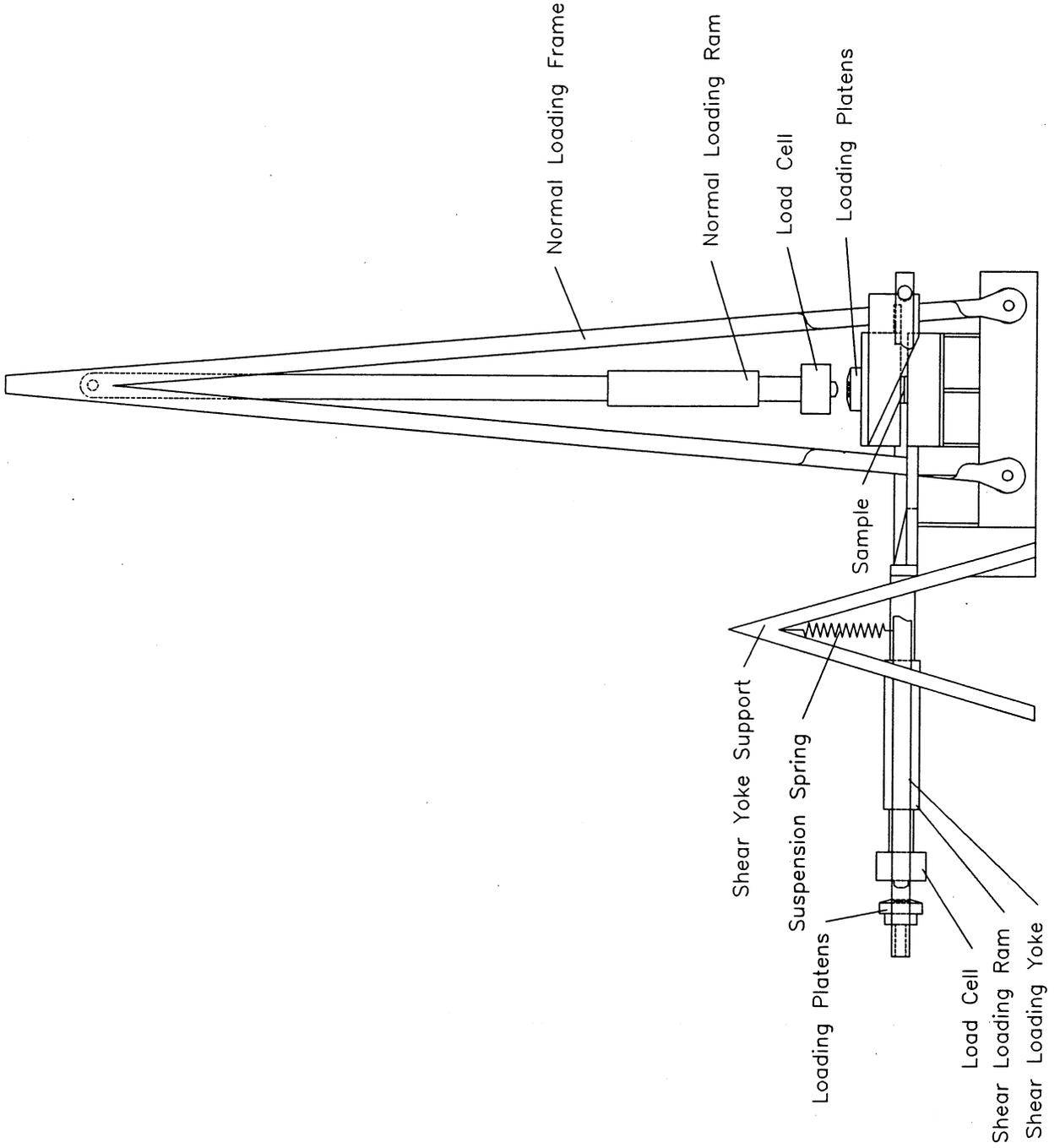
Power is applied to the data acquisition system and signal conditioners at least one hour prior to testing to permit the electronics to reach thermal equilibrium. Once stabilized, the load cell conditioning systems are adjusted with the help of shunt calibration resistors. The LVDT conditioners are also adjusted (the null, zero, span and symmetry) with the help of a Mitutoyo digital micrometer and LVDT holding jigs.

With the data acquisition system in a setup mode, the LVDTs are positioned and the desired normal load is applied to the sample. The shear loading piston is extended and a light seating load is applied (up to 100 lb, depending on the level of normal load).

Once the test setup is satisfactorily aligned, the data acquisition system is started and the test proceeds under computer control. The loads and displacements are printed on the computer screen along with a plot of shear load vs displacement. Thus one has a clear image of the sample behavior at any stage of the test.

If a multistage test is being performed, the normal load is increased at the first clear indication of shear failure. The final stage of testing proceeds until a clear shear strength plateau develops or until the shear LVDT reaches its extreme limit (this limit is usually on the order of 0.8 inches)

All of the data are recorded in a computer data file which includes a title block identifying the client, job, sample and sample dimensions. The data block includes data legends and units along with columns of time, shear and normal loads and shear, normal and lateral displacements. These files are used to develop computer generated plots of the sample behavior.



**BORING 98-21**

## **Modulus and Unconfined Compression Tests**

DATA SHEET

Determination of Rock Modulus and Poisson's Ratio (ASTM D3148)

Date: 10/27/98

Person performing the test: A. Bro

Client: F. Jo

Job: #92-SFOBB

Sample ID: B98-21 S26a

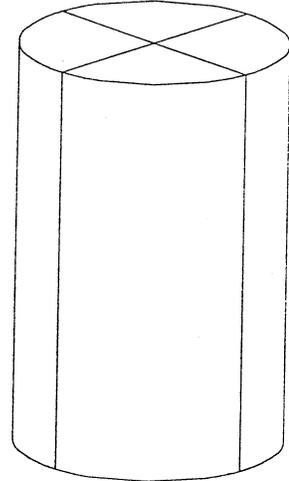
Sample Description: medium gray sandstone with particles of claystone created a layered appearance, bedded about 45° to the core axis

Sample Depth: 72.5'

Sample Condition: received & tested moist

d <sub>1</sub>	d <sub>2</sub>
2.389	2.387
2.391	2.388
2.387	2.386
2.391	2.389
2.385	2.388

l <sub>1</sub>	l <sub>2</sub>
-0.0008	-0.0002
+0.0001	+0.0001
+0.0009	+0.0001



Avg. diameter: 2.388

Avg. length: 5.301

Sample area: 4.479

l/d ratio: 2.22

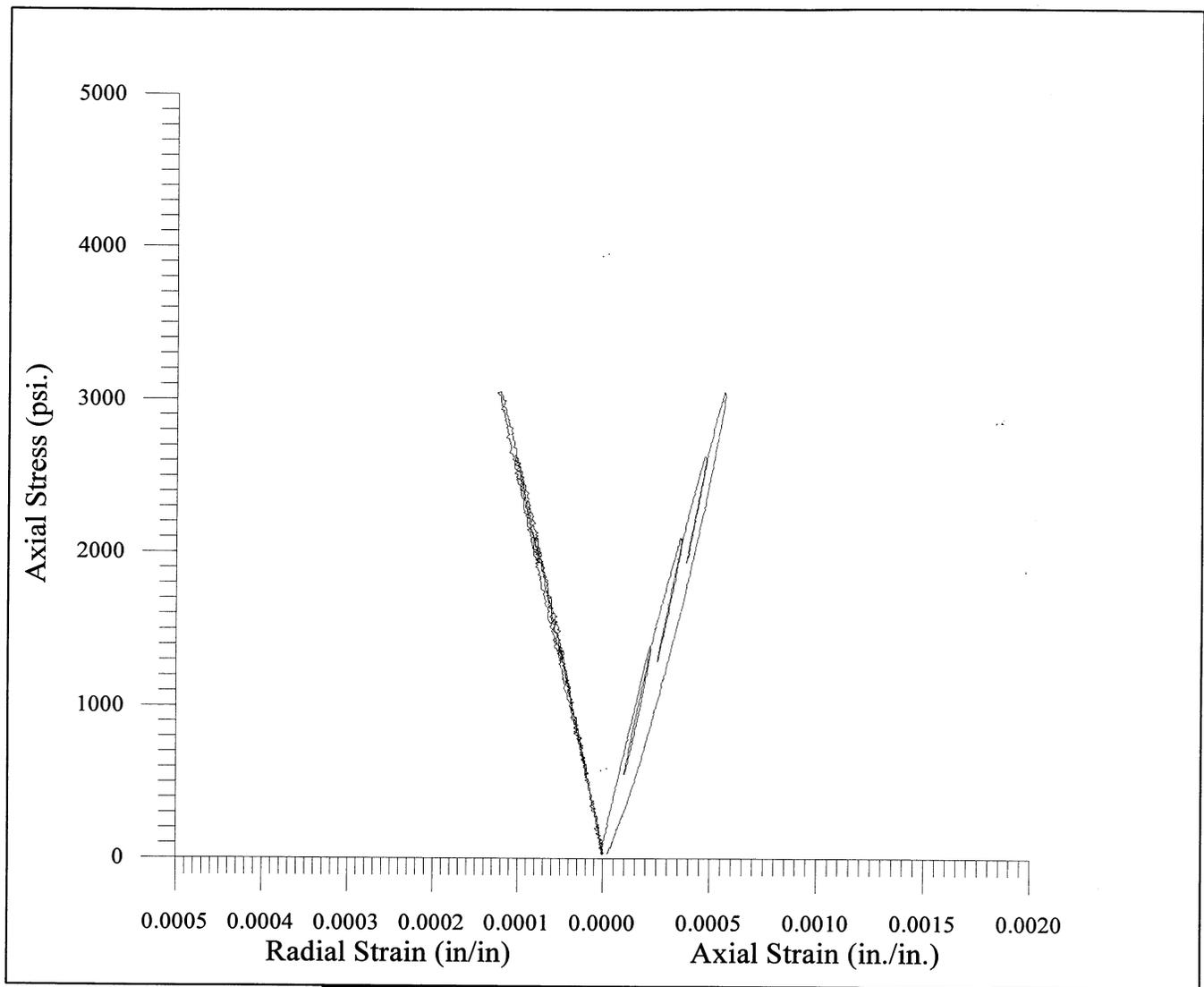
Sample volume(in<sup>3</sup>): 23.742

Sample weight (g): 1042.8g

Density: 43.928/in<sup>3</sup> = 167.3 pcf (1 g/in<sup>3</sup> = 3.8095 lb/ft<sup>3</sup>)

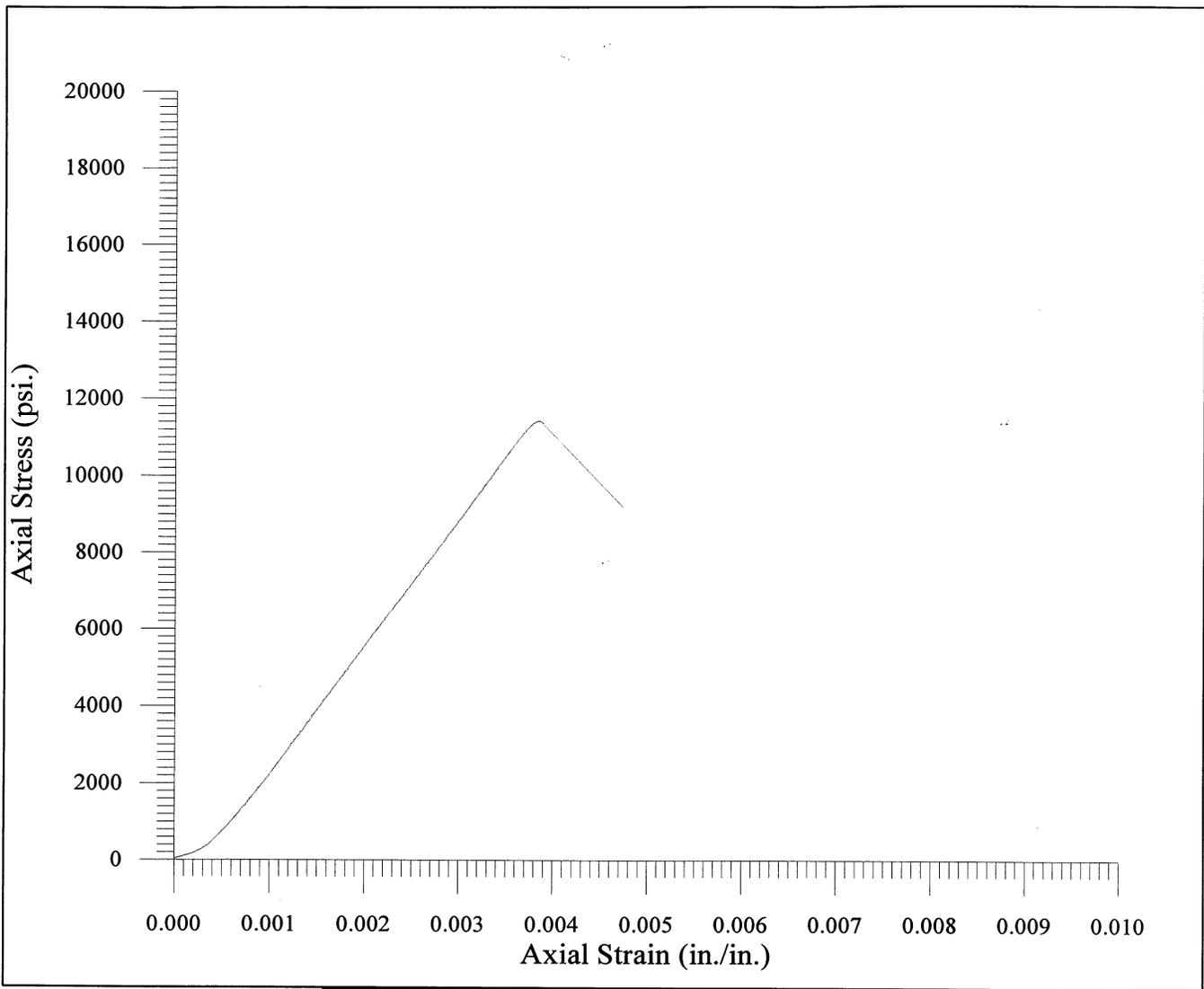
Gauge length: 2000 in

Comments: Failed by shear parallel to bedding & some splitting.



**ELASTIC MODULUS TEST**  
**Axial Stress vs. Axial & Radial Strain**

<p><b>SAMPLE ID:</b> Boring: 98-21  Sample: 26a  Depth: 72.5'</p> <p style="text-align: center;"><b>DESCRIPTION</b></p> <p>Medium gray sandstone with small claystone chips creating a bedded appearance with bedding about 45 degrees to the core axis.</p> <p><b>MODULUS:</b> 6,940,000 psi</p> <p><b>POISSON'S RATIO:</b> .27</p>	<div style="text-align: center;">   <b>Geo Test Unlimited</b> </div> <p style="text-align: right;">800 Peralta Ave  San Leandro, CA 94577</p> <hr/> <p><b>Client:</b> Fugro West, Inc.  5855 Olivas Park Dr.  Ventura, CA 93003</p> <p><b>Project:</b> San Francisco Oakland Bay Bridge  East Span Replacement Project</p> <p><b>Job Number:</b> 98-42-0053</p> <hr/> <p><b>Test Date:</b> October 27, 1998</p>
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**UNCONFINED COMPRESSION TEST  
Axial Stress vs. Axial Strain**

<p><b>SAMPLE ID:</b> Boring : 98-21 Sample: 26a Depth: 72.5'</p>	<p align="center"> <i>Geo</i>  <i>Test</i>  <b>Unlimited</b> 800 Peralta Ave  San Leandro, CA 94577 </p>
<p align="center"><b>DESCRIPTION</b></p> <p>Medium gray sandstone with small claystone chips creating a bedded appearance with bedding about 45 degrees to the core axis.</p>	
<p><b>STRENGTH:</b> 11,426 psi</p>	<p><b>Client:</b> Fugro West, Inc. 5855 Olivas Park Dr. Ventura, CA 93003</p> <p><b>Project:</b> San Francisco Oakland Bay Bridge East Span Replacement Project</p> <p><b>Job Number:</b> 98-42-0053</p>
	<p><b>Test Date:</b> October 27, 1998</p>

DATA SHEET

Determination of Rock Modulus and Poisson's Ratio (ASTM D3148)

Date: 10/27/98

Person performing the test: A. B. R.

Client: Fugro

Job: B98-21 529a

Sample ID: \_\_\_\_\_

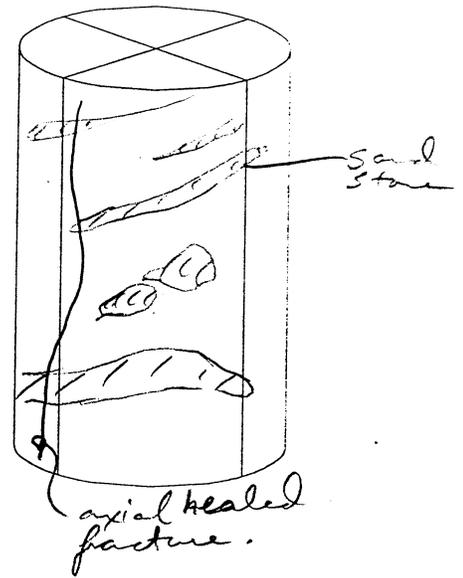
Sample Description: Dark gray claystone with a few irregular sandstone lenses. Contains many calcite healed bedding fractures parallel to bedding, about 33° to the core axis. Also one axial healed hairline fracture.  
calcite.

Sample Depth: 83'

Sample Condition: received & tested moist

d <sub>1</sub>	d <sub>2</sub>
2.387	2.385
2.389	2.384
2.386	2.385
2.385	2.382
2.379	2.385

l <sub>1</sub>	l <sub>2</sub>
-0.0007	-0.0001
0.0001	0.0001
0.0009	0.0001



Avg. diameter: 2.385

Avg. length: 5.122

Sample area: 4.468

l/d ratio: 2.15

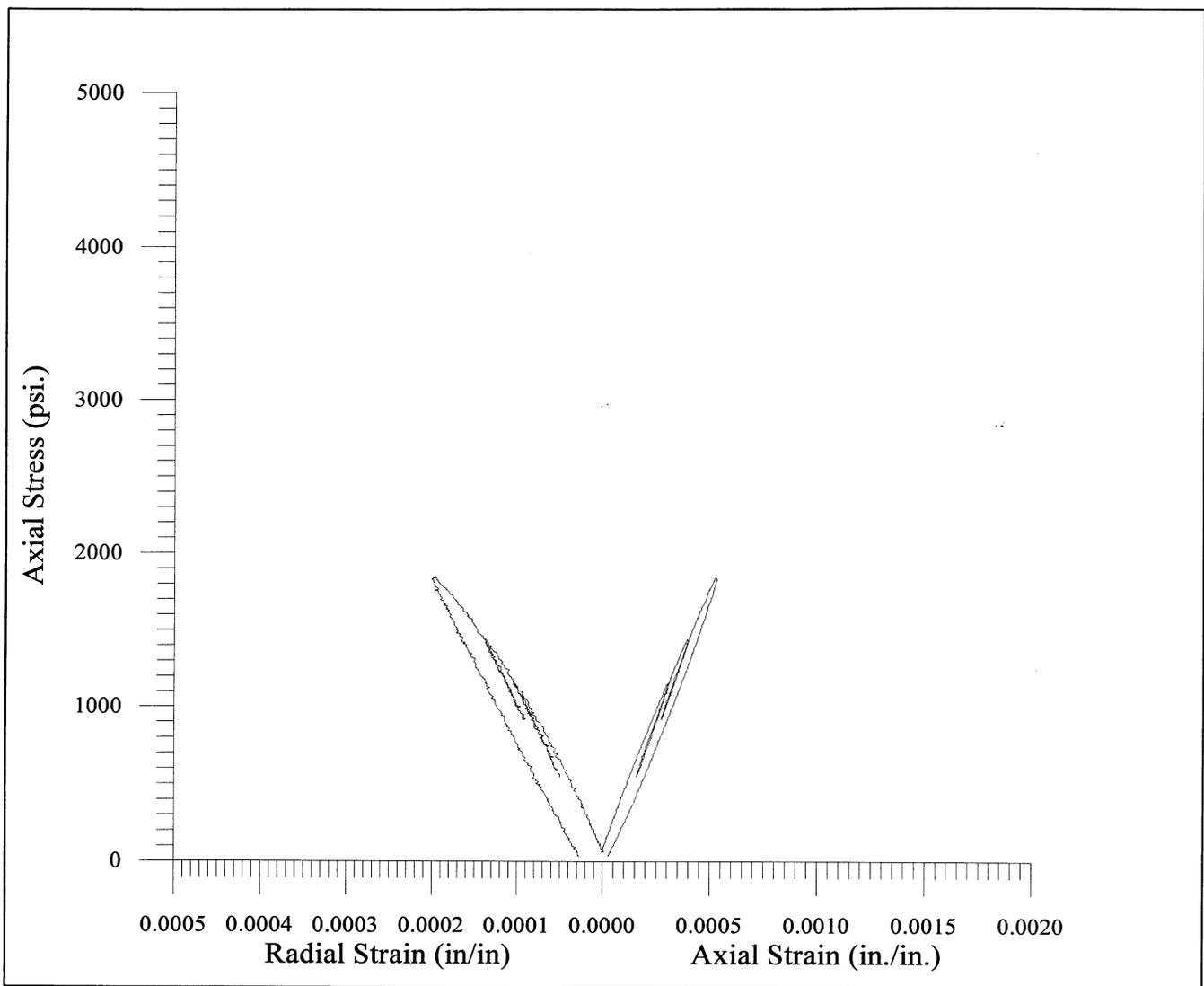
Sample volume (in<sup>3</sup>): 22.883

Sample weight (g): 1012.48

Density: 44.248/in<sup>3</sup> = 168.5 pcf (1 g/in<sup>3</sup> = 3.8095 lb/ft<sup>3</sup>)

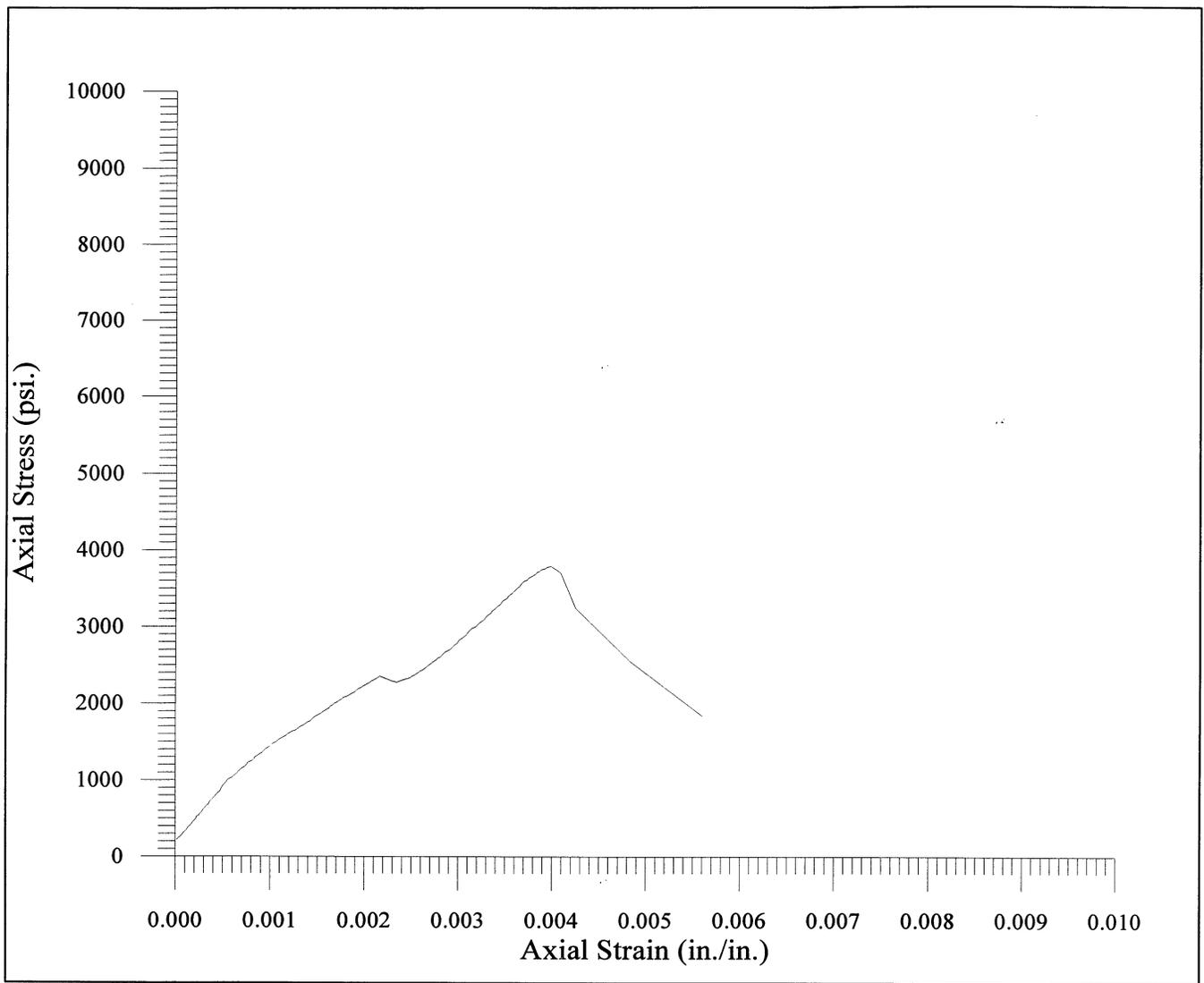
Gauge length: 2.000 in.

Comments: failed in shear along calcite  
healed hair line fractures, and by splitting.



**ELASTIC MODULUS TEST**  
**Axial Stress vs. Axial & Radial Strain**

<p><b>SAMPLE ID:</b> Boring: 98-21  Sample: 29a  Depth: 83'</p> <p align="center"><b>DESCRIPTION</b></p> <p>Dark gray claystone with a few irregular sandstone lenses. Contains many calcite healed hairline fractures parallel to the bedding about 53 degrees to the core axis.</p> <p><b>MODULUS:</b> 4,170,000 psi  <b>POISSON'S RATIO:</b> .35</p>	<p align="center"> <i>Geo</i>  <i>U</i>  <i>Test</i>  <b>Unlimited</b> </p> <p align="right">800 Peralta Ave  San Leandro, CA 94577</p>
	<p><b>Client:</b> Fugro West, Inc.  5855 Olivas Park Dr.  Ventura, CA 93003</p> <p><b>Project:</b> San Francisco Oakland Bay Bridge  East Span Replacement Project</p> <p><b>Job Number:</b> 98-42-0053</p>
	<p><b>Test Date:</b> October 27, 1998</p>



**UNCONFINED COMPRESSION TEST  
Axial Stress vs. Axial Strain**

<p><b>SAMPLE ID:</b> Boring : 98-21 Sample: 29a Depth: 83'</p> <p align="center"><b>DESCRIPTION</b></p> <p>Dark gray claystone with a few irregular sandstone lenses. Contains many calcite healed hairline fractures parallel to the bedding, about 53 degrees to the core axis.</p> <p><b>STRENGTH:</b> 3787 psi</p>	<p align="center"> <i>Geo</i>  <i>U</i>  <i>Test</i>  <b>Unlimited</b> </p> <p align="right">800 Peralta Ave San Leandro, CA 94577</p> <hr/> <p><b>Client:</b> Fugro West, Inc. 5855 Olivas Park Dr. Ventura, CA 93003</p> <p><b>Project:</b> San Francisco Oakland Bay Bridge East Span Replacement Project</p> <p><b>Job Number:</b> 98-42-0053</p> <hr/> <p><b>Test Date:</b> October 27, 1998</p>
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DATA SHEET

Determination of Rock Modulus and Poisson's Ratio (ASTM D3148)

Date: 10/27/98

Person performing the test: A B R

Client: Fuyo

Job: H92-SFOBB

Sample ID: B98-21 S31a

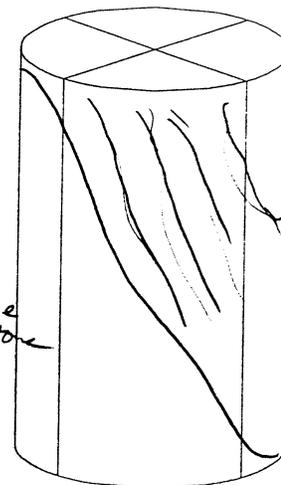
Sample Description: Dark gray fine sandy siltstone and siltstone interbedded with claystone in other sample half. Bedding about 25° to the core axis

Sample Depth: 97'

Sample Condition: received & tested moist

d <sub>1</sub>	d <sub>2</sub>
2.371	2.381
2.371	2.382
2.366	2.381
2.365	2.381
2.364	2.380

l <sub>1</sub>	l <sub>2</sub>
-0.0007	-0.0003
±0.0000	±0.0001
+0.0008	+0.0004



Avg. diameter: 2.374

Avg. length: 5.253

Sample area: 4.426

l/d ratio: 2.21

Sample volume (in<sup>3</sup>): 23.252

Sample weight (g): 1024.18

Density: 44.048/in<sup>3</sup> = 167.8 pcf (1 g/in<sup>3</sup> = 3.8095 lb/ft<sup>3</sup>)

Gauge length: 2.000 in.

Comments: Failed by diagonal shear along interface

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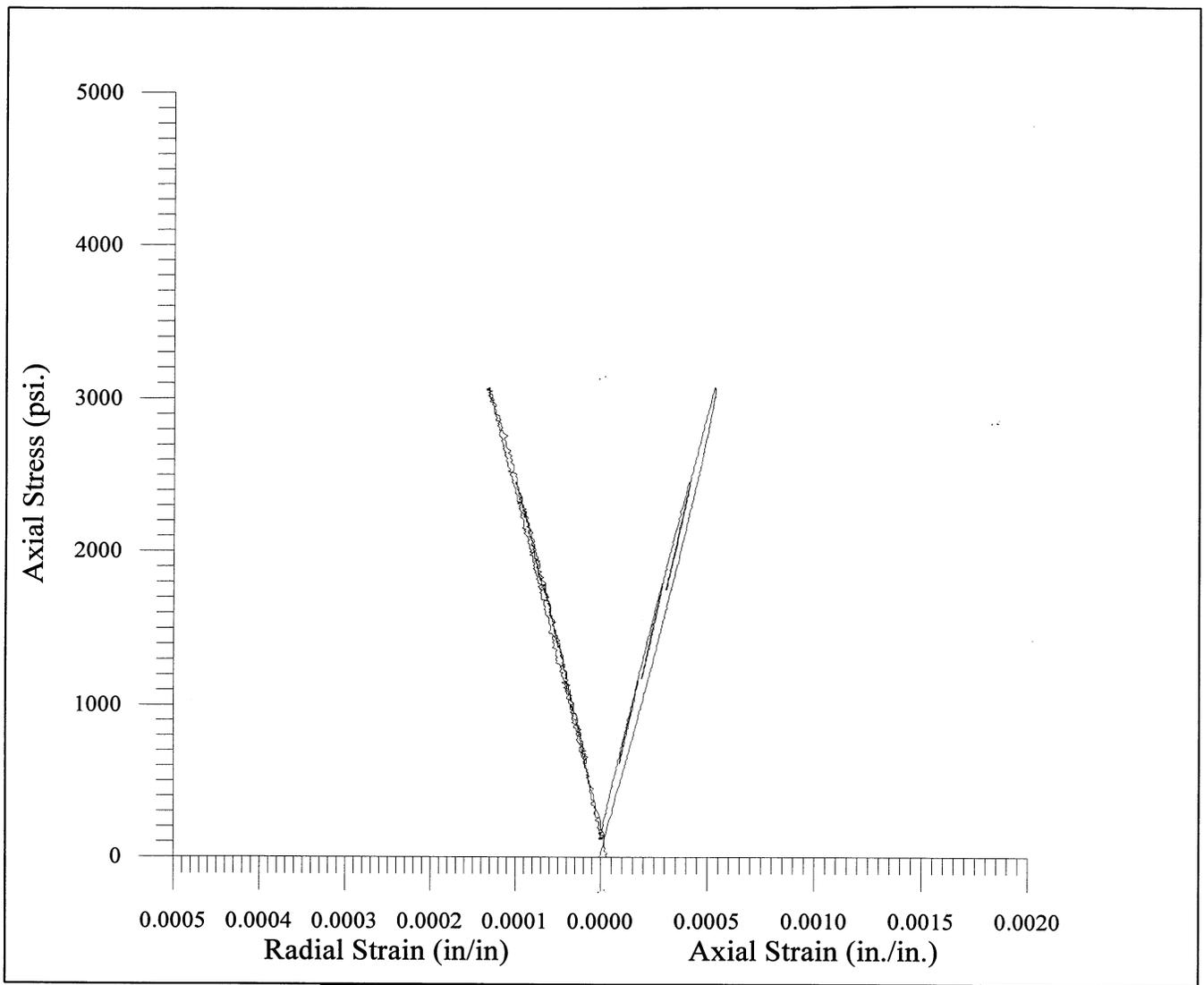
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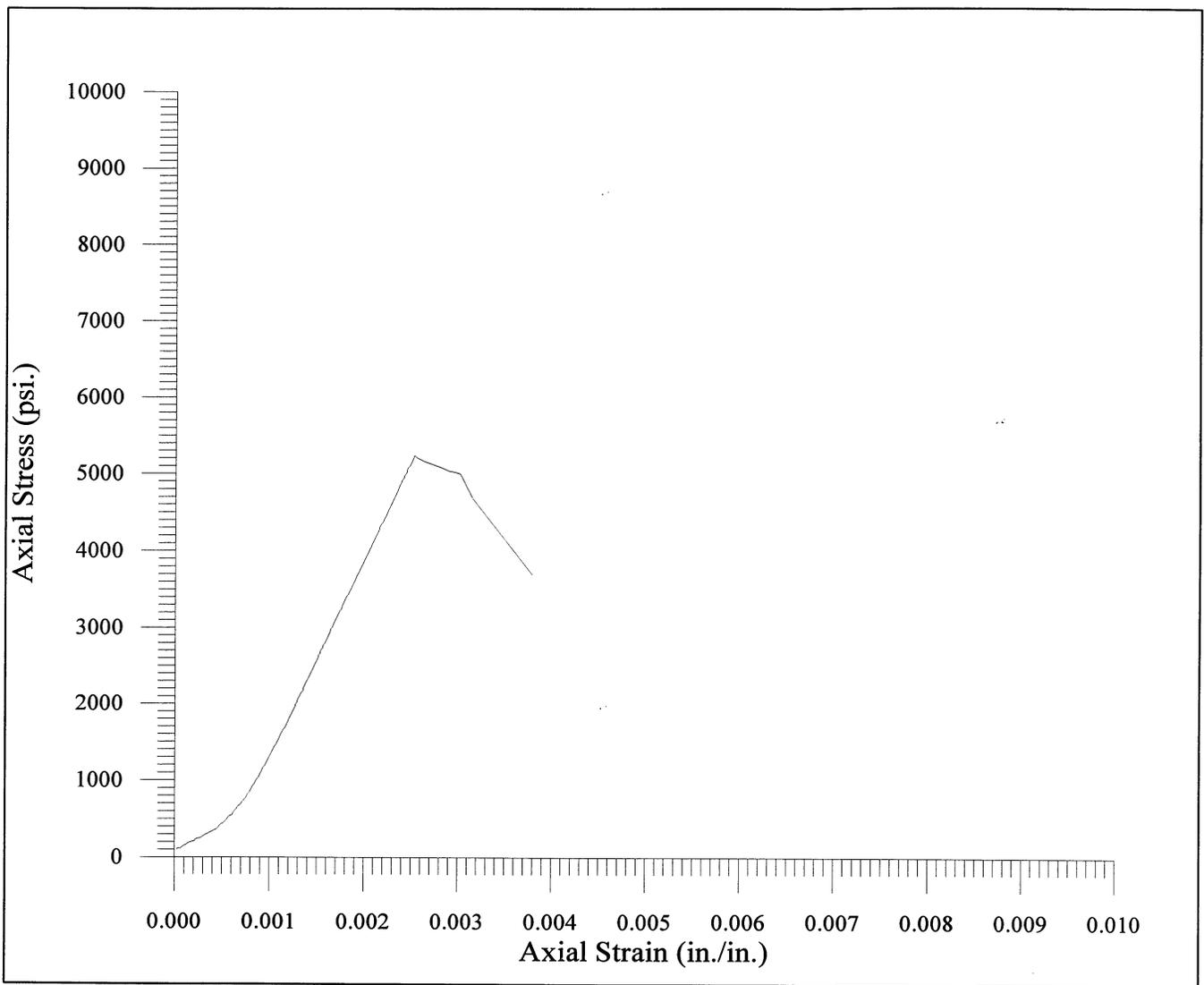


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**ELASTIC MODULUS TEST**  
**Axial Stress vs. Axial & Radial Strain**

<p><b>SAMPLE ID:</b> Boring: 98-21  Sample: 31a  Depth: 97'</p> <p style="text-align: center;"><b>DESCRIPTION</b></p> <p>In one sample half, dark gray fine sandy siltstone and siltstone interbedded with claystone. The other half consists of claystone. Bedding about 25 degrees to the core axis.</p> <p><b>MODULUS:</b> 6,410,000 psi  <b>POISSON'S RATIO:</b> .29</p>	<div style="text-align: center;">   <b>Geo Test Unlimited</b> </div> <p style="text-align: right;">800 Peralta Ave  San Leandro, CA 94577</p> <hr/> <p><b>Client:</b> Fugro West, Inc.  5855 Olivas Park Dr.  Ventura, CA 93003</p> <p><b>Project:</b> San Francisco Oakland Bay Bridge  East Span Replacement Project</p> <p><b>Job Number:</b> 98-42-0053</p> <hr/> <p><b>Test Date:</b> October 27, 1998</p>
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**UNCONFINED COMPRESSION TEST  
Axial Stress vs. Axial Strain**

**SAMPLE ID:** Boring : 98-21  
 Sample: 31a  
 Depth: 97'

**DESCRIPTION**

In one sample half, dark gray fine sandy siltstone and siltstone interbedded with claystone. The other half consists of claystone. Bedding about 25 degrees to the core axis.

**STRENGTH:** 5236 psi

*Geo*  *Test*  
**Unlimited** 800 Peralta Ave  
 San Leandro, CA 94577

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**Client:** Fugro West, Inc.  
 5855 Olivas Park Dr.  
 Ventura, CA 93003

**Project:** San Francisco Oakland Bay Bridge  
 East Span Replacement Project

**Job Number:** 98-42-0053

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**Test Date:** October 27, 1998

DATA SHEET

Determination of Rock Modulus and Poisson's Ratio (ASTM D3148)

Date: 10/27/98

Person performing the test: A. Bro

Client: Fujio

Job: #92-SFQBB

Sample ID: B98-21 S32a

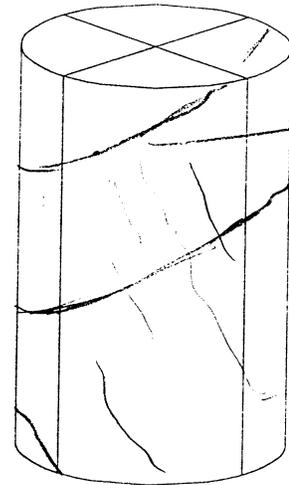
Sample Description: medium gray banded sandstone with a large claystone chip and 2 calcite healed bedding plane fractures and calcite healed hairline fractures perpendicular to bedding: bedding 50° to core axis.

Sample Depth: 106.5'

Sample Condition: received & tested moist

d <sub>1</sub>	d <sub>2</sub>
2.389	2.384
2.390	2.381
2.390	2.382
2.390	2.385
2.393	2.385

l <sub>1</sub>	l <sub>2</sub>
-0.0008	0
±.0001	±.0001
+0.0009	0



healed  
bedding  
fractures

Avg. diameter: 2.387

Avg. length: 5.396

Sample area: 4.475 in<sup>2</sup>

l/d ratio: 2.26

Sample volume (in<sup>3</sup>): 24.147

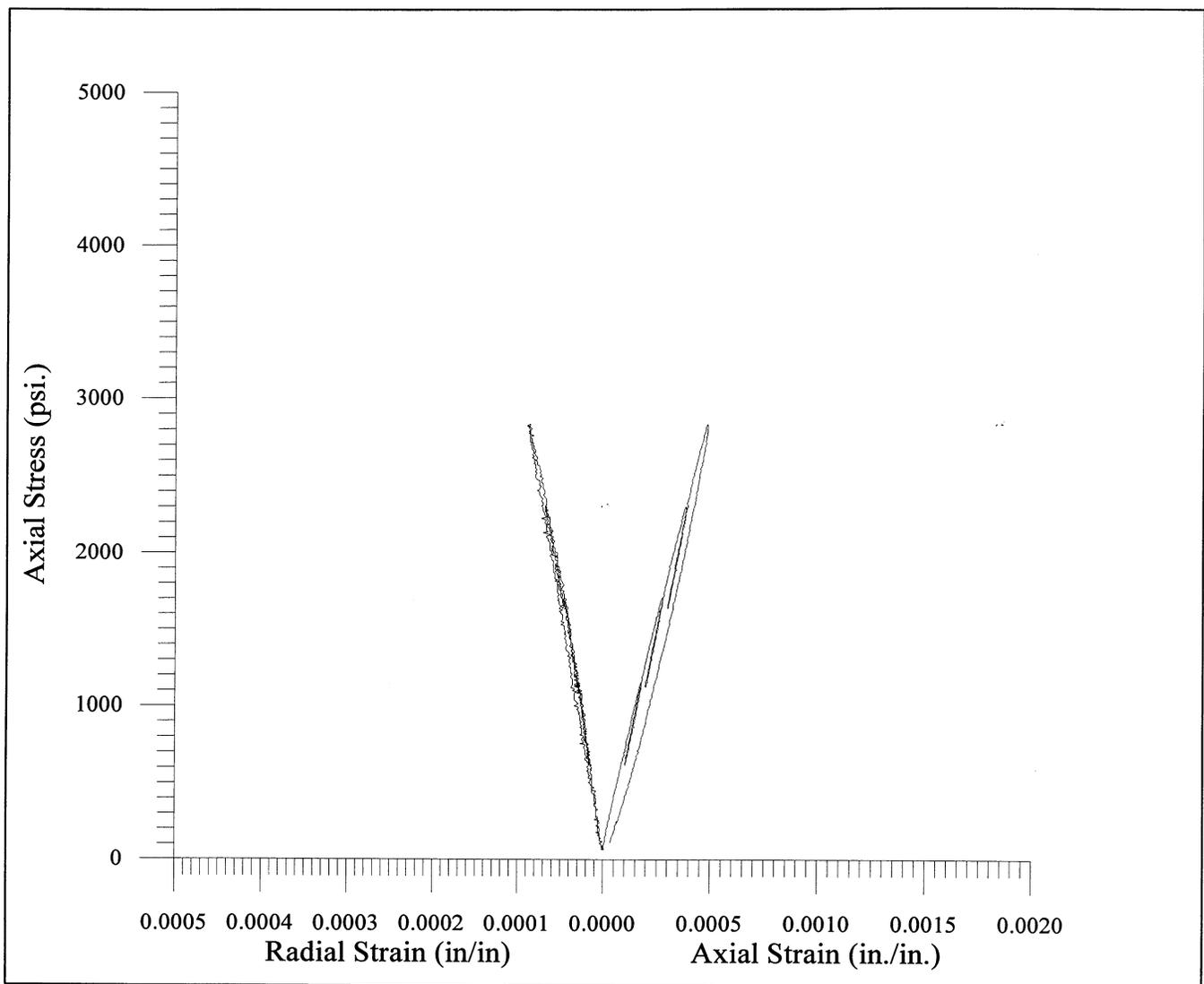
Sample weight (g): 1061.38

Density: 43.958/in<sup>3</sup> = 167.4 pcf (1 g/in<sup>3</sup> = 3.8095 lb/ft<sup>3</sup>)

Gauge length: 2.000 in.

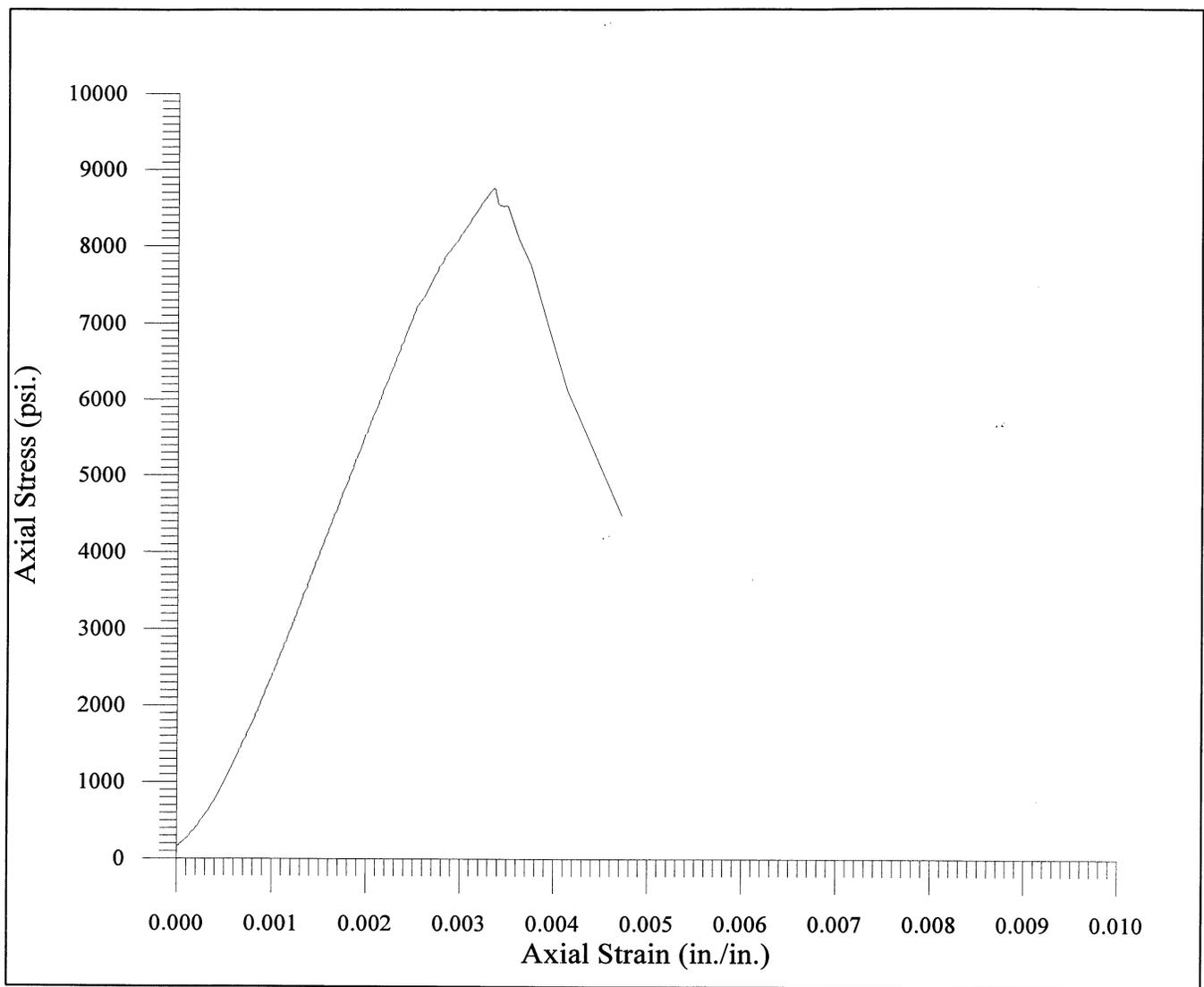
Comments: Failed by shear on bedding fractures and axial splitting.

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\_\_\_\_\_  
\_\_\_\_\_



**ELASTIC MODULUS TEST**  
**Axial Stress vs. Axial & Radial Strain**

<p><b>SAMPLE ID:</b> Boring: 98-21  Sample: 32a  Depth: 106.5'</p> <p style="text-align: center;"><b>DESCRIPTION</b></p> <p>Medium gray bedded sandstone with a long claystone flake and two calcite healed bedding plane fractures, and many calcite healed hairline fractures perpendicular to the bedding (50 degrees to the core axis).</p> <p><b>MODULUS:</b> 7,250,000 psi  <b>POISSON'S RATIO:</b> .22</p>	<div style="text-align: center;">   <b>Geo Test Unlimited</b> </div> <p style="text-align: right;">800 Peralta Ave  San Leandro, CA 94577</p> <hr/> <p><b>Client:</b> Fugro West, Inc.  5855 Olivas Park Dr.  Ventura, CA 93003</p> <p><b>Project:</b> San Francisco Oakland Bay Bridge  East Span Replacement Project</p> <p><b>Job Number:</b> 98-42-0053</p> <hr/> <p><b>Test Date:</b> October 27, 1998</p>
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**UNCONFINED COMPRESSION TEST**  
**Axial Stress vs. Axial Strain**

**SAMPLE ID:** Boring : 98-21  
 Sample: 32a  
 Depth: 106.5'

**DESCRIPTION**  
 Medium gray bedded sandstone with a long claystone flake and two calcite healed bedding plane fractures, and many calcite healed hairline fractures perpendicular to the bedding (50 degrees to the core axis).

**STRENGTH:** 8757 psi

*Geo*  *Test*  
**Unlimited** 800 Peralta Ave  
 San Leandro, CA 94577

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**Client:** Fugro West, Inc.  
 5855 Olivas Park Dr.  
 Ventura, CA 93003

**Project:** San Francisco Oakland Bay Bridge  
 East Span Replacement Project

**Job Number:** 98-42-0053

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**Test Date:** October 27, 1998

DATA SHEET

Determination of Rock Modulus and Poisson's Ratio (ASTM D3148)

Date: 10/27/98

Person performing the test: A. Bro

Client: Fugro

Job: #92-SFOBB

Sample ID: B98-21 S34a

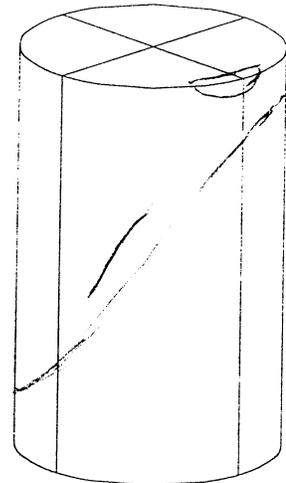
Sample Description: medium gray sandstone with a calcite healed hairline fracture about 32° to the core axis

Sample Depth: 122.5'

Sample Condition: received & tested moist

d <sub>1</sub>	d <sub>2</sub>
2.390	2.391
2.387	2.388
2.389	2.387
2.388	2.387
2.387	2.389

l <sub>1</sub>	l <sub>2</sub>
-.0008	0
±.0001	±.0001
+.0008	0



Avg. diameter: 2.388

Avg. length: 5.467

Sample area: 4.479

l/d ratio: 2.29

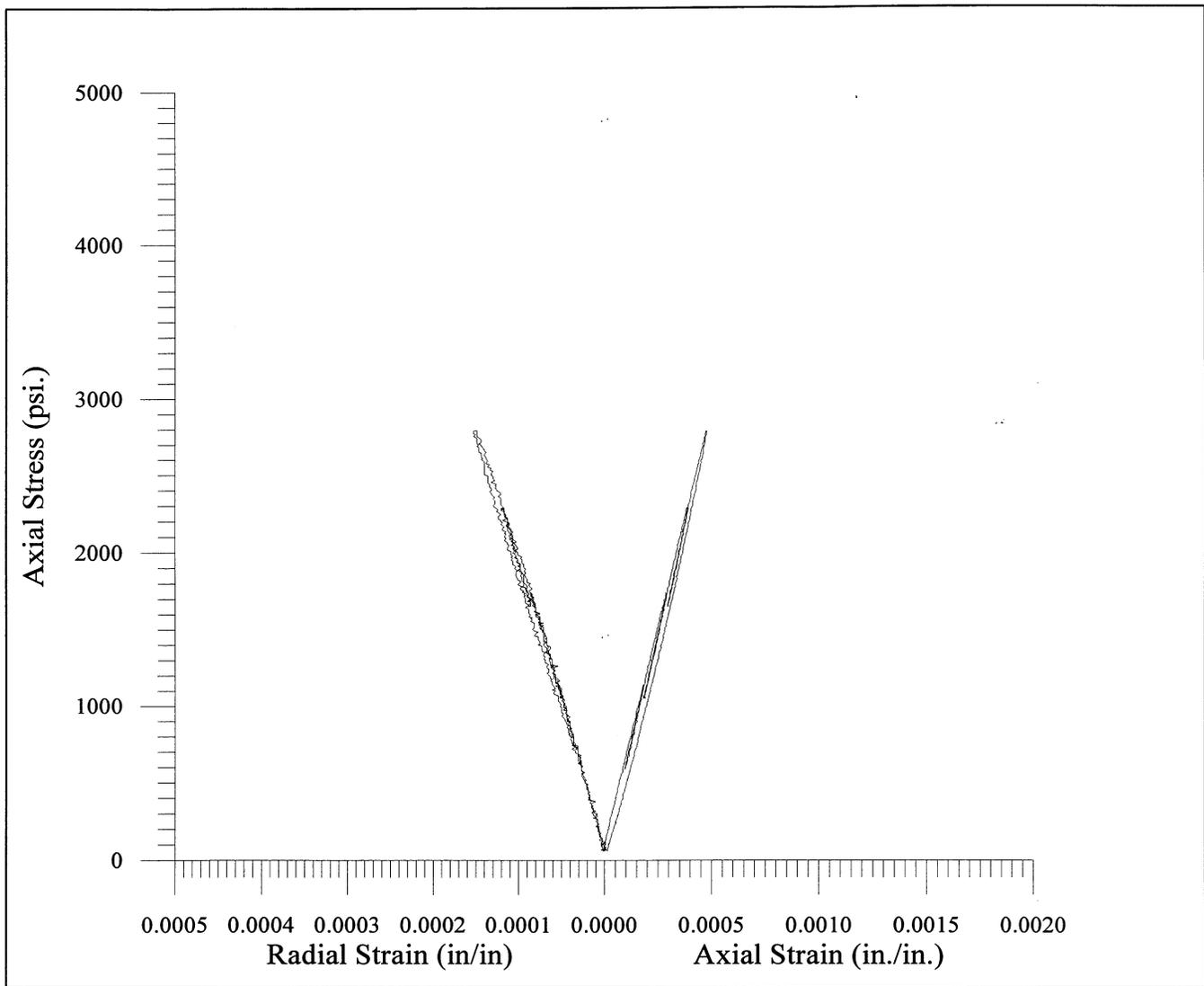
Sample volume (in<sup>3</sup>): 24.485

Sample weight (g): 1084.3

Density: 44.28 g/in<sup>3</sup> = 168.7 pcf (1 g/in<sup>3</sup> = 3.8095 lb/ft<sup>3</sup>)

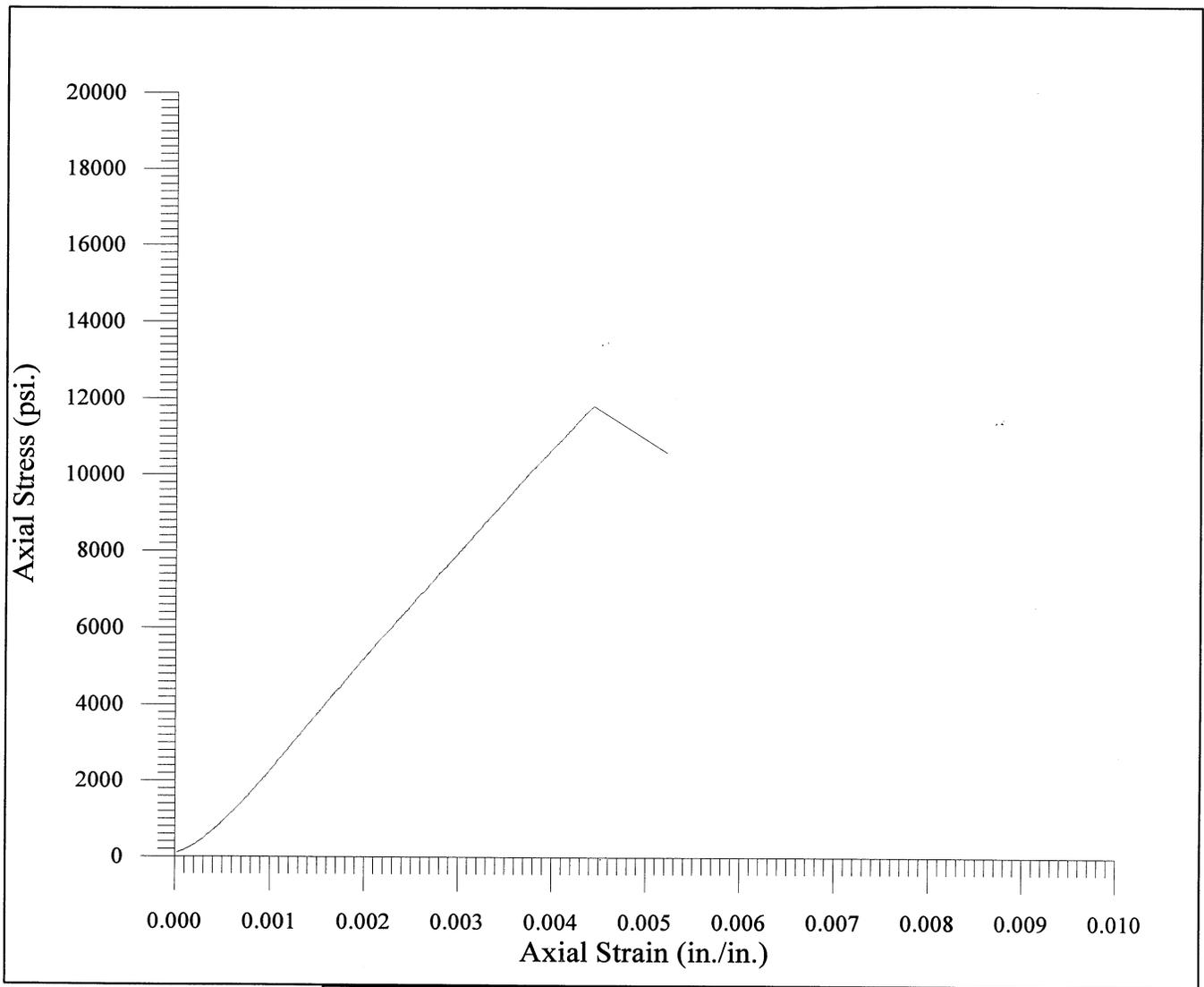
Gauge length: 2.000 in.

Comments: Failed by shear on healed fracture



**ELASTIC MODULUS TEST**  
**Axial Stress vs. Axial & Radial Strain**

<p><b>SAMPLE ID:</b> Boring: 98-21          Sample: 34a          Depth: 122.5'</p>	<p align="center"> <i>Geo</i>  <i>Test</i>  <b>Unlimited</b> 800 Peralta Ave          San Leandro, CA 94577       </p>
<p align="center"><b>DESCRIPTION</b></p> <p align="center">Medium gray sandstone with a calcite healed hairline fracture about 32 degrees to the core axis.</p> <p><b>MODULUS:</b> 6,490,000 psi  <b>POISSON'S RATIO:</b> .32</p>	<p><b>Client:</b> Fugro West, Inc.          5855 Olivas Park Dr.          Ventura, CA 93003</p> <p><b>Project:</b> San Francisco Oakland Bay Bridge          East Span Replacement Project</p> <p><b>Job Number:</b> 98-42-0053</p>
	<p><b>Test Date:</b> October 27, 1998</p>



**UNCONFINED COMPRESSION TEST  
Axial Stress vs. Axial Strain**

<p><b>SAMPLE ID:</b> Boring : 98-21 Sample: 34a Depth: 122.5'</p> <p align="center"><b>DESCRIPTION</b></p> <p>Medium gray sandstone with a calcite healed hairline fracture about 32 degrees to the core axis.</p> <p><b>STRENGTH:</b> 11,791 psi</p>	<div style="text-align: center;">  <p><b>Geo Test Unlimited</b> 800 Peralta Ave San Leandro, CA 94577</p> </div> <hr/> <p><b>Client:</b> Fugro West, Inc. 5855 Olivas Park Dr. Ventura, CA 93003</p> <p><b>Project:</b> San Francisco Oakland Bay Bridge East Span Replacement Project</p> <p><b>Job Number:</b> 98-42-0053</p> <hr/> <p><b>Test Date:</b> October 27, 1998</p>
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DATA SHEET

Determination of Rock Modulus and Poisson's Ratio (ASTM D3148)

Date: 10/27/98

Person performing the test: A. Bro

Client: Fujio

Job: #92-SFOBB

Sample ID: B9B-215352

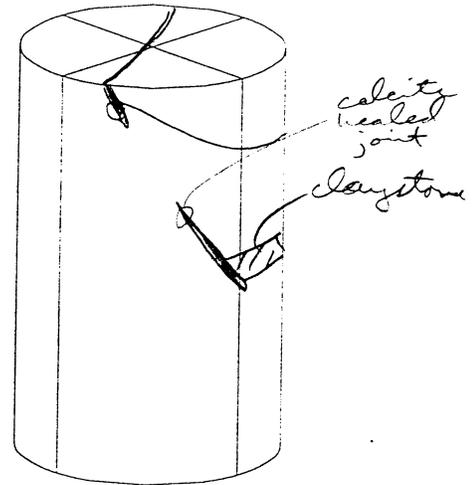
Sample Description: medium dark fine sandy siltstone with a few claystone inclusions and one calcite healed joint 24° to core axis

Sample Depth: 130'

Sample Condition: received & tested moist

d <sub>1</sub>	d <sub>2</sub>
2.392	2.390
2.391	2.388
2.396	2.388
2.390	2.390
2.389	2.388

l <sub>1</sub>	l <sub>2</sub>
-.0009	0
±.0001	±.0001
+.0008	0



Avg. diameter: 2.390

Avg. length: 5.398

Sample area: 4.486 in<sup>2</sup>

l/d ratio: 2.26

Sample volume (in<sup>3</sup>): 24.217

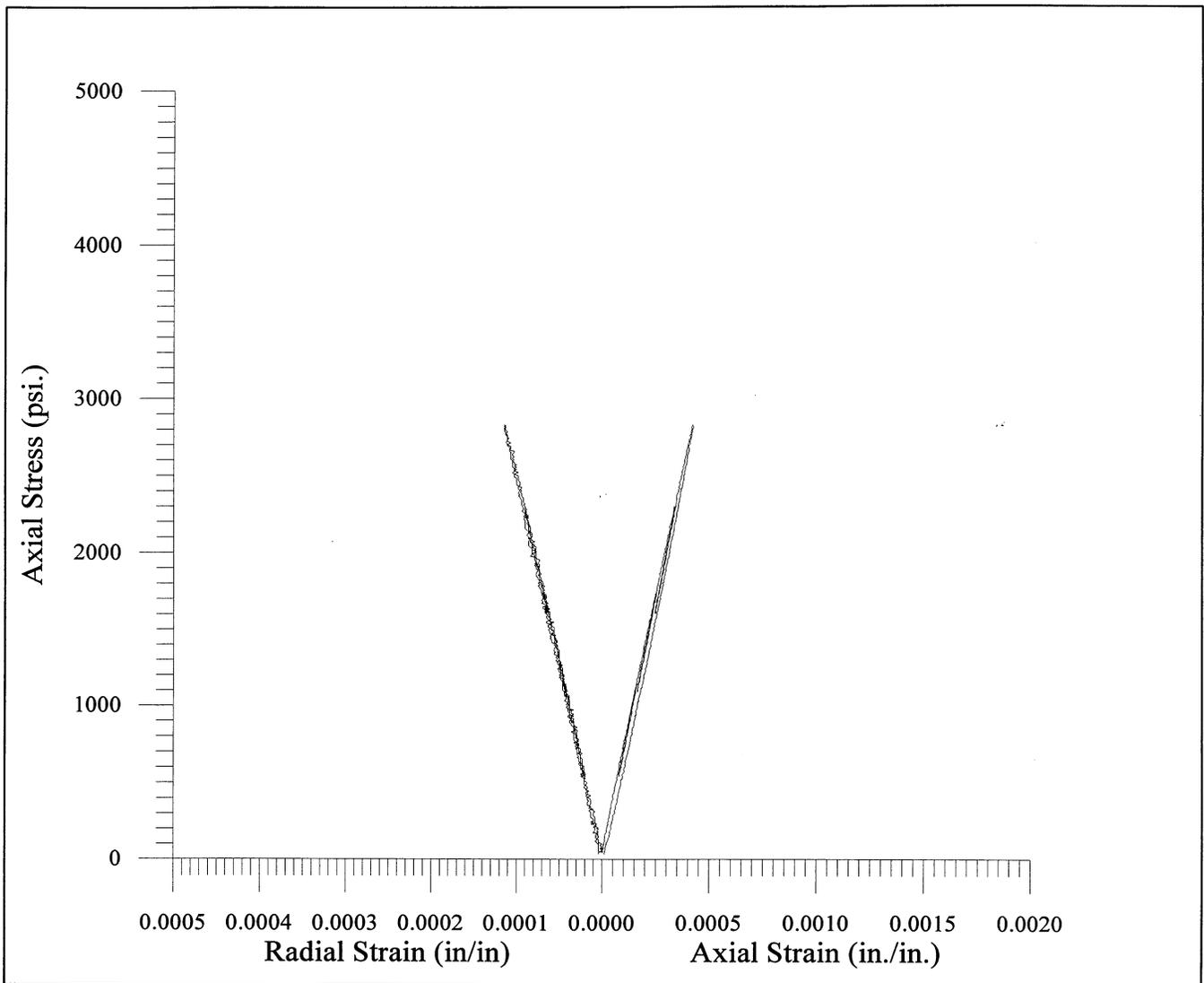
Sample weight (g): 1074.28

Density: 44.368/in<sup>3</sup> = 169.0

(1 g/in<sup>3</sup> = 3.8095 lb/ft<sup>3</sup>)

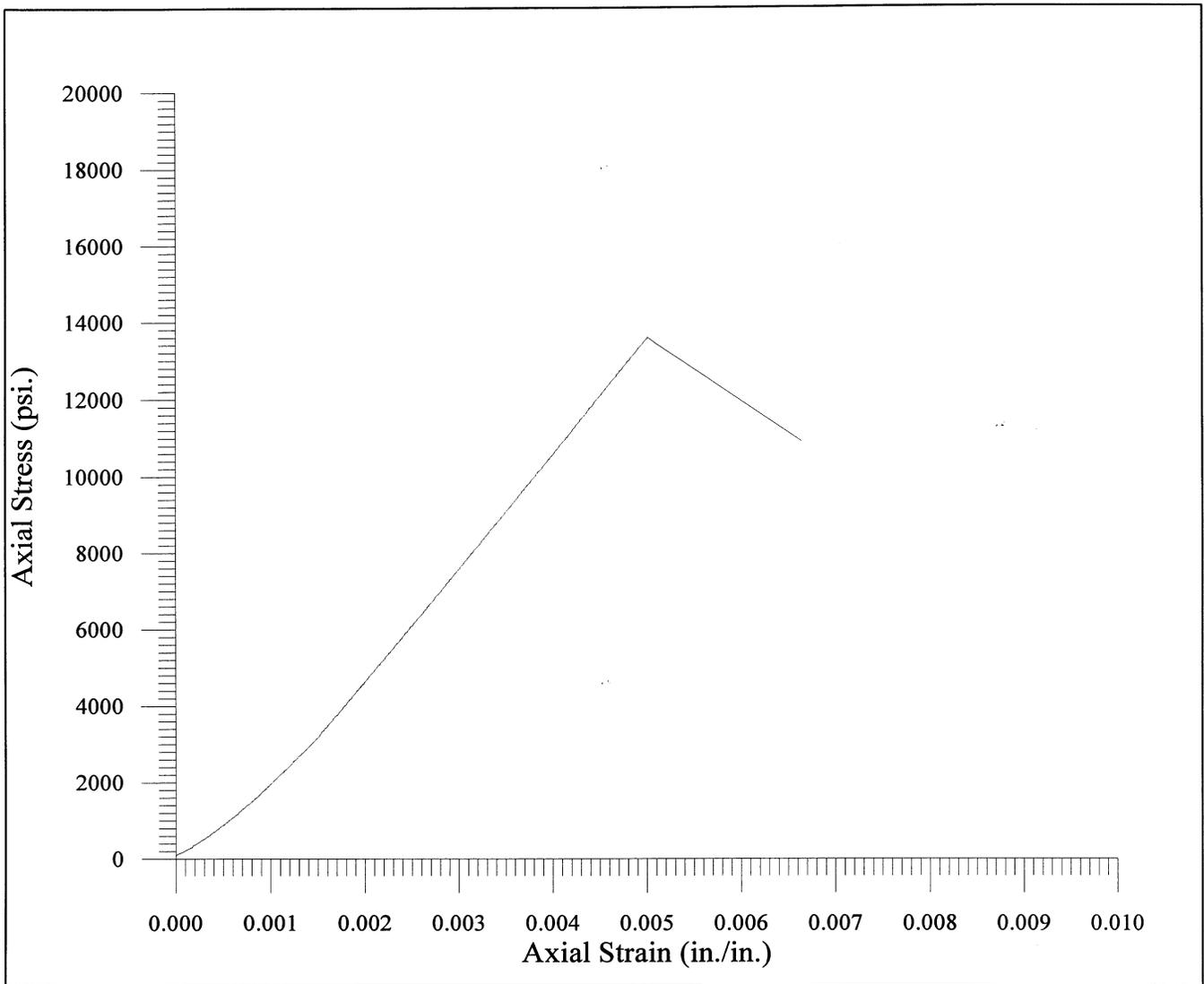
Gauge length: 2.000 in

Comments: Failed by shear partially along healed joint, and by axial splitting.



**ELASTIC MODULUS TEST**  
**Axial Stress vs. Axial & Radial Strain**

<p><b>SAMPLE ID:</b> Boring: 98-21  Sample: 35a  Depth: 130'</p> <p align="center"><b>DESCRIPTION</b></p> <p>Medium dark gray fine sandy siltstone to sandstone with a few claystone inclusions and one non-continuous calcite healed joint, about 24 degrees to the core axis.</p> <p><b>MODULUS:</b> 7,810,000 psi  <b>POISSON'S RATIO:</b> .32</p>	<p align="center"> <i>Geo</i>  <i>Test</i>  <b>Unlimited</b> 800 Peralta Ave  San Leandro, CA 94577 </p> <hr/> <p><b>Client:</b> Fugro West, Inc.  5855 Olivas Park Dr.  Ventura, CA 93003</p> <p><b>Project:</b> San Francisco Oakland Bay Bridge  East Span Replacement Project</p> <p><b>Job Number:</b> 98-42-0053</p> <hr/> <p><b>Test Date:</b> October 27, 1998</p>
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**UNCONFINED COMPRESSION TEST**  
**Axial Stress vs. Axial Strain**

<p><b>SAMPLE ID:</b> Boring : 98-21 Sample: 35a Depth: 130'</p> <p style="text-align: center;"><b>DESCRIPTION</b></p> <p>Medium dark gray fine sandy siltstone to sandstone with a few claystone inclusions and one non-continuous calcite healed joint, about 24 degrees to the core axis.</p> <p><b>STRENGTH:</b> 13,580 psi</p>	<div style="text-align: center;"> <p><i>Geo</i>  <i>Test</i></p> <p><b>Unlimited</b> 800 Peralta Ave San Leandro, CA 94577</p> </div> <hr/> <p><b>Client:</b> Fugro West, Inc. 5855 Olivas Park Dr. Ventura, CA 93003</p> <p><b>Project:</b> San Francisco Oakland Bay Bridge East Span Replacement Project</p> <p><b>Job Number:</b> 98-42-0053</p> <hr/> <p><b>Test Date:</b> October 27, 1998</p>
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## Direct Shear Tests

**DATA SHEET**  
Direct Shear of Rock (ISRM)

Date: 10/28/08

Person performing the test: A. B. R.

Client: Fugro

Job: #92-SFOBB

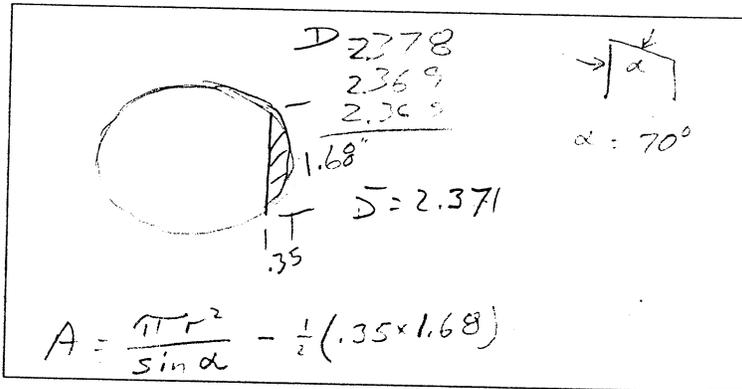
Sample ID: B98-21 S20a

Sample Description: Planar bedding joint in dark grey limestone.

Sample Depth: 45'

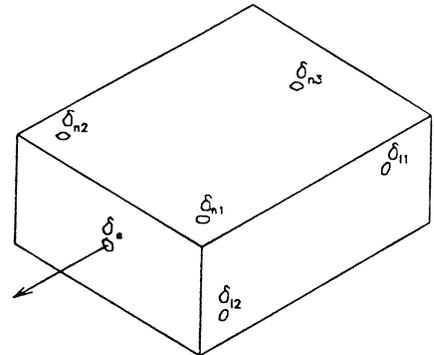
Sample Water Condition: received & tested in air

Sketch of Shear Surface



Sample area: 4.405 in<sup>2</sup>

Location of LVDTs on top shear box

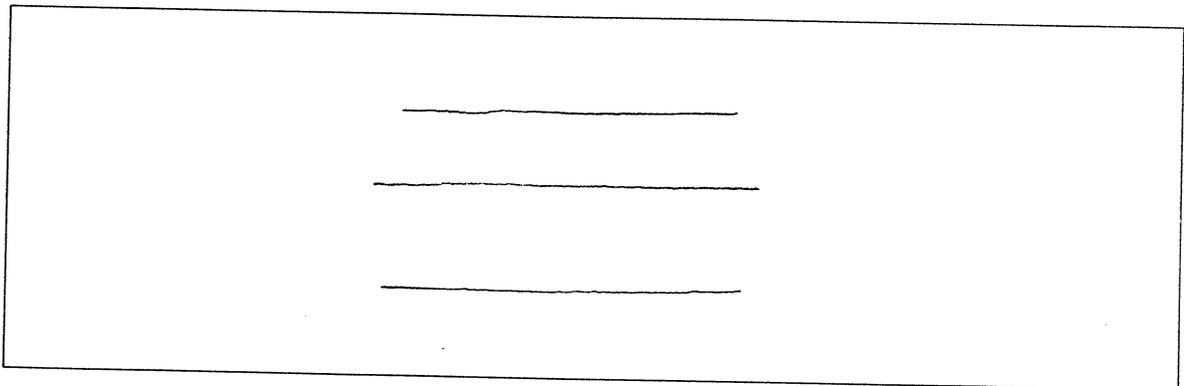


Estimated Top Box Weight: \_\_\_\_\_

Measured Top Box Weight: 15.4 lb

$\sigma_n$	<u>25</u>	<u>75</u>	<u>150</u>	psi
$F_n$	<u>110</u>	<u>330</u>	<u>660</u>	lb
$F_n - W_b$	<u>95</u>	<u>315</u>	<u>645</u>	lb

Joint Profiles

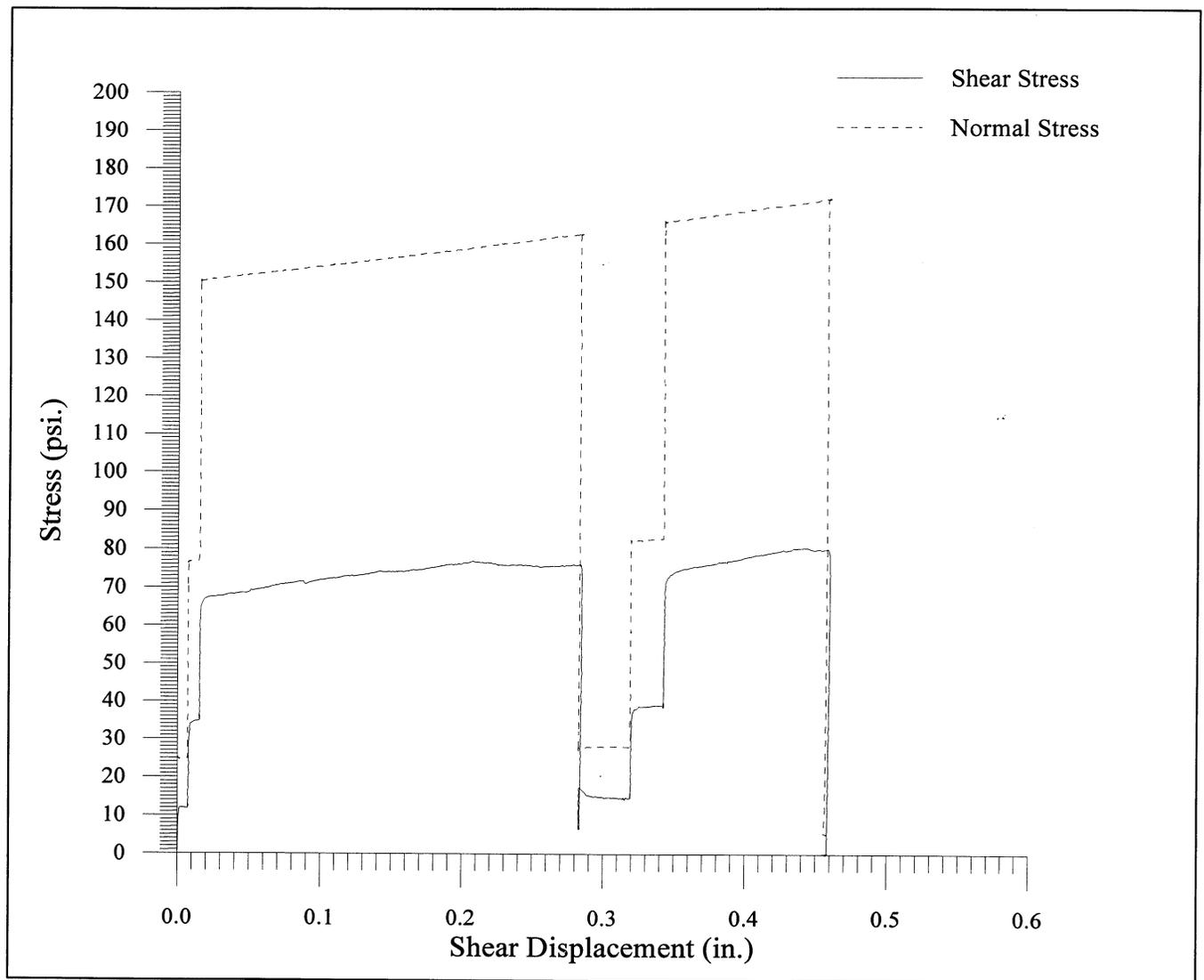


Summary of Test Results

Rate of Loading				
Shr. Displ. Rate				
Normal Stress				
Shear Strength				

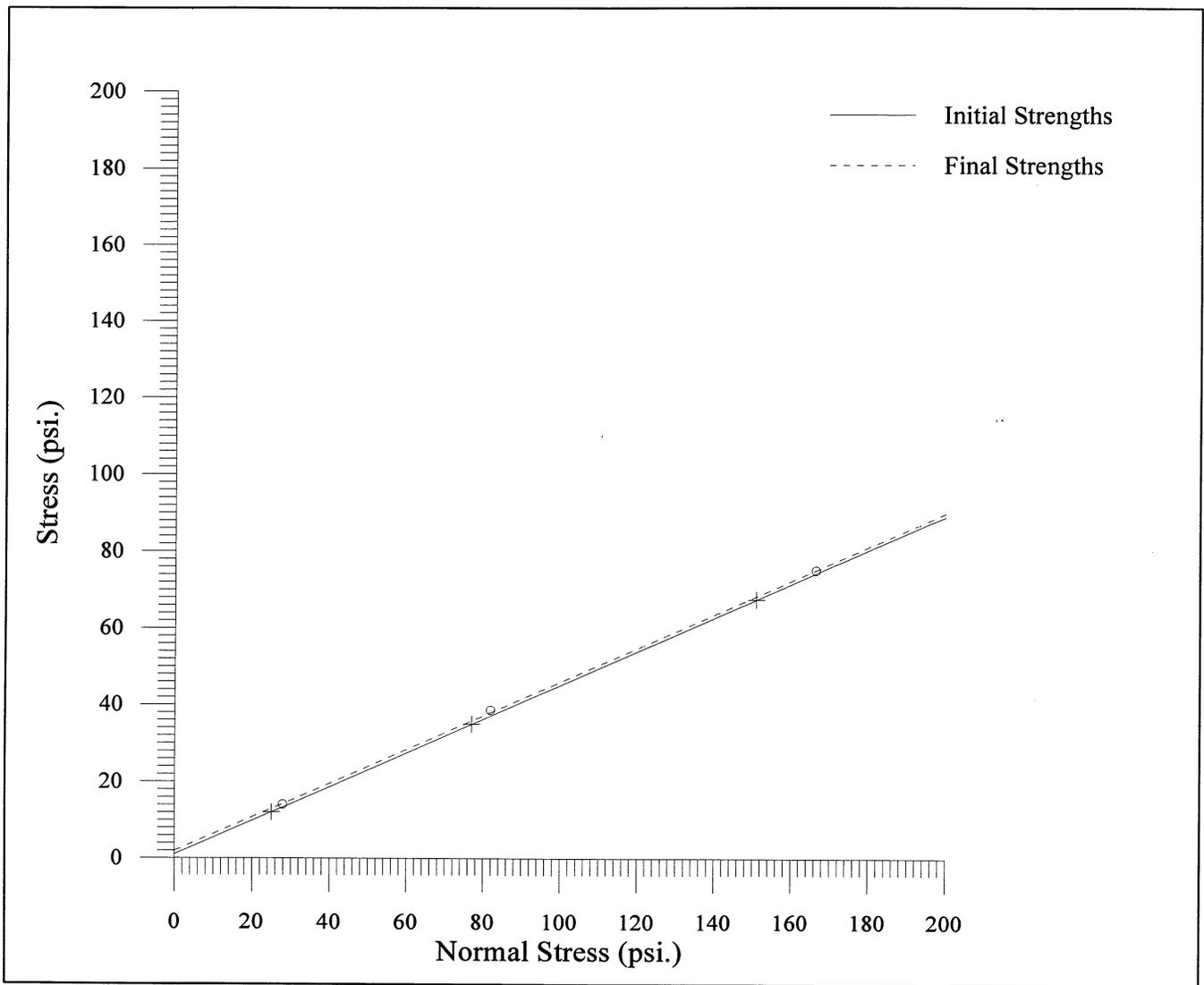
Sj: \_\_\_\_\_

phi: \_\_\_\_\_



**DIRECT SHEAR TEST**  
**Shear and Normal Stress vs. Shear Displacement**

<b>SAMPLE ID:</b> Boring: 98-21 Sample: 20a Depth: 45'		 800 Peralta Ave San Leandro, CA 94577																		
<b>DESCRIPTION</b> Planar bedding joint in dark gray claystone.																				
	<table border="1"> <thead> <tr> <th></th> <th>Normal Stress</th> <th>Shear Strength</th> </tr> </thead> <tbody> <tr> <td rowspan="3">Initial</td> <td>25</td> <td>12</td> </tr> <tr> <td>77</td> <td>35</td> </tr> <tr> <td>151</td> <td>67.5</td> </tr> <tr> <td rowspan="3">Final</td> <td>28</td> <td>14</td> </tr> <tr> <td>82</td> <td>38.5</td> </tr> <tr> <td>166.5</td> <td>75</td> </tr> </tbody> </table>		Normal Stress	Shear Strength	Initial	25	12	77	35	151	67.5	Final	28	14	82	38.5	166.5	75	<b>Client:</b> Fugro West, Inc. 5855 Olivas Park Dr. Ventura, CA 93003	
	Normal Stress	Shear Strength																		
Initial	25	12																		
	77	35																		
	151	67.5																		
Final	28	14																		
	82	38.5																		
	166.5	75																		
		<b>Project:</b> San Francisco Oakland Bay Bridge East Span Replacement Project																		
		<b>Job Number:</b> 98-42-0053																		
		<b>Test Date:</b> October 28, 1998																		



**DIRECT SHEAR TEST  
Failure Envelope**

<p><b>SAMPLE ID:</b> Boring: 98-21 Sample: 20a Depth: 45'</p> <p style="text-align: center;"><b>DESCRIPTION</b></p> <p>Planar bedding joint in dark gray claystone.</p>	<div style="text-align: center;">  <p><b>Geo Test Unlimited</b> 800 Peralta Ave San Leandro, CA 94577</p> </div>									
<table border="1" style="width: 100%; border-collapse: collapse; margin-top: 20px;"> <thead> <tr> <th style="width: 10%;"></th> <th style="width: 20%;">Shear Intercept (psi)</th> <th style="width: 20%;">Friction Angle (degrees)</th> </tr> </thead> <tbody> <tr> <td>Initial</td> <td style="text-align: center;">1.0</td> <td style="text-align: center;">23.8</td> </tr> <tr> <td>Final</td> <td style="text-align: center;">2.0</td> <td style="text-align: center;">23.7</td> </tr> </tbody> </table>		Shear Intercept (psi)	Friction Angle (degrees)	Initial	1.0	23.8	Final	2.0	23.7	<p><b>Client:</b> Fugro West, Inc. 5855 Olivas Park Dr. Ventura, CA 93003</p> <p><b>Project:</b> San Francisco Oakland Bay Bridge East Span Replacement Project</p> <p><b>Job Number:</b> 98-42-0053</p> <p><b>Test Date:</b> October 28, 1998</p>
	Shear Intercept (psi)	Friction Angle (degrees)								
Initial	1.0	23.8								
Final	2.0	23.7								

DATA SHEET  
Direct Shear of Rock (ISRM)

Date: 10/29/98

Person performing the test: A. B. D

Client: Fugro

Job: #92-SF033

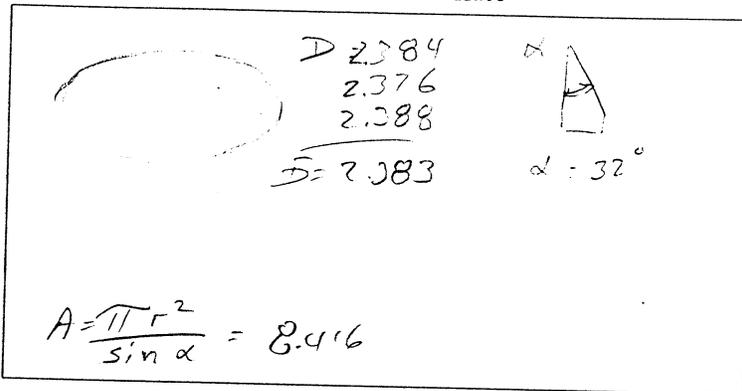
Sample ID: B98-21 S 316

Sample Description: Steples in direct plane between gray siltstone and dark gray fine grained siltstone

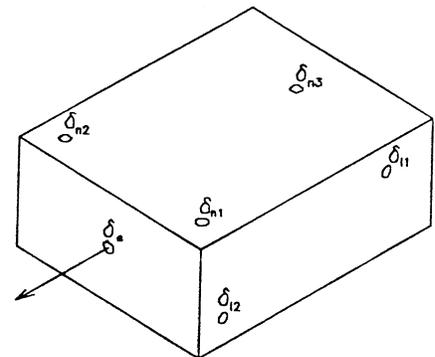
Sample Depth: 98'

Sample Water Condition: received & tested moist

Sketch of Shear Surface



Location of LVDTs on top shear box

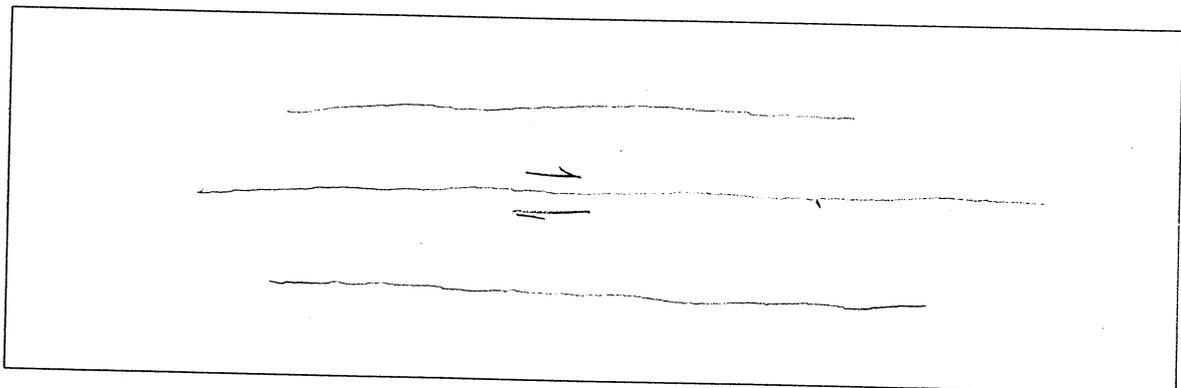


Sample area: 8.416

Estimated Top Box Weight: \_\_\_\_\_  
Measured Top Box Weight: 15.9

$\sigma_n$	<u>25</u>	<u>75</u>	<u>150</u>	psi
$F_n$	<u>210</u>	<u>630</u>	<u>1260</u>	lb
$F_n - W_b$	<u>194</u>	<u>614</u>	<u>1244</u>	lb

Joint Profiles

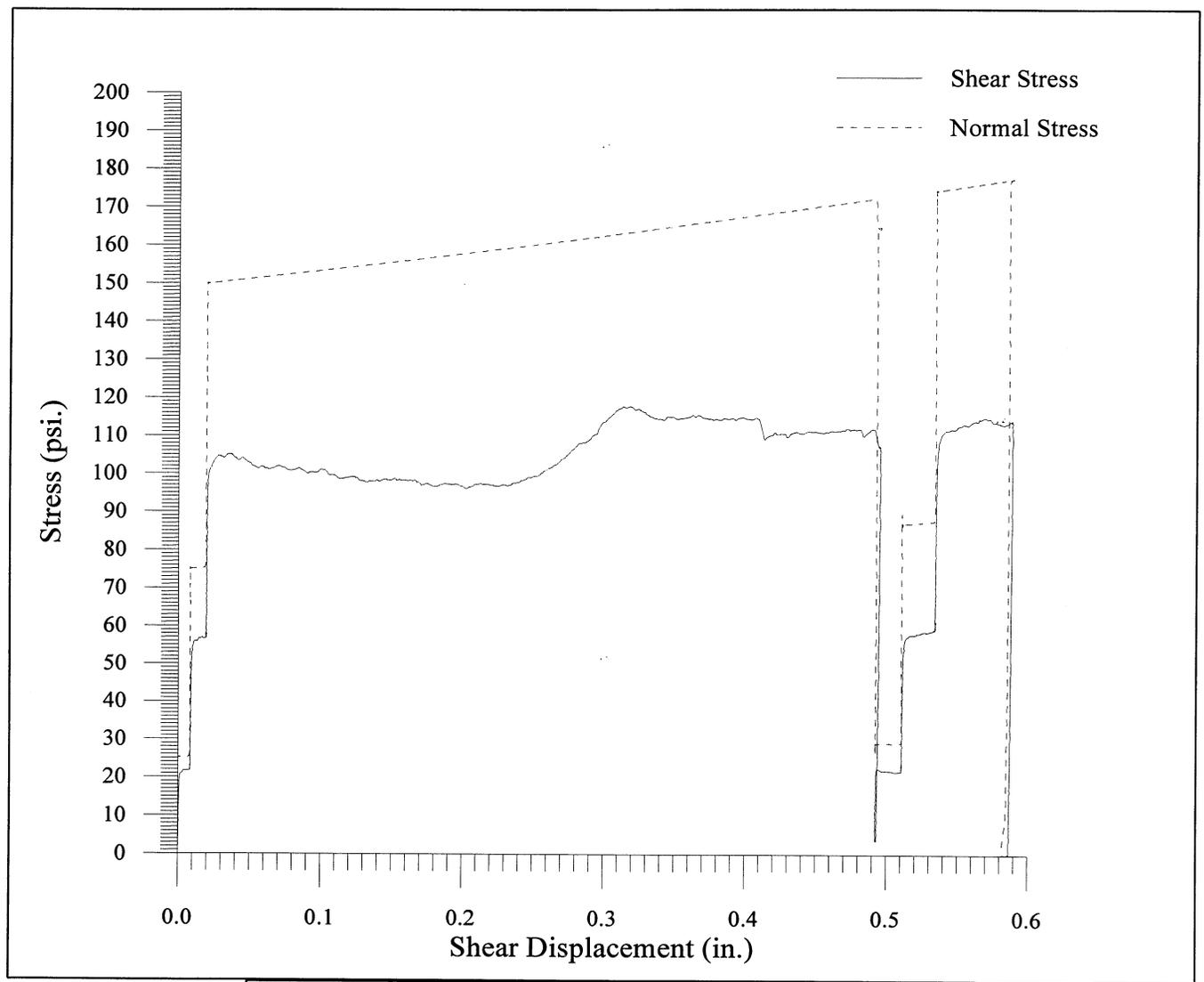


Summary of Test Results

Rate of Loading				
Shr. Displ. Rate				
Normal Stress				
Shear Strength				

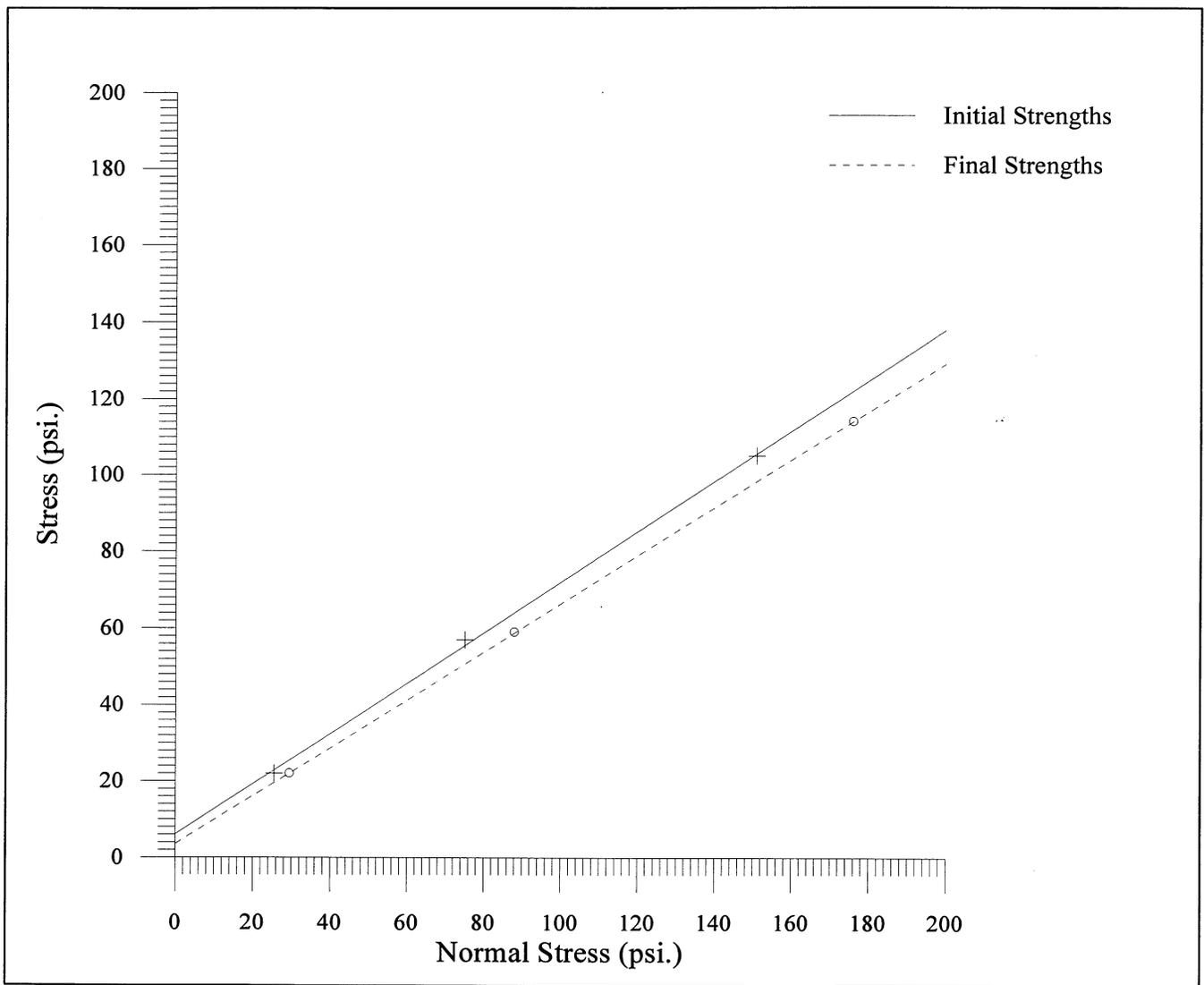
S<sub>j</sub>: \_\_\_\_\_

φ: \_\_\_\_\_



**DIRECT SHEAR TEST**  
**Shear and Normal Stress vs. Shear Displacement**

<p><b>SAMPLE ID:</b> Boring: 98-21          Sample: 31b          Depth: 98'</p> <p style="text-align: center;"><b>DESCRIPTION</b></p> <p>Planar parting between gray sandstone and dark gray fine sandy siltstone.</p>	<div style="text-align: center;">  </div> <p style="text-align: right;">800 Peralta Ave          San Leandro, CA 94577</p>																	
<table border="1" style="width: 100%; border-collapse: collapse; margin-top: 10px;"> <thead> <tr> <th style="width: 10%;"></th> <th style="width: 40%;">Normal Stress</th> <th style="width: 50%;">Shear Strength</th> </tr> </thead> <tbody> <tr> <td rowspan="3" style="text-align: center; vertical-align: middle;">Initial</td> <td style="text-align: center;">25.5</td> <td style="text-align: center;">22</td> </tr> <tr> <td style="text-align: center;">75</td> <td style="text-align: center;">57</td> </tr> <tr> <td style="text-align: center;">151</td> <td style="text-align: center;">105</td> </tr> <tr> <td rowspan="3" style="text-align: center; vertical-align: middle;">Final</td> <td style="text-align: center;">29.5</td> <td style="text-align: center;">22</td> </tr> <tr> <td style="text-align: center;">88</td> <td style="text-align: center;">59</td> </tr> <tr> <td style="text-align: center;">176</td> <td style="text-align: center;">114</td> </tr> </tbody> </table>		Normal Stress	Shear Strength	Initial	25.5	22	75	57	151	105	Final	29.5	22	88	59	176	114	<p><b>Client:</b> Fugro West, Inc.          5855 Olivas Park Dr.          Ventura, CA 93003</p> <p><b>Project:</b> San Francisco Oakland Bay Bridge          East Span Replacement Project</p> <p><b>Job Number:</b> 98-42-0053</p>
	Normal Stress	Shear Strength																
Initial	25.5	22																
	75	57																
	151	105																
Final	29.5	22																
	88	59																
	176	114																
<p><b>Test Date:</b> October 29, 1998</p>																		



**DIRECT SHEAR TEST  
Failure Envelope**

<p><b>SAMPLE ID:</b> Boring: 98-21 Sample: 31b Depth: 98'</p> <p style="text-align: center;"><b>DESCRIPTION</b></p> <p>Planar parting between gray sandstone and dark gray fine sandy siltstone.</p> <table style="width: 100%; margin-top: 10px;"> <thead> <tr> <th></th> <th style="text-align: center;">Shear Intercept (psi)</th> <th style="text-align: center;">Friction Angle (degrees)</th> </tr> </thead> <tbody> <tr> <td style="text-align: left;">Initial</td> <td style="text-align: center;">6.1</td> <td style="text-align: center;">33.3</td> </tr> <tr> <td style="text-align: left;">Final</td> <td style="text-align: center;">3.6</td> <td style="text-align: center;">32.1</td> </tr> </tbody> </table>		Shear Intercept (psi)	Friction Angle (degrees)	Initial	6.1	33.3	Final	3.6	32.1	<div style="text-align: center; margin-bottom: 10px;">  <p><b>800 Peralta Ave San Leandro, CA 94577</b></p> </div> <p><b>Client:</b> Fugro West, Inc. 5855 Olivas Park Dr. Ventura, CA 93003</p> <p><b>Project:</b> San Francisco Oakland Bay Bridge East Span Replacement Project</p> <p><b>Job Number:</b> 98-42-0053</p> <p><b>Test Date:</b> October 29, 1998</p>
	Shear Intercept (psi)	Friction Angle (degrees)								
Initial	6.1	33.3								
Final	3.6	32.1								

DATA SHEET  
Direct Shear of Rock (ISRM)

Date: 10/29/98

Person performing the test: A. J. B. R.

Client: Furro

Job: #92-SFORB

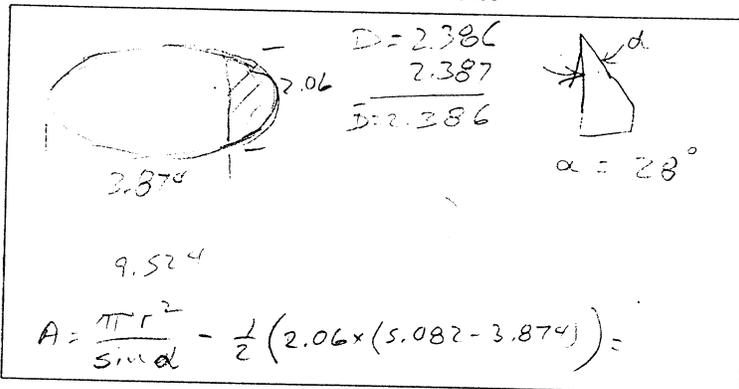
Sample ID: B98-21 S346

Sample Description: Planar calcite coated joint in medium dark gray fine sandy siltstone

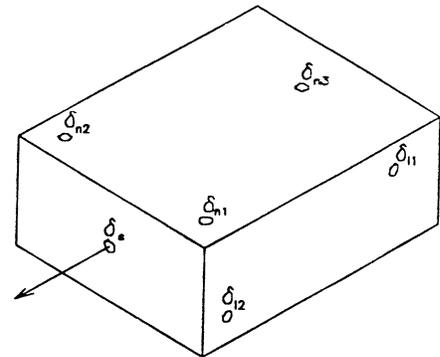
Sample Depth: 123.5'

Sample Water Condition: received & tested moist

Sketch of Shear Surface



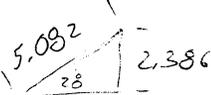
Location of LVDTs on top shear box



Sample area: 8.280

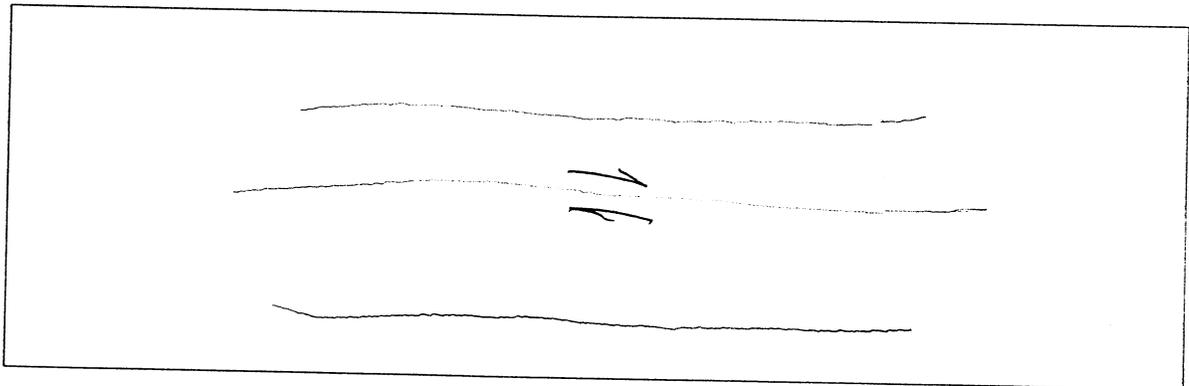
Estimated Top Box Weight: \_\_\_\_\_

Measured Top Box Weight: 16.2 lb



$\sigma_n$	<u>25</u>	<u>75</u>	<u>150</u>	psi
$F_n$	<u>207</u>	<u>621</u>	<u>1242</u>	lb
$F_{n-wb}$	<u>191</u>	<u>605</u>	<u>1226</u>	lb

Joint Profiles

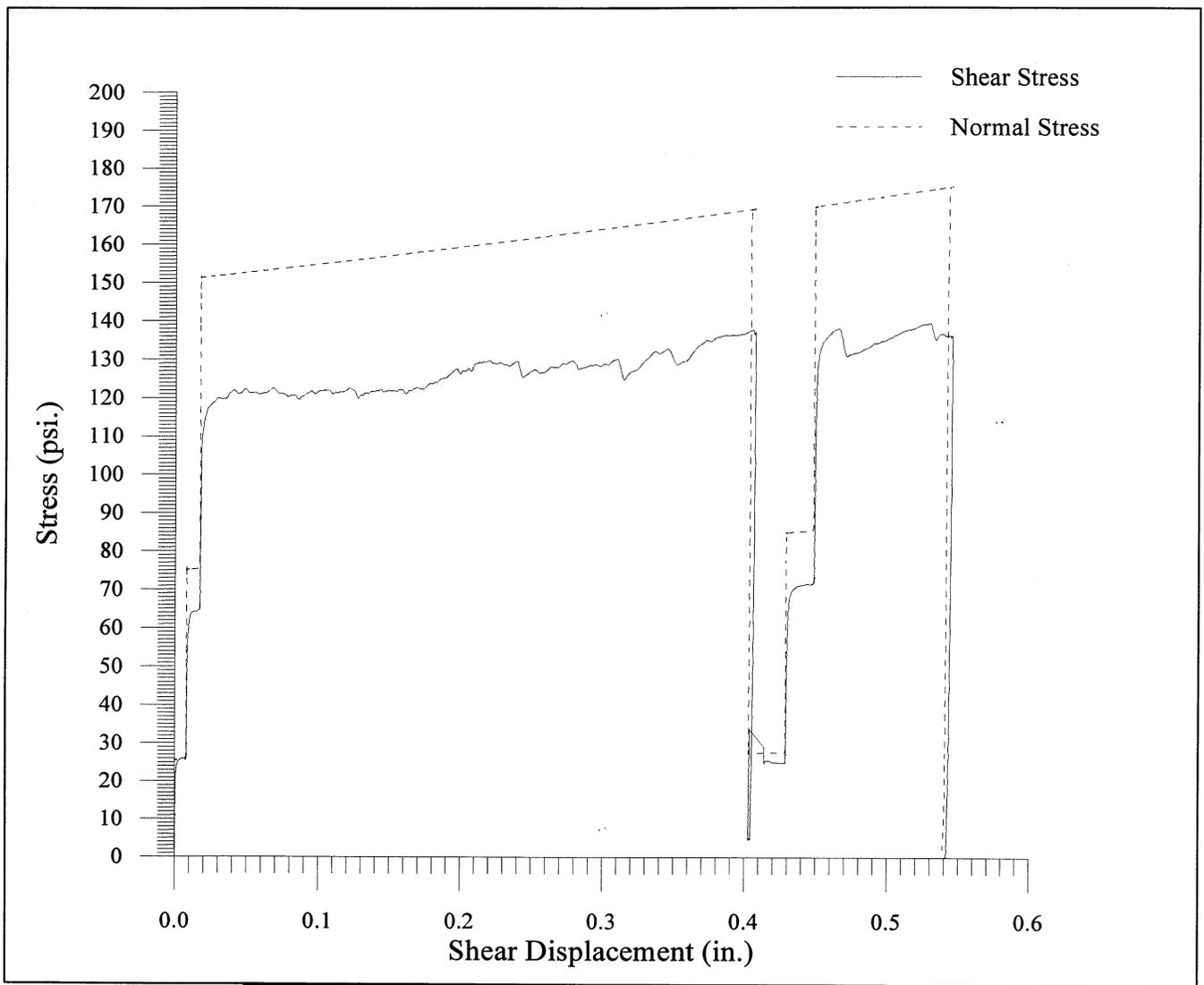


Summary of Test Results

Rate of Loading				
Shr. Displ. Rate				
Normal Stress				
Shear Strength				

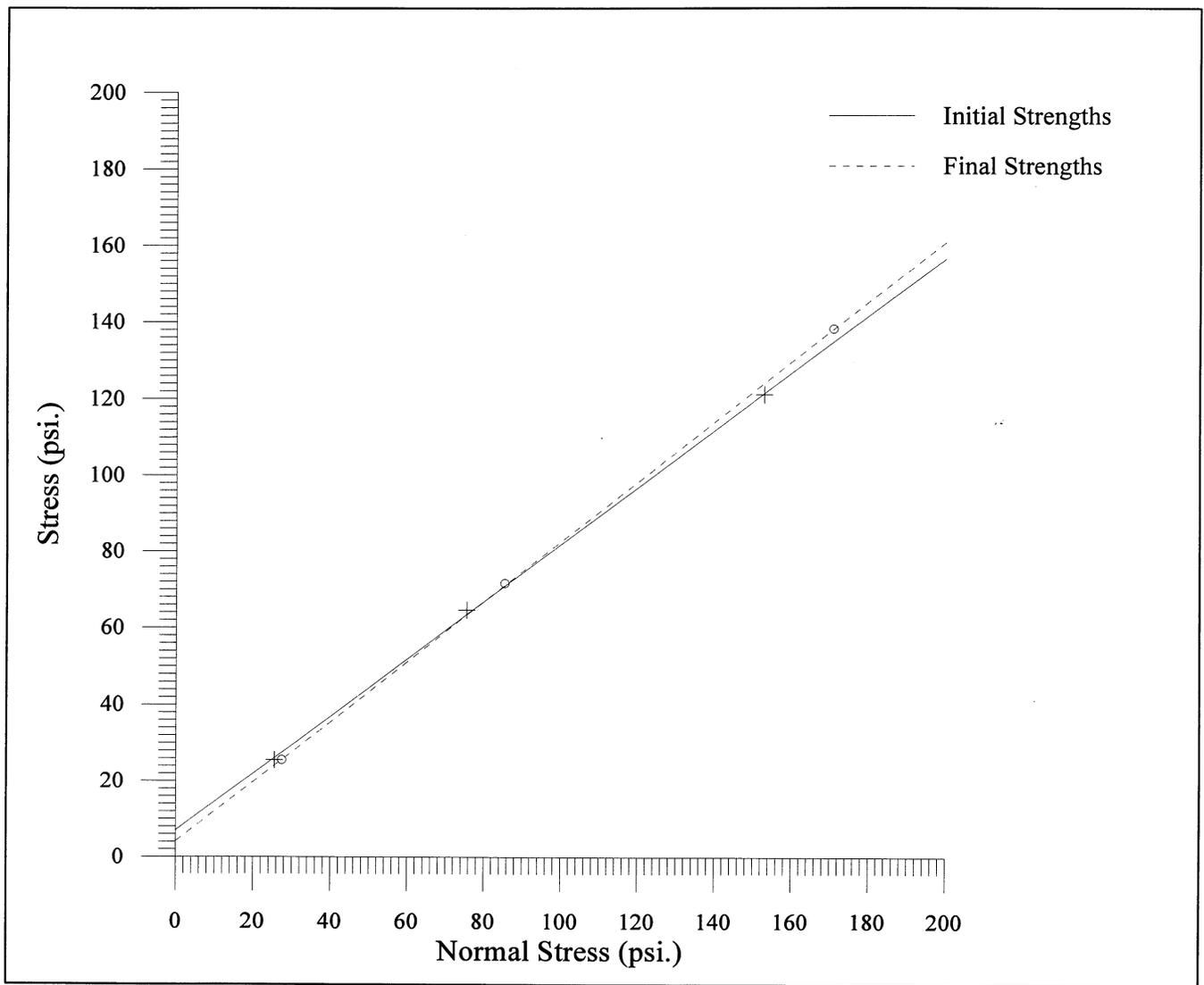
S<sub>j</sub>: \_\_\_\_\_

φ: \_\_\_\_\_



**DIRECT SHEAR TEST**  
**Shear and Normal Stress vs. Shear Displacement**

<p><b>SAMPLE ID:</b> Boring: 98-21          Sample: 34b          Depth: 123.5'</p> <p align="center"><b>DESCRIPTION</b></p> <p>Planar calcite coated joint in medium dark gray fine sandy siltstone.</p>		<p align="center"> <i>Geo</i>  <i>Test</i>  <b>Unlimited</b> </p> <p align="right">800 Peralta Ave          San Leandro, CA 94577</p>																		
		<p><b>Client:</b> Fugro West, Inc.          5855 Olivas Park Dr.          Ventura, CA 93003</p>																		
	<table border="1"> <thead> <tr> <th></th> <th>Normal Stress</th> <th>Shear Strength</th> </tr> </thead> <tbody> <tr> <td rowspan="3">Initial</td> <td>25.5</td> <td>25.5</td> </tr> <tr> <td>75.5</td> <td>64.5</td> </tr> <tr> <td>153</td> <td>121</td> </tr> <tr> <td rowspan="3">Final</td> <td>27.5</td> <td>25.5</td> </tr> <tr> <td>85.5</td> <td>71.5</td> </tr> <tr> <td>171</td> <td>138</td> </tr> </tbody> </table>		Normal Stress	Shear Strength	Initial	25.5	25.5	75.5	64.5	153	121	Final	27.5	25.5	85.5	71.5	171	138	<p><b>Project:</b> San Francisco Oakland Bay Bridge          East Span Replacement Project</p> <p><b>Job Number:</b> 98-42-0053</p>	
	Normal Stress	Shear Strength																		
Initial	25.5	25.5																		
	75.5	64.5																		
	153	121																		
Final	27.5	25.5																		
	85.5	71.5																		
	171	138																		
		<p><b>Test Date:</b> October 29, 1998</p>																		



**DIRECT SHEAR TEST  
Failure Envelope**

<p><b>SAMPLE ID:</b> Boring: 98-21 Sample: 34b Depth: 123.5'</p> <p style="text-align: center;"><b>DESCRIPTION</b></p> <p>Planar calcite coated joint in medium dark gray fine sandy siltstone.</p> <table style="width: 100%; margin-top: 10px;"> <thead> <tr> <th></th> <th style="text-align: center;">Shear Intercept (psi)</th> <th style="text-align: center;">Friction Angle (degrees)</th> </tr> </thead> <tbody> <tr> <td style="text-align: left;">Initial</td> <td style="text-align: center;">7.1</td> <td style="text-align: center;">36.8</td> </tr> <tr> <td style="text-align: left;">Final</td> <td style="text-align: center;">4.2</td> <td style="text-align: center;">38.1</td> </tr> </tbody> </table>		Shear Intercept (psi)	Friction Angle (degrees)	Initial	7.1	36.8	Final	4.2	38.1	<div style="text-align: center;">  <p><b>800 Peralta Ave San Leandro, CA 94577</b></p> </div> <hr/> <p><b>Client:</b> Fugro West, Inc. 5855 Olivas Park Dr. Ventura, CA 93003</p> <p><b>Project:</b> San Francisco Oakland Bay Bridge East Span Replacement Project</p> <p><b>Job Number:</b> 98-42-0053</p> <hr/> <p><b>Test Date:</b> October 29, 1998</p>
	Shear Intercept (psi)	Friction Angle (degrees)								
Initial	7.1	36.8								
Final	4.2	38.1								

## DATA SHEET

### Direct Shear of Rock (ISRM)

Date: 10/29/98

Person performing the test: A. Bro

Client: Fugro

Job: #92-SFO3B

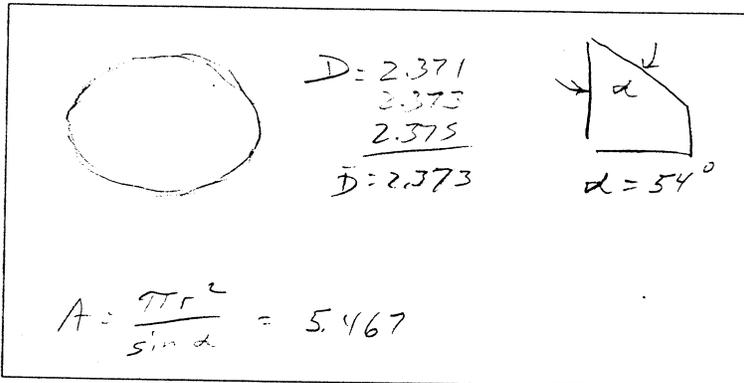
Sample ID: B98-21 S36a

Sample Description: Dark gray planar bedding plane joint in

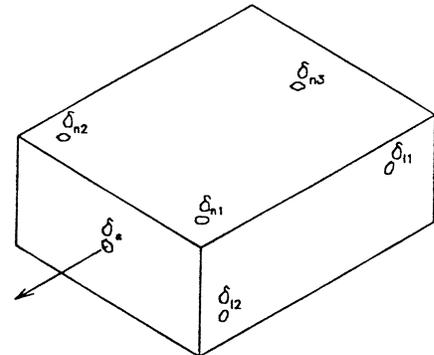
Sample Depth: 133'

Sample Water Condition: received & tested moist

Sketch of Shear Surface



Location of LVDTs on top shear box



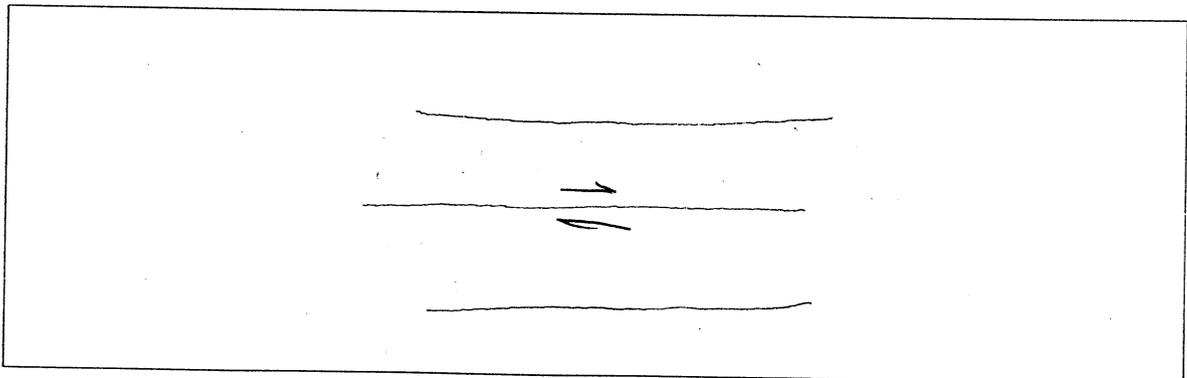
Sample area: 5.467

Estimated Top Box Weight: \_\_\_\_\_

Measured Top Box Weight: 16.1 lb

$\sigma_n$	<u>25</u>	<u>75</u>	<u>150</u>	psi
$F_n$	<u>137</u>	<u>411</u>	<u>822</u>	lb
$F_n - W_b$	<u>121</u>	<u>395</u>	<u>806</u>	lb

Joint Profiles

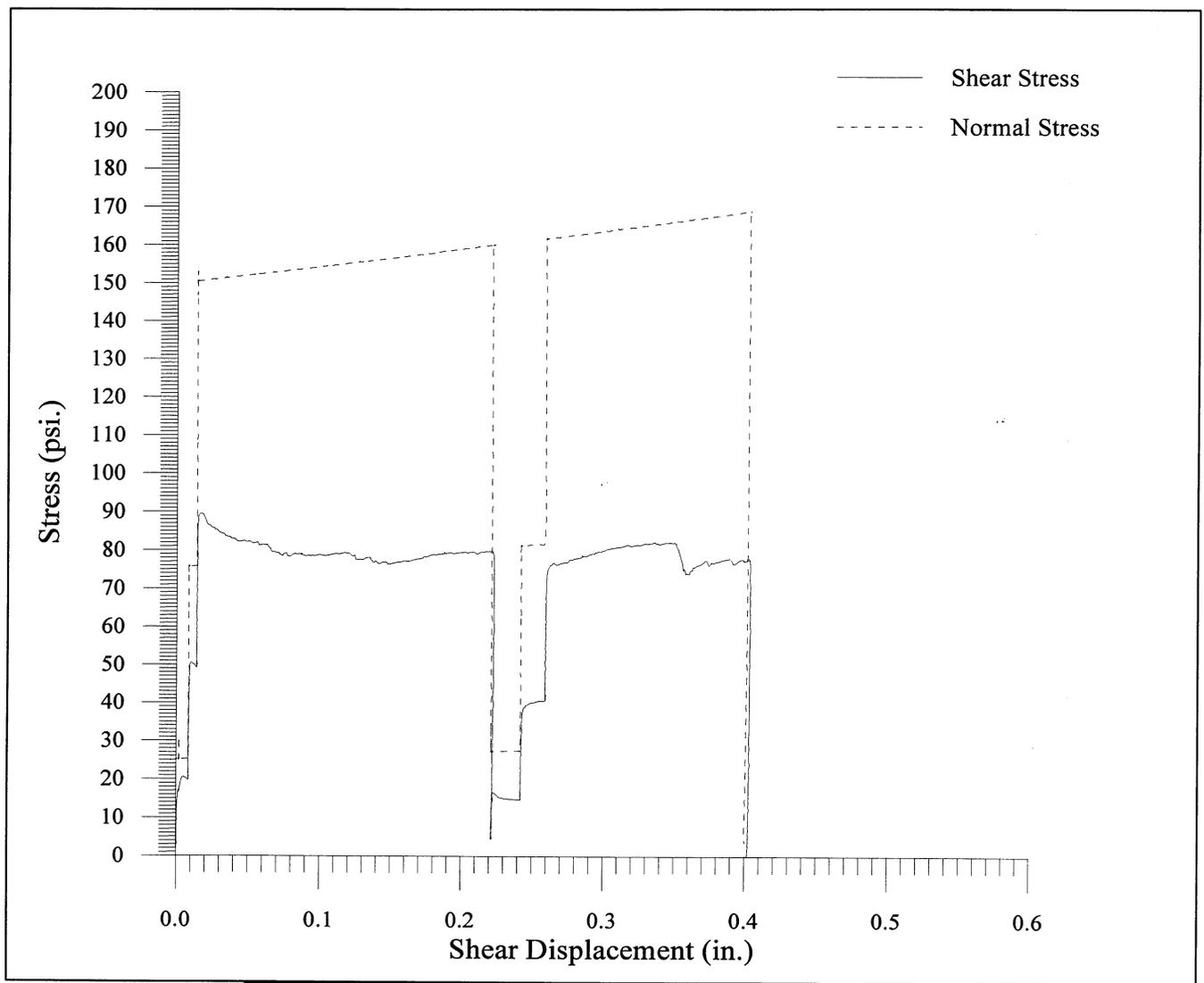


Summary of Test Results

Rate of Loading				
Shr. Displ. Rate				
Normal Stress				
Shear Strength				

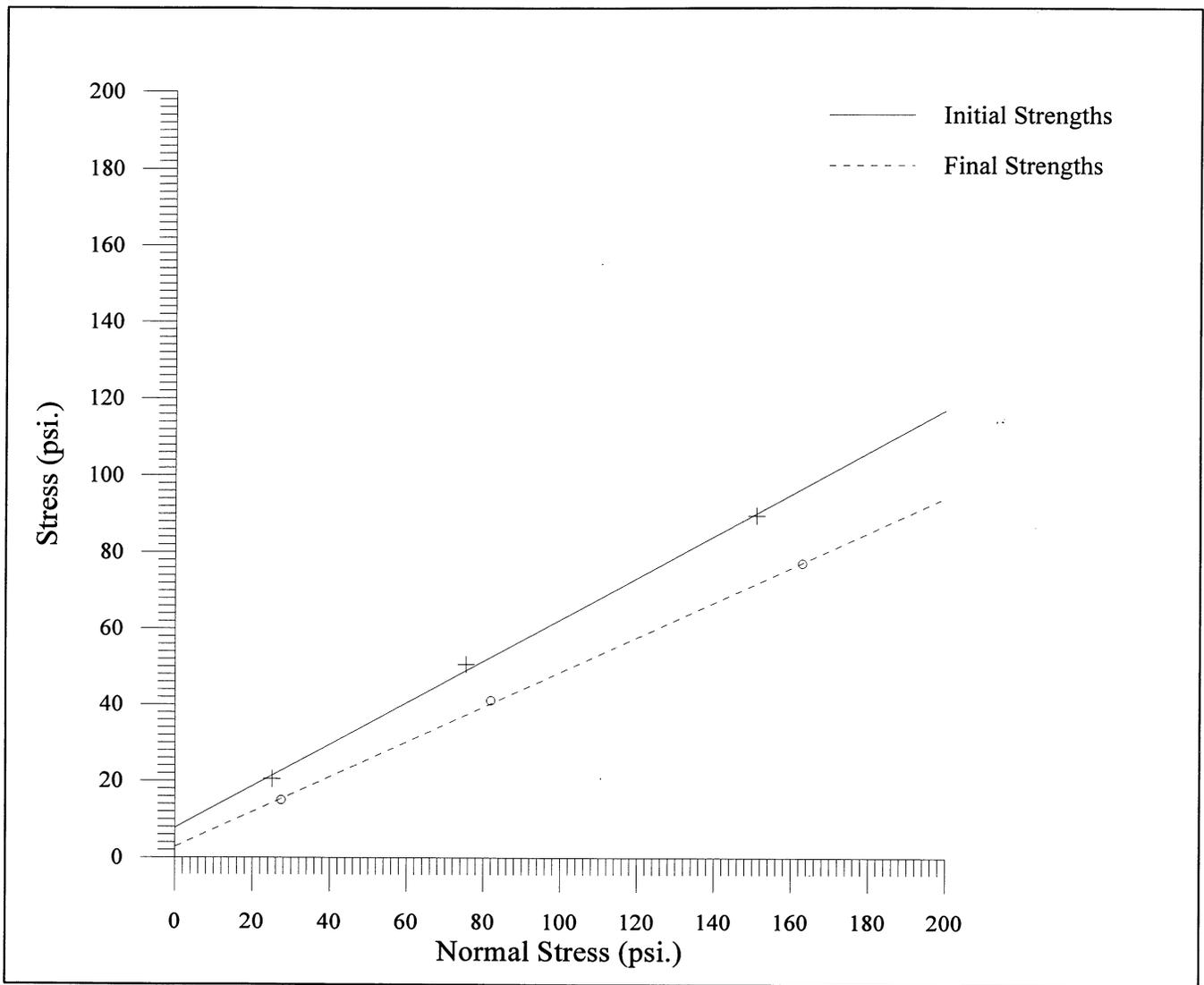
Sj: \_\_\_\_\_

phi: \_\_\_\_\_



**DIRECT SHEAR TEST**  
**Shear and Normal Stress vs. Shear Displacement**

<b>SAMPLE ID:</b> Boring: 98-21 Sample: 36a Depth: 133'			 <b>800 Peralta Ave</b> <b>San Leandro, CA 94577</b>	
<b>DESCRIPTION</b> Planar bedding plane joint in dark gray claystone.				
	<u>Normal Stress</u>	<u>Shear Strength</u>	<b>Client:</b> Fugro West, Inc. 5855 Olivas Park Dr. Ventura, CA 93003	
Initial	25	20.5	<b>Project:</b> San Francisco Oakland Bay Bridge East Span Replacement Project	
	75.5	50.5		
	151	89.5		
Final	27.5	15	<b>Job Number:</b> 98-42-0053	
	82	41	<b>Test Date:</b> October 29, 1998	
	163	77		



**DIRECT SHEAR TEST  
Failure Envelope**

<p><b>SAMPLE ID:</b> Boring: 98-21 Sample: 36a Depth: 133'</p> <p><b>DESCRIPTION</b> Planar bedding plane joint in dark gray claystone.</p> <table border="1"> <thead> <tr> <th></th> <th>Shear Intercept (psi)</th> <th>Friction Angle (degrees)</th> </tr> </thead> <tbody> <tr> <td>Initial</td> <td>7.8</td> <td>28.6</td> </tr> <tr> <td>Final</td> <td>2.9</td> <td>24.5</td> </tr> </tbody> </table>		Shear Intercept (psi)	Friction Angle (degrees)	Initial	7.8	28.6	Final	2.9	24.5	<p align="center"> <b>Geo</b>  <b>Test</b>  <b>Unlimited</b> 800 Peralta Ave  San Leandro, CA 94577 </p>
		Shear Intercept (psi)	Friction Angle (degrees)							
Initial	7.8	28.6								
Final	2.9	24.5								
<p><b>Client:</b> Fugro West, Inc. 5855 Olivas Park Dr. Ventura, CA 93003</p> <p><b>Project:</b> San Francisco Oakland Bay Bridge East Span Replacement Project</p> <p><b>Job Number:</b> 98-42-0053</p> <p><b>Test Date:</b> October 29, 1998</p>										

**DATA SHEET**  
**Direct Shear of Rock (ISRM)**

Date: 10/29/98

Person performing the test: A. Bro

Client: Fugro

Job: H92-SFORB

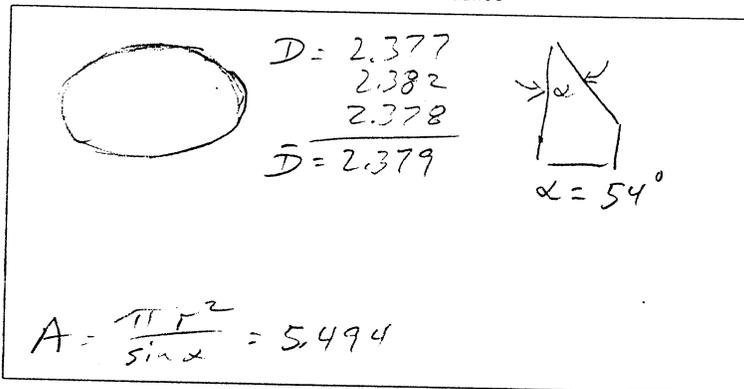
Sample ID: B98-21 S366

Sample Description: Planar bedding joint in a dark gray claystone bed.

Sample Depth: 135.5'

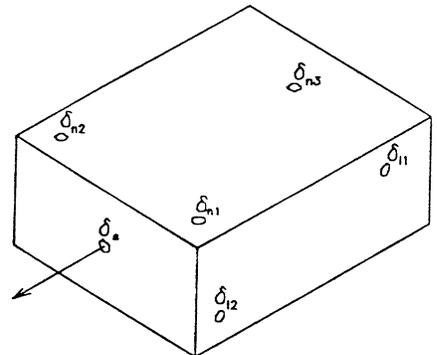
Sample Water Condition: received & tested moist

Sketch of Shear Surface



Sample area: 5.494 in<sup>2</sup>

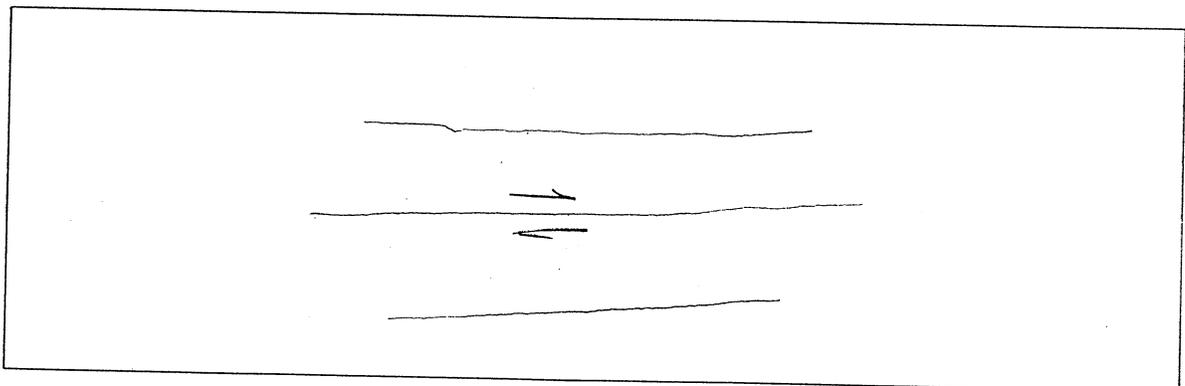
Location of LVDTs on top shear box



Estimated Top Box Weight: \_\_\_\_\_  
Measured Top Box Weight: 16.3

$\sigma_n$	<u>25</u>	<u>75</u>	<u>150</u>	psi
$F_n$	<u>137</u>	<u>411</u>	<u>822</u>	lb
$F_n - W_b$	<u>121</u>	<u>395</u>	<u>806</u>	lb

Joint Profiles

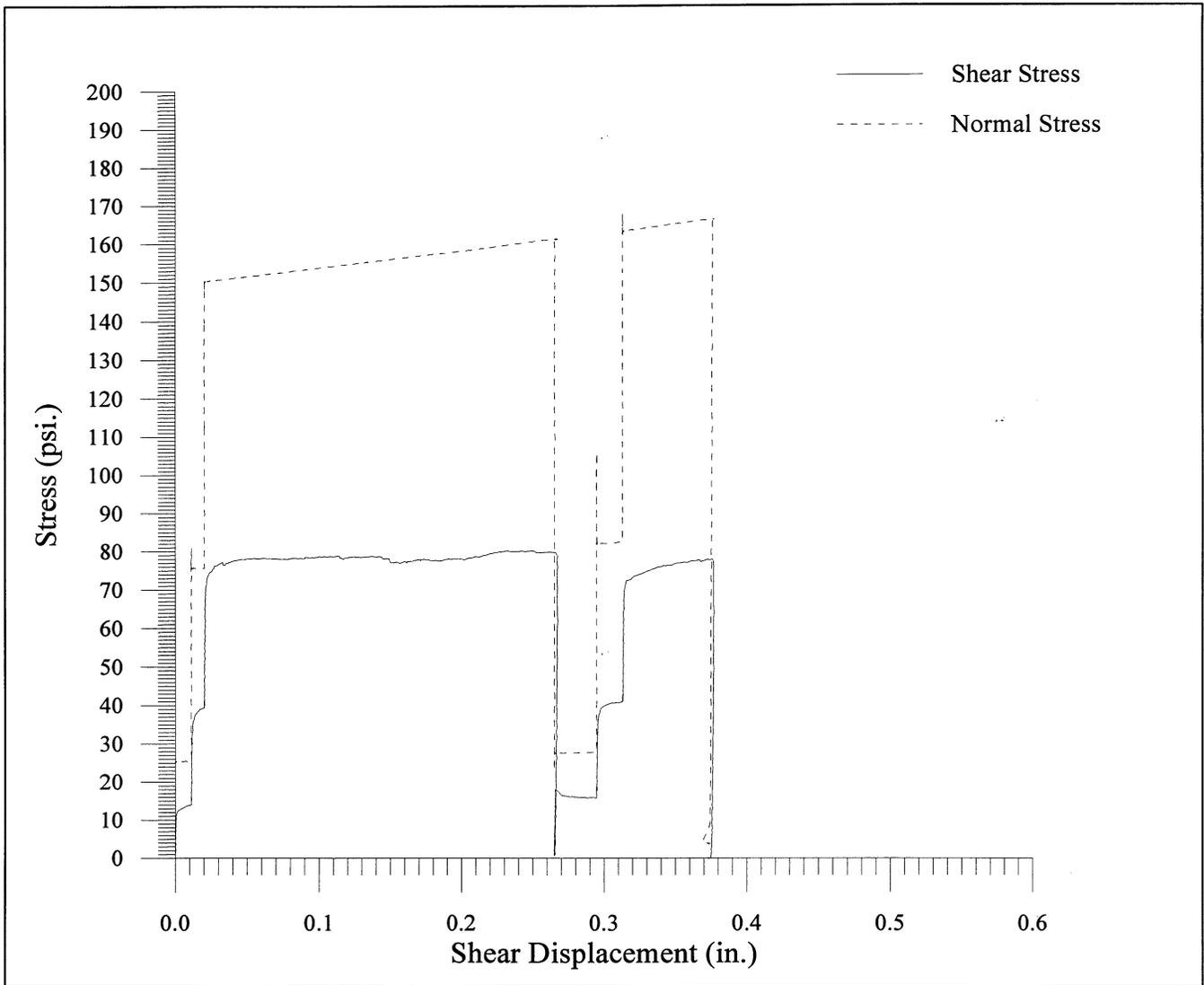


Summary of Test Results

Rate of Loading				
Shr. Displ. Rate				
Normal Stress				
Shear Strength				

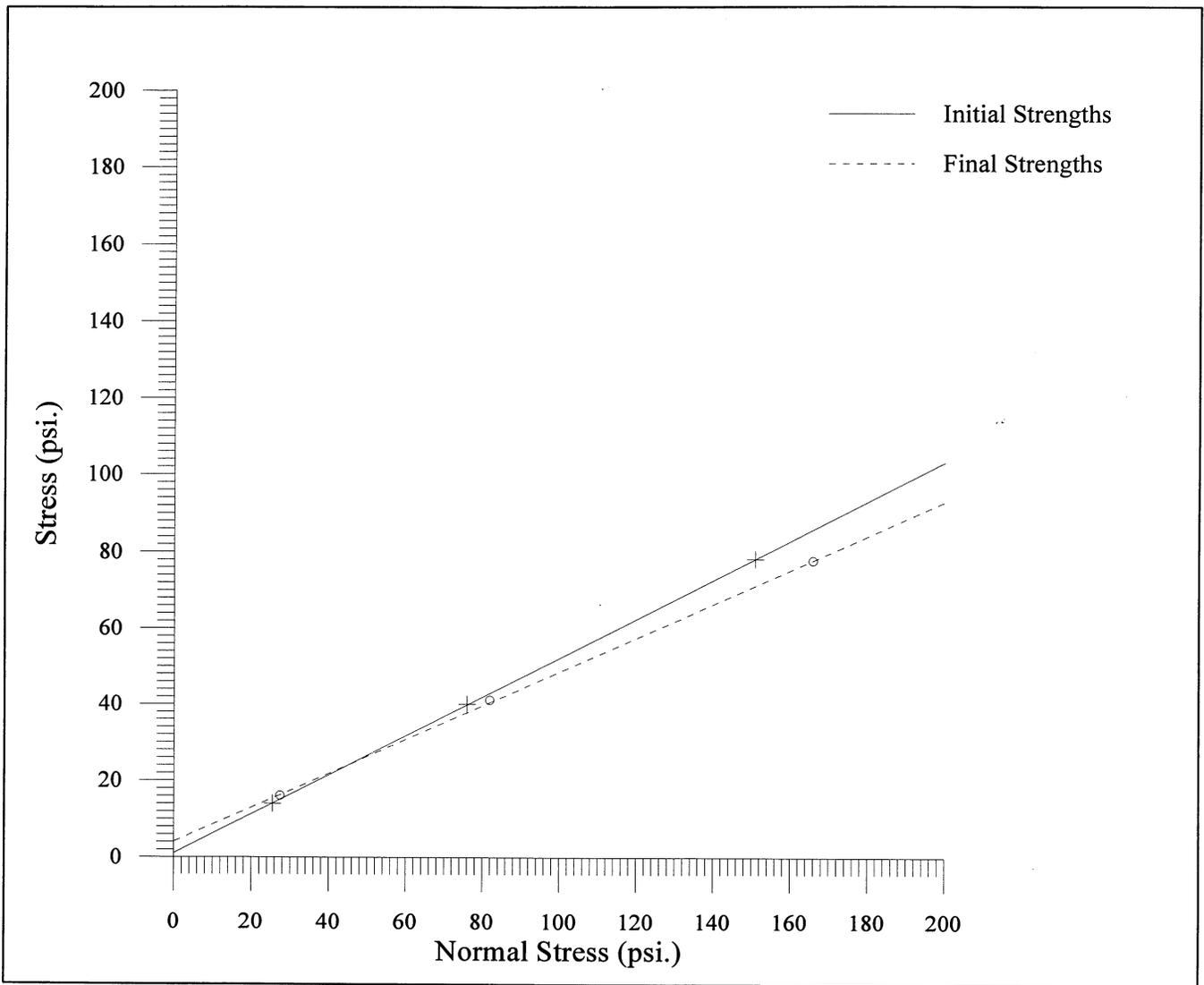
Sj: \_\_\_\_\_

phi: \_\_\_\_\_



**DIRECT SHEAR TEST**  
**Shear and Normal Stress vs. Shear Displacement**

<p><b>SAMPLE ID:</b> Boring: 98-21  Sample: 36b  Depth: 135.5'</p> <p align="center"><b>DESCRIPTION</b></p> Planar bedding plane joint in a thin dark gray claystone bed.	<p align="center"><b>Geo</b>  <b>Test</b>  <b>Unlimited</b> 800 Peralta Ave  San Leandro, CA 94577</p>																		
	<p><b>Client:</b> Fugro West, Inc.  5855 Olivas Park Dr.  Ventura, CA 93003</p>																		
	<p><b>Project:</b> San Francisco Oakland Bay Bridge  East Span Replacement Project</p>																		
	<p><b>Job Number:</b> 98-42-0053</p>																		
	<p><b>Test Date:</b> October 29, 1998</p>																		
	<table border="1"> <thead> <tr> <th></th> <th>Normal Stress</th> <th>Shear Strength</th> </tr> </thead> <tbody> <tr> <td rowspan="3">Initial</td> <td>25.5</td> <td>14</td> </tr> <tr> <td>76</td> <td>40</td> </tr> <tr> <td>151</td> <td>78</td> </tr> <tr> <td rowspan="3">Final</td> <td>27.5</td> <td>16</td> </tr> <tr> <td>82</td> <td>41</td> </tr> <tr> <td>166</td> <td>77.5</td> </tr> </tbody> </table>		Normal Stress	Shear Strength	Initial	25.5	14	76	40	151	78	Final	27.5	16	82	41	166	77.5	
	Normal Stress	Shear Strength																	
Initial	25.5	14																	
	76	40																	
	151	78																	
Final	27.5	16																	
	82	41																	
	166	77.5																	



**DIRECT SHEAR TEST  
Failure Envelope**

<p><b>SAMPLE ID:</b> Boring: 98-21 Sample: 36b Depth: 135.5'</p> <p align="center"><b>DESCRIPTION</b></p> <p>Planar bedding plane joint in a thin dark gray claystone bed.</p> <table border="1"> <thead> <tr> <th></th> <th>Shear Intercept (psi)</th> <th>Friction Angle (degrees)</th> </tr> </thead> <tbody> <tr> <td>Initial</td> <td>1.1</td> <td>27.0</td> </tr> <tr> <td>Final</td> <td>4.1</td> <td>23.9</td> </tr> </tbody> </table>		Shear Intercept (psi)	Friction Angle (degrees)	Initial	1.1	27.0	Final	4.1	23.9	<p align="center"> <i>Geo</i>  <i>Test</i>  <b>Unlimited</b> 800 Peralta Ave  San Leandro, CA 94577 </p>
		Shear Intercept (psi)	Friction Angle (degrees)							
Initial	1.1	27.0								
Final	4.1	23.9								
<p><b>Client:</b> Fugro West, Inc. 5855 Olivas Park Dr. Ventura, CA 93003</p> <p><b>Project:</b> San Francisco Oakland Bay Bridge East Span Replacement Project</p> <p><b>Job Number:</b> 98-42-0053</p> <p><b>Test Date:</b> October 29, 1998</p>										

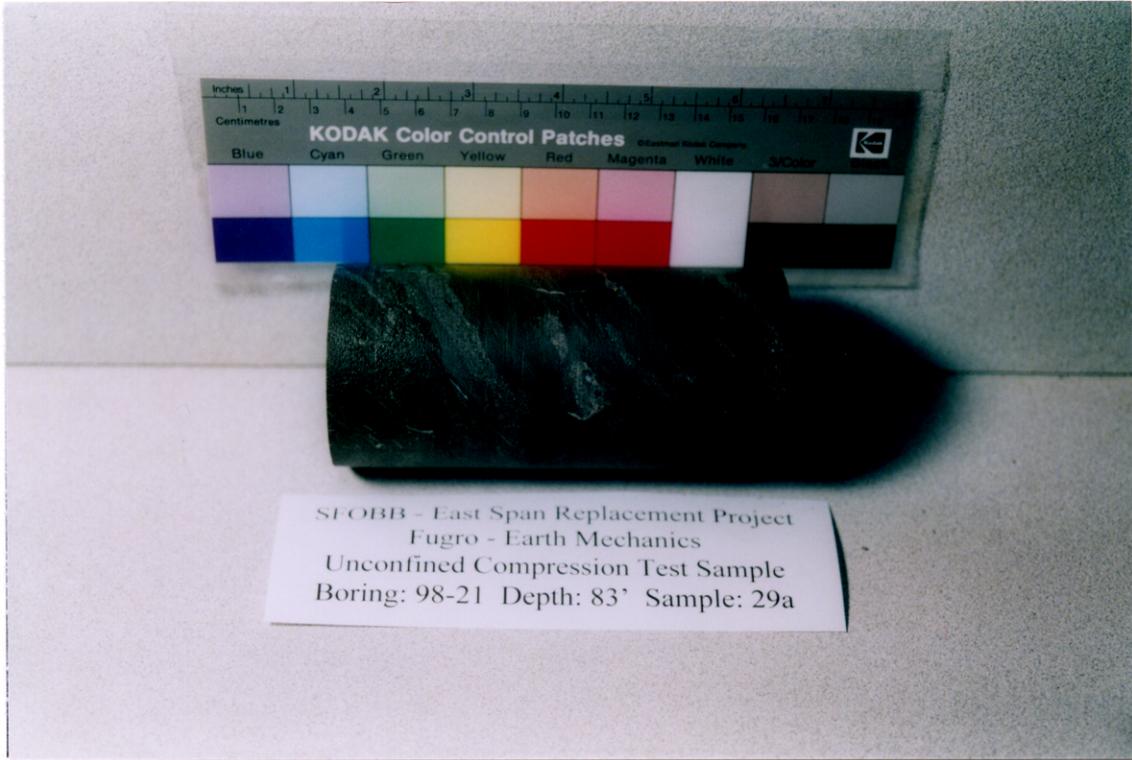
# Photographs



SFOBB - East Span Replacement Project  
Fugro - Earth Mechanics  
Unconfined Compression Test Sample  
Boring: 98-21 Depth: 72.5' Sample: 26a



SFOBB - East Span Replacement Project  
Fugro - Earth Mechanics  
Unconfined Compression Test Sample  
Boring: 98-21 Depth: 72.5' Sample: 26a





SFOBB - East Span Replacement Project  
Fugro - Earth Mechanics  
Unconfined Compression Test Sample  
Boring: 98-21 Depth: 97' Sample: 31a



SFOBB - East Span Replacement Project  
Fugro - Earth Mechanics  
Unconfined Compression Test Sample  
Boring: 98-21 Depth: 97' Sample: 31a

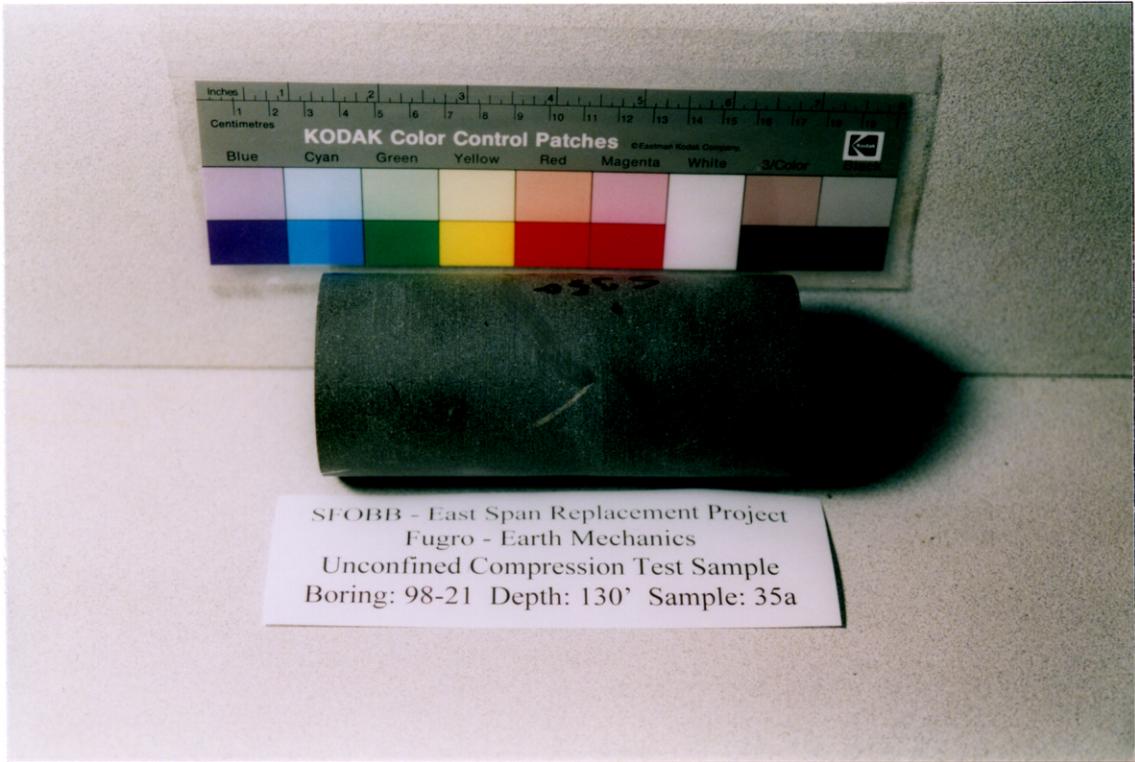


SFOBB - East Span Replacement Project  
Fugro - Earth Mechanics  
Unconfined Compression Test Sample  
Boring: 98-21 Depth: 106.5' Sample: 32a



SFOBB - East Span Replacement Project  
Fugro - Earth Mechanics  
Unconfined Compression Test Sample  
Boring: 98-21 Depth: 106.5' Sample: 32a





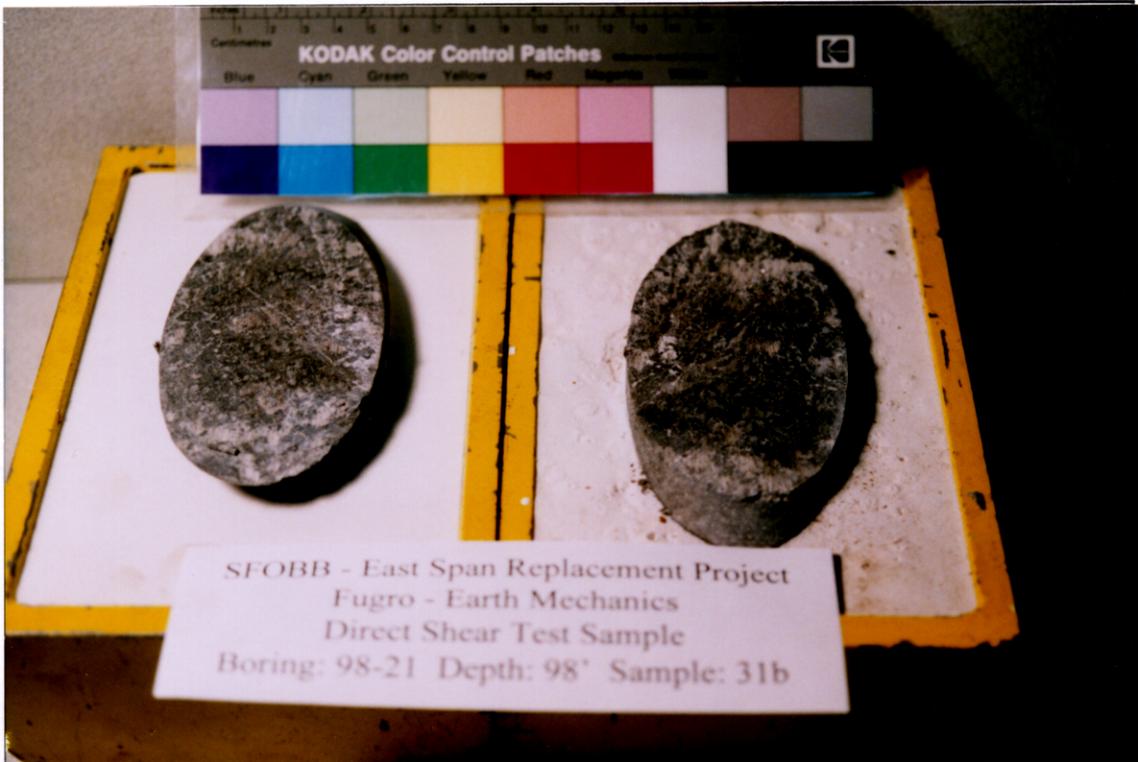
SFOBB - East Span Replacement Project  
Fugro - Earth Mechanics  
Unconfined Compression Test Sample  
Boring: 98-21 Depth: 130' Sample: 35a



SFOBB - East Span Replacement Project  
Fugro - Earth Mechanics  
Unconfined Compression Test Sample  
Boring: 98-21 Depth: 130' Sample: 35a



SFOBB - East Span Replacement Project  
Fugro - Earth Mechanics  
Direct Shear Test Sample  
Boring: 98-21 Depth: 45' Sample: 20a

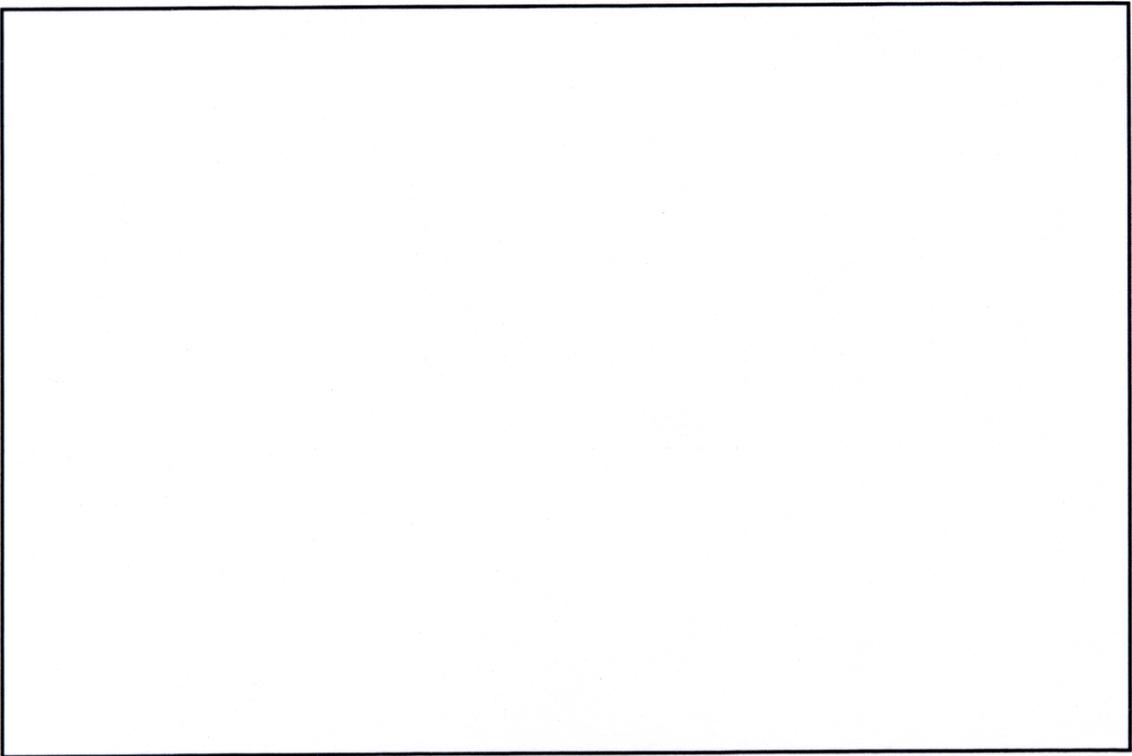


SFOBB - East Span Replacement Project  
Fugro - Earth Mechanics  
Direct Shear Test Sample  
Boring: 98-21 Depth: 98' Sample: 31b





SFOBB - East Span Replacement Project  
Fugro - Earth Mechanics  
Direct Shear Test Sample  
Boring: 98-21 Depth: 135.5' Sample: 36b



**BORING 98-22**

## **Modulus and Unconfined Compression Tests**

DATA SHEET

Determination of Rock Modulus and Poisson's Ratio (ASTM D3148)

Date: 10/18-19/98

Person performing the test: A. Bro

Client: Fugro

Job: #92-SFOBB

Sample ID: B98-22 516a

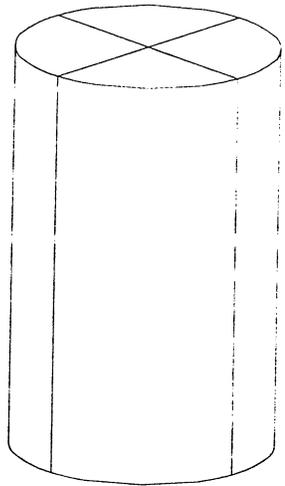
Sample Description: Tan massive sandstone (unfractured)

Sample Depth: 35'

Sample Condition: received & tested moist

d <sub>1</sub>	d <sub>2</sub>
2.396	2.390
2.395	2.395
2.397	2.396
2.395	2.397
2.393	2.393

l <sub>1</sub>	l <sub>2</sub>
-.0011	-.0001
±.0001	±.0001
+.0010	.0



Avg. diameter: 2.395

Avg. length: 4.792

Sample area: 4.505

l/d ratio: 2.00 in

Sample volume(in<sup>3</sup>): 21.588

moist

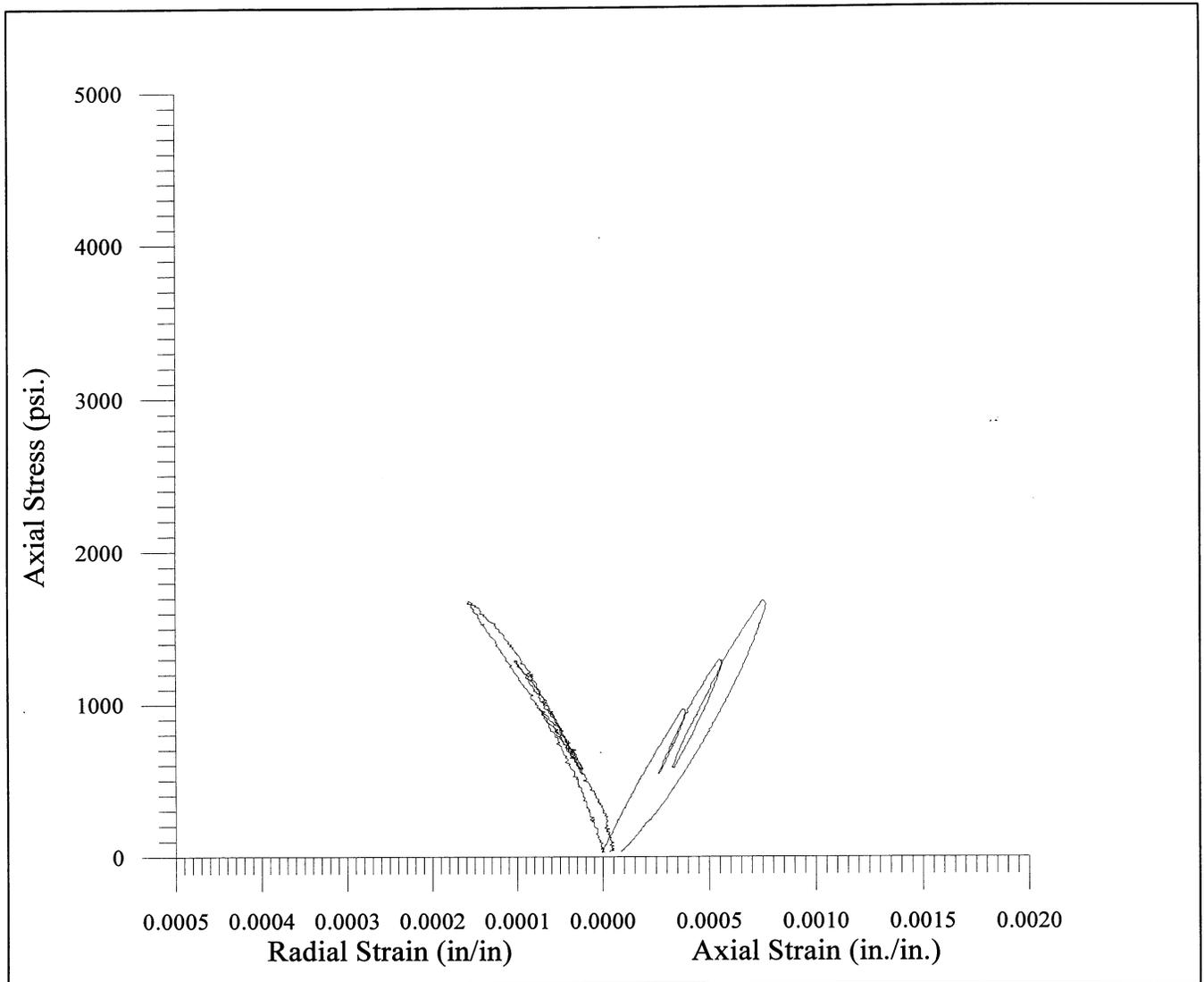
Sample weight (g): 931.2g

Density: 43.138/in<sup>3</sup> = 164.3pcf (1 g/in<sup>3</sup>=3.8095lb/ft<sup>3</sup>)

Gauge length: 2.00 in

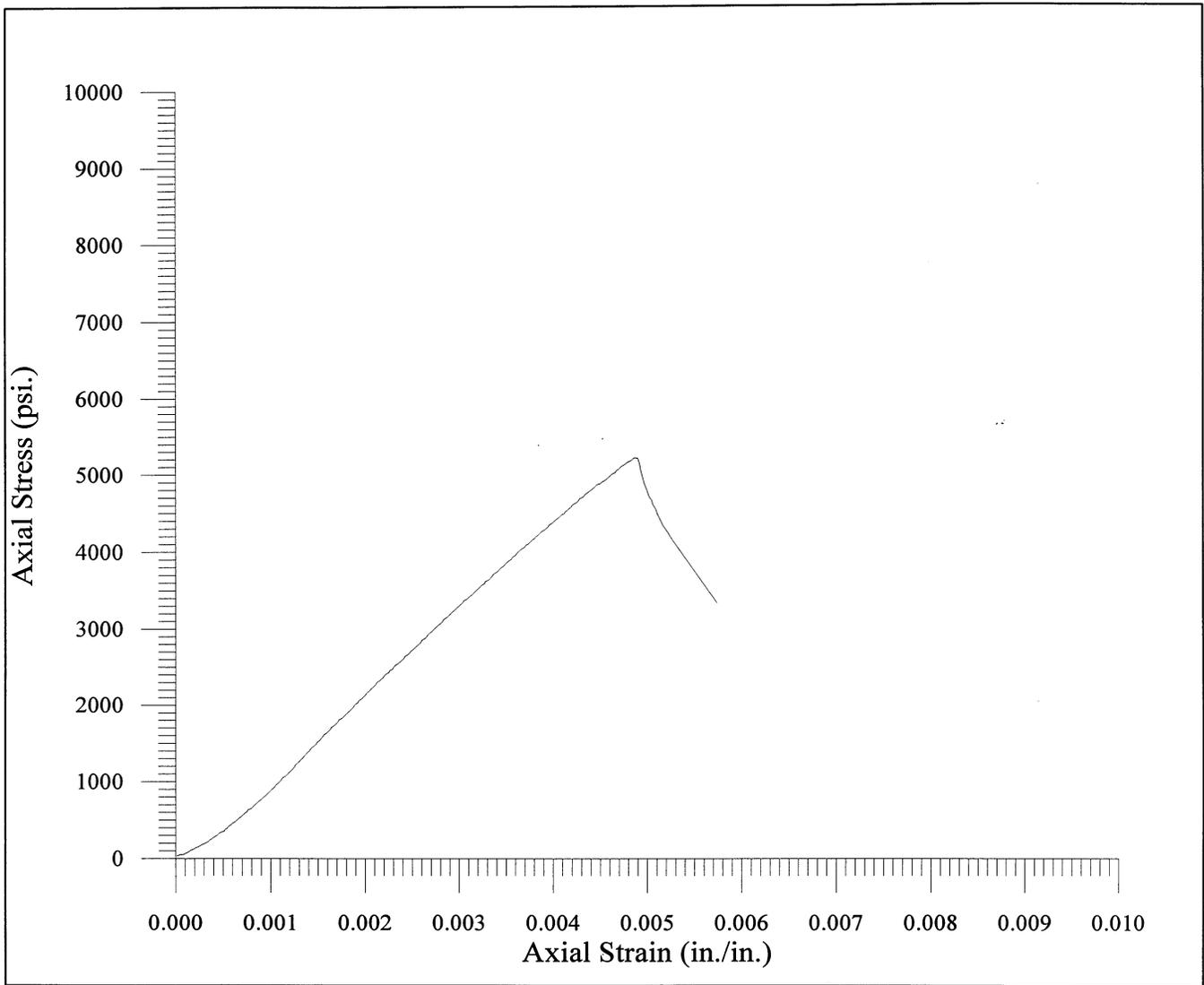
Comments: Failed by shear

\_\_\_\_\_  
 \_\_\_\_\_  
 \_\_\_\_\_  
 \_\_\_\_\_  
 \_\_\_\_\_



**ELASTIC MODULUS TEST**  
**Axial Stress vs. Axial & Radial Strain**

<p><b>SAMPLE ID:</b> Boring: 98-22  Sample: 16a  Depth: 35'</p> <p align="center"><b>DESCRIPTION</b></p> <p>Tan weathered massive sandstone.</p> <p><b>MODULUS:</b> 2,780,000 psi  <b>POISSON'S RATIO:</b> .31</p>	<p align="center"> <i>Geo</i>  <i>U</i>  <i>Test</i>  <b>Unlimited</b> </p> <p align="right">800 Peralta Ave  San Leandro, CA 94577</p>
	<p><b>Client:</b> Fugro West, Inc.  5855 Olivas Park Dr.  Ventura, CA 93003</p> <p><b>Project:</b> San Francisco Oakland Bay Bridge  East Span Replacement Project</p> <p><b>Job Number:</b> 98-42-0053</p>
	<p><b>Test Date:</b> October 18, 1998</p>



**UNCONFINED COMPRESSION TEST**  
**Axial Stress vs. Axial Strain**

<p><b>SAMPLE ID:</b> Boring : 98-22 Sample: 16a Depth: 35'</p> <p style="text-align: center;"><b>DESCRIPTION</b></p> <p style="text-align: center;">Tan weathered massive sandstone.</p> <p><b>STRENGTH:</b> 5217 psi</p>	<div style="text-align: center;">  </div> <p style="text-align: right;">800 Peralta Ave San Leandro, CA 94577</p> <hr/> <p><b>Client:</b> Fugro West, Inc. 5855 Olivas Park Dr. Ventura, CA 93003</p> <p><b>Project:</b> San Francisco Oakland Bay Bridge East Span Replacement Project</p> <p><b>Job Number:</b> 98-42-0053</p> <hr/> <p><b>Test Date:</b> October 19, 1998</p>
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DATA SHEET

Determination of Rock Modulus and Poisson's Ratio (ASTM D3148)

Date: 10/18/98

Person performing the test: A. Boo

Client: Fugro

Job: #92-SFOBB

Sample ID: B98-22 S17a

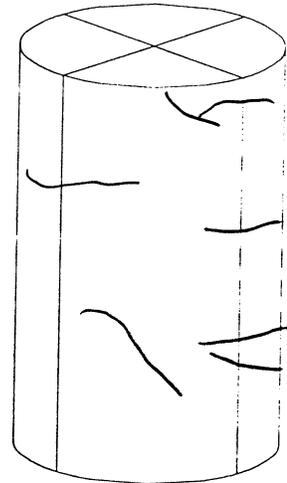
Sample Description: Olive tan, sandy siltstone with a few yellowish tan fine sandstone inclusions (turbidite). Contains a few partially healed fractures

Sample Depth: 38.5'

Sample Condition: received & tested moist

d <sub>1</sub>	d <sub>2</sub>
2.378	2.386
2.382	2.384
2.381	2.385
2.382	2.380
2.386	2.388

l <sub>1</sub>	l <sub>2</sub>
-.0011	-.0002
±.0001	±.0001
+.0012	+.0002



Avg. diameter: 2.383

Avg. length: 5.332

Sample area: 4.460

l/d ratio: 2.24

Sample volume(in<sup>3</sup>): 23.781

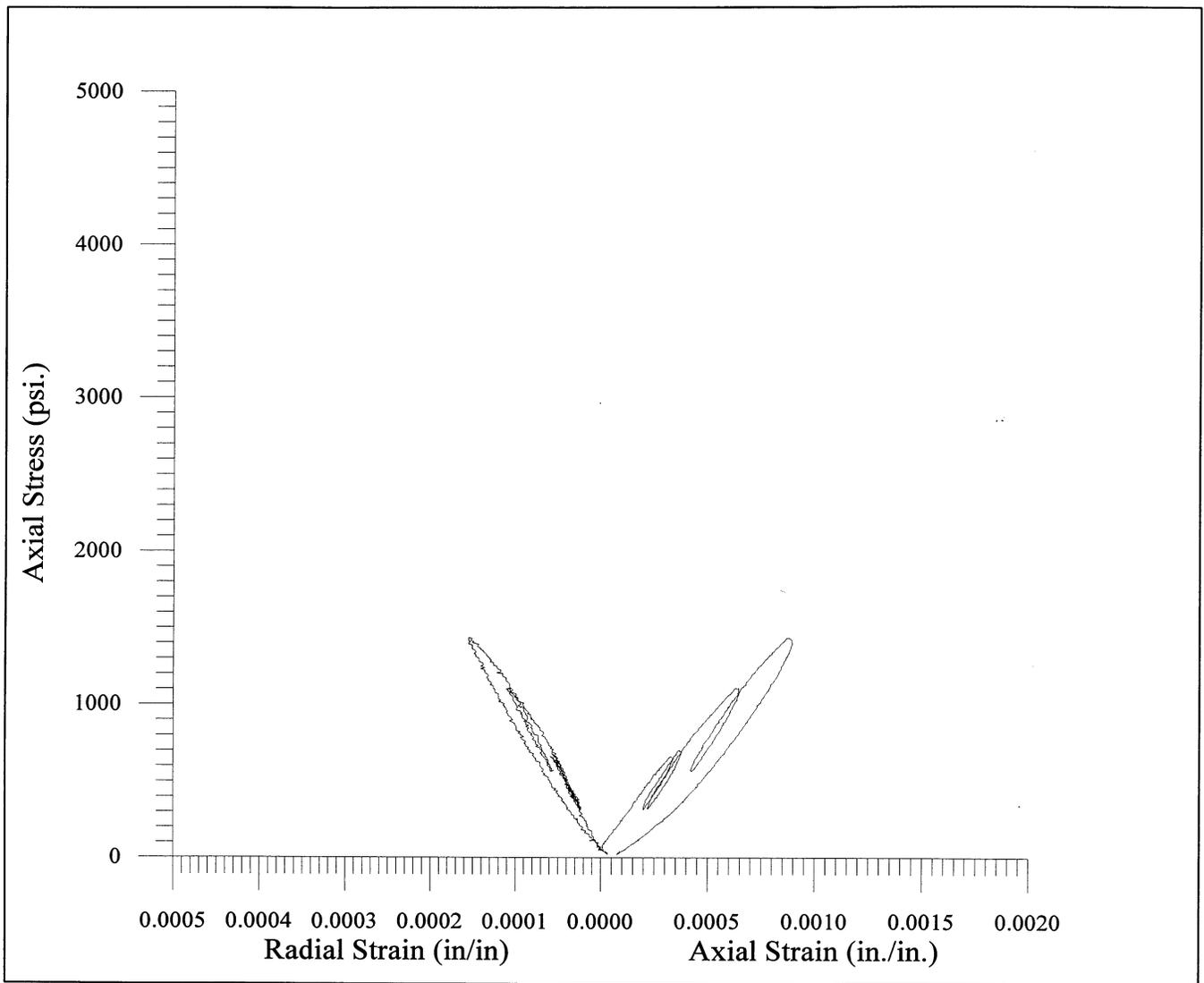
moist Sample weight (g): 1014.5g

Density: 42.66g/in<sup>3</sup> = 162.5pcf (1 g/in<sup>3</sup>=3.8095lb/ft<sup>3</sup>)

Gauge length: 2000 in.

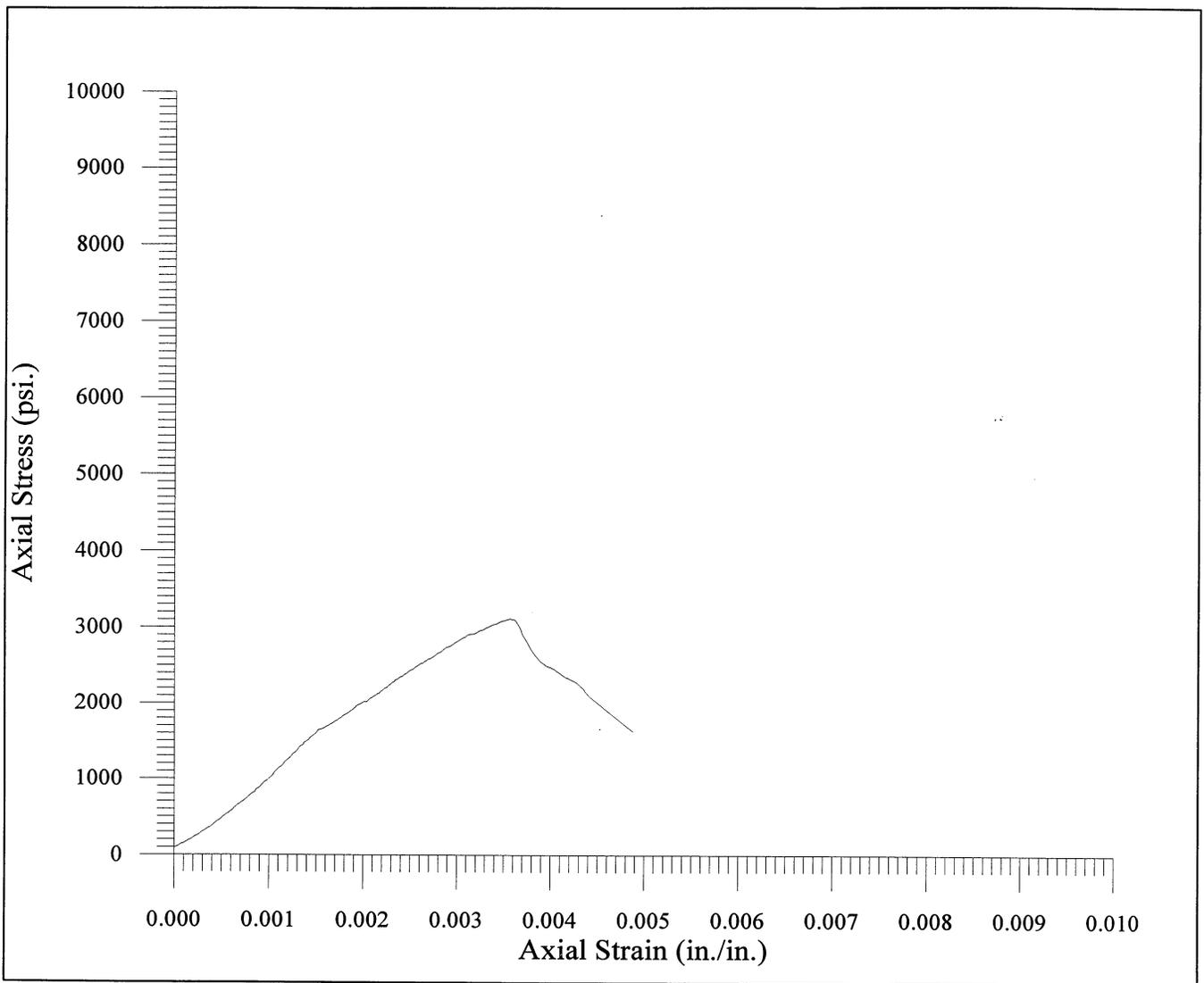
Comments: Failed by shear and a small amount of axial splitting

\_\_\_\_\_  
 \_\_\_\_\_  
 \_\_\_\_\_



**ELASTIC MODULUS TEST**  
**Axial Stress vs. Axial & Radial Strain**

<p><b>SAMPLE ID:</b> Boring: 98-22          Sample: 17a          Depth: 38.5'</p>	<p align="center"> <i>Geo</i>  <i>U</i>  <i>Test</i>  <b>Unlimited</b> 800 Peralta Ave          San Leandro, CA 94577       </p>
<p align="center"><b>DESCRIPTION</b></p> <p>Olive gray sandy siltstone with a few yellowish tan fine sandstone inclusions and a few partially healed fractures.</p> <p><b>MODULUS:</b> 2,240,000 psi  <b>POISSON'S RATIO:</b> .20</p>	
<p><b>Test Date:</b> October 18, 1998</p>	



**UNCONFINED COMPRESSION TEST**  
**Axial Stress vs. Axial Strain**

**SAMPLE ID:** Boring : 98-22  
 Sample: 17a  
 Depth: 38.5'

**DESCRIPTION**

Olive gray sandy siltstone with a few yellowish tan fine sandstone inclusions and a few partially healed fractures.

**STRENGTH:** 3111 psi

  
**800 Peralta Ave**  
**San Leandro, CA 94577**

---

**Client:** **Fugro West, Inc.**  
**5855 Olivas Park Dr.**  
**Ventura, CA 93003**

**Project:** **San Francisco Oakland Bay Bridge**  
**East Span Replacement Project**

**Job Number:** **98-42-0053**

---

**Test Date:** **October 19, 1998**

**DATA SHEET**

**Determination of Rock Modulus and Poisson's Ratio (ASTM D3148)**

Date: 10/18 & 19/98

Person performing the test: A. Bro

Client: Fujio

Job: #92-SFOBB

Sample ID: B98-22 518a

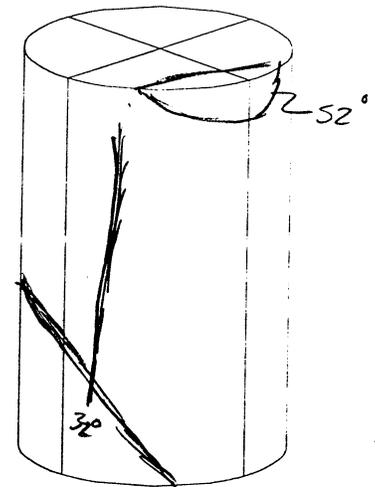
Sample Description: medium gray sandstone with calcite healed axial fracture and two healed diagonal fractures 53° E. 32° to core axis

Sample Depth: 48"

Sample Condition: received & tested moist

d <sub>1</sub>	d <sub>2</sub>
2.399	2.397
2.396	2.399
2.400	2.401
2.401	2.401
2.401	2.402

l <sub>1</sub>	l <sub>2</sub>
-0.0007	0
±0.0001	±0.0001
+0.0007	0



Avg. diameter: 2.400

Avg. length: 5.306

Sample area: 4.524

l/d ratio: 2.21

Sample volume(in<sup>3</sup>): 24.004

moist

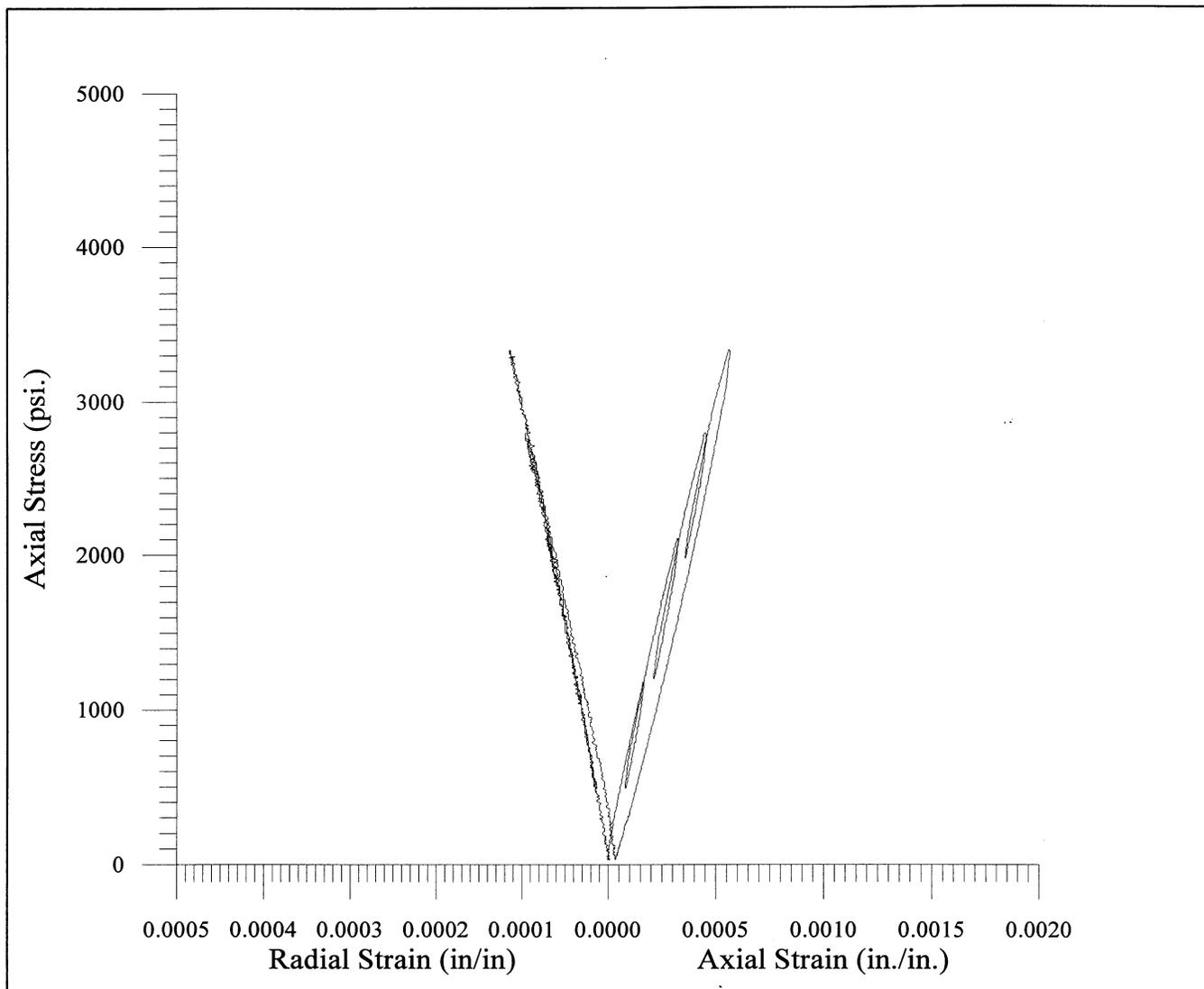
Sample weight (g): 1058.48

Density: 44.09g/in<sup>3</sup> = 168.0 (1 g/in<sup>3</sup> = 3.8095 lb/ft<sup>3</sup>)

Gauge length: 2.000 in

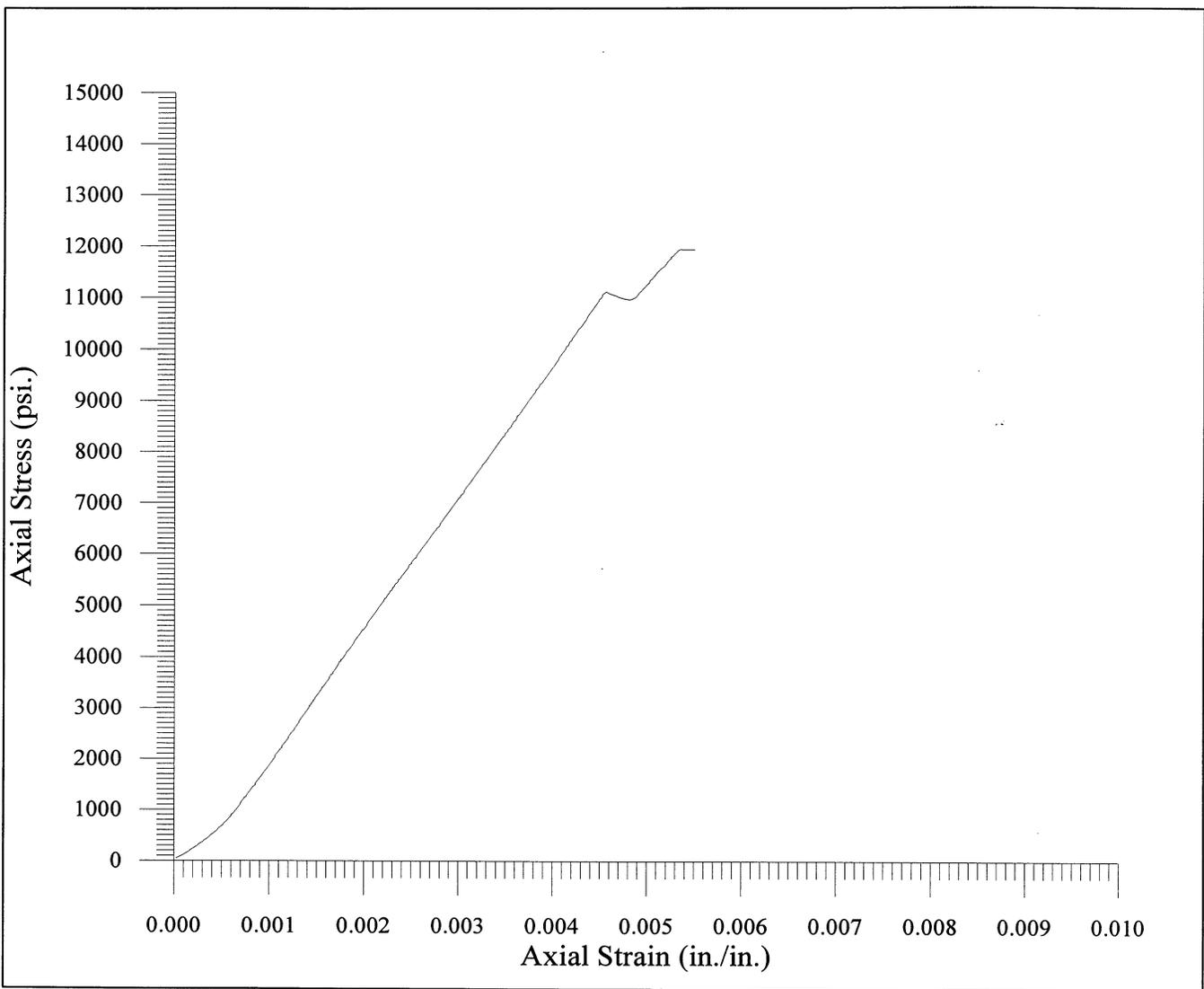
Comments: Failed by axial splitting & shear along 32° joint

\_\_\_\_\_  
 \_\_\_\_\_  
 \_\_\_\_\_  
 \_\_\_\_\_



**ELASTIC MODULUS TEST**  
**Axial Stress vs. Axial & Radial Strain**

<p><b>SAMPLE ID:</b> Boring: 98-22  Sample: 18a  Depth: 48'</p> <p style="text-align: center;"><b>DESCRIPTION</b></p> <p>Medium gray sandstone with calcite healed fractures 0, 32, and 53 degrees to the core axis.</p> <p><b>MODULUS:</b> 7,580,000 psi  <b>POISSON'S RATIO:</b> .25</p>	<div style="text-align: center;">  <p><b>Geo Test Unlimited</b></p> </div> <p style="text-align: right;">800 Peralta Ave  San Leandro, CA 94577</p> <hr/> <p><b>Client:</b> Fugro West, Inc.  5855 Olivas Park Dr.  Ventura, CA 93003</p> <p><b>Project:</b> San Francisco Oakland Bay Bridge  East Span Replacement Project</p> <p><b>Job Number:</b> 98-42-0053</p> <hr/> <p><b>Test Date:</b> October 18, 1998</p>
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**UNCONFINED COMPRESSION TEST**  
**Axial Stress vs. Axial Strain**

<p><b>SAMPLE ID:</b> Boring : 98-22          Sample: 18a          Depth: 48'</p>	<p align="center"> <i>Geo</i>  <i>Test</i>  <b>Unlimited</b> 800 Peralta Ave          San Leandro, CA 94577       </p>
<p align="center"><b>DESCRIPTION</b></p> <p>Medium gray sandstone with calcite healed fractures 0, 32, and 53 degrees to the core axis.</p> <p><b>STRENGTH:</b> 11,934 psi</p>	<p><b>Client:</b> Fugro West, Inc.          5855 Olivas Park Dr.          Ventura, CA 93003</p> <p><b>Project:</b> San Francisco Oakland Bay Bridge          East Span Replacement Project</p> <p><b>Job Number:</b> 98-42-0053</p>
	<p><b>Test Date:</b> October 19, 1998</p>

DATA SHEET

Determination of Rock Modulus and Poisson's Ratio (ASTM D3148)

Date: 10/18 & 19/1998

Person performing the test: A. Bro

Client: Fugro

Job: #92-SFOBB

Sample ID: B98-22 S20a

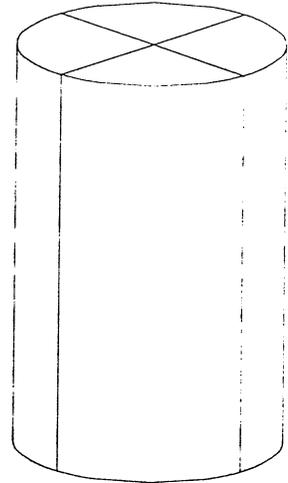
Sample Description: medium gray massive sandy siltstone with a few small chert inclusions.

Sample Depth: 59'

Sample Condition: received & tested moist

d <sub>1</sub>	d <sub>2</sub>
2.399	2.396
2.399	2.394
2.397	2.394
2.397	2.394
2.395	2.392

l <sub>1</sub>	l <sub>2</sub>
- .0008	0
± .0001	± .0001
± .0007	0



Avg. diameter: 2.396

Avg. length: 5.267

Sample area: 4.509

l/d ratio: 2.20

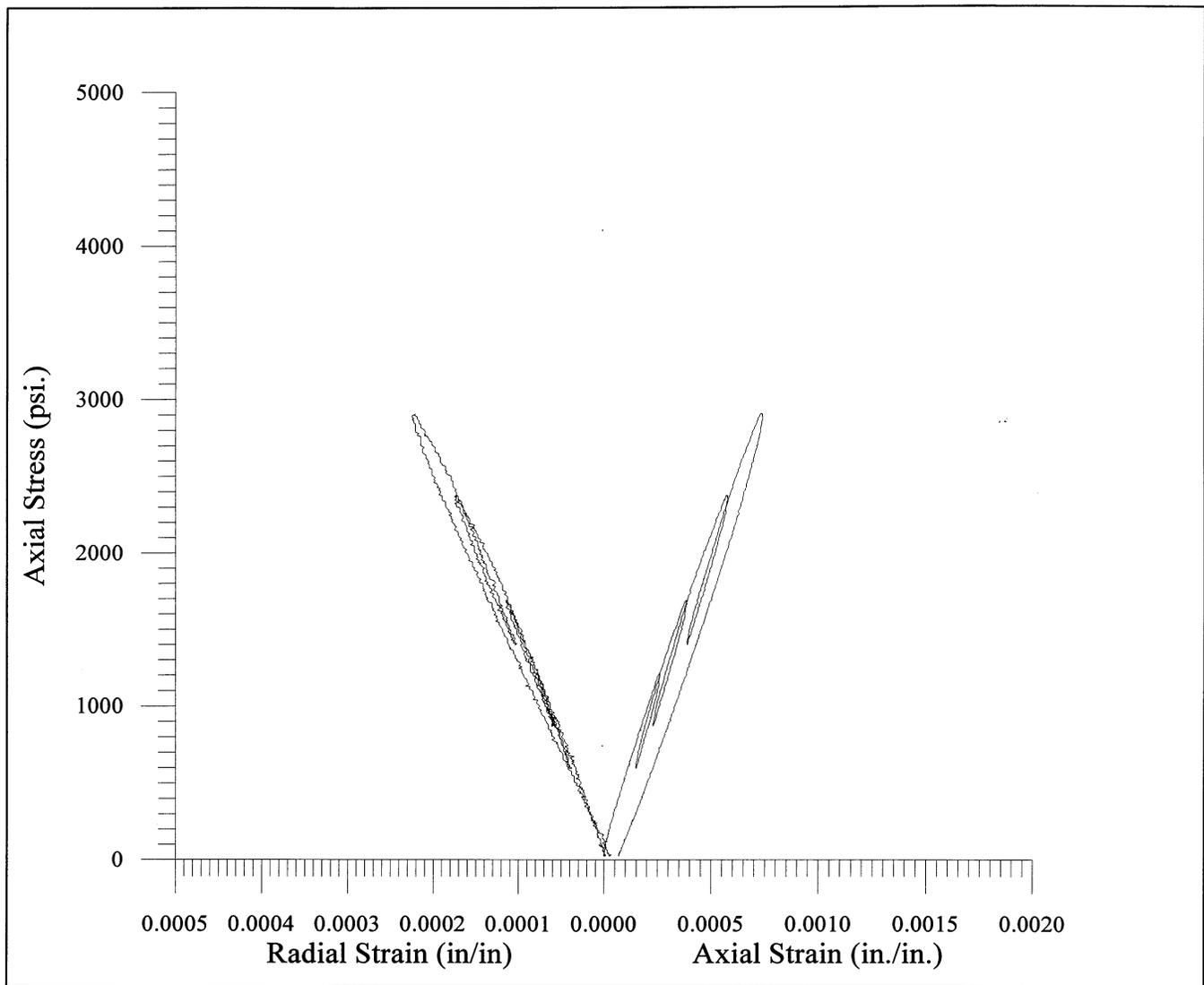
Sample volume (in<sup>3</sup>): 23.748

moist Sample weight (g): 1049.0

Density: 44.178/in<sup>3</sup> = 168.3 pcf (1 g/in<sup>3</sup> = 3.8095 lb/ft<sup>3</sup>)

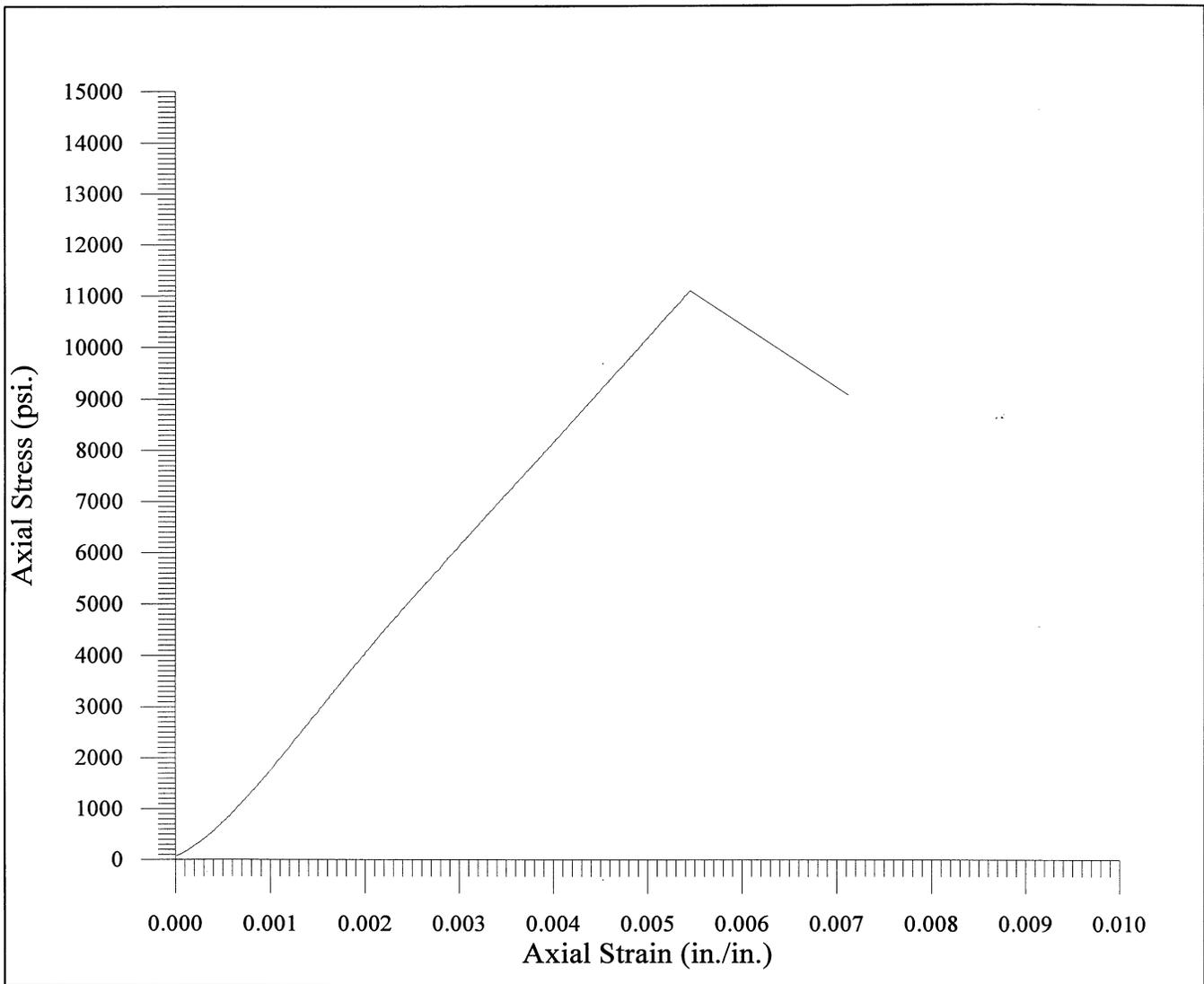
Gauge length: 2.000 in

Comments: Failed by diagonal shear (probably a non visible joint) and axial splitting.



**ELASTIC MODULUS TEST**  
**Axial Stress vs. Axial & Radial Strain**

<p><b>SAMPLE ID:</b> Boring: 98-22  Sample: 20a  Depth: 59'</p> <p><b>DESCRIPTION</b>  Medium gray massive sandy siltstone with a few small claystone inclusions.</p> <p><b>MODULUS:</b> 4,900,000 psi  <b>POISSON'S RATIO:</b> .34</p>	<p align="center"> <i>Geo</i>  <i>Test</i>  <b>Unlimited</b> 800 Peralta Ave  San Leandro, CA 94577</p> <hr/> <p><b>Client:</b> Fugro West, Inc.  5855 Olivas Park Dr.  Ventura, CA 93003</p> <p><b>Project:</b> San Francisco Oakland Bay Bridge  East Span Replacement Project</p> <p><b>Job Number:</b> 98-42-0053</p> <hr/> <p><b>Test Date:</b> October 18, 1998</p>
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**UNCONFINED COMPRESSION TEST**  
**Axial Stress vs. Axial Strain**

<p><b>SAMPLE ID:</b> Boring : 98-22 Sample: 20a Depth: 59'</p> <p style="text-align: center;"><b>DESCRIPTION</b></p> <p>Medium gray massive sandy siltstone with a few small claystone inclusions.</p> <p><b>STRENGTH:</b> 11,087 psi</p>	<div style="text-align: center;">  <p><b>Geo Test Unlimited</b></p> </div> <p style="text-align: right;">800 Peralta Ave San Leandro, CA 94577</p> <hr/> <p><b>Client:</b> Fugro West, Inc. 5855 Olivas Park Dr. Ventura, CA 93003</p> <p><b>Project:</b> San Francisco Oakland Bay Bridge East Span Replacement Project</p> <p><b>Job Number:</b> 98-42-0053</p> <hr/> <p><b>Test Date:</b> October 19, 1998</p>
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DATA SHEET

Determination of Rock Modulus and Poisson's Ratio (ASTM D3148)

Date: 10/18 & 19/98

Person performing the test: A. Bro

Client: Fugro

Job: #92-SFOBB

Sample ID: B98-22 S 21a

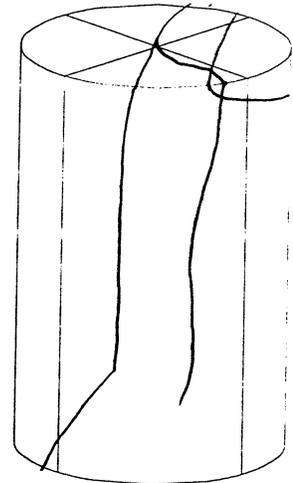
Sample Description: medium gray sandstone with a few calcite healed (partially) axial fractures

Sample Depth: 70'

Sample Condition: received & tested moist

d <sub>1</sub>	d <sub>2</sub>
2.397	2.395
2.401	2.401
2.403	2.403
2.403	2.402
2.401	2.402

l <sub>1</sub>	l <sub>2</sub>
-0.0008	-0.0003
±0.0001	±0.0001
+0.0007	+0.0001



Avg. diameter: 2.401

Avg. length: 5.246

Sample area: 4.528

l/d ratio: 2.18

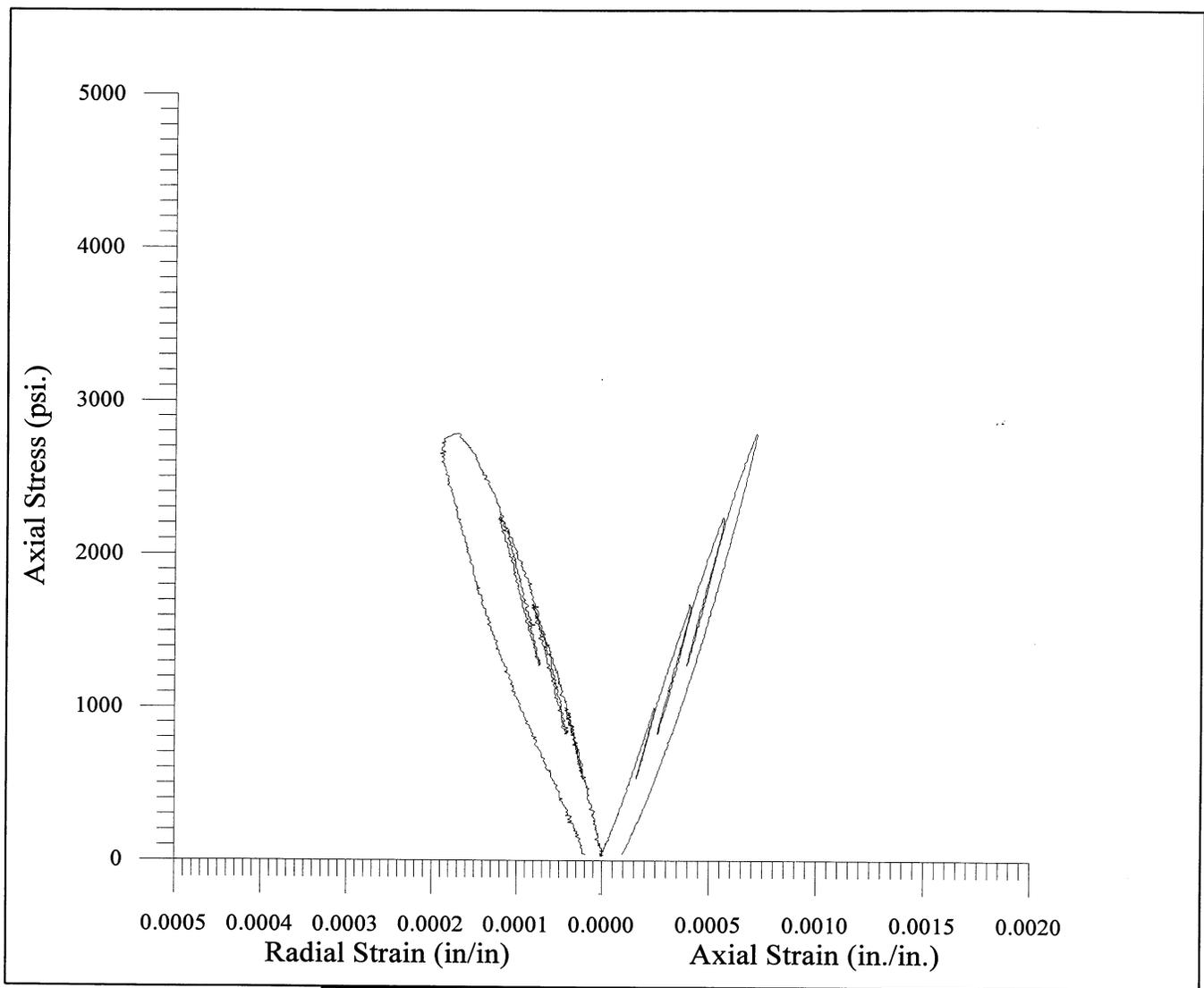
Sample volume(in<sup>3</sup>): 23.752

moist Sample weight (g): 1044.2g

Density: 43.968/in<sup>3</sup> = 167.5 pcf (1 g/in<sup>3</sup> = 3.8095 lb/ft<sup>3</sup>)

Gauge length: 2000 in

Comments: Failed by shear on existing joint



**ELASTIC MODULUS TEST**  
**Axial Stress vs. Axial & Radial Strain**

**SAMPLE ID:** Boring: 98-22  
 Sample: 21a  
 Depth: 70'

**DESCRIPTION**  
 Medium gray sandstone with a few axial fractures partially healed with calcite.

**MODULUS:** 5,380,000 psi  
**POISSON'S RATIO:** .25

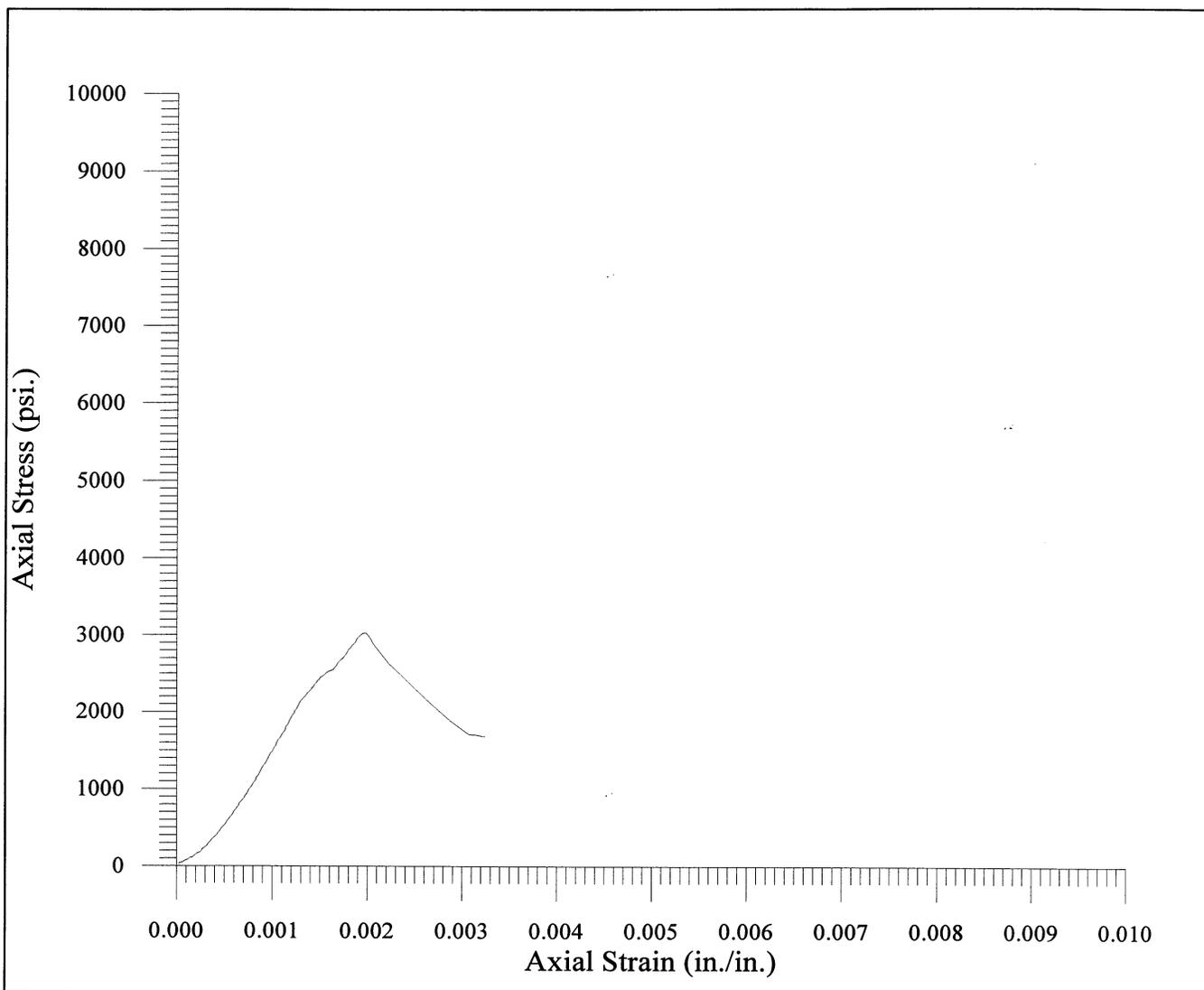
*Geo*  *Test*  
**Unlimited** 800 Peralta Ave  
 San Leandro, CA 94577

**Client:** Fugro West, Inc.  
 5855 Olivas Park Dr.  
 Ventura, CA 93003

**Project:** San Francisco Oakland Bay Bridge  
 East Span Replacement Project

**Job Number:** 98-42-0053

**Test Date:** October 18, 1998



**UNCONFINED COMPRESSION TEST**  
**Axial Stress vs. Axial Strain**

<p><b>SAMPLE ID:</b> Boring : 98-22          Sample: 21a          Depth: 70'</p> <p align="center"><b>DESCRIPTION</b></p> <p align="center">Medium gray sandstone with a few axial fractures partially healed with calcite.</p> <p><b>STRENGTH:</b> 3030 psi</p>	<p align="center"> <i>Geo</i>  <i>Test</i>  <b>Unlimited</b> </p> <p align="right">800 Peralta Ave          San Leandro, CA 94577</p> <hr/> <p><b>Client:</b> Fugro West, Inc.          5855 Olivas Park Dr.          Ventura, CA 93003</p> <p><b>Project:</b> San Francisco Oakland Bay Bridge          East Span Replacement Project</p> <p><b>Job Number:</b> 98-42-0053</p> <hr/> <p><b>Test Date:</b> October 19, 1998</p>
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DATA SHEET

Determination of Rock Modulus and Poisson's Ratio (ASTM D3148)

Date: 10/18 & 19/98

Person performing the test: A. Bro

Client: Fugro

Job: #92 - SFOIB

Sample ID: B98-22 SZ1a (b)

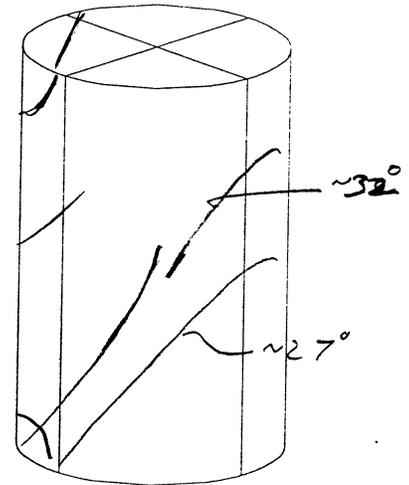
Sample Description: medium gray sandstone with a few diagonal calcite healed fractures

Sample Depth: 70.5'

Sample Condition: received & tested moist

d <sub>1</sub>	d <sub>2</sub>
2.403	2.403
2.400	2.402
2.403	2.403
2.403	2.400
2.402	2.401

l <sub>1</sub>	l <sub>2</sub>
-.0007	-.0001
±.0001	±.0001
+.0007	.0



Avg. diameter: 2.402

Avg. length: 5.198

Sample area: 4.531

l/d ratio: 2.16

Sample volume (in<sup>3</sup>): 23.554

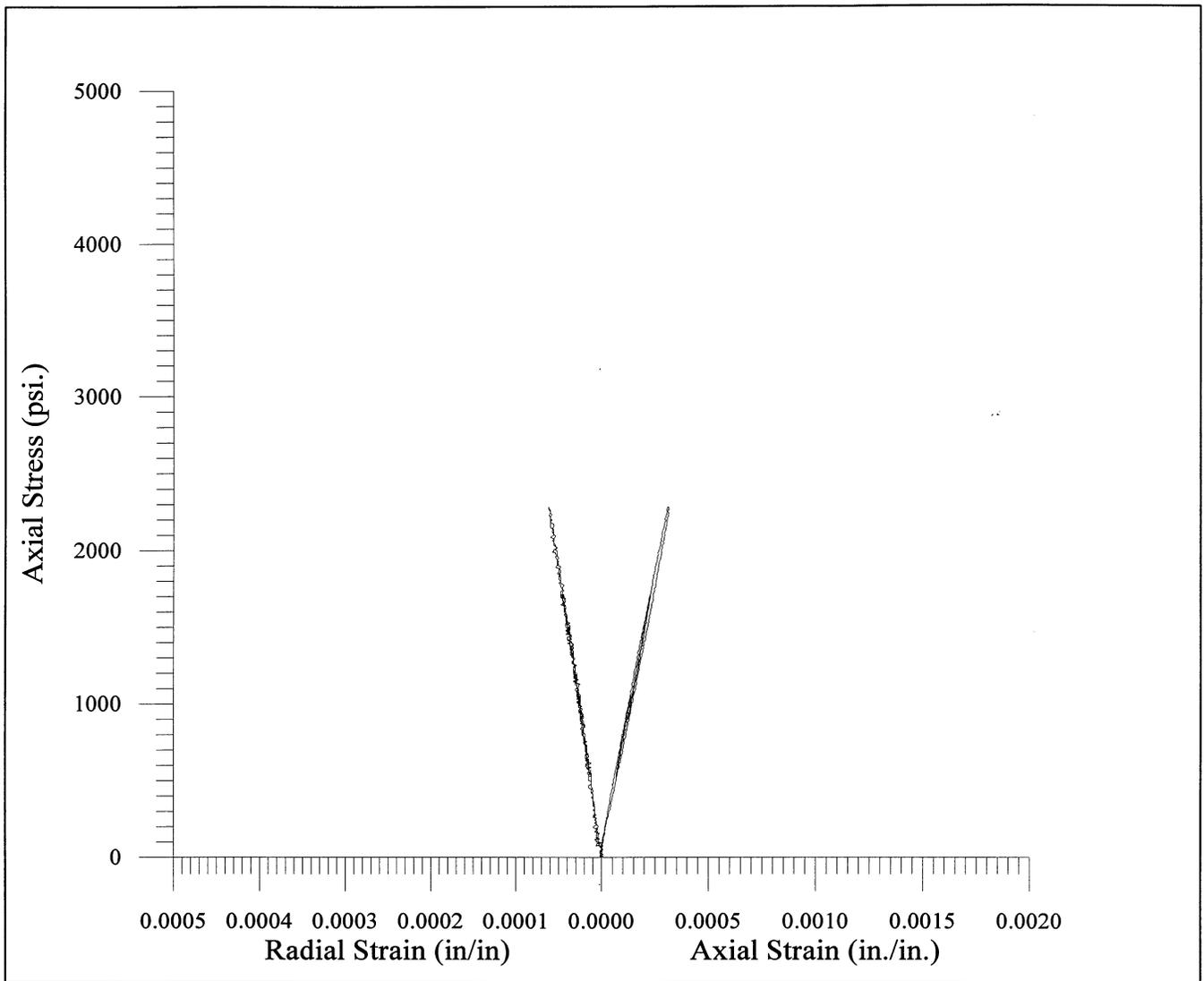
Sample weight (g): 1036.8g

Density: 44.02g/in<sup>3</sup> = 167.7pcf (1 g/in<sup>3</sup> = 3.8095 lb/ft<sup>3</sup>)

Gauge length: 2.000 in.

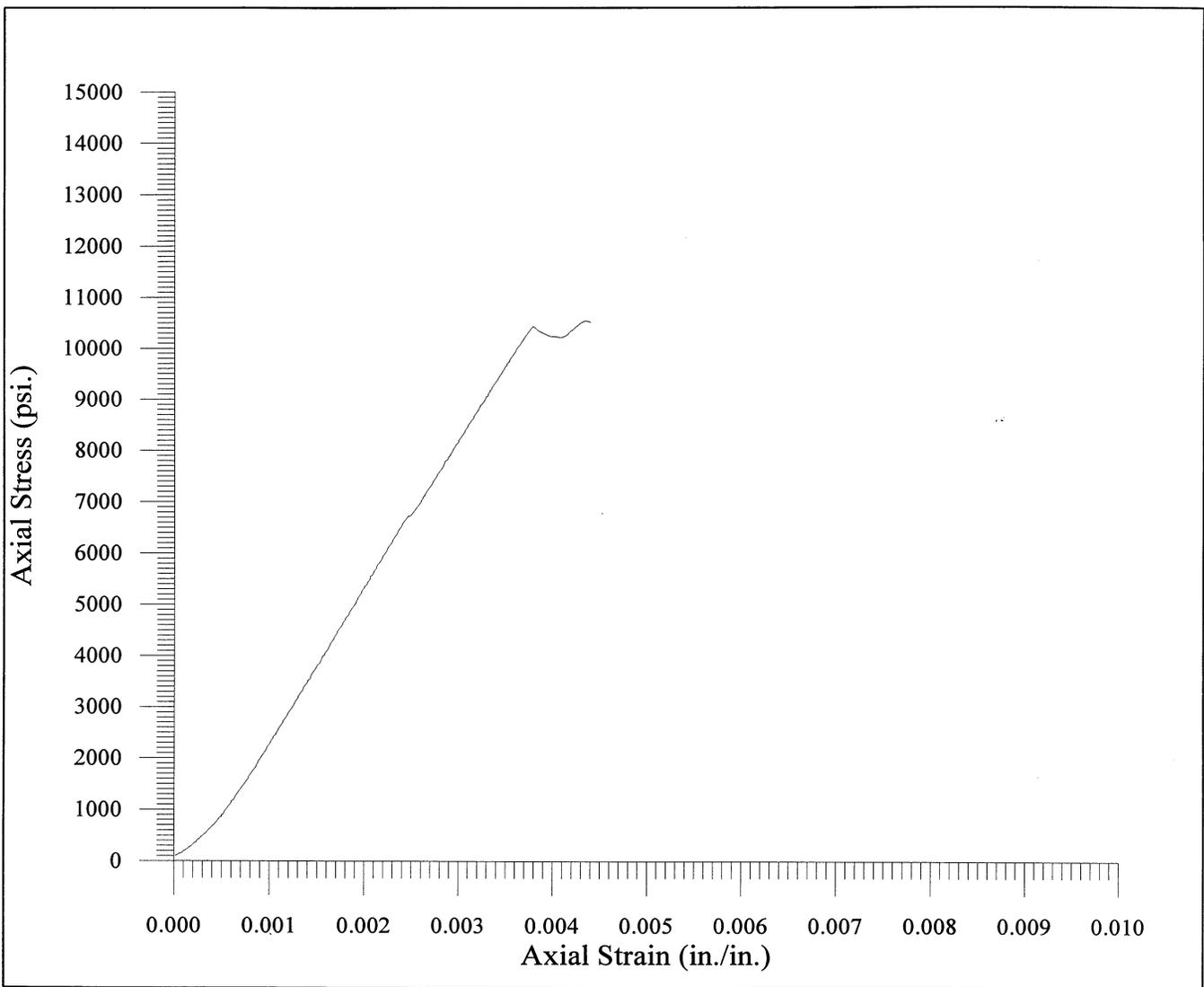
Comments: SZ1a, SZ1a (b) & SZ1a (c) were tested to investigate the sample variation in a very flat length. These samples were immediately adjacent to each other.

Failed by axial splitting.



**ELASTIC MODULUS TEST**  
**Axial Stress vs. Axial & Radial Strain**

<p><b>SAMPLE ID:</b> Boring: 98-22  Sample: 21a(b)  Depth: 70.5'</p> <p style="text-align: center;"><b>DESCRIPTION</b></p> <p>Medium gray sandstone with a few calcite healed fractures, 27 and 32 degrees to the core axis.</p> <p><b>MODULUS:</b> 7,690,000 psi  <b>POISSON'S RATIO:</b> .21</p>	<div style="text-align: center;">  </div> <p style="text-align: right;">800 Peralta Ave  San Leandro, CA 94577</p> <hr/> <p><b>Client:</b> Fugro West, Inc.  5855 Olivas Park Dr.  Ventura, CA 93003</p> <p><b>Project:</b> San Francisco Oakland Bay Bridge  East Span Replacement Project</p> <p><b>Job Number:</b> 98-42-0053</p> <hr/> <p><b>Test Date:</b> October 18, 1998</p>
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**UNCONFINED COMPRESSION TEST**  
**Axial Stress vs. Axial Strain**

**SAMPLE ID:** Boring : 98-22  
 Sample: 21a (b)  
 Depth: 70.5'

**DESCRIPTION**

Medium gray sandstone with a few calcite healed fractures, 27 and 32 degrees to the core axis.

**STRENGTH:** 10,543 psi



800 Peralta Ave  
 San Leandro, CA 94577

**Client:** Fugro West, Inc.  
 5855 Olivas Park Dr.  
 Ventura, CA 93003

**Project:** San Francisco Oakland Bay Bridge  
 East Span Replacement Project

**Job Number:** 98-42-0053

**Test Date:** October 19, 1998

DATA SHEET

Determination of Rock Modulus and Poisson's Ratio (ASTM D3148)

Date: 10/18 & 19/98

Person performing the test: A. B. B.

Client: Fugro

Job: #92-SFOBB

Sample ID: B98-22 521a (c)

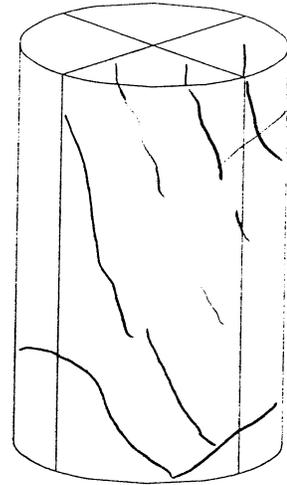
Sample Description: medium gray sandstone with many calcite healed hairline fractures, ~20° to the core axis

Sample Depth: 71'

Sample Condition: received & tested moist

d <sub>1</sub>	d <sub>2</sub>
2.402	2.401
2.400	2.401
2.401	2.402
2.402	2.402
2.401	2.403

l <sub>1</sub>	l <sub>2</sub>
-.0007	0
±.0001	±.0001
+.0008	0



Avg. diameter: 2.402

Avg. length: 5.220

Sample area: 4.531

l/d ratio: 2.17

Sample volume (in<sup>3</sup>): 23.654

Sample weight (g): 1044.2g

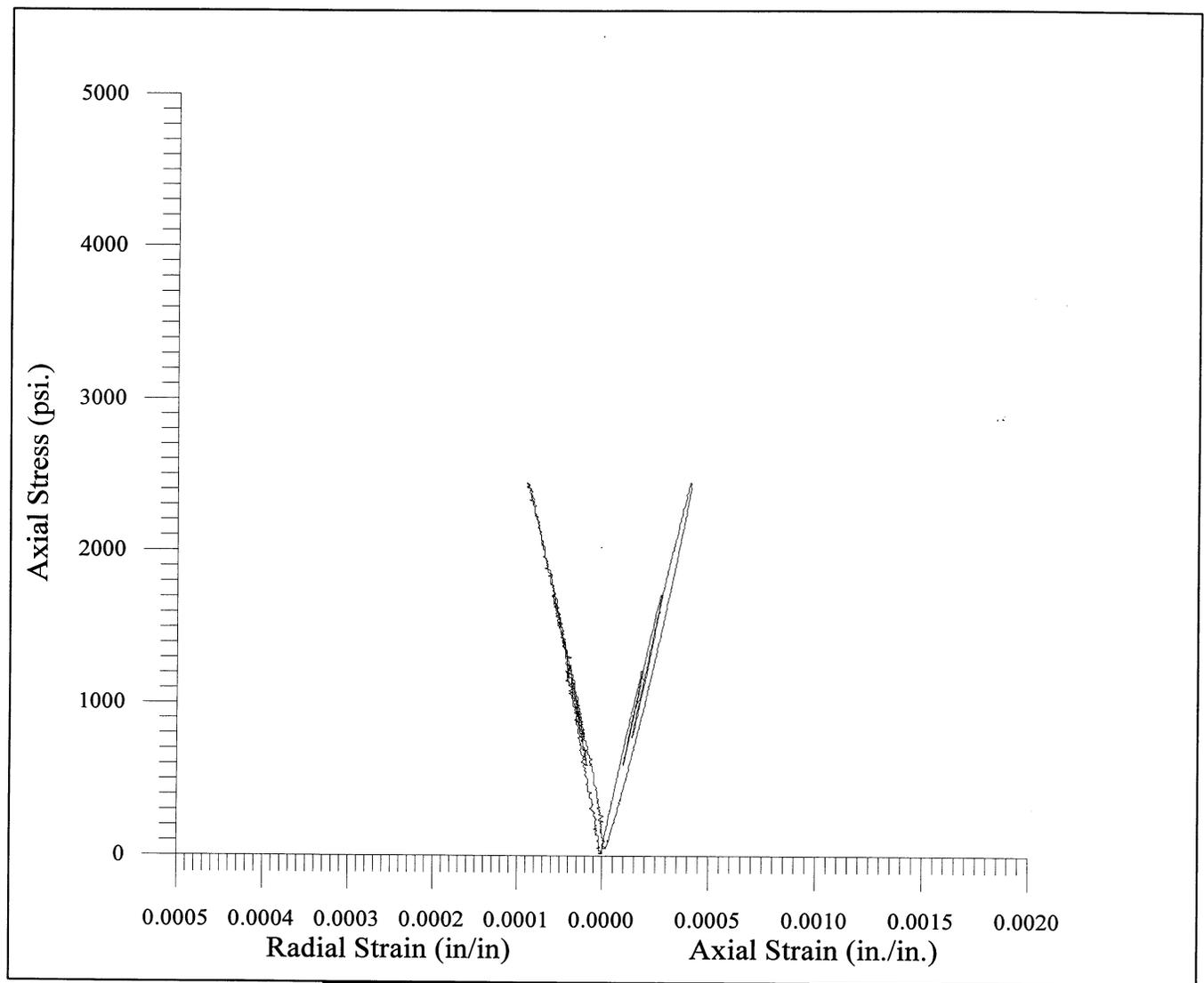
Density: 44.14 g/in<sup>3</sup> = 168.2 pcf (1 g/in<sup>3</sup> = 3.8095 lb/ft<sup>3</sup>)

Gauge length: 2.000 in

moist

Comments: Failed by splitting / shear along healed fractures.

\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_



**ELASTIC MODULUS TEST**  
**Axial Stress vs. Axial & Radial Strain**

**SAMPLE ID:** Boring: 98-22  
 Sample: 21a(c)  
 Depth: 71'

**DESCRIPTION**  
 Medium gray sandstone with a few calcite healed hairline fractures, about 20 degrees to the core axis.

**MODULUS:** 6,670,000 psi  
**POISSON'S RATIO:** .22

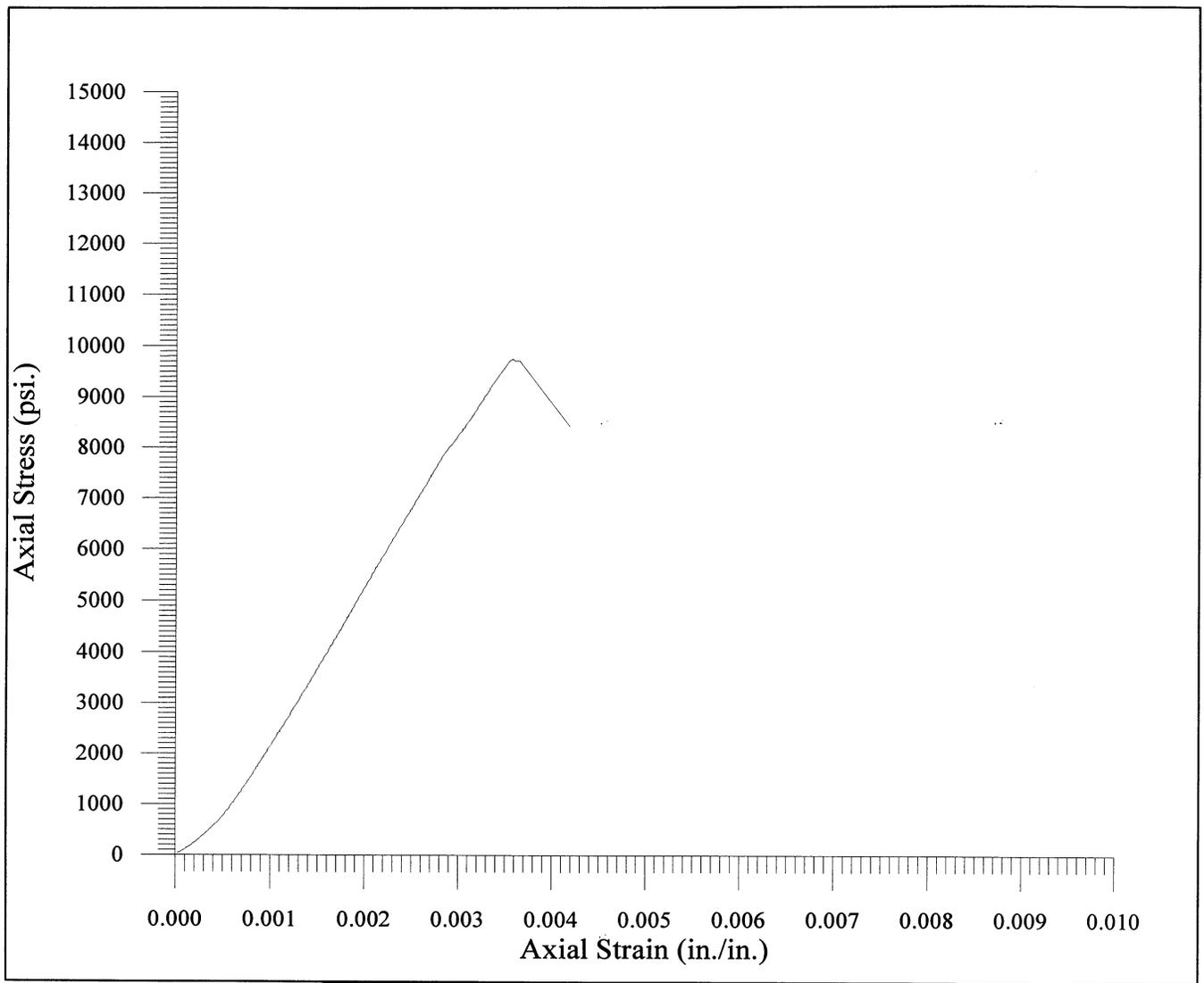
  
**Geo Test Unlimited**  
 800 Peralta Ave  
 San Leandro, CA 94577

**Client:** Fugro West, Inc.  
 5855 Olivas Park Dr.  
 Ventura, CA 93003

**Project:** San Francisco Oakland Bay Bridge  
 East Span Replacement Project

**Job Number:** 98-42-0053

**Test Date:** October 18, 1998



**UNCONFINED COMPRESSION TEST**  
**Axial Stress vs. Axial Strain**

<p><b>SAMPLE ID:</b> Boring : 98-22          Sample: 21a (c)          Depth: 71'</p> <p align="center"><b>DESCRIPTION</b></p> <p>Medium gray sandstone with a few calcite healed hairline fractures, about 20 degrees to the core axis.</p> <p><b>STRENGTH:</b> 9746 psi</p>	<p align="center"> <i>Geo</i>  <i>Test</i>  <b>Unlimited</b> </p> <p align="right">800 Peralta Ave          San Leandro, CA 94577</p> <hr/> <p><b>Client:</b> Fugro West, Inc.          5855 Olivas Park Dr.          Ventura, CA 93003</p> <p><b>Project:</b> San Francisco Oakland Bay Bridge          East Span Replacement Project</p> <p><b>Job Number:</b> 98-42-0053</p> <hr/> <p><b>Test Date:</b> October 19, 1998</p>
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DATA SHEET  
 Determination of Rock Modulus and Poisson's Ratio (ASTM D3148)

Date: 10/18 & 19/98  
 Person performing the test: A. Bro

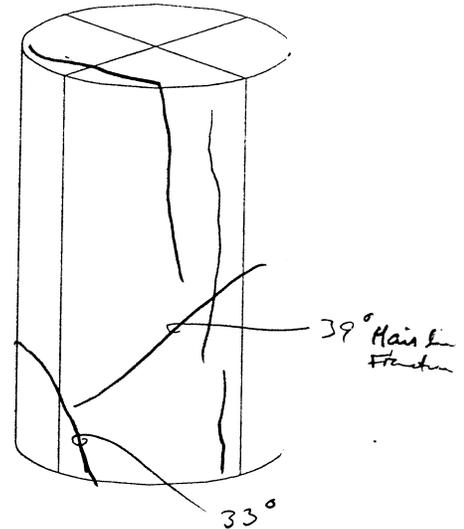
Client: Fuyo  
 Job: #92-SFOB3  
 Sample ID: B98-22 525a

Sample Description: medium gray sandstone with a few calcite healed joints and transverse fractures. with a few small claystone inclusions.

Sample Depth: 85' Sample Condition: received & tested moist

d <sub>1</sub>	d <sub>2</sub>
2.402	2.403
2.401	2.402
2.403	2.402
2.402	2.403
2.402	2.402

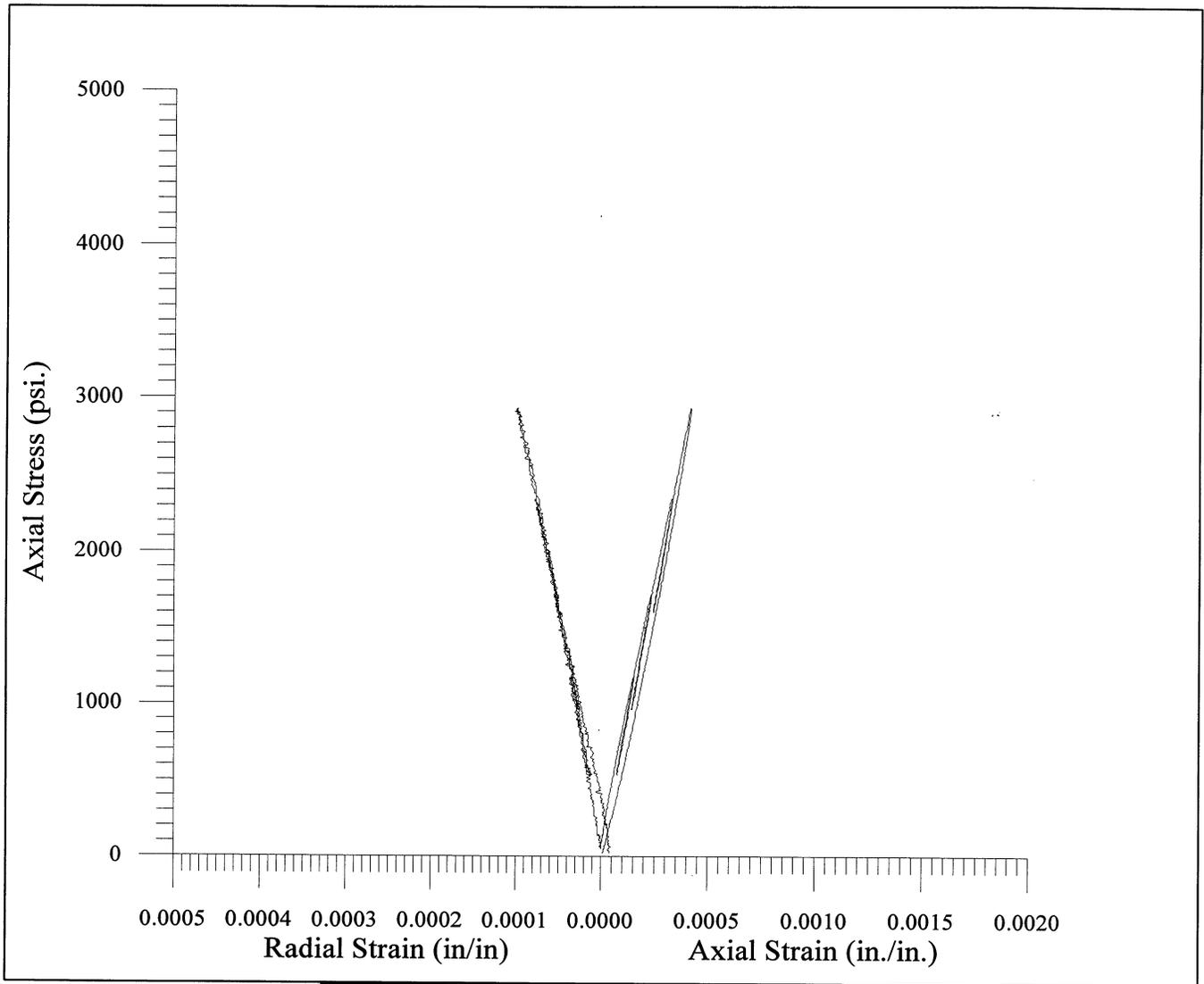
l <sub>1</sub>	l <sub>2</sub>
-0.0008	-0.0003
±0.0001	±0.0001
+0.0007	+0.0002



Avg. diameter: 2.402 Avg. length: 5.251  
 Sample area: 4.531 l/d ratio: 2.19  
 Sample volume(in<sup>3</sup>): 23.795  
 Sample weight (g): 1057.4g  
 Density: 44.44g/in<sup>3</sup> = 169.3pcf (1 g/in<sup>3</sup>=3.8095lb/ft<sup>3</sup>)  
 Gauge length: 2.000 in

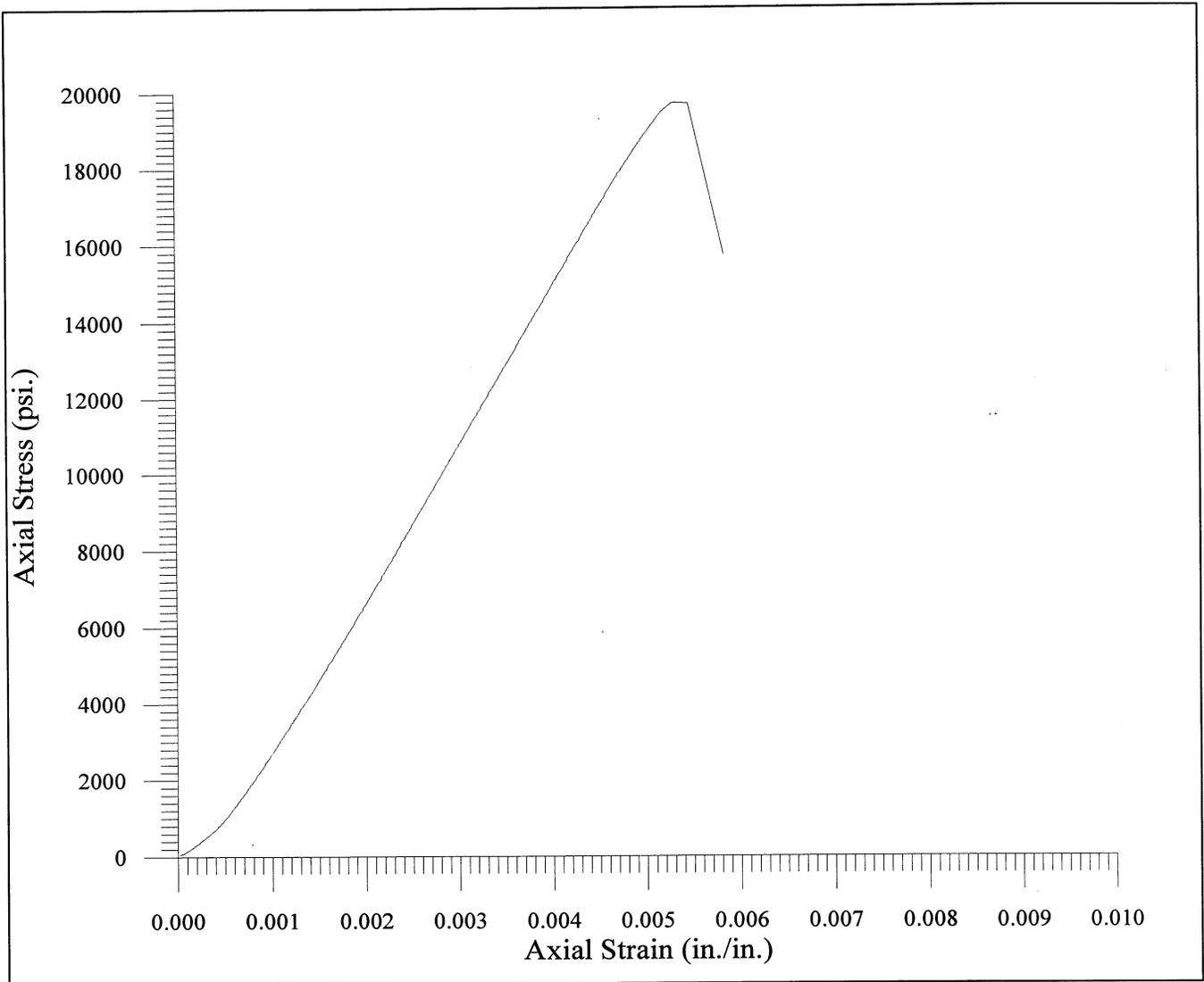
waist

Comments: Failed by shear - along calcite healed joint - 37° Fracture.



**ELASTIC MODULUS TEST**  
**Axial Stress vs. Axial & Radial Strain**

<p><b>SAMPLE ID:</b> Boring: 98-22  Sample: 25a  Depth: 85'</p> <p align="center"><b>DESCRIPTION</b></p> <p>Medium gray sandstone with a few calcite healed joints and hairline fractures, 33 and 39 degrees to the core axis, with a few small claystone inclusions.</p> <p><b>MODULUS:</b> 8,330,000 psi  <b>POISSON'S RATIO:</b> .29</p>	<p align="center"> <i>Geo</i>  <i>Test</i>  <b>Unlimited</b> </p> <p align="right">800 Peralta Ave  San Leandro, CA 94577</p> <hr/> <p><b>Client:</b> Fugro West, Inc.  5855 Olivas Park Dr.  Ventura, CA 93003</p> <p><b>Project:</b> San Francisco Oakland Bay Bridge  East Span Replacement Project</p> <hr/> <p><b>Job Number:</b> 98-42-0053</p> <hr/> <p><b>Test Date:</b> October 18, 1998</p>
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**UNCONFINED COMPRESSION TEST**  
**Axial Stress vs. Axial Strain**

<p><b>SAMPLE ID:</b> Boring : 98-22          Sample: 25a          Depth: 85'</p> <p align="center"><b>DESCRIPTION</b></p> <p>Medium gray sandstone with a few calcite healed joints and hairline fractures, 33 and 39 degrees to the core axis, with a few small claystone inclusions.</p> <p><b>STRENGTH:</b> 19,710 psi</p>	<p><i>Geo</i>  <i>Test</i></p> <p><b>Unlimited</b> 800 Peralta Ave          San Leandro, CA 94577</p>
	<p><b>Client:</b> Fugro West, Inc.          5855 Olivas Park Dr.          Ventura, CA 93003</p>
	<p><b>Project:</b> San Francisco Oakland Bay Bridge          East Span Replacement Project</p>
	<p><b>Job Number:</b> 98-42-0053</p>
	<p><b>Test Date:</b> October 19, 1998</p>

RETEST /

DATA SHEET

Determination of Rock Modulus and Poisson's Ratio (ASTM D3148)

Date: 10/18, 22, 23/98

Person performing the test: A. Bro

Client: Fugro

Job: #92-SFOBD

Sample ID: B98-22 S27a

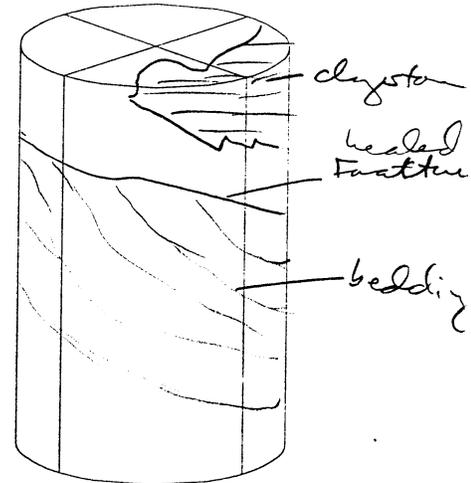
Sample Description: Finely interbedded medium gray sandstone and claystone ~60° to core axis with claystone on one e. and a calcite healed fracture (73° to axis)

Sample Depth: 98.5'

Sample Condition: received & tested moist

d <sub>1</sub>	d <sub>2</sub>
2.398	2.402
2.399	2.401
2.401	2.397
2.402	2.401
2.400	2.393

l <sub>1</sub>	l <sub>2</sub>
-0.0010	-0.0001
±0.0001	±0.0001
+0.0009	+0.0001



Avg. diameter: 2.399

Avg. length: 5.271

Sample area: 4.520

l/d ratio: 2.20

Sample volume(in<sup>3</sup>): 23.826

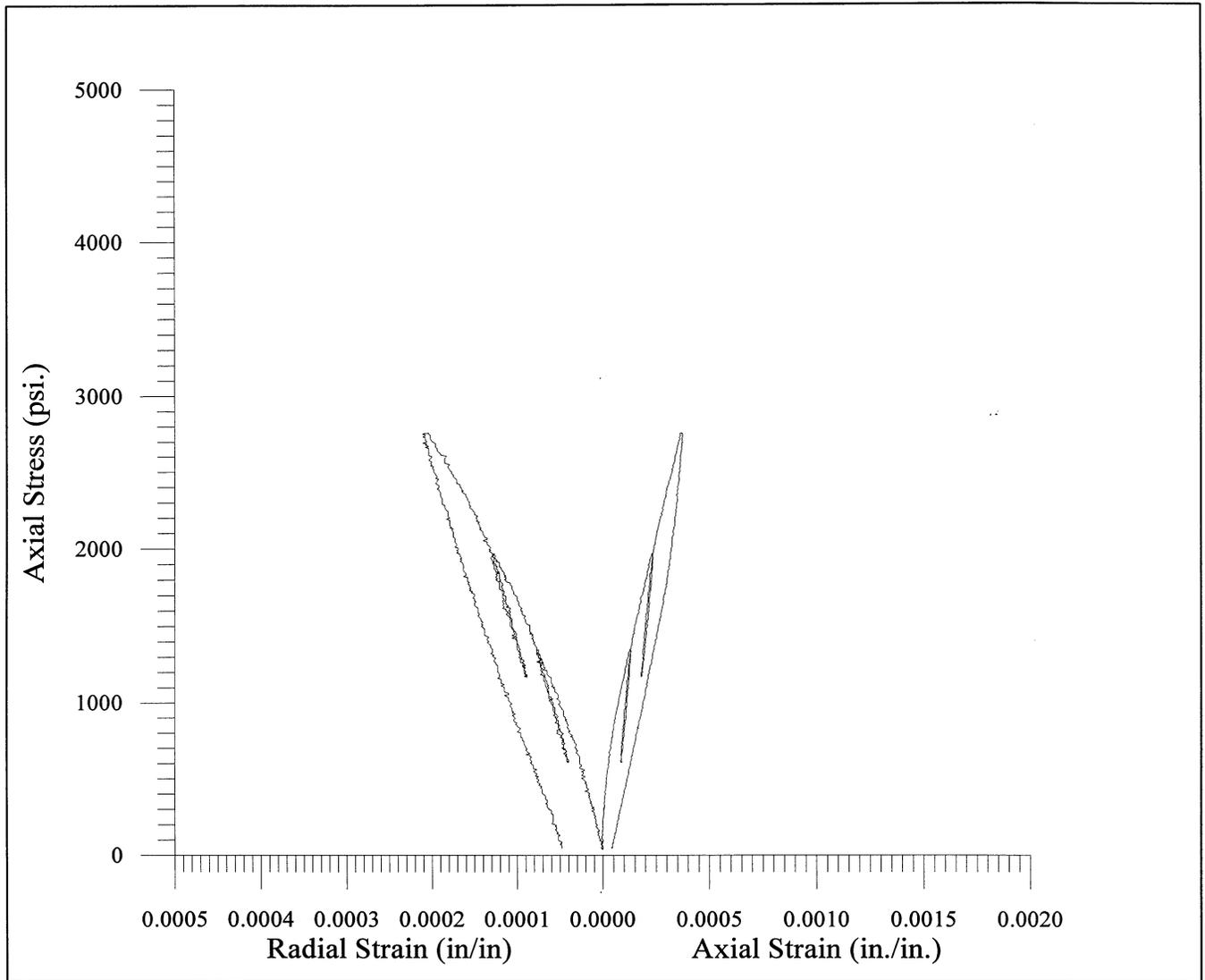
moist Sample weight (g): 1053.28

Density: 44.208/in<sup>3</sup> = 168.4 pcf (1 g/in<sup>3</sup> = 3.8095 lb/ft<sup>3</sup>)

Gauge length: 2.000 in

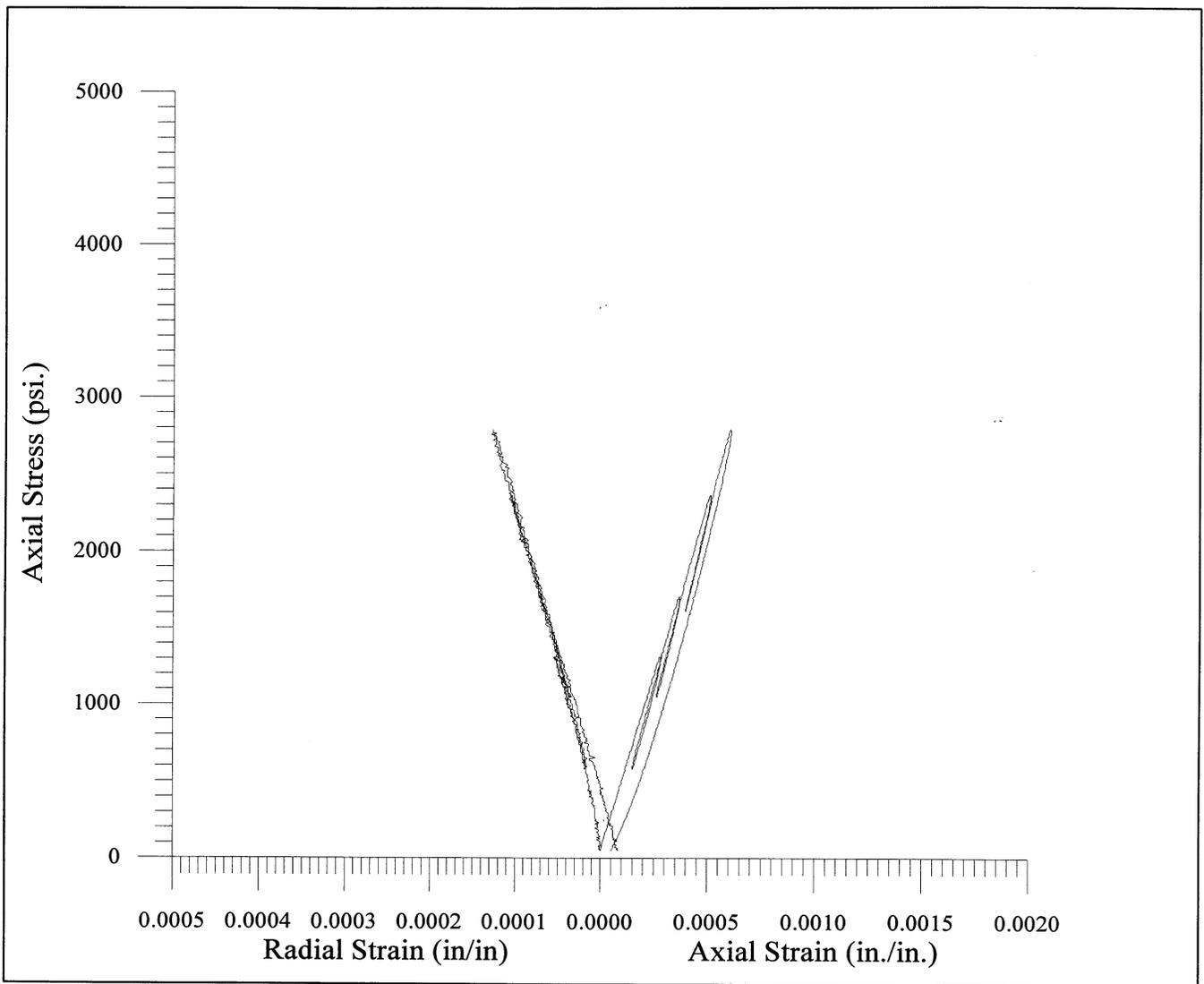
Comments: 2<sup>nd</sup> test at gauge across healed fracture @ top

Failed by diagonal & axial splitting.



**ELASTIC MODULUS TEST**  
**Axial Stress vs. Axial & Radial Strain**

<p><b>SAMPLE ID:</b> Boring: 98-22  Sample: 27a  Depth: 98.5'</p>	<p style="text-align: center;"><i>Geo</i>  <i>Test</i>  <b>Unlimited</b> 800 Peralta Ave  San Leandro, CA 94577</p>
<p style="text-align: center;"><b>DESCRIPTION</b></p> <p>Finely interbedded medium gray sandstone and claystone, bedding about 60 degrees to the core axis, with claystone on one end and a calcite healed fracture about 37 degrees to the core axis.</p> <p><b>MODULUS:</b> NA (15,630,000 psi)</p> <p><b>POISSON'S RATIO:</b> NA (.77)</p>	
	<p><b>Test Date:</b> October 18, 1998</p>



**ELASTIC MODULUS TEST**  
**Axial Stress vs. Axial & Radial Strain**

**SAMPLE ID:** Boring: 98-22  
 Sample: 27a (Retest)  
 Depth: 98.5'

**DESCRIPTION**  
 Finely interbedded medium gray sandstone and claystone, bedding about 60 degrees to the core axis, with claystone on one end and a calcite healed fracture about 37 degrees to the core axis.

**MODULUS:** 5,750,000 psi

**POISSON'S RATIO:** .31

*Geo*  *Test*  
**Unlimited** 800 Peralta Ave  
 San Leandro, CA 94577

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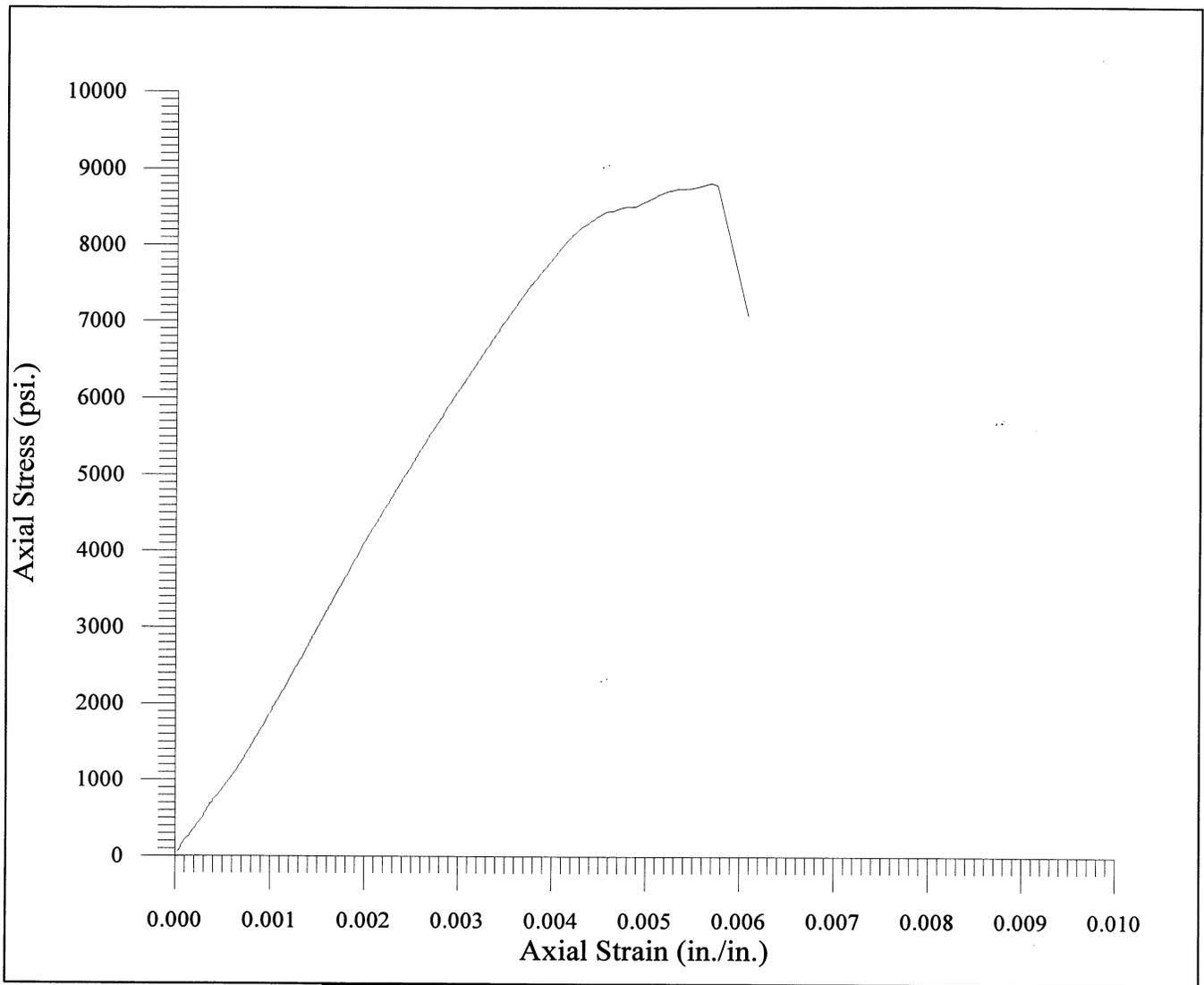
**Client:** Fugro West, Inc.  
 5855 Olivas Park Dr.  
 Ventura, CA 93003

**Project:** San Francisco Oakland Bay Bridge  
 East Span Replacement Project

**Job Number:** 98-42-0053

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**Test Date:** October 22, 1998



**UNCONFINED COMPRESSION TEST  
Axial Stress vs. Axial Strain**

<p><b>SAMPLE ID:</b> Boring : 98-22 Sample: 27a Depth: 98.5'</p> <p align="center"><b>DESCRIPTION</b></p> <p>Finely interbedded medium gray sandstone and claystone, bedding about 60 degrees to the core axis, with claystone on one end and a calcite healed fracture about 37 degrees to the core axis.</p> <p><b>STRENGTH:</b> 8799 psi</p>	<div style="text-align: center;"> <p><i>Geo</i>  <i>U</i></p> <p><i>Test</i></p> <p><i>Unlimited</i></p> </div> <p align="right">800 Peralta Ave San Leandro, CA 94577</p> <hr/> <p><b>Client:</b> Fugro West, Inc. 5855 Olivas Park Dr. Ventura, CA 93003</p> <p><b>Project:</b> San Francisco Oakland Bay Bridge East Span Replacement Project</p> <p><b>Job Number:</b> 98-42-0053</p> <hr/> <p><b>Test Date:</b> October 23, 1998</p>
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DATA SHEET

Determination of Rock Modulus and Poisson's Ratio (ASTM D3148)

Date: 10/18 & 19/98

Person performing the test: A. Bro

Client: Fuyo

Job: #92-SFOBT

Sample ID: B98-22 S29a

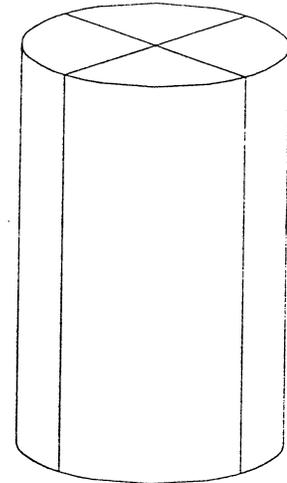
Sample Description: medium gray massive sandstone with one calcite healed hairline fracture 45° to core axis

Sample Depth: 112'

Sample Condition: received & tested moist

d <sub>1</sub>	d <sub>2</sub>
2.399	2.401
2.400	2.401
2.398	2.401
2.402	2.398
2.401	2.402

l <sub>1</sub>	l <sub>2</sub>
- .0008	- .0001
± .0001	± .0001
+ .0008	+ .0001



Avg. diameter: 2.400"

Avg. length: 5.287"

Sample area: 4.524

l/d ratio: 2.20

Sample volume(in<sup>3</sup>): 23.918

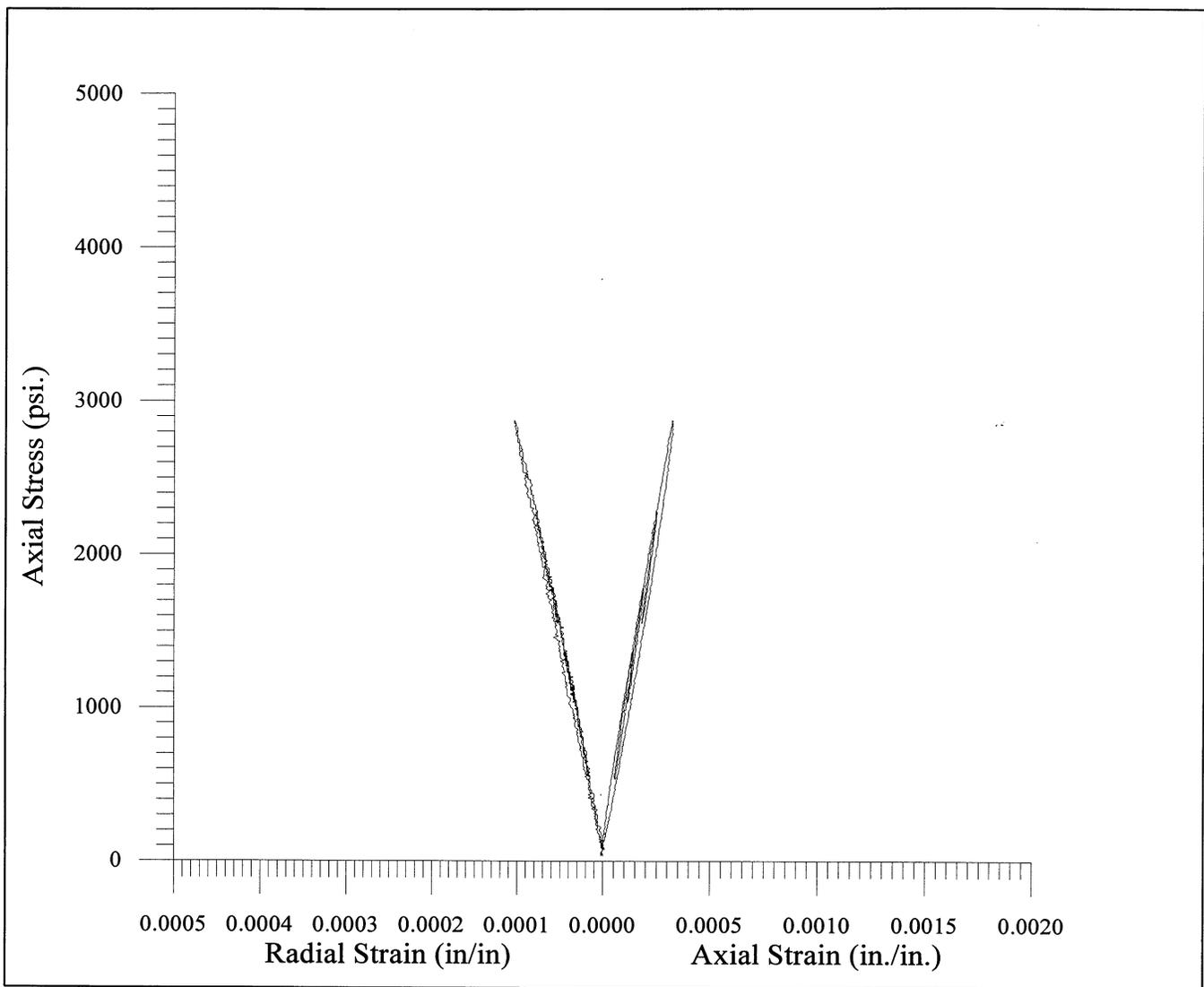
*moist* Sample weight (g): 1061.18

Density: 44.368/in<sup>3</sup> = 169.0pcf (1 g/in<sup>3</sup> = 3.8095 lb/ft<sup>3</sup>)

Gauge length: 2.000 in

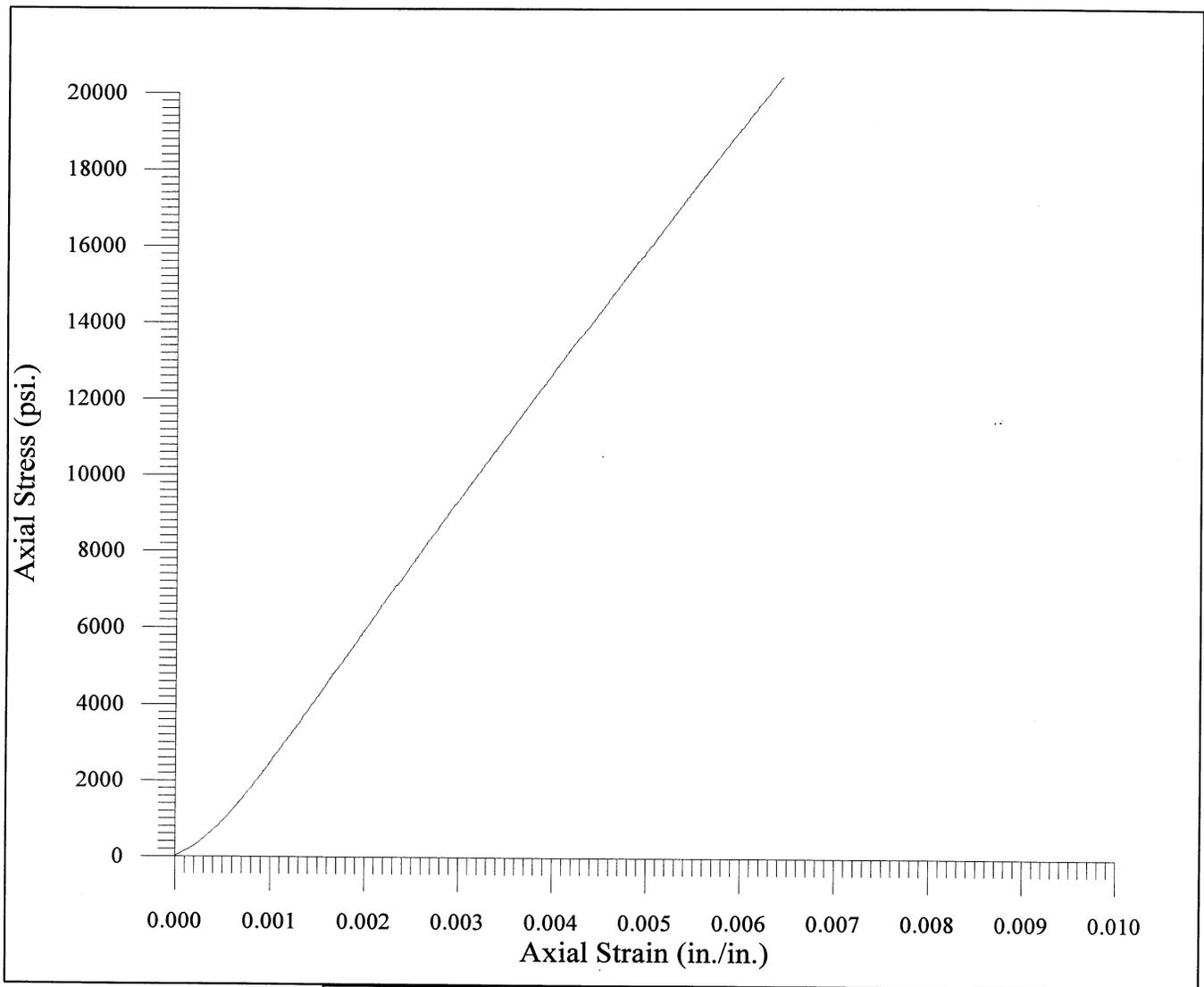
Comments: explosive failure - splitting & shear on calcite healed fracture.

\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_



**ELASTIC MODULUS TEST**  
**Axial Stress vs. Axial & Radial Strain**

<p><b>SAMPLE ID:</b> Boring: 98-22  Sample: 29a  Depth: 112'</p> <p><b>DESCRIPTION</b>  Medium gray massive sandstone with one calcite healed hairline fracture about 45 degrees to the core axis.</p> <p><b>MODULUS:</b> 10,000,000 psi  <b>POISSON'S RATIO:</b> .38</p>	<p align="center"> <i>Geo</i>  <i>Test</i>  <b>Unlimited</b> 800 Peralta Ave  San Leandro, CA 94577</p> <hr/> <p><b>Client:</b> Fugro West, Inc.  5855 Olivas Park Dr.  Ventura, CA 93003</p> <p><b>Project:</b> San Francisco Oakland Bay Bridge  East Span Replacement Project</p> <p><b>Job Number:</b> 98-42-0053</p> <hr/> <p><b>Test Date:</b> October 18, 1998</p>
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**UNCONFINED COMPRESSION TEST**  
**Axial Stress vs. Axial Strain**

**SAMPLE ID:** Boring : 98-22  
 Sample: 29a  
 Depth: 112'

**DESCRIPTION**

Medium gray massive sandstone with one calcite healed hairline fracture about 45 degrees to the core axis.

**STRENGTH:** 20,414 psi

*Geo*  *Test*  
**Unlimited**

800 Peralta Ave  
 San Leandro, CA 94577

---

**Client:** Fugro West, Inc.  
 5855 Olivas Park Dr.  
 Ventura, CA 93003

**Project:** San Francisco Oakland Bay Bridge  
 East Span Replacement Project

**Job Number:** 98-42-0053

---

**Test Date:** October 19, 1998

DATA SHEET

Determination of Rock Modulus and Poisson's Ratio (ASTM D3148)

Date: 10/18 & 19/98

Person performing the test: A. Bru

Client: Fugro

Job: #92-SFO3B

Sample ID: B98-22 S31a

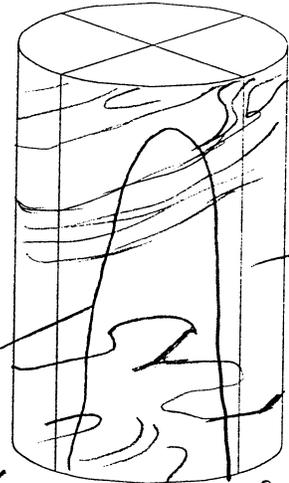
Sample Description: Dark gray claystone interbedded with sandy siltstone. Many hairline fractures parallel bedding (60° to core axis) and one axial calcite healed fracture.

Sample Depth: 124'

Sample Condition: received & tested moist

d <sub>1</sub>	d <sub>2</sub>
2.395	2.394
2.391	2.385
2.388	2.386
2.390	2.397
2.390	2.388

l <sub>1</sub>	l <sub>2</sub>
-.0012	-.0004
±.0001	±.0001
+.0012	+.0003



Avg. diameter: 2.390

Avg. length: 5.208

Sample area: 4.486

l/d ratio: 2.18

Sample volume (in<sup>3</sup>): 23.365

Sample weight (g): 1027.3

Density: 43.978/in<sup>3</sup> = 167.5 pcf (1 g/in<sup>3</sup> = 3.8095 lb/ft<sup>3</sup>)

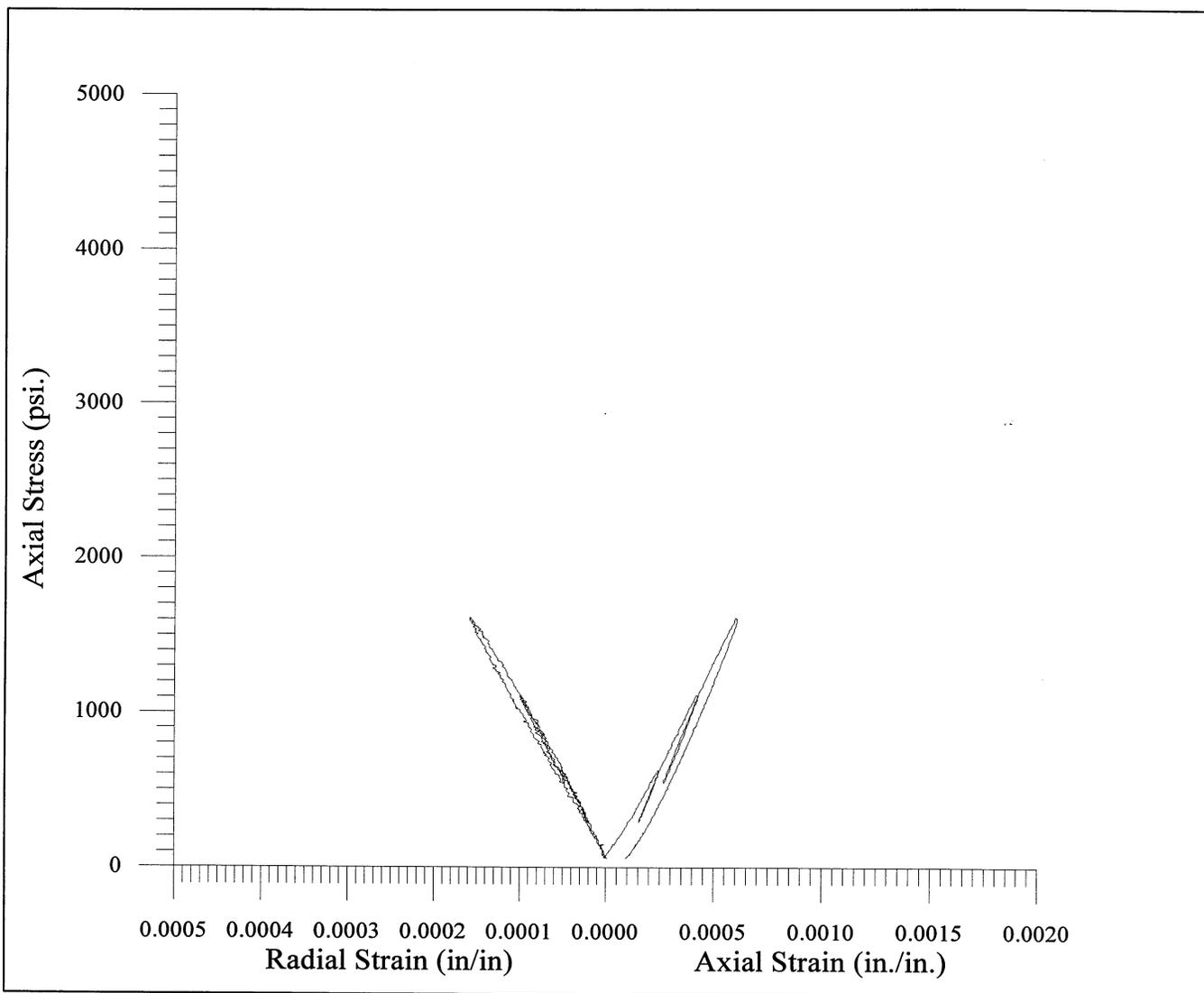
Gauge length: 2.000 in

moist

calcite healed axial fracture.

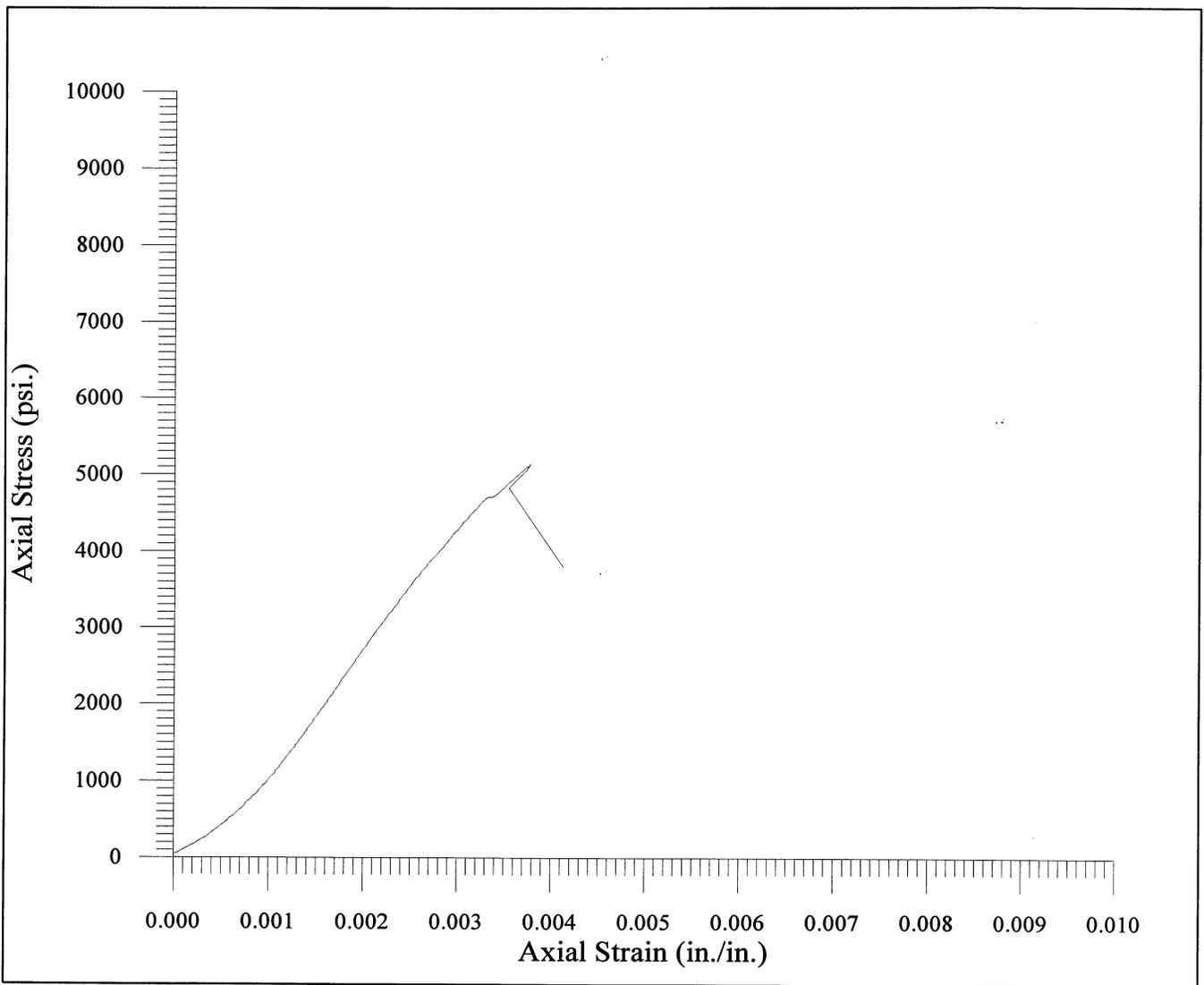
sandy siltstone

Comments: Failed by splitting, and shear along bedding planes



**ELASTIC MODULUS TEST**  
**Axial Stress vs. Axial & Radial Strain**

<p><b>SAMPLE ID:</b> Boring: 98-22  Sample: 31a  Depth: 124'</p> <p align="center"><b>DESCRIPTION</b></p> <p>Dark gray claystone interbedded with sandy siltstone, with many hairline fractures parallel to the bedding (60 degrees to the core axis) and one calcite healed axial fracture.</p> <p><b>MODULUS:</b> 3,530,000 psi  <b>POISSON'S RATIO:</b> .31</p>	<p align="center"> <i>Geo</i>  <i>U</i>  <i>Test</i>  <i>Unlimited</i> </p> <p align="right">800 Peralta Ave  San Leandro, CA 94577</p> <hr/> <p><b>Client:</b> Fugro West, Inc.  5855 Olivas Park Dr.  Ventura, CA 93003</p> <p><b>Project:</b> San Francisco Oakland Bay Bridge  East Span Replacement Project</p> <hr/> <p><b>Job Number:</b> 98-42-0053</p> <hr/> <p><b>Test Date:</b> October 18, 1998</p>
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**UNCONFINED COMPRESSION TEST**  
**Axial Stress vs. Axial Strain**

**SAMPLE ID:** Boring : 98-22  
 Sample: 31a  
 Depth: 124'

**DESCRIPTION**

Dark gray claystone interbedded with sandy siltstone, with many hairline fractures parallel to the bedding (60 degrees to the core axis) and one calcite healed axial fracture.

**STRENGTH:** 5141 psi

*Geo*  *Test*  
**Unlimited** 800 Peralta Ave  
 San Leandro, CA 94577

---

**Client:** Fugro West, Inc.  
 5855 Olivas Park Dr.  
 Ventura, CA 93003

**Project:** San Francisco Oakland Bay Bridge  
 East Span Replacement Project

**Job Number:** 98-42-0053

---

**Test Date:** October 19, 1998

RETEST!

DATA SHEET

Determination of Rock Modulus and Poisson's Ratio (ASTM D3148)

Date: 10/18, 22 & 23/98

Person performing the test: ABro

Client: Fugro

Job: #92-SFOBR

Sample ID: B98-22 S32a massive

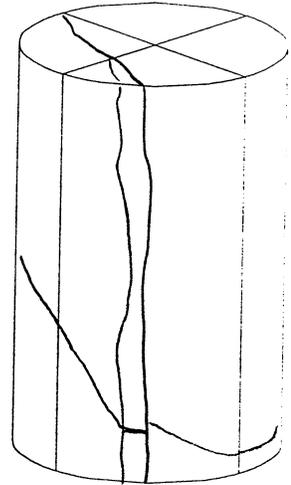
Sample Description: medium gray sandy siltstone with two calcite healed fractures, 0° and 50° to the core axis

Sample Depth: 130'

Sample Condition: received & tested moist

d <sub>1</sub>	d <sub>2</sub>
2.399	2.401
2.402	2.402
2.403	2.402
2.402	2.402
2.402	2.402

l <sub>1</sub>	l <sub>2</sub>
-.0006	-.0002
±.0001	±.0001
+.0006	+.0002



Avg. diameter: 2.402

Avg. length: 5.213

Sample area: 4.531

l/d ratio: 2.17

Sample volume(in<sup>3</sup>): 23.622

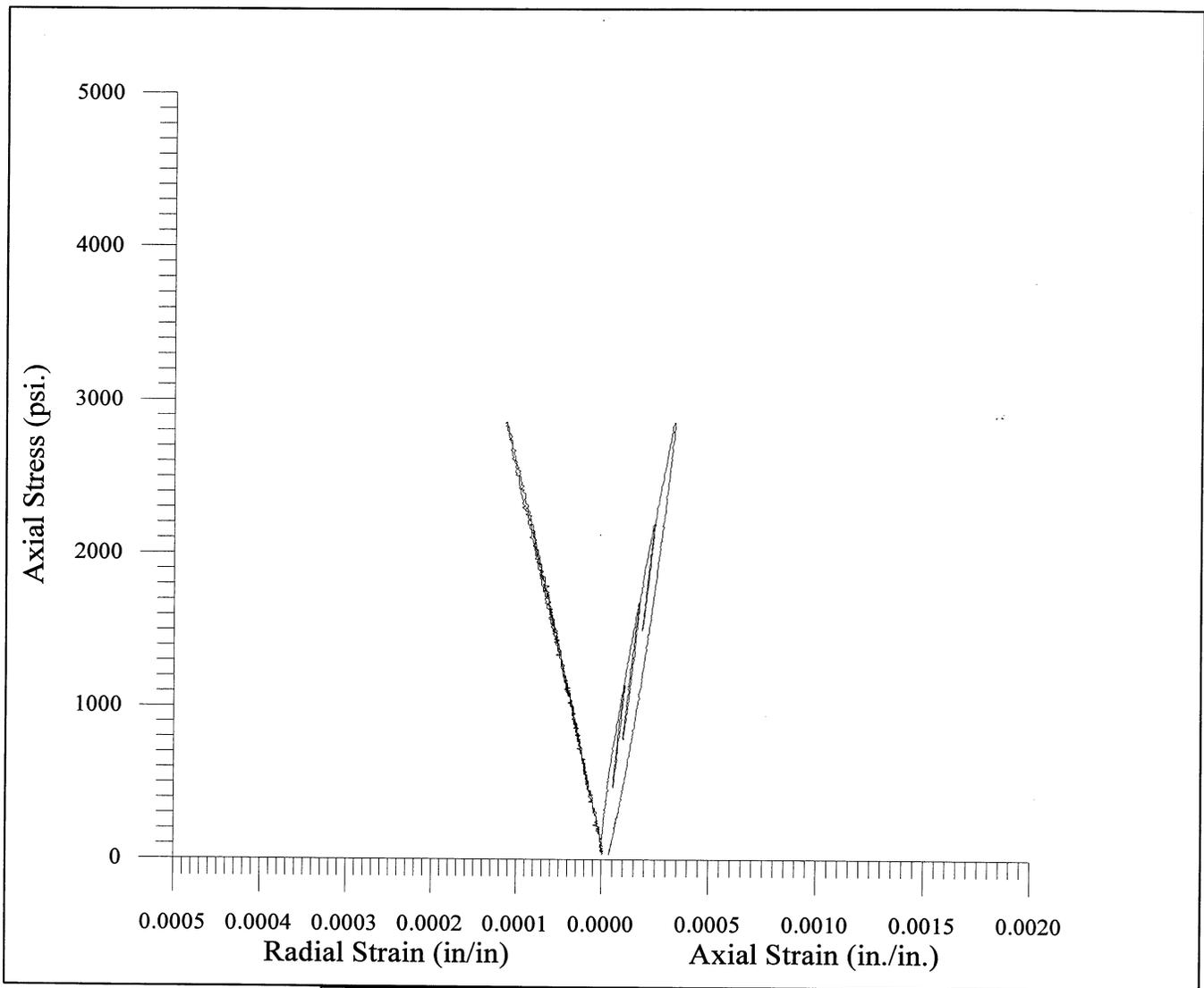
moist Sample weight (g): 1043.1

Density: 44.168/in<sup>3</sup> = 168.2 pcf (1 g/in<sup>3</sup> = 3.8095 lb/ft<sup>3</sup>)

Gauge length: 2000 in

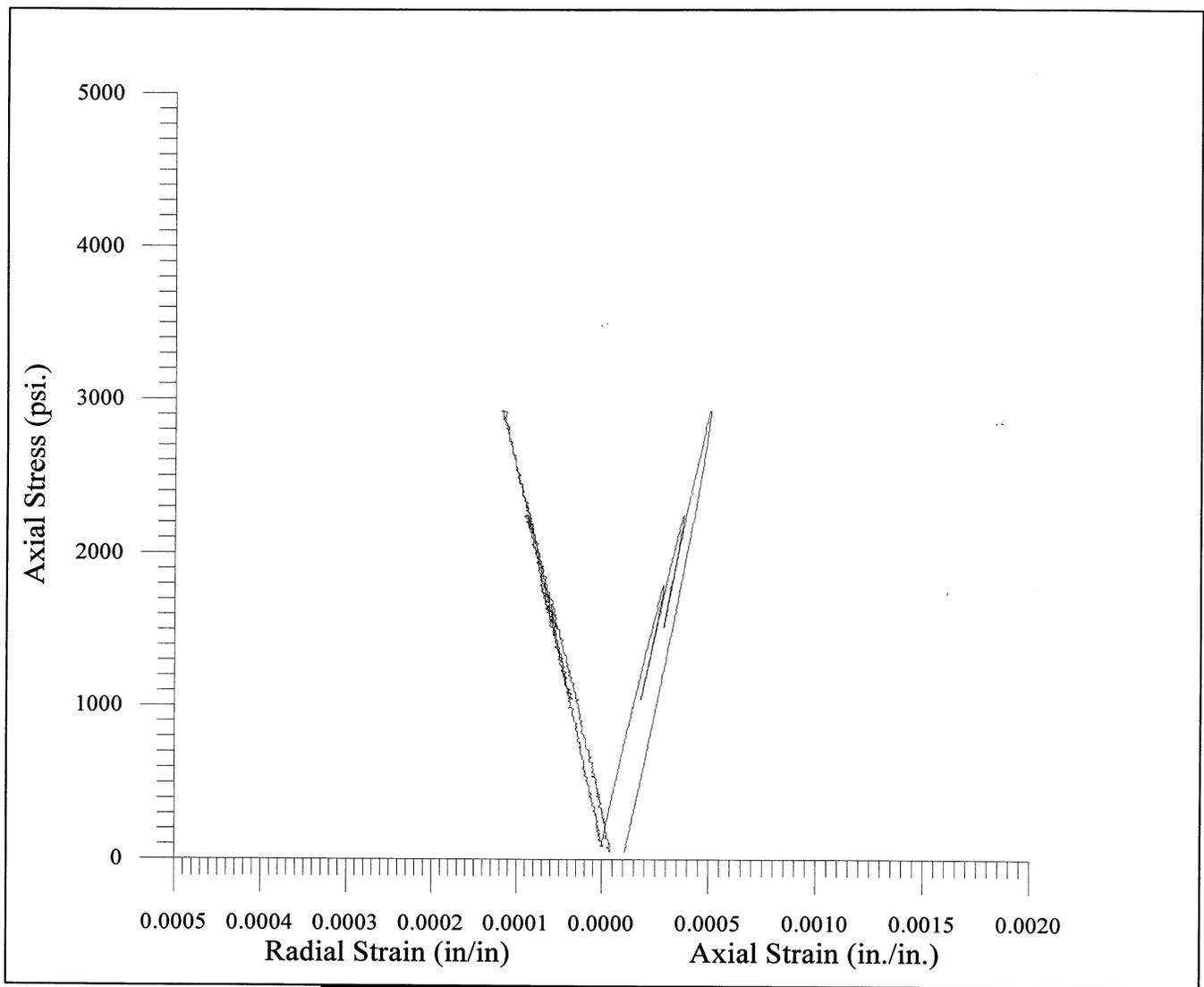
Comments: on retest note that axial gauges across the healed joint - and that on unloading E<sub>a</sub> is much stiffer than on loading... due to joint closure?

Failed by axial splitting and conical shear at one end.



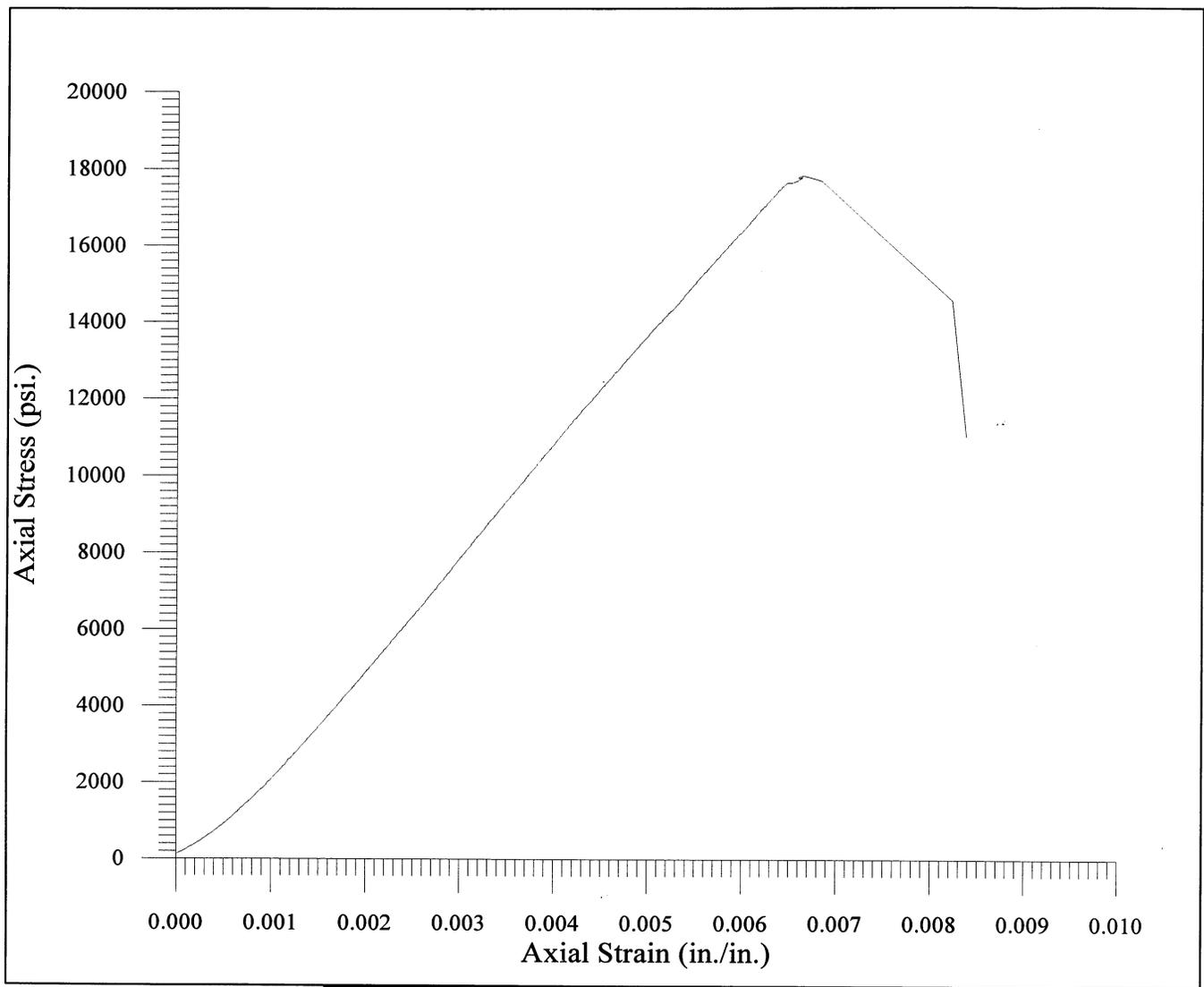
**ELASTIC MODULUS TEST**  
**Axial Stress vs. Axial & Radial Strain**

<p><b>SAMPLE ID:</b> Boring: 98-22  Sample:32a  Depth: 130'</p> <p><b>DESCRIPTION</b>  Medium gray massive sandy siltstone with two calcite healed fractures, 0 and 50 degrees to the core axis.</p> <p><b>MODULUS:</b> NA (13,890,000 psi)  <b>POISSON'S RATIO:</b> NA (.55)</p>	<p align="center"> <i>Geo</i>  <i>U</i>  <i>Test</i>  <b>Unlimited</b> </p> <p align="right">800 Peralta Ave  San Leandro, CA 94577</p>
	<p><b>Client:</b> Fugro West, Inc.  5855 Olivas Park Dr.  Ventura, CA 93003</p> <p><b>Project:</b> San Francisco Oakland Bay Bridge  East Span Replacement Project</p> <p><b>Job Number:</b> 98-42-0053</p>
	<p><b>Test Date:</b> October 18, 1998</p>



**ELASTIC MODULUS TEST**  
**Axial Stress vs. Axial & Radial Strain**

<p><b>SAMPLE ID:</b> Boring: 98-22  Sample:32a (Retest)  Depth: 130'</p>	<p align="center"><i>Geo</i>  <i>Test</i>  <b>Unlimited</b> 800 Peralta Ave  San Leandro, CA 94577</p>
<p align="center"><b>DESCRIPTION</b></p> <p>Medium gray massive sandy siltstone with two calcite healed fractures, 0 and 50 degrees to the core axis.</p> <p><b>MODULUS:</b> 6,670,000 psi  <b>POISSON'S RATIO:</b> .27</p>	<p><b>Client:</b> Fugro West, Inc.  5855 Olivas Park Dr.  Ventura, CA 93003</p> <p><b>Project:</b> San Francisco Oakland Bay Bridge  East Span Replacement Project</p> <p><b>Job Number:</b> 98-42-0053</p>
	<p><b>Test Date:</b> October 22, 1998</p>



**UNCONFINED COMPRESSION TEST**  
**Axial Stress vs. Axial Strain**

<p><b>SAMPLE ID:</b> Boring : 98-22          Sample: 32a          Depth: 130'</p> <p align="center"><b>DESCRIPTION</b></p> <p>Medium gray massive sandy siltstone with two calcite healed fractures, 0 and 50 degrees to the core axis.</p> <p><b>STRENGTH:</b> 17,808 psi</p>	<p align="center"> <i>Geo</i>  <i>Test</i>  <b>Unlimited</b> 800 Peralta Ave          San Leandro, CA 94577       </p>
	<p><b>Client:</b> Fugro West, Inc.          5855 Olivas Park Dr.          Ventura, CA 93003</p> <p><b>Project:</b> San Francisco Oakland Bay Bridge          East Span Replacement Project</p> <p><b>Job Number:</b> 98-42-0053</p>
	<p><b>Test Date:</b> October 23, 1998</p>

DATA SHEET

Determination of Rock Modulus and Poisson's Ratio (ASTM D3148)

Date: 10/18 & 19/98

Person performing the test: A. Bro

Client: Fugro

Job: #92-SFOBB

Sample ID: B98-22 S35a

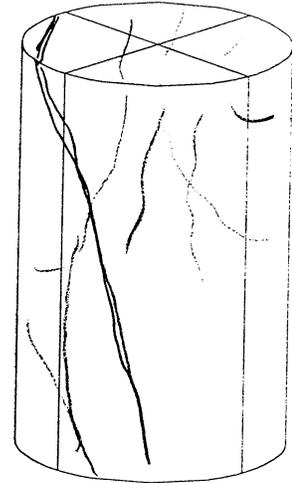
Sample Description: medium gray massive sandstone with  
many axial calcite healed hairline fractures.

Sample Depth: 149'

Sample Condition: received & tested moist

d <sub>1</sub>	d <sub>2</sub>
2.402	2.398
2.400	2.402
2.402	2.402
2.398	2.400
2.398	2.400

l <sub>1</sub>	l <sub>2</sub>
-0.0009	-0.0002
±0.0001	±0.0001
+0.0009	+0.0001



Avg. diameter: 2.400

Avg. length: 5.215

Sample area: 4.524

l/d ratio: 2.17

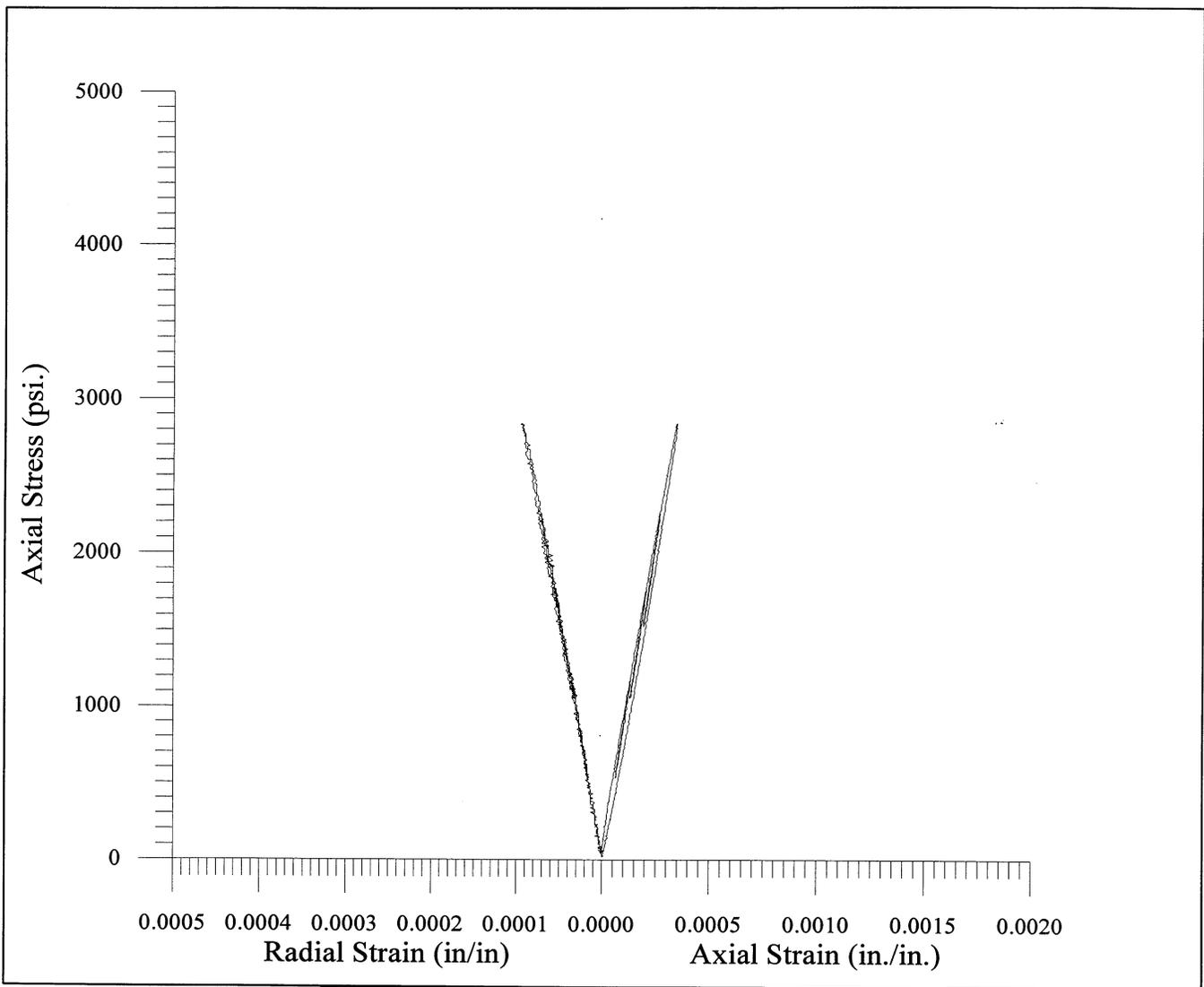
Sample volume (in<sup>3</sup>): 23.592

moist Sample weight (g): 1046.9g

Density: 44.388/in<sup>3</sup> = 169.0 pcf (1 g/in<sup>3</sup> = 3.8095 lb/ft<sup>3</sup>)

Gauge length: 2.000 in

Comments: Failed by axial splitting along hairline fractures.



**ELASTIC MODULUS TEST**  
**Axial Stress vs. Axial & Radial Strain**

**SAMPLE ID:** Boring: 98-22  
 Sample: 35a  
 Depth: 149'

**DESCRIPTION**  
 Medium gray massive sandstone with many calcite healed axial hairline fractures.

**MODULUS:** 9,250,000 psi  
**POISSON'S RATIO:** .30

*Geo*  *Test*  
**Unlimited** 800 Peralta Ave  
 San Leandro, CA 94577

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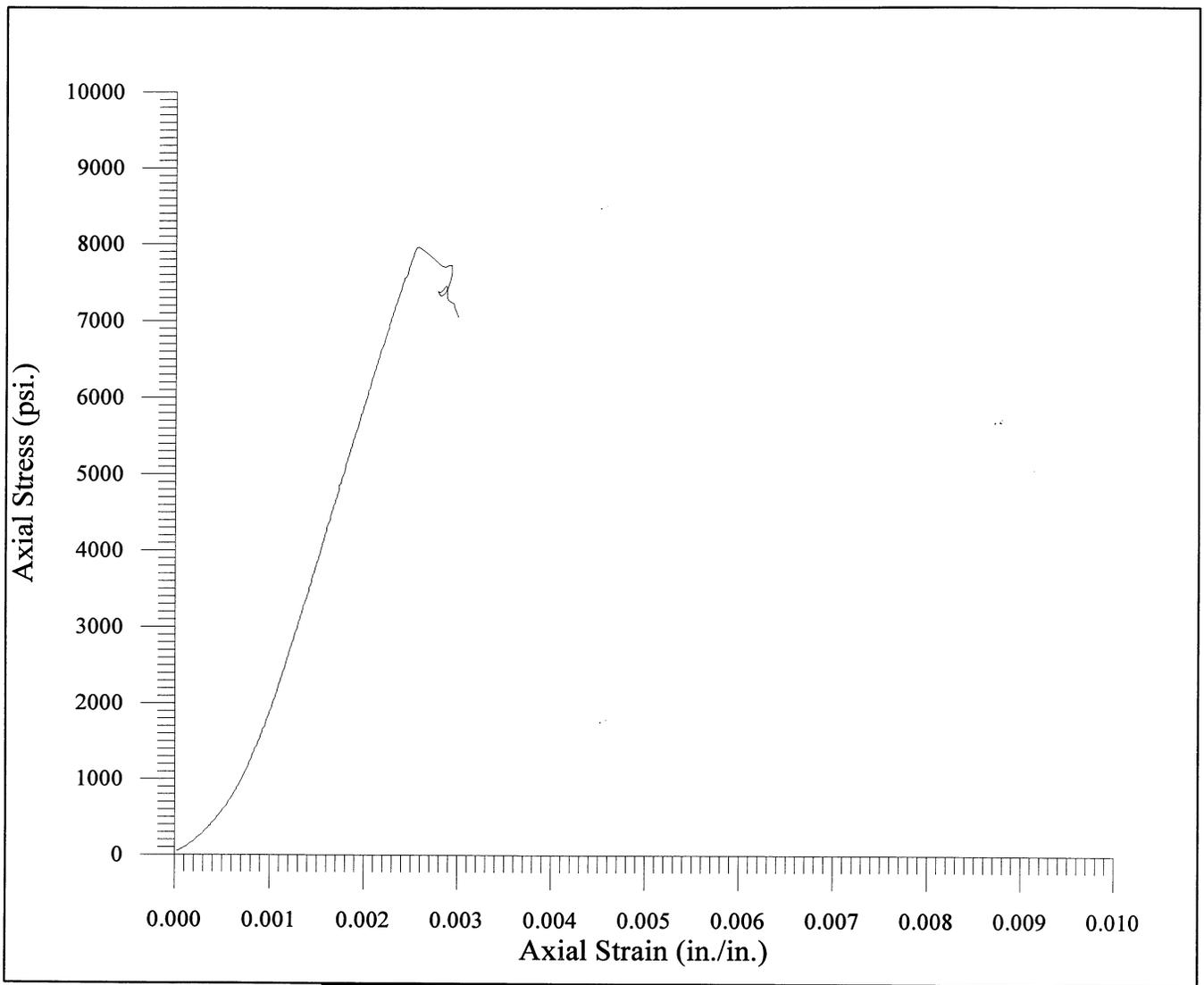
**Client:** Fugro West, Inc.  
 5855 Olivas Park Dr.  
 Ventura, CA 93003

**Project:** San Francisco Oakland Bay Bridge  
 East Span Replacement Project

**Job Number:** 98-42-0053

---

**Test Date:** October 18, 1998



**UNCONFINED COMPRESSION TEST**  
**Axial Stress vs. Axial Strain**

<p><b>SAMPLE ID:</b> Boring : 98-22          Sample: 35a          Depth: 149'</p> <p align="center"><b>DESCRIPTION</b></p> <p>Medium gray massive sandstone with many calcite healed axial hairline fractures.</p> <p><b>STRENGTH:</b> 7962 psi</p>	<p align="center"> <i>Geo</i>  <i>Test</i>  <b>Unlimited</b> 800 Peralta Ave          San Leandro, CA 94577       </p>
	<p><b>Client:</b> Fugro West, Inc.          5855 Olivas Park Dr.          Ventura, CA 93003</p> <p><b>Project:</b> San Francisco Oakland Bay Bridge          East Span Replacement Project</p> <p><b>Job Number:</b> 98-42-0053</p>
	<p><b>Test Date:</b> October 19, 1998</p>

## Direct Shear Tests

**DATA SHEET**  
**Direct Shear of Rock (ISRM)**

Date: 10/29/98

Person performing the test: AJB

Client: Fugro

Job: #92-SFOBB

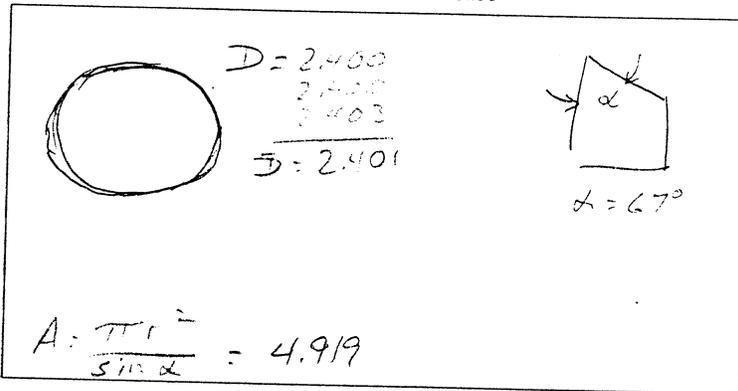
Sample ID: B98-22 S19a

Sample Description: Planes joint in medium grained stone brown oxide coated, slightly rough

Sample Depth: 51'

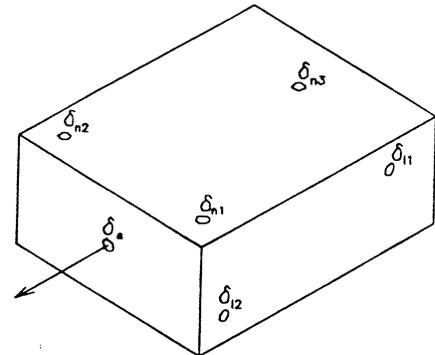
Sample Water Condition: received & tested moist

Sketch of Shear Surface



Sample area: 4.919 in<sup>2</sup>

Location of LVDTs on top shear box

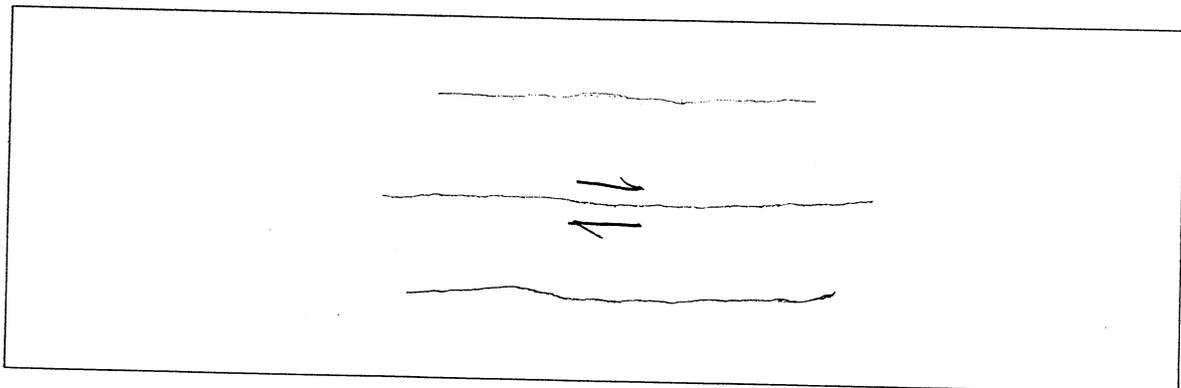


Estimated Top Box Weight: \_\_\_\_\_

Measured Top Box Weight: 15.8 lb

$\sigma_n$	<u>25</u>	<u>75</u>	<u>150 psi</u>
$F_n$	<u>123</u>	<u>369</u>	<u>738 lb</u>
$F_n - W_b$	<u>107</u>	<u>353</u>	<u>722</u>

Joint Profiles

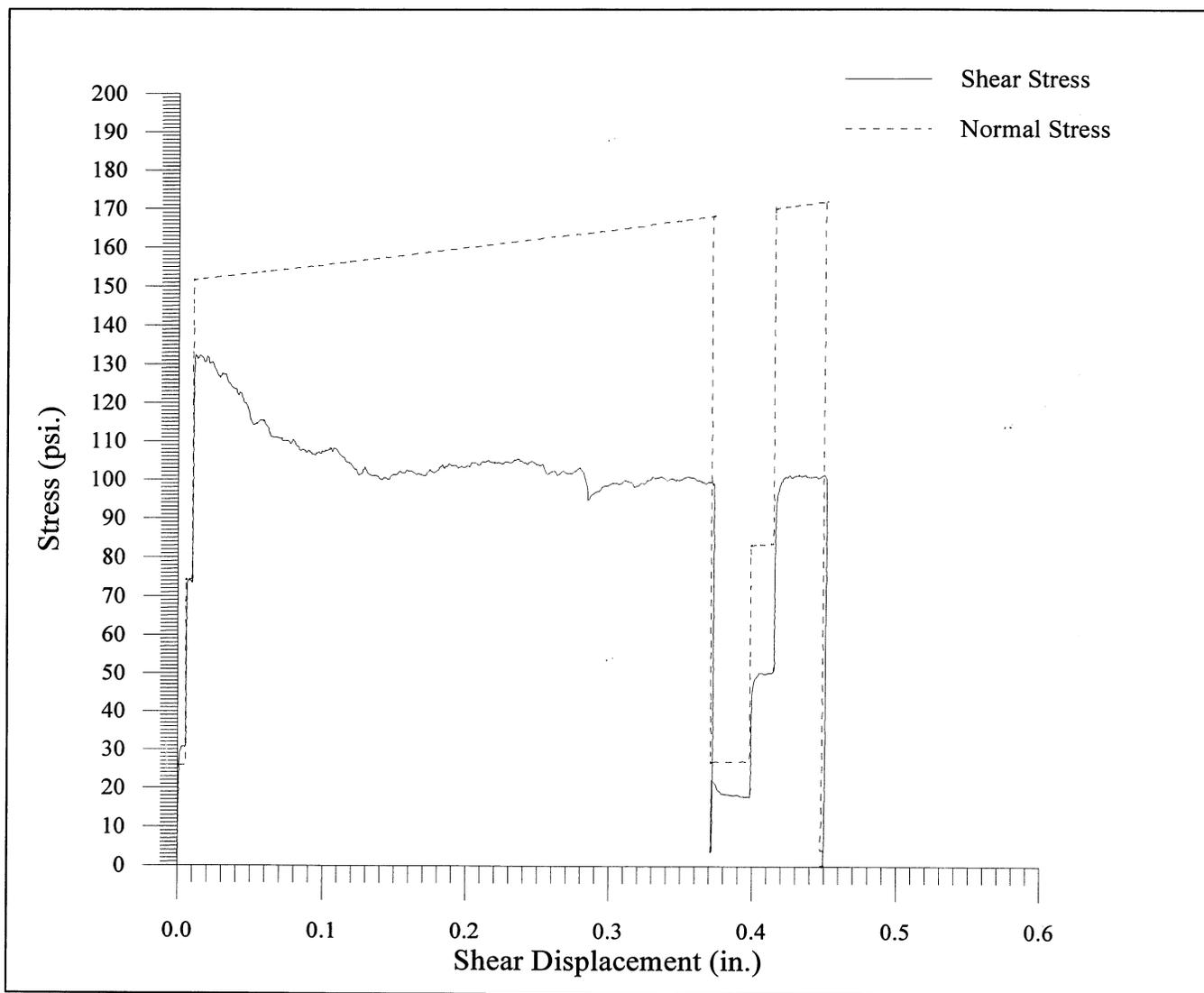


Summary of Test Results

Rate of Loading				
Shr. Displ. Rate				
Normal Stress				
Shear Strength				

Sj: \_\_\_\_\_

phi: \_\_\_\_\_



**DIRECT SHEAR TEST**  
**Shear and Normal Stress vs. Shear Displacement**

**SAMPLE ID:** Boring: 98-22  
 Sample: 19a  
 Depth: 51'

**DESCRIPTION**  
 Slightly rough, oxide coated joint in medium gray sandstone.

	Normal Stress	Shear Strength
Initial	26	31
	74.5	74.5
	152	132
Final	27	18
	84	50
	171.5	101.5

*Geo*  *Test*

**Unlimited** 800 Peralta Ave  
 San Leandro, CA 94577

---

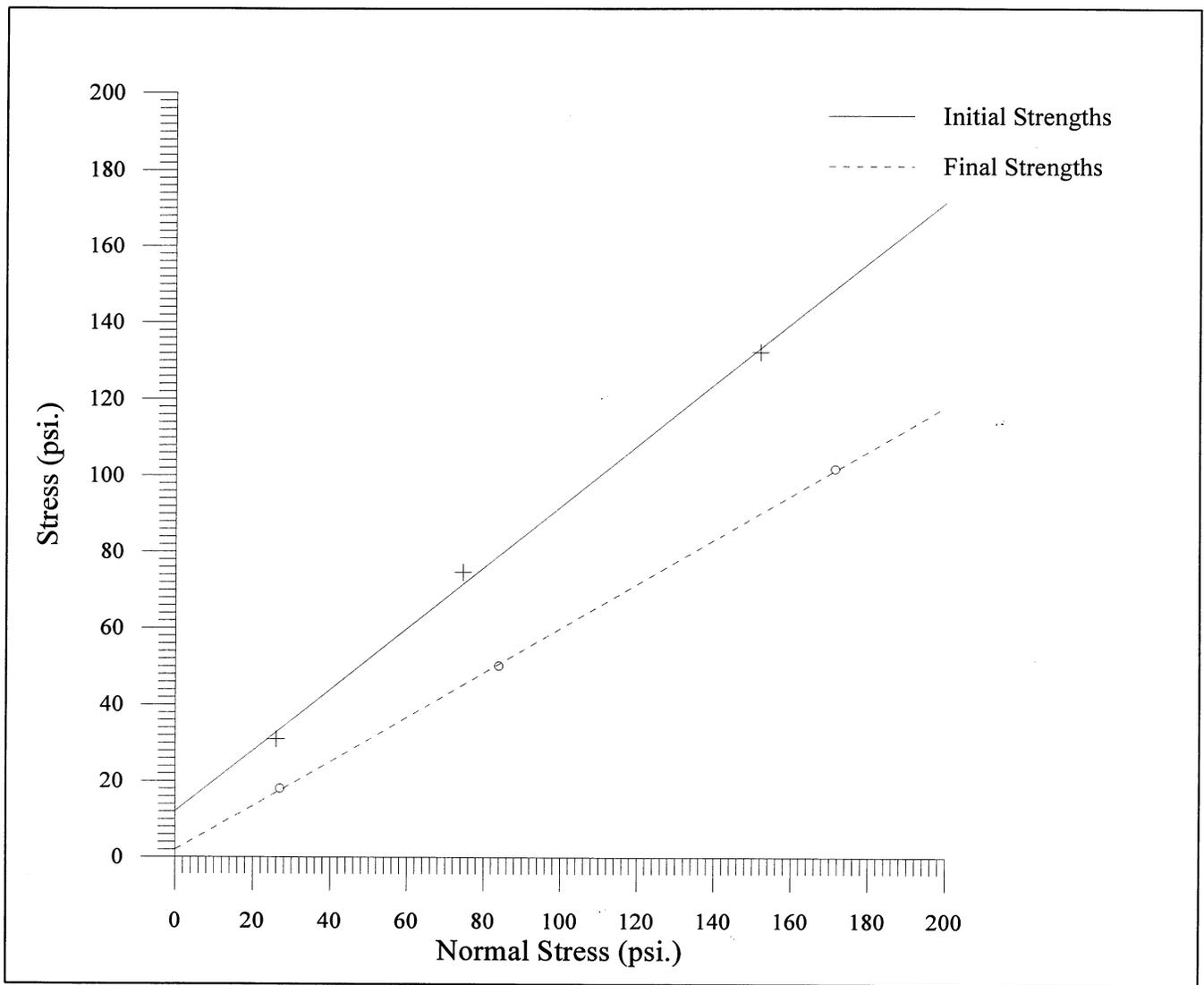
**Client:** Fugro West, Inc.  
 5855 Olivas Park Dr.  
 Ventura, CA 93003

**Project:** San Francisco Oakland Bay Bridge  
 East Span Replacement Project

**Job Number:** 98-42-0053

---

**Test Date:** October 29, 1998



**DIRECT SHEAR TEST  
Failure Envelope**

<p><b>SAMPLE ID:</b> Boring: 98-22 Sample: 19a Depth: 51'</p> <p><b>DESCRIPTION</b></p> <p>Slightly rough, oxide coated joint in medium gray sandstone.</p>	 <b>Geo Test Unlimited</b> 800 Peralta Ave San Leandro, CA 94577									
	<p><b>Client:</b> Fugro West, Inc. 5855 Olivas Park Dr. Ventura, CA 93003</p> <p><b>Project:</b> San Francisco Oakland Bay Bridge East Span Replacement Project</p> <p><b>Job Number:</b> 98-42-0053</p>									
<table border="1"> <thead> <tr> <th></th> <th>Shear Intercept (psi)</th> <th>Friction Angle (degrees)</th> </tr> </thead> <tbody> <tr> <td>Initial</td> <td>12.2</td> <td>38.5</td> </tr> <tr> <td>Final</td> <td>2.0</td> <td>30.1</td> </tr> </tbody> </table>		Shear Intercept (psi)	Friction Angle (degrees)	Initial	12.2	38.5	Final	2.0	30.1	<p><b>Test Date:</b> October 29, 1998</p>
	Shear Intercept (psi)	Friction Angle (degrees)								
Initial	12.2	38.5								
Final	2.0	30.1								

**DATA SHEET**  
**Direct Shear of Rock (ISRM)**

Date: 10/29/00

Person performing the test: A. Bro

Client: Fugro

Job: #92-SFOBB

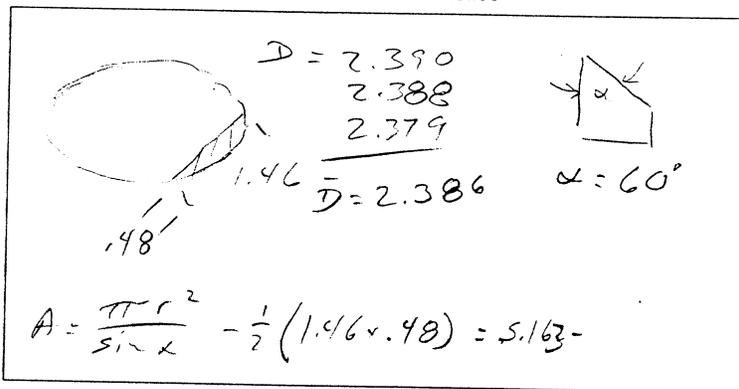
Sample ID: B98-22 S19b

Sample Description: Irregular Vee joint in dark gray siltstone with slight oxidizing.

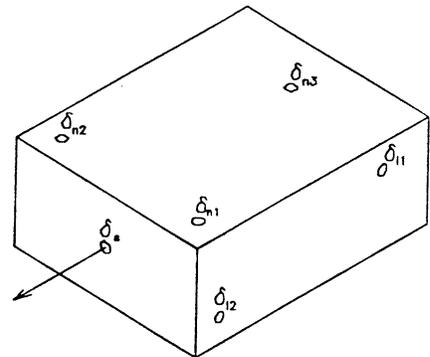
Sample Depth: 55'

Sample Water Condition: received & tested in moist

Sketch of Shear Surface



Location of LVDTs on top shear box



Sample area: 4.813

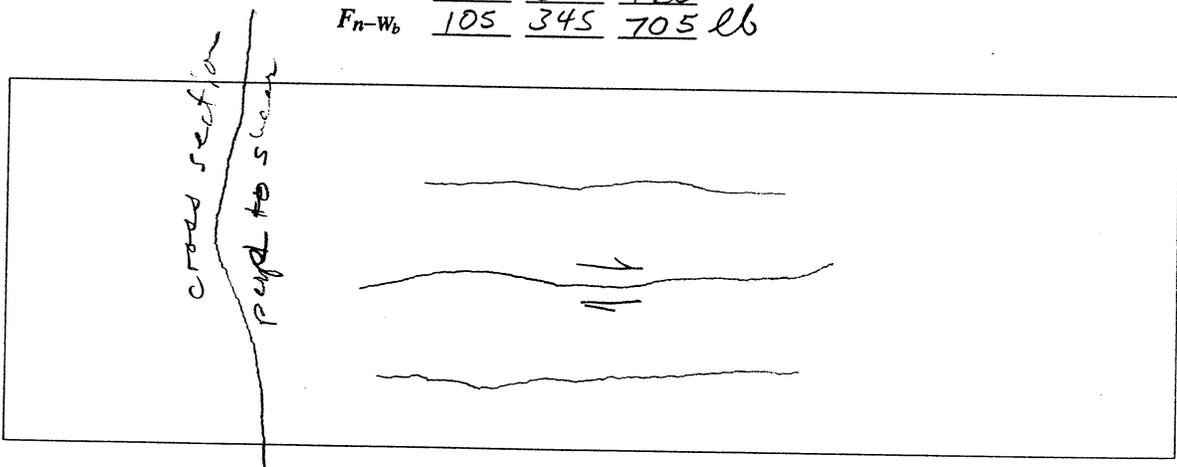
Estimated Top Box Weight: \_\_\_\_\_

Measured Top Box Weight: 15.2 lb

Notes: Shear parallel to Vee intersection

$\sigma_n$	<u>25</u>	<u>75</u>	<u>150</u>	psi
$F_n$	<u>120</u>	<u>360</u>	<u>720</u>	lb
$F_n - W_b$	<u>105</u>	<u>345</u>	<u>705</u>	lb

Joint Profiles

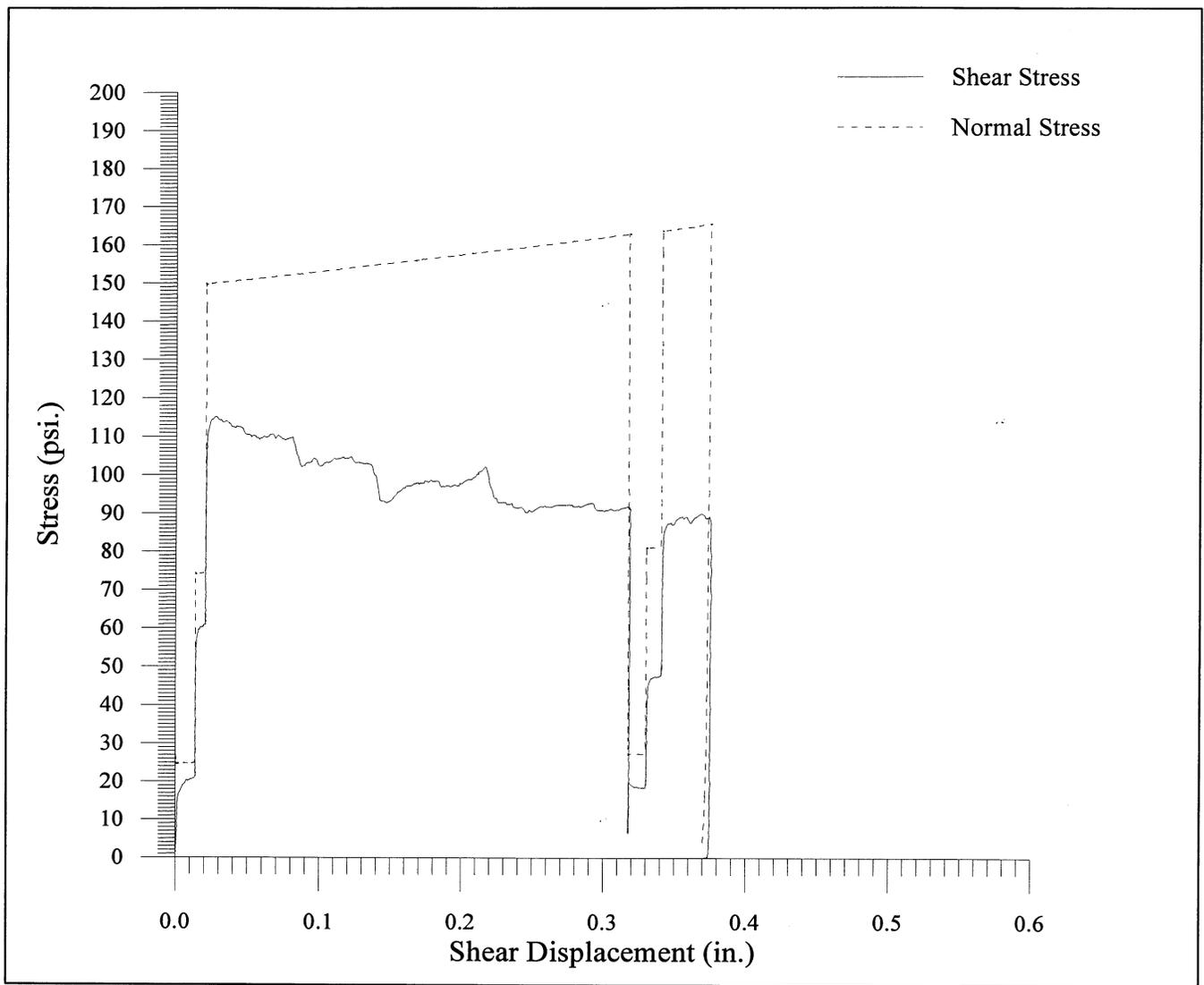


Summary of Test Results

Rate of Loading				
Shr. Displ. Rate				
Normal Stress				
Shear Strength				

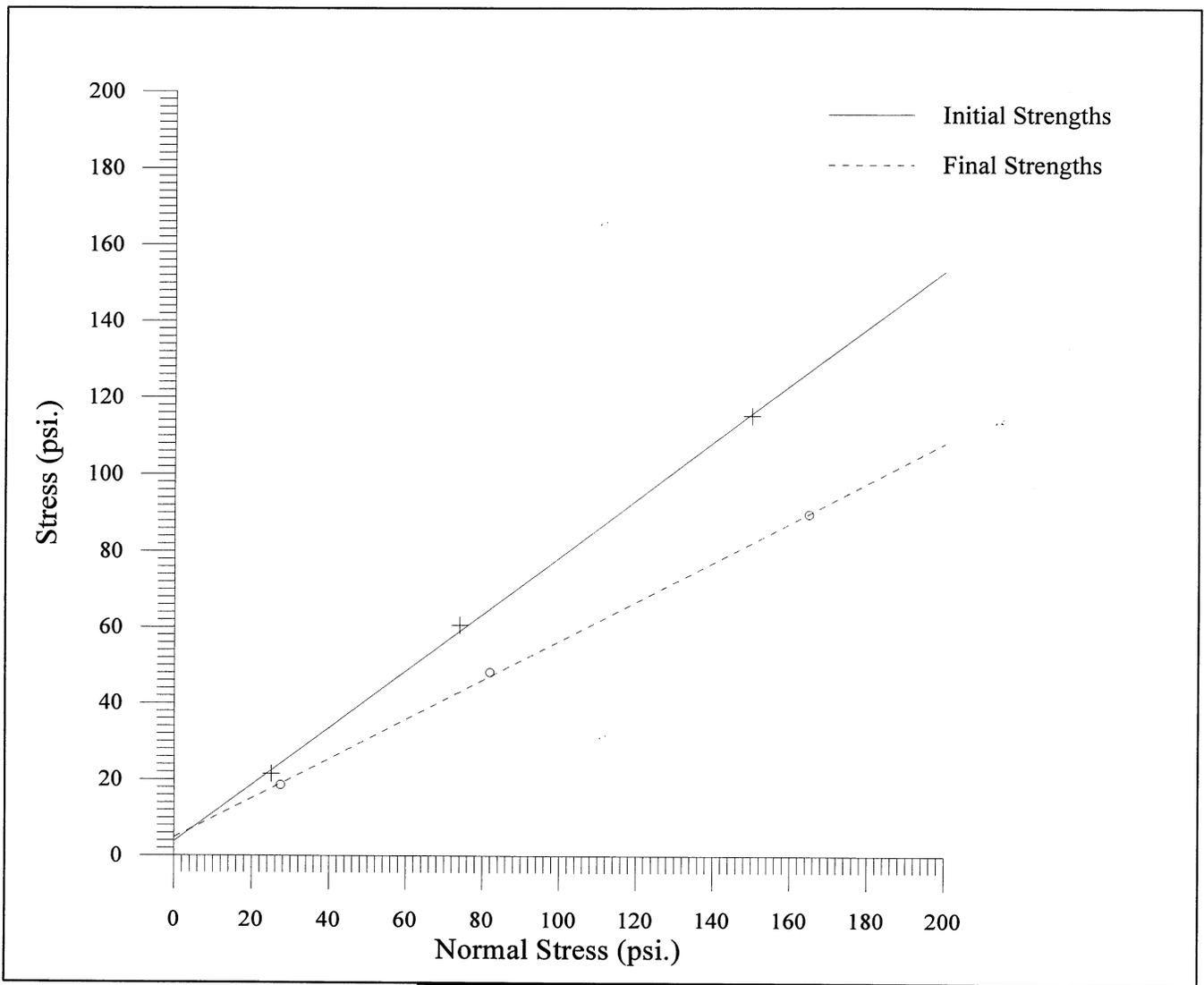
Sj: \_\_\_\_\_

$\phi$ : \_\_\_\_\_



**DIRECT SHEAR TEST**  
**Shear and Normal Stress vs. Shear Displacement**

<p><b>SAMPLE ID:</b> Boring: 98-22  Sample: 19b  Depth: 55'</p> <p align="center"><b>DESCRIPTION</b></p> <p>Irregular Vee shaped joint in dark gray siltstone with a slight oxide coating.</p> <table border="1"> <thead> <tr> <th></th> <th>Normal Stress</th> <th>Shear Strength</th> </tr> </thead> <tbody> <tr> <td rowspan="3">Initial</td> <td>25</td> <td>21.5</td> </tr> <tr> <td>74</td> <td>60.5</td> </tr> <tr> <td>150</td> <td>115</td> </tr> <tr> <td rowspan="3">Final</td> <td>27.5</td> <td>18.5</td> </tr> <tr> <td>82</td> <td>48</td> </tr> <tr> <td>165</td> <td>89.5</td> </tr> </tbody> </table>		Normal Stress	Shear Strength	Initial	25	21.5	74	60.5	150	115	Final	27.5	18.5	82	48	165	89.5	<p align="center"> <i>Geo</i>  <i>Test</i>  <b>Unlimited</b> </p> <p align="right">800 Peralta Ave  San Leandro, CA 94577</p>
		Normal Stress	Shear Strength															
Initial	25	21.5																
	74	60.5																
	150	115																
Final	27.5	18.5																
	82	48																
	165	89.5																
<p><b>Client:</b> Fugro West, Inc.  5855 Olivas Park Dr.  Ventura, CA 93003</p> <p><b>Project:</b> San Francisco Oakland Bay Bridge  East Span Replacement Project</p> <p><b>Job Number:</b> 98-42-0053</p>	<p><b>Test Date:</b> October 29, 1998</p>																	



**DIRECT SHEAR TEST  
Failure Envelope**

**SAMPLE ID:** Boring: 98-22  
Sample: 19b  
Depth: 55'

**DESCRIPTION**  
Irregular Vee shaped joint in dark gray siltstone with a slight oxide coating.

	Shear Intercept (psi)	Friction Angle (degrees)
Initial	3.8	36.7
Final	4.9	27.2

*Geo*  *Test*  
**Unlimited** 800 Peralta Ave  
 San Leandro, CA 94577

---

**Client:** Fugro West, Inc.  
5855 Olivas Park Dr.  
Ventura, CA 93003

**Project:** San Francisco Oakland Bay Bridge  
East Span Replacement Project

**Job Number:** 98-42-0053

---

**Test Date:** October 29, 1998

**DATA SHEET**  
Direct Shear of Rock (ISRM)

Date: 10/29/98

Person performing the test: A. Bro

Client: Fugro

Job: #92-SFOBB

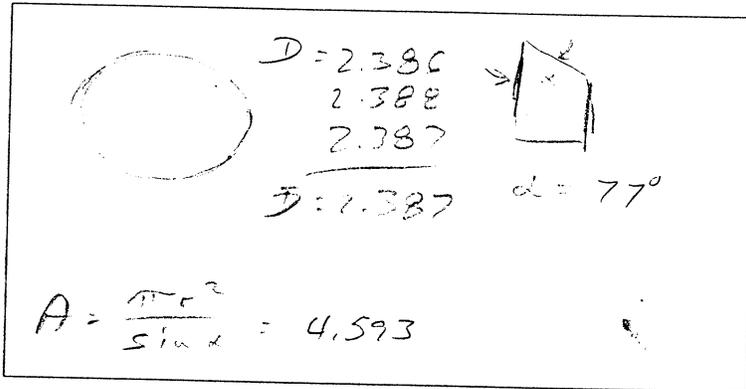
Sample ID: B98-22 S256 bedding

Sample Description: planar joint in dark gray dolomite with calcite coating  
Slickenside striations, but not in direction of this test  
shear displacement.

Sample Depth: 86'

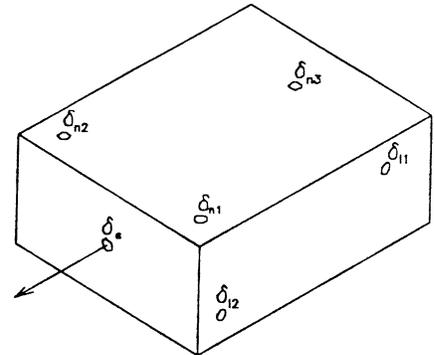
Sample Water Condition: received & tested moist

Sketch of Shear Surface



Sample area: 4.593 in<sup>2</sup>

Location of LVDTs on top shear box

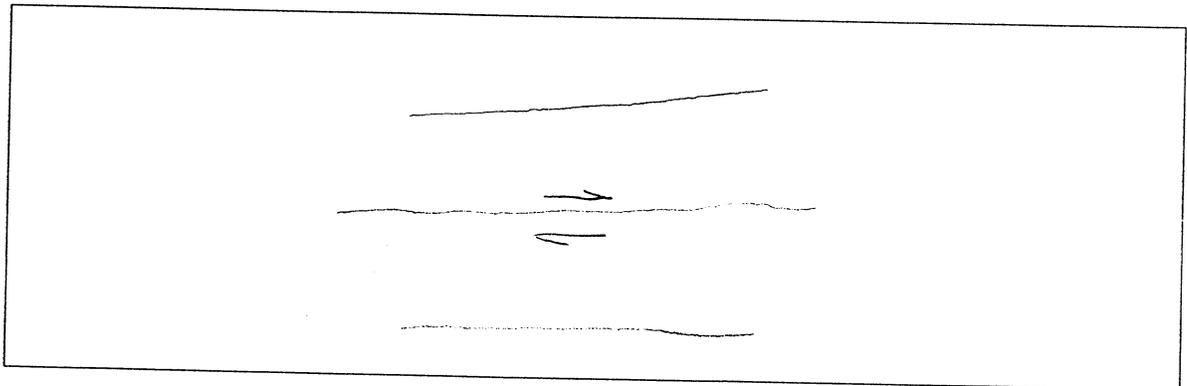


Estimated Top Box Weight:

Measured Top Box Weight: 15.8 lb

$\sigma_n$	<u>25</u>	<u>75</u>	<u>150</u>	<u>psi</u>
$F_n$	<u>115</u>	<u>345</u>	<u>690</u>	<u>lb</u>
$F_n - W_b$	<u>99</u>	<u>329</u>	<u>674</u>	<u>lb</u>

Joint Profiles

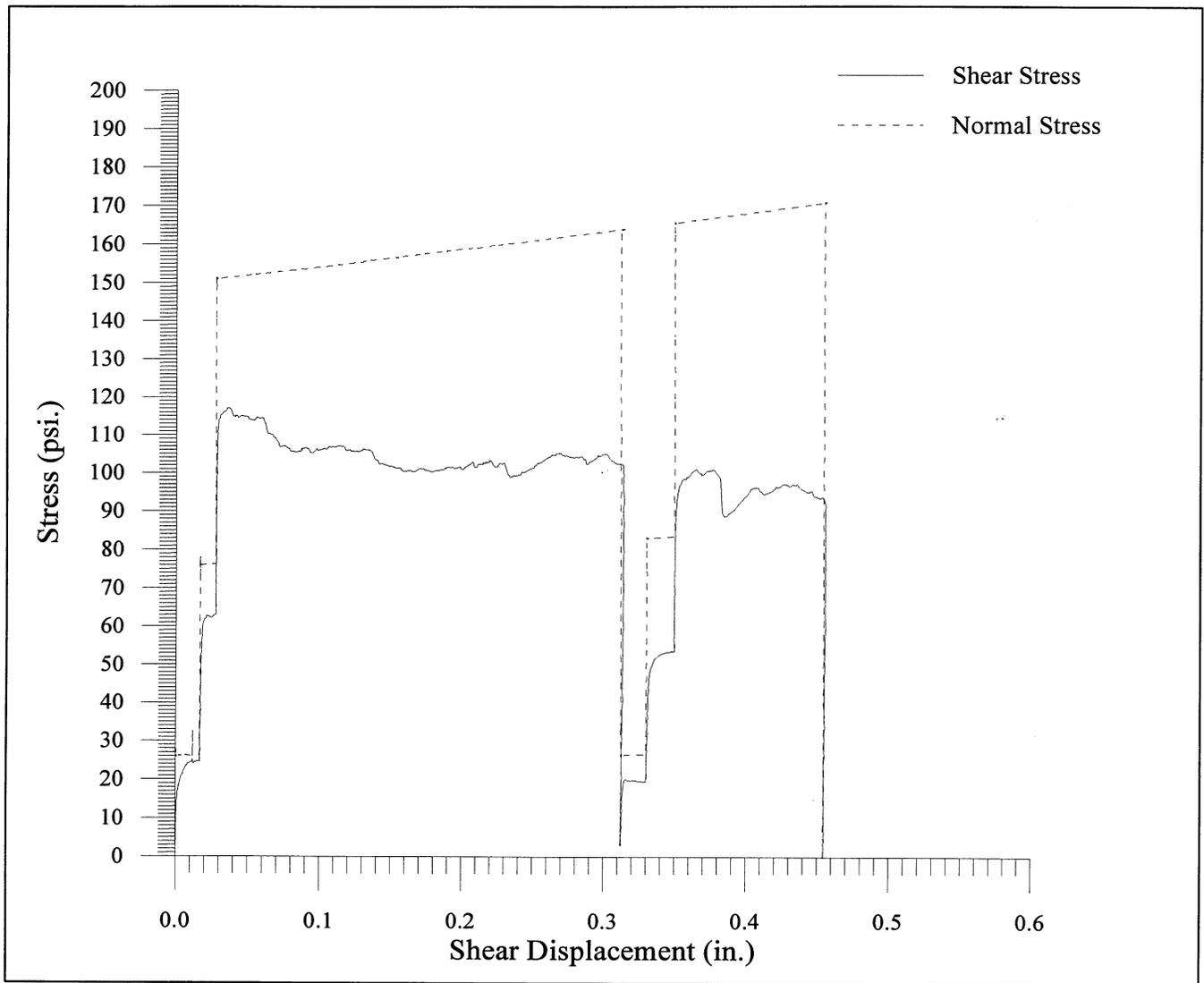


Summary of Test Results

Rate of Loading				
Shr. Displ. Rate				
Normal Stress				
Shear Strength				

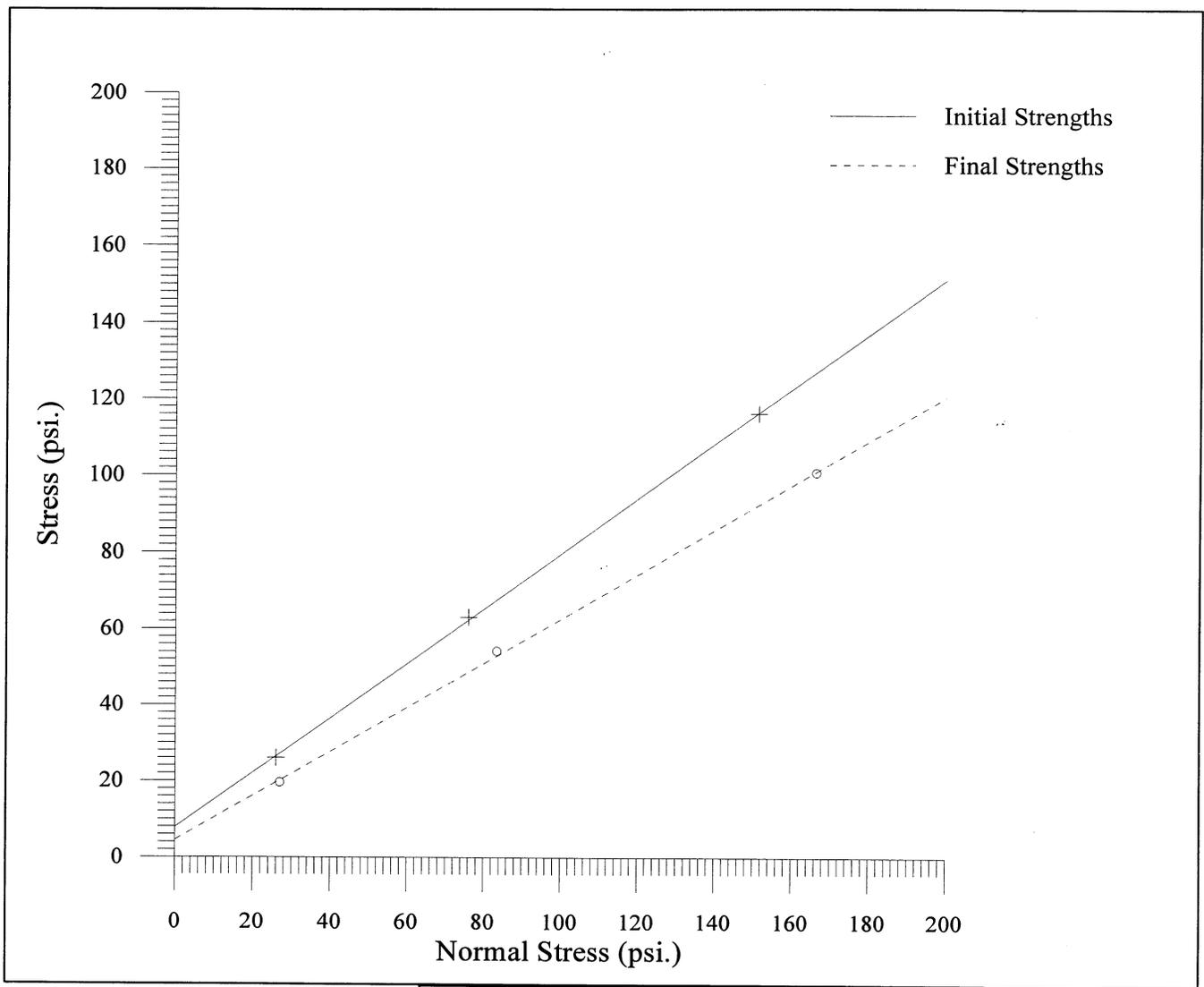
Sj: \_\_\_\_\_

φ: \_\_\_\_\_



**DIRECT SHEAR TEST**  
**Shear and Normal Stress vs. Shear Displacement**

<b>SAMPLE ID:</b> Boring: 98-22 Sample: 25b Depth: 86'		 800 Peralta Ave San Leandro, CA 94577																		
<b>DESCRIPTION</b> Planar calcite coated bedding plane joint in dark gray claystone.		<b>Client:</b> Fugro West, Inc. 5855 Olivas Park Dr. Ventura, CA 93003																		
	<table border="1"> <thead> <tr> <th></th> <th>Normal Stress</th> <th>Shear Strength</th> </tr> </thead> <tbody> <tr> <td rowspan="3">Initial</td> <td>26</td> <td>26</td> </tr> <tr> <td>76</td> <td>63</td> </tr> <tr> <td>151.5</td> <td>116</td> </tr> <tr> <td rowspan="3">Final</td> <td>27</td> <td>19.5</td> </tr> <tr> <td>83.5</td> <td>54</td> </tr> <tr> <td>166.5</td> <td>100.5</td> </tr> </tbody> </table>		Normal Stress	Shear Strength	Initial	26	26	76	63	151.5	116	Final	27	19.5	83.5	54	166.5	100.5	<b>Project:</b> San Francisco Oakland Bay Bridge East Span Replacement Project  <b>Job Number:</b> 98-42-0053	
	Normal Stress	Shear Strength																		
Initial	26	26																		
	76	63																		
	151.5	116																		
Final	27	19.5																		
	83.5	54																		
	166.5	100.5																		
		<b>Test Date:</b> October 29, 1998																		



**DIRECT SHEAR TEST  
Failure Envelope**

**SAMPLE ID:** Boring: 98-22  
Sample: 25b  
Depth: 86'

**DESCRIPTION**  
Planar calcite coated bedding plane joint in dark gray claystone.

	Shear Intercept (psi)	Friction Angle (degrees)
Initial	7.8	35.6
Final	4.5	30.1

**Geo**  **Test**  
**Unlimited** 800 Peralta Ave  
 San Leandro, CA 94577

**Client:** Fugro West, Inc.  
5855 Olivas Park Dr.  
Ventura, CA 93003

**Project:** San Francisco Oakland Bay Bridge  
East Span Replacement Project

**Job Number:** 98-42-0053

**Test Date:** October 29, 1998

**DATA SHEET**  
**Direct Shear of Rock (ISRM)**

Date: 10/29/98

Person performing the test: A. Bro

Client: Fuyo

Job: #92-SFOBB

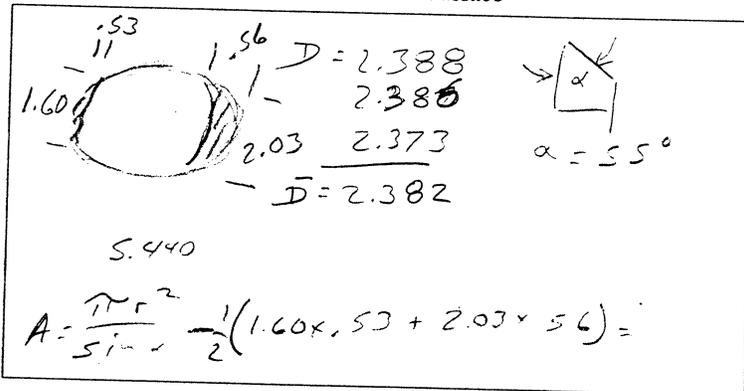
Sample ID: B98-22 525C

Sample Description: Planar bedding joint in dark gray limestone adjacent to sandstone / limestone contact with a partial calcite coating.

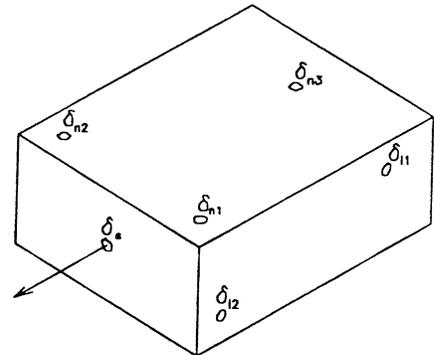
Sample Depth: 91.5'

Sample Water Condition: received & tested moist

Sketch of Shear Surface



Location of LVDTs on top shear box



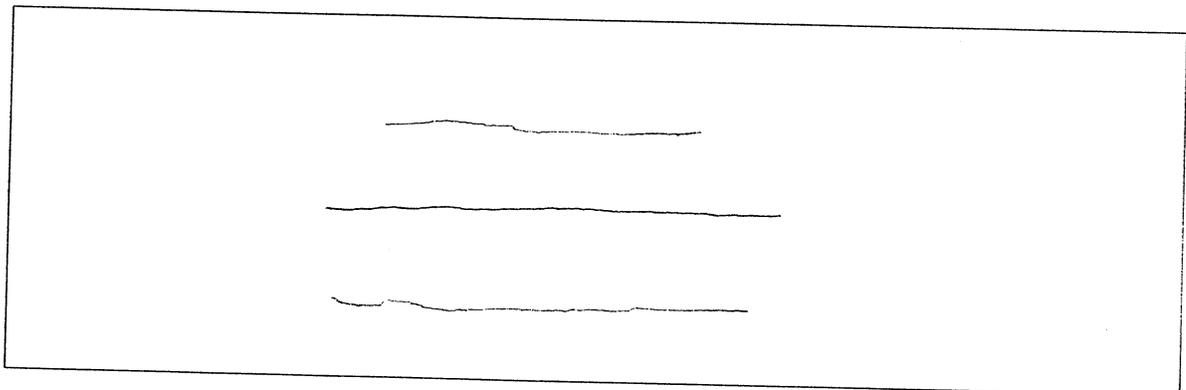
Sample area: 4.448

Estimated Top Box Weight: \_\_\_\_\_

Measured Top Box Weight: 15.9 lb

$\sigma_n$	<u>25</u>	<u>75</u>	<u>150</u>	psi
$F_n$	<u>111</u>	<u>333</u>	<u>666</u>	lb
$F_n - W_b$	<u>95</u>	<u>317</u>	<u>650</u>	lb

Joint Profiles

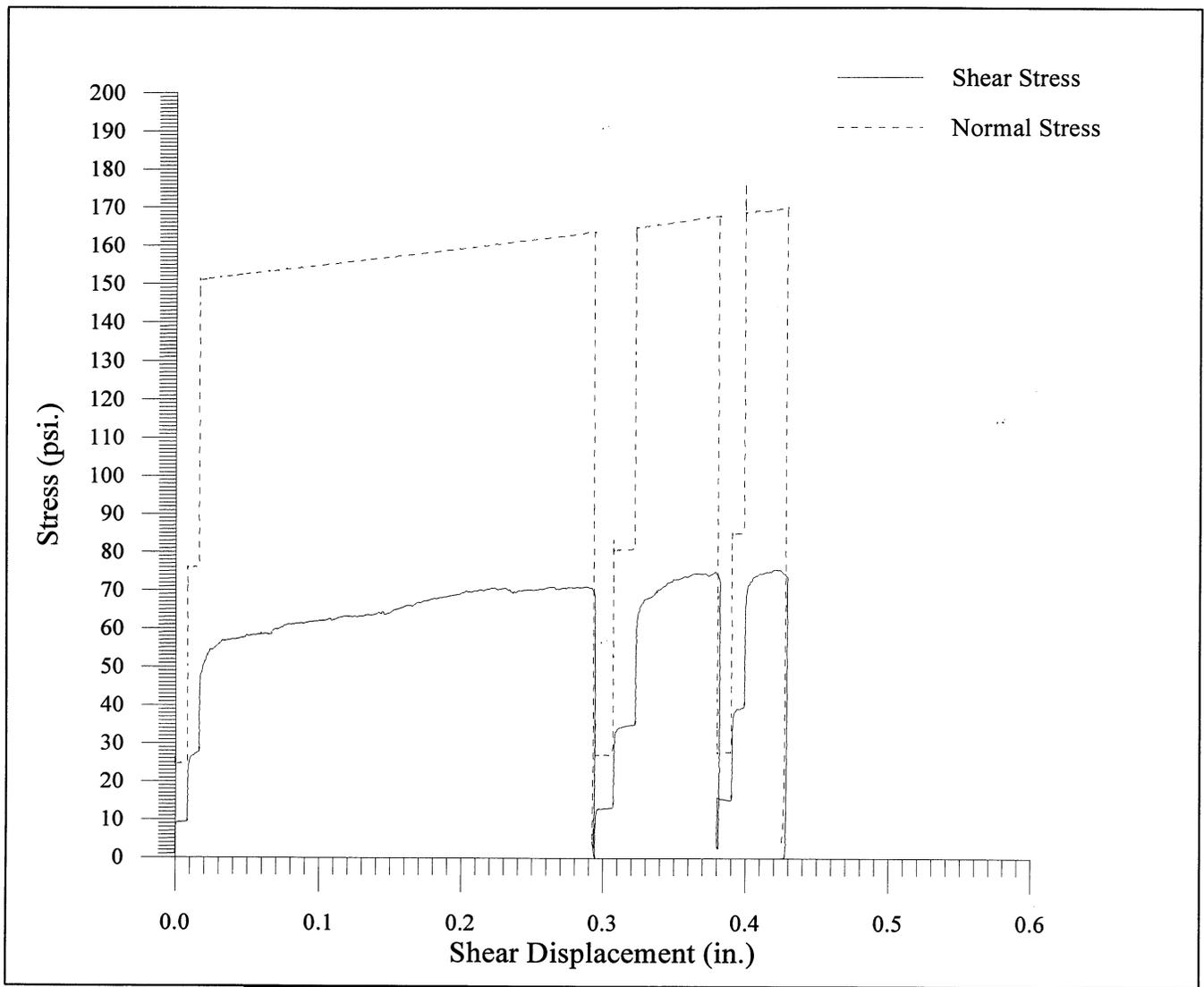


Summary of Test Results

Rate of Loading				
Shr. Displ. Rate				
Normal Stress				
Shear Strength				

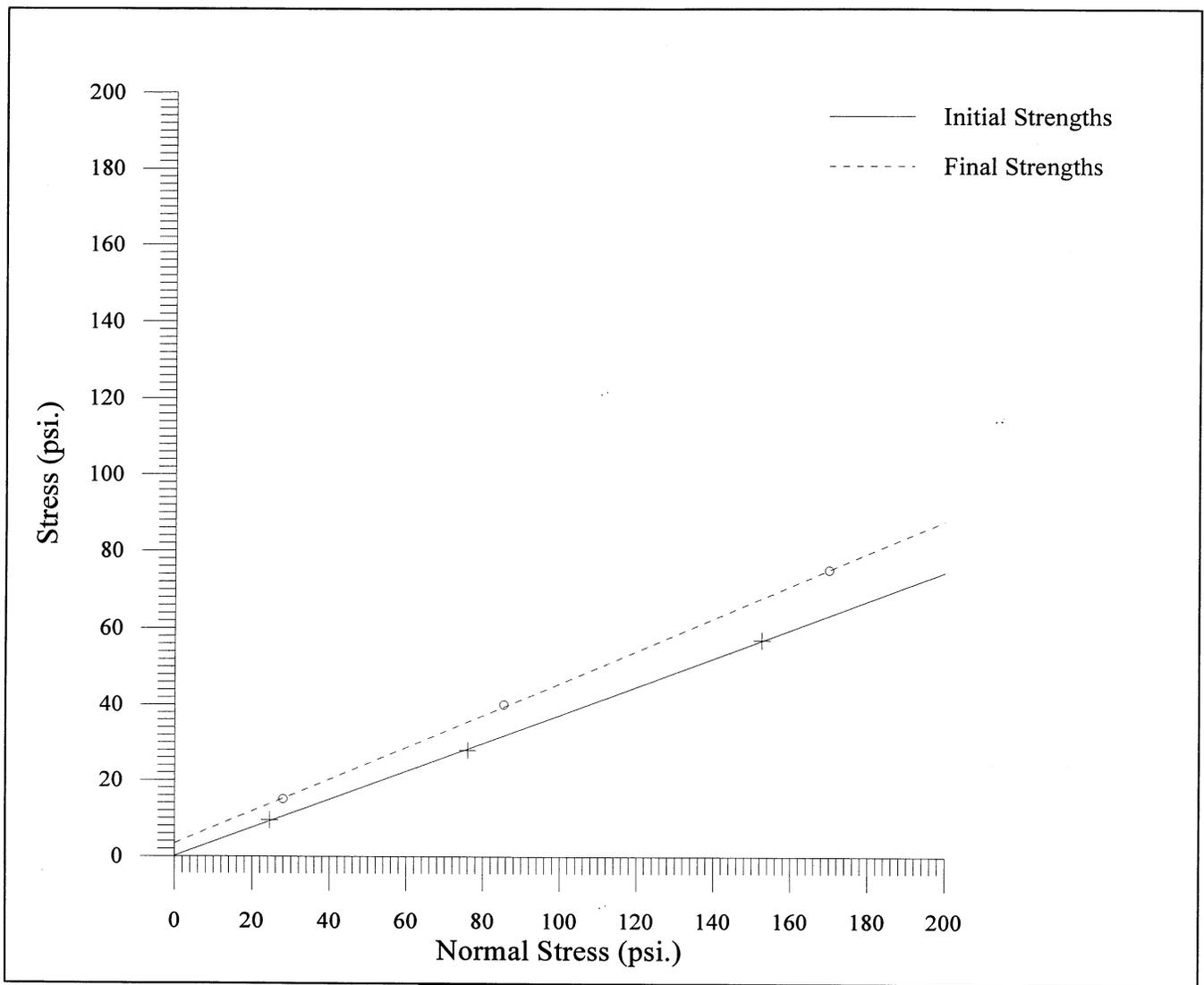
Sj: \_\_\_\_\_

phi: \_\_\_\_\_



**DIRECT SHEAR TEST**  
**Shear and Normal Stress vs. Shear Displacement**

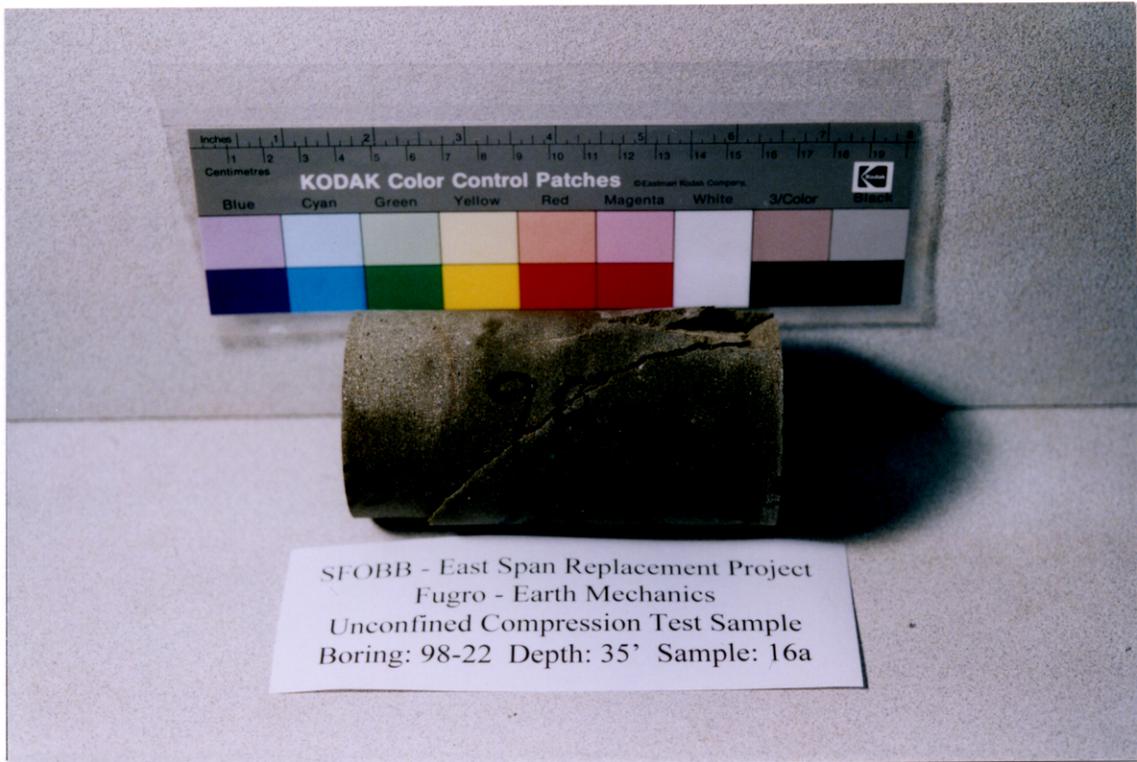
<p><b>SAMPLE ID:</b> Boring: 98-22          Sample: 25c          Depth: 91.5'</p> <p align="center"><b>DESCRIPTION</b></p> <p>Planar calcite coated bedding plane joint in dark gray claystone adjacent to a claystone/sandstone contact.</p> <table border="1"> <thead> <tr> <th></th> <th>Normal Stress</th> <th>Shear Strength</th> </tr> </thead> <tbody> <tr> <td rowspan="3">Initial</td> <td>24.5</td> <td>9.5</td> </tr> <tr> <td>76</td> <td>28</td> </tr> <tr> <td>152.5</td> <td>57</td> </tr> <tr> <td rowspan="3">Final</td> <td>28</td> <td>15</td> </tr> <tr> <td>85.5</td> <td>40</td> </tr> <tr> <td>170</td> <td>75</td> </tr> </tbody> </table>		Normal Stress	Shear Strength	Initial	24.5	9.5	76	28	152.5	57	Final	28	15	85.5	40	170	75	<p align="center">   <b>Geo Test Unlimited</b>          800 Peralta Ave          San Leandro, CA 94577       </p>
		Normal Stress	Shear Strength															
Initial	24.5	9.5																
	76	28																
	152.5	57																
Final	28	15																
	85.5	40																
	170	75																
<p><b>Client:</b> Fugro West, Inc.          5855 Olivas Park Dr.          Ventura, CA 93003</p> <p><b>Project:</b> San Francisco Oakland Bay Bridge          East Span Replacement Project</p> <p><b>Job Number:</b> 98-42-0053</p>	<p><b>Test Date:</b> October 29, 1998</p>																	



**DIRECT SHEAR TEST  
Failure Envelope**

<p><b>SAMPLE ID:</b> Boring: 98-22 Sample: 25c Depth: 91.5'</p> <p align="center"><b>DESCRIPTION</b></p> <p>Planar calcite coated bedding plane joint in dark gray claystone adjacent to a claystone/sandstone contact.</p> <table border="1"> <thead> <tr> <th></th> <th>Shear Intercept (psi)</th> <th>Friction Angle (degrees)</th> </tr> </thead> <tbody> <tr> <td>Initial</td> <td>0.2</td> <td>20.3</td> </tr> <tr> <td>Final</td> <td>3.5</td> <td>22.9</td> </tr> </tbody> </table>		Shear Intercept (psi)	Friction Angle (degrees)	Initial	0.2	20.3	Final	3.5	22.9	<p align="center"> <i>Geo</i>  <i>Test</i>  <b>Unlimited</b> 800 Peralta Ave  San Leandro, CA 94577 </p>
		Shear Intercept (psi)	Friction Angle (degrees)							
Initial	0.2	20.3								
Final	3.5	22.9								
<p><b>Client:</b> Fugro West, Inc. 5855 Olivas Park Dr. Ventura, CA 93003</p> <p><b>Project:</b> San Francisco Oakland Bay Bridge East Span Replacement Project</p> <p><b>Job Number:</b> 98-42-0053</p> <p><b>Test Date:</b> October 29, 1998</p>										

# Photographs







SFOBB - East Span Replacement Project  
Fugro - Earth Mechanics  
Unconfined Compression Test Sample  
Boring: 98-22 Depth: 48' Sample: 18a



SFOBB - East Span Replacement Project  
Fugro - Earth Mechanics  
Unconfined Compression Test Sample  
Boring: 98-22 Depth: 48' Sample: 18a





SFOBB - East Span Replacement Project  
Fugro - Earth Mechanics  
Unconfined Compression Test Sample  
Boring: 98-22 Depth: 70' Sample: 21a

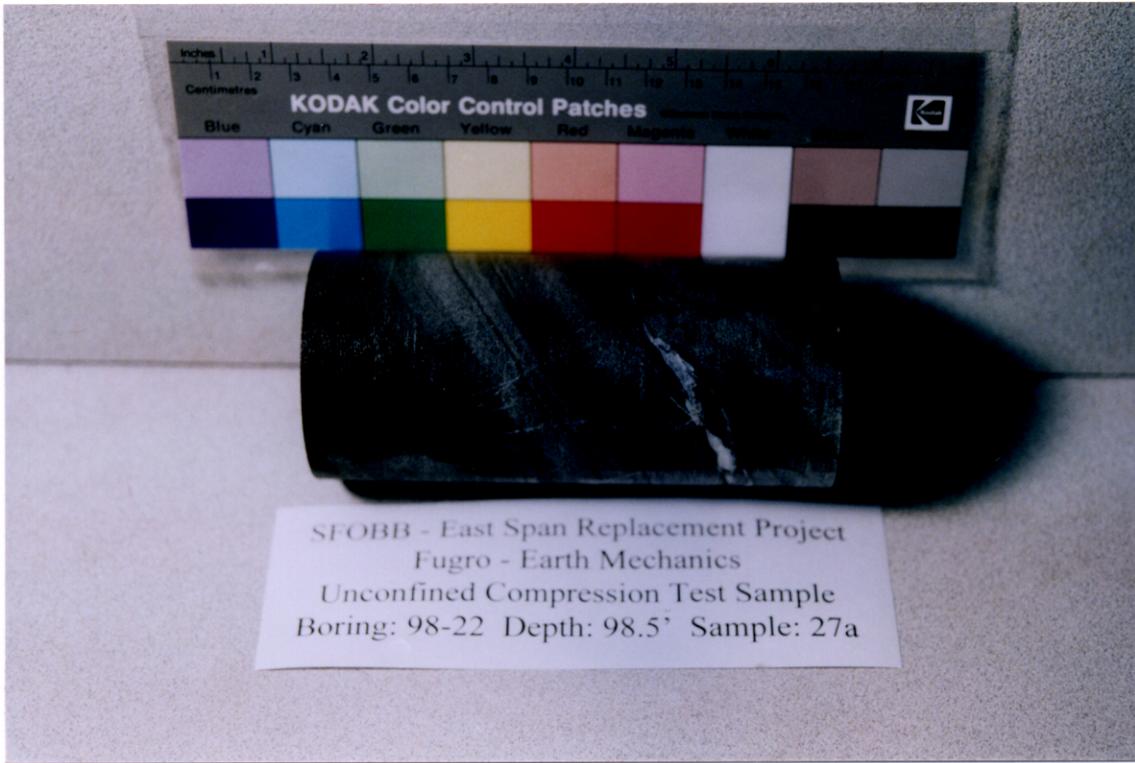


SFOBB - East Span Replacement Project  
Fugro - Earth Mechanics  
Unconfined Compression Test Sample  
Boring: 98-22 Depth: 70' Sample: 21a



















SFOBB - East Span Replacement Project  
Fugro - Earth Mechanics  
Direct Shear Test Sample  
Boring: 98-22 Depth: 51' Sample: 19a



SFOBB - East Span Replacement Project  
Fugro - Earth Mechanics  
Direct Shear Test Sample  
Boring: 98-22 Depth: 55' Sample: 19b



**BORING 98-23**

## **Modulus and Unconfined Compression Tests**

DATA SHEET

Determination of Rock Modulus and Poisson's Ratio (ASTM D3148)

Date: 10/22 & 23/98

Person performing the test: A. Bro

Client: Fugro

Job: #92-SFOBB

Sample ID: B98-23 S6a

Sample Description: Light brown massive sandstone with a diagonal open fracture 32° to the core axis and a calcite coating on one side

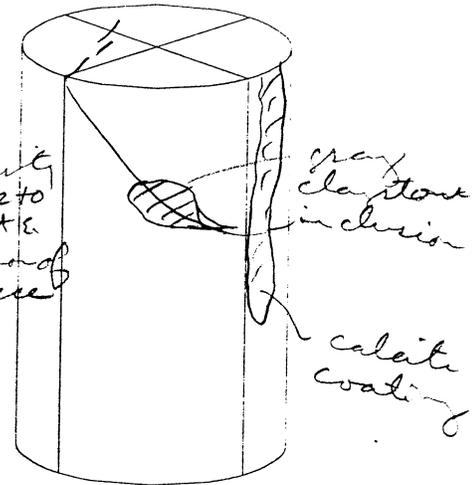
Sample Depth: 14.5'

Sample Condition: received & tested in situ

d <sub>1</sub>	d <sub>2</sub>
2.390	2.384
2.385	2.386
2.370	2.360
2.371	2.369
2.381	2.378

l <sub>1</sub>	l <sub>2</sub>
-0.0008	-0.0005
±0.0001	0 ±0.0001
+0.0007	0

non planar due to joint & rotation of top piece



Avg. diameter: 2.377

Avg. length: 5.404"

Sample area: 4.438

l/d ratio: 2.27

Sample volume (in<sup>3</sup>): 23.98

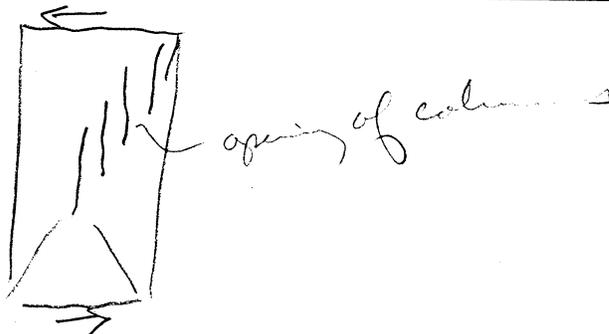
Sample weight (g): 1018.9 g

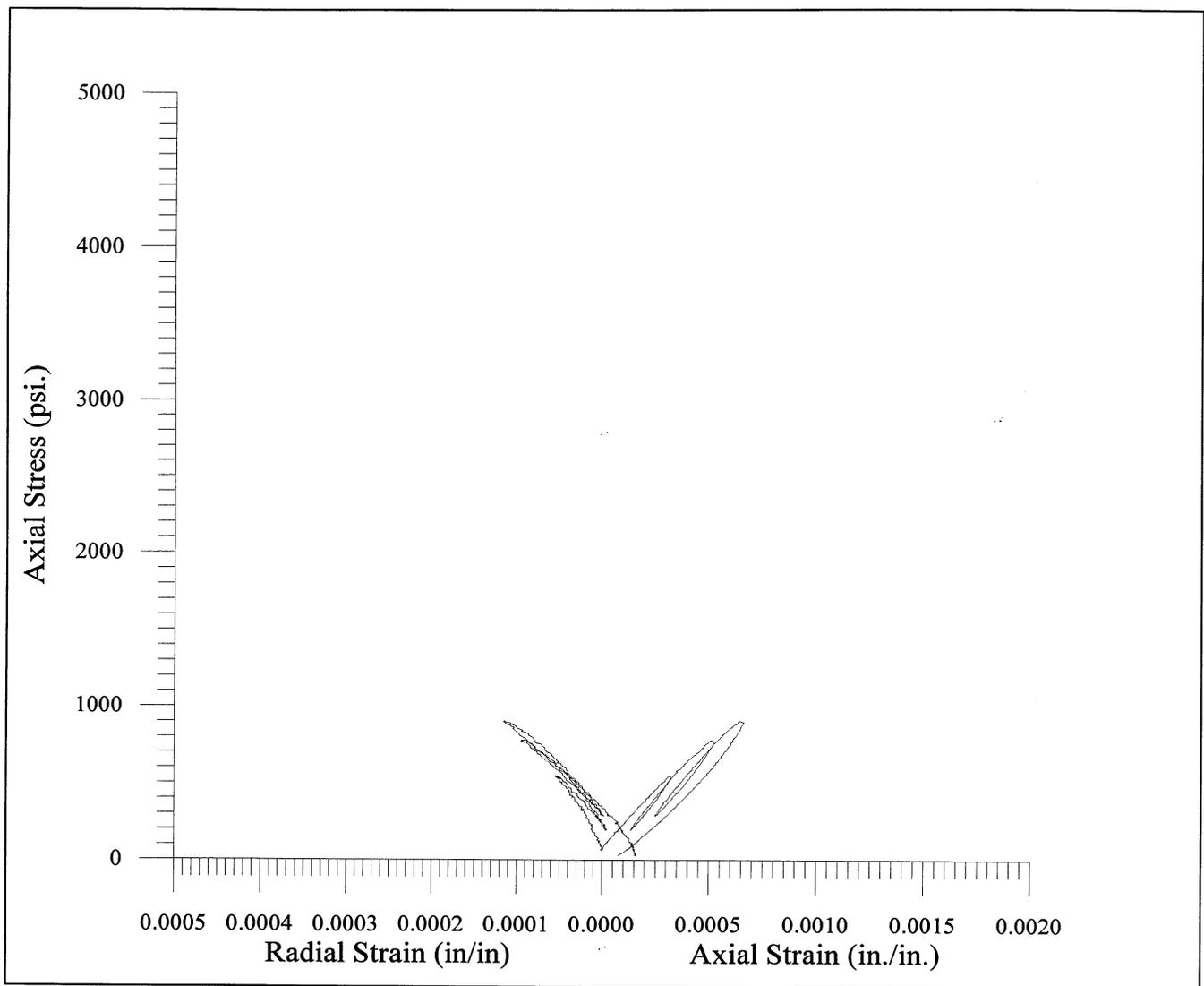
Density: 42.49 g/in<sup>3</sup> = 161.9 pcf (1 g/in<sup>3</sup> = 3.8095 lb/ft<sup>3</sup>)

Gauge length: 2.000 in.

Comments: edge of joint lightly glued to maintain sample integrity.

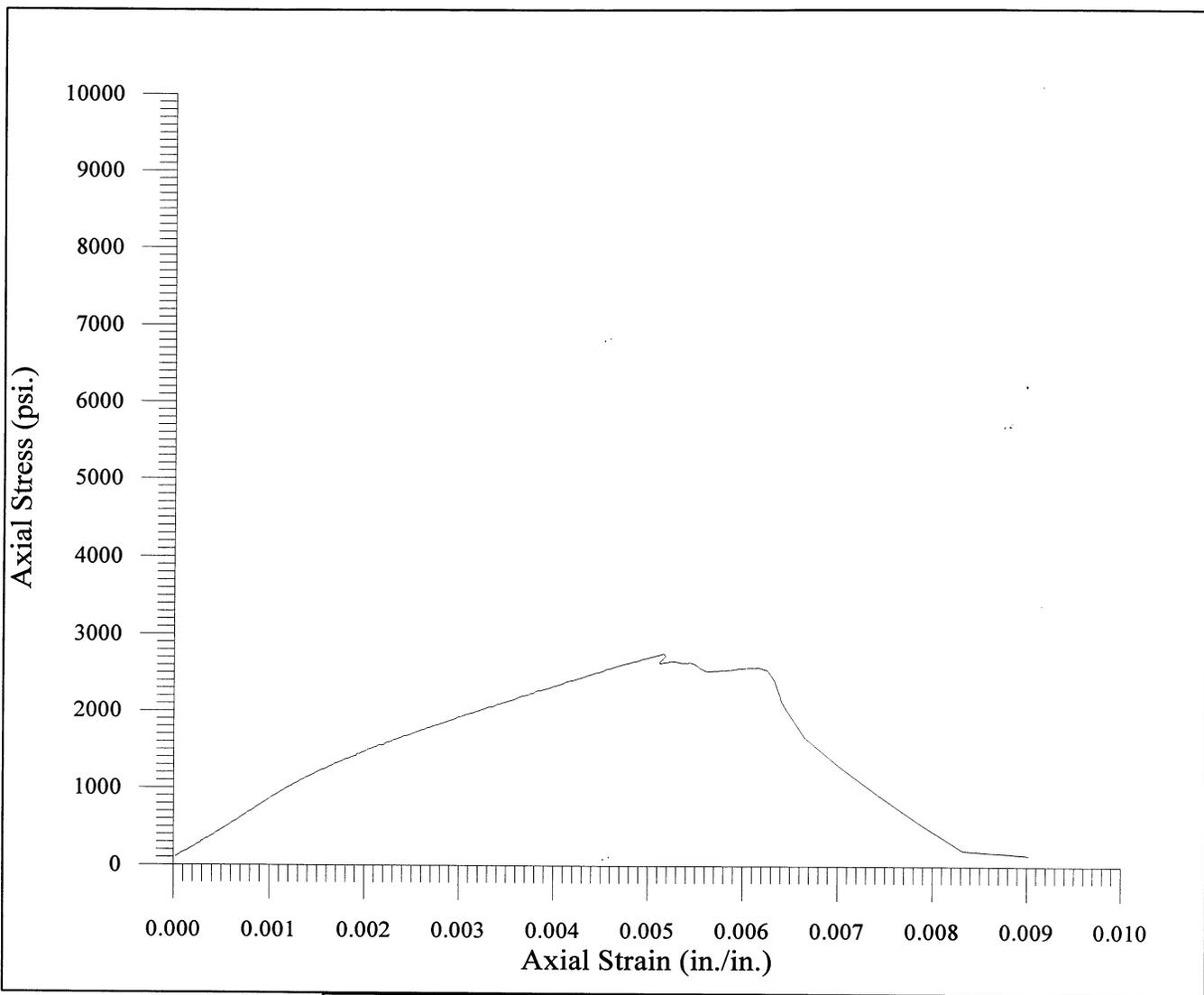
Failed by shear/axial splitting





**ELASTIC MODULUS TEST**  
**Axial Stress vs. Axial & Radial Strain**

<p><b>SAMPLE ID:</b> Boring: 98-23  Sample: 6a  Depth: 14.5'</p> <p><b>DESCRIPTION</b>  Light brown massive sandstone with an open fracture near the core end, 32 degrees to the core axis, and a calcite coating on one side.</p> <p><b>MODULUS:</b> 1,770,000 psi  <b>POISSON'S RATIO:</b> .30</p>	<p align="center"> <i>Geo</i>  <i>U</i>  <i>Test</i>  <b>Unlimited</b> </p> <p align="right">800 Peralta Ave  San Leandro, CA 94577</p> <hr/> <p><b>Client:</b> Fugro West, Inc.  5855 Olivas Park Dr.  Ventura, CA 93003</p> <p><b>Project:</b> San Francisco Oakland Bay Bridge  East Span Replacement Project</p> <p><b>Job Number:</b> 98-42-0053</p> <hr/> <p><b>Test Date:</b> October 22, 1998</p>
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**UNCONFINED COMPRESSION TEST  
Axial Stress vs. Axial Strain**

**SAMPLE ID:** Boring : 98-23  
 Sample: 6a  
 Depth: 14.5'

**DESCRIPTION**  
 Light brown massive sandstone with an open fracture near the core end, 32 degrees to the core axis, and a calcite coating on one side.

**STRENGTH:** 2756 psi

  
**Geo Test Unlimited**  
 800 Peralta Ave  
 San Leandro, CA 94577

---

**Client:** Fugro West, Inc.  
 5855 Olivas Park Dr.  
 Ventura, CA 93003

**Project:** San Francisco Oakland Bay Bridge  
 East Span Replacement Project

**Job Number:** 98-42-0053

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**Test Date:** October 23, 1998

DATA SHEET

Determination of Rock Modulus and Poisson's Ratio (ASTM D3148)

Date: 10/22 & 23/98

Person performing the test: A. Bro

Client: Fuyo

Job: #92-SFOBD

Sample ID: B98-23 S11a

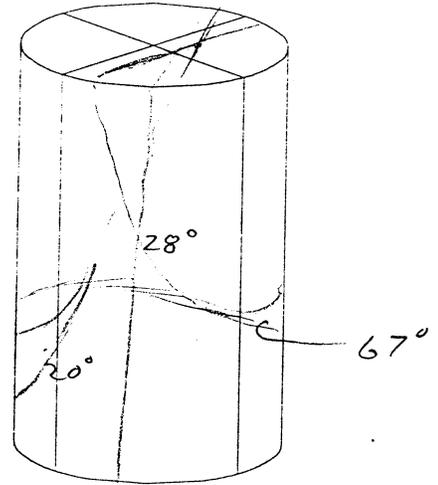
Sample Description: Medium gray sandstone with a few calcite healed hairline fractures 0°, 20°, 28°, 67° to the core axis

Sample Depth: 34'

Sample Condition: received & tested moist

d <sub>1</sub>	d <sub>2</sub>
2.398	2.397
2.396	2.395
2.396	2.394
2.396	2.392
2.396	2.396

l <sub>1</sub>	l <sub>2</sub>
-.0008	-.0001
±.0001	±.0001
+.0008	+.0001



Avg. diameter: 2.396

Avg. length: 5.219

Sample area: 4.509

l/d ratio: 2.18

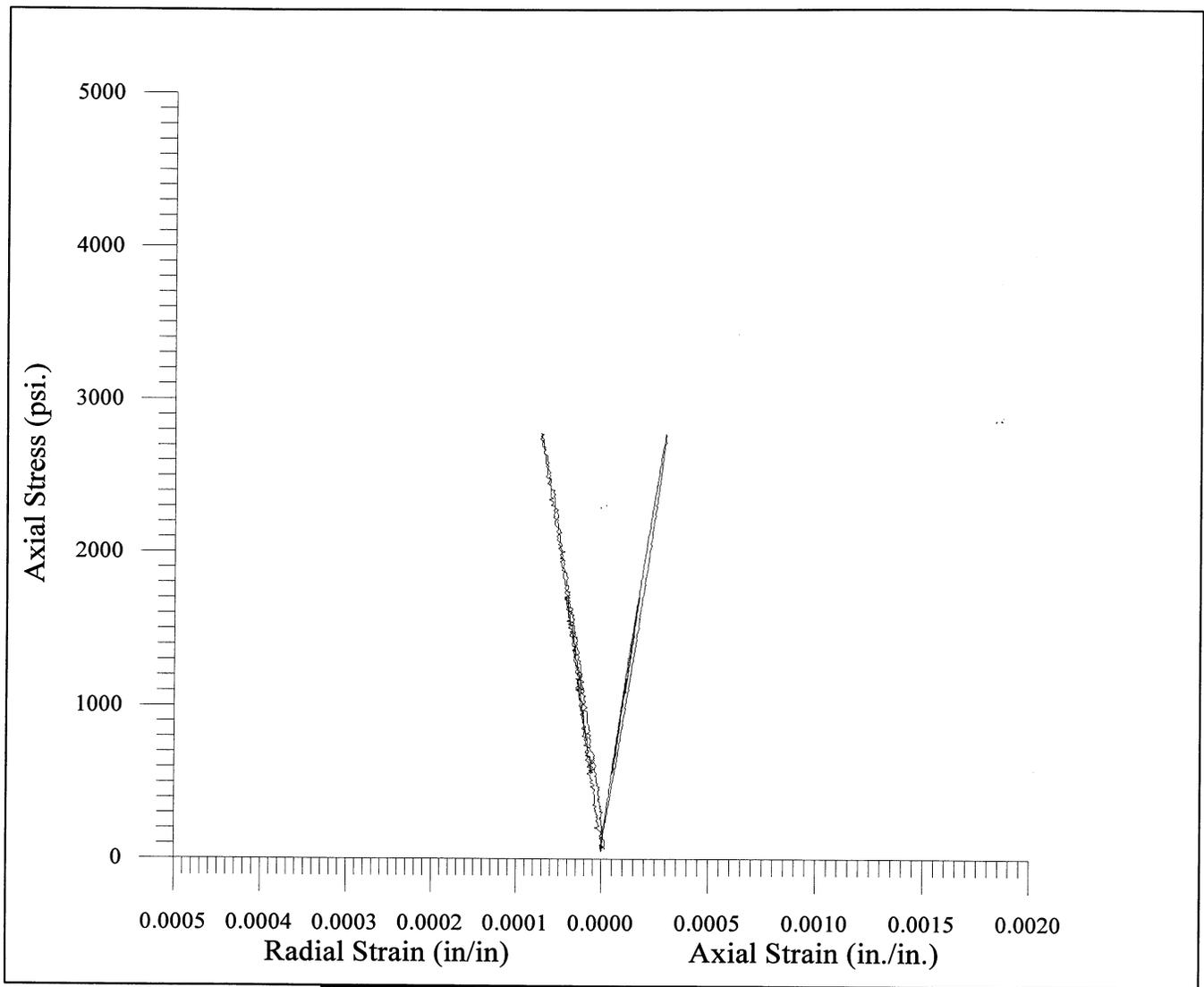
Sample volume(in<sup>3</sup>): 23.532

Sample weight (g): 1043.8g

Density: 44.36g/in<sup>3</sup> = 119.0 (1 g/in<sup>3</sup> = 3.8095 lb/ft<sup>3</sup>)

Gauge length: 2.000 in

Comments: Failed by axial splitting & shear on 28° healed joint.



**ELASTIC MODULUS TEST**  
**Axial Stress vs. Axial & Radial Strain**

**SAMPLE ID:** Boring: 98-23  
 Sample: 11a  
 Depth: 34'

**DESCRIPTION**  
 Medium gray sandstone with a few calcite healed hairline fractures, 0, 20, 28, and 67 degrees to the core axis.

**MODULUS:** 9,090,000 psi  
**POISSON'S RATIO:** .21

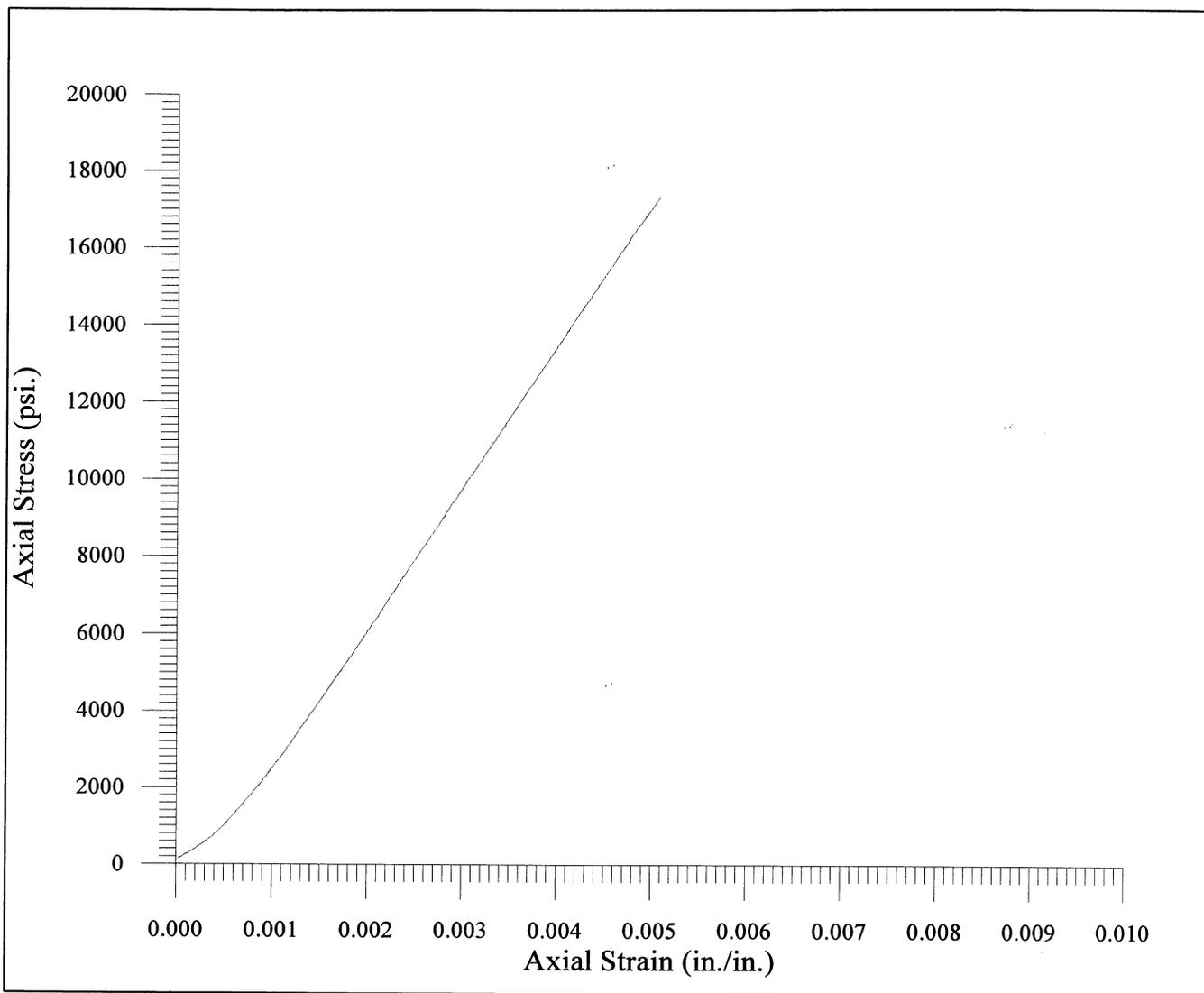
*Geo*  *Test*  
**Unlimited** 800 Peralta Ave  
 San Leandro, CA 94577

**Client:** Fugro West, Inc.  
 5855 Olivas Park Dr.  
 Ventura, CA 93003

**Project:** San Francisco Oakland Bay Bridge  
 East Span Replacement Project

**Job Number:** 98-42-0053

**Test Date:** October 22, 1998



**UNCONFINED COMPRESSION TEST  
Axial Stress vs. Axial Strain**

<p><b>SAMPLE ID:</b> Boring : 98-23 Sample: 11a Depth: 34'</p> <p align="center"><b>DESCRIPTION</b></p> <p>Medium gray sandstone with a few calcite healed hairline fractures, 0, 20, 28, and 67 degrees to the core axis.</p> <p><b>STRENGTH:</b> 17,330 psi</p>	<div style="text-align: center;">   <b>Geo Test Unlimited</b>              800 Peralta Ave              San Leandro, CA 94577         </div> <hr/> <p><b>Client:</b> Fugro West, Inc. 5855 Olivas Park Dr. Ventura, CA 93003</p> <p><b>Project:</b> San Francisco Oakland Bay Bridge East Span Replacement Project</p> <p><b>Job Number:</b> 98-42-0053</p> <hr/> <p><b>Test Date:</b> October 23, 1998</p>
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DATA SHEET

Determination of Rock Modulus and Poisson's Ratio (ASTM D3148)

Date: 10/22 & 23/98

Person performing the test: A. B. W.

Client: Fugro

Job: #92-SFOBB

Sample ID: B98-23 S14a

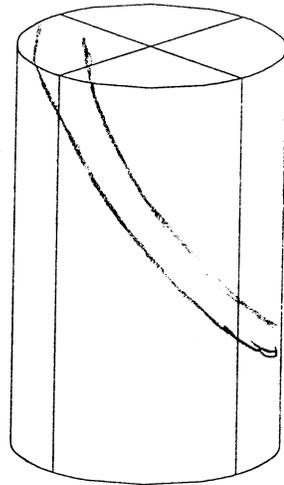
Sample Description: medium gray sandstone with two calcite healed hairline fractures 33° to the core axis.

Sample Depth: 46.5'

Sample Condition: received & tested moist

d <sub>1</sub>	d <sub>2</sub>
2.396	2.397
2.397	2.394
2.397	2.397
2.397	2.394
2.397	2.394

l <sub>1</sub>	l <sub>2</sub>
-0.0009	-0.0001
+0.0001	+0.0001
+0.0010	+0.0001



Avg. diameter: 2.396

Avg. length: 5.183

Sample area: 4.509

l/d ratio: 2.16

Sample volume(in<sup>3</sup>): 23.369

Sample weight (g): 1041.0g

Density: 44.558/in<sup>3</sup> = 969.7 pcf (1 g/in<sup>3</sup>=3.8095lb/ft<sup>3</sup>)

Gauge length: 2.000 in

Comments: Failed by shear on existing fracture

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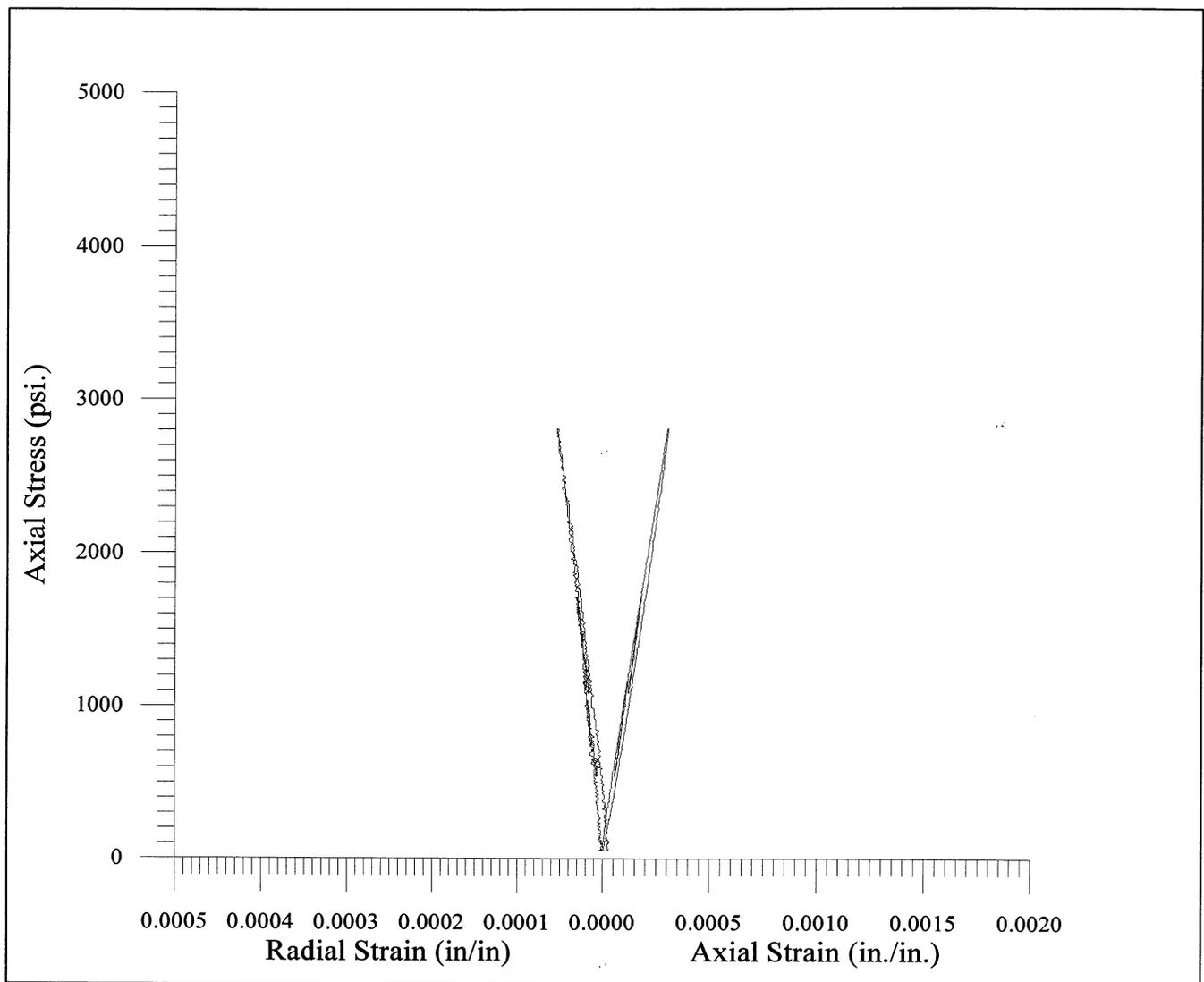
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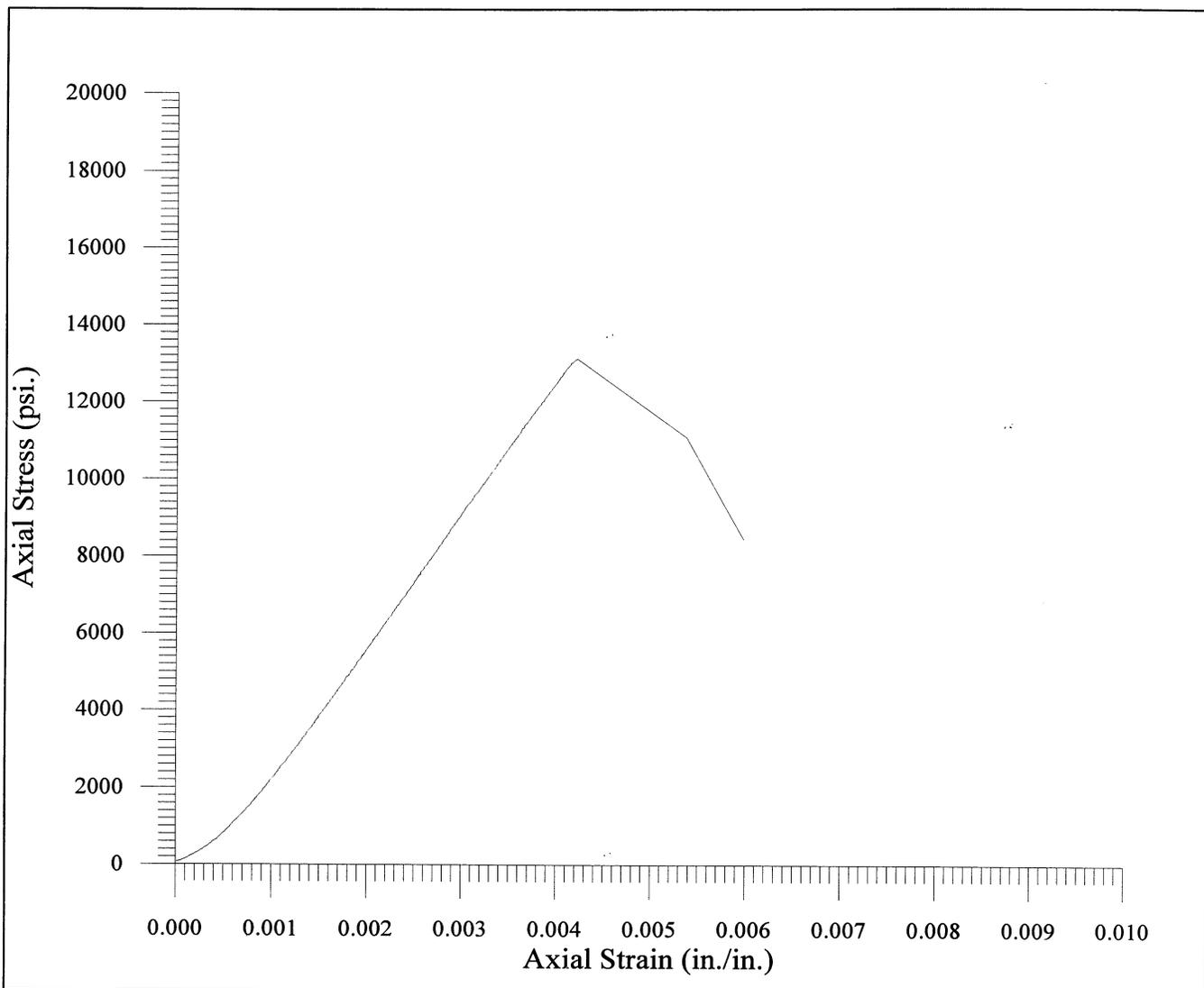


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**ELASTIC MODULUS TEST**  
**Axial Stress vs. Axial & Radial Strain**

<p><b>SAMPLE ID:</b> Boring: 98-23  Sample: 14a  Depth: 46.5'</p>	<p align="center"><i>Geo</i>  <i>Test</i>  <b>Unlimited</b> 800 Peralta Ave  San Leandro, CA 94577</p>
<p align="center"><b>DESCRIPTION</b></p> <p>Medium gray sandstone with two calcite healed hairline fractures, 33 degrees to the core axis.</p> <p><b>MODULUS:</b> 11,630,000 psi  <b>POISSON'S RATIO:</b> .26</p>	<p><b>Client:</b> Fugro West, Inc.  5855 Olivas Park Dr.  Ventura, CA 93003</p> <p><b>Project:</b> San Francisco Oakland Bay Bridge  East Span Replacement Project</p> <p><b>Job Number:</b> 98-42-0053</p>
	<p><b>Test Date:</b> October 22, 1998</p>



**UNCONFINED COMPRESSION TEST**  
**Axial Stress vs. Axial Strain**

<p><b>SAMPLE ID:</b> Boring : 98-23          Sample: 14a          Depth: 46.5'</p>	<p><i>Geo</i>  <i>Test</i>  <b>Unlimited</b> 800 Peralta Ave          San Leandro, CA 94577</p>
<p><b>DESCRIPTION</b>          Medium gray sandstone with two calcite          healed hairline fractures, 33 degrees          to the core axis.</p>	<p><b>Client:</b> Fugro West, Inc.          5855 Olivas Park Dr.          Ventura, CA 93003</p>
<p><b>STRENGTH:</b> 13,109 psi</p>	<p><b>Project:</b> San Francisco Oakland Bay Bridge          East Span Replacement Project</p>
	<p><b>Job Number:</b> 98-42-0053</p>
	<p><b>Test Date:</b> October 23, 1998</p>

DATA SHEET

Determination of Rock Modulus and Poisson's Ratio (ASTM D3148)

Date: 10/22 & 23/98

Person performing the test: A. J. RO

Client: Fugro

Job: #92-SFOBR

Sample ID: B98-23 S17a

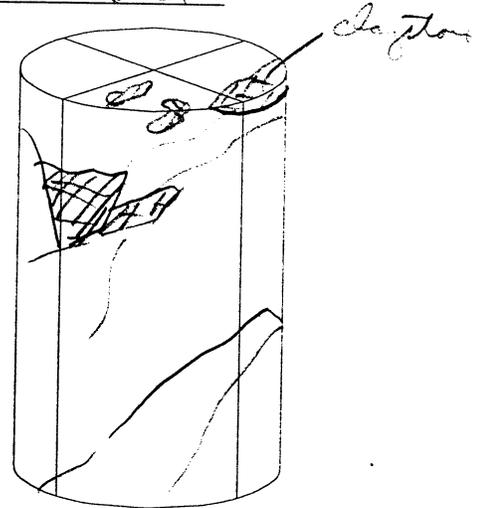
Sample Description: Dark gray fine sandy siltstone with claystone inclusions. Also contains many calcite healed fracture features between 30° & 50° to the core axis.

Sample Depth: 57.5'

Sample Condition: received & tested moist

d <sub>1</sub>	d <sub>2</sub>
2.393	2.384
2.383	2.387
2.394	2.395
2.394	2.391
2.395	2.394

l <sub>1</sub>	l <sub>2</sub>
-0.0012	-0.0002
±0.0001	±0.0001
+0.0010	+0.0001



Avg. diameter: 2.391

Avg. length: 5.191"

Sample area: 4.490

l/d ratio: 2.17

Sample volume(in<sup>3</sup>): 23.308

Sample weight (g): 1030.6g

Density: 44.22 g/in<sup>3</sup> = 168.4 pcF (1 g/in<sup>3</sup>=3.8095lb/ft<sup>3</sup>)

Gauge length: 2.000 in

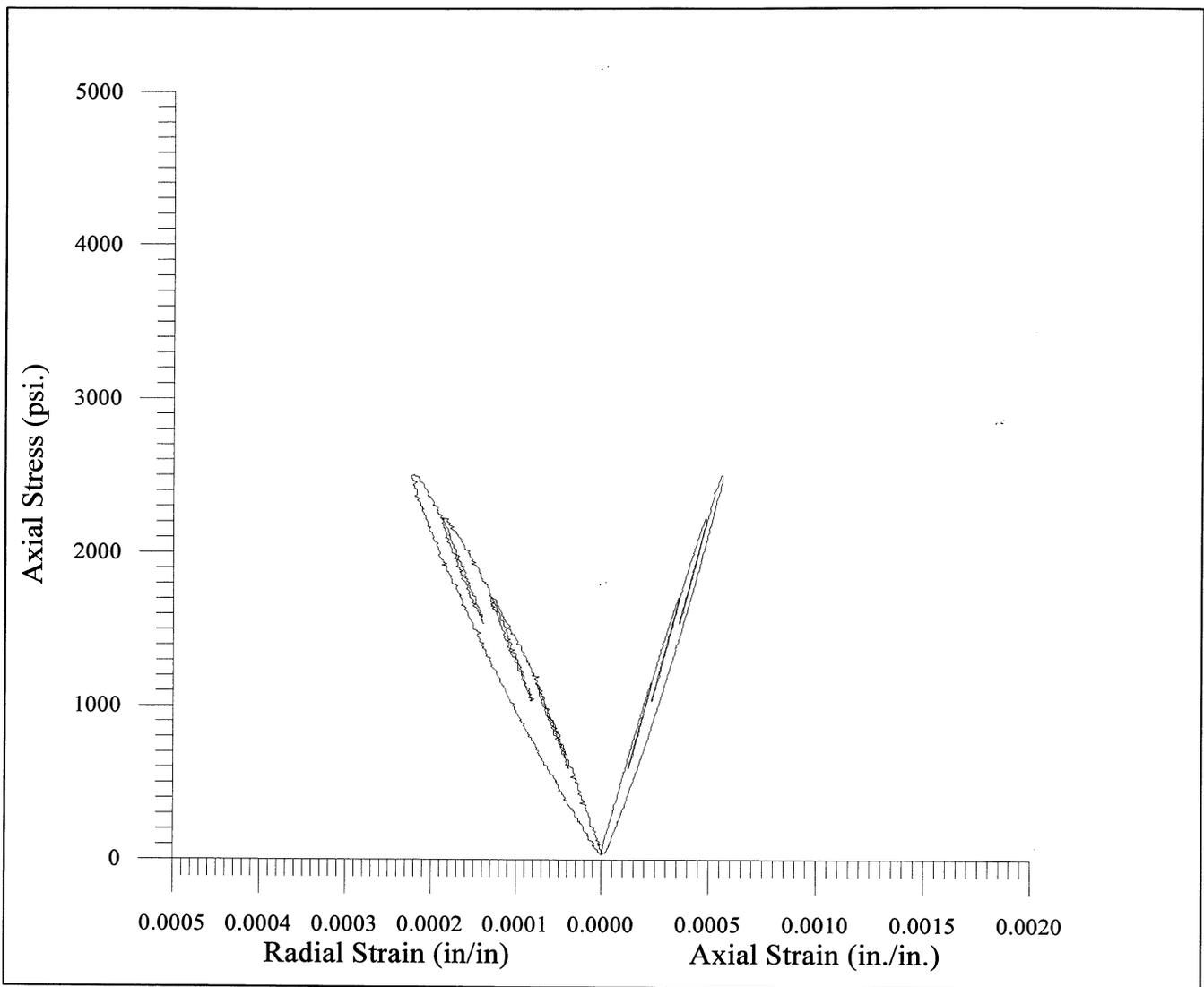
Comments: Failed by axial splitting and shear

\_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_



**ELASTIC MODULUS TEST**  
**Axial Stress vs. Axial & Radial Strain**

**SAMPLE ID:** Boring: 98-23  
 Sample: 17a  
 Depth: 57.5'

**DESCRIPTION**  
 Dark gray fine sandy siltstone with claystone inclusions and many calcite healed hairline fractures, 30 and 50 degrees to the core axis.

**MODULUS:** 5,210,000 psi  
**POISSON'S RATIO:** .36

*Geo*  *Test*  
**Unlimited** 800 Peralta Ave  
 San Leandro, CA 94577

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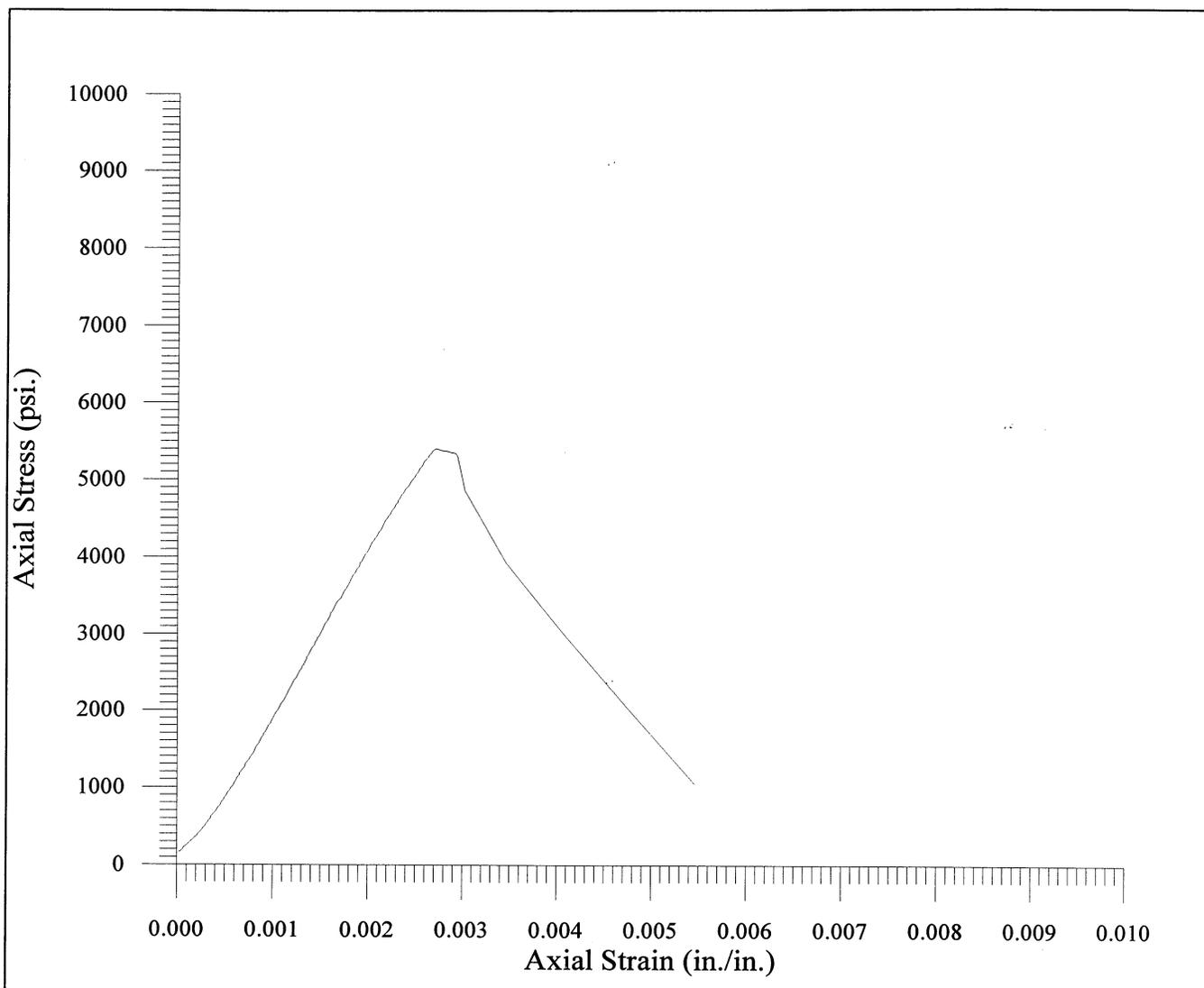
**Client:** Fugro West, Inc.  
 5855 Olivas Park Dr.  
 Ventura, CA 93003

**Project:** San Francisco Oakland Bay Bridge  
 East Span Replacement Project

**Job Number:** 98-42-0053

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**Test Date:** October 22, 1998



**UNCONFINED COMPRESSION TEST**  
**Axial Stress vs. Axial Strain**

<p><b>SAMPLE ID:</b> Boring : 98-23          Sample: 17a          Depth: 57.5'</p> <p align="center"><b>DESCRIPTION</b></p> <p>Dark gray fine sandy siltstone with claystone inclusions and many calcite healed hairline fractures, 30 and 50 degrees to the core axis.</p> <p><b>STRENGTH:</b> 5398 psi</p>	<div align="center">  <p><b>Geo Test Unlimited</b>              800 Peralta Ave              San Leandro, CA 94577</p> </div> <hr/> <p><b>Client:</b> Fugro West, Inc.          5855 Olivas Park Dr.          Ventura, CA 93003</p> <p><b>Project:</b> San Francisco Oakland Bay Bridge          East Span Replacement Project</p> <p><b>Job Number:</b> 98-42-0053</p> <hr/> <p><b>Test Date:</b> October 23, 1998</p>
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DATA SHEET

Determination of Rock Modulus and Poisson's Ratio (ASTM D3148)

Date: 10/22/98

Person performing the test: A. Bro

Client: Fugro

Job: #92-SFOBB

Sample ID: B98-23 S1Ba

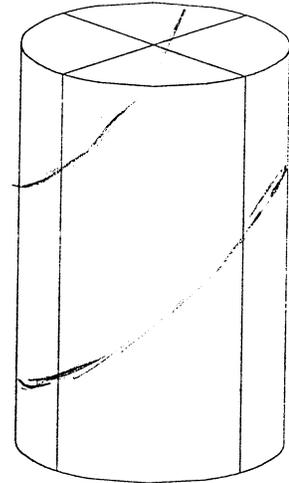
Sample Description: borderline dark gray sandstone to fine sandy siltstone with two calcite healed hairline fractures, 41° to the core axis

Sample Depth: 63'

Sample Condition: received & tested moist

d <sub>1</sub>	d <sub>2</sub>
2.367	2.365
2.375	2.370
2.373	2.372
2.376	2.367
2.374	2.373

l <sub>1</sub>	l <sub>2</sub>
-0.0010	-0.0001
±0.0001	±0.0001
+0.0009	+0.0001



Avg. diameter: 2.371

Avg. length: 5.233

Sample area: 4.415

l/d ratio: 2.21

Sample volume(in<sup>3</sup>): 23.105

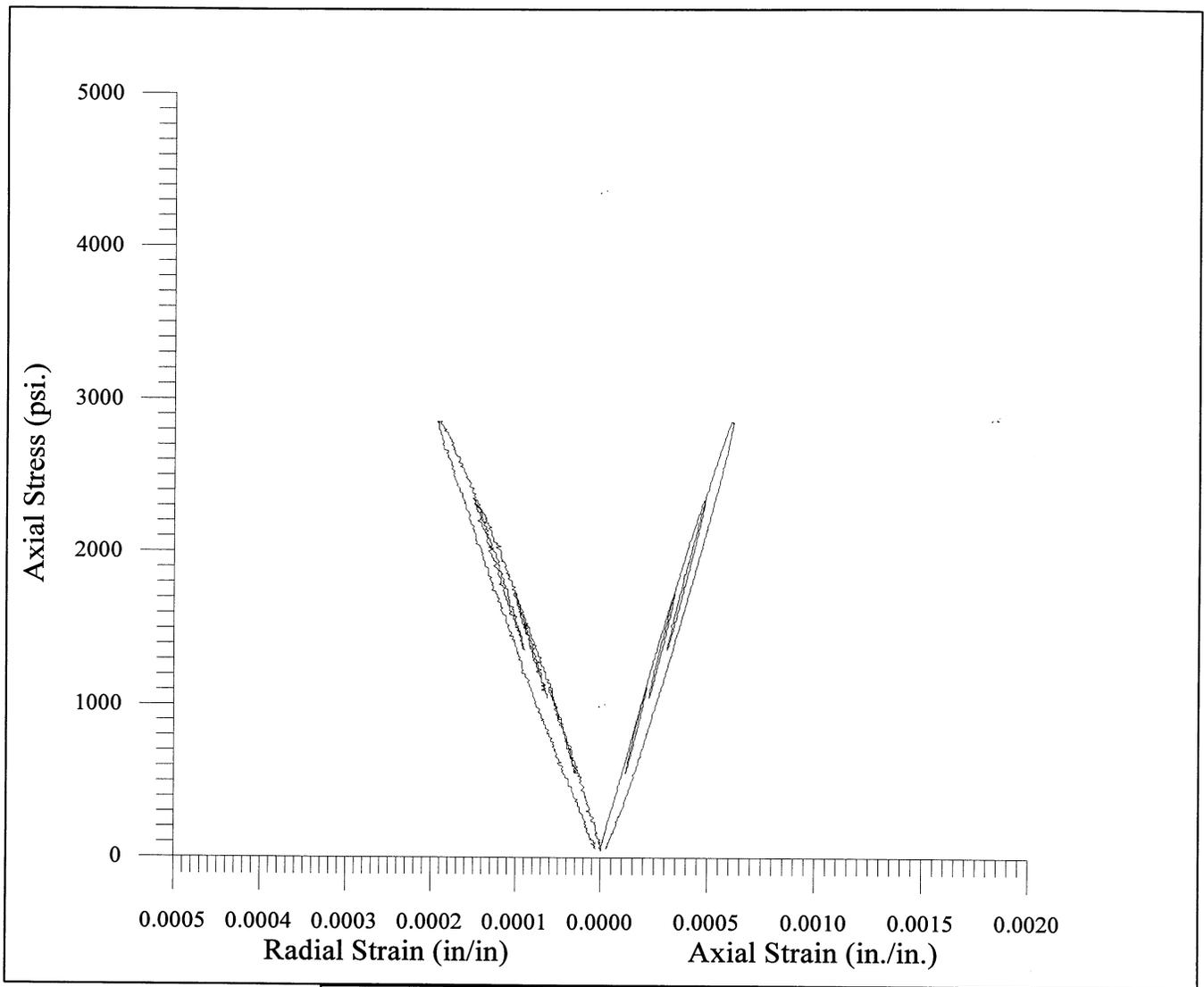
Sample weight (g): 1019.1g

Density: 44.11 g/in<sup>3</sup> = 168.0 pcf (1 g/in<sup>3</sup> = 3.8095 lb/ft<sup>3</sup>)

Gauge length: 2.000 in.

Comments: Failed by shear on existing joints and axial splitting

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\_\_\_\_\_  
\_\_\_\_\_



**ELASTIC MODULUS TEST**  
**Axial Stress vs. Axial & Radial Strain**

**SAMPLE ID:** Boring: 98-23  
 Sample: 18a  
 Depth: 63'

**DESCRIPTION**  
 Dark gray sandstone to fine sandy siltstone with two calcite healed hairline fractures, 41 degrees to the core axis.

**MODULUS:** 5,750,000 psi  
**POISSON'S RATIO:** .33

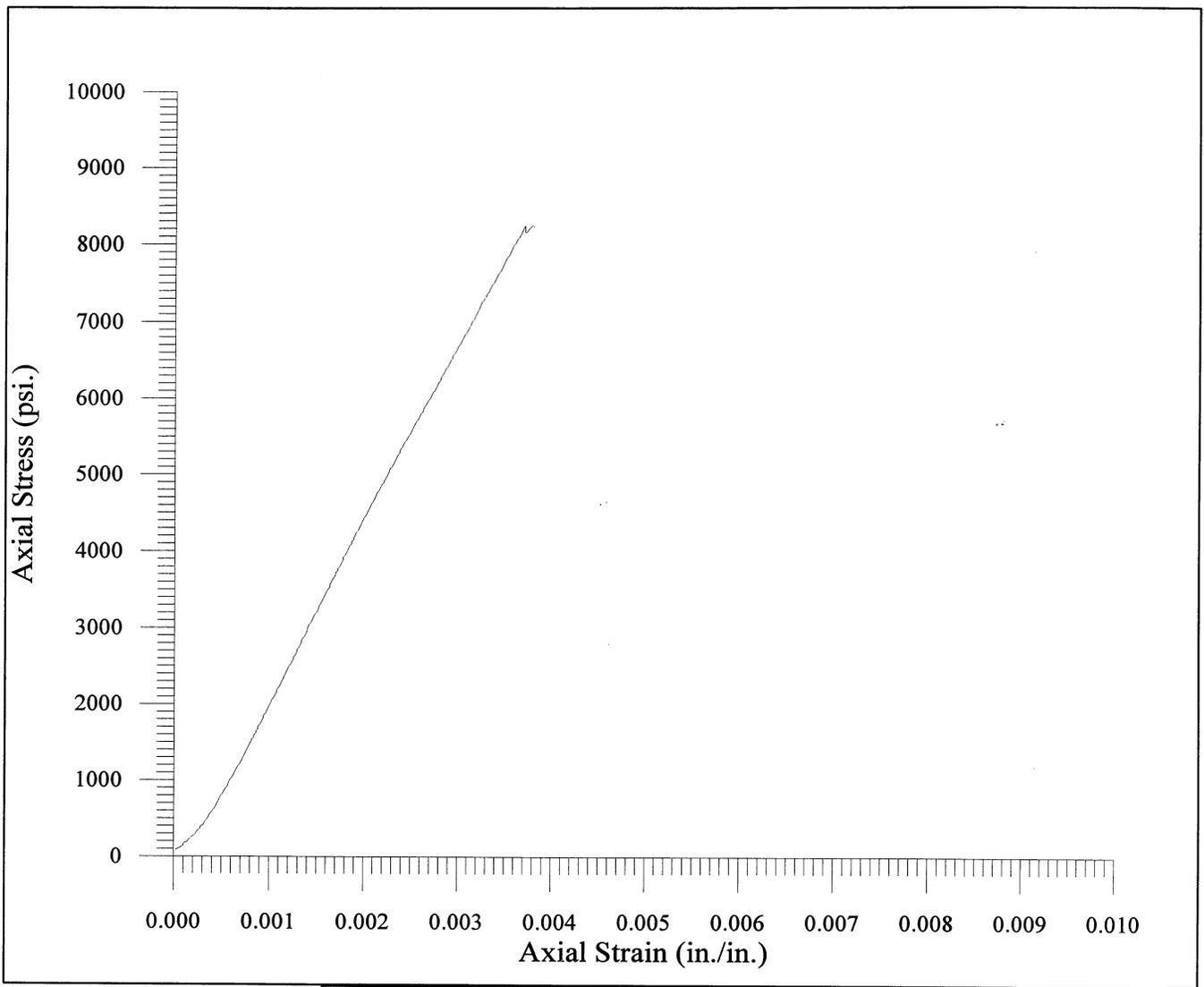
*Geo*  *Test*  
**Unlimited** 800 Peralta Ave  
 San Leandro, CA 94577

**Client:** Fugro West, Inc.  
 5855 Olivas Park Dr.  
 Ventura, CA 93003

**Project:** San Francisco Oakland Bay Bridge  
 East Span Replacement Project

**Job Number:** 98-42-0053

**Test Date:** October 22, 1998



**UNCONFINED COMPRESSION TEST  
Axial Stress vs. Axial Strain**

<p><b>SAMPLE ID:</b> Boring : 98-23 Sample: 18a Depth: 63'</p>	<p align="center"><i>Geo</i>  <i>Test</i> <b>Unlimited</b> 800 Peralta Ave San Leandro, CA 94577</p>
<p align="center"><b>DESCRIPTION</b></p> <p>Dark gray sandstone to fine sandy siltstone with two calcite healed hairline fractures, 41 degrees to the core axis.</p> <p><b>STRENGTH:</b> 8249 psi</p>	<p><b>Client:</b> Fugro West, Inc. 5855 Olivas Park Dr. Ventura, CA 93003</p> <p><b>Project:</b> San Francisco Oakland Bay Bridge East Span Replacement Project</p> <p><b>Job Number:</b> 98-42-0053</p>
	<p><b>Test Date:</b> October 23, 1998</p>

DATA SHEET

Determination of Rock Modulus and Poisson's Ratio (ASTM D3148)

Date: 10/22 & 23/98

Person performing the test: A. Bro

Client: Fylo

Job: #92-SFOBB

Sample ID: B98-23 320a

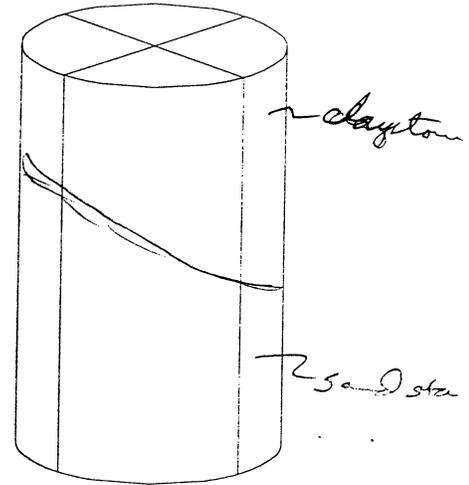
Sample Description: medium gray sandstone with fine interbeds of claystone / siltstone. Other sample half is dark gray claystone / siltstone, separated by calcite healed joint. 63° to core axis. Numerous calcite healed hairline fractures in the claystone half.

Sample Depth: 74'

Sample Condition: received & tested moist

d <sub>1</sub>	d <sub>2</sub>
2.357	2.358
2.352	2.355
2.351	2.359
2.366	2.368
2.366	2.363

l <sub>1</sub>	l <sub>2</sub>
-0.0005	0
±0.0001	±0.0001
+0.0005	0



Avg. diameter: 2.360

Avg. length: 5.140

Sample area: 4.374

l/d ratio: 2.18

Sample volume (in<sup>3</sup>): 22.484

Sample weight (g): 987.1g

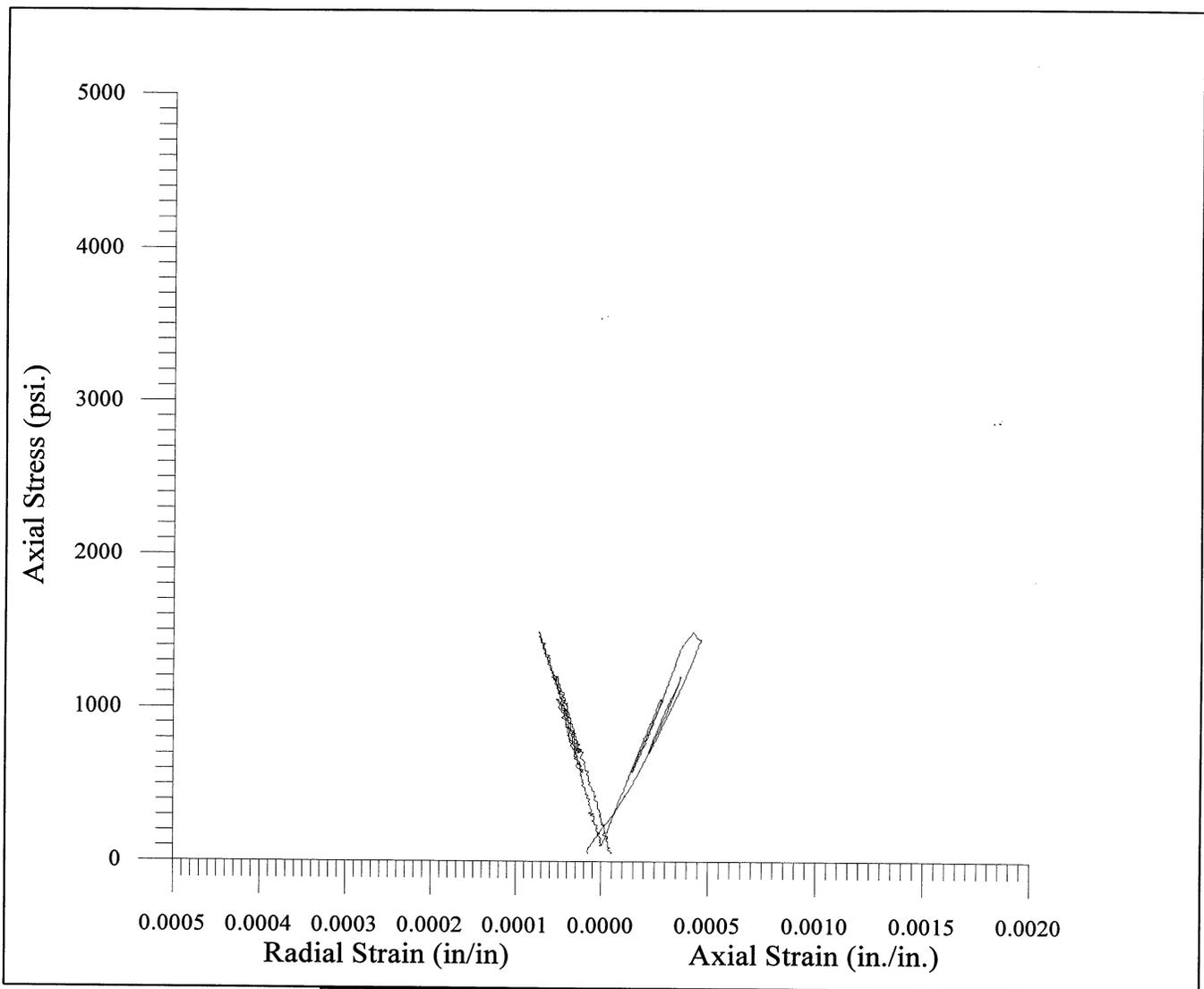
Density: 43.908 g/in<sup>3</sup> = 167.2 pcf (1 g/in<sup>3</sup> = 3.8095 lb/ft<sup>3</sup>)

Gauge length: 2.000 in.

Comments: ε<sub>c</sub> placed on sandstone ε<sub>a</sub> includes claystone

ν<sub>act</sub> → started to fail @ 2<sup>nd</sup> reload test stopped.

α<sub>c</sub> → Failure by splitting & shear in claystone.



**ELASTIC MODULUS TEST**  
**Axial Stress vs. Axial & Radial Strain**

**SAMPLE ID:** Boring: 98-23  
 Sample: 20a  
 Depth: 74'

**DESCRIPTION**  
 Medium gray sandstone finely interbedded with claystone and siltstone in one sample half, claystone and siltstone in the other half, separated by a calcite healed joint 63 degrees to the core axis.

**MODULUS:** 3,380,000 psi

**POISSON'S RATIO:** .19 (NA?)

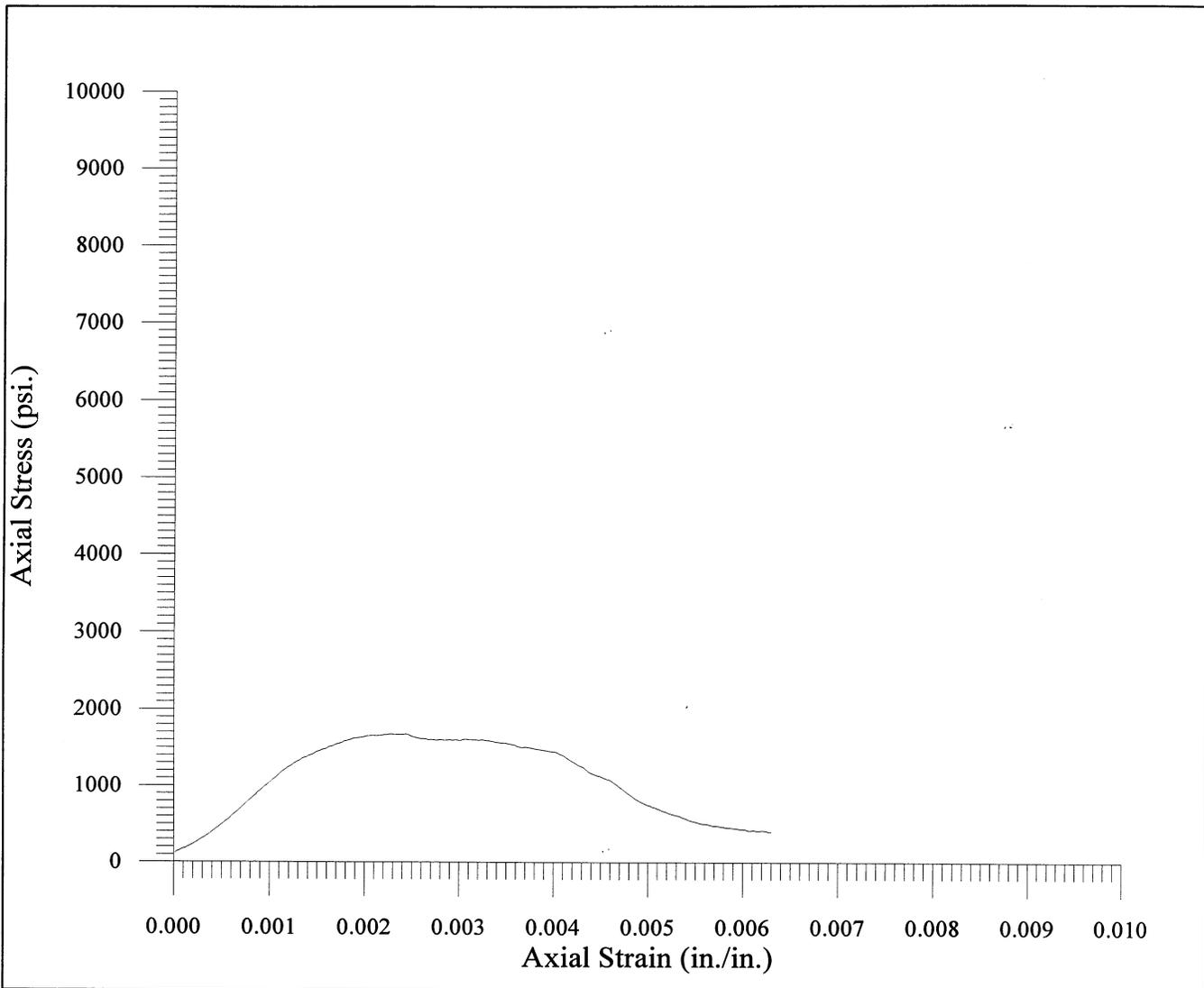
*Geo*  *Test*  
**Unlimited** 800 Peralta Ave  
 San Leandro, CA 94577

**Client:** Fugro West, Inc.  
 5855 Olivas Park Dr.  
 Ventura, CA 93003

**Project:** San Francisco Oakland Bay Bridge  
 East Span Replacement Project

**Job Number:** 98-42-0053

**Test Date:** October 22, 1998



**UNCONFINED COMPRESSION TEST  
Axial Stress vs. Axial Strain**

<p><b>SAMPLE ID:</b> Boring : 98-23 Sample: 20a Depth: 74'</p> <p align="center"><b>DESCRIPTION</b></p> <p>Medium gray sandstone finely interbedded with claystone and siltstone in one sample half, claystone and siltstone in the other half, separated by a calcite healed joint 63 degrees to the core axis.</p> <p><b>STRENGTH:</b> 1678 psi</p>	<p align="center"> <i>Geo</i>  <i>U</i>  <i>Test</i>  <b>Unlimited</b> 800 Peralta Ave  San Leandro, CA 94577 </p>
	<p><b>Client:</b> Fugro West, Inc. 5855 Olivas Park Dr. Ventura, CA 93003</p> <p><b>Project:</b> San Francisco Oakland Bay Bridge East Span Replacement Project</p> <p><b>Job Number:</b> 98-42-0053</p>
	<p><b>Test Date:</b> October 23, 1998</p>

DATA SHEET

Determination of Rock Modulus and Poisson's Ratio (ASTM D3148)

Date: 10/22 & 23/98

Person performing the test: A. Bro

Client: Enyo

Job: #92-SFOB

Sample ID: B98-23 S206

Sample Description: Dark gray silt-stn. (claystone) with  
innumerable calcite healed hair line fractures  
parallel to bedding, ~62° to the core axis

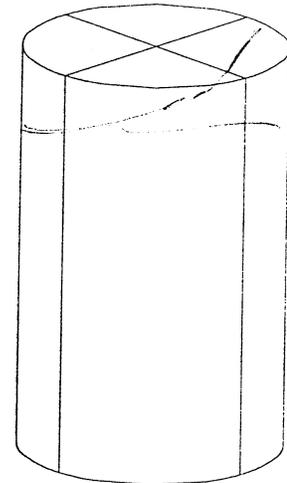
Sample Depth: 74.5'

Sample Condition: received & tested in situ

d <sub>1</sub>	d <sub>2</sub>
2.348	2.344
2.350	2.369
2.360	2.360
2.363	2.367
2.357	2.365

l <sub>1</sub>	l <sub>2</sub>
-.0005	0
	-.0002/0
±.0001	±.0001
+.0010	+.0004

*diagonal joint*



Avg. diameter: 2.358

Avg. length: 5.137"

Sample area: 4.367

l/d ratio: 2.18

Sample volume(in<sup>3</sup>): 22.433

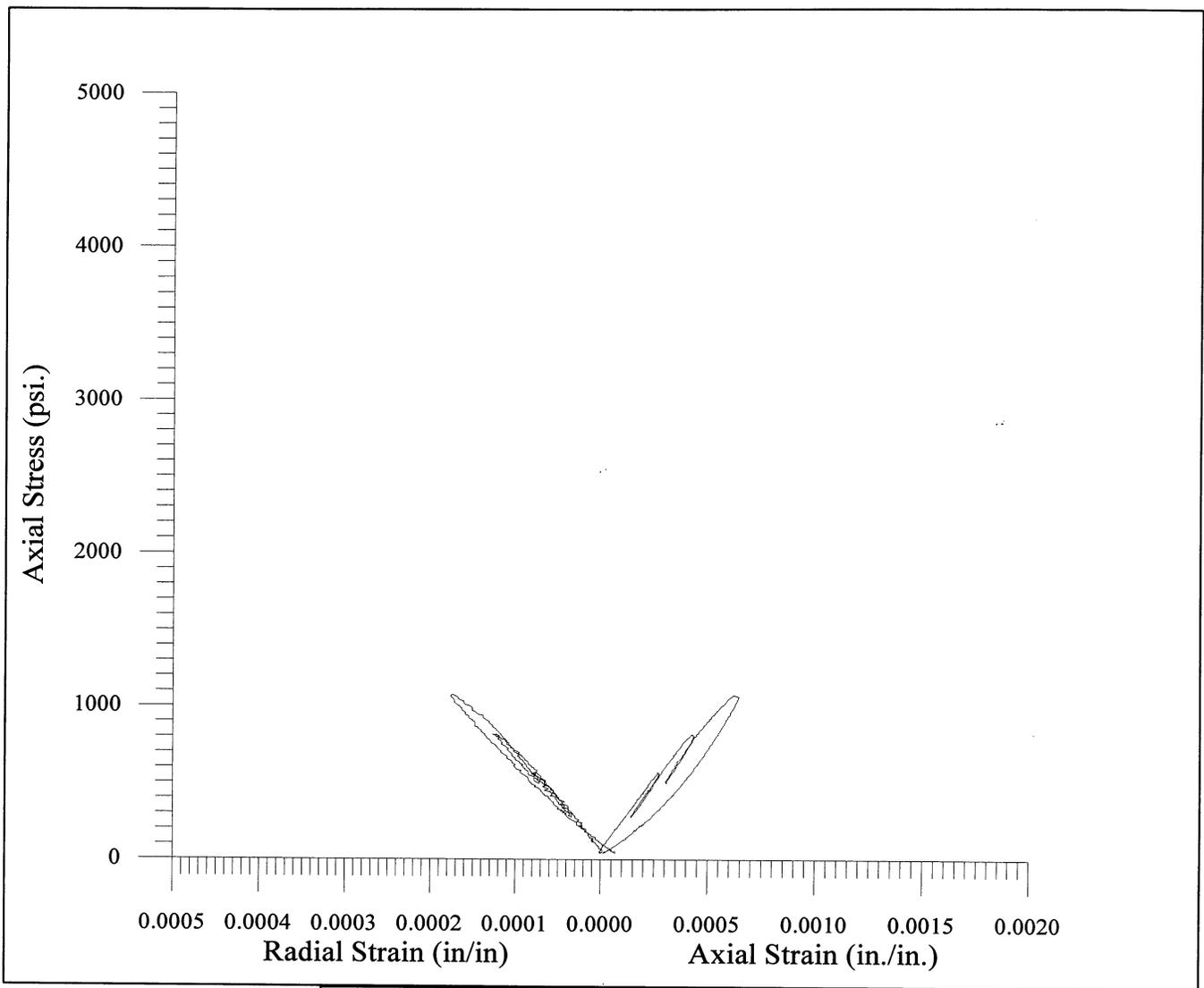
Sample weight (g): 985.3g

Density: 43.928/in<sup>3</sup> = 167.3 pcf (1 g/in<sup>3</sup>=3.8095lb/ft<sup>3</sup>)

Gauge length: 2.000 in.

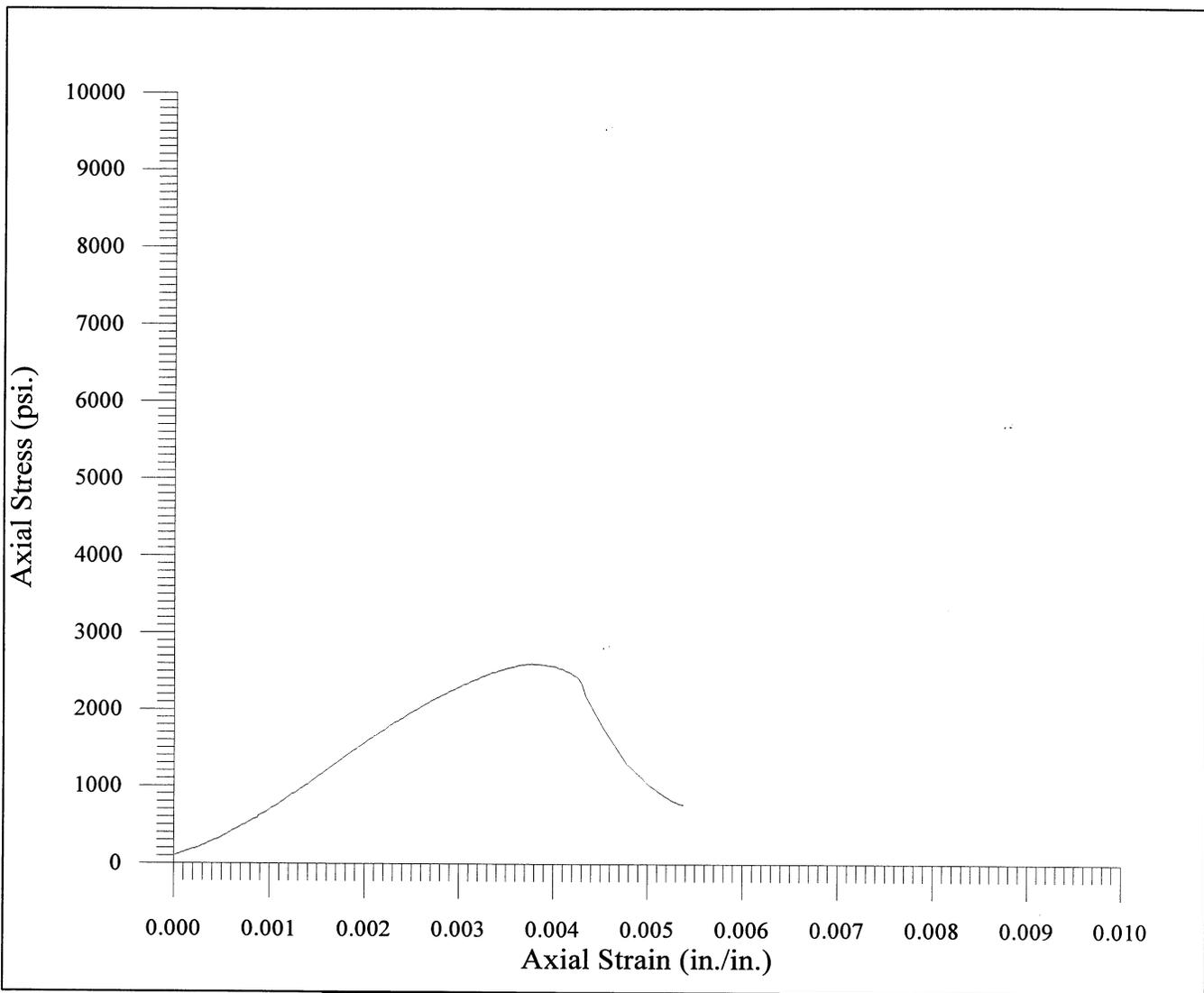
Comments: Failed by "shear" (crack) along partially  
healed joints

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**ELASTIC MODULUS TEST**  
**Axial Stress vs. Axial & Radial Strain**

<p><b>SAMPLE ID:</b> Boring: 98-23  Sample: 20b  Depth: 74.5'</p> <p><b>DESCRIPTION</b>  Dark gray claystone and siltstone with numerous calcite healed hairline fractures parallel to the bedding, 62 degrees to the core axis.</p> <p><b>MODULUS:</b> 2,140,000 psi  <b>POISSON'S RATIO:</b> .33</p>	<p align="center"> <i>Geo</i>  <i>U</i>  <i>Test</i>  <b>Unlimited</b> </p> <p align="right">800 Peralta Ave  San Leandro, CA 94577</p> <hr/> <p><b>Client:</b> Fugro West, Inc.  5855 Olivas Park Dr.  Ventura, CA 93003</p> <p><b>Project:</b> San Francisco Oakland Bay Bridge  East Span Replacement Project</p> <p><b>Job Number:</b> 98-42-0053</p> <hr/> <p><b>Test Date:</b> October 22, 1998</p>
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**UNCONFINED COMPRESSION TEST  
Axial Stress vs. Axial Strain**

<p><b>SAMPLE ID:</b> Boring : 98-23 Sample: 20b Depth: 74.5'</p> <p align="center"><b>DESCRIPTION</b></p> <p>Dark gray claystone and siltstone with numerous calcite healed hairline fractures parallel to the bedding, 62 degrees to the core axis.</p> <p><b>STRENGTH:</b> 2602 psi</p>	<p align="center"> <i>Geo</i>  <i>U</i>  <i>Test</i>  <i>Unlimited</i> </p> <p align="right">800 Peralta Ave San Leandro, CA 94577</p>
	<p><b>Client:</b> Fugro West, Inc. 5855 Olivas Park Dr. Ventura, CA 93003</p> <p><b>Project:</b> San Francisco Oakland Bay Bridge East Span Replacement Project</p> <p><b>Job Number:</b> 98-42-0053</p>
	<p><b>Test Date:</b> October 23, 1998</p>

DATA SHEET

Determination of Rock Modulus and Poisson's Ratio (ASTM D3148)

Date: 10/22 & 23/98

Person performing the test: A. Bro

Client: Fugro

Job: #92-SFOBB

Sample ID: B98-23 S21a

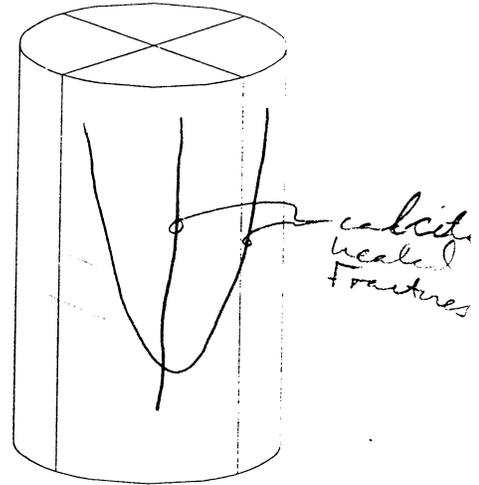
Sample Description: medium gray sandstone <sup>Finely</sup> inter bedded with dark gray siltstone/claystone, bedding about 65° to the core axis. Contains a few calcite healed axial fractures.

Sample Depth: 78'

Sample Condition: received & tested moist

d <sub>1</sub>	d <sub>2</sub>
2.363	2.372
2.386	2.385
2.391	2.386
2.382	2.384
2.381	2.383

l <sub>1</sub>	l <sub>2</sub>
-0.0005	-0.0003
	-0.0001
+0.0001	+0.0001
+0.0004	+0.0001



Avg. diameter: 2.381

Avg. length: 5.259

Sample area: 4.453

l/d ratio: 2.21

Sample volume(in<sup>3</sup>): 23.416

Sample weight (g): 1031.2

Density: 44.048 lb/in<sup>3</sup> = 167.8 pcf (1 g/in<sup>3</sup>=3.8095 lb/ft<sup>3</sup>)

Gauge length: 2.000 in

Comments: Failed by a shear wedge.

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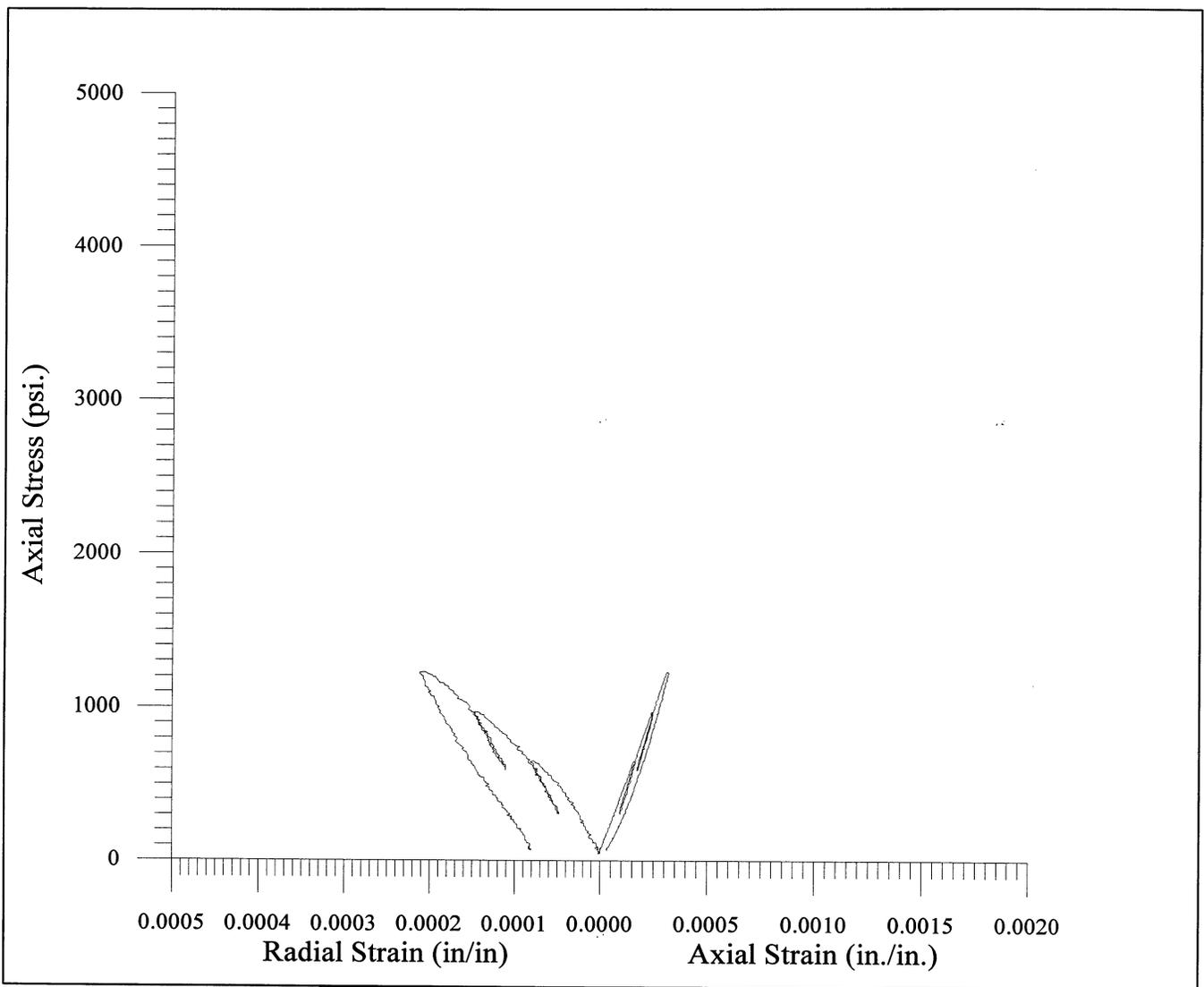
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**ELASTIC MODULUS TEST**  
**Axial Stress vs. Axial & Radial Strain**

**SAMPLE ID:** Boring: 98-23  
 Sample: 21a  
 Depth: 78'

**DESCRIPTION**  
 Medium gray sandstone finely interbedded with dark gray siltstone and claystone, with bedding about 65 degrees to the core axis. Also contains a few calcite healed axial hairline fractures.

**MODULUS:** 5,000,000 psi  
**POISSON'S RATIO:** NA (.49)

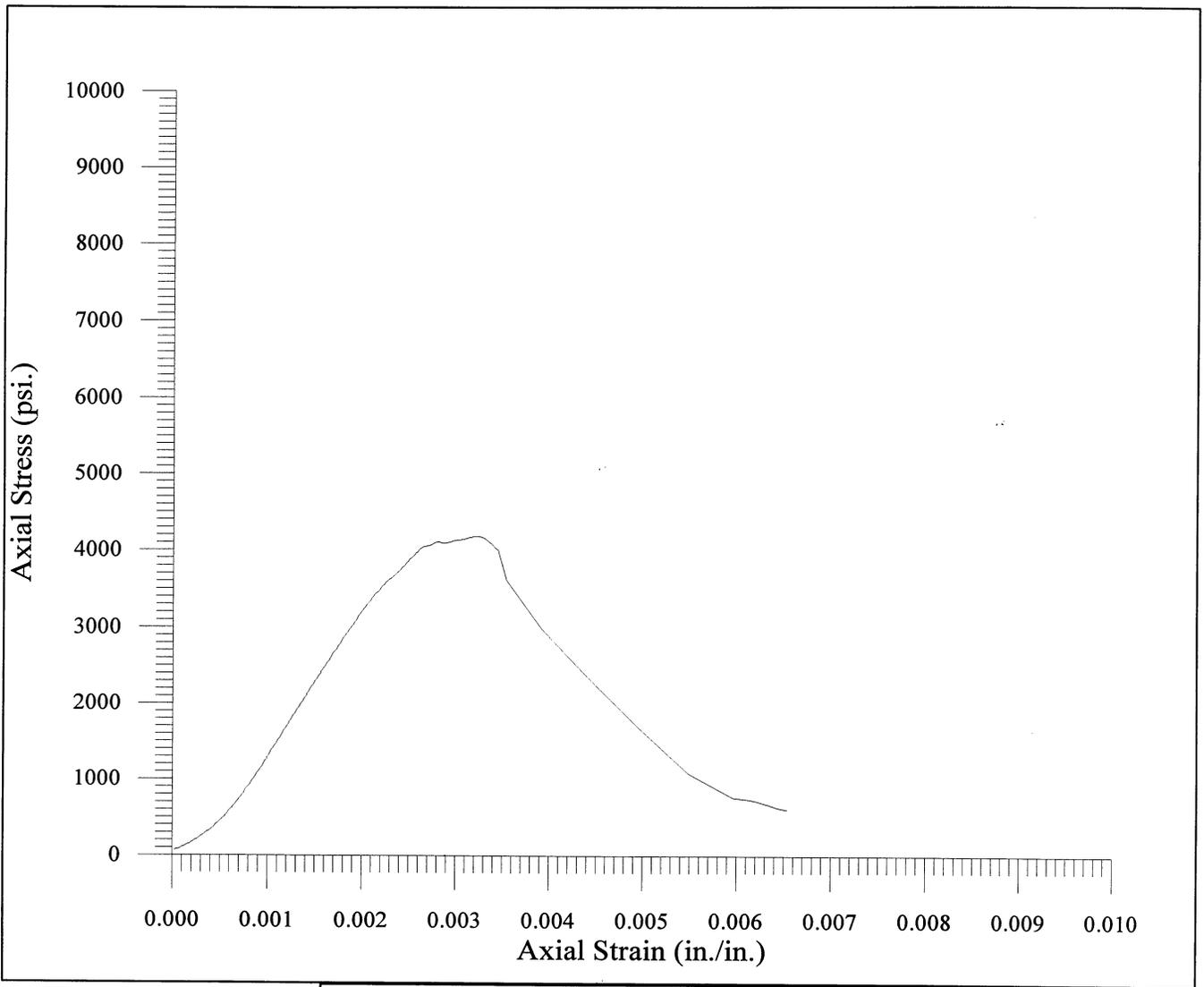
*Geo*  *Test*  
**Unlimited** 800 Peralta Ave  
 San Leandro, CA 94577

**Client:** Fugro West, Inc.  
 5855 Olivas Park Dr.  
 Ventura, CA 93003

**Project:** San Francisco Oakland Bay Bridge  
 East Span Replacement Project

**Job Number:** 98-42-0053

**Test Date:** October 22, 1998



**UNCONFINED COMPRESSION TEST  
Axial Stress vs. Axial Strain**

<p><b>SAMPLE ID:</b> Boring : 98-23 Sample: 21a Depth: 78'</p> <p align="center"><b>DESCRIPTION</b></p> <p>Medium gray sandstone finely interbedded with dark gray siltstone and claystone, with bedding about 65 degrees to the core axis. Also contains a few calcite healed axial hairline fractures.</p> <p><b>STRENGTH:</b> 4177 psi</p>	<p align="center"><i>Geo</i>  <i>Test</i> <b>Unlimited</b> 800 Peralta Ave San Leandro, CA 94577</p>
	<p><b>Client:</b> Fugro West, Inc. 5855 Olivas Park Dr. Ventura, CA 93003</p> <p><b>Project:</b> San Francisco Oakland Bay Bridge East Span Replacement Project</p> <p><b>Job Number:</b> 98-42-0053</p>
	<p><b>Test Date:</b> October 23, 1998</p>

DATA SHEET

Determination of Rock Modulus and Poisson's Ratio (ASTM D3148)

Date: 10/22/23/98

Person performing the test: A. Bro

Client: Fugro

Job: #92-SFOBR

Sample ID: B98-23 522a

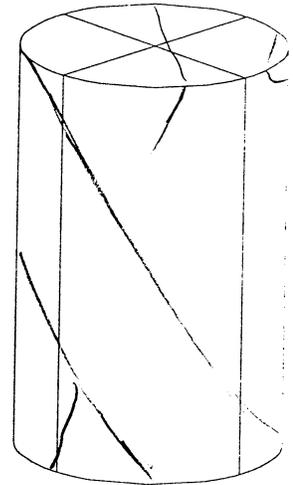
Sample Description: medium gray sandstone with a few calcite healed hairline fractures, 27° to the core axis.

Sample Depth: 85'

Sample Condition: received & tested moist

d <sub>1</sub>	d <sub>2</sub>
2.390	2.390
2.390	2.388
2.390	2.392
2.391	2.392
2.393	2.391

l <sub>1</sub>	l <sub>2</sub>
-0.0008	-0.0001
±0.0001	±0.0001
+0.0008	+0.0002



Avg. diameter: 2.391

Avg. length: 5.256

Sample area: 4.490

l/d ratio: 2.20

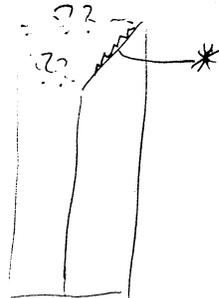
Sample volume(in<sup>3</sup>): 23.600

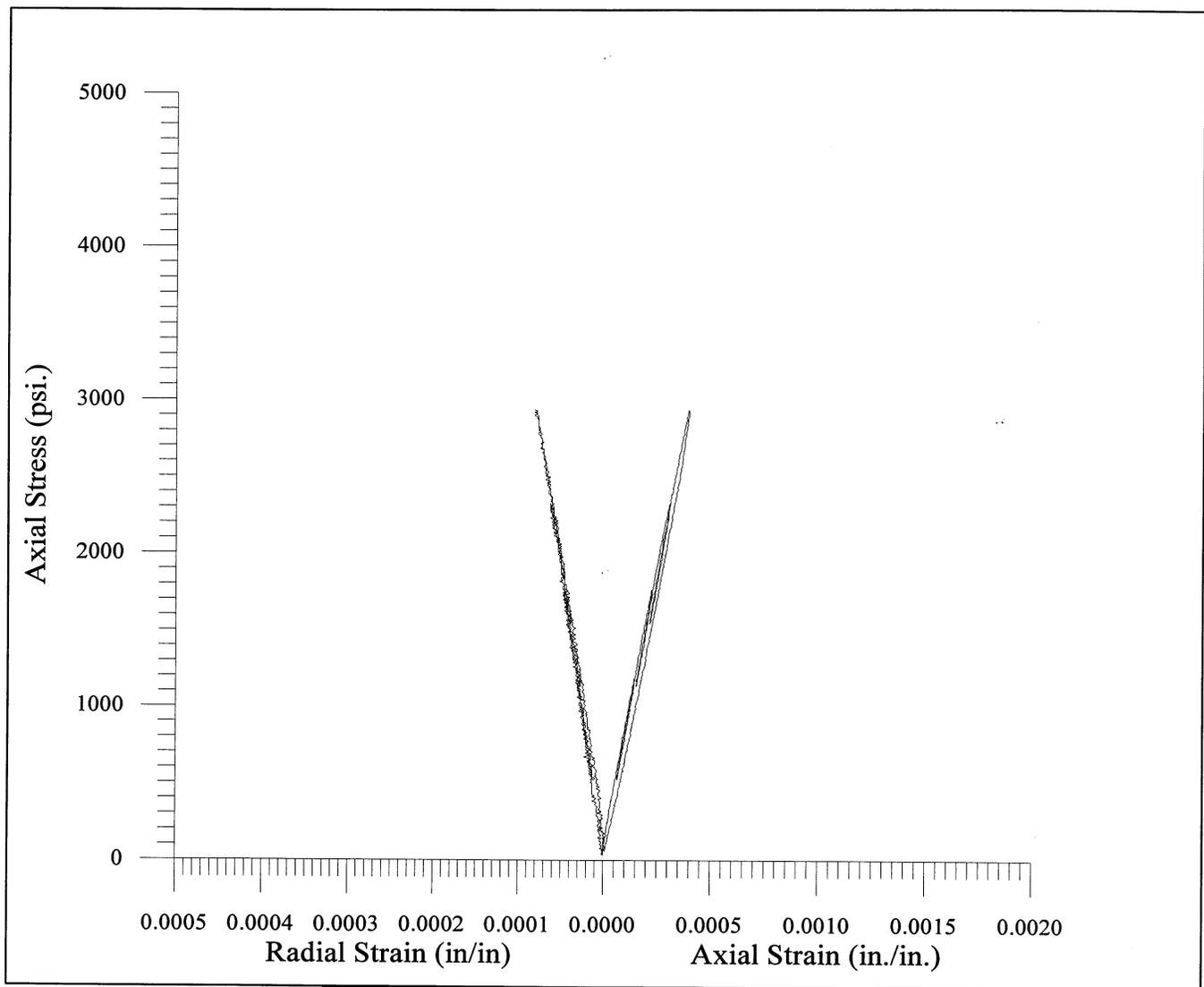
Sample weight (g): 1050.5g

Density: 44.518/in<sup>3</sup> = 169.6 pcf (1 g/in<sup>3</sup>=3.8095lb/ft<sup>3</sup>)

Gauge length: 2.000 in

Comments: Failed by axial splitting - not along healed joints. Note the ridges on top diagonal\* indicates vertical splitting columns, not shear. explosive failure.





**ELASTIC MODULUS TEST**  
**Axial Stress vs. Axial & Radial Strain**

**SAMPLE ID:** Boring: 98-23  
 Sample: 22a  
 Depth: 85'

**DESCRIPTION**  
 Medium gray sandstone with a few calcite healed hairline fractures, 27 degrees to the core axis.

**MODULUS:** 8,330,000 psi  
**POISSON'S RATIO:** .24

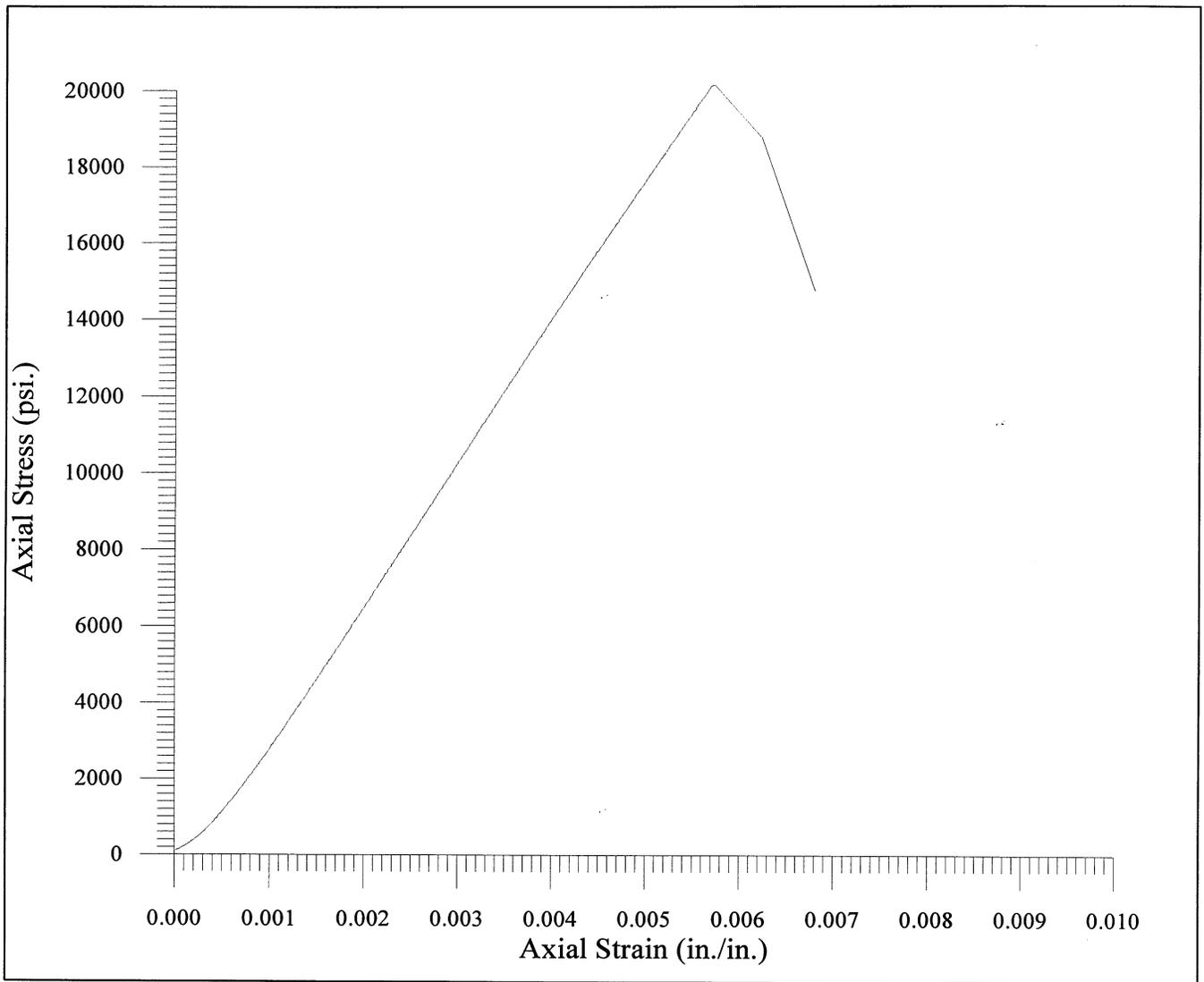
  
**Geo Test Unlimited**  
 800 Peralta Ave  
 San Leandro, CA 94577

**Client:** Fugro West, Inc.  
 5855 Olivas Park Dr.  
 Ventura, CA 93003

**Project:** San Francisco Oakland Bay Bridge  
 East Span Replacement Project

**Job Number:** 98-42-0053

**Test Date:** October 22, 1998



**UNCONFINED COMPRESSION TEST  
Axial Stress vs. Axial Strain**

<p><b>SAMPLE ID:</b> Boring : 98-23 Sample: 22a Depth: 85'</p> <p align="center"><b>DESCRIPTION</b></p> <p>Medium gray sandstone with a few calcite healed hairline fractures, 27 degrees to the core axis.</p> <p><b>STRENGTH:</b> 20,140 psi</p>	<p align="center"> <i>Geo</i>  <i>U</i>  <i>Test</i>  <b>Unlimited</b> </p> <p align="right">800 Peralta Ave San Leandro, CA 94577</p> <hr/> <p><b>Client:</b> Fugro West, Inc. 5855 Olivas Park Dr. Ventura, CA 93003</p> <p><b>Project:</b> San Francisco Oakland Bay Bridge East Span Replacement Project</p> <p><b>Job Number:</b> 98-42-0053</p> <hr/> <p><b>Test Date:</b> October 23, 1998</p>
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DATA SHEET

Determination of Rock Modulus and Poisson's Ratio (ASTM D3148)

Date: 10/22 & 23/98

Person performing the test: A. B. D.

Client: Fugro

Job: #92-SFQBR

Sample ID: B98-23 S 27a

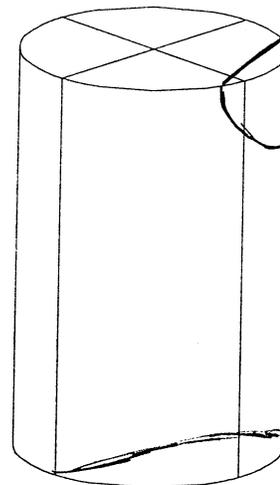
Sample Description: Dark grey fine sandy siltstone, generally massive with only two minor calcite healed vein-like fractures

Sample Depth: 106.5'

Sample Condition: received & tested moist

d <sub>1</sub>	d <sub>2</sub>
2.391	2.394
2.392	2.396
2.391	2.394
2.389	2.393
2.390	2.393

l <sub>1</sub>	l <sub>2</sub>
-0.0007	-0.0001
+0.0001	+0.0001
+0.0008	+0.0001



Avg. diameter: 2.392

Avg. length: 5.268

Sample area: 4.494

l/d ratio: 2.20

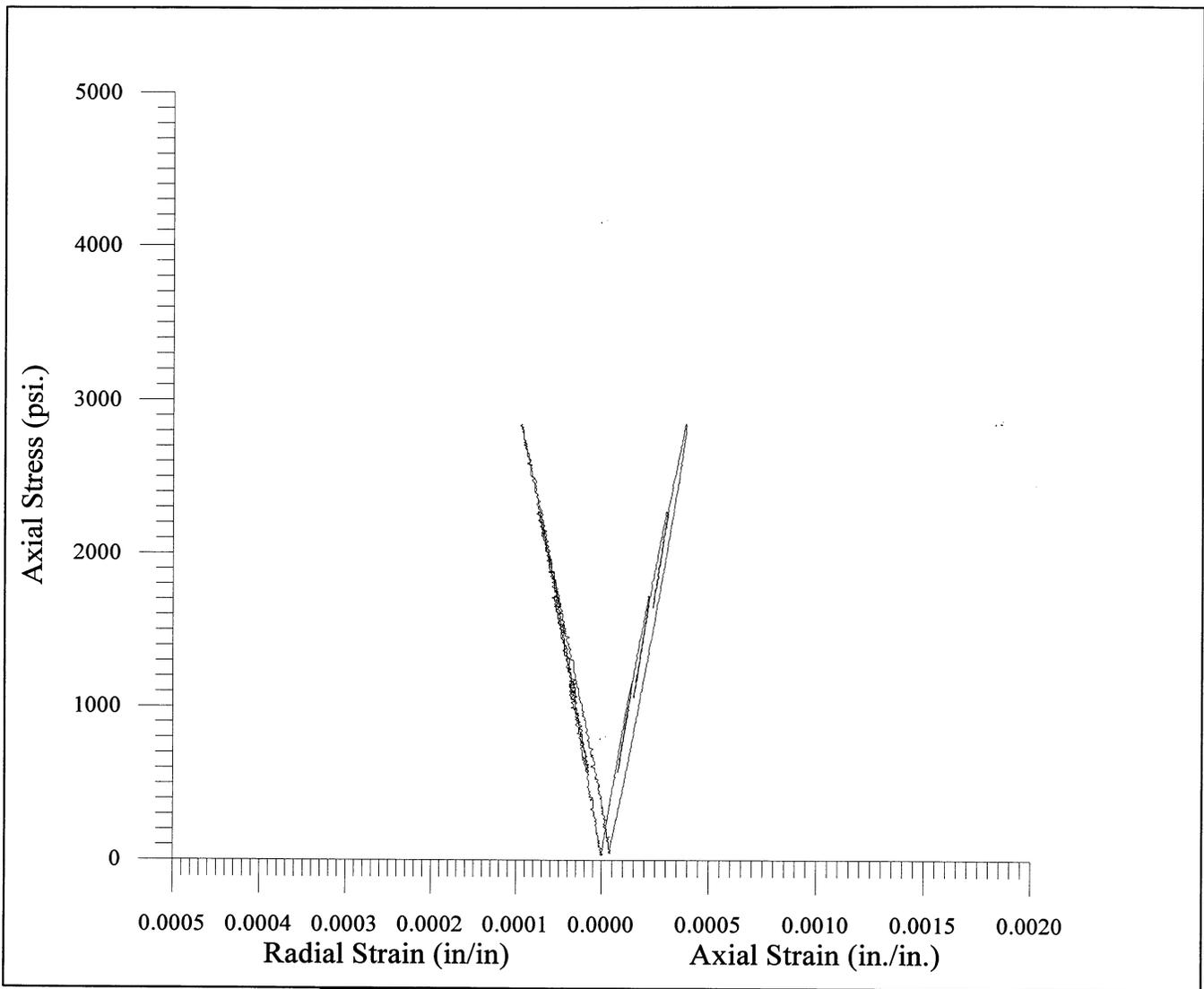
Sample volume(in<sup>3</sup>): 23.673

Sample weight (g): 1050.28

Density: 44.368/in<sup>3</sup> = 169.0 pcf (1 g/in<sup>3</sup> = 3.8095 lb/ft<sup>3</sup>)

Gauge length: 2.000 in

Comments: failed by shear on what must have been a pre-existing (not seen in sample) joint. 28° to core axis



**ELASTIC MODULUS TEST**  
**Axial Stress vs. Axial & Radial Strain**

**SAMPLE ID:** Boring: 98-23  
 Sample: 27a  
 Depth: 106.5'

**DESCRIPTION**  
 Dark gray fine sandy siltstone, with two minor calcite healed hairline fractures.

**MODULUS:** 9,430,000 psi  
**POISSON'S RATIO:** .36

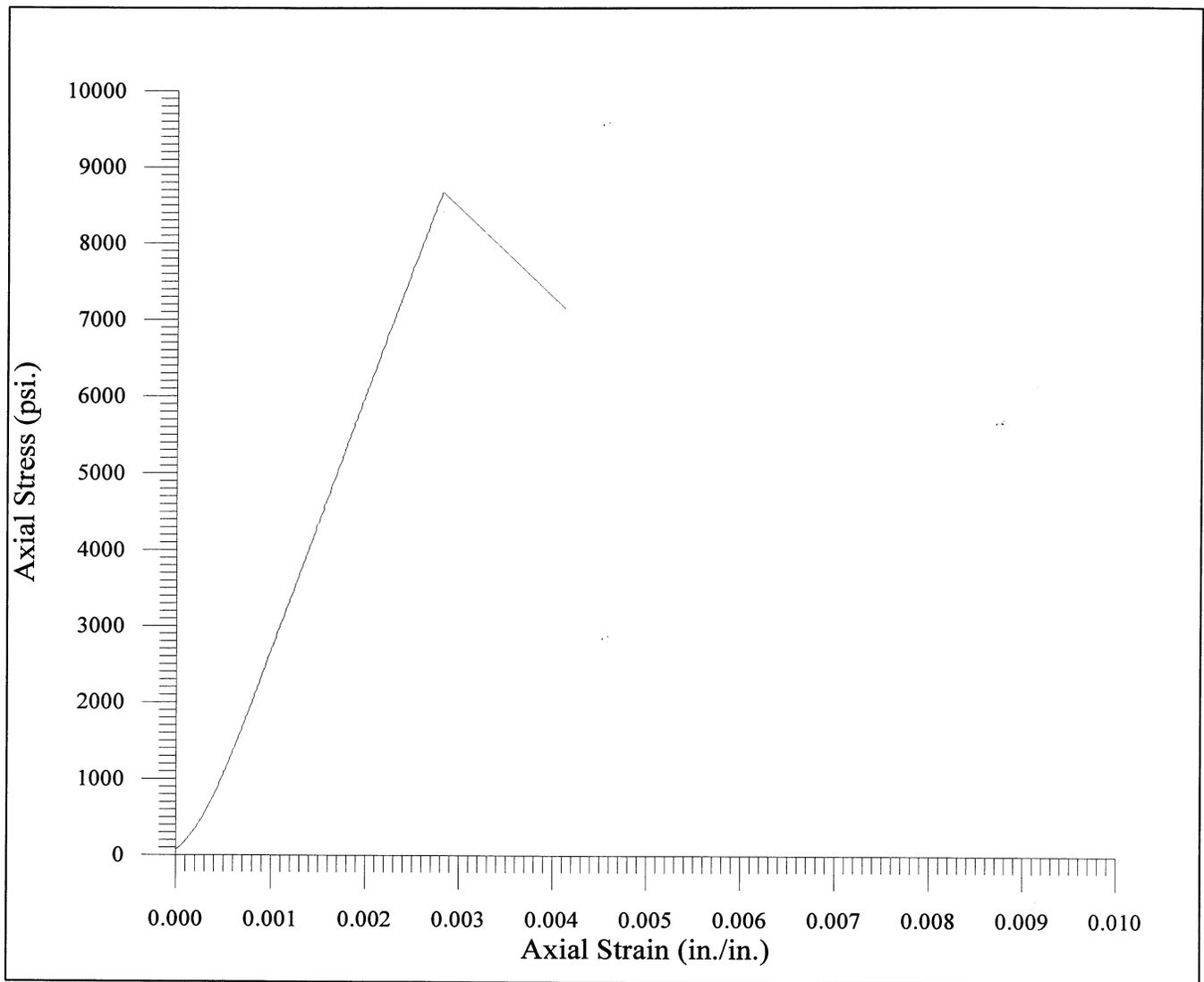
*Geo*  *Test*  
**Unlimited** 800 Peralta Ave  
 San Leandro, CA 94577

**Client:** Fugro West, Inc.  
 5855 Olivas Park Dr.  
 Ventura, CA 93003

**Project:** San Francisco Oakland Bay Bridge  
 East Span Replacement Project

**Job Number:** 98-42-0053

**Test Date:** October 22, 1998



**UNCONFINED COMPRESSION TEST**  
**Axial Stress vs. Axial Strain**

<p><b>SAMPLE ID:</b> Boring : 98-23  Sample: 27a  Depth: 106.5'</p> <p align="center"><b>DESCRIPTION</b></p> <p>Dark gray fine sandy siltstone, with two minor calcite healed hairline fractures.</p> <p><b>STRENGTH:</b> 8673 psi</p>	<div style="text-align: center;"> <p><i>Geo</i>  <i>U</i></p> <p><i>Test</i></p> <p><i>Unlimited</i></p> </div> <p align="right">800 Peralta Ave  San Leandro, CA 94577</p> <hr/> <p><b>Client:</b> Fugro West, Inc.  5855 Olivas Park Dr.  Ventura, CA 93003</p> <p><b>Project:</b> San Francisco Oakland Bay Bridge  East Span Replacement Project</p> <p><b>Job Number:</b> 98-42-0053</p> <hr/> <p><b>Test Date:</b> October 23, 1998</p>
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DATA SHEET

Determination of Rock Modulus and Poisson's Ratio (ASTM D3148)

Date: 10/22/2003/98

Person performing the test: A. Bro

Client: Fuyo

Job: #92-SFOBR

Sample ID: B98-23 528a

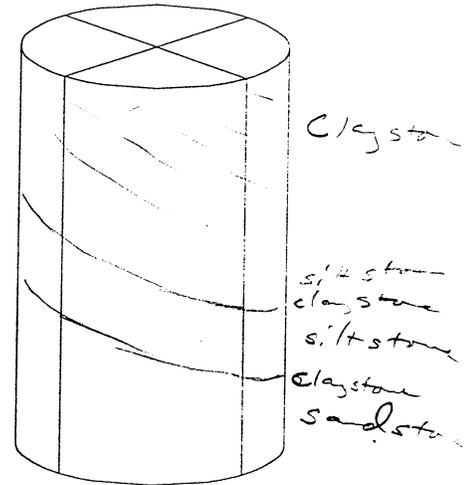
Sample Description: Dark gray interbedded claystone, siltstone and sandstone, bedding about 70° to core axis

Sample Depth: 114'

Sample Condition: received & tested moist

d <sub>1</sub>	d <sub>2</sub>
2.363	2.377
2.358	2.363
2.363	2.367
2.391	2.382
2.392	2.386

l <sub>1</sub>	l <sub>2</sub>
-0.0007	-0.0002
±0.0001	±0.0001
+0.0007	+0.0002



Avg. diameter: 2.374

Avg. length: 5.284

Sample area: 4.426

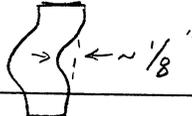
l/d ratio: 2.23

Sample volume(in<sup>3</sup>): 23.389

Sample weight (g): 1032.1g

Density: 44.138/in<sup>3</sup> = 168.1 pcf (1 g/in<sup>3</sup> = 3.8095 lb/ft<sup>3</sup>)

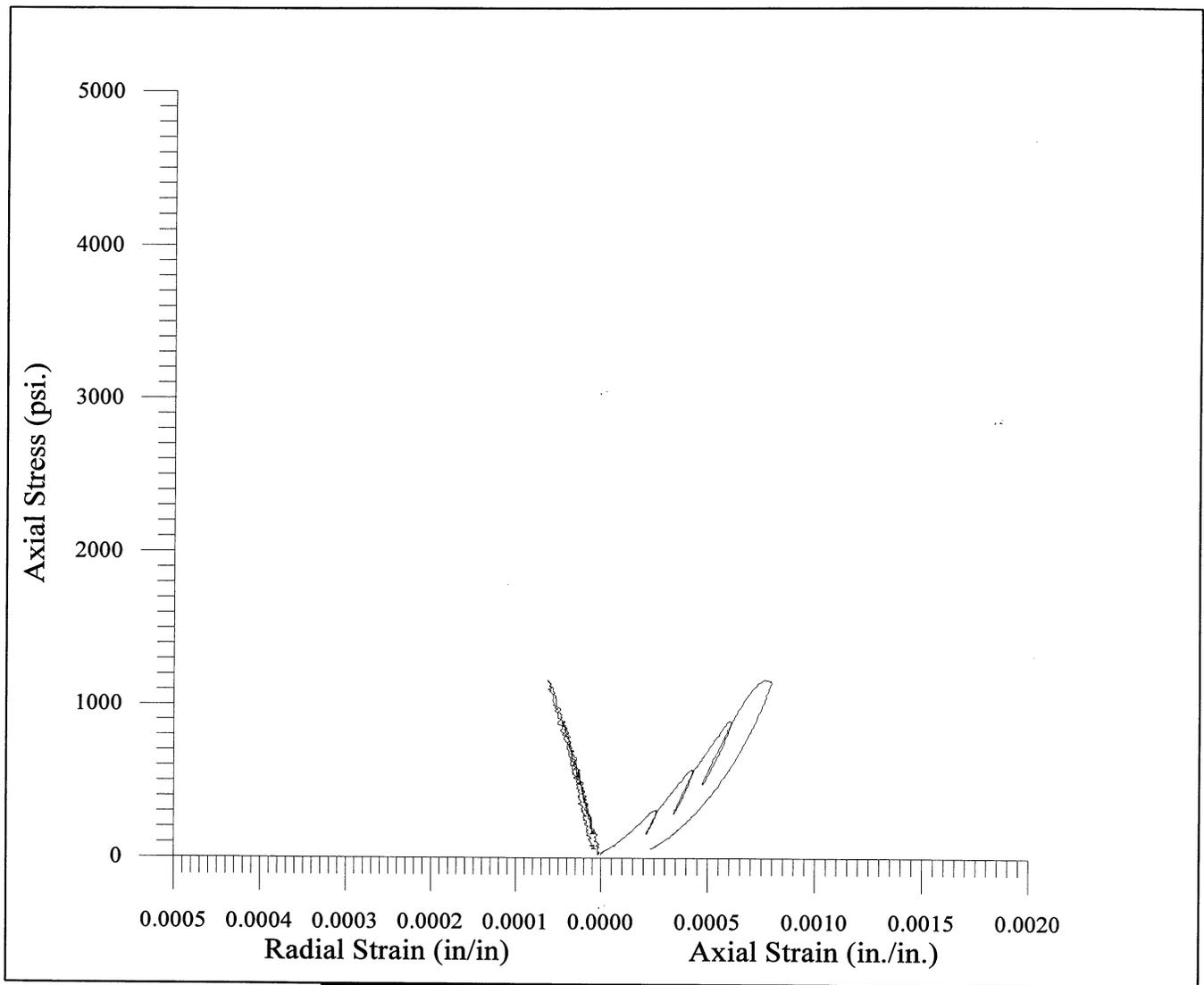
Gauge length: 2.000 in.

Comments: crooked sample 

started to fail in modulus test

E<sub>r</sub> @ sandstone - E<sub>c</sub> on claystone ⇒ V is not valid?

Failed by axial splitting



**ELASTIC MODULUS TEST**  
**Axial Stress vs. Axial & Radial Strain**

**SAMPLE ID:** Boring: 98-23  
 Sample: 28a  
 Depth: 114'

**DESCRIPTION**

Dark gray interbedded claystone, siltstone and sandstone, bedded about 70 degrees to the core axis.

**MODULUS:** 2,880,000 psi

**POISSON'S RATIO:** NA (.14)

*Geo*  *Test*  
**Unlimited** 800 Peralta Ave  
 San Leandro, CA 94577

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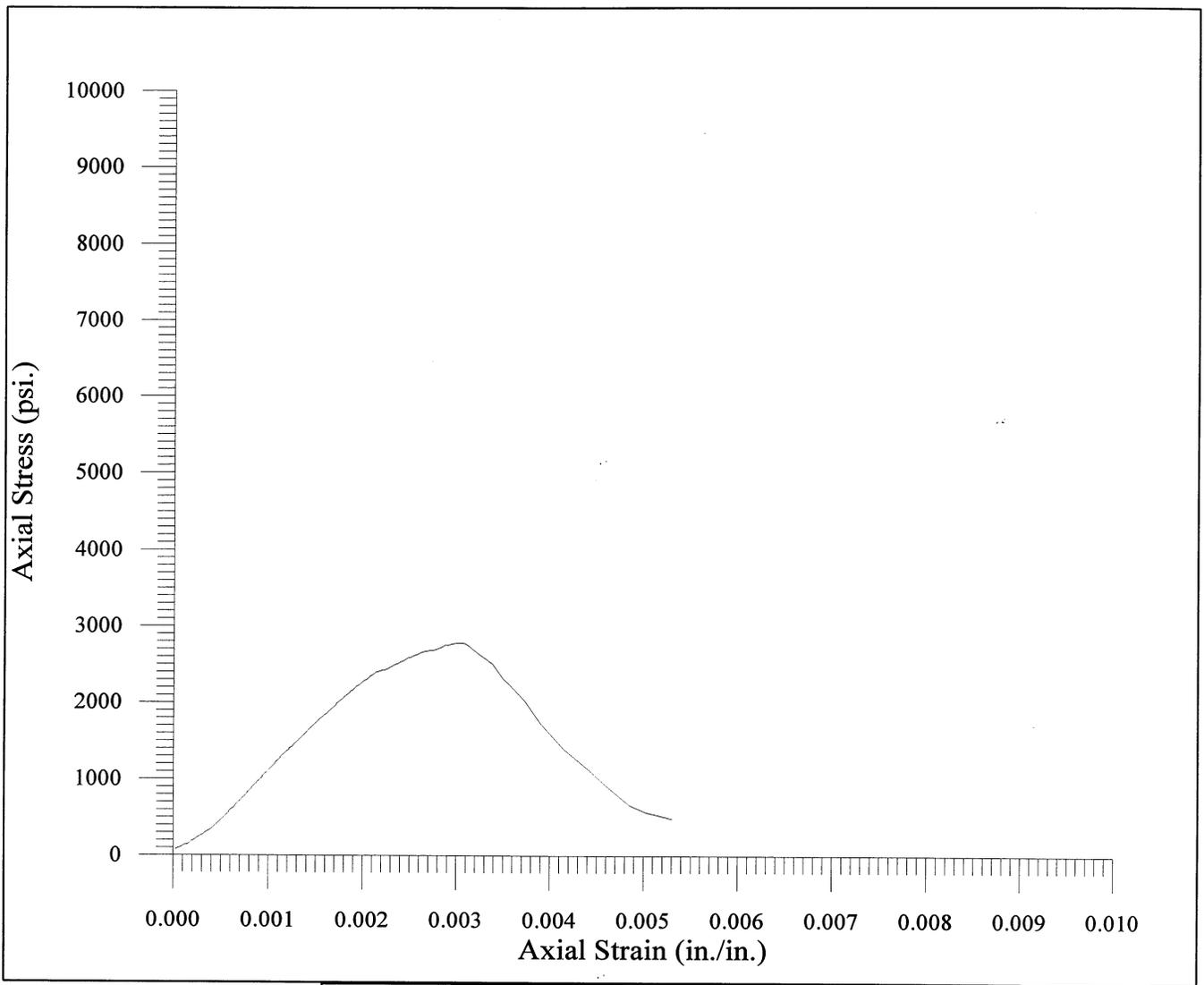
**Client:** Fugro West, Inc.  
 5855 Olivas Park Dr.  
 Ventura, CA 93003

**Project:** San Francisco Oakland Bay Bridge  
 East Span Replacement Project

**Job Number:** 98-42-0053

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**Test Date:** October 22, 1998



**UNCONFINED COMPRESSION TEST  
Axial Stress vs. Axial Strain**

<p><b>SAMPLE ID:</b> Boring : 98-23 Sample: 28a Depth: 114'</p> <p align="center"><b>DESCRIPTION</b></p> <p>Dark gray interbedded claystone, siltstone and sandstone, bedded about 70 degrees to the core axis.</p> <p><b>STRENGTH:</b> 2778 psi</p>	<div style="text-align: center;"> <p><i>Geo</i>  <i>U</i></p> <p><i>Test</i></p> <p><i>Unlimited</i></p> </div> <p align="right">800 Peralta Ave San Leandro, CA 94577</p> <hr/> <p><b>Client:</b> Fugro West, Inc. 5855 Olivas Park Dr. Ventura, CA 93003</p> <p><b>Project:</b> San Francisco Oakland Bay Bridge East Span Replacement Project</p> <p><b>Job Number:</b> 98-42-0053</p> <hr/> <p><b>Test Date:</b> October 23, 1998</p>
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DATA SHEET

Determination of Rock Modulus and Poisson's Ratio (ASTM D3148)

Date: 10/22 & 23/98

Person performing the test: A Bro

Client: Fugro

Job: #92-SFOBB

Sample ID: B58-23 S29a

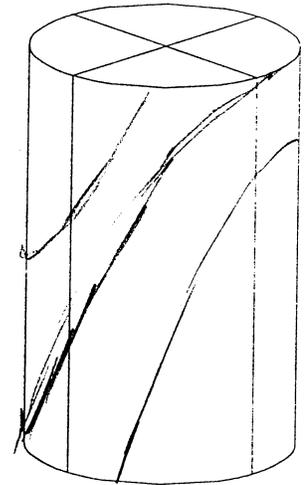
Sample Description: Medium gray fine sandy siltstone to sandstone with several calcite healed hairline fractures, about 15-25° to the core axis

Sample Depth: 120.5'

Sample Condition: received & tested moist

d <sub>1</sub>	d <sub>2</sub>
2.396	2.390
2.396	2.390
2.394	2.390
2.395	2.391
2.394	2.390

l <sub>1</sub>	l <sub>2</sub>
-0.0009	-0.0001
±0.0001	±0.0001
+0.0009	0



Avg. diameter: 2.393

Avg. length: 5.328

Sample area: 4.498

l/d ratio: 2.23

Sample volume(in<sup>3</sup>): 23.963

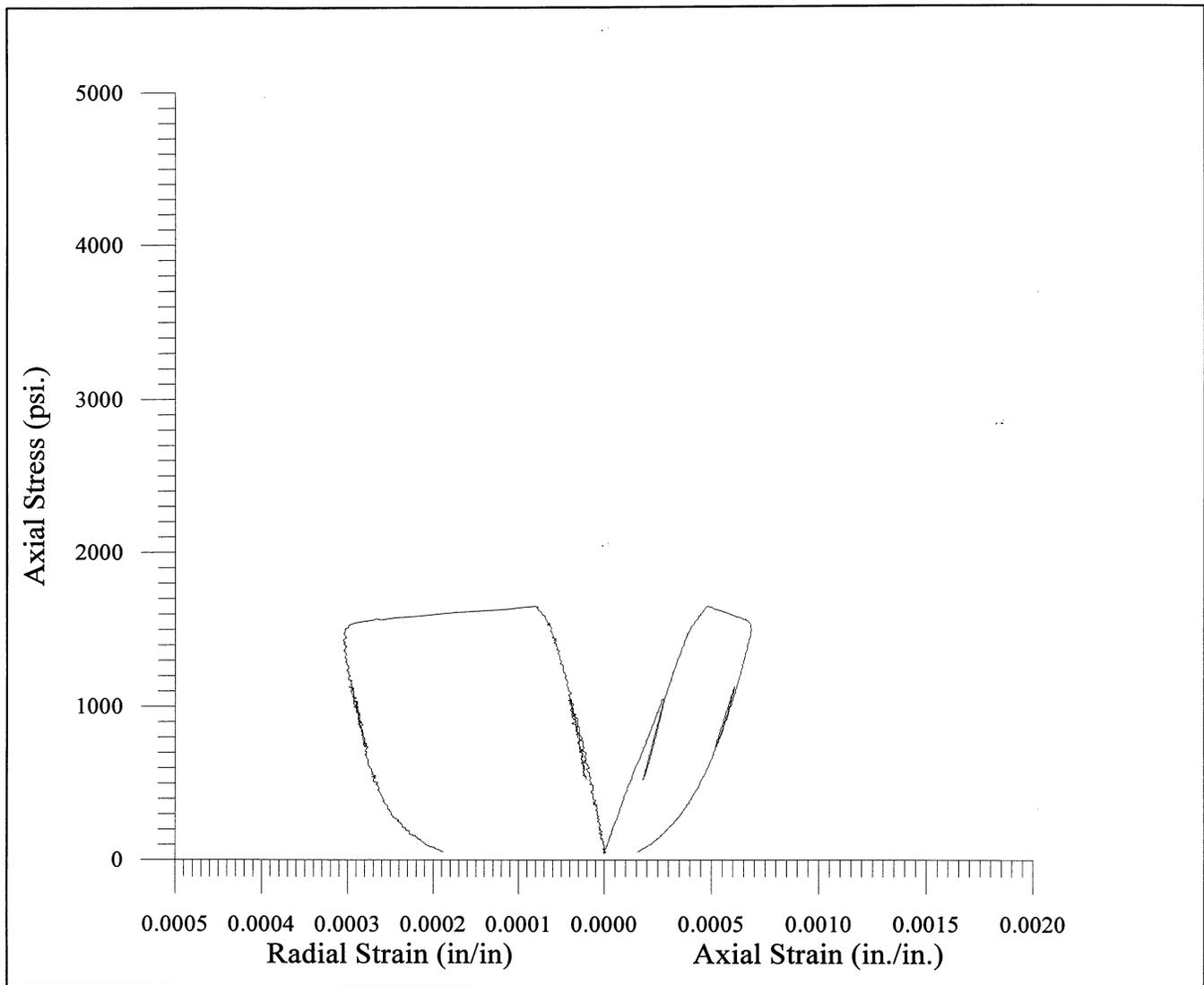
Sample weight (g): 1066.38

Density: 44.508/in<sup>3</sup> = 169.5 pcf (1 g/in<sup>3</sup> = 3.8095 lb/ft<sup>3</sup>)

Gauge length: 2.000 in.

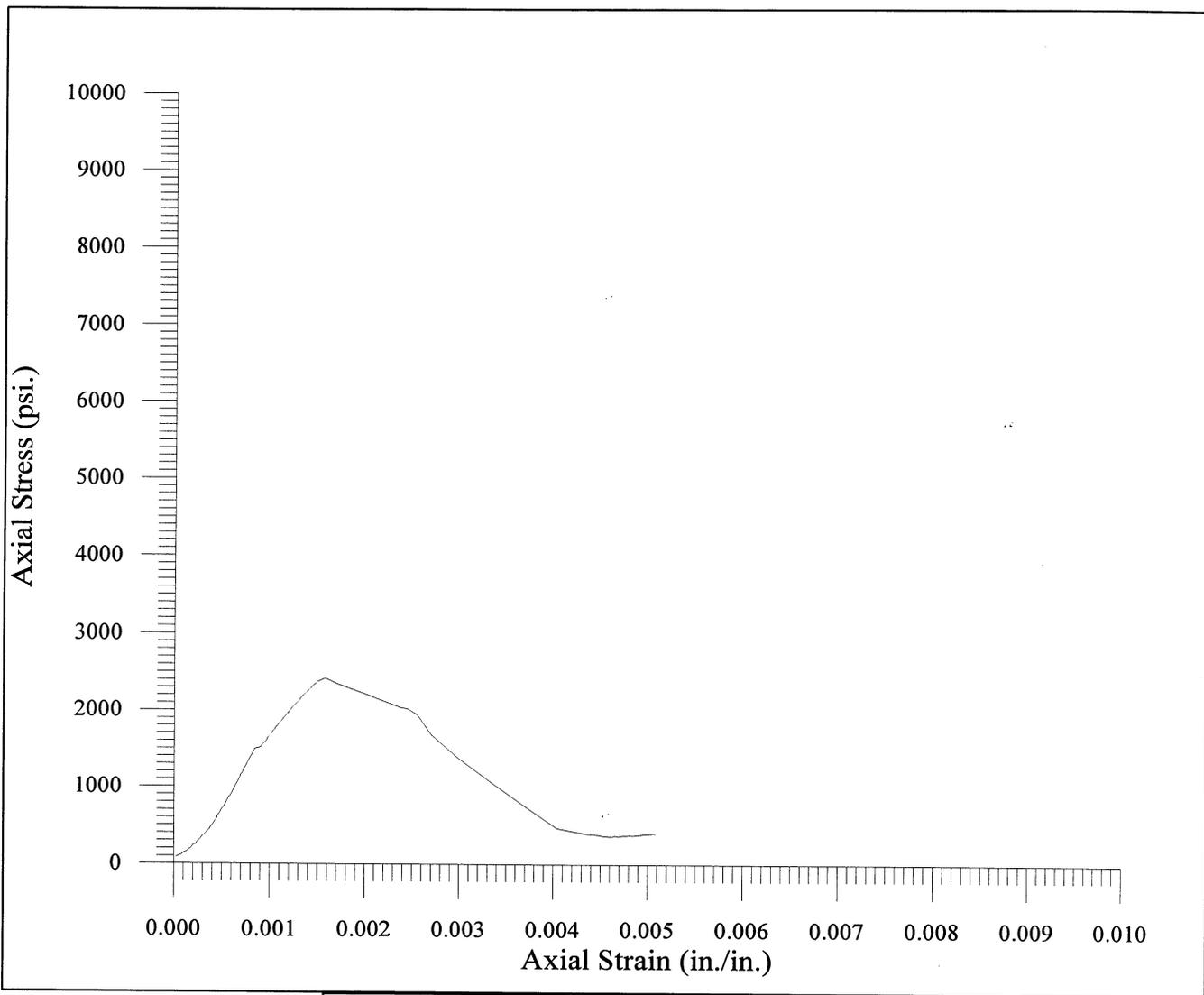
Comments: started to fail in modulus test, but no clear indication of failure on sample.

UC: Failed by shear on existing joints.



**ELASTIC MODULUS TEST**  
**Axial Stress vs. Axial & Radial Strain**

<p><b>SAMPLE ID:</b> Boring: 98-23  Sample: 29a  Depth: 120.5'</p> <p style="text-align: center;"><b>DESCRIPTION</b></p> <p>Medium gray fine sandy siltstone to sandstone with several calcite healed hairline fractures about 15 to 25 degrees to the core axis.</p> <p><b>MODULUS:</b> 5,480,000 psi  <b>POISSON'S RATIO:</b> .21</p>	<div style="text-align: center;">  <p><b>800 Peralta Ave</b>  <b>San Leandro, CA 94577</b></p> </div> <hr/> <p><b>Client:</b> Fugro West, Inc.  5855 Olivas Park Dr.  Ventura, CA 93003</p> <p><b>Project:</b> San Francisco Oakland Bay Bridge  East Span Replacement Project</p> <p><b>Job Number:</b> 98-42-0053</p> <hr/> <p><b>Test Date:</b> October 22, 1998</p>
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**UNCONFINED COMPRESSION TEST**  
**Axial Stress vs. Axial Strain**

**SAMPLE ID:** Boring : 98-23  
 Sample: 29a  
 Depth: 120.5'

**DESCRIPTION**  
 Medium gray fine sandy siltstone to sandstone with several calcite healed hairline fractures about 15 to 25 degrees to the core axis.

**STRENGTH:** 2412 psi

*Geo*  *Test*  
**Unlimited** 800 Peralta Ave  
 San Leandro, CA 94577

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**Client:** Fugro West, Inc.  
 5855 Olivas Park Dr.  
 Ventura, CA 93003

**Project:** San Francisco Oakland Bay Bridge  
 East Span Replacement Project

**Job Number:** 98-42-0053

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**Test Date:** October 23, 1998

DATA SHEET

Determination of Rock Modulus and Poisson's Ratio (ASTM D3148)

Date: 10/22 & 23/98

Person performing the test: A. Bro

Client: Fugro

Job: #12-SFOBB

Sample ID: B98-23 S30b

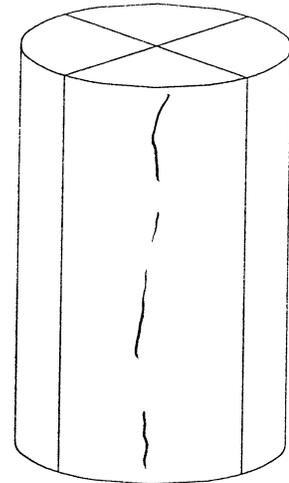
Sample Description: medium gray sandstone with an axial calcite healed horizontal fracture.

Sample Depth: 128.5'

Sample Condition: received & tested moist

d <sub>1</sub>	d <sub>2</sub>
2.388	2.389
2.388	2.390
2.390	2.390
2.390	2.391
2.390	2.391

l <sub>1</sub>	l <sub>2</sub>
-.0007	-.0002
±.0001	±.0001
+.0007	+.0001



Avg. diameter: 2.390

Avg. length: 5.252

Sample area: 4.486

l/d ratio: 2.20

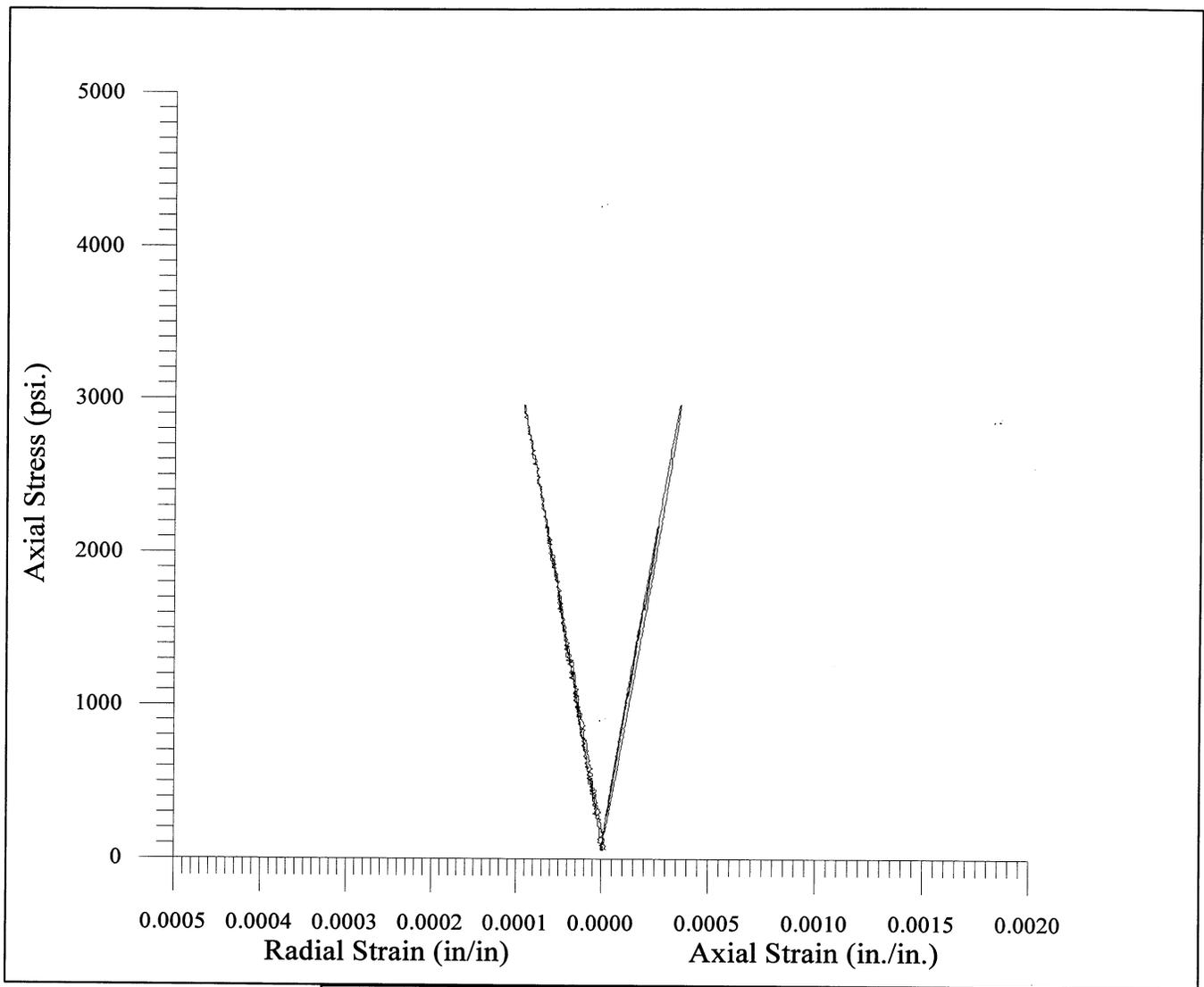
Sample volume(in<sup>3</sup>): 23.562

Sample weight (g): 1052.5g

Density: 44.67g/in<sup>3</sup> = 170.2 pcf (1 g/in<sup>3</sup> = 3.8095 lb/ft<sup>3</sup>)

Gauge length: 2.000 in.

Comments: Failed by diagonal shear.



**ELASTIC MODULUS TEST**  
**Axial Stress vs. Axial & Radial Strain**

**SAMPLE ID:** Boring: 98-23  
 Sample: 30b  
 Depth: 128.5'

**DESCRIPTION**  
 Medium gray sandstone with a calcite healed hairline axial fracture.

**MODULUS:** 8,330,000 psi  
**POISSON'S RATIO:** .25

*Geo*  *Test*  
**Unlimited** 800 Peralta Ave  
 San Leandro, CA 94577

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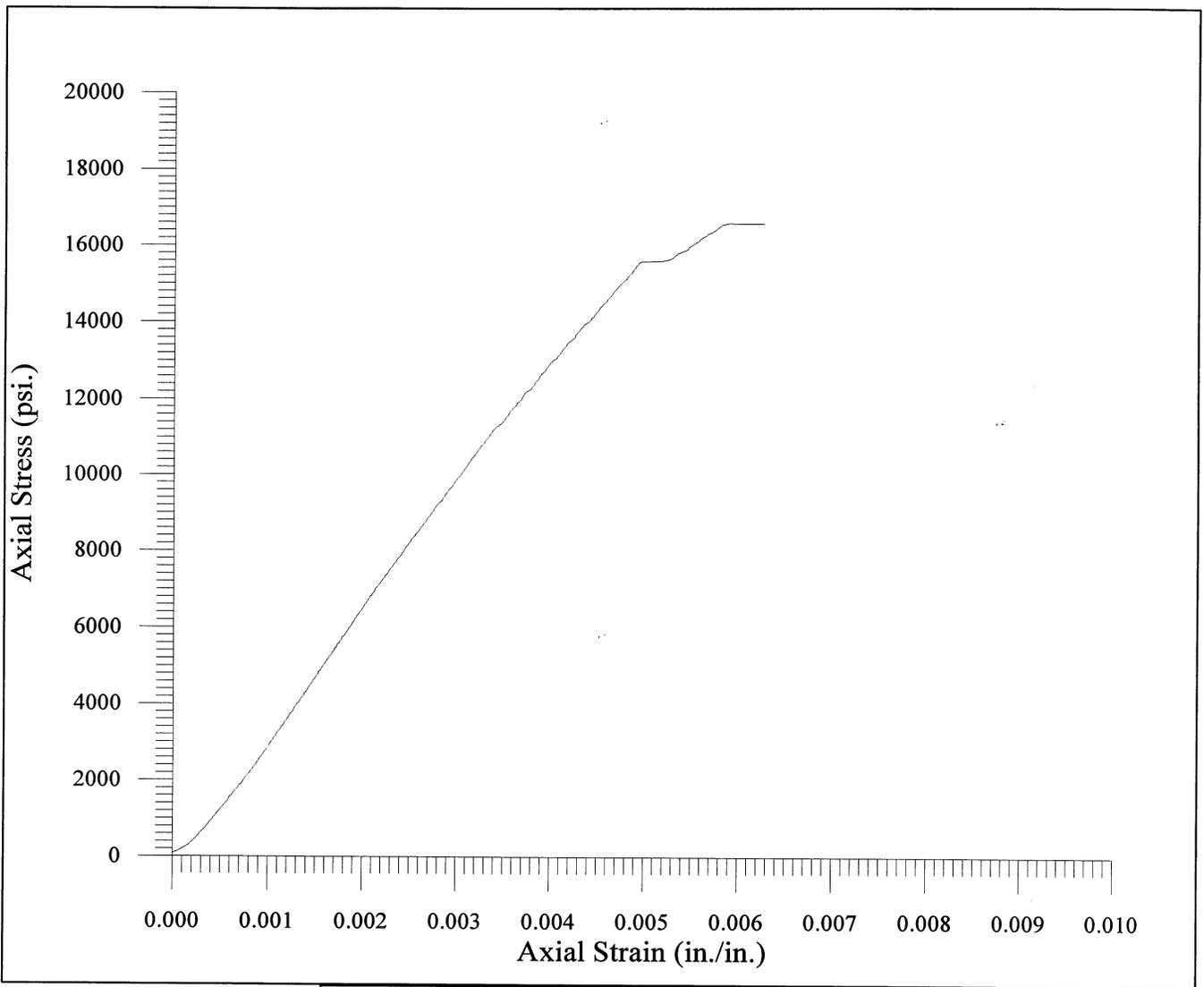
**Client:** Fugro West, Inc.  
 5855 Olivas Park Dr.  
 Ventura, CA 93003

**Project:** San Francisco Oakland Bay Bridge  
 East Span Replacement Project

**Job Number:** 98-42-0053

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**Test Date:** October 22, 1998



**UNCONFINED COMPRESSION TEST  
Axial Stress vs. Axial Strain**

<p><b>SAMPLE ID:</b> Boring : 98-23 Sample: 30b Depth: 128.5'</p> <p align="center"><b>DESCRIPTION</b></p> <p>Medium gray sandstone with a calcite healed hairline axial fracture.</p> <p><b>STRENGTH:</b> 16,579 psi</p>	<p align="center"> <i>Geo</i>  <i>U</i>  <i>Test</i>  <i>Unlimited</i> </p> <p align="right">800 Peralta Ave San Leandro, CA 94577</p>
	<p><b>Client:</b> Fugro West, Inc. 5855 Olivas Park Dr. Ventura, CA 93003</p> <p><b>Project:</b> San Francisco Oakland Bay Bridge East Span Replacement Project</p> <p><b>Job Number:</b> 98-42-0053</p>
	<p><b>Test Date:</b> October 23, 1998</p>

DATA SHEET

Determination of Rock Modulus and Poisson's Ratio (ASTM D3148)

Date: 10/22 & 23/98

Person performing the test: A. Bro

Client: Fugro

Job: #92-SFQBB

Sample ID: B98-23 S31a

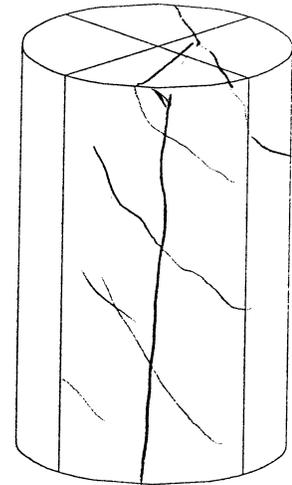
Sample Description: medium gray sandstone alternating with fine sandy siltstone. Contains numerous calcite healed fracture fractures, about 24-37 degrees to the core axis and one axial healed fracture

Sample Depth: 135'

Sample Condition: received & tested in situ

d <sub>1</sub>	d <sub>2</sub>
2.393	2.389
2.392	2.390
2.392	2.391
2.393	2.392
2.389	2.391

l <sub>1</sub>	l <sub>2</sub>
-.0008	0
±.0001	±.0001
+.0008	0



Avg. diameter: 2.391

Avg. length: 5.294

Sample area: 4.4190

l/d ratio: 2.21

Sample volume(in<sup>3</sup>): 23.770

Sample weight (g): 1061.78

Density: 44.678/in<sup>3</sup> = 170.2 pcf (1 g/in<sup>3</sup>=3.8095lb/ft<sup>3</sup>)

Gauge length: 2.000 in.

Comments: Failed by splitting on existing vert. joint.

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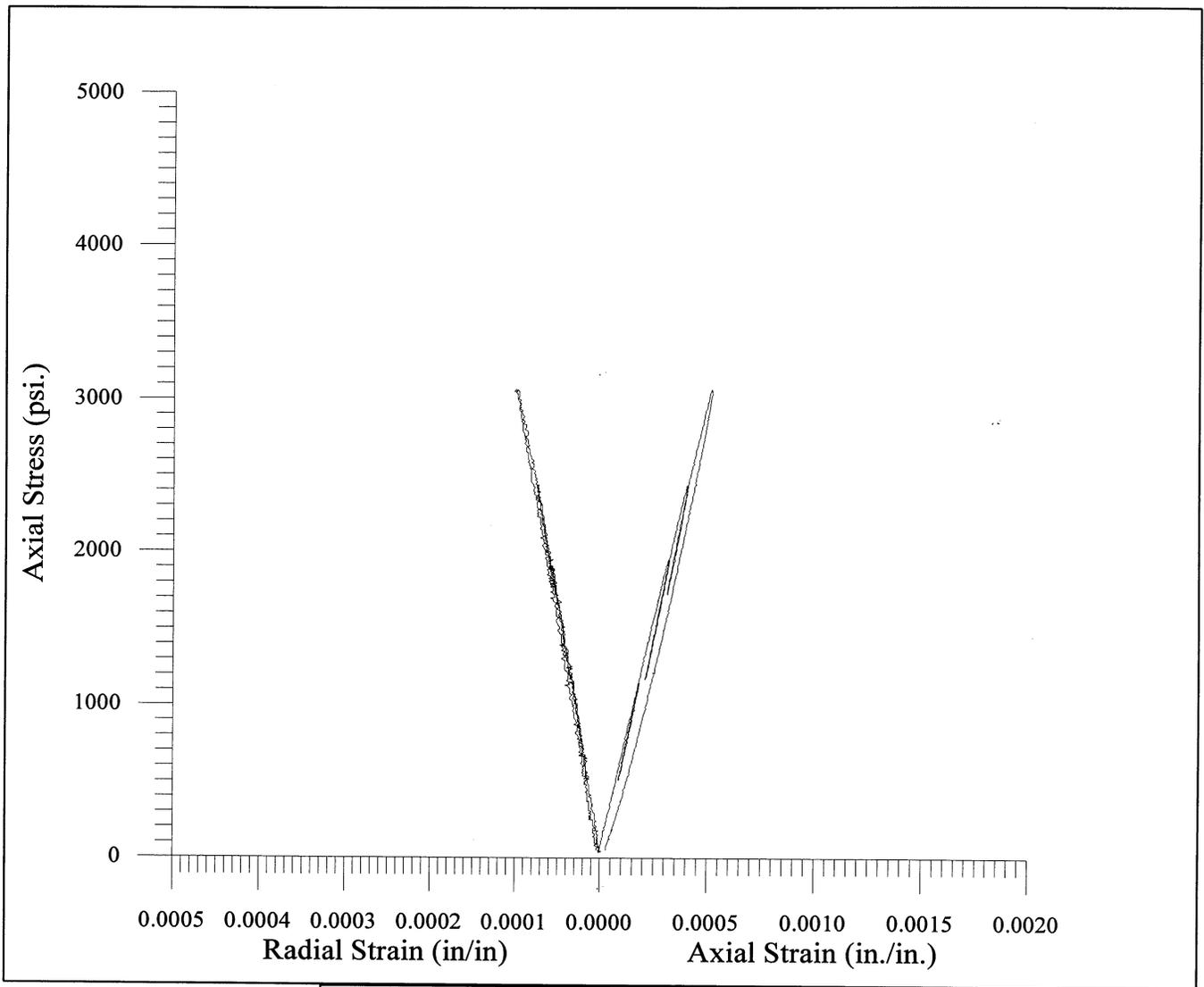
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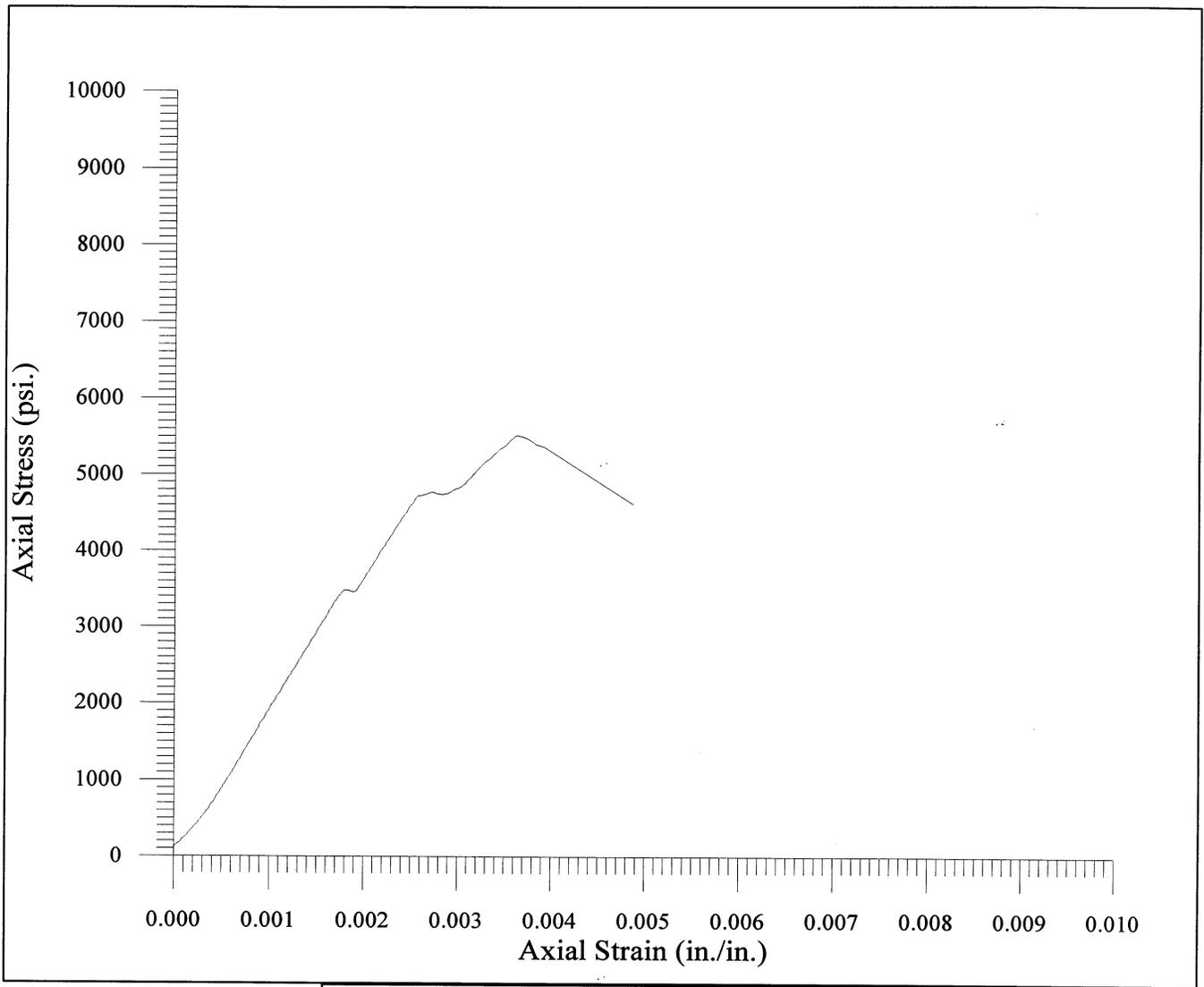


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**ELASTIC MODULUS TEST**  
**Axial Stress vs. Axial & Radial Strain**

<p><b>SAMPLE ID:</b> Boring: 98-23  Sample: 31a  Depth: 135'</p> <p><b>DESCRIPTION</b>  Medium gray sandstone alternating with fine sandy siltstone. Contains numerous calcite healed hairline fractures about 24-37 degrees to the core axis and one axial healed fracture.</p> <p><b>MODULUS:</b> 6,940,000 psi</p> <p><b>POISSON'S RATIO:</b> .22</p>	<div style="text-align: center;">   <b>Geo Test Unlimited</b>  800 Peralta Ave  San Leandro, CA 94577 </div> <hr/> <p><b>Client:</b> Fugro West, Inc.  5855 Olivas Park Dr.  Ventura, CA 93003</p> <p><b>Project:</b> San Francisco Oakland Bay Bridge  East Span Replacement Project</p> <p><b>Job Number:</b> 98-42-0053</p> <p><b>Test Date:</b> October 22, 1998</p>
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**UNCONFINED COMPRESSION TEST  
Axial Stress vs. Axial Strain**

<p><b>SAMPLE ID:</b> Boring : 98-23 Sample: 31a Depth: 135'</p> <p align="center"><b>DESCRIPTION</b></p> <p>Medium gray sandstone alternating with fine sandy siltstone. Contains numerous calcite healed hairline fractures about 24-37 degrees to the core axis and one axial healed fracture.</p> <p><b>STRENGTH:</b> 5512 psi</p>	<div style="text-align: center;"> <p><i>Geo</i>  <i>U</i></p> <p><i>Test</i></p> <p><b>Unlimited</b></p> </div> <p align="right">800 Peralta Ave San Leandro, CA 94577</p> <hr/> <p><b>Client:</b> Fugro West, Inc. 5855 Olivas Park Dr. Ventura, CA 93003</p> <p><b>Project:</b> San Francisco Oakland Bay Bridge East Span Replacement Project</p> <p><b>Job Number:</b> 98-42-0053</p> <hr/> <p><b>Test Date:</b> October 23, 1998</p>
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DATA SHEET

Determination of Rock Modulus and Poisson's Ratio (ASTM D3148)

Date: 10/22 & 23/98

Person performing the test: A. B. R.

Client: Fuyo

Job: #92-SFOBIS

Sample ID: B98-23 S32a

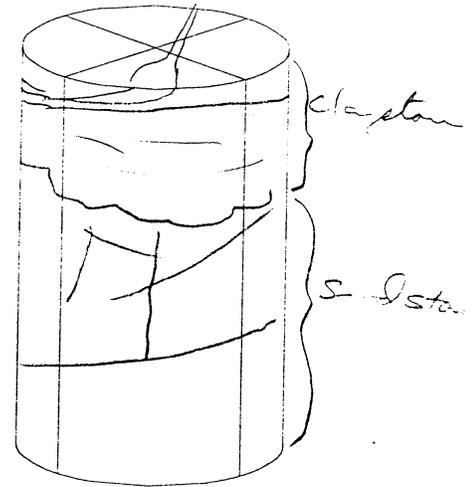
Sample Description: Medium gray sandstone with a zone of contacted claystone (dark gray to olive gray). Sample contains many calcite healed hairline fractures

Sample Depth: 142.8'

Sample Condition: received & tested moist

d <sub>1</sub>	d <sub>2</sub>
2.388	2.381
2.388	2.389
2.392	2.390
2.390	2.391
2.392	2.392

l <sub>1</sub>	l <sub>2</sub>
-.0006	0
±.0001	±.0001
+.0006	0



Avg. diameter: 2.389

Avg. length: 5.298

Sample area: 4.483

l/d ratio: 2.22

Sample volume(in<sup>3</sup>): 23.748

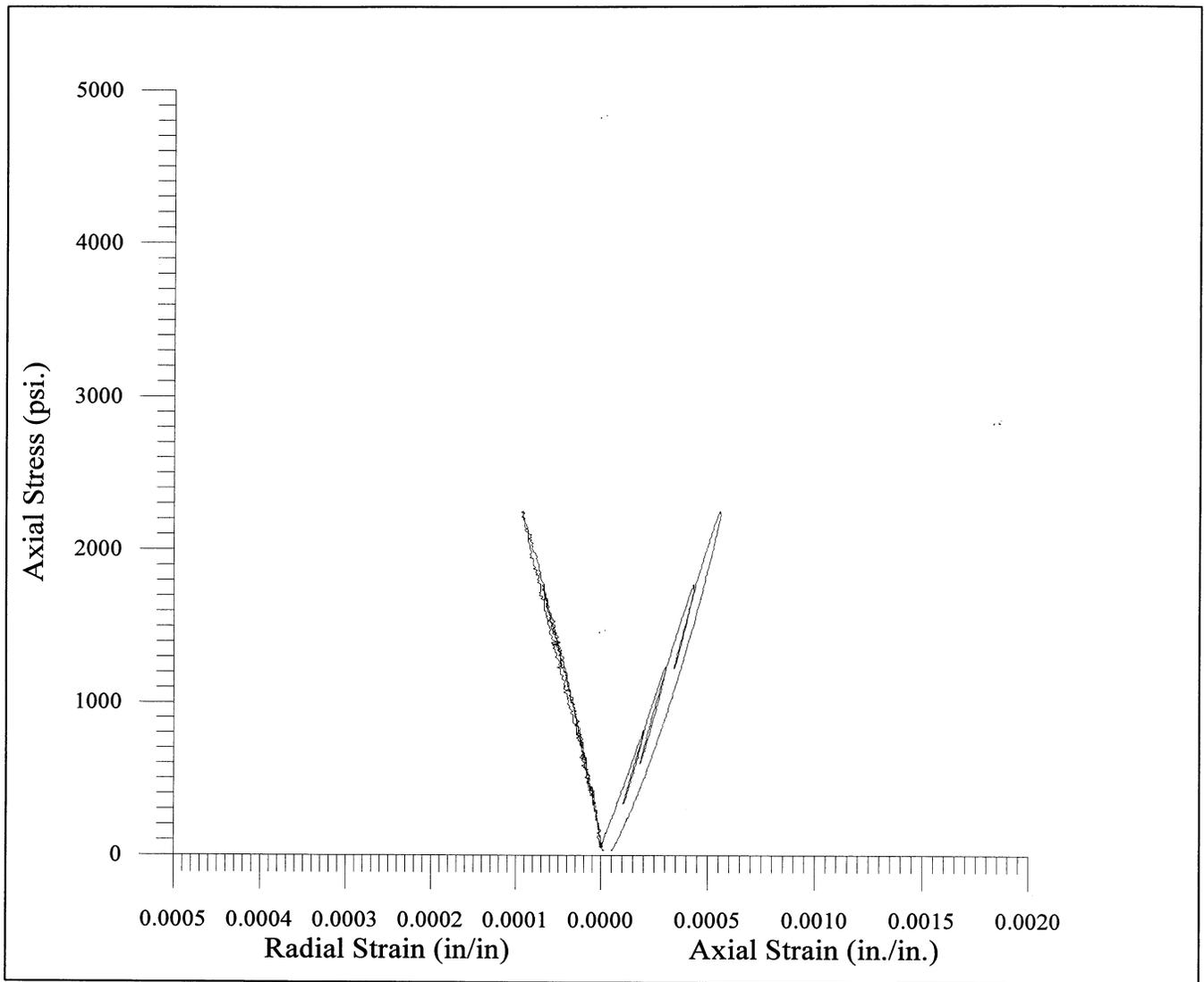
Sample weight (g): 1052.8g

Density: 44.33 g/in<sup>3</sup> = 168.9 pcf (1 g/in<sup>3</sup> = 3.8095 lb/ft<sup>3</sup>)

Gauge length: 2.000 in

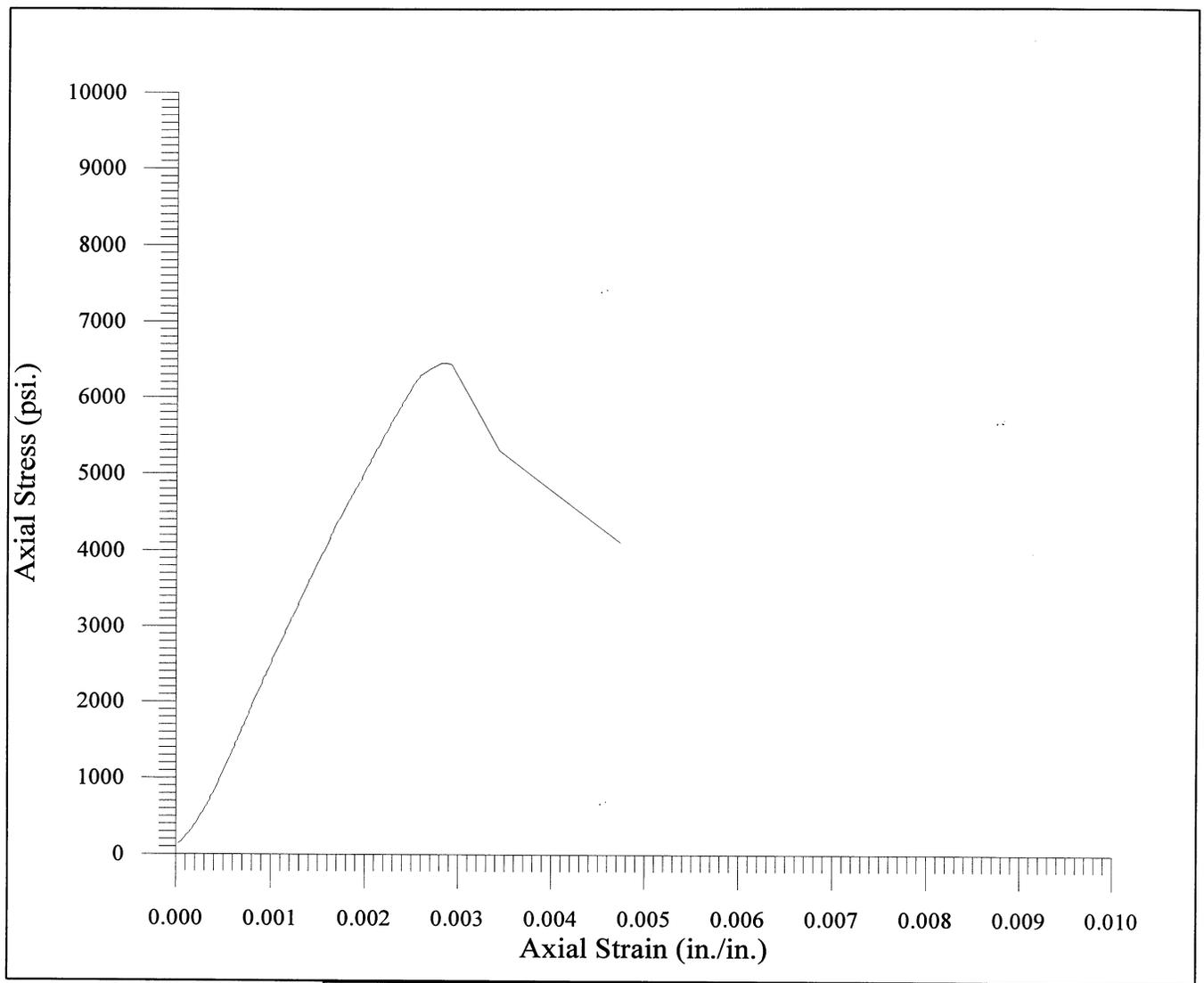
Comments: Er in ss Eain c.s. => not valid?

Failed by shear on various existing joints.



**ELASTIC MODULUS TEST**  
**Axial Stress vs. Axial & Radial Strain**

<p><b>SAMPLE ID:</b> Boring: 98-23  Sample: 32a  Depth: 142.8'</p> <p align="center"><b>DESCRIPTION</b></p> <p>Medium gray sandstone with an end zone of contorted dark gray to olive gray claystone and many calcite healed hairline fractures.</p> <p><b>MODULUS:</b> 5,380,000 psi  <b>POISSON'S RATIO:</b> .24</p>	<p align="center"> <i>Geo</i>  <i>Test</i>  <b>Unlimited</b> </p> <p align="right">800 Peralta Ave  San Leandro, CA 94577</p> <hr/> <p><b>Client:</b> Fugro West, Inc.  5855 Olivas Park Dr.  Ventura, CA 93003</p> <p><b>Project:</b> San Francisco Oakland Bay Bridge  East Span Replacement Project</p> <p><b>Job Number:</b> 98-42-0053</p>
	<p><b>Test Date:</b> October 22, 1998</p>



**UNCONFINED COMPRESSION TEST**  
**Axial Stress vs. Axial Strain**

<p><b>SAMPLE ID:</b> Boring : 98-23          Sample: 32a          Depth: 142.8'</p>	<p><i>Geo</i>  <i>Test</i>  <b>Unlimited</b> 800 Peralta Ave          San Leandro, CA 94577</p>
<p><b>DESCRIPTION</b>          Medium gray sandstone with an end zone of contorted dark gray to olive gray claystone and many calcite healed hairline fractures.</p>	<p><b>Client:</b> Fugro West, Inc.          5855 Olivas Park Dr.          Ventura, CA 93003</p>
<p><b>STRENGTH:</b> 6449 psi</p>	<p><b>Project:</b> San Francisco Oakland Bay Bridge          East Span Replacement Project</p>
	<p><b>Job Number:</b> 98-42-0053</p>
	<p><b>Test Date:</b> October 23, 1998</p>

## Direct Shear Tests

**DATA SHEET**  
Direct Shear of Rock (ISRM)

Date: 10/30/98

Person performing the test: A. Bro

Client: Furol

Job: #92-SFOBB

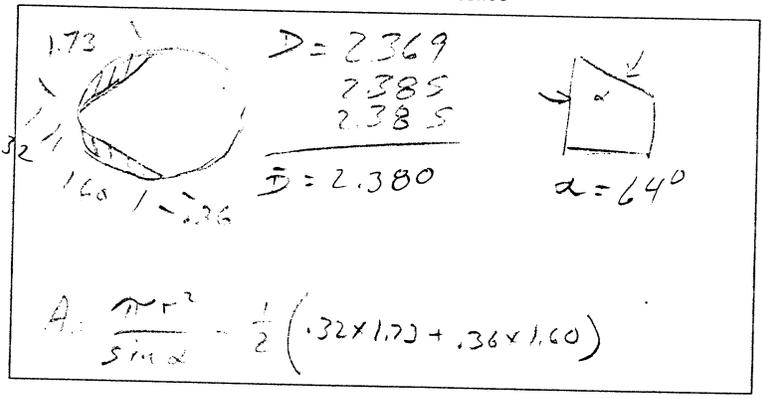
Sample ID: B98-23 STA

Sample Description: Slightly dry to moist with light tan clay coating on top and sides

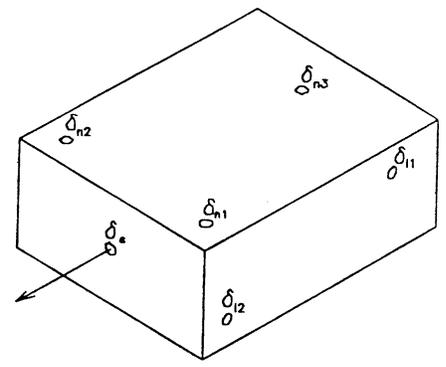
Sample Depth: 17.5'

Sample Water Condition: received & tested moist

Sketch of Shear Surface



Location of LVDTs on top shear box



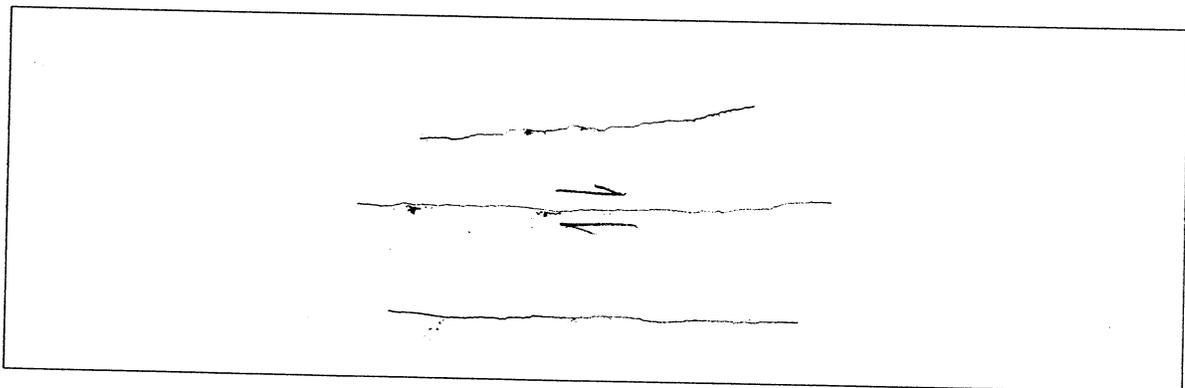
Sample area: 4.385

*slump drop in strength end of 2nd stage, 1st cycle*

Estimated Top Box Weight: \_\_\_\_\_  
Measured Top Box Weight: 15.7

$\sigma_n$	<u>25</u>	<u>75</u>	<u>150</u> psi
$F_n$	<u>110</u>	<u>330</u>	<u>660</u> lb
$F_n - W_b$	<u>94</u>	<u>314</u>	<u>644</u> lb

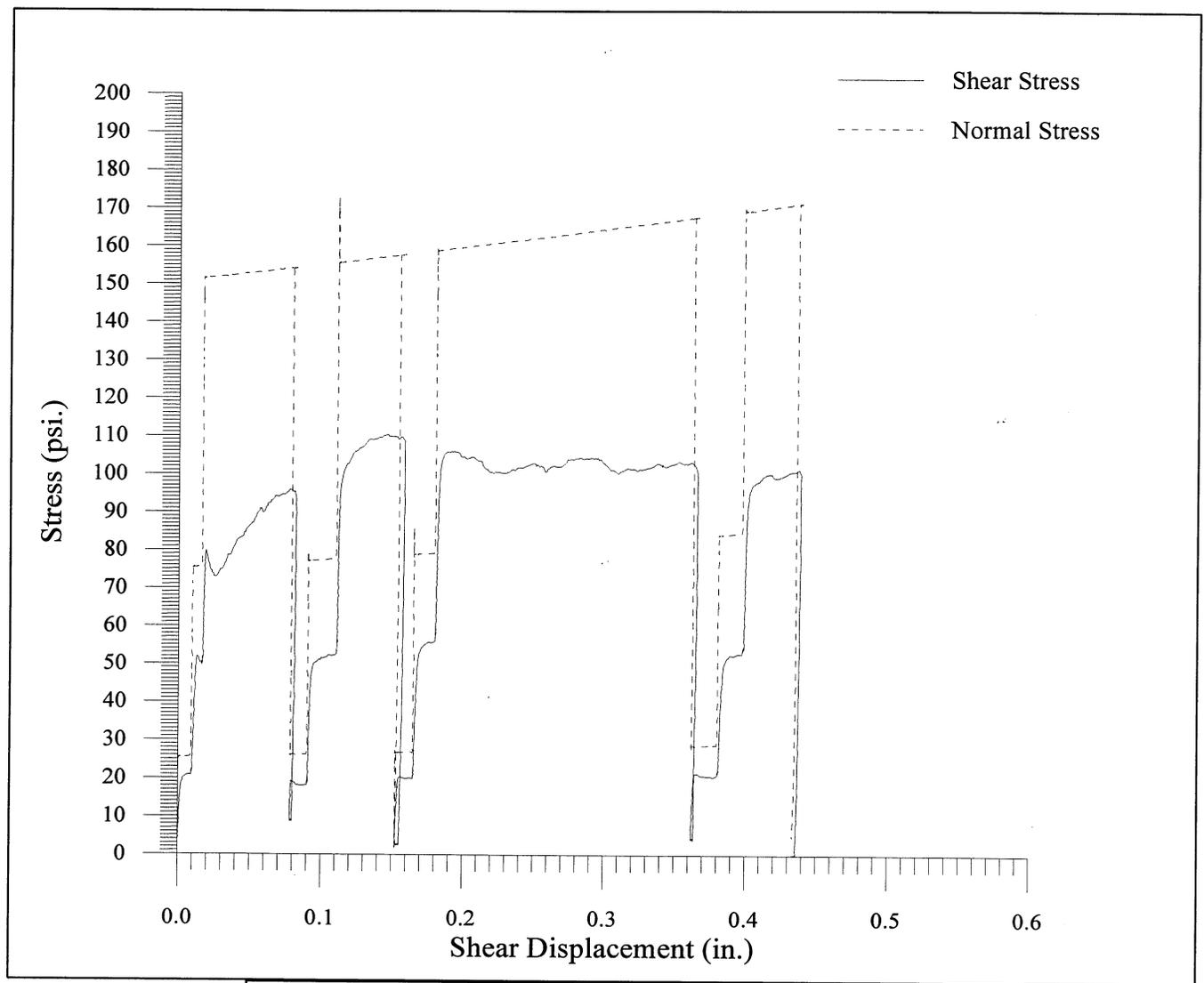
Joint Profiles



Summary of Test Results

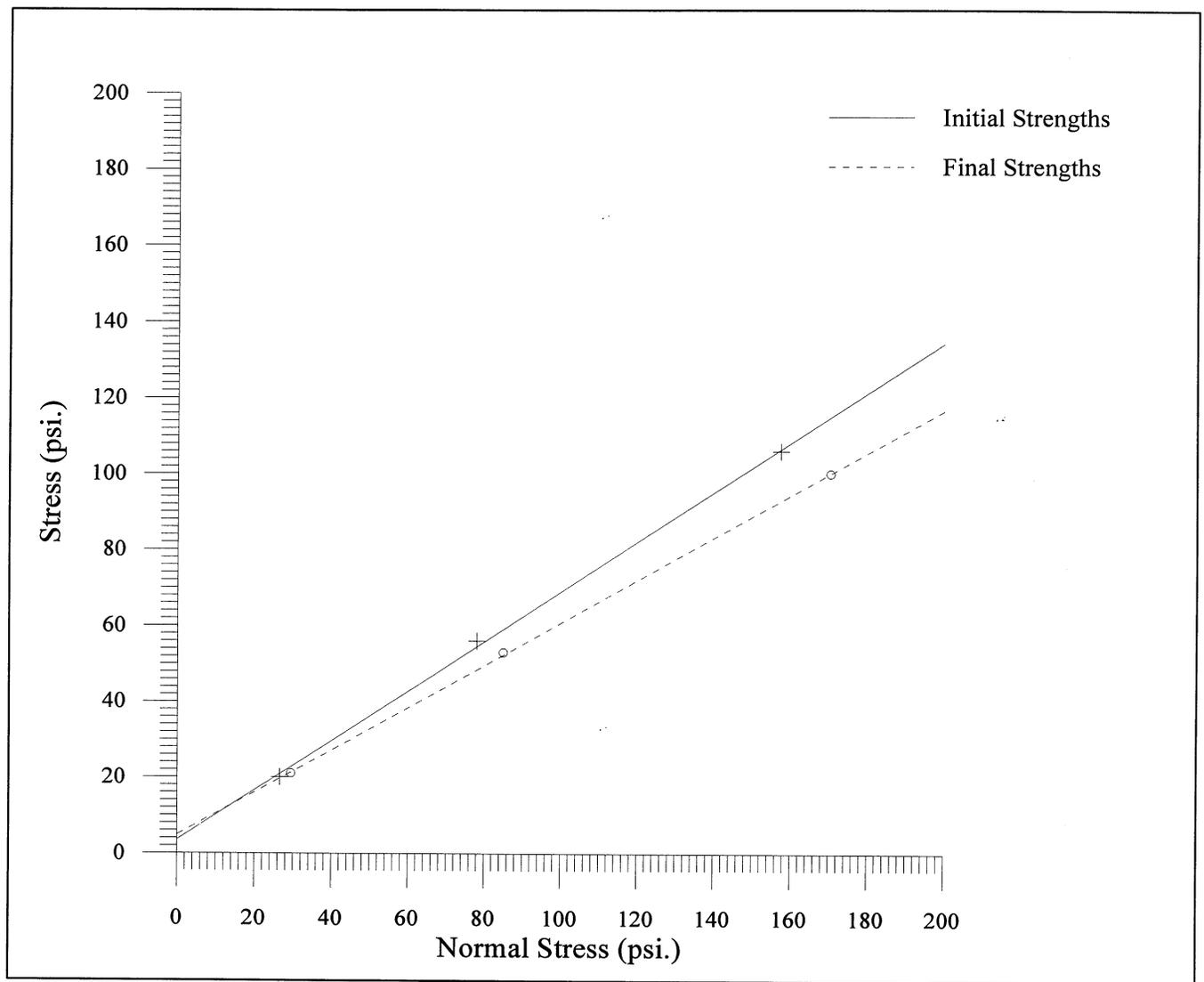
Rate of Loading				
Shr. Displ. Rate				
Normal Stress				
Shear Strength				

Sj: \_\_\_\_\_  
phi: \_\_\_\_\_



**DIRECT SHEAR TEST**  
**Shear and Normal Stress vs. Shear Displacement**

<p><b>SAMPLE ID:</b> Boring: 98-23          Sample: 7a          Depth: 17.5'</p> <p style="text-align: center;"><b>DESCRIPTION</b></p> <p>Slightly rough joint in tan sandstone,          with a light tan clay or silt coating.</p> <table style="width: 100%; margin-top: 10px;"> <thead> <tr> <th></th> <th style="text-align: center;">Normal Stress</th> <th style="text-align: center;">Shear Strength</th> </tr> </thead> <tbody> <tr> <td rowspan="3" style="vertical-align: top;">Initial</td> <td style="text-align: center;">26.5</td> <td style="text-align: center;">20</td> </tr> <tr> <td style="text-align: center;">78</td> <td style="text-align: center;">56</td> </tr> <tr> <td style="text-align: center;">157.5</td> <td style="text-align: center;">106</td> </tr> <tr> <td rowspan="3" style="vertical-align: top;">Final</td> <td style="text-align: center;">29.5</td> <td style="text-align: center;">21</td> </tr> <tr> <td style="text-align: center;">85</td> <td style="text-align: center;">53</td> </tr> <tr> <td style="text-align: center;">170.5</td> <td style="text-align: center;">100</td> </tr> </tbody> </table>		Normal Stress	Shear Strength	Initial	26.5	20	78	56	157.5	106	Final	29.5	21	85	53	170.5	100	<div style="text-align: center;">  <p><b>800 Peralta Ave</b>  <b>San Leandro, CA 94577</b></p> </div> <hr/> <p><b>Client:</b> <b>Fugro West, Inc.</b>  <b>5855 Olivas Park Dr.</b>  <b>Ventura, CA 93003</b></p> <p><b>Project:</b> <b>San Francisco Oakland Bay Bridge</b>  <b>East Span Replacement Project</b></p> <p><b>Job Number:</b> <b>98-42-0053</b></p> <hr/> <p><b>Test Date:</b> <b>October 30, 1998</b></p>
	Normal Stress	Shear Strength																
Initial	26.5	20																
	78	56																
	157.5	106																
Final	29.5	21																
	85	53																
	170.5	100																



**DIRECT SHEAR TEST  
Failure Envelope**

<p><b>SAMPLE ID:</b> Boring: 98-23 Sample: 7a Depth: 17.5'</p> <p><b>DESCRIPTION</b></p> <p>Slightly rough joint in tan sandstone with a light tan clay or silt coating.</p>	 <b>Geo Test Unlimited</b> 800 Peralta Ave San Leandro, CA 94577									
	<p><b>Client:</b> Fugro West, Inc. 5855 Olivas Park Dr. Ventura, CA 93003</p> <p><b>Project:</b> San Francisco Oakland Bay Bridge East Span Replacement Project</p> <p><b>Job Number:</b> 98-42-0053</p>									
<table border="1"> <thead> <tr> <th></th> <th>Shear Intercept (psi)</th> <th>Friction Angle (degrees)</th> </tr> </thead> <tbody> <tr> <td>Initial</td> <td>3.5</td> <td>33.2</td> </tr> <tr> <td>Final</td> <td>4.9</td> <td>29.2</td> </tr> </tbody> </table>		Shear Intercept (psi)	Friction Angle (degrees)	Initial	3.5	33.2	Final	4.9	29.2	<p><b>Test Date:</b> October 30, 1998</p>
	Shear Intercept (psi)	Friction Angle (degrees)								
Initial	3.5	33.2								
Final	4.9	29.2								

DATA SHEET  
Direct Shear of Rock (ISRM)

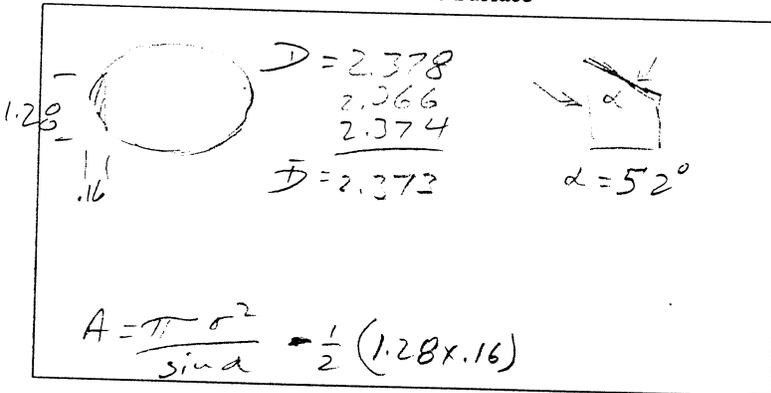
Client: Fugro  
Job: #92-SFOBR  
Sample ID: B98-23 S76  
Sample Description: Planes, slightly rough joint in tan sandstone

Date: 10/30/98  
Person performing the test: A. Bro

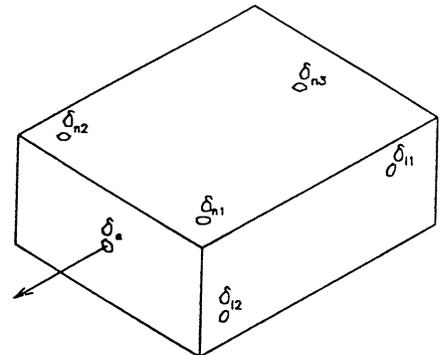
Sample Depth: 17.7'

Sample Water Condition: received & tested moist

Sketch of Shear Surface



Location of LVDTs on top shear box



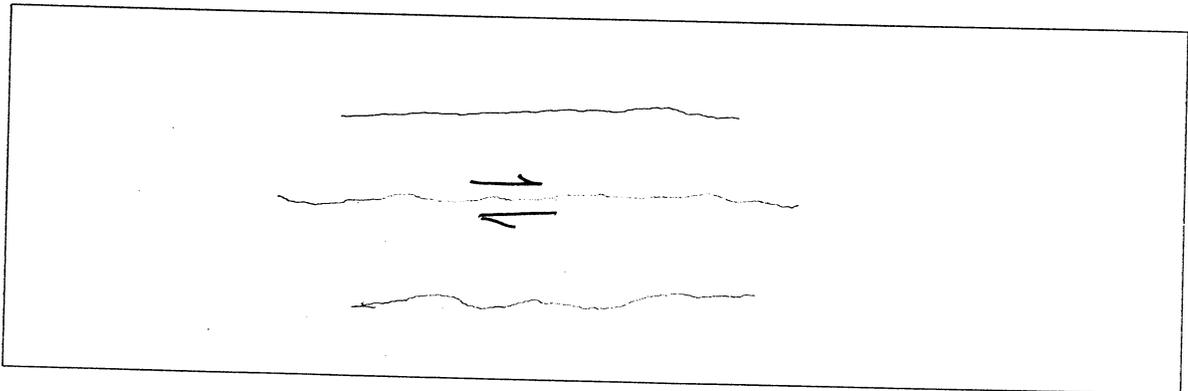
Sample area: 5.510

Estimated Top Box Weight: \_\_\_\_\_  
Measured Top Box Weight: 15.8 lb

Initial friction angle probably underestimated due to weakening on 3rd stage.

$\sigma_n$	25	75	150 psi
$F_n$	138	414	828 lb
$F_{n-wb}$	122	378	812 lb

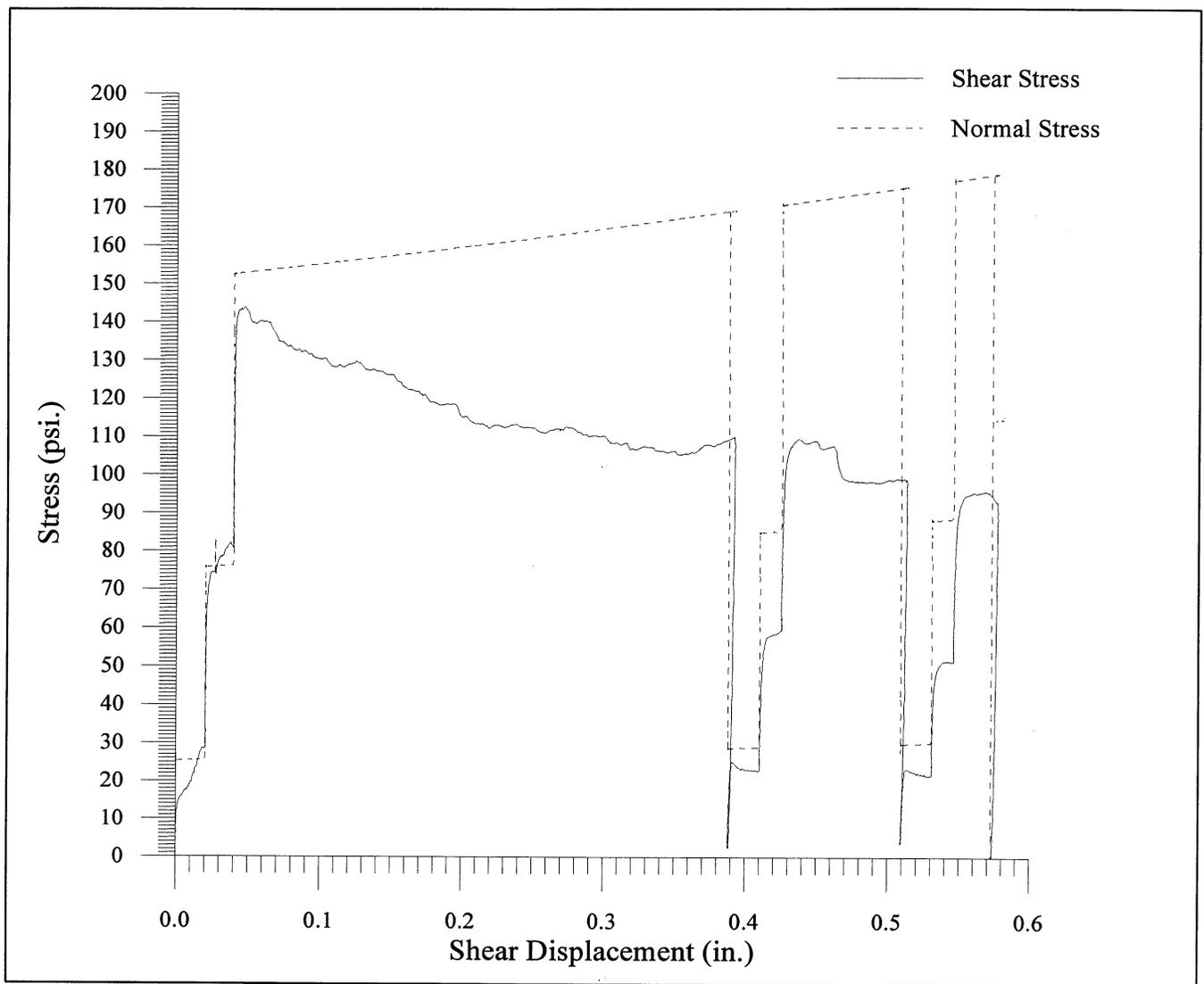
Joint Profiles



Summary of Test Results

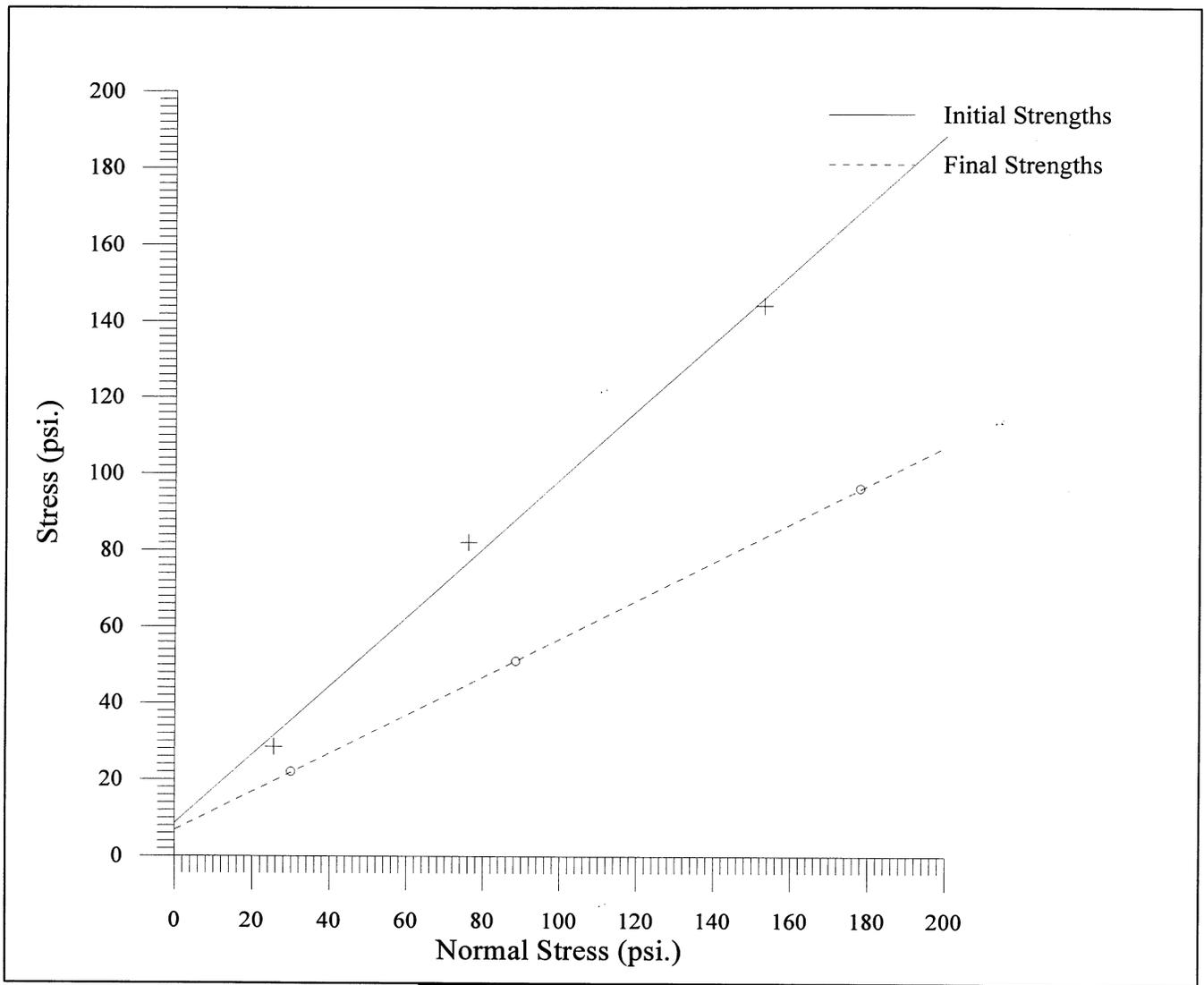
Rate of Loading				
Shr. Displ. Rate				
Normal Stress				
Shear Strength				

Sj: \_\_\_\_\_  
phi: \_\_\_\_\_



**DIRECT SHEAR TEST**  
**Shear and Normal Stress vs. Shear Displacement**

<b>SAMPLE ID:</b> Boring: 98-23 Sample: 7b Depth: 17.7'			 800 Peralta Ave San Leandro, CA 94577		
<b>DESCRIPTION</b> Slightly rough joint in tan sandstone.					
	<u>Normal Stress</u>		<u>Shear Strength</u>	<b>Client:</b> Fugro West, Inc. 5855 Olivas Park Dr. Ventura, CA 93003	
Initial	25.5		28.5	<b>Project:</b> San Francisco Oakland Bay Bridge East Span Replacement Project	
	76		82	<b>Job Number:</b> 98-42-0053	
	153		144	<b>Test Date:</b> October 30, 1998	
Final	30		22		
	88.5		51		
	178		96		



**DIRECT SHEAR TEST  
Failure Envelope**

**SAMPLE ID:** Boring: 98-23  
Sample: 7b  
Depth: 17.7'

**DESCRIPTION**  
Slightly rough joint in tan sandstone.

	Shear Intercept (psi)	Friction Angle (degrees)
Initial	8.7	41.9
Final	6.9	26.6

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

800 Peralta Ave  
San Leandro, CA 94577

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**Client:** Fugro West, Inc.  
5855 Olivas Park Dr.  
Ventura, CA 93003

**Project:** San Francisco Oakland Bay Bridge  
East Span Replacement Project

**Job Number:** 98-42-0053

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**Test Date:** October 30, 1998

**DATA SHEET**  
**Direct Shear of Rock (ISRM)**

Date: 10/30/98

Person performing the test: A. Bro

Client: Fugro

Job: #92-SFOBR

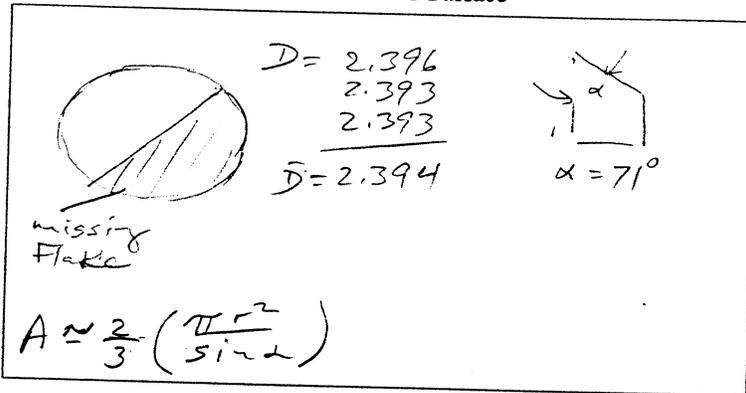
Sample ID: B98-23 5176

Sample Description: Planar joint in dark grey chert with thin calcite coating

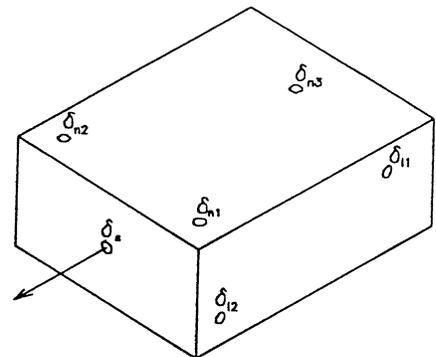
Sample Depth: 58'

Sample Water Condition: received & tested moist

Sketch of Shear Surface



Location of LVDTs on top shear box



Sample area: 3.174

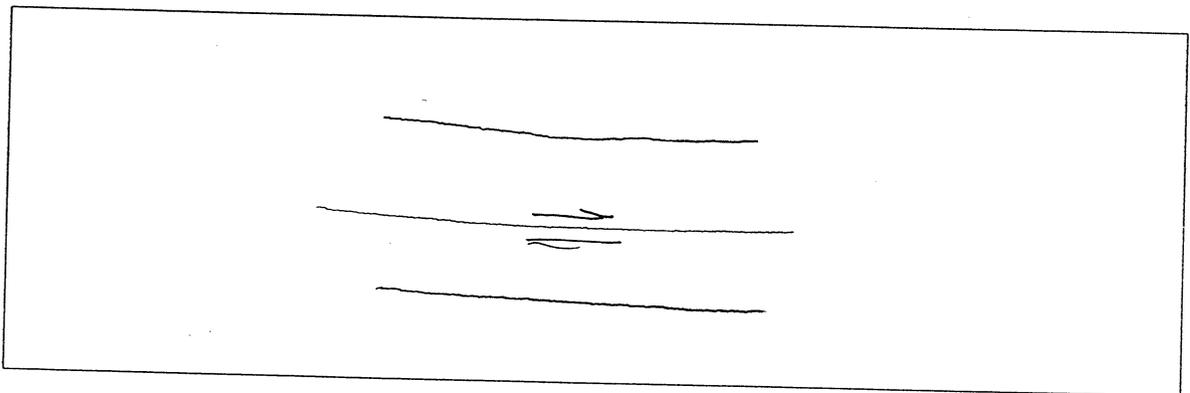
Estimated Top Box Weight: \_\_\_\_\_

Measured Top Box Weight: 15.3

*Small drops are indicative of edge fracture.*

$\sigma_n$	<u>25</u>	<u>75</u>	<u>150</u>	<u>ppsi</u>
$F_n$	<u>79</u>	<u>237</u>	<u>474</u>	<u>lb</u>
$F_{n-w_b}$	<u>64</u>	<u>222</u>	<u>459</u>	<u>lb</u>

Joint Profiles

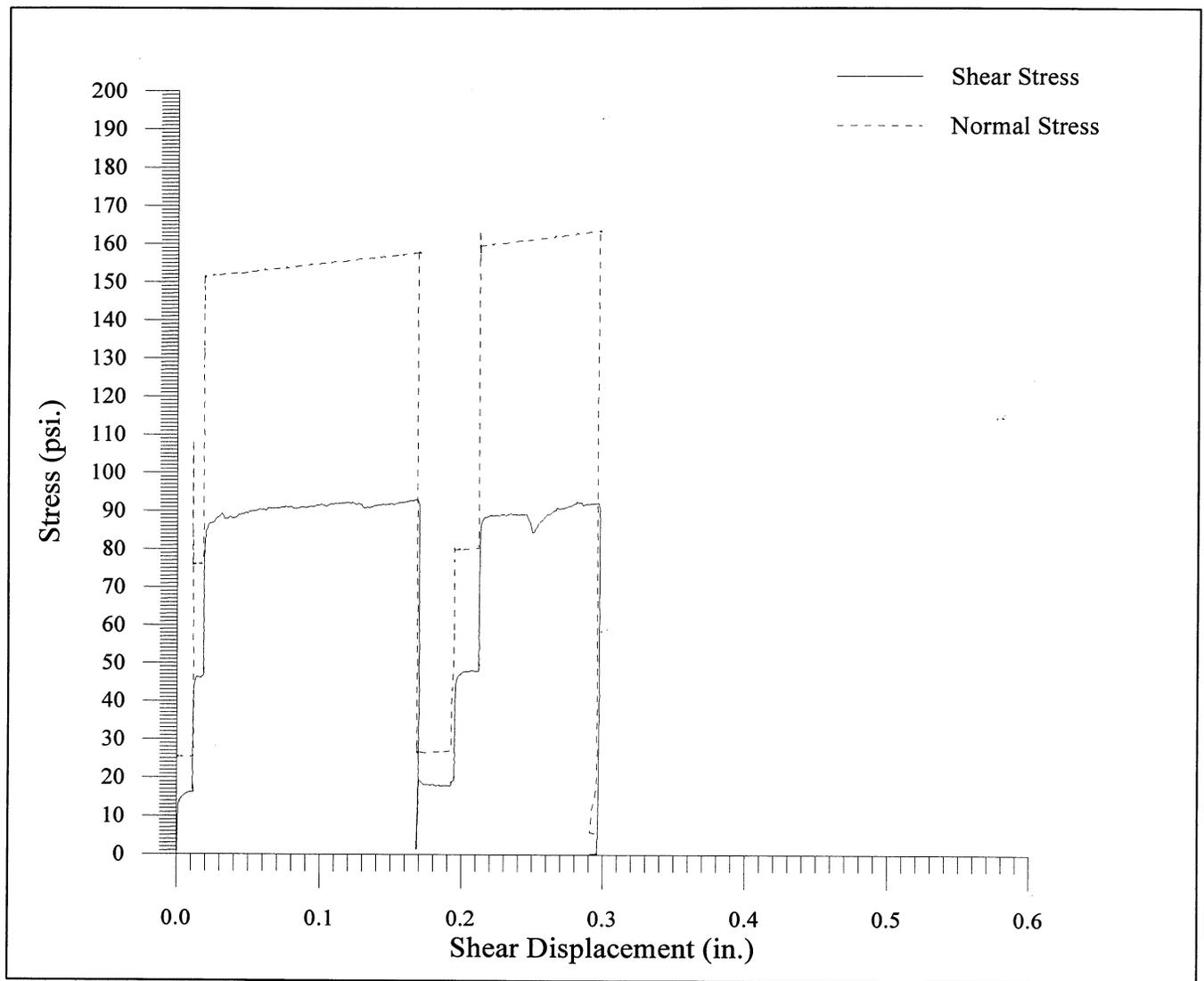


Summary of Test Results

Rate of Loading				
Shr. Displ. Rate				
Normal Stress				
Shear Strength				

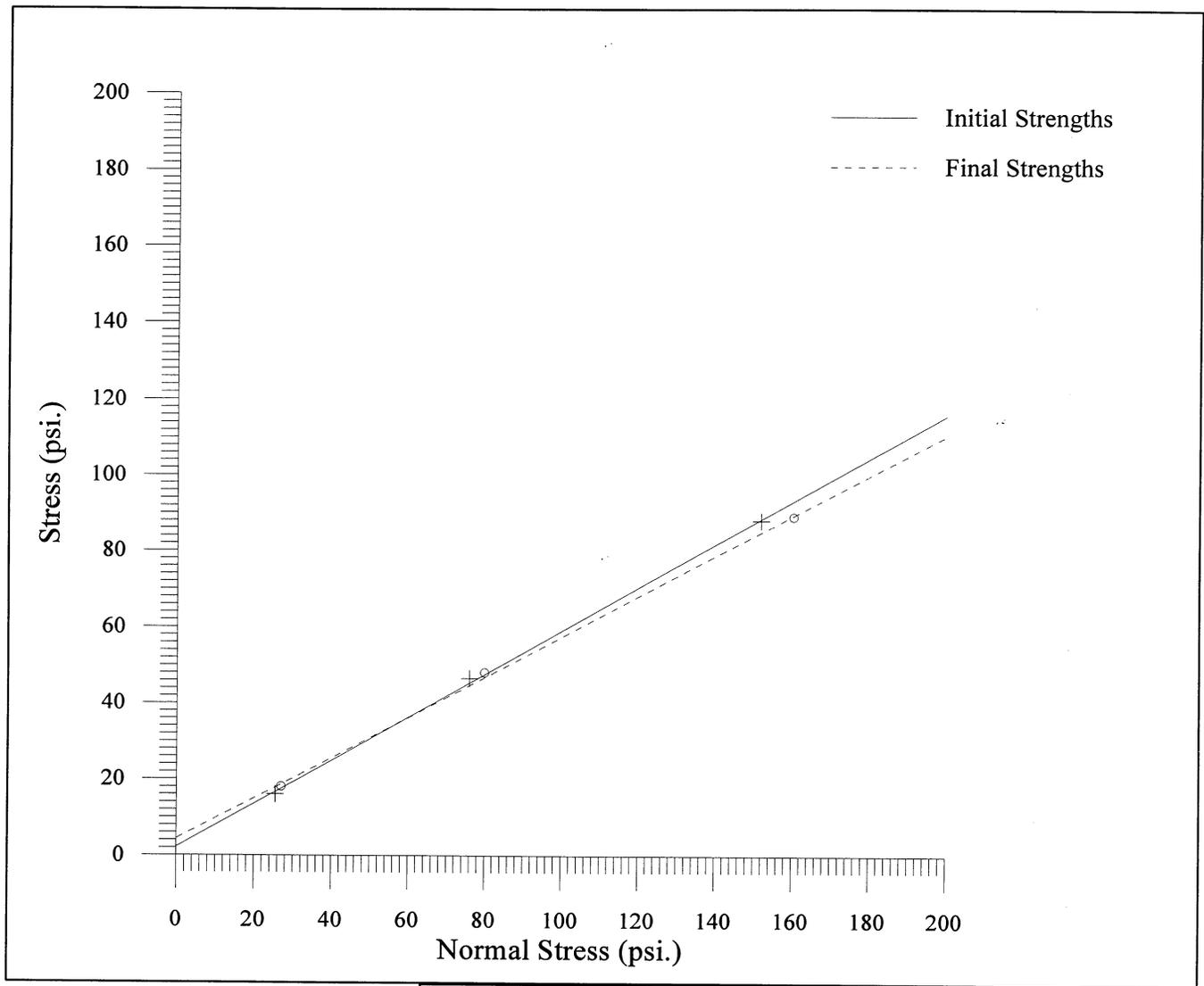
Sj: \_\_\_\_\_

φ: \_\_\_\_\_



**DIRECT SHEAR TEST**  
**Shear and Normal Stress vs. Shear Displacement**

<p><b>SAMPLE ID:</b> Boring: 98-23  Sample: 17b  Depth: 58'</p> <p><b>DESCRIPTION</b>  Planar calcite coated joint in dark gray claystone.</p>	<p align="center"> <i>Geo</i>  <i>U</i>  <i>Test</i>  <b>Unlimited</b> </p> <p align="right">800 Peralta Ave  San Leandro, CA 94577</p>																		
	<p><b>Client:</b> Fugro West, Inc.  5855 Olivas Park Dr.  Ventura, CA 93003</p>																		
<table border="1"> <thead> <tr> <th></th> <th>Normal Stress</th> <th>Shear Strength</th> </tr> </thead> <tbody> <tr> <td rowspan="3">Initial</td> <td>25.5</td> <td>16</td> </tr> <tr> <td>76</td> <td>46.5</td> </tr> <tr> <td>152</td> <td>88</td> </tr> <tr> <td rowspan="3">Final</td> <td>27</td> <td>18</td> </tr> <tr> <td>80</td> <td>48</td> </tr> <tr> <td>160.5</td> <td>89</td> </tr> </tbody> </table>		Normal Stress	Shear Strength	Initial	25.5	16	76	46.5	152	88	Final	27	18	80	48	160.5	89	<p><b>Project:</b> San Francisco Oakland Bay Bridge  East Span Replacement Project</p>	
	Normal Stress	Shear Strength																	
Initial	25.5	16																	
	76	46.5																	
	152	88																	
Final	27	18																	
	80	48																	
	160.5	89																	
<p><b>Job Number:</b> 98-42-0053</p>																			
<p><b>Test Date:</b> October 30, 1998</p>																			



**DIRECT SHEAR TEST  
Failure Envelope**

<p><b>SAMPLE ID:</b> Boring: 98-23 Sample: 17b Depth: 58'</p> <p align="center"><b>DESCRIPTION</b></p> <p>Planar calcite coated joint in dark gray claystone.</p>	<p><b>Geo Test Unlimited</b> 800 Peralta Ave San Leandro, CA 94577</p>									
	<p><b>Client:</b> Fugro West, Inc. 5855 Olivas Park Dr. Ventura, CA 93003</p>									
<table border="1"> <thead> <tr> <th></th> <th>Shear Intercept (psi)</th> <th>Friction Angle (degrees)</th> </tr> </thead> <tbody> <tr> <td>Initial</td> <td>2.2</td> <td>29.6</td> </tr> <tr> <td>Final</td> <td>4.4</td> <td>27.9</td> </tr> </tbody> </table>		Shear Intercept (psi)	Friction Angle (degrees)	Initial	2.2	29.6	Final	4.4	27.9	<p><b>Project:</b> San Francisco Oakland Bay Bridge East Span Replacement Project</p>
	Shear Intercept (psi)	Friction Angle (degrees)								
Initial	2.2	29.6								
Final	4.4	27.9								
	<p><b>Job Number:</b> 98-42-0053</p>									
	<p><b>Test Date:</b> October 30, 1998</p>									

DATA SHEET  
Direct Shear of Rock (ISRM)

Date: 10/20/98

Person performing the test: A. Bro

Client: Fugro

Job: #92-SFOBB

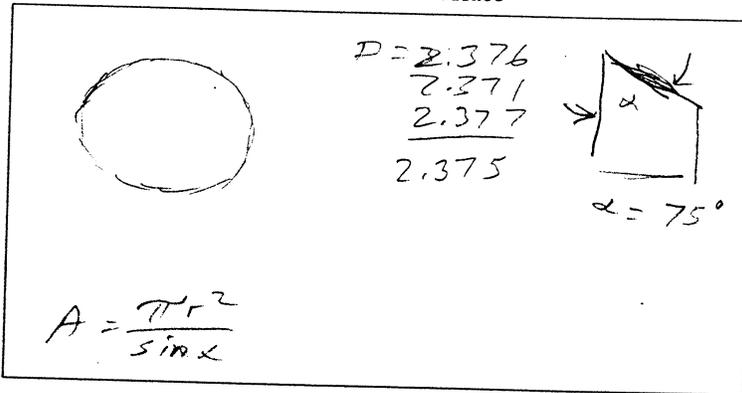
Sample ID: B98-23 S24a

Sample Description: Planar calcite coated joint in sandstone/siltstone

Sample Depth: 96.5'

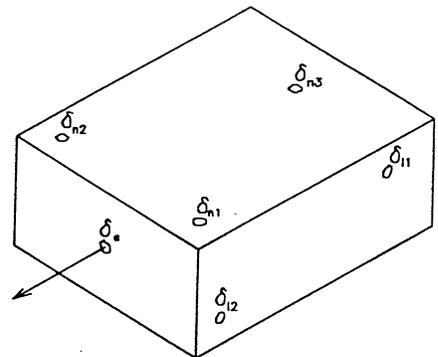
Sample Water Condition: received & tested moist

Sketch of Shear Surface



Sample area: 4.586 in<sup>2</sup>

Location of LVDTs on top shear box

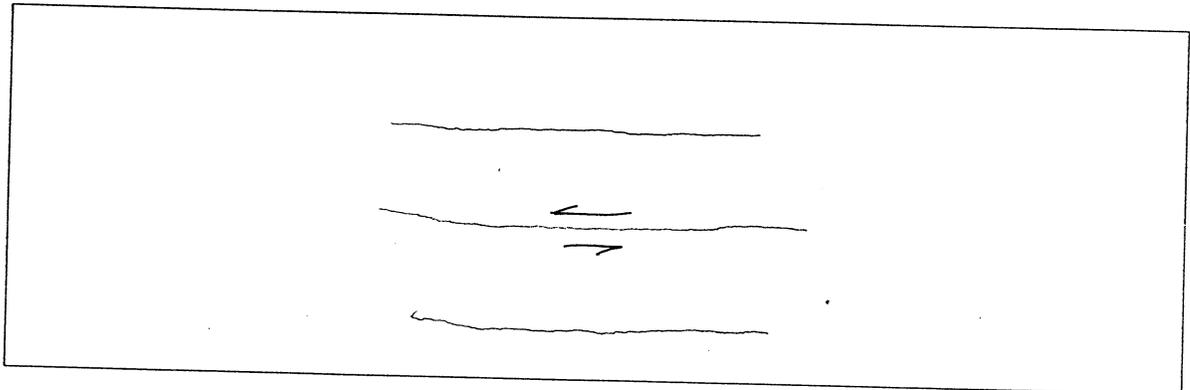


Estimated Top Box Weight: \_\_\_\_\_

Measured Top Box Weight: 15.3

$\sigma_n$	<u>25</u>	<u>75</u>	<u>150</u>	<u>psi</u>
$F_n$	<u>115</u>	<u>345</u>	<u>690</u>	<u>lb</u>
$F_n - W_b$	<u>100</u>	<u>330</u>	<u>675</u>	<u>lb</u>

Joint Profiles

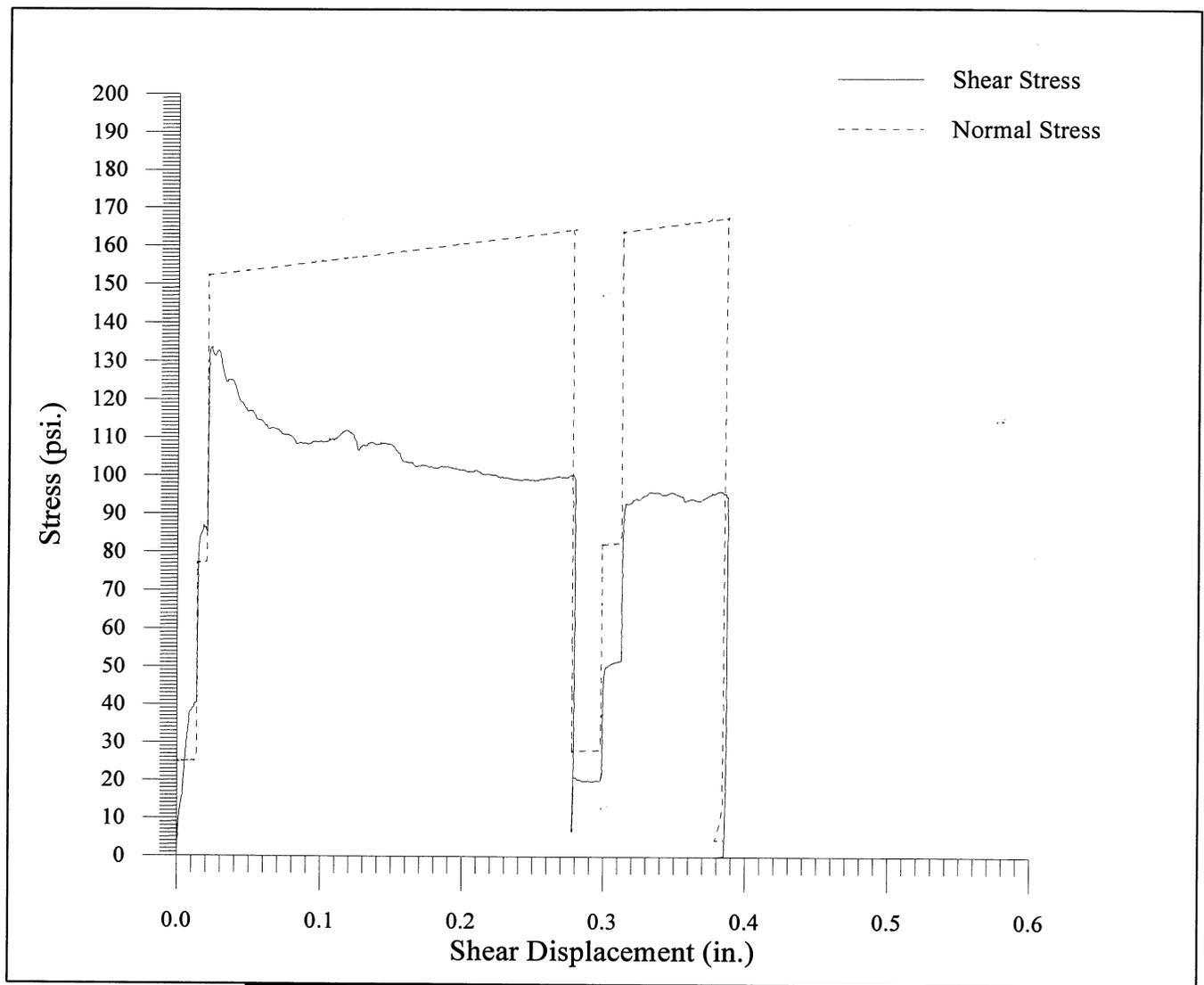


Summary of Test Results

Rate of Loading				
Shr. Displ. Rate				
Normal Stress				
Shear Strength				

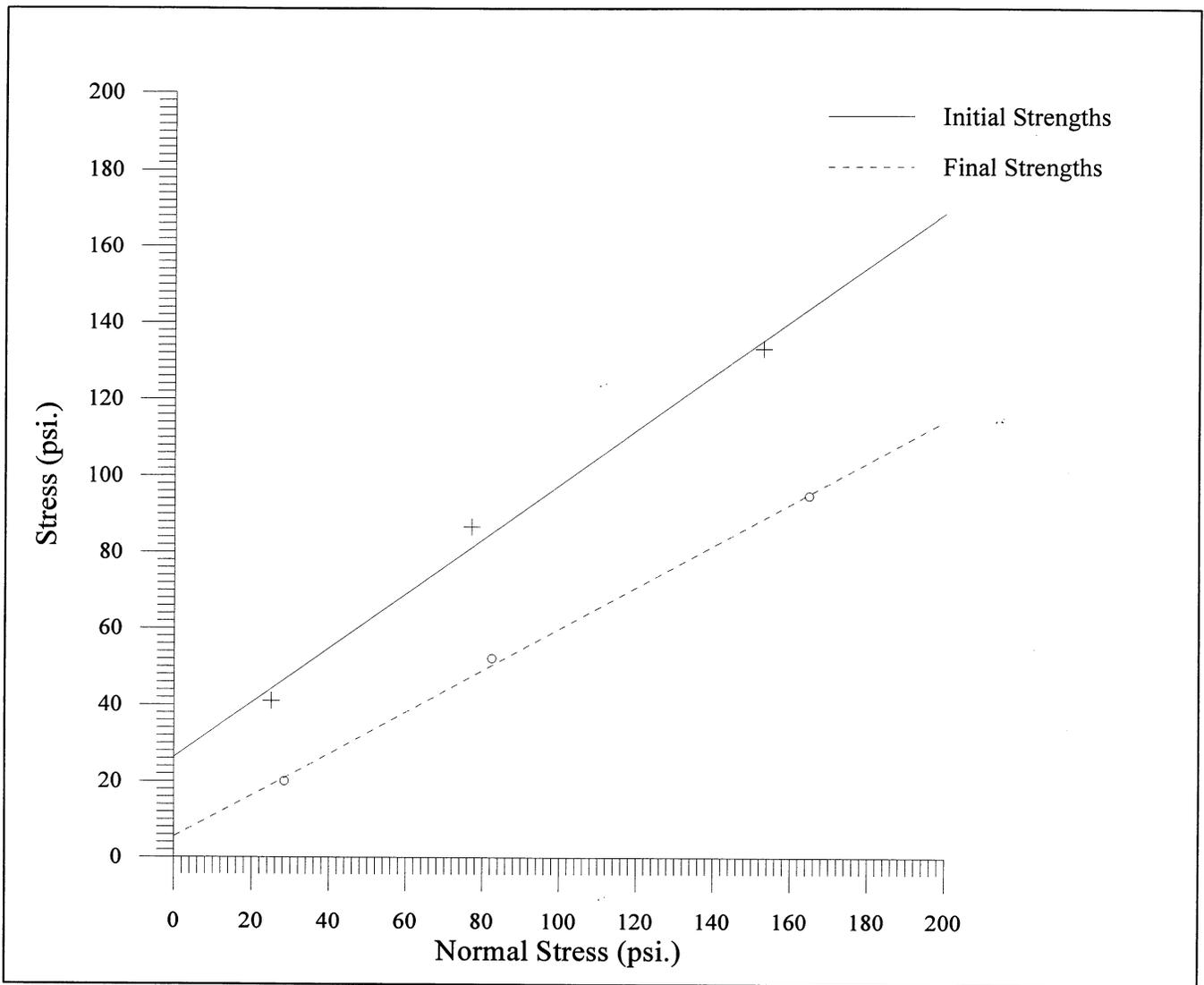
S<sub>j</sub>: \_\_\_\_\_

φ: \_\_\_\_\_



**DIRECT SHEAR TEST**  
**Shear and Normal Stress vs. Shear Displacement**

<p><b>SAMPLE ID:</b> Boring: 98-23          Sample: 24a          Depth: 96.5'</p> <p style="text-align: center;"><b>DESCRIPTION</b></p> <p>Planar calcite coated joint in dark gray claystone/siltstone.</p>	 <p>800 Peralta Ave          San Leandro, CA 94577</p>																	
<table border="1" style="width: 100%; border-collapse: collapse;"> <thead> <tr> <th></th> <th style="text-align: center;">Normal Stress</th> <th style="text-align: center;">Shear Strength</th> </tr> </thead> <tbody> <tr> <td rowspan="3" style="vertical-align: middle;">Initial</td> <td style="text-align: center;">25</td> <td style="text-align: center;">41</td> </tr> <tr> <td style="text-align: center;">77</td> <td style="text-align: center;">86.5</td> </tr> <tr> <td style="text-align: center;">153</td> <td style="text-align: center;">133</td> </tr> <tr> <td rowspan="3" style="vertical-align: middle;">Final</td> <td style="text-align: center;">28.5</td> <td style="text-align: center;">20</td> </tr> <tr> <td style="text-align: center;">82.5</td> <td style="text-align: center;">52</td> </tr> <tr> <td style="text-align: center;">165</td> <td style="text-align: center;">94.5</td> </tr> </tbody> </table>		Normal Stress	Shear Strength	Initial	25	41	77	86.5	153	133	Final	28.5	20	82.5	52	165	94.5	<p><b>Client:</b> Fugro West, Inc.          5855 Olivas Park Dr.          Ventura, CA 93003</p> <p><b>Project:</b> San Francisco Oakland Bay Bridge          East Span Replacement Project</p> <p><b>Job Number:</b> 98-42-0053</p>
	Normal Stress	Shear Strength																
Initial	25	41																
	77	86.5																
	153	133																
Final	28.5	20																
	82.5	52																
	165	94.5																
<p><b>Test Date:</b> October 30, 1998</p>																		



**DIRECT SHEAR TEST  
Failure Envelope**

<p><b>SAMPLE ID:</b> Boring: 98-23 Sample: 24a Depth: 96.5'</p> <p align="center"><b>DESCRIPTION</b></p> <p>Planar calcite coated joint in dark gray claystone/siltstone.</p> <table border="1"> <thead> <tr> <th></th> <th>Shear Intercept (psi)</th> <th>Friction Angle (degrees)</th> </tr> </thead> <tbody> <tr> <td>Initial</td> <td>26.4</td> <td>35.4</td> </tr> <tr> <td>Final</td> <td>5.5</td> <td>28.5</td> </tr> </tbody> </table>		Shear Intercept (psi)	Friction Angle (degrees)	Initial	26.4	35.4	Final	5.5	28.5	<p align="center"> <i>Geo</i>  <i>Test</i>  <b>Unlimited</b> 800 Peralta Ave  San Leandro, CA 94577 </p>
		Shear Intercept (psi)	Friction Angle (degrees)							
Initial	26.4	35.4								
Final	5.5	28.5								
<p><b>Client:</b> Fugro West, Inc. 5855 Olivas Park Dr. Ventura, CA 93003</p> <p><b>Project:</b> San Francisco Oakland Bay Bridge East Span Replacement Project</p> <p><b>Job Number:</b> 98-42-0053</p> <p><b>Test Date:</b> October 30, 1998</p>										

**DATA SHEET**  
**Direct Shear of Rock (ISRM)**

Date: 10/30/98

Person performing the test: A. Bro

Client: Fugro

Job: #92-SFOBB

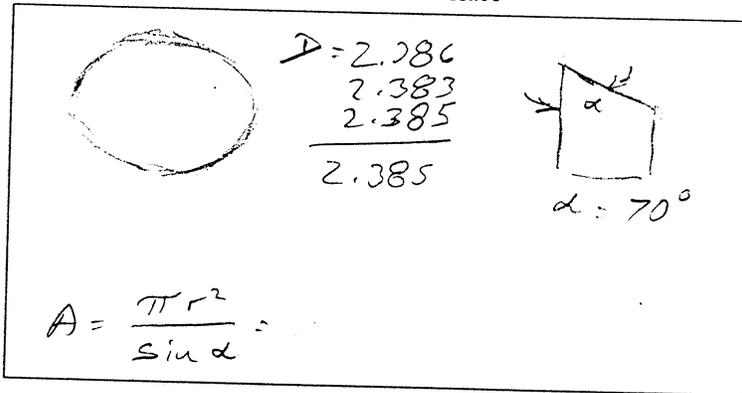
Sample ID: B78-23 SZ6a

Sample Description: Planar bedding joint (calcite coated) between dark gray claystone and siltstone. With a few pyrite crystals on the joint.

Sample Depth: 103.5'

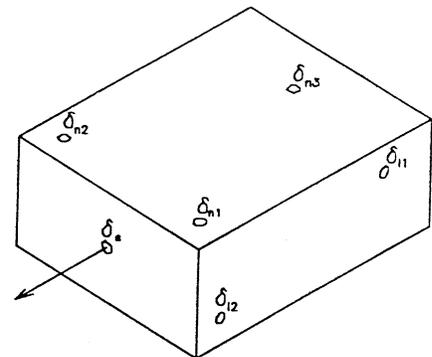
Sample Water Condition: received & tested moist

Sketch of Shear Surface



Sample area: 4.754 in<sup>2</sup>

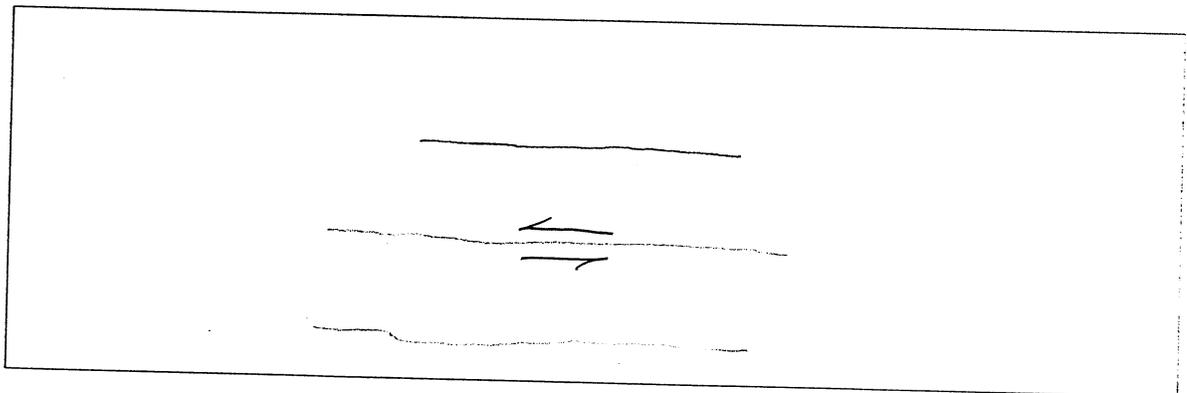
Location of LVDTs on top shear box



Estimated Top Box Weight: \_\_\_\_\_  
 Measured Top Box Weight: 15.6 lb

$\sigma_n$	<u>25</u>	<u>75</u>	<u>150 psi</u>
$F_n$	<u>119</u>	<u>357</u>	<u>714 lb</u>
$F_n - W_b$	<u>103</u>	<u>341</u>	<u>698 lb</u>

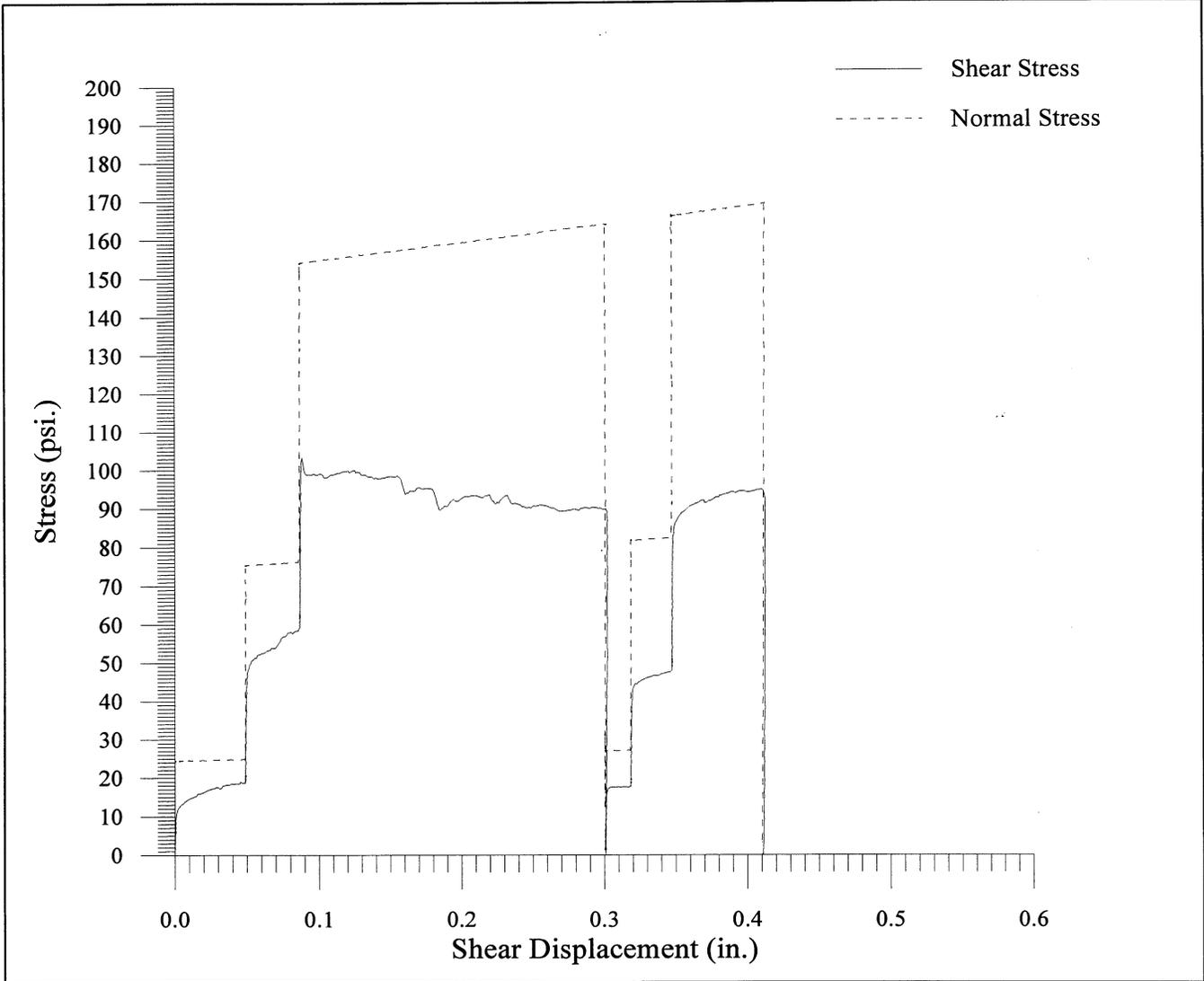
Joint Profiles



Summary of Test Results

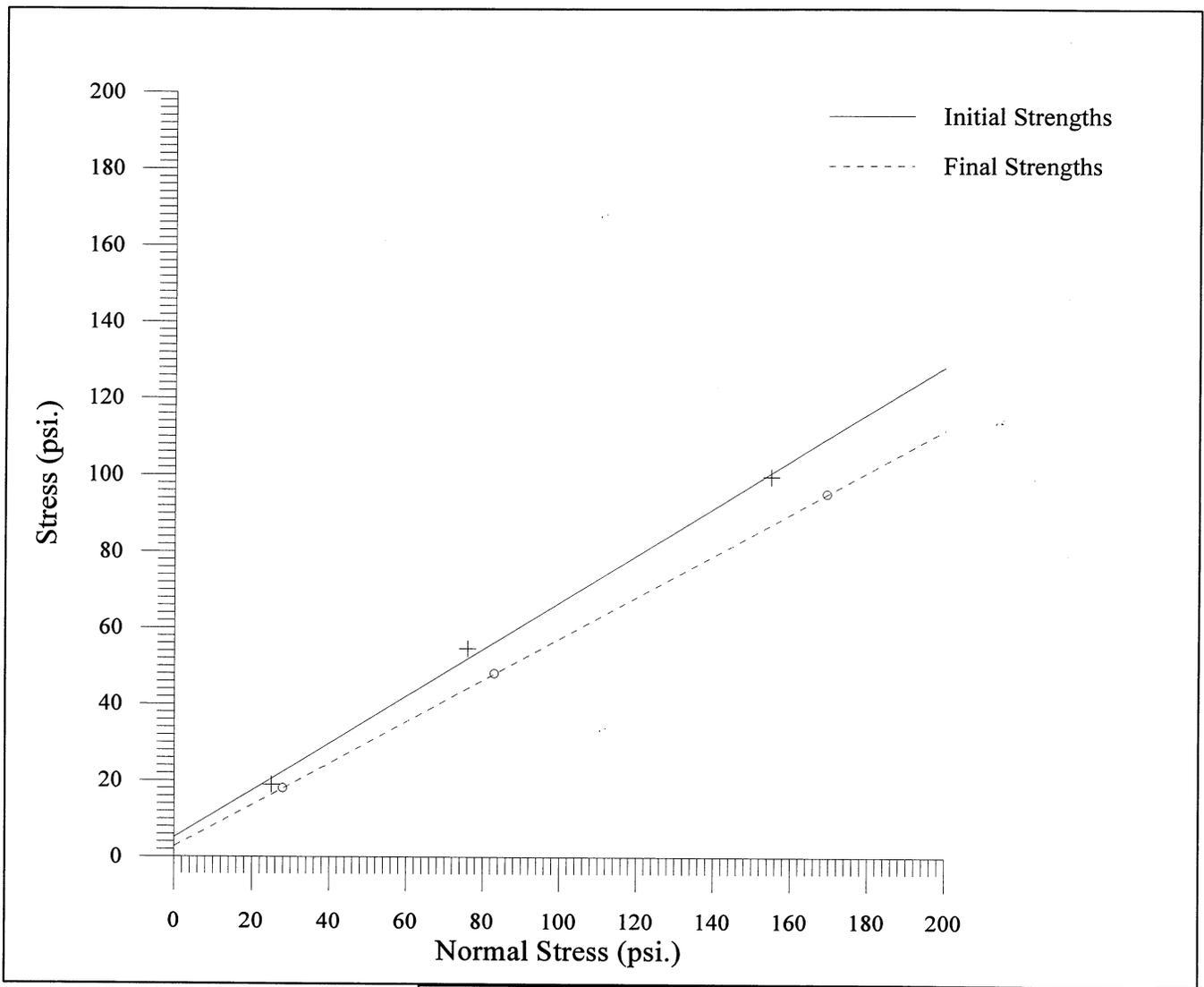
Rate of Loading				
Shr. Displ. Rate				
Normal Stress				
Shear Strength				

S<sub>j</sub>: \_\_\_\_\_  
 φ: \_\_\_\_\_



**DIRECT SHEAR TEST**  
**Shear and Normal Stress vs. Shear Displacement**

<p><b>SAMPLE ID:</b> Boring: 98-23          Sample: 26a          Depth: 103.5'</p> <p align="center"><b>DESCRIPTION</b></p> <p>Planar calcite coated bedding joint between dark gray claystone and siltstone. The joint contains a few pyrite crystals.</p> <table border="1"> <thead> <tr> <th></th> <th>Normal Stress</th> <th>Shear Strength</th> </tr> </thead> <tbody> <tr> <td rowspan="3">Initial</td> <td>25</td> <td>19</td> </tr> <tr> <td>76</td> <td>54.5</td> </tr> <tr> <td>155</td> <td>99.5</td> </tr> <tr> <td rowspan="3">Final</td> <td>28</td> <td>18</td> </tr> <tr> <td>83</td> <td>48</td> </tr> <tr> <td>169.5</td> <td>95</td> </tr> </tbody> </table>		Normal Stress	Shear Strength	Initial	25	19	76	54.5	155	99.5	Final	28	18	83	48	169.5	95	<p align="center">   <b>Geo Test Unlimited</b>          800 Peralta Ave          San Leandro, CA 94577       </p>
		Normal Stress	Shear Strength															
Initial	25	19																
	76	54.5																
	155	99.5																
Final	28	18																
	83	48																
	169.5	95																
<p><b>Client:</b> Fugro West, Inc.          5855 Olivas Park Dr.          Ventura, CA 93003</p> <p><b>Project:</b> San Francisco Oakland Bay Bridge          East Span Replacement Project</p> <p><b>Job Number:</b> 98-42-0053</p>	<p><b>Test Date:</b> October 30, 1998</p>																	



**DIRECT SHEAR TEST  
Failure Envelope**

**SAMPLE ID:** Boring: 98-23  
Sample: 26a  
Depth: 103.5'

**DESCRIPTION**

Planar calcite coated bedding joint between dark gray claystone and siltstone. The joint contains a few pyrite crystals.

	Shear Intercept (psi)	Friction Angle (degrees)
Initial	5.2	31.6
Final	2.8	28.6

  
**Geo Test Unlimited**  
 800 Peralta Ave  
 San Leandro, CA 94577

---

**Client:** Fugro West, Inc.  
5855 Olivas Park Dr.  
Ventura, CA 93003

**Project:** San Francisco Oakland Bay Bridge  
East Span Replacement Project

**Job Number:** 98-42-0053

---

**Test Date:** October 30, 1998

DATA SHEET  
Direct Shear of Rock (ISRM)

Date: 10/20/98

Person performing the test: A. Bro

Client: Fugro

Job: #92-SFO5B

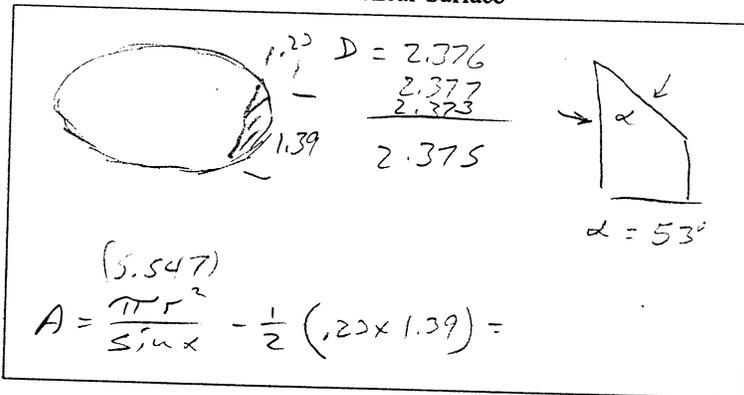
Sample ID: B78-23 S266

Sample Description: Undulating joint (calcite coated) in bank  
gray claystone.

Sample Depth: 104.5'

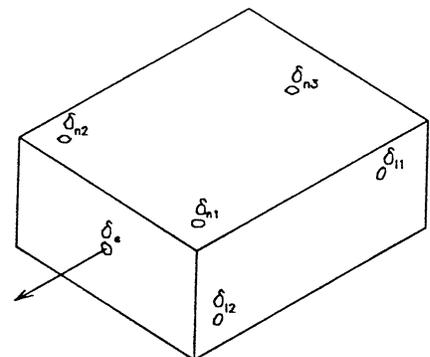
Sample Water Condition: received & tested moist

Sketch of Shear Surface



Sample area: 5.387

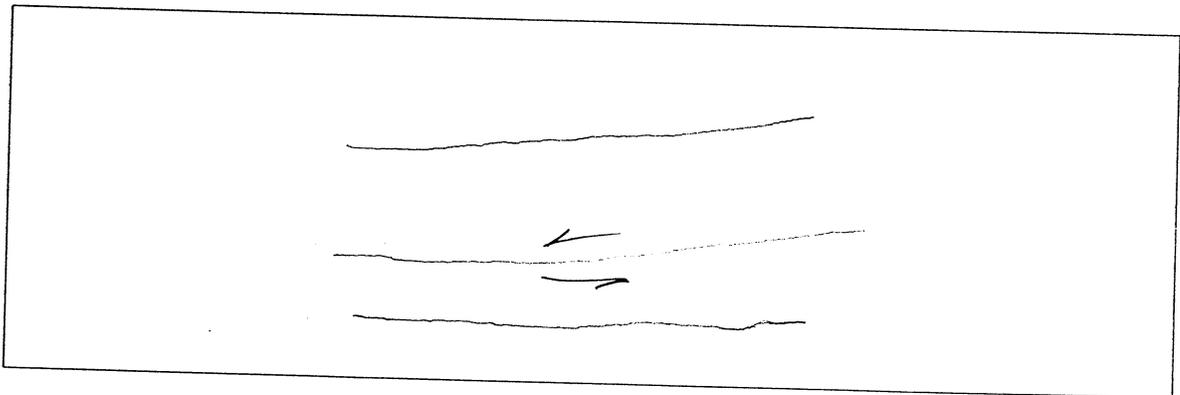
Location of LVDTs on top shear box



Estimated Top Box Weight: \_\_\_\_\_  
Measured Top Box Weight: 15.6

$\sigma_n$	<u>25</u>	<u>75</u>	<u>150</u>	<u>psi</u>
$F_n$	<u>135</u>	<u>405</u>	<u>810</u>	<u>lb</u>
$F_{n-wb}$	<u>119</u>	<u>389</u>	<u>794</u>	

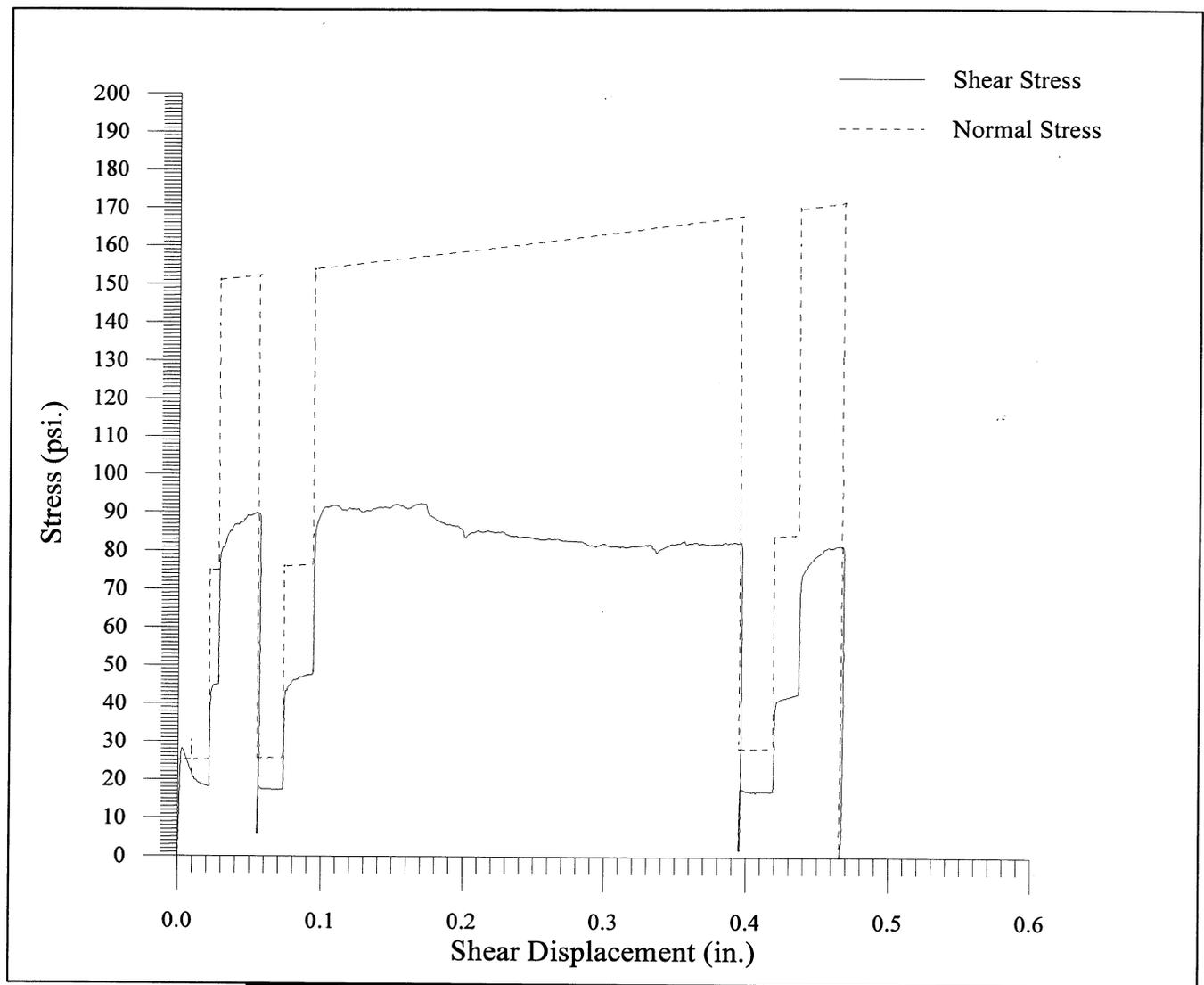
Joint Profiles



Summary of Test Results

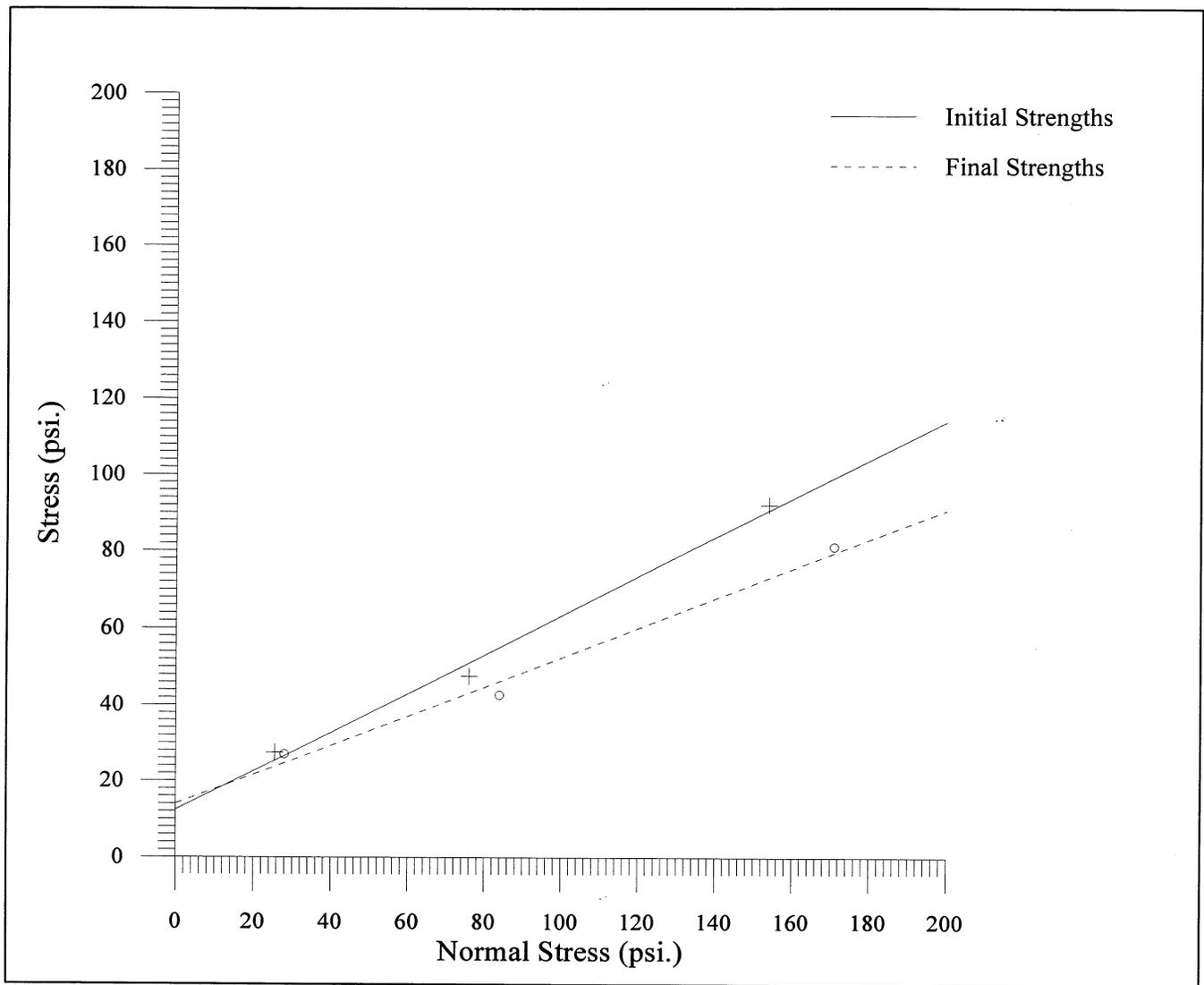
Rate of Loading				
Shr. Displ. Rate				
Normal Stress				
Shear Strength				

Sj: \_\_\_\_\_  
phi: \_\_\_\_\_



**DIRECT SHEAR TEST**  
**Shear and Normal Stress vs. Shear Displacement**

<p><b>SAMPLE ID:</b> Boring: 98-23  Sample: 26b  Depth: 104.5'</p> <p><b>DESCRIPTION</b>  Undulating calcite coated joint  in dark gray claystone.</p> <table border="1"> <thead> <tr> <th></th> <th>Normal Stress</th> <th>Shear Strength</th> </tr> </thead> <tbody> <tr> <td rowspan="3">Initial</td> <td>25.5</td> <td>27.5</td> </tr> <tr> <td>76</td> <td>47.5</td> </tr> <tr> <td>154</td> <td>92</td> </tr> <tr> <td rowspan="3">Final</td> <td>28</td> <td>27</td> </tr> <tr> <td>84</td> <td>42.5</td> </tr> <tr> <td>171</td> <td>81</td> </tr> </tbody> </table>		Normal Stress	Shear Strength	Initial	25.5	27.5	76	47.5	154	92	Final	28	27	84	42.5	171	81	<p align="center"> <b>Geo</b>  <b>U</b>  <b>Test</b>  <b>Unlimited</b> </p> <p align="right"> 800 Peralta Ave  San Leandro, CA 94577 </p>
		Normal Stress	Shear Strength															
Initial	25.5	27.5																
	76	47.5																
	154	92																
Final	28	27																
	84	42.5																
	171	81																
<p><b>Client:</b> Fugro West, Inc.  5855 Olivas Park Dr.  Ventura, CA 93003</p> <p><b>Project:</b> San Francisco Oakland Bay Bridge  East Span Replacement Project</p> <p><b>Job Number:</b> 98-42-0053</p>	<p><b>Test Date:</b> October 30, 1998</p>																	



**DIRECT SHEAR TEST  
Failure Envelope**

<p><b>SAMPLE ID:</b> Boring: 98-23 Sample: 26b Depth: 104.5'</p> <p style="text-align: center;"><b>DESCRIPTION</b></p> <p style="text-align: center;">Undulating calcite coated joint in dark gray claystone.</p> <table style="width: 100%; margin-top: 10px;"> <thead> <tr> <th></th> <th style="text-align: center;">Shear Intercept (psi)</th> <th style="text-align: center;">Friction Angle (degrees)</th> </tr> </thead> <tbody> <tr> <td style="text-align: left;">Initial</td> <td style="text-align: center;">12.4</td> <td style="text-align: center;">26.9</td> </tr> <tr> <td style="text-align: left;">Final</td> <td style="text-align: center;">14.0</td> <td style="text-align: center;">21.0</td> </tr> </tbody> </table>		Shear Intercept (psi)	Friction Angle (degrees)	Initial	12.4	26.9	Final	14.0	21.0	<div style="text-align: center;">  <p><b>Geo Test Unlimited</b></p> </div> <p style="text-align: right;">800 Peralta Ave San Leandro, CA 94577</p> <hr/> <p><b>Client:</b> Fugro West, Inc. 5855 Olivas Park Dr. Ventura, CA 93003</p> <p><b>Project:</b> San Francisco Oakland Bay Bridge East Span Replacement Project</p> <p><b>Job Number:</b> 98-42-0053</p> <hr/> <p><b>Test Date:</b> October 30, 1998</p>
	Shear Intercept (psi)	Friction Angle (degrees)								
Initial	12.4	26.9								
Final	14.0	21.0								

DATA SHEET  
Direct Shear of Rock (ISRM)

Date: 10/30/98

Person performing the test: A Bro

Client: Fugro

Job: #92-SFOBB

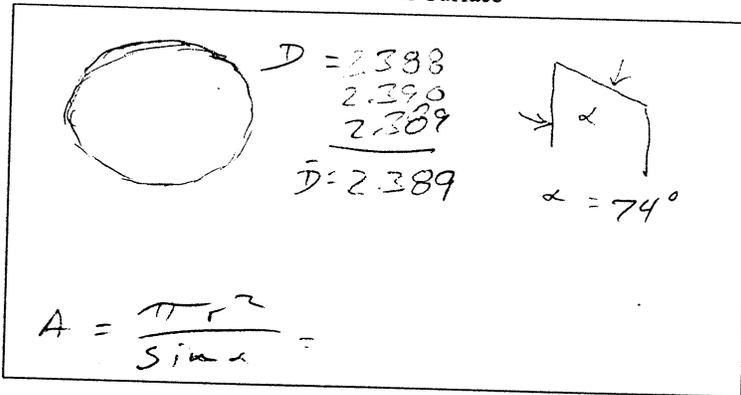
Sample ID: B98-23 S30a

Sample Description: Slightly wavy joint in darkish gray fine sandy siltstone

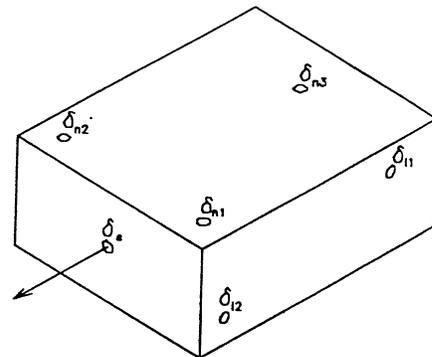
Sample Depth: 128'

Sample Water Condition: received & tested moist

Sketch of Shear Surface



Location of LVDTs on top shear box



Sample area: 4.663

Estimated Top Box Weight: \_\_\_\_\_

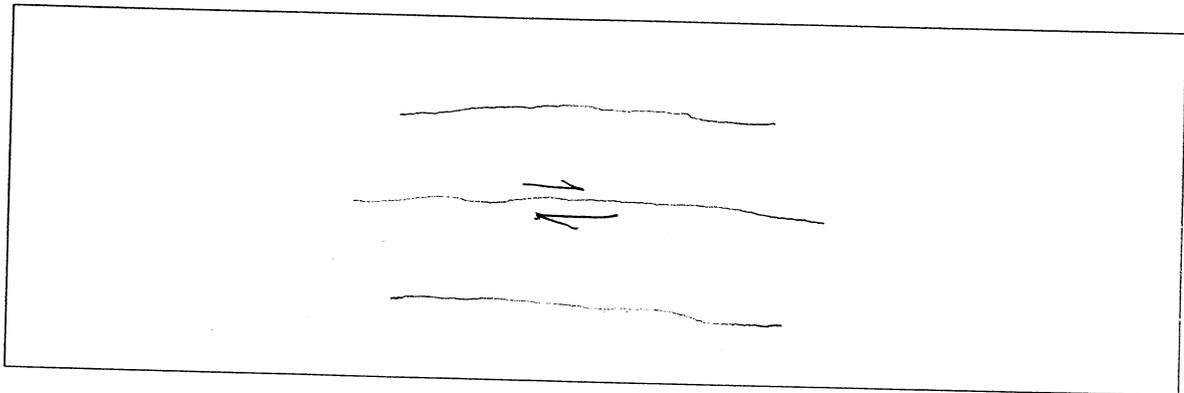
Measured Top Box Weight: 15.6

$\delta_s \approx .36''$  reset  $\delta_{n1}$

Difficult to establish a good set of "initial" stresses.  $\phi$  is probably higher than shown.

$\sigma_n$	<u>25</u>	<u>75</u>	<u>150</u>	psi
$F_n$	<u>117</u>	<u>351</u>	<u>702</u>	lb
$F_{n-wb}$	<u>101</u>	<u>335</u>	<u>686</u>	

Joint Profiles

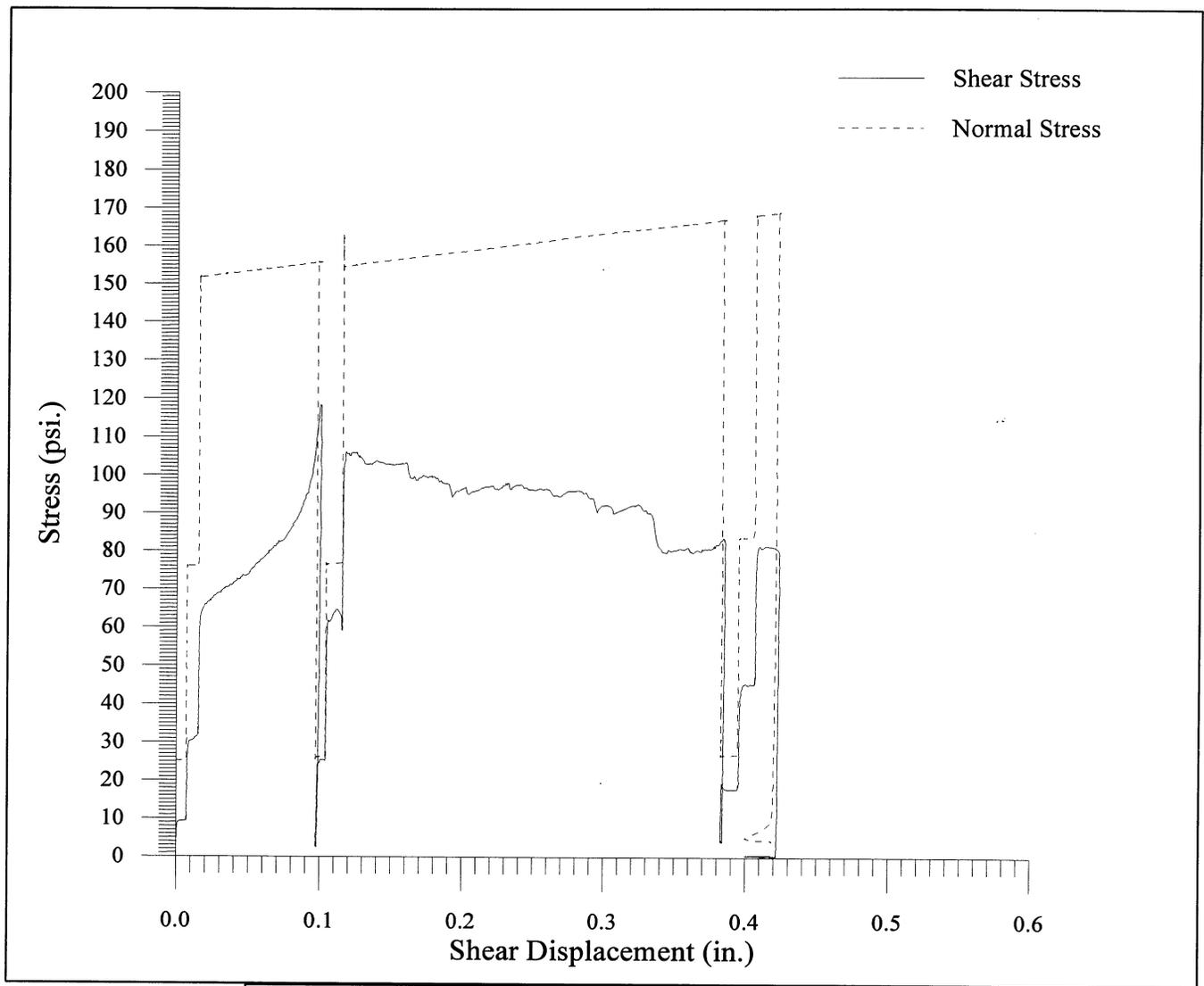


Summary of Test Results

Rate of Loading				
Shr. Displ. Rate				
Normal Stress				
Shear Strength				

Sj: \_\_\_\_\_

$\phi$ : \_\_\_\_\_



**DIRECT SHEAR TEST**  
**Shear and Normal Stress vs. Shear Displacement**

**SAMPLE ID:** Boring: 98-23  
 Sample: 30a  
 Depth: 128'

**DESCRIPTION**

Slightly wavy joint in medium dark gray fine sandy siltstone.

	Normal Stress	Shear Strength
Initial	26	25
	76.5	64.5
	155.5	104.5
Final	27	18
	84	45.5
	169	81

*Geo* **GTU** *Test*

**Unlimited**

800 Peralta Ave  
 San Leandro, CA 94577

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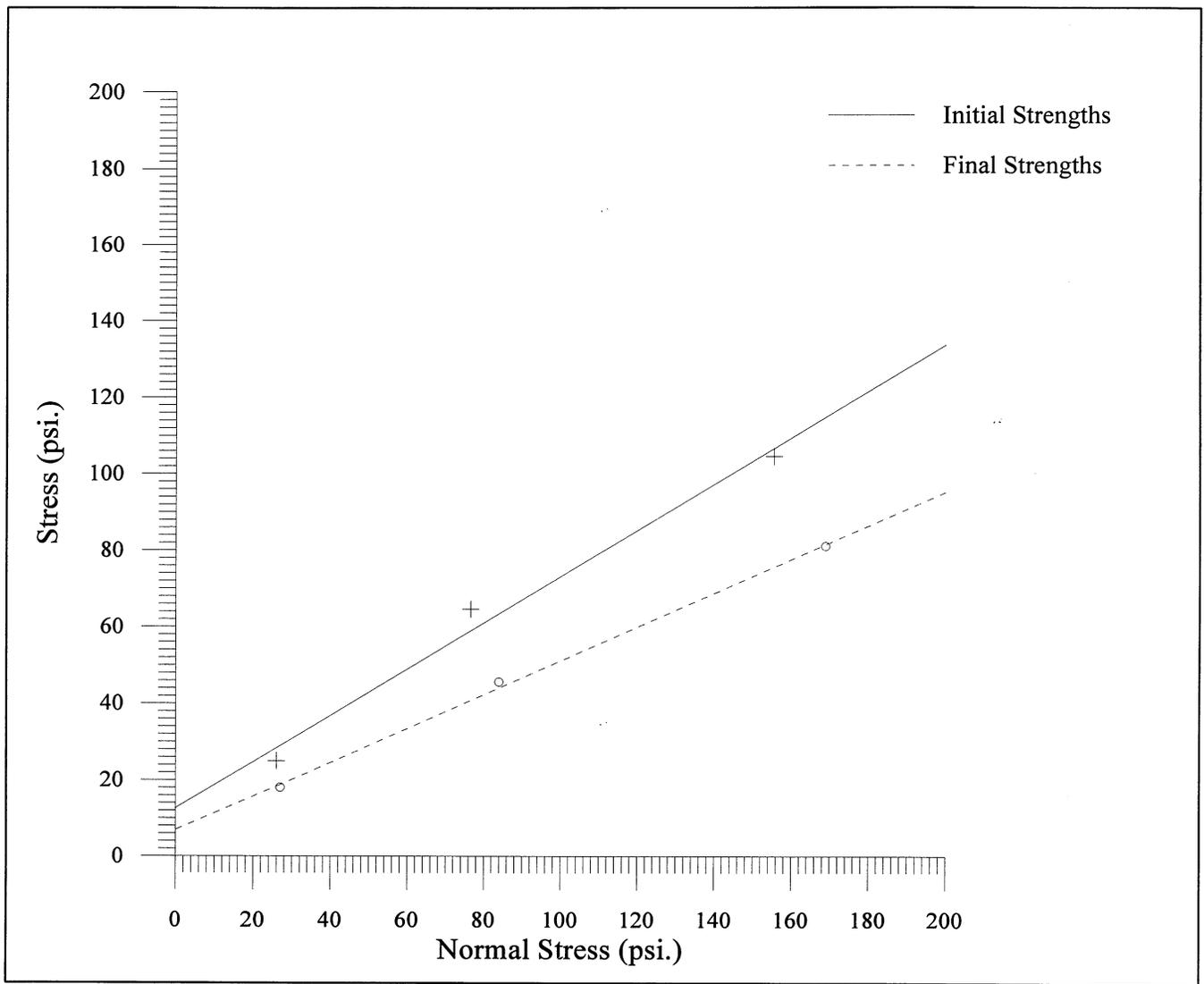
**Client:** Fugro West, Inc.  
 5855 Olivas Park Dr.  
 Ventura, CA 93003

**Project:** San Francisco Oakland Bay Bridge  
 East Span Replacement Project

**Job Number:** 98-42-0053

---

**Test Date:** October 30, 1998



**DIRECT SHEAR TEST  
Failure Envelope**

<p><b>SAMPLE ID:</b> Boring: 98-23 Sample: 30a Depth: 128'</p> <p align="center"><b>DESCRIPTION</b></p> <p>Slightly wavy joint in medium dark gray fine sandy siltstone.</p>		<p>800 Peralta Ave San Leandro, CA 94577</p>								
	<table border="1"> <thead> <tr> <th></th> <th>Shear Intercept (psi)</th> <th>Friction Angle (degrees)</th> </tr> </thead> <tbody> <tr> <td>Initial</td> <td>12.7</td> <td>31.1</td> </tr> <tr> <td>Final</td> <td>6.9</td> <td>23.8</td> </tr> </tbody> </table>		Shear Intercept (psi)	Friction Angle (degrees)	Initial	12.7	31.1	Final	6.9	23.8
	Shear Intercept (psi)	Friction Angle (degrees)								
Initial	12.7	31.1								
Final	6.9	23.8								
		<p><b>Test Date:</b> October 30, 1998</p>								

# Photographs





SFOBB - East Span Replacement Project  
Fugro - Earth Mechanics  
Unconfined Compression Test Sample  
Boring: 98-23 Depth: 34' Sample: 11a



SFOBB - East Span Replacement Project  
Fugro - Earth Mechanics  
Unconfined Compression Test Sample  
Boring: 98-23 Depth: 34' Sample: 11a



SFOBB - East Span Replacement Project  
Fugro - Earth Mechanics  
Unconfined Compression Test Sample  
Boring: 98-23 Depth: 46.5' Sample: 14a



SFOBB - East Span Replacement Project  
Fugro - Earth Mechanics  
Unconfined Compression Test Sample  
Boring: 98-23 Depth: 46.5' Sample: 14a



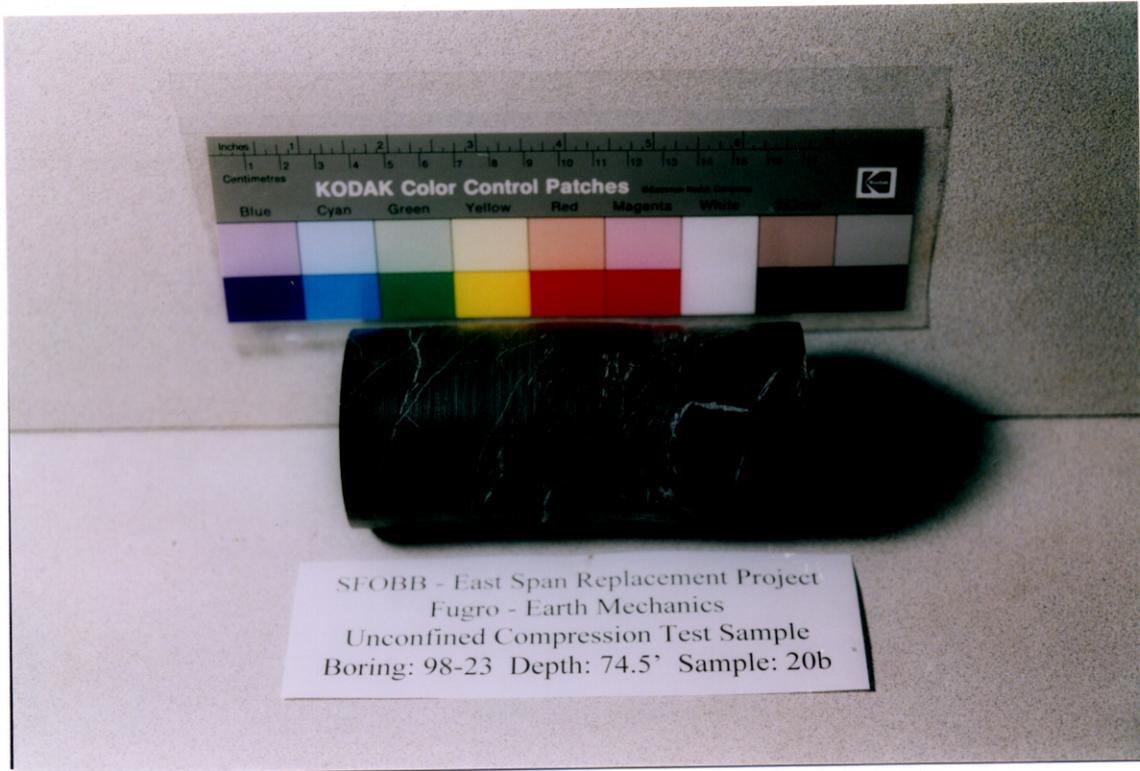


SFOBB - East Span Replacement Project  
Fugro - Earth Mechanics  
Unconfined Compression Test Sample  
Boring: 98-23 Depth: 63' Sample: 18a

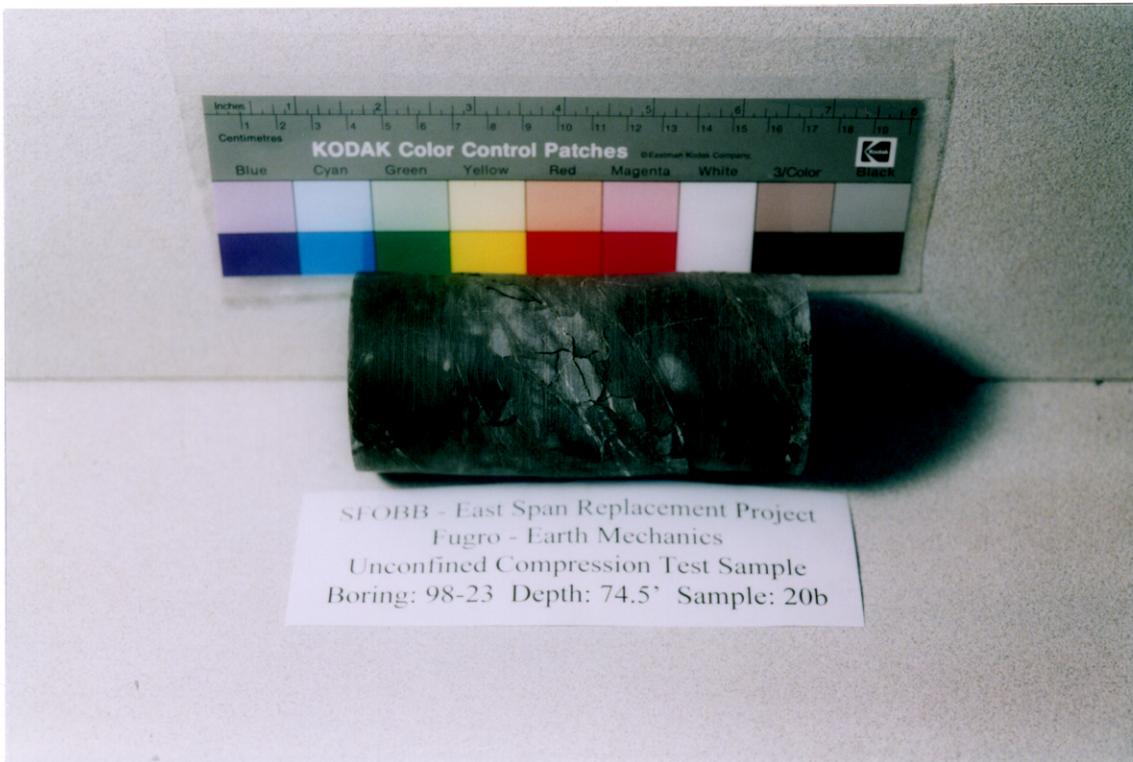


SFOBB - East Span Replacement Project  
Fugro - Earth Mechanics  
Unconfined Compression Test Sample  
Boring: 98-23 Depth: 63' Sample: 18a



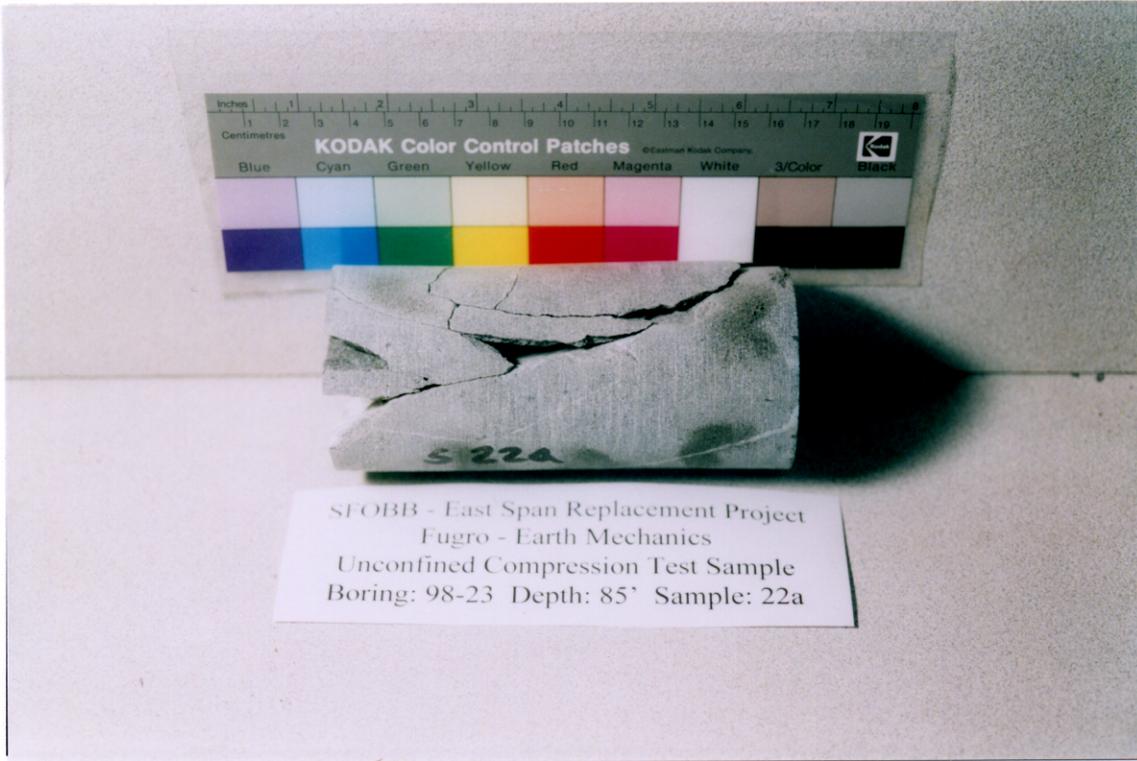


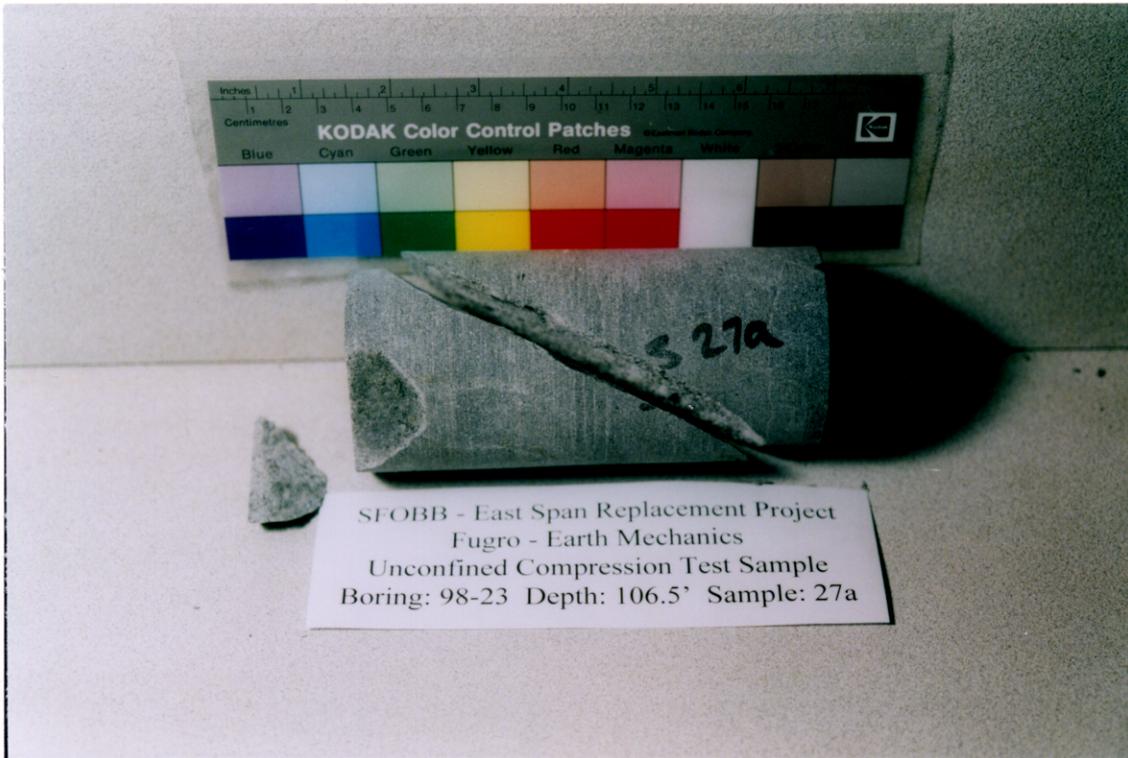
SFOBB - East Span Replacement Project  
Fugro - Earth Mechanics  
Unconfined Compression Test Sample  
Boring: 98-23 Depth: 74.5' Sample: 20b



SFOBB - East Span Replacement Project  
Fugro - Earth Mechanics  
Unconfined Compression Test Sample  
Boring: 98-23 Depth: 74.5' Sample: 20b









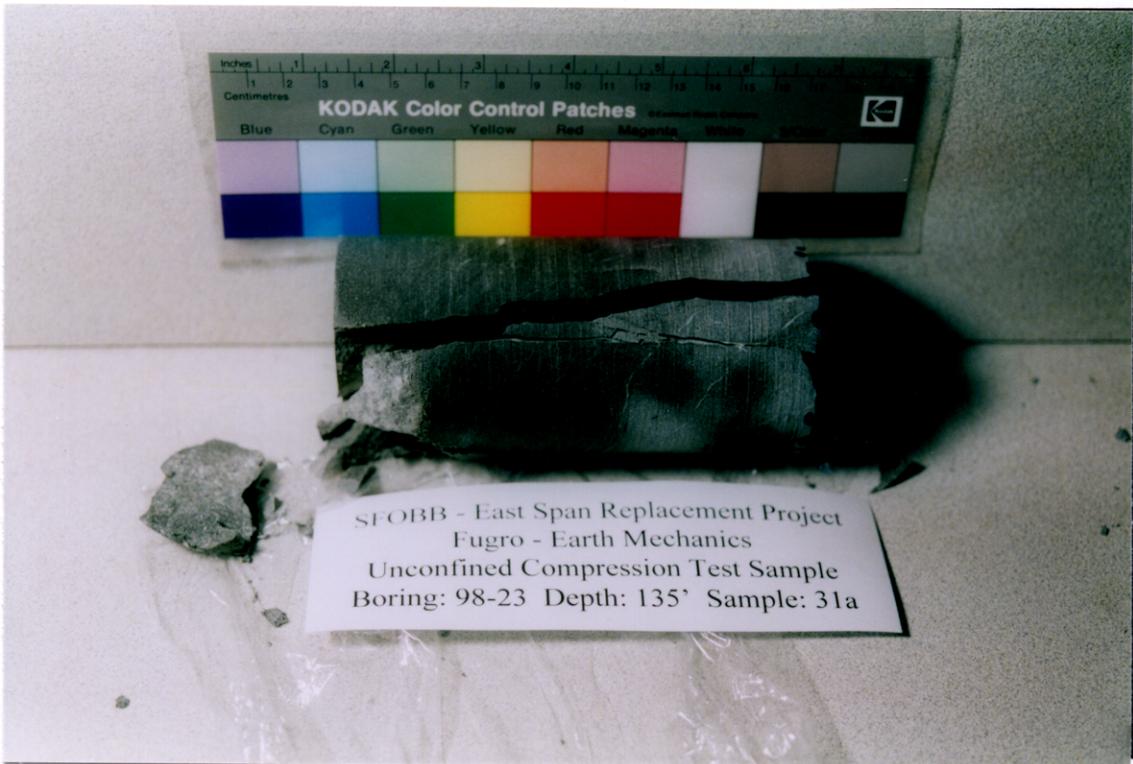




SFOBB - East Span Replacement Project  
Fugro - Earth Mechanics  
Unconfined Compression Test Sample  
Boring: 98-23 Depth: 128.5' Sample: 30b



SFOBB - East Span Replacement Project  
Fugro - Earth Mechanics  
Unconfined Compression Test Sample  
Boring: 98-23 Depth: 128.5' Sample: 30b

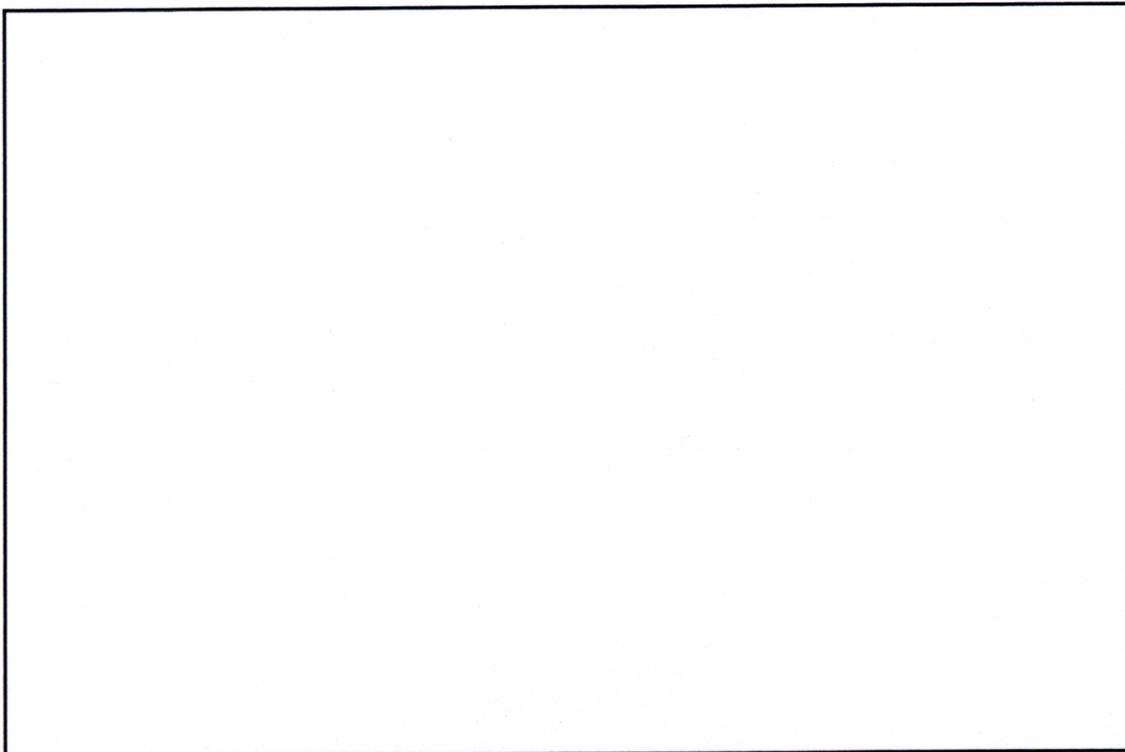












**BORING 98-24**

## **Modulus and Unconfined Compression Tests**

**DATA SHEET**

**Determination of Rock Modulus and Poisson's Ratio (ASTM D3148)**

Date: 10/14/98

Person performing the test: ABW

Client: Fugro

Job: #92-SFOBB

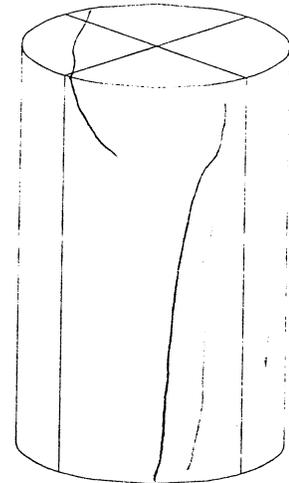
Sample ID: B:98-24 S12a

Sample Description: Medium gray sandstone with a small amount of calcite veiled axial fractures

Sample Depth: 11.7m (38.5') Sample Condition: received & tested moist

d <sub>1</sub>	d <sub>2</sub>
2.395	2.390
2.392	2.391
2.388	2.394
2.391	2.394
2.395	2.394

l <sub>1</sub>	l <sub>2</sub>
-0.0008	-0.0001
±0.0001	±0.0001
±0.0009	±0.0001



Avg. diameter: 2.392

Avg. length: 5.236

Sample area: 4.494

l/d ratio: 2.19

Sample volume(in<sup>3</sup>): 23.529

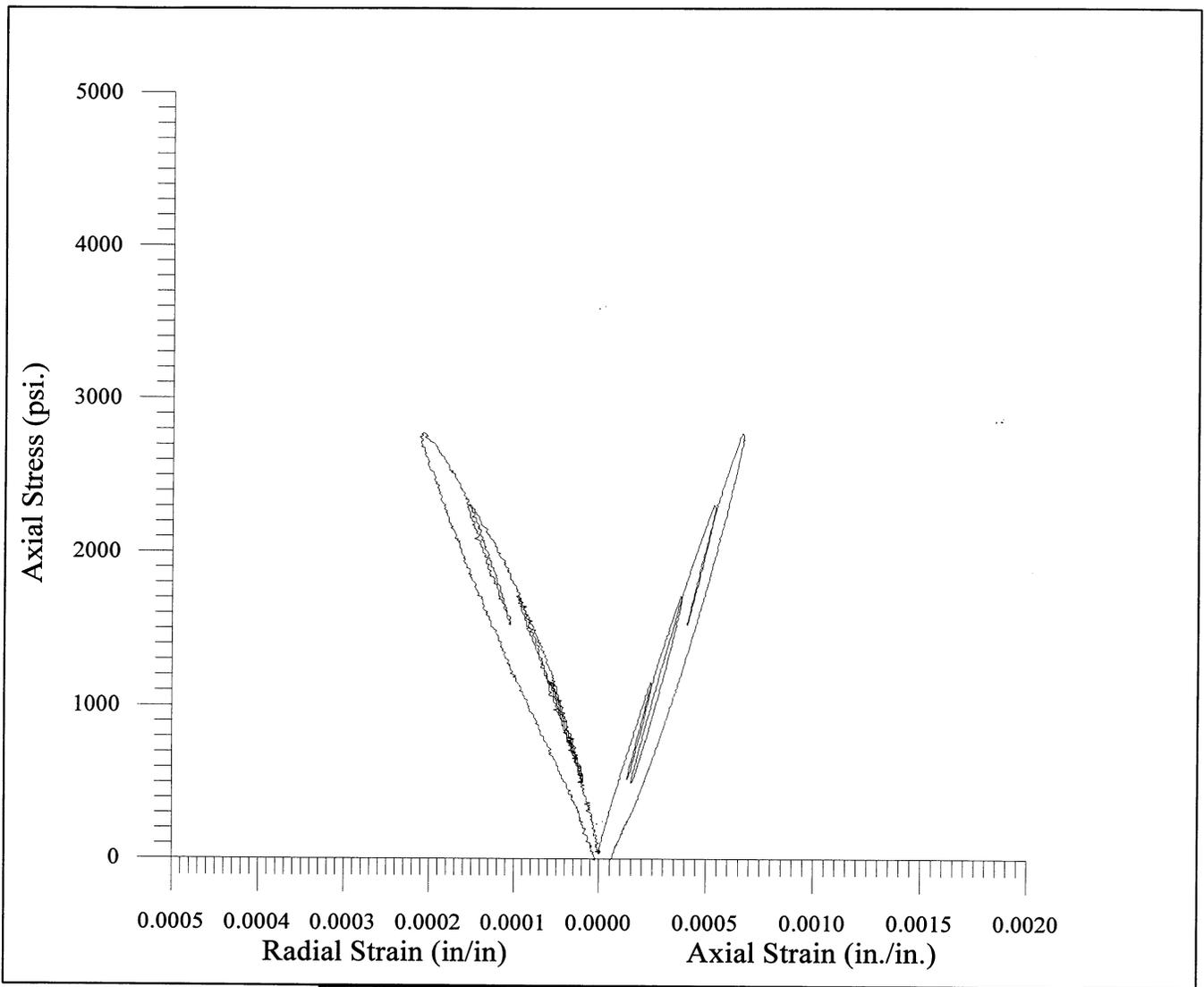
Sample weight (g): 1037.5g

Density: 44.09 g/in<sup>3</sup> = 168.0 pcf (1 g/in<sup>3</sup> = 3.8095 lb/ft<sup>3</sup>)

Gauge length: 2000

*in Sect*

Comments: Failed by shear and mainly axial splitting along existing joints.



**ELASTIC MODULUS TEST**  
**Axial Stress vs. Axial & Radial Strain**

**SAMPLE ID:** Boring: 98-24  
 Sample: 12a  
 Depth: 38.5'

**DESCRIPTION**  
 Medium gray sandstone with a small swarm of calcite healed axial fractures.

**MODULUS:** 5,550,000 psi  
**POISSON'S RATIO:** .31

*Geo*  *U*  
*Test*  
**Unlimited**

800 Peralta Ave  
 San Leandro, CA 94577

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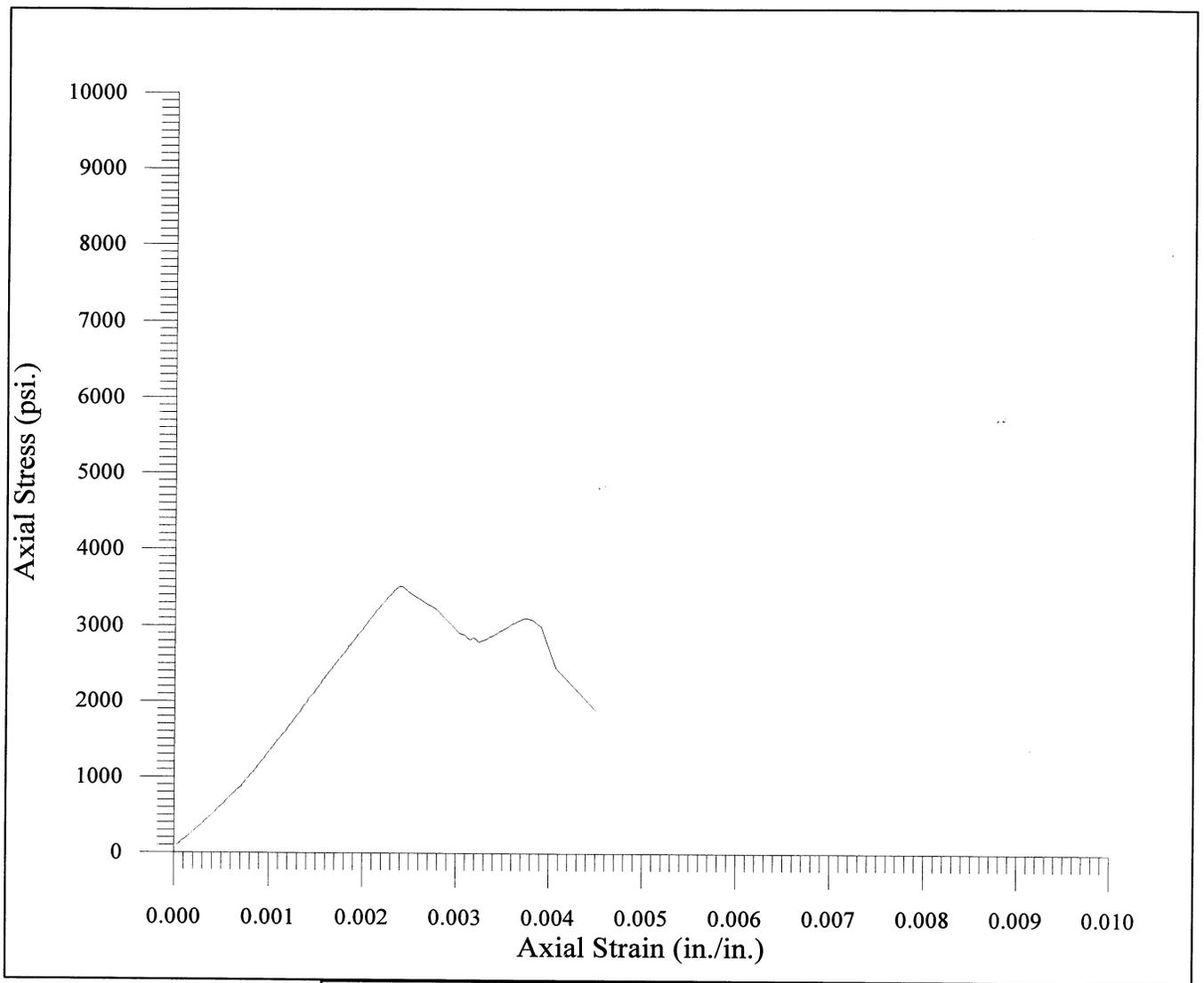
**Client:** Fugro West, Inc.  
 5855 Olivas Park Dr.  
 Ventura, CA 93003

**Project:** San Francisco Oakland Bay Bridge  
 East Span Replacement Project

**Job Number:** 98-42-0053

---

**Test Date:** October 14, 1998



**UNCONFINED COMPRESSION TEST**  
**Axial Stress vs. Axial Strain**

<p><b>SAMPLE ID:</b> Boring : 98-24  Sample: 12a  Depth: 38.5'</p> <p align="center"><b>DESCRIPTION</b></p> <p>Medium gray sandstone with a small swarm of calcite healed axial fractures.</p> <p><b>STRENGTH:</b> 3521 psi</p>	<p><i>Geo</i>  <i>U</i></p> <p><i>Test</i></p> <p><b>Unlimited</b> 800 Peralta Ave  San Leandro, CA 94577</p>
	<p><b>Client:</b> Fugro West, Inc.  5855 Olivas Park Dr.  Ventura, CA 93003</p>
	<p><b>Project:</b> San Francisco Oakland Bay Bridge  East Span Replacement Project</p>
	<p><b>Job Number:</b> 98-42-0053</p>
	<p><b>Test Date:</b> October 14, 1998</p>

**DATA SHEET**

**Determination of Rock Modulus and Poisson's Ratio (ASTM D3148)**

Date: 10/14/98

Person performing the test: A. B. ID

Client: Fugro

Job: #92-SFORB

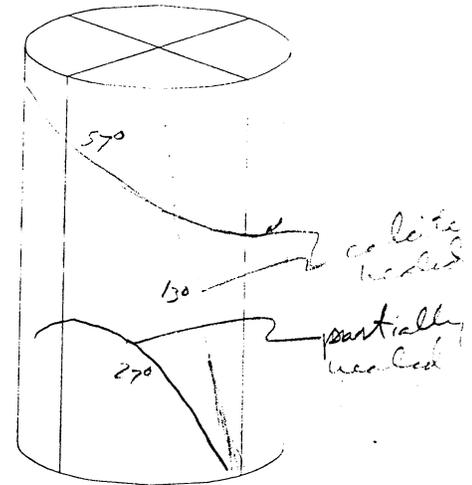
Sample ID: B198-24 S:13a

Sample Description: Medium gray sandstone, with partially healed calcite healed fractures 27, 13°, & 57° to core axis

Sample Depth: 13.7m (45') Sample Condition: received & tested moist

d <sub>1</sub>	d <sub>2</sub>
2.375	2.385
2.384	2.386
2.377	2.382
2.386	2.381
2.376	2.392

l <sub>1</sub>	l <sub>2</sub>
- .0008	- 0 -
± .0001	± .0001
+ .0008	- 0 -



Avg. diameter: 2.382

Avg. length: 5.314

Sample area: 4.456

l/d ratio: 2.23

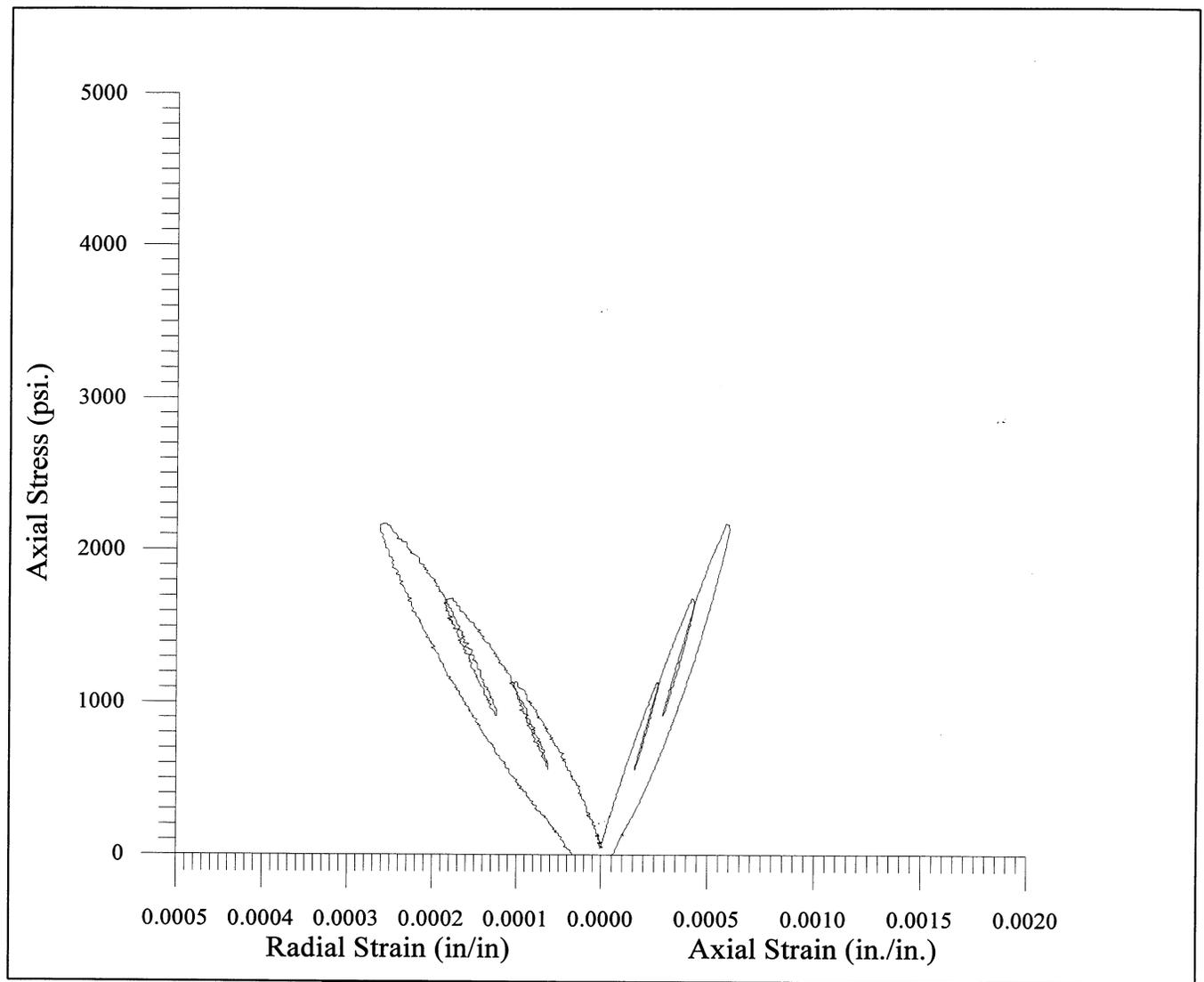
Sample volume(in<sup>3</sup>): 23.681

Sample weight (g): 1042.7g

Density: 44.038/in<sup>3</sup> = 167.7pcf (1 g/in<sup>3</sup> = 3.8095lb/ft<sup>3</sup>)

Gauge length: 2.000 in

Comments: Failed by splitting on steeply inclined joint -



**ELASTIC MODULUS TEST**  
**Axial Stress vs. Axial & Radial Strain**

**SAMPLE ID:** Boring: 98-24  
 Sample: 13a  
 Depth: 45'

**DESCRIPTION**

Medium gray sandstone with partially healed and calcite healed fractures, 13, 27, and 57 degrees to the core axis.

**MODULUS:** 5,000,000 psi  
**POISSON'S RATIO:** .37

*Geo*  *Test*  
**Unlimited** 800 Peralta Ave  
 San Leandro, CA 94577

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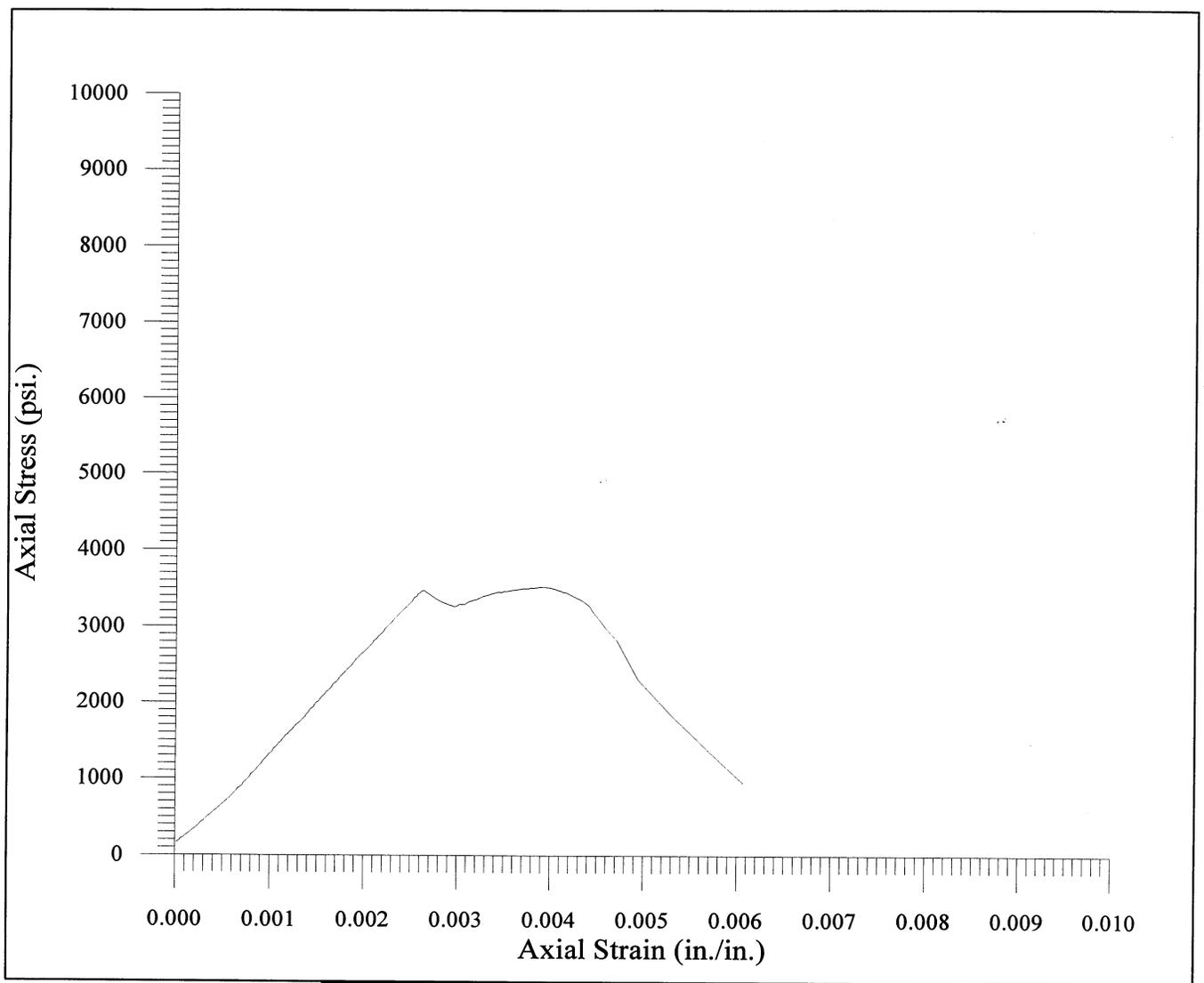
**Client:** Fugro West, Inc.  
 5855 Olivas Park Dr.  
 Ventura, CA 93003

**Project:** San Francisco Oakland Bay Bridge  
 East Span Replacement Project

**Job Number:** 98-42-0053

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**Test Date:** October 14, 1998



**UNCONFINED COMPRESSION TEST**  
**Axial Stress vs. Axial Strain**

**SAMPLE ID:** Boring : 98-24  
 Sample: 13a  
 Depth: 45'

**DESCRIPTION**

Medium gray sandstone with partially healed and calcite healed fractures, 13, 27, and 57 degrees to the core axis.

**STRENGTH:** 3519 psi

  
**Geo Test Unlimited**

800 Peralta Ave  
 San Leandro, CA 94577

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**Client:** Fugro West, Inc.  
 5855 Olivas Park Dr.  
 Ventura, CA 93003

**Project:** San Francisco Oakland Bay Bridge  
 East Span Replacement Project

**Job Number:** 98-42-0053

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**Test Date:** October 14, 1998

**DATA SHEET**

**Determination of Rock Modulus and Poisson's Ratio (ASTM D3148)**

Date: 10/14/98

Person performing the test: A. Bro

Client: Fugro

Job: #92-SFOBB

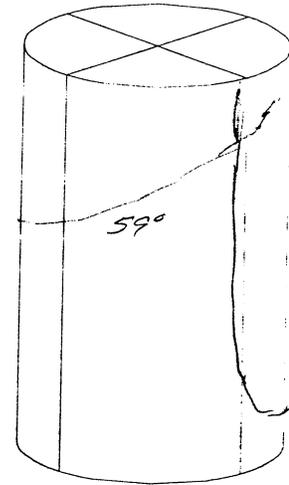
Sample ID: B:98-24 S:14a

Sample Description: Dark gray siltstone with many hairline fractures and two calcite healed fractures 59° and 0° to core axis.

Sample Depth: 15.9 m (52') Sample Condition: received & tested moist

d <sub>1</sub>	d <sub>2</sub>
2.378	2.379
2.381	2.373
2.362	2.385
2.386	2.384
2.377	2.384

l <sub>1</sub>	l <sub>2</sub>
-0.0008	-0.0006
±0.0001	±0.0001
+0.0009	+0.0006



Avg. diameter: 2.379

Avg. length: 4.872

Sample area: 4.445

l/d ratio: 2.05

Sample volume (in<sup>3</sup>): 21.656

Sample weight (g): 941.9 g\*

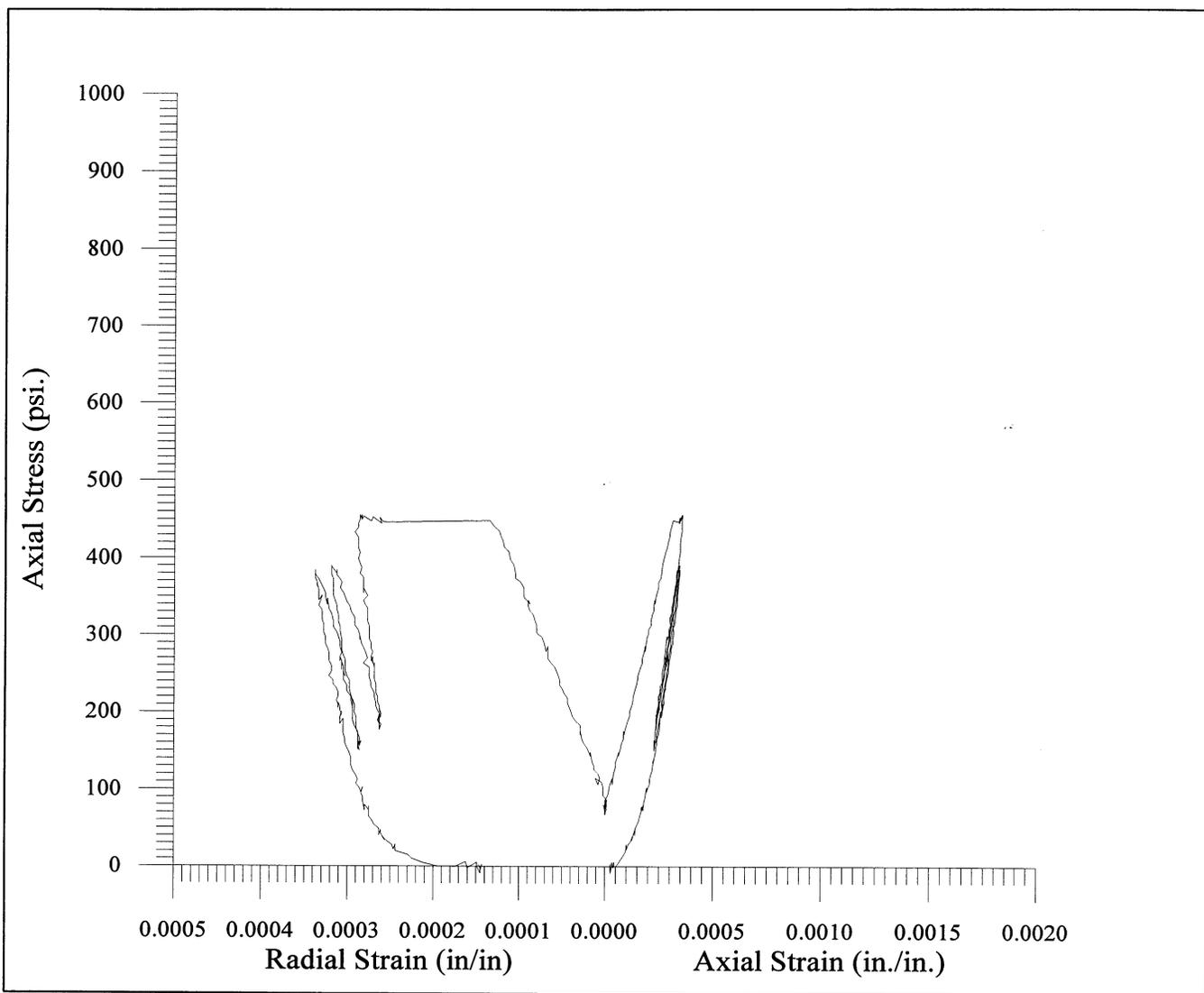
Density: 43.49 g/in<sup>3</sup> = 165.7 pcf (1 g/in<sup>3</sup> = 3.8095 lb/ft<sup>3</sup>)

Gauge length: 2.000 in

Comments: \*End needed to be capped w/ hydrostone  
This is NOT ASTM!

In modulus test, 1 axial & 1 radial gauge registered failure at low axial loads. Nice demonstration of behavior non-homogeneity.

Failed along existing joints, generally splitting w/a little shear on suitably oriented joints.



**ELASTIC MODULUS TEST**  
**Axial Stress vs. Axial & Radial Strain**

**SAMPLE ID:** Boring: 98-24  
 Sample: 14a  
 Depth: 52'

**DESCRIPTION**  
 Dark gray siltstone and claystone with many hairline fractures and two calcite healed fractures 0 and 59 degrees to the core axis.

**MODULUS:** 2,080,000 psi  
**POISSON'S RATIO:** .31

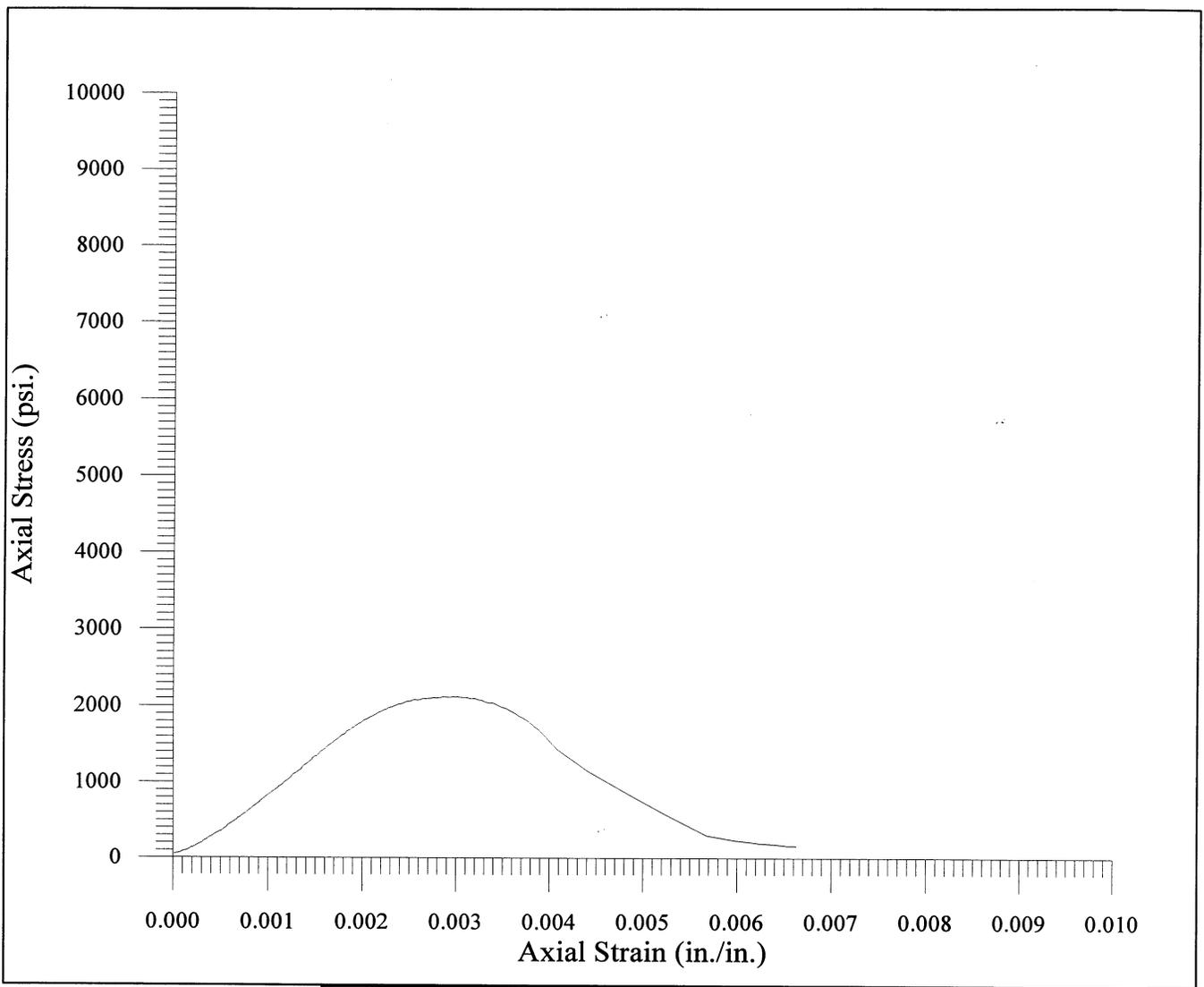
*Geo*  *Test*  
**Unlimited** 800 Peralta Ave  
 San Leandro, CA 94577

**Client:** Fugro West, Inc.  
 5855 Olivas Park Dr.  
 Ventura, CA 93003

**Project:** San Francisco Oakland Bay Bridge  
 East Span Replacement Project

**Job Number:** 98-42-0053

**Test Date:** October 14, 1998



**UNCONFINED COMPRESSION TEST**  
**Axial Stress vs. Axial Strain**

**SAMPLE ID:** Boring : 98-24  
 Sample: 14a  
 Depth: 52'

**DESCRIPTION**

Dark gray siltstone and claystone with many hairline fractures and two calcite healed fractures 0 and 59 degrees to the core axis.

**STRENGTH:** 2118 psi

*Geo*  *Test*  
**Unlimited**

800 Peralta Ave  
 San Leandro, CA 94577

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**Client:** Fugro West, Inc.  
 5855 Olivas Park Dr.  
 Ventura, CA 93003

**Project:** San Francisco Oakland Bay Bridge  
 East Span Replacement Project

**Job Number:** 98-42-0053

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**Test Date:** October 14, 1998

**DATA SHEET**

**Determination of Rock Modulus and Poisson's Ratio (ASTM D3148)**

Date: 10/14/98

Person performing the test: A. Bro

Client: Fugro

Job: #92-SFOBB

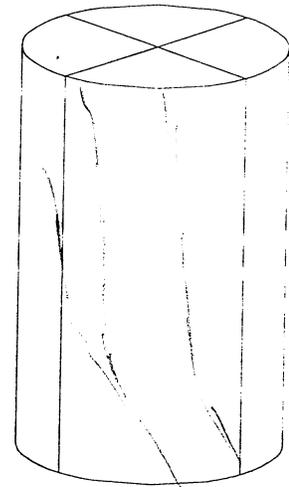
Sample ID: B:98-24 S:15a

Sample Description: Medium gray sandstone with many calcite healed fractures (hairline to 3/16" wide) 45° to parallel the core axis

Sample Depth: 16.5m (54') Sample Condition: received & tested moist

d <sub>1</sub>	d <sub>2</sub>
2.395	2.389
2.397	2.391
2.398	2.391
2.395	2.392
2.392	2.386

l <sub>1</sub>	l <sub>2</sub>
-0.0007	-0.0002
+0.0001	+0.0001
+0.0008	+0.0001



Avg. diameter: 2.393

Avg. length: 5.261

Sample area: 4.498

l/d ratio: 2.20

Sample volume(in<sup>3</sup>): 23.662

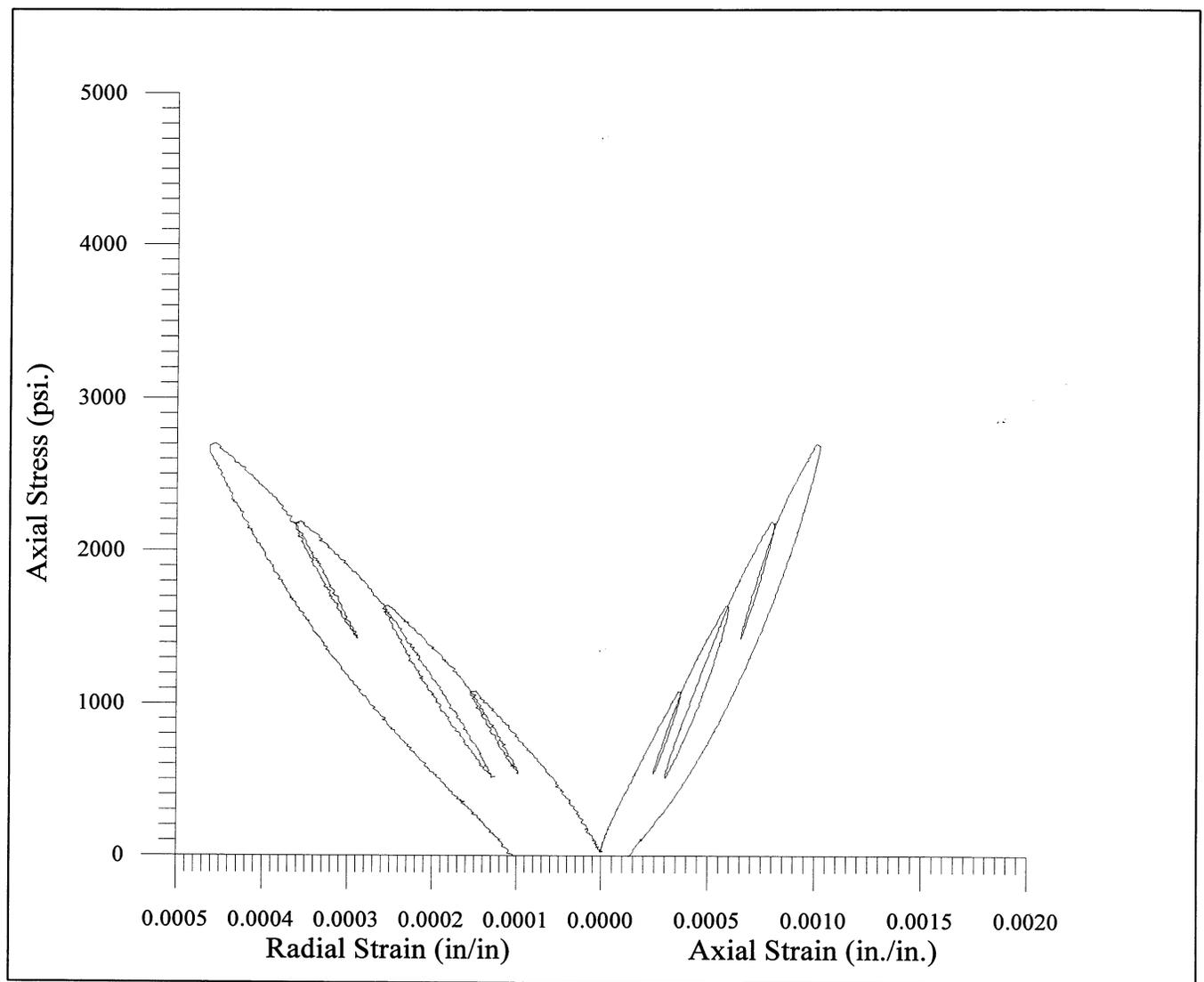
moist Sample weight (g): 1046.6g

Density: 44.23g/in<sup>3</sup> = 168.5 pcf (1 g/in<sup>3</sup> = 3.8095 lb/ft<sup>3</sup>)

Gauge length: 2.000 in.

Comments: failed by wedge shear on existing joints (steeply inclined)

\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_



**ELASTIC MODULUS TEST**  
**Axial Stress vs. Axial & Radial Strain**

**SAMPLE ID:** Boring: 98-24  
 Sample: 15a  
 Depth: 54'

**DESCRIPTION**  
 Medium gray sandstone with with many calcite healed fractures (hairline to 3/16 inch wide) 0 to 45 degrees to the core axis.

**MODULUS:** 3,910,000 psi  
**POISSON'S RATIO:** .36

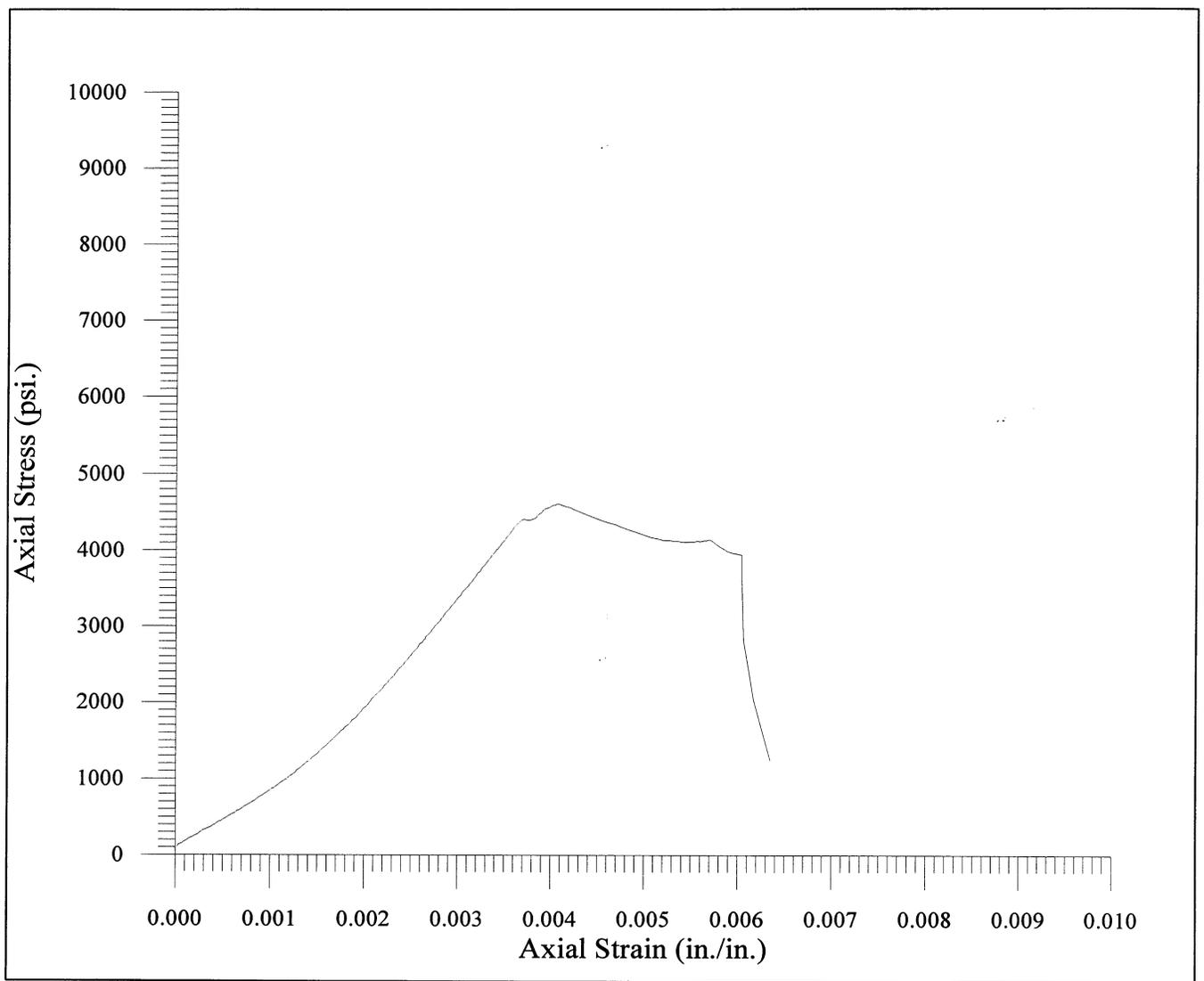
*Geo*  *Test*  
**Unlimited** 800 Peralta Ave  
 San Leandro, CA 94577

**Client:** Fugro West, Inc.  
 5855 Olivas Park Dr.  
 Ventura, CA 93003

**Project:** San Francisco Oakland Bay Bridge  
 East Span Replacement Project

**Job Number:** 98-42-0053

**Test Date:** October 14, 1998



**UNCONFINED COMPRESSION TEST**  
**Axial Stress vs. Axial Strain**

<p><b>SAMPLE ID:</b> Boring : 98-24  Sample: 15a  Depth: 54'</p> <p align="center"><b>DESCRIPTION</b></p> <p>Medium gray sandstone with many calcite healed fractures (hairline to 3/6 inch wide) 0 to 45 degrees to the core axis.</p> <p><b>STRENGTH:</b> 4610 psi</p>	<p align="center"> <i>Geo</i>  <i>U</i>  <i>Test</i>  <b>Unlimited</b> 800 Peralta Ave  San Leandro, CA 94577 </p>
	<p><b>Client:</b> Fugro West, Inc.  5855 Olivas Park Dr.  Ventura, CA 93003</p> <p><b>Project:</b> San Francisco Oakland Bay Bridge  East Span Replacement Project</p> <p><b>Job Number:</b> 98-42-0053</p>
	<p><b>Test Date:</b> October 14, 1998</p>

DATA SHEET

Determination of Rock Modulus and Poisson's Ratio (ASTM D3148)

Date: 10/14/98

Person performing the test: A. Bro

Client: Fugro

Job: #92-SFOBB

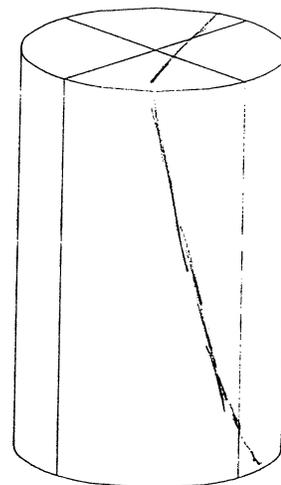
Sample ID: B:98-24 S:16a

Sample Description: medium gray sandstone with a small claystone inclusion and a calcite healed hairline fracture ~10° to core axis

Sample Depth: 18.1m (59.5') Sample Condition: received & tested moist

d <sub>1</sub>	d <sub>2</sub>
2.395	2.393
2.392	2.394
2.391	2.395
2.392	2.394
2.394	2.389

l <sub>1</sub>	l <sub>2</sub>
-0.0008	-0.0001
±0.0001	±0.0001
+0.0008	+0.0001



Avg. diameter: 2.393

Avg. length: 5.240

Sample area: 4.498

l/d ratio: 2.19

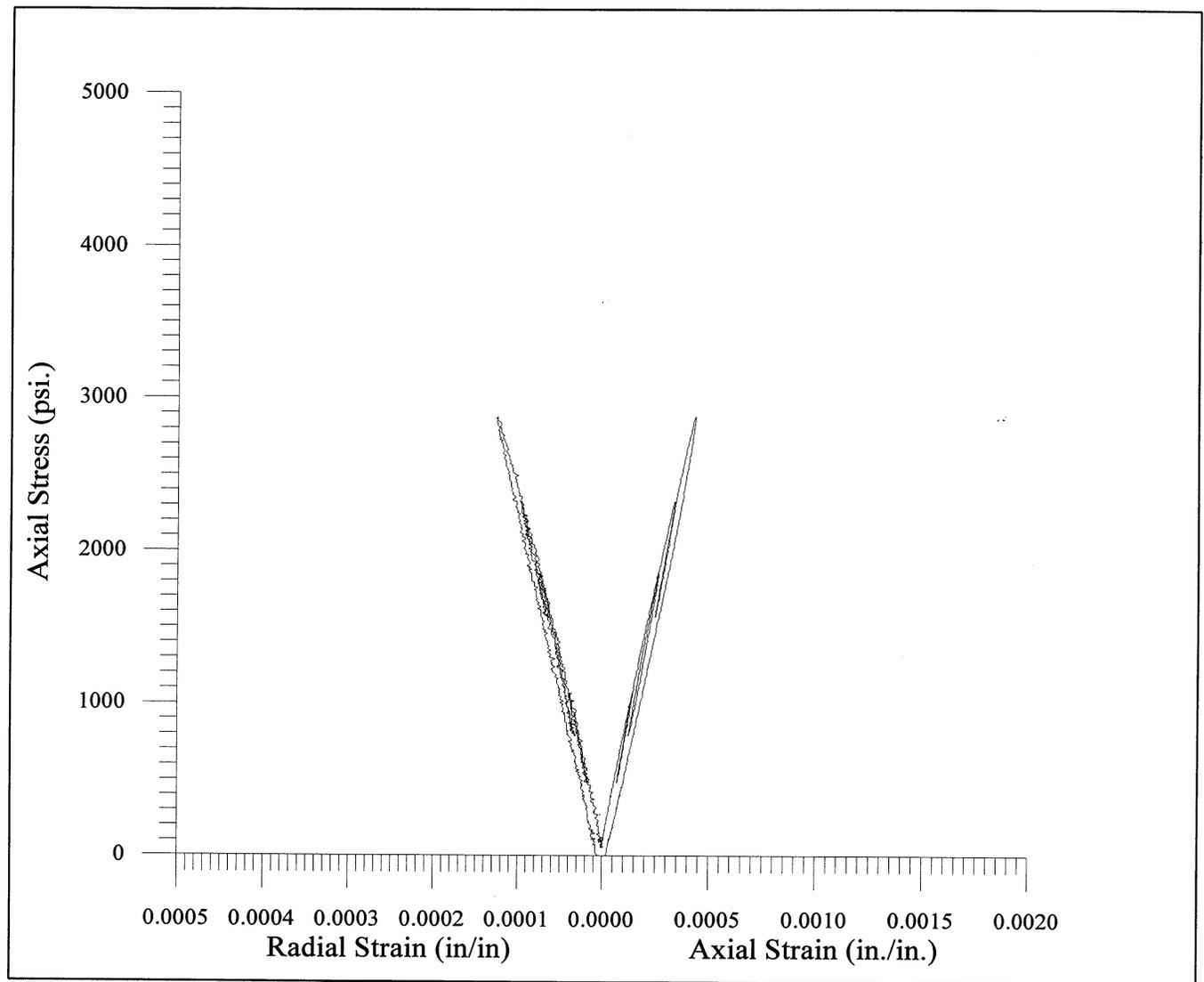
Sample volume(in<sup>3</sup>): 23.567

Sample weight (g): 1046.7g

Density: 44.41 g/in<sup>3</sup> = 169.2 pcf (1 g/in<sup>3</sup> = 3.8095 lb/ft<sup>3</sup>)

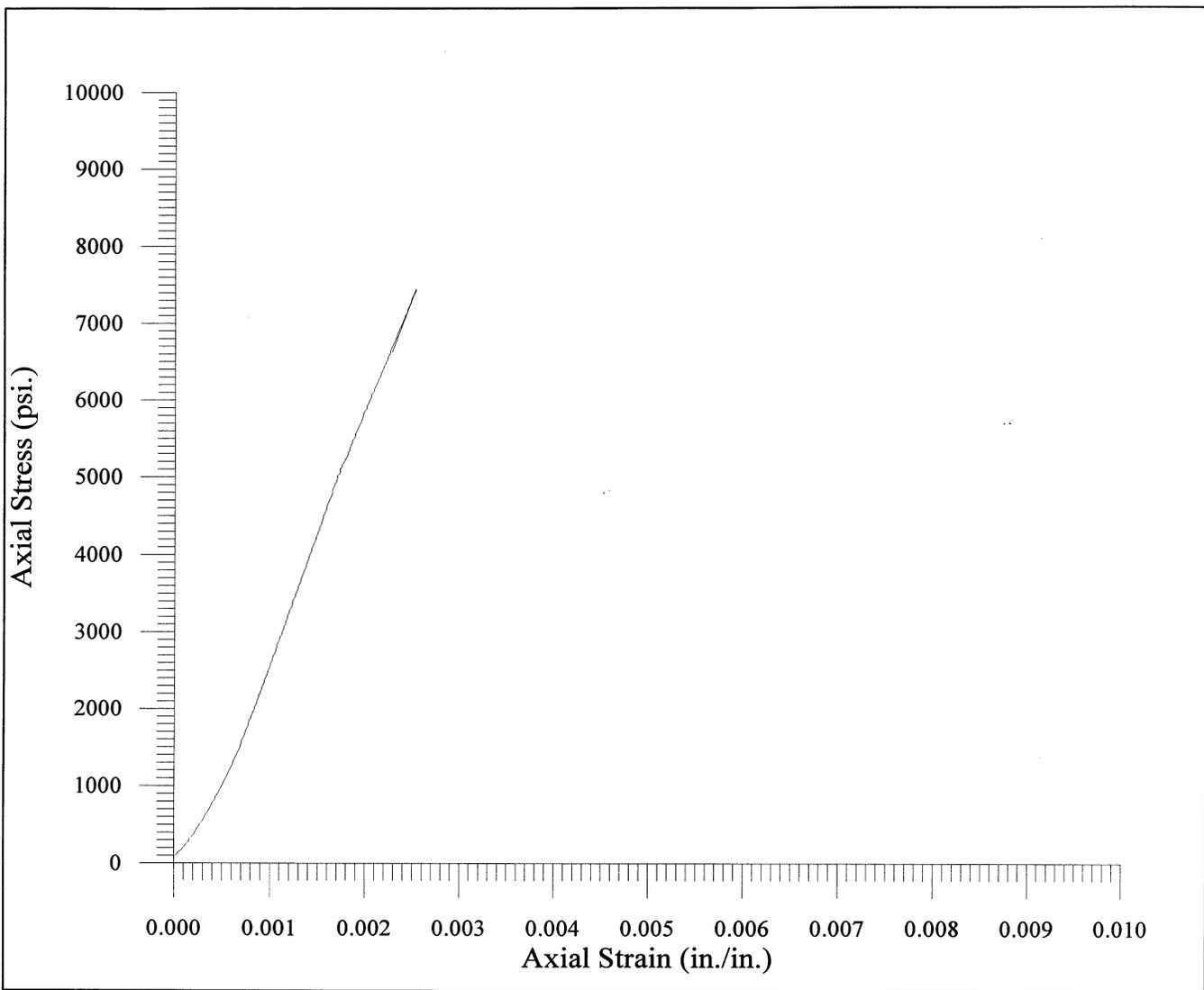
Gauge length: 2.000 in

Comments: shear failure along existing healed joint.



**ELASTIC MODULUS TEST**  
**Axial Stress vs. Axial & Radial Strain**

<p><b>SAMPLE ID:</b> Boring: 98-24  Sample: 16a  Depth: 59.5'</p> <p style="text-align: center;"><b>DESCRIPTION</b></p> <p>Medium gray sandstone with a small claystone inclusion and a calcite healed hairline fracture about 10 degrees to the core axis.</p> <p><b>MODULUS:</b> 8,060,000 psi  <b>POISSON'S RATIO:</b> .32</p>	<div style="text-align: center;">  <p><b>Geo <i>GTU</i> Test Unlimited</b></p> </div> <p style="text-align: right;">800 Peralta Ave  San Leandro, CA 94577</p> <hr/> <p><b>Client:</b> Fugro West, Inc.  5855 Olivas Park Dr.  Ventura, CA 93003</p> <p><b>Project:</b> San Francisco Oakland Bay Bridge  East Span Replacement Project</p> <p><b>Job Number:</b> 98-42-0053</p> <hr/> <p><b>Test Date:</b> October 14, 1998</p>
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**UNCONFINED COMPRESSION TEST**  
**Axial Stress vs. Axial Strain**

**SAMPLE ID:** Boring : 98-24  
 Sample: 16a  
 Depth: 59.5'

**DESCRIPTION**

Medium gray sandstone with a small claystone inclusion and a calcite healed hairline fracture about 10 degrees to the core axis.

**STRENGTH:** 7451 psi

*Geo*  *Test*  
**Unlimited** 800 Peralta Ave  
 San Leandro, CA 94577

---

**Client:** Fugro West, Inc.  
 5855 Olivas Park Dr.  
 Ventura, CA 93003

**Project:** San Francisco Oakland Bay Bridge  
 East Span Replacement Project

**Job Number:** 98-42-0053

---

**Test Date:** October 14, 1998

DATA SHEET

Determination of Rock Modulus and Poisson's Ratio (ASTM D3148)

Date: 10/14/98

Person performing the test: A. Bro

Client: Fugro

Job: #92-SFOBR

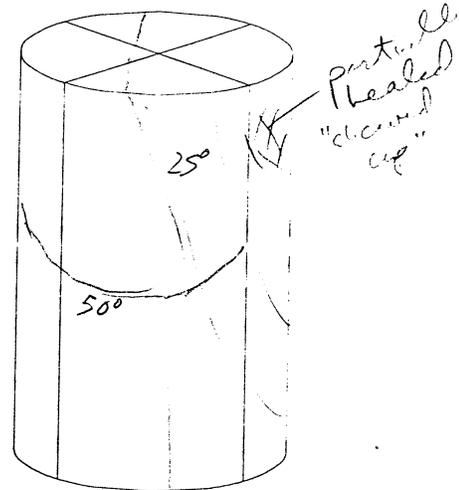
Sample ID: B198-24 S:20a

Sample Description: medium gray sandstone with partially healed and calcite healed fractures generally 25° to core axis. (1-50° to core axis.)

Sample Depth: 23.0m (75.5') Sample Condition: received & tested moist

d <sub>1</sub>	d <sub>2</sub>
2.398	2.398
2.396	2.399
2.397	2.399
2.396	2.397
2.397	2.399

l <sub>1</sub>	l <sub>2</sub>
-0.0008	-0.0001
±0.0001	±0.0001
+0.0008	+0.0001



Avg. diameter: 2.398

Avg. length: 5.247

Sample area: 4.516

l/d ratio: 2.19

Sample volume(in<sup>3</sup>): 23.697

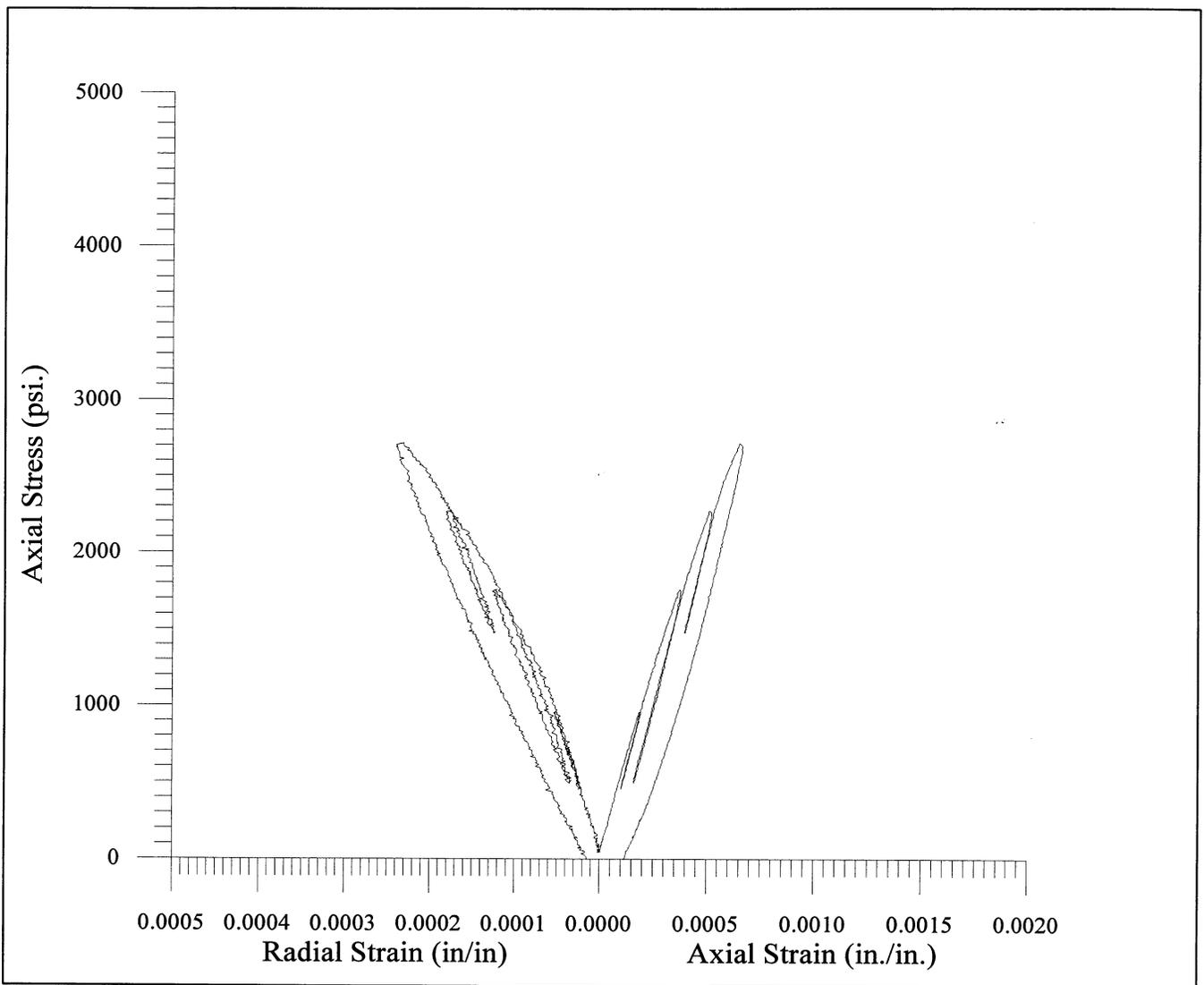
Sample weight (g): 1048.2g

Density: 44.238/in<sup>3</sup> = 166.5 pcf (1 g/in<sup>3</sup>=3.8095lb/ft<sup>3</sup>)

Gauge length: 2.000 in.

Comments: due to joints, quite unequal E<sub>o1</sub> & E<sub>o2</sub> E<sub>o1</sub> ≈ 2 × E<sub>o2</sub> may be starting to fail at end of mod. test.

Failed by shear in partially healed zone along 25° joints.



**ELASTIC MODULUS TEST**  
**Axial Stress vs. Axial & Radial Strain**

**SAMPLE ID:** Boring: 98-24  
 Sample: 20a  
 Depth: 75.5'

**DESCRIPTION**  
 Medium gray sandstone with partially healed and calcite healed fractures, generally 25 degrees to the core axis and one 50 degrees to the core axis.

**MODULUS:** 6,100,000 psi  
**POISSON'S RATIO:** .37

*Geo*  *U*  
*Test*  
*Unlimited*

800 Peralta Ave  
 San Leandro, CA 94577

---

**Client:** Fugro West, Inc.  
 5855 Olivas Park Dr.  
 Ventura, CA 93003

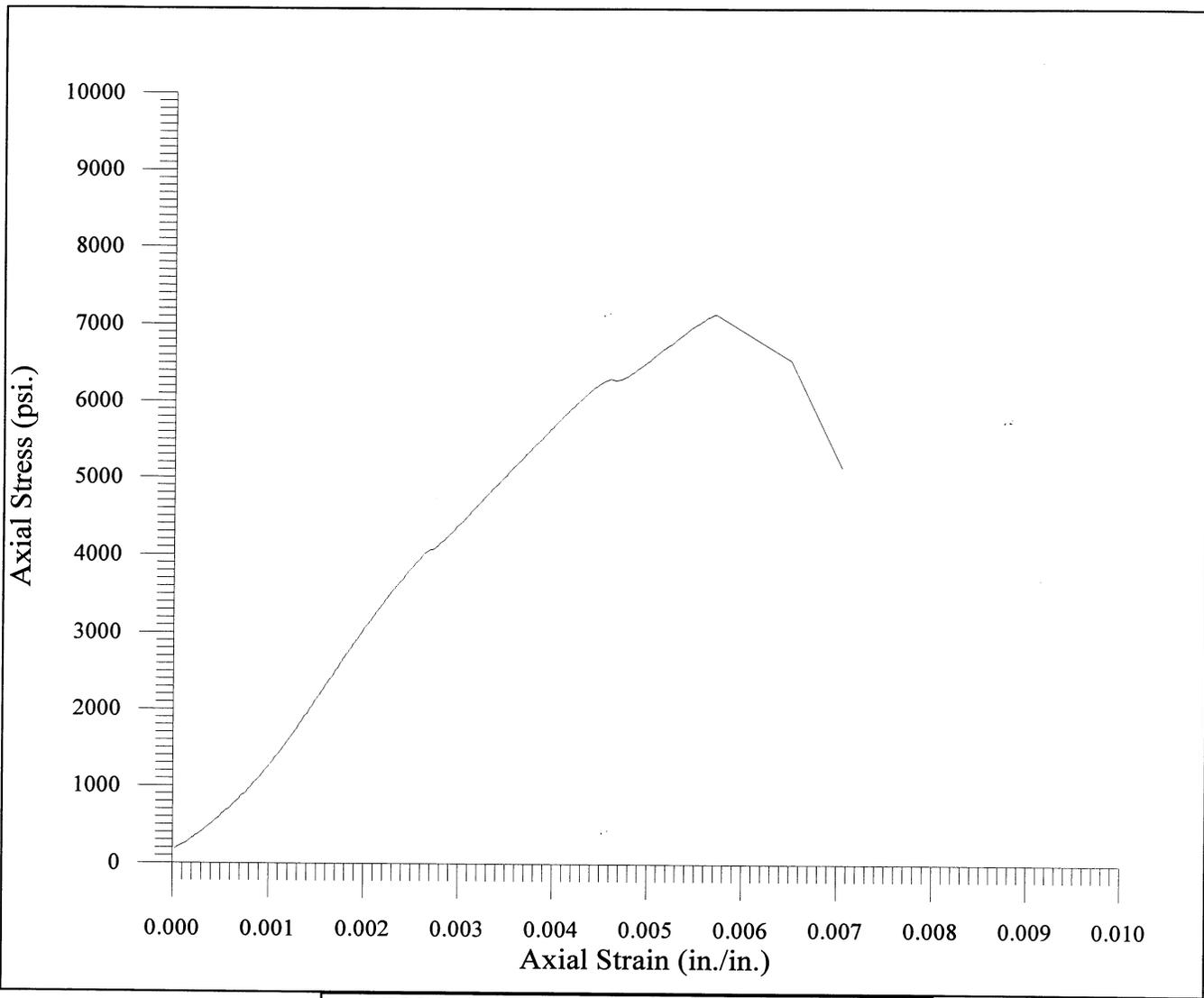
**Project:** San Francisco Oakland Bay Bridge  
 East Span Replacement Project

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**Job Number:** 98-42-0053

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**Test Date:** October 14, 1998



**UNCONFINED COMPRESSION TEST**  
**Axial Stress vs. Axial Strain**

<p><b>SAMPLE ID:</b> Boring : 98-24  Sample: 20a  Depth: 75.5'</p> <p align="center"><b>DESCRIPTION</b></p> <p>Medium gray sandstone with partially healed and calcite healed fractures, generally 25 degrees to the core axis and one 50 degrees to the axis.</p> <p><b>STRENGTH:</b> 7134 psi</p>	<p align="center"> <i>Geo</i>  <i>U</i>  <i>Test</i>  <b>Unlimited</b> </p> <p align="right">800 Peralta Ave  San Leandro, CA 94577</p>
	<p><b>Client:</b> Fugro West, Inc.  5855 Olivas Park Dr.  Ventura, CA 93003</p> <p><b>Project:</b> San Francisco Oakland Bay Bridge  East Span Replacement Project</p> <p><b>Job Number:</b> 98-42-0053</p>
	<p><b>Test Date:</b> October 14, 1998</p>

**DATA SHEET**

**Determination of Rock Modulus and Poisson's Ratio (ASTM D3148)**

Date: 10/14/98

Person performing the test: A. Bro

Client: Fugro

Job: #92-SFOBB

Sample ID: B:98-24 S:21a

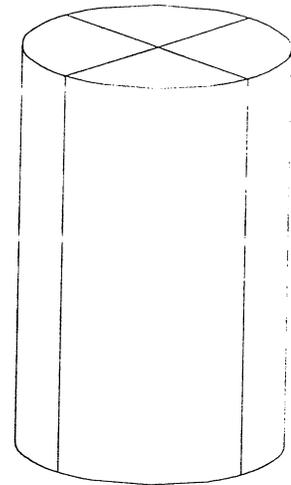
Sample Description: Dark gray siltstone with some beds of sandstone. Numerous horizontal fractures in the siltstone parallel to bedding at 65° to core axis.

Sample Depth: 24.1m (79')

Sample Condition: received & tested in air

d <sub>1</sub>	d <sub>2</sub>
2.398	2.399
2.397	2.397
2.399	2.394
2.394	2.393
2.389	2.394

l <sub>1</sub>	l <sub>2</sub>
-0.0006	-0.0001
+0.0001	+0.0001
+0.0006	+0.0001



Avg. diameter: 2.395

Avg. length: 5.166

Sample area: 4.505

l/d ratio: 2.16

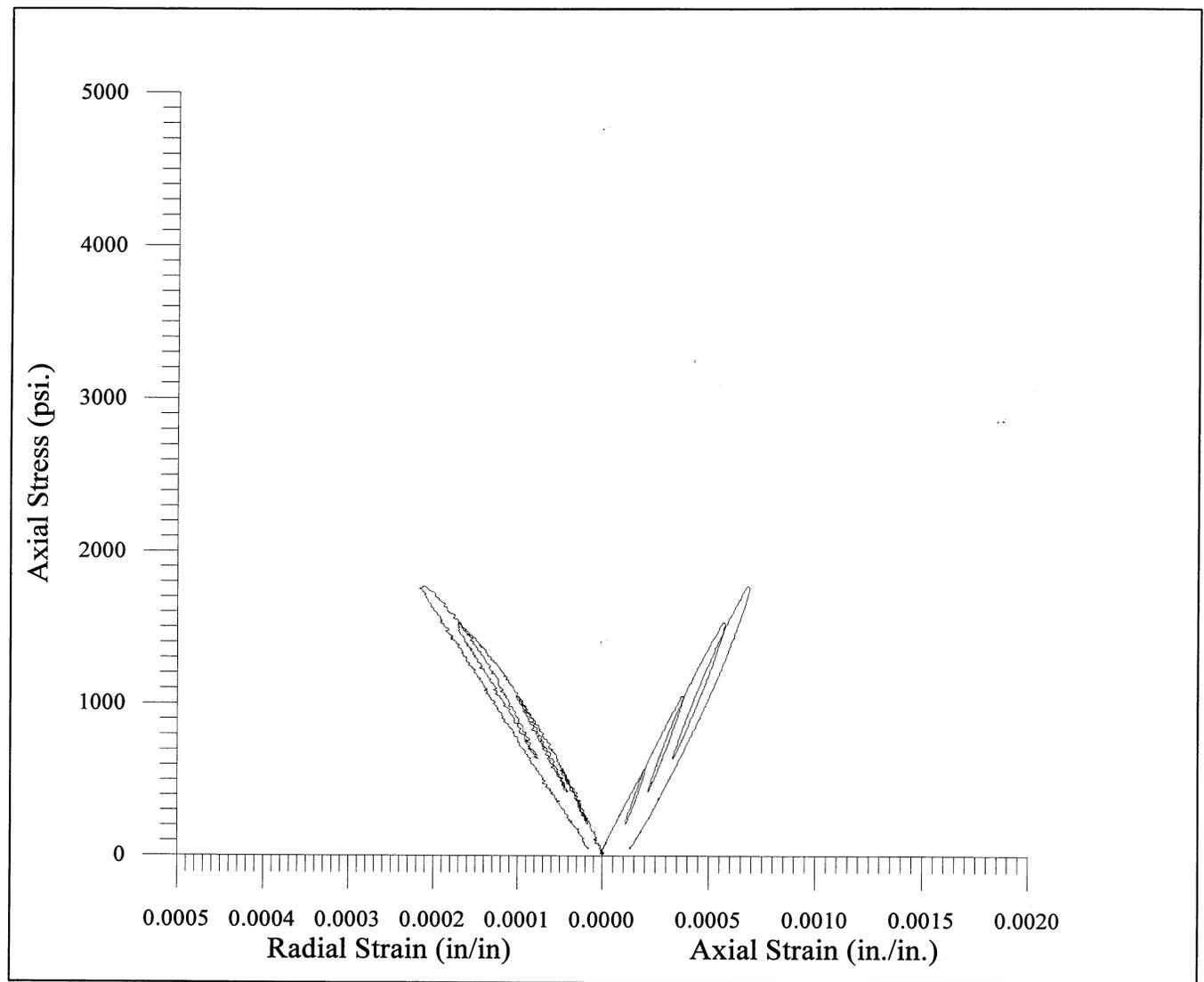
Sample volume(in<sup>3</sup>): 23.273

Sample weight (g): 1026.1g

Density: 44.098/in<sup>2</sup> = 168.0 (1 g/in<sup>3</sup> = 3.8095 lb/ft<sup>3</sup>)

Gauge length: 2.000 in.

Comments: failed by shear and axial splitting



**ELASTIC MODULUS TEST**  
**Axial Stress vs. Axial & Radial Strain**

**SAMPLE ID:** Boring: 98-24  
 Sample: 21a  
 Depth: 79'

**DESCRIPTION**  
 Dark gray siltstone with sandstone layers. The siltstone contains many hairline fractures parallel to the bedding, about 65 degrees to the core axis.

**MODULUS:** 4,100,000 psi  
**POISSON'S RATIO:** .35

*Geo*  *U*

*Test*

**Unlimited**

800 Peralta Ave  
 San Leandro, CA 94577

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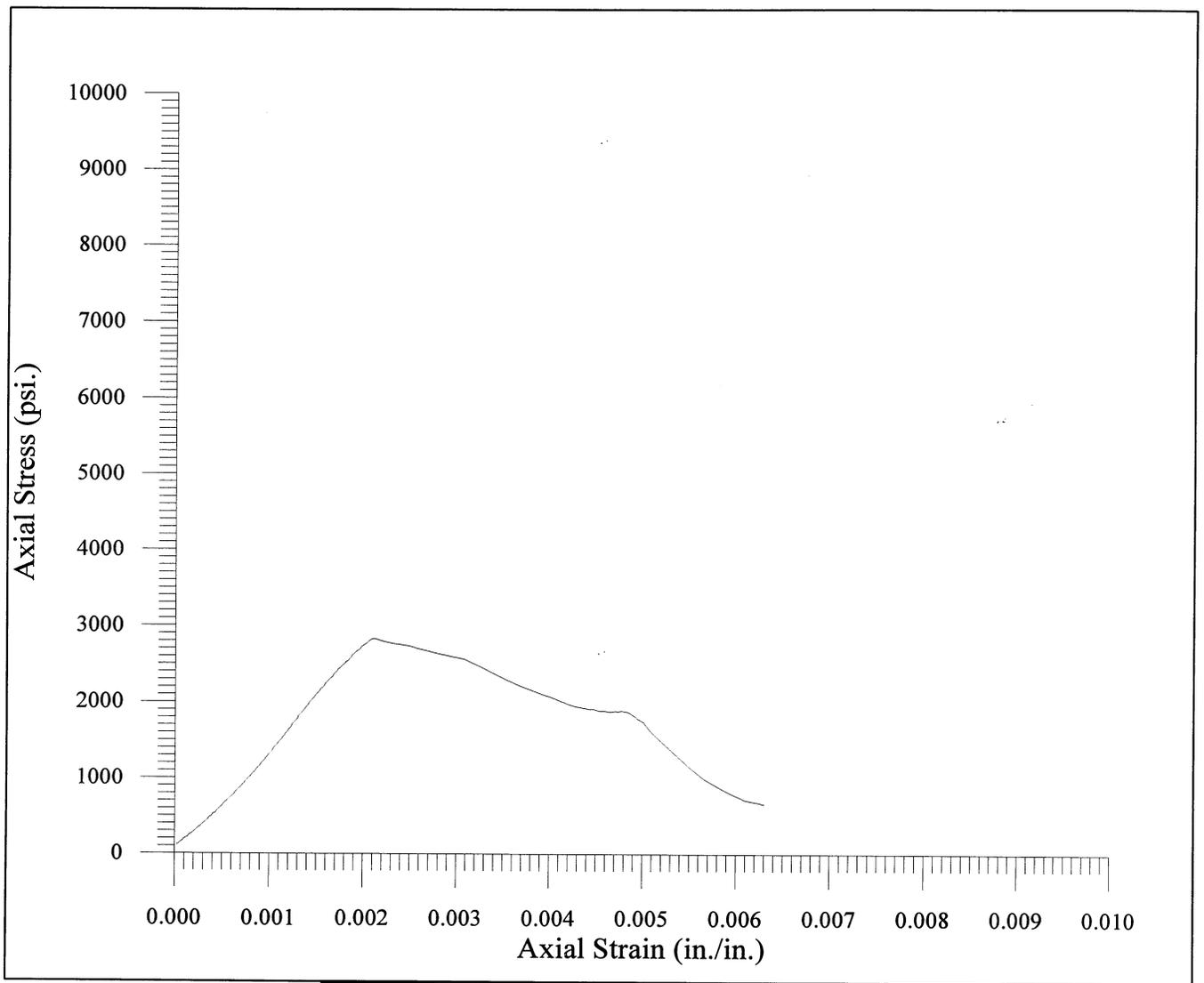
**Client:** Fugro West, Inc.  
 5855 Olivas Park Dr.  
 Ventura, CA 93003

**Project:** San Francisco Oakland Bay Bridge  
 East Span Replacement Project

**Job Number:** 98-42-0053

---

**Test Date:** October 14, 1998



**UNCONFINED COMPRESSION TEST**  
**Axial Stress vs. Axial Strain**

**SAMPLE ID:** Boring : 98-24  
 Sample: 21a  
 Depth: 79'

**DESCRIPTION**

Dark gray siltstone with sandstone layers. The siltstone contains many hairline fractures parallel to the bedding, about 65 degrees to the core axis.

**STRENGTH:** 2827 psi

*Geo*  *Test*  
**Unlimited** 800 Peralta Ave  
 San Leandro, CA 94577

**Client:** Fugro West, Inc.  
 5855 Olivas Park Dr.  
 Ventura, CA 93003

**Project:** San Francisco Oakland Bay Bridge  
 East Span Replacement Project

**Job Number:** 98-42-0053

**Test Date:** October 14, 1998

DATA SHEET

Determination of Rock Modulus and Poisson's Ratio (ASTM D3148)

Date: 10/14/98

Person performing the test: A. Bro

Client: Fugro

Job: #92-SFOBB

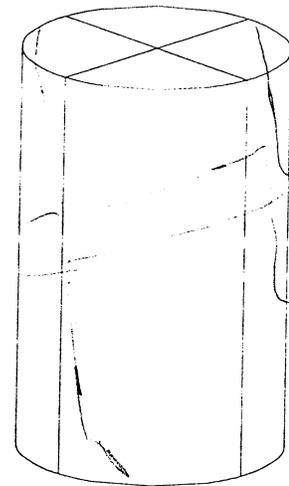
Sample ID: B:98-24 S:22a

Sample Description: medium gray sandstone with several thin calcite healed fractures 62° & 12° to core axis

Sample Depth: 26.7m (87.5') Sample Condition: received & tested moist

d <sub>1</sub>	d <sub>2</sub>
2.401	2.400
2.400	2.399
2.400	2.399
2.400	2.399
2.399	2.399

l <sub>1</sub>	l <sub>2</sub>
-0.0009	-0-
±0.0001	±0.0001
+0.0008	-0-



Avg. diameter: 2.400

Avg. length: 5.367"

Sample area: 4.524

l/d ratio: 2.24

Sample volume(in<sup>3</sup>): 24.280

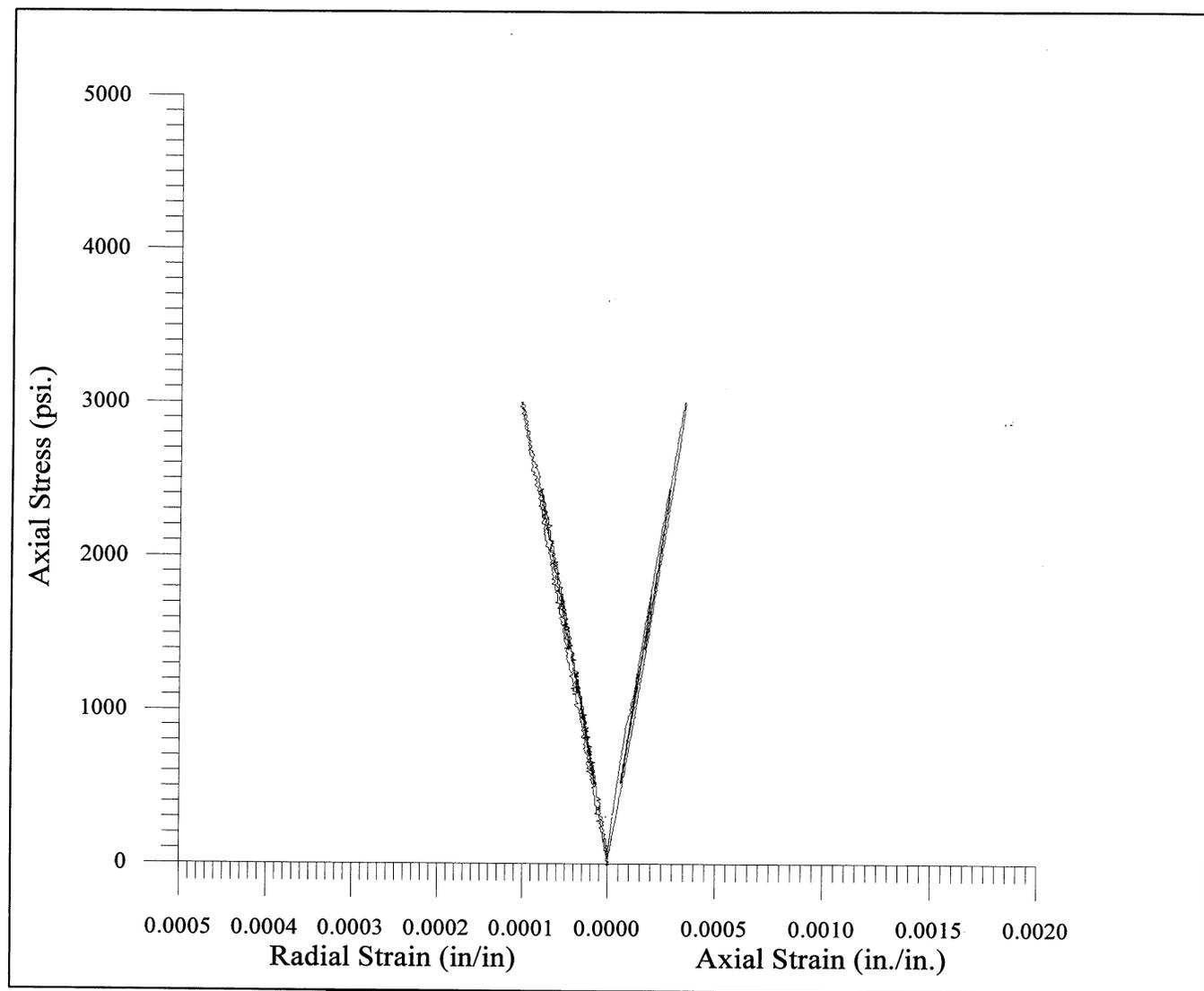
moist Sample weight (g): 1080.38

Density: 44.498/in<sup>3</sup> = 169.5pcf (1 g/in<sup>3</sup> = 3.8095 lb/ft<sup>3</sup>)

Gauge length: 2.000 in

Comments: Failed by axial splitting

\_\_\_\_\_  
 \_\_\_\_\_  
 \_\_\_\_\_  
 \_\_\_\_\_  
 \_\_\_\_\_



**ELASTIC MODULUS TEST**  
**Axial Stress vs. Axial & Radial Strain**

**SAMPLE ID:** Boring: 98-24  
 Sample: 22a  
 Depth: 87.5'

**DESCRIPTION**  
 Medium gray sandstone with several calcite healed hairline fractures, 12 and 62 degrees to the core axis.

**MODULUS:** 9,430,000 psi  
**POISSON'S RATIO:** .31

*Geo*  *U*  
*Test*  
*Unlimited*

800 Peralta Ave  
 San Leandro, CA 94577

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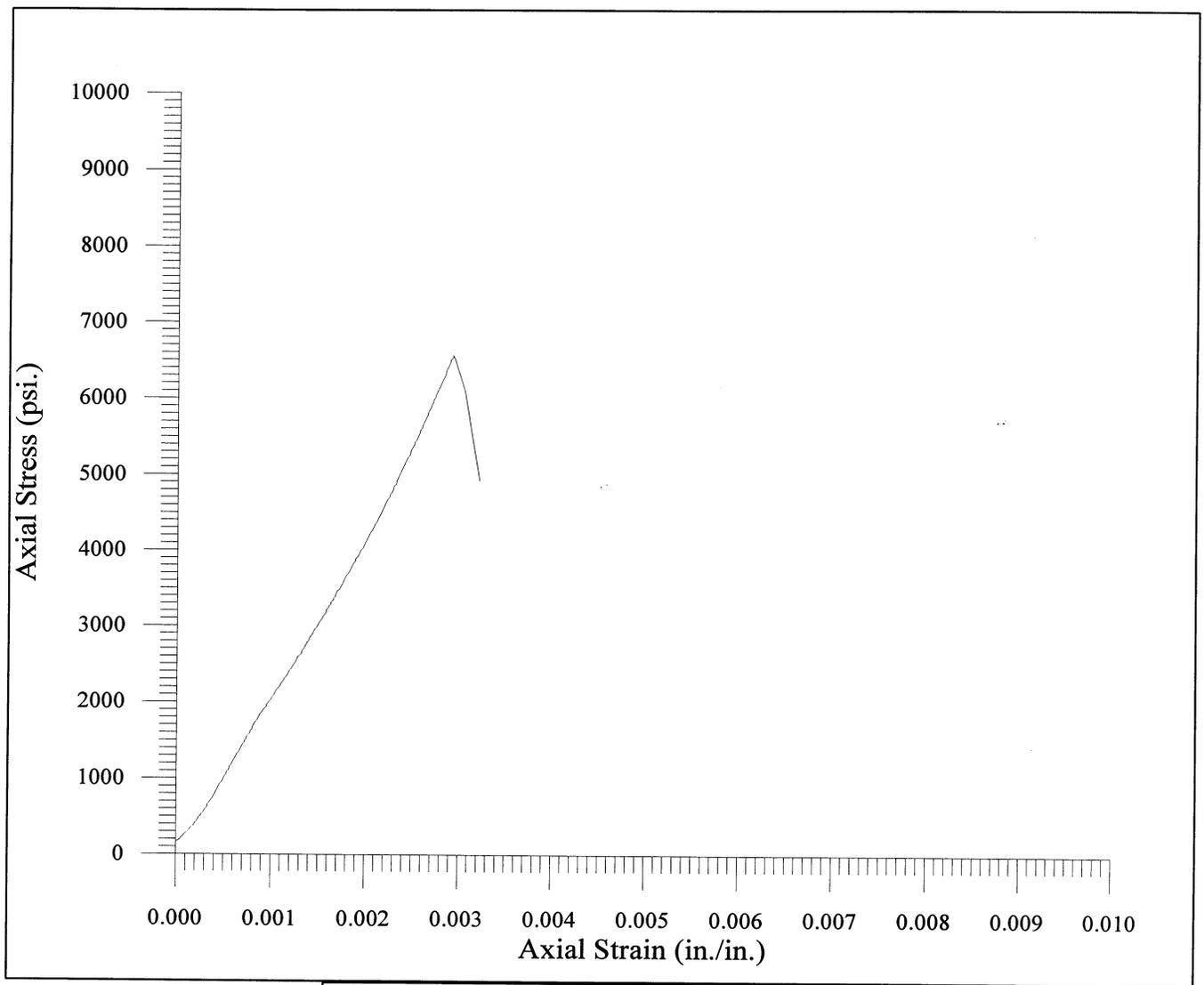
**Client:** Fugro West, Inc.  
 5855 Olivas Park Dr.  
 Ventura, CA 93003

**Project:** San Francisco Oakland Bay Bridge  
 East Span Replacement Project

**Job Number:** 98-42-0053

---

**Test Date:** October 14, 1998



**UNCONFINED COMPRESSION TEST**  
**Axial Stress vs. Axial Strain**

<p><b>SAMPLE ID:</b> Boring : 98-24          Sample: 22a          Depth: 87.5'</p> <p align="center"><b>DESCRIPTION</b></p> <p>Medium gray sandstone with several calcite healed hairline fractures, 12 and 62 degrees to the core axis.</p> <p><b>STRENGTH:</b> 6562 psi</p>	<p><i>Geo</i>  <i>U</i></p> <p><i>Test</i></p> <p><b>Unlimited</b> 800 Peralta Ave          San Leandro, CA 94577</p>
	<p><b>Client:</b> Fugro West, Inc.          5855 Olivas Park Dr.          Ventura, CA 93003</p>
	<p><b>Project:</b> San Francisco Oakland Bay Bridge          East Span Replacement Project</p>
	<p><b>Job Number:</b> 98-42-0053</p>
	<p><b>Test Date:</b> October 14, 1998</p>

DATA SHEET

Determination of Rock Modulus and Poisson's Ratio (ASTM D3148)

Date: 10/14/98

Person performing the test: A. Bro

Client: Fugro

Job: #92-SFOBB

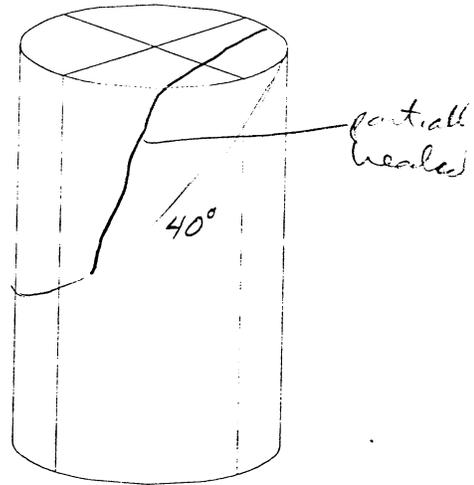
Sample ID: B:98-24 S:24a

Sample Description: medium gray sandstone with partially healed and calcite healed fractures.

Sample Depth: 29.9m (98') Sample Condition: received & tested moist

d <sub>1</sub>	d <sub>2</sub>
2.399	2.400
2.396	2.401
2.399	2.401
2.400	2.401
2.400	2.401

l <sub>1</sub>	l <sub>2</sub>
-0.0007	-0-
±.0001	±.0001
+0.0007	-0-



Avg. diameter: 2.400

Avg. length: 5.231

Sample area: 4.524

l/d ratio: 2.18

Sample volume(in<sup>3</sup>): 23.664

Sample weight (g): 1053.9g

Density: 44.548/in<sup>3</sup> = 169.7pcf (1 g/in<sup>3</sup>=3.8095lb/ft<sup>3</sup>)

Gauge length: 2000in

moist

Comments: Failed by shear on 40° healed joint

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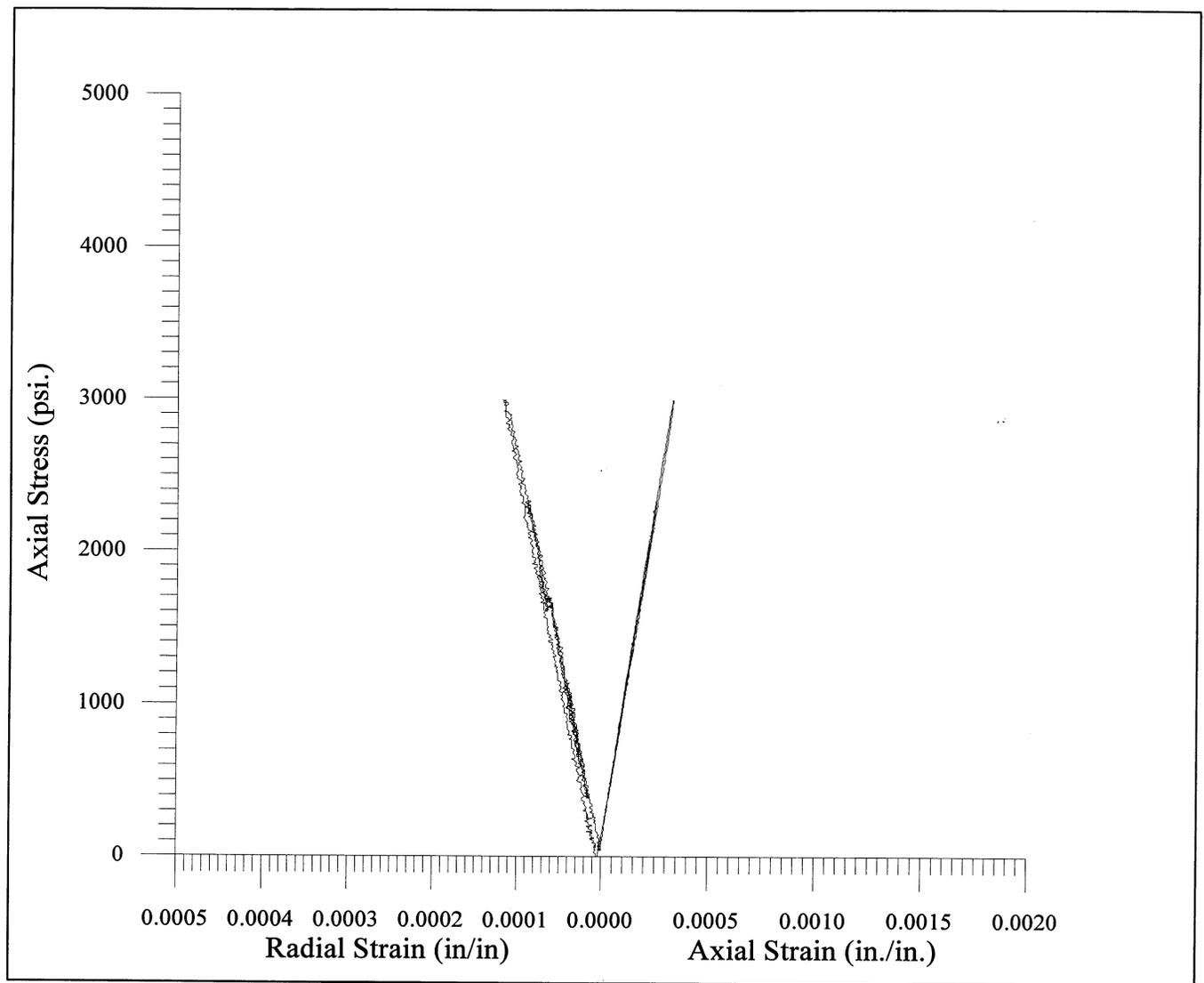
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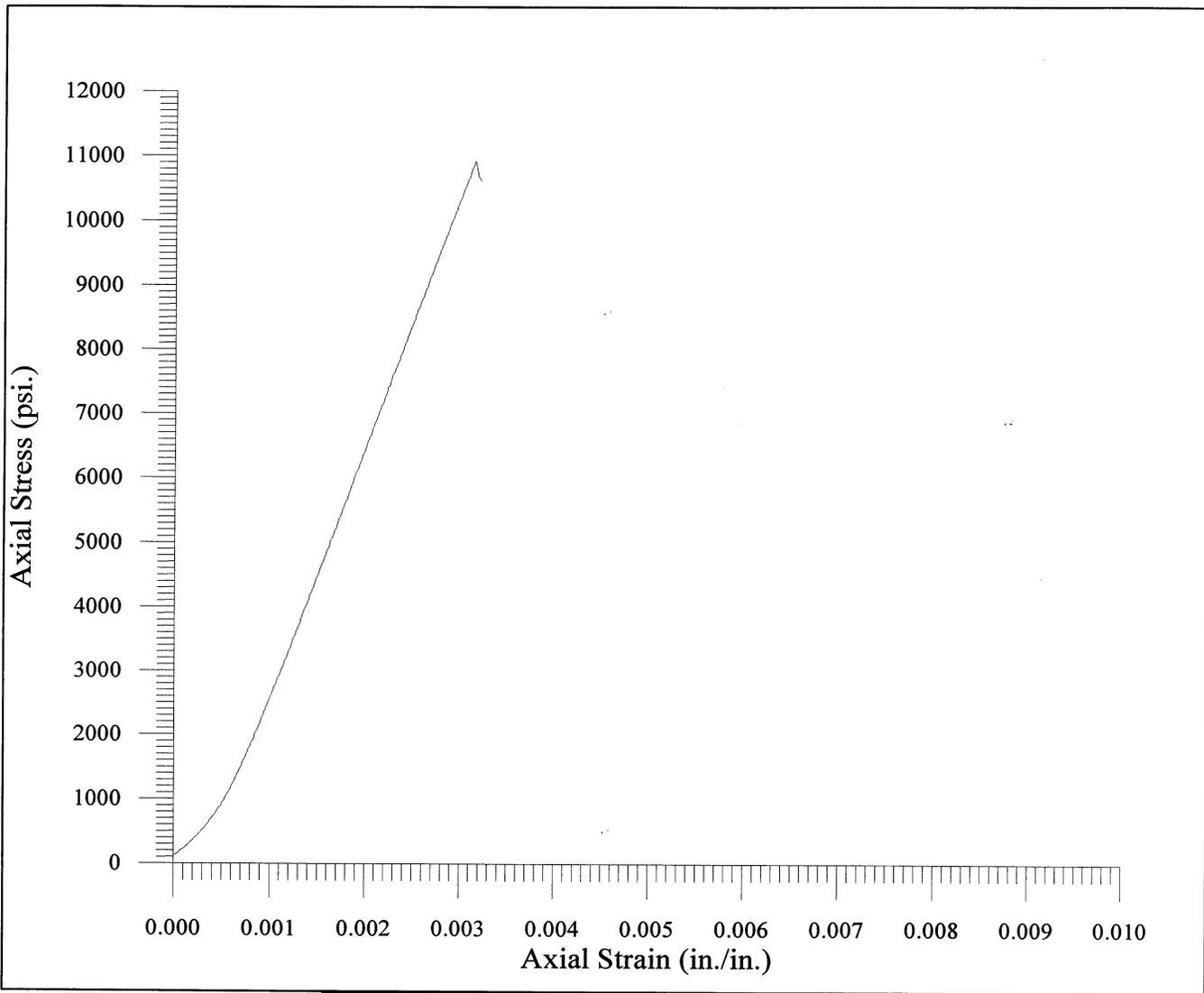
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**ELASTIC MODULUS TEST**  
**Axial Stress vs. Axial & Radial Strain**

<p><b>SAMPLE ID:</b> Boring: 98-24  Sample: 24a  Depth: 98'</p> <p><b>DESCRIPTION</b>  Medium gray sandstone with partially healed and calcite healed fractures about 40 degrees to the core axis.</p> <p><b>MODULUS:</b> 9,620,000 psi  <b>POISSON'S RATIO:</b> .30</p>	<p align="center"> <i>Geo</i>  <i>U</i>  <i>Test</i>  <b>Unlimited</b> </p> <p align="right">800 Peralta Ave  San Leandro, CA 94577</p>
	<p><b>Client:</b> Fugro West, Inc.  5855 Olivas Park Dr.  Ventura, CA 93003</p> <p><b>Project:</b> San Francisco Oakland Bay Bridge  East Span Replacement Project</p> <p><b>Job Number:</b> 98-42-0053</p>
<p><b>Test Date:</b> October 14, 1998</p>	



**UNCONFINED COMPRESSION TEST**  
**Axial Stress vs. Axial Strain**

<p><b>SAMPLE ID:</b> Boring : 98-24  Sample: 24a  Depth: 98'</p> <p align="center"><b>DESCRIPTION</b></p> <p>Medium gray sandstone with partially healed and calcite healed fractures about 40 degrees to the core axis.</p> <p><b>STRENGTH:</b> 10,912 psi</p>	<p align="center"> <i>Geo</i>  <i>U</i>  <i>Test</i>  <b>Unlimited</b> </p> <p align="right">800 Peralta Ave  San Leandro, CA 94577</p>
	<p><b>Client:</b> <b>Fugro West, Inc.</b>  <b>5855 Olivas Park Dr.</b>  <b>Ventura, CA 93003</b></p> <p><b>Project:</b> <b>San Francisco Oakland Bay Bridge</b>  <b>East Span Replacement Project</b></p> <p><b>Job Number:</b> 98-42-0053</p>
	<p><b>Test Date:</b> October 14, 1998</p>

DATA SHEET

Determination of Rock Modulus and Poisson's Ratio (ASTM D3148)

Date: 10/14 - /98

Person performing the test: A. Bro

Client: Fugro

Job: #92-SFOBB

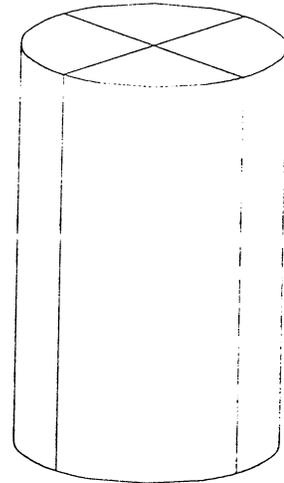
Sample ID: B:98-24 S:25A

Sample Description: medium gray massive sandstone

Sample Depth: 32.0m (105') Sample Condition: received & tested moist

d <sub>1</sub>	d <sub>2</sub>
2.402	2.401
2.402	2.399
2.402	2.402
2.402	2.401
2.401	2.402

l <sub>1</sub>	l <sub>2</sub>
- .0008	- 0 -
± .0001	± .0001
± .0008	- 0 -



Avg. diameter: 2.401

Avg. length: 5.277

Sample area: 4.528

l/d ratio: 2.20

Sample volume (in<sup>3</sup>): 23.892

moist Sample weight (g): 1065.1

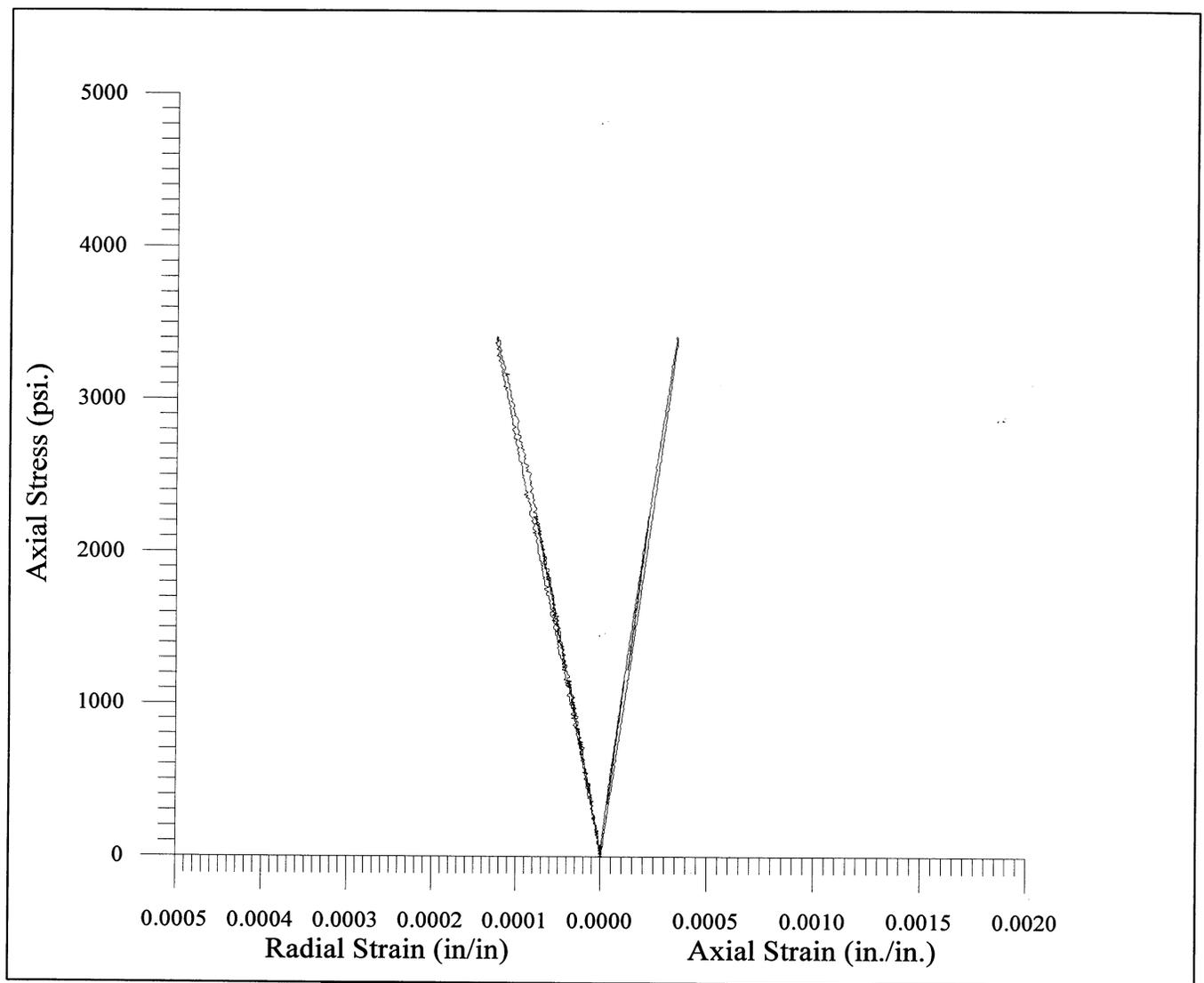
Density: 44.588/in<sup>3</sup> = 169.8 pcf (1 g/in<sup>3</sup> = 3.8095 lb/ft<sup>3</sup>)

Gauge length: 2.000 in

Comments: hard strong rock  $E_{1a} = E_{2a}$ ! implies that for the  
weaker/fractured rock, that  $E$  is very non uniform.

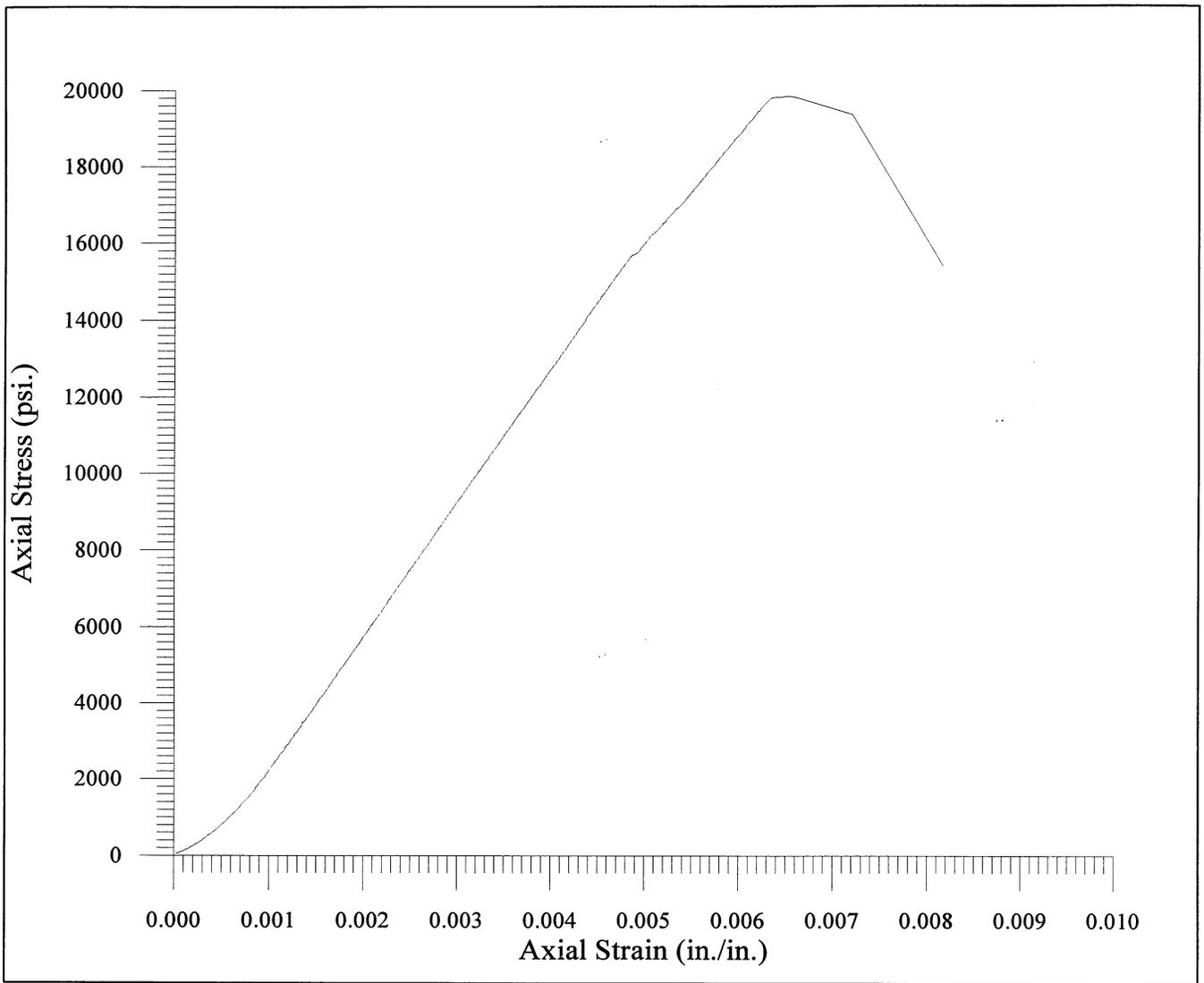
probably axial split @ ~70kips (slight change in  $\sigma$ - $\epsilon$  slope)  
heard a cracking sound.

Failed by shear and splitting



**ELASTIC MODULUS TEST**  
**Axial Stress vs. Axial & Radial Strain**

<p><b>SAMPLE ID:</b> Boring: 98-24  Sample: 25a  Depth: 105'</p> <p align="center"><b>DESCRIPTION</b></p> <p align="center">Medium gray massive sandstone.</p> <p><b>MODULUS:</b> 10,000,000 psi</p> <p><b>POISSON'S RATIO:</b> .35</p>	<p align="center"> <i>Geo</i>  <i>U</i>  <i>Test</i>  <b>Unlimited</b> </p> <p align="right">800 Peralta Ave  San Leandro, CA 94577</p>
	<p><b>Client:</b> Fugro West, Inc.  5855 Olivas Park Dr.  Ventura, CA 93003</p> <p><b>Project:</b> San Francisco Oakland Bay Bridge  East Span Replacement Project</p> <p><b>Job Number:</b> 98-42-0053</p>
	<p><b>Test Date:</b> October 14, 1998</p>



**UNCONFINED COMPRESSION TEST**  
**Axial Stress vs. Axial Strain**

<p><b>SAMPLE ID:</b> Boring : 98-24          Sample: 25a          Depth: 105'</p> <p align="center"><b>DESCRIPTION</b></p> <p align="center">Medium gray massive sandstone.</p> <p><b>STRENGTH:</b> 19,835 psi</p>	<p align="center"> <i>Geo</i>  <i>U</i>  <i>Test</i>  <b>Unlimited</b> </p> <p align="right">800 Peralta Ave          San Leandro, CA 94577</p> <hr/> <p><b>Client:</b> Fugro West, Inc.          5855 Olivas Park Dr.          Ventura, CA 93003</p> <p><b>Project:</b> San Francisco Oakland Bay Bridge          East Span Replacement Project</p> <p><b>Job Number:</b> 98-42-0053</p> <hr/> <p><b>Test Date:</b> October 14, 1998</p>
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## Direct Shear Tests

**DATA SHEET**  
Direct Shear of Rock (ISRM)

Date: 10/30/98

Person performing the test: AJB

Client: Fugro

Job: #92-SEOPR

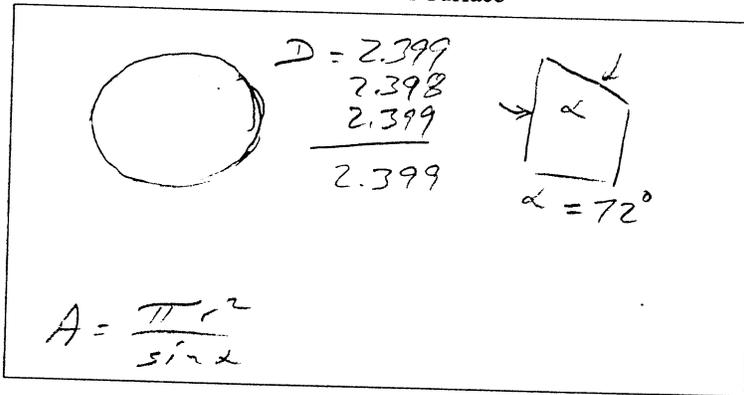
Sample ID: B98-24 S21b

Sample Description: Planned bedding plane joint in dark gray claystone at siltstone/claystone interface.

Sample Depth: 78'

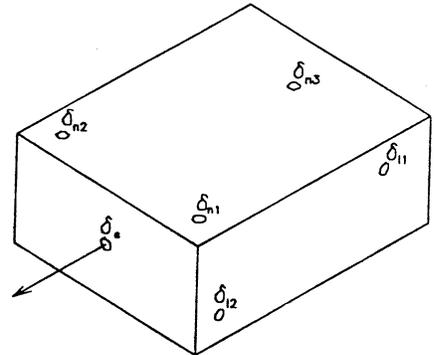
Sample Water Condition: received & tested moist

Sketch of Shear Surface



Sample area: 4.753

Location of LVDTs on top shear box

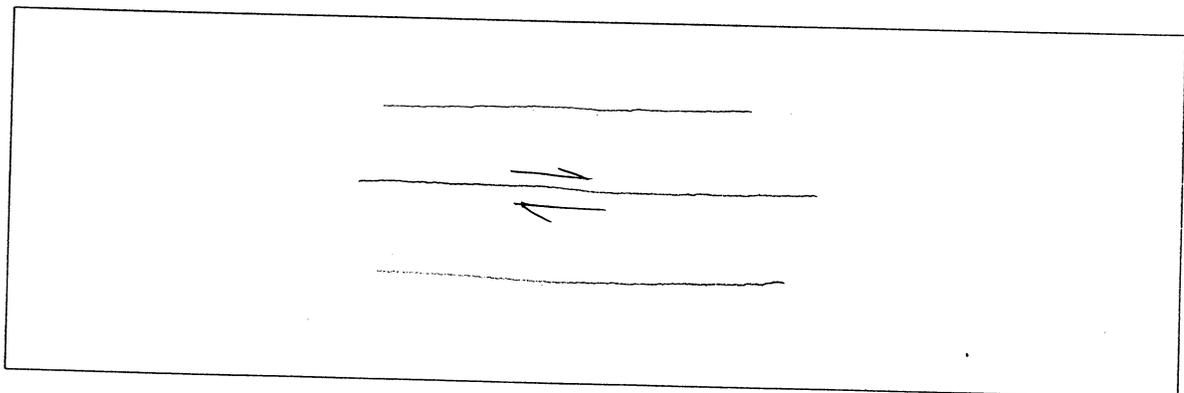


Estimated Top Box Weight: \_\_\_\_\_

Measured Top Box Weight: 15.7 lb

$\sigma_n$	<u>25</u>	<u>75</u>	<u>150</u>	psi
$F_n$	<u>119</u>	<u>357</u>	<u>714</u>	lb
$F_{n-w_b}$	<u>103</u>	<u>341</u>	<u>678</u>	lb

Joint Profiles

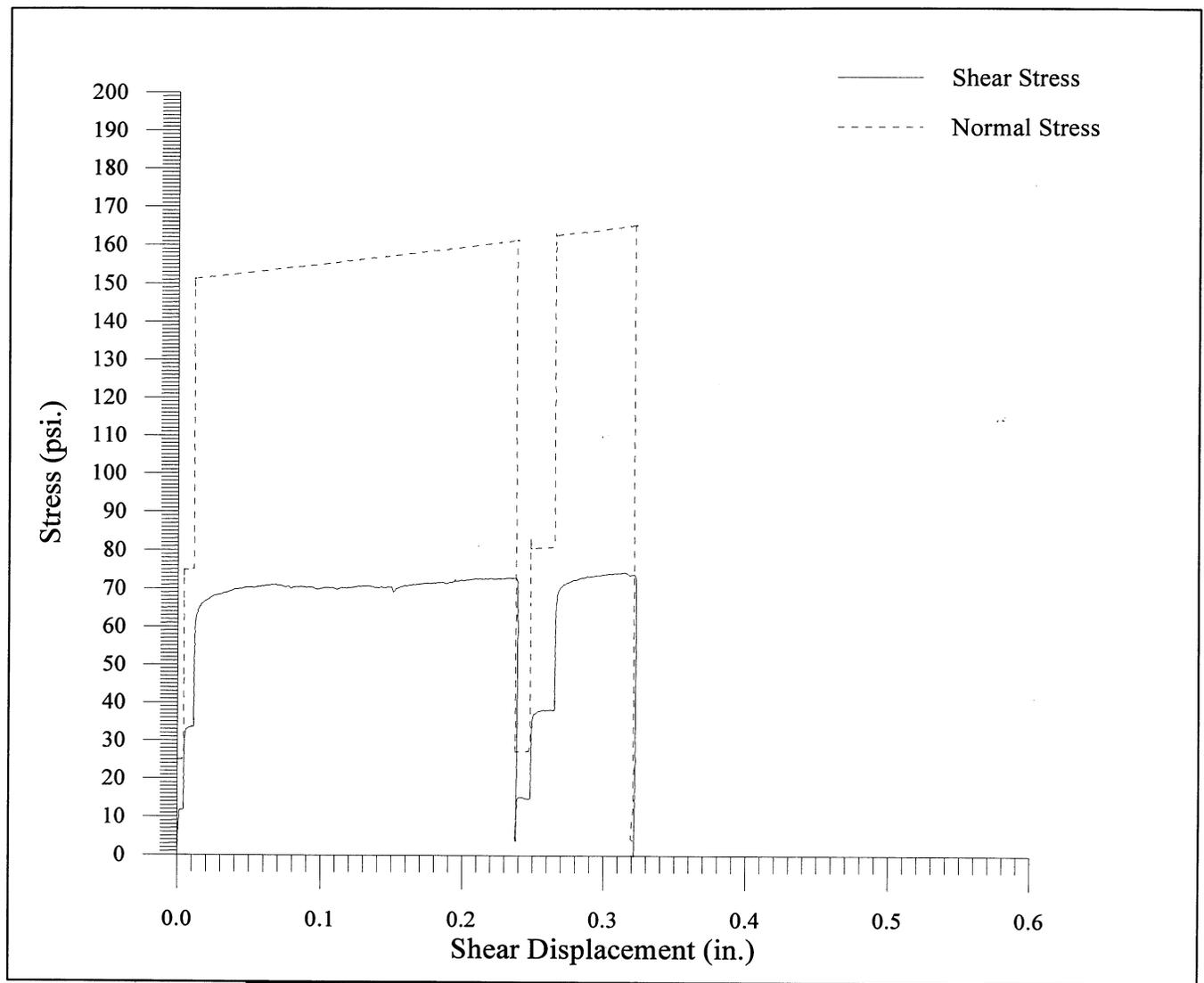


Summary of Test Results

Rate of Loading				
Shr. Displ. Rate				
Normal Stress				
Shear Strength				

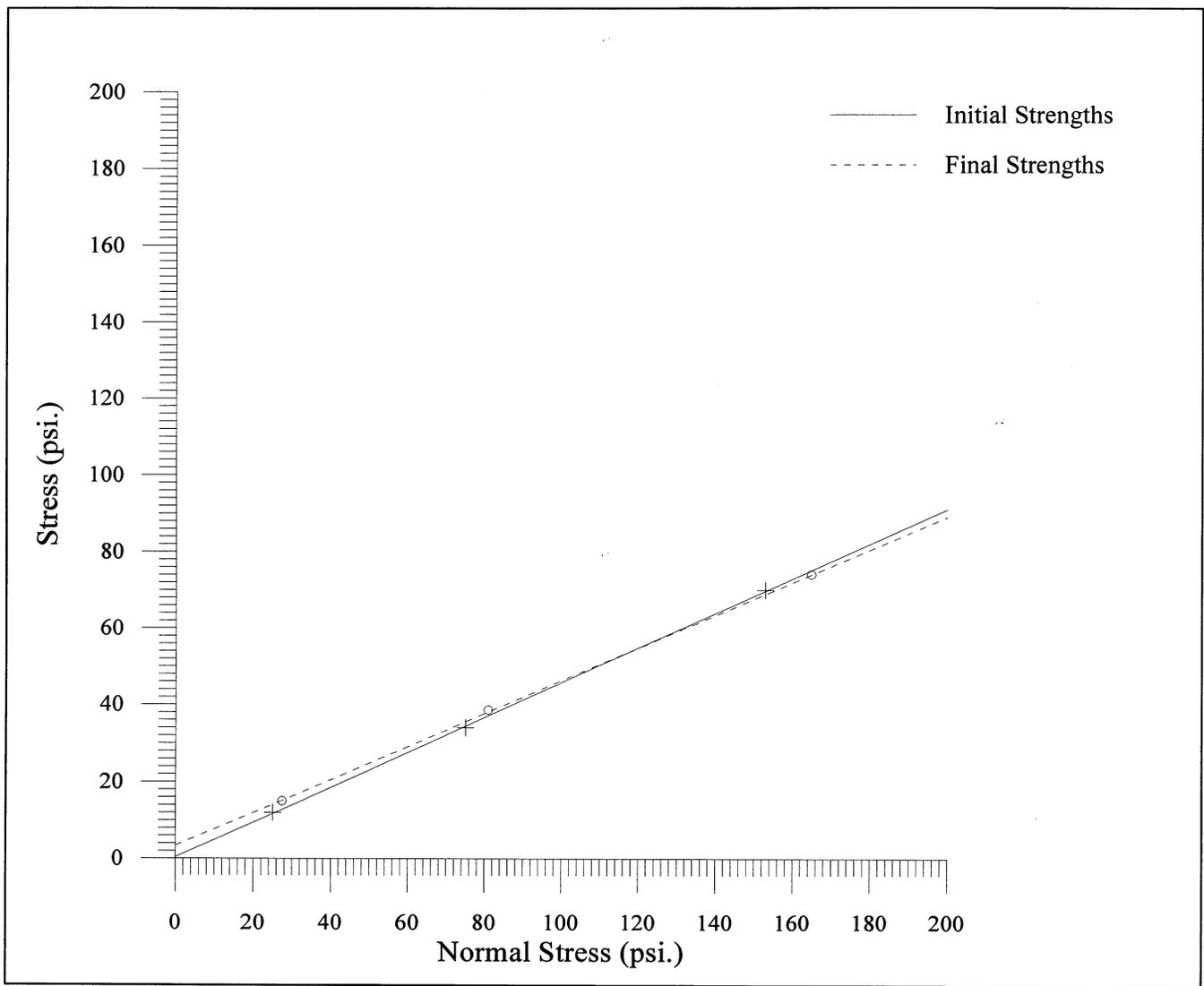
S<sub>j</sub>: \_\_\_\_\_

φ: \_\_\_\_\_



**DIRECT SHEAR TEST**  
**Shear and Normal Stress vs. Shear Displacement**

<p><b>SAMPLE ID:</b> Boring: 98-24          Sample: 21b          Depth: 79'</p> <p style="text-align: center;"><b>DESCRIPTION</b></p> <p>Planar bedding plane joint in dark gray claystone at a claystone/siltstone interface.</p> <table style="width: 100%; margin-top: 10px;"> <thead> <tr> <th style="width: 10%;"></th> <th style="width: 40%; text-align: center;">Normal Stress</th> <th style="width: 50%; text-align: center;">Shear Strength</th> </tr> </thead> <tbody> <tr> <td rowspan="3" style="vertical-align: top;">Initial</td> <td style="text-align: center;">25</td> <td style="text-align: center;">12</td> </tr> <tr> <td style="text-align: center;">75</td> <td style="text-align: center;">34</td> </tr> <tr> <td style="text-align: center;">153</td> <td style="text-align: center;">70</td> </tr> <tr> <td rowspan="3" style="vertical-align: top;">Final</td> <td style="text-align: center;">27.5</td> <td style="text-align: center;">15</td> </tr> <tr> <td style="text-align: center;">81</td> <td style="text-align: center;">38.5</td> </tr> <tr> <td style="text-align: center;">165</td> <td style="text-align: center;">74</td> </tr> </tbody> </table>		Normal Stress	Shear Strength	Initial	25	12	75	34	153	70	Final	27.5	15	81	38.5	165	74	<div style="text-align: center; margin-bottom: 10px;">  <p><b>Geo Test Unlimited</b></p> </div> <p style="text-align: right;">800 Peralta Ave          San Leandro, CA 94577</p> <hr/> <p><b>Client:</b> Fugro West, Inc.          5855 Olivas Park Dr.          Ventura, CA 93003</p> <p><b>Project:</b> San Francisco Oakland Bay Bridge          East Span Replacement Project</p> <p><b>Job Number:</b> 98-42-0053</p> <hr/> <p><b>Test Date:</b> October 30, 1998</p>
	Normal Stress	Shear Strength																
Initial	25	12																
	75	34																
	153	70																
Final	27.5	15																
	81	38.5																
	165	74																



**DIRECT SHEAR TEST  
Failure Envelope**

<p><b>SAMPLE ID:</b> Boring: 98-24 Sample: 21b Depth: 79'</p> <p align="center"><b>DESCRIPTION</b></p> <p>Planar bedding plane joint in dark gray claystone at a claystone/siltstone interface.</p> <table border="1"> <thead> <tr> <th></th> <th>Shear Intercept (psi)</th> <th>Friction Angle (degrees)</th> </tr> </thead> <tbody> <tr> <td>Initial</td> <td>0.4</td> <td>24.4</td> </tr> <tr> <td>Final</td> <td>3.4</td> <td>23.2</td> </tr> </tbody> </table>		Shear Intercept (psi)	Friction Angle (degrees)	Initial	0.4	24.4	Final	3.4	23.2	<p align="center"> <i>Geo</i>  <i>Test</i>  <b>Unlimited</b> 800 Peralta Ave  San Leandro, CA 94577 </p>
		Shear Intercept (psi)	Friction Angle (degrees)							
Initial	0.4	24.4								
Final	3.4	23.2								
<p><b>Client:</b> Fugro West, Inc. 5855 Olivas Park Dr. Ventura, CA 93003</p> <p><b>Project:</b> San Francisco Oakland Bay Bridge East Span Replacement Project</p> <p><b>Job Number:</b> 98-42-0053</p> <p><b>Test Date:</b> October 30, 1998</p>										

**DATA SHEET**  
**Direct Shear of Rock (ISRM)**

Date: 10/30/98

Person performing the test: A. Bro

Client: Fugro

Job: #92-SFO3B

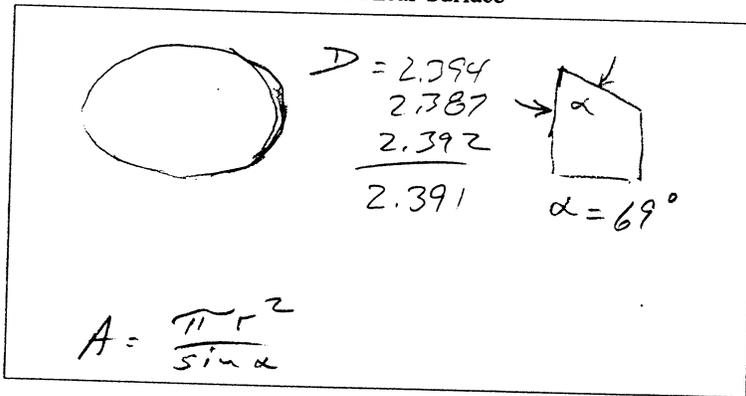
Sample ID: B98-24 S21C

Sample Description: Planar bedding joint in dark gray claystone

Sample Depth: 80'

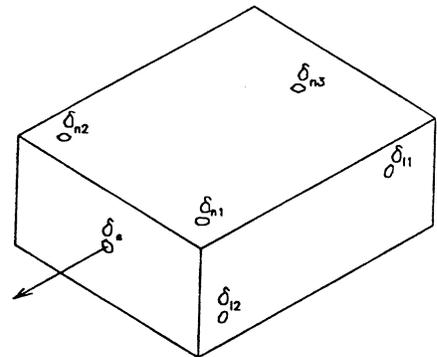
Sample Water Condition: received & tested moist

Sketch of Shear Surface



Sample area: 4.809 in<sup>2</sup>

Location of LVDTs on top shear box

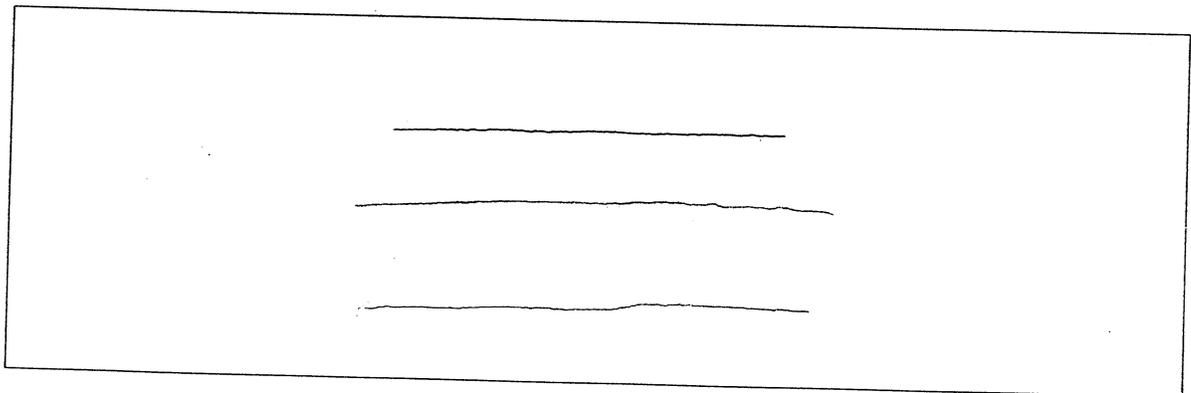


Estimated Top Box Weight: \_\_\_\_\_

Measured Top Box Weight: 16.1

$\sigma_n$	<u>25</u>	<u>75</u>	<u>150</u>	psi
$F_n$	<u>120</u>	<u>360</u>	<u>720</u>	lb
$F_n - W_b$	<u>104</u>	<u>344</u>	<u>704</u>	

Joint Profiles

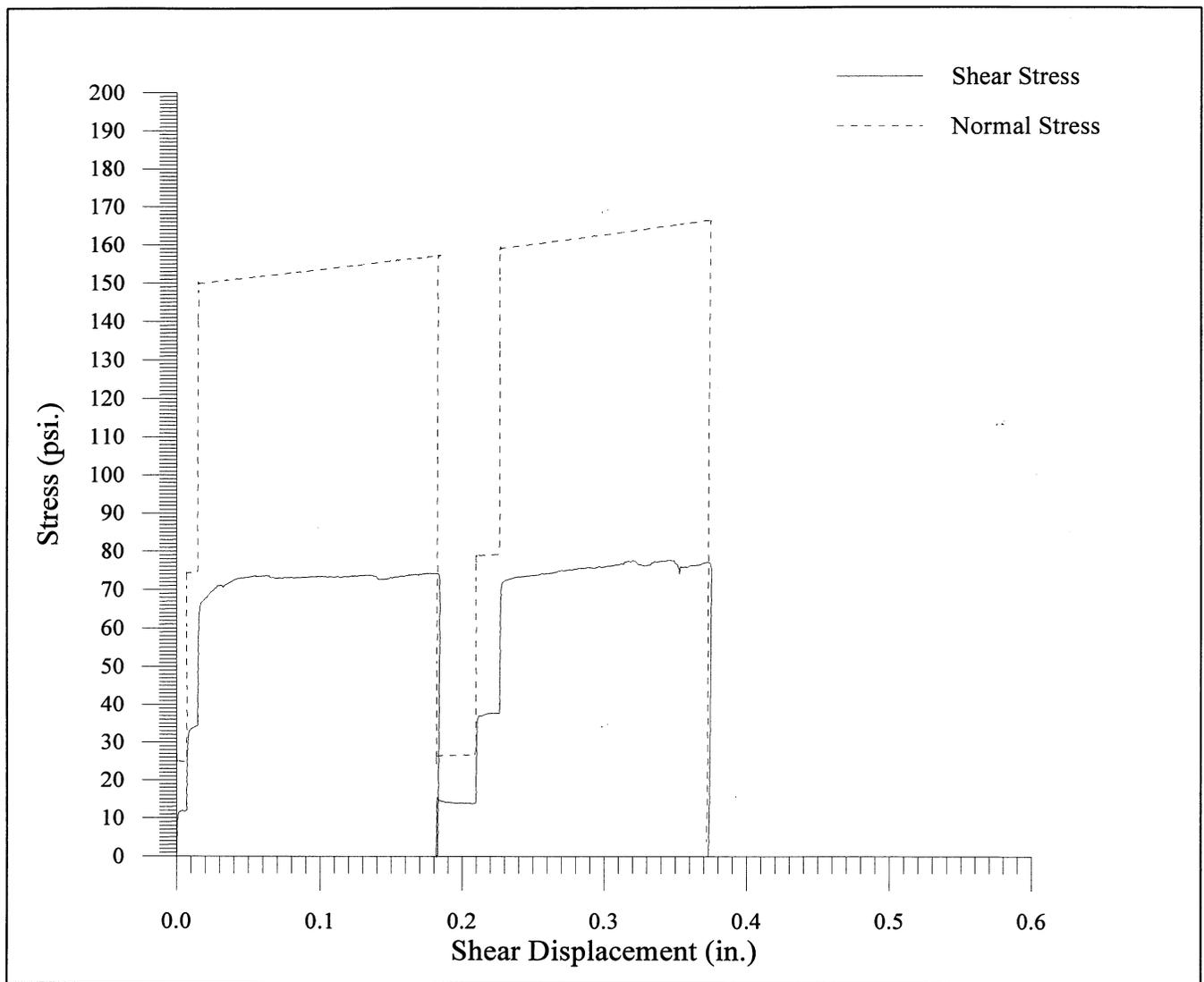


Summary of Test Results

Rate of Loading				
Shr. Displ. Rate				
Normal Stress				
Shear Strength				

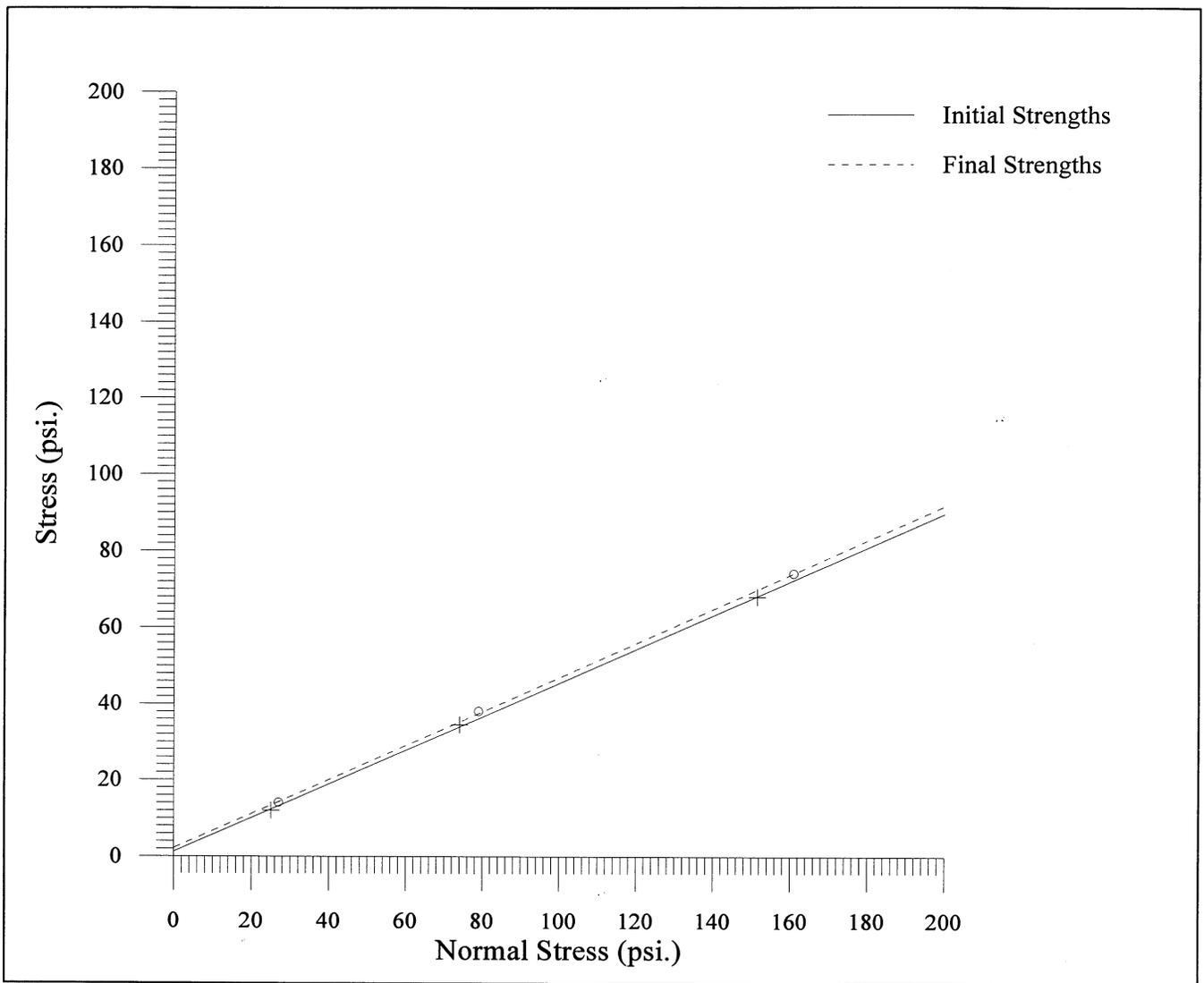
Sj: \_\_\_\_\_

phi: \_\_\_\_\_



**DIRECT SHEAR TEST**  
**Shear and Normal Stress vs. Shear Displacement**

<p><b>SAMPLE ID:</b> Boring: 98-24          Sample: 21c          Depth: 80'</p> <p style="text-align: center;"><b>DESCRIPTION</b></p> <p style="text-align: center;">Planar bedding plane joint in          dark gray claystone.</p>	<div style="text-align: center;">  </div> <p style="text-align: right;">800 Peralta Ave          San Leandro, CA 94577</p>																	
<table style="width: 100%; border-collapse: collapse;"> <thead> <tr> <th style="width: 10%;"></th> <th style="width: 40%; border-bottom: 1px solid black;">Normal Stress</th> <th style="width: 50%; border-bottom: 1px solid black;">Shear Strength</th> </tr> </thead> <tbody> <tr> <td rowspan="3" style="vertical-align: top;">Initial</td> <td style="text-align: center;">25</td> <td style="text-align: center;">12</td> </tr> <tr> <td style="text-align: center;">74</td> <td style="text-align: center;">34.5</td> </tr> <tr> <td style="text-align: center;">151.5</td> <td style="text-align: center;">68</td> </tr> <tr> <td rowspan="3" style="vertical-align: top;">Final</td> <td style="text-align: center;">27</td> <td style="text-align: center;">14</td> </tr> <tr> <td style="text-align: center;">79</td> <td style="text-align: center;">38</td> </tr> <tr> <td style="text-align: center;">161</td> <td style="text-align: center;">74</td> </tr> </tbody> </table>		Normal Stress	Shear Strength	Initial	25	12	74	34.5	151.5	68	Final	27	14	79	38	161	74	<p><b>Client:</b> Fugro West, Inc.          5855 Olivas Park Dr.          Ventura, CA 93003</p> <p><b>Project:</b> San Francisco Oakland Bay Bridge          East Span Replacement Project</p> <p><b>Job Number:</b> 98-42-0053</p>
	Normal Stress	Shear Strength																
Initial	25	12																
	74	34.5																
	151.5	68																
Final	27	14																
	79	38																
	161	74																
<p><b>Test Date:</b> October 30, 1998</p>																		



**DIRECT SHEAR TEST  
Failure Envelope**

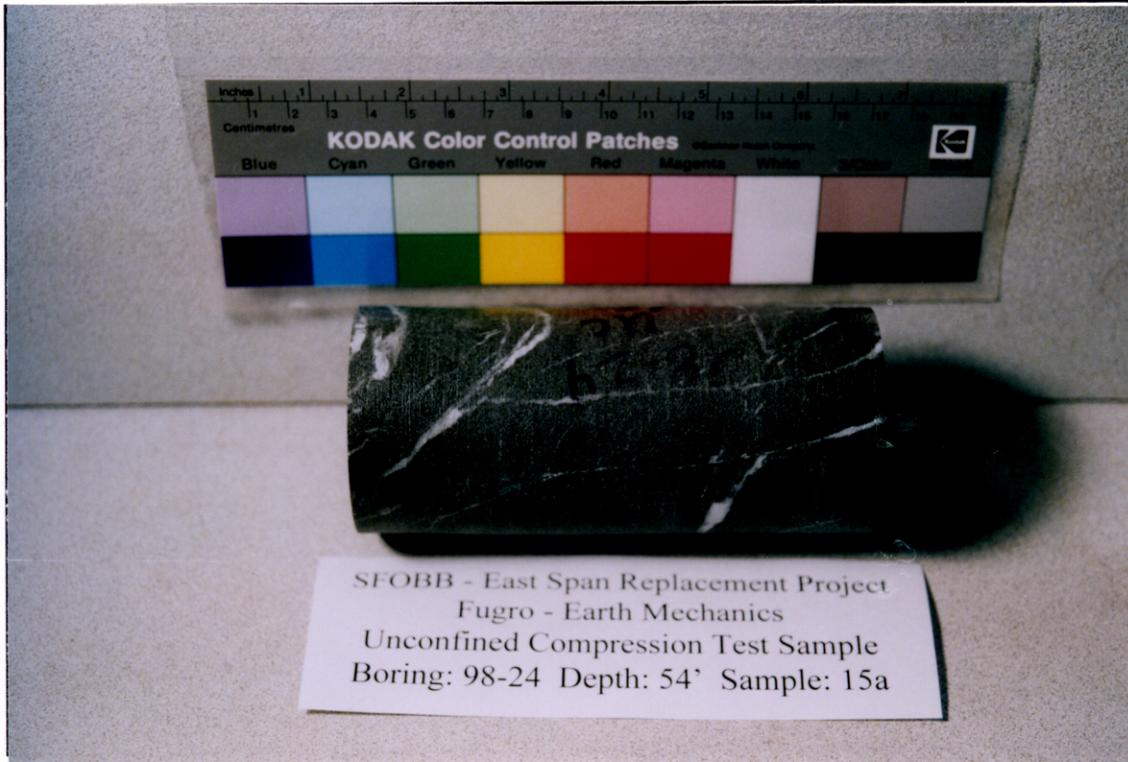
<p><b>SAMPLE ID:</b> Boring: 98-24 Sample: 21c Depth: 80'</p> <p style="text-align: center;"><b>DESCRIPTION</b></p> <p style="text-align: center;">Planar bedding plane joint in dark gray claystone.</p> <table style="width: 100%; margin-top: 10px;"> <thead> <tr> <th></th> <th style="text-align: center;">Shear Intercept (psi)</th> <th style="text-align: center;">Friction Angle (degrees)</th> </tr> </thead> <tbody> <tr> <td style="text-align: left;">Initial</td> <td style="text-align: center;">1.3</td> <td style="text-align: center;">23.8</td> </tr> <tr> <td style="text-align: left;">Final</td> <td style="text-align: center;">2.2</td> <td style="text-align: center;">24.1</td> </tr> </tbody> </table>		Shear Intercept (psi)	Friction Angle (degrees)	Initial	1.3	23.8	Final	2.2	24.1	<div style="text-align: center;">  <p><b>800 Peralta Ave San Leandro, CA 94577</b></p> </div> <p><b>Client:</b> Fugro West, Inc. 5855 Olivas Park Dr. Ventura, CA 93003</p> <p><b>Project:</b> San Francisco Oakland Bay Bridge East Span Replacement Project</p> <p><b>Job Number:</b> 98-42-0053</p> <p><b>Test Date:</b> October 30, 1998</p>
	Shear Intercept (psi)	Friction Angle (degrees)								
Initial	1.3	23.8								
Final	2.2	24.1								

# Photographs

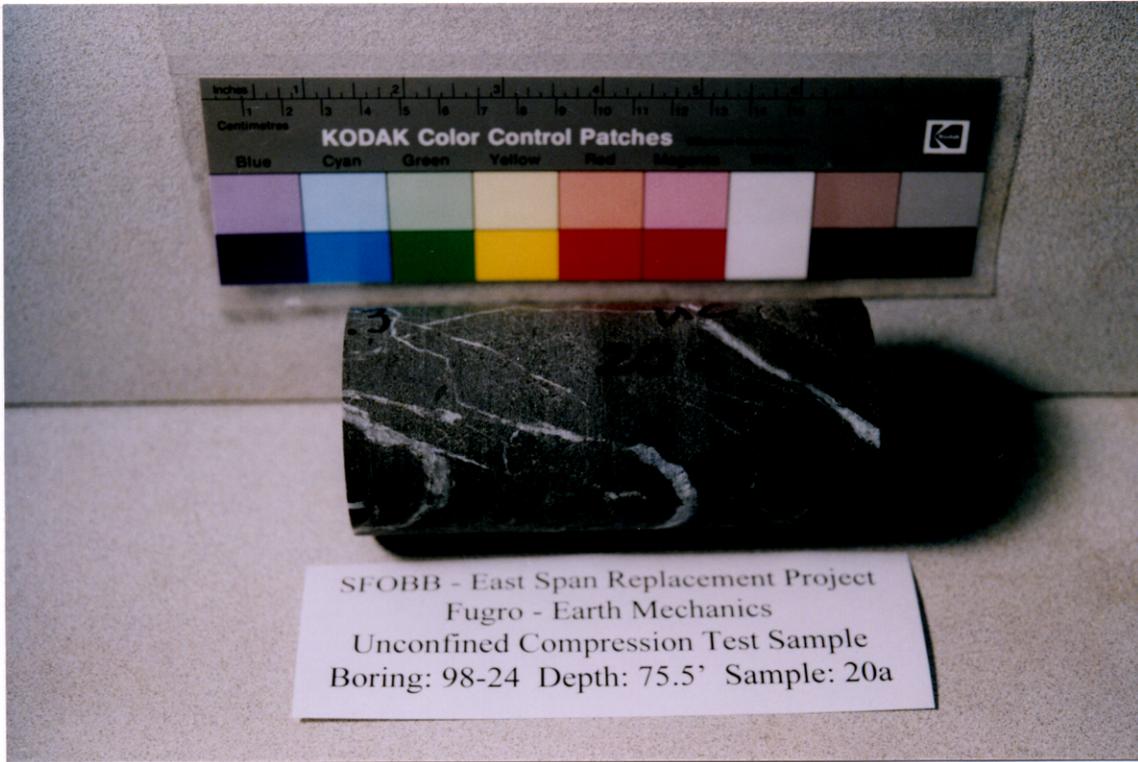












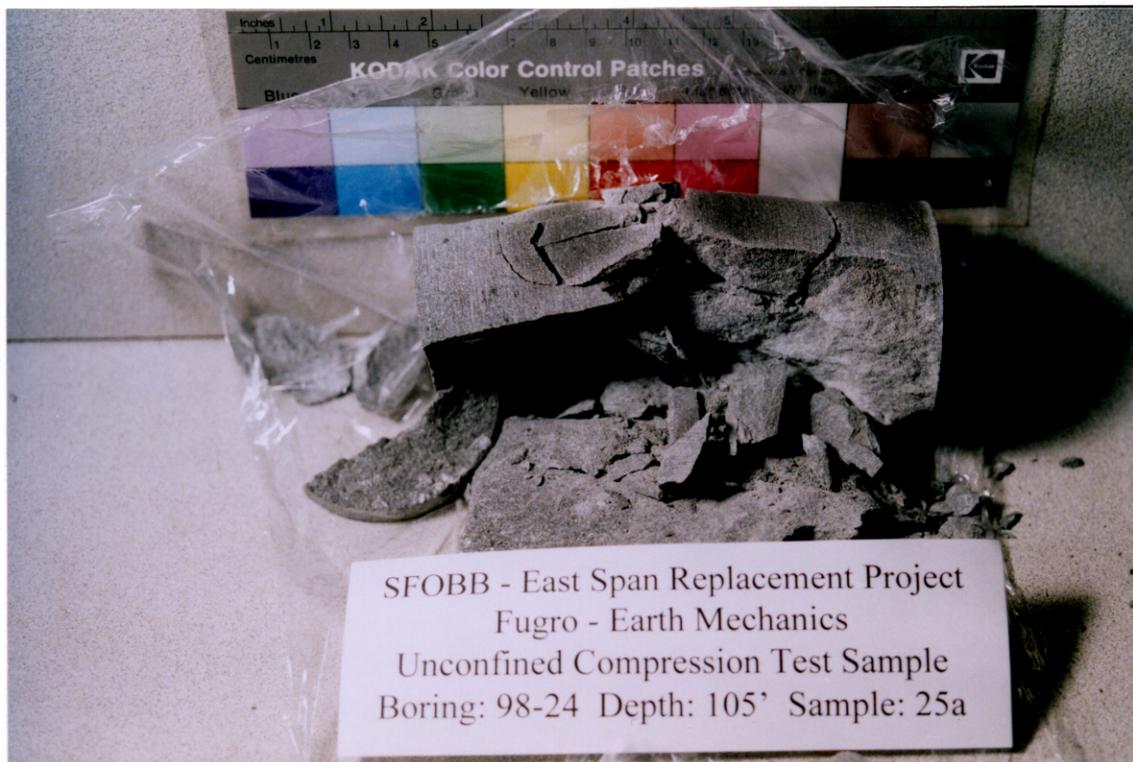








SFOBB - East Span Replacement Project  
Fugro - Earth Mechanics  
Unconfined Compression Test Sample  
Boring: 98-24 Depth: 105' Sample: 25a



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Unconfined Compression Test Sample  
Boring: 98-24 Depth: 105' Sample: 25a



**BORING 98-48**

## **Modulus and Unconfined Compression Tests**

DATA SHEET

Determination of Rock Modulus and Poisson's Ratio (ASTM D3148)

Date: 10/27/98

Person performing the test: A. Bro

Client: Fugro

Job: #92-SFOBB

Sample ID: B98-24A, S6a

Sample Description: Massive tan sandstone with an unhealed fracture about 72° to the core axis (spec needed to maintain sample integrity)

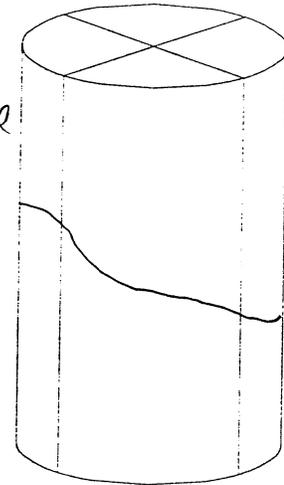
Sample Depth: 33'

Sample Condition: received & tested moist

d <sub>1</sub>	d <sub>2</sub>
2.384	2.378
2.391	2.383
2.392	2.388
2.383	2.388
2.393	2.392

l <sub>1</sub>	l <sub>2</sub>
- .0023	- .0014
± .0001	± .0001
+ .0022	+ .0010

non-parallel due to open joint



Avg. diameter: 2.387

Avg. length: 5.005"

Sample area: 4.475

l/d ratio: 2.10

Sample volume (in<sup>3</sup>): 22.400

Sample weight (g): 983.2g

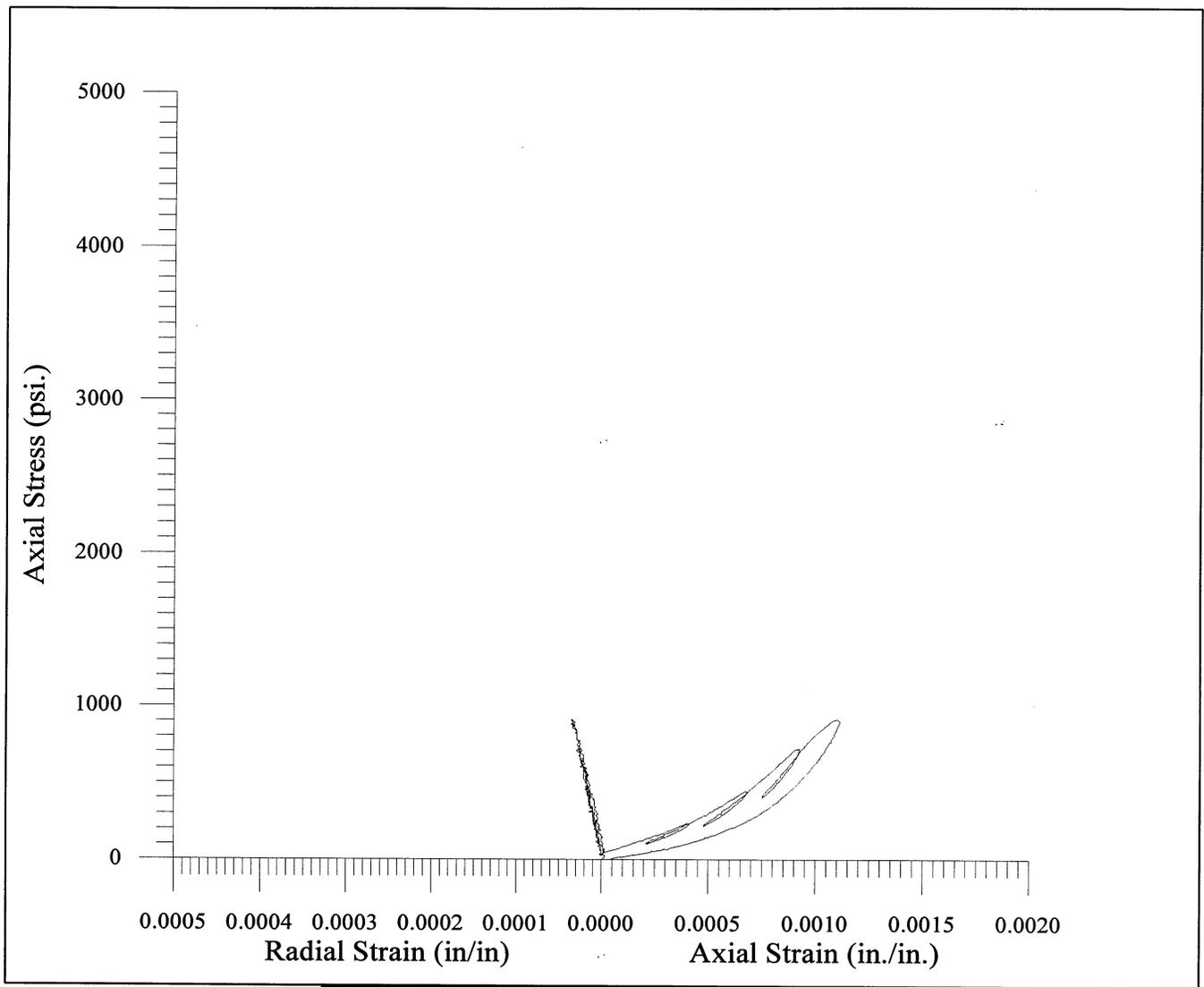
Density: 43.908/in<sup>3</sup> = 167.2 pcf (1 g/in<sup>3</sup> = 3.8095 lb/ft<sup>3</sup>)

Gauge length: 2.000"

Comments: Bad v due to open fracture (very low E)

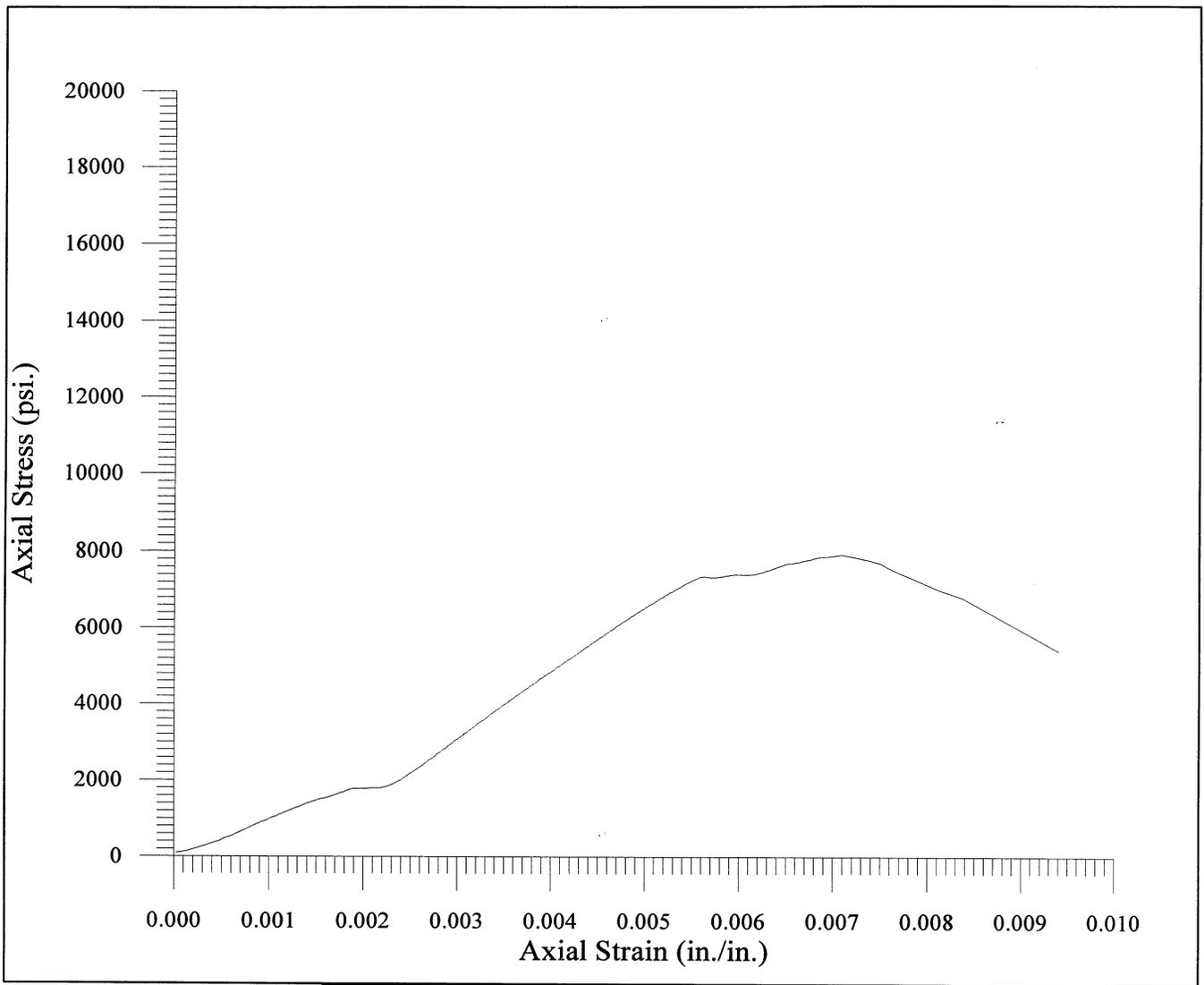
may be able to use this test to determine joint normal stiffness! Assume v, use E<sub>r</sub> to get E<sub>n</sub> of intact rock & then S<sub>a</sub>ness - S<sub>a</sub> assumed = S<sub>a</sub> across fracture.

UC: 1<sup>st</sup> relaxation probably due to compression of the joint. Failed by splitting.



**ELASTIC MODULUS TEST**  
**Axial Stress vs. Axial & Radial Strain**

<p><b>SAMPLE ID:</b> Boring: 98-24a  Sample: 6a  Depth: 33'</p> <p style="text-align: center;"><b>DESCRIPTION</b></p> <p>Massive tan sandstone with an unhealed fracture about 72 degrees to the core axis.</p> <p><b>MODULUS:</b> 1,690,000 psi (NA?)  <b>POISSON'S RATIO:</b> NA (.07)</p>	<div style="text-align: center;">   <b>Geo Test Unlimited</b> </div> <p style="text-align: right;">800 Peralta Ave  San Leandro, CA 94577</p> <hr/> <p><b>Client:</b> Fugro West, Inc.  5855 Olivas Park Dr.  Ventura, CA 93003</p> <p><b>Project:</b> San Francisco Oakland Bay Bridge  East Span Replacement Project</p> <p><b>Job Number:</b> 98-42-0053</p> <hr/> <p><b>Test Date:</b> October 27, 1998</p>
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**UNCONFINED COMPRESSION TEST**  
**Axial Stress vs. Axial Strain**

**SAMPLE ID:** Boring : 98-24A  
 Sample: 6a  
 Depth: 33'

**DESCRIPTION**

Massive tan sandstone with an unhealed fracture about 72 degrees to the core axis.

**STRENGTH:** 7901 psi

*Geo*  *Test*  
**Unlimited** 800 Peralta Ave  
 San Leandro, CA 94577

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**Client:** Fugro West, Inc.  
 5855 Olivas Park Dr.  
 Ventura, CA 93003

**Project:** San Francisco Oakland Bay Bridge  
 East Span Replacement Project

**Job Number:** 98-42-0053

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**Test Date:** October 27, 1998

DATA SHEET

Determination of Rock Modulus and Poisson's Ratio (ASTM D3148)

Date: 10/27/98

Person performing the test: ABTO

Client: Fugro

Job: #92-SFOBB

Sample ID: B98-24A, STA

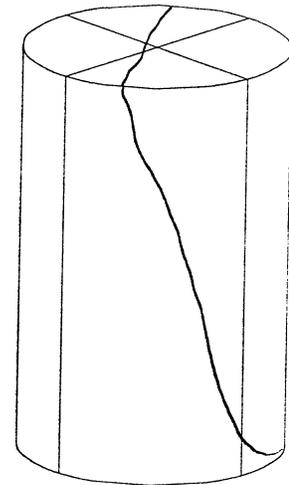
Sample Description: medium dark gray fine sandy siltstone with a calcite healed hairline fracture about 15° to the core axis.

Sample Depth: 38'

Sample Condition: received & tested moist

d <sub>1</sub>	d <sub>2</sub>
2.394	2.393
2.390	2.393
2.392	2.393
2.394	2.392
2.393	2.392

l <sub>1</sub>	l <sub>2</sub>
-0.0009	-0.0002
±0.0001	±0.0001
+0.0009	+0.0001



Avg. diameter: 2.393

Avg. length: 5.325

Sample area: 4.498

l/d ratio: 2.23

Sample volume (in<sup>3</sup>): 23.949

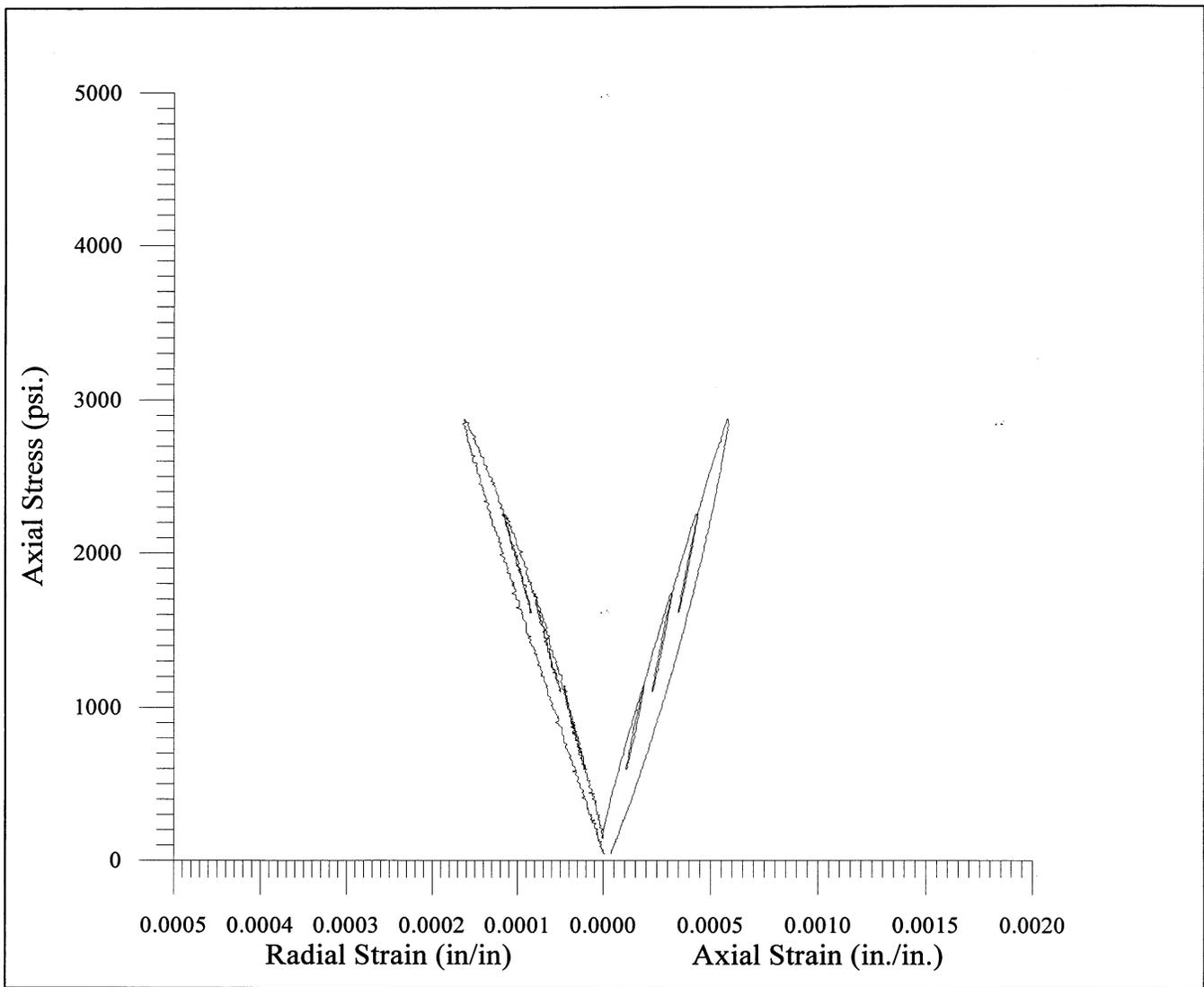
Sample weight (g): 1061.6g

Density: 44.338/in<sup>3</sup> = 168.9 pcf (1 g/in<sup>3</sup> = 3.8095 lb/ft<sup>3</sup>)

Gauge length: 2.000 in.

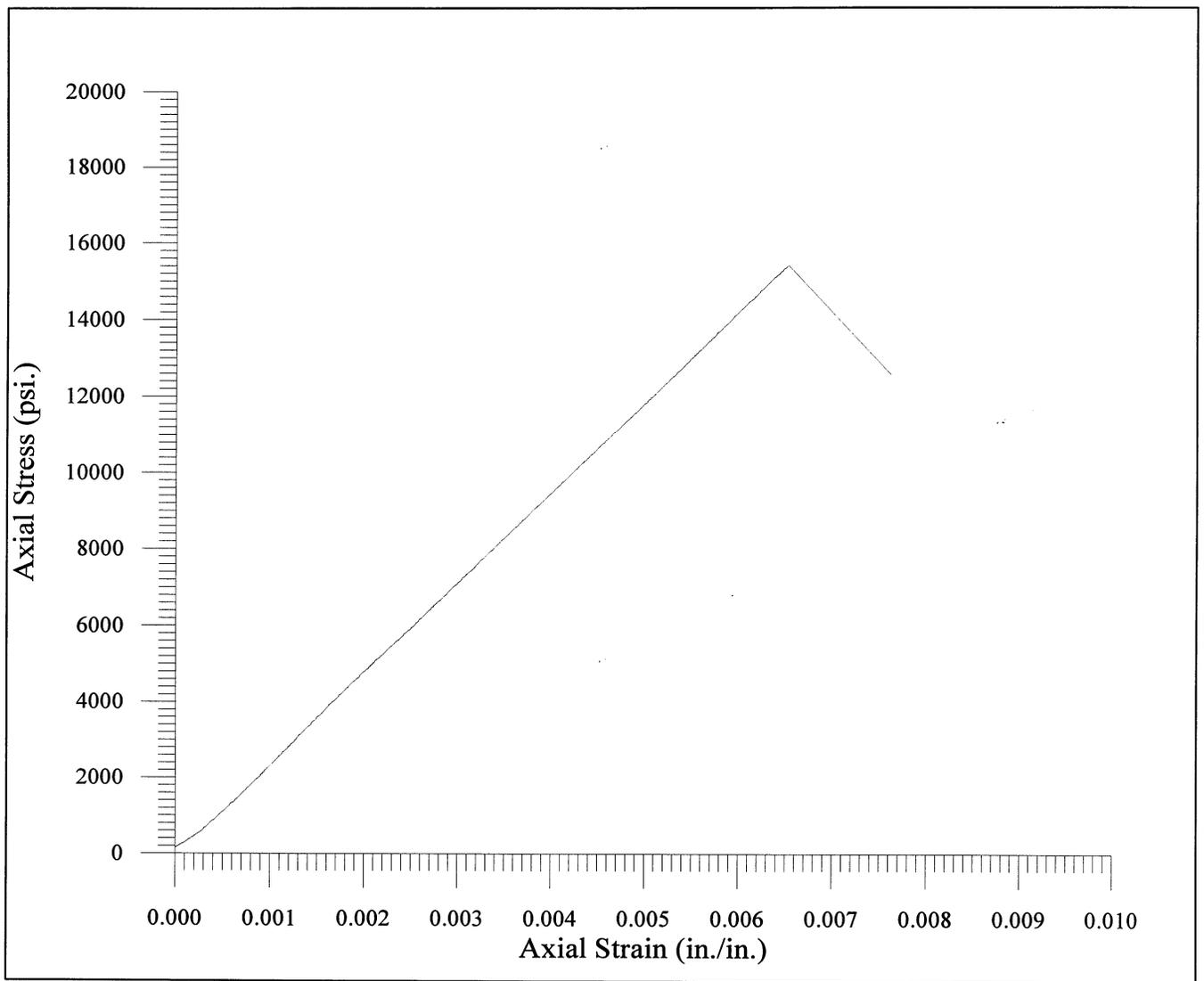
Comments: failed by axial splitting along steep healed joint.

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**ELASTIC MODULUS TEST**  
**Axial Stress vs. Axial & Radial Strain**

<p><b>SAMPLE ID:</b> Boring: 98-24a  Sample: 7a  Depth: 38'</p>	<p align="center"> <i>Geo</i>  <i>Test</i>  <b>Unlimited</b> 800 Peralta Ave  San Leandro, CA 94577 </p>
<p align="center"><b>DESCRIPTION</b></p> <p>Medium dark gray fine sandy siltstone with a calcite healed hairline fracture about 15 degrees to the core axis.</p> <p><b>MODULUS:</b> 6,670,000 psi  <b>POISSON'S RATIO:</b> .33</p>	<p><b>Client:</b> Fugro West, Inc.  5855 Olivas Park Dr.  Ventura, CA 93003</p> <p><b>Project:</b> San Francisco Oakland Bay Bridge  East Span Replacement Project</p> <p><b>Job Number:</b> 98-42-0053</p>
	<p><b>Test Date:</b> October 27, 1998</p>



**UNCONFINED COMPRESSION TEST**  
**Axial Stress vs. Axial Strain**

<p><b>SAMPLE ID:</b> Boring : 98-24A  Sample: 7a  Depth: 38'</p> <p align="center"><b>DESCRIPTION</b></p> <p>Medium dark gray fine sandy siltstone with a calcite healed hairline fracture about 15 degrees to the core axis.</p> <p><b>STRENGTH:</b> 15,417 psi</p>	 <p><b>800 Peralta Ave</b>  <b>San Leandro, CA 94577</b></p>
	<p><b>Client:</b> <b>Fugro West, Inc.</b>  <b>5855 Olivas Park Dr.</b>  <b>Ventura, CA 93003</b></p>
	<p><b>Project:</b> <b>San Francisco Oakland Bay Bridge</b>  <b>East Span Replacement Project</b></p>
	<p><b>Job Number:</b> <b>98-42-0053</b></p>
<p><b>Test Date:</b> <b>October 27, 1998</b></p>	

DATA SHEET

Determination of Rock Modulus and Poisson's Ratio (ASTM D3148)

Date: 10/27/98

Person performing the test: A Bro

Client: Ford

Job: #92-5FOBB

Sample ID: B98-24A 58a massive

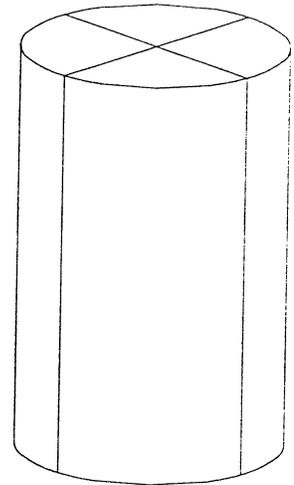
Sample Description: Dark gray fine sandy siltstone w/no visible fractures.

Sample Depth: 48'

Sample Condition: received & tested moist

d <sub>1</sub>	d <sub>2</sub>
2.382	2.361
2.376	2.365
2.376	2.363
2.379	2.373
2.390	2.389

l <sub>1</sub>	l <sub>2</sub>
-.0008	-.0002
+.0001	+.0001
+.0008	+.0001



Avg. diameter: 2.375

Avg. length: 5.306"

Sample area: 4.430

l/d ratio: 2.23

Sample volume(in<sup>3</sup>): 23.506

Sample weight (g): 1040.38

Density: 44.268/in<sup>3</sup> = 168.6 pcf (1 g/in<sup>3</sup>=3.8095lb/ft<sup>3</sup>)

Gauge length: 2.000 in.

Comments: Failed by axial splitting

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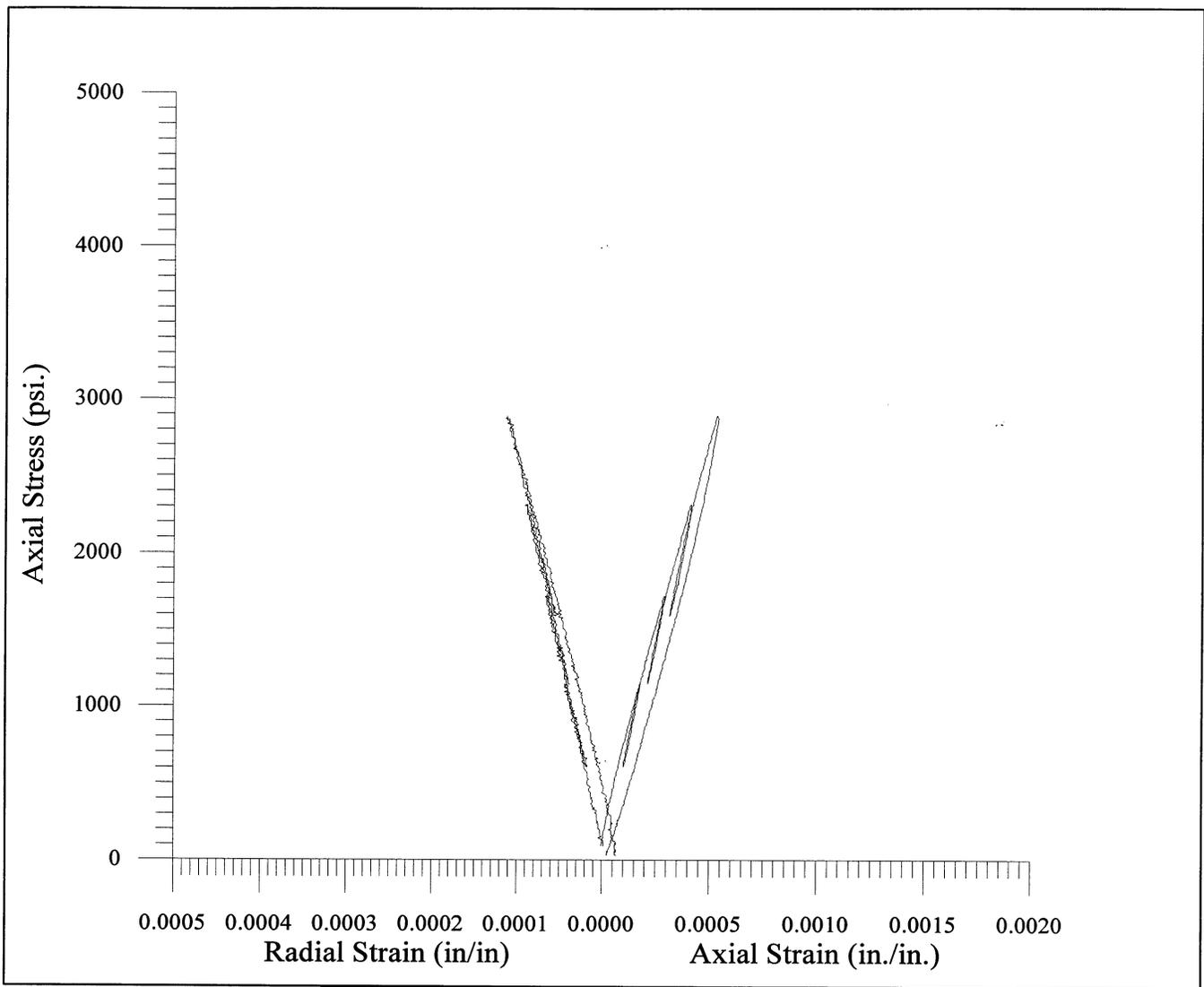
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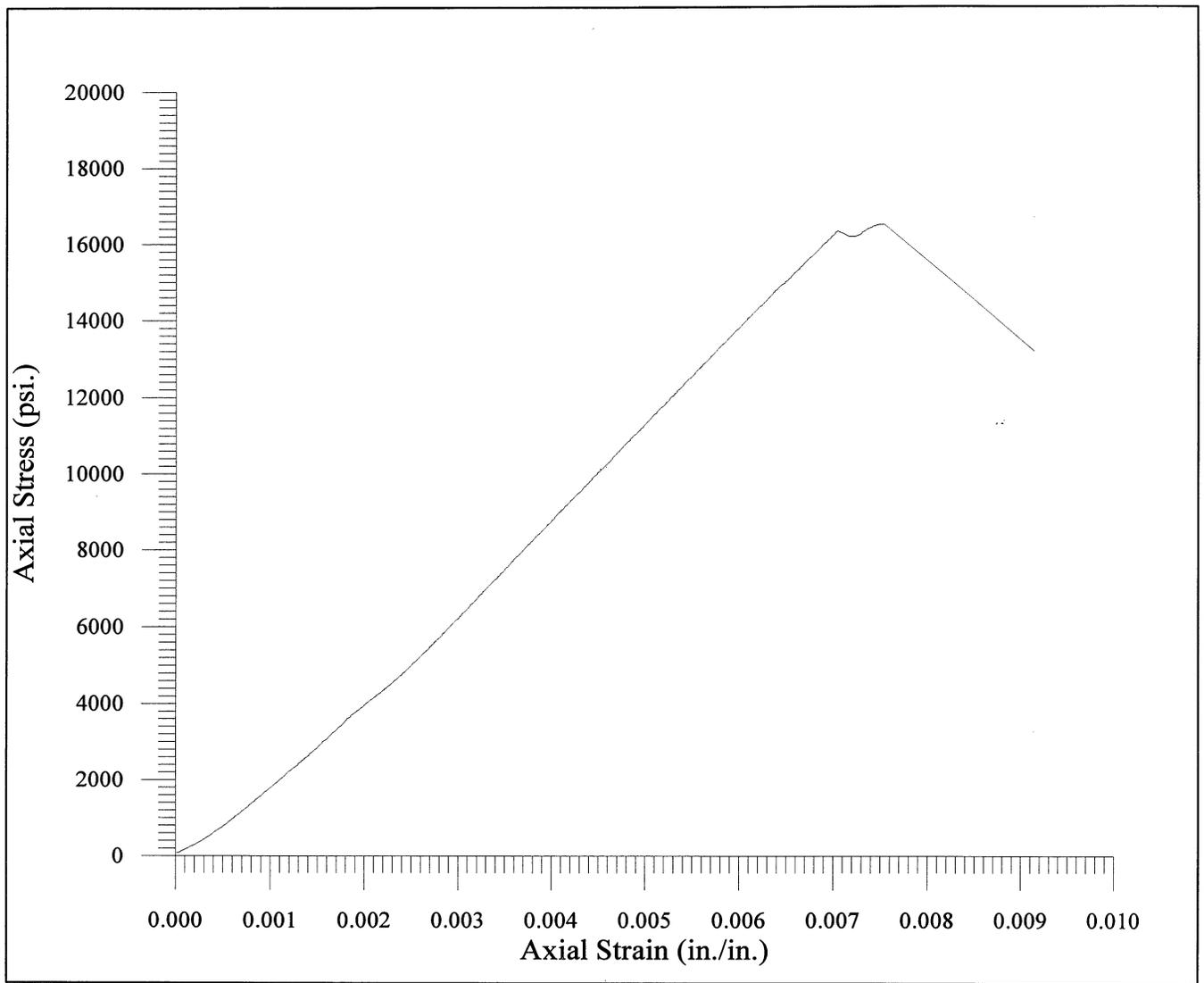


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**ELASTIC MODULUS TEST  
Axial Stress vs. Axial & Radial Strain**

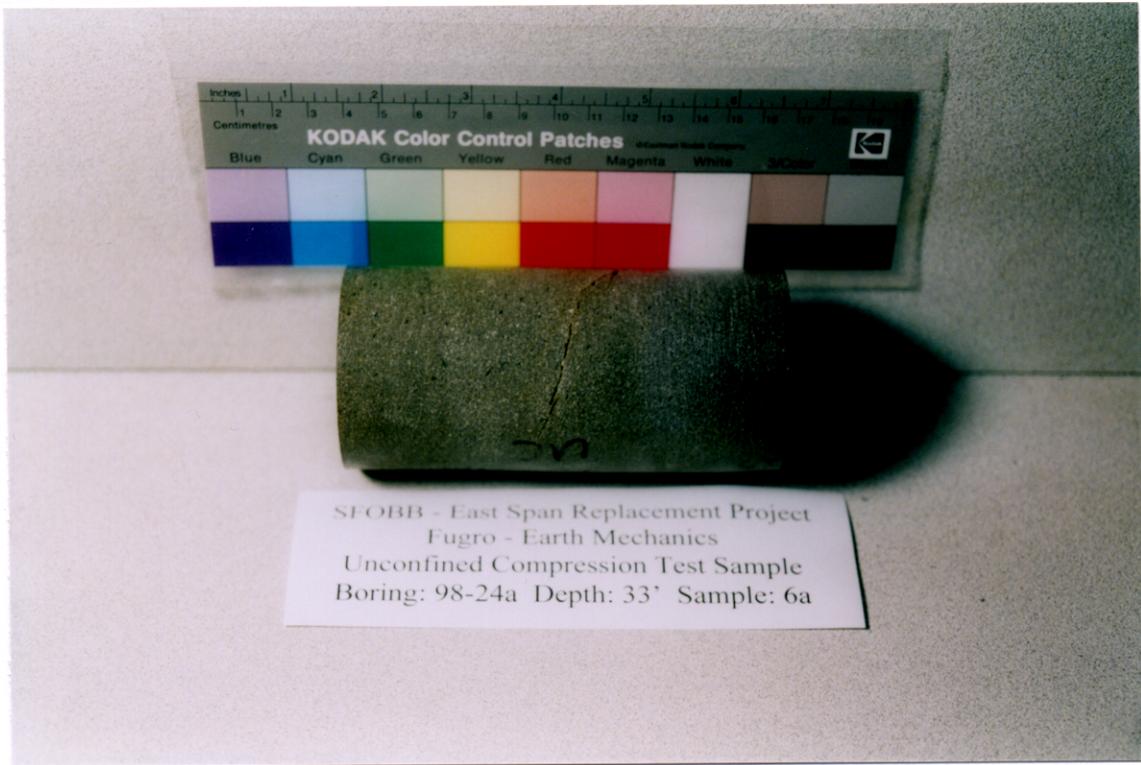
<p><b>SAMPLE ID:</b> Boring: 98-24a Sample: 8a Depth: 48'</p> <p><b>DESCRIPTION</b> Dark gray massive fine sandy siltstone with no visible fractures.</p> <p><b>MODULUS:</b> 7,040,000 psi <b>POISSON'S RATIO:</b> .31</p>	<div style="text-align: center;">   <b>Geo Test Unlimited</b>              800 Peralta Ave              San Leandro, CA 94577         </div> <hr/> <p><b>Client:</b> Fugro West, Inc. 5855 Olivas Park Dr. Ventura, CA 93003</p> <p><b>Project:</b> San Francisco Oakland Bay Bridge East Span Replacement Project</p> <p><b>Job Number:</b> 98-42-0053</p> <hr/> <p><b>Test Date:</b> October 27, 1998</p>
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**UNCONFINED COMPRESSION TEST**  
**Axial Stress vs. Axial Strain**

<p><b>SAMPLE ID:</b> Boring : 98-24A          Sample: 8a          Depth: 48'</p>	<p align="center"> <i>Geo</i>  <i>Test</i>  <b>Unlimited</b> 800 Peralta Ave          San Leandro, CA 94577       </p>
<p align="center"><b>DESCRIPTION</b></p> <p>Dark gray massive fine sandy siltstone          with no visible fractures.</p> <p><b>STRENGTH:</b> 16,514 psi</p>	<p><b>Client:</b> Fugro West, Inc.          5855 Olivas Park Dr.          Ventura, CA 93003</p> <p><b>Project:</b> San Francisco Oakland Bay Bridge          East Span Replacement Project</p> <p><b>Job Number:</b> 98-42-0053</p>
	<p><b>Test Date:</b> October 27, 1998</p>

# Photographs







SFOBB - East Span Replacement Project  
Fugro - Earth Mechanics  
Unconfined Compression Test Sample  
Boring: 98-24a Depth: 48' Sample: 8a



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Unconfined Compression Test Sample  
Boring: 98-24a Depth: 48' Sample: 8a