McClelland engineers, inc. / geotechnical consultants
6100 HILLCROFT / HOUSTON, TEXAS 77081
TEL. 713 / 772-3701 / TELEX 762-447

Report No. 0181-0217
Supplement No. 1
May 4, 1982

Det Norske Veritas
Research Division
Section for Ocean Environments
and Geotechnics
P.O. Box 300, N-1322 NOVIK
Oslo, Norway

Attention: Mr. Tore Kvalstad
Senior Research Engineer

Geotechnical Investigation
West Delta Area
Gulf of Mexico

In response to your telex dated March 31, 1982, we have prepared the following answers to your questions:

A) Remote Vane. Three sizes of vanes were used. The table which follows presents their dimensions. The vane has four blades. The blades are trapezoidal in shape with the longer base welded to the shaft. The short base of this trapezoid has dimension "D". The sides of the trapezoid slope at 45 degrees towards the long base. The blade thickness has been labeled as "F". The diameter of the cylinder when the vane is rotated has been called dimension "E". The shaft diameter has been labeled dimension "A". All dimensions are in inches.

Vane Size	A	D	E	F
Large	0.620	6.015	2.25	0.125
Medium	0.620	4.125	1.749	0.125
Small	0.620	2.656	1.252	0.094

The nominal rate of vane blade rotation was 11 degrees per minute. Time to failure ranged from 26 to 64 seconds with an average of 43 seconds. The large vane was used for undrained shear strength up to 0.7 ksf, the medium vane up to 1.8 ksf, and the small vane up to 5.4 ksf.

B) Miniature Vane. Two sizes of miniature vanes were used. The table which follows presents their dimensions. The vane has four blades. The blades are rectangular in shape. The diameter of the cylinder when the vane is rotated has been labeled dimension "E". The length of the rectangle or height of the vane has been labeled dimension "B". The blade thickness has been labeled as "F" The shaft diameter has been called dimension "A". All dimensions are in inches.

Blade Size	A	B	E	F
Large	0.118	1	1	0.024
Small	0.118	0.5	0.5	0.024

The miniature vane system does not provide a constant rate of strain. Without soil resistance, the vane will rotate at 48 degrees per minute. Calibrated coil springs are selected to provide a rotation of the spring greater than 50 degrees with typical rotations of 90 degrees. Rotation is limited to 180 degrees. These numbers would indicate time to failure of from approximately one to four minutes.

C) Cone Penetration Tests

- Editing Procedure. The edited cone penetration data is presented on Plate 3. The cone data was edited to make data consistent with the conventional CPT data from a mechanical type cone. The raw data was edited to remove the effects of hydrostatic pressure, start and end of a cone push, human errors, boat motion,and radio interference. Each of these items will be discussed in detail below.

The editing was performed using a HP-85 computer and a series of programs specifically designed for editing cone data. All editing was performed by a geotechnical engineer. All edited cone data is recorded on a separate tape, so that the raw cone data is available for examination.

At the beginning of each cone push, the hydrostatic water pressure was measured using the cone tip transducer. The hydrostatic pressure depends on the density of the drilling mud in the borehole, the boring depth, and the water depth. For the geometry of the cone, the measured values ranged from about 0.7 to 0.8 of the computed hydrostatic water pressure at the test depth, where the cone was pushed. The cone data was edited by subtracting the measured hydrostatic pressure from the raw data over the cone test depth.

In the report, the effects of start and end of a cone push are referred to as "shoulders." At the beginning of each push, some finite distance is required to mobilize the soil resistance because of possible drilling disturbance below the bottom of the borehole. Also, at the end of each push when the Swordfish ram is fully extended before removal, reduced resistance is measured because of the inability of the cone to penetrate further. These shoulders are removed to provide a continuous record of actual readings. The computer program will delete the shoulders from the cone records.

Human errors may sometimes be made by the electro-mechanical technician in the field. From the driller, he obtains the start depth. He then records the start depth, finish depth, the cone point and sleeve factors, water depth, etc. A human error can easily be detected by plotting all of the cone pushs on a continuous plot. All of the cone factors, start depth, finish depth, etc., are reviewed and checked by the geotechnical engineer performing the editing.

At very shallow penetrations, the motion compensating system does not have the ability to completely eliminate boat motion. This will cause the cone to move at rates different from the desired rate of 2 cm/sec. This can be easily seen in the cone records. The records will have sharp distinct valleys in the record caused by the cone not penetrating the soil, as the vessel moves upwards. These values are simply eliminated and curves smoothed at those points by the computer program.

Certain radio frequencies can be recorded by the electronic digitizing equipment. These readings are easily identified because of an abrupt variation in sleeve friction and point resistance. The computer program deletes these values and smooths out the curve.

- Plate 10. Changes to the text of the report were sent on April 1, 1982 to Mr. Jack Chan to expand on this question. On page seven of the report, the line, "In addition, we modified the cone resistance by subtracting the existing total overburden at the test depth," has been replaced with the following:

> "The cone resistances which have been corrected for hydrostatic pressure, shown on Plate 3, have been further modified by subtracting the effective overburden pressure at the test depth. The resulting correction to the raw cone resistances is to remove the total overburden pressure at the test point."

The correlation on Plate 10 was presented to show the compatibility of the in-situ cone and Remote Vane data. The correlation is between the net bearing capacity of the cone and the in-situ undrained shear strength measured by the Remote Vane. The net bearing capacity of the cone was obtained by subtracting effective overburden pressure from the edited cone data.

D) Underconsolidation. We do not have pore pressure measurements from other locations in the West Delta area. Pore pressure measurements were reported at some locations in the South Pass area by Shephard, Bryant, and Dunlap in the Offshore Technology Conference Proceedings, #3167, dated May 1978. The measurements indicate preconsolidation pressure of about 50 percent of the effective overburden pressure computed for a normally consolidated condition. This confirms our results presented on Plate 4.

We penetrated only about 1 to 2 ft into the sand stratum encountered at 252 ft. We have no knowledge of its extent or the presence or absence of excess pore water pressure in it. It is likely that the sand has excess pore pressure.

E) Laboratory Tests. The unconsolidated-undrained triaxial tests were conducted at strain rate of about 2 percent per minute, the static simple shear tests at 1.7 percent per minute, and the K_o consolidated-undrained triaxial compression tests at about 0.0070 percent per minute.

- Plate B-6. A well developed, diagonal shear plane that extended across the top of the specimen, and some bulging, was observed for this triaxial specimen. Slip plane activation and non-uniform specimen geometry would contribute to the drop and regain in shear resistance.

- Plates B-9 and B-13. Little or no post peak reduction in shear stress, as well as an approximately linear vertical stress reduction, is observed for these test specimens. The gassy or expansive nature of the sediment may contribute to the linearity observed in the vertical stress reduction, especially where this stress decrease is measured using a boundary load cell.
- Plates B-15, 17, and 20. These plates have been replotted and are enclosed.
- Back Pressure During Consolidation Tests. Back pressure was not applied to the incremental consolidation tests. Back pressures were used in the controlled-rate-of-strain (CRS) consolidation tests and were 700 Kpa at 69-ft and 600 Kpa at 149.5 and 228.7-ft penetrations.

F) <u>General Comments on the Material.</u> Some of the materials from the boring experienced significant expansion as a result of stress relief during sampling. To conduct meaningful tests on the recovered samples, these should be consolidated to pressures from about twice to four times the maximum previous consolidation pressure to reduce the disturbance effects of the sampling process. Further, the design parameters should be based on an interpretation of laboratory test results that is tempered by the in-situ strength (Remote Vane and Swordfish cone) data.

Please contact us if we can be of further assistance.

Very truly yours,

McCLELLAND ENGINEERS, INC.

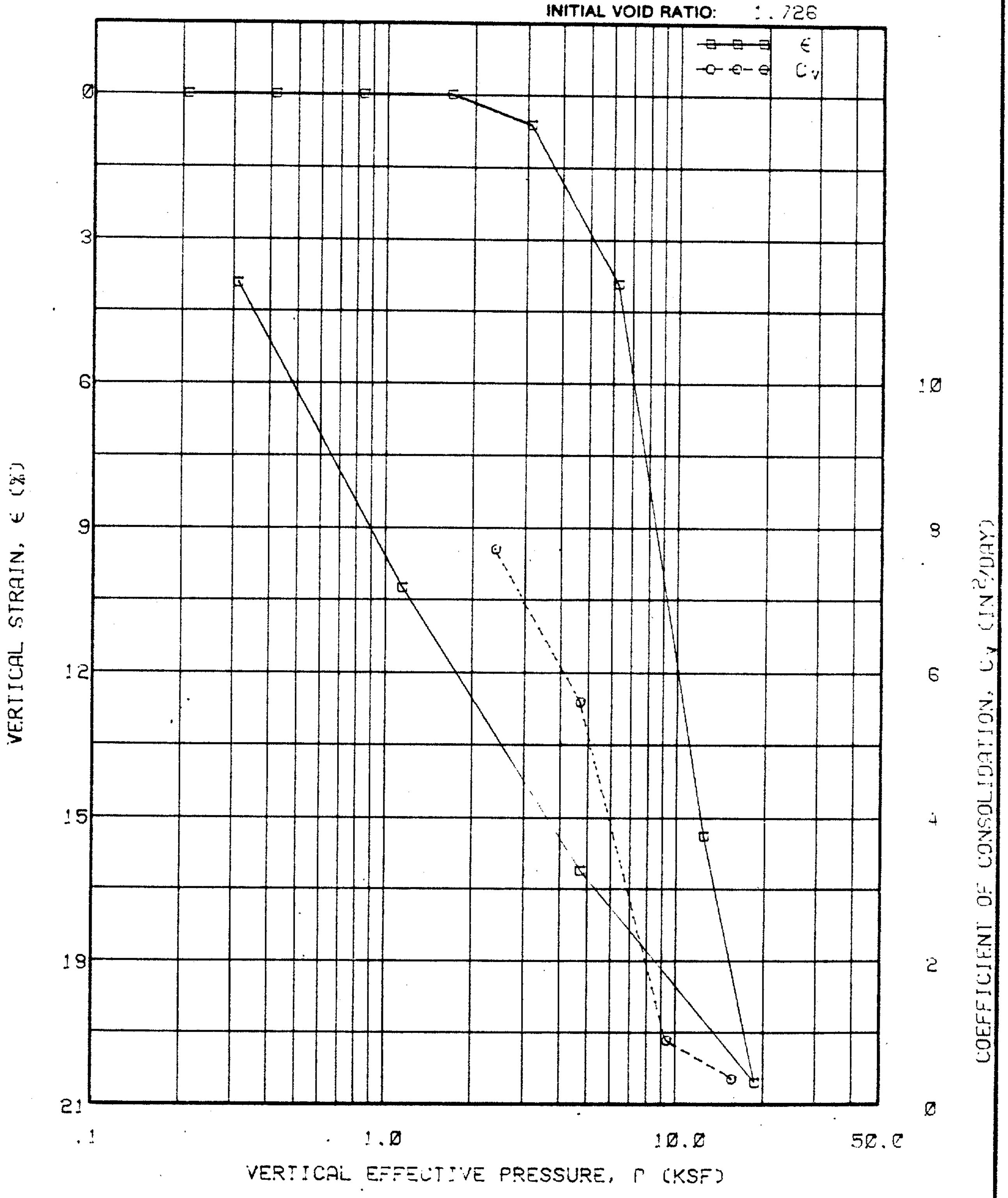
Alan G Young

Alan G Young, P.E.
Engineer Manager

DEH/RNB/AGY/ps
Copies Submitted:
Mr. Tore Kvalstad, Det Norske Veritas, Oslo, Norway (3)
Mr. Jack Chan, Conoco Inc., Houston (1)
Mr. Tom Hamilton, Ertec Inc., Houston (1)

BORING: 5 **PENETRATION:** 228.7 FT.
MATERIAL: Olive gray clay

DRY MASS DENSITY: 64 PCF
WATER CONTENT: 62 %
LIQUID LIMIT:
PLASTIC LIMIT:
SPECIFIC GRAVITY: 2.80
INITIAL VOID RATIO: 1.726

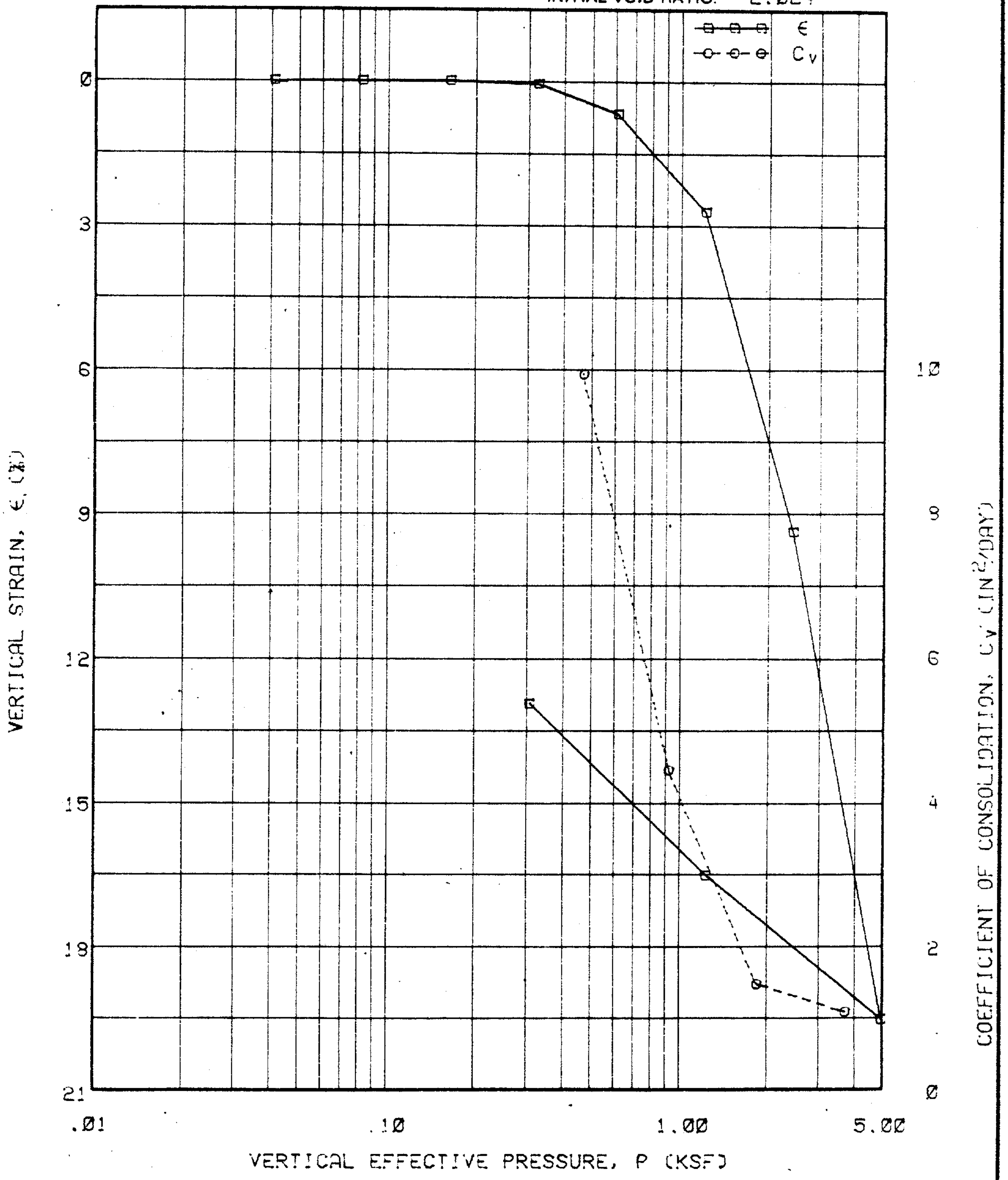


INCREMENTAL CONSOLIDATION TEST RESULTS

181-0217

BORING: 5 PENETRATION: 69.0 FT.
MATERIAL: Olive gray clay

DRY MASS DENSITY: 57 PCF
WATER CONTENT: 74 %
LIQUID LIMIT:
PLASTIC LIMIT:
SPECIFIC GRAVITY: 2.75 (ASSUMED)
INITIAL VOID RATIO: 2.024

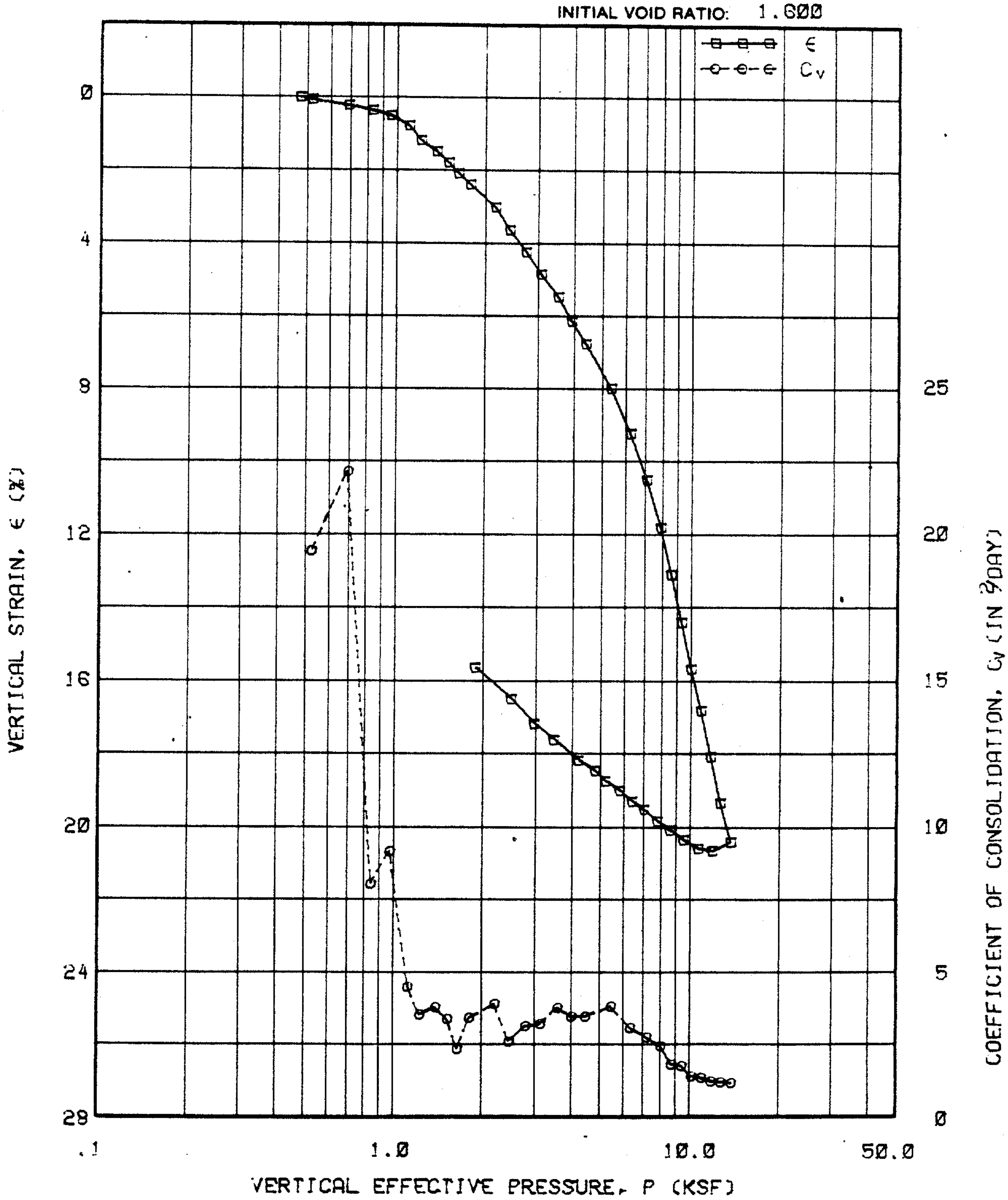


INCREMENTAL CONSOLIDATION TEST RESULTS

McCLELLAND
ENGINEERS

BORING: 5 **PENETRATION:** 228.7 FT.
MATERIAL: Olive gray clay

DRY MASS DENSITY: 67 PCF
WATER CONTENT: 62 %
LIQUID LIMIT:
PLASTIC LIMIT:
SPECIFIC GRAVITY: 2.80
INITIAL VOID RATIO: 1.600



CRS CONSOLIDATION TEST RESULTS

GEOTECHNICAL INVESTIGATION
BORINGS 4, 5,& 6, BLOCK 58
WEST DELTA AREA
GULF OF MEXICO

* * *

Report

to

CONOCO INC.
Houston, Texas

* * *

By

McCLELLAND ENGINEERS, INC.
Geotechnical Consultants
Houston, Texas

February 1982

McClelland engineers, inc. / geotechnical consultants
6100 HILLCROFT / HOUSTON, TEXAS 77081
TEL. 713 / 772-3701 / TELEX 762-447

Report No. 0181-0217
February 19, 1982

Conoco Inc.
c/o Mr. Jack Chan
P. O. Box 2197
Houston, Texas 77001

Attention: Mr. Tore J. Kvalstad

Geotechnical Investigation
Borings 4, 5 & 6, Block 58
West Delta Area
Gulf of Mexico

This report presents the results of our geotechnical investigation to explore soil and foundation conditions at the West Delta, Block 58 site. This study was authorized by Mr. Jack Chan in a telex dated October 29, 1981.

Preliminary information was sent to you on November 20, 1981. This information included a field boring log, a summary of field operations, a summary of Remote Vane data, and a plot of field and interpreted cone penetrometer data. This report includes all field and laboratory data in final form.

We appreciate the opportunity to work with you on this investigation. Please call us when we can be of further assistance.

Very truly yours,

McCLELLAND ENGINEERS, INC.

Alan G Young

Alan G Young, P.E.
Engineer Manager

DEH/GWQ/AGY/ps
Copies Submitted:
Mr. Horace F. House, Conoco Inc., Houston (1)
Mr. Jack Chan, Conoco Inc., Houston (6)

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SUMMARY

McClelland Engineers performed a geotechnical investigation in West Delta, Block 58 in the Gulf of Mexico to explore soil and foundation conditions at a pile load test site. To meet these objectives, we drilled and sampled a boring to 242 ft (73.8 m) below the seafloor. We obtained soil samples by pushing a 3.0-in.-diameter (76-mm) thin-wall tube. In-situ shear strengths of the soils at the site were measured using the Remote Vane. In addition, we performed cone penetrometer tests using our Swordfish system to obtain continuous information on soil conditions. Conventional and advanced laboratory tests were performed on recovered soil specimens to evaluate the pertinent physical and strength properties of the foundation soils.

Results of our investigation show that soils at the study site consist of moderately to highly plastic clays from the seafloor to the final sample penetration of 242 ft (73.8 m). The consistency of the clays ranges from very soft at the seafloor to stiff at about 242 ft (73.8 m). We measured the water depth to be 53 ft (16.2 m) at 0910 hours on November 11, 1981.

This report presents a composite log of soil description based on Borings 4, 5, and 6. The log also shows a graphical representation of the results of the standard testing performed for these borings. Strength data from the various borings has been color coded. Data from Boring 4 is printed in blue; Boring 5 is in black; Boring 6 is in red. The results of the Remote Vane tests have been plotted in black on the boring log's graph and are tabulated in Appendix B. The cone penetrometer log has been edited and is presented on a separate plate. The text of the report presents a general description of field and laboratory work performed. The text also includes a brief discussion of stress history, sensitivity, SHANSEP design method, cone penetrometer data, and possible variations in clay type as they apply to this site. A detailed summary of the standard testing has been placed in Appendix B. Special testing for this job consisted of K_o consolidated-undrained triaxial compression, static simple shear, constant-rate-of-strain consolidation and incremental consolidation tests. Tabulated and graphic results of the special testing are available in Appendix B.

INTRODUCTION

Project Description

McClelland Engineers, Inc., conducted a geotechnical investigation to develop information on soil and foundation conditions at your site in Block 58 of West Delta Area in the Gulf of Mexico. The study area is located on the Mississippi Delta where the water depth is 53 ft (16.2 m). Conoco plans to conduct a tension pile load test at this site.

Purpose and Scope

The main purpose of our geotechnical study was to obtain information on soil and foundation conditions at the proposed load test location. To meet this objective, we drilled three borings and quantified soil properties, using three techniques: (1) 3-in.-diameter pushed samples, (2) in-situ undrained shear measurements with our Remote Vane, and (3) cone penetrometer tests using our Swordfish system. Standard and special laboratory tests on samples were used to characterize the soil conditions at the test site.

Report Format

This report begins with a brief description of the field and laboratory phases of the investigation. These sections are followed by a brief discussion of soil conditions at the West Delta Block 58 site. Appendix B presents the standard and special laboratory test results.

FIELD INVESTIGATION

McClelland Engineers' field crews explored soil conditions at the West Delta Block 58, Platform A site from November 4 to November 12, 1981 by drilling, sampling, and testing three borings. Previously, three borings had been drilled by McClelland Engineers in this block. To remain consistent with the nomenclature used for those earlier borings, we numbered consecutively, the borings performed for this study as 4, 5, and 6. The borings were performed adjacent to structure "A" in the subject block. A sketch of the relative location of the borings is presented on Plate 1. Excessive boat motion due to inclement weather on several occasions required the suspension of drilling operations. The borings are labeled to indicate the consecutive number of the set-ups and appear as the number after the slash on the boring designation. A water depth of 53 ft (16.2 m) was measured at 0910 hours on November 11, 1981, using an electronic seafloor sensor through the drill pipe. The water depth was checked before drilling each boring. It was found not to vary more than 0.5 feet. We did not correct for tidal variations during drilling and sampling since tides in the Gulf of Mexico generally vary less than 1.0 ft.

The borings were drilled with 4-1/2-in. IF drill pipe by a skid-mounted Failing 2000 rotary rig operating through a centerwell in the deck of the M/V "R.L. Perkins." A 2.5-in.-OD (64-mm-OD), 1.125-in.-ID (29-mm-ID) liner sampler was used to obtain samples to 37-ft (11.3-m) penetration. All other samples were taken using a latch-in push sampler developed by McClelland Engineers, Inc. The technique involves pushing a 3.0-in.-OD (76-mm-OD), 2.25-in.-ID (57-mm-ID), thin-wall tube sampler into the soil by latching the sampling tube into the drill bit and using the weight of drill pipe to advance the sampler into the soil. Boring 4 was used to perform cone penetrometer tests from 12- (3.7-) to 228-ft (69.5-m) penetration. Samples were taken at three-foot (one-meter) intervals in this boring from 228- (69.5-) to 240-ft (73.2-m) penetration. Boring 5 was drilled to provide samples at closely spaced intervals from the seafloor to 227.5-ft (69.3-m) penetration. Cone penetrometer tests were conducted from 229.5- (70.0-) to 254-ft (77.4-m) penetration in this boring. Boring 6 was used to provide Remote Vane shear strength data at 10-ft (3.0-m) intervals from 24- (7.3-) to 244-ft (74.4-m) penetration. Samples were also taken in this boring at selected intervals.

After recovering the soil specimen, our field engineer or soil technician cleaned the drilling fluid and cuttings from the top of the sample tubes, classified the soil in the bottom of the tube, performed miniature vane and Torvane tests, and then either sealed the tube or extruded the sample, examined it, and then sealed representative portions in containers. Samples were returned to Houston for either testing by McClelland Engineers or shipment to Ertec, Inc.

The boring log shown on Plate 2 represents a composite of information gathered in all three borings. The samples taken using the liner sampler are indicated by a blow count of zero. Because of the nearly continuous sampling at this site, the description under "Blow Count" is PUSH for all samples below 37-ft (11.3-m) penetration. We have color coded the strength test results in order to distinguish between the three borings. Shear strength test results from from Boring 4, 5, and 6 have been plotted in blue, black, and red, respectively.

In addition to the sampling program, McClelland Engineers' crews also made in-situ shear strength measurements using the Remote Vane and conducted cone penetrometer tests using the Swordfish system. The Remote Vane is pushed 3 (.9) to 5 ft (1.5 m) into the soil below the bottom of the borehole, and the four-bladed vane is rotated by an electric motor. The undrained shear strength is measured from the torque-rotation data recorded during the test. All Remote Vane data are presented on the boring log and in the summary of test results in Appendix B. Corrections were not made for plasticity.

The Swordfish system uses a hydraulic ram to push a standard cone (60-degree apex angle, 10-square centimeter base area, 150-square centimeter friction sleeve) into the soil below the drilled depth of the boring. The tests were performed in accordance with procedures outlined in ASTM D-3441-75, using a penetration rate of 2 cm per second. During penetration, cone resistance and sleeve friction are recorded in analog form and fed directly into a combined amplifier/digitizer/memory unit. A plot of edited cone penetrometer data is presented on Plate 3. Editing consisted primarily of subtracting hydrostatic head developed at the bottom of the borehole and removing the "shoulders" caused by drilling disturbance at the start of the stroke and by the inability to penetrate further at the completion of the stroke.

Appendix A provides a brief chronological summary of the field operations at this site.

FIELD AND LABORATORY TESTS

We planned our field and laboratory test programs mainly to evaluate pertinent physical and strength properties of the foundation materials. The types and numbers of tests performed are presented in this section along with some general comments. For a more detailed discussion on the specific test procedures and results, refer to Appendix B.

Classification Tests

We performed soil classification tests in the laboratory to confirm our field classifications and to supplement strength test data. The following number of classification and soil properties tests were performed:

Type of Test	Number of Tests
Plastic and Liquid Limits	9
Specific Gravity	2

The results of most of these tests are presented on the plate entitled, Summary of Test Results in Appendix B.

Strength and Compressibility Tests

Engineering properties of the soils such as shear strength and compressibility were obtained by the following tests:

Type of Test	Number of Tests
Miniature Vane	
Undisturbed	76
Torvane	73
Unconsolidated-Undrained Triaxial Compression	
Undisturbed	5
Remolded	5
K_o Consolidated-Undrained Triaxial Compression with Pore Pressure Measurement	2
Consolidated-Undrained Static Simple Shear	3
Constant-Rate-of-Strain Consolidation	3
Incremental Consolidation	3

We performed some strength tests in the field concurrently with drilling operations. Undrained shear strengths of the cohesive samples were determined by miniature vane tests. We also made estimates of the shear strength of the cohesive soils using a Torvane. The results of miniature vane and Torvane tests performed on samples not retained by McClelland Engineers are tabulated separately in Appendix B. All other tests were conducted in the laboratory and reported on the Summary of Test Results in Appendix B.

DISCUSSION

The scope of this report does not allow for a detailed discussion of the test results. However, limited analysis has been performed using techniques similar to those applied to data from deepwater borings. Also, a preliminary assessement of the cone penetrometer data has been made. Finally, a short discussion of possible changes in soil condition is included.

In-Situ Vertical Effective Stress

Consolidation tests were performed to help develop the stress history of the site. To provide an independent check of results, both incremental and constant-rate-of-strain (CRS) consolidation tests were performed at the same interval. Examination of the curves resulting from the consolidation tests indicate more disturbed samples than those taken in deep water with the same latch-in sampling technique. The curves from the CRS consolidation tests resulted in higher preconsolidation pressures than those determined using the incremental consolidation tests. Plate 4 presents the preconsolidation pressures for the two types of tests, along with the effective overburden pressure profile for a normally consolidated clay. The preconsolidation pressures, when compared with the computed effective overburden stress profile, indicate that the soils at this site are underconsolidated.

Comparison of Undrained Strength Measurements

To compare shear strengths from this boring and those from deep water borings, we plotted remolded, laboratory, and Remote Vane shear strengths vs. Liquidity Index (LI). Several studies of soil properties have indicated that LI vs. log in-situ shear strength data is a straight line in the strength range under consideration. Also, this line is nearly parallel to the LI vs. log remolded shear strength line. We plotted the remolded strengths on Plate 5 to determine a relationship. This relationship, line AA', was then transcribed to plots of LI vs. Remote Vane shear strengths and laboratory shear strengths, Plate 6 and 7, respectively. Lines with sensitivities of two and three have been added to provide a reference. The shear strengths from the Remote Vane indicate a sensitivity of approximately two. The plot of laboratory shear strength includes points from a limited number of miniature vane tests, unconsolidated-undrained (UU) triaxial compression tests, K_o consolidated-undrained (K_oCU) triaxial compression tests, and static simple shear tests. Examination of miniature vane and UU triaxial compression test results on Plate 7 shows a sensitivity of less than two. The sensitivity of the clays from deep water borings was approximately 50% greater than those determined from miniature vane and UU triaxial compression tests for this boring. A slightly higher value of sensitivity is suggested by the limited data from K_oCU triaxial compression and static simple shear tests. These tests provide a more reasonable estimate of sensitivity perhaps because the consolidation phase of the test helps reduce the effects of disturbance. We believe the apparent low sensitivity of the miniature vane and UU triaxial tests is a function of the disturbance caused by the gassy nature of this deposit.

To further evaluate the undrained shear strength at the West Delta Block 58 site, we applied the SHANSEP(2) design method to the results obtained from the static simple shear, K_oCU triaxial compression, and CRS consolidation tests. The vertical consolidation pressure, $\bar{\sigma}_v$, vs the shear strength for the static simple shear and selected K_oCU triaxial compression tests have been plotted on Plate 8. The ratio, $S_u/\bar{\sigma}_v$, was determined by selecting a line of best fit. The value of $S_u/\bar{\sigma}_v$ was found to be 0.26. When this value was applied to the preconsolidation pressures from the CRS consolidation tests, the resulting strengths are within the range of the measured shear strengths.

NEW PAGE ISSUED

Evaluation of Cone Penetrometer Data

In addition to the edited cone penetrometer log, we also plotted friction ratio vs. log cone resistance and Remote Vane shear strength vs. cone resistance less the existing overburden pressure. The literature presents several criteria for determining material type based on the relationship of friction ratio and log cone resistance. The trace of friction ratio vs. log cone resistance, presented on Plate 9, also includes the material descriptions suggested by Douglas and Olsen(1). The trace indicates a sensitive clay grading to a sensitive mixture of clay and silt. Quantitative measures of sensitivity are not available from the literature. However, we expect them to exceed the measured value of less than two. Sample disturbance caused by the gassy nature of this deposit could account for the apparent discrepancy in sensitivity between shear strength measurements and cone data. Another plot, typically produced from cone data for clays, is cone resistance vs. shear strength. Plate 10 presents this plot. We selected for this correlation, the shear strength measured by the Remote Vane. In addition, we modified the cone resistance by subtracting the existing total overburden at the test depth. A correlation line, forced through zero, has a slope, N_k, equal to 6.2. The literature typically reports N_k values greater than 6.2. The correlations presented in the literature are generally for overconsolidated and normally consolidated clays and are based on shear strengths measured from laboratory tests rather than in-situ vane tests. The reduction in cone resistance resulting from the total overburden term was approximately 50 percent of the cone resistance. In addition, the shear strengths from the Remote Vane are generally the upper bound of possible shear strength profiles. These two factors may have combined to reduce N_k.

Soil Conditions

The clay soils at this site could be separated into at least two subdivisions. Descriptions of the soils indicate that differences in soil structure start to occur at about 180-ft penetration. This change was also evident in the results of the laboratory index and strength tests and cone penetrometer tests. First, the Liquidity Index, LI, at 190-ft penetration changes from a gradually decreasing number and begins to increase. This can

NEW PAGE ISSUED

~~be seen on Plate 11, a plot of LI vs. penetration. Secondly, the submerged unit weights on Plate 2 show a shift at approximately 170-ft penetration. Thirdly, the friction ratio begins to decrease at approximately 192-ft penetration. Lastly, the slope of shear strength, with respect to depth, increases significantly below 190-ft penetration. The scope of McClelland Engineers' testing program did not allow for further investigation of the differences in the two subdivisions.~~

~~REFERENCES~~

~~(1) Douglas, B.J. and Olsen, R. S. (1981), "Soil Classification Using Electric Cone Penetrometer," Proceedings, Session sponsored by the Geotechnical Engineering Division at the ASCE National Convention, St. Louis, Missouri, October 26-30, 1981, pp. 209-227.~~

~~(2) Ladd, C.C. and Foott, R. (1974), "New Design Procedures for Stability of Soft Clays," Journal of the Geotechnical Engineering Division, ASCE, Vol. 100, No. GT7, pp. 763-786.~~

Evaluation of Cone Penetrometer Data

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Soil Conditions

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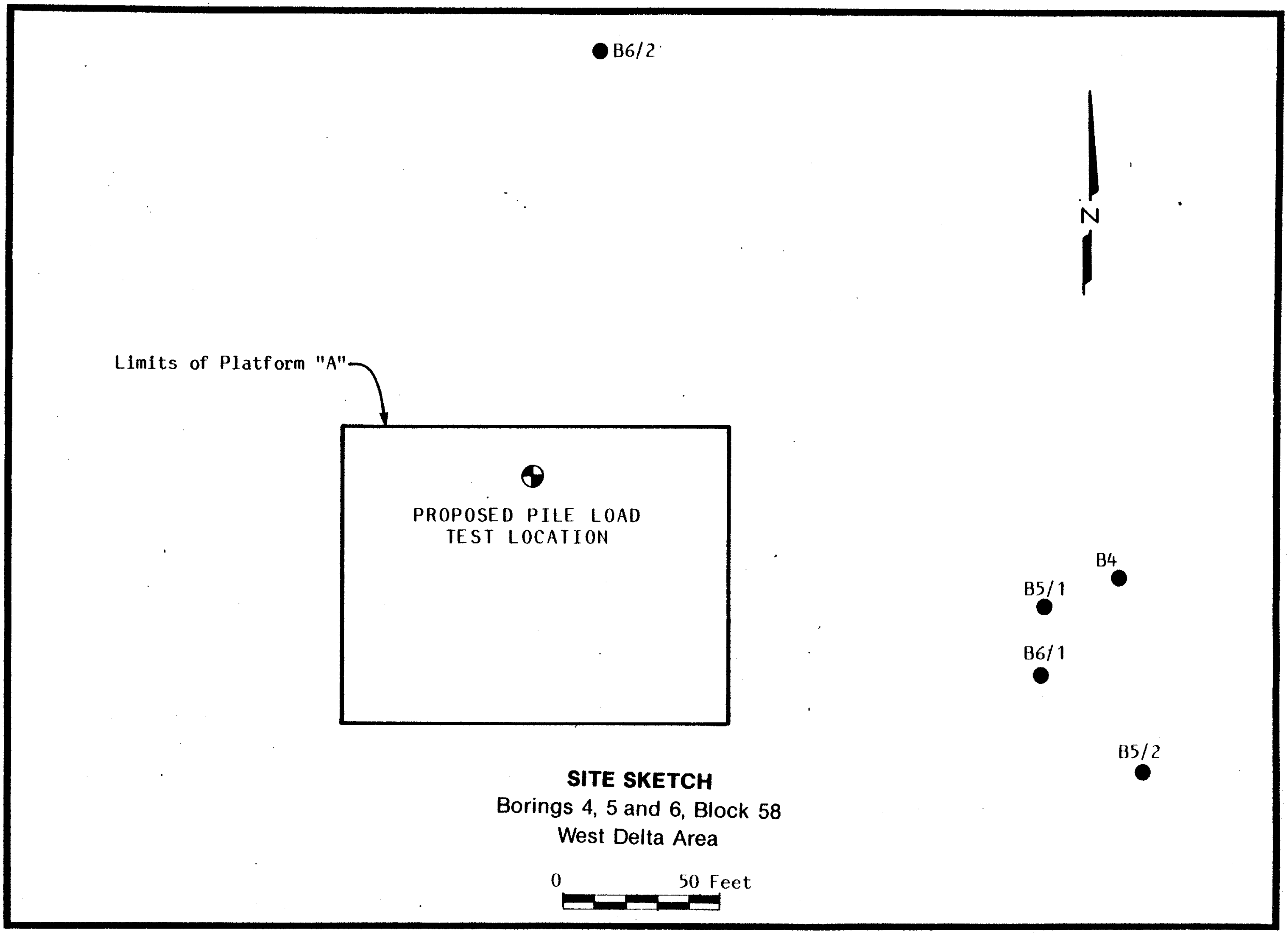
Thirdly, the friction ratio begins to decrease at approximately 192-ft penetration. Lastly, the slope of shear strength, with respect to depth, increases significantly below 190-ft penetration. The scope of McClelland Engineers' testing program did not allow for further investigation of the differences in the two subdivisions.

REFERENCES

(1) Douglas, B.J. and Olsen, R. S. (1981), "Soil Classification Using Electric Cone Penetrometer," Proceedings, Session sponsored by the Geotechnical Engineering Division at the ASCE National Convention, St. Louis, Missouri, October 26-30, 1981, pp. 209-227.

(2) Ladd, C.C. and Foott, R. (1974), "New Design Procedures for Stability of Soft Clays," Journal of the Geotechnical Engineering Division, ASCE, Vol. 100, No. GT7, pp. 763-786.

ILLUSTRATIONS



SITE SKETCH
Borings 4, 5 and 6, Block 58
West Delta Area

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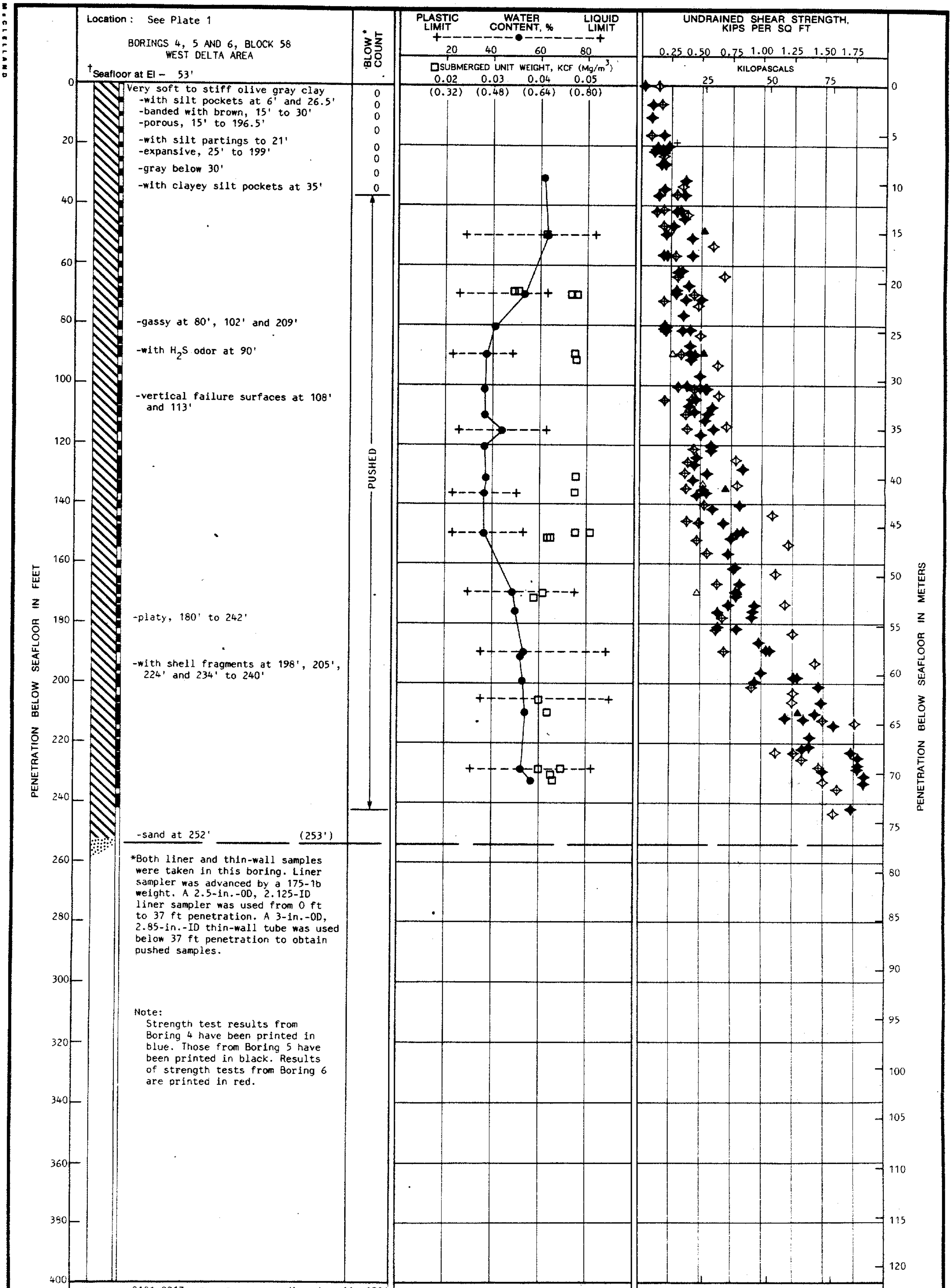
ENGINEERS

PLATE 1



Very soft to stiff olive gray clay
- -with silt pockets at 6' and 26.5'
- -banded with brown, 15' to 30'
- -porous, 15' to 196.5'
- -with silt partings to 21'
- -expansive, 25' to 199'
- -gray below 30'
- -with clayey silt pockets at 35'
- -gassy at 80', 102' and 209'
- -with H_2S odor at 90'
- -vertical failure surfaces at 108' and 113'
- -platy, 180' to 242'
- -with shell fragments at 198', 205', 224' and 234' to 240'
- -sand at 252'

*Both liner and thin-wall samples were taken in this boring. Liner sampler was advanced by a 175-lb weight. A 2.5-in.-OD, 2.125-ID liner sampler was used from 0 ft to 37 ft penetration. A 3-in.-OD, 2.85-in.-ID thin-wall tube was used below 37 ft penetration to obtain pushed samples.

Note:
Strength test results from Boring 4 have been printed in blue. Those from Boring 5 have been printed in black. Results of strength tests from Boring 6 are printed in red.

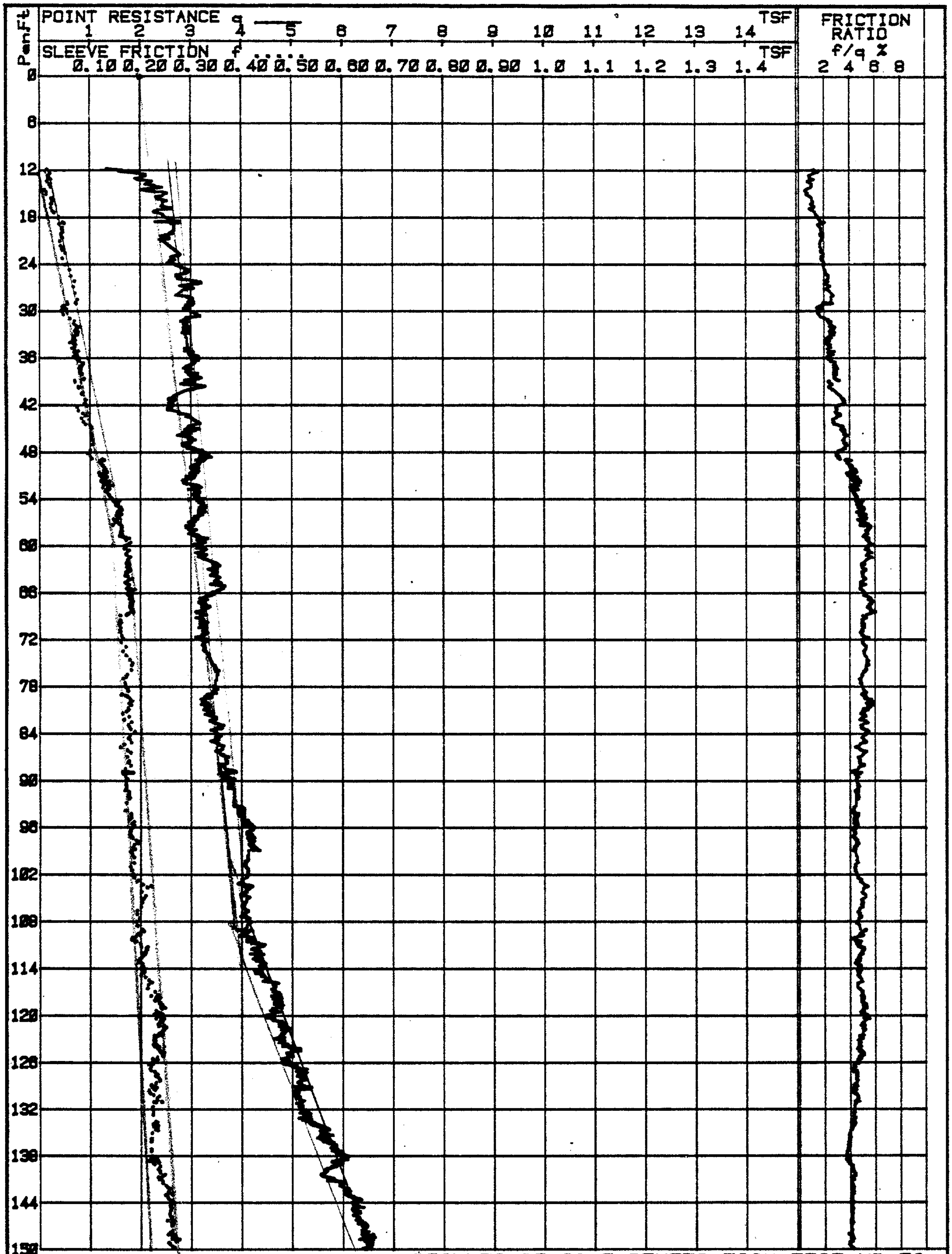
Job No. : 0181-0217 Date Completed : November 11, 1981
Final Penetration : 253' Field Engineer : D. Harman
†Water Depth Measurement : 0910 hours on November 11, 1981

STRENGTH LEGEND

◆ MINIATURE VANE	● UNCONFINED COMPRESSION
◇ TORVANE	▲ UNCONSOLIDATED-UNDRAINED TRIAXIAL COMPRESSION
◇ REMOTE VANE	

(Open symbols indicate remolded tests)

LOG AND TEST RESULTS
BORINGS 4, 5 AND 6, BLOCK 58
WEST DELTA AREA



TEST PERFORMED: NOVEMBER 1981

RESULTS OF CONE PENETRATION TEST WD 58

LOCATION: WEST DELTA 58 WATER DEPTH: 53.0 Ft CONOCO 0181-0217

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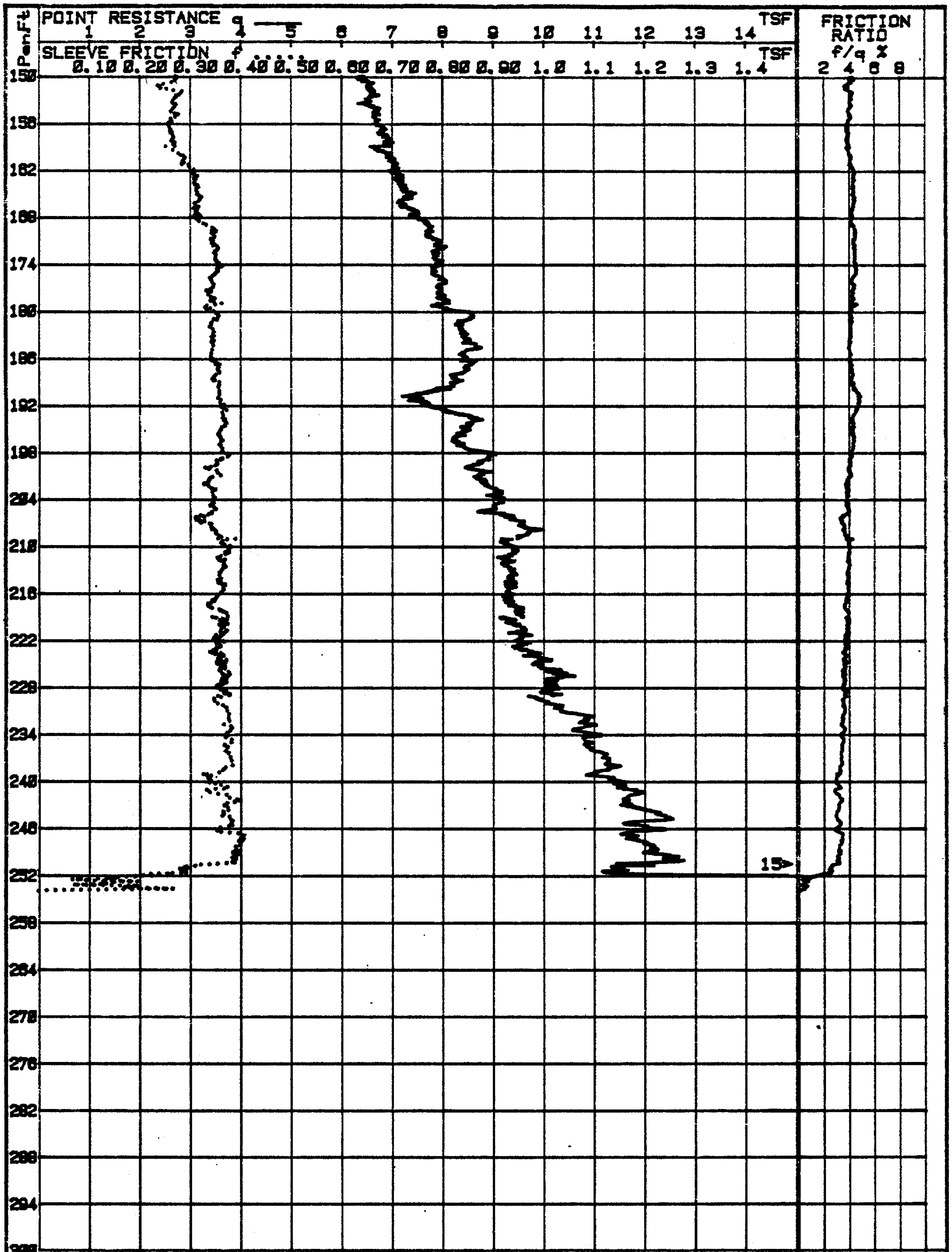
PLATE 3a



TEST PERFORMED: NOVEMBER 1981 RESULTS OF CONE PENETRATION TEST WD 58

LOCATION: WEST DELTA 58 WATER DEPTH: 53.0 Ft CONOCO 0181-0217

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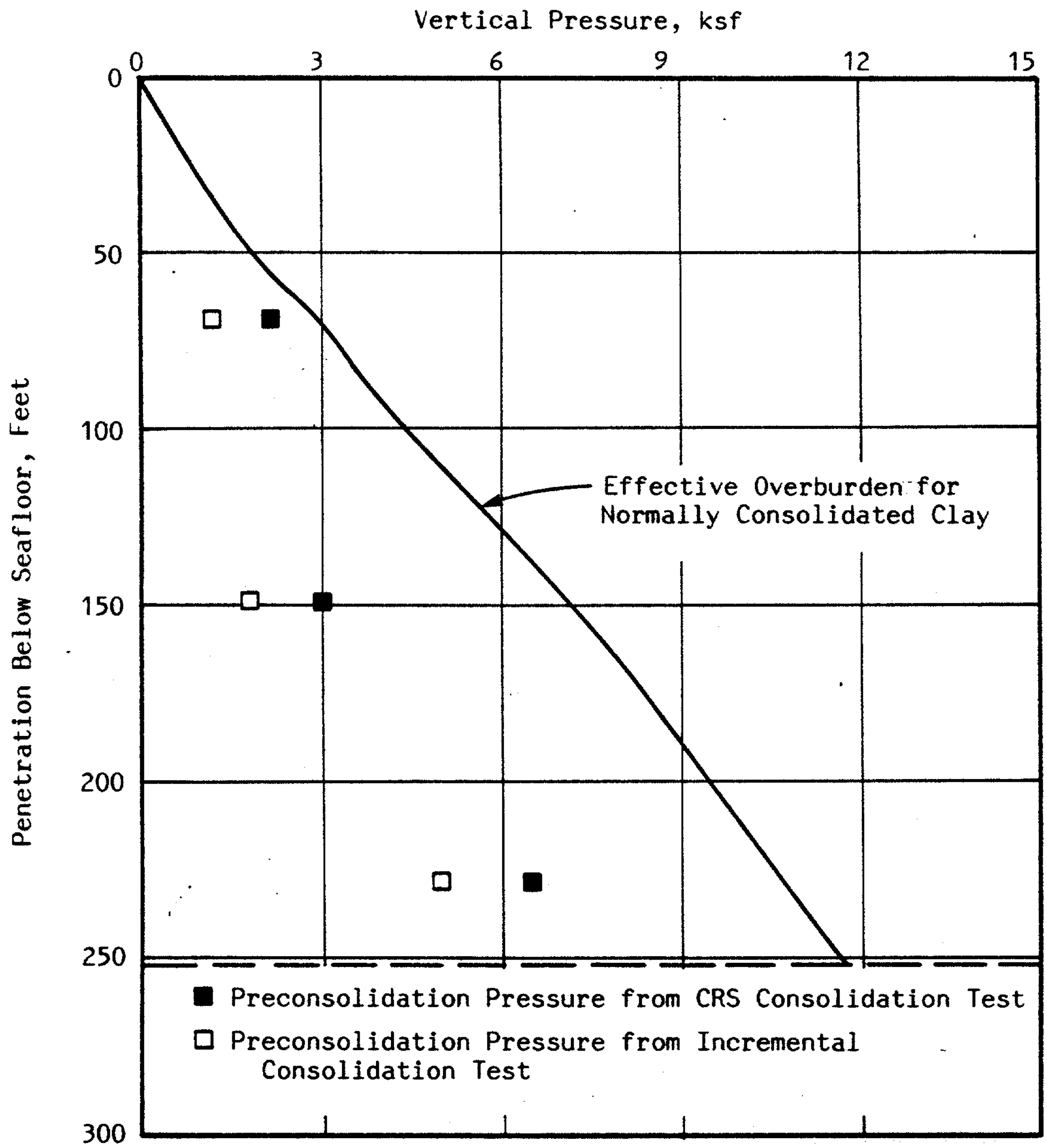
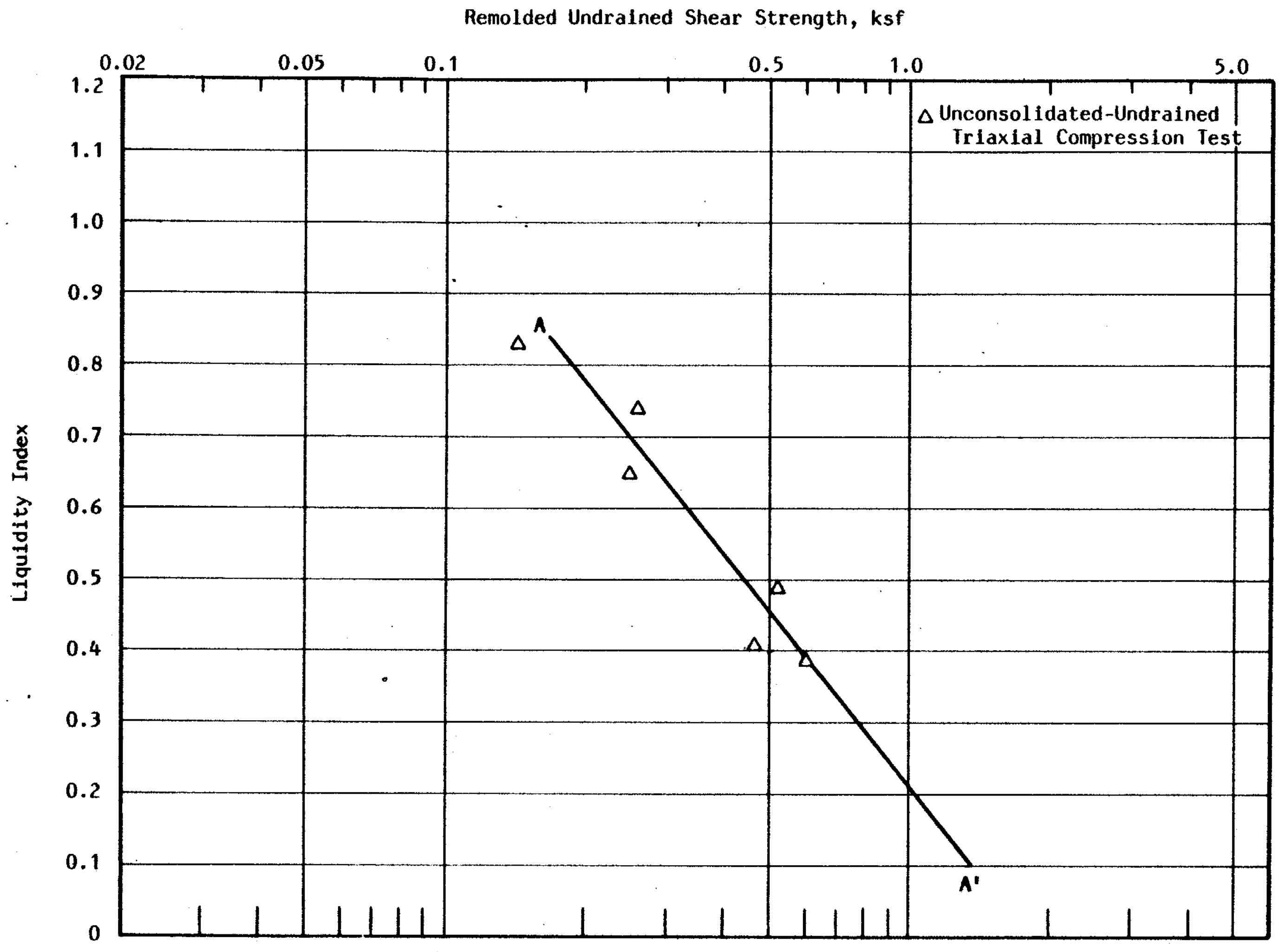
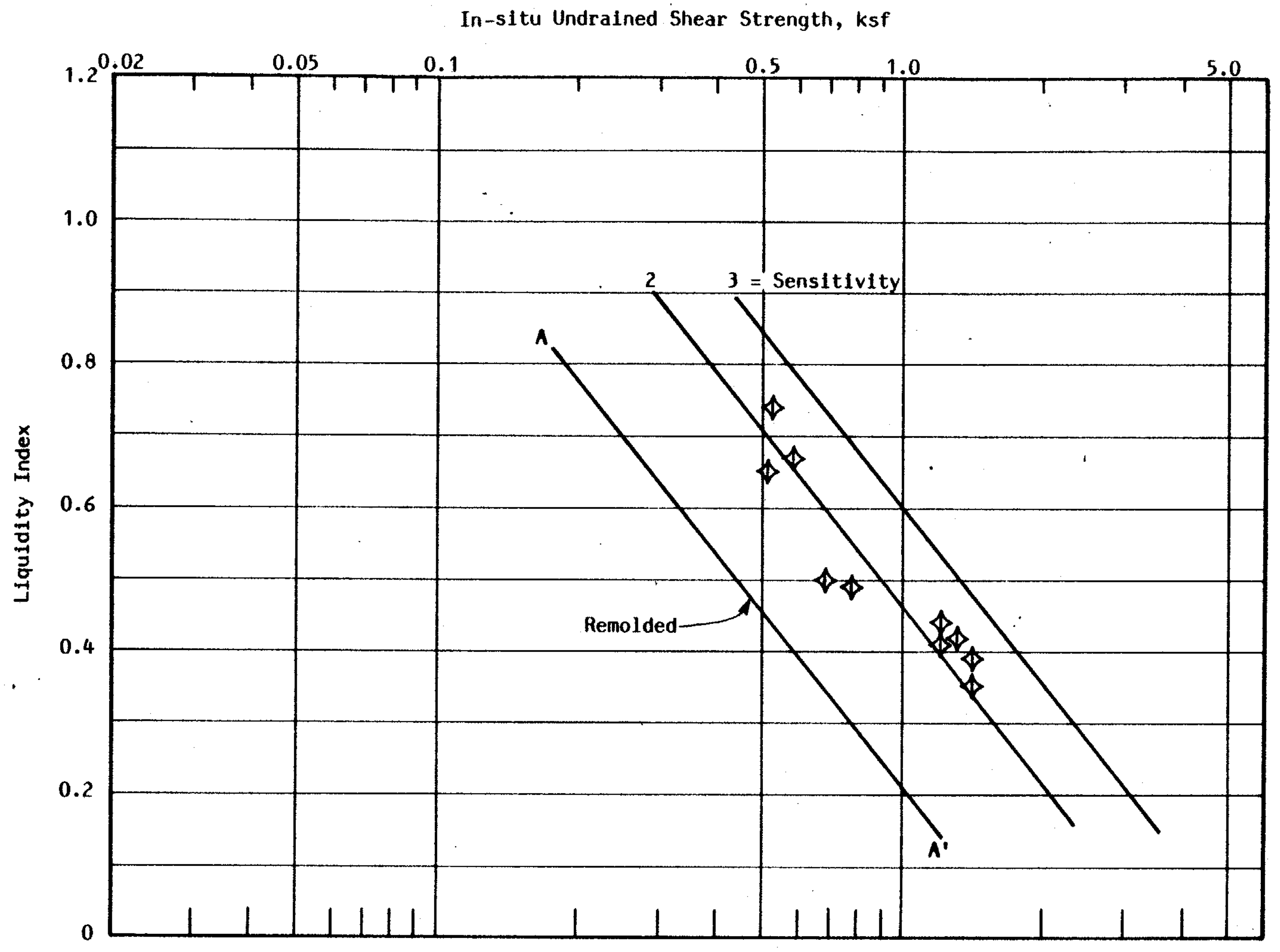
PLATE 3b



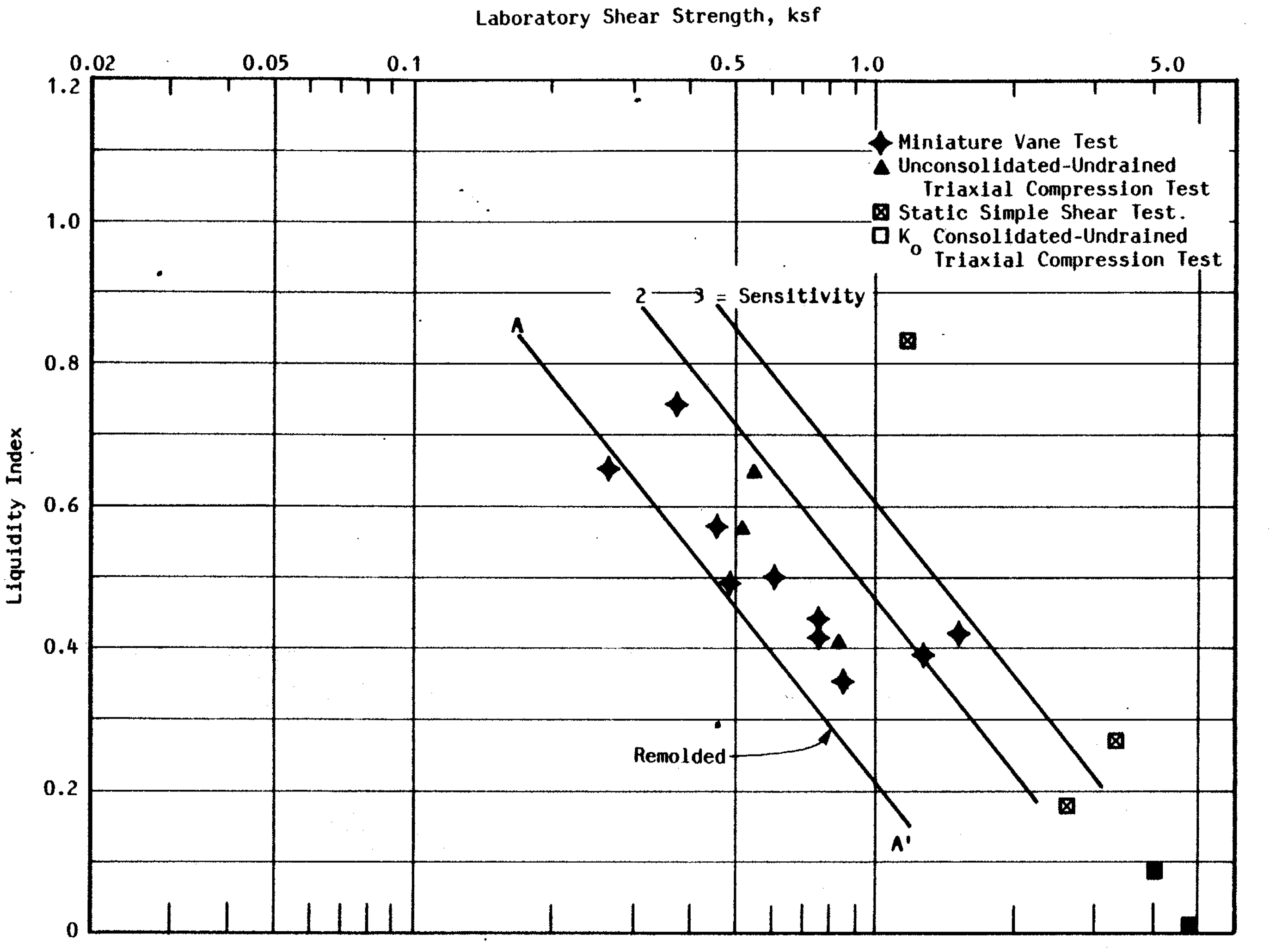
VERTICAL PRESSURE vs PENETRATION
Borings 4 and 5, Block 58
West Delta Area



LIQUIDITY INDEX vs REMOLDED SHEAR STRENGTH
Borings 4, 5 and 6, Block 58
West Delta Area



LIQUIDITY INDEX vs IN-SITU SHEAR STRENGTH
Boring 6, Block 58
West Delta Area



LIQUIDITY INDEX vs LABORATORY SHEAR STRENGTH
Borings 4, 5 and 6, Block 58
West Delta Area

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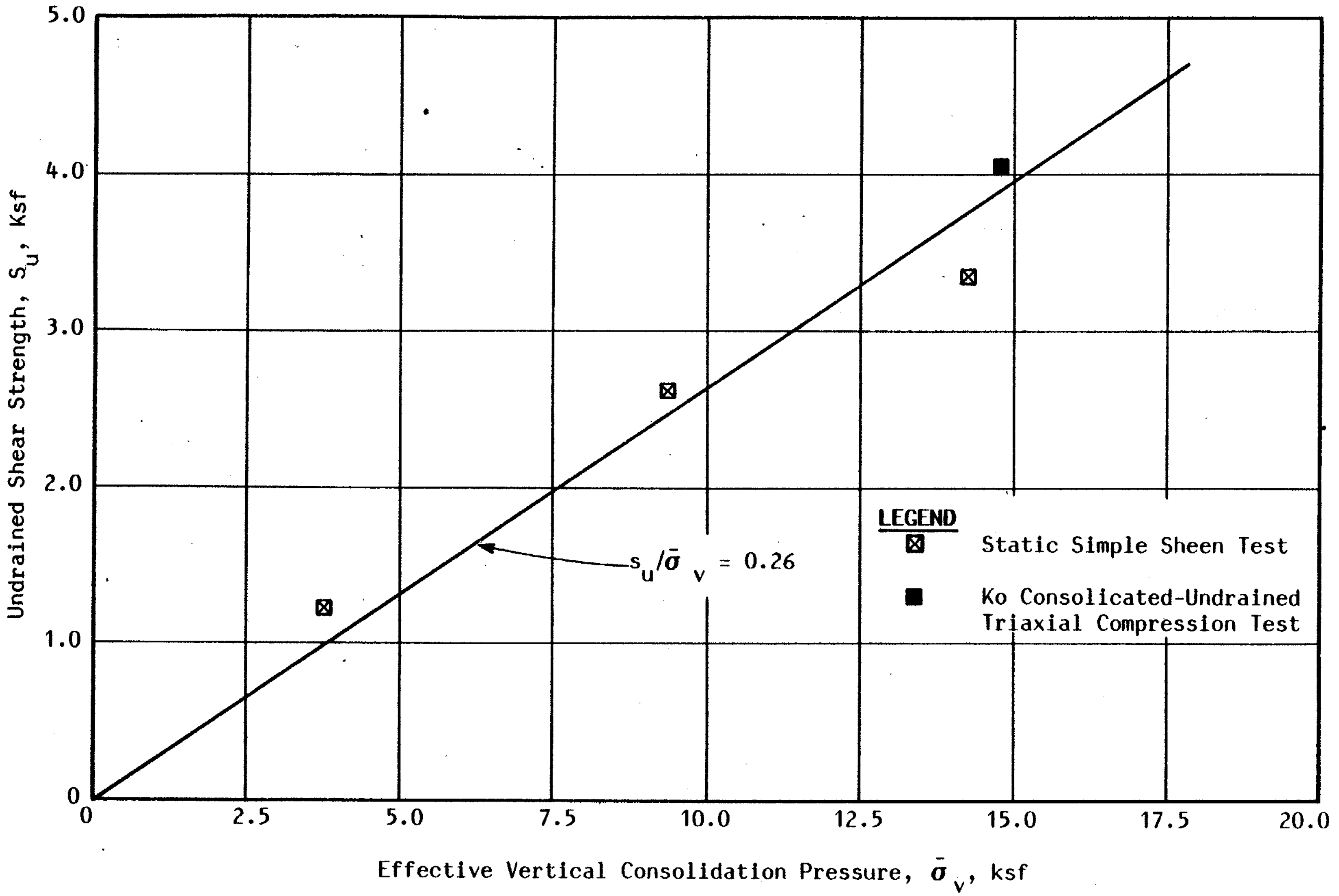
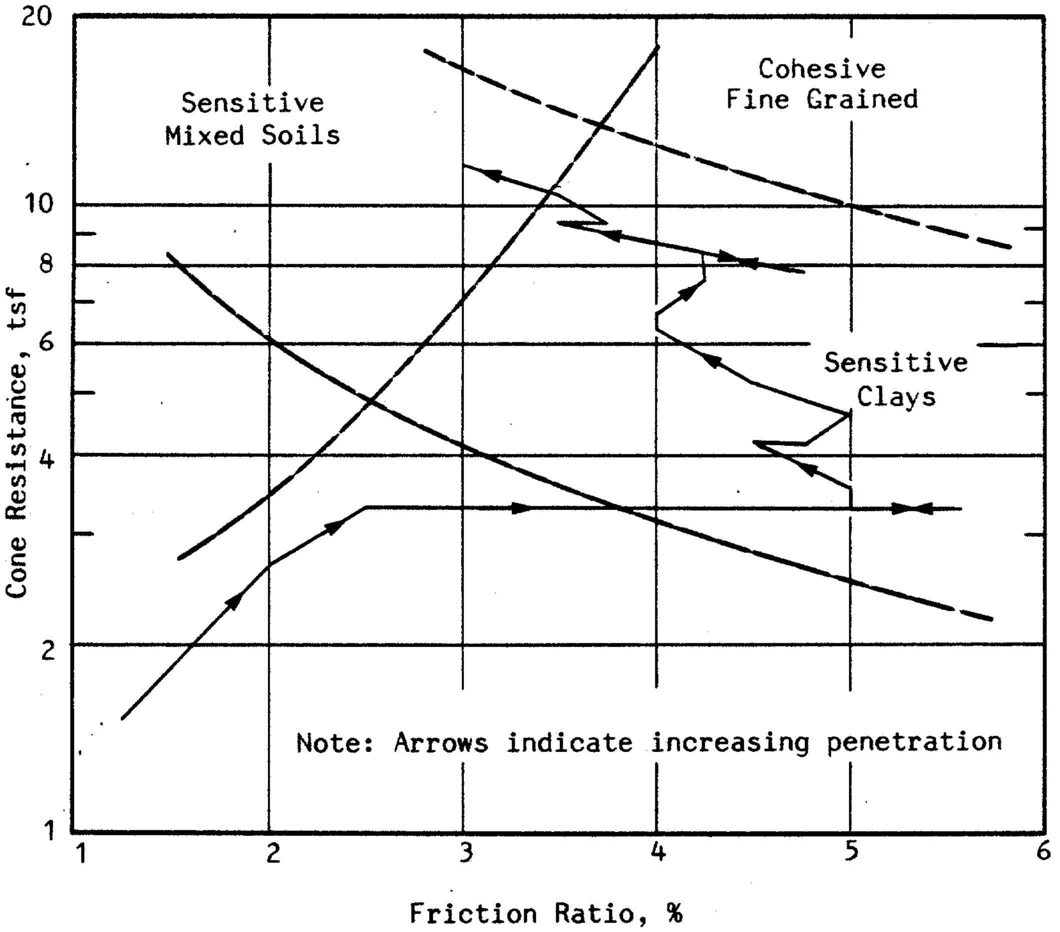


EFFECTIVE VERTICAL CONSOLIDATION PRESSURE vs SHEAR STRENGTH

Boring 5, Block 58

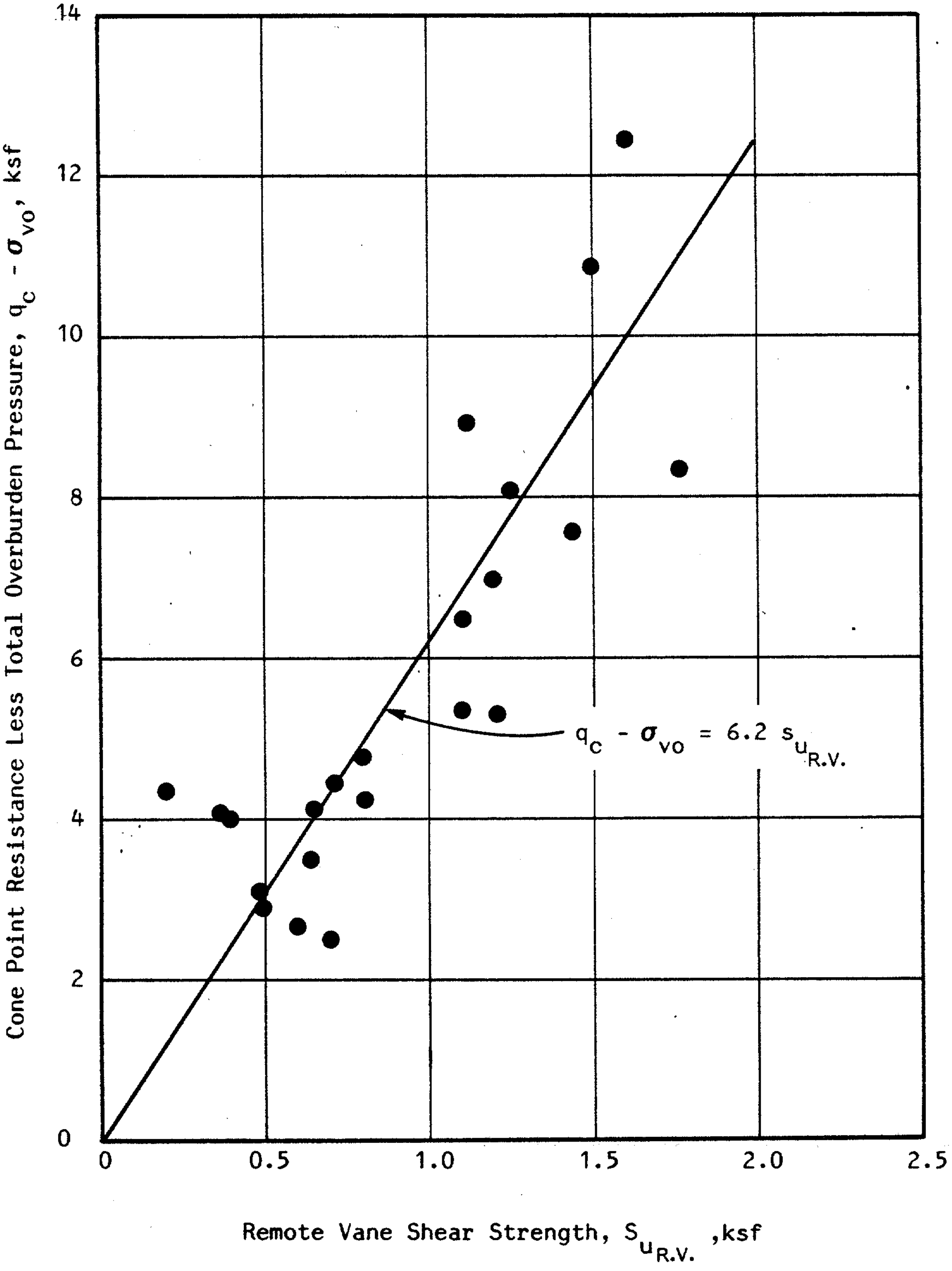
West Delta Area



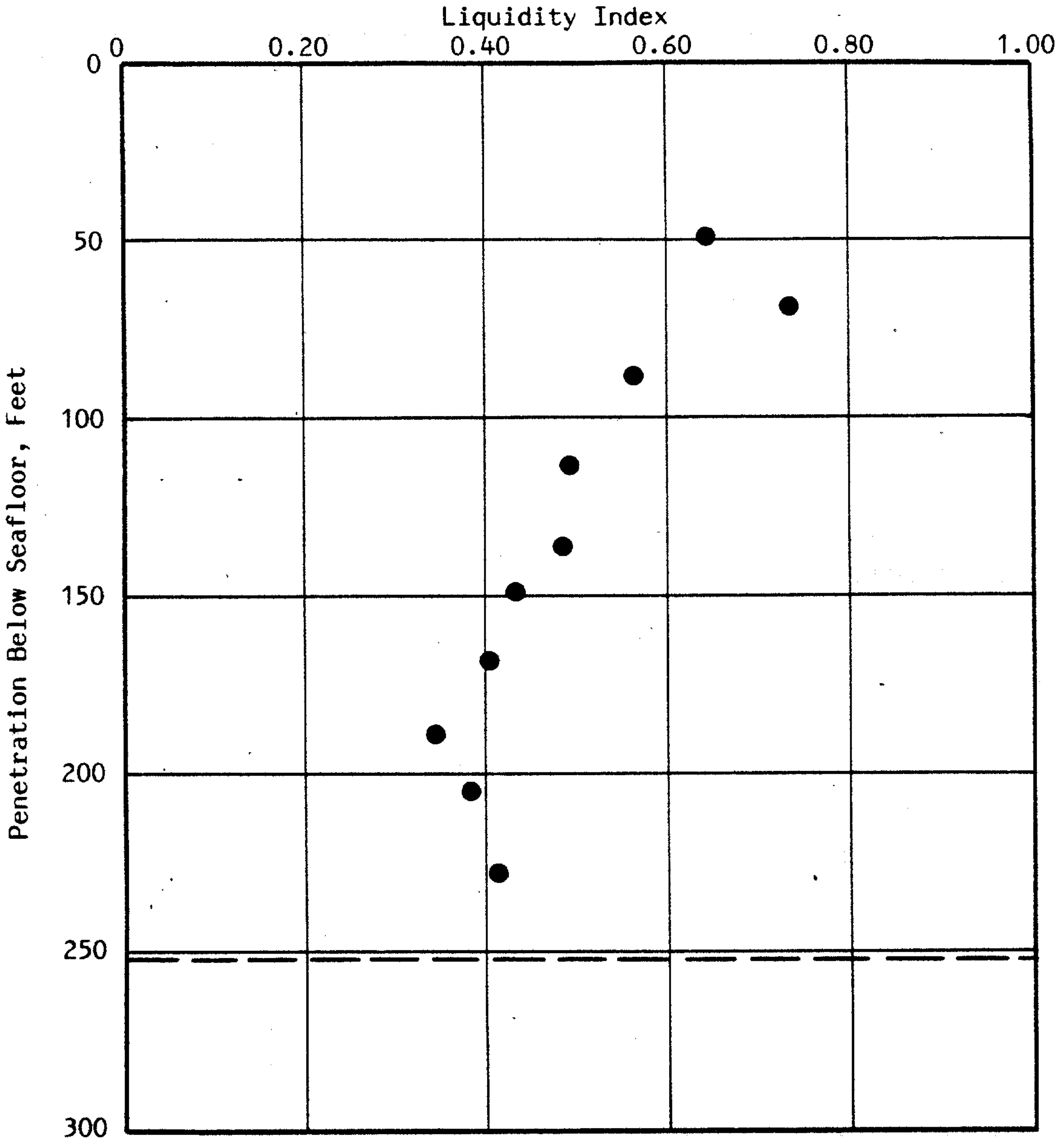
FRICTION RATIO vs CONE RESISTANCE

Boring 4, Block 58

West Delta Area



MODIFIED CONE RESISTANCE vs REMOTE VANE SHEAR STRENGTH
Boring 4 and 6, Block 58
West Delta Area



LIQUIDITY INDEX vs PENETRATION

Boring 5 and 6, Block 58

West Delta Area

APPENDIX A

SUMMARY OF FIELD OPRATIONS

Date	Time From	Time To	Description of Activity
November 4, 1981	----	1130	M/V "R.L. Perkins" arrives at dock in Grand Isle, Louisiana
	1130	2400	Loading equipment and mud
November 5, 1981	0000	0100	Loading mud
	0100	0500	Traveling to Block 58, West Delta Area
	0500	0800	Setting anchors
	0800	2400	Cone testing Boring 4
November 6, 1981	0000	1615	Cone testing and grouting Boring 4
	1615	1700	Relocating on anchor spread
	1700	2330	Drilling and sampling Boring 5
	2330	2400	Waiting for improved sea conditions
November 7, 1981	0000	1215	Waiting for improved sea conditions
	1215	1315	Relocating on anchor spread
	1315	2400	Drilling and sampling Boring 5
November 8, 1981	0000	1415	Drilling and sampling Boring 5
	1415	1530	Grouting Boring 5
	1530	1900	Relocating on anchor spread
	1900	2400	Drilling, sampling, and remote vane testing Boring 6
November 9, 1981	0000	0430	Drilling and sampling Boring 6

(Continued on Plate Alb)

SUMMARY OF FIELD OPERATIONS

Borings 4, 5 and 6, Block 58
West Delta Area

Date	Time From	Time To	Description of Activity
(Continued from A1a)			
November 9, 1981	0430	1600	Waiting for improved sea conditions (reduced rate)
	1600	1700	Pulling anchors (reduced rate)
	1700	2400	Waiting for improved sea conditions (reduced rate)
November 10, 1981	0000	1600	Waiting for improved sea conditions (reduced rate)
	1600	1730	Setting anchors (reduced rate)
	1730	2400	Waiting for improved sea conditions (reduced rate)
November 11, 1981	0000	0400	Waiting for improved sea conditions (reduced rate)
	0400	2345	Drilling, sampling, and remote vane testing Boring 6, used a total of 900 bags of weight material, 400 bags of saltwater gel material, and 90 bags of cement
	2345	2400	Pulling anchors
November 12, 1981	0000	0045	Pulling anchors
	0045	0400	Traveling to Grand Isle, Louisiana to demobilize equipment
	0400	0900	Waiting for crane
	0900	1030	Offloading equipment
	1030	----	M/V "R.L. Perkins" departs for next client's location

SUMMARY OF FIELD OPERATIONS

Borings 4, 5 and 6, Block 58
West Delta Area

APPENDIX B

LABORATORY SOIL TEST RESULTS

CONTENTS

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ILLUSTRATIONS

Plate

APPENDIX B

LABORATORY SOIL TEST RESULTS

Static Strength Tests

Several procedures were used in the field and in the laboratory to determine the strengths of foundation soils under various conditions. The different test procedures used are described in the following paragraphs. Reference is made to the manner in which results are presented.

Miniature Vane and Torvane Tests. Two types of strength tests were performed on the soil samples in the field as they were recovered. Undisturbed shear strengths of cohesive samples were determined with a motorized miniature vane device while the samples were still in the sampling tubes. Estimates of shear strength were also made using a Torvane device. The results of these tests are tabulated on Plate B-1 and are plotted on Plate 2.

Unconsolidated-Undrained Triaxial Compression Tests. In this type of strength test the soil specimen is enclosed in a thin rubber membrane and subjected to a selected confining pressure. The specimen is not allowed to consolidate under the influence of this confining pressure. The specimen is then loaded axially to failure at a constant rate of strain without any drainage from the specimen. For this investigation, the confining pressure was selected to be about equal to the computed soil buoyant overburden pressure.

Shear strengths of undisturbed cohesive samples determined in the laboratory by this type of test are included in the graphic plots on Plate 2. All these test data are tabulated on Plate B-1 together with the confining pressure, percent strain at failure, and type of failure.

K_o Consolidated-Undrained Triaxial Tests

The physical set-up of this test is similar to the unconsolidated-undrained triaxial compression test described above. The major difference is that the specimen is allowed to drain under a particular cell confining pressure. To fully saturate this sample, back-pressure is applied. Increments of vertical and horizontal stress are then added in such a manner as to make all changes in specimen water content a function of sample height change. Final confining pressures were selected so as to assure the sample would be consolidated in excess of the estimated maximum past-vertical consolidation pressure.

Upon completion of consolidation, the specimen is sheared with the drainage lines closed. Shear is induced by increasing the axial load at a constant rate of strain. Parameters measured during shear include axial load, axial deformation, and excess pore pressure.

Plates B-4 through B-7 present the stress-strain curves and p'-q diagrams determined in the laboratory for 2 samples by this type of test. Summaries of the test results are tabulated on Plate B-3. The summary on Plate B-3 includes initial and final moisture contents, initial unit dry weight, confining pressure, failure strain, and other information for each test.

Static Simple Shear Tests. Simple shear specimens were trimmed to 0.75-in.-height and 1.875-in.-diameter to fit into a wire-reinforced rubber membrane. The membrane restricts lateral deformation during consolidation. Increments of normal (vertical) load were applied to consolidate the sample. After consolidation, the specimen was sheared to failure at constant volume by applying a horizontal shear load. Summaries of the test results are tabulated on Plate B-8. Consolidation pressure and stress-strain curves for these specimens are included on Plates B-9 through B-14.

Consolidation Tests

Two types of consolidation tests were performed for this project: (1) incremental and (2) controlled-rate-of strain (CRS). For an incremental consolidation test, the total load on the specimen remains constant and deflection is measured. During the CRS consolidation test, load is applied to the specimen by introducing an increasing strain into it.

In the incremental-load oedometer test, the soil specimen is placed in a 1.765-in.-ID ring and immersed in water. Then, loads are added to prevent swelling. When the swell pressure is established, vertical load is added in increments that are usually doubled, yielding a load increment ratio of one. Each load increment is held for 24 hours with primary consolidation determined by the logarithm of time method. The data readings are used To compute vertical strain, vertical pressure, and coefficient of consolidation. The results of this type test are presented on Plate B-15 through Plate B-17.

The CRS consolidation testing equipment is similar to that used for a consolidated-undrained triaxial test. The base of a conventional triaxial cell is fitted with a 1.875-in.-ID stainless steel ring. Back pressure, used in saturating the soil specimen, can be provided through porous stones fitted at each end of the specimen. The rate of strain is selected to produce a minimum excess pore pressure of 1 psi and limit the ratio of maximum excess pore pressure to applied vertical pressure to 30 percent. Vertical loading deflection and pore pressure response of the specimen are all monitored continuously using electronic instrumentation. The test results for this type of test are presented on Plates B-18 through B-20 as curves of percent change in height (vertical strain) versus applied vertical effective pressure.

Classification Tests

Plastic and liquid limits, collectively termed the Atterberg limits, were determined for the cohesive samples to provide classification information. Natural water content tests were also performed on selected specimens. The results of these water content tests, together with the Atterberg limit test results, are plotted on Plate 2. Natural water content and density determinations were made for each compression test specimen. To complete the water content profile shown on the above plates, results of water content tests made in conjunction with the compression tests; additional water content tests are also plotted. All of the above data are tabulated on Plate B-1.

ILLUSTRATIONS

APPENDIX B

SUMMARY OF TEST RESULTS

SAMPLE NUMBER	PENETRATION, FEET	CLASSIFICATION TESTS					TORVANE	MINIATURE VANE		COMPRESSION TESTS								
		LIQUID LIMIT	PLASTIC LIMIT	WATER CONTENT, %	UNIT WET WEIGHT, LB/CU FT	PERCENT PASSING NO. 200 SIEVE	SHEAR STRENGTH, KSF/(kPa)	TYPE OF TEST	SHEAR STRENGTH KSF/(kPa)	TYPE OF TEST	WATER CONTENT, %		UNIT DRY WEIGHT, PCF/(Mg/m3)	SHEAR STRENGTH, KSF/(kPa)	ϵ_{50} STRAIN, %	LATERAL PRESSURE, KSF/(kPa)	FAILURE STRAIN, %	TYPE OF FAILURE
											Initial	Final						
								BORING 5										-
25	49.5				106					2-U 2-R	49 47		71 67	0.54 0.25		1.73 1.73	7.5 13.5	C A,C
	15.09m				(1.70)					2-U 2-R	49 47		(1.14) (1.07)	(25.84) (11.96)		(82.78) (82.78)	7.5 13.5	C A,C
26	50.0	84	29	64			0.22	U	0.22									
	15.24m	84	29	64			(10.53)	U	(10.53)									
42	69.0									CRS and Incremental Consolidation Tests (See Plates B-18 and B-15) Static Simple Shear Test (See Plate B-9 and B-10)								
	21.03m									CRS and Incremental Consolidation Tests (See Plates B-16 and B-15) Static Simple Shear Test (See Plates B-9 and B-10)								
43	69.5	64	27	54			0.20	U	0.30									
	21.19m	64	27	54			(9.57)	U	(14.35)									
53	89.5				112					2-U 22-R	38 39		80 76	0.51 0.26		3.17 3.17	15.8 9.9	A A
	27.29m				(1.79)					2-U 2-R	38 39		(1.28) (1.22)	(24.40) (12.44)		(151.67) (151.67)	15.8 9.9	A A
54	90.0	49	24	38			0.34	U	0.45									
	27.44m	49	24	38			(16.27)	U	(21.53)									
64	109.5			37			0.32	U	0.56									
	33.38m			37			(15.31)	U	(26.79)									
69	114.5									3-U	42	30	70	4.03		9.06	4.4	A
	34.91m									3-U	42	30	(1.12)	(192.82)		(433.50)	4.4	A
70	115.0	64	27	45			0.40	U	0.61									
	35.06m	64	27	45			(19.14)	U	(29.19)									
75	126.0						0.40	U	0.46									
	38.41m						(19.14)	U	(22.00)									
85	149.5									CRS and Incremental Consolidation Tests (See Plates B-19 and B-16) Static Simple Shear Test (See Plate B-11 and B-12)								
	45.58m									CRS and Incremental Consolidation Tests (See Plates B-19 and B-16) Static Simple Shear (See Plates B-11 and B-12)								
86	150.0	54	24	37			0.44	U	0.84									
	45.73m	54	24	37			(21.05)	U	(40.19)									
89	152.5			48			0.48											
	46.49m			48			(22.97)											
98	169.5				105					2-U 2-R	45 48		71 68	0.83 0.47		7.06 7.06	10.2 15.9	A,B A
	51.69m				(1.68)					2-U 2-R	48 48		(1.14) (1.09)	(39.71) (22.49)		(337.80) (337.80)	10.2 15.9	A,B A
99	170.0	76	31	49			0.62	U	0.79									
	51.83m	76	31	49			(29.67)	U	(37.80)									
110	189.2									3-U	54	36	66	4.74		15.98	5.5	A,B
	57.67m									3-U	54	36	(1.05)	(226.79)		(764.60)	5.5	A,B

(Continued on Plate B-1b)

LEGEND AND NOTES

TYPE OF TEST	TYPE OF FAILURE
1 UNCONFINED COMPRESSION	A = BULGE
2 UNCONSOLIDATED-UNDRAINED TRIAXIAL	B = SINGLE SHEAR PLANE
3 Ko CONSOLIDATED-UNDRAINED TRIAXIAL	C = MULTIPLE SHEAR PLANE
U = UNDISTURBED R = REMOLDED	D = VERTICAL FRACTURE

(a) GRAIN-SIZE DISTRIBUTION CURVE PRESENTED SEPARATELY
(b) STRESS-STRAIN CURVE PRESENTED SEPARATELY

BORING 5, BLOCK 58
WEST DELTA AREA

Seafloor at El - 53'

SUMMARY OF TEST RESULTS

SAMPLE NUMBER	PENETRATION, FEET	CLASSIFICATION TESTS					TORVANE	MINIATURE VANE		COMPRESSION TESTS								
		LIQUID LIMIT	PLASTIC LIMIT	WATER CONTENT, %	UNIT WET WEIGHT, PCF/(Mg/m3)	PERCENT PASSING NO. 200 SIEVE	SHEAR STRENGTH, KSF/(kPa)	TYPE OF TEST	SHEAR STRENGTH KSF/(kPa)	TYPE OF TEST	WATER CONTENT, % Initial	WATER CONTENT, % Final	UNIT DRY WEIGHT, PCF/(Mg/m3)	SHEAR STRENGTH, KSF/(kPa)	ϵ_{50} STRAIN, %	LATERAL PRESSURE, KSF/(kPa)	FAILURE STRAIN, %	TYPE OF FAILURE
							(Continued from Plate B-1a)											
112	190.0	89	36	54			0.70	U	1.05									
	57.93m	89	36	54			(33.49)	U	(50.23)									
116	200.0			54			0.86	U	1.27									
	60.98m			54			(41.15)	U	(60.77)									
122	210.0				106					2-U 2-R	55 52		68 66	1.27 0.60		8.78 8.78	7.0 14.5	C A
	64.02m				(1.70)					2-U 2-R	55 52		(1.09) (1.06)	(60.77) (28.71)		(420.10) (420.10)	7.0 14.5	C A
138	228.7									CRS and incremental Consolidation Test (See Plates B-20 and B-17) Static Simple Shear Test (See Plate B-13 and B-14)								
	69.73m									CRS and incremental Consolidation Test (See Plates B-20 and B-17) Static Simple Shear Test (See Plates B-13 and B-14)								
139	229.0	83	32	53			1.48	U	1.80									
	69.82m	83	32	53			(70.81)	U	(86.12)									
								BORING 4										
6	233.0			57			1.28	U	1.25									
	71.04m			57			(61.24)	U	(59.81)									
								BORING 6										
23	81.0			41				U	0.21									
	24.70m			41				U	(10.05)									
25	101.5			37			0.44	U	0.53									
	30.95m			37			(21.05)	U	(25.36)									
31	121.0			37				U	0.59									
	36.89m			37				U	(28.23)									
36B	136.0				112					2-U 2-R	36 34		82 85	0.70 0.52		5.62 5.62	12.9 12.9	A A
	41.46m				(1.79)					2-U 2-R	36 34		(1.31) (1.36)	(33.49) (24.88)		(268.90) (268.90)	12.9 12.9	A A
37	136.5	51	24	37			0.38	U	0.52									
	41.62m	51	24	37			(18.18)	U	(24.88)									
52	176.3			51			0.52	U	0.94									
	53.75m			51			(24.88)	U	(44.98)									
58	200.8						0.70											
	61.22m						(33.49)											

LEGEND AND NOTES

TYPE OF TEST	TYPE OF FAILURE
1 UNCONFINED COMPRESSION	A = BULGE
2 UNCONSOLIDATED-UNDRAINED TRIAXIAL	B = SINGLE SHEAR PLANE
3 Ko CONSOLIDATED-UNDRAINED TRIAXIAL	C = MULTIPLE SHEAR PLANE
U = UNDISTURBED R = REMOLDED	D = VERTICAL FRACTURE

(a) GRAIN-SIZE DISTRIBUTION CURVE PRESENTED SEPARATELY
(b) STRESS-STRAIN CURVE PRESENTED SEPARATELY

BORINGS 4, 5 AND 6, BLOCK 58
WEST DELTA AREA

Seafloor at El - 53'

McCLELLAND ENGINEERS

SUMMARY OF TEST RESULTS

SAMPLE NUMBER	PENETRATION, FEET	CLASSIFICATION TESTS					TORVANE	MINIATURE VANE		COMPRESSION TESTS								
		LIQUID LIMIT	PLASTIC LIMIT	WATER CONTENT, %	UNIT WET WEIGHT, PCF/(Mg/m3)	PERCENT PASSING NO. 200 SIEVE	SHEAR STRENGTH, KSF/(kPa)	TYPE OF TEST	SHEAR STRENGTH KSF/(kPa)	TYPE OF TEST	WATER CONTENT, %		UNIT DRY WEIGHT, PCF/(Mg/m3)	SHEAR STRENGTH, KSF/(kPa)	ϵ_{50} STRAIN, %	LATERAL PRESSURE, KSF/(kPa)	FAILURE STRAIN, %	TYPE OF FAILURE
											Initial	Final						
							REMOTE VANE											
							BORING 6											
	24.0								0.20									
	7.32m								(9.57)									
	34.0								0.36									
	10.37m								(17.22)									
	44.0								0.39									
	13.41m								(18.66)									
	54.0								0.60									
	16.46m								(28.71)									
	64.0								0.70									
	19.51m								(33.49)									
	74.0								0.48									
	22.56m								(22.97)									
	84.0								0.49									
	25.61m								(23.44)									
	94.0								0.64									
	28.66m								(30.62)									
	104.0								0.65									
	31.71m								(31.10)									
	114.0								0.72									
	34.76m								(34.45)									
	125.0								0.79									
	38.11m								(37.80)									
	134.0								0.81									
	40.85m								(38.76)									
	144.0								1.10									
	43.90m								(52.63)									
	154.0								1.22									
	46.95m								(58.37)									
	164.0								1.12									
	50.00m								(53.59)									

(Continued on Plate B-1d)

LEGEND AND NOTES

TYPE OF TEST	TYPE OF FAILURE
1 UNCONFINED COMPRESSION	A = BULGE
2 UNCONSOLIDATED-UNDRAINED TRIAXIAL	B = SINGLE SHEAR PLANE
3 Ko CONSOLIDATED-UNDRAINED TRIAXIAL	C = MULTIPLE SHEAR PLANE
U = UNDISTURBED R = REMOLDED	D = VERTICAL FRACTURE

(a) GRAIN-SIZE DISTRIBUTION CURVE PRESENTED SEPARATELY
(b) STRESS-STRAIN CURVE PRESENTED SEPARATELY

BORING 6, BLOCK 58
WEST DELTA AREA

Seafloor at El - 53'

SUMMARY OF TEST RESULTS

SAMPLE NUMBER	PENETRATION, FEET	CLASSIFICATION TESTS					TORVANE	MINIATURE VANE		COMPRESSION TESTS								
		LIQUID LIMIT	PLASTIC LIMIT	WATER CONTENT, %	UNIT WET WEIGHT, PCF/(Mg/m3)	PERCENT PASSING NO. 200 SIEVE	SHEAR STRENGTH, KSF/(kPa)	TYPE OF TEST	SHEAR STRENGTH KSF/(kPa)	TYPE OF TEST	WATER CONTENT, %		UNIT DRY WEIGHT, PCF/(Mg/m3)	SHEAR STRENGTH, KSF/(kPa)	ϵ_{50} STRAIN, %	LATERAL PRESSURE, KSF/(kPa)	FAILURE STRAIN, %	TYPE OF FAILURE
											Initial	Final						
							(Continued from Plate											
							REMOTE VANE											
							BORING 6											
	174.0								1.20									
	53.05m								(57.42)									
	184.0								1.25									
	56.08m								(59.81)									
	194.0								1.44									
	59.15m								(68.90)									
	214.0								1.77									
	65.24m								(84.69)									
	224.0								1.12									
	68.29m								(53.59)									
	234.0								1.50									
	71.34m								(71.77)									
	244.0								1.60									
	74.39m								(76.56)									

LEGEND AND NOTES

TYPE OF TEST	TYPE OF FAILURE
1 UNCONFINED COMPRESSION	A = BULGE
2 UNCONSOLIDATED-UNDRAINED TRIAXIAL	B = SINGLE SHEAR PLANE
3 Ko CONSOLIDATED-UNDRAINED TRIAXIAL	C = MULTIPLE SHEAR PLANE
U = UNDISTURBED R = REMOLDED	D = VERTICAL FRACTURE

(a) GRAIN-SIZE DISTRIBUTION CURVE PRESENTED SEPARATELY
(b) STRESS-STRAIN CURVE PRESENTED SEPARATELY

BORING 6, BLOCK 58
WEST DELTA AREA

Seafloor at El - 53'

Boring No.	Penetration, Ft (m)	Torvane ksf (kPa)	Miniature Vane ksf (kPa)
5	0.5 (1.64)	0.032 (1.53)	0.025 (1.20)
	6.0 (19.68)	0.088 (4.21)	0.087 (4.16)
	11.0 (36.08)	-	0.087 (4.16)
	17.0 (5.18)	0.100 (4.78)	0.190 (9.10)
	21.5 (6.55)	0.148 (7.09)	0.230 (11.01)
	26.5 (8.08)	0.184 (8.81)	0.200 (9.57)
	32.0 (11.28)	0.320 (15.32)	0.360 (17.23)
	32.0 (11.28) R	-	0.102 (4.88)
	35.5 (10.82)	0.180 (8.62)	0.190 (9.10)
	37.0 (11.28)	0.120 (5.74)	0.150 (7.18)
	42.0 (12.80)	0.200 (9.57)	0.320 (15.32)
	47.0 (14.33)	0.200 (9.57)	0.270 (12.93)
	47.0 (14.33) R	-	0.145 (6.96)
	52.0 (15.85)	0.300 (14.36)	0.420 (20.11)
	52.0 (15.85)	-	0.033 (1.57)
	57.0 (17.38)	0.300 (14.36)	0.420 (20.11)
	57.0 (17.38)	0.216 (10.34)	0.200 (9.57)
	62.0 (18.90)	0.224 (10.72)	0.350 (16.76)
	67.0 (20.43)	0.300 (14.36)	0.390 (18.67)
	67.0 (20.43) R	-	0.371 (17.73)
	72.0 (21.95)	0.200 (9.57)	0.370 (17.71)
	77.0 (23.47)	0.180 (8.61)	0.361 (17.28)
	77.0 (23.47) R	-	0.216 (10.32)
	82.0 (25.00)	0.220 (10.53)	0.420 (20.11)
	87.0 (26.52)	0.200 (9.57)	0.408 (19.52)
	92.0 (28.05)	0.280 (13.40)	0.450 (21.54)
	97.0 (29.57)	-	0.488 (23.34)
	97.0 (29.57) R	-	0.286 (13.69)
	102.0 (31.09)	-	0.544 (26.03)
	107.0 (32.61)	-	0.399 (19.07)
	112.0 (34.14)	-	0.530 (25.36)
	117.0 (35.67)	0.340 (16.28)	0.500 (23.94)
	117.0 (35.67)	-	0.236 (11.22)
	122.0 (37.20)	0.460 (22.02)	0.610 (29.20)
	130.0 (39.63)	0.380 (18.19)	0.560 (26.81)
	132.0 (40.24)	-	0.440 (21.06)
	137.0 (41.77)	0.360 (17.23)	0.470 (22.50)
	137.0 (41.77) R	-	0.349 (16.71)
	142.0 (43.29)	0.540 (25.85)	0.810 (38.78)
	152.0 (46.33)	0.520 (24.89)	0.750 (35.90)
	157.0 (47.87)	0.560 (26.81)	0.730 (34.95)
	157.0 (47.87) R	-	0.370 (17.69)

(Continued on Plate B-2b)

Note: R Denotes residual miniature vane test

SUMMARY OF TORVANE AND MINIATURE VANE TEST RESULTS FOR SAMPLES NOT RETAINED BY McCLELLAND ENGINEERS, INC.

Borings 4, 5, and 6, Block 58
West Delta Area

(Continued from Plate B-2a)

Boring No.	Penetration, Ft (m)	Torvane ksf (kPa)	Miniature Vane ksf (kPa)
	162.0 (49.39)	-	0.790 (37.82)
	167.0 (50.91)	0.640 (30.64)	0.830 (39.73)
	174.0 (53.04)	0.520 (24.89)	0.740 (35.43)
	177.0 (53.96)	0.540 (25.85)	0.650 (31.11)
	179.0 (54.57)	0.700 (33.51)	0.920 (44.04)
	182.0 (55.49)	0.700 (33.51)	0.637 (30.46)
	182.0 (55.49) R	-	0.308 (14.74)
	187.0 (57.00)	0.700 (33.51)	0.976 (46.68)
	197.0 (60.06)	0.840 (40.21)	0.990 (47.39)
	202.0 (61.58)	0.980 (46.91)	1.470 (70.37)
	207.0 (63.11)	1.260 (60.32)	1.500 (71.81)
	212.0 (64.63)	1.320 (63.19)	1.440 (68.94)
	213.0 (64.94)	1.500 (71.81)	1.360 (65.11)
	215.0 (65.55)	1.100 (52.66)	1.600 (76.60)
	219.0 (66.77)	1.200 (57.45)	1.410 (67.50)
	219.0 (66.77) R	-	0.575 (27.52)
	224.0 (68.29)	1.260 (60.32)	1.730 (82.82)
	226.0 (68.90)	1.340 (64.15)	1.790 (85.69)
	226.0 (68.90) R	-	0.760 (36.36)
4	231.0 (70.42)	1.240 (59.36)	1.500 (71.81)
	237.0 (72.26)	1.640 (78.51)	1.850 (88.56)
	237.0 (72.26) R	-	1.087 (52.03)
	240.0 (73.17)	1.500 (71.83)	1.900 (90.96)
6	22.0 (6.71)	1.108 (5.17)	0.190 (9.10)
	42.0 (12.80)	0.130 (6.22)	0.290 (13.88)
	62.0 (18.90)	0.200 (9.57)	0.300 (14.36)
	82.0 (25.00)	0.200 (9.57)	0.340 (16.28)
	101.0 (30.79)	0.360 (17.23)	0.380 (18.19)
	105.0 (32.01)	0.200 (9.57)	0.460 (22.02)
	128.0 (39.02)	-	0.840 (40.21)
	142.0 (43.29)	0.460 (22.02)	0.590 (28.24)
	146.6 (44.70)	0.480 (22.98)	0.680 (32.55)
	162.0 (49.30)	0.540 (22.85)	0.770 (36.86)
	182.0 (55.49)	0.620 (29.68)	0.780 (37.34)
	212.0 (64.63)	1.040 (49.79)	1.190 (56.97)
	222.0 (67.68)	1.200 (57.45)	1.330 (63.67)
	242.0 (73.78)	1.440 (68.94)	1.730 (82.82)

Note: R denotes residual miniature vane test

SUMMARY OF TORVANE AND MINIATURE VANE TEST RESULTS FOR SAMPLES NOT RETAINED BY McCLELLAND ENGINEERS, INC.

Borings 4, 5 and 6, Block 58
West Delta Area

Boring No.	Penetration, Ft (m)	Torvane ksf (kPa)	Miniature Vane ksf (kPa)
5	0.5 (1.64)	0.032 (1.53)	0.025 (1.20)
	6.0 (19.68)	0.088 (4.21)	0.087 (4.16)
	11.0 (36.08)	-	0.087 (4.16)
	17.0 (5.18)	0.100 (4.78)	0.190 (9.10)
	21.5 (6.55)	0.148 (7.09)	0.230 (11.01)
	26.5 (8.08)	0.184 (8.81)	0.200 (9.57)
	32.0 (11.28)	0.320 (15.32)	0.360 (17.23)
	35.5 (10.82)	0.180 (8.62)	0.190 (9.10)
	37.0 (11.28)	0.120 (5.74)	0.150 (7.18)
	42.0 (12.80)	0.200 (9.57)	0.320 (15.32)
	47.0 (14.33)	0.200 (9.57)	0.270 (12.93)
	52.0 (15.85)	0.300 (14.36)	0.420 (20.11)
	57.0 (17.38)	0.300 (14.36)	0.420 (20.11)
	57.0 (17.38)	0.216 (10.34)	0.200 (9.57)
	62.0 (18.90)	0.224 (10.72)	0.350 (16.76)
	67.0 (20.43)	0.300 (14.36)	0.390 (18.67)
	72.0 (21.95)	0.200 (9.57)	0.370 (17.71)
	82.0 (25.00)	0.220 (10.53)	0.420 (20.11)
	92.0 (28.05)	0.280 (13.40)	0.450 (21.54)
	117.0 (35.67)	0.340 (16.28)	0.500 (23.94)
	122.0 (37.20)	0.460 (22.02)	0.610 (29.20)
	130.0 (39.63)	0.380 (18.19)	0.560 (26.81)
	132.0 (40.24)	-	0.440 (21.06)
	137.0 (41.77)	0.360 (17.23)	0.470 (22.50)
	142.0 (43.29)	0.540 (25.85)	0.810 (38.78)
	150.0 (45.73)	0.520 (24.89)	0.750 (35.90)
	157.0 (47.87)	0.560 (26.81)	0.730 (34.95)
	162.0 (49.39)	-	0.790 (37.82)
	167.0 (50.91)	0.640 (30.64)	0.830 (39.73)
	174.0 (53.04)	0.520 (24.89)	0.740 (35.43)
	177.0 (53.96)	0.540 (25.85)	0.650 (31.11)
	179.0 (54.57)	0.700 (33.51)	0.920 (44.04)
	182.0 (55.49)	0.700 (33.51)	-
	197.0 (60.06)	0.840 (40.21)	0.990 (47.39)
	202.0 (61.58)	0.980 (46.91)	1.470 (70.37)
	207.0 (63.11)	1.260 (60.32)	1.500 (71.81)
	212.0 (64.63)	1.320 (63.19)	1.440 (68.94)
	213.0 (64.94)	1.500 (71.81)	1.360 (65.11)
	215.0 (65.55)	1.100 (52.66)	1.600 (76.60)
	219.0 (66.77)	1.200 (57.45)	1.440 (67.50)
	222.0 (67.68)	1.140 (54.57)	1.410 (67.50)
	224.0 (68.29)	1.260 (60.32)	1.730 (82.82)
	226.0 (68.90)	1.340 (64.15)	1.790 (85.69)

(Continued on Plate B-2b)

SUMMARY OF TORVANE AND MINIATURE VANE TEST RESULTS FOR SAMPLES NOT RETAINED BY McCLELLAND ENGINEERS, INC.

Borings 4, 5 and 6, Block 58
West Delta Area

(Continued from Plate B-2a)

Boring No.	Penetration, Ft (m)	Torvane ksf (kPa)	Miniature Vane ksf (kPa)
4	231.0 (70.42)	1.240 (59.36)	1.500 (71.81)
	237.0 (72.26)	1.640 (78.51)	1.850 (88.56)
	240.0 (73.17)	1.500 (71.81)	1.900 (90.96)
6	22.0 (6.71)	1.108 (5.17)	0.190 (9.10)
	42.0 (12.80)	0.130 (6.22)	0.290 (13.88)
	62.0 (18.90)	0.200 (9.57)	0.300 (14.36)
	82.0 (25.00)	0.200 (9.57)	0.340 (16.28)
	101.0 (30.79)	0.360 (17.23)	0.380 (18.19)
	105.0 (32.01)	0.200 (9.57)	0.460 (22.02)
	128.0 (39.02)	-	0.840 (40.21)
	142.0 (43.29)	0.460 (22.02)	0.590 (28.24)
	146.6 (44.70	0.480 (22.98)	0.680 (32.55)
	162.0 (49.39)	0.540 (22.85)	0.770 (36.86)
	182.0 (55.49)	0.620 (29.68)	0.780 (37.34)
	212.0 (64.63)	1.040 (49.79)	1.190 (56.97)
	222.0 (67.68)	1.200 (57.45)	1.330 (63.67)
	242.0 (73.78)	1.440 (68.94)	1.730 (82.82)

SUMMARY OF TORVANE AND MINIATURE VANE TEST RESULTS FOR SAMPLES NOT RETAINED BY McCLELLAND ENGINEERS, INC.

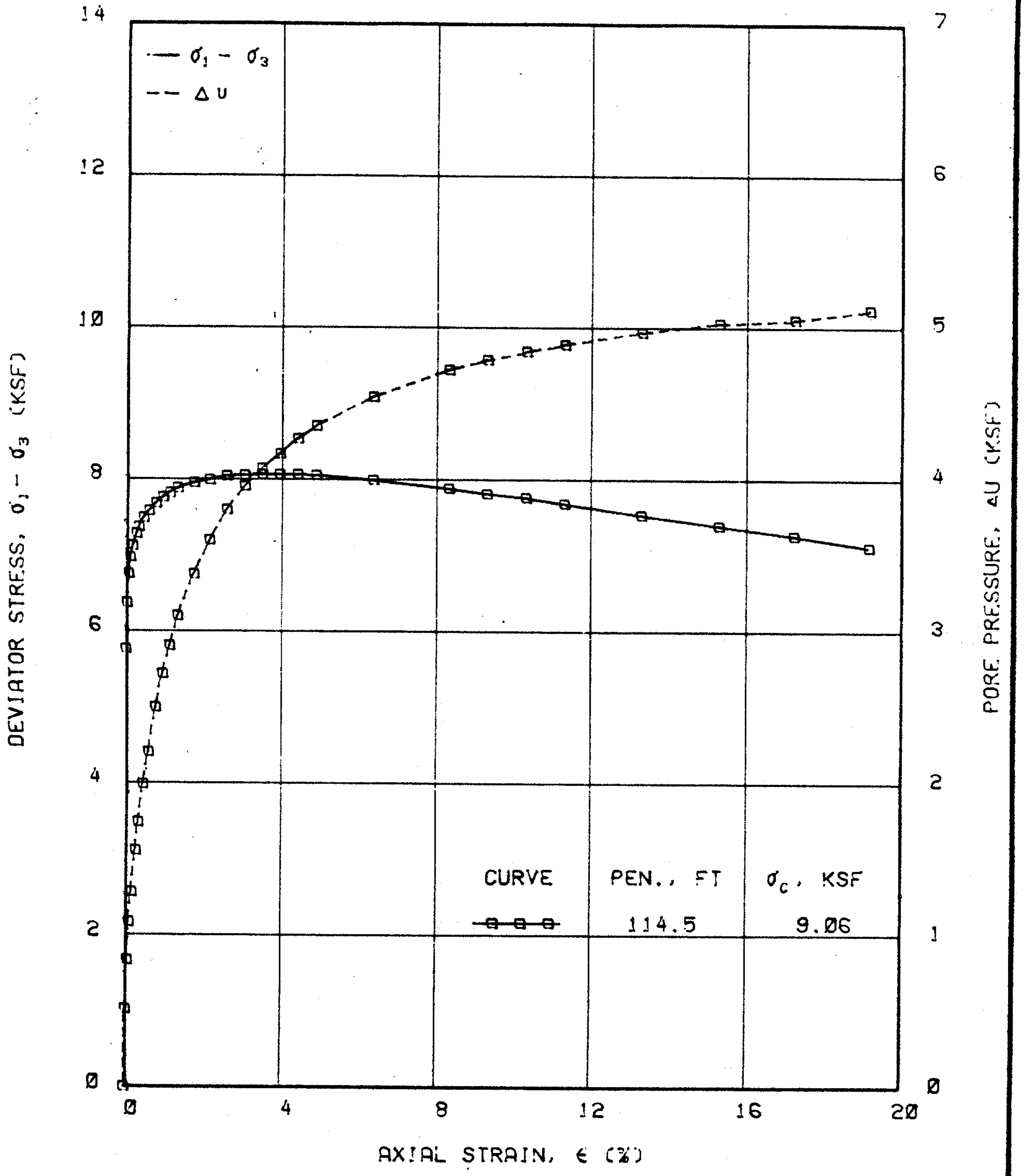
Borings 4, 5, and 6, Block 58

West Delta Area

Boring No.	Sample No.	Penetration, Ft (m)	Liquid Limit, %	Plastic Limit, %	Water Content, %		Liquidity Index Final	Unit Dry Weight Final, pcf (Mg/m^3)	Sample Dimensions, in., (mm)		Anisotropic Consolidation Data		Failure Pressure and Stresses, ksf (kPa)				Undrained Shear Strength, s_u, ksf (kPa)	$s_u/\bar{\sigma}_v$	Strain at Failure, %
					Initial	Final			Initial Diameter	Initial Height	Confining Pressure, ksf (kPa)	K_o	σ_1	Δu	$\bar{\sigma}_1$	$\bar{\sigma}_3$			
5	69	114.5 (34.9)	64	27	42	30	0.08	92.8 (1.490)	2.15 (54.61)	3.90 (99.06)	9.06 (434)	0.61	17.13 (820)	4.26 (204)	12.87 (616)	4.80 (23.0)	4.03 (192.9)	0.27	4.43
5	110	189.2 (57.7)	89	36	54	36	0.00	100.7 (1.613)	2.20 (52.88)	3.82 (47.02)	15.98 (765)	0.79	25.44 (1218)	6.77 (324)	18.68 (894)	9.21 (441)	4.73 (226.5)	0.23	5.46

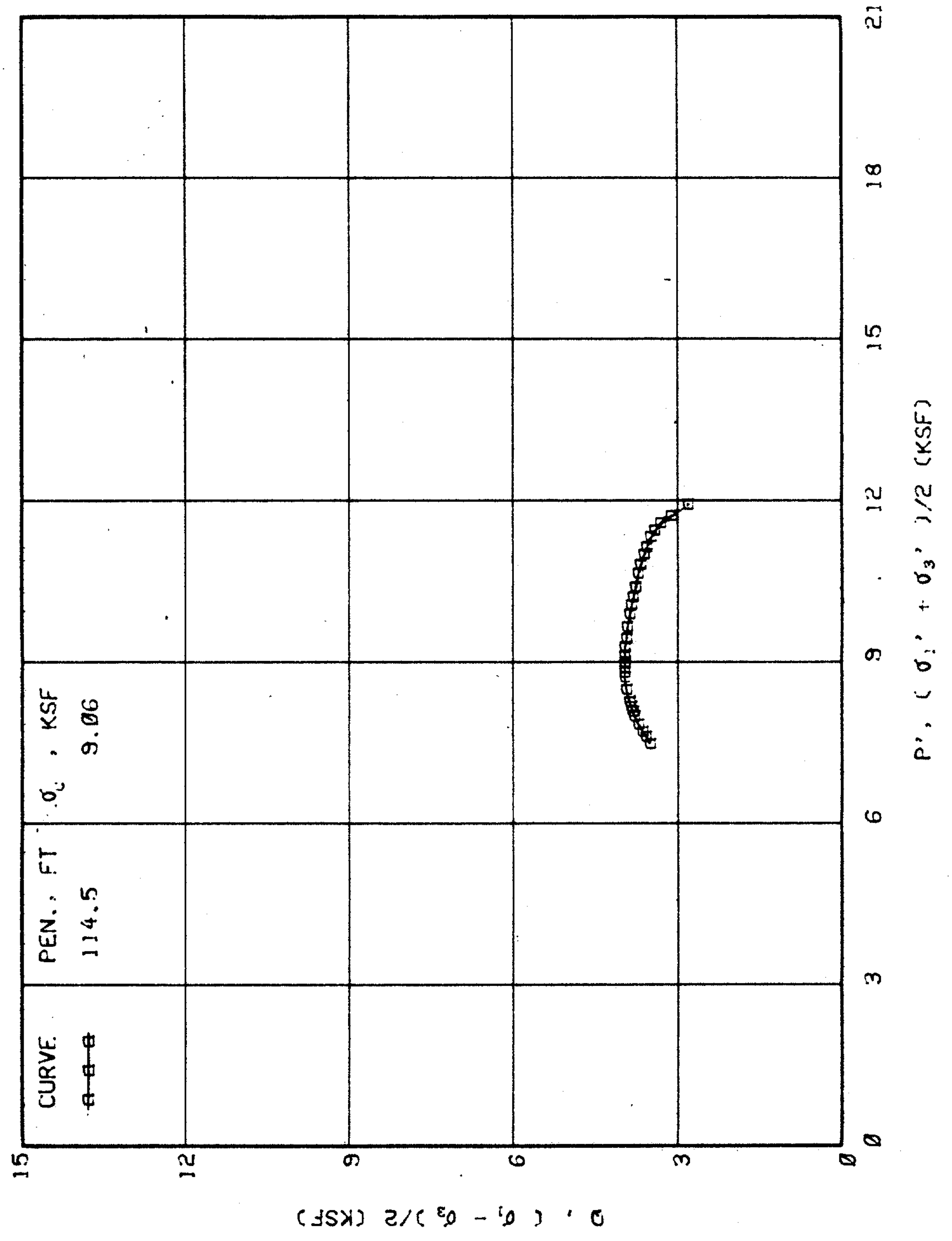
SUMMARY OF Ko CONSOLIDATED-UNDRAINED TRIAXIAL TEST RESULTS

Boring 5, Block 58
West Delta Area



STRESS-STRAIN CURVES
Ko Consolidated-Undrained Triaxial Test
Boring 5

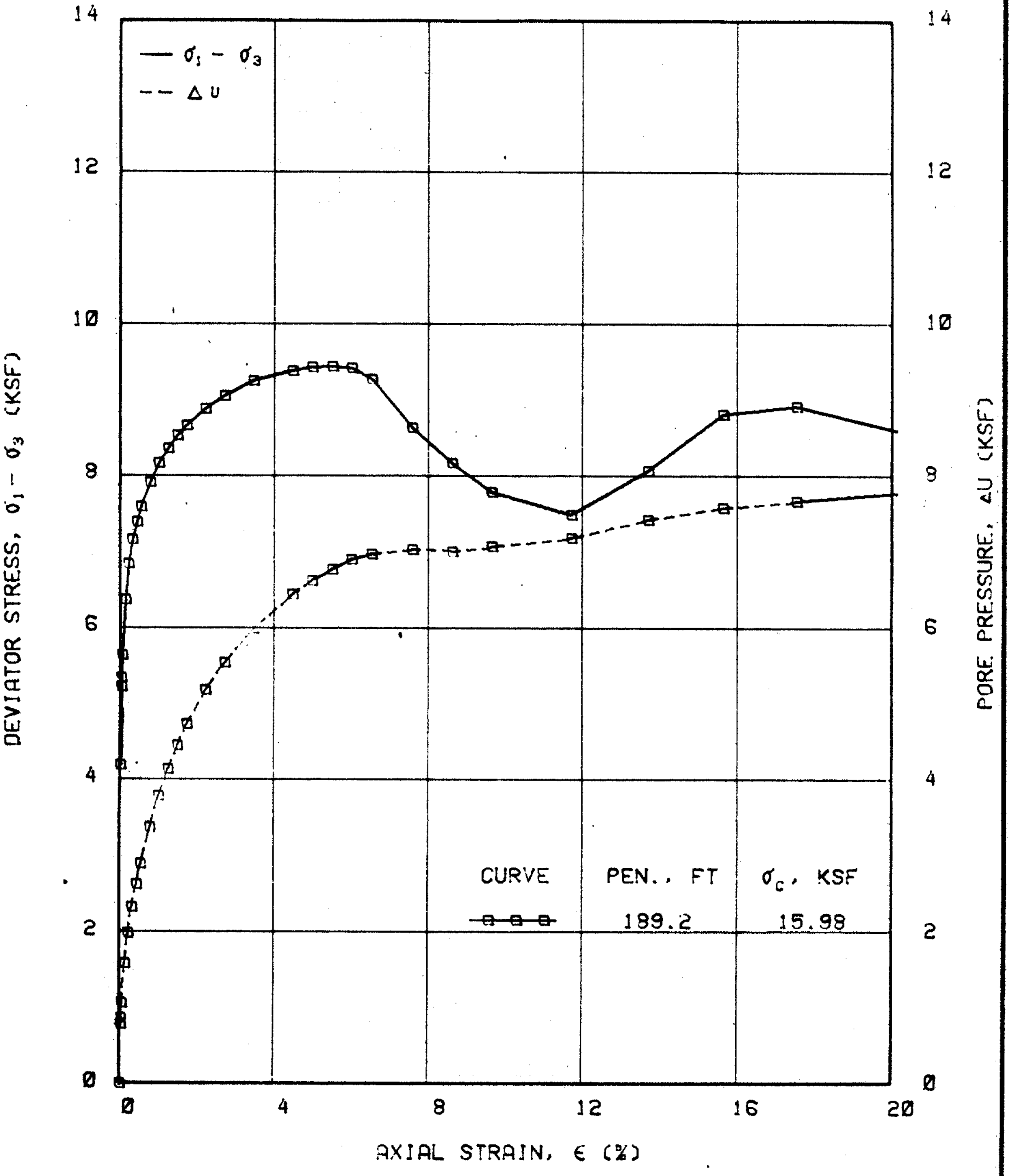
0181-0217



P' - Q DIAGRAM

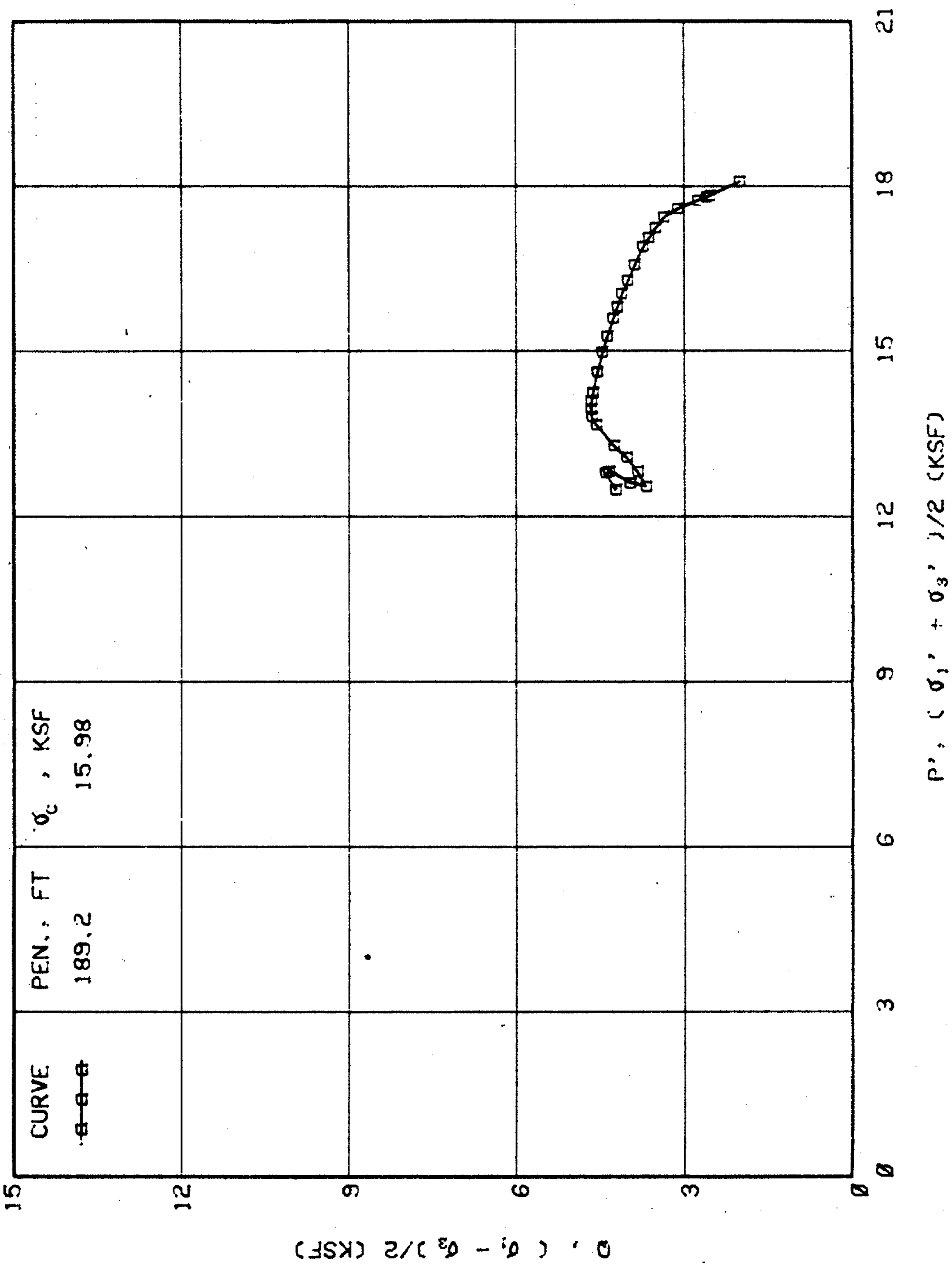
Ko Consolidated-Undrained Triaxial Test

Boring 5



STRESS-STRAIN CURVES
Ko Consolidated-Undrained Triaxial Test
Boring 5

0181-0217



P' - Q DIAGRAM

Ko Consolidated-Undrained Triaxial Test

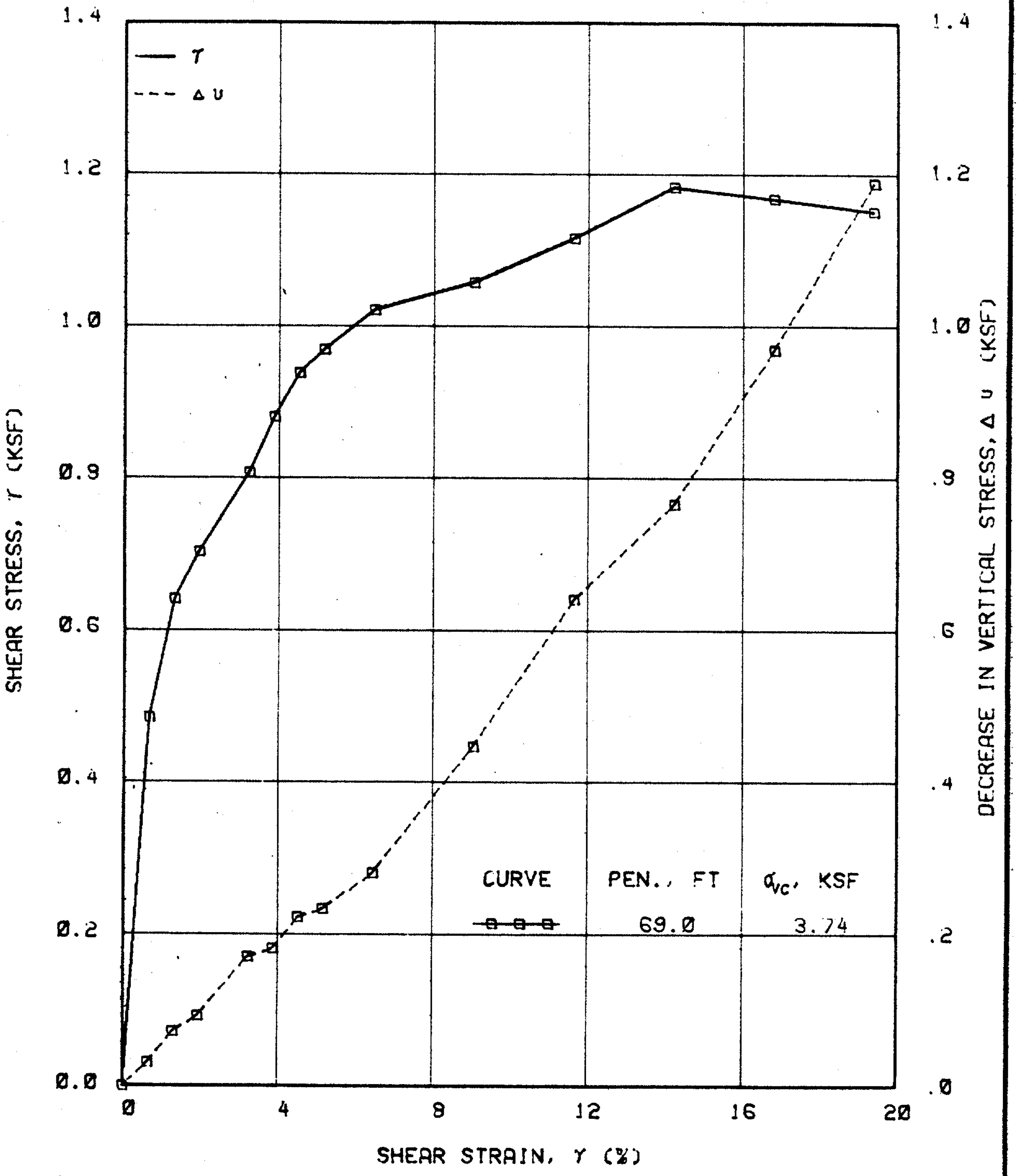
Boring 5

McCLELLAND
ENGINEERS

Boring No.	Sample No.	Penetration, Ft (m)	Liquid Limit, %	Plastic Limit, %	Water Content, %		Liquidity Index Final	Sample Height, in. (mm)		Effective Vertical Consolidation Pressure, $\bar{\sigma}_{vc}$, ksf (kPa)	OCR	Undrained Shear Strength, s_u, ksf (kPa)	$s_u/\bar{\sigma}_{vc}$	Shear Strain at Failure, %
					Initial	Final		Initial	Final					
5	42	69.0 (21.0)	64	27	73	58	0.84	0.75 (19.05)	0.61 (15.50)	3.74 (179)	1	1.18 (56.7)	0.32	14.1
5	85	149.5 (45.5)	54	24	36	29	0.17	0.75 (19.05)	0.63 (16.00)	9.36 (448)	1	2.58 (12.3)	0.28	13.8
5	138	228.7 (69.7)	83	32	63	44	0.24	0.75 (19.05)	0.62 (15.75)	14.26 (683)	1	3.30 (158)	0.23	19.2

SUMMARY OF STATIC SIMPLE SHEAR TEST RESULTS

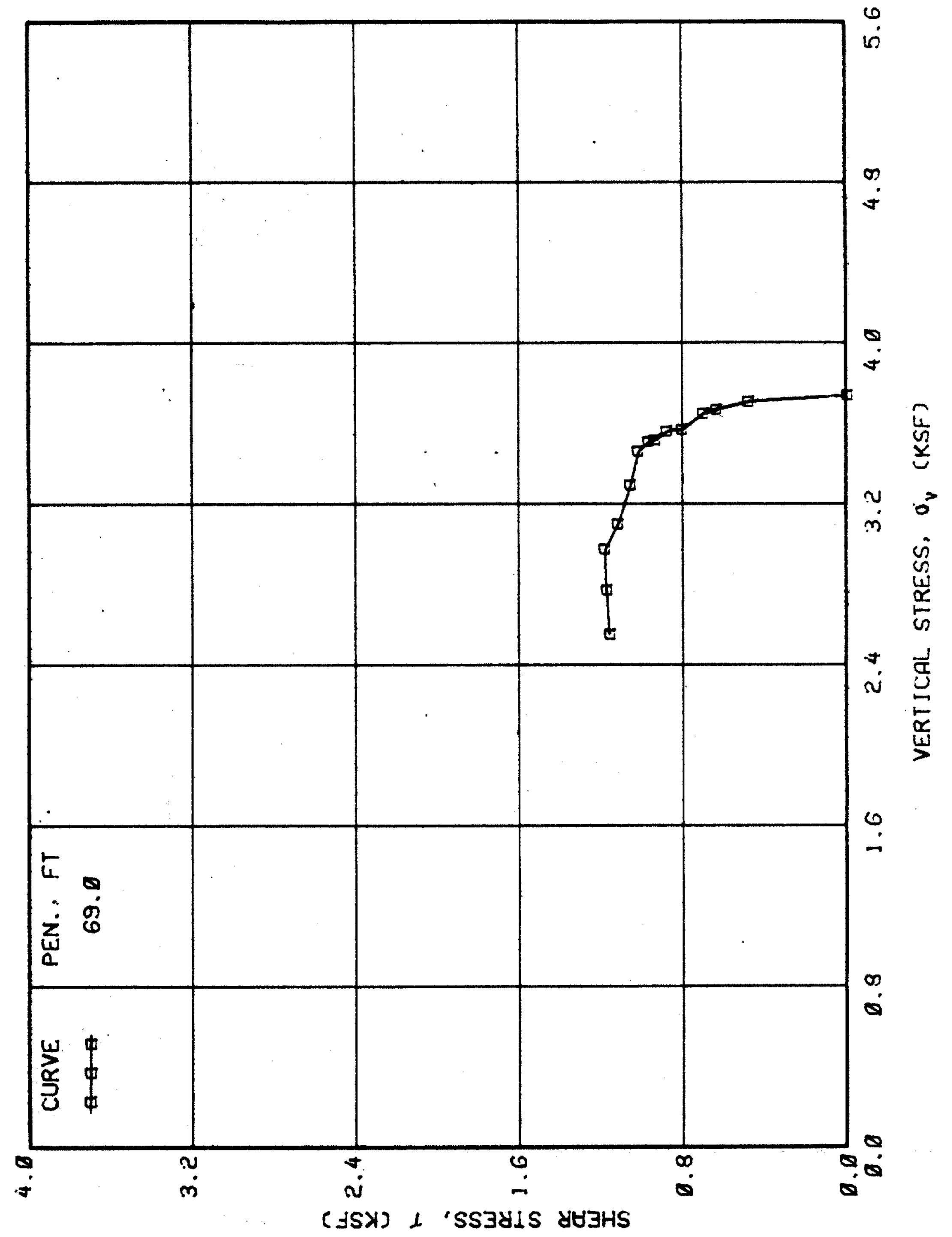
Boring 5, Block 58
West Delta Area



STRESS-STRAIN CURVES

DEFORMATION-CONTROLLED SIMPLE SHEAR TEST

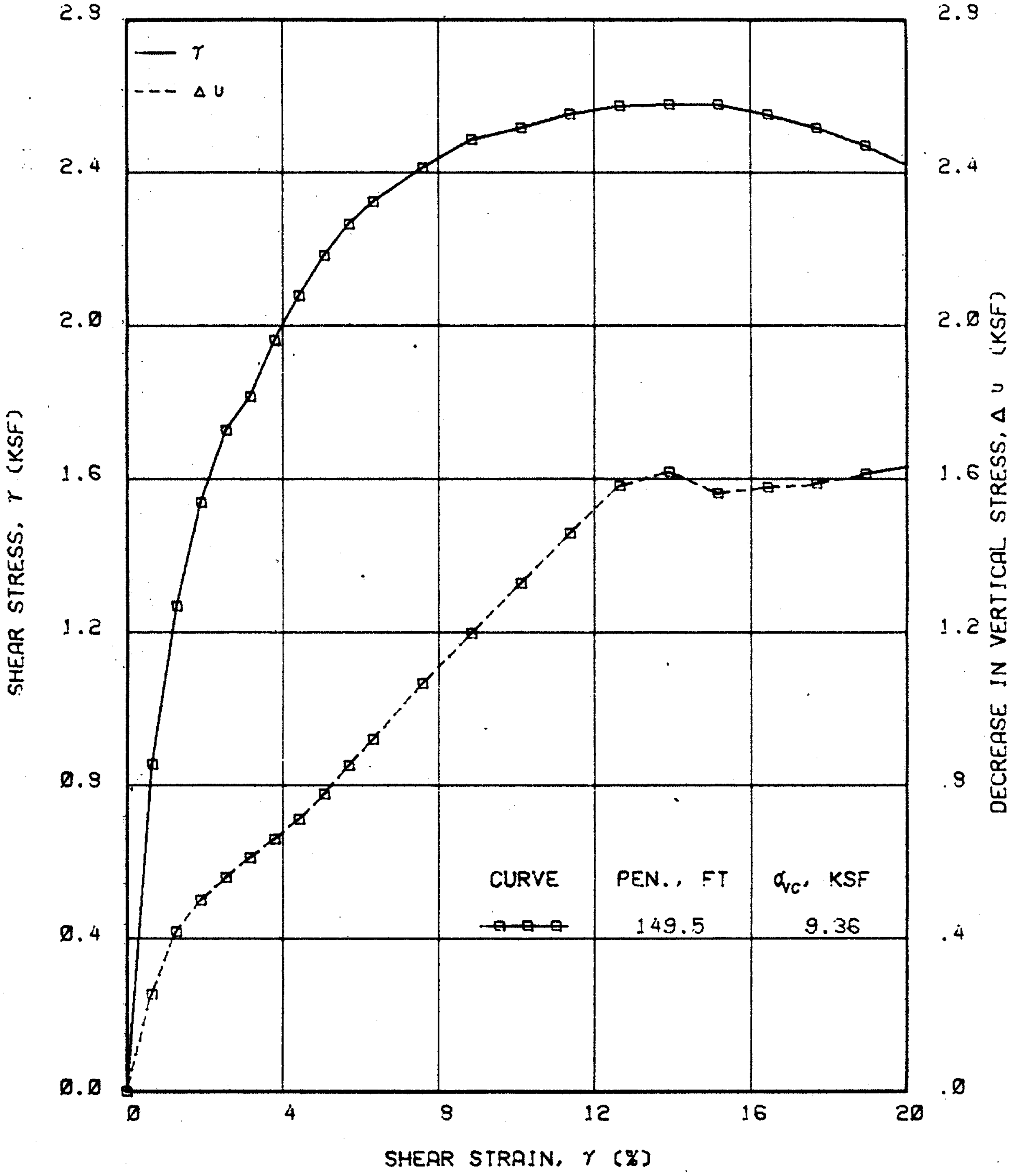
BORING 5



STRESS PATH

DEFORMATION-CONTROLLED SIMPLE SHEAR TEST

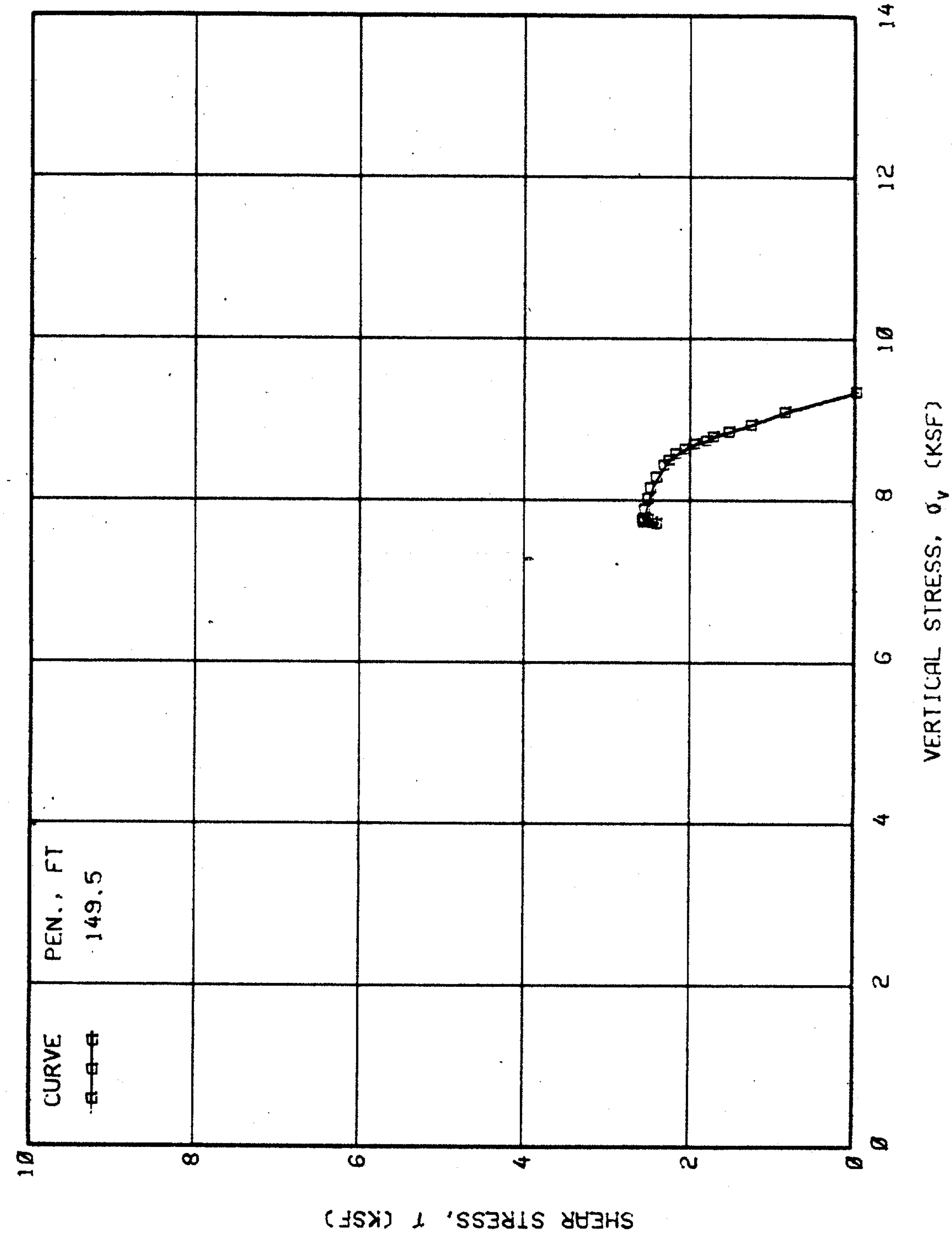
BORING 5



STRESS-STRAIN CURVES

DEFORMATION-CONTROLLED SIMPLE SHEAR TEST

BORING 5

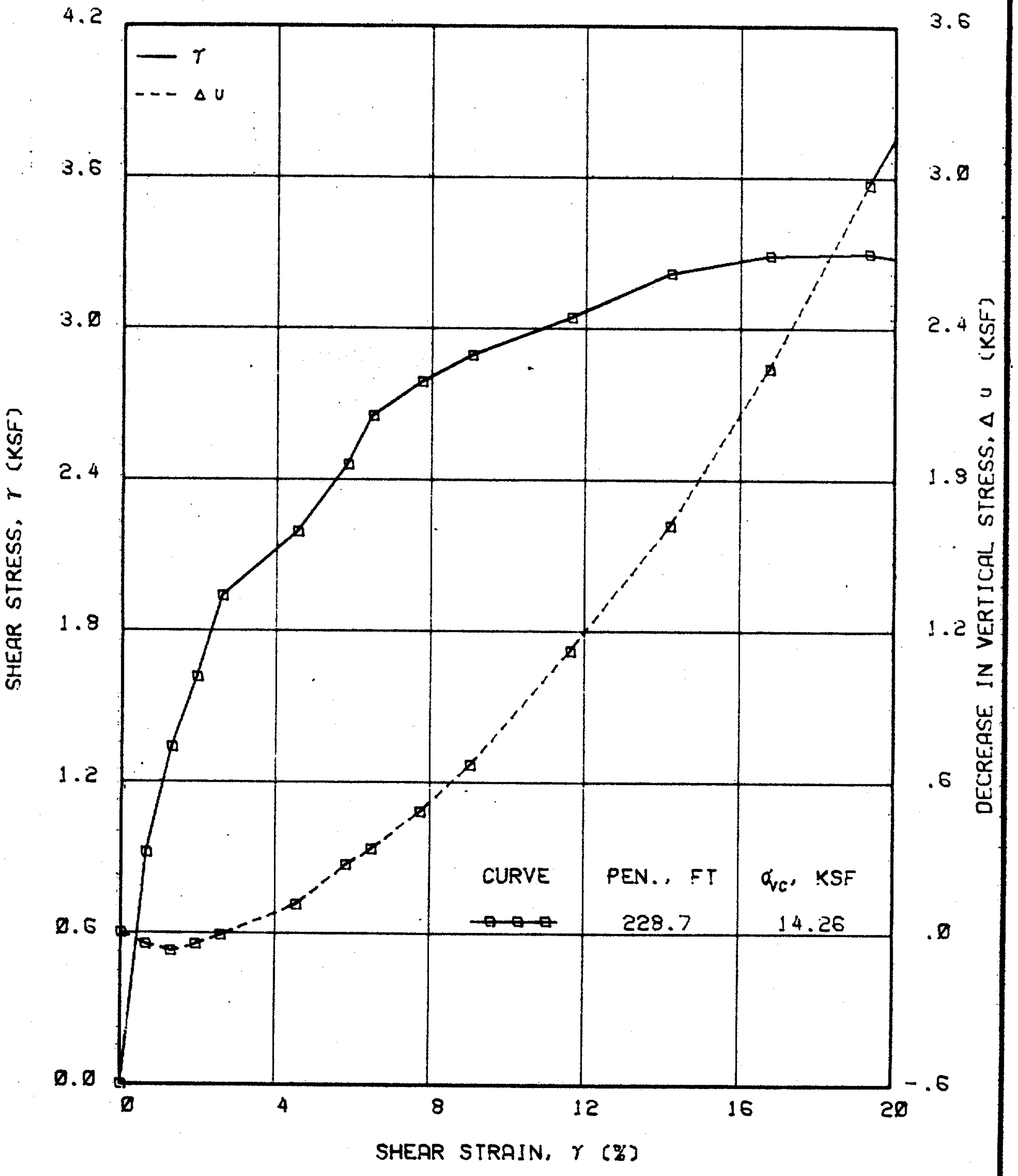


STRESS PATH

DEFORMATION-CONTROLLED SIMPLE SHEAR TEST

BORING 5

0181-0217

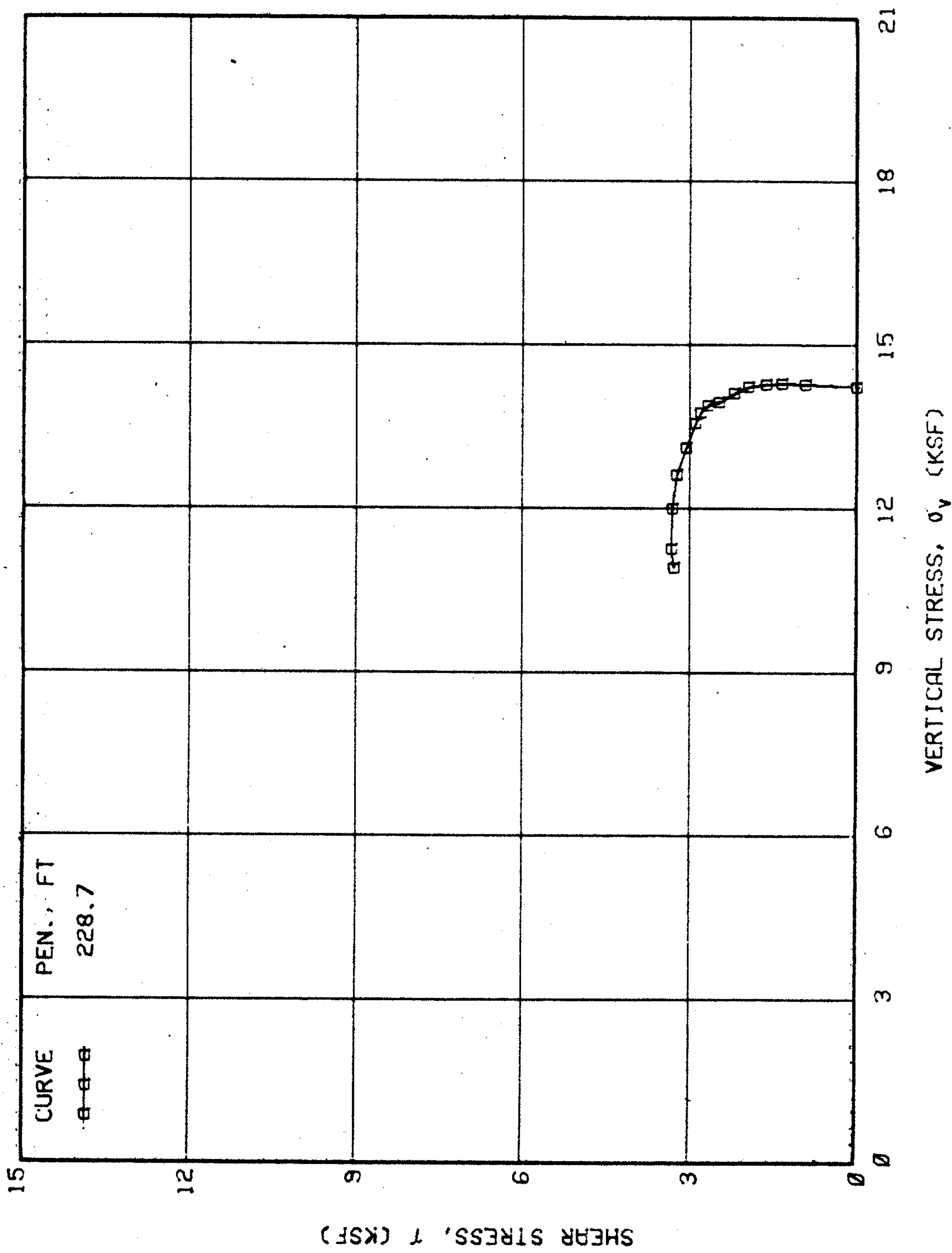


STRESS-STRAIN CURVES

DEFORMATION-CONTROLLED SIMPLE SHEAR TEST

BORING 5

0181-0217



STRESS PATH

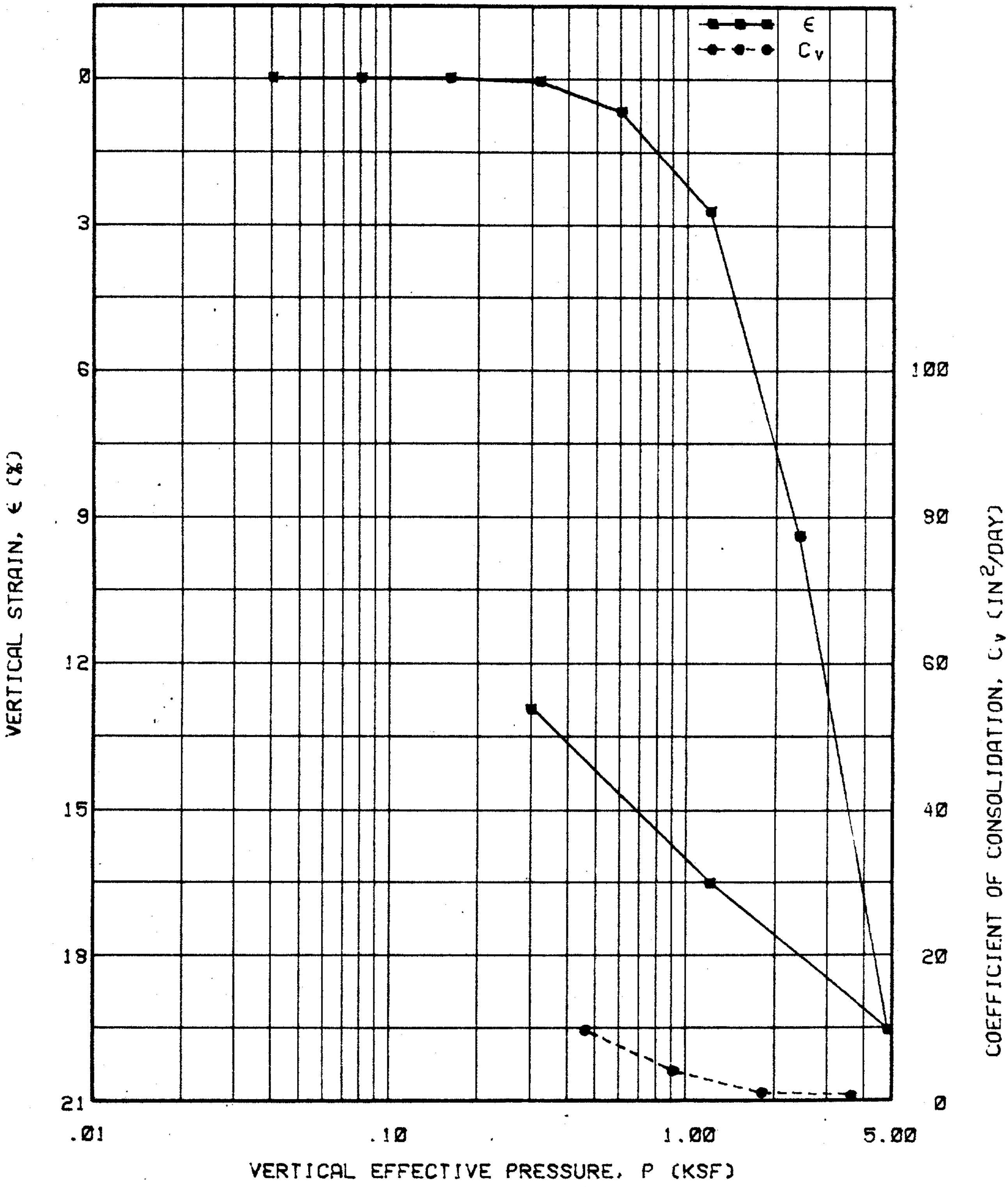
DEFORMATION-CONTROLLED SIMPLE SHEAR TEST

BORING 5

181-0217

BORING: 5 **PENETRATION:** 69.0 FT.
MATERIAL:

DRY MASS DENSITY: 57 PCF
WATER CONTENT: 74 %
LIQUID LIMIT:
PLASTIC LIMIT:
SPECIFIC GRAVITY: 2.75 (ASSUMED)
INITIAL VOID RATIO: 2.024



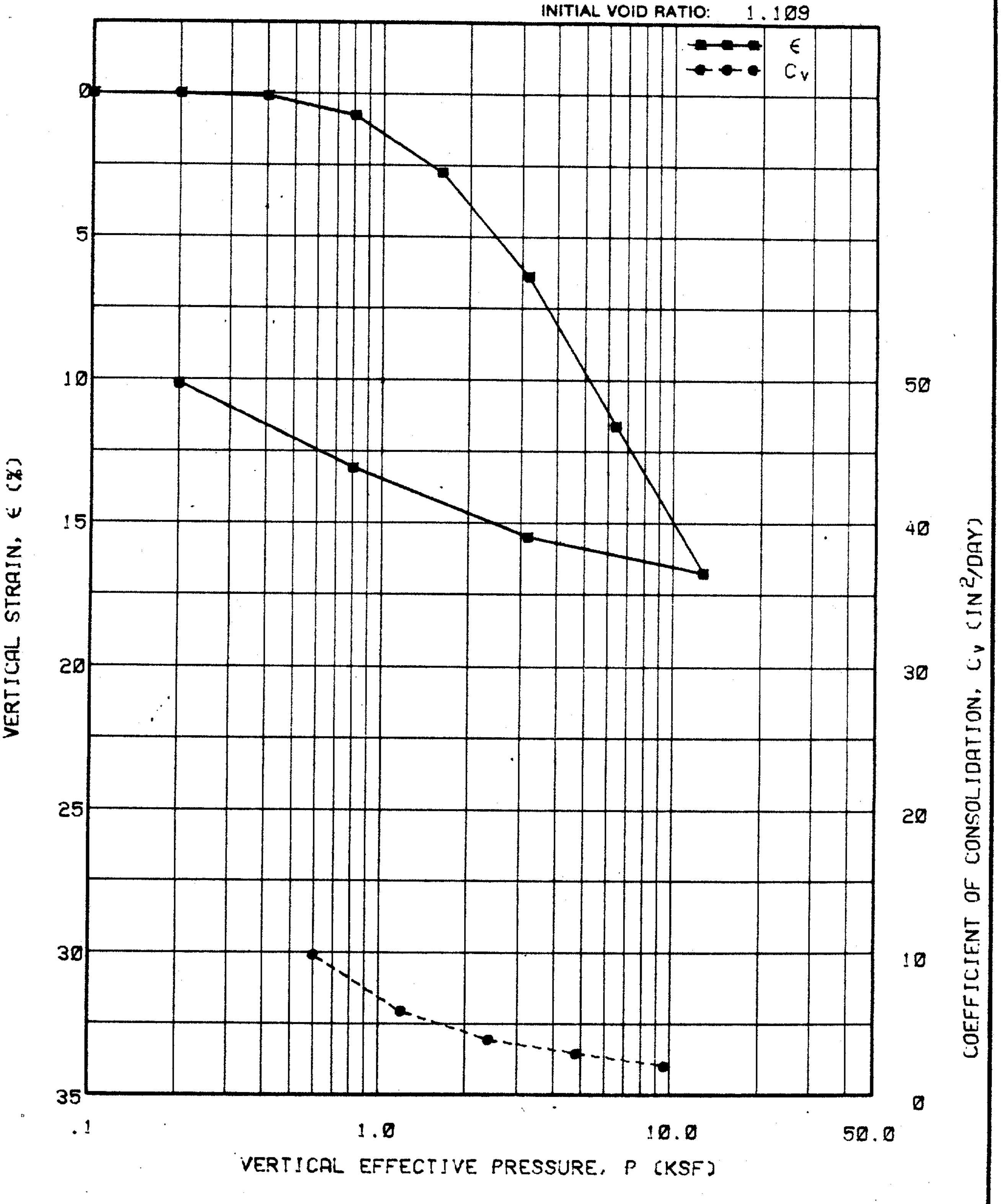
INCREMENTAL CONSOLIDATION TEST RESULTS

McCLELLAND
ENGINEERS

181-0217

BORING: 5 **PENETRATION:** 149.5 FT.
MATERIAL:

DRY MASS DENSITY: 91 PCF
WATER CONTENT: 39 %
LIQUID LIMIT:
PLASTIC LIMIT:
SPECIFIC GRAVITY: 2.75 (ASSUMED)
INITIAL VOID RATIO: 1.109



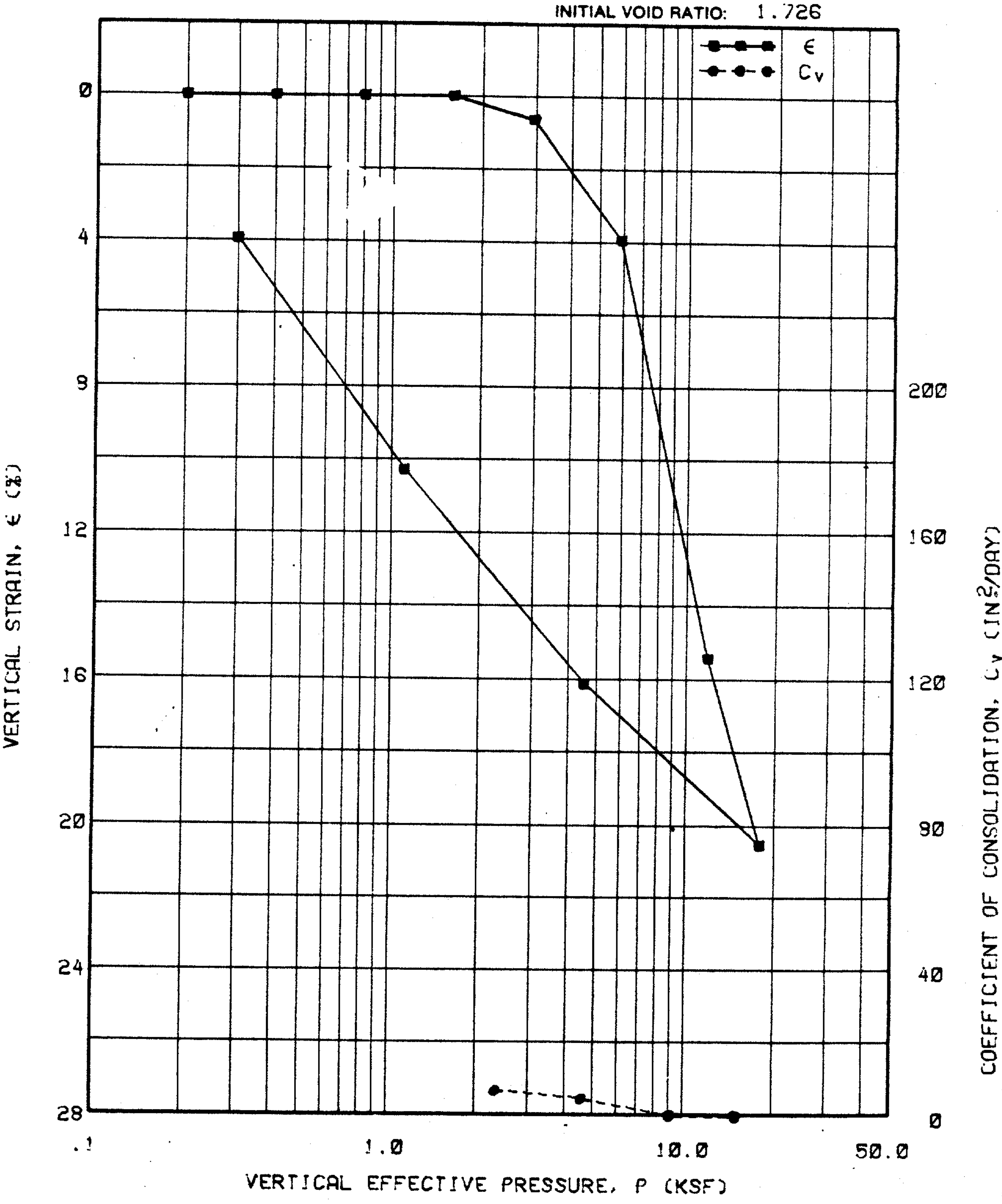
INCREMENTAL CONSOLIDATION TEST RESULTS

McCLELLAND ENGINEERS

181-0217

BORING: 5 PENETRATION: 228.7 FT.
MATERIAL:

DRY MASS DENSITY: 64 PCF
WATER CONTENT: 62 %
LIQUID LIMIT:
PLASTIC LIMIT:
SPECIFIC GRAVITY: 2.90
INITIAL VOID RATIO: 1.726



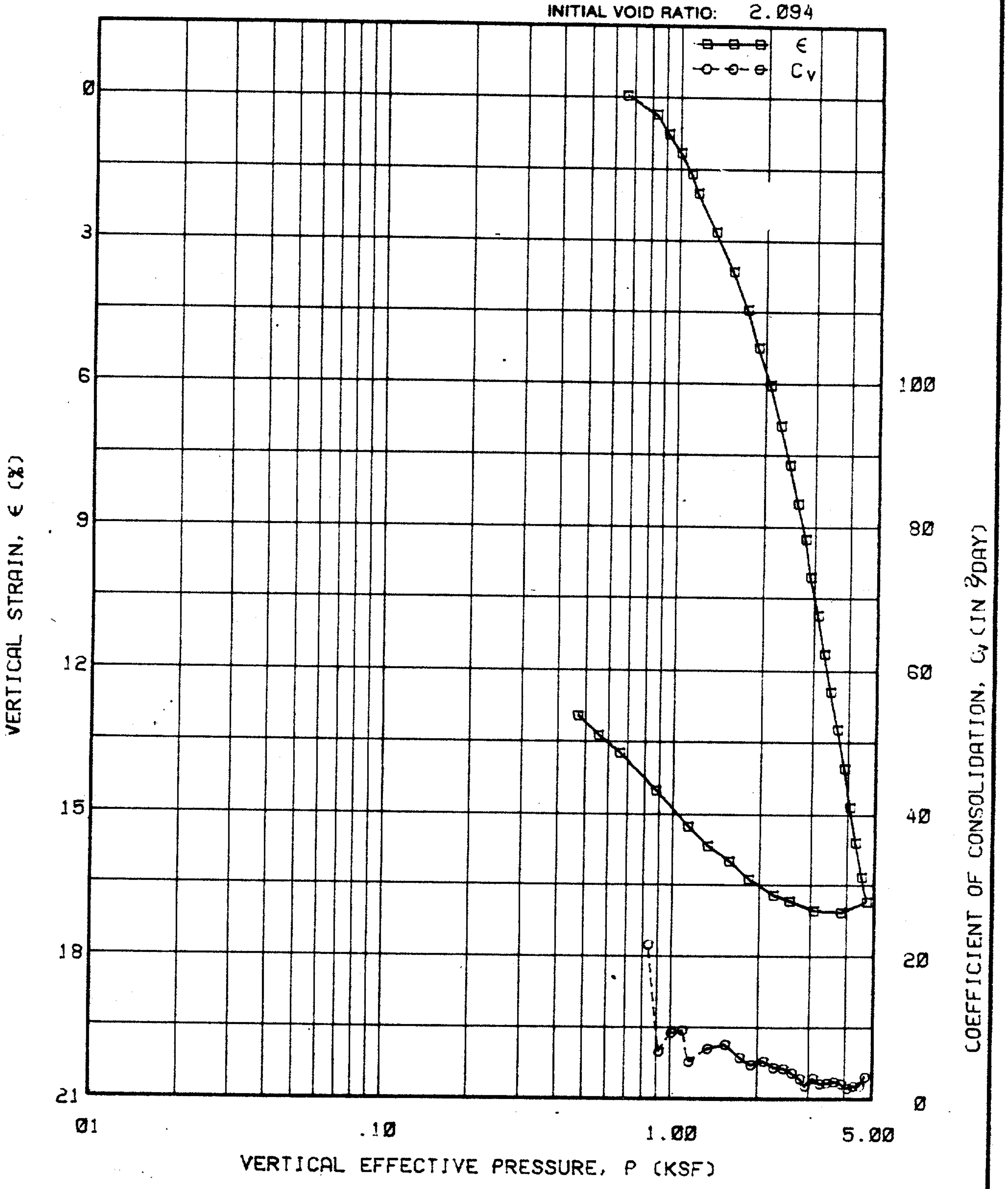
INCREMENTAL CONSOLIDATION TEST RESULTS

0181-0217

BORING: 5
MATERIAL:

PENETRATION: 69.0 FT.

DRY MASS DENSITY: 57 PCF
WATER CONTENT: 76 %
LIQUID LIMIT:
PLASTIC LIMIT:
SPECIFIC GRAVITY: 2.90
INITIAL VOID RATIO: 2.094



CRS CONSOLIDATION TEST RESULTS

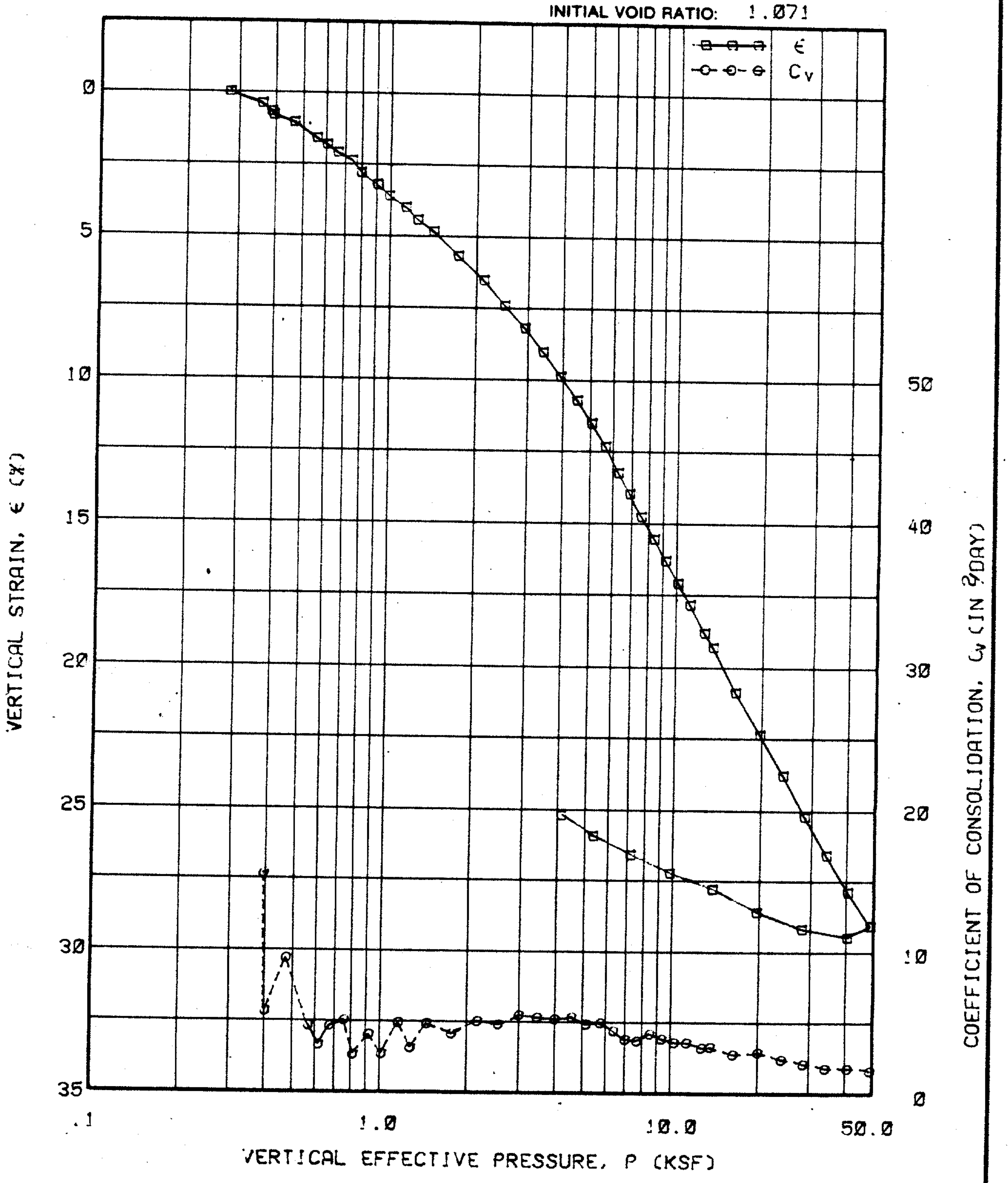
McCLELLAND
ENGINEERS

0181-0217

BORING: 5
MATERIAL:

PENETRATION: 149.5 FT.

DRY MASS DENSITY: 83 PCF
WATER CONTENT: 39 %
LIQUID LIMIT:
PLASTIC LIMIT:
SPECIFIC GRAVITY: 2.75 (ASSUMED)
INITIAL VOID RATIO: 1.071



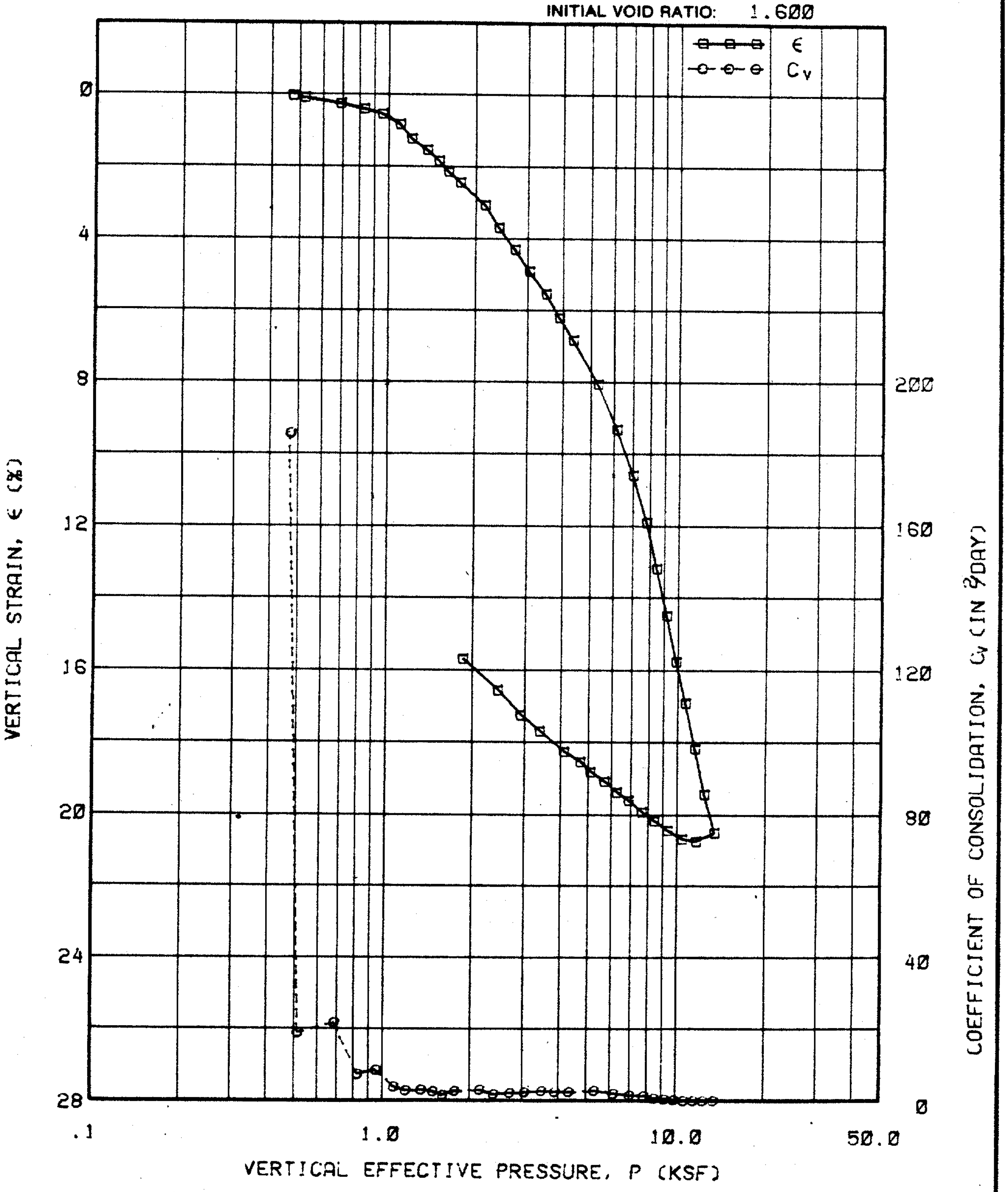
CRS CONSOLIDATION TEST RESULTS

0181-0217

BORING: 5
MATERIAL:

PENETRATION: 228.7 FT.

DRY MASS DENSITY: 67 PCF
WATER CONTENT: 62 %
LIQUID LIMIT:
PLASTIC LIMIT:
SPECIFIC GRAVITY: 2.90
INITIAL VOID RATIO: 1.600



CRS CONSOLIDATION TEST RESULTS

McCLELLAND ENGINEERS