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COLLEGE OF ENGINEERING

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Draft Report

PROCEDURES FOR CONDUCTING CONSOLIDATED DRAINED AND CONSOLIDATED UNDRAINED TRIAXIAL TESTS

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INTRODUCTION

Soil types that cause problems for the Michigan Department of State Highways (MDSH) are the sediments such as found in the valleys of the St. Joseph, Muskegon and Saginaw Rivers. These sediments consist of strata of loose sand, and organic silt and clay. The methods used to build highways over these deposits vary with the depth and stratification of the deposit and the importance of the highway. Shallow deposits are usually excavated and replaced with sound fill. Deep deposits are bridged using a deep foundation if the highway warrants the cost involved.

If the deposit is deep and if bridging is too costly, the method used involves the limited excavation of the sediments and the floating of the fill. With this method, the soil consolidates under the weight of the fill and the fill settles. To minimize settlement after the pavement structure is built the fill is constructed as far in advance as possible before paving. Any settlement after paving is taken care of by periodic maintenance. The amount of settlement and the time for it to occur are based on past experience.

The laboratory tests, the analytical methods and the field techniques are available for determining reasonable estimates of the rate of surcharging and of the resulting settlement. The use of these procedures could result in construction and maintenance costs savings to the MDSH. For example, it may be more economical on some major projects to surcharge and consolidate these sediments, perhaps with aid of vertical sand drains, than to bridge them using deep foundations. On other projects a more adequate knowledge of the consolidation characteristics of these deposits could result in better control of the surcharging and the settlement. This in turn would lead to a reduction in maintenance after the completion of the project.

The major input data required for the analytical methods are the consolidation characteristics of the soil and the parameters needed to predict the increase in shear strength with consolidation. These imput data are obtained from consolidation and triaxial tests conducted in the laboratory on undisturbed soil specimens. In the past the MDSH has not been able to avail itself of these methods mainly because the Testing Laboratory has not been in a position to conduct the necessary tests on a routine basis. The Testing Laboratory now has the necessary consolidation and triaxial equipment. The major purpose of this project is to develop tests procedures for the triaxial equipment so the required shear strength parameters can be determined.

TYPES OF TRIAXIAL TESTS

The shear strength of fine-grained soils is very complex and not completely understood. These soils are relatively compressible when compared with granular soils. Therefore, when the load is first applied it is initially supported by the pore fluid as an excess pressure or neutral stress and is not transmitted to the soil structure. As the excess pressure dissipates the intergranular pressure or effective stress between the soil particles increases. The rate at which this transfer takes place is dependent upon the permeability of the soil and on the nature of the pore fluid; whether it is air, water or both. In other words, whether the soil is dry, partially saturated or saturated. Further complicating the understanding of the shear strength of fine-grained soils are the very significant forces of attraction and repulsion developed between clay particles because of their large specific surfaces.

Three basic types of triaxial tests are run to study the shear strength of fine-grained soils. These tests are defined in terms of the neutral stress dissipation and the increase in effective stress. The consolidated drained test (CD test) is run in such a manner so as to cause no change in the neutral stress. Any increase in total stress produces a corresponding change in effective stress. The consolidation of the soil takes place in two stages. First, the soil is consolidated under the confining cell pressure and second during the application of the axial load. In both stages the soil is allowed to drain freely, and the stresses are applied slowly so that the neutral stress remains unchanged. The void ratio and the water content are reduced during both stages.

The consolidated undrained test (CU test) is also conducted in two stages. The soil is first consolidated with free drainage under the confining pressure. During this stage the neutral stress remains unchanged and there is a reduction in void ratio and water content. After consolidation is complete, the axial stress is applied rapidly without drainage. The increase in stress results in changes in the neutral stress. In the case of saturated soils the void ratio and water content remains unchanged during this stage. In partially saturated soils the water content remains unchanged since there is no drainage but the void ratio can change.

The third type of triaxial test is the unconsolidated undrained test (UU test). This procedure differs from the others in that drainage is not allowed at any time and, therefore, no consolidation takes place. The confining pressure is applied followed immediately by the axial stress. In saturated soils, the void ratio and water content remain unchanged and all of the added stress is supported by the neutral stress.

Since the neutral stress remains unchanged in the CD test, the effective stress and total stress are the same. The shear strength parameters determined from this test are in terms of effective stress. In the UU and CU tests the excess pore pressure is not allowed to dissipate during the shearing process. Therefore, the total stress and effective stress differ by the magnitude of the excess pore pressure. The shear strength parameters from these two tests, then, are in terms of total stress. The parameters can be found in terms of effective stress if accurate pore pressure measurements are made. This is frequently done because of the excessive testing time required for CD tests on soils with low permeability.

The MDSH Testing Laboratory has a procedure for conducting UU tests and have been performing this type for a number of years. The procedure used essentially follows that outlined in ASTM

Designation: D2850 - 70, Standard Method of Test for Unconsolidated, Undrained Strength of Cohesive Soils in Triaxial Compression.

The Testing Laboratory does not have procedures for the CD and CU tests. As noted in the introduction, the purpose of this project is to develop procedures for these two types of tests.

METHODS OF LOADING

There are two methods of loading that can be used in conducting the tests: controlling the strain or controlling the stress. In the former the sample is deformed at a constant rate of strain. The stress is determined at various strains so that a stress-strain curve can be plotted. The rate at which the sample is strained is dependent upon the type of test and whether pore pressure measurements are to be made.

The stress controlled method uses incremental loading. The strain is determined for each loading so that a stress-strain curve can be plotted. The magnitude and duration of the load increments is dependent upon the type of test and whether pore pressure measurements are to be made.

There are advantages and disadvantages in each method relative to the other. A paper by Lundgren, Mitchell and Wilson (Reference 1) discusses this topic and presents a triaxial apparatus which uses both procedures at various stages of the test.

The major advantage of the stress controlled method is that, by monitoring the volume change, the duration of the load increment can be adjusted to assure complete dissipation of the pore pressure in the CD test. Pore pressure measurements can also be obtained, if desired, in UU and CU tests by using load durations that result in pore pressure equalization. The pore pressure can be determined by using a pressure transducer. If possible the load increments should be equal, and the duration of each increment should be the same for clay soils to minimize secondary compression effects.

With the strain controlled method pore pressure dissipation in CD tests can only be assured if the rate of strain is very slow which means the time for testing may be excessive. A method of estimating the strain rate by studying the volume change is presented in Bishop and Henkel (Reference 2) on page 124. Filter paper drains can be used to reduce the testing time (page 81, Reference 2).

In UU and CU tests, the strain rate must be slow enough to allow pore pressure equalization. This rate can be found for CU tests during the consolidation stage by monitoring the pore pressures. UU tests would require the consolidation at the same confining pressure of a duplicate specimen.

There are two other advantages of the stress controlled method. First, for any load increment, strain versus time curves can be plotted. These provide the time dependent creep properties and would allow the plotting of a yield value curve as is done in the transverse shear test. Second, an indication of the yield stress of structure sensitive clays may be obtained.

One of the disadvantages of the stress controlled method is that failure may be abrupt and result in complete collapse of the specimen. With this type of failure it is difficult, if not impossible, to determine the peak failure stress and strain, or to study the stress-strain relationships beyond the peak point. Without the accurate measurement of the peak failure stress and strain, the shear strength parameters would be in error for all three types of test.

Another disadvantage is that in the CD test the application of the failure load can result in failure under undrained or partially drained conditions rather than the complete drainage desired. The failure stress, then, would not be the effective stress as excess pore pressure would be present. Therefore, the shear strength parameters at failure would not be the effective parameters desired.

In UU and CU tests, the application of the failure load increment can cause rapid or abrupt failure so that pore pressures at this time cannot be accurately measured. If this occurs it would preclude the determination of the effective shear strength parameters from the undrained test results.

One other disadvantage is that influence of the rate of strain on shear strength cannot be conveniently studied. The rate at which soils are strained has an effect on the shear strength as discussed by Casagrande and Wilson (Reference 3) and by Bishop and Henkel (Reference 2).

The MDSH Testing Laboratory has used the stress controlled method of loading in its shear testing of soils since the early 1930's. The procedures for the transverse, the unconfined compression and the UU triaxial shear tests employ this loading procedure. The latest triaxial apparatus purchased by the Laboratory, Karol-Warner Model 541 Triaxial Tester, is of the stress controlled type. The test procedures for the CD and CU tests developed under this project also use this loading method. Because of the disadvantages of the stress control method discussed above, it is recommended that the MDSH consider the purchase of a strain controlled apparatus to add flexibility to its triaxial testing program.

DISCUSSION OF PROCEDURES

The detailed step-by-step test procedures employing the MDSH Testing Laboratory's equipment are presented in Appendix I. Since the procedures are given in detail they will not be discussed in depth.

Procedures for conducting CD and CU tests using stress controlled loading are outlined. They follow quite closely, except for the method of loading, the procedures as given in Bishop and Henkel (Reference 2). The most difficult part is the estimation of the load increments. Enough increments must be used so that a well-defined stress-strain curve can be plotted. The magnitude should be such as that the peak strength can be selected as accurately as possible. This requirement will usually result in using equal increments at first and then decreasing them in the later stages of the test.

The duration of the increment depends upon the type of test being run. In CD tests, there must be time for complete drainage. This can be determined by monitoring the volume change or from past experience with similar soils. In CU tests, the pore pressures should be equalized before applying the next load increment. Either past experience or pore pressure measurements can be used to find the time necessary for equalization. The measuring of the pore pressures has the advantage of permitting the determination of the effective shear strength parameters.

As part of the procedure for CU tests the steps for using the pressure transducer are presented. Also outlined in this procedure is the volume change method for determining when primary consolidation is complete. Both of these methods require that all parts of the involved systems be completely filled with water. Any entrapped air will affect the accuracy of the results.

A procedure for saturating specimens through back pressuring is also outlined. Use of back pressuring and when it is needed is discussed in Bishop and Henkel (Reference 2). It is very important that the specimen be under a confining pressure equal to the back pressure. This will minimize volume changes during saturation.

The set-up of the transducer amplifier is the last procedure presented. The equipment was calibrated and the necessary calibration resistors were installed. There were indications during the use of the pressure transducer and amplifier system that the system lacks the sensitivity necessary for accurate measurement of the pore pressures. The needle on the amplifier showed no change in pore pressure when it was known that changes were taking place. If further testing confirms this, the manufacturer should be contacted to see if the sensitivity can be increased.

DISCUSSION OF TEST RESULTS

To aid in the development and to test the procedures, a number of triaxial tests were performed. The results of these tests are presented in Appendix II.

Initially it was intended to use an artificially sedimented compressible silt-clay mixture. It was hoped that a soil could be produced that would be somewhat similar to the river sediments mentioned at the beginning of this report. The attempt was abandoned after several unsuccessful tries due to the problems encountered and the lack of time.

The soil selected for use in the testing program was a non-plastic sandy silt taken from near Glacier Way, a road in the vicinity of the North Campus of the University of Michigan. This soil was selected because it has been used for a number of studies conducted in the Soil Mechanics Laboratory of the University. It has enough cohesion so that it can be trimmed to the desired dimensions, and has fair permeability so that pore pressure equilibrium is established in a reasonable time. The graduation of the soil is shown in Fig. 1.

The first series of triaxial tests were CD tests run using the constant rate of strain apparatus in the Soil Mechanics Laboratory of the University of Michigan. The sandy silt was first consolidated under the given cell pressure and then tested at a constant rate of strain of 14.9 min/mm. The resulting stress-strain curves are presented in Fig. 2. Problems with the loading system were encountered in Test CSN-CD3 after a strain of 1.75%. The data after this point is from a previous test conducted in a soil testing class. This test was not used in determining the strength envelope.

The Mohr's circles and the strength envelope for the first series of tests are shown in Fig. 3. The effective angle of internal friction is 38° and the effective cohesion intercept is 0.3 kg/cm^2. The data for the first series follows Fig. 3.

The second series of triaxial tests were CD tests run using the stress controlled apparatus in the MDSH Testing Laboratory. The specimens were first consolidated under the given cell pressure and then loaded in increments until failure. In Tests CSS-CD1, CSS-CD2 and CSS-CD3, the load was applied in equal increments during most of the test. These increments were maintained until the rate of strain approached zero. As the rate of strain increased in the later stages of the tests, the load increments were decreased and duration of loading was reduced so as to determine the peak strength as accurately as possible. Test CSS-CD4 was different in that each load increment was held for three minutes. Average rates of strain varied as follows: 87 min/mm for CSS-CD1, 115 min/mm for CSS-CD2, 94 min/mm for CSS-CD3 and 24 min/mm for CSS-CD4. This is from about 1.6 to 7.7 times slower than used in the constant rate of strain tests.

The stress-strain curves for this series of tests are presented in Fig. 4. Comparing these curves with those in Fig. 2 reveal that there are differences in the stress-strain properties of the tested soil as determined by the two test procedures. For example, under a confining pressure of 0.8 kg/cm^2 the maximum deviator stress is 4.08 kg/cm^2 at a strain of 1.3% using a constant rate of strain. Under the same confining pressure the maximum deviator stress is 3.52 kg/cm^2 at a strain of 2.3%. A possible explanation for these differences is the variations in the rates of strain pointed out above. The specimens were loaded more rapidly in the constant rate of strain tests which would result in higher strengths.

The Mohr's circles and the strength envelope for the second test series are shown in Fig. 5. The effective angle of internal friction is 36° compared with 38° from the constant strain tests. The respective values of the effective cohesion intercept are 0.35 kg/cm^2 and 0.3 kg/cm^2. These differences are a result of the differences in maximum deviator stresses discussed previously. Therefore, they are also due to the variations in the rates of strain. The data for second series follows Fig. 5.

The last tests presented were run as part of the development of the CU procedure, including the pore pressure measuring and the back pressuring procedures. In Test CSS-CU1, the specimen was first consolidated under a cell pressure of 1.49 kg/cm^2. A back pressure of 1.0 kg/cm^2 was used to saturate the soil. At the time this pressure was applied to the soil, the cell pressure was increased by the amount of the back pressure to 2.49 kg/cm^2. This was done so that the effective cell pressure would still be equal to 1.49 kg/cm^2. Since the consolidation pressure and the effective cell pressure were equal the overconsolidation ratio (OCR) is 1.0.

In Test CSS-CU2, the soil was first consolidated under a pressure of 2.98 kg/cm^2. The specimen was then saturated under a back pressure of 1.0 kg/cm^2 with the cell pressure of 2.49 kg/cm^2. The effective cell pressure, as in the first test, was 1.49 kg/cm^2. The consolidation pressure in this case was twice the effective cell pressure so the overconsolidation ratio was 2.0.

After the saturation, undrained triaxial tests with pore pressure measurements were conducted using the stress controlled load method. The load was gradually increased and deflection and pore pressure measurements were taken. The stress-strain curves for the two tests are presented in Fig. 6, and the data follows Fig. 6.

An examination of the data shows that both specimens developed negative pore pressures as they failed due to expansion of the soil structure. These pore pressures must be subtracted if positive and added if negative to the confining and vertical stresses to get the effective stresses.

As can be seen in Fig. 6 there is some scatter of the data points as the strain increases. It is felt that the major cause of the scatter is inadequate sensitivity of the pore pressure measuring equipment.

CONCLUSIONS AND RECOMMENDATIONS

The main purpose of this project was accomplished. Test procedures for conducting CD and CU tests were developed for use with the present MDSH equipment. Included were methods for monitoring volume change during consolidation, for measuring pore pressure and for back pressuring.

The procedures use the stress controlled method of loading because the MDSH triaxial tester is of this type. The advantages and disadvantages of this loading method have been discussed previously. It will take experimentation with different soil types found in Michigan by MDSH personnel to develop the needed experience, especially in the selection of load increments and the duration of each increment. If it is found that the disadvantages of the stress controlled method lead to inaccurate results, then consideration should be given to the purchase of a strain controlled loading device.

Also, as part of the experimentation program, the sensitivity of the pore pressure measuring system should be investigated. If the suspected lack of sensitivity is confirmed, the manufacturer of the present equipment should be consulted about the possibility of increasing the sensitivity. Should this prove to be impossible, consideration should be given to the purchase of more sensitive equipment.

ACKNOWLEDGMENT

This project was financed by the Michigan Department of State Highways. Their support is very much appreciated.

Thanks are also due to Neville F. Allen, graduate student in soil mechanics at the University of Michigan, who made the necessary modifications in the MDSH equipment to fit the procedures developed. He also ran most of the tests, and aided in the analysis of the data and the preparation of this report.

LIST OF REFERENCES

1. Lundgren, R., Mitchell, J.K. and Wilson, J.H., "Effects of Loading Method on Triaxial Test Results", Journal of the Soil Mechanics and Foundations Division, Proceedings, ASCE, Vol. 94, No. SM2, March, 1968.

2. Bishop, A.W. and Henkel, D.J., The Measurement of Soil Properties in the Triaxial Test, Edward Arnold, London,

2nd Ed., 1962.

3. Casagrande, A. and Wilson, S.D., "Effect of Rate of Loading on the Strength of Clays and Shales at Constant Water Content," <u>Geotechnique</u>, Vol. 2, 1951, pp. 251-263.

APPENDIX I

TEST PROCEDURES

TEST PROCEDURES

PREPARATION OF SPECIMEN

1. Prepare all the apparatus to be used before trimming the specimen.

2. Trim the specimen to within 1/8 to 1/4 inch of its final diameter (See Notes 1 and 2).

3. Take water content sample from the cuttings from the middle part of the specimen while trimming.

4. Trim the specimen carefully to its final diameter.

5. Place the specimen in a mold and take water content samples from the top and bottom cuttings as the specimen is trimmed to final length.

Note 1: Steps 2, 3 and 4 are not necessary if the diameter of the undisturbed specimen is that required for testing.

Note 2: Always trim from the edges toward the center for essentially cohesionless materials.

PROCEDURE FOR CONSOLIDATED DRAINED TESTS

A. Set-up of the Triaxial Cell

1. Grease the O-ring seal at the base.

2. Grease the base pedestal and top cap where the O-rings seal the specimen against leakage.

3. Place the specimen on the base with porous stones at the bottom and top and set top cap in place (See Note 3).

4. With the aid of a membrane holder secure a membrane to the top cap and base pedestal.

5. Lightly grease the inner surface of another membrane and repeat Step 2.

6. Seal the membranes to the top cap and base pedestal with O-rings.

7. Determine that the piston is well lubricated and moves freely in the cell cover.

8. Remove piston from the cell cover.

9. Place a 3/8 - 1/2 inch ball bearing on the top cap and set cell cover in place.

10. Tighten simultaneously opposite clamps on the base.

11. Replace the piston so that it rests on the ball bearing on the top cap.

12. Place the cell in the loading apparatus and connect the cell water line at A. Open the overflow valve at B (See Note 4).

13. Fill the cell to overflowing. Close overflow valve B.

Note 3: Boil the porous stones in distilled water and use them in the saturated condition. This reduces air entrapment. For fine-grained specimens of low permeability use circular bits of filter paper between the specimen and porous stones. To facilitate radial drainage, cut a drainage filter from filter paper (See Fig. 54, page 81, in Bishop and Henkel, Reference 2) and place around sample. Dip all filter paper drains in water before using to saturate them.

Note 4: The various lines and valves have been identified by labels affixed to the triaxial apparatus.

B. Consolidation of the Specimen

1. Hold piston in contact with ball bearing by use of the clamp and bar arrangement.

2. Connect cell pressure line.

3. Apply a cell pressure equal to the desired consolidation pressure. Valve G must be open so drainage can take place. The time of primary consolidation is dependent upon the permeability of the soil. Consolidation overnight is usually more than adequate.

4. For saturated specimens, the volume change method for determining the time for 100% primary consolidation is outlined in the Procedure for Consolidated Undrained Tests, Part B, Consolidation of the Specimen.

C. Testing

1. Bring the proving ring into mere contact with the piston by applying air pressure in the loading system.

2. Set the deflection indicator in contact with the cell and adjust to zero reading.

3. Remove the clamp on the piston. The piston will rise because of the cell pressure.

4. Restore the zero deflection reading by applying more air pressure to the loading system. The piston is now in its original position at the end of consolidation.

5. Note the proving ring reading at zero deflection. The axial load indicated must be subtracted from subsequent proving ring readings to obtain the actual vertical load.

6. Estimate the failure load and select the load increment. The magnitude of the load increment is a matter of judgement and past experience. Enough increments should be used so as to develop a well defined stress-strain curve, usually 10 to 15.

7. Apply the load increment and leave in place until drainage is complete. Valve G must remain open during entire test. The volume change procedure can be used to determine when drainage is complete for saturated specimens.

8. Read the deflection before the application of the next load increment. If strain versus time plots are desired, intermediate deflection readings are required.

9. Apply load increments until the specimen fails, the peak strength is attained or the strain is greater than 20%.

PROCEDURE FOR CONSOLIDATED UNDRAINED TESTS

A. Set-up of the Triaxial Cell

Before following the steps outlined in the Procedure for Consolidated Drained Tests, Part A, Set-up of the Triaxial Cell, complete the following steps if pore pressures are to be measured with the pressure transducer.

1. With valve G closed, run distilled water through the opening in the base pedestal and out the line to which the transducer is to be attached.

2. Fill the pressure sensing end of the transducer with distilled water making sure no air is entrapped.

3. Connect the transducer while water is still flowing from the line. During this operation maintain the transducer in a near upright position in order to minimize the possibility of air entrapment.

4. Open valve G and allow water to flush the line of air and then close the valve.

5. Before placing the specimen on the base pedestal, be sure that water is still at the surface level of the opening in the base pedestal.

B. Consolidation of the Specimen

Before following the steps outlined in the Procedure for Consolidated Drained Tests, Part B, Consolidation of Specimen, complete the following steps before Step 3 of that procedure if the volume change method is to be used to determine the time for 100% primary consolidation or when drainage is complete.

1. Attach a distilled water filled tube to valve G. Hold a finger over the free end while screwing on the other.

2. Insert a water filled burette at the free end of the tube.

3. Place the burette on a stand and adjust the water level in the burette to the mid-height of the specimen.

4. Open valve G and allow a few minutes for equilibrium to be established.

5. Before applying the required cell pressure note the initial burette reading.

6. Apply the cell pressure and start a timer.

7. Take burette readings at 1, 4, 9, 16, 25 minutes etc. Continue burette readings until there is no change indicating drainage is complete.

8. Plot the change in burette readings, ΔV, versus the square root of time. The time for 100% primary consolidation is determined as the intersection of the straight line through the initial readings and the horizontal line through the final readings (See Fig. 89 on page 126 of Bishop and Henkel, Reference 2).

C. Testing

The procedure is essentially the same as outlined in the Procedure for Consolidated Drained Tests, Part C, Testing, except for Step 7. In the consolidated undrained test, valve G is closed after consolidation is complete as no drainage is wanted during application of the shearing load. Each load increment should be left in place until pore pressure equalization is achieved. The pressure transducer can be used to determine when this occurs.

PROCEDURE FOR BACK PRESSURING

1. Fill the back pressure tube and line with distilled water using the following procedure.

   a. Remove the back pressure tube by unscrewing the nut at the top.

   b. Connect the distilled water line to connection C and air release line to connection D.

   c. Place finger over the end of the back pressure tube and fill it with water.

   d. Disconnect the water supply and air release lines.

   e. Hold the end of the tube over the coupling E, quickly remove finger and insert tube in coupling.

   f. Fasten the tube support by replacing the nut at the top of the system.

   g. Clamp the tube in place by means of the nuts and metal bar attached to the tube support. <u>WARNING</u>: Failure to do this will result in the tube disconnecting at the coupling when pressure is applied.

2. Connect the back pressure line to the cell. Close valve F and open back pressure regulator to the desired back pressure. <u>WARNING</u>: Until the pressure capacity of the back pressure tube is determined, use pressures not much greater than 14 psi.

3. Open valve G and then valve F. Increase the cell pressure by the value of the back pressure. From valve G there should occur a flow of water followed by a flow of air as air from the specimen is expelled. When a steady flow of water resumes, close valve G. Pore pressure as indicated by the pressure transducer should be the same as the applied back pressure when saturation is achieved. Allow at least four hours for the back pressuring of clay specimens.

4. Before testing, disconnect the back pressure line from the cell. Close the back pressure regulator and release the pressure in the tube by the quick-connect at D.

SET-UP OF THE TRANSDUCER AMPLIFIER

1. Turn on equipment (sensitivity multiplier on standby) and allow 10 minutes for warming up.

2. Connect cable to the transducer and while the sample is still in the consolidation stage (valve G open to the volume change monitoring system) turn the sensitivity multiplier to X20 and depress PUSH TO CALIBRATE button. Needle should read 71 on the upper scale. If it does not, adjust the appropriate channel sensitivity control (i.e. channel B) to read 71.

3. If reading cannot be adjusted 71 by use of the sensitivity control, follow the instruction booklet for the amplifier, Section C, Paragraphs 1, 2, 3, 3A and 4.

4. The amplifier is now ready for operation. During the consolidation stage the meter should read no more than 2 psi on the lower scale.

APPENDIX II

TEST RESULTS

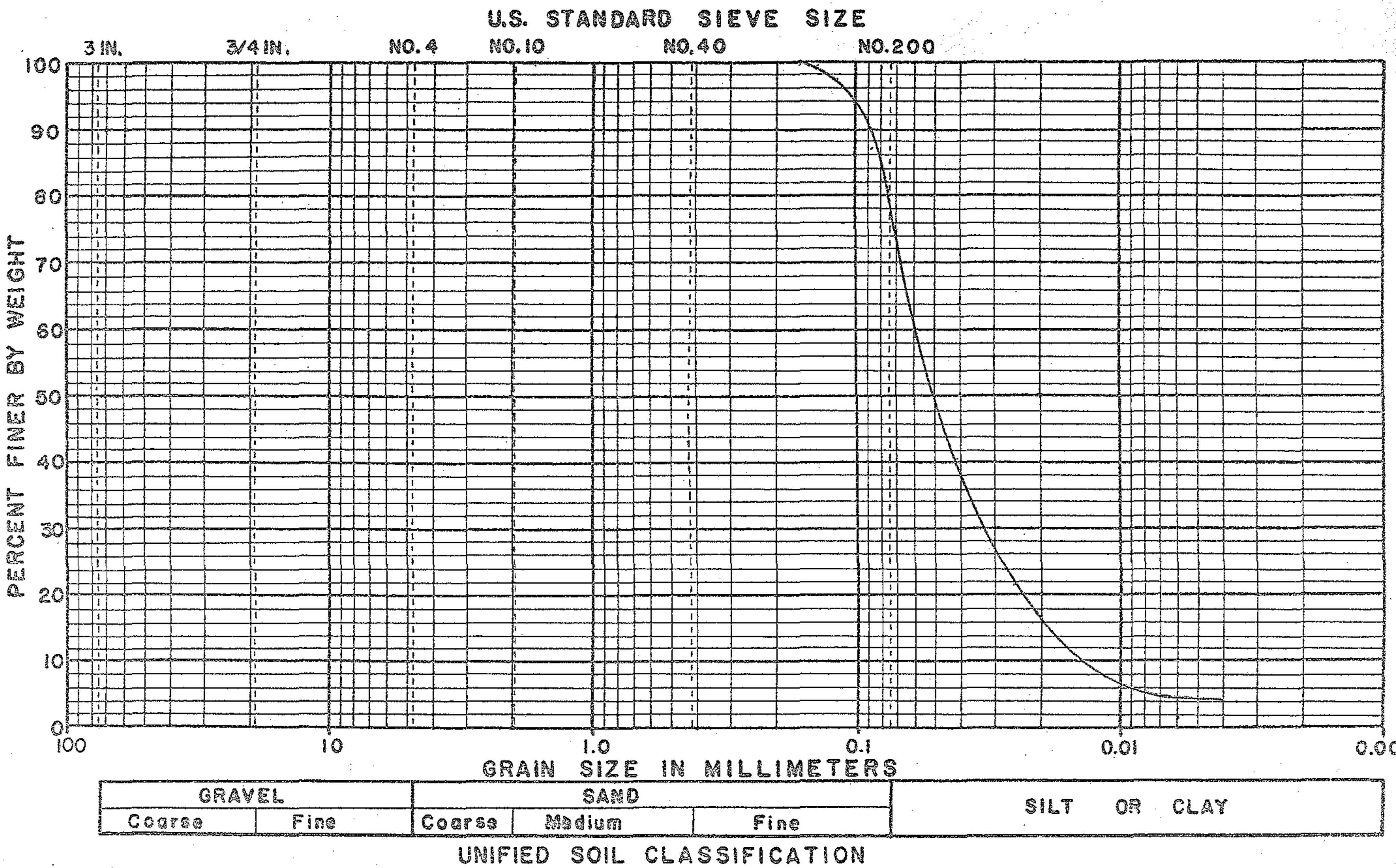


FIG. 1. GRADATION OF GLACIER WAY SANDY SILT

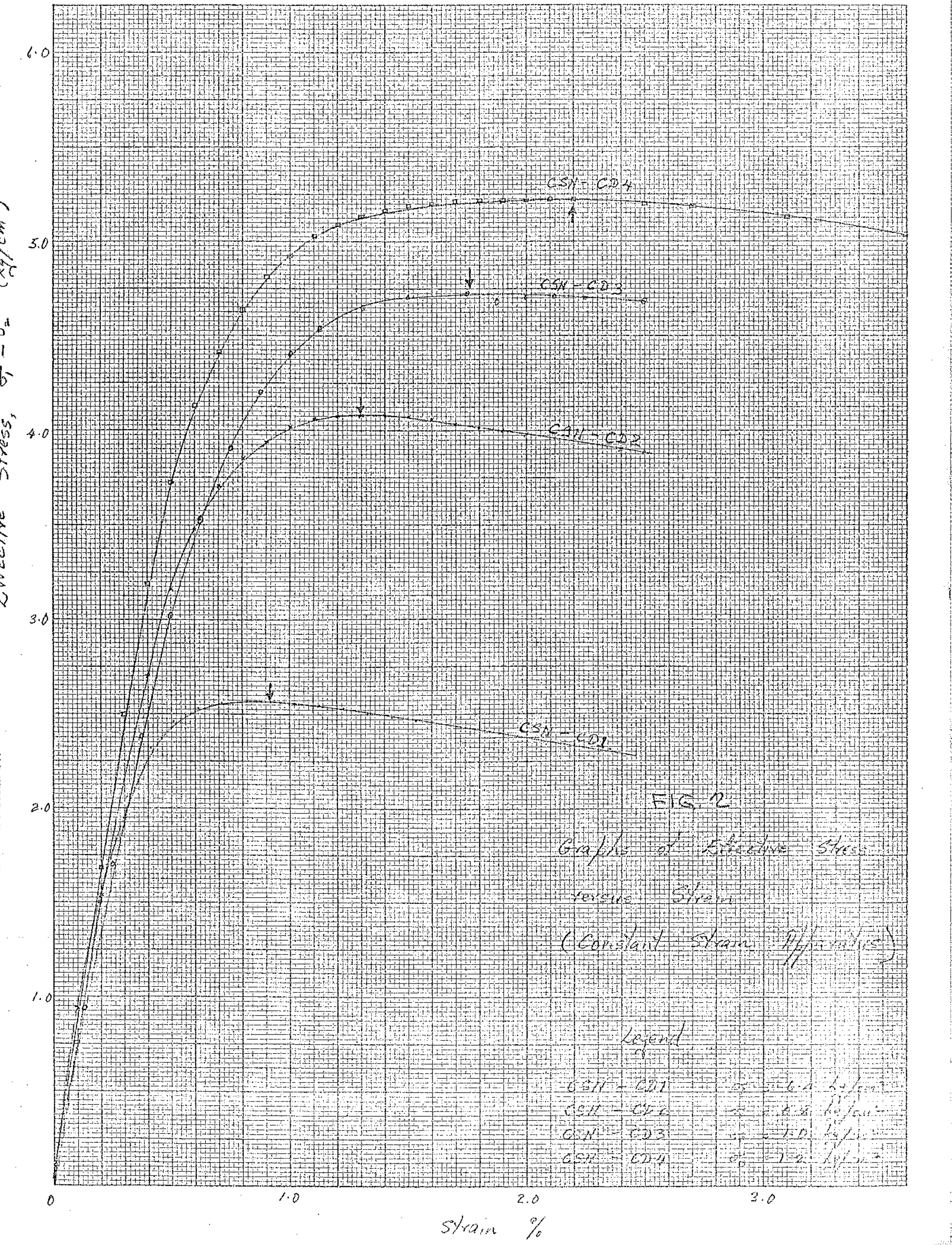


FIG. 2

Graphs of Effective Stress versus Strain

(Constant Strain Apparatus)

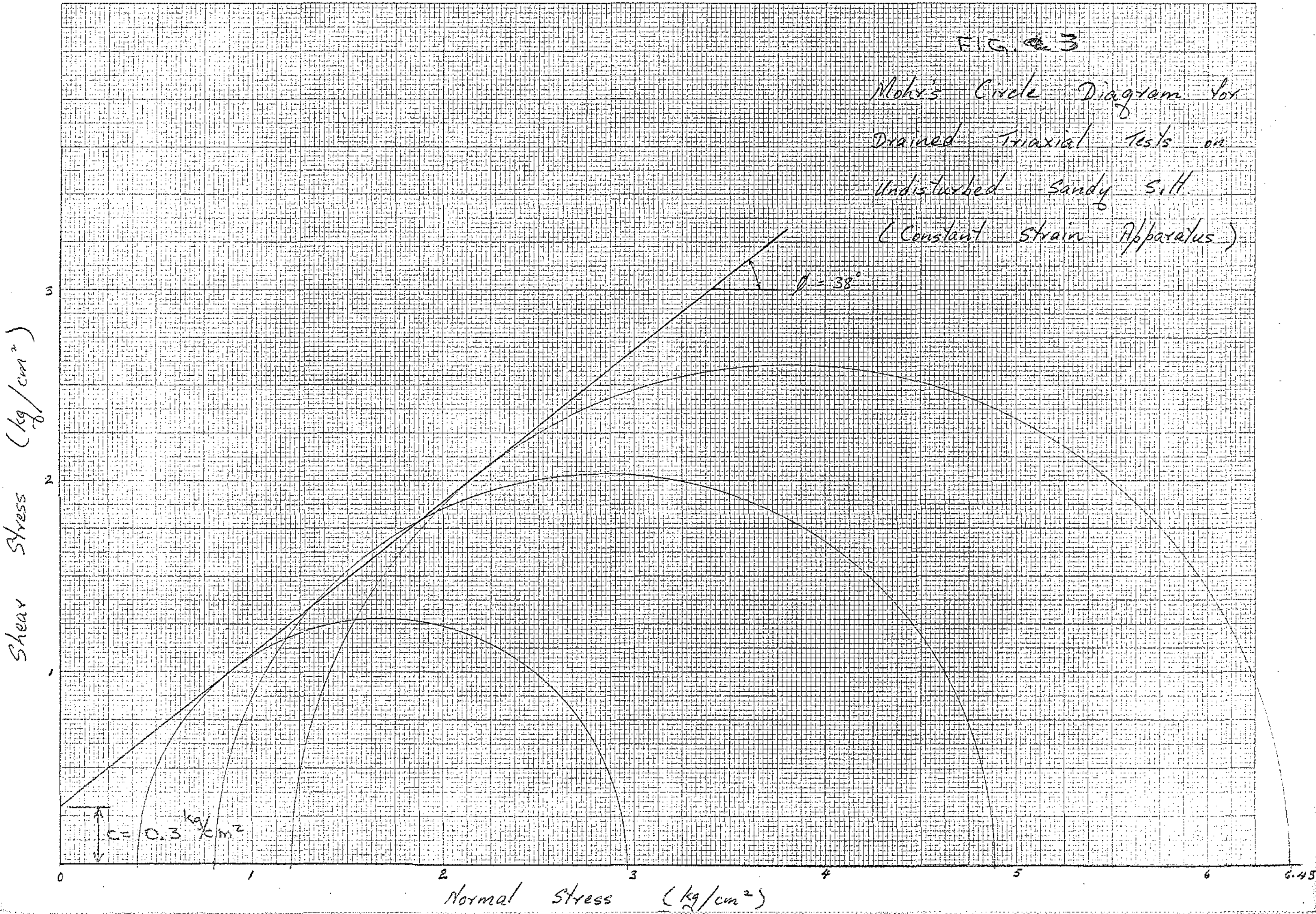


FIG. 3
Mohr's Circle Diagram for Drained Triaxial Tests on Undisturbed Sandy Silt (Constant Strain Apparatus)
ø = 38°
c = 0.3 kg/cm²
Shear Stress (kg/cm²)
Normal Stress (kg/cm²)
0
1
2
3
4
5
6
6.45

Consolidated-Drained Test on Glacier Way Sandy Silt (in-situ condition)

Proving Ring # 925 Confining Pressure 0.4 kg/cm² Back Pressure –

Deflection (Div)	Proving Ring Dial (Div)	P. P. Reading (in/in)	Strain (%)	Axial Stress (kg/cm²) $\sigma_1 - \sigma_3$	Pore Pressure (kg/cm²)	Vertical Stress (kg/cm²)	Effective Vertical Stress (kg/cm²)	Effective Lateral Stress (kg/cm²)	Stress Ratio (σ_1/σ_3)	Area $\frac{A_0}{1-\frac{\Delta L}{L}}$
10	173		.102	.865						10.53
20	318		.204	1.575						10.54
30	414		.307	2.066						10.55
40	468		.409	2.32						10.56
50	497		.511	2.46						10.57
60	512		.614	2.53						10.58
70	517.5		.716	2.56						10.59
80	519.8		.818	2.57						10.6
90	519.9		.92	2.57						10.615
100	518.4		1.02	2.56						10.626
110	517		1.124	2.55						10.637
120	513.8		1.228	2.53						10.647
130	511		1.328	2.5						10.658
140	506.7		1.432	2.48						10.67
150	504.5		1.533	2.47						10.68

Proving Ring Calibration Factor 0.0524 kg/div Sample No CSN-GD1 Date 4/11/72 Operator NFA

Consolidated-Drained Test on Glacier Way Sandy Silt (in-situ condition)

Proving Ring # 925 Confining Pressure 0.4 kg/cm² Back Pressure –

Deflection (Div)	Proving Ring Reading (Div)	P. P. Reading (mm/10)	Strain (%)	Axial Stress (kg/cm²)	Pore Pressure (kg/cm²)	Vertical Stress (kg/cm²)	Effective Vertical Stress (kg/cm²)	Effective Lateral Stress (kg/cm²)	Stress Ratio ($\bar{\sigma}_1/\bar{\sigma}_3$)	Area $\frac{A_0}{1-\frac{\Delta L}{L}}$
160	500.5		1.636	2.45						10.69
170	497		1.737	2.44						10.7
180	493.5		1.84	2.41						10.71
190	490.8		1.94	2.40						10.72
200	486.7		2.04	2.38						10.73
210	483		2.145	2.36						10.74
220	479.2		2.25	2.34						10.75
230	476		2.35	2.31						10.767

Proving Ring Calibration Factor 0.0524 kg/div Sample No CSN-CD1 Date 4/11/72 Operator NFA

Consolidated - Drained Test on Glacier Way Sandy Silt (in-situ condition)

Proving Ring #: 925 Confining Pressure 0.8 kg/cm Back Pressure —

Deflection (Div)	Proving Ring Dial (Div)	P. P. Reading (mm/10)	Strain (%)	Axial Stress (kg/cm²) $\sigma_1 - \sigma_2$	Pore Pressure (kg/cm²)	Vertical Stress (kg/cm²)	Effective Vertical Stress (kg/cm²)	Effective Lateral Stress (kg/cm²)	Stress Ratio ($\bar{\sigma}_1/\bar{\sigma}_3$)	Area $\frac{A_0}{1-\frac{\Delta L}{L}}$
10	178		0.1	0.94						9.896
20	293		0.2	1.54						9.906
30	364		0.3	1.93						9.916
40	513		0.4	2.71						9.926
50	599		0.5	3.17						9.936
60	661.5		0.6	3.48						9.946
70	705		0.7	3.71						9.956
80	732		0.8	3.85						9.966
90	751.5		0.9	3.94						9.976
100	764.8		1.0	4.02						9.986
110	773		1.1	4.06						9.996
120	777.8		1.2	4.08						10.006
130	779.7		1.3	4.08						10.016
140	780.3		1.4	4.08						10.026
150	779.8		1.5	4.075						10.036

Proving Ring Calibration Factor 0.0524 kg/div Sample No CSN-CD2 Date 4/12/72 Operator NFB

Consolidated - Drained Test on Glacier Way Sandy Silt (in-situ condition)

Proving Ring No. 925 Confining Pressure 0.8 kg/cm² Back Pressure —

Deflection (Div)	Proving Ring Defl. (Div)	P. P. Reading (cm/in)	Strain (%)	Axial Stress (kg/cm²) $\sigma_1 - \sigma_2$	Pore Pressure (kg/cm²)	Vertical Stress (kg/cm²)	Effective Vertical Stress (kg/cm²)	Effective Lateral Stress (kg/cm²)	Stress Ratio (σ_1/σ_3)	Area $\frac{A_o}{1-\frac{\Delta L}{L}}$
160	777.3		1.6	4.06						10.046
170	775		1.7	4.04						10.056
180	772.5		1.8	4.02						10.066
190	769.1		1.9	4.0						10.077
200	766		2.0	3.98						10.087
210	763.4		2.1	3.96						10.098
220	760.5		2.2	3.94						10.108
230	757		2.3	3.92						10.119
240	755		2.4	3.9						10.129
250	753		2.5	3.89						10.139

Proving Ring Calibration Factor 0.0524 kg/div Sample No CSN-CD2 Date 4/12/72 Operator NFA

Consolidated - Drained Test on Glacier Way Sandy Silt (in-situ condition)

925 [illegible] 1.0 kg/cm² [illegible]

[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	$A = \frac{A_0}{1-\frac{\Delta L}{L}}$
10	178		.125	(9.3) .944						9.855
20	321		.25	(16.8) 1.703						9.867
30	451		.375	(22.6) 2.389						9.879
40	571		.5	(29.9) 3.023						9.892
50	667		.625	(34.9) 3.524						9.904
60	740		.75	(38.7) 3.902						9.917
70	797		.875	(41.7) 4.2						9.929
80	837		1.0	(43.[illegible]) 4.406						9.942
90	864		1.125	(45.2) 4.541						9.954
105	886		1.3125	([illegible]) 4.653						9.973
110	893		1.375	(46.7) 4.679						9.980
120	897		1.5	(47.0) 4.704						9.992
130	902		1.625	(47.2) 4.718						10.005
140	904.5		1.75	(47.35) 4.726						10.018
150	— Motor stopped 895		1.875	(47.0) 4.686						10.030

Motor stopped after this reading. Data from this point on from previous class test.

0.0524 kg/in CSN-CD3 [illegible] 5/18/77. [illegible] N.A.

Consolidated-Drained Test on Glacier Way Sandy Silts (in-situ condition)

[illegible] 925 [illegible] 1.0 kg/cm² [illegible] —

[illegible]	[illegible]	[illegible]	[illegible] (%)	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	
160	903.5		2.0	47.3 4.71						10.043
170	904.5		2.125	47.35 4.71						10.056
180	[illegible]		2.25	47.36 4.704						10.068
190	906		2.375	47.4 4.701						10.082
200	904.5		2.5	47.35 4.690						10.095
210			2.625							10.108
220			2.75							10.121
230			2.875							10.134
240			3.0							10.147

Note : Results were plotted with previous class data and found to be in agreement with class findings.

0.0524 kg/div [illegible] CSN-CD3 [illegible] 5/16/72 [illegible] N.A.

Consolidated- Drained Test on Glacier Way Sandy Silt (in-situ condition)

Proving Ring # 925 Confining Pressure 1.2 kg/cm² Back Pressure —

Deflection (Div)	Proving Ring Deflect (Div)	P. P. Reading (cm/in)	Strain (%)	Axial Stress (kg/cm²)	Pore Pressure (kg/cm²)	Vertical Stress (kg/cm²)	Effective Vertical Stress (kg/cm²)	Effective Lateral Stress (kg/cm²)	Stress Ratio ($\bar{\sigma}_1/\bar{\sigma}_3$)	Area $A = \frac{A_0}{1-\frac{\Delta L}{L}}$
10	146		0.1	0.764						9.947
20	321		0.2	1.687						9.957
30	475		0.3	2.5						9.967
40	607		0.4	3.187						9.977
50	712		0.5	3.725						9.987
60	787		0.6	4.13						9.997
70	844		0.7	4.417						10.007
80	888		0.8	4.64						10.017
90	920		0.9	4.807						10.027
100	946		1.0	4.92						10.037
110	965		1.1	5.026						10.047
120	979		1.2	5.09						10.058
130	989		1.3	5.135						10.068
140	997		1.4	5.17						10.078
150	1003		1.5	5.194						10.088

Proving Ring Calibration Factor 0.0524 kg/div Sample No CSN-CD4 Date 5/18/72 Operator NFA

Consolidated - Drained Test on Glacier Way Sandy Silt (in-situ condition)

Proving Ring No. 925 Confining Pressure 1.2 kg/cm² Back Pressure —

Deflection (Div)	Proving Ring Deflect (Div)	P. P. Reading (mm/cm)	Strain (%)	Axial Stress (kg/cm²)	Pore Pressure (kg/cm²)	Vertical Stress (kg/cm²)	Effective Vertical Stress (kg/cm²)	Effective Lateral Stress (kg/cm²)	Stress Ratio (σ_1/σ_3)	Area $\frac{A_o}{1-\frac{\Delta L}{L}}$
160	1007.5		1.6	5.209						10.098
170	1010.8		1.7	5.22						10.108
180	1013.2		1.8	5.23						10.119
190	1014.8		1.9	5.23						10.129
200	1016.2		2.0	5.227						10.140
210	1017.2		2.1	5.232						10.150
220	1017.4		2.2	5.23						10.160
230	1017.0		2.3	5.22						10.171
240	1016.9		2.4	5.216						10.181
250	1016.4		2.5	5.2						10.192
260	1015.9		2.6	5.195						10.202
270	1015.2		2.7	5.189						10.213
280	1014.		2.8	5.184						10.223
290	1012		2.9	5.169						10.234
300	1010		3.0	5.144						10.244

Proving Ring Calibration Factor 0.0524 kg/div Test No. CSN-CD 4. Date 5/12/72 Operator NFQ

Consolidated-Drained Test on Glacier Way Sandy Silt (in situ condition)

Proving Ring # 925 Confining Pressure 1.2 kg/cm² Back Pressure —

Deflection (Div)	Proving Ring Deflect (Div)	P. P. Reading (mm/in)	Strain (%)	Axial Stress (kg/cm²)	Pore Pressure (kg/cm²)	Vertical Stress (kg/cm²)	Effective Vertical Stress (kg/cm²)	Effective Lateral Stress (kg/cm²)	Stress Ratio (σ_1/σ_3)	Area $\frac{A_0}{1-\frac{\Delta L}{L}}$
310	1007		3.1	5.129						10.255
320	1004		3.2	5.114						10.265
330	1001.5		3.3	5.089						10.276
340	999		3.4	5.075						10.286
350	997.5		3.5	5.06						10.297
360	994.6		3.6	5.044						10.308

Proving Ring Calibration Factor 0.0524 kg/div Sample No CSN-CD.4 Date 5/18/22 Operator NEA

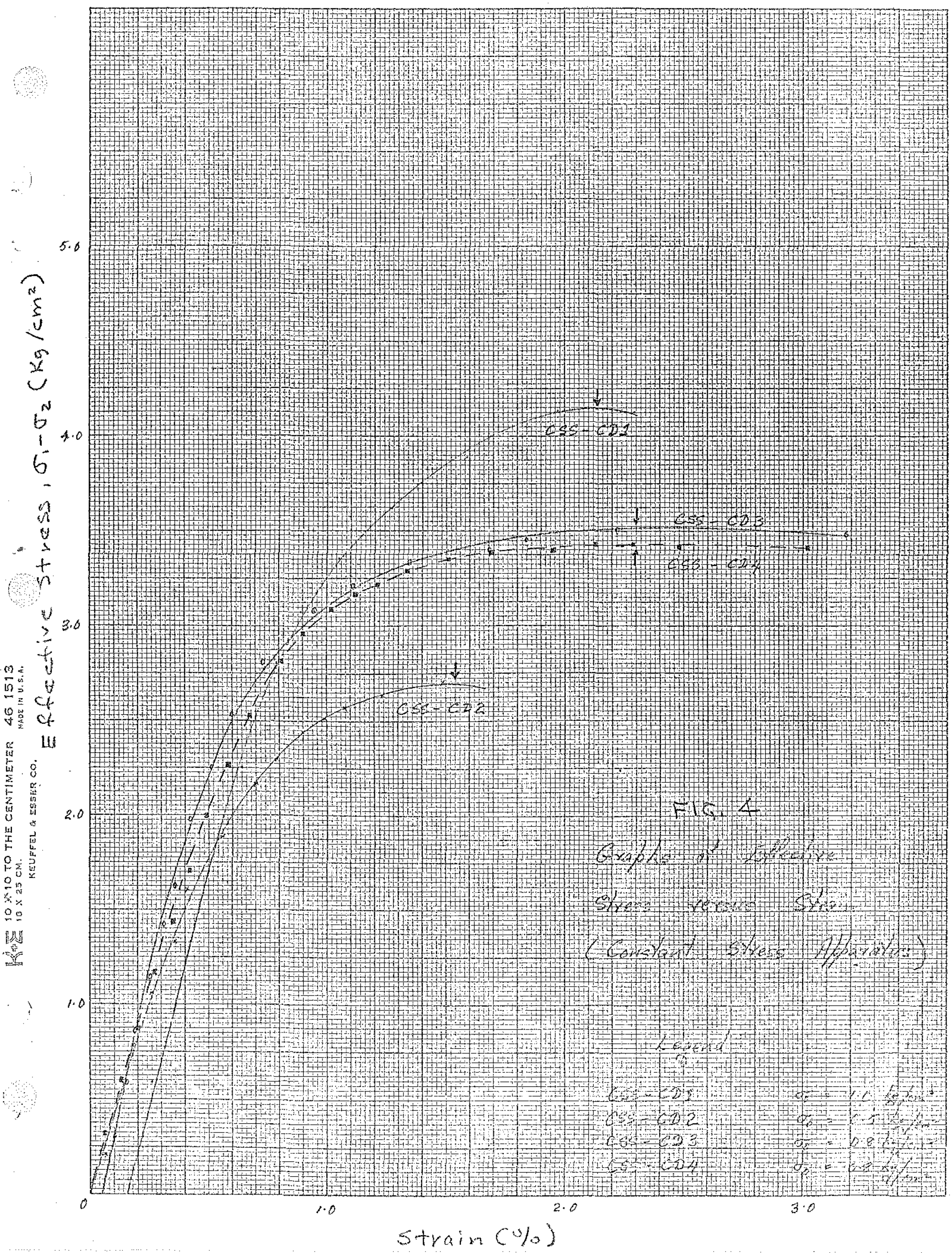
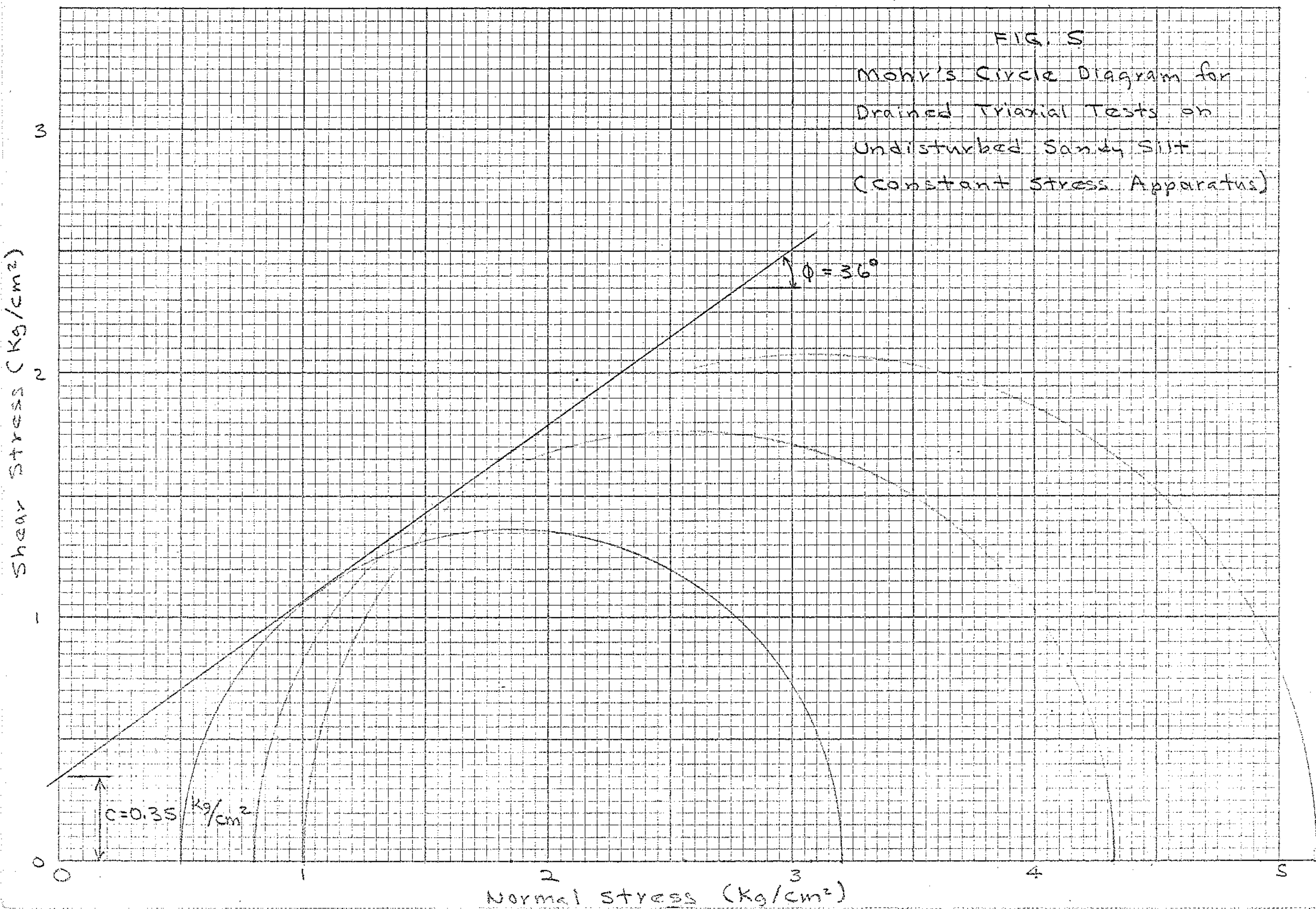


FIG. 4

Graphs of Effective Stress versus Strain (Constant Stress Apparatus)

FIG. 5

Mohr's Circle Diagram for Drained Triaxial Tests on Undisturbed Sandy Silt (Constant Stress Apparatus)



Consolidated Drained Test #1 (Constant Stress)

Proving Ring Reading	Vertical Load kg Read	Vertical Load kg Actual	Time (min)	Deflection	Corrected Area	Effective stress kg/cm²	Strain %
18	4.01	0	0	0	9.898	0	0
40	7.06	3.05	5	6.4	9.92	0.31	.22
60	9.83	5.82	4	8.2	9.924	0.59	.26
80	12.6	8.59	4	10.0	9.93	0.87	.32
100	15.4	11.36	7	12.0	9.936	1.14	.38
120	18.19	14.14	6	13.7	9.941	1.42	.4[illegible]
140	20.92	16.91	7	15.7	9.948	1.7	[illegible]
160	23.69	19.68	7	17.5	9.953	1.98	[illegible]
180	26.46	22.45	10	20.0	9.961	2.25	.6[illegible]
200	29.24	25.22	11	22.1	9.968	2.53	.70
220	32.01	27.99	10	24.9	9.977	2.81	.77
240	34.78	30.77	10	28.1	9.987	3.08	.87
260	37.55	33.54	20	33.0	10.003	3.35	1.05
280	40.32	36.31	25	40.0	10.025	3.62	1.2[illegible]
300	43.09	39.08	25	50.2	10.058	3.89	1.5[illegible]
320	45.87	41.85	3	62.0	10.097	4.14	1.97
320	45.87	41.85	6	72	10.13	4.13	2.7[illegible]
			160				

Notes: 1. Shear plane observed at strain of 1.9%

2. Angle of shear plane to the horizontal approximately 65°

Date 6/12/72 Sample CSS-CD1 Confining Pressure 1.0 kg/cm²

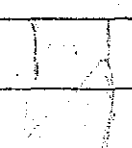
14.2 psi

Consolidated Drained Test #2 (Constant Stress)

Proving Ring Reading	Vertical Load kg Read	Vertical Load kg Actual	Time	Deflection	Corrected Area	Effective stress	[illegible]
4.3	2.11	0	0	0	9.898	0.0	0
20	4.29	2.18	3	2	9.904	0.22	.06
40	7.06	4.95	5	3.7	9.910	0.50	.12
60	9.83	7.72	5	5.8	9.916	0.78	.18
80	12.6	10.49	7	8.1	9.924	1.06	.26
100	15.38	13.26	8	11.2	9.933	1.34	.36
120	18.15	16.03	11	15.0	9.939	1.61	.47
140	20.92	18.81 !	15	17.8	9.954	1.89	.56
160	23.69	21.58	17	21.9	9.969	2.17	.70
170	25.08	22.96	17	24.9	9.977	2.30	.79
180	26.46	24.35	16	28.2	9.987	2.44	.90
185	27.16	25.04	12	31.0	9.996	2.51	.98
190	27.85	25.74	10	34.0	10.006	2.57	1.08
195	28.54	26.43	6	39	10.022	2.64	1.24
200	29.23	27.12	5	47	10.048	2.7	1.44
			137				

Note: 1. Shear plane at approximately 60° to the horizontal

2.



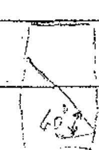
Date 6/13/72 Sample CSS-CD2 Confining Pressure 0.5 kg/cm²
7.1 psi

Consolidated Drained Test # 3 (Constant Stress)

Proving Ring Reading	Vertical Load kg Read	Vertical Load kg Actual	Time	Deflection	Corrected Area cm^2	Effective Stress kg/cm^2	%
18	4.01	0	0	0	9.898	0	0
40	7.06	3.05	5	3.2	9.908	·308	·10
60	9.83	5.82	6	4.6	9.913	·587	·15
80	12.6	8.59	10	6.1	9.917	·866	·19
100	15.38	11.37	10	8.0	9.923	1.146	·25
120	18.15	14.14	13	9.7	9.929	1.424	·31
140	20.92	16.91	13	11.4	9.934	1.702	·36
160	23.69	19.68	13	13.3	9.94	1.98	·42
180	26.46	22.45	15	16.0	9.949	2.257	·51
200	29.24	25.23	17	19.0	9.958	2.534	·6
220	32.01	28.0	25	23.0	9.971	2.808	·73
240	34.78	30.77	29	30.0	9.993	3.079	·95
250	36.17	32.16	24	35.0	10.009	3.213	1.11
260	37.55	33.54	26	42.5	10.033	3.343	1.35
265	38.24	34.23	21	53	10.067	3.400	1.68
270	38.94	34.93	5	58	10.084	3.464	1.84
275	39.63	35.62	3	70	10.123	3.519	2.22
275	39.63	35.62	4	100	10.223	3.484	3.18
			239				

Notes

1. Runaway deflection after three minutes at proving ring reading of 275
2. Sketch of failure plane



Date 6/14/72 Sample CSS - CD3 Confining Pressure 0.8 kg/cm² 11.36 psi

Consolidated Drained Test # 4 (Constant Stress)

Proving Ring Reading	Vertical Load		Elapsed Time	Deflection		Corrected Area	Effective Stress	Strain %
	Read	Actual						
17	3.87	0	0		0	9.898	0	0
40	7.06	3.19	3	6.8	2	9.899	.322	.06
60	9.83	5.96	6	8.8	4	9.911	.601	.13
80	12.6	8.73	9	11.0	6.2	9.918	.88	.2
100	15.38	11.5	12	13.3	8.5	9.925	1.16	.27
120	18.15	14.27	15	15.7	10.9	9.932	1.44	.35
140	20.92	17.05	18	18.0	13.2	9.940	1.71	.42
160	23.69	19.82	21	20.2	15.4	9.947	1.99	.49
180	26.46	22.59	24	23.2	18.4	9.956	2.27	.58
200	29.24	25.36	27	26.2	21.4	9.966	2.54	.68
220	32.01	28.13	30	30.2	25.4	9.978	2.82	.81
230	33.39	29.52	33	33.1	28.3	9.988	2.96	.90
240	34.78	30.91	36	37.0	32.2	10.000	3.09	1.02
245	35.47	31.6	39	40.0	35.2	10.010	3.16	1.12
250	36.16	32.29	42	43.0	38.2	10.020	3.22	1.21
255	36.86	32.98	45	46.9	42.1	10.032	3.29	1.34
260	37.55	33.68	48	52.5	47.7	10.050	3.35	1.51
262.5	37.9	34.02	51	58.0	52.2	10.068	3.38	1.69
265	38.24	34.37	54	66.2	61.4	10.095	3.40	1.95
267.5	38.59	34.72	55	72.0	67.2	10.114	3.43	2.13
267.5	38.59	34.72	56	77.0	72.2	10.130	3.43	2.29
267.5	38.59	34.72	57	83.0	78.2	10.150	3.42	2.48
270	38.94	35.06	58	100	95.2	10.207	3.43	3.02

Note. Each load increment held for three minutes

Date 6/15/72 Sample CSS-CD4 Confining Pressure 0.8 kg/cm² 11.36 psi

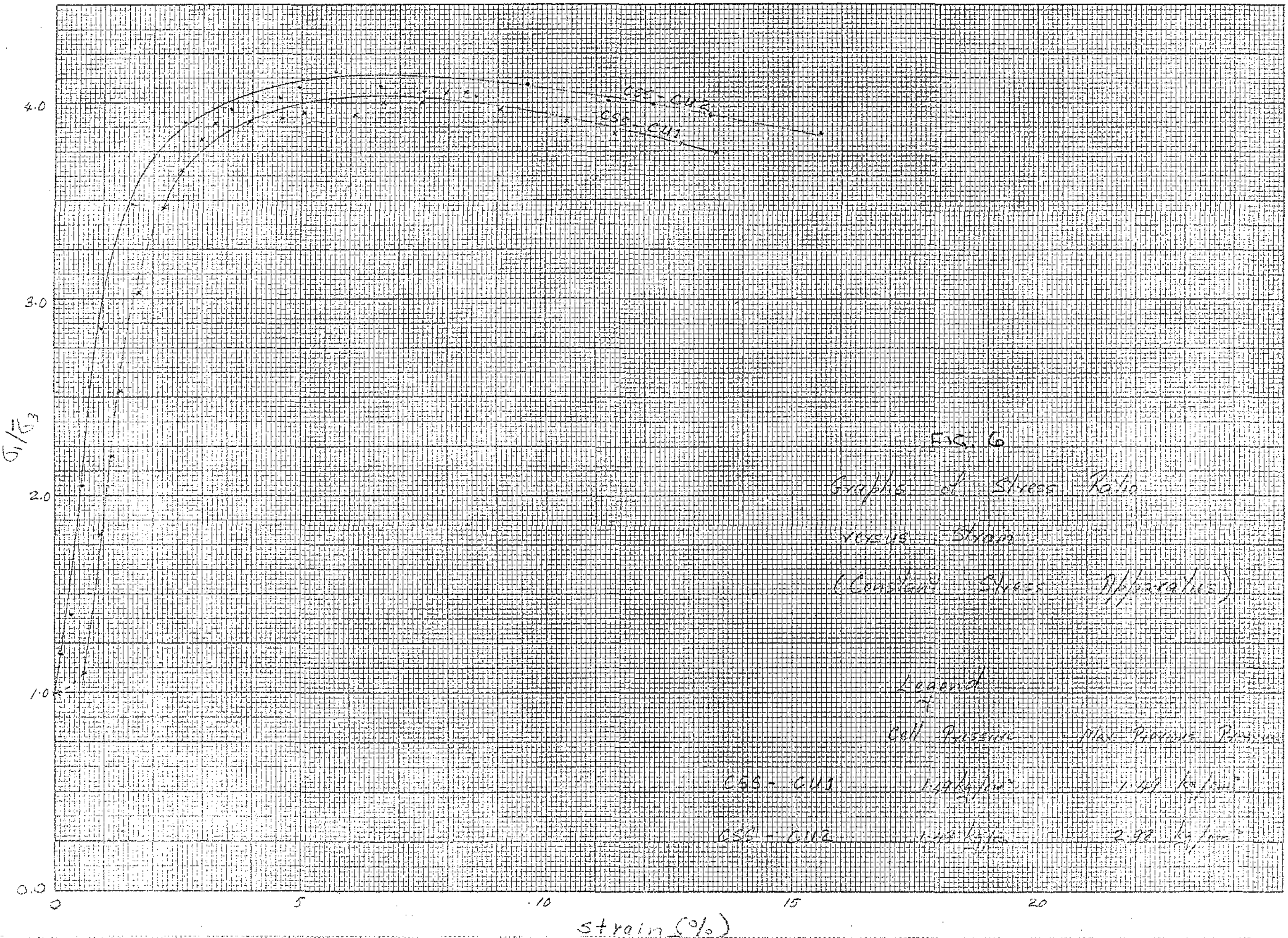


FIG. 6

Graphs of Stress Ratio versus Strain (Constant Stress Apparatus)

Proving Ring # 2790 Confining Pressure 35.5 psi (2.49 kg/cm²) Back Pressure 14.2 psi (1.0 kg/cm²) O.C.R. = 1

Time (min)	Deflection (Dial)	Proving Ring Deflection (Div)	P. P. Reading (PSI)	Strain (%)	Axial Stress (kg/cm²)	Pore Pressure (kg/cm²)	Vertical Stress (kg/cm²)	Effective Vertical Stress (kg/cm²)	Effective Lateral Stress (kg/cm²)	[illegible]
0	0	49	15.2	0	0	0	1.49	1.49	1.49	1.0
1	4.0	47.5	15.2	.127	[illegible]	0	1.5	1.5	1.49	1.0
2	4.0	47.5	15.2	.127	0.0067	0	1.5	1.5	1.49	1.0
3	2.0	[illegible]	15.2	.25	.0121	0	1.5	1.5	1.49	1.01
4	[illegible]	[illegible]	15.2	.31	.0121	0	1.5	1.5	1.49	1.01
5	[illegible]	[illegible]	15.2	.39	.0121	0	1.5	1.5	1.49	1.01
6	[illegible]	[illegible]	15.2	.41	.0134	0	1.503	1.503	1.49	1.01
7	[illegible]	[illegible]	15.2	.53	.0134	0	1.503	1.503	1.49	1.01
8	[illegible]	[illegible]	[illegible]	.60	.147	0	1.64	1.64	1.49	1.1
10	[illegible]	[illegible]	[illegible]	.72	.267	0	1.76	1.76	1.49	1.18
12	[illegible]	[illegible]	[illegible]	.76	.534	0	2.02	2.02	1.49	1.36
14	[illegible]	[illegible]	15.4	.84	.913	.014	2.4	2.39	1.48	1.62
16	[illegible]	[illegible]	[illegible]	.93	1.199	.007	2.69	2.68	1.48	1.81
18	[illegible]	[illegible]	[illegible]	1.05	1.53	.007	3.02	3.1	1.48	2.05
[illegible]	[illegible]	[illegible]	[illegible]	1.14	1.78	.007	3.27	3.26	1.48	2.20

Proving Ring Calibration Factor ——— Sample No CSS-CU1 Date 6/29/72 Operator [illegible]

Proving Ring No. 2790 Confining Pressure 35.5 psi (2.49 kg/cm²) Back Pressure 14.2 psi (1.0 kg/cm²) O.C.R. =

Time (min)	[illegible]	[illegible]	[illegible]	Strain (%)	Axial Stress (kg/cm²)	Pore Pressure (kg/cm²)	Vertical Stress (kg/cm²)	Effective Vertical Stress (kg/cm²)	Effective Lateral Stress (kg/cm²)	[illegible]
[illegible]	37	141	[illegible]	1.17	1.887	-.01	3.38	3.38	1.5	2.26
[illegible]	[illegible]	[illegible]	[illegible]	1.22	2.019	-.01	3.51	3.52	1.5	2.35
24	40	211	[illegible]	1.27	2.151	0.0	3.64	3.64	1.49	2.44
[illegible]	42	221	[illegible]	1.33	2.282	0.0	3.77	3.77	1.49	2.53
[illegible]	[illegible]	[illegible]	15.2	1.38	2.427	0.0	3.92	3.92	1.49	2.63
[illegible]	[illegible]	[illegible]	[illegible]	1.46	2.570	0.004	4.06	4.06	1.49	2.73
[illegible]	[illegible]	[illegible]	[illegible]	1.53	2.71	0.004	4.20	4.20	1.49	2.83
[illegible]	[illegible]	265	[illegible]	1.6	2.86	.007	4.35	4.34	1.48	2.93
[illegible]	[illegible]	[illegible]	[illegible]	1.7	3.01	.007	4.5	4.49	1.48	3.03
[illegible]	57	[illegible]	[illegible]	1.81	3.195	.007	4.69	4.68	1.48	3.15
33	[illegible]	[illegible]	15.3	1.94	3.376	.007	4.87	4.86	1.48	3.28
[illegible]	[illegible]	[illegible]	15.2	2.06	3.529	0.0	5.02	5.02	1.49	3.37
[illegible]	[illegible]	[illegible]	[illegible]	2.19	3.682	0.0	5.17	5.17	1.49	3.47
[illegible]	[illegible]	[illegible]	15.2	2.35	3.92	0.0	5.41	5.41	1.49	3.63
38	[illegible]	[illegible]	15.0	2.56	3.983	-0.014	5.47	5.49	1.50	3.65

Sample No CSS-CU1 Date 6/29/72 Operator NFB

O.C.R. = 1

Proving Ring # 8790 Confining Pressure 35.5 psi (2.49 kg/cm²) Back Pressure 14.2 psi (1.0 kg/cm²)

Time (min)	Deflection (Div)	Proving Ring Deflect (Div)	P. P. Reading	Strain (%)	Axial Stress (kg/cm²)	Pore Pressure (kg/cm²)	Vertical Stress (kg/cm²)	Effective Vertical Stress (kg/cm²)	Effective Lateral Stress (kg/cm²)	[illegible]
40	[illegible]	[illegible]	[illegible]	2.79	4.117	-.028	5.61	5.64	1.52	3.71
41	[illegible]	[illegible]	[illegible]	2.98	4.27	-.028	5.76	5.78	1.52	3.81
43	[illegible]	[illegible]	[illegible]	3.24	4.41	-.035	5.90	5.94	1.53	3.89
[illegible]	[illegible]	[illegible]	[illegible]	3.97	4.55	-.085	6.04	6.12	1.57	3.89
[illegible]	145	412	13.7	4.6	4.656	-.106	6.15	6.25	1.6	3.92
[illegible]	[illegible]	422	13.4	5.05	4.76	-.127	6.25	6.38	1.62	3.95
60	192	432	13.0	6.1	4.836	-.155	6.33	6.48	1.64	3.94
65	200	438	13.0	6.35	4.898	-.155	6.39	6.54	1.64	3.99
72	210	445	12.8	6.67	4.97	-.169	6.46	6.63	1.66	4.0
95	231	451	12.5	7.33	5.01	-.190	6.5	6.69	1.68	3.98
100	235	457	12.3	7.46	5.08	-.204	6.57	6.77	1.69	4.0
106	241	464	12.2	7.65	5.15	-.211	6.64	6.85	1.70	4.03
111	250	471	12.0	7.94	5.22	-.225	6.71	6.94	1.72	4.05
115	262	475	11.9	8.32	5.25	-.232	6.74	6.97	1.72	4.05
120	285	480	11.1	9.05	5.27	-.289	6.76	7.05	1.78	3.96

Proving Ring Calibration Factor ______ Sample No. CSS-CU1 Date 6/29/72 Operator NFA

2.49 kg/cm² O.C.R. = 1

8790 35.5 psi 14.2 psi (1.0 kg/cm²)

Time (min)										
125	307	482	10.9	9.75	5.25	-.303	6.75	7.05	1.79	3.93
120	328	484	10.7	10.41	5.24	-.317	6.73	7.05	1.81	3.90
135	344	485.5	10.4	10.92	5.23	-.338	6.72	7.06	1.83	3.86
140	359	487.5	10.2	11.4	5.22	-.352	6.71	7.06	1.84	3.84
145	374	489	10.1	11.87	5.21	-.359	6.70	7.06	1.85	3.82
150	390	490.2	10.0	12.37	5.20	-.366	6.69	7.05	1.86	3.80
155	402	491.8	9.9	12.76	5.19	-.373	6.68	7.06	1.86	3.79
160	428	492.8	9.6	13.59	5.16	-.394	6.65	7.04	1.88	3.74

CSS-CU1 6/29/72 YFA

8790 2.49 kg/cm² 35.5 psi 14.2 psi (1.0 kg/cm²)

Time (min)			ΔY							
0	0	51	14.3	0	0	0	1.49	1.49	1.49	1.0
1	3.2	73	14.35	.1	.30	.004	1.79	1.78	1.49	1.2
2	4.2	76	14.35	.13	.34	.004	1.83	1.82	1.49	1.22
4	10	82	14.25	.32	.42	.004	1.91	1.91	1.49	1.28
6	11	95	14.25	.35	.59	-.004	2.08	2.08	1.49	1.39
8	13	121	14.3	.41	.94	0	2.43	2.43	1.49	1.63
10	14.8	143.5	14.35	.47	1.24	.004	2.73	2.72	1.49	1.83
12	17	167	14.4	.54	1.55	.007	3.04	3.03	1.48	2.05
14	20	188	14.5	.64	1.83	.014	3.32	3.31	1.48	2.24
16	22.5	207	14.6	.71	2.08	.021	3.57	3.55	1.47	2.42
18	24.7	221	14.5	.78	2.27	.014	3.76	3.74	1.48	2.54
20	27.5	239	14.6	.87	2.51	.021	4.0	3.97	1.47	2.71
22	31	256	14.5	.98	2.73	.014	4.22	4.21	1.48	2.85
24	34	273	14.65	1.08	2.95	.025	4.44	4.42	1.47	3.02
26	38.5	292	14.65	1.22	3.20	.025	4.69	4.67	1.47	3.18

CSS-CU2 6/30/72 NFA

O.C.R. = 2

8790 2.49 kg/cm² 35.5 psi 14.2 psi (1.0 kg/cm²)

Time (min)											
28	43.5	311	14.5	1.38	3.45	.014	4.94	4.92	1.48	3.34	
30	49	328	14.5	1.56	3.67	.014	5.16	5.14	1.48	3.48	
32	57	347	14.3	1.81	3.91	0	5.4	5.4	1.49	3.62	
34	63	359.5	14.2	2.0	4.07	-.007	5.56	5.56	1.5	3.72	
36	70.5	371	14.1	2.24	4.21	-.014	5.7	5.71	1.5	3.8	
38	78	381	13.9	2.48	4.33	-.028	5.82	5.85	1.52	3.85	
40	83	389	13.8	2.64	4.42	-.035	5.92	5.95	1.53	3.9	
42	92	398	13.6	2.92	4.53	-.049	6.02	6.07	1.54	3.94	
44	100	404	13.4	3.18	4.6	-.063	6.09	6.15	1.55	3.96	
46	106.5	408	13.2	3.38	4.64	-.077	6.13	6.21	1.57	3.96	
48	112	412	13.1	3.56	4.68	-.084	6.17	6.26	1.57	3.97	
50	120	416	13	3.81	4.72	-.091	6.21	6.3	1.58	3.99	
55	129	422	12.9	4.1	4.78	-.098	6.27	6.37	1.59	4.01	
60	138.5	426	12.8	4.4	4.82	-.105	6.31	6.42	1.6	4.02	
65	144	428.5	12.75	4.57	4.84	-.108	6.33	6.44	1.6	4.03	

CSS-CU2 6/30/72 NFA

O.C.R. = 2

2.49 kg/cm²

8790 355 psi. 14.2 psi. (1.0 kg/cm²)

70	146.5	431	12.7	4.65	4.87	-.113	6.36	6.47	1.6	4.04
75	151	436	12.6	4.79	4.93	-.12	6.42	6.54	1.61	4.06
80	153	436	12.55	4.86	4.93	-.123	6.42	6.54	1.61	4.05
85	156	441	12.5	4.95	4.98	-.127	6.47	6.6	1.62	4.08
90	163	451	12.3	5.18	5.1	-.141	6.59	6.73	1.63	4.13
95	179	462	12.0	5.68	5.21	-.162	6.70	6.86	1.65	4.16
100	196	467	11.8	6.22	5.25	-.176	6.74	6.91	1.67	4.15
105	208	471	11.2	6.60	5.27	-.218	6.76	6.98	1.71	4.09
110	226	474	11.0	7.18	5.28	-.232	6.77	7.0	1.72	4.07
115	236	477.5	10.8	7.49	5.31	-.246	6.8	7.04	1.74	4.06
120	246	480	10.7	7.81	5.32	-.253	6.81	7.06	1.74	4.05
125	254	483	10.5	8.06	5.34	-.267	6.83	7.1	1.76	4.04
130	262	486	10.4	8.32	5.36	-.274	6.85	7.13	1.76	4.04
135	269.7	489	10.3	8.56	5.39	-.281	6.88	7.16	1.77	4.04
140	281	492.5	10.2	8.92	5.41	-.288	6.9	7.19	1.78	4.04

CSS-CU2 6/30/72 NFR

2.49 kg/cm² O.C.R. = 2 4 of 4

Proving Ring # 8790 Confining Pressure 35.5 psi - Back Pressure 14.2 psi (1.0 kg/cm²)

	Deflection (Div)	Proving Ring Deflect (Div)	P. R. Reading (kg/..)	Strain (%)	Axial Stress (kg/cm²)	Pore Pressure (kg/cm²)	Vertical Stress (kg/cm²)	Effective Vertical Stress (kg/cm²)	Effective Lateral Stress (kg/cm²)	[illegible]
150	286.8	495	10.2	9.11	5.43	-.288	6.92	7.21	1.78	4.05
155	292	499	10.2	9.27	5.47	-.288	6.96	7.24	1.78	4.07
160	302	506	10.1	9.59	5.53	-.295	7.02	7.32	1.79	4.1
165	354	515	9.3	11.24	5.54	-.352	7.03	7.38	1.84	4.01
166	370	518.5	9.3	11.75	5.55	-.352	7.04	7.39	1.84	4.01
167	384	518.5	9.2	12.19	5.52	-.359	7.01	7.37	1.85	3.99
168	395.5	518.5	9.0	12.56	5.5	-.373	6.99	7.36	1.86	3.95
169	405	518.5	9.0	12.86	5.48	-.373	6.97	7.34	1.86	3.94
170	420	520	9.0	13.34	5.47	-.373	6.96	7.33	1.86	3.93
171	490	520	8.8	15.56	5.33	-.387	6.82	7.20	1.88	3.84

Proving Ring [illegible] 66524 Sample No CSS-C42 Date 6/30/72 Operator YFR