GEOTECHNICAL PROPERTIES OF FLORIDA PHOSPHATIC CLAYS

by

JOHN RICHARD ROMA
BS, Northeastern University
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Submitted in partial fulfillment

of the requirements for the degree of

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at the

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Signature redacted

Signature of Author..
Department of Civil Engineering, February 9, 1976

Signature redacted

Certified by ....
Thesis Supervisor

Signature redacted

Accepted by..
Chairman, Departmental Committee on Graduate Students of the Department of Civil Engineering

ABSTRACT

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Submitted to the Department of Civil Engineering on February 9, 1976, in partial fulfillment of the requirements for the degree of Master of Science in Civil Engineering.

One of the waste products of the Florida phosphate mining industry is a highly plastic CH clay (P.I.=70 to 190%) that is pumped to "storage" ponds in the form of a slurry at 3 to 5 per cent solids. The very long time required for consolidation of the clay causes three major problems: (1) loss of water that is required for mining; (2) the necessity of constructing dams around the storage ponds in order to contain all the waste, and (3) the long time required before the land can be reclaimed.

Numerous methods have been investigated to accelerate "dewatering" of ponds, but few have considered basic soil mechanics. Researchers at M.I.T. were engaged to apply soil mechanics principles to the problem, define the pertinent engineering properties of phosphatic clay, and to evaluate the methods of dewatering.

This thesis deals with the laboratory measurements of the geotechnical engineering properties of three Florida phosphatic clays. The program included: (1) designing and constructing an eight inch diameter consolidometer for consolidation and permeability tests; (2) consolidating from about 0.001 to 1.5 kg/cm^2 in the consolidometer, and then trimming samples for constant rate of strain (CRSC) consolidation tests and K_0 consolidated-undrained direct-simple shear (CK_0UDSS) tests; (3) using a slightly smaller container for consolidation under seepage forces; (4) performing sedimentation tests with concentration, height and diameter of containers as variables; (5) comparing the addition of flocculant to a clay that had no flocculant, and (6) performing specific gravity and Atterberg Limits tests.

Consolidation and permeability data were obtained from six tests on untreated and flocculated samples of two clays. Compression curves and coefficient of consolidation data are presented over a range of stresses varying from 1 gm/cm^2 to 16 kg/cm^2. The magnitude of c_v was quite constant at about $1.8 \pm 0.4 \times 10^{-4}$ cm^2/sec for normally consolidated clay. Values of permeability, both directly measured and calculated from $k = c_v m_v \gamma_w$, range from about 10^{-4} cm/sec at 10 per cent solids to about 10^{-7} cm/sec at 40 to 50 per cent solids. The K_o consolidated-undrained direct-simple shear tests yield an undrained strength ratio of 0.22 for normally consolidated samples.

Thesis Supervisor: Charles C. Ladd

Title: Professor

ACKNOWLEDGEMENTS

I am deeply appreciative to the following individuals for their guidance and help in the preparation of this thesis and in my professional development:

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A. Allen Gass, who inspired me with the comment "Well John, other fools have done it."

Robert Pine, a good friend who gave freely of his time when I very much needed help.

DEDICATION

TO JEAN

A DAMN FINE WIFE

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CHAPTER 1 INTRODUCTION

1.1 General

In 1974, Florida produced 35 million tons of phosphate, which is over 80 per cent of the United States' and one-third of the world's marketable supply (Florida Phosphate Council, 1975). At present, there are 14 operational mining and processing companies in Florida, and together they form a trade association known as the Florida Phosphate Council. Although 90 per cent of the marketable supply of Florida's phosphate is used for agricultural fertilizer, phosphate has dozens of uses, including food preservatives, dyes, toothpaste, and additives for gasoline and oil.

One of the major problems associated with phosphate mining is the disposal of a very plastic clay that is part of the mined material. The clay comes as slurry from the processing plant at 3 to 5 per cent solids content (the ratio of weight of solids to the total weight of the slurry) and is disposed of in a previously mined area. Because of the low solids content, and therefore high water content, the volume of slurry pumped back into a mined area is much greater than the initial volume of raw material removed. This has resulted in the necessity of building dams around the periphery of the mined area to contain the slurry. As an appreciation for the magnitude of the problem, every one foot depth of raw material mined generates about 9 feet of slurry.

The slurry exhibits extremely slow consolidation characteristics and has required many tens of years to reach a state where the land may be reclaimed. Thus with thousands of acres being mined annually, land reclamation and water supply are major problems. Although 85 per cent of the water used in the overall mining operation is recirculated, many millions of gallons remain in the settling ponds, thereby placing a burden on Florida's water supply.

The Florida Phosphatic Clay Research Council was established to conduct and support research aimed at improving disposal methods of the clay slurry. The objective of the research is to develop an economical process whereby the clay slurry and sand may be disposed of and returned to the original volume occupied by the raw material matrix within five years without requiring the construction of dams.

1.2 Scope of Work

Professor C.C. Ladd and Doctor R.T. Martin were engaged by the Florida Phosphatic Clay Research Council to study the geotechnical engineering aspects of the problem. The scope of work included:

(a) Measurement of the engineering properties of the clay slurry, especially consolidation behavior and sedimentation characteristics.

(b) Make a prediction of field rates of consolidation and the effect of hydraulic boundary conditions.

(c) Investigate various means of accelerating the consolidation process, such as the use of sand drains.

The author was engaged by the above in this research project with primary emphasis on developing the required engineering properties.

In order to better define the engineering properties of Florida phosphatic clay slurries, a laboratory program was initiated at M.I.T. An eight inch diameter consolidometer was especially designed and built for consolidation-permeability tests. After consolidation to about 1.5 Kg/cm^2, samples were trimmed from the large consolidation unit for constant rate of strain (CRSC) consolidation tests and Ko consolidated-undrained direct-simple shear ($\overline{CK_0U}DSS$) tests. Also, a slightly smaller container was used for consolidation tests using seepage forces.

Sedimentation tests were performed on several slurries with a number of variables, such as diameter and height of containers and initial per cent solids.

Engineering tests were run on six laboratory prepared clay slurries (four untreated and two flocculated) and on a block sample of a flocculated clay slurry taken from a field test site in Florida.

The above engineering tests were supplemented by index tests (Atterberg Limits and specific gravity) and mineralogical analyses using x-ray diffraction.

The purpose of this thesis is to:

(a) describe the experimental procedures; and

(b) present and analyze test data.

CHAPTER 2 BACKGROUND

2.1 Geology

The land-pebble phosphate deposits underlie an area of about 2000 square miles in Central Florida. Figure 2.1 presents a map of this location. This area is known as the Bone Valley Formation and is a shallow water, marine and estuarine phosphorite of the Pliocene age (10 to 15 million years ago). The phosphorus mineral was present in the waters of the oceans which swept across what is now Florida and settled into these areas in a matrix with sand and clay (U.S. Geological Survey, 1964). The size of phosphate in this deposit ranges from one half inch pebbles to extremely fine sized particles. The matrix is generally comprised of one third phosphate, one third clay, and one third sand.

The thickness of the matrix ranges from 1 to 50 ft, and averages about 16 ft. The overburden covering the matrix consists principally of quartz sand, and averages about 24 ft in thickness. Figure 2.2 presents a schematic sketch of the Bone Valley Formation. The matrix ranges in color from green to brown to black. The bone phosphate of lime (BPL) contents of the matrix, calculated as $Ca_3(PO_4)_2$, ranges from 15 to 40 per cent, which is equivalent to 7 to 18 per cent P_2O_5 (recoverable phosphate).

2.2 History of Mining

In 1881, Captain J. F. Le Baron of the Army Corps of Engineers discovered phosphate pebble along the Peace River in Central Florida, but the deposits were not mined until 1888. In that year, the Arcadia Phosphate Company mined 3000 tons of phosphate. In 1888 further discoveries were made and by 1892 over 100 mining companies were in operation, most of them being in the hardrock field inland from the river pebble (U.S. Geological Survey, 1964).

From 1888 to the present day, production has increased steadily from 3000 tons in 1888, 22,000 tons in 1892, 15 million tons in 1963, to 35 million tons in 1974. The companies presently in operation today, however, number only 14.

2.3 Mining Operation

The first step in the mining of phosphate is for prospecting crews to determine the location, quality and thickness of the matrix. If required, swampy areas are drained and vegetation is removed by bulldozers. All mining in Florida is done by open pit methods using electrically-powered walking draglines. The machines presently in operation generally are equipped with buckets ranging from 35 to 60 cubic yard capacity and booms 225 to 300 ft in length. The machines may weigh over 2000 tons (Florida Phosphate Council, 1975).

The initial overburden from a new area is placed on top of natural ground. Cuts are generally 150 to 250 ft in width, may be up to 70 ft in depth, and may range from a few hundred yards to a mile or more in length. Overburden from succeeding cuts is side-cast into a previously mined area. The matrix is then dug out and dumped into a previously excavated "sump" or "sluice pit", where high-pressure water guns convert it to a fluid mixture, called a "slurry". The slurry is then forced by centrifugal pumps through a pipeline to the recovery plant located up to five miles away.

2.4 Beneficiation and Recovery

Each plant process may differ somewhat, but a generalized process is as follows. When the slurry matrix of phosphate, sand, and clay arrives through the pipe at the plant, the first treatment is in the washing and screening section. The slurry is first washed, then screened to separate phosphate pebble larger than 1/32 of an inch. What is left after the washing and screening section is made up of fine particles of sand, phosphate, and clay, which was discarded in the early days of mining. Today, modern methods enable about two-thirds of the phosphate in the ore to be recovered (Florida Phosphate Council,1975).

The clays and very fine phosphate particles are then separated out and pumped to the settling ponds, as there is no economical method of removing the very fine phosphate particles. Next, using a process called "double flotation", the remaining fine sand and phosphate mixture is throughly mixed with a chemical, called a reagent, in an air-water bath to form a froth. The sand drops to the bottom of the tank where it will be removed and used elsewhere, while the phosphate, clinging to the air bubbles at the top of the tank, is skimmed off with paddles. The skimmed phosphate still has some fine sand particles clinging to it, however, and therefore is put through a reverse process whereupon the reagent combines with the sand which floats to the surface where it is skimmed off. The recovered phosphate is then dried in kilns before shipping.

2.5 Description of Phosphatic Clay Slime

The major portion of the phosphate slimes is made up of the following five clay minerals: smectite (montmorillonite), kaolinite, palygorskite (attapulgite), illite, and sepiolite. Smectite, kaolinite, and palygorkite are generally observed as major constituents of the slimes, with smectite being the most common and abundant. Kaolinite is the next most common constituent, followed by palygorskite, as observed by the U.S. Bureau of Mines (1975).

Illite is occasionally found as a minor constituent, while sepiolite occurs very rarely in trace amounts. All the clay minerals are generally less than 2 microns in size.

There are several non-clay minerals consistently present in the slimes, of which apatite, quartz, dolomite, and various aluminum phosphate minerals are the most common. Apatite is found in all slimes, as is quartz. Dolomite is frequently found, but in very small amounts. Apatite is less than 1/2 micron in size, while dolomite is generally more than 2 microns in size. Quartz is usually found as sand size particles. Wavellite, crandallite, and millisite are the aluminum phosphates generally found in the slimes. Wavellite is the most common, but all are found in minor amounts. Other non-clay minerals, generally occurring if at all in trace amounts, are orthoclase, microcline, plogioclase, shert, calcite, muscovite, and gypsum.

The occurence of the above specific minerals in the slimes is relatively consistent, but the relative amounts may very considerably. Generally speaking, the variation in minerals at one plant is as large as the variation over the field.

Atterberg Limits are used in geotechnical engineering to help classify cohesive soil according to their engineering properties. Figure 2.3 presents Atterberg Limit data plotted on Casagrande's Plasticity Chart for several slimes and some of the clay minerals typically found in the slimes. Soils plotting above the A-line behave as typical "clays", while those below the A-line behave as typical "silts" and "organic soils". Results of the Atterberg Limit tests run on the slimes would suggest that they behave as very highly plastic clays and silts, CH and OH soils on the Unified Soil Classification system.

The U.S. Bureau of Mines reported that the range of specific gravities for tests performed on slimes was 2.56 to 2.81, with an average of 2.69.

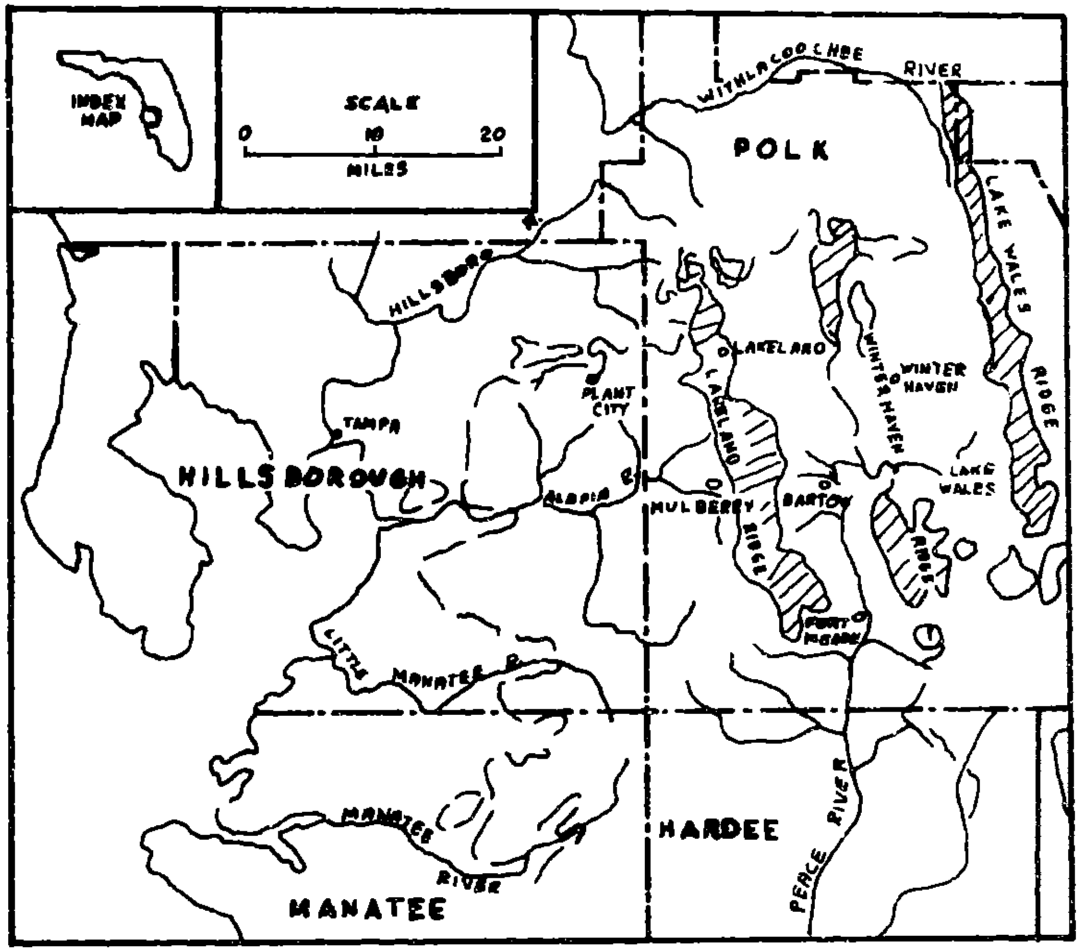
2.6 Methods of Disposal and Storage Requirements

Upon completion of processing at the plant, the clay with phosphate fines are in the form of a slurry with 3 to 5 per cent solids. The slurry is pumped into a previously mined area for storage and disposal. The volume of slurry pumped into a mined area is much greater than the entire initial volume of raw material removed. This necessitates the building of dams around the periphery to contain the slurry. Dams are constructed from a mixture of overburden and the uniform fine to medium sand from the processing plant. What has been a major problem in the past, but has not occurred within the past few years because of stricter controls, is the failure of dams resulting in great environmental damage to aquatic, plant, and animal life (U.S.B.M., 1975).

2.7 Environmental Problems

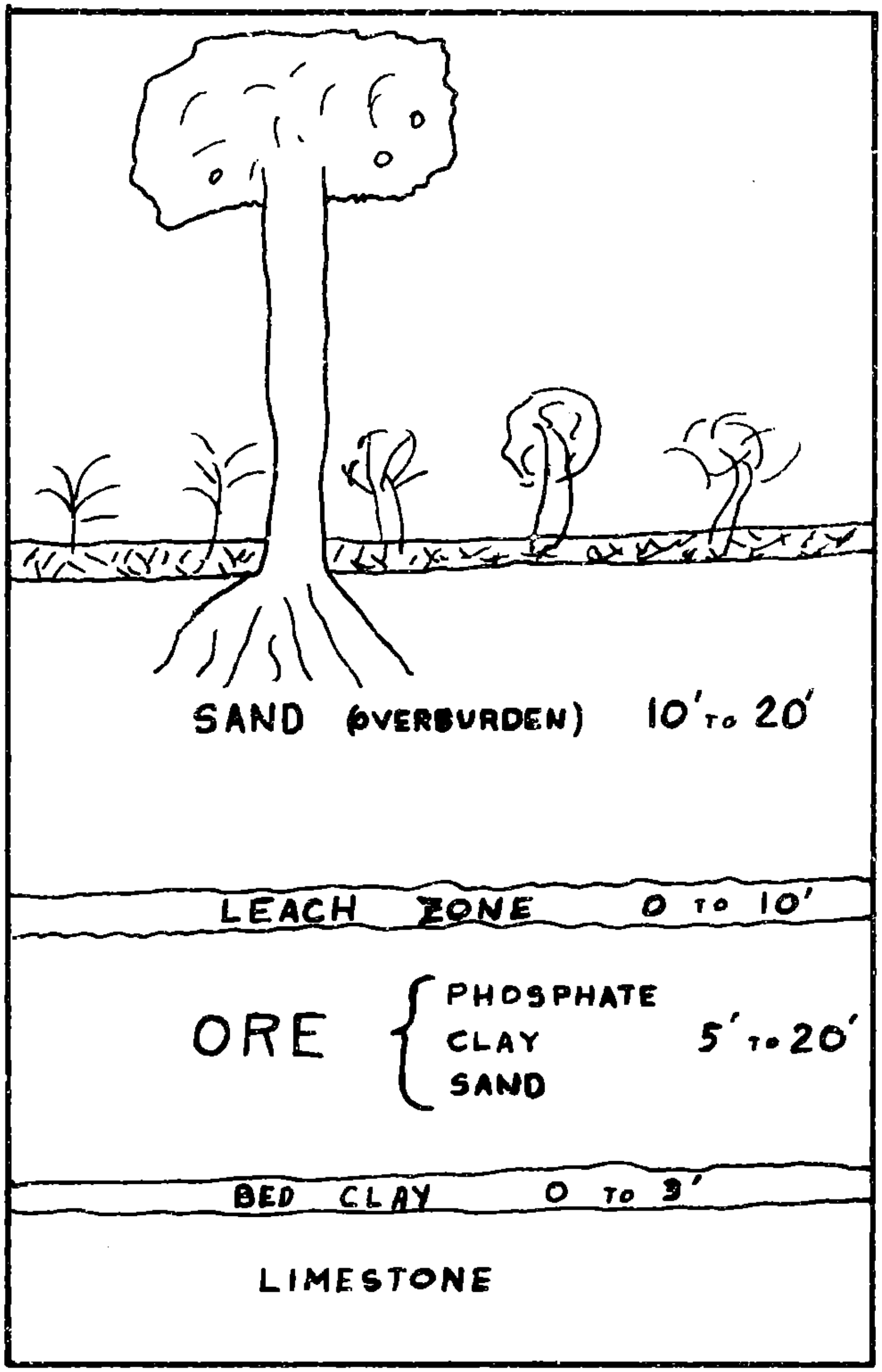
Aside from the problem of damage when a dam fails, environmentalists are also concerned with water loss and land reclamation. Many billions of gallons of water are retained within the settling ponds because of the very slow consolidation characteristics of the slurry. Though the mining companies take great care to recirculate as much water as possible, deep wells are required to supplement the thousands of gallons of water used daily in the phosphate recovery operation. On the average, a total of 10,000 gallons of water are needed for every ton of phosphate produced, which puts a great demand on Florida's water supply. Of this amount, about 8500 gallons are recirculated and 1500 gallons are from wells.

With many thousands of acres being mined annually and replaced with settling ponds, land reclamation becomes a major problem. Figure 2.4 presents a typical surve of solids content in a storage pond versus time. Solids content from the plant is 3 to 5 per cent and increases relatively quickly to 15 per cent. However, consolidation to 20 per cent and higher is a very slow process. In some field cases, ponds over 40 years old have achieved a solids content of only about 35 per cent.



MAP of WEST-CENTRAL FLORIDA SHOWING LAND-PEBBLE PHOSPHATE DISTRICT. (USBM, 1975)

FIGURE 2.1



SCHEMATIC SKETCH of BONE VALLEY FORMATION
(FLORIDA PHOSPHATE COUNCIL, 1975)
FIGURE 2.2

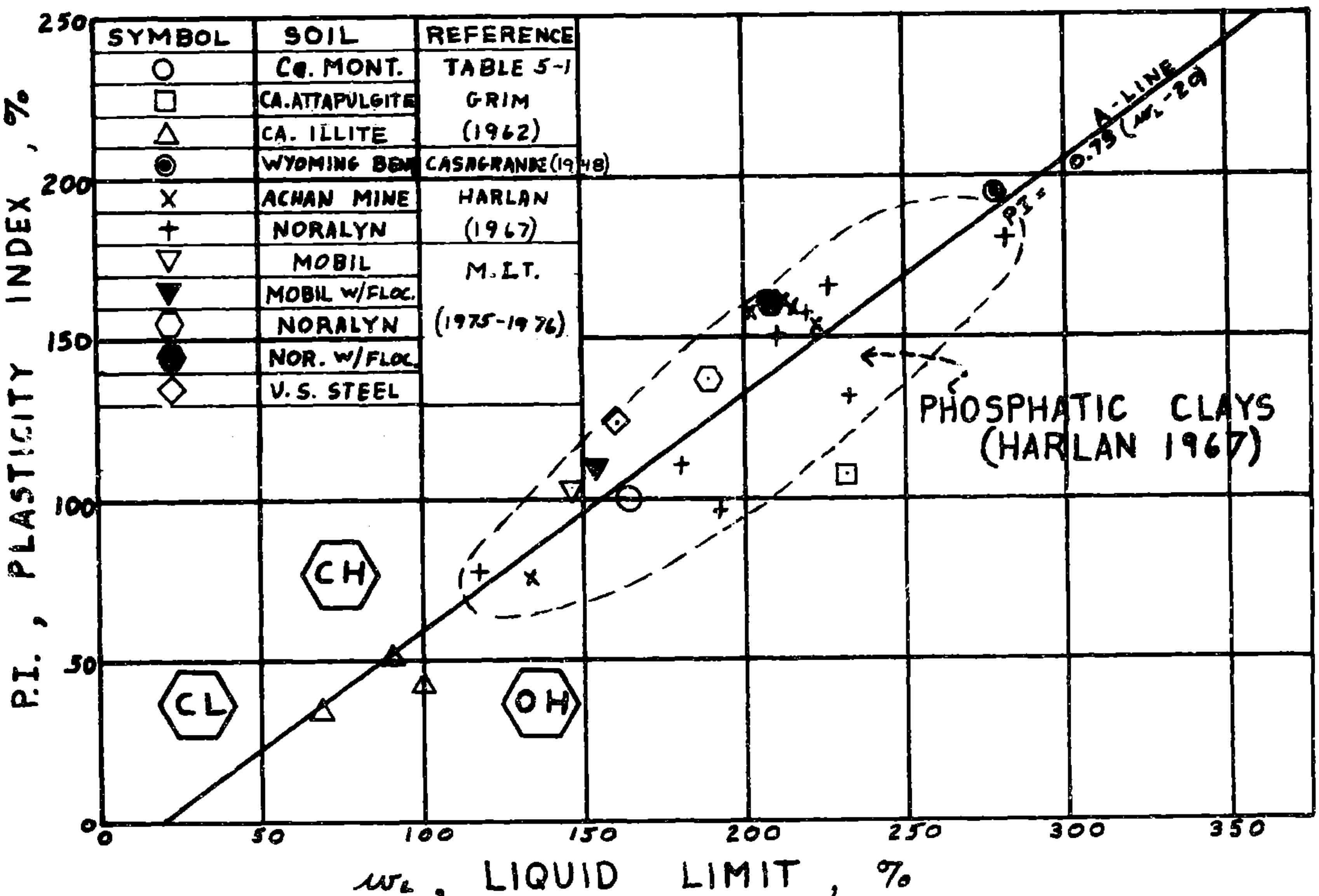
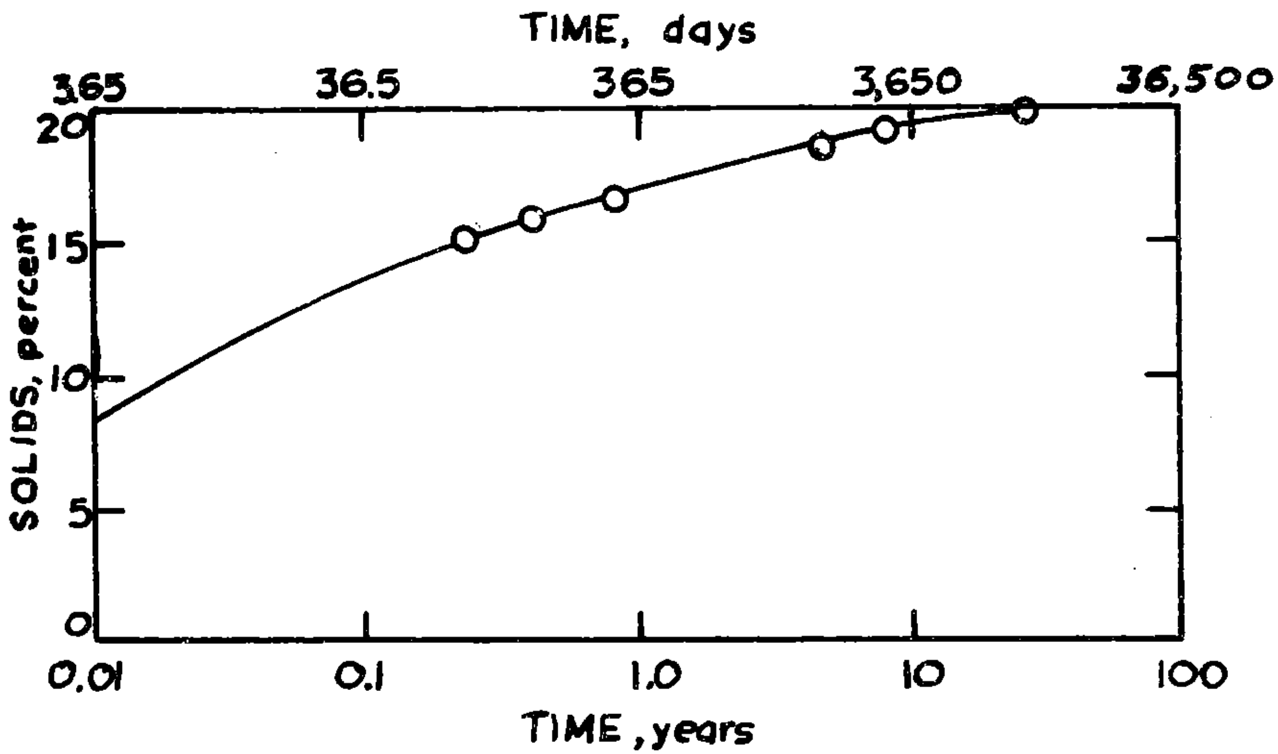


FIGURE 2.3 PLASTICITY CHART - PHOSPHATIC CLAYS • CLAY MINERALS



TYPICAL CURVE of SOLIDS CONTENT IN A STORAGE POND VERSUS TIME (USBM, 1975)

FIGURE 2.4

CHAPTER 3 DESCRIPTION OF LABORATORY TEST PROGRAM

3.1 Scope and Materials Tested

The objective of the laboratory test program was to define the engineering properties of the Florida phosphate slimes. Index properties were determined by Atterberg Limits and specific gravity tests. One-dimensional consolidation tests were performed wherein the effective vertical stress varied from a slurry settling under its own weight (≈ 0.7 gm/cm^2) to several kg/cm^2. The coefficient of consolidation, c_v, and the vertical permeability, k, were determined as a function of effective stress. Measured permeability values are compared with the permeability calculated from the coefficient of volume change, m_v, and the coefficient of consolidation, $k = \gamma_w c_v m_v$. The undrained strength was also determined as a function of the effective vertical stress. Finally the sedimentation characteristics of the slimes were examined.

The materials tested were collected at the Mobil, Noralyn, and U.S. Steel processing plants in Florida at 3 to 5 per cent solids content by weight. After allowing the solids to settle somewhat, water was drawn off and like samples mixed together, resulting in a slurry of 6 to 8 per cent solids. This slurry was then sent to M.I.T., where tests were performed on slurries as received from Florida. Also, Dow "Separan MG-500" flocculant at 0.01

per cent solution was added to Mobil and Noralyn slurries. The flocculant was added to the slurry and throughly mixed until flocs formed of about one eighth inch diameter.

Results of Atterberg Limit tests on the natural and flocculated samples are plotted on Figure 2.3. The specific gravity of the samples are :

	SPECIFIC GRAVITY	
NAME	NATURAL	FLOCCULATED
Mobil	2.94	2.87
Noralyn	2.75	2.73
U.S. Steel	2.86	----

3.2 Sedimentation

After a search of literature regarding sedimentation, it was realized that no theory of sedimentation exists that is applicable to a wide range of materials and conditions. An article by Michaels and Bolger (1962) involving kaolin suspensions seemed to come closest to the problem at hand. However, after a series of tests it was concluded that their theory may not be applicable to the very plastic Florida phosphatic clays at the per cent solids of primary interest.

For both the Mobil and Noralyn slurries, the following sedimentation tests were performed.

(1) In the original containers sent from Florida (approximately 14 inches square by 18 inches tall), read-

ings of the clay-water interface with time were made. The initial solids content and height varied in these tests.

(2) At the beginning of each large-diameter consolidation test (about 8 inches and 7 inches diameter by 28 cm high), slurries were allowed to settle under their own weight before applying seepage forces. The initial solids content varied.

(3) A series of tests were made in 3 inch diameter glass containers up to 4 ft long. The initial solids content and height varied in these tests.

3.3 Large Diameter Consolidation

Two large diameter consolidometers were especially designed and constructed for the project. Both units were constructed of lucite and measure 8 and 6 7/8 inches inside diameter, 12 1/2 and 23 1/2 inches high respectively. Also both units were designed to enable the direct measurement of permeability during consolidation increments.

The first consolidometer is equipped with a transducer at the bottom porous stone surface for total stress measurements, a transducer at the wall one inch from the bottom, and a porous tip at the center one inch from the bottom connected to a differential pressure transducer for pore pressure measurements. Ports were placed at varying heights on the wall for connection to standpipes, also for pore pressure measurements.

Consolidation first occurred by the solids settling under their own weight. Next, increased increments of seepage forces were applied. Finally, further consolidation was achieved by a porous piston applying a vertical force at the top of the sample. This consolidation scheme provided drainage from both ends of the sample. The piston was operated by air pressure through a calibrated load cell, with maximum loads on the order of 1.5 kg/cm^2. Data were periodically recorded by an automatic data acquisition system. The temperature was also recorded via thermisters placed around the test. Constant-head permeability tests were run at the end of each consolidation increment.

Stresses were applied in the second consolidometer solely by seepage forces. Head losses were incrementally increased to achieve consolidation of the slurry.

3.4 Constant Rate of Strain Consolidation

Using the Constant Rate of Strain Consolidation device (CRSC) developed at M.I.T. (Wissa et al., 1971), tests were performed on all samples upon completion of loading in the large diameter consolidometer unit. The rate of strain was selected to try to keep the excess pore pressure within 5 to 10 per cent of the applied load, as suggested by Wissa et al. (1971) in order to properly define the compression curve and obtain continuous c_v data.

3.5 CU Strength Tests

Using a Geonor direct-simple shear device (Bjerrum and Landva, 1966; Ladd and Edgers, 1972) consolidated-undrained direct-simple shear tests ($\overline{Ck_0U}DSS$) were performed on samples upon completion of loading in the large diameter consolidometer unit. This type of test was selected since it requires less time and effort than isotropically consolidated undrained compression tests (CIUC). Also, this test attempts to reproduce in the laboratory all the strain conditions in the field when a portion of soil has horizontal displacement due to shear.

The cakes of slime were consolidated incrementally in the Geonor device to varying stresses and were either sheared to failure normally consolidated, or unloaded in increments and sheared over-consolidated. Constant volume was maintained throughout shearing.

CHAPTER 4 RESULTS OF SEDIMENTATION TESTS

4.1 General

First, let a "sediment" be defined as soil particles independent of each other in a fluid suspension with zero effective stress and a "soil" be defined as soil particles in contact with one another with an effective stress greater than zero.

According to our present state of knowledge no successful theory of sedimentation applicable to a wide range of materials and conditions has been derived. Therefore when dealing with a particular soil one has either to run a limited number of tests, trying to match a problem with an existing theory or to run a fairly extensive number of tests to derive an individual experimental model. The goal of this investigation was primarily to reach the former.

The most attractive theory found in the literature was that developed by Michaels and Bolger, 1962. Even though the components of phosphatic slimes are quite different from the kaolinite used by Michaels and Bolger, it was hoped that the general principles might apply. Therefore the aim of the experimental study was to asses the effect of the concentration of the slime and of the testing container height and diameter upon the rate of sedimentation and the final solids content.

No evident similarity was found, however, with the Michaels and Bolger data when compared with Florida phosphatic slimes, because the slimes did not appear to fit the theory very well. Other questions which still require an answer are; (1) what is the maximum per cent solids after which "sedimentation" will not occur and (2) what is the per cent solids at the "end of sedimentation".

4.2 Effect of Slime Concentration

In Figures 4.1 and 4.2 are presented the results of a Mobil sedimentation test with varying initial per cent solids. Three containers were used, all with a diameter of 6 cm and the initial slurry height was 28 cm. As may be seen in Figure 4.2, the trend is that the lower the initial per cent solids, the faster the initial rate of settling. But as can be seen in Figure 4.1, a slurry of lower initial per cent solids will not reach with time as high a per cent solids as a slurry starting with a higher initial per cent solids.

4.3 Effect of Height

In Figures 4.3 through 4.8 are presented the results of sedimentation tests on samples of U.S. Steel slurry to determine the effect of initial height of slurry. Slurry with an initial solids content of 7.46 per cent was used in containers 6 cm in diameter. Five containers were used with the initial slurry height varying from 15.30 to 103.10 cm. As can be seen in the figures, the higher the initial height of slurry, the faster the initial rate of settling, and the greater the final per cent solids. For example, the slurry of initial height 15.30 cm settles a maximum rate of 0.00175 cm/min with a final per cent solids of 10.98. The slurry of initial height 103.10 cm settles a maximum rate of 0.026 cm/min with a final per cent solids of 11.90. This is quite reasonable as the higher the slurry, the greater the effective stress due to the weight of slurry.

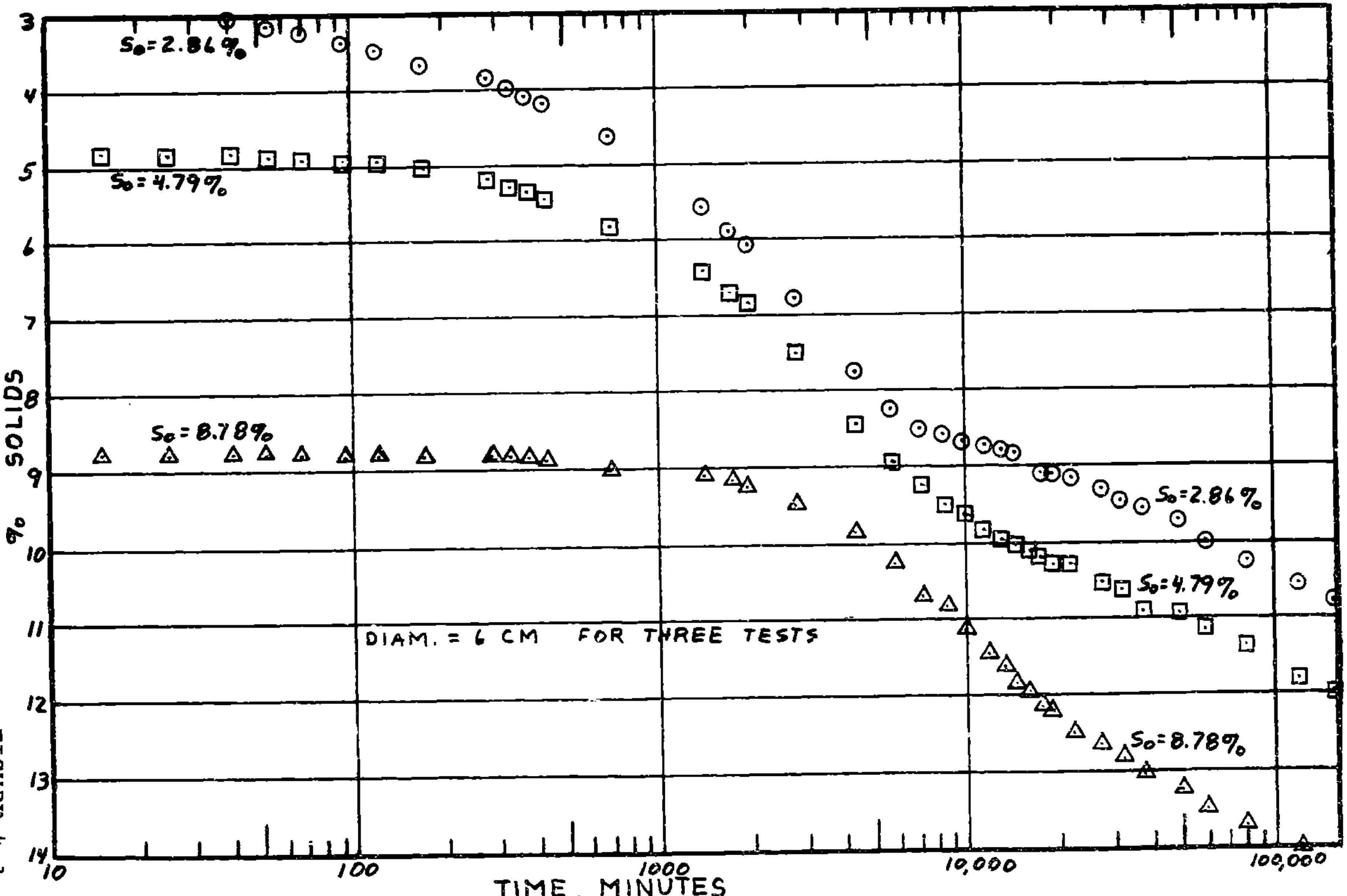
4.4 Effect of Diameter

In Figure 4.9 is presented the results of two Mobil tests to determine the effect of the container diameter on sedimentation. The author believes, however, that because the initial per cent solids was so high, no valid conclusions may be drawn.

4.5 Discussion

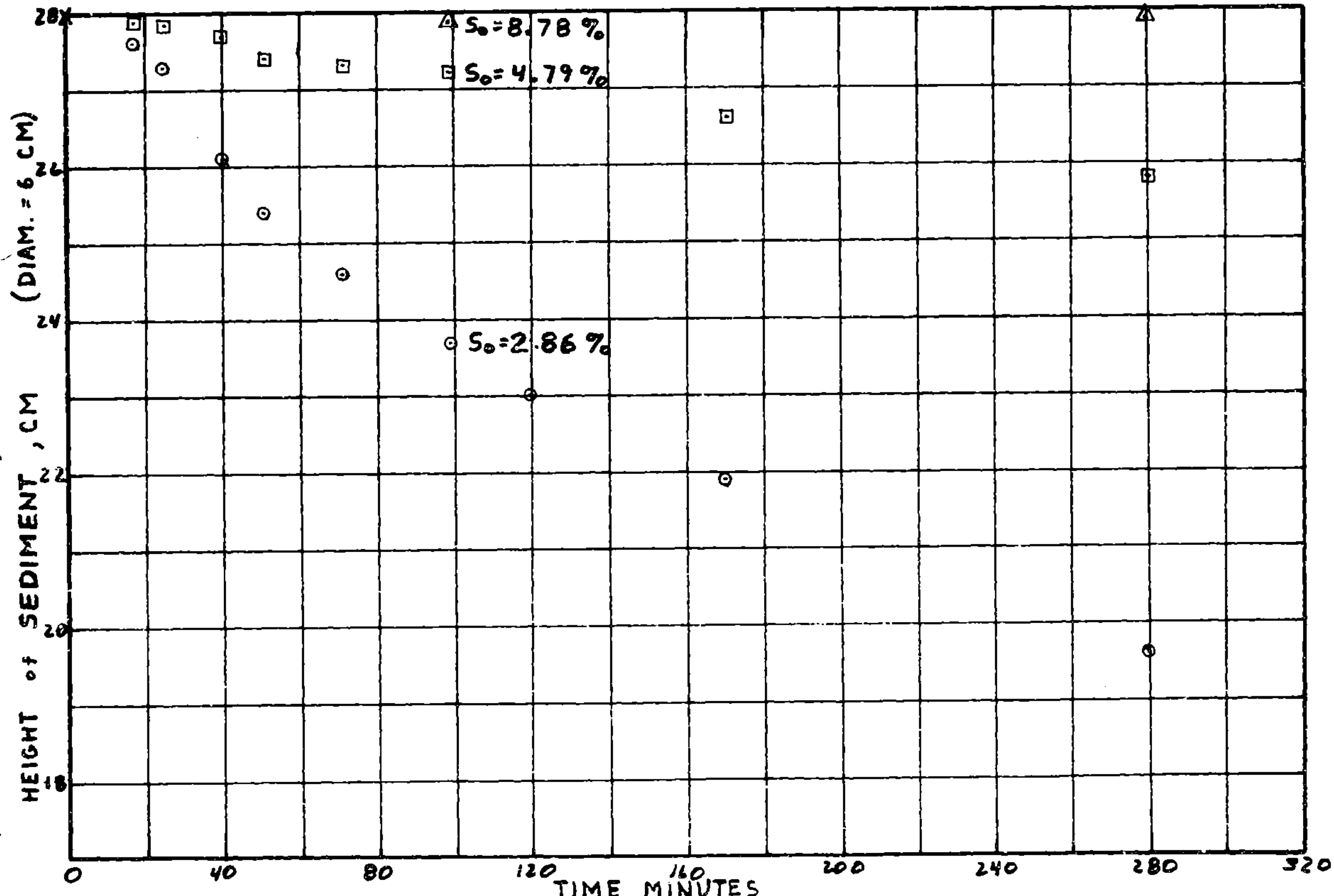
This series of tests has not provided any new empirical formula applicable to the settlement behavior of phosphate slimes.

As to the question of what is the maximum per cent solids at which sedimentation can occur, it would seem that there is no straightforward answer. In Figures 4.1 and 4.2 with Mobil, sedimentation occurs at 2.86 per cent and most likely at 4.79 per cent, but not 8.78 per cent. In Figures 4.3 through 4.8 for USS, it appears that sedimentation occurs with 7.46 per cent solids. It would seem therefore that the maximum per cent solids at which sedimentation can occur will vary from slurry to slurry.



MOBIL SEDIMENTATION AT VARYING S_o, AND H_o=28 CM FOR THREE TESTS

FIGURE 4.1



MOBIL SEDIMENTATION AT VARYING S_o, AND H_o=28 CM FOR THREE TESTS

FIGURE 4.2

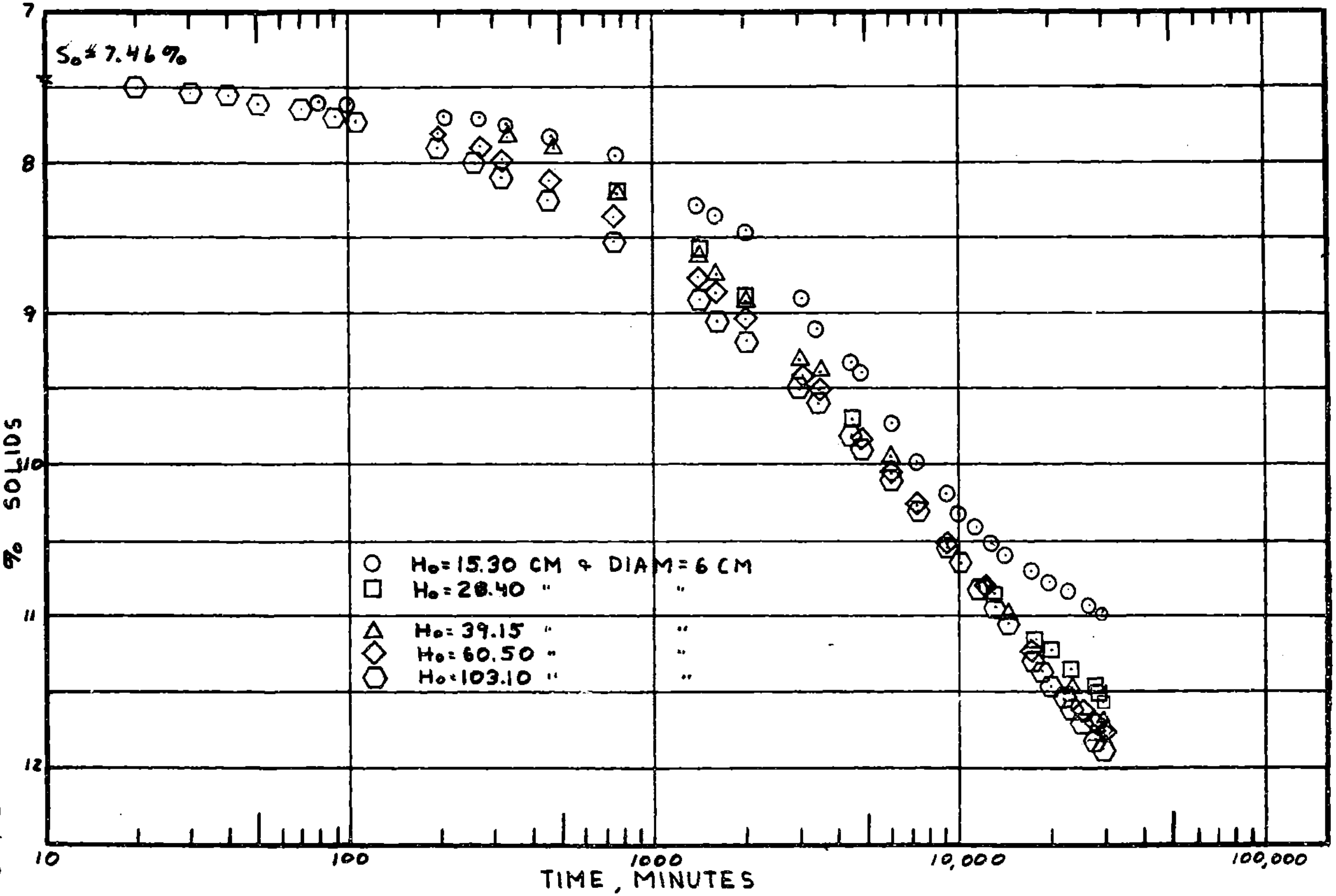
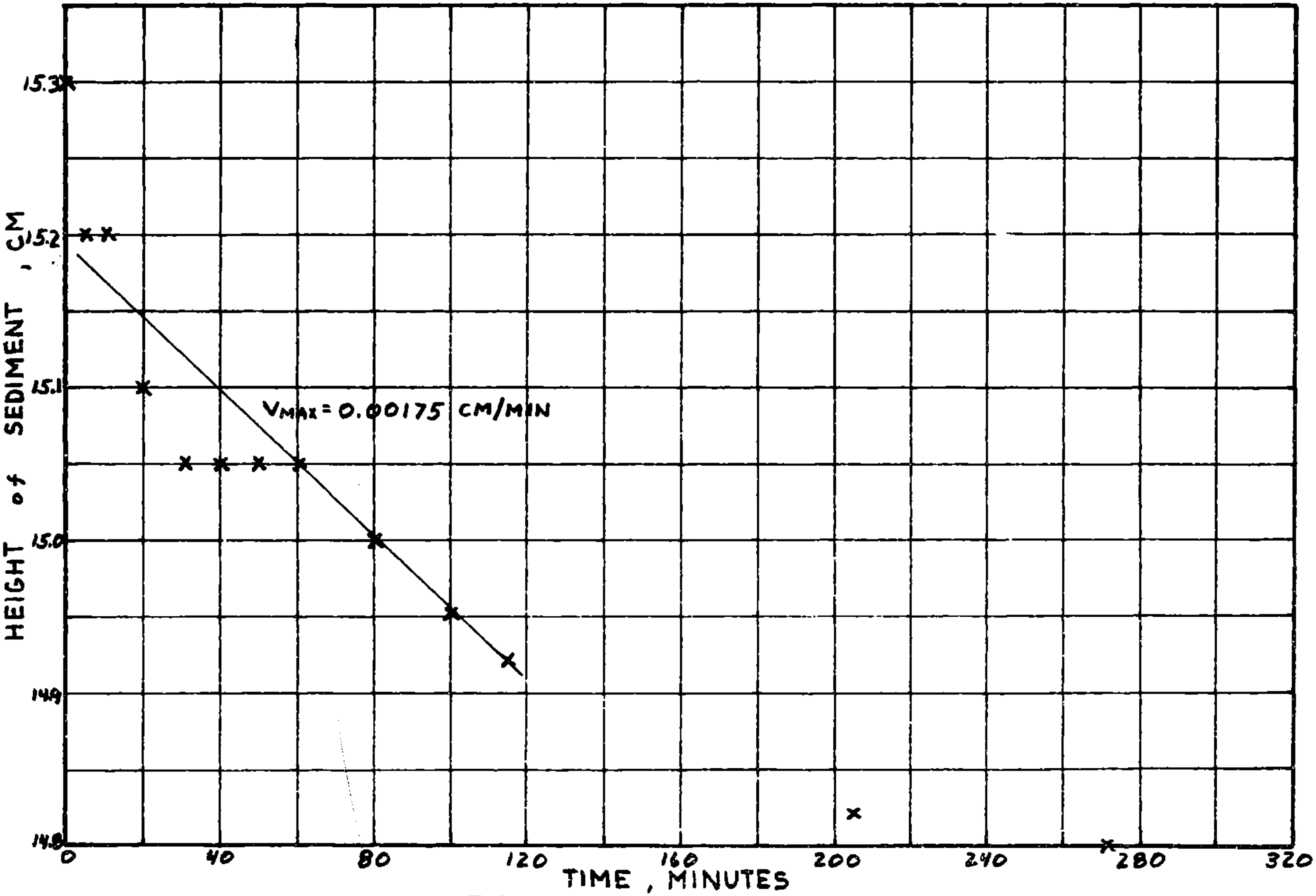


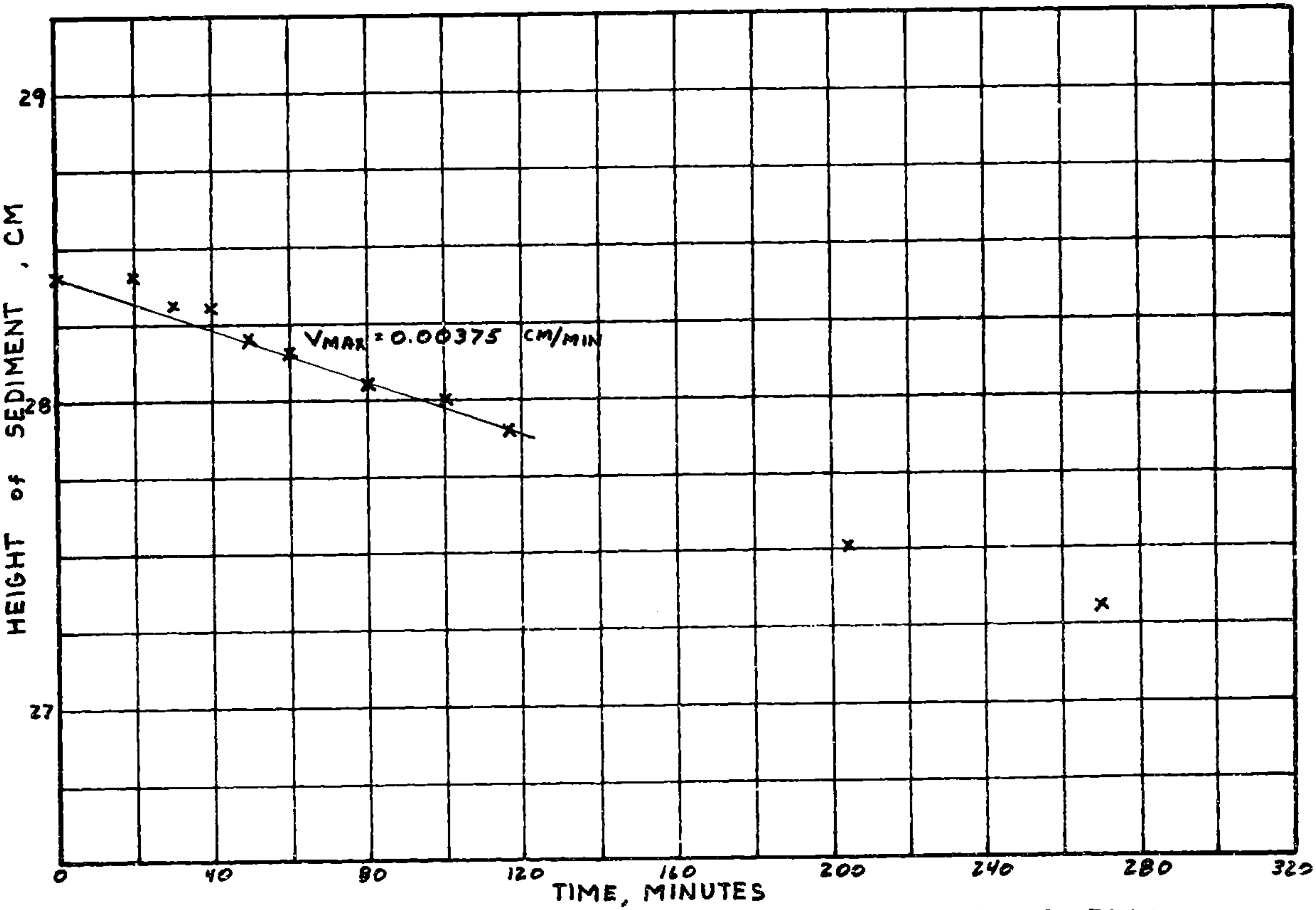
FIGURE 4.3

USS SEDIMENTATION AT VARYING INITIAL HEIGHTS AND S_o=7.46% FOR ALL TESTS



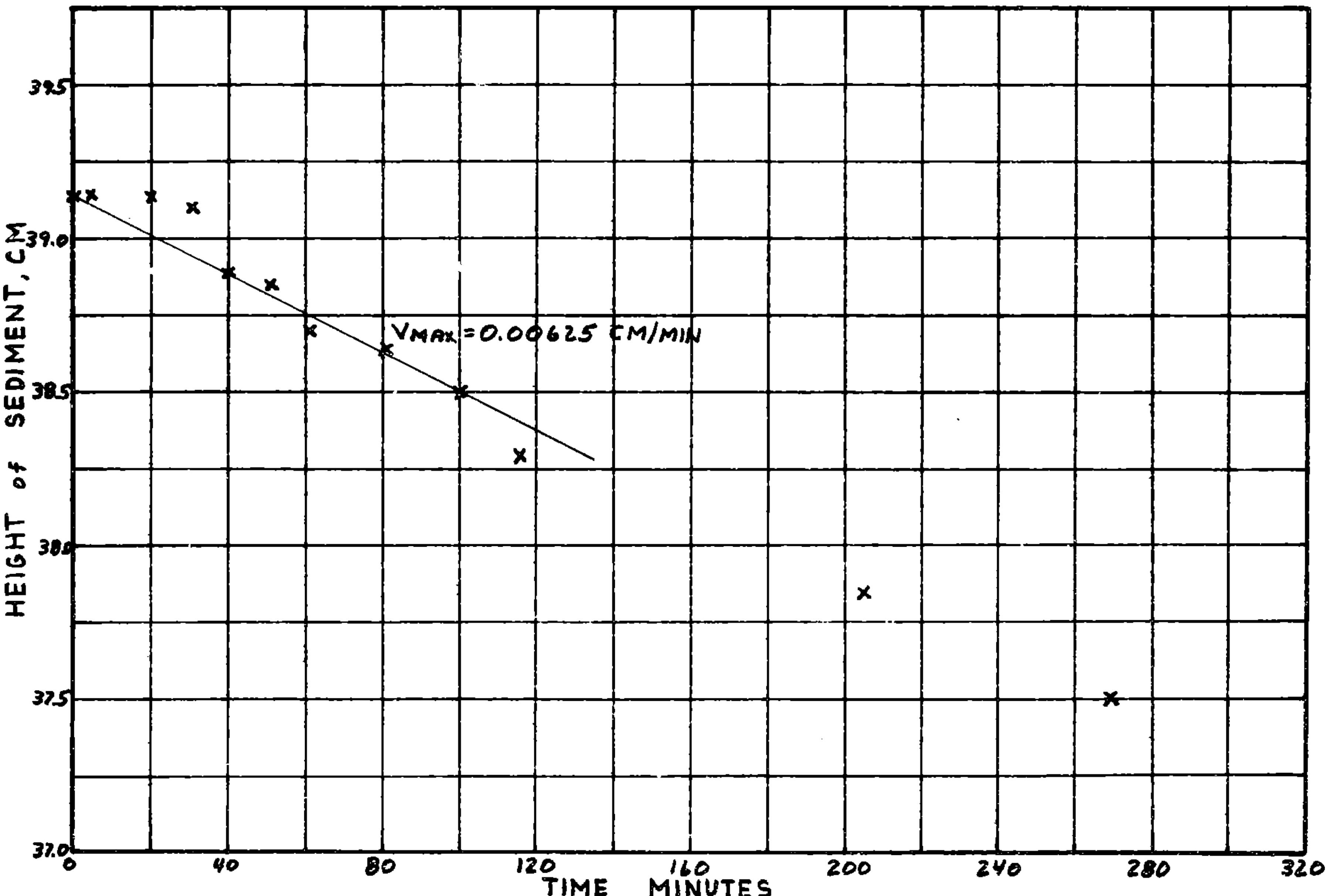
USS SEDIMENTATION AT H_o = 15.3 CM AND S_o = 7.46 %

FIGURE 4.4



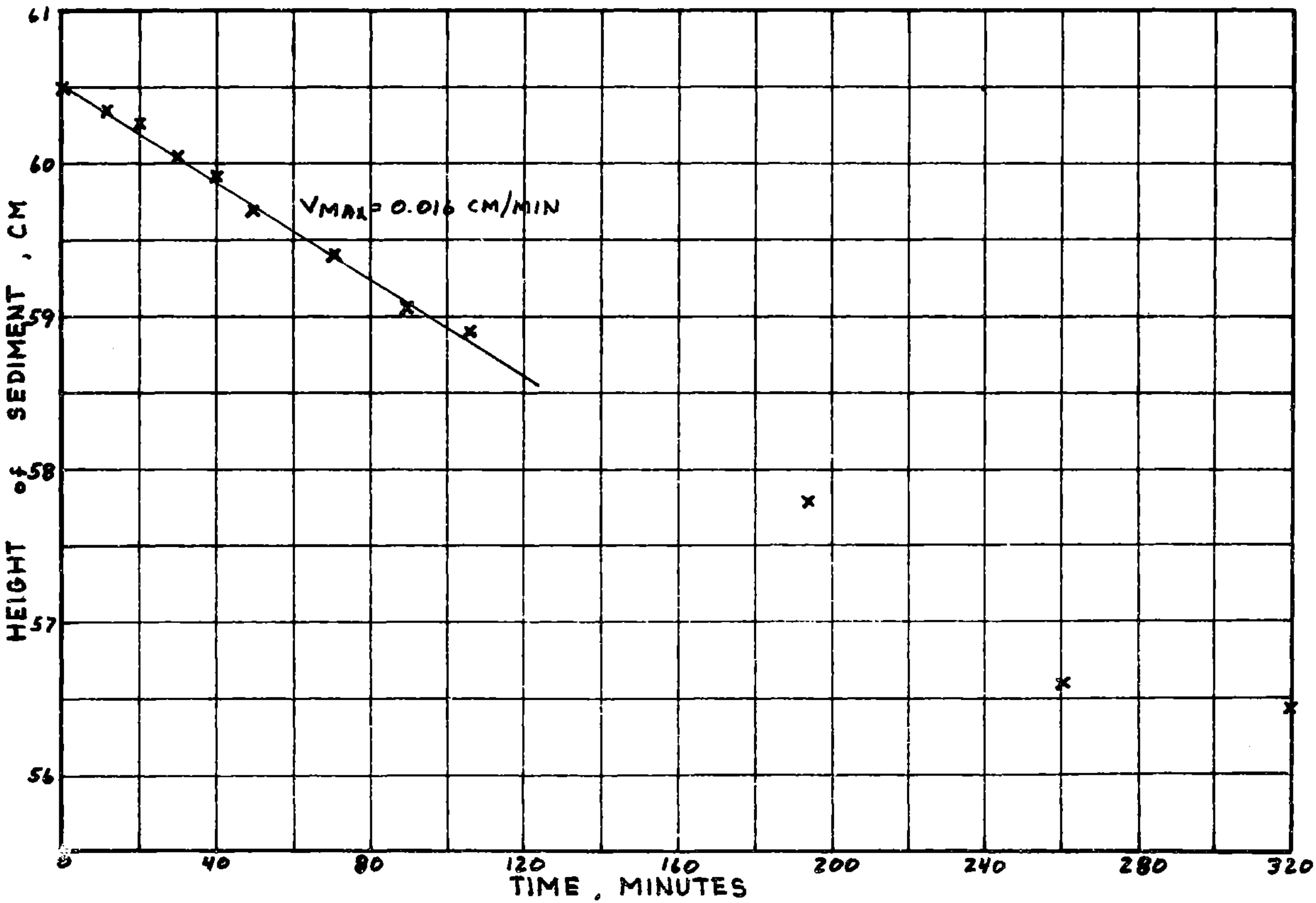
USS SEDIMENTATION AT $H_o = 28.4$ CM AND $S_o = 7.46$ %

FIGURE 4.5



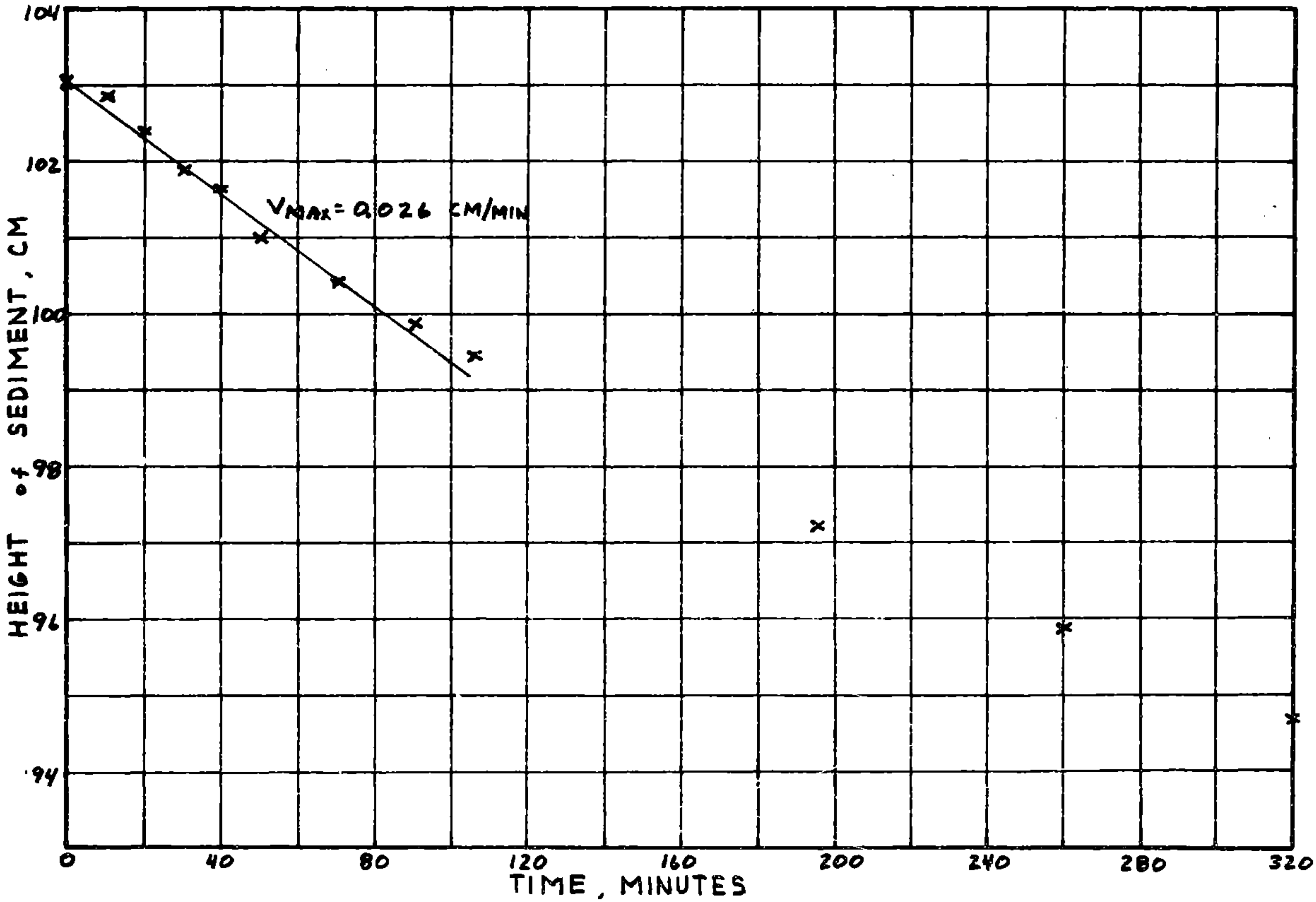
USS SEDIMENTATION AT H_0 = 39.15 CM AND S_0 = 7.46 %

FIGURE 4.6



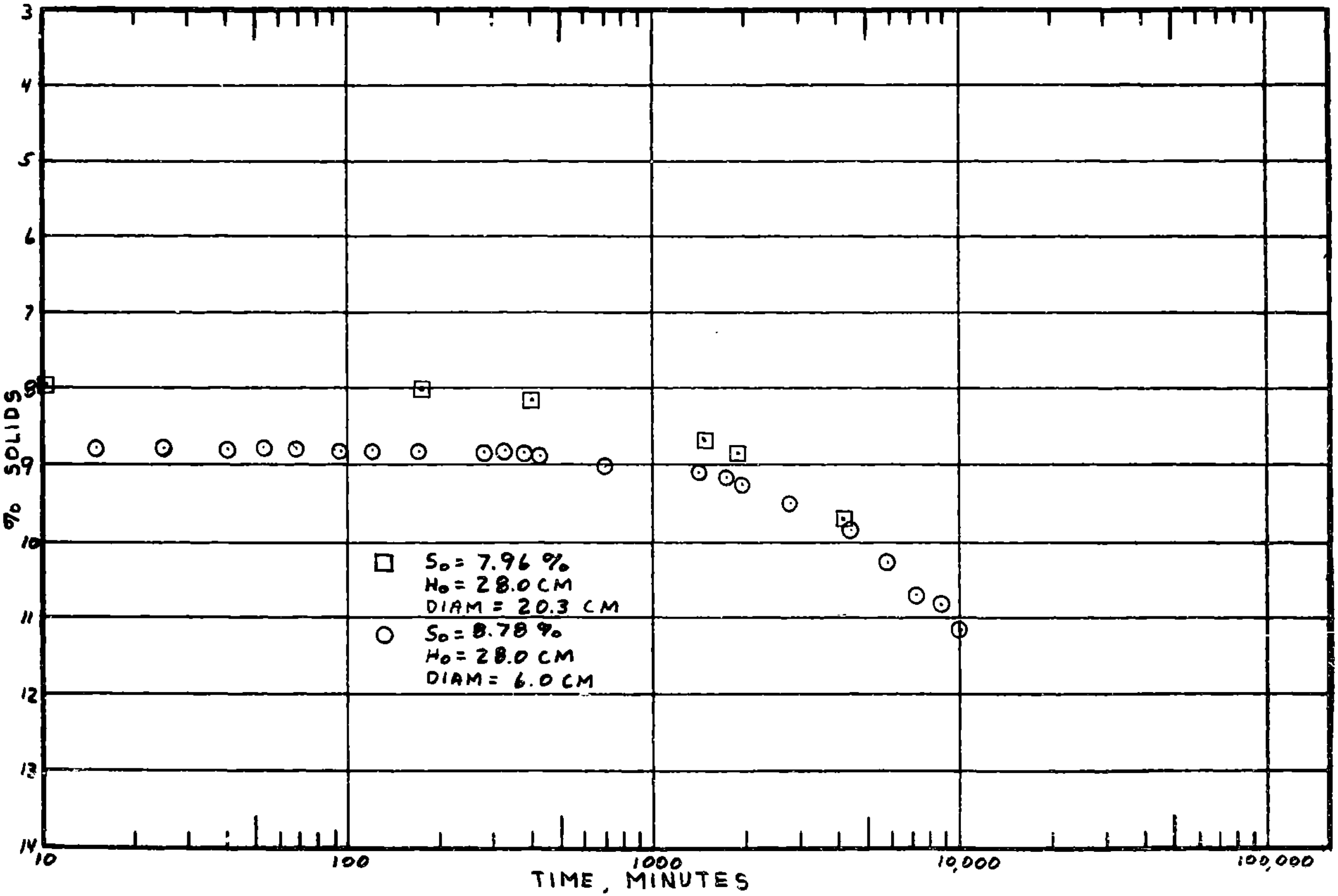
VSS SEDIMENTATION AT H_0= 60.50 CM AND S_0= 7.46 %

FIGURE 4.7



USS SEDIMENTATION AT H_0=103.10 CM AND S_0=7.46%

FIGURE 4.8



MOBIL SEDIMENTATION - COMPARE EFFECTS OF CONTAINER DIAMETER

FIGURE 4.9

CHAPTER 5 RESULTS OF CONSOLIDATION-PERMEABILITY TESTS

5.1 Compressibility

Tables 5.2, 5.4, 5.6, 5.8, 5.10, and 5.12 present a summary of results from the four consolidation and two seepage tests performed. Details of the tests are presented in Appendix C.

Void ratio versus log consolidation stress data are presented in Figures 5.4, 5.6, 5.8, 5.10, 5.12, and 5.14 for each test and the results are summarized in Figure 5.1. Most discrepancies in void ratio occur at lower stresses. As can be seen, a disproportionate decrease in void ratio results when the piston load is applied to the sample. An example of this may be seen for consolidation test No. 2 in Figure 5.6 and summarized in Table 5.4. A disproportionate decrease in void ratio is obtained by increasing the effective stress from 3.82 gm/cm^2 to 8.62 gm/cm^2. The effective stress of 3.82 gm/cm^2 is caused by a seepage force and the soil's own weight, while the stress of 8.62 gm/cm^2 is due to a piston load, a seepage force and the soil's own weight. For the seepage forces, a uniform stress distribution from zero at the top of the soil to a maximum at the bottom of the soil-top of porous stone interface was assumed. This is quite probably not the case with the exact distribution being unknown. Because of this variable effective stress distribution, we have a variable per cent solids distribution. This leads to a variable permeability and therefore head loss through the sample. A problem that developed during the application of seepage forces was that the higher the seepage force the more the sides of the slurry would pull away from the sides of the consolidometer, with the maximum amount being about 5 mm at the top tapering to zero somewhere near the bottom. A dish also occurred at the top of the slurry with the application of seepage forces. With the application of piston loads, the slurry was pressed against the sides of the consolidometer and the dish was removed. The author believes that with the slurry pulling away from the sides of the consolidometer, the full seepage effect was not acting on the soil, partially resulting in the discrepancies shown on the compression curve summary sheet, particularly at higher head losses. After the piston forces were applied, quite consistent compressibility results were attained. Also during some load increments, primary consolidation was not reached. A note is made on the summary sheets and on the figures for these cases. In about every case, however, the final reading was close to primary and therefore the void ratio would not have appreciably changed.

5.2 Coefficient of Consolidation

A summary of the coefficient of consolidation, c_v, versus effective stress, $\bar{\sigma}_v$, is presented in Figure 5.3. For most clays, c_v, in the normally consolidated range is approximately constant. With the exception of some scatter, particularly at low stresses, the coefficient of consolidation appears reasonably constant in Figure 5.3 at a value of about 1.8×10^{-4} cm^2/sec. This is shown through four orders of magnitude of change in effective stress. C_v results from the seepage portion of the tests are also plotted in Figure 5.3, but because of the aforementioned problems the author believes them to be misleading and therefore should not be weighed as heavily as results from consolidation under an applied piston load. Results of c_v from the square root method and the log fitting method agree quite well, but generally c_v computed from the square root method tends to be slightly higher than the log fitting method.

5.3 Temperature

All consolidation and seepage tests were conducted in a "constant temperature room", with the temperature being set at 70°F. To measure any changes, thermisters were placed around the consolidation tests. The thermisters showed a fluctuation of plus or minus 1 to 2 degrees F on a weekly basis, increasing and decreasing as the lights were turned on and off. On a long term basis, however, every two to three months, trouble would develop with the air conditioning system and the temperature would rise to about 88°F for a week or two until the system was repaired and returned to 70°F. No direct temperature measurements were taken of the water in the consolidometer during these high temperatures, but cooler tap water was occasionally substituted during the test to offset the higher room temperatures.

5.4 Coefficient of Permeability

The permeability results are presented in Tables 5.1 through 5.12. Measured results and values calculated from $k=c_v\gamma_w m_v$, where k is the permeability and m_v is the coefficient of volume change, are plotted for each test in Figures 5.5, 5.7, 5.9, 5.11, 5.13, and 5.15 while a summary of measured results for the four consolidation tests are plotted in Figure 5.2. Calculated results generally tend to be slightly lower than measured, with permeabilities calculated by the square root method slightly greater than those by the log fitting method. The measured permeability from the four consolidation tests in Figure 5.2 show excellent agreement among consolidation tests No. 2 through 4 on Noralyn, while results of test of test No. 1 on Mobil show the permeability several times larger at the same per cent solids. Differences in mineralogy could explain this difference.

At the completion of seepage test No.1, an experiment was performed in that tailings sand was placed in the bottom of the consolidometer and the Noralyn slurry was placed on top of the sand. A head loss of 128 cm was immediately applied to the slurry and this head loss was maintained as the slurry consolidated. At the completion of this experiment, the Noralyn sample was dissected to determine the per cent solids distribution through the sample. It was noted that because the sand is fine enough, no slurry entered the sand-slime interface. Also there existed a more highly consolidated "cake" of soil about 2 mm in thickness at the bottom of Noralyn-top of sand interface. This "cake" was stiffer in consistency and was at a higher per cent solids than the rest of sample, but an exact determination of the per cent solids of the cake could not be obtained because of some sand mixing in with the slime while being dissected. The author observed this cake when a very large head loss was suddenly applied to the slurry, but it should be pointed out that no cake was observed if small head losses, such as 2 cm, was applied and incrementally increased by doubling the head losses to a maximum of 128 cm.

5.5 Pressure Measurements

Three pressure transducers were used throughout the consolidation tests. One for total stress measurements was placed level with the porous stone surface at the bottom of the consolidometer, midway between the center of the stone and the side of consolidometer. Another for pore pressure measurement was placed through the center of the porous stone with the tip one inch above the porous stone. The third, also for measuring pore pressures, was placed on the side of the consolidometer, one inch from the bottom. Quantitative measurements were unable to be made with any of the transducers because of the insensitivity of each. Zero readings fluctuated to such an extent that no meaningful absolute values could be attained. It was possible, however, during the test to measure qualitative trends. At higher stresses, all three transducer readings showed an immediate increase when loads were applied. Then as consolidation took place and excess pore pressure dissipated, the pore pressure readings would decrease.

Ten ports for standpipes were placed at the sides of the consolidometer at varying heights around the circumference. Three to four ports were used for a test and the remaining ones blocked off. It was realized that the standpipes served little use during consolidation increments because of the time it took for the water to flow into the pipes, i.e. excessive time lag. The standpipes were to serve for checking the head losses through the sample during permeability tests. During the sedimentation and consolidation increments however, the standpipes became clogged with slurry and no meaningful results could be obtained.

5.6 Effect of Flocculant

To find the effect of flocculation on phosphatic clays Dow Seperan MG-500 flocculant at 0.01 per cent solution was continually added to a slurry in small amounts and stirred until flocs appeared. This was done for consolidation test No. 4 on a Noralyn sample, and seepage test No. 2 on a Mobil sample. The maximum size flocs that could be obtained was about 3 mm. The time for a slurry to consolidate under its own weight was decreased by at least an order of magnitude by the addition of a flocculant. When small seepage forces were applied however, the time for consolidation was generally increased by about two orders of magnitude. With larger seepage forces and piston loads, the time for consolidation was not changed significantly. In all cases, the amount of consolidation from a load increment, whether flocculated or not, was not appreciably changed, as can be noted from Figure 5.1.

It would seem at low effective stresses after settling under its own weight, that a much longer time is needed to break down the bonds due to flocs, but at higher stresses, no particular differences are noted between flocculated slurries and slurries that had no flocculant added.

5.7 CRSC Results

Figures 5.16 through 5.26 present results from five Constant Rate of Strain Consolidation, CRSC, tests. Four tests, CRSC No. 1 through 4, were performed on soil upon completion of testing in the large-diameter consolidometer, while the fifth test, CRSC No. 21, was performed on a portion of a block field sample of Mobil flocculated slime taken in Florida.

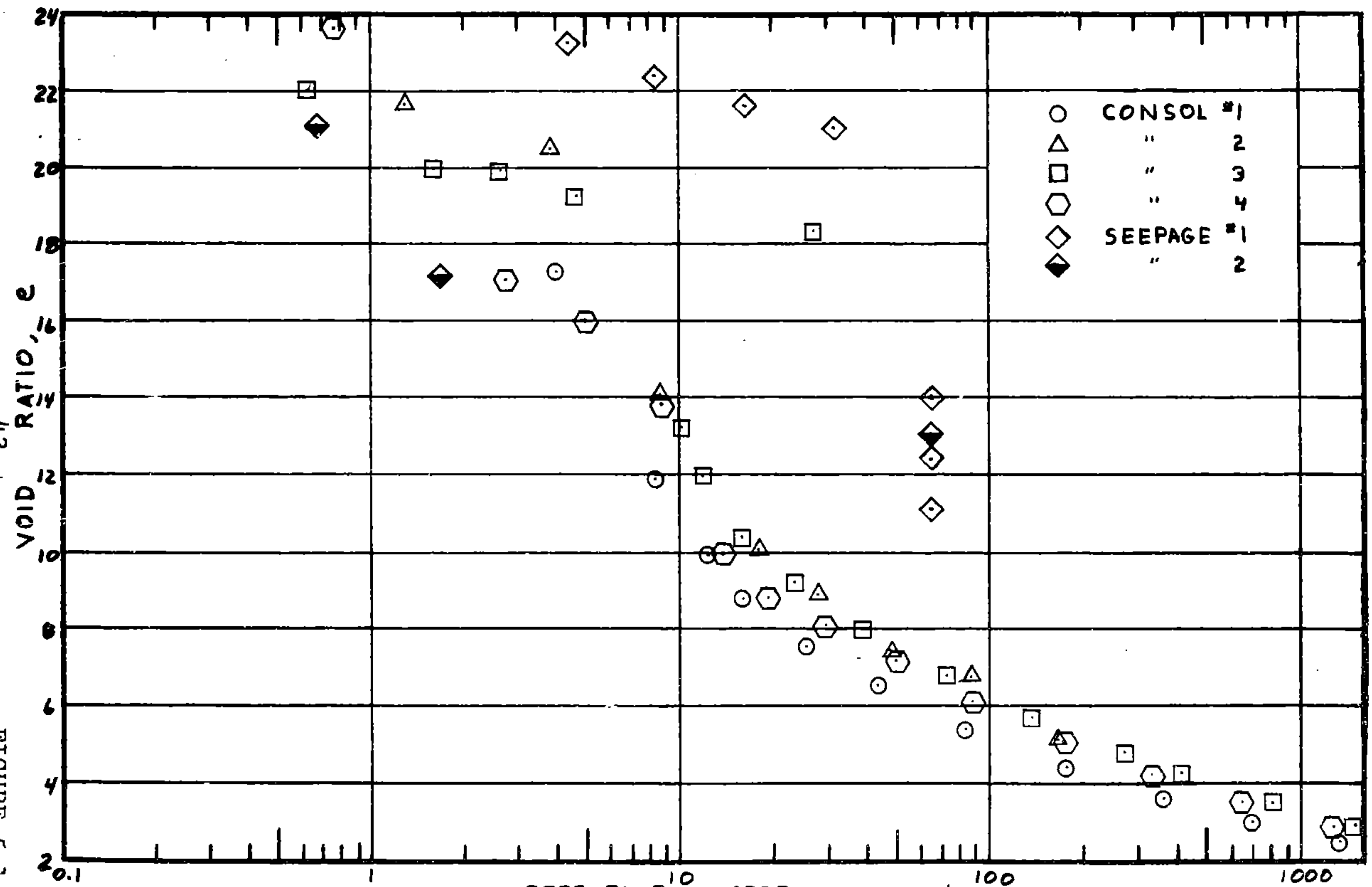
In Figures 5.17 and 5.18 are plotted c_v results from CRSC No. 1 using non-linear and linear theory respectively. Non-linear theory assumes C_c, the compression index, to be constant, while linear theory assumes m_v, the coefficient of volume compressibility, to be constant. Because the intervals of time and consequently the change in effective stress between readings is kept relatively small, the difference in the computed c_v is generally not significantly influenced by assuming constant C_c rather than constant m_v. This may be observed in Figures 5.17 and 5.18 which show very little difference.

Figure 5.27 presents a summary of e-LOG $\bar{\sigma}_v$ curves for the loading portions of CRSC tests. Very consistent results were obtained for the tests, with a void ratio of 1.6 to 1.7 at a stress of 10,000 gm/cm^2. The compression index, C_c, varied between 1.0 and 4.0 depending where on the normally consolidated curve the slope was taken. Generally for $\bar{\sigma}_v$ less than 1000 gm/cm^2, C_c equalled about 2 to 4 while for $\bar{\sigma}_v$ between 4000 and 10,000 gm/cm^2, C_c equalled about 1 to 1.5. Difficulty with the automatic data acquisition system resulted in various load-unload cycles of CRSC No. 2.

The coefficient of consolidation, c_v, should decrease during recompression and then become constant in the normally consolidated range. This trend can be noted in the c_v versus consolidation stress plots in Figures 5.17, 5.18, 5.22, 5.26 for CRSC No.'s 1, 3, and 21. For CRSC No. 2 and 4 on Figures 5.20 and 5.24, the trend seems to be that c_v is continously decreasing. The author is unable to explain this or the fact that in Figure 5.20, c_v for the second loading portion is so low. Because the loading is recompression, c_v should be much higher in Figure 5.20.

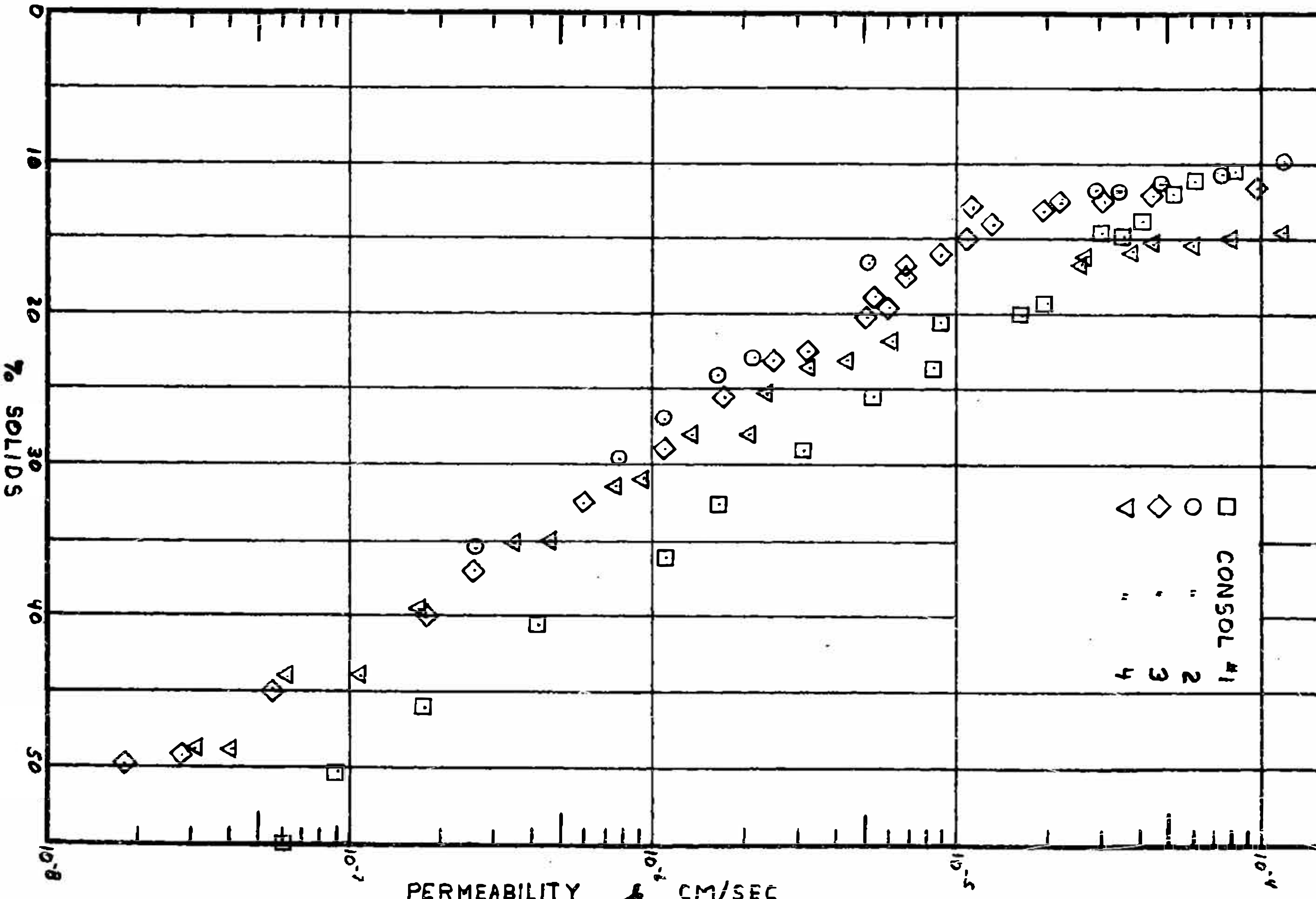
The values of c_v for the normally consolidated soil range from about 1 x 10^{-4} to 3 x 10^{-4} cm^2/sec., which agree reasonably well with c_v data obtained from the large-diameter consolidometer tests.

Tabulated values of e and $\bar{\sigma}_v$ for the five CRSC tests are presented in Appendix E.



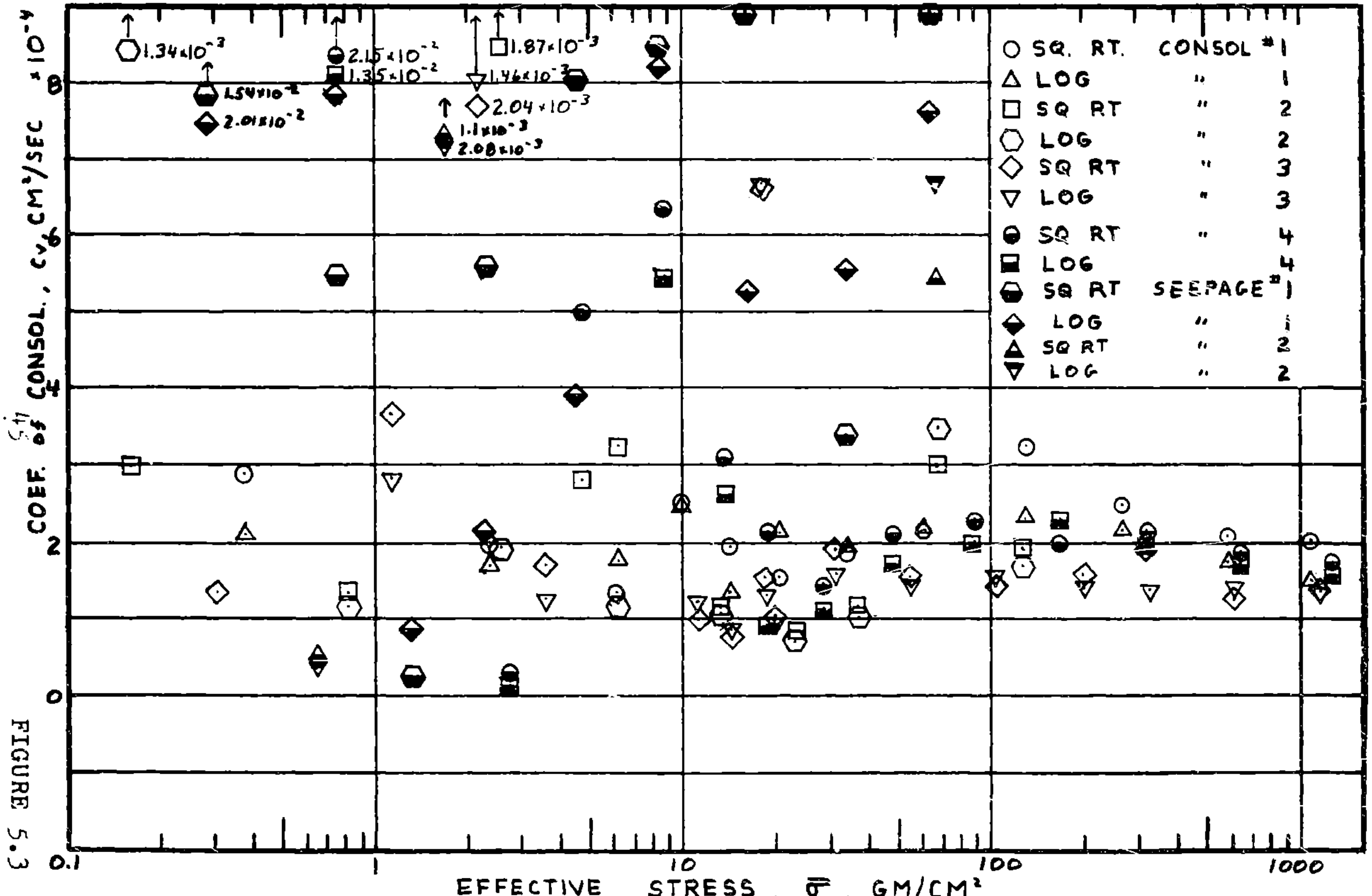
SUMMARY of COMPRESSION CURVES

FIGURE 5.1



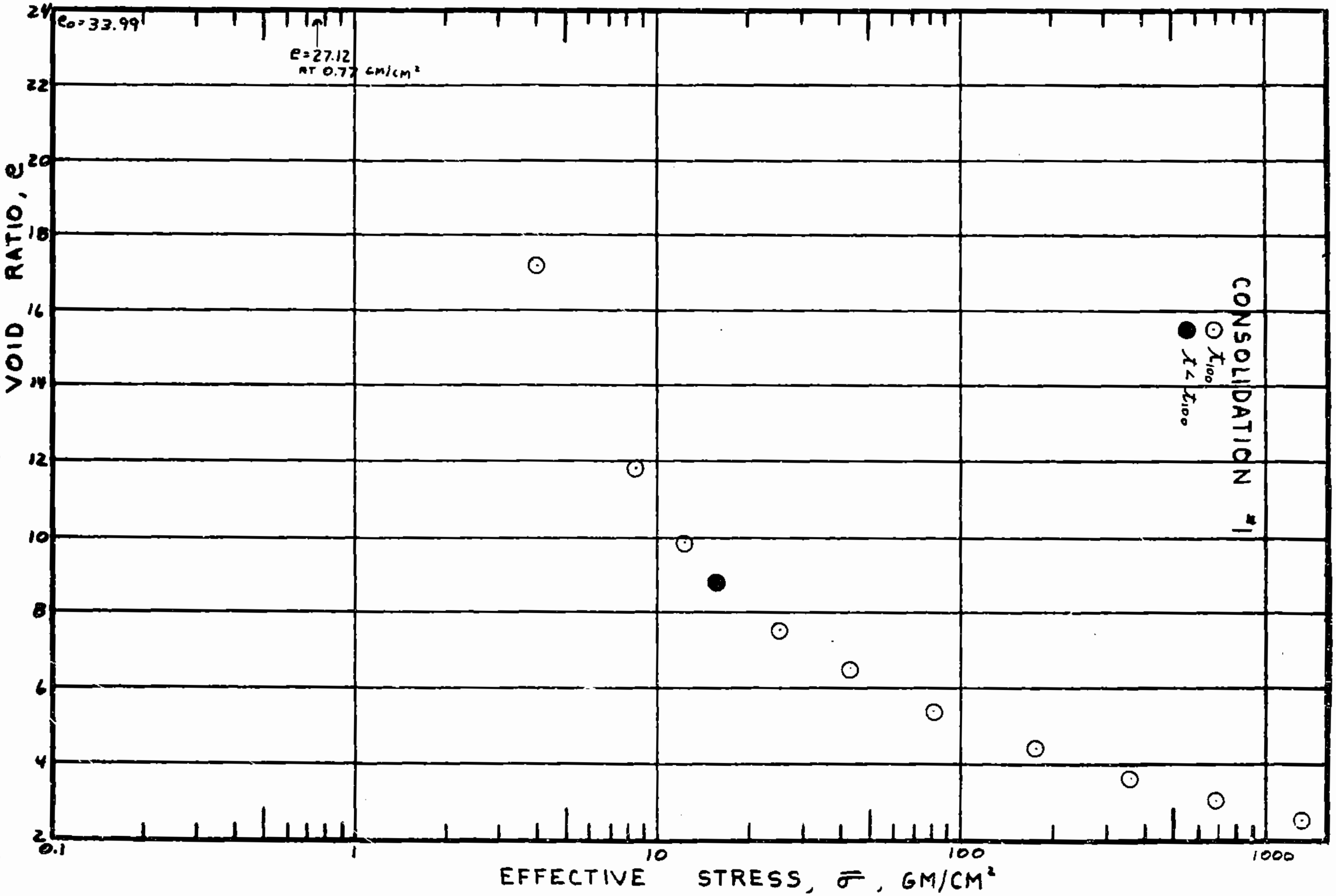
SUMMARY % SOLIDS - PERMEABILITY (MEASURED)

FIGURE 5.2



SUMMARY — c_v VERSUS AVERAGE $\bar{\sigma}$

FIGURE 5.3



e₀ = 33.99
e = 27.12 AT 0.77 GM/CM²
VOID RATIO, e
24
22
20
18
16
14
12
10
8
6
4
2
0.1
1
10
100
1000
EFFECTIVE STRESS, σ̄, GM/CM²
CONSOLIDATION #1

FIGURE 5.4

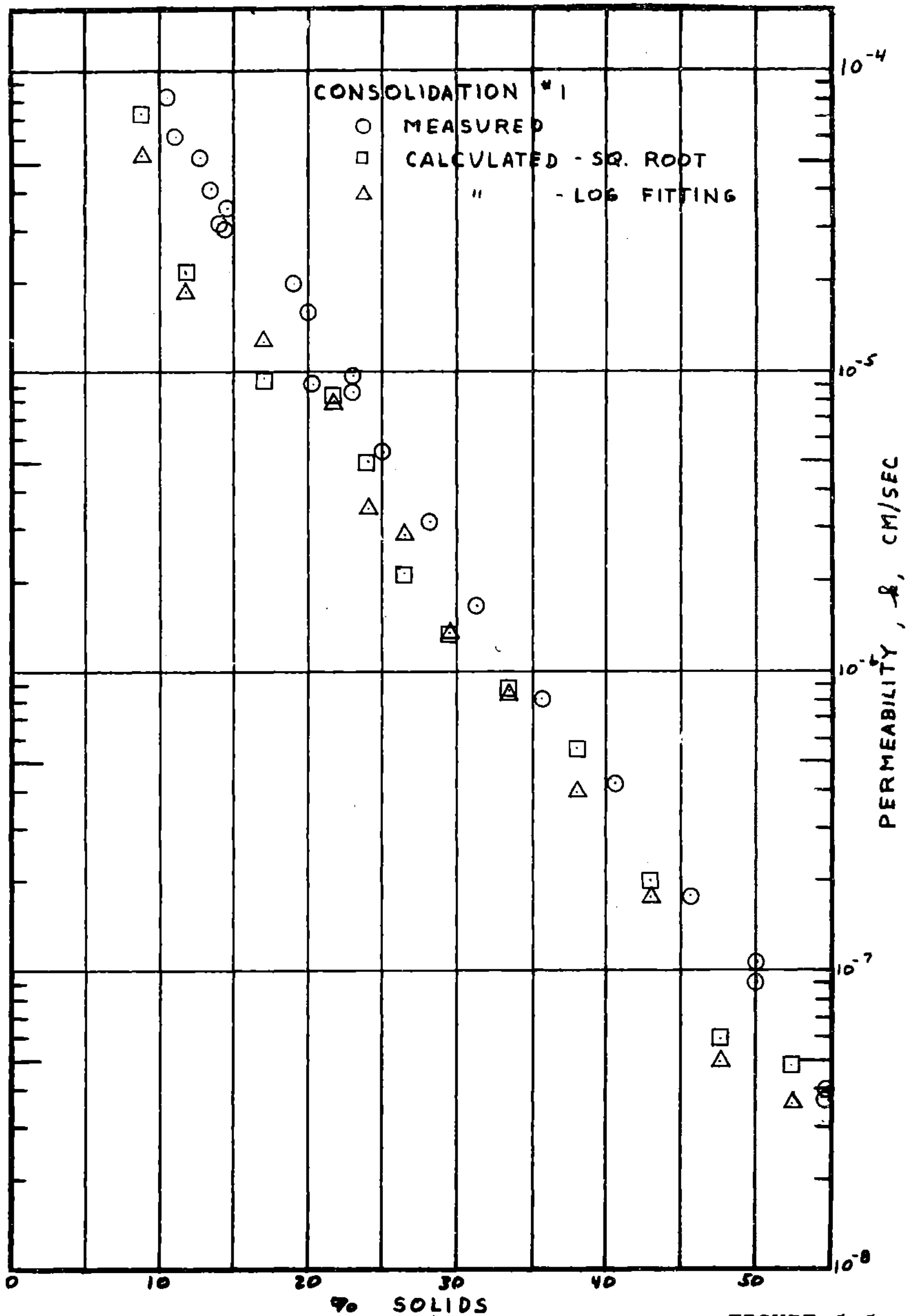

CONSOLIDATION #1
○ MEASURED
□ CALCULATED - SQ. ROOT
△ " - LOG FITTING
10^-4
10^-5
10^-6
10^-7
10^-8
PERMEABILITY, k, CM/SEC
0
10
20
30
40
50
% SOLIDS

FIGURE 5.5

RESULTS of MEASURED PERMEABILITIES

CONSOLIDATION TEST No. 1 Sheet 1 of 1

INCR.	DATE	TIME	H CM	% S	k CM/SEC	INCR	DATE	TIME	H CM	% S	k CM/SEC
2	10 MAR	1300	21.00	10.44	8.3×10^{-5}	9	29 MAR	1030	4.30	40.63	4.21×10^{-7}
	11 MAR	0820	19.70	11.08	6.12×10^{-5}	10	31 MAR	0800	3.66	45.70	1.77×10^{-7}
	12 MAR	0750	17.00	12.70	5.20×10^{-5}	11	1 APR	1805	3.20	50.20	1.05×10^{-7}
	13 MAR	0845	16.10	13.35	4.12×10^{-5}		2 APR	1028	3.20	50.20	9.12×10^{-8}
	14 MAR	0810	15.20	14.07	3.16×10^{-5}	12	4 APR	0753	2.80	54.90	3.98×10^{-8}
	15 MAR	1530	14.80	14.42	3.03×10^{-5}	12	5 APR	1135	2.80	54.90	3.65×10^{-8}
	16 MAR	1515	14.70	14.50	3.17×10^{-5}						
	17 MAR	0730	14.60	14.60	3.55×10^{-5}						
3	18 MAR	1900	10.85	19.04	1.97×10^{-5}						
	20 MAR	1330	10.32	19.89	1.64×10^{-5}						
	21 MAR	1110	1005	2036	9.05×10^{-6}						
4	23 MAR	0954	8.75	2295	9.59×10^{-6}						
	24 MAR	1218	8.65	23.17	8.47×10^{-6}						
5	25 MAR	0830	7.90	25.03	5.40×10^{-6}						
6	26 MAR	0845	6.85	28.18	3.14×10^{-6}						
7	27 MAR	0855	6.03	31.27	1.64×10^{-6}						
8	28 MAR	0903	5.10	35.69	8.05×10^{-7}						

TABLE 5.1

SUMMARY of CONSOLIDATION TEST No. 1

Sheet 1 of 2

G_s 2.94

INITIAL %S: 7.96

" HT.: 28.0 CM

SAMPLE: MOBIL #1 BY JRR DATES: 7 MAR 75 – 7 APR 75

TABLE 5.2

INCR.	$\bar{\sigma}$ GM/CM²	VOID RATIO, e e_o	e_p	e_f	% SOLIDS S_{AVG}	S_f	C_v, ×10⁻⁴ CM²/SEC $\sqrt{t}$	Log t	k CM/SEC C_v $\sqrt{t}$	C_v Log t	MEASURED	REMARKS
0	0	33.99										
					8.78		2.91	2.09	7.42×10^{-5}	5.33×10^{-5}		
1	0.77	33.99	27.12	27.12		9.79					—	SW *
					11.72		2.00	1.71	2.16×10^{-5}	1.85×10^{-5}		
2	4.02	27.12	17.25	17.25		14.60					3.55×10^{-5}	SW + SF
					17.06		1.34	1.77	9.46×10^{-6}	1.25×10^{-5}		
3	8.52	17.25	11.85	11.45		20.52					9.05×10^{-6}	SW + SF + PF
					21.77		2.47	2.45	8.13×10^{-6}	8.06×10^{-6}		
4	12.52	11.45	9.87	9.81		23.17					8.47×10^{-6}	
					24.09		1.96	1.35	4.98×10^{-6}	3.43×10^{-6}		
5	16.02	9.81	8.85	8.85		25.08					5.40×10^{-6}	e_p NOT REACHED
					26.54		1.56	2.12	2.11×10^{-6}	2.86×10^{-6}		
6	25.72	8.85	7.57	7.56		28.18					3.14×10^{-6}	
					29.65		1.92	1.89	1.33×10^{-6}	1.31×10^{-6}		
7	42.92	7.56	6.56	6.54		31.27					1.64×10^{-6}	
					33.33		2.16	2.12	8.42×10^{-7}	8.26×10^{-7}		
8	82.72	6.54	5.39	5.37		35.69					8.05×10^{-7}	
					38.00		3.25	2.32	5.47×10^{-7}	3.90×10^{-7}		
9	176.0	5.37	4.41	4.37		40.63					4.21×10^{-7}	

SW = SELF WEIGHT PF = PISTON FORCE

SF = SEEPAGE FORCE * FROM EXTRAPOLATION, CALCULATE e

SUMMARY of CONSOLIDATION TEST No. 1

Sheet 2 of 2

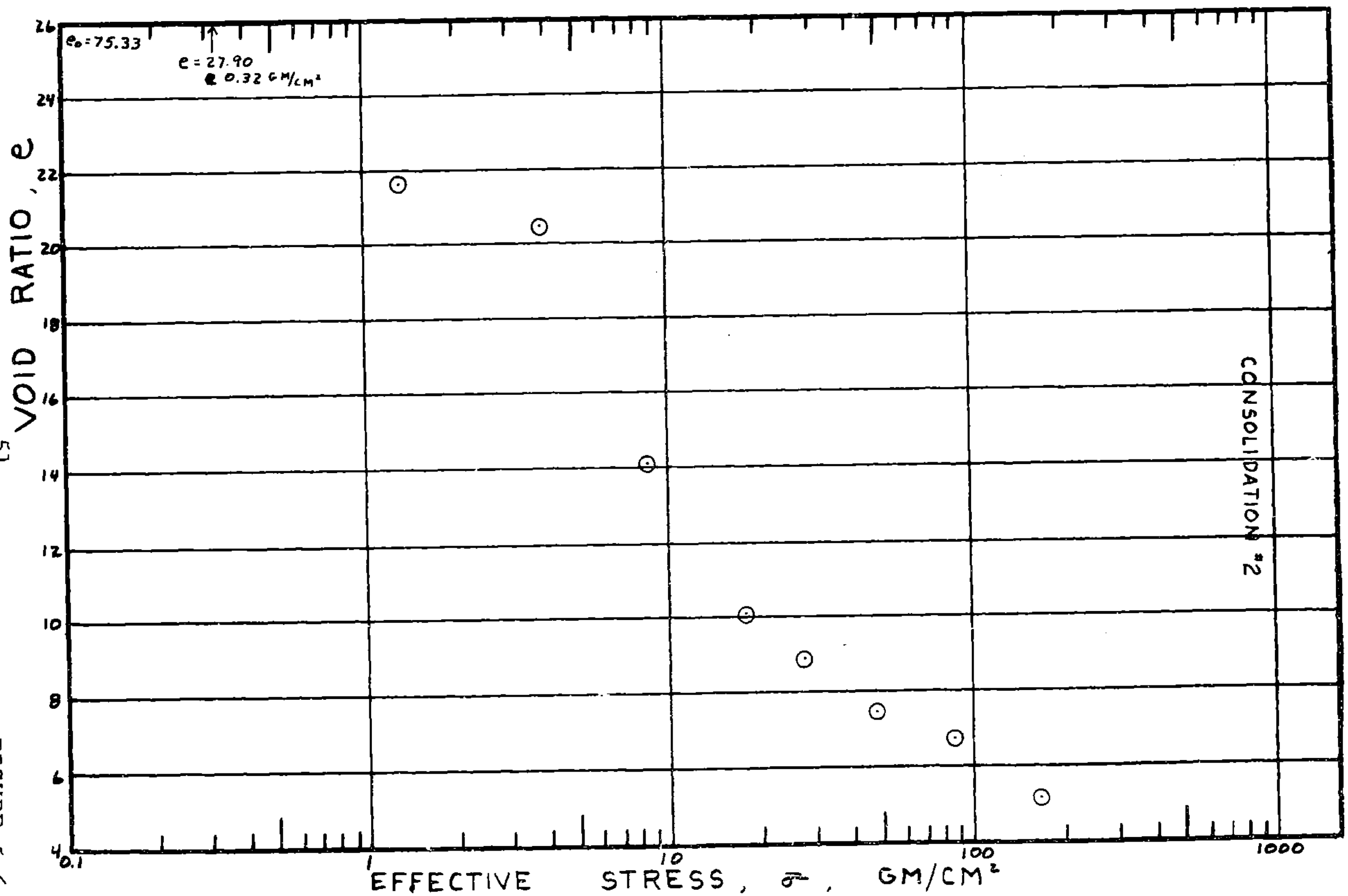
G_s 2.94

SAMPLE: MOBIL #1 BY JRR DATES: 7MAR75 - 7APR75

INITIAL %S: 7.96

" HT.: 2.80 CM

INCR.	σ GM/CM²	VOID RATIO, e			% SOLIDS		C_v, ×10⁻⁴ CM²/SEC		k CM/SEC			REMARKS
		e_o	e_p	e_f	S_{AVG}	S_f	$\sqrt{t}$	Log t	C_v $\sqrt{t}$	C_v Log t	MEASURED	
					43.02		2.49	2.17	1.98×10^{-7}	1.73×10^{-7}		
10	363.0	4.37	3.62	3.57		45.70					1.77×10^{-7}	
					47.84		2.08	1.74	5.86×10^{-8}	4.91×10^{-8}		
11	806.0	3.57	3.02	3.00		50.20					9.12×10^{-8}	
					52.50		2.03	1.53	4.75×10^{-8}	3.58×10^{-8}		
12	1350.0	3.00	2.54	2.49		55.02					3.65×10^{-8}	



VOID RATIO, e
EFFECTIVE STRESS, σ, GM/CM²
CONSOLIDATION #2
e₀ = 75.33
e = 27.90 @ 0.32 GM/CM²
26
24
22
20
18
16
14
12
10
8
6
4
0.1
1
10
100
1000

FIGURE 5.6

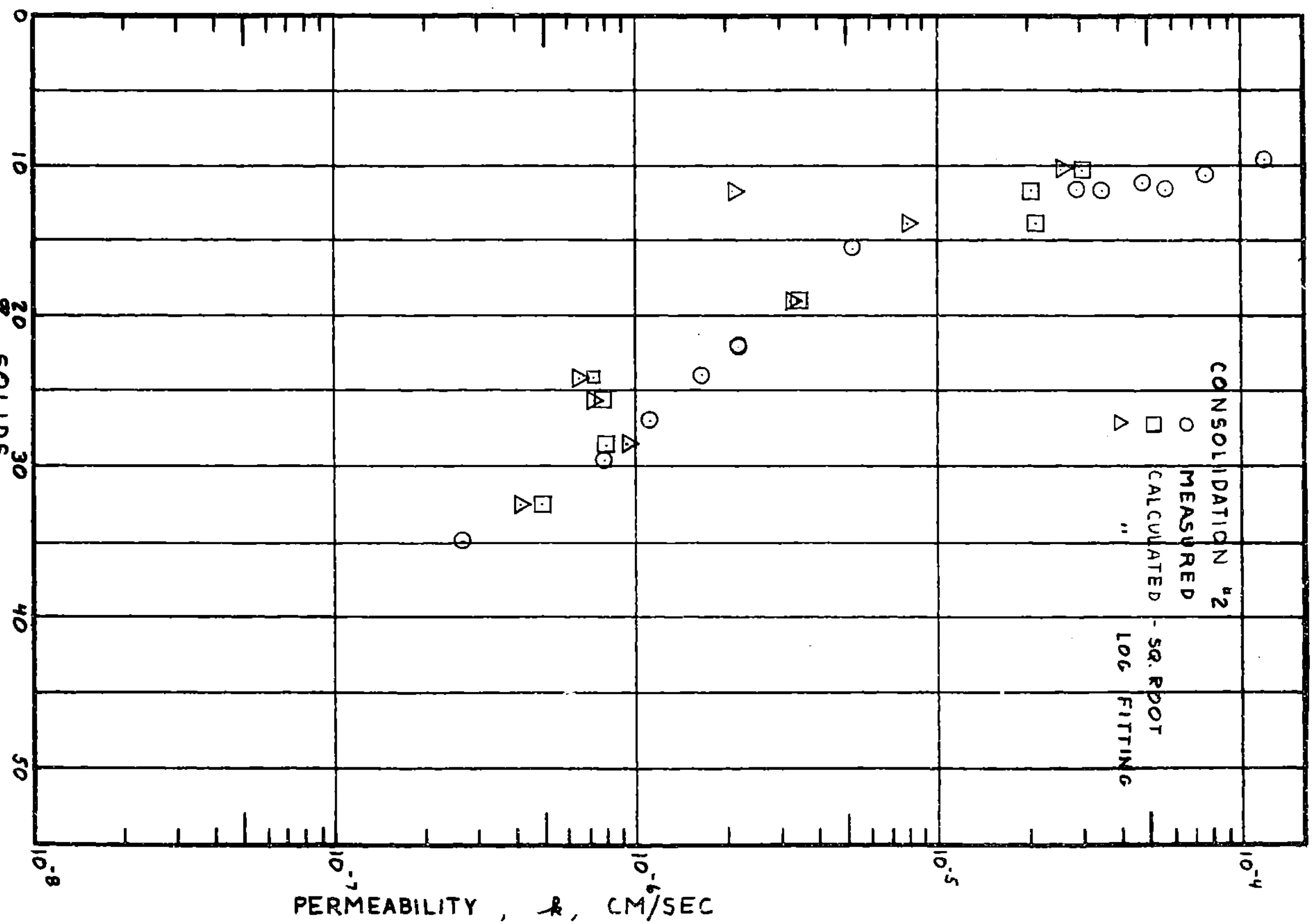

CONSOLIDATION #2
○ MEASURED
□ CALCULATED - SQ. ROOT
△ " LOG FITTING
% SOLIDS
0
10
20
30
40
50
PERMEABILITY, k, CM/SEC
10^{-8}
10^{-7}
10^{-6}
10^{-5}
10^{-4}

FIGURE 5.7

RESULTS of MEASURED PERMEABILITIES CONSOLIDATION TEST No. 2 Sheet 1 of 1											
INCR.	DATE	TIME	H CM	% S	k CM/SEC	INCR.	DATE	TIME	H CM	% S	k CM/SEC
2	22 MAY	1110	10.17	9.33	2.34×10^{-4}						
2	22 MAY	1435	9.78	9.68	1.22×10^{-4}						
2	23 MAY	0750	8.75	10.74	7.76×10^{-5}						
2	24 MAY	0920	8.33	11.25	4.79×10^{-5}						
2	26 MAY	1135	8.19	11.43	5.41×10^{-5}						
3	27 MAY	1148	8.04	11.62	5.71×10^{-5}						
3	27 MAY	1510	7.95	11.74	3.50×10^{-5}						
3	28 MAY	0905	7.95	11.74	2.92×10^{-5}						
4	5 JUN	0625	5.43	16.63	5.23×10^{-6}						
5	10 JUN	0855	3.90	22.25	2.20×10^{-6}						
6	11 JUN	0845	3.56	24.05	1.65×10^{-6}						
7	12 JUN	0800	3.08	27.16	1.12×10^{-6}						
8	13 JUN	0750	2.76	29.73	7.88×10^{-7}						
9	14 JUN	1015	2.22	35.24	2.60×10^{-7}						
9	14 JUN	1130	2.22	35.24	2.70×10^{-7}						

TABLE 5.3

SUMMARY of CONSOLIDATION TEST No. 2

G_s 2.75

SAMPLE: NORALYN #1 BY JRR DATES: 15 MAY 75 - 14 JUNE 75 INITIAL %S 3.52

" HT. 28.0 cm

INCR.	σ GM/CM²	VOID RATIO, e e_o	e_p	e_f	% SOLIDS S_{AVG}	S_f	C_v, ×10⁻⁴ cm²/sec $\sqrt{t}$	Log t	k CM/SEC C_v $\sqrt{t}$	Log t	MEASURED	REMARKS
0	0	75.33										
					5.08		2.99	0.134	5.87×10^{-4}	2.63×10^{-3}		SW
1	0.32	75.33	27.90	27.35		9.14					—	
					10.19		1.37	1.17	3.00×10^{-5}	2.56×10^{-5}		SW+SF
2	1.32	27.35	21.63	21.14		11.52					5.5×10^{-5}	
					11.66		0.187	1.95	2.03×10^{-5}	2.11×10^{-6}		
3	3.82	21.14	20.56	20.54		11.81					2.92×10^{-5}	
					13.79		3.25	1.22	2.10×10^{-5}	7.88×10^{-6}		SW+SF+PF
4	8.62	20.54	14.10	13.86		16.58					5.23×10^{-6}	
					19.00		1.14	1.09	3.41×10^{-6}	3.26×10^{-6}		
5	18.12	13.86	10.10	9.63		22.25					2.20×10^{-6}	
					23.11		85.3	76.1	7.17×10^{-7}	6.39×10^{-7}		
6	28.42	9.63	8.90	8.71		24.05					1.65×10^{-6}	
					25.51		1.14	1.08	7.73×10^{-7}	7.32×10^{-7}		
7	48.32	8.71	7.42	7.40		27.16					1.12×10^{-6}	
					28.39		3.01	3.50	7.90×10^{-7}	9.19×10^{-7}		
8	88.22	7.40	6.69	6.52		29.73					7.88×10^{-7}	
					32.30		1.96	1.70	4.75×10^{-7}	4.12×10^{-7}		
9	168.82	6.52	5.11	5.05		35.24					2.70×10^{-7}	

SW = SELF WEIGHT PF = PISTON FORCE

SF = SEEPAGE FORCE

TABLE 5.4

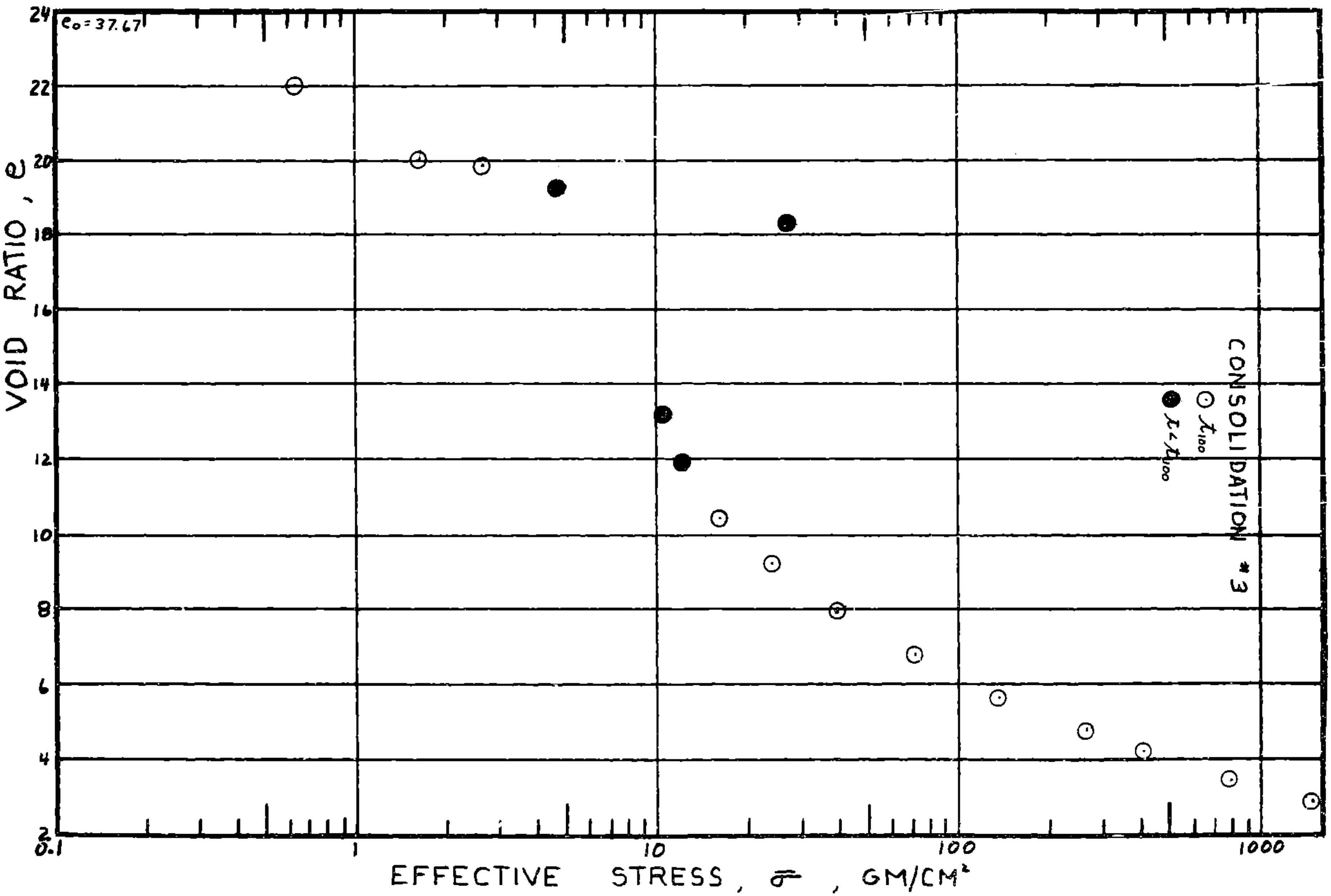

e₀ = 37.67
VOID RATIO, e
EFFECTIVE STRESS, σ̄, GM/CM²
CONSOLIDATION #3
0.1
1
10
100
1000
2
4
6
8
10
12
14
16
18
20
22
24

FIGURE 5.8

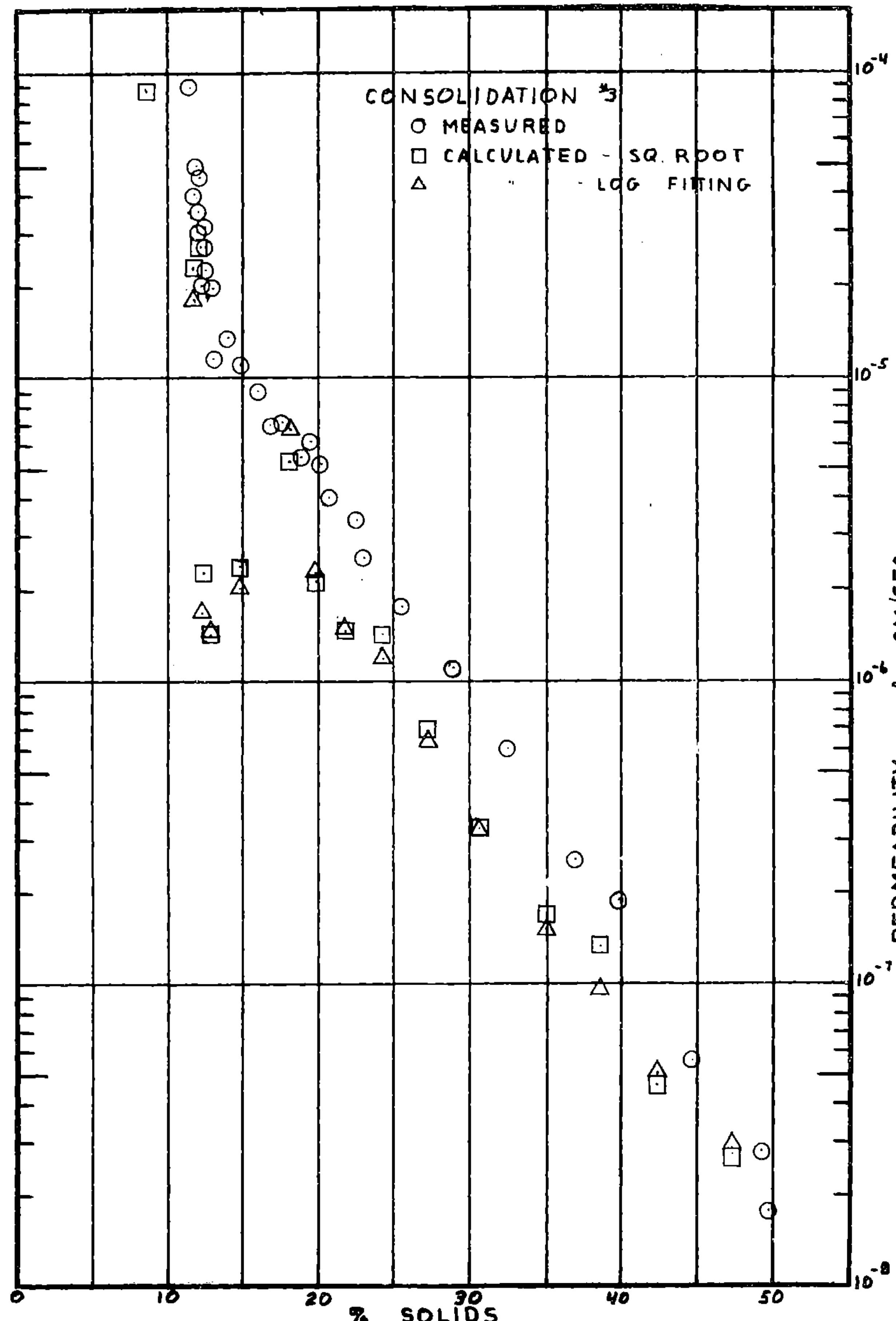

CONSOLIDATION #3
○ MEASURED
□ CALCULATED - SQ. ROOT
△ " - LOG FITTING
PERMEABILITY, k, CM/SEC
10^-4
10^-5
10^-6
10^-7
10^-8
% SOLIDS
0
10
20
30
40
50

FIGURE 5.9

RESULTS of MEASURED PERMEABILITIES

CONSOLIDATION TEST No. 3 Sheet 1 of 1

INCR.	DATE	TIME	H CM	% S	k CM/SEC	INCR.	DATE	TIME	H CM	% S	k CM/SEC
2	14 JUL	0900	16.3	11.33	2.09×10^{-4}	6	21 JUL	1240	14.50	12.62	2.27×10^{-5}
2	14 JUL	0913	16.29	11.34	4.57×10^{-4}	6	21 JUL	1259	14.40	12.71	1.96×10^{-5}
2	14 JUL	0919	16.29	11.34	1.94×10^{-4}	6	22 JUL	0709	13.95	13.08	1.15×10^{-5}
2	14 JUL	1257	16.09	11.47	1.01×10^{-4}	7	23 JUL	0844	11.28	15.87	9.03×10^{-6}
2	14 JUL	1409	16.05	11.49	9.23×10^{-5}	7	24 JUL	0908	10.60	16.78	7.03×10^{-6}
2	15 JUL	0937	15.65	11.77	3.96×10^{-5}	8	26 JUL	0931	10.11	17.50	7.17×10^{-6}
2	16 JUL	1250	15.35	11.98	3.03×10^{-5}	8	28 JUL	0900	9.35	18.75	5.52×10^{-6}
2	17 JUL	0740	15.35	11.98	5.13×10^{-5}	9	30 JUL	0738	8.40	20.60	4.03×10^{-6}
3	17 JUL	0935	15.25	12.05	4.15×10^{-5}	9	31 JUL	1110	8.33	20.75	3.85×10^{-6}
3	17 JUL	1156	15.20	12.09	4.13×10^{-5}	10	4 AUG	1112	7.40	22.98	2.54×10^{-6}
3	18 JUL	0825	15.10	12.16	3.56×10^{-5}	11	6 AUG	1036	6.51	25.61	1.81×10^{-6}
4	18 JUL	!056	15.08	12.18	4.58×10^{-5}	12	7 AUG	0823	5.63	28.88	1.10×10^{-6}
4	18 JUL	1422	15.00	12.24	1.99×10^{-5}	13	9 AUG	1015	4.84	32.62	6.0×10^{-7}
4	21 JUL	0725	14.70	12.47	2.68×10^{-5}	14	11 AUG	0815	4.11	37.06	2.60×10^{-7}
5	21 JUL	0815	14.70	12.47	3.13×10^{-5}	15	12 AUG	1200	3.71	39.88	1.79×10^{-7}
5	21 JUL	1004	14.60	12.54	2.66×10^{-5}	16	13 AUG	1035	3.19	44.73	5.62×10^{-8}
5	21 JUL	1213	14.57	12.57	2.52×10^{-5}	17	15 AUG	0650	2.78	49.27	2.81×10^{-8}
						17	16 AUG	1410	2.74	49.76	1.79×10^{-8}

TABLE 5.5

TABLE 5.6

SUMMARY of CONSOLIDATION TEST No. 3

Sheet 1 of 2

G_s 2.75

SAMPLE NORALYN #2 BY JRR DATES 24 JUN 75 - 18 AUG 75 INITIAL %S 6.80

" HT. 28.0 cm

INCR.	$\bar{\sigma}$ GM/CM²	VOID RATIO, e e_o	e_p	e_f	% SOLIDS S_{AVG}	S_f	C_v, $\times 10^{-4}$ cm²/sec $\sqrt{t}$	Log t	k CM/SEC C_v $\sqrt{t}$	Log t	MEASURED	REMARKS
0	0	37.67										
					8.49		1.34	11.5	8.87×10^{-5}	7.62×10^{-4}		
1	0.63	37.67	22.06	21.55		11.33					—	SW
					11.65		3.68	2.85	2.32×10^{-5}	1.79×10^{-5}		
2	1.63	21.55	20.20	20.13		12.00					5.13×10^{-5}	SW + SF
					12.09		20.4	14.6	2.70×10^{-5}	1.93×10^{-5}		
3	2.63	20.13	19.85	19.85		12.16					3.56×10^{-5}	
					12.31		1.70	1.26	2.24×10^{-6}	1.66×10^{-6}		
4	4.63	19.85	19.30	19.30		12.47					2.6×10^{-5}	e_p NOT REACHED
					12.52		—	—	—	—		
5	8.63	19.30	—	19.12		12.57					2.52×10^{-5}	e_p NOT REACHED
					12.82		6.60	6.68	1.47×10^{-6}	1.49×10^{-6}		
6	27.38	19.12	18.27	18.27		13.08					1.95×10^{-5}	e_p NOT REACHED
					14.87		1.54	1.30	2.36×10^{-6}	1.99×10^{-6}		
7	10.33	18.27	13.23	13.23		17.10					7.1×10^{-6}	SW + SF + PF e_p NOT REACHED
					17.98		0.977	1.25	5.19×10^{-6}	6.64×10^{-6}		
8	12.13	13.23	11.87	11.87		18.80					5.52×10^{-6}	e_p NOT REACHED
					19.73		0.804	0.852	2.11×10^{-6}	2.23×10^{-6}		

SW = SELF WEIGHT PF = PISTON FORCE

SF = SEEPAGE FORCE

SUMMARY of CONSOLIDATION TEST No. 3

Sheet 2 of 2

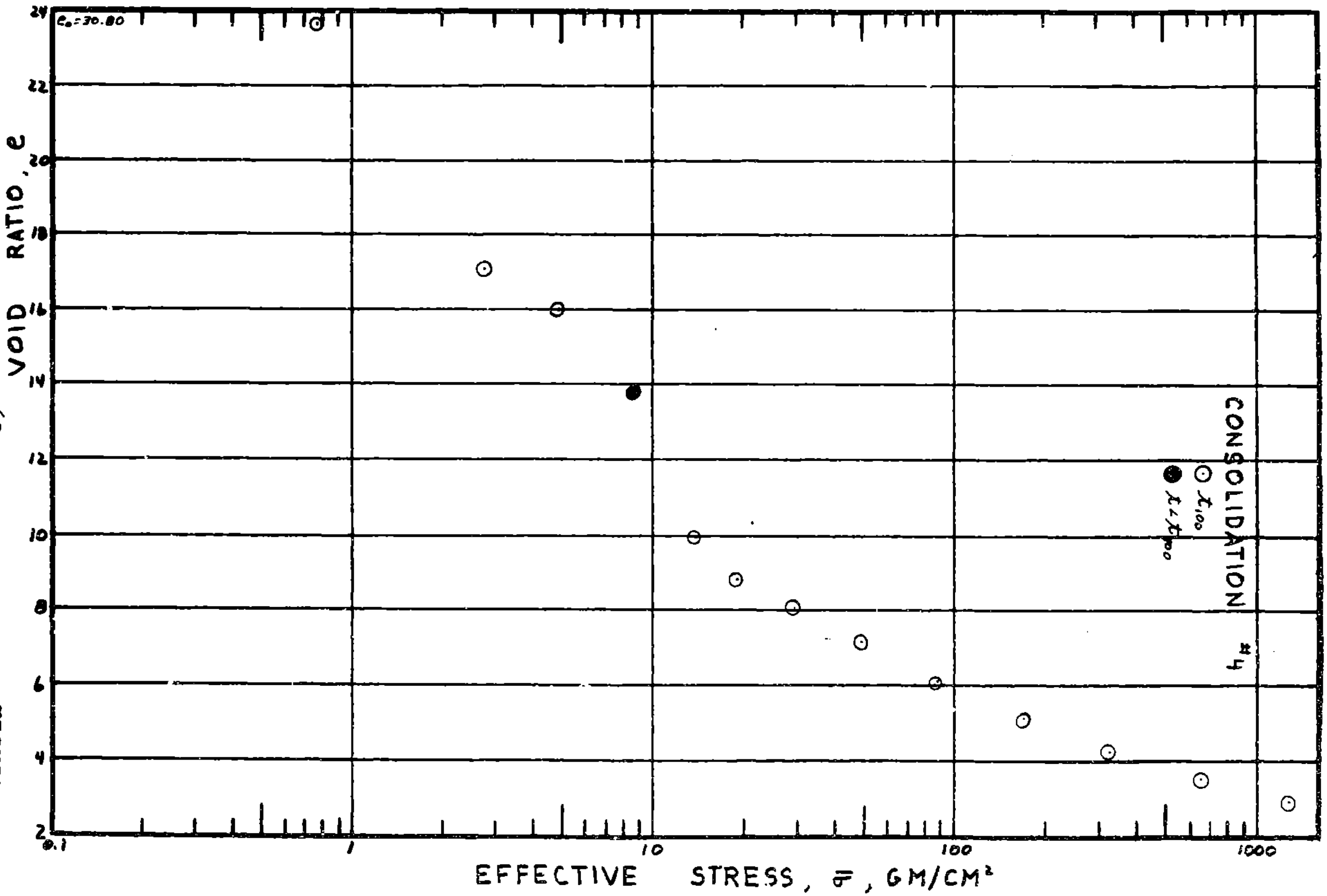
G_s 2.75

SAMPLE NORALYN #2 BY JRR DATES 24 JUN 75 - 18 AUG 75

INITIAL %S 6.80

" HT. 28.0 cm

INCR.	σ GM/CM²	VOID RATIO, e e_o	e_p	e_f	% SOLIDS S_{AVG}	S_f	C_v, ×10⁻⁴ cm²/sec $\sqrt{t}$	C_v, ×10⁻⁴ cm²/sec Log t	k CM/SEC C_v $\sqrt{t}$	k CM/SEC C_v Log t	k CM/SEC MEASURED	REMARKS
9	16.19	11.87	10.50	10.50		20.75					3.85×10^{-6}	
					21.81		1.03	1.02	1.44×10^{-6}	1.43×10^{-6}		
10	24.13	10.50	9.23	9.22		22.98					2.54×10^{-6}	
					24.22		1.90	1.59	1.41×10^{-6}	1.18×10^{-6}		
11	40.33	9.22	8.02	7.99		25.61					1.81×10^{-6}	
					27.17		1.55	1.51	6.67×10^{-7}	6.50×10^{-7}		
12	72.13	7.99	6.76	6.76		28.88					1.10×10^{-6}	
					30.83		1.47	1.53	3.46×10^{-7}	3.60×10^{-7}		
13	136.13	6.76	5.67	5.59		33.00					6.0×10^{-7}	
					34.92		1.58	1.41	1.70×10^{-7}	1.52×10^{-7}		
14	264.13	5.59	4.73	4.68		37.06					2.60×10^{-7}	
					38.50		1.99	1.39	1.35×10^{-7}	9.45×10^{-8}		
15	409.13	4.68	4.18	4.12		39.90					1.80×10^{-7}	
					42.30		1.29	1.39	4.61×10^{-8}	4.97×10^{-8}		
16	808.13	4.12	3.43	3.39		44.75					5.62×10^{-8}	
					47.17		1.38	1.44	2.74×10^{-8}	2.86×10^{-8}		
17	1508.13	3.39	2.88	2.78		49.76					1.79×10^{-8}	



$e_0 = 30.80$
VOID RATIO, e
24
22
20
18
16
14
12
10
8
6
4
2
0.1
1
10
100
1000
EFFECTIVE STRESS, $\bar{\sigma}$, GM/CM²
CONSOLIDATION #4
t_{100}
$t < t_{100}$

FIGURE 5.10

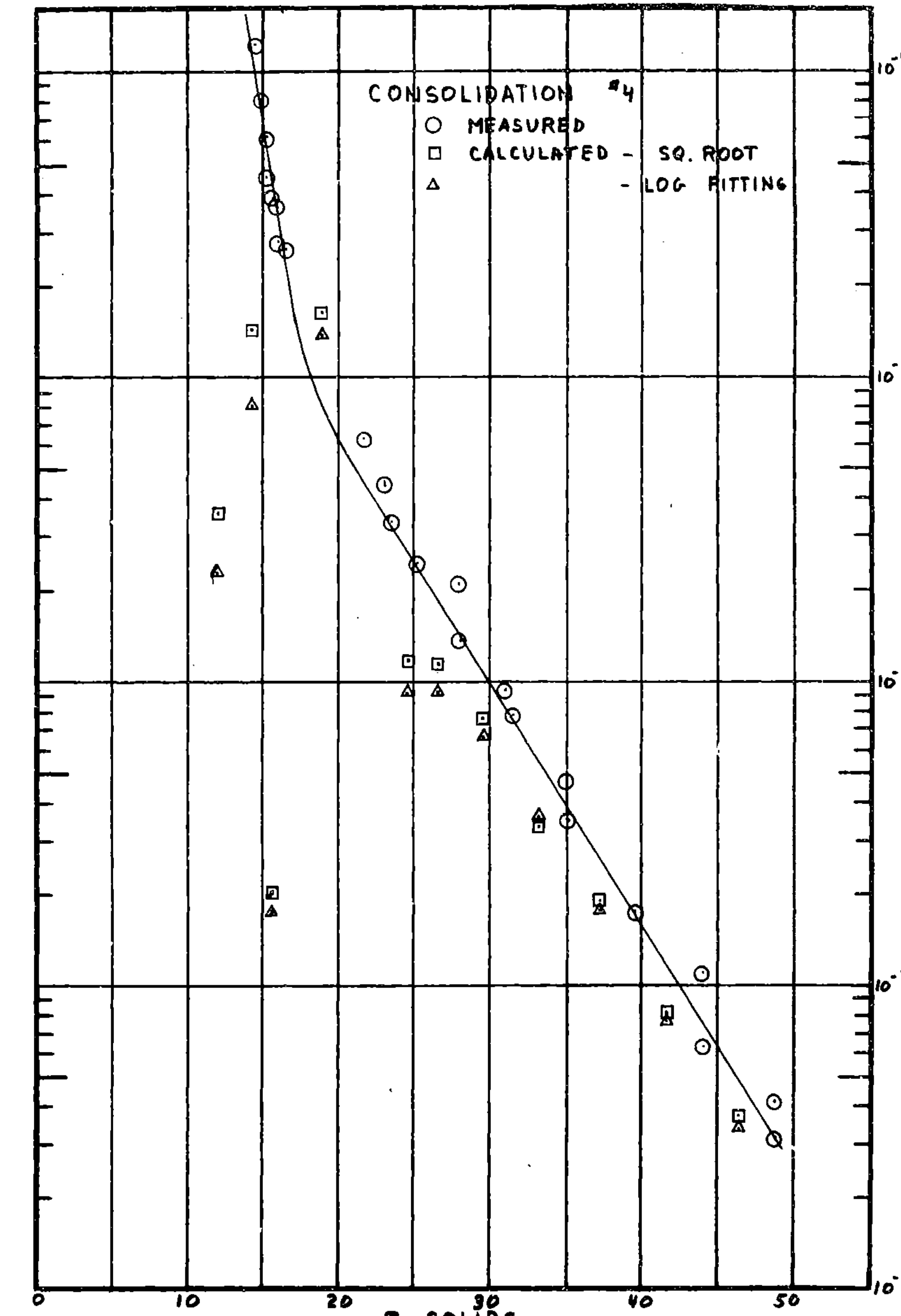

CONSOLIDATION #4
MEASURED
CALCULATED - SQ. ROOT
- LOG FITTING
PERMEABILITY, k, CM/SEC
% SOLIDS
0
10
20
30
40
50
10^{-4}
10^{-5}
10^{-6}
10^{-7}
10^{-8}

FIGURE 5.11

RESULTS of MEASURED PERMEABILITIES

CONSOLIDATION TEST No. 4 Sheet 1 of 2

INCR.	DATE	TIME	H CM	% S	k CM/SEC	INCR.	DATE	TIME	H CM	% S	k CM/SEC
2	25 AUG	0907	21.39	10.49	7.20×10^{-4}		9 SEP	0843	18.40	12.06	6.08×10^{-4}
		1014	21.39	10.49	6.14×10^{-4}		10 SEP	1155	18.10	12.25	6.10×10^{-4}
		1110	21.35	10.51	5.98×10^{-4}		11 SEP	0818	18.10	12.25	8.14×10^{-4}
		1135	21.35	10.51	6.17×10^{-4}		12 SEP	0832	18.10	12.25	6.71×10^{-4}
		1456	21.35	10.51	2.79×10^{-4}		13 SEP	0840	17.90	12.38	5.89×10^{-4}
3	26 AUG	0938	21.30	10.53	6.78×10^{-4}		15 SEP	1228	17.45	12.67	5.60×10^{-4}
		1237	21.28	10.54	7.46×10^{-4}		17 SEP	0811	16.95	13.01	3.80×10^{-4}
		1540	21.27	10.54	6.34×10^{-4}		19 SEP	1234	16.50	13.34	2.45×10^{-4}
	27 AUG	0920	21.27	10.54	8.51×10^{-4}		22 SEP	0754	16.26	13.52	2.42×10^{-4}
4		1450	21.10	10.62	1.02×10^{-3}		25 SEP	0945	16.09	13.65	2.18×10^{-4}
	28 AUG	1050	20.80	10.77	1.48×10^{-3}		29 SEP	0758	15.92	13.78	2.07×10^{-4}
	29 AUG	0930	20.40	10.96	1.32×10^{-3}	5	2 OCT	0756	15.17	14.40	1.22×10^{-4}
	2 SEP	0950	19.70	11.33	8.97×10^{-4}		6 OCT	0810	14.95	14.60	1.69×10^{-4}
	3 SEP	0817	19.60	11.38	5.81×10^{-4}	6	9 OCT	0802	14.59	14.92	8.09×10^{-5}
	4 SEP	1023	19.00	11.71	6.92×10^{-4}		14 OCT	0808	14.32	15.18	4.47×10^{-5}
	5 SEP	1141	19.00	11.71	7.84×10^{-4}		18 OCT	1100	14.22	15.27	6.09×10^{-5}
	8 SEP	0805	1850	12.00	6.36×10^{-4}		23 OCT	0815	14.09	15.40	5.54×10^{-5}

TABLE 5.7

RESULTS of MEASURED PERMEABILITIES

CONSOLIDATION TEST No. 4 Sheet 2 of 2

INCR.	DATE	TIME	H CM	% S	k CM/SEC	INCR	DATE	TIME	H CM	% S	k CM/SEC
	28 OCT	1428	13.98	15.51	4.77×10^{-5}		6 JAN	0800	7.08	27.98	1.36×10^{-6}
	3 NOV	0756	13.89	15.60	4.14×10^{-5}	11	7 JAN	0848	6.22	31.09	9.41×10^{-7}
	7 NOV	0802	13.78	15.71	3.83×10^{-5}		9 JAN	0823	6.14	31.42	7.70×10^{-7}
	12 NOV	0821	13.70	15.80	3.77×10^{-5}	12	10 JAN	1123	5.37	34.93	4.63×10^{-7}
	18 NOV	1346	13.59	15.91	3.58×10^{-5}		13 JAN	0751	5.32	35.19	3.47×10^{-7}
	25 NOV	1242	13.40	16.11	2.75×10^{-5}	13	15 JAN	0915	4.58	39.47	1.74×10^{-7}
	2 DEC	1110	13.22	16.31	2.92×10^{-5}	14	16 JAN	0830	3.96	43.95	1.11×10^{-7}
	5 DEC	0737	13.19	16.34	2.63×10^{-5}		18 JAN	1500	3.94	44.11	6.32×10^{-8}
	11 DEC	1440	13.08	16.47	2.61×10^{-5}	15	20 JAN	0833	3.42	48.77	4.16×10^{-8}
7	17 DEC	1339	9.58	21.67	6.15×10^{-6}		20 JAN	2025	3.42	48.77	3.18×10^{-8}
	18 DEC	0852	9.53	21.76	6.37×10^{-6}						
8	19 DEC	1355	8.90	23.08	4.41×10^{-6}						
	23 DEC	0812	8.67	23.60	3.29×10^{-6}						
	26 DEC	1120	8.63	23.70	3.27×10^{-6}						
9	29 DEC	1042	8.02	25.22	2.42×10^{-6}						
	2 JAN	1123	7.95	25.40	2.40×10^{-6}						
10	5 JAN	0752	7.09	27.94	2.10×10^{-6}						

TABLE 5.8

SUMMARY of CONSOLIDATION TEST No. 4

Sheet 1 of 2

G_s: 2.73

SAMPLE: NORALYN W/ FLOCCULANT BY JRR DATES: 22 AUG 75 – 21 JAN 76 INITIAL %S: 8.14
" HT.: 28 CM

INCR.	$\bar{\sigma}$ GM/CM²	VOID RATIO, e e_o	e_p	e_f	% SOLIDS S_{AVG}	S_f	C_v, $\times 10^{-4}$ CM²/SEC $\sqrt{t}$	Log t	k CM/SEC C_v $\sqrt{t}$	C_v Log t	MEASURED	REMARKS
0	0	30.80										
					9.16		215.0	135.0	6.65×10^{-3}	4.18×10^{-3}		
1	0.76	30.80	23.64	23.32		10.48					—	SW
					—		—	—	—	—		
2	1.26	23.32	—	—		—					—	SW + SF
					—		—	—	—	—		
3	1.76	—	—	—		—					8.51×10^{-4}	
					11.92		27.8	17.8	3.59×10^{-6}	2.30×10^{-6}		
4	2.76	—	17.04	17.04		13.81					2.18×10^{-4}	
					14.19		5.00	2.79	1.47×10^{-5}	8.20×10^{-6}		
5	4.76	17.04	15.98	15.98		14.60					1.69×10^{-4}	
					15.50		634.	546.	2.02×10^{-7}	1.74×10^{-7}		
6	8.76	15.98	13.81	13.81		16.51					2.61×10^{-5}	e_p NOT REACHED
					18.78		3.11	2.61	1.66×10^{-5}	1.39×10^{-5}		
7	13.8	13.81	9.90	9.82		21.76					6.37×10^{-6}	SW + SF + PF
					22.69		2.13	96.7	3.72×10^{-6}	1.69×10^{-6}		
8	19.2	9.82	8.81	8.80		23.70					3.27×10^{-6}	
					24.52		1.44	1.12	1.18×10^{-6}	$9.17\times10^{-}$		
9	28.8	8.80	8.06	8.03		25.40					2.40×10^{-6}	

SW = SELF WEIGHT PF = PISTON FORCE

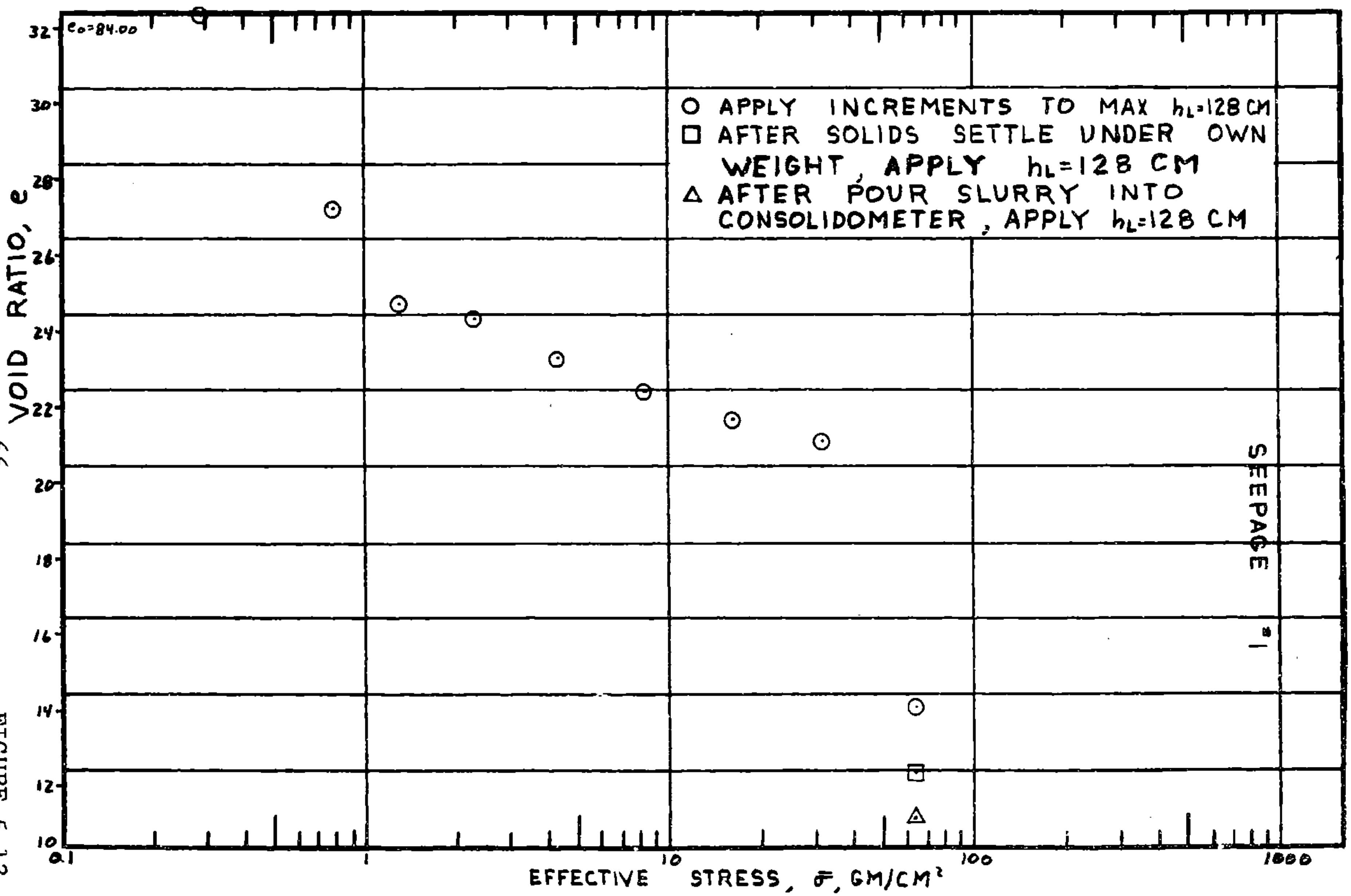
SF = SEEPAGE FORCE

SUMMARY of CONSOLIDATION TEST No. 4

G_s: 2.73

SAMPLE: NORALYN W/ FLOCCULANT BY JRR DATES: 22 AUG 75 – 21 JAN 76 INITIAL %S: 8.14 HT.: 28 CM

INCR.	σ GM/CM²	VOID RATIO, e e_o	e_p	e_f	% SOLIDS S_{AVG}	S_f	C_v, ×10⁻⁴ CM²/SEC √t	Log t	k CM/SEC C_v √t	C_v Log t	MEASURED	REMARKS
					26.63		2.08	1.69	1.14×10^{-6}	9.26×10^{-7}		
10	48.8	8.03	7.09	7.04		27.98					1.36×10^{-6}	
					29.60		2.28	1.99	7.58×10^{-7}	6.62×10^{-7}		
11	88.8	7.04	6.06	5.97		31.42					7.70×10^{-7}	
					33.20		2.01	2.15	3.35×10^{-7}	3.58×10^{-7}		
12	168.8	5.97	5.11	5.04		35.19					3.47×10^{-7}	
					37.21		2.17	2.02	1.89×10^{-7}	1.76×10^{-7}		
13	328.3	5.04	4.25	4.20		39.47					1.74×10^{-7}	
					41.66		1.87	1.75	8.09×10^{-8}	7.57×10^{-8}		
14	648.8	4.20	3.52	3.48		44.11					6.32×10^{-8}	
					46.32		1.76	1.59	3.68×10^{-8}	3.33×10^{-8}		
15	1288.8	3.48	2.91	2.88		48.77					3.18×10^{-8}	



VOID RATIO, e
EFFECTIVE STRESS, σ̄, GM/CM²
e₀=84.00
APPLY INCREMENTS TO MAX h_L=128 CM
AFTER SOLIDS SETTLE UNDER OWN WEIGHT, APPLY h_L=128 CM
AFTER POUR SLURRY INTO CONSOLIDOMETER, APPLY h_L=128 CM
SEEPAGE
0.1
1
10
100
1000
10
12
14
16
18
20
22
24
26
28
30
32

FIGURE 5.12

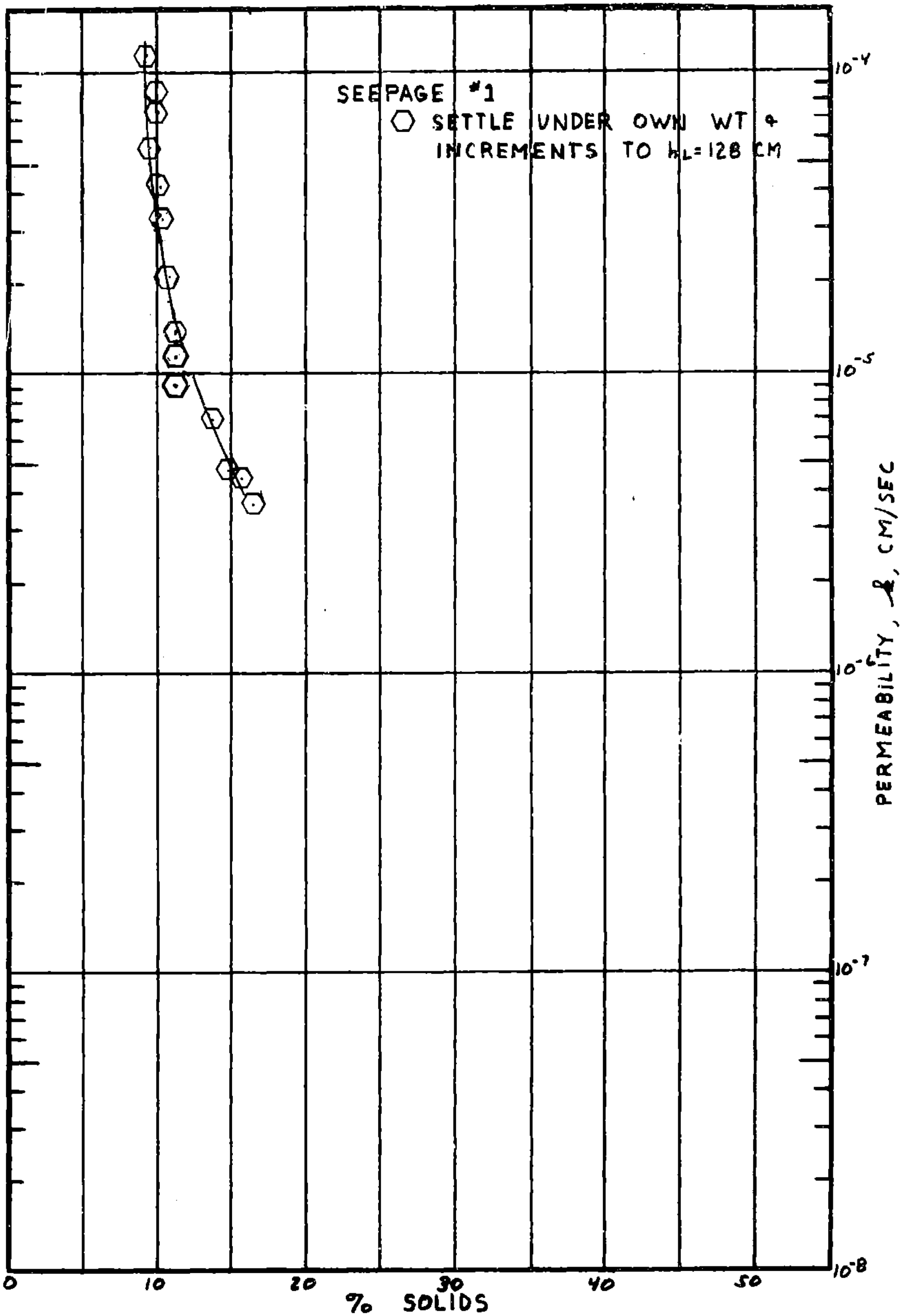

SEEPAGE #1
SETTLE UNDER OWN WT + INCREMENTS TO hL=128 CM
10-4
10-5
10-6
10-7
10-8
PERMEABILITY, k, CM/SEC
0
10
20
30
40
50
% SOLIDS

FIGURE 5.13

RESULTS of MEASURED PERMEABILITIES SEEPAGE TEST No. 1 Sheet 1 of 3											
INCR.	DATE	TIME	H CM	% S	k CM/SEC	INCR	DATE	TIME	H CM	% S	k CM/SEC
2	25 JUN	0930	9.45	9.04	9.52×10^{-5}			1421	8.50	9.98	7.43×10^{-5}
		1705	9.30	9.18	2.75×10^{-5}		4 JULY	0844	8.48	10.01	7.03×10^{-5}
	26 JUN	0930	9.30	9.18	4.48×10^{-5}		5 JULY	0901	8.46	10.03	7.06×10^{-5}
3		1054	9.30	9.18	1.98×10^{-4}		6 JULY	0908	8.45	10.04	8.67×10^{-5}
		1230	9.17	9.30	1.15×10^{-4}		7 JULY	0718	8.45	10.04	6.34×10^{-5}
		1410	9.09	9.37	1.03×10^{-4}			1143	8.45	10.04	5.69×10^{-5}
	27 JUN	0745	8.82	9.64	6.55×10^{-5}		8 JULY	0720	8.45	10.04	7.39×10^{-5}
		1500	8.78	9.69	5.59×10^{-5}			1300	8.45	10.04	6.64×10^{-5}
		1715	8.78	9.69	4.97×10^{-5}		9 JULY	0722	8.45	10.04	5.79×10^{-5}
	28 JUN	0935	8.76	9.71	7.14×10^{-5}	4		0833	8.44	10.05	6.26×10^{-5}
		1300	8.76	9.71	6.95×10^{-5}			1311	8.39	10.11	5.15×10^{-5}
	30 JUN	0742	8.64	9.83	7.25×10^{-5}		10 JULY	0912	8.35	10.15	4.51×10^{-5}
	1 JULY	0730	8.55	9.93	5.10×10^{-5}			1328	8.34	10.16	4.47×10^{-5}
		1455	8.55	9.93	6.66×10^{-5}		11 JULY	1312	8.32	10.19	4.34×10^{-5}
	2 JULY	1508	8.53	9.95	5.91×10^{-5}		12 JULY	0900	8.32	10.19	4.32×10^{-5}
	3 JULY	0940	8.50	9.98	8.72×10^{-5}		14 JULY	0710	8.32	10.19	4.18×10^{-5}
		1201	8.50	9.98	8.90×10^{-5}	5		1210	8.31	10.20	6.03×10^{-5}

TABLE 5.9

RESULTS of MEASURED PERMEABILITIES

SEEPAGE TEST No. 1 Sheet 2 of 3

INCR.	DATE	TIME	H CM	% S	k CM/SEC	INCR	DATE	TIME	H CM	% S	k CM/SEC
	14 JULY	1332	8.18	10.35	3.27×10^{-5}			1306	5.15	15.83	4.46×10^{-6}
	15 JULY	0724	8.00	10.57	2.88×10^{-5}			1354	5.10	15.97	3.79×10^{-6}
6		0926	7.90	10.69	4.50×10^{-5}		20 JULY	0948	4.95	16.40	3.66×10^{-6}
		0948	7.88	10.72	3.34×10^{-5}		21 JULY	0724	4.95	16.40	3.74×10^{-6}
		1020	7.88	10.72	2.55×10^{-5}						
		1435	7.72	10.92	2.08×10^{-5}	10	22 JULY	0855	27.8	3.19	3.44×10^{-4}
	16 JULY	0822	7.70	10.95	1.97×10^{-5}			0906	27.3	3.25	2.08×10^{-4}
7		0956	7.70	10.95	2.55×10^{-5}			0951	25.4	3.49	9.99×10^{-5}
		1040	7.60	11.08	1.79×10^{-5}			1006	22.0	4.01	7.86×10^{-5}
		1310	7.54	11.17	1.36×10^{-5}			1021	20.4	4.32	6.35×10^{-5}
	17 JULY	0719	7.45	11.29	1.25×10^{-5}			1042	18.3	4.80	5.33×10^{-5}
8		0814	7.39	11.38	1.15×10^{-5}			1137	15.8	5.53	3.79×10^{-5}
		1112	7.28	11.54	9.18×10^{-6}			2021	7.00	11.96	7.58×10^{-6}
		1145	7.28	11.54	8.76×10^{-6}		23 JULY	0846	4.50	17.86	2.22×10^{-5}
	18 JULY	0821	7.24	11.57	9.28×10^{-6}			1053	4.20	18.98	1.20×10^{-5}
		0943	6.00	13.78	6.89×10^{-6}			1148	4.20	18.98	1.01×10^{-5}
9		1046	5.50	14.92	4.76×10^{-6}			2357	3.80	20.72	4.53×10^{-6}

RESULTS of MEASURED PERMEABILITIES

SEEPAGE TEST No. 1 Sheet 3 of 3

INCR.	DATE	TIME	H CM	% S	k CM/SEC	INCR	DATE	TIME	H CM	% S	k CM/SEC
10	24 JULY	0912	3.70	21.2	4.06×10^{-4}			1303	4.50	17.86	4.78×10^{-6}
		1204	3.70	21.2	3.71×10^{-6}			2215	4.30	18.59	4.07×10^{-6}
	25 JULY	1010	3.30	23.39	2.28×10^{-6}		6 AUG	1034	4.20	18.98	2.98×10^{-6}
		1148	3.30	23.39	3.11×10^{-6}			1408	4.20	18.98	3.73×10^{-6}
	26 JULY	0934	3.30	23.39	3.04×10^{-6}		7 AUG	1431	4.20	18.98	3.51×10^{-6}
	28 JULY	0902	3.30	23.39	2.95×10^{-6}		8 AUG	0904	4.10	19.39	3.25×10^{-6}
							9 AUG	1028	4.00	19.81	3.04×10^{-6}
12	4 AUG	1320	9.60	8.90	9.35×10^{-5}		11 AUG	0822	3.90	20.25	2.93×10^{-6}
		1327	9.10	9.36	4.58×10^{-5}		12 AUG	1433	3.80	20.72	2.93×10^{-6}
		1333	8.90	9.56	3.36×10^{-5}						
		1337	8.80	9.66	3.16×10^{-5}						
		1342	8.60	9.88	2.23×10^{-5}						
		1407	8.00	10.57	1.91×10^{-5}						
		1525	7.00	11.96	1.09×10^{-5}						
		1534	6.80	12.29	1.03×10^{-5}						
		2225	6.20	13.38	8.12×10^{-6}						
	5 AUG	1045	4.50	17.86	4.55×10^{-6}						

TABLE 5.10

SUMMARY of SEEPAGE TEST No. 1

Sheet 1 of 2

G_s : 2.75

SAMPLE: NORALYN BY JRR DATES: 6 JUN 75 - 10 AUG 75

INITIAL %S: 3.17

" HT.: 28 CM

INCR.	$\bar{\sigma}$ GM/CM²	VOID RATIO, e: e_o	e_p	e_f	% SOLIDS: S_{AVG}	S_f	C_v, ×10⁻⁴ CM²/SEC: $\sqrt{t}$	Log t	k CM/SEC, C_v: $\sqrt{t}$	Log t	MEASURED	REMARKS
0	0	84.00										
					4.68		0.0154	0.0201	3.50×10^{-2}	4.57×10^{-2}		
1	0.29	84.00	32.39	27.99		8.95						SW
					9.06		5.44	8.09	2.85×10^{-5}	4.24×10^{-5}		
2	0.79	27.99	27.23	27.23		9.18					4.48×10^{-5}	SW + SF
					9.59		26.5	85.5	4.84×10^{-6}	1.56×10^{-5}		
3	1.29	27.23	24.65	24.65		10.04					5.79×10^{-5}	
					10.11		5.63	2.06	8.56×10^{-6}	3.13×10^{-6}		
4	2.29	24.65	24.26	24.26		10.19					4.18×10^{-5}	
					10.37		8.14	3.90	1.56×10^{-5}	7.49×10^{-6}		
5	4.29	24.26	23.29	23.29		10.57					2.88×10^{-5}	
					10.75		8.48	8.41	7.94×10^{-6}	7.88×10^{-6}		
6	8.29	23.29	22.37	22.38		10.95					1.97×10^{-5}	
					11.12		9.67	5.24	3.93×10^{-6}	2.13×10^{-6}		
7	16.29	22.38	21.62	21.62		11.29					1.25×10^{-5}	
					11.43		3.32	5.56	5.60×10^{-7}	9.37×10^{-7}		
8	32.29	21.62	21.01	21.01		11.58					9.22×10^{-6}	
					13.58		9.13	7.64	9.05×10^{-6}	7.57×10^{-6}		
9	64.29	21.01	14.06	14.03		16.40					3.74×10^{-6}	

SW = SELF WEIGHT

SF = SEEPAGE FORCE

SUMMARY of SEEPAGE TEST No. 1

Sheet 2 of 2

SAMPLE: NORALYN BY JRR DATES: 6JUN75 - 10 AUG75

G_s: 2.75

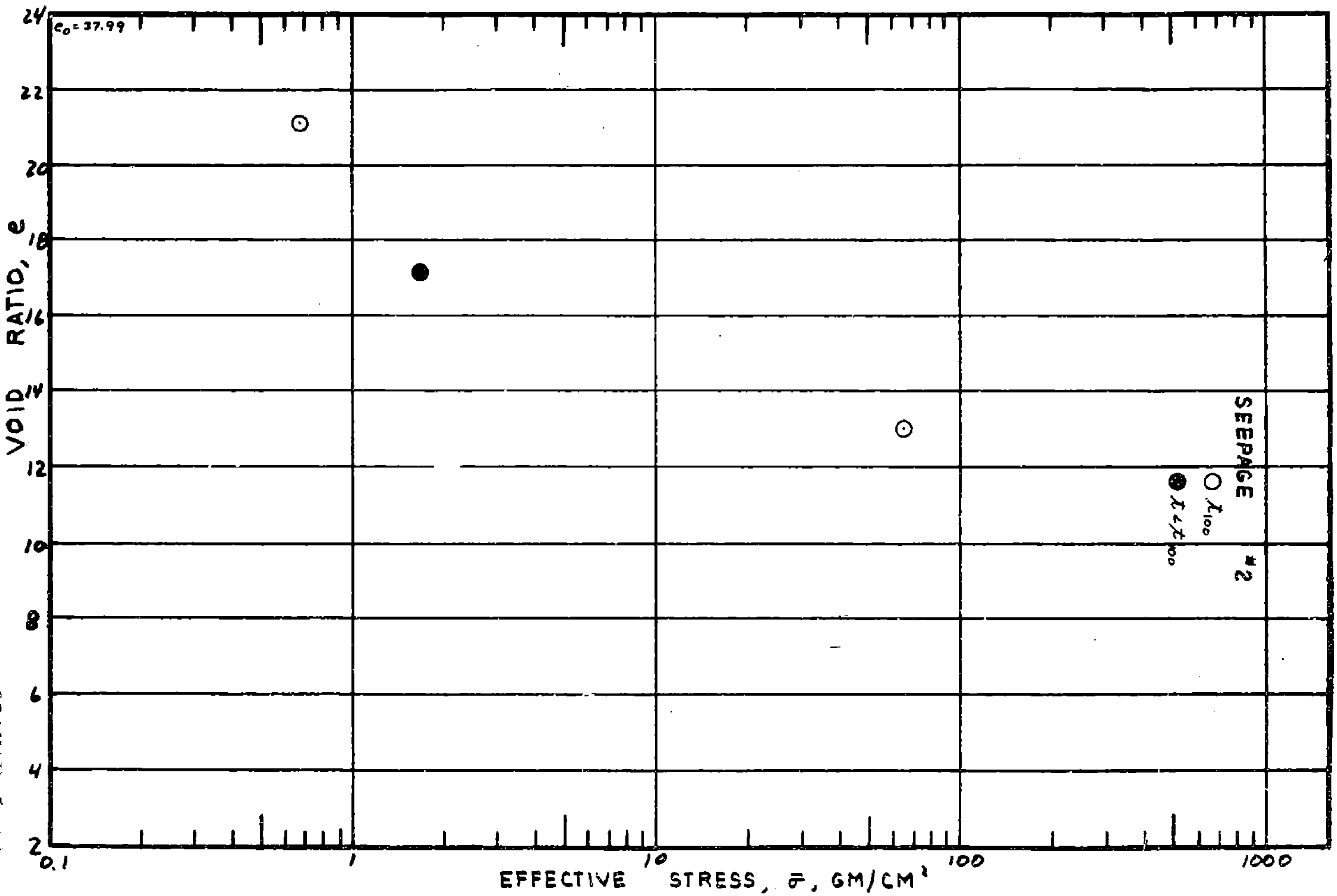
INITIAL %S: 3.17

" HT.: 28 CM

INCR.	σ GM/CM²	VOID RATIO, e e_o	e_p	e_f	% SOLIDS S_{AVG}	S_f	C_v, $\times 10^{-4}$ CM²/SEC $\sqrt{t}$	Log t	k CM/SEC C_v $\sqrt{t}$	C_v Log t	MEASURED	REMARKS
0	0	84.00										
					5.58		0.577	0.487	7.92×10^{-5}	6.68×10^{-5}		
10	64.29	84.00	11.14	9.02		23.39					3.04×10^{-6}	SW+SF
0	0	84.00										
					4.66		0.169	0.167	3.81×10^{-3}	3.76×10^{-3}	—	
11	0.29	84.00	32.39	28.45		8.82						SW
					12.29		5.04	3.16	4.71×10^{-6}	2.95×10^{-6}	2.92×10^{-6}	
12	64.29	28.45	12.36	10.84		20.25						SW+SF

SW = SELF WEIGHT

SF = SEEPAGE FORCE



$e_o = 37.99$
VOID RATIO, e
24
22
20
18
16
14
12
10
8
6
4
2
0.1
1
10
100
1000
EFFECTIVE STRESS, $\bar{\sigma}$, GM/CM²
SEEPAGE #2
○ t_{100}
● $t < t_{100}$

FIGURE 5.14

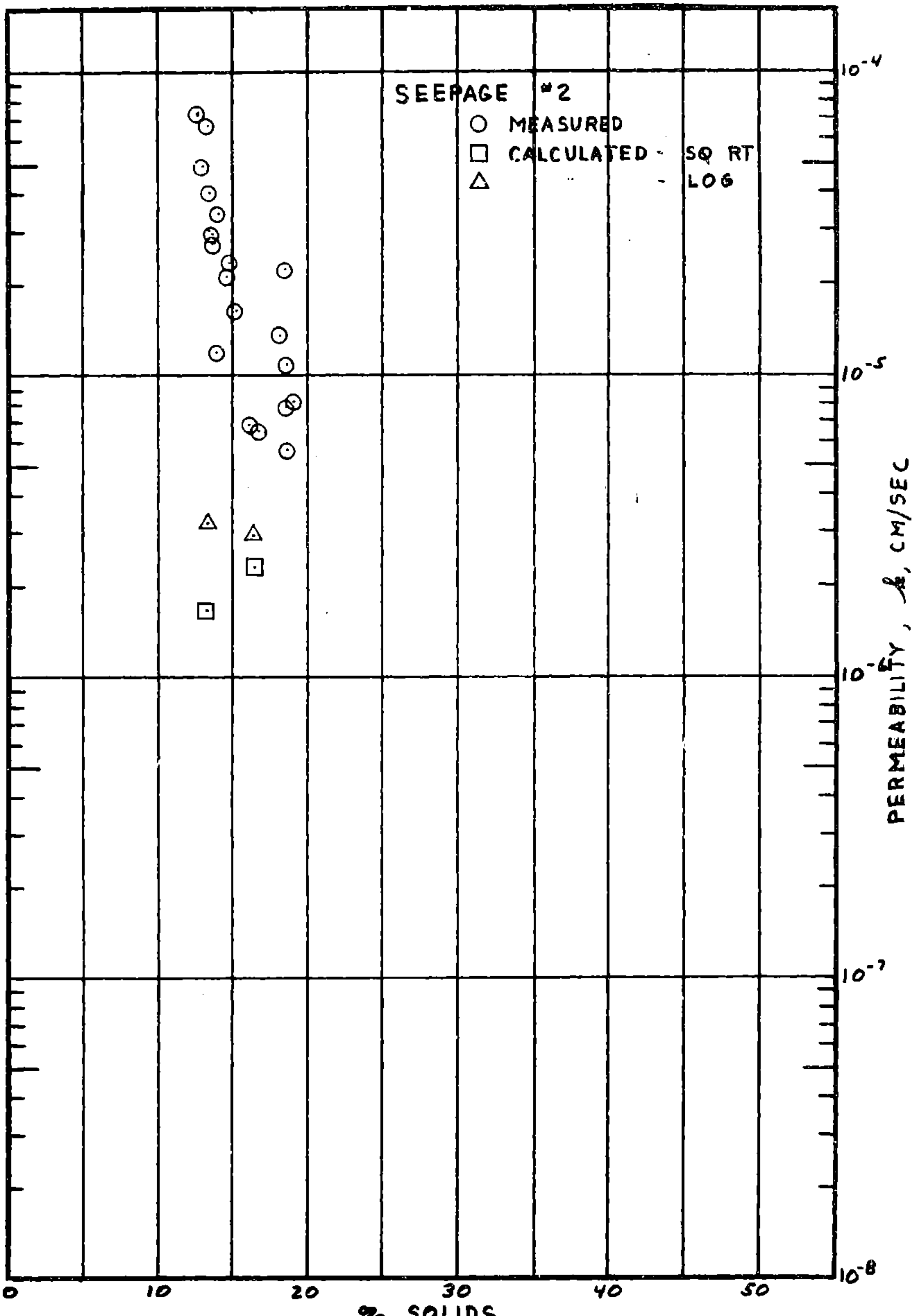

SEEPAGE #2
○ MEASURED
□ CALCULATED - SQ RT
△ - LOG
10-4
10-5
10-6
10-7
10-8
PERMEABILITY, k, CM/SEC
0
10
20
30
40
50
% SOLIDS

FIGURE 5.15

RESULTS of MEASURED PERMEABILITIES

SEEPAGE TEST No. 2 Sheet 1 of 1

INCR.	DATE	TIME	H CM	% S	k CM/SEC	INCR.	DATE	TIME	H CM	% S	k CM/SEC
2	20 OCT	1004	14.89	12.71	7.37×10^{-5}			1458	10.95	16.80	6.52×10^{-6}
	21 OCT	0826	14.48	13.04	4.95×10^{-5}		10 JAN	1445	10.00	18.21	1.34×10^{-5}
	23 OCT	0840	14.20	13.27	6.77×10^{-5}		11 JAN	1253	9.90	18.38	2.25×10^{-5}
	28 OCT	0805	13.95	13.49	4.41×10^{-5}		13 JAN	0929	9.80	18.54	7.82×10^{-6}
	3 NOV	0820	13.69	13.73	3.70×10^{-5}		14 JAN	0933	9.75	18.62	1.07×10^{-5}
	7 NOV	0830	13.60	13.81	2.87×10^{-5}		15 JAN	1405	9.70	18.71	8.17×10^{-6}
	12 NOV	0855	13.45	13.95	1.19×10^{-5}		16 JAN	0807	9.65	18.80	5.57×10^{-6}
	18 NOV	1200	13.40	14.00	4.07×10^{-5}		19 JAN	1230	9.50	19.06	8.06×10^{-6}
	25 NOV	0750	13.29	14.10	3.43×10^{-5}						
	2 DEC	0815	13.20	14.19	3.37×10^{-5}						
	5 DEC	0758	13.19	14.20	3.05×10^{-5}						
3	26 DEC	1333	12.82	14.57	2.71×10^{-5}						
	29 DEC	1410	12.79	14.60	2.83×10^{-5}						
	6 JAN	0930	12.72	14.68	2.34×10^{-5}						
	9 JAN	0823	12.70	14.70	2.12×10^{-5}						
4	9 JAN	1015	12.18	15.26	1.66×10^{-5}						
		1410	11.40	16.10	6.82×10^{-6}						

TABLE 5.11

SUMMARY of SEEPAGE TEST No. 2

Sheet 1 of 1

G_s: 2.87

SAMPLE: MOBIL W/FLOCCULANT BY JRR DATES: 9 OCT 75 – 19 JAN 76 INITIAL %S: 7.02

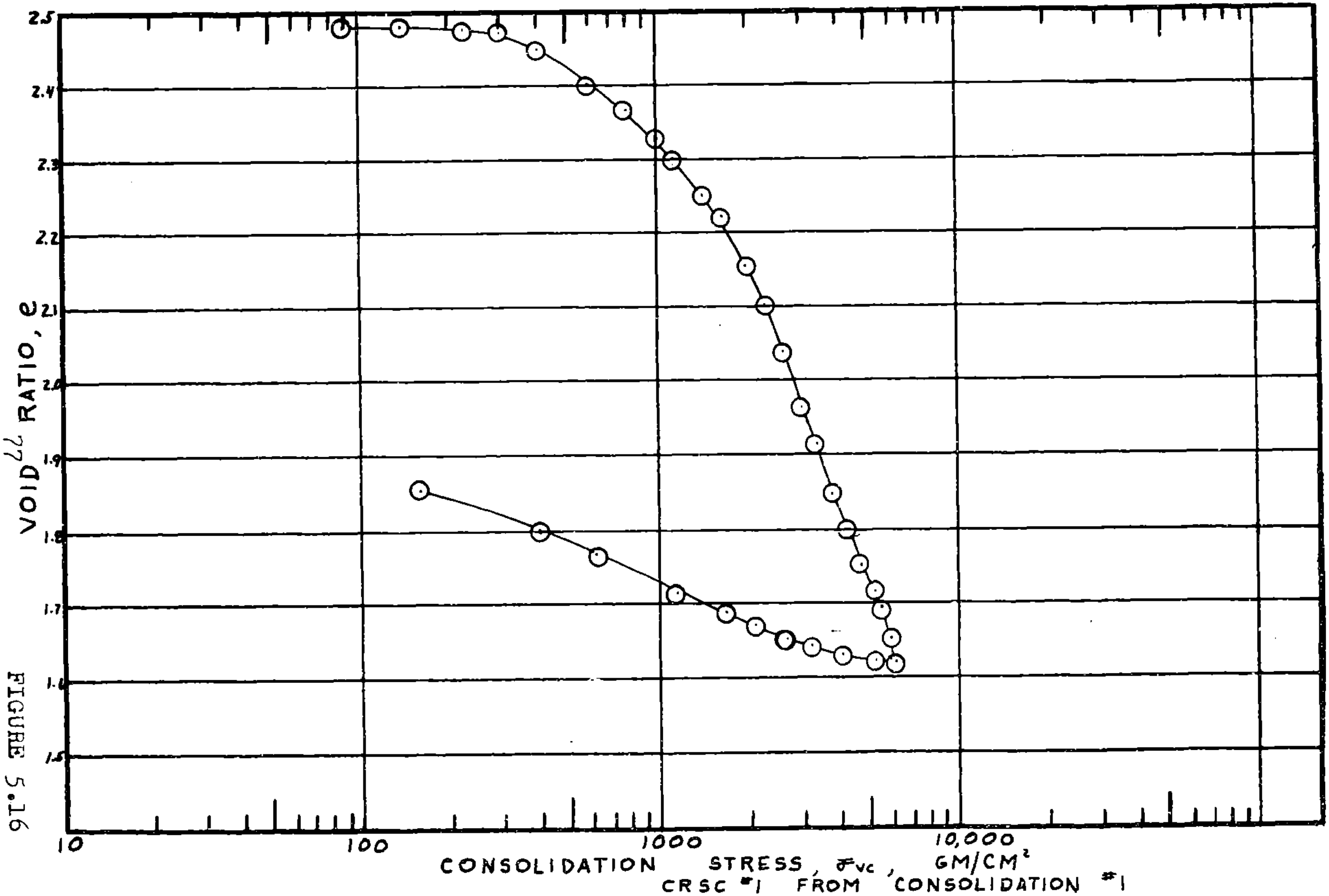
" HT.: 28 CM

INCR.	$\bar{\sigma}$ GM/CM²	VOID RATIO, e e_o	e_p	e_f	% SOLIDS S_{AVG}	S_f	C_v, ×10⁻⁴ CM²/SEC $\sqrt{t}$	Log t	k CM/SEC C_v $\sqrt{t}$	C_v Log t	MEASURED	REMARKS
0	0	37.99										
					8.94		0.438	0.292	2.94×10^{-3}	1.96×10^{-3}		
1	0.67	37.99	21.14	20.47		12.30					—	SW
					13.24		11.00	20.80	1.68×10^{-6}	3.18×10^{-6}		
2	1.67	20.47	17.19	17.19		14.33					3.05×10^{-5}	SW + SF e_p NOT REACHED
					—		—	—	—	—		
3	2.67	17.19	—	—		—					2.12×10^{-5}	
					16.36		5.34	6.74	2.31×10^{-6}	2.92×10^{-6}		
4	64.67	—	12.99	12.23		19.06					8.06×10^{-6}	

SW = SELF WEIGHT

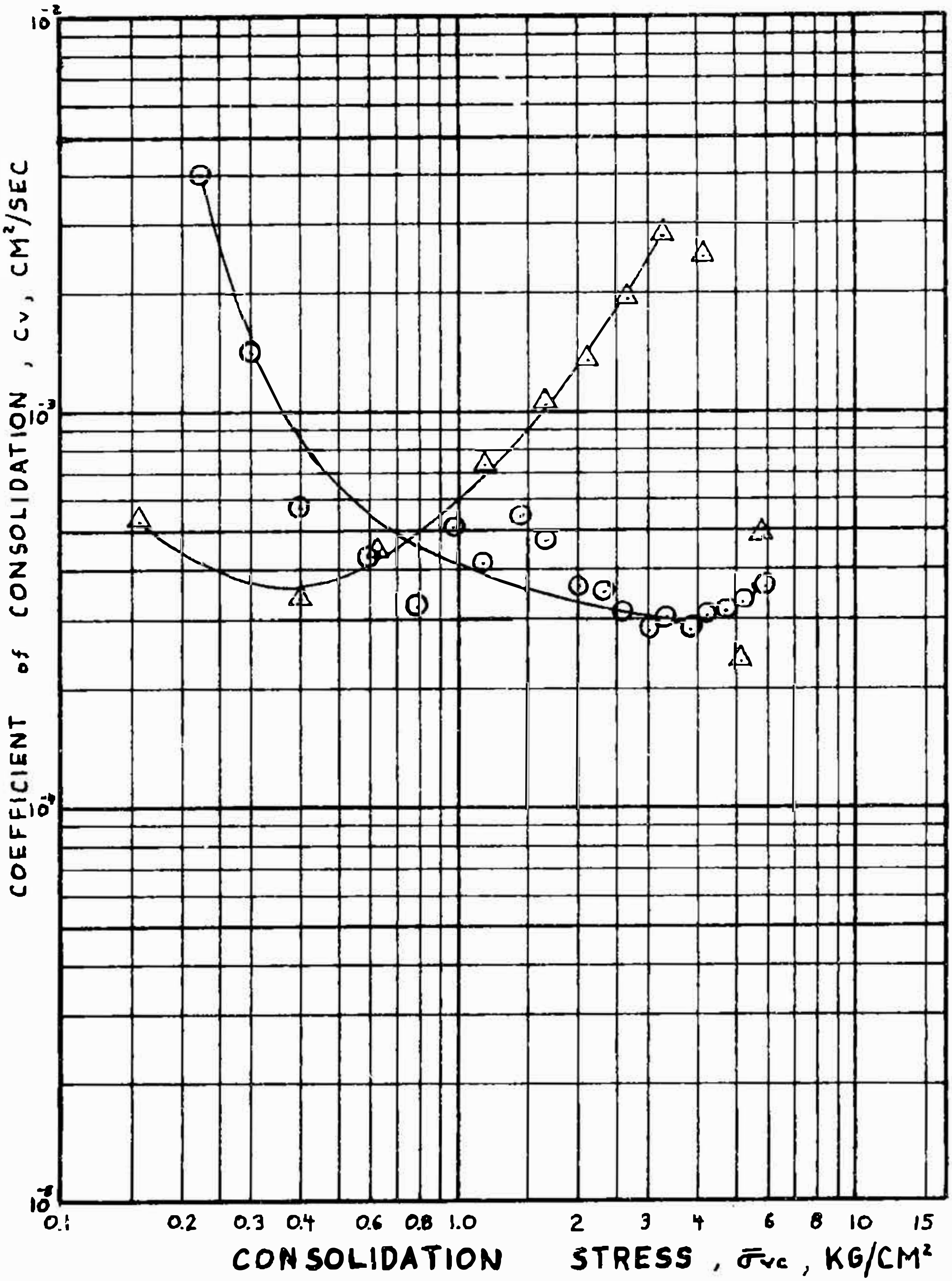
SF = SEEPAGE FORCE

TABLE 5.12



2.5
2.4
2.3
2.2
2.1
2.0
1.9
1.8
1.7
1.6
1.5
VOID RATIO, e
10
100
1000
10,000
CONSOLIDATION STRESS, σvc, GM/CM²
CRSC #1 FROM CONSOLIDATION #1

FIGURE 5.16



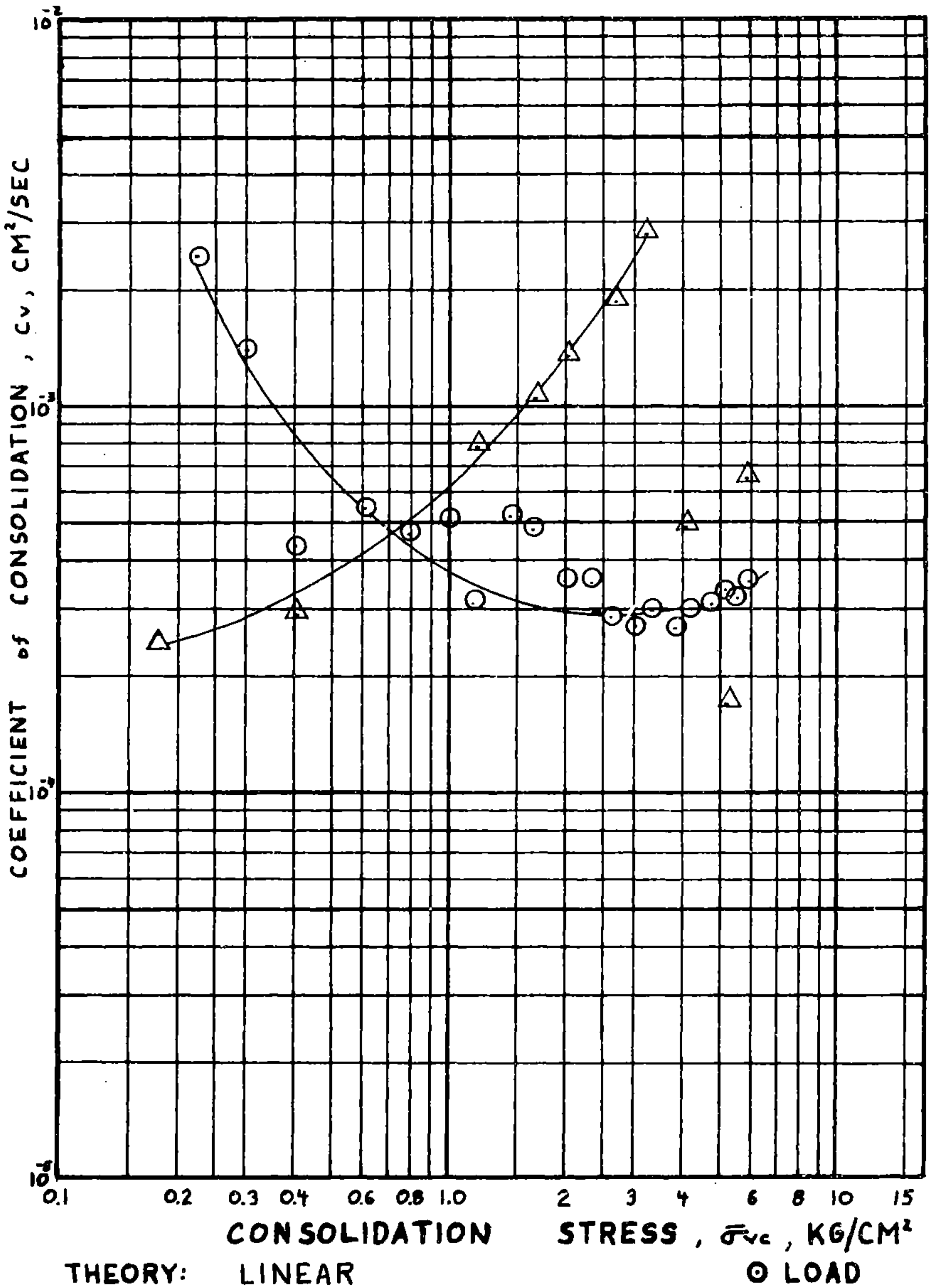
THEORY: NON-LINEAR

CRSC # 1 FROM CONSOLIDATION # 1

O LOAD

Δ UNLOAD

FIGURE 5.17



THEORY: LINEAR

CRSC # 1 FROM CONSOLIDATION # 1

O LOAD

▲ UNLOAD

FIGURE 5.18

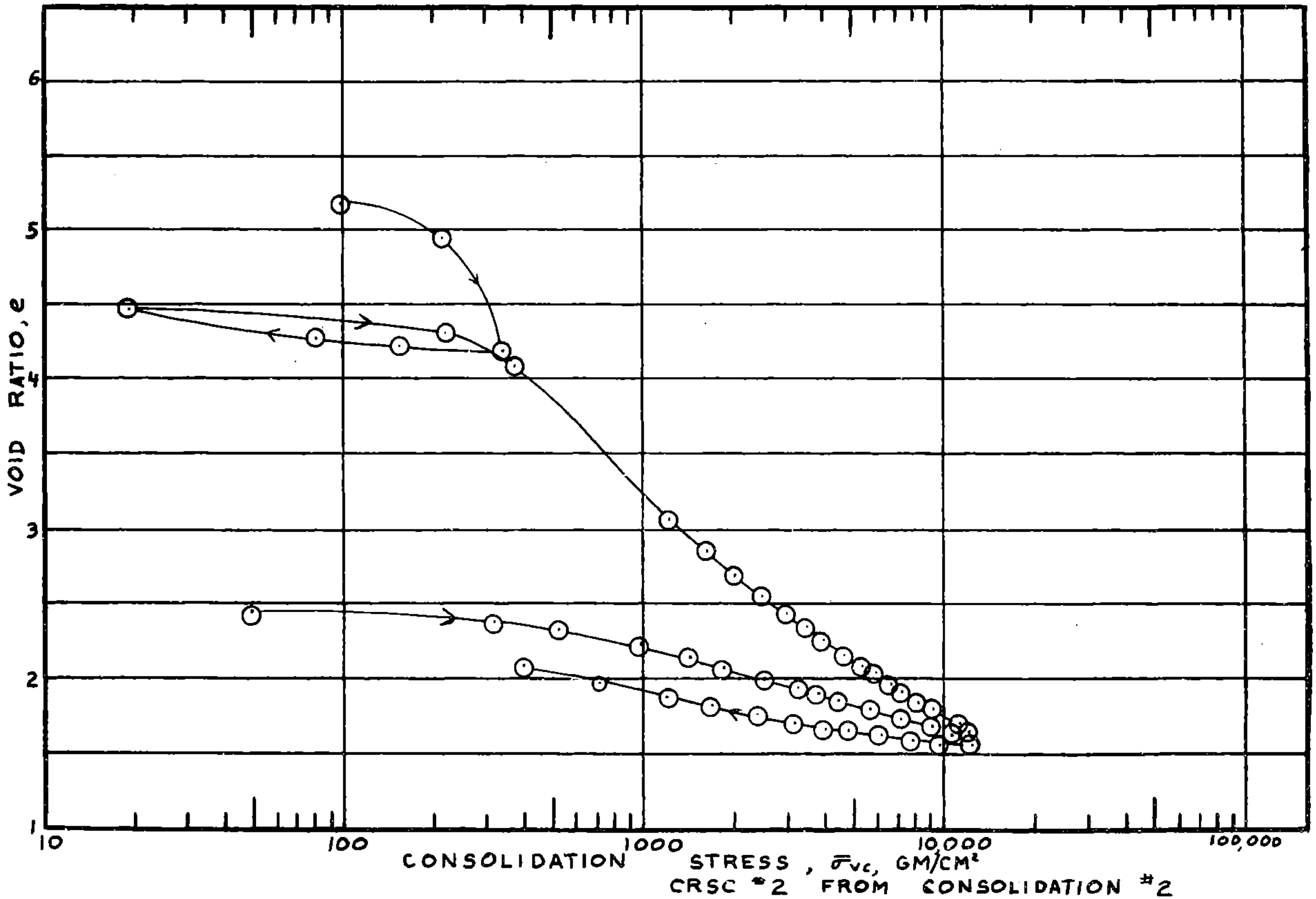

6
5
4
3
2
1
VOID RATIO, e
10
100
1000
10,000
100,000
CONSOLIDATION STRESS, $\bar{\sigma}_{vc}$, GM/CM²
CRSC #2 FROM CONSOLIDATION #2

FIGURE 5.19

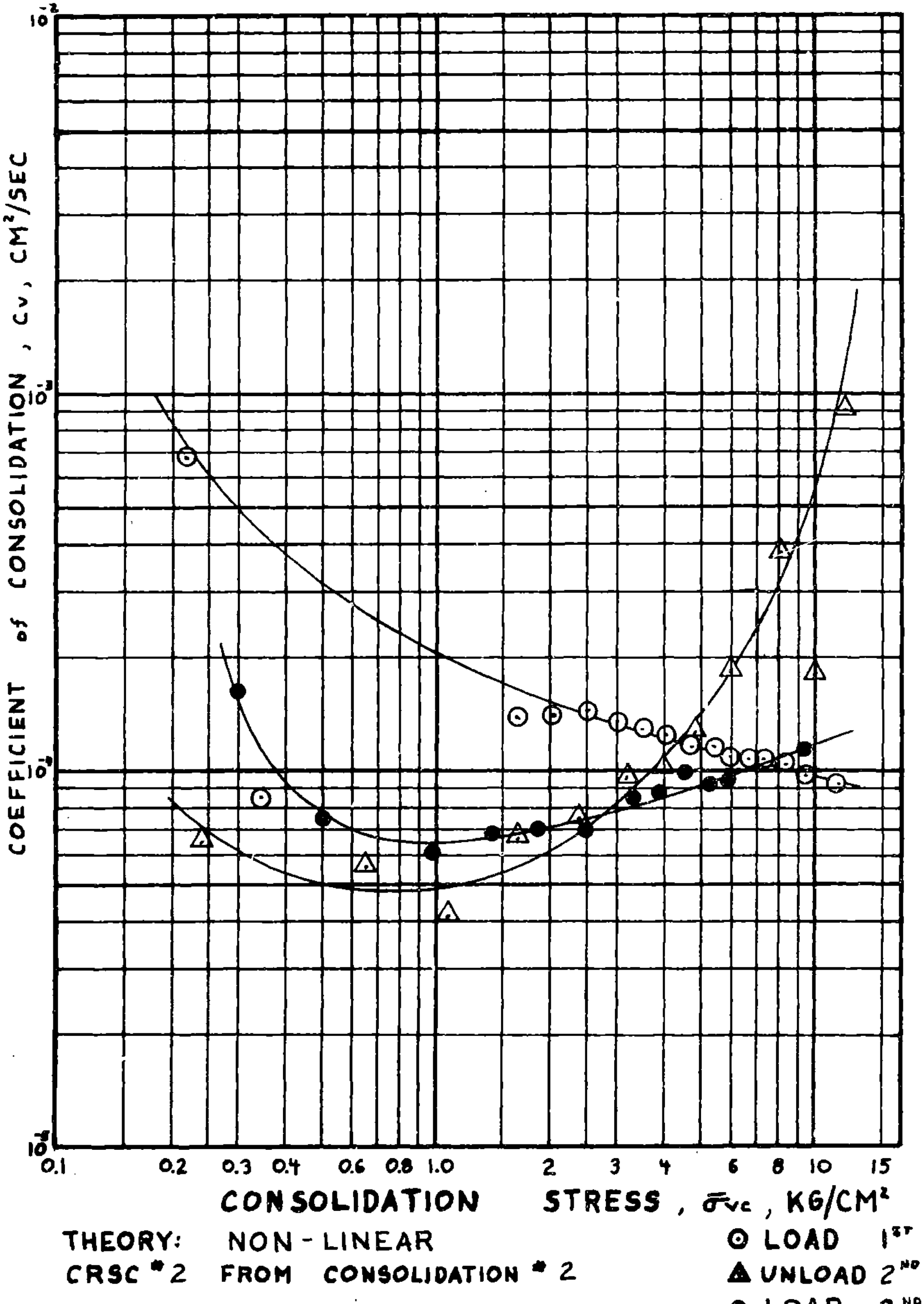
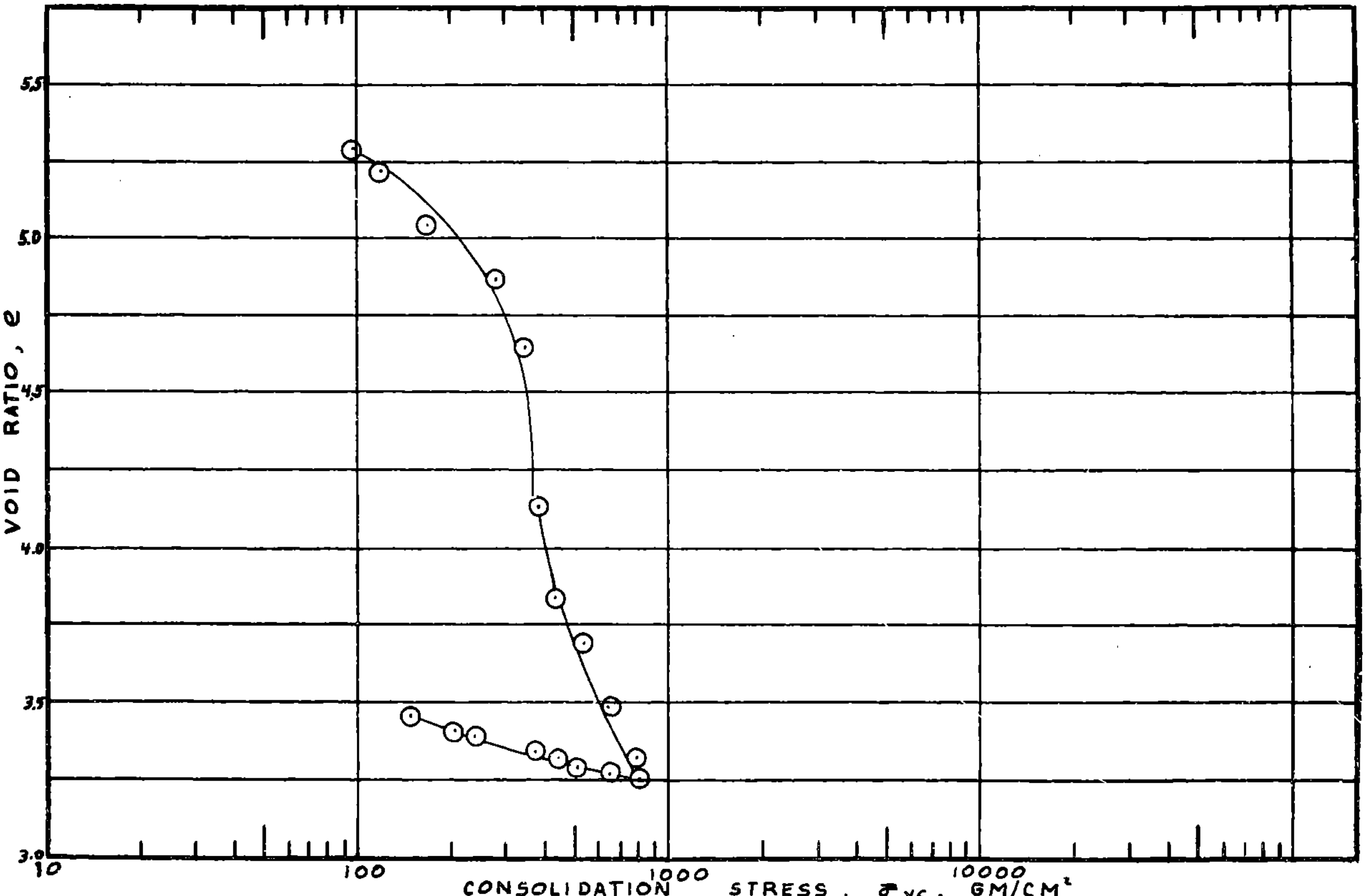
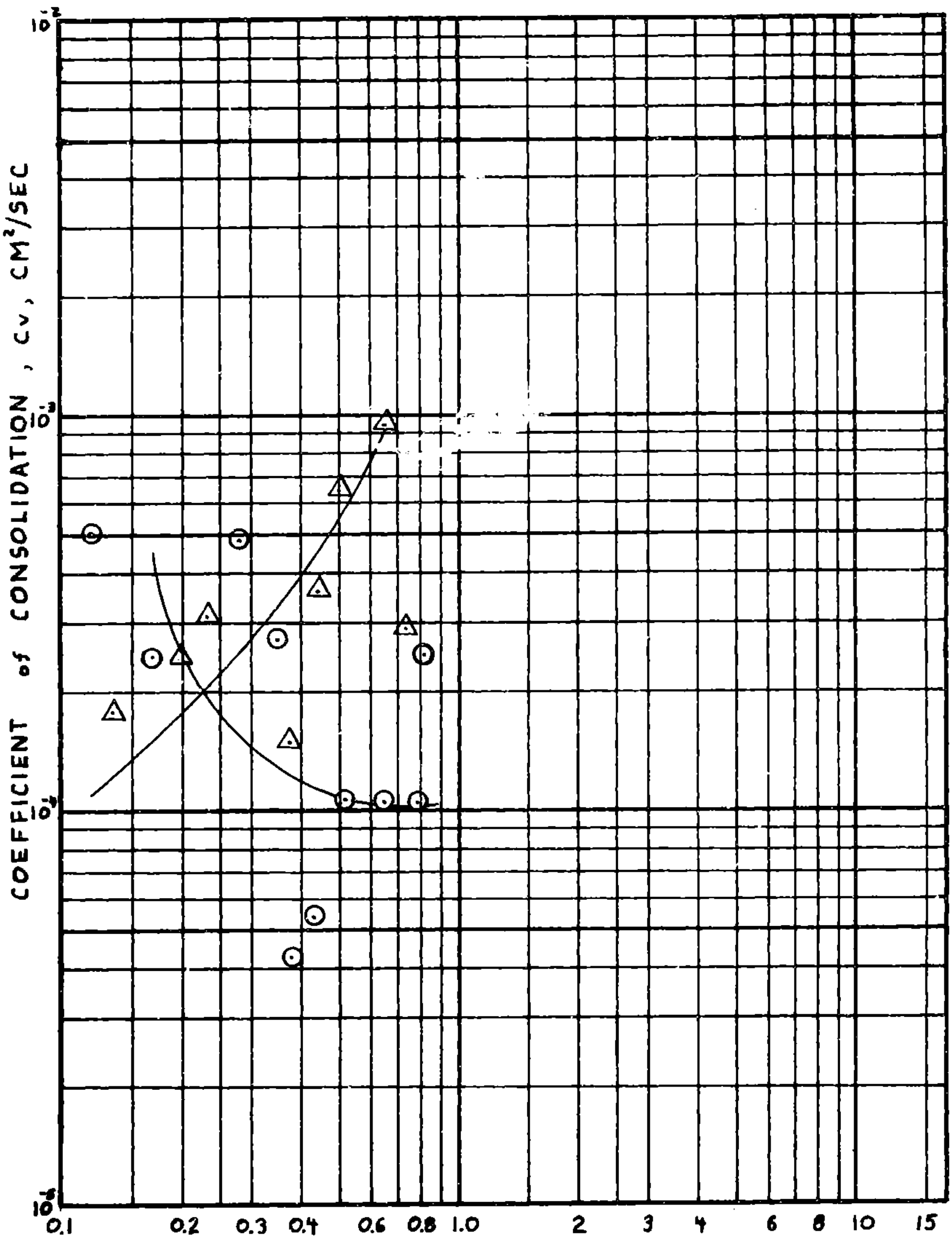

COEFFICIENT of CONSOLIDATION, Cv, CM²/SEC
CONSOLIDATION STRESS, σvc, KG/CM²
0.1
0.2
0.3
0.4
0.6
0.8
1.0
2
3
4
6
8
10
15
THEORY: NON-LINEAR
CRSC # 2 FROM CONSOLIDATION # 2
LOAD 1ST
UNLOAD 2ND
LOAD 2ND

FIGURE 5.20



CRSC #3 FROM CONSOLIDATION #2

FIGURE 5.21



CONSOLIDATION STRESS , $\bar{\sigma}_{vc}$, KG/CM²

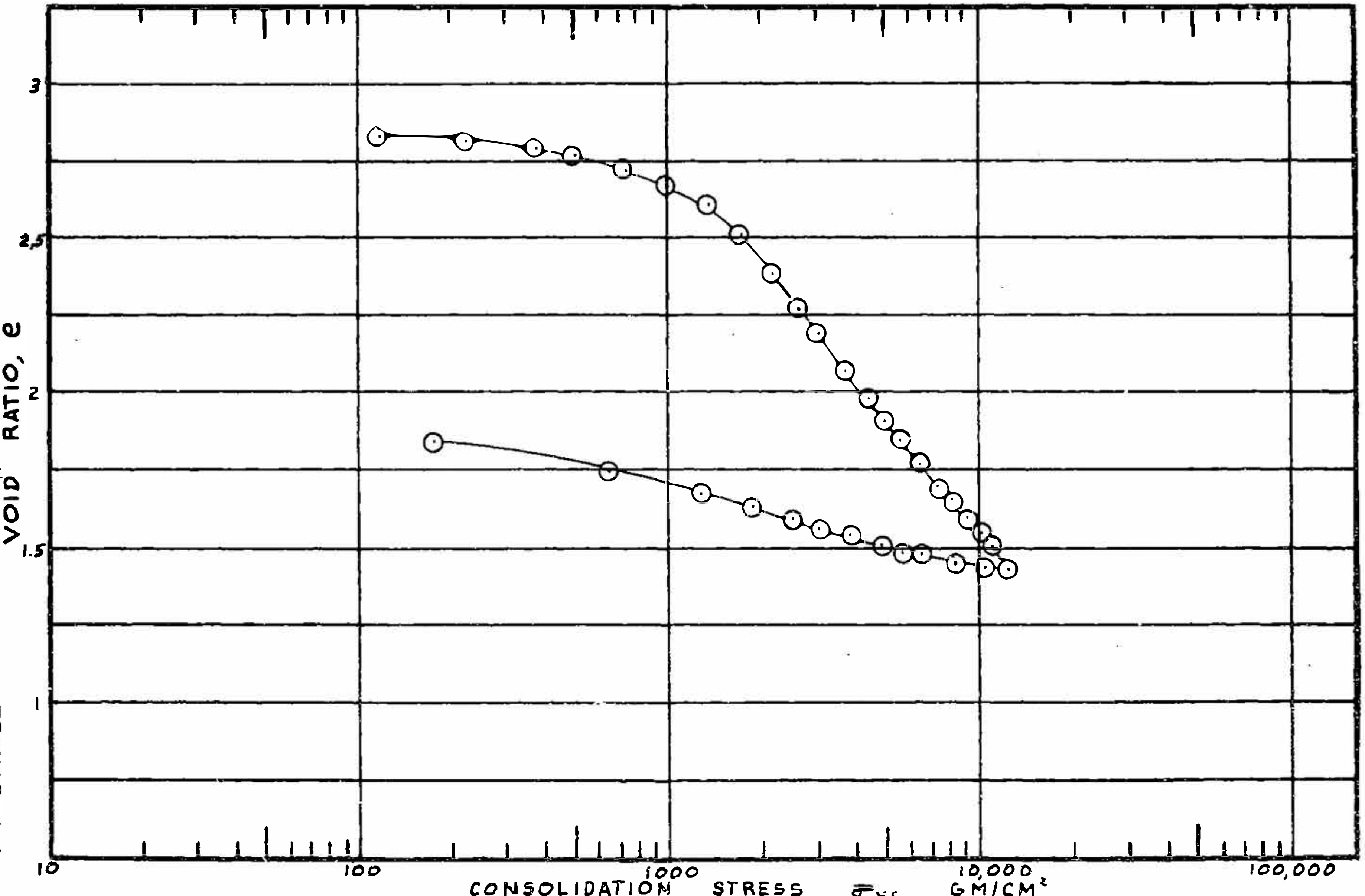
THEORY: NON-LINEAR

CRSC # 3 FROM CONSOLIDATION # 2

⊙ LOAD

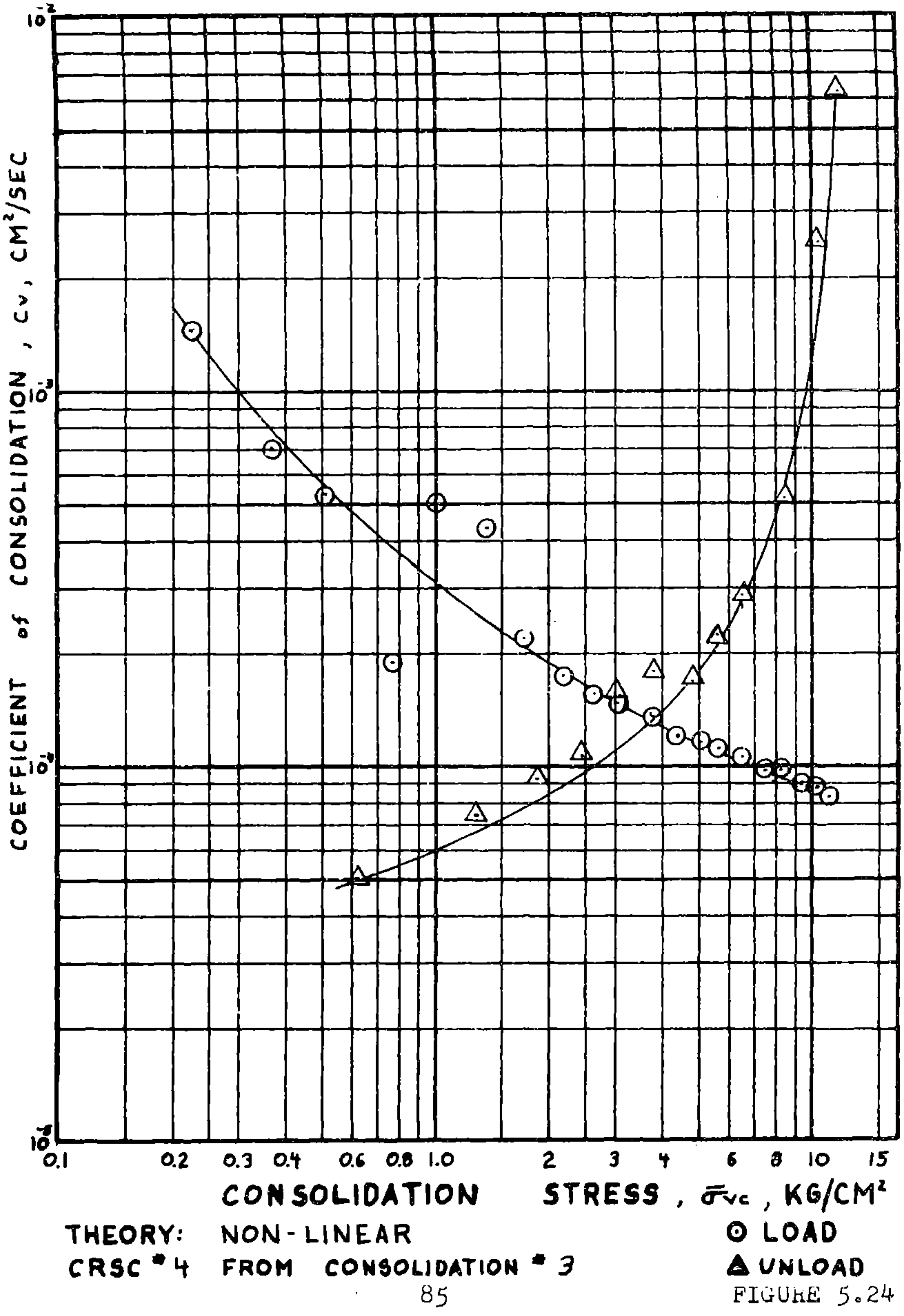
▲ UNLOAD

FIGURE 5.22



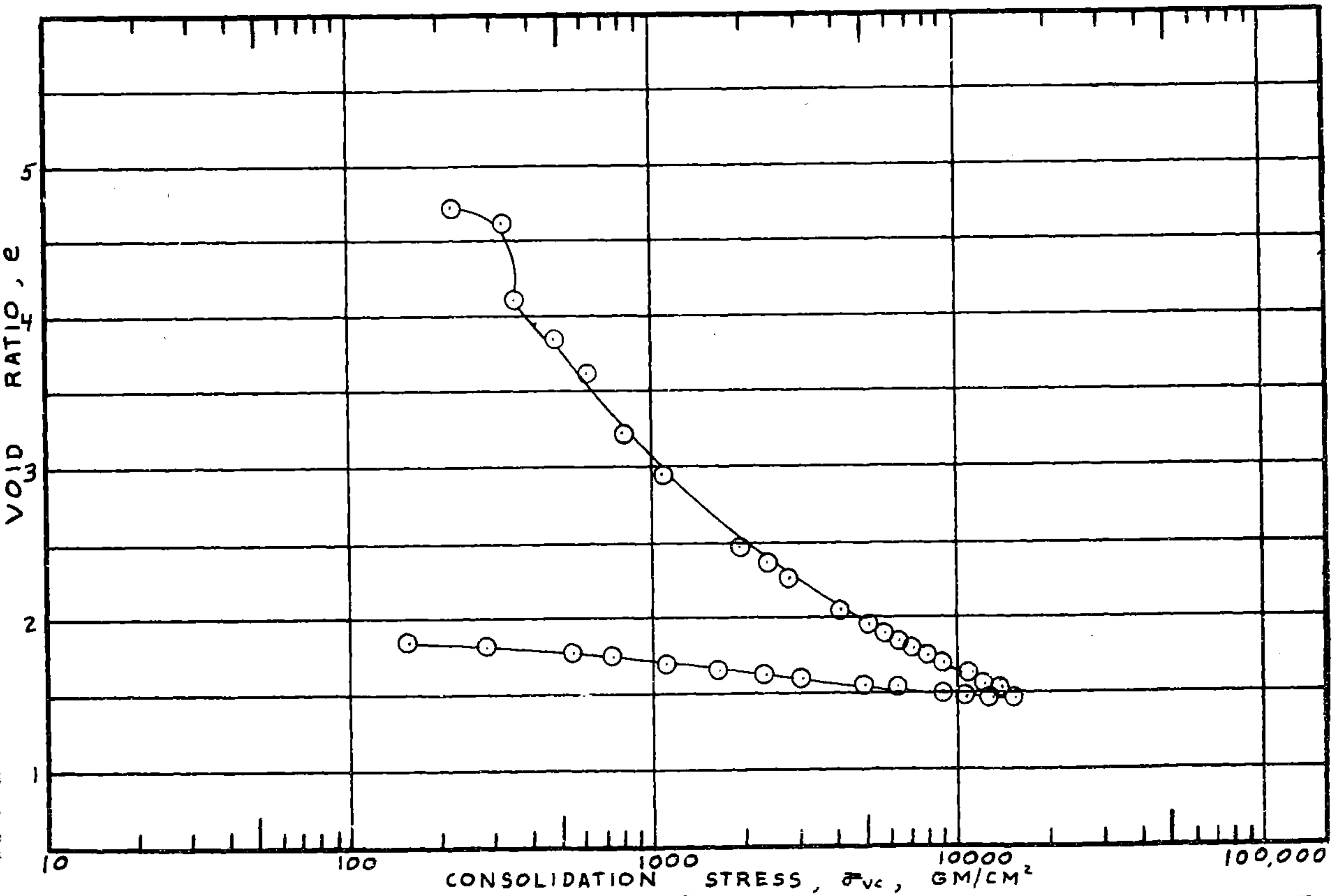
CRSC #4 FROM CONSOLIDATION #3

FIGURE 5.23



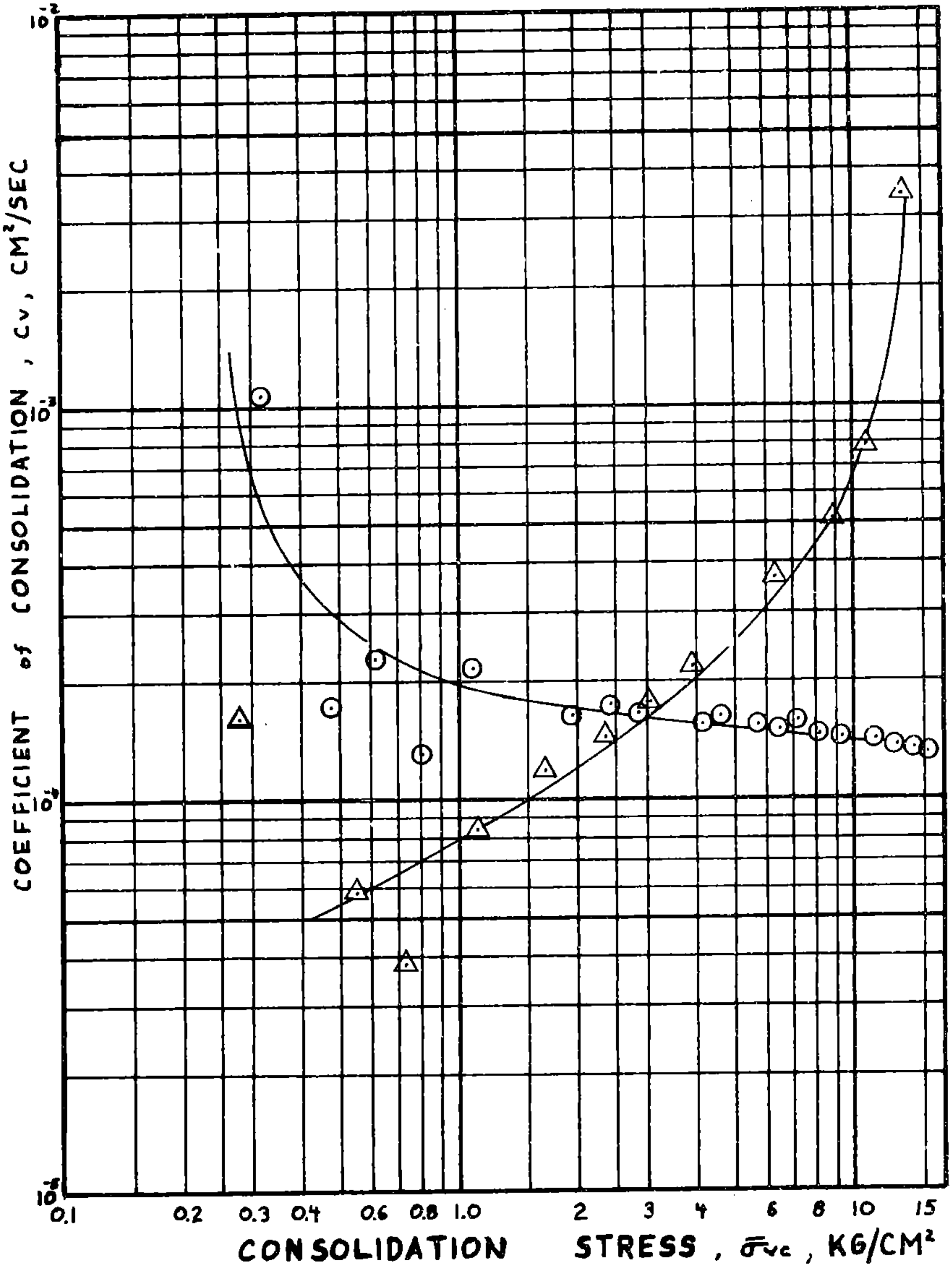
10⁻²
10⁻³
10⁻⁴
10⁻⁵
COEFFICIENT of CONSOLIDATION , Cv , CM²/SEC
0.1
0.2
0.3
0.4
0.6
0.8
1.0
2
3
4
6
8
10
15
CONSOLIDATION STRESS , σ̄vc , KG/CM²
THEORY: NON-LINEAR
CRSC # 4 FROM CONSOLIDATION # 3
⊙ LOAD
△ UNLOAD

FIGURE 5.24



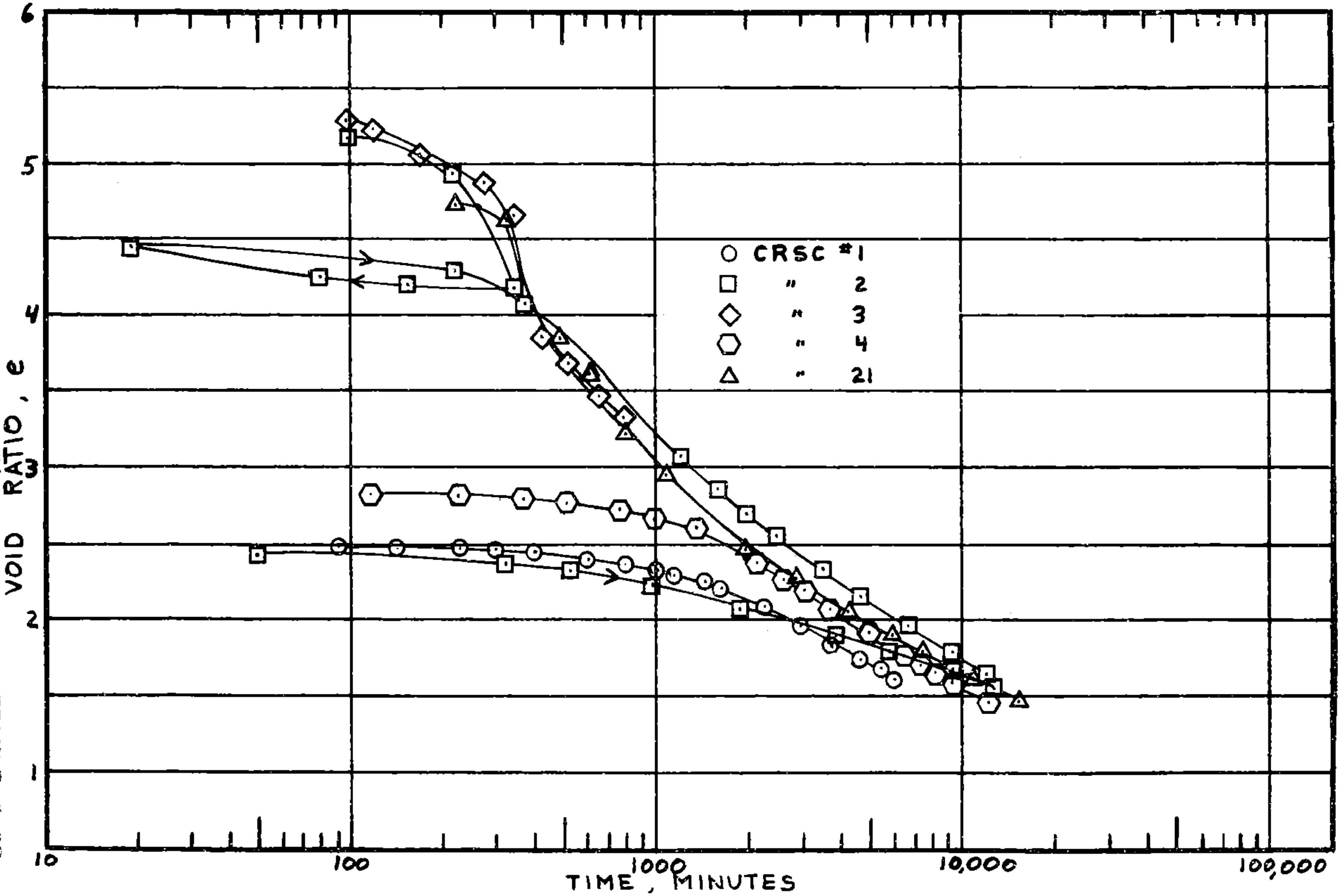
CRSC #21 FROM MOBIL FLOCCULATED FIELD SAMPLE

FIGURE 5.25



THEORY: NON-LINEAR
CRSC #21 FROM MOBIL FLOCCULATED
FIELD BLOCK SAMPLE

FIGURE 5.26



SUMMARY of e-LOG σ FOR LOADING PORTIONS of CRSC TESTS

FIGURE 5.27

CHAPTER 6 RESULTS OF CU STRENGTH TESTS

6.1 Test Program and Procedures

Three K_o consolidated-undrained direct-simple shear ($\overline{CK_o}UDSS$) tests were performed on samples of phosphatic clay upon completion of testing in the large diameter consolidometer; one test on Mobil and two tests on Noralyn slimes. All tests were K_o consolidated and sheared under controlled strain conditions. The first two samples were sheared normally consolidated. The third, a Noralyn sample, was sheared normally consolidated to its peak strength, returned to zero horizontal strain, further consolidated and rebounded to an OCR=4 and then again was sheared.

The direct-simple shear test attempts to reproduce in the laboratory the conditions which exist in the field when an element of soil deforms horizontally due to shear. Although the stress state in the sample during the test is not completely defined, the test results probably yield a reasonably accurate knowledge of the stresses on the horizontal plane. Undrained failure is defined as the peak horizontal shear stress.

The tests were performed in the Geonor Direct Simple Shear Device using the procedure outlined in Bjerrum and Landva (1966), and Ladd and Edgers (1972). The sample which is cylindrical with a nominal height of two cm and an area of 50 cm^2, is prepared with a special cutting frame and shoe. This apparatus trims the sample and aligns it for placement in a wire reinforced rubber membrane which prevents lateral deformation during consolidation. The sample volume is maintained constant during shear (thus modeling undrained conditions) by adjusting the normal load to keep a constant sample height. In order to ensure pore pressure equalization during shear, a nominal strain rate of 5 per cent per hour was selected.

6.2 Results of $\overline{CK_0}$UDSS Tests

The results are presented in Table 6.1 and Figures 6.1 through 6.18. Appendix D contains tabulated stress-strain data. The vertical strain-log $\bar{\sigma}_{vc}$ curves are consistent with the maximum past pressure and compressibility from the large-diameter consolidometer.

The three normally consolidated (N.C.) tests with $\bar{\sigma}_{vc}$ =3, 0.8, and 2.5 KG/cm^2 yielded fairly consistent normalized behavior. The value of $s_u/\bar{\sigma}_{vc}\left[s_u=(\tau_h)_{max}\right]$ ranged from 0.22 to 0.227. The shear strain at failure is quite high (γ =15 to 20 per cent), and there is little strain softening after failure, except for No. 2. The normalized stress paths in Figures 6.3, 6.7, and 6.11 show a continous decrease in vertical effective stress during shear, which is typical of $\overline{CK_0U}DSS$ tests on N.C. clays. Little significance can be attached to the values of $\bar{\phi}$ = arctan ($\tau_h/\bar{\sigma}_v$) presented in Figures 6.3 and 6.7 because of the unknown stress conditions within the sample (Ladd and Edgers, 1972). E_u/s_u versus the applied shear stress level data are plotted in Figure 6.14. E_u is the secant Young's modulus computed assuming that the applied stresses are pure shear. The first and third tests give reasonably consistent data, with E_u/s_u decreasing from about 800 to 40 as the stress level increased from 10 to 90 per cent of the undrained shear strength. For the second test, E_u/s_u decreased from about 200 to 40 as the stress level increased from 10 to 85 per cent of the undrained shear strength. Because each load increment was left on for about the same time, perhaps this low modulus of the second test is associated with the low confining stress.

Data from the overconsolidated portion of the third test (OCR=4) shows an increase in $Su/\bar{\sigma}_{vc}$. The stress-strain and stress path data in Figure 6.13, 6.14, and 6.15 show development of negative "pore pressures" for overconsolidated samples prior to failure. After failure the "pore pressures" increase and the sample exhibits strain softening. Of course, the "pore pressures" are actually a negative change in effective stress required to maintain constant volume. This behavior is typical of $\overline{CK_oU}DSS$

tests on overconsolidated samples. E_u/s_u decreased from about 250 to 40 as the stress level increased from 10 to 65 per cent of the undrained shear strength.

6.3 Discussion

The program of $\overline{CK_0}$UDSS tests generally yielded excellent stress-strain-strength data that fit in well with results on other clays.

The most useful information derived from $\overline{CK_0}$UDSS tests are the values of $s_u/\bar{\sigma}_{vc}$ and E_u/s_u. Figure 6.17 presents a plot of $s_u/\bar{\sigma}_{vc}$ versus OCR from $\overline{CK_0}$UDSS tests on five clays. The phosphatic clays has a higher undrained strength ratio than the lean, somewhat sensitive illitic Boston Blue Clay and the Connecticut Valley varved clay, which has a very low strength for shear parallel to the varves. The Bangkok Clay, which is a slightly less plastic deltaic clay than the Louisiana backswamp clay, has a similar undrained strength behavior and both are somewhat higher than the phosphatic clays.

E_u/s_u versus stress level data are plotted in Figure 6.18 for four normally consolidated clays. The normalized modulus of the Louisiana backswamp clay and the Florida phosphatic clays is generally one half to one fifth the Boston Blue or Bangkok clays. One would predict larger undrained deformations for construction on clays with a lower modulus. It is unusual, however, that the modulus of phosphatic clay is so high compared to Louisiana backswamp clay since the phosphatic clay is much more plastic.

TEST	STRESS HISTORY			AT (τ_h) MAXIMUM					AT $(\tau_h/\bar{\sigma}_v)$ MAXIMUM					$WC_o,\%$	CONSOL.	REMARKS
	OCR	$\bar{\sigma}_{vc}$ $\bar{\sigma}_{vm}$	t_c (day)	$\gamma^{(1)}$ (%)	$\dot{\gamma}^{(2)}$	τ_h $\bar{\sigma}_{vc}$	τ_h $\bar{\sigma}_v$	$\tau_h/\bar{\sigma}_v$ $\bar{\Phi}^{(3)}$	γ (%)	$\dot{\gamma}$	τ_h $\bar{\sigma}_{vc}$	τ_h $\bar{\sigma}_v$	$\tau_h/\bar{\sigma}_v$ $\bar{\Phi}$	$WC_f,\%$	No.	
1	1.00	3.037 3.037	3.0	17.3	4.43	0.227	0.689 1.714	0.403 27.0°	27.9	4.43	0.207	0.630 1.311	0.481 —	85.3 72.0	1	
2	1.00	0.802 0.802	5.0	23.4	4.81	0.224	0.180 0.525	0.343 19.0°	23.4	4.81	0.224	0.180 0.525	0.343 —	187.0 123.4	2	
3^A	1.00	2.468 2.468	4.2	10.8	2.98	0.220	0.544 1.831	0.297 —	—	—	—	— —	— —	— —	3	TEST 3A STOPPED AT γ=11.4 %
3^B	3.983	1.254 4.996	3.0	20.8	3.49	0.656	0.822 1.804	0.456 —	20.8	3.49	0.656	0.822 1.804	0.456 —	— 79.3	3	

(1) γ = SHEAR STRAIN

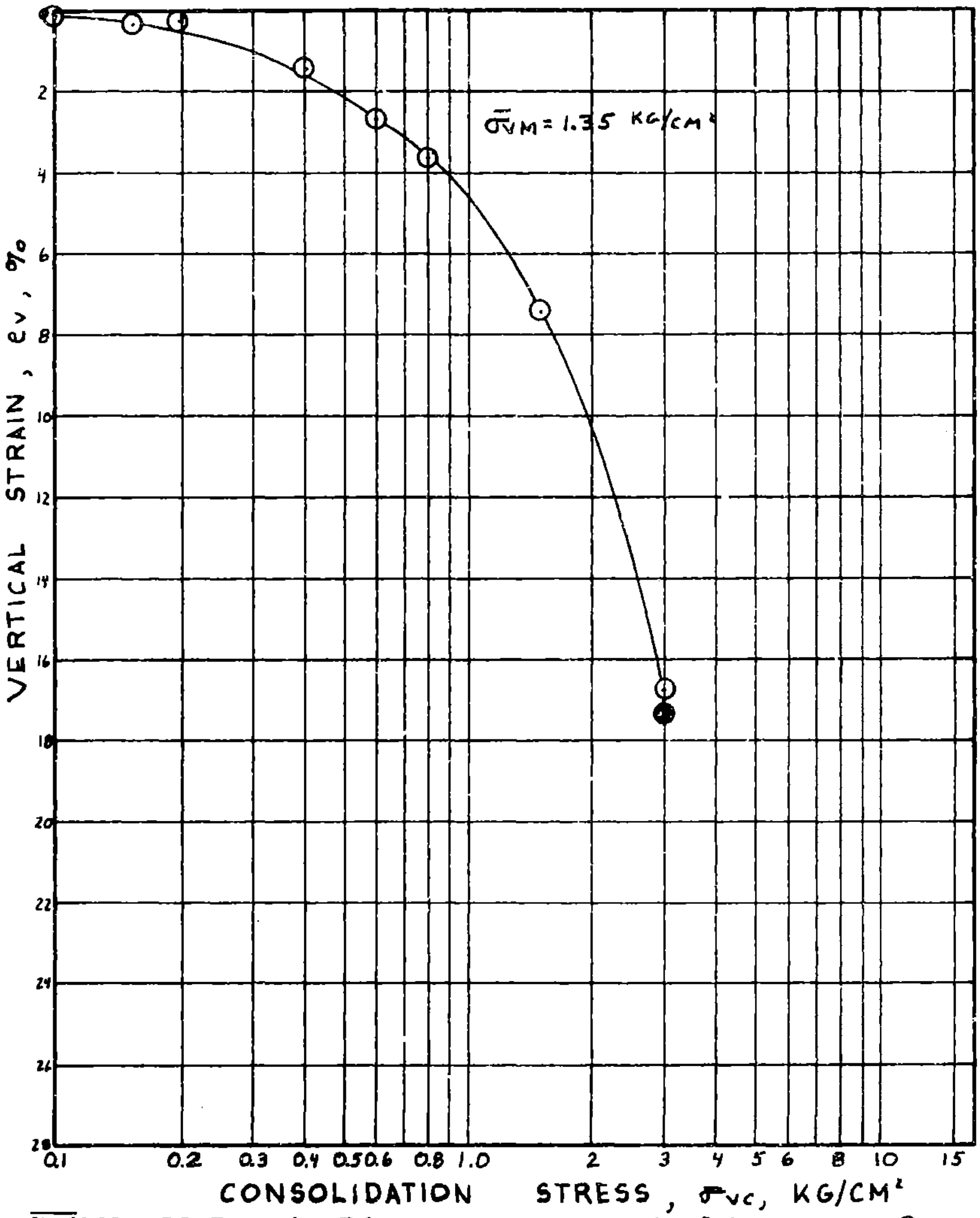
(2) $\dot{\gamma} = d\gamma/dt$ IN PERCENT PER HOUR

$\bar{\Phi} = \tan^{-1}(\tau_h/\bar{\sigma}_v)$

ALL STRESSES IN KG/CM²

SUMMARY OF $\overline{CK_o}$UDSS TESTS ON PHOSPHATIC CLAYS

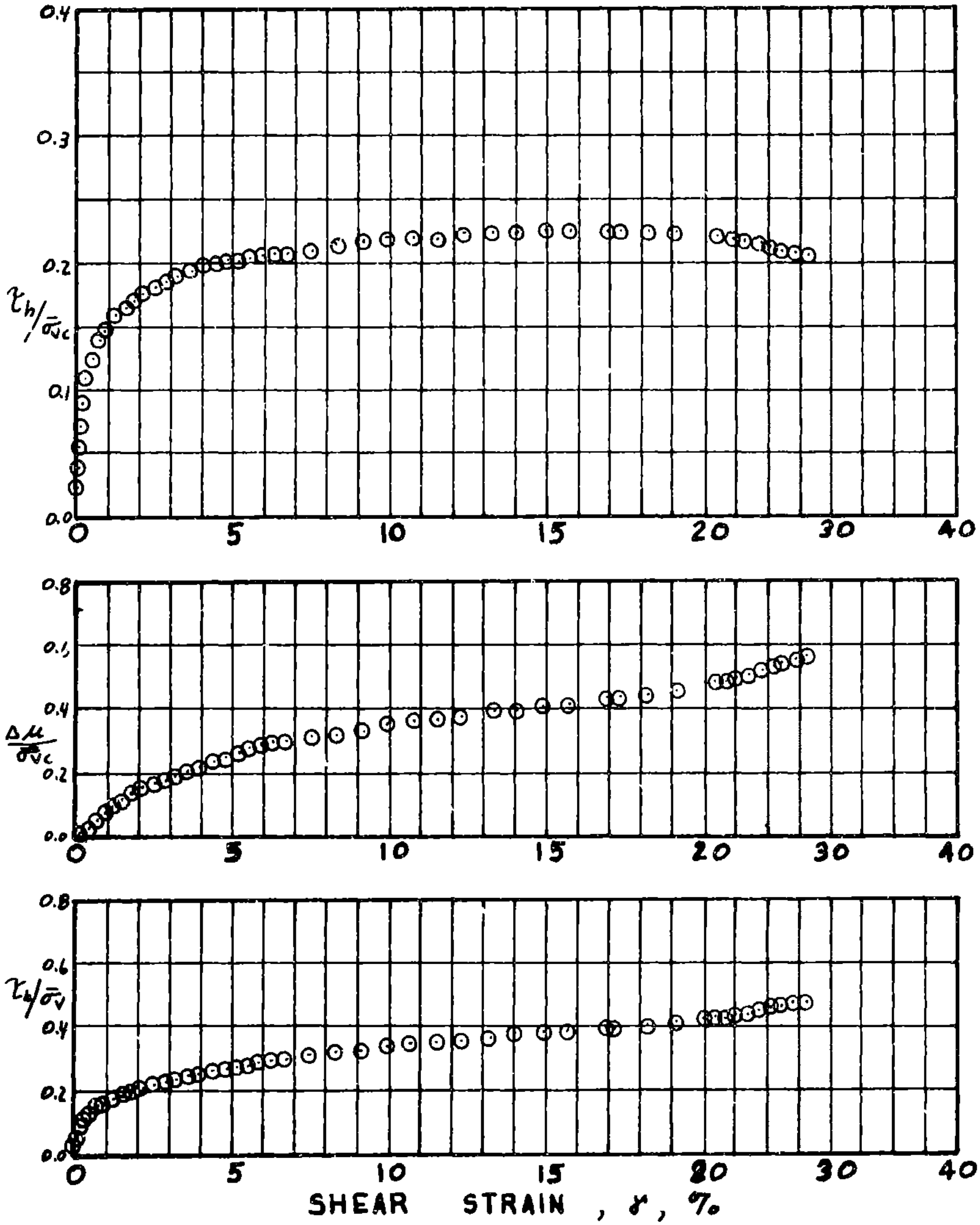
TABLE 6.1



$\overline{CK_oU}$DSS TEST No. 1 FROM CONSOLIDATION # 1

COMPRESSION CURVE

FIGURE 6.1



STRESS vs. STRAIN $\overline{CK_0}$UDSS #1 FROM

CONSOLIDATION #1

$\bar{\sigma}_{vc} = 3.037$ OCR = 1

FIGURE 6.2

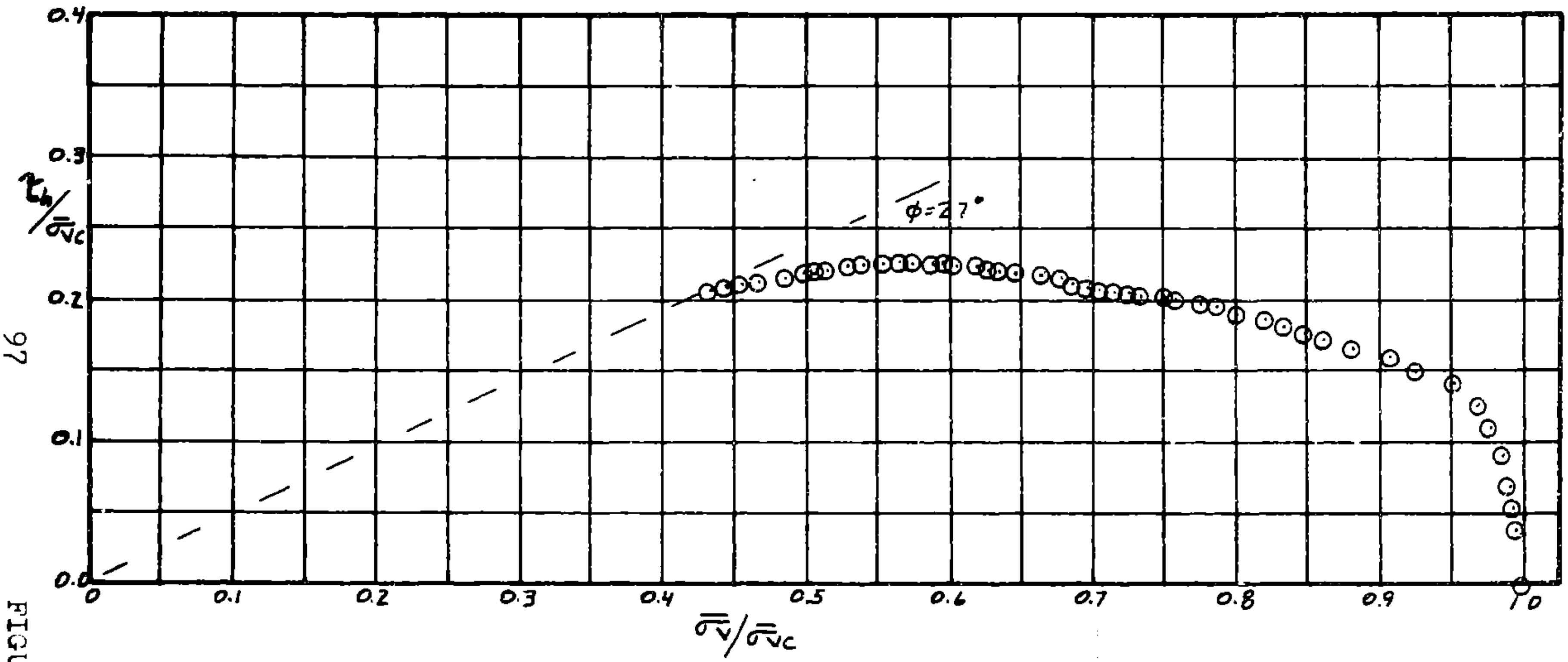
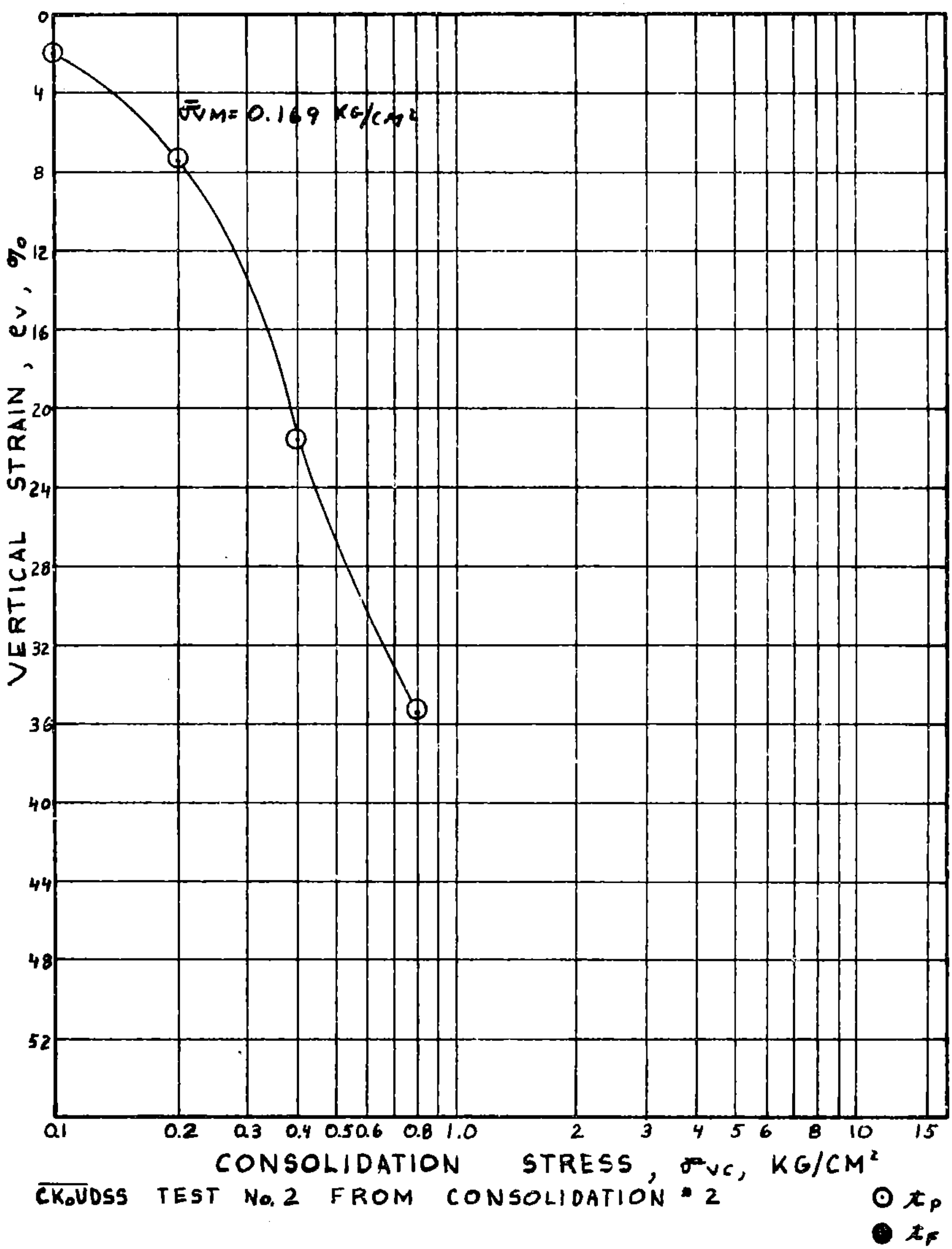


FIGURE 6.3

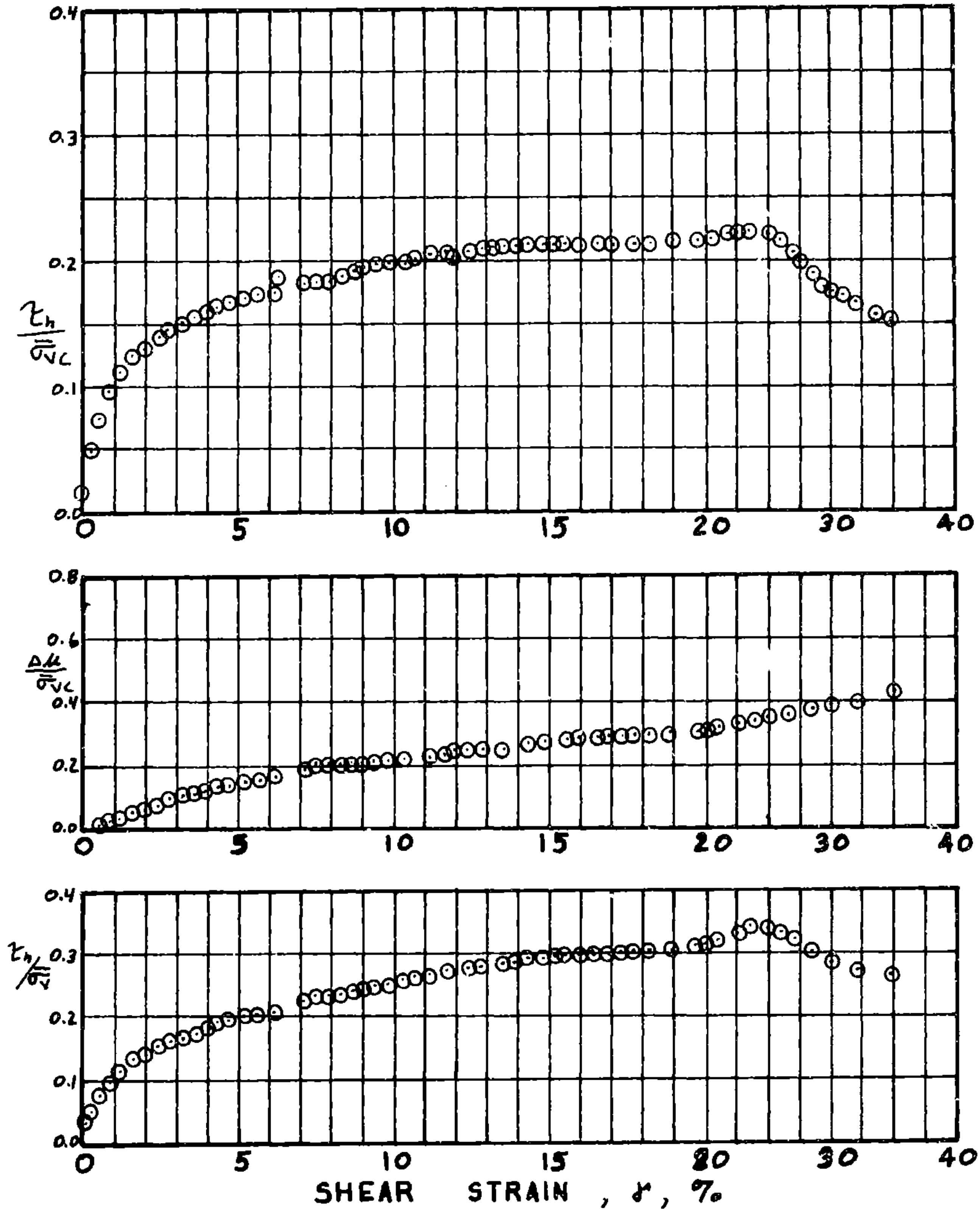
STRESS PATH FROM $\overline{CK_oUDSS}$ # 1 ON NORMALLY CONSOLIDATED SOIL

$\bar{\sigma}_{vc} = 3.037$ KG/CM^2 OCR = 1



COMPRESSION CURVE FROM $\overline{CK_0UDSS}$ #2

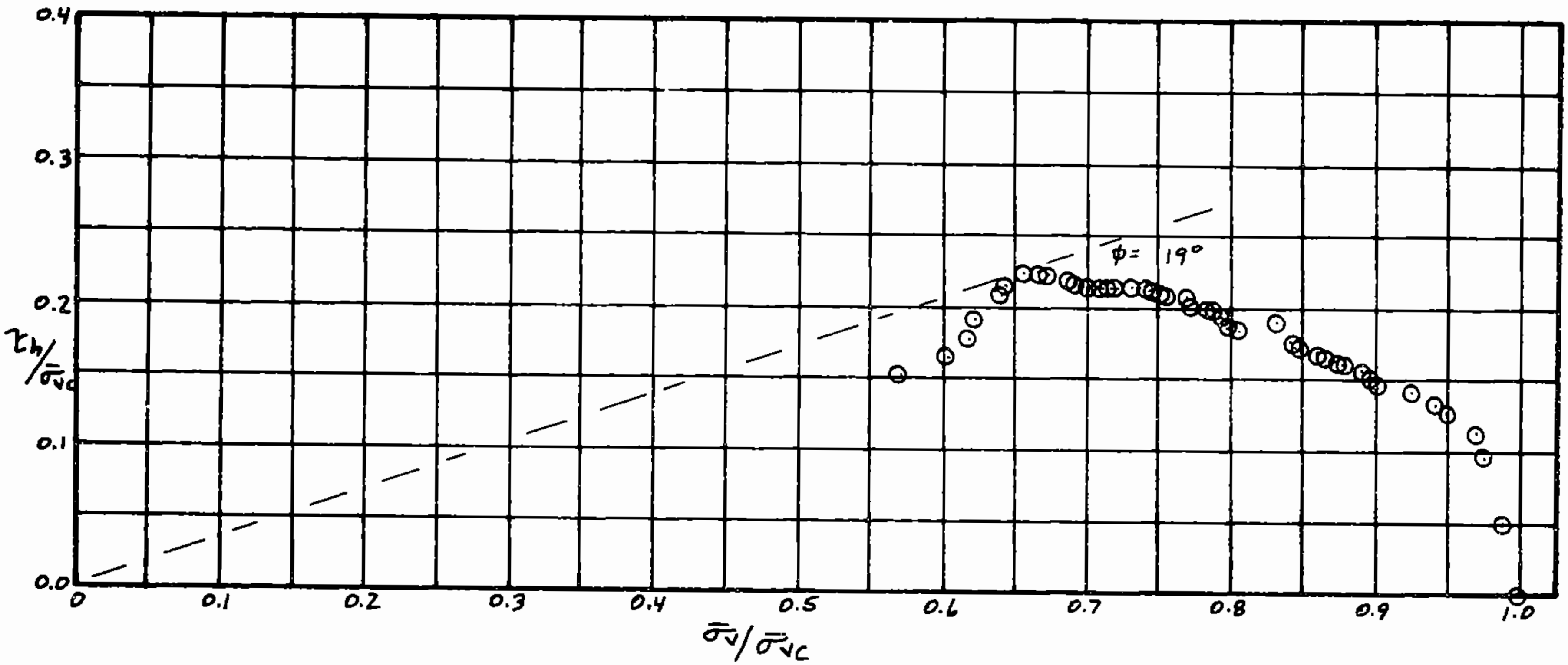
FIGURE 6.4



STRESS vs. STRAIN $\overline{CK_oUDSS}$ #2 FROM CONSOLIDATION #2

$\bar{\sigma}_{vc} = 0.802$ KG/CM^2 OCR=1

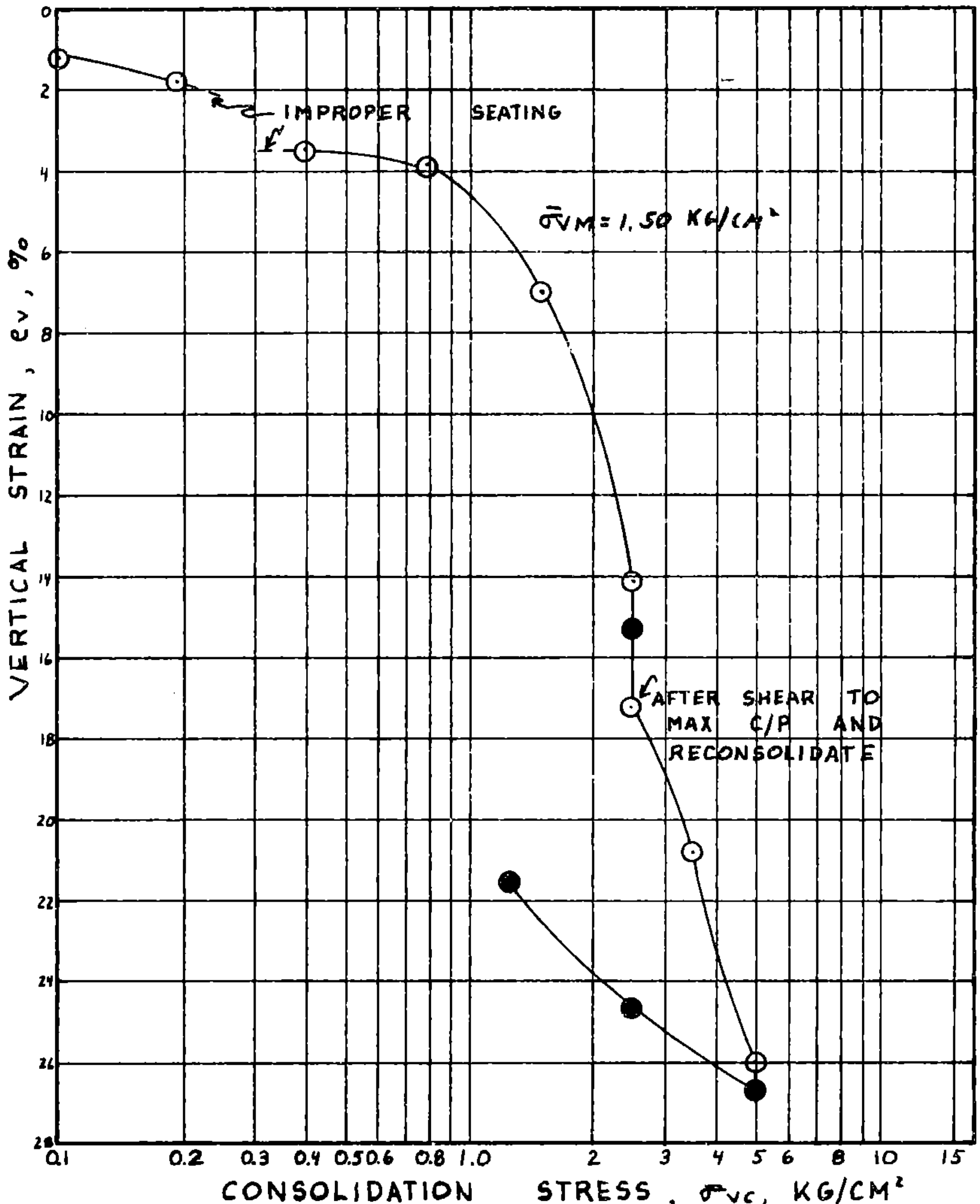
FIGURE 6.5



STRESS PATH FROM CK_oUDSS #2 ON NORMALLY CONSOLIDATED SOIL

$\bar{\sigma}_{vc} = 0.802$ KG/CM^2 OCR = 1

FIGURE 6.6



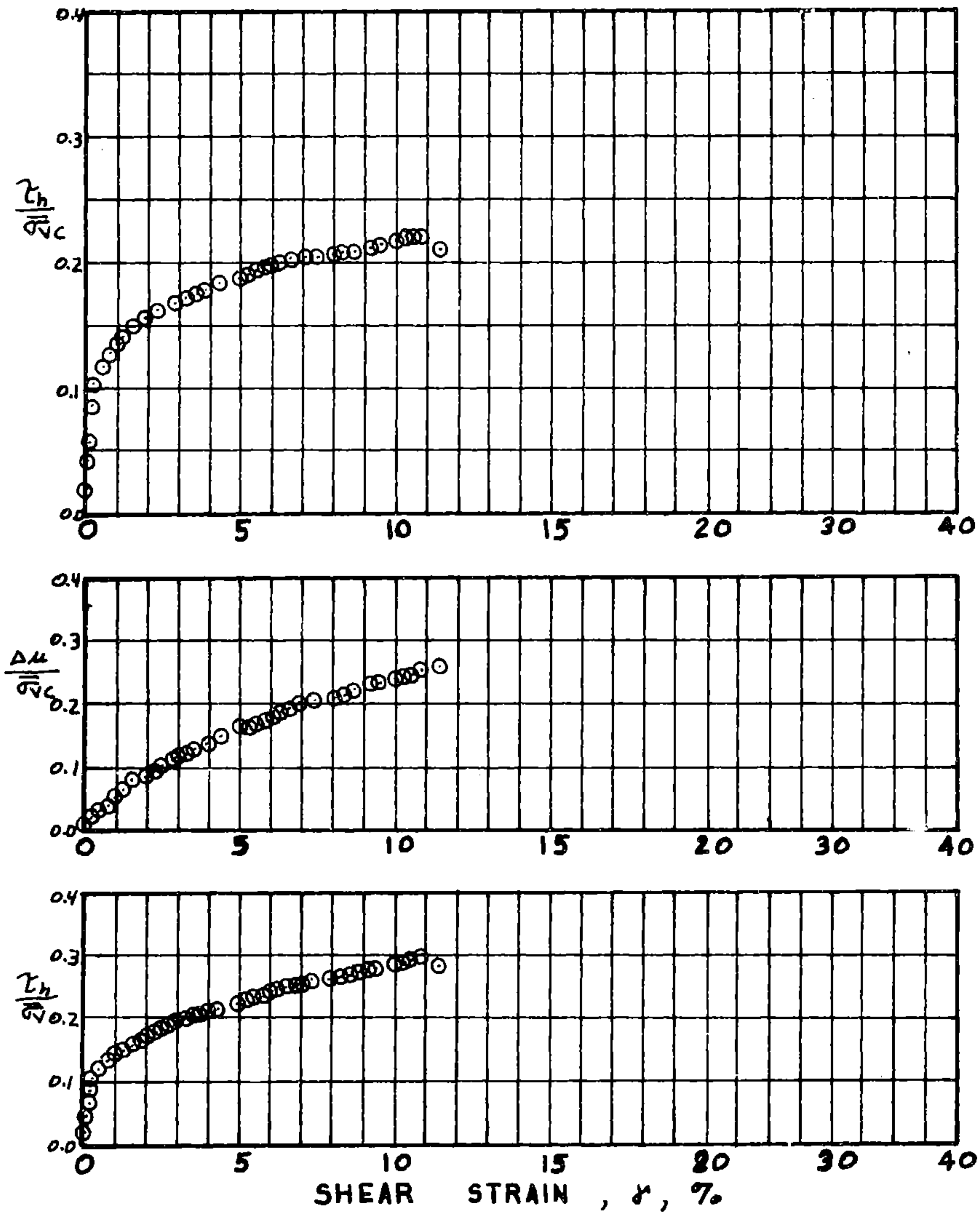
$\overline{CK_oUDSS}$ TEST No. 3 FROM CONSOLIDATION # 3

⊙ t_p

● t_F

COMPRESSION CURVE $\overline{CK_oUDSS}$ #3

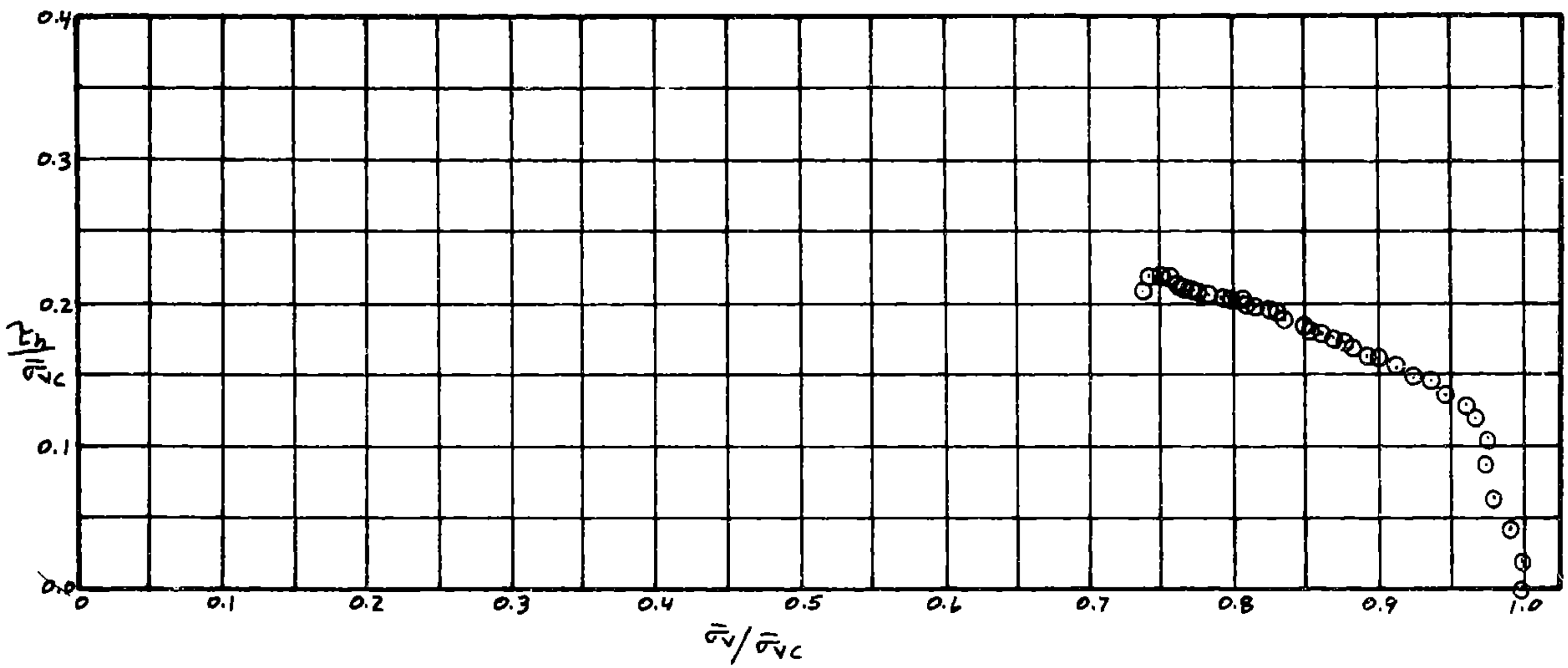
FIGURE 6.7



STRESS vs. STRAIN CK_oUDSS # 3^A FROM CONSOLIDATION # 3

$\bar{\sigma}_{vc} = 2.468$ OCR = 1

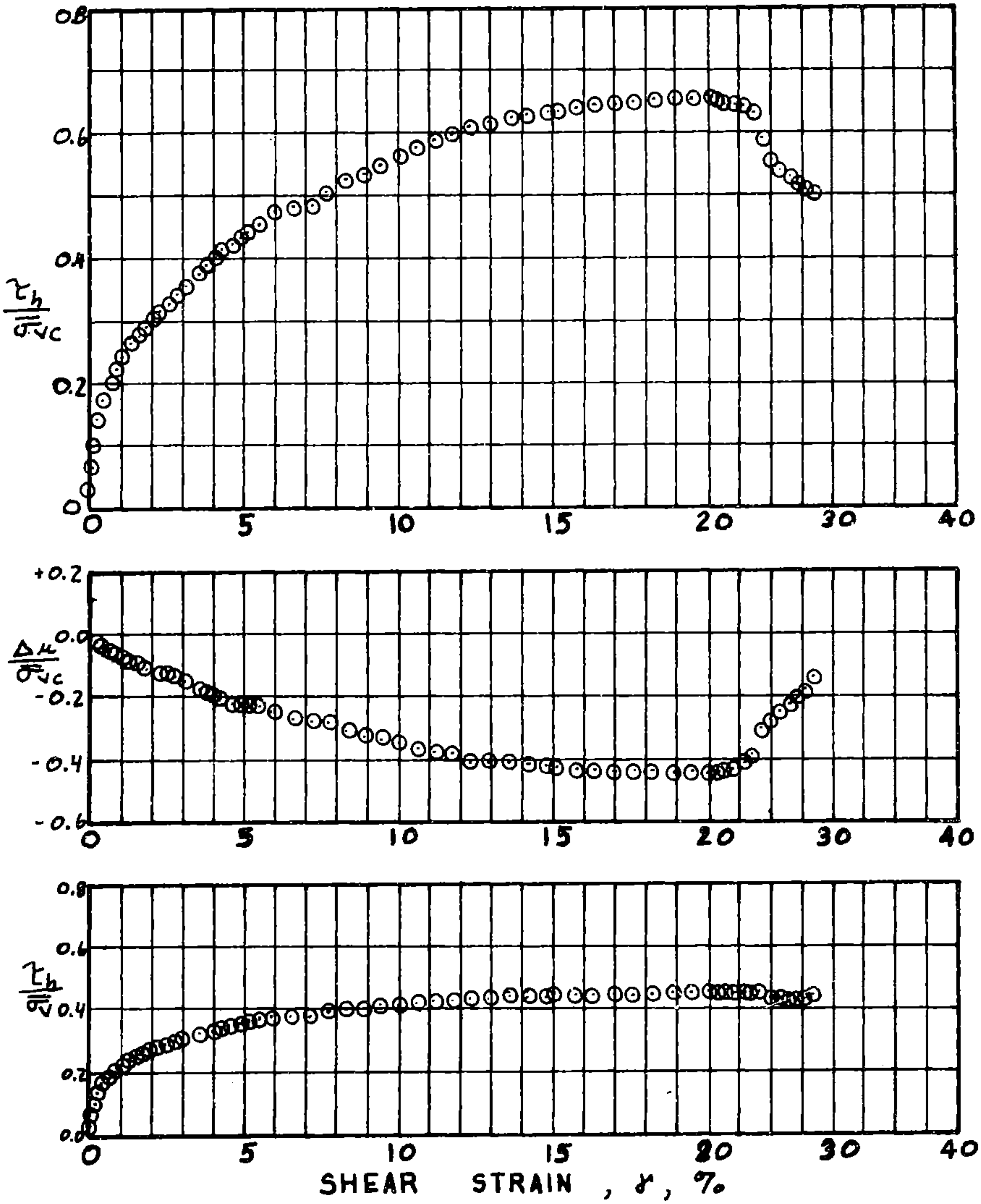
FIGURE 6.8



STRESS PATH FROM $\overline{CK_oUDSS}$ #3[A] ON NORMALLY CONSOLIDATED SOIL

$\bar{\sigma}_{vc} = 2.468$ KG/CM^2 OCR=1

FIGURE 6.9



STRESS vs. STRAIN $\overline{CK_oU}DSS$ #3[B] FROM

CONSOLIDATION # 3

$\bar{\sigma}_{vc} = 1.254\ KG/CM^2$ OCR = 3.983

FIGURE 6.10

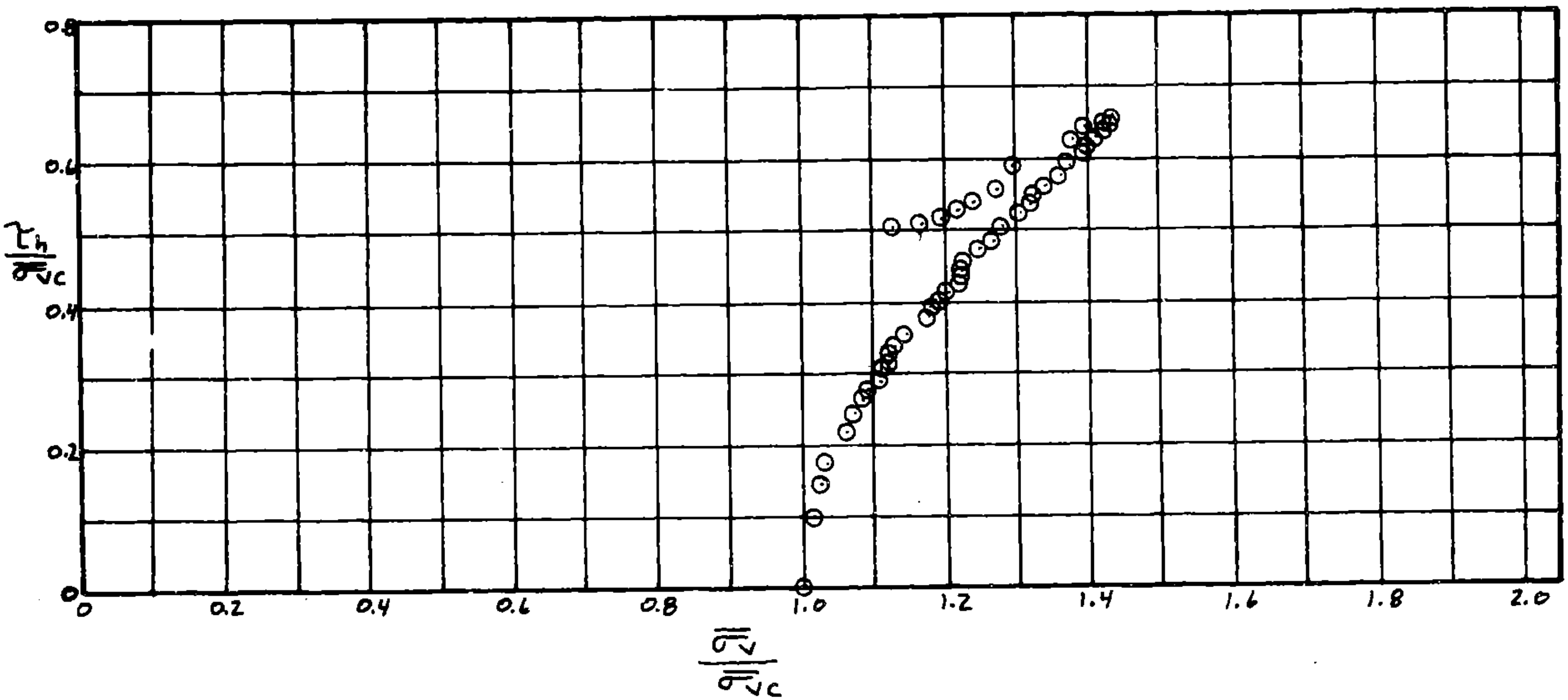
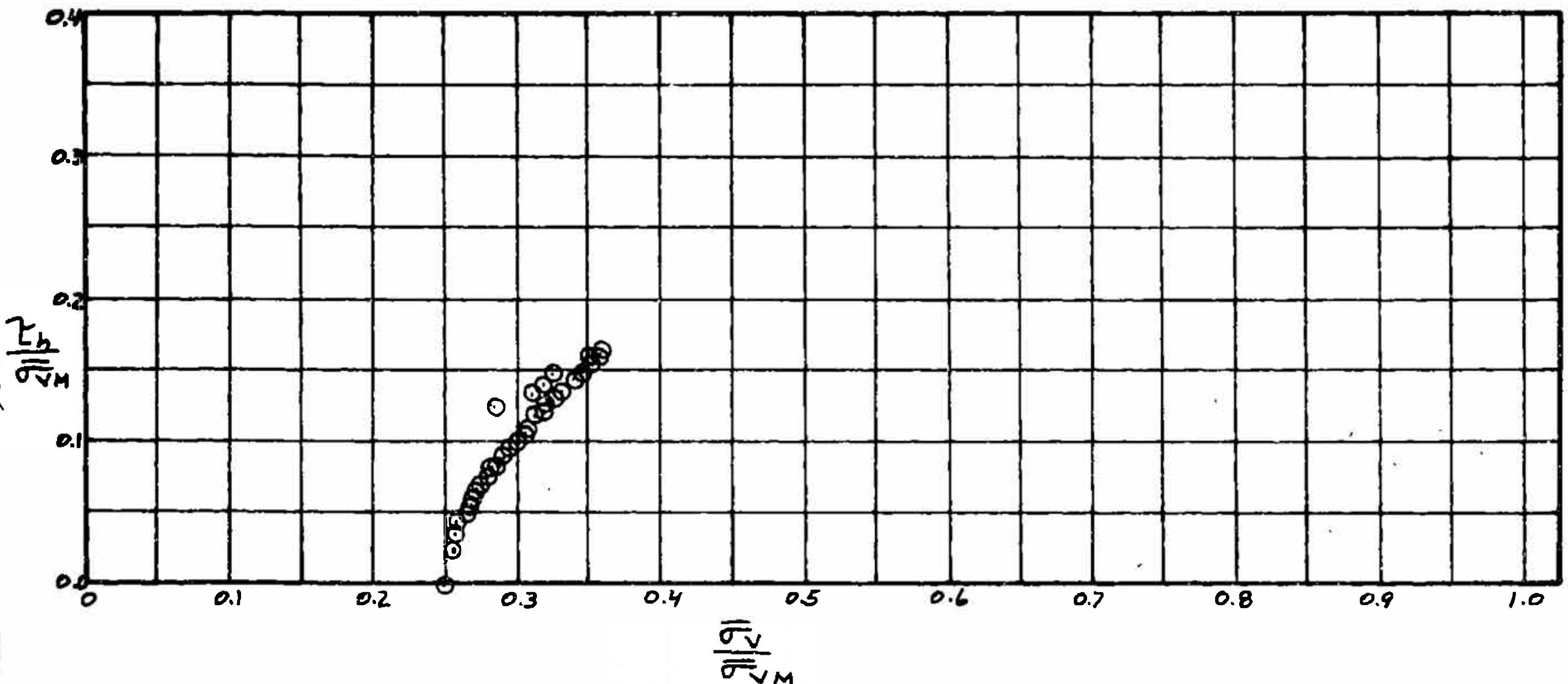


FIGURE 6.11

STRESS PATH FROM $\overline{CK_0UDSS}$ #3B ON OVERCONSOLIDATED SOIL

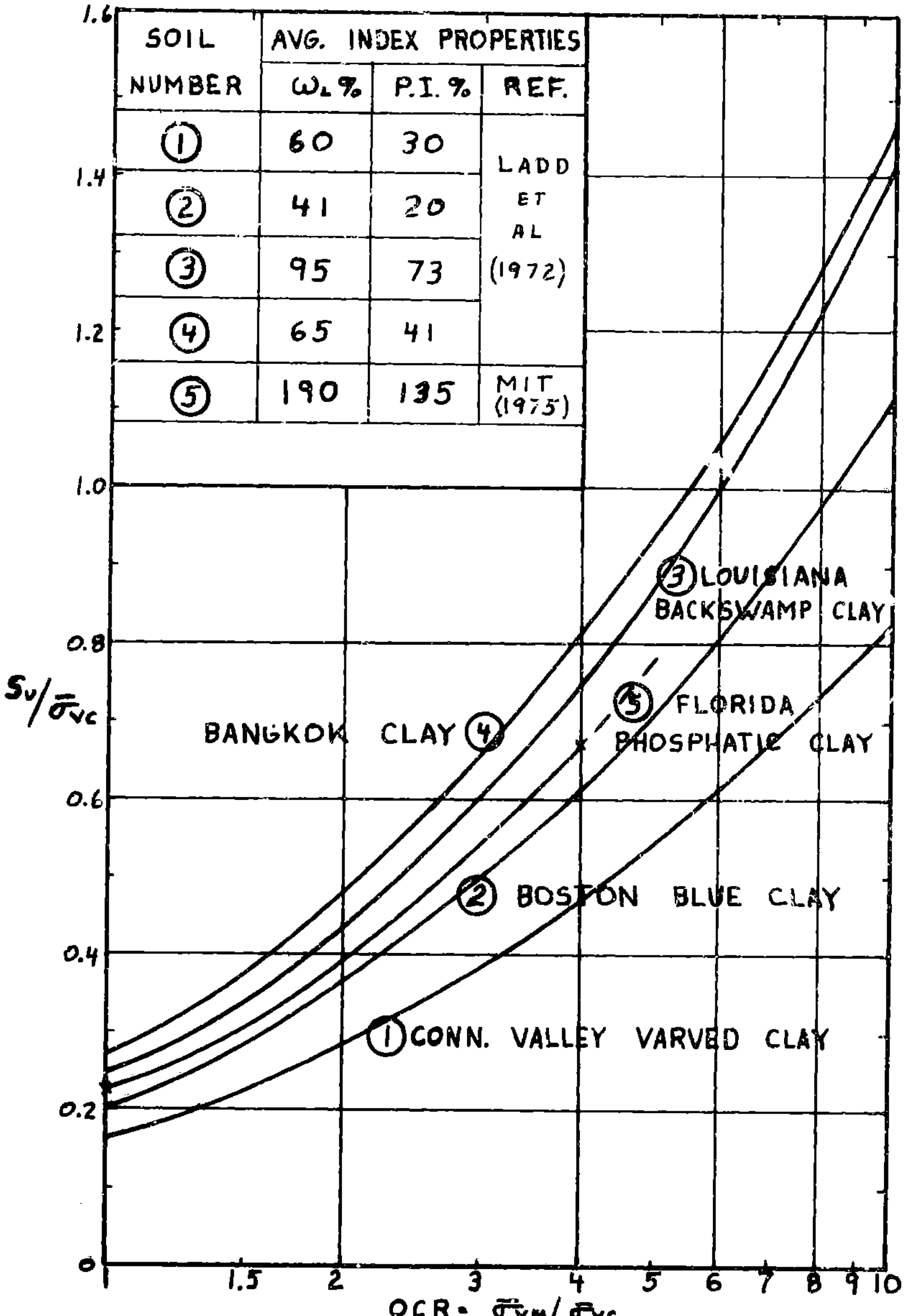
$\bar{\sigma}_{vc} = 1.254$ KG/CM^2 OCR = 3.983



STRESS PATH FROM $\overline{CK_oUDSS}$ #3B ON OVERCONSOLIDATED SOIL

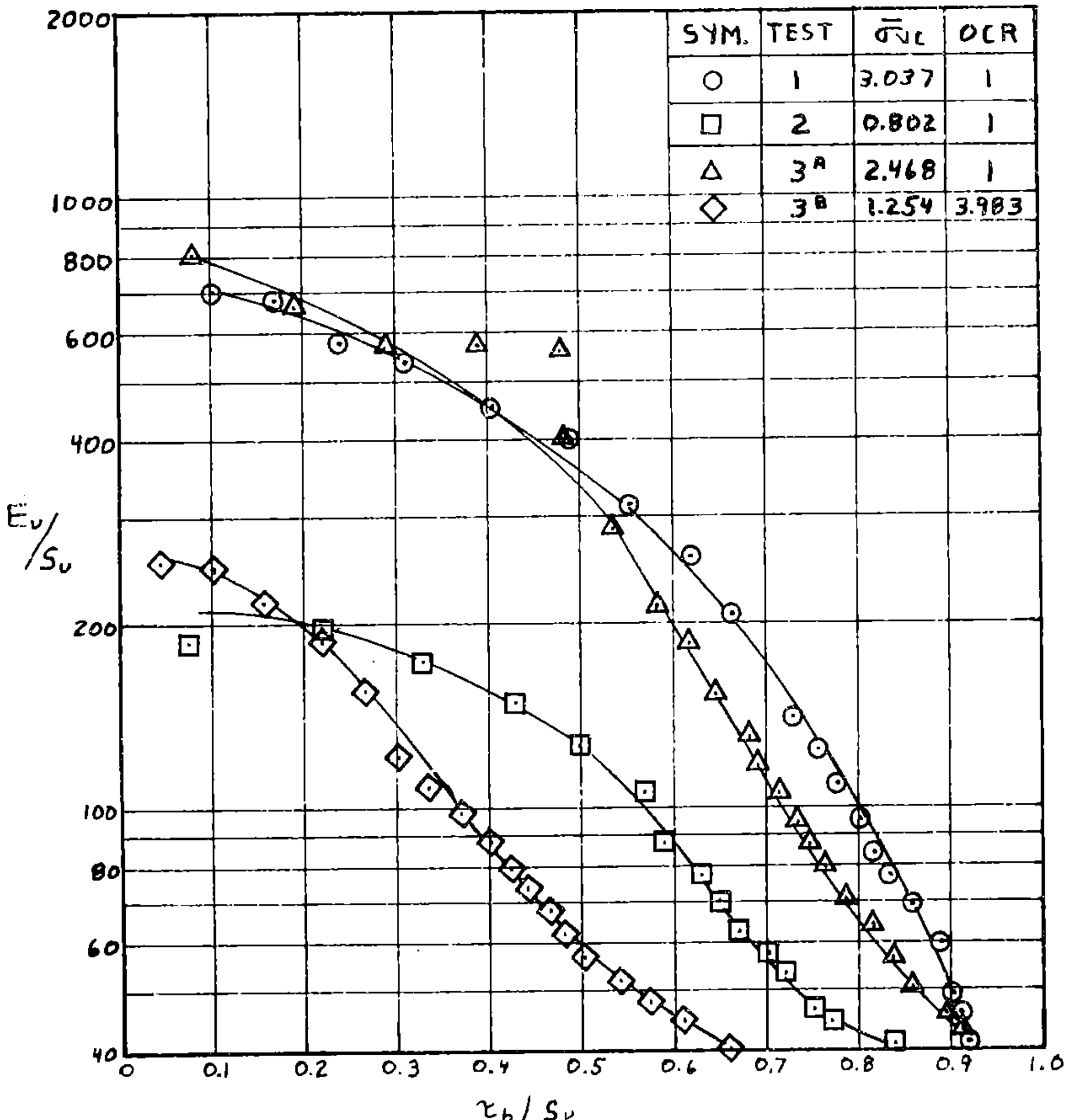
$\bar{\sigma}_{vc}$ = 1.254 KG/CM^2 OCR=3.983

FIGURE 6.12



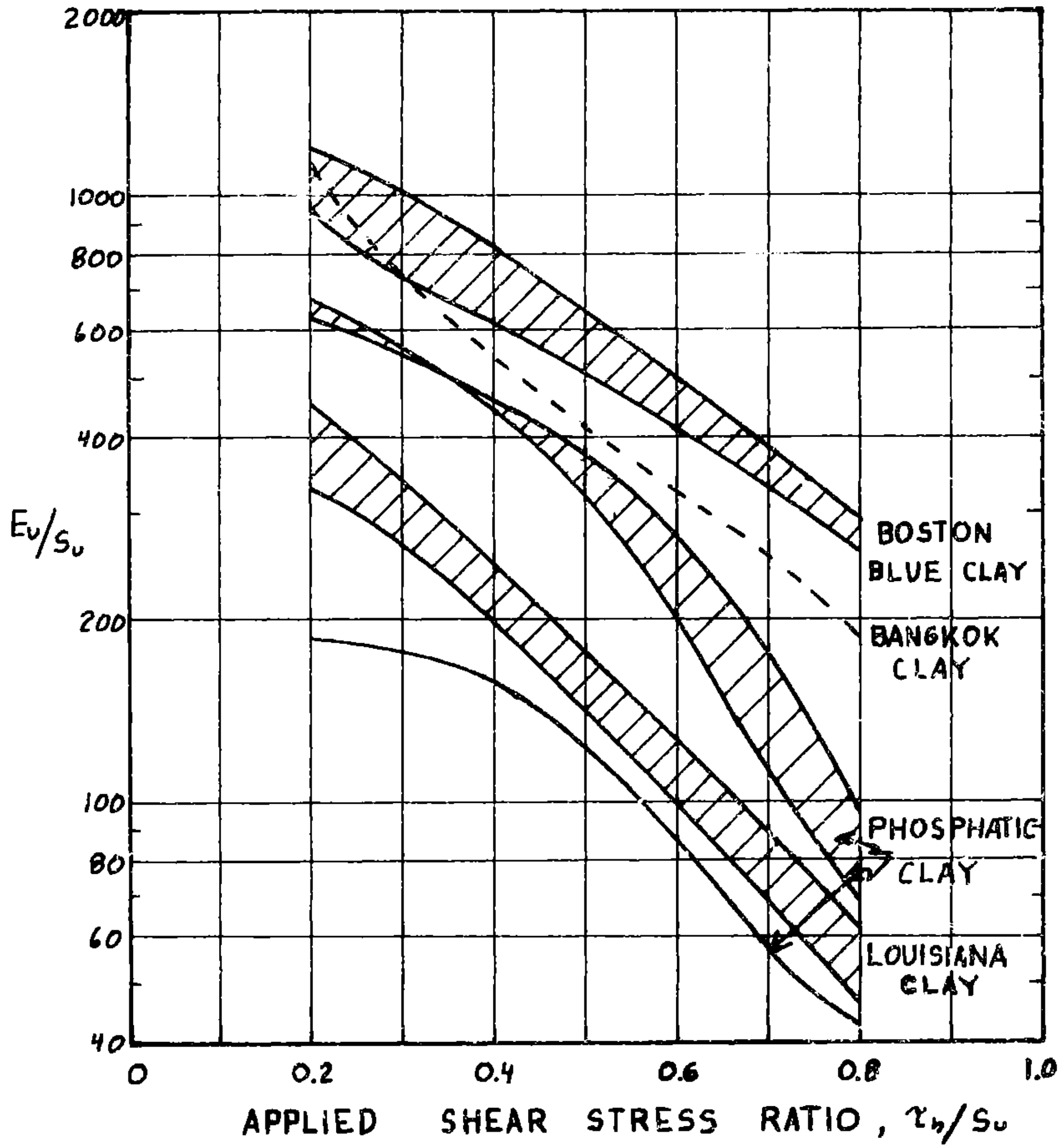
$S_u/\bar{\sigma}_{vc}$ VS OCR FROM CK_oU DSS TESTS

FIGURE 6.13



E_v/s_v VS APPLIED SHEAR STRESS RATIO FROM $\overline{CK_oU}$DSS TESTS

FIGURE 6.14



E_u/S_u VS. APPLIED SHEAR STRESS RATIO FROM $\overline{CK_oU}DSS$ TESTS

(DATA ON OTHER CLAYS FROM LADD + EDGERS, 1972)

FIGURE 6.15

CHAPTER 7 SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

One of the major problems associated with phosphate mining is the disposal of a very plastic clay (P.I.=70 to 190 per cent) that is part of the mined material. The clay comes as slurry from the processing plant at 3 to 5 per cent solids content and is disposed of in a previously mined area. Because the volume of slurry pumped back into a mined area is much greater than the initial volume of raw material removed, the necessity arises to build dams around the periphery of the mined area to contain the slurry. The slurry exhibits extremely slow consolidation characteristics and requires many tens of years to reach a state where the land may be reclaimed. Although 85 per cent of the water used in the overall mining operation is recirculated, many millions of gallons remain in the settling ponds, thereby placing a burden on Florida's water supply. Research was initiated to develop an economical process whereby the clay slurry may be disposed of and returned to the original volume occupied by the raw material within five years without requiring the construction of dams.

In order to better define the engineering properties of Florida phosphatic clay slurries, a laboratory program was initiated at M.I.T. An eight inch diameter consolidometer was especially designed and built for consolidation-permeability tests. After consolidation to about 1.5 kg/cm^2, samples were trimmed from the large consolidation unit for constant rate of strain (CRSC) consolidation tests and K_0 consolidated-undrained direct-simple shear ($\overline{CK_0UDSS}$) tests. Also, a slightly smaller container was used for consolidation tests using seepage forces. Sedimentation tests were performed on several slurries with concentration, height and diameter of containers used as variables. Engineering tests were run on six laboratory prepared clay slurries (four untreated and two flocculated) and on a block sample of a flocculated clay taken from a field test site in Florida. The engineering tests were supplemented by specific gravity and Atterberg Limits tests.

Tables 5.2, 5.4, 5.6 5.8, 5.10, and 5.12 present a summary of results from the four consolidation and two seepage tests performed. Figure 5.1 summarizes void ratio versus log consolidation stress data. Most discrepancies in void ratio occur at lower stresses. For the seepage forces, a uniform stress distribution from zero at the top of the soil to a maximum at the bottom of the soil-top of porous stone interface was assumed. This is quite probably not the case with the exact distribution being unknown. A problem that developed during the application of seepage forces was that the higher the seepage force, the more the sides of the slurry would pull away from the sides of the consolidometer, with the maximum amount being about 5 mm at the top tapering to zero somewhere near the bottom. With the application of piston loads, the slurry was pressed against the sides of the consolidometer. After the piston forces were applied, quite consistent compressibility results were attained.

A summary of the coefficient of consolidation, c_v, versus effective stress, $\bar{\sigma}_v$, is presented in Figure 5.3. With the exception of some scatter, particularly at low stresses, the coefficient of consolidation appears reasonably constant in Figure 5.3 at a value of about 1.8 x 10^{-4} cm^2/sec. This is shown through four orders of magnitude of change in effective stress. Results of c_v from the square root method and the log fitting method agree quite well.

All consolidation and seepage tests were conducted in a "constant temperature room", with the temperature being 70 degrees F ± 1 to 2 degrees F. Occasionally when trouble would arise with the air conditioning system, the temperature would rise considerably for a short period of time. When this problem arose, cooler tap water was occasionally substituted in the consolidometer to offset the higher room temperatures.

The permeability results are presented in Tables 5.1 through 5.12. A summary of measured results for the four consolidation tests are plotted in Figure 5.2. Calculated results from $k=c_v \gamma_w m_v$ generally tend to be slightly lower than measured. Values of permeability range from about 10^{-4} cm/sec at 10 per cent solids to about 10^{-7} cm/sec at 40 to 50 per cent solids.

From an experiment of slurry consolidating on sand, it appeared that when a very large head loss was suddenly applied to the slurry, a more highly consolidated "cake" of soil about 2 mm in thickness resulted at the top of sand-bottom of slurry interface. No cake was observed if small head losses was applied and incrementally increased by doubling the head loss to the same very large head loss.

Three pressure transducers were used throughout the consolidation tests. One was used for total stress measurements and two were used for pore-pressure measurements. While quantitative results could not be obtained because of zero reading fluctuations, it was possible to measure qualitative trends that showed an immediated pore pressure increase when higher loads were applied.

To find the effect of flocculation on phosphatic clays Dow Seperan MG-500 flocculant at 0.01 per cent solution was added to a slurry. The time for a slurry to consolidate under its own weight was decreased by at least an order of magnitude by the addition of a flocculant. When small seepage forces were applied however, the time for consolidation was generally increased by about two orders of magnitude. With larger seepage forces and piston loads, the time for consolidation was not changed significantly. In all cases, the amount of consolidation from a load increment, whether flocculated or not, was not appreciably changed, as can be noted from Figure 5.1.

Figures 5.16 through 5.26 present results from five Constant Rate of Strain Consolidation, CRSC, tests. Very consistent results were obtained for the tests, with a void ratio of 1.6 to 1.7 at a stress of 10,000 gm/cm^2. The values of c_v for the normally consolidated soil range from about 1 x 10^{-4} to 3 x 10^{-4} cm^2/sec, which agree reasonably well with c_v data obtained from the large-diameter consolidometer tests.

From the sedimentation tests, it would seem that there is no straightforward answer as to the question of what is the maximum per cent solids at which sedimentation can occur, and that it will vary from slurry to slurry. Generally speaking, it appears that sedimentation will not occur over about 8 per cent solids. At an initial solids content of 7.46 per cent and a height of 103.10 cm, sedimentation occurs at a maximum rate of 0.026 cm/min.

Three K_o consolidated-undrained direct-simple shear tests were performed on samples upon completion of testing in the large-diameter consolidometer. The results are presented in Table 6.1 and Figures 6.1 through 6.18. The value of $s_u/\bar{\sigma}_{vc}$ ranged from 0.220 to 0.227 with E_u/s_u for two tests decreasing from about 800 to 40 as the stress level increased from 10 to 90 per cent of the undrained shear strength. One test on overconsolidated clay showed the same trends with increasing $s_u/\bar{\sigma}_{vc}$ with OCR as for other clays.

It is hoped that field tests being performed will provide information to correlate with the laboratory tests in order to aid in arriving at an economical solution of phosphatic clay slurry disposal.

REFERENCES

1. Bjerrum, L., and Landva, A., 1966, "Direct-Simple Shear Tests on a Norwegian Quick Clay", Geotechnique, Vol. No. 1, pp. 1-20.

2. Florida Phosphate Council, "Economics Fact Sheet, 1975".

3. Florida Phosphate Council, "Environmental Fact Sheet, 1975".

4. Florida Phosphate Council, "Phosphate", 1975.

5. Ladd, C.C. and L. Edgers, 1972, "Consolidated-Undrained Direct-simple Shear Tests on Saturated Clays", Department of Civil Engineering, Massachusetts Institute of Technology.

6. Michaels, A.S. and J. C. Bolger, "Settling Rates and Sediment Volumes of Flocculated Kaolin Suspensions", Ind. Eng. Chem. Fundamentals, Vol. 1 No. 1, Feb., 1962.

7. U.S. Bureau of Mines, "The Florida Phosphate Slimes Problem, A Review and Bibliography", 1975.

8. U.S. Geological Survey, "Geology and Geochemistry of the Bone Valley Formation and Its Phosphate Deposits, West Central Florida", Z.S. Altschuler, J.B. Cathcart, and E.J. Young, 1964.

9. Wissa, A.E.Z., Christian, J.T., Davis, E.H., and Heiberg, S., "Consolidation at Constant Rate of Strain", JSMFD, Oct., 1971, Sm 10.

APPENDIX A

NOTATION

Note: Prefix Δ indicates a change

A bar over a stress indicates an effective stress

1. STRESSES AND PRESSURES

u	Pore water pressure
σ	Total normal stress
$\bar{\sigma}$	Effective normal stress
$\bar{\sigma}_{vM}$	Maximum past pressure
τ	Shear stress

2. STRESS RATIOS

K_o	Coefficient of earth pressure at rest
OCR	Overconsolidation Ratio= $\bar{\sigma}_{vM}/\bar{\sigma}_{vc}$

3. STRENGTH PARAMETERS

$\bar{\phi}$	Friction angle of τ_{ff} vs. $\bar{\sigma}_{ff}$ envelope
ϕ	Arctan $\tau_h/\bar{\sigma}_v$ from $\bar{C}K_o$UDSS test
E	Young's secant modulus in terms of total stresses
E_u	E from an undrained test
s_u	Undrained shear strength

4. $\overline{CK_o}$UDSS — K_o consolidated undrained direct simple shear with pore pressure measurements

5. CONSOLIDATION

C_c	Virgin compression index
c_v	Coefficient of consolidation

NOTATION con't

NC	Normally consolidated
OC	Overconsolidated
CRSC	Constant rate of strain consolidation test

6. MISCELLANEOUS

e	Void ratio
e_o	Initial void ratio
G_s	Specific Gravity
t	Time
t_c	Consolidation time under last increment
t_p	Time required for primary consolidation
w	Water content
W	Weight
k	Permeability
m_v	Coefficient of volume change
h_l	Head loss
H	Height of sediment
s	Per cent solids
V	Volume
w_l	Liquid limit
w_p	Plastic limit
P.I.	Plasticity Index
γ_T	Total unit weight
S	Degree of saturation

APPENDIX - B

PROCEDURES FOR TESTING SLURRY IN LARGE-DIAMETER CONSOLIDOMETER

The following is the step by step procedure used in testing the slurry in the large-diameter consolidometer.

1. Thoroughly shake slurry in container as received from Florida.

2. If flocculant was used, add Dow Separan MG-500 flocculant at 0.01% solution to slurry, continuously stirring and adding flocculant until flocs formed.

3. Pour slurry into dish for water content determination.

4. Place de-aired transducers into place.

5. Pour slurry into consolidometer.

6. Start time.

7. Record solids settlement with time.

8. Start automatic data acquisition system for periodic readings of output voltage, total stress, pore pressure measurements, and thermisters - note that transducers had previously been calibrated.

9. Also take periodic readings of transducers using a voltmeter.

10. Allow slurry to settle under its own weight-note that bottom drain was closed in this increment, but in piston-loaded consolidometer, generally 4 to 6 ports were open for standpipes at various heights.

11. Set drain outlet for desired head loss.

12. Open drain valve at bottom to start seepage forces.

13. Start permeability measurements.

14. For 3rd and 4th consolidation and 2nd seepage tests, place constant water supply into operation - prior to this, water level was periodically adjusted - the constant water supply kept water level within ± 1.5 mm.

APPENDIX - B

(continued)

15. After consolidation at an increment, double the head loss for further consolidation.

16. With the exception of using transducers, the above steps were the same whether a consolidation or seepage test.

17. At the completion of seepage forces, place porous piston into operation and apply load to top of sample - loads are applied through a calibrated load cell - a head loss is maintained throughout piston loading.

18. At end of consolidation for an increment, piston loads are doubled for further consolidation.

19. At end of test, keep piston load applied while remove water from consolidometer.

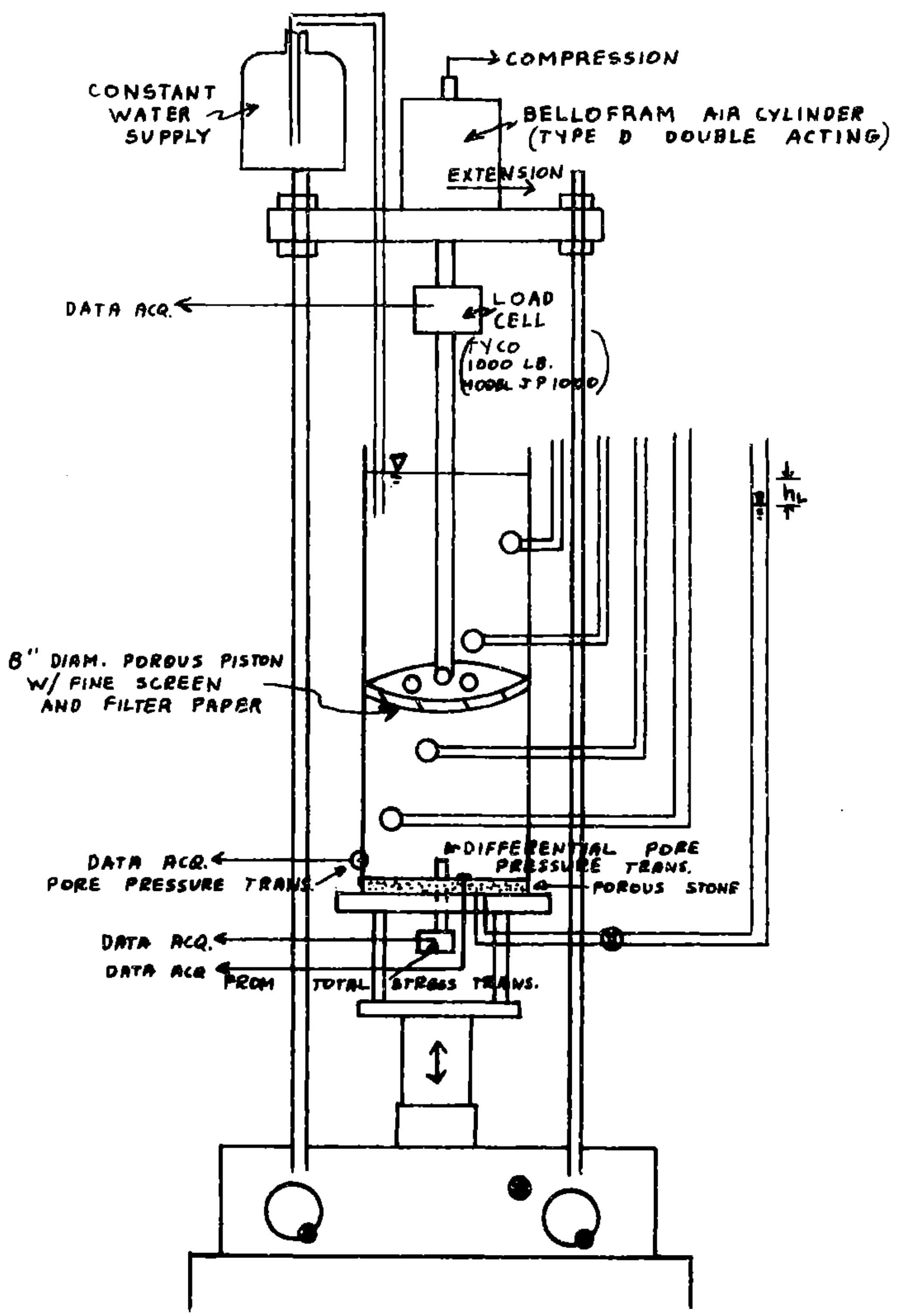
20. Remove piston load.

21. Remove cake of soil from consolidometer.

22. Immediately take representative water contents.

23. Store well-wrapped remaining sample in moist room for future use such as CRSC,DSS, and limits testing.

24. If there was a discrepancy between actual final water content and the final as calculated using the initial water content, the actual final was used to backfigure the actual initial water content, void ratio, and percent solids.



SCHEMATIC SKETCH of CONSOLIDOMETER WITH LOAD FRAME

FIGURE B.1

TYPICAL CALCULATIONS

USE CONSOL #4 AS AN EXAMPLE

INITIAL:

$$AREA = \frac{\pi D^2}{4} = \frac{3.14 \times (8'' \times 2.54)^2}{4} = 324.3\ cm^2$$

$H_0 = 28.0\ cm$ ∴ $VOL = 324.3 \times 28 = 9080\ cm^3$

SPEC. GRAV. = G = 2.73

FINAL:

FINAL AVG. WC = 105.5% (FROM END OF CONSOL. TEST)

$e_f = (G)\, wc_f$ ASSUMING $S = 100\%$

$= (2.73)(1.055)$

∴ $e_f = 2.88$ & $H_f = 3.42\ cm$ (FROM END OF CONSOL. TEST)

BACKFIGURE USING FINAL RESULTS:

$$\Delta e = \frac{(1+e_o)\Delta H}{H_o} = \frac{(1+e_o)(28-3.42)}{28}$$

$$(e_o - 2.88) = (1+e_o)(0.878)$$

$$\therefore e_o = 30.80$$

$G\,W = S\,e$ ∴ $WC_o = \frac{30.80}{2.73}$ & ASSUME $S=1$

$WC_o = 1128.2\%$

$$\therefore S_o = \frac{1}{1+wc} = \frac{1}{1+11.282} = 8.14\%$$

NOW: $W_s = 8.14\ W_T = 0.0814(W_s + W_v)$

$9080 = V_v + V_s$, ∴ $9080 - V_s = V_v$ & $V_v = W_v$

$W_s = 0.0814\, W_s + 0.0814\, W_v \rightarrow W_v = \frac{W_s - 0.0814\, W_s}{0.0814}$

& $2.73\ V_s = W_s \rightarrow V_s = \frac{W_s}{2.73}$

CON'T NEXT SHEET

TYPICAL CALCULATIONS CON'T

$$9080 - \frac{W_s}{2.73} = \frac{W_s - 0.0814\,W_s}{0.0814}$$

$$779.16 \text{ GMS} = W_s$$

$$\& \; V_s = \frac{779.16}{2.73} = 285.41 \text{ CM}^3$$

$$\therefore V_v = 9080 - 285.41 = 8794.59 \text{ CM}^3$$

$$\therefore e_o = \frac{8794.59}{285.41} = 30.81$$ & AGREES W/ PREVIOUS PAGE

$$\therefore W_T = 779.16 + 8794.59 = 9573.75$$

$$\therefore \gamma_T = \frac{9573.75}{9080} = 1.054 \text{ GM/CM}^3$$

$$\therefore \gamma_\ell = 0.054 \text{ GM/CM}^3$$

$$\bar{\sigma}_{V\ \text{BOTTOM}} = 28 \text{ CM} \times 0.054 \text{ GM/CM}^3 = 1.512 \text{ GM/CM}^2$$

$$\bar{\sigma}_{V\ \text{MID-HT}} = \tfrac{1}{2}(1.512) = 0.76 \text{ GM/CM}^2$$ = AVG. EFF. STRESS OF SOLIDS SETTLING UNDER THEIR OWN WEIGHT

TO CALCULATE PER CENT SOLIDS AS SLURRY CONSOLIDATES :

$$S_f = \frac{S_o}{1 - \left[\left(\frac{H_o - H_f}{H_o}\right)(1 - 0.63\,S_o)\right]}$$

SHEET 2 of 2

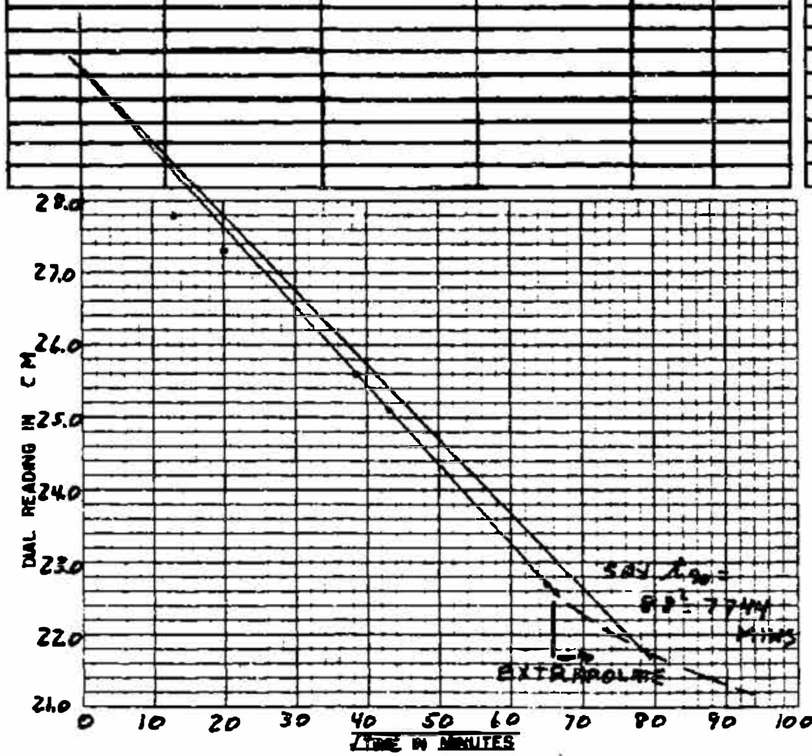
CONSOLIDATION TEST

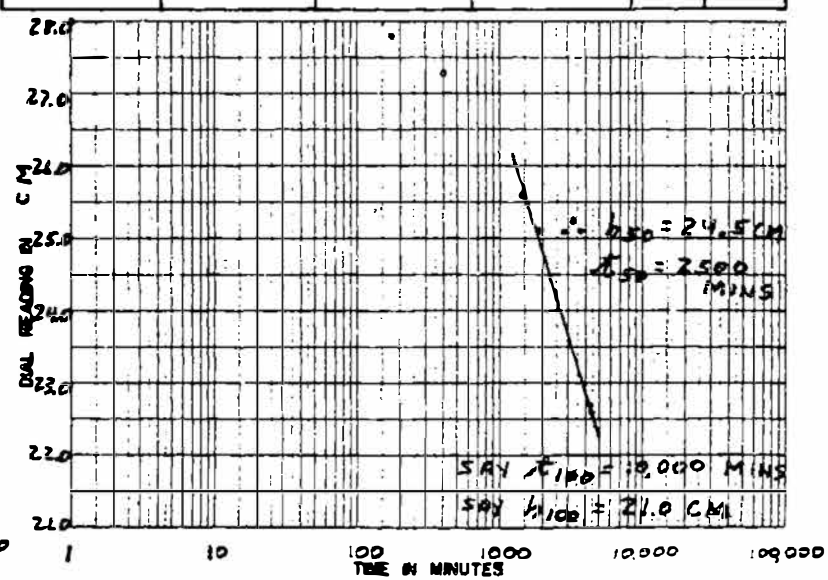
INCR. NO. 1

TEST NO. CONSOL #1 MOBIL 1/7 TESTED BY JRR PRESSURE INCREMENT FROM 0 kg/sq cm. TO 0.00077 kg/sq cm.

DATE	TIME	ELAPSED TIME, t IN min	$\sqrt{t}$ IN $\sqrt{min}$	COMPRESSION DIAL IN CM	
7 MAR	0935	0	0	28.05	7.96
	1220	175	13.23	27.80	8.01
	1605	400	20.00	27.30	8.15
8 "	1000	1475	38.40	25.60	8.66
	1645	1880	43.36	25.10	8.83
10 "	0745	4220	64.96	22.70	9.70
	1005	4360	66.03	22.60	9.74

DATE	TIME	ELAPSED TIME, t IN min	$\sqrt{t}$ IN $\sqrt{min}$	COMPRESSION DIAL IN CM	





APPENDIX C con't TABULATED DATA

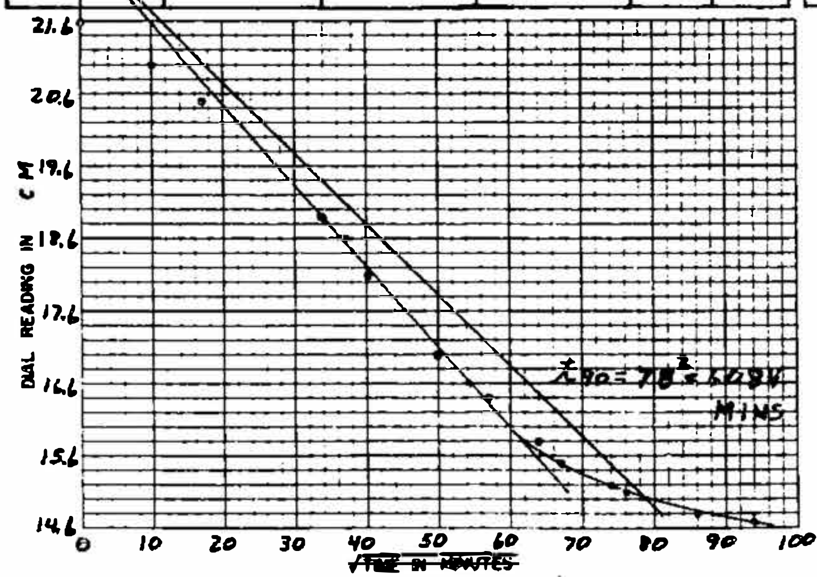
CONSOLIDATION TEST

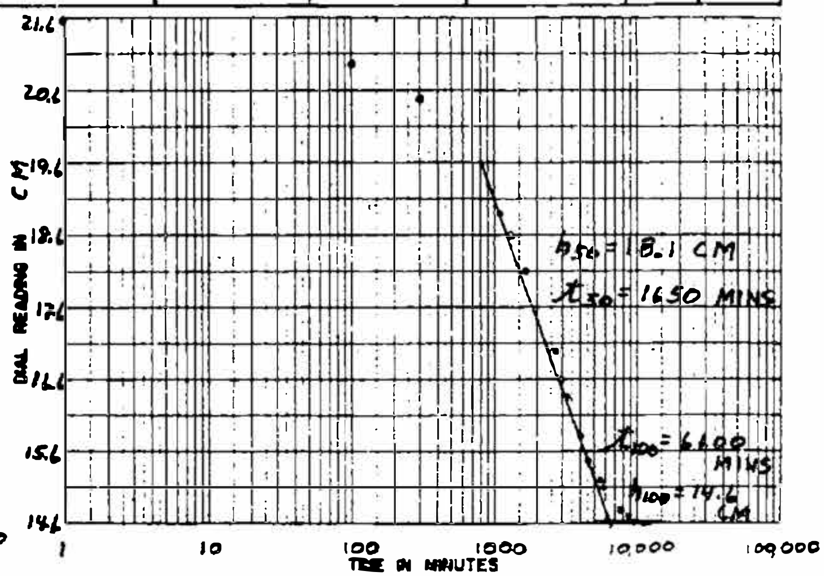
TEST NO. CONSOL #1 MOBIL #1 TESTED BY JRR PRESSURE INCREMENT FROM 0.00077 kg/sq. cm. TO 0.00402 kg/sq. cm.

INCR. NO. 2

DATE	TIME	ELAPSED TIME, t IN min	$\sqrt{t}$ IN $\sqrt{min}$	COMPRESSION DIAL IN CM
10 MAR	1300	0	0	21.60
	1445	105	10.25	21.00
	1800	300	17.32	20.50
11 "	0800	1140	33.76	18.90
	1145	1365	36.94	18.60
	1630	1650	40.62	18.10
12 "	0750	2570	50.70	17.00
	1415	2955	54.36	16.60
	1830	3210	56.66	16.40
13 "	0845	4065	63.76	15.80
	1545	4485	66.97	15.50
14 "	0810	5470	73.96	15.20
	1410	5830	76.35	15.10
15 "	1530	7350	85.73	14.80
16 "	1515	8775	93.67	14.70
17 "	0730	9750	98.74	14.60
	1810	10,390	101.93	14.60
18 "	0800	11220	105.92	14.60

DATE	TIME	ELAPSED TIME, t IN min	$\sqrt{t}$ IN $\sqrt{min}$	COMPRESSION DIAL IN CM





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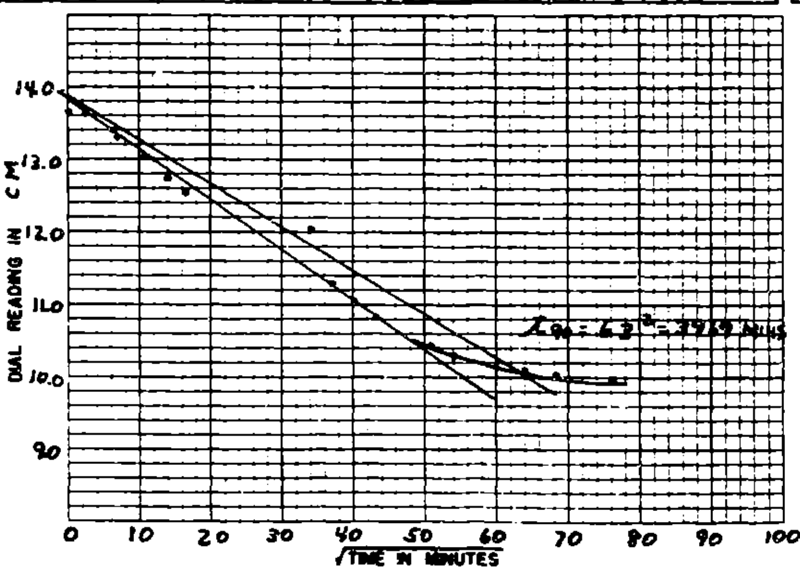
CONSOLIDATION TEST

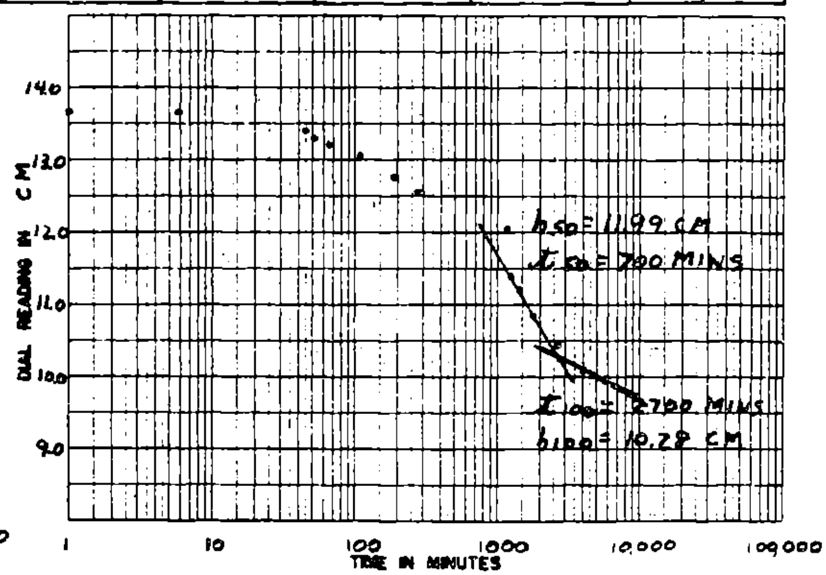
TEST NO. CONSOL #1 MOBIL #1 TESTED BY JRR PRESSURE INCREMENT FROM 0.00402 kg/sq. cm. TO 0.00852 kg/sq. cm.

INCR. NO. 3

DATE	TIME	ELAPSED TIME, t IN min	$\sqrt{t}$ IN $\sqrt{min}$	COMPRESSION DIAL IN CM
18 MAR	1220	0	0	13.65
	1226	6	2.45	13.65
	1304	44	6.63	13.40
	1311	51	7.14	13.30
	1320	60	7.74	13.30
	1325	65	8.06	13.28
	1410	110	10.49	13.05
	1537	197	14.04	12.25
	1655	275	16.58	12.55
19 MAR	0727	1147	33.87	12.05
	0804	1184	34.41	12.00
	0945	1285	35.85	11.40
	1100	1360	36.88	11.30
	1220	1440	37.95	11.20
	1314	1494	38.65	11.15
	1535	1635	40.43	11.05
	1900	1840	42.89	10.85
20 "	0800	2620	51.18	10.45
	1330	2950	54.31	10.32
21 "	0730	4030	63.48	10.10
	1845	4705	68.59	10.02
22 "	1215	5755	75.86	9.96

DATE	TIME	ELAPSED TIME, t IN min	$\sqrt{t}$ IN $\sqrt{min}$	COMPRESSION DIAL IN CM





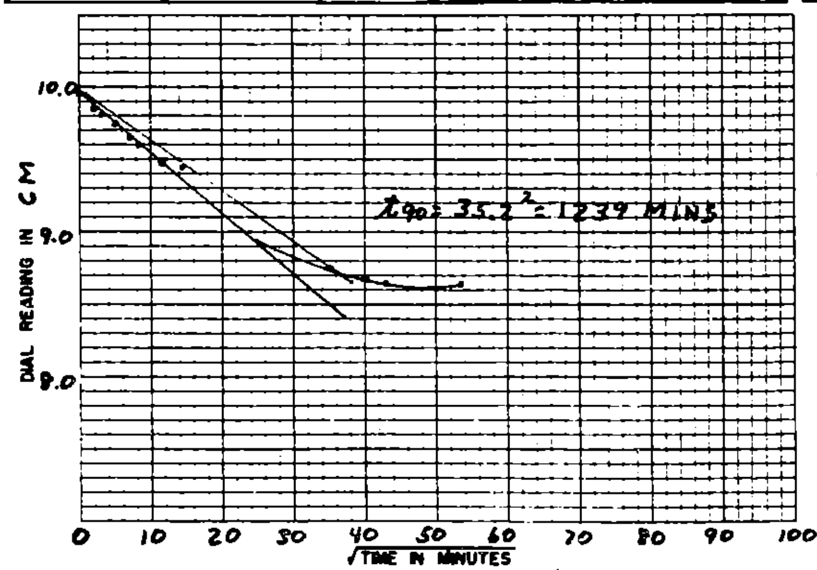
CONSOLIDATION TEST

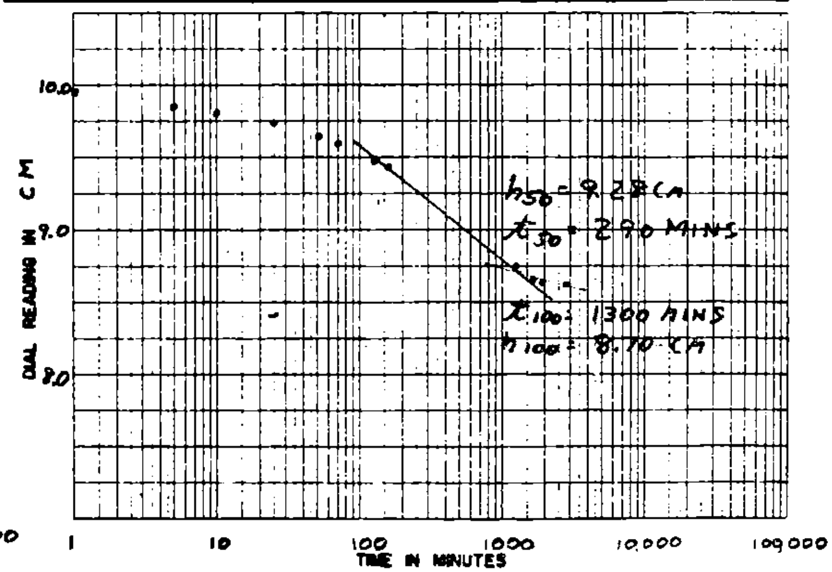
INCR. NO. 4

TEST NO. CONSOL #1 MOBIL #1 TESTED BY JRR PRESSURE INCREMENT FROM 0.00852 kg/sq. cm. TO 0.01252 kg/sq. cm.

DATE	TIME	ELAPSED TIME, t in min	$\sqrt{t}$ in $\sqrt{min}$	COMPRESSION DIAL IN CM	
22 MAR	1250	0	0	9.96	
	1255	5	2.24	9.85	
	1300	10	3.16	9.81	
	1315	25	5.00	9.74	
	1340	50	7.07	9.66	
	1400	70	8.37	9.60	
	1505	135	11.62	9.48	
	1530	160	12.65	9.44	
23 "	0954	1264	35.55	8.75	
	1550	1620	40.25	8.68	
24 "	0730	1890	43.47	8.65	
	1235	2865	53.52	8.65	

DATE	TIME	ELAPSED TIME, t in min	$\sqrt{t}$ in $\sqrt{min}$	COMPRESSION DIAL IN CM	





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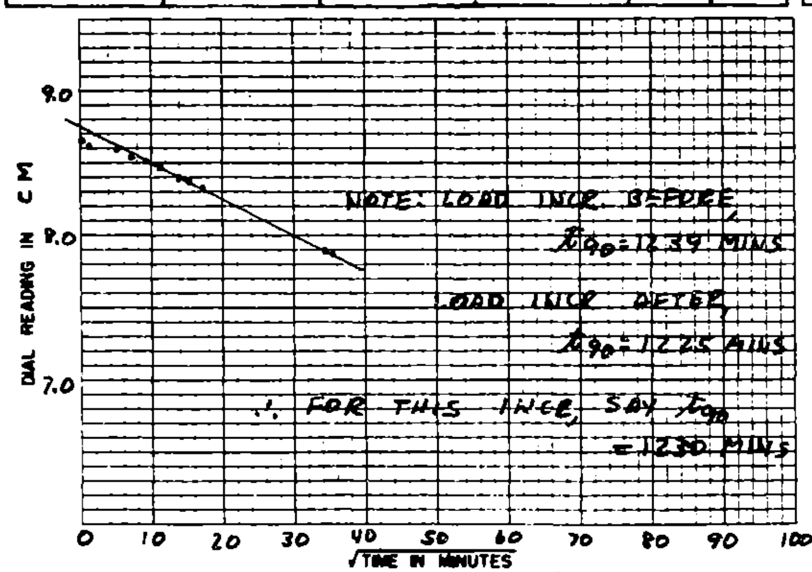
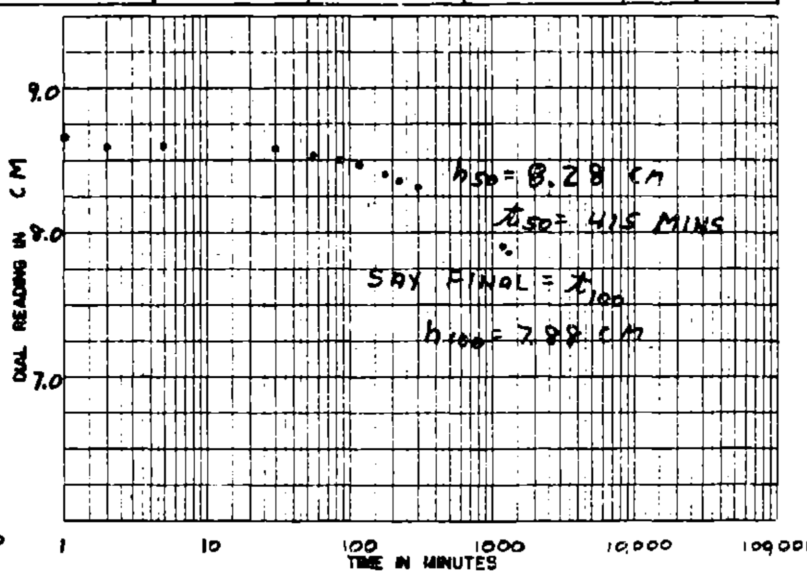
CONSOLIDATION TEST

TEST NO. CONSOL #1 MOBIL #1 TESTED BY JRR PRESSURE INCREMENT FROM 0.01252 kg/sq. cm. TO 0.01602 kg/sq. cm. INCR. NO. 5

DATE	TIME	ELAPSED TIME, t in min	$\sqrt{t}$ in $\sqrt{min}$	COMPRESSION DIAL in CM	
24 MAR	1235	0	0	8.65	
	1237	2	1.41	8.62	
	1240	5	2.24	8.61	
	1305	30	5.48	8.59	
	1330	55	7.42	8.54	
	1400	85	9.22	8.51	
	1430	115	10.72	8.48	
	1540	185	13.60	8.40	
	1625	235	15.33	8.38	
	1735	300	17.32	8.33	
25 "	0815	1180	34.35	7.90	
	0920	1245	35.28	7.88	

DATE	TIME	ELAPSED TIME, t in min	$\sqrt{t}$ in $\sqrt{min}$	COMPRESSION DIAL in CM	





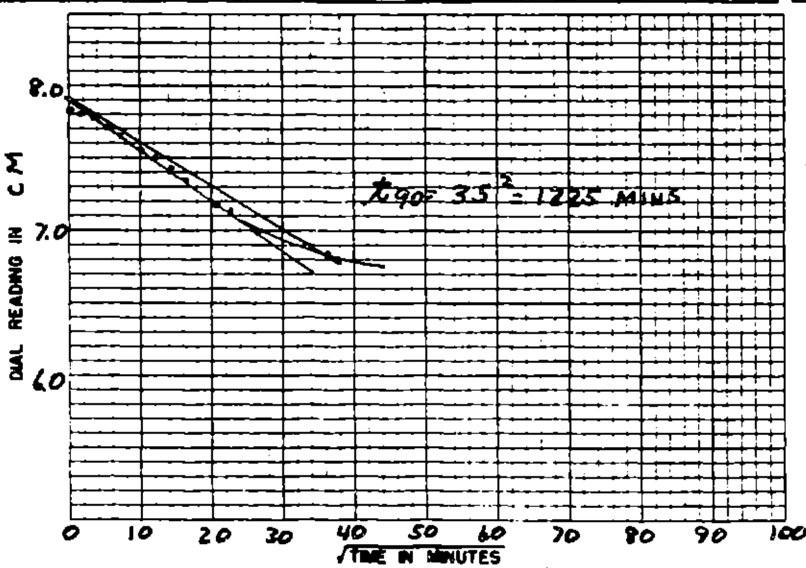
CONSOLIDATION TEST

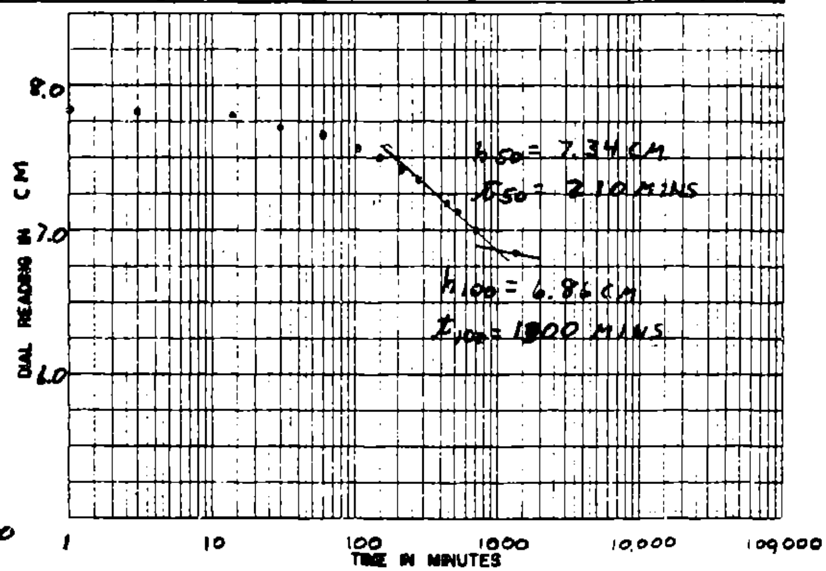
TEST NO. CONSOL #1 MOBIL #1 TESTED BY JRR PRESSURE INCREMENT INCR. NO. 6

FROM 0.01602 kg/sq. cm. TO 0.02572 kg/sq. cm.

DATE	TIME	ELAPSED TIME, t IN min	$\sqrt{t}$ IN $\sqrt{min}$	COMPRESSION DIAL IN CM	
25 MAR	0930	0	0	7.82	
	0931	1	1.00	782	
	0933	3	1.73	7.81	
	0944	14	3.74	7.79	
	1000	30	5.48	7.72	
	1030	60	7.74	7.66	
	1115	105	10.25	7.56	
	1200	150	12.25	7.50	
	1255	205	14.32	7.42	
	1400	270	16.43	7.34	
	1640	430	20.74	7.19	
	1800	510	22.58	7.13	
	2109	699	26.44	700	
26 "	0745	1335	36.54	6.85	
	0920	1430	37.82	6.82	

DATE	TIME	ELAPSED TIME, t IN min	$\sqrt{t}$ IN $\sqrt{min}$	COMPRESSION DIAL IN CM	



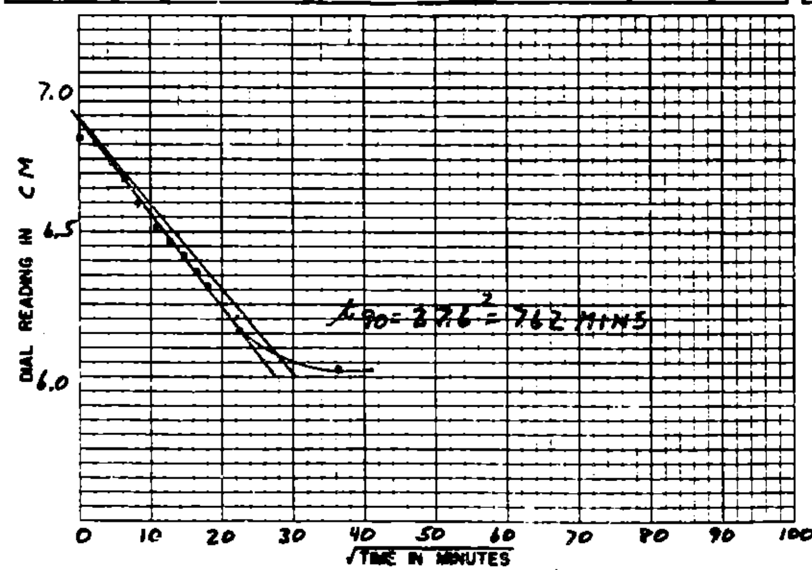


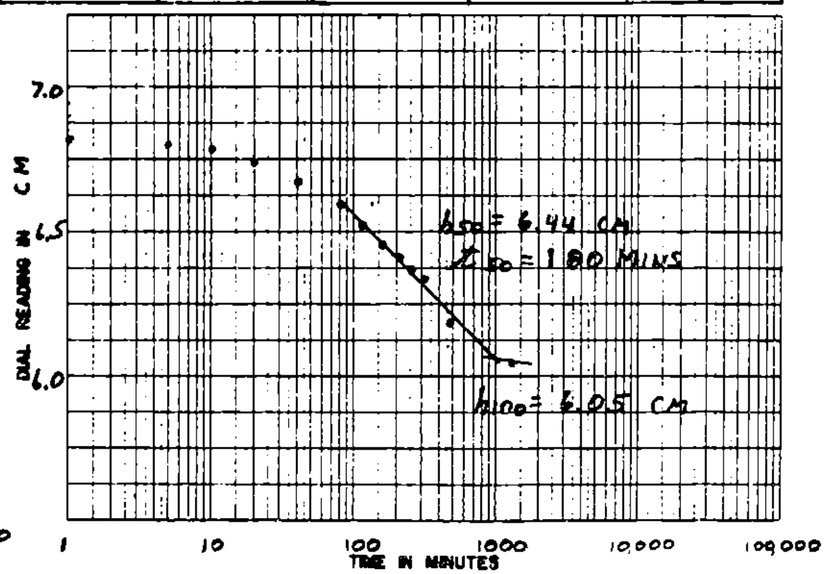
CONSOLIDATION TEST

TEST NO. CONSOL #1 MOBIL #1 TESTED BY JRR PRESSURE INCREMENT FROM 0.02572 kg/sq. cm. TO 0.04292 kg/sq. cm.

INCR. NO. 7

DATE	TIME	ELAPSED TIME, t in min	$\sqrt{t}$ in $\sqrt{min}$	COMPRESSION DIAL IN CM
26 "	0920	0	0	6.82
	0922	2	1.41	6.82
	0925	5	2.24	6.81
	0930	10	3.16	6.79
	0940	20	4.47	6.74
	1000	40	6.32	6.68
	1025	65	8.06	6.60
	1115	115	10.72	6.52
	1200	160	12.65	6.47
	1245	205	14.32	6.42
	1335	255	15.97	6.36
	1430	310	17.61	6.31
	1725	485	22.02	6.16
27 "	0725	1325	36.40	6.03



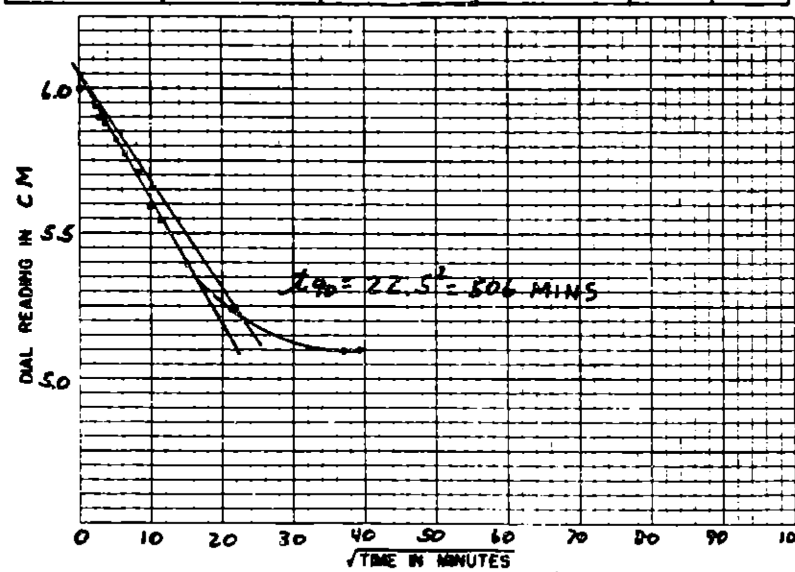


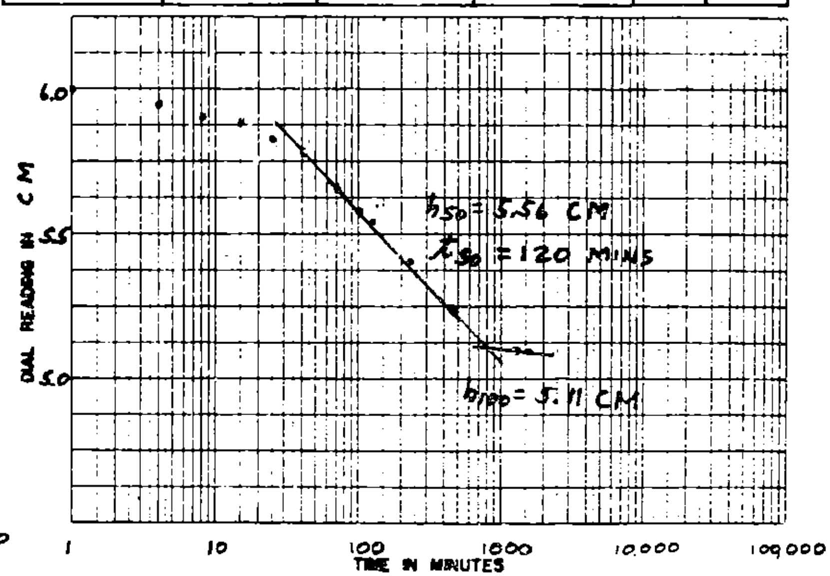
CONSOLIDATION TEST

TEST NO. CONSOL #1 MOBIL #1 TESTED BY JPR PRESSURE INCREMENT FROM 0.04292 kg/sq cm. TO 0.08272 kg/sq cm. INCR. NO. 8

DATE	TIME	ELAPSED TIME, t in min	$\sqrt{t}$ in $\sqrt{min}$	COMPRESSION DIAL in CM	
27 MAR	0920	0	0	6.00	
	0924	4	2.00	5.94	
	0928	8	2.83	5.90	
	0935	15	3.87	5.88	
	0945	25	5.00	5.82	
	1000	40	6.32	5.77	
	1030	70	8.37	5.66	
	1100	100	10.00	5.59	
	1130	130	11.40	5.54	
	1310	230	15.16	5.40	
	1655	455	21.33	5.24	
28 MAR	0815	1375	37.08	5.10	
	1100	1540	39.24	5.10	

DATE	TIME	ELAPSED TIME, t in min	$\sqrt{t}$ in $\sqrt{min}$	COMPRESSION DIAL in CM	





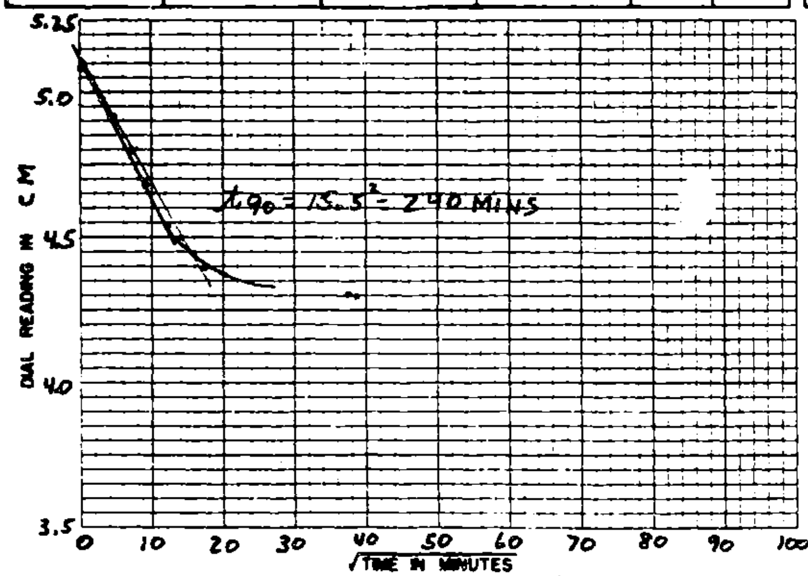
CONSOLIDATION TEST

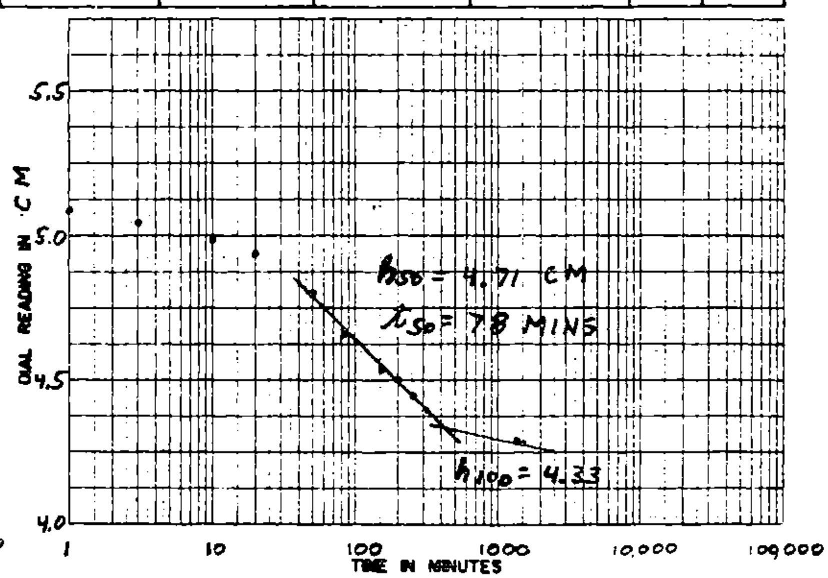
INCR. NO. 9

TEST NO. CONSOL #1 MOBIL #1 TESTED BY JPP PRESSURE INCREMENT FROM 0.08272 kg/sq. cm. TO 0.176 kg/sq. cm.

DATE	TIME	ELAPSED TIME, t IN min	$\sqrt{t}$ IN $\sqrt{min}$	COMPRESSION DIAL IN CM
28 MAR	1110	0	0	5.08
	1111	1	1.00	5.08
	1113	3	1.73	5.05
	1120	10	3.16	4.98
	1130	20	4.47	4.92
	1200	50	7.07	4.80
	1235	85	9.22	4.68
	1345	155	12.45	4.54
	1430	200	14.14	4.50
	1530	250	15.81	4.44
	1615	305	17.46	4.40
29 "	1030	1400	37.42	4.31
	1200	1490	38.60	4.30

DATE	TIME	ELAPSED TIME, t IN min	$\sqrt{t}$ IN $\sqrt{min}$	COMPRESSION DIAL IN CM

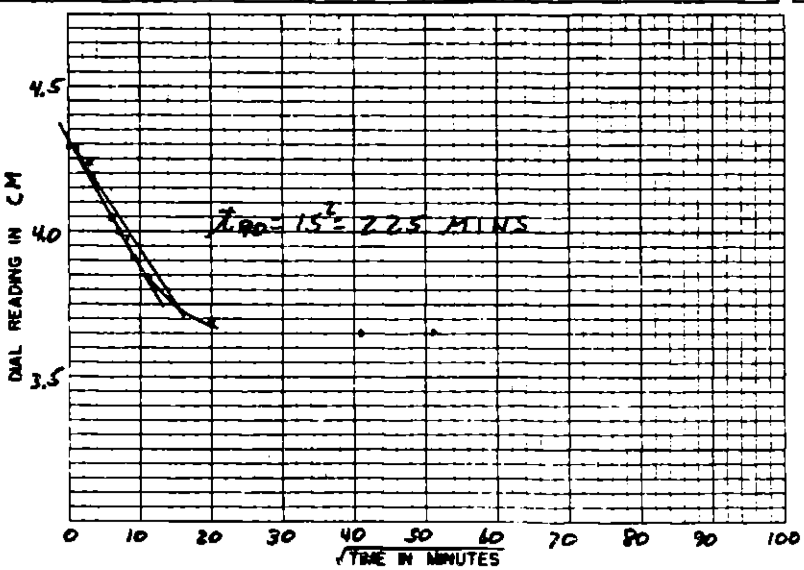


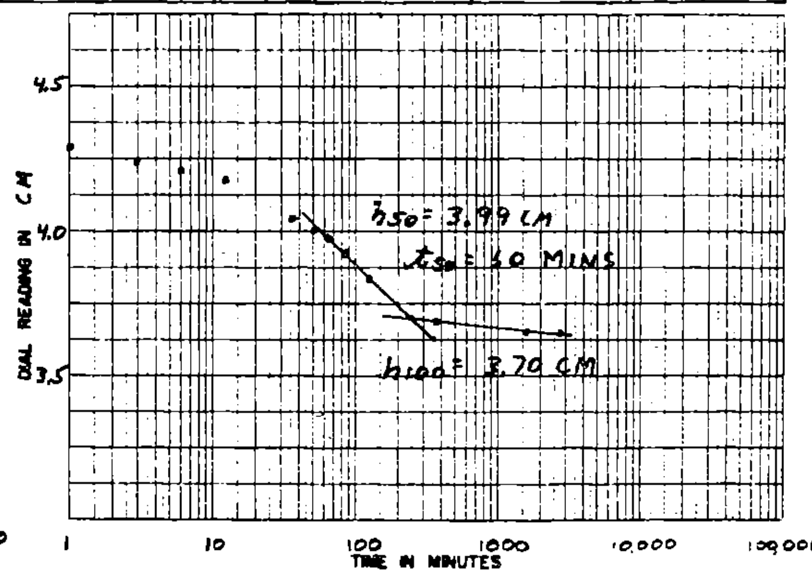


CONSOLIDATION TEST

TEST NO. CONSOL #1 MOBIL #1 TESTED BY JRR PRESSURE INCREMENT FROM 0.176 kg/sq. cm. TO 0.363 kg/sq. cm. INCR. NO. 10

DATE	TIME	ELAPSED TIME, t IN min	√t IN √min	COMPRESSION DIAL IN CM	
29 MAR	1205	0	0	4.29	
	1206	1	1.00	4.28	
	1208	3	1.73	4.24	
	1211	6	2.45	4.22	
	1218	13	3.61	4.18	
	1240	35	5.92	4.05	
	1255	50	7.07	4.01	
	1310	65	8.06	3.98	
	1322	77	8.77	3.92	
	1407	122	11.04	3.84	
	1830	385	19.62	3.69	
30 "	1615	1690	41.11	3.66	
31 "	0800	2635	51.33	3.66	



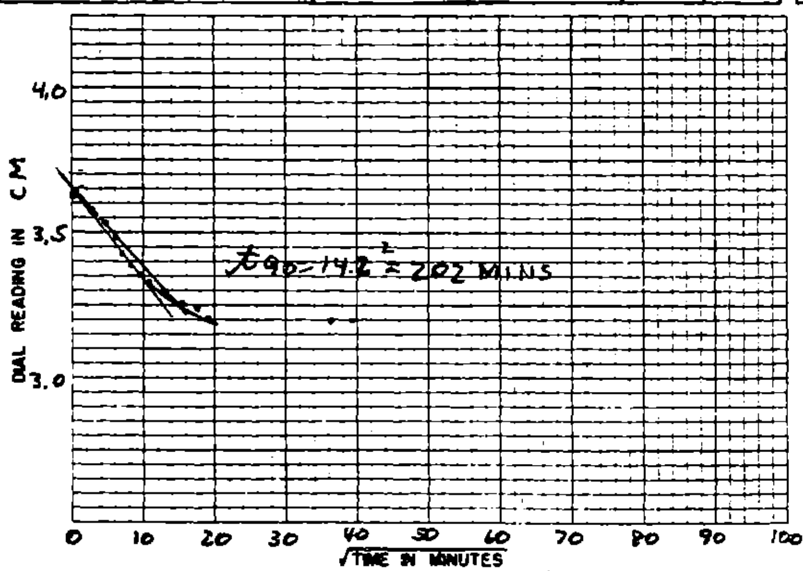


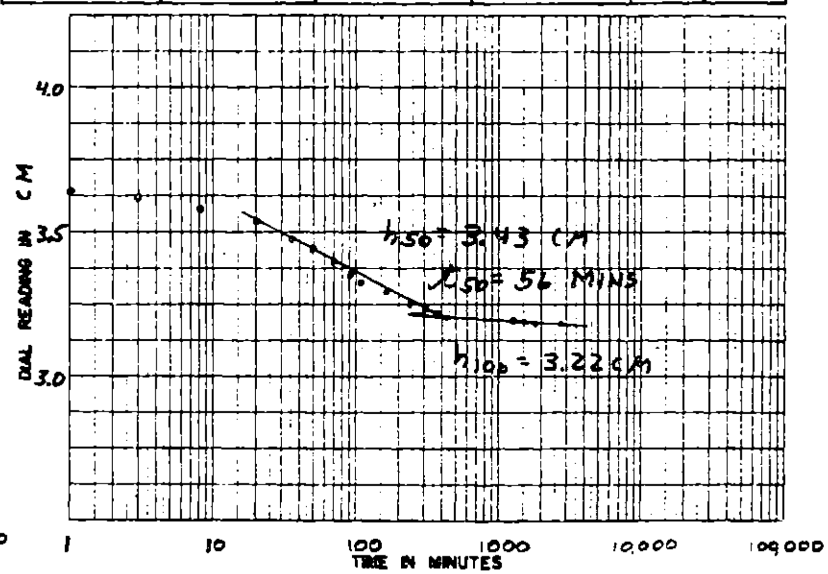
CONSOLIDATION TEST

TEST NO. CONSOL #1 MOBIL #1 TESTED BY JEP PRESSURE INCREMENT FROM 0.363 kg/sq. cm. TO 0.806 kg/sq. cm. INCR. NO. 11

DATE	TIME	ELAPSED TIME, t IN min	$\sqrt{t}$ IN $\sqrt{min}$	COMPRESSION DIAL IN CM	
31 MAR	1010	0	0	3.63	
	1011	1	1.00	3.63	
	1013	3	1.73	3.62	
	1018	8	2.83	3.58	
	1030	20	4.47	3.53	
	1045	35	5.92	3.48	
	1100	50	7.07	3.43	
	1120	70	8.37	3.39	
	1140	90	9.49	3.36	
	1200	110	10.49	3.33	
	1300	170	13.04	3.29	
	1410	240	15.49	3.26	
	1515	305	17.46	3.24	
	1615	365	19.10	3.22	
1 APR	0800	1310	36.19	3.20	
	1200	1550	39.37	3.20	
	1805	1855	43.07	3.20	
2 "	0800	2750	52.44	3.20	

DATE	TIME	ELAPSED TIME, t IN min	$\sqrt{t}$ IN $\sqrt{min}$	COMPRESSION DIAL IN CM	



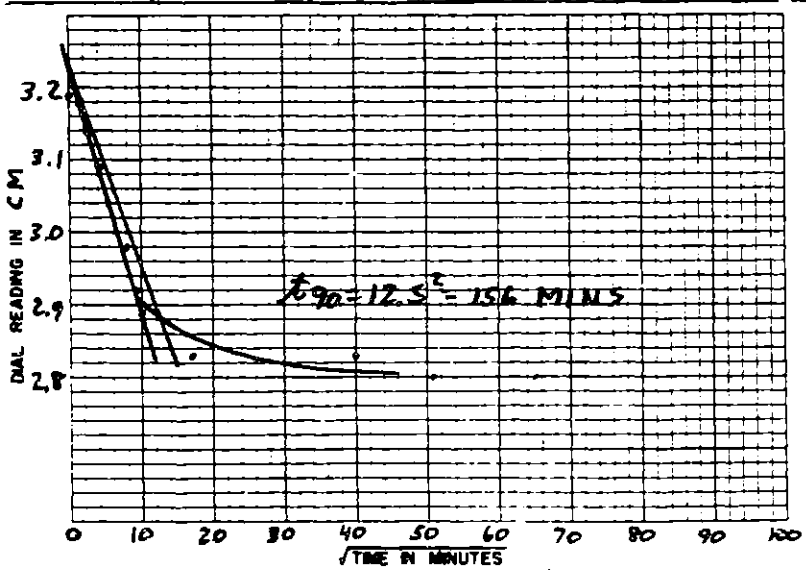


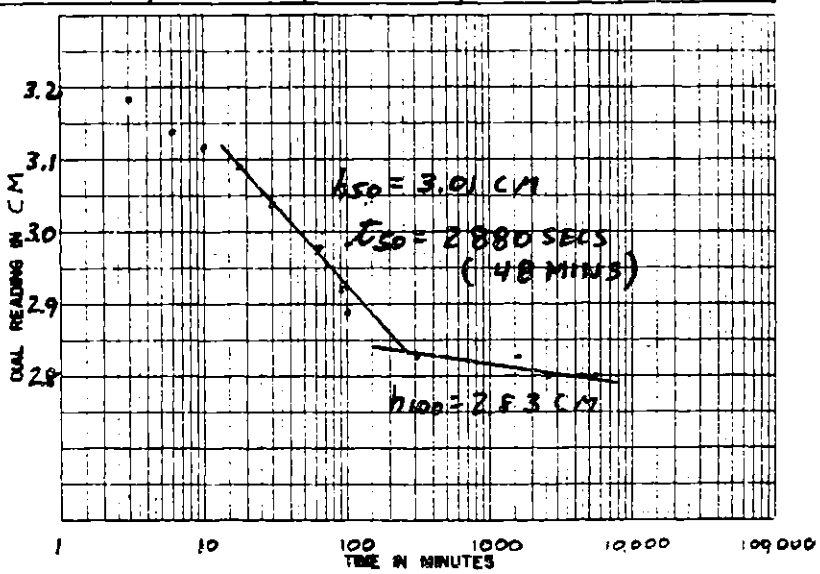
CONSOLIDATION TEST

TEST NO. CONSOL #1 MOBIL #1 TESTED BY JRR PRESSURE INCREMENT INCR. NO. 12

FROM 0.806 kg/sq. cm. TO 1.350 kg/sq. cm.

DATE	TIME	ELAPSED TIME, t IN min	$\sqrt{t}$ IN $\sqrt{min}$	COMPRESSION DIAL IN CM
2 APR	1130	0	0	3.19
	1131	1	1.00	3.19
	1133	3	1.73	3.18
	1136	6	2.45	3.14
	1140	10	3.16	3.12
	1148	18	4.24	3.09
	1200	30	5.48	3.04
	1233	63	7.94	2.98
	1300	90	9.49	2.92
	1410	100	10.00	2.89
	1635	305	17.46	2.83
3 "	1435	1625	40.31	2.83
4 "	0745	2655	51.53	2.80
5 "	1135	4325	65.76	2.80
7 "	0705	5495	74.13	2.80





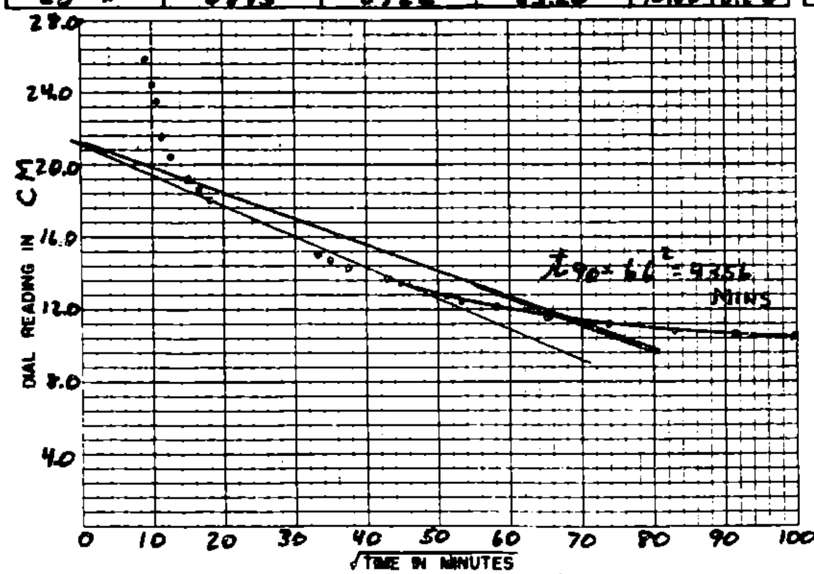
CONSOLIDATION TEST

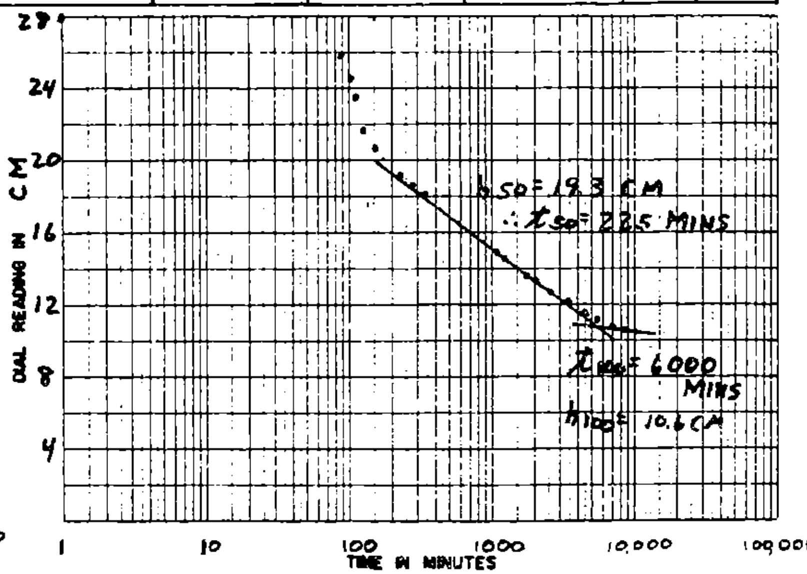
INCR. NO. 1

TEST NO. CONSOL #2 TESTED BY JRR PRESSURE INCREMENT
NORALYN #1 FROM 0 kg/sq cm TO 0.00032 kg/sq cm

DATE	TIME	ELAPSED TIME, t in min	$\sqrt{t}$ in $\sqrt{min}$	COMPRESSION DIAL in CM	
15 MAY	1323	0	0	28.0	3.52
	1450	87	9.33	25.8	
	1505	102	10.10	24.5	
	1513	110	10.49	23.50	
	1530	127	11.27	21.50	
	1600	157	12.53	20.60	
	1705	222	14.90	19.30	
	1800	277	16.64	18.70	
	1900	337	18.36	18.10	
16 "	0815	1132	33.64	15.00	
	1005	1242	35.24	14.70	
	1230	1387	37.24	14.40	
	2000	1837	42.86	13.70	
	2300	2017	44.91	13.40	7.18
17 "	0920	2637	51.35	12.70	
	1130	2767	52.60	12.60	
	1325	2882	53.68	12.45	
	2140	3377	58.11	12.10	
18 "	1330	4327	65.78	11.60	
19 "	0800	5437	73.74	11.20	
	1200	5677	75.34	11.10	
20 "	0845	6922	83.20	10.80	8.82

DATE	TIME	ELAPSED TIME, t in min	$\sqrt{t}$ in $\sqrt{min}$	COMPRESSION DIAL in CM	
21 MAY	0900	8377	91.52	10.60	
22 "	0945	9862	99.31	10.40	9.14





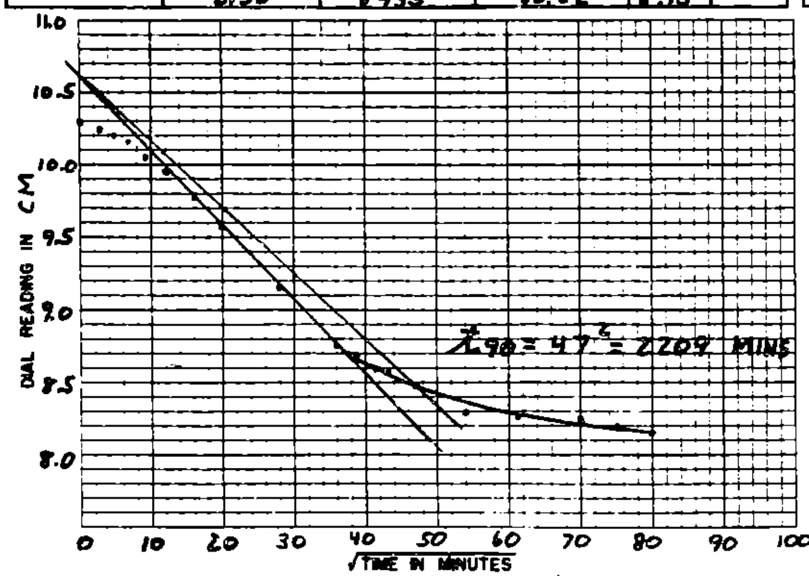
CONSOLIDATION TEST

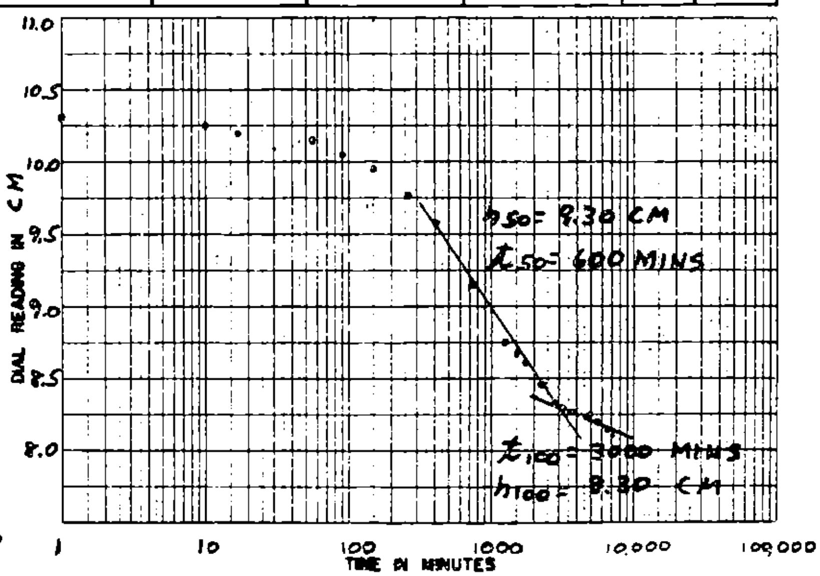
INCR. NO. 2

TEST NO. CONSOL #2 TESTED BY JRR PRESSURE INCREMENT
NORALYN #1
FROM 0.00032 kg/sq. cm. TO 0.00132 kg/sq. cm.

DATE	TIME	ELAPSED TIME, t in min	$\sqrt{t}$ in $\sqrt{min}$	COMPRESSION DIAL in CM
22 MAY	1015	0	0	10.30
	1025	10	3.16	10.26
	1037	27	5.20	10.20
	1110	55	7.42	10.17
	1145	90	9.49	10.06
	1245	150	12.25	9.95
	1435	260	16.12	9.78
	1655	400	20.00	9.58
	2320	785	28.02	9.15
23 "	0750	1295	35.99	8.75
	1135	1520	38.99	8.69
	1455	1720	41.47	8.60
	1700	1845	42.95	8.58
	2330	2235	47.28	8.48
24 "	0700	2685	51.82	8.30
	0920	2825	53.15	8.33
	1400	3105	55.72	8.30
25 "	0036	3741	61.16	8.28
	1945	4890	69.93	8.25
26 "	0750	5615	74.93	8.20
	1135	5840	76.42	8.19
	2130	6435	80.22	8.15

DATE	TIME	ELAPSED TIME, t in min	$\sqrt{t}$ in $\sqrt{min}$	COMPRESSION DIAL IN CM
27 MAY	0830	7095	84.85	8.12





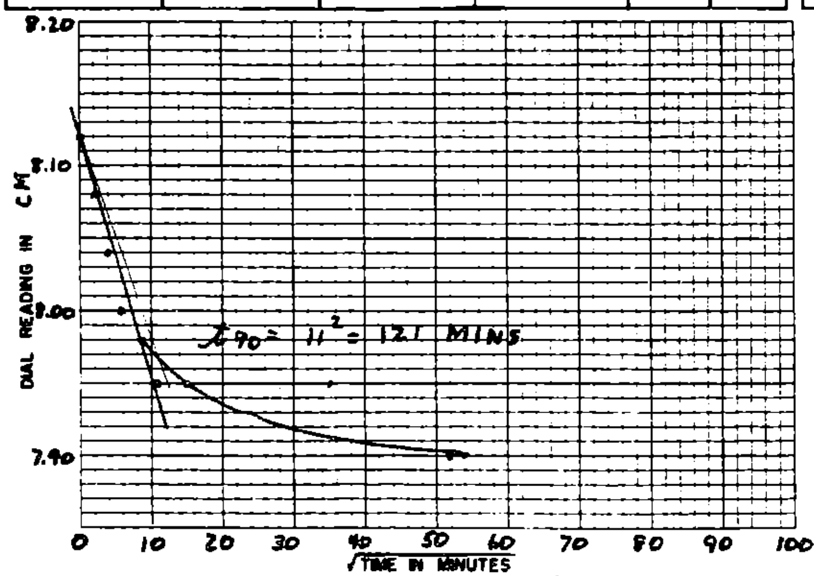
CONSOLIDATION TEST

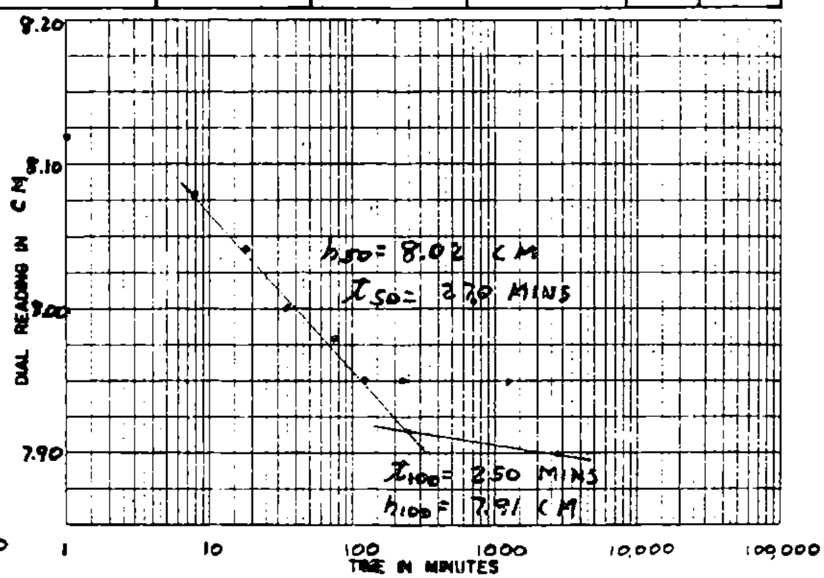
TEST NO. CONSOL #2 NORALYN #1 TESTED BY JRR PRESSURE INCREMENT FROM 0.00132 kg/sq. cm. TO 0.00382 kg/sq. cm.

INCR. NO. 3

DATE	TIME	ELAPSED TIME, t in min	$\sqrt{t}$ in $\sqrt{min}$	COMPRESSION DIAL in CM	
27 MAY	1130	0	0	8.12	
	1138	8	2.83	8.08	
	1148	18	4.24	8.04	
	1205	35	5.92	8.00	
	1245	75	8.66	7.98	
	1330	120	10.95	7.95	
	1510	220	14.83	7.95	
28 "	0815	1245	35.28	7.95	
29 "	0800	2670	51.67	7.90	
	1150	2900	53.85	7.90	

DATE	TIME	ELAPSED TIME, t in min	$\sqrt{t}$ in $\sqrt{min}$	COMPRESSION DIAL IN CM	





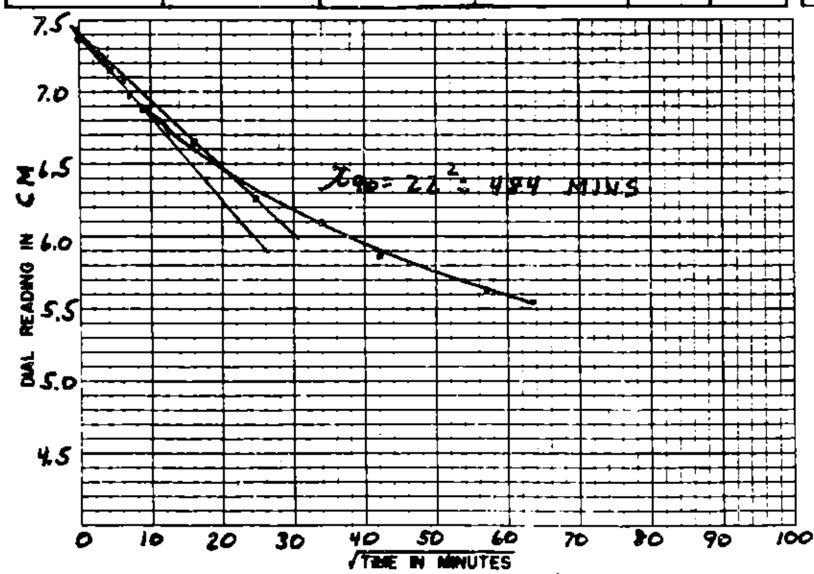
CONSOLIDATION TEST

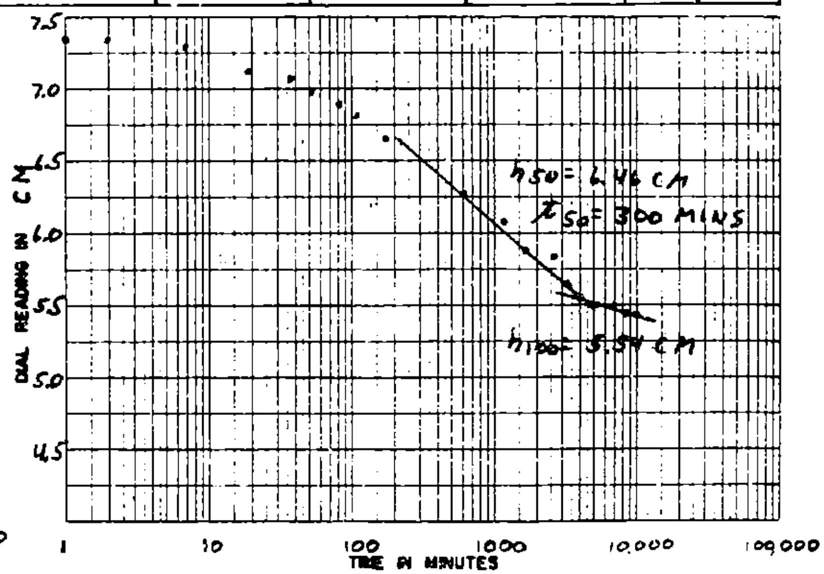
TEST NO. CONSOL #2 NORALYN #1 TESTED BY JRR PRESSURE INCREMENT INCR. NO. 4

FROM 0.00382 kg/sq cm. TO 0.00862 kg/sq cm.

DATE	TIME	ELAPSED TIME, t IN min	$\sqrt{t}$ IN $\sqrt{min}$	COMPRESSION DIAL IN CM	
29 MAY	1253	0	0	7.38	
	1255	2	1.41	7.34	
	1300	7	2.64	7.30	
	1312	19	4.36	7.16	
	1330	37	6.08	7.08	
	1345	52	7.21	6.97	
	1415	82	9.06	6.88	
	1445	112	10.58	6.80	
	1550	177	13.30	6.65	
	2300	607	2464	6.28	
30 "	0830	1177	3431	6.10	
	1100	1327	36.43	5.95	
	1700	1687	4407	5.88	
31 "	0900	2647	51.45	5.86	
	1900	3247	56.98	5.63	
1 JUN	0825	4052	63.65	5.56	
2 "	0815	5482	7404	5.50	
3 "	0810	6917	83.17	5.50	
4 "	0730	8317	91.20	5.46	
5 "	1240	10067	100.33	5.44	

DATE	TIME	ELAPSED TIME, t IN min	$\sqrt{t}$ IN $\sqrt{min}$	COMPRESSION DIAL IN CM	





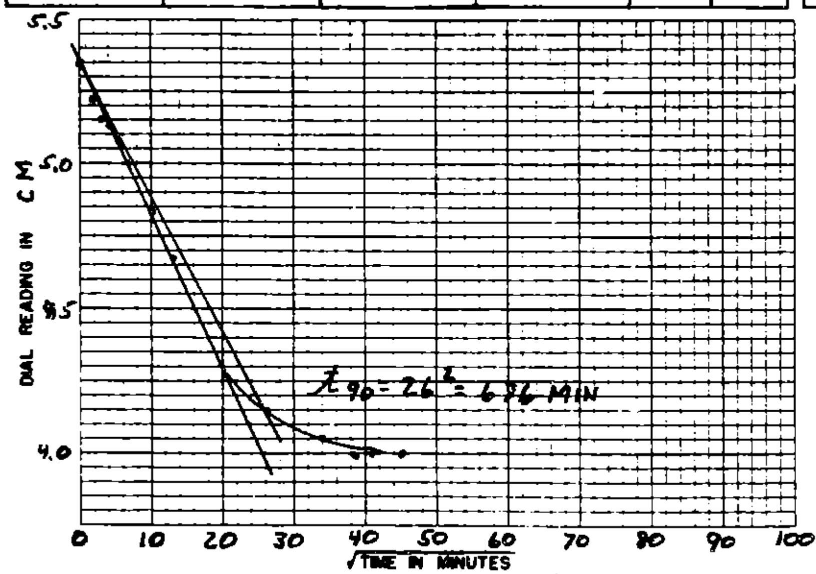
CONSOLIDATION TEST

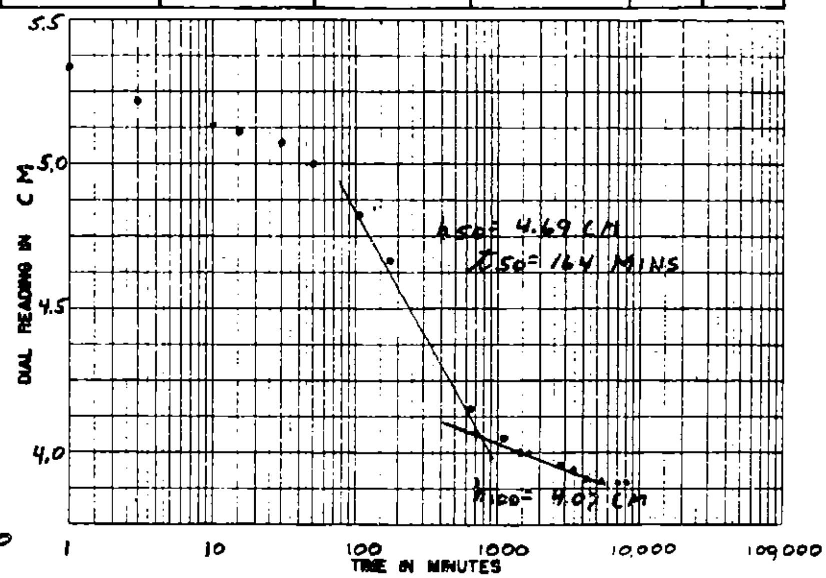
INCR. NO. 5

TEST NO. CONSOL #2 NORBLYN #1 TESTED BY ________ PRESSURE INCREMENT FROM 0.00862 kg/sq. cm. TO 0.01812 kg/sq. cm.

DATE	TIME	ELAPSED TIME, t IN min	$\sqrt{t}$ IN $\sqrt{min}$	COMPRESSION DIAL IN CM	
5 JUNE	1315	0	0	5.35	
	1318	3	1.73	5.22	
	1325	10	3.16	5.16	
	1331	16	4.00	5.13	
	1345	30	5.48	5.07	
	1405	50	7.07	5.00	
	1500	105	10.25	4.83	
	1610	175	13.23	4.7	
6 "	0030	675	25.98	4.15	
	0815	1140	33.76	4.05	
	1400	1485	38.54	4.00	
	1940	1705	41.29	4.00	
	2300	2025	45.00	4.00	
7 "	1152	2797	52.89	3.95	
	2330	3495	59.12	3.92	
8 "	1145	4230	65.04	3.90	
	2030	4755	68.96	3.90	
9 "	0810	5455	73.86	3.90	
10 "	0850	6935	83.28	3.90	
	1020	7025	83.82	3.90	

DATE	TIME	ELAPSED TIME, t IN min	$\sqrt{t}$ IN $\sqrt{min}$	COMPRESSION DIAL IN CM	





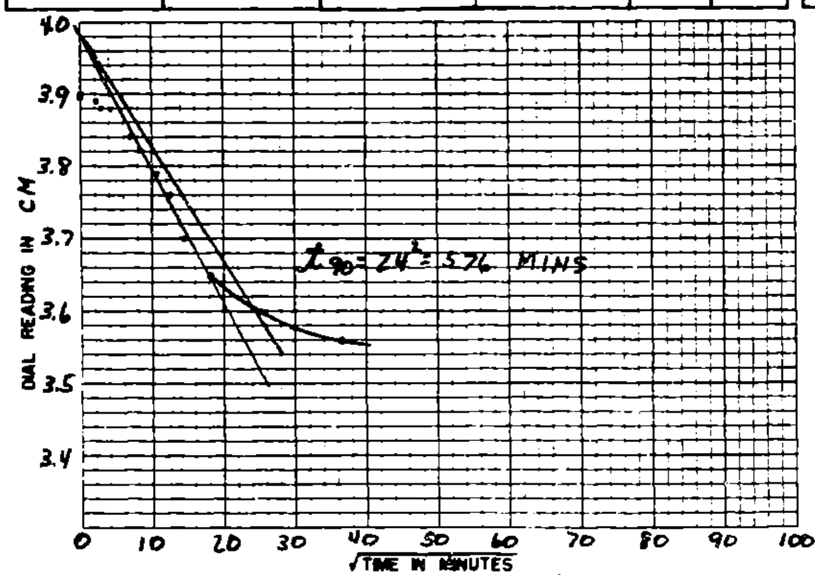
CONSOLIDATION TEST

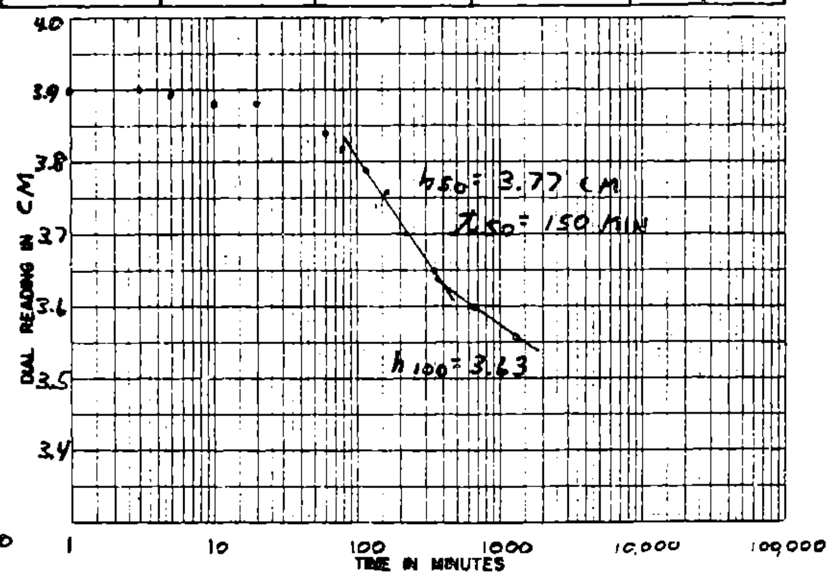
TEST NO. CONSOL #2 NORALYN #1 TESTED BY JRR PRESSURE INCREMENT INCR. NO. 6

FROM 0.01812 kg/sq. cm. TO 0.02842 kg/sq. cm.

DATE	TIME	ELAPSED TIME, t in min	$\sqrt{t}$ in $\sqrt{min}$	COMPRESSION DIAL in CM	
10 JUNE	1020	0	0	3.90	
	1023	3	1.73	3.90	
	1025	5	2.24	3.89	
	1030	10	3.16	3.88	
	1040	20	4.47	3.88	
	1120	60	7.74	3.84	
	1140	80	8.94	3.82	
	1220	120	10.95	3.79	
	1305	165	12.84	3.76	
	1400	220	14.83	3.70	
	1600	340	18.44	3.65	
	2115	655	25.59	3.60	
11 "	0845	1345	36.67	3.56	

DATE	TIME	ELAPSED TIME, t in min	$\sqrt{t}$ in $\sqrt{min}$	COMPRESSION DIAL in CM	





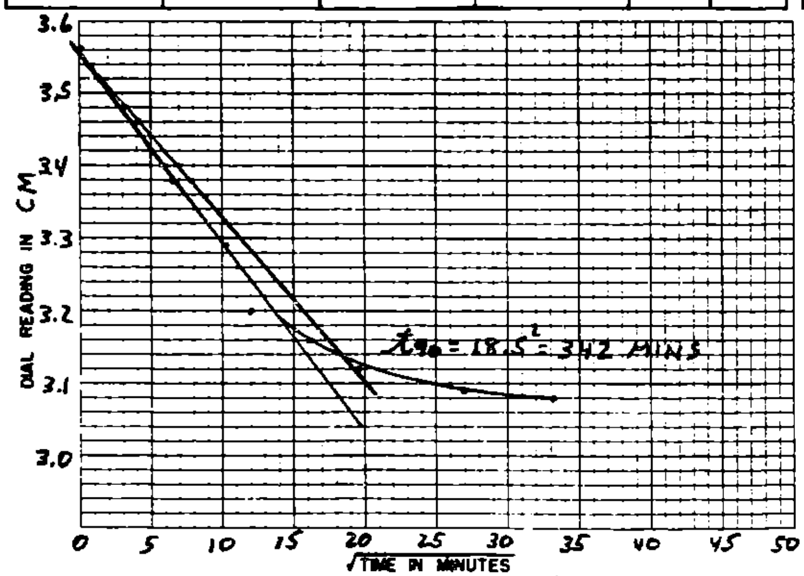
CONSOLIDATION TEST

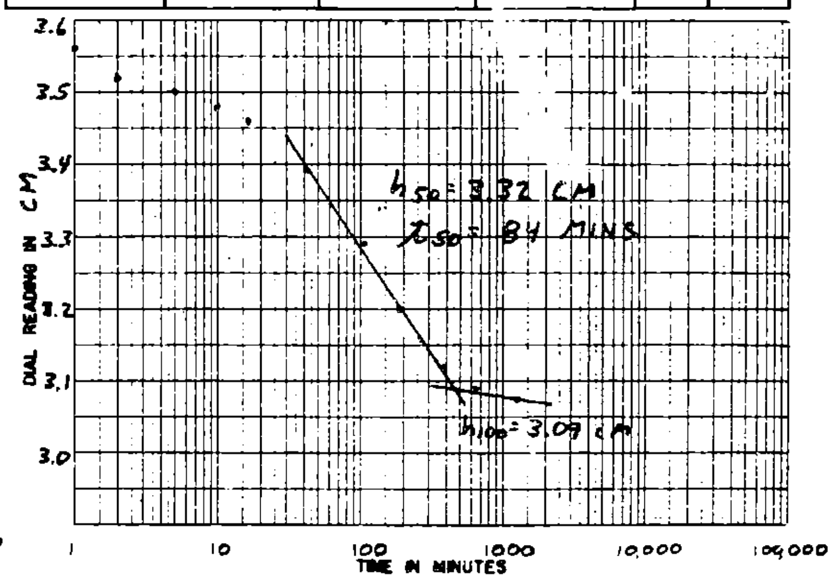
TEST NO. CONSOL # 2 NORALYN #1 TESTED BY J R R PRESSURE INCREMENT INCR. NO. 7

FROM 0.02842 kg/sq. cm. TO 0.04832 kg/sq. cm.

DATE	TIME	ELAPSED TIME, t in min	$\sqrt{t}$ in $\sqrt{min}$	COMPRESSION DIAL in CM	
11 JUNE	1000	0	0	3.56	
	1002	2	1.41	3.52	
	1005	5	2.24	3.50	
	1010	10	3.16	3.48	
	1016	16	4.00	3.46	
	1042	42	6.48	3.39	
	1145	105	10.25	3.29	
	1315	195	13.96	3.20	
	1420	260	16.12	3.16	
	1630	390	19.75	3.12	
	2220	740	27.20	3.09	
12 "	0800	1320	36.33	3.08	

DATE	TIME	ELAPSED TIME, t in min	$\sqrt{t}$ in $\sqrt{min}$	COMPRESSION DIAL in CM	





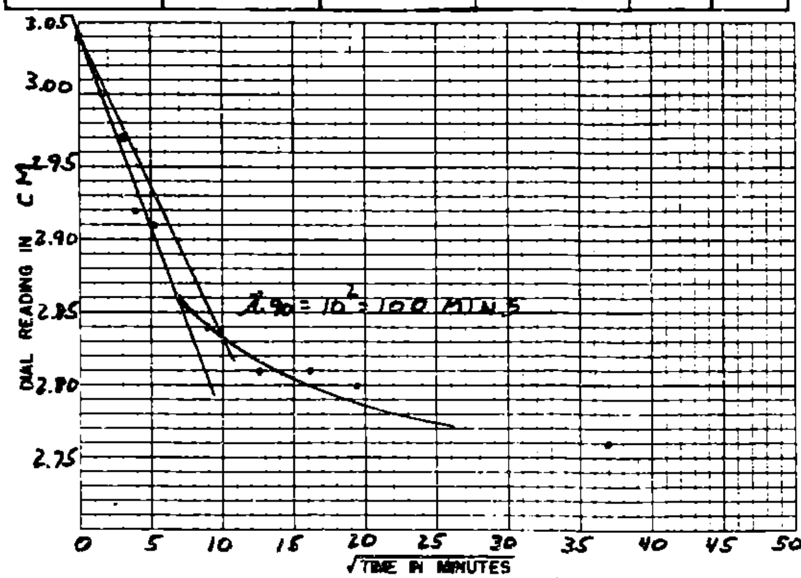
CONSOLIDATION TEST

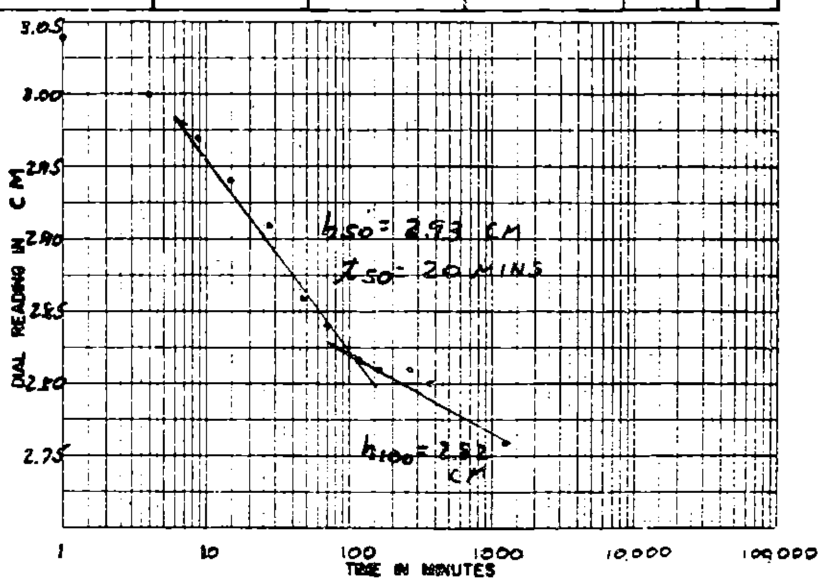
INCR. NO. 8

TEST NO. CONSOL #2 TESTED BY JRR PRESSURE INCREMENT
NORALYN #1
FROM 0.04832 kg/sq. cm. TO 0.08822 kg/sq. cm.

DATE	TIME	ELAPSED TIME, t in min	$\sqrt{t}$ in $\sqrt{min}$	COMPRESSION DIAL in CM	
12 JUN	0905	0	0	3.04	
	0908	3	1.73	3.00	
	0914	9	3.00	2.97	
	0920	15	3.87	2.94	
	0932	27	5.20	2.91	
	0953	48	6.93	2.86	
	1024	79	8.89	2.84	
	1145	160	12.65	2.81	
	1330	265	16.28	2.81	
	1530	385	19.62	2.80	
13 JUN	0750	1365	36.94	2.76	

DATE	TIME	ELAPSED TIME, t in min	$\sqrt{t}$ in $\sqrt{min}$	COMPRESSION DIAL in CM	





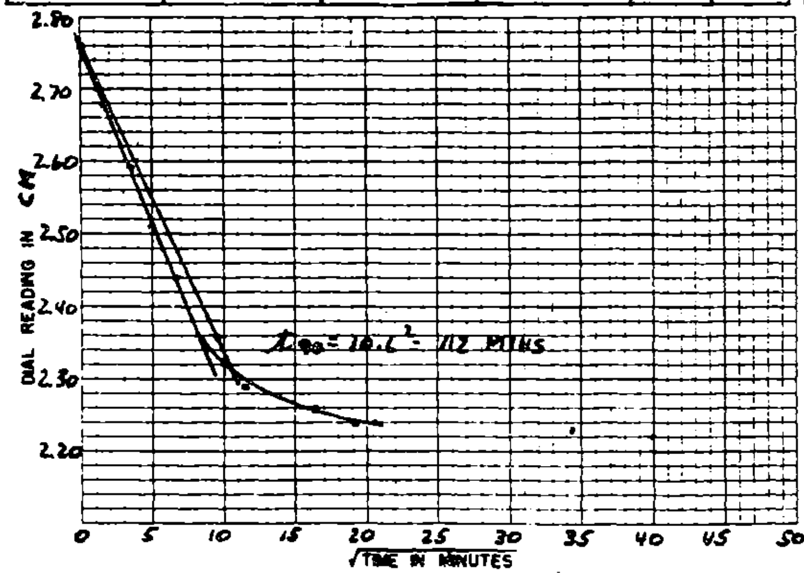
CONSOLIDATION TEST

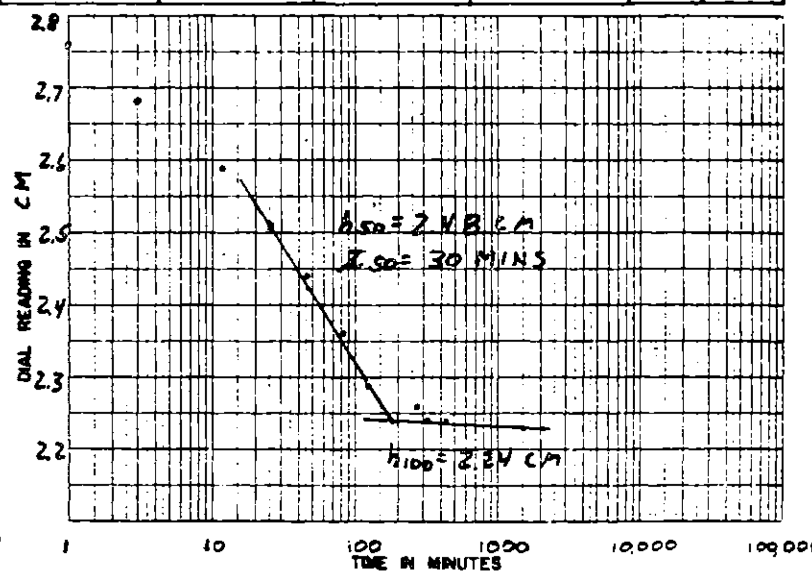
TEST NO. CONSOL #2 TESTED BY JRR PRESSURE INCREMENT INCR. NO. 9

NORALYN #1 FROM 0.08822 kg/sq cm. TO 0.16882 kg/sq cm.

DATE	TIME	ELAPSED TIME, t IN min	$\sqrt{t}$ IN $\sqrt{min}$	COMPRESSION DIAL IN CM	
13 JUN	0900	0	0	2.76	
	0903	3	1.73	2.68	
	0912	12	3.46	2.59	
	0925	25	5.00	2.51	
	0945	45	6.71	2.44	
	1022	82	9.06	2.36	
	1110	130	11.40	2.29	
	1330	270	16.43	2.26	
	1530	330	18.16	2.24	
	1600	420	20.49	2.24	
14 JUN	1015	1515	38.92	2.23	
	1210	1630	40.37	2.22	

DATE	TIME	ELAPSED TIME, t IN min	$\sqrt{t}$ IN $\sqrt{min}$	COMPRESSION DIAL IN CM	





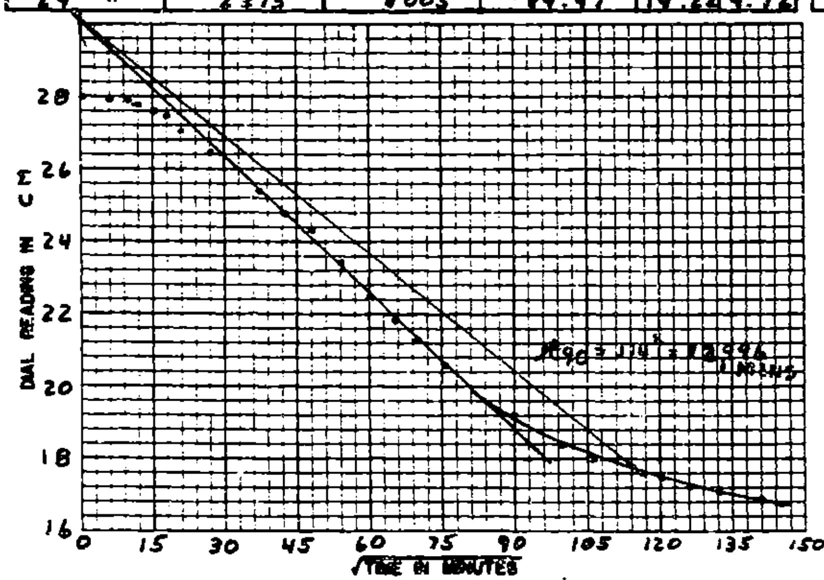
CONSOLIDATION TEST

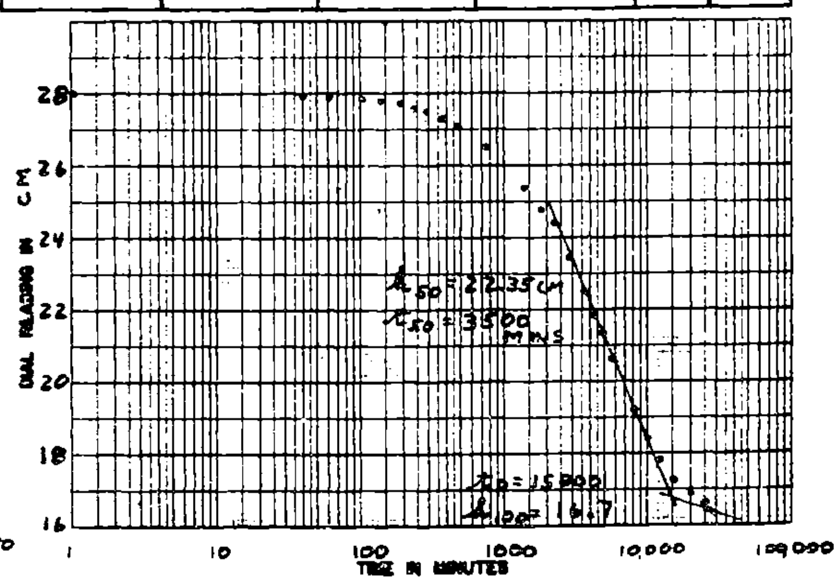
INCR. NO. 1

TEST NO. CONSOL #3 NORALYN #2 TESTED BY JRR PRESSURE INCREMENT FROM 0 kg/sq. cm. TO 0.00063 kg/sq. cm.

S, %

DATE	TIME	ELAPSED TIME, t in min	$\sqrt{t}$ in $\sqrt{min}$	COMPRESSION DIAL in CM	S, %
24 JUNE	0850	0	0	28.0	6.80
	0930	40	6.32	27.95	6.81
	1000	70	8.37	27.90	6.82
	1035	105	10.25	27.85	6.83
	1110	140	11.83	27.80	6.85
	1200	190	13.78	27.70	6.87
	1235	235	15.33	27.60	6.89
	1345	295	17.18	27.48	6.92
	1505	375	19.36	27.30	6.97
	1640	470	21.68	27.05	7.03
	2120	750	27.39	26.50	7.17
25 JUNE	0800	1390	37.28	25.40	7.46
	1015	1525	39.05	25.30	7.49
	1200	1630	40.37	25.15	7.53
	1615	1885	43.42	24.80	7.64
	2145	2215	47.06	24.35	7.77
26 "	0900	2890	53.76	23.45	8.05
	2140	3650	60.42	22.50	8.37
27 "	0730	4240	65.12	21.90	8.59
	1830	4900	70.00	21.30	8.82
28 "	0830	5740	75.76	20.60	9.10
29 "	2315	8005	89.47	19.22	9.72
30 JUNE	0730	8560	92.52	18.96	9.84
1 JULY	0730	10,000	100.00	18.40	10.12
2 "	0700	11,410	106.82	18.00	10.33
3 "	0700	12,850	113.36	17.80	10.44
4 "	0645	14,275	119.48	17.50	10.61
5 "	0900	15850	125.90	17.25	10.75
6 "	0900	17290	131.49	17.15	10.81
7 "	0710	18620	136.45	17.00	10.91
8 "	0715	20065	141.65	16.90	10.96
9 "	0715	21505	146.65	16.75	11.05
10 "	0700	22930	151.43	16.70	11.08
11 "	1120	24630	156.94	16.60	11.14
12 "	0900	25930	161.03	16.50	11.20
13 "	1000	27430	165.62	16.40	11.27
14 "	0900	28810	169.74	16.33	11.31





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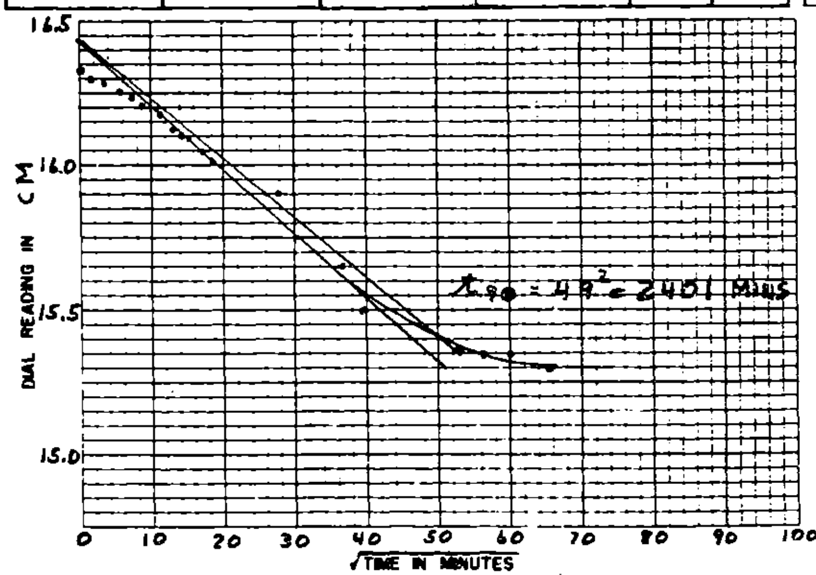
CONSOLIDATION TEST

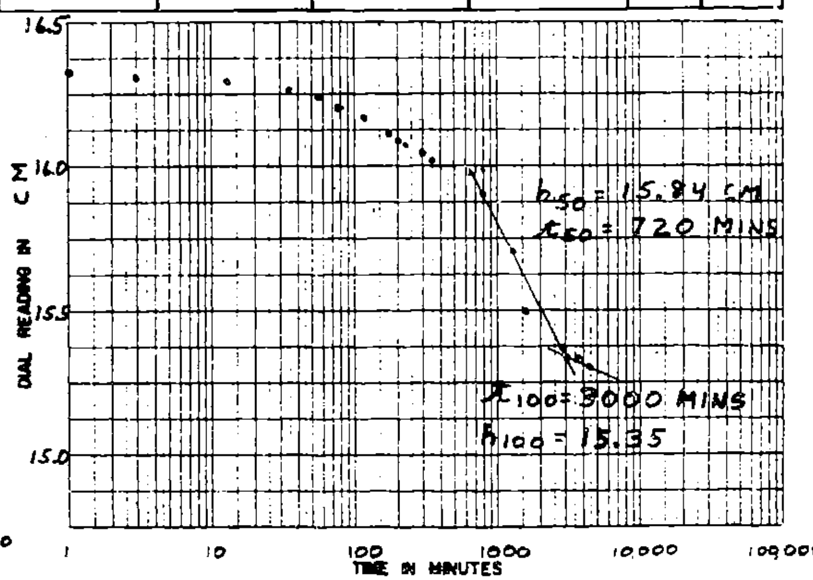
INCR. NO. 2

TEST NO. CONSOL #3 TESTED BY JRR PRESSURE INCREMENT
NORALYN #2
FROM 0.00063 kg/sq. cm. TO 0.00163 kg/sq. cm.

DATE	TIME	ELAPSED TIME, t IN min	$\sqrt{t}$ IN $\sqrt{min}$	COMPRESSION DIAL IN CM	
14 JULY	0900	0	0	16.33	
	0903	3	1.73	16.30	
	0913	13	3.61	16.29	
	0919	19	4.36	16.29	
	0935	35	5.92	16.26	
	0955	55	7.42	16.24	
	1015	75	8.66	16.21	
	1100	120	10.95	16.18	
	1150	170	13.04	16.12	
	1220	200	14.14	16.10	11.46
	1245	225	15.00	16.09	
	1400	300	17.32	16.05	
	1445	345	18.57	16.02	
	2220	800	28.28	15.90	11.59
15 JULY	0710	1330	36.47	15.65	
	1110	1570	39.62	15.50	
16 "	0810	2830	53.20	15.37	
	1059	2999	54.76	15.35	
	1340	3160	56.21	15.35	
	2120	3620	60.17	15.35	
17 "	0900	4320	65.73	15.30	12.02

DATE	TIME	ELAPSED TIME, t IN min	$\sqrt{t}$ IN $\sqrt{min}$	COMPRESSION DIAL IN CM	





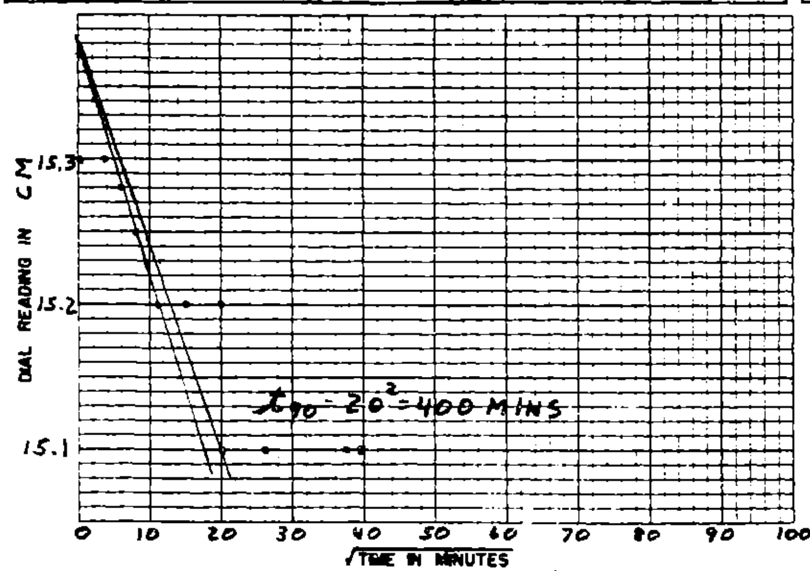
CONSOLIDATION TEST

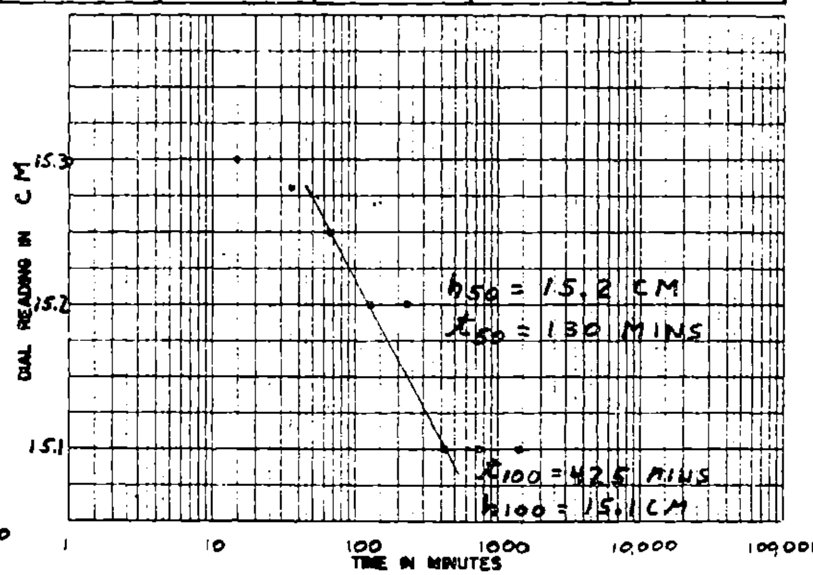
TEST NO. CONSOL #3 NORALYN #2 TESTED BY JRR PRESSURE INCREMENT FROM 0.00163 kg/sq. cm. TO 0.00263 kg/sq. cm.

INCR. NO. 3

DATE	TIME	ELAPSED TIME, t IN min	$\sqrt{t}$ IN $\sqrt{min}$	COMPRESSION DIAL IN CM	
17 JULY	0900	0	0	15.30	12.02
	0915	15	3.87	15.30	
	0935	35	5.92	15.28	
	1005	65	8.06	15.25	
	1105	125	11.18	15.20	
	1250	230	15.16	15.20	
	1555	415	20.37	15.10	
	2045	705	26.55	15.10	
18 "	0815	1395	37.35	15.10	
	1050	1550	39.37	15.10	12.16

DATE	TIME	ELAPSED TIME, t IN min	$\sqrt{t}$ IN $\sqrt{min}$	COMPRESSION DIAL IN CM	





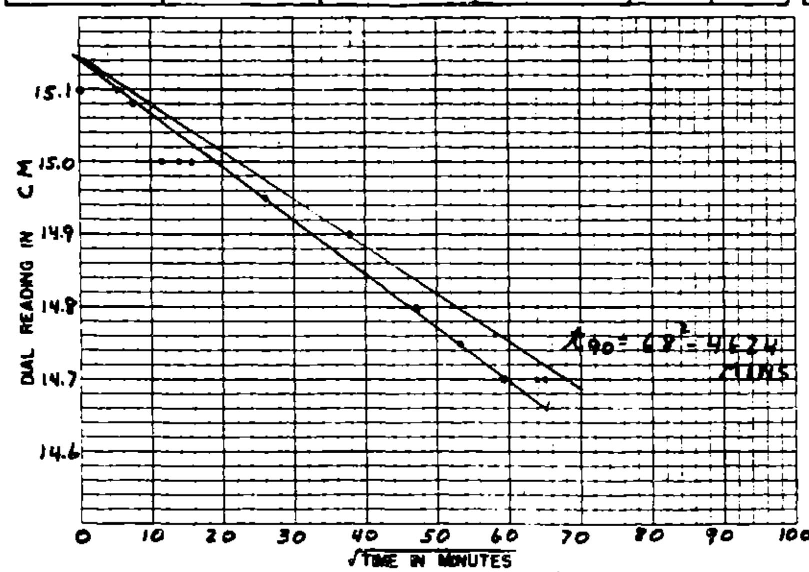
CONSOLIDATION TEST

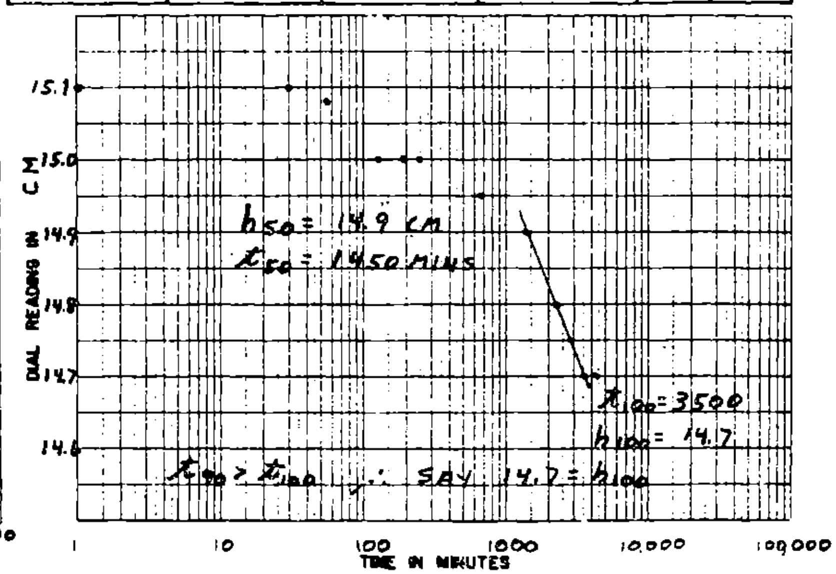
INCR. NO. 4

TEST NO. CONSOL #3 TESTED BY J R R PRESSURE INCREMENT
NORALYN #2
FROM 0.00263 kg/sq. cm. TO 0.00463 kg/sq. cm.

DATE	TIME	ELAPSED TIME, t in min	√t in √min	COMPRESSION DIAL in CM	
18 JULY	1050	0	0	15.10	
	1120	30	5.48	15.10	
	1145	55	7.42	15.08	
	1300	130	11.40	15.00	
	1400	190	13.78	15.00	12.24
	1500	250	15.81	15.00	
	2210	680	26.08	14.95	
19 JULY	1030	1420	37.68	14.90	
	2350	2220	47.12	14.80	
20 "	0945	2815	53.06	14.75	
	2035	3465	58.86	14.70	12.47
21 "	0720	4110	64.11	14.70	
	0815	4165	64.54	14.70	

DATE	TIME	ELAPSED TIME, t in min	√t in √min	COMPRESSION DIAL IN CM	



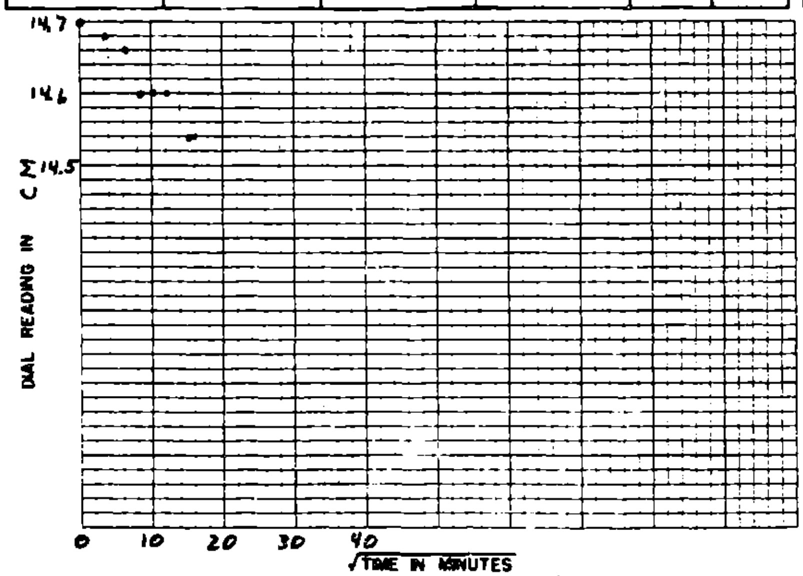


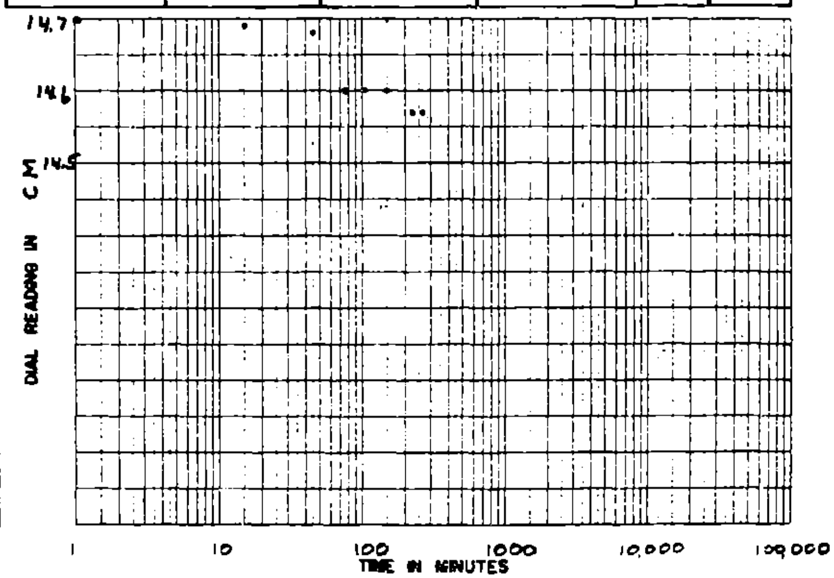
CONSOLIDATION TEST

TEST NO. CONSOL #3 NORALYN #2 TESTED BY JRR PRESSURE INCREMENT FROM 0.00463 kg/sq. cm. TO 0.00863 kg/sq. cm. INCR. NO. 5

DATE	TIME	ELAPSED TIME, t in min	$\sqrt{t}$ in $\sqrt{min}$	COMPRESSION DIAL in CM	
21 JULY	0815	0	0	14.70	
	0830	15	3.87	14.69	
	0900	45	6.71	14.68	
	0930	75	8.66	14.60	12.54
	1000	105	10.25	14.60	
	1045	150	12.25	14.60	
	1200	225	15.00	14.57	
	1230	255	15.97	14.57	12.57

DATE	TIME	ELAPSED TIME, t in min	$\sqrt{t}$ in $\sqrt{min}$	COMPRESSION DIAL in CM	





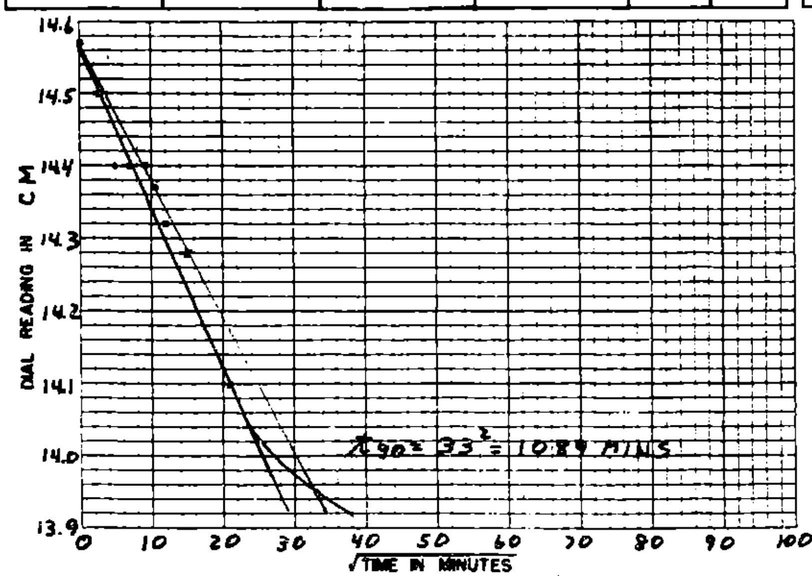
CONSOLIDATION TEST

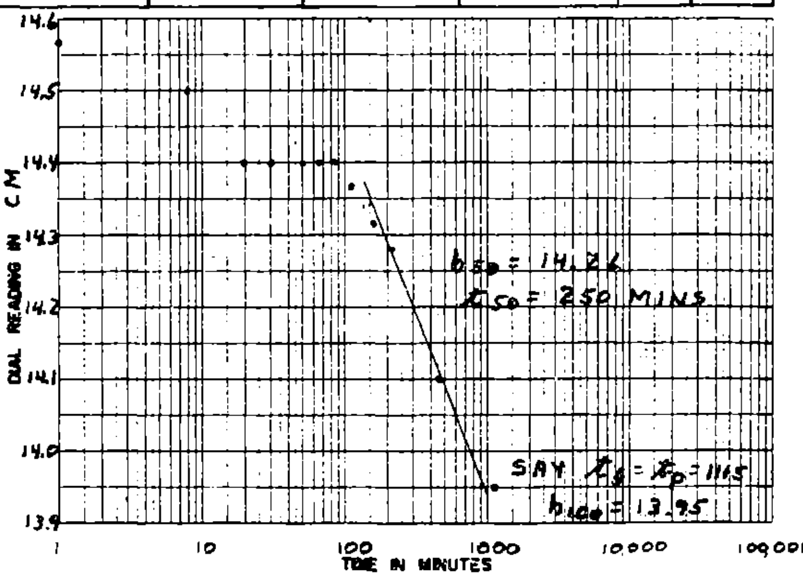
INCR. NO. 6

TEST NO. CONSOL #3 TESTED BY JRR PRESSURE INCREMENT
NORALYN #2
FROM 0.00863 kg/sq. cm. TO 0.02738 kg/sq. cm.

DATE	TIME	ELAPSED TIME, t IN min	√t IN √min	COMPRESSION DIAL IN CM
21 JULY	1230	0	0	14.57
	1238	8	2.83	14.50
	1250	20	4.47	14.40
	1300	30	5.48	14.40
	1320	50	7.07	14.40
	1335	65	8.06	14.40
	1355	85	9.22	14.40
	1425	115	10.72	14.37
	1510	160	12.65	14.32
	1605	215	14.66	14.28
	2210	460	21.45	14.10
22 JULY	0705	1115	33.39	13.95

DATE	TIME	ELAPSED TIME, t IN min	√t IN √min	COMPRESSION DIAL IN CM





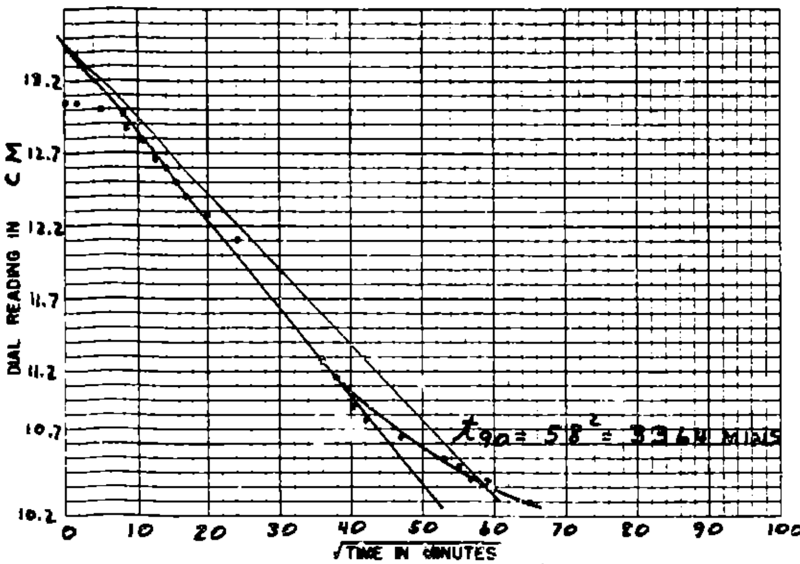
CONSOLIDATION TEST

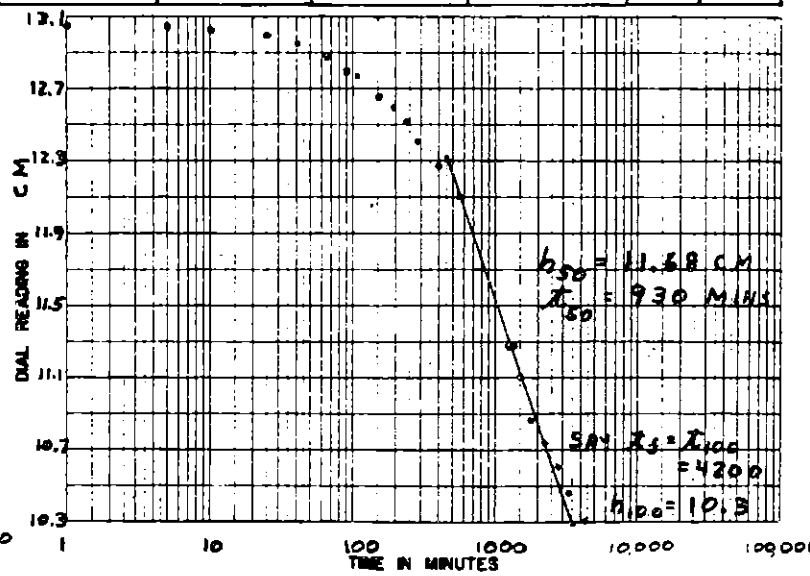
INCR. NO. 7

TEST NO. CONSOL #3 TESTED BY J R R PRESSURE INCREMENT
NORALYN #2
FROM 0.02738 kg/sq. cm. TO 0.01033 kg/sq. cm.

DATE	TIME	ELAPSED TIME, t in min	$\sqrt{t}$ in $\sqrt{min}$	COMPRESSION DIAL in CM	
22 JULY	1055	0	0	13.05	
	1100	5	2.24	13.04	
	1105	10	3.16	13.03	
	1120	25	5.00	13.00	13.95
	1135	40	6.32	12.95	
	1200	65	8.06	12.88	
	1225	90	9.49	12.80	
	1245	110	10.49	12.79	
	1300	125	11.18	12.75	
	1325	150	12.25	12.66	
	1410	195	13.96	12.60	
	1454	239	15.46	12.51	14.36
	1538	283	16.82	12.40	
	1731	396	19.90	12.28	
	2015	560	23.66	12.10	
23 "	0830	1295	35.99	11.28	
	1054	1439	37.93	11.16	
	1200	1505	38.79	11.10	16.10
	1355	1620	40.25	10.95	
	1630	1775	42.13	10.87	
	2350	2215	47.06	10.75	
24 "	0900	2765	52.58	10.60	16.78

DATE	TIME	ELAPSED TIME, t in min	$\sqrt{t}$ in $\sqrt{min}$	COMPRESSION DIAL in CM	
24 JULY	1325	3030	55.04	10.53	
	1620	3205	56.61	10.46	
24 "	2140	3525	59.37	10.46	
25 "	0930	4235	65.08	10.30	17.21



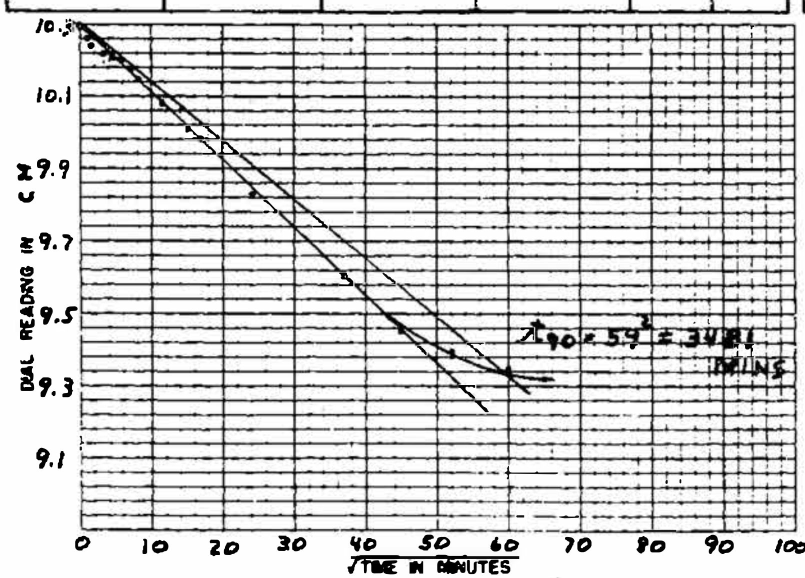


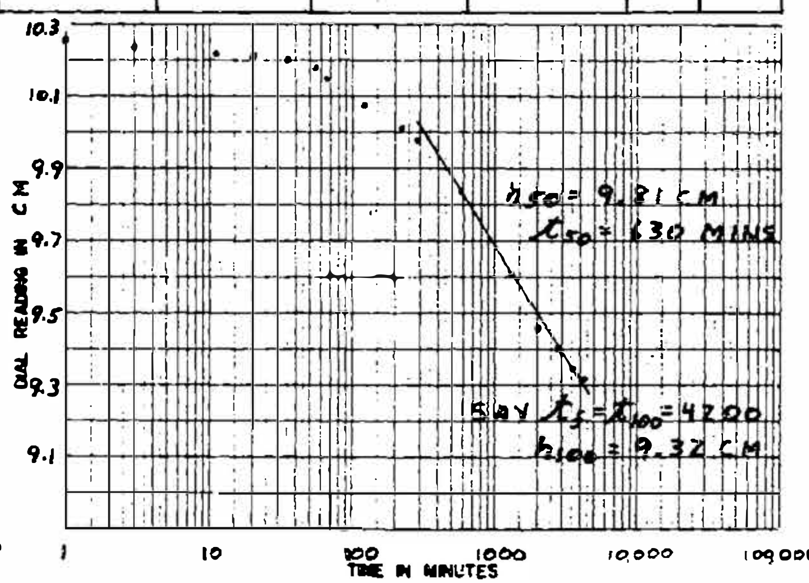
CONSOLIDATION TEST

TEST NO. CONSOL #3 TESTED BY JRR PRESSURE INCREMENT INCR. NO. 8
NORALYN #2
FROM 0.01033 kg/sq cm. TO 0.01213 kg/sq cm.

DATE	TIME	ELAPSED TIME, t IN min	$\sqrt{t}$ IN $\sqrt{min}$	COMPRESSION DIAL IN CM	
25 JULY	1030	0	0	10.30	
	1031	1	1.00	10.26	
	1033	3	1.73	10.24	
	1041	11	3.32	10.22	
	1050	20	4.47	10.21	
	1105	35	5.92	10.20	17.36
	1125	55	7.42	10.18	
	1135	65	8.06	10.15	
	1240	130	11.40	10.08	
	1418	228	15.10	10.01	
	1522	292	17.09	9.98	17.70
	2021	591	24.31	9.83	
26 JULY	0925	1375	37.08	9.61	
	2010	2020	44.94	9.46	
27 "	0750	2720	52.15	9.40	
	2250	3620	60.17	9.35	
28 "	0945	4275	65.38	9.32	18.81

DATE	TIME	ELAPSED TIME, t IN min	$\sqrt{t}$ IN $\sqrt{min}$	COMPRESSION DIAL IN CM	





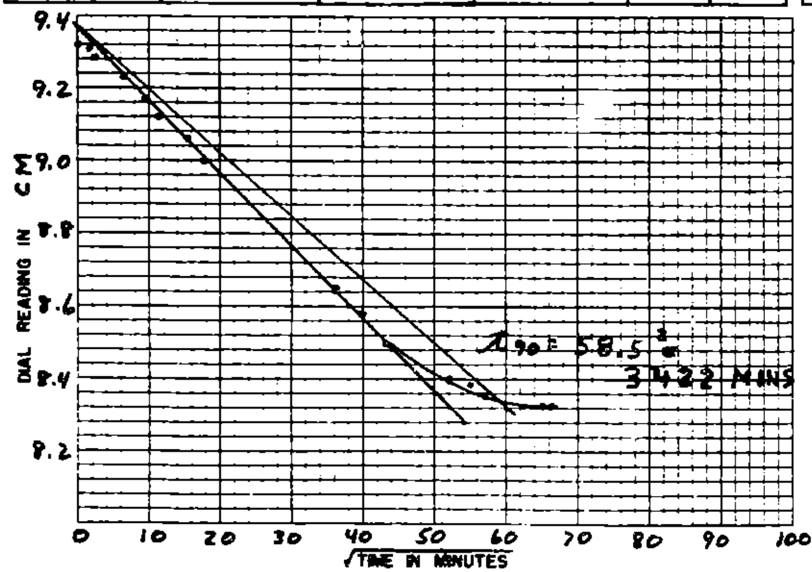
CONSOLIDATION TEST

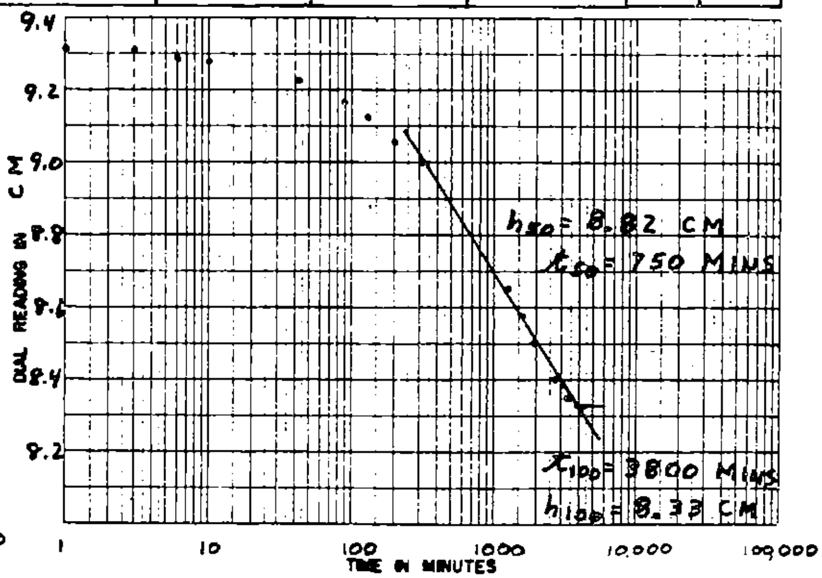
TEST NO. CONSOL #3 NORALYN #2 TESTED BY JRR PRESSURE INCREMENT INCR. NO. 9

FROM 0.01213 kg/sq cm. TO 0.01619 kg/sq cm.

DATE	TIME	ELAPSED TIME, t IN min	$\sqrt{t}$ IN $\sqrt{min}$	COMPRESSION DIAL IN CM
28 JULY	0945	0	0	9.32
	0948	3	1.73	9.31
	0951	6	2.45	9.29
	0955	10	3.16	9.28
	1028	43	6.56	9.23
	1115	90	9.49	9.17
	1200	135	11.62	9.12
	1352	247	15.72	9.06
	1500	315	17.75	9.00
29 "	0730	1305	36.12	8.65
	1215	1590	39.87	8.58
	1730	1905	43.65	8.50
30 "	0730	2745	52.39	8.40
	1300	3075	55.45	8.39
	1605	3260	57.10	8.35
31 "	0820	4235	65.08	8.33
	1105	4400	66.33	8.33

DATE	TIME	ELAPSED TIME, t IN min	$\sqrt{t}$ IN $\sqrt{min}$	COMPRESSION DIAL IN CM





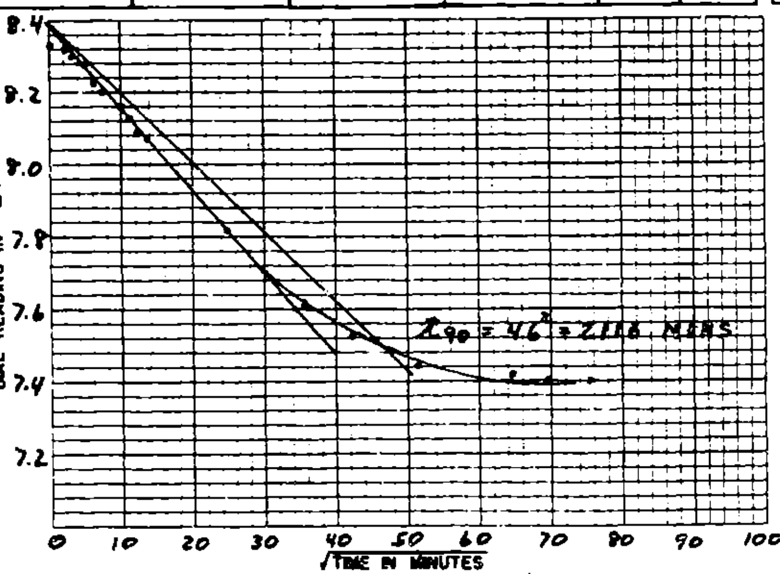
CONSOLIDATION TEST

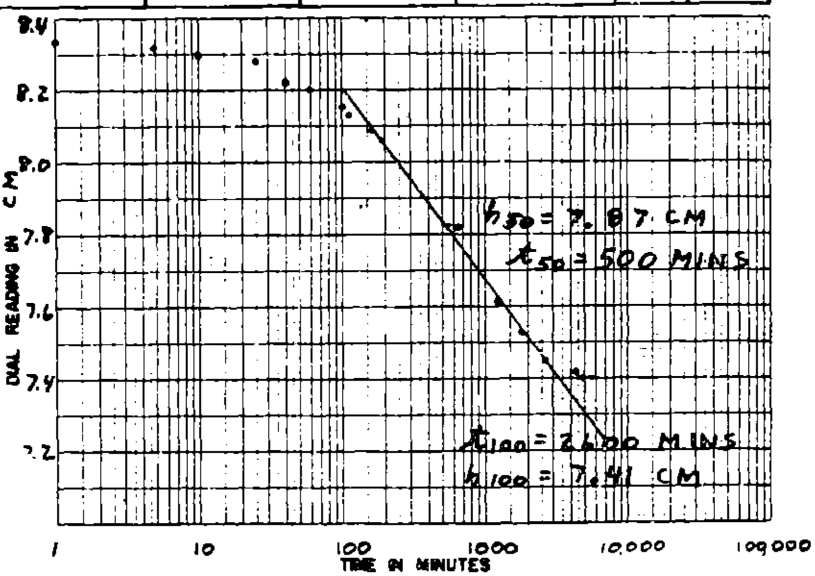
INCR. NO. 10

TEST NO. CONSOL #3 TESTED BY JRR PRESSURE INCREMENT
NORALYN #2
FROM 0.01619 kg/sq. cm. TO 0.02413 kg/sq. cm.

DATE	TIME	ELAPSED TIME, t IN min	√t IN √min	COMPRESSION DIAL IN CM	
31 JULY	1200	0	0	8.33	
	1201	1	1.00	8.33	
	1205	5	2.24	8.32	
	1210	10	3.16	8.30	
	1225	25	5.00	8.28	
	1240	40	6.32	8.22	
	1300	60	7.74	8.20	21.04
	1340	100	10.00	8.16	
	1400	120	10.95	8.13	
	1440	160	12.65	8.09	
	1510	190	13.78	8.07	
	2210	610	24.70	7.82	21.92
1 AUG	0900	1260	35.50	7.61	
	1740	1780	42.19	7.53	
2 "	0755	2635	51.33	7.45	
3 "	1000	4200	64.81	7.42	
	2120	4880	69.86	7.40	
4 "	1030	5670	75.30	7.40	22.98

DATE	TIME	ELAPSED TIME, t IN min	√t IN √min	COMPRESSION DIAL IN CM	





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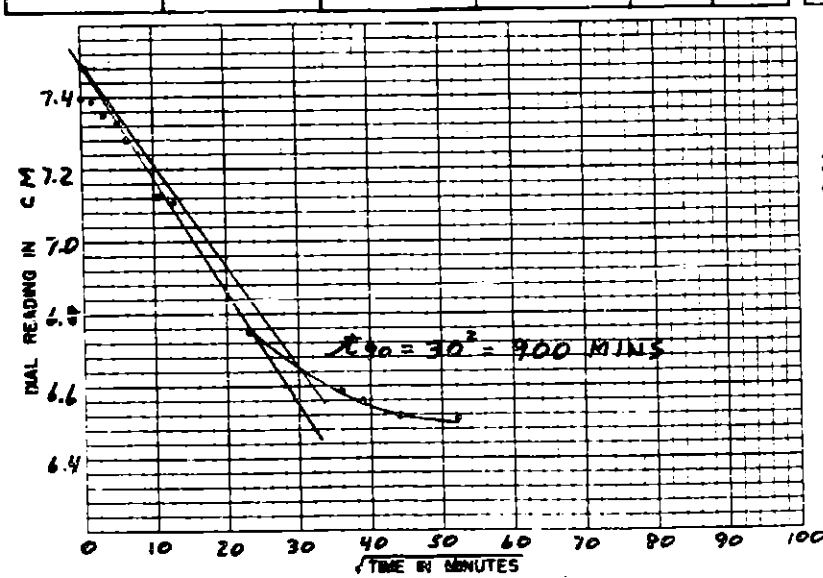
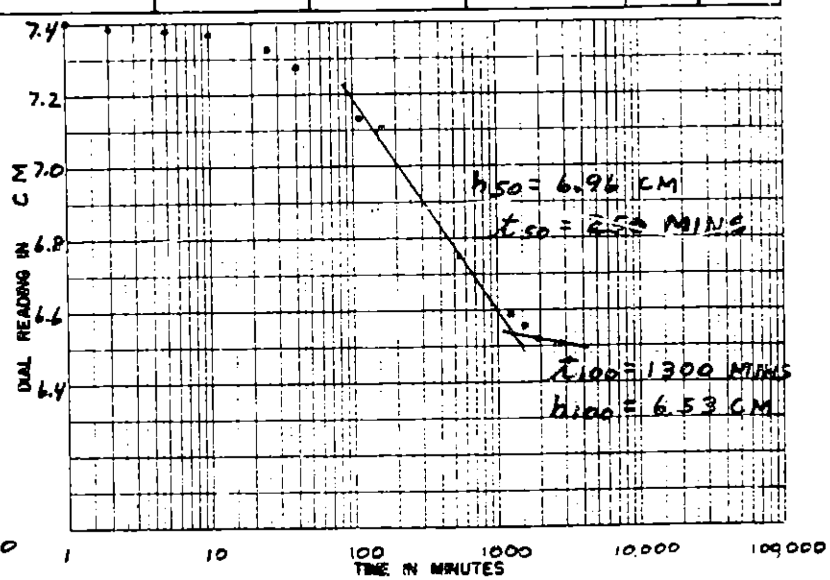
CONSOLIDATION TEST

INCR. NO. 11

TEST NO. CONSOL #3 TESTED BY JRR PRESSURE INCREMENT
MORALYN #2
FROM 0.02413 kg/sq. cm. TO 0.04033 kg/sq. cm.

DATE	TIME	ELAPSED TIME, t IN min	$\sqrt{t}$ IN $\sqrt{min}$	COMPRESSION DIAL IN CM	
4 AUG	1315	0	0	7.40	
	1317	2	1.41	7.39	
	1320	5	2.24	7.38	
	1325	10	3.16	7.37	
	1340	25	5.00	7.33	
	1355	40	6.32	7.28	23.30
	1510	115	10.72	7.13	
	1600	165	12.85	7.11	
	2220	545	23.35	6.75	
5 "	1030	1275	35.71	6.59	25.35
	1430	1515	38.92	6.56	
	2200	1965	44.32	6.52	
6 "	1030	2715	52.11	6.51	25.61





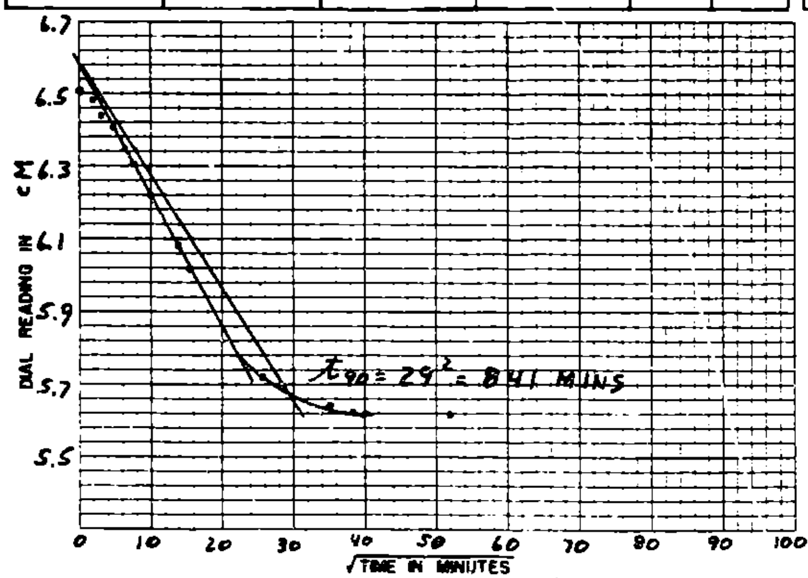
CONSOLIDATION TEST

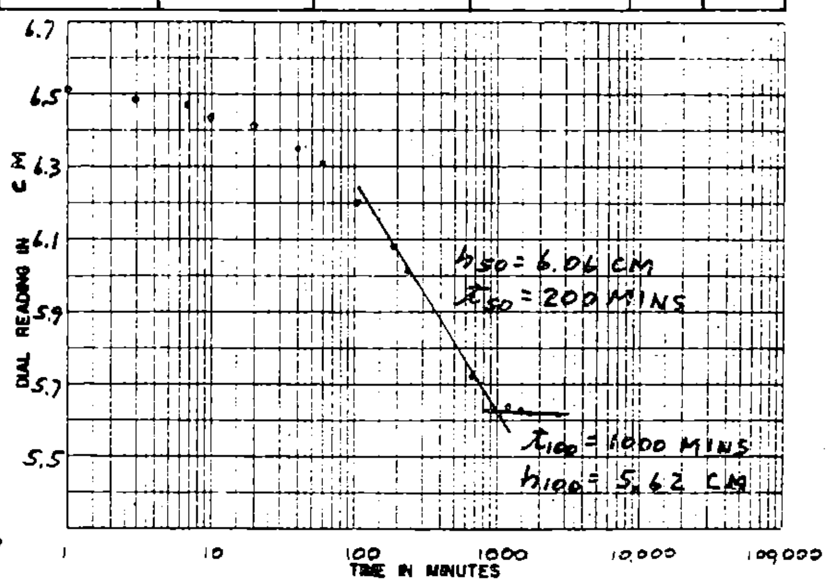
INCR. NO. 12

TEST NO. CONSOL #3 TESTED BY JRR PRESSURE INCREMENT
NORALYN #2
FROM 0.04033 kg/sq. cm. TO 0.07213 kg/sq. cm.

DATE	TIME	ELAPSED TIME, t IN min	$\sqrt{t}$ IN $\sqrt{min}$	COMPRESSION DIAL IN CM	
6 AUG	1200	0	0	6.51	
	1201	1	1.00	6.51	
	1203	3	1.73	6.48	
	1206	6	2.45	6.47	
	1210	10	3.16	6.44	
	1220	20	4.47	6.41	
	1240	40	6.32	6.35	26.15
	1300	60	7.74	6.31	
	1345	105	10.25	6.20	
	1515	195	13.96	6.08	
	1600	240	15.49	6.02	27.34
	2300	660	25.69	5.72	
7 AUG	0820	1220	34.93	5.64	
	1250	1490	38.60	5.63	
	1530	1650	40.62	5.62	
8 "	0900	2700	51.96	5.62	28.93

DATE	TIME	ELAPSED TIME, t IN min	$\sqrt{t}$ IN $\sqrt{min}$	COMPRESSION DIAL IN CM	





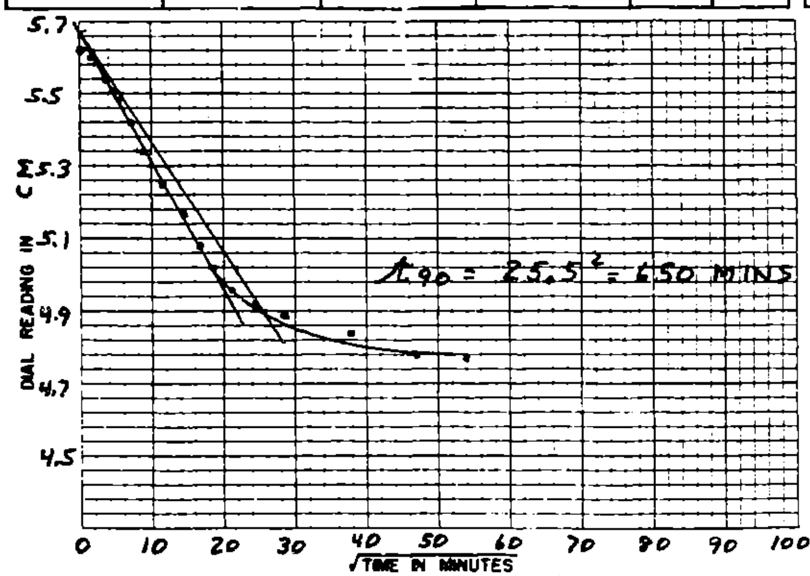
CONSOLIDATION TEST

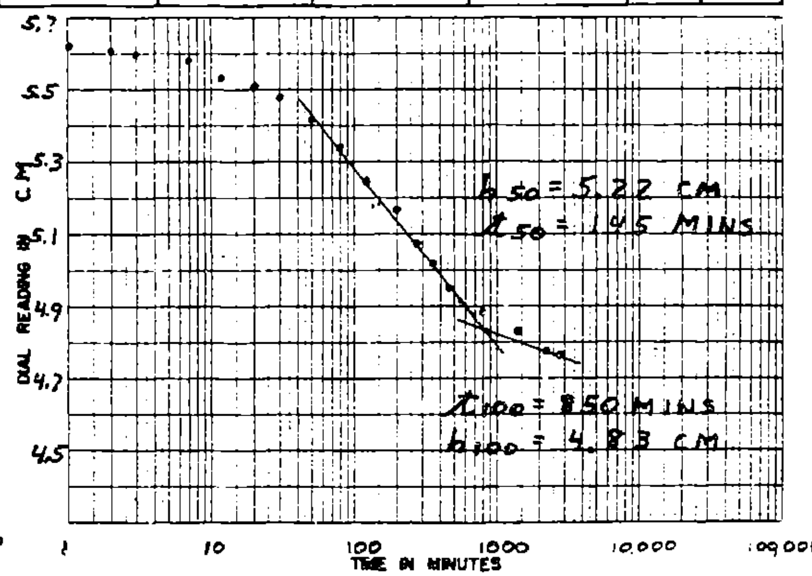
INCR. NO. 13

TEST NO. CONSOL #3 TESTED BY JRR PRESSURE INCREMENT
NORALYN #2
FROM 0.07213 kg/sq. cm. TO 0.13613 kg/sq. cm.

DATE	TIME	ELAPSED TIME, t in min	$\sqrt{t}$ in $\sqrt{min}$	COMPRESSION DIAL in CM	
8 AUG	1000	0	0	5.62	
	1001	1	1.00	5.62	
	1002	2	1.41	5.61	
	1003	3	1.73	5.60	
	1007	7	2.64	5.58	
	1012	12	3.46	5.54	
	1020	20	4.47	5.51	
	1030	30	5.48	5.48	
	1050	50	7.07	5.42	29.79
	1120	80	8.94	5.34	
	1210	130	11.40	5.25	
	1320	200	14.14	5.17	
	1440	280	16.73	5.08	31.39
	1550	350	18.71	5.02	
	1730	450	21.21	4.96	
	1950	590	24.29	4.92	
	2330	810	28.46	4.89	
9 "	1015	1455	38.14	4.84	
	2250	2210	47.01	4.78	
10 "	1015	2895	53.80	4.77	33.00

DATE	TIME	ELAPSED TIME, t in min	$\sqrt{t}$ in $\sqrt{min}$	COMPRESSION DIAL in CM	





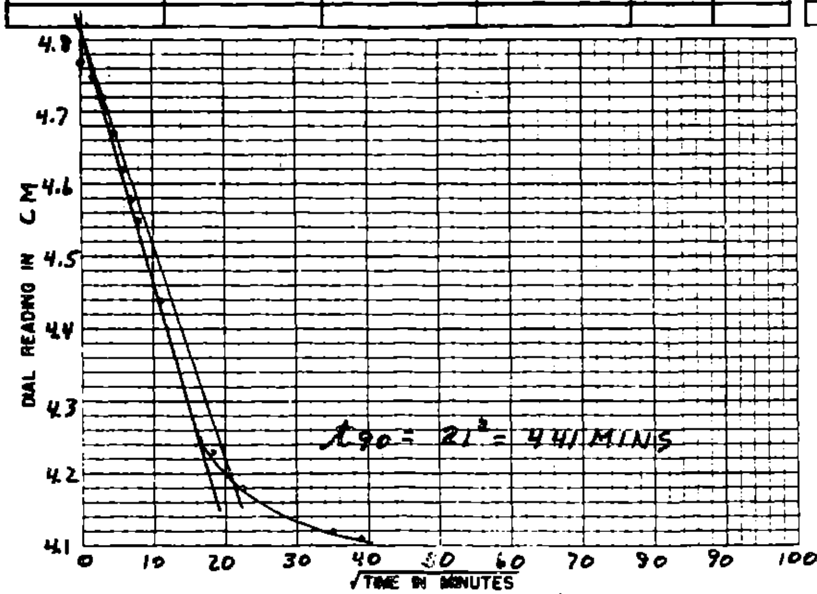
CONSOLIDATION TEST

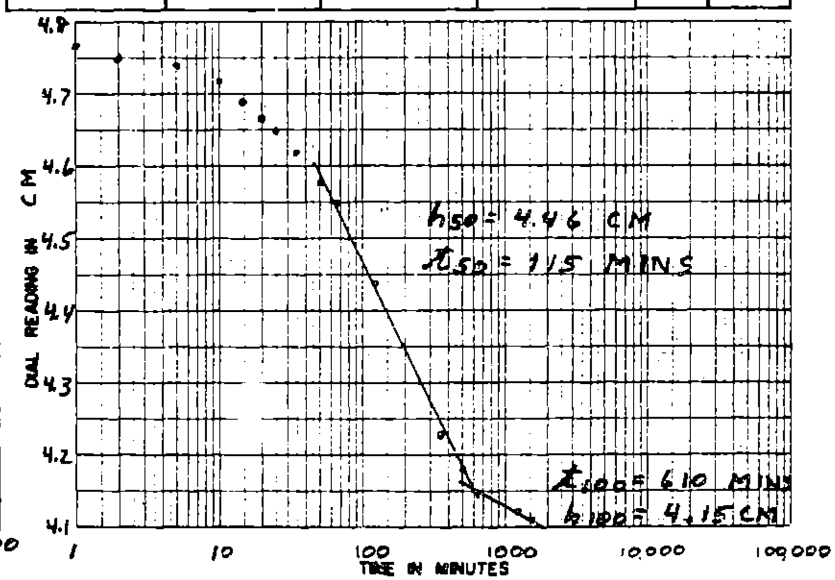
INCR. NO. 14

TEST NO. CONSOL #3 TESTED BY JRR PRESSURE INCREMENT
NORALYN #2
FROM 0.13613 kg/sq. cm. TO 0.26413 kg/sq. cm.

DATE	TIME	ELAPSED TIME, t IN min	$\sqrt{t}$ IN $\sqrt{min}$	COMPRESSION DIAL IN CM	
10 AUG	1125	0	0	4.77	
	1126	1	1.00	4.76	
	1127	2	1.41	4.75	
	1128	3	1.73	4.75	
	1130	5	2.24	4.74	
	1135	10	3.16	4.72	
	1140	15	3.87	4.69	
	1145	20	4.47	4.67	
	1150	25	5.00	4.65	33.67
	1200	35	5.92	4.62	
	1215	50	7.07	4.58	
	1230	65	8.06	4.55	
	1330	125	11.18	4.44	
	1710	345	18.57	4.23	
	1950	505	22.47	4.18	
11 AUG	0815	1280	35.35	4.12	
	1300	1535	39.18	4.11	37.06

DATE	TIME	ELAPSED TIME, t IN min	$\sqrt{t}$ IN $\sqrt{min}$	COMPRESSION DIAL IN CM	





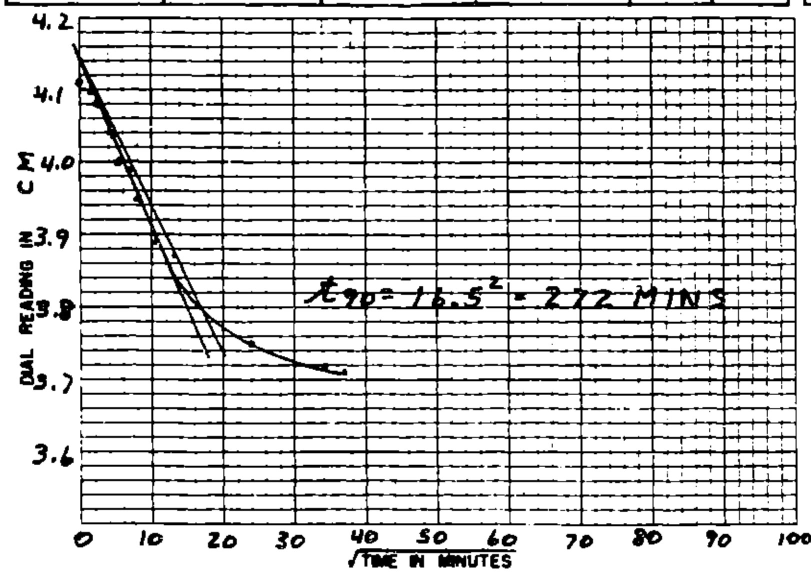
CONSOLIDATION TEST

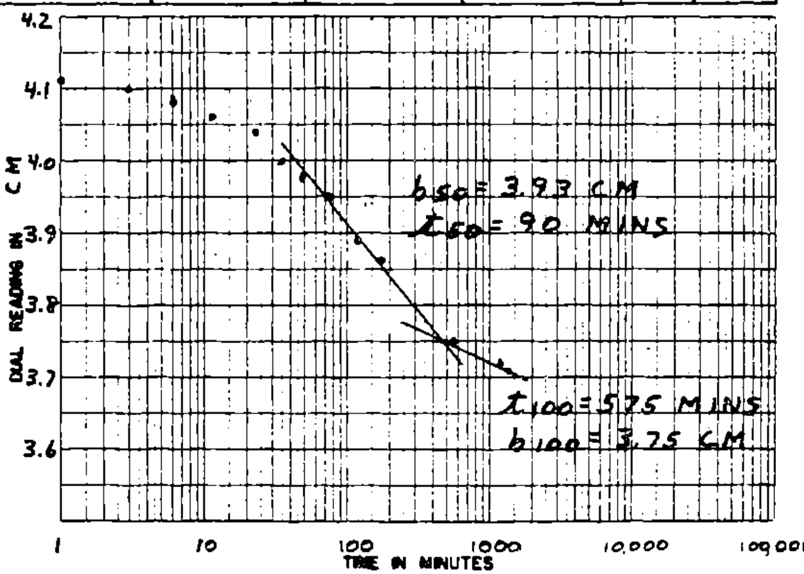
INCR. NO. 15

TEST NO. CONSOL #3 NORALYN #2 TESTED BY JRR PRESSURE INCREMENT FROM 0.26413 kg/sq. cm. TO 0.40913 kg/sq. cm.

DATE	TIME	ELAPSED TIME, t IN min	$\sqrt{t}$ IN $\sqrt{min}$	COMPRESSION DIAL IN CM	
11 AUG	1315	0	0	4.11	
	1316	1	1.00	4.11	
	1318	3	1.73	4.10	
	1321	6	2.45	4.08	
	1327	12	3.46	4.06	
	1338	23	4.80	4.04	
	1350	35	5.92	4.00	37.84
	1405	50	7.07	3.98	
	1420	75	8.66	3.95	
	1515	120	10.95	3.89	
	1615	180	13.42	3.87	
	2300	585	24.19	3.75	
12 "	0900	1185	34.42	3.72	
	1200	1365	36.94	3.71	40.05

DATE	TIME	ELAPSED TIME, t IN min	$\sqrt{t}$ IN $\sqrt{min}$	COMPRESSION DIAL IN CM	





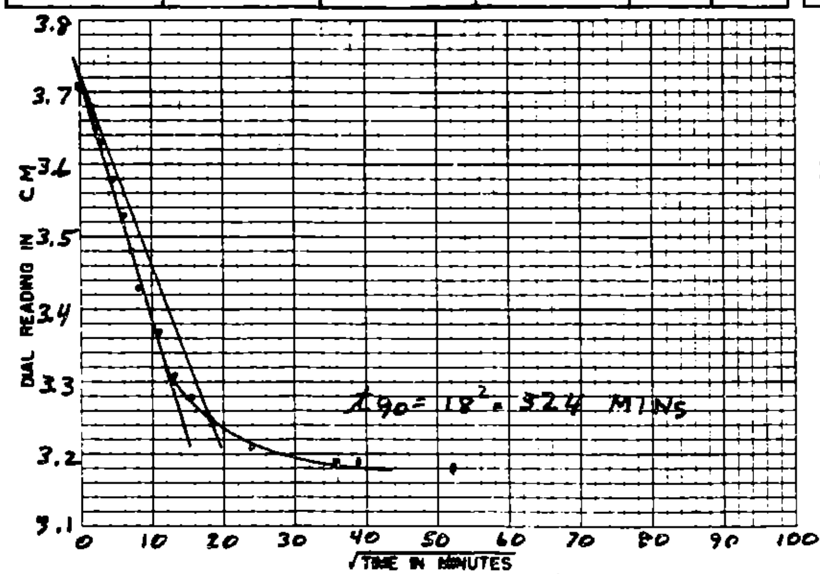
CONSOLIDATION TEST

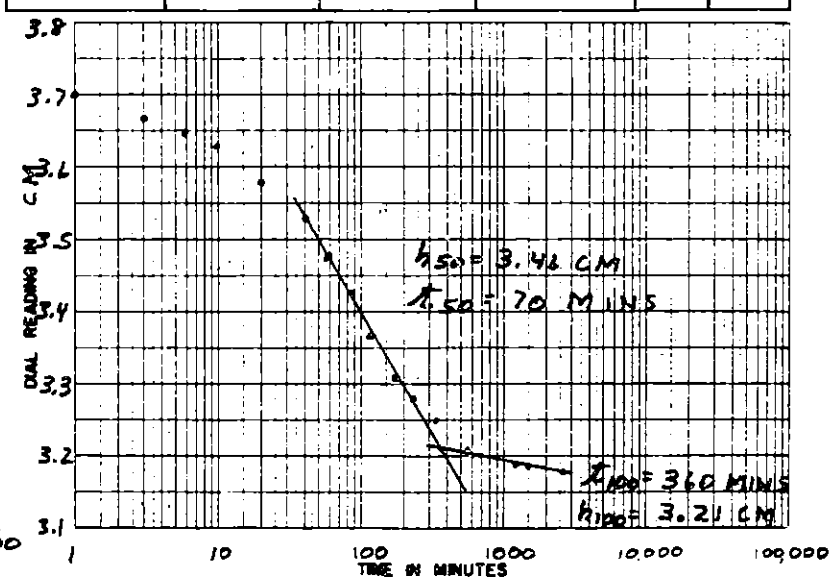
TEST NO. CONSOL #3 NORALYN #2 **TESTED BY** JRR **PRESSURE INCREMENT** INCR. NO. 16

FROM 0.40913 kg/sq. cm. **TO** 0.80813 kg/sq. cm.

DATE	TIME	ELAPSED TIME, t in min	$\sqrt{t}$ in $\sqrt{min}$	COMPRESSION DIAL in CM	
12 AUG	1300	0	0	3.71	
	1301	1	1.00	3.70	40.13
	1303	3	1.73	3.67	
	1306	6	2.45	3.65	
	1310	10	3.16	3.63	
	1320	20	4.47	3.58	
	1340	40	6.32	3.53	
	1400	60	7.74	3.48	
	1430	90	9.49	3.43	
	1505	125	11.18	3.37	
	1605	185	13.60	3.31	43.55
	1700	240	15.49	3.28	
	1840	340	18.44	3.25	
	2220	560	23.66	3.21	
13 "	1025	1285	35.85	3.19	
	1400	1500	38.73	3.19	
14 "	0910	2650	51.48	3.18	44.83

DATE	TIME	ELAPSED TIME, t in min	$\sqrt{t}$ in $\sqrt{min}$	COMPRESSION DIAL in CM	





CONSOLIDATION TEST

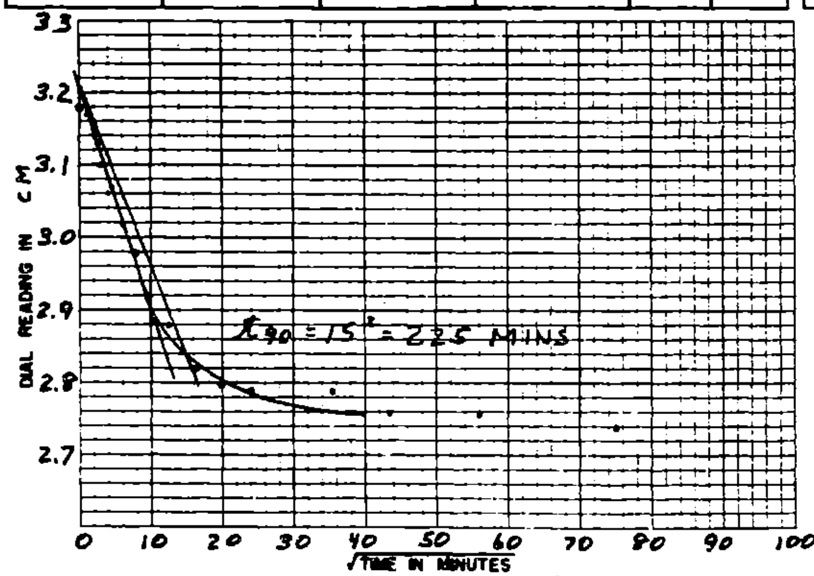
TEST NO. CONSOL *3 TESTED BY JRR PRESSURE INCREMENT INCR. NO. 17

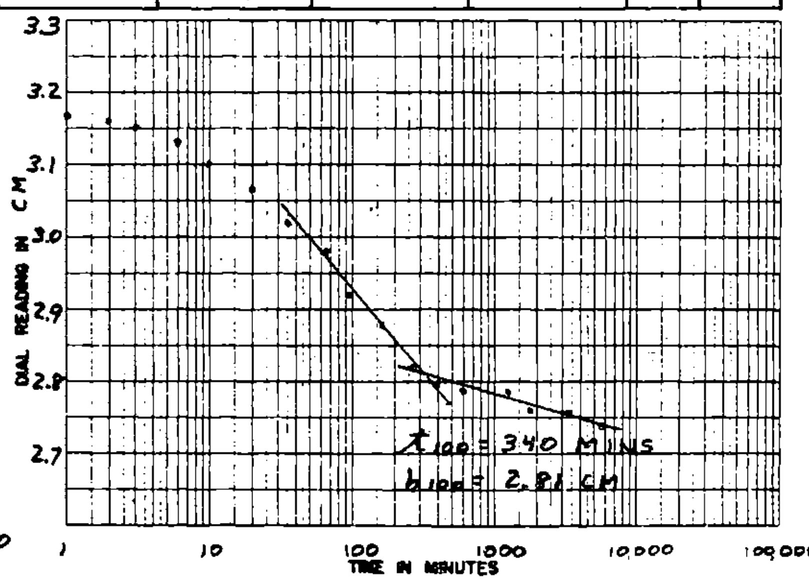
NORALYN #2

FROM 0.80813 kg/sq cm. TO 1.50813 kg/sq cm.

DATE	TIME	ELAPSED TIME, t IN min	$\sqrt{t}$ IN $\sqrt{min}$	COMPRESSION DIAL IN CM	
14 AUG	0935	0	0	3.18	
	0936	1	1.00	3.17	
	0937	2	1.41	3.16	
	0938	3	1.73	3.15	
	0941	6	2.45	3.13	
	0945	10	3.16	3.10	
	0955	20	4.47	3.07	
	1010	35	5.92	3.02	46.50
	1040	65	8.06	2.98	
	1110	95	9.75	2.92	
	1215	160	12.65	2.88	
	1400	265	16.28	2.82	
	1615	400	20.00	2.80	
	1930	595	24.39	2.79	
15 "	0650	1275	35.71	2.79	
	1700	1885	43.42	2.76	
16 "	1410	3155	56.17	2.76	
18 "	0800	5665	75.27	2.74	49.76

DATE	TIME	ELAPSED TIME, t IN min	$\sqrt{t}$ IN $\sqrt{min}$	COMPRESSION DIAL IN CM	





CONSOLIDATION TEST

INCR. NO. 1

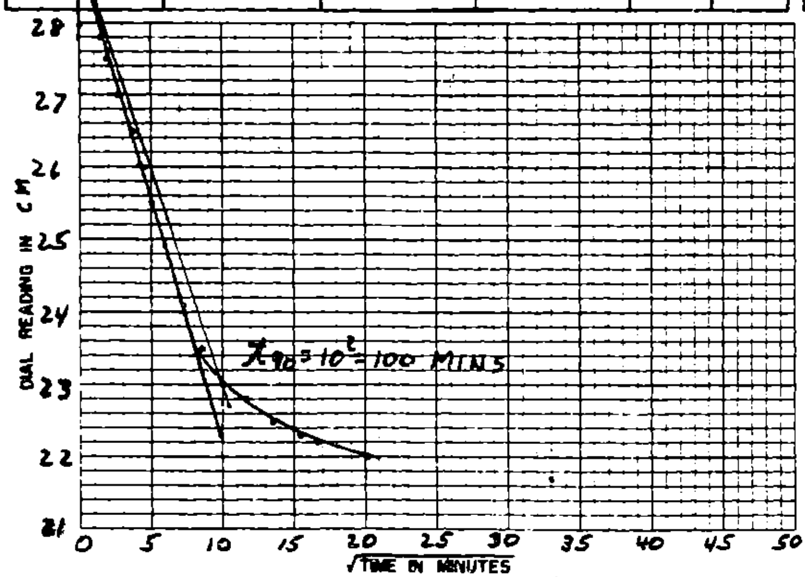
TEST NO. CONSOL #4 TESTED BY JRR PRESSURE INCREMENT FROM 0 kg/sq. cm. TO 0.00076 kg/sq. cm.

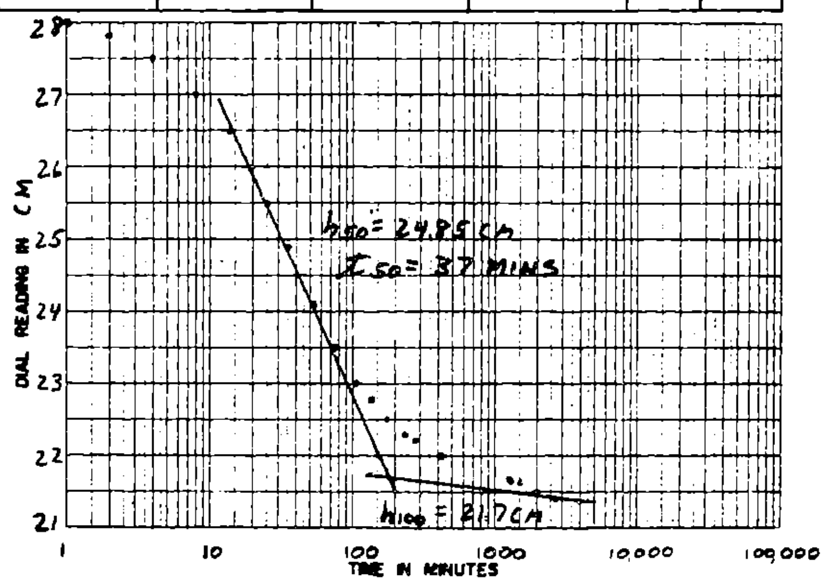
NORALYN COMPOSITE
w/ FLOCCULANT

S, %

DATE	TIME	ELAPSED TIME, t in min	$\sqrt{t}$ in $\sqrt{min}$	COMPRESSION DIAL in CM	
22 AUG	1225	0	0	28.00	8.14
	1227	2	1.41	27.80	
	1229	4	2.00	27.50	
	1233	8	2.83	27.00	
	1239	14	3.74	26.50	
	1245	20	4.47	26.00	
	1250	25	5.00	25.50	
	1300	35	5.92	24.90	
	1318	53	7.28	24.10	
	1340	75	8.66	23.50	
	1410	105	10.25	23.00	
	1445	140	11.83	22.80	
	1530	185	13.60	22.50	
	1620	235	15.33	22.30	
	1710	285	16.88	22.22	
	1920	415	20.37	22.00	
23 "	0950	1285	35.85	21.70	
	1340	1515	38.92	21.67	
	2220	2035	45.11	21.50	
24 "	0915	2690	51.86	21.42	
25 "	0815	4070	63.80	21.41	

DATE	TIME	ELAPSED TIME, t in min	$\sqrt{t}$ in $\sqrt{min}$	COMPRESSION DIAL in CM	





CONSOLIDATION TEST

INCR. NO. 2

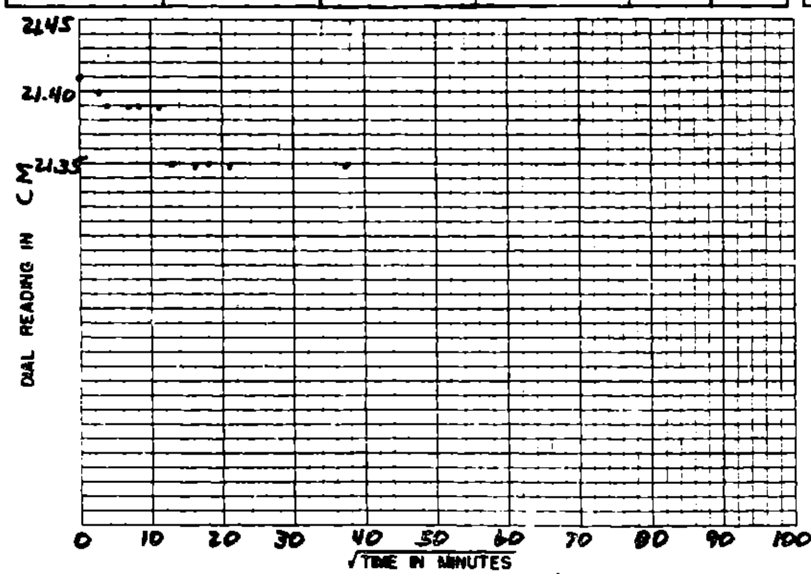
TEST NO. CONSOL #4 TESTED BY JRR PRESSURE INCREMENT FROM 0.00076 kg/sq. cm. TO 0.00126 kg/sq. cm.

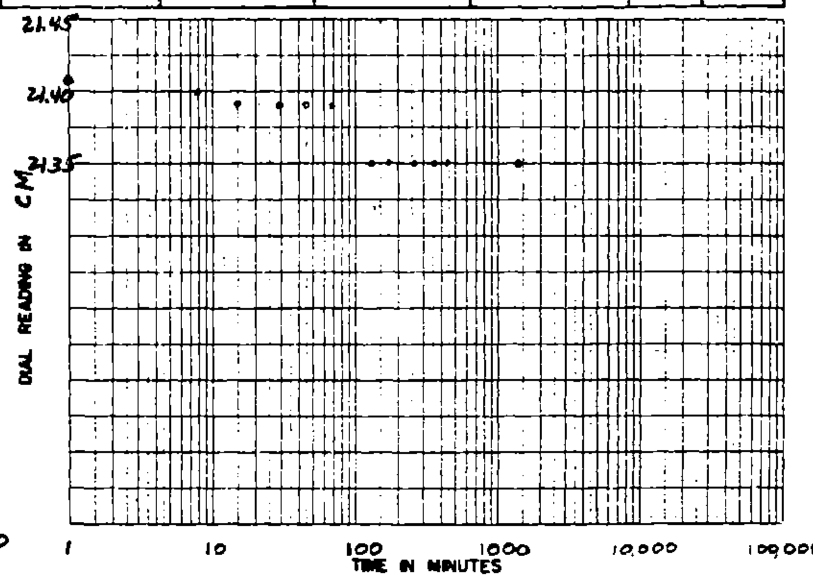
NORALYN COMPOSITE w/ FLOCCULANT

S, %

DATE	TIME	ELAPSED TIME, t IN min	$\sqrt{t}$ IN $\sqrt{min}$	COMPRESSION DIAL IN CM	
25 AUG	0900	0	0	21.41	
	0908	8	2.83	21.40	
	0915	15	3.87	21.39	10.49
	0930	30	5.48	21.39	
	0945	45	6.71	21.39	
	1010	70	8.37	21.39	
	1110	130	11.40	21.35	
	1150	170	13.04	21.35	
	1320	260	16.13	21.35	
	1455	355	18.84	21.35	
	1610	430	20.74	21.35	
26 "	0830	1410	37.55	21.35	

DATE	TIME	ELAPSED TIME, t IN min	$\sqrt{t}$ IN $\sqrt{min}$	COMPRESSION DIAL IN CM	





CONSOLIDATION TEST

INCR. NO. 3

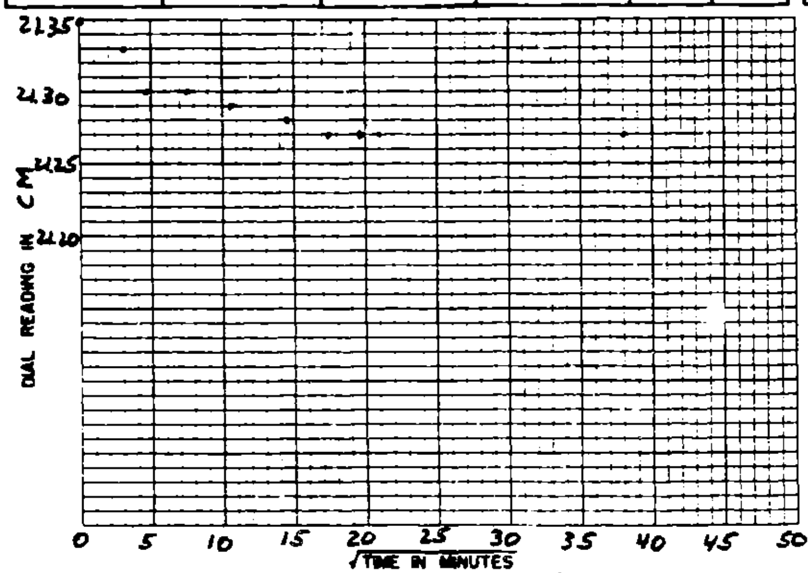
TEST NO. CONSOL #4 TESTED BY JRR PRESSURE INCREMENT FROM 0.00126 kg/sq. cm. TO 0.00176 kg/sq. cm.

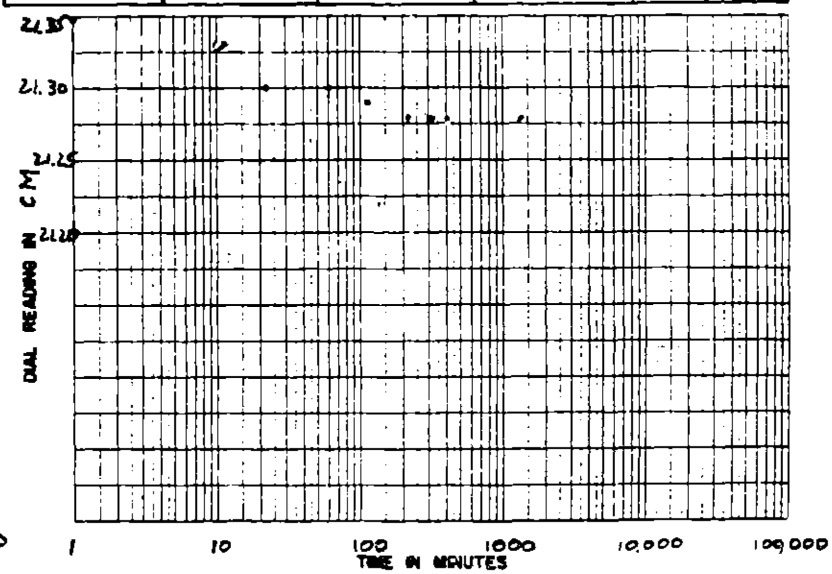
NORALYN COMPOSITE
W/ FLOCCULANT

S. 9o

DATE	TIME	ELAPSED TIME, t IN min	√t IN √min	COMPRESSION DIAL IN CM	
26 AUG	0900	0	0	21.35	10.51
	0910	10	3.16	21.33	
	0932	22	4.69	21.30	
	1000	60	7.74	21.30	
	1055	115	10.72	21.29	
	1235	215	14.66	21.28	
	1405	305	17.46	21.27	
	1530	390	19.75	21.27	
	1620	440	20.98	21.27	
27 "	0900	1440	37.95	21.27	10.54

DATE	TIME	ELAPSED TIME, t IN min	√t IN √min	COMPRESSION DIAL IN CM	





CONSOLIDATION TEST

INCR. NO. 4

TEST NO. CONSOL # 4 TESTED BY JRK PRESSURE INCREMENT

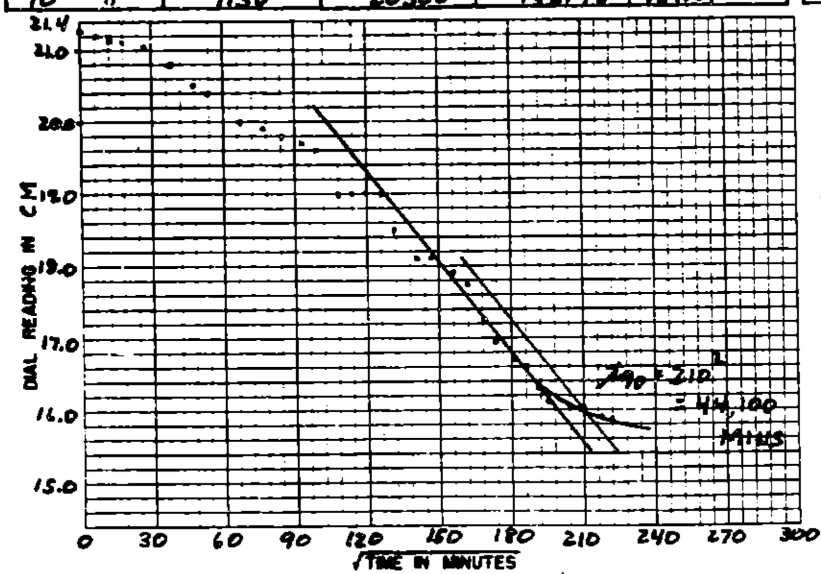
NORALYN COMPOSITE

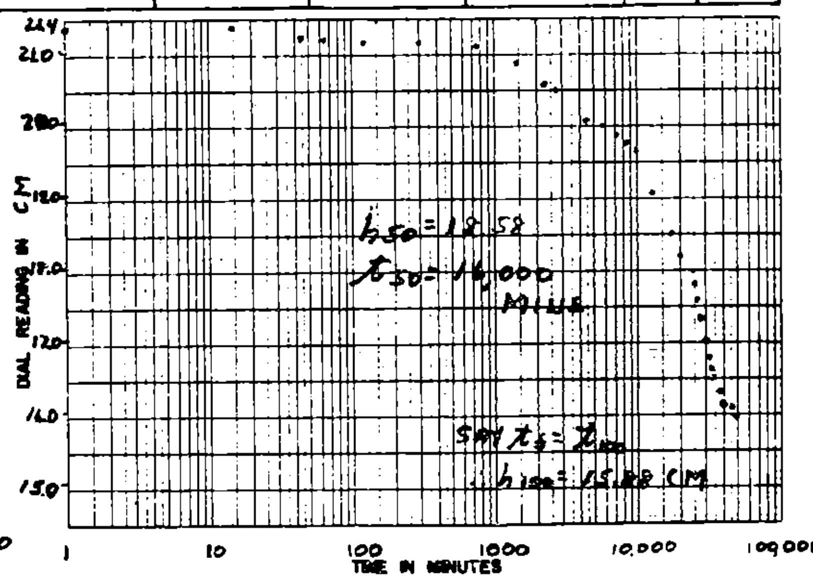
W/ FLOCCULANT

FROM 0.00176 kg/sq cm. TO 0.00276 kg/sq cm.

S, %

DATE	TIME	ELAPSED TIME, t IN min	√t IN √min	COMPRESSION DIAL IN CM	
27 AUG	0930	0	0	21.27	10.54
	0945	15	3.87	21.26	
	1015	45	6.71	21.20	
	1035	65	8.06	21.18	
	1135	125	11.18	21.15	
	1430	300	17.32	21.10	
	2200	750	27.39	21.05	
28 "	1030	1500	38.73	20.80	10.77
	2330	2280	47.75	20.50	
29 "	0930	2880	53.67	20.40	
30 "	1145	4455	66.74	20.00	
31 "	1150	5900	76.81	19.90	
1 SEPT	1115	7305	85.47	19.80	
2 "	0945	8655	93.03	19.70	11.33
3 "	0815	10005	99.72	19.60	
4 "	1020	11570	107.56	19.00	
5 "	0745	12855	113.38	19.00	
6 "	0930	14400	120.00	19.00	
7 "	0930	15840	125.86	19.00	
8 "	0800	17190	131.11	18.50	12.00
9 "	0915	18705	136.77	18.40	
10 "	1150	20300	142.48	18.10	
11 SEPT	0815	21525	146.71	18.10	
12 "	0825	22975	151.58	18.10	
13 "	0825	24415	156.25	17.90	
14 "	1110	26020	161.31	17.75	
15 "	0840	27310	165.26	17.50	
16 "	0825	28735	169.51	17.25	
17 "	0810	30160	173.67	16.95	
18 "	0755	31585	177.72	16.70	
19 "	0745	33015	181.70	16.50	13.34
20 "	1125	34675	186.21	16.40	
21 "	1705	36455	190.93	16.30	
22 "	0755	37345	193.25	16.26	
23 "	0735	38765	196.89	16.20	
24 "	0750	40220	200.55	16.13	
25 "	0850	41720	204.25	16.09	
26 "	0755	43105	207.62	16.08	
27 "	0910	44620	211.23	16.03	
29 "	0800	47430	217.78	15.92	13.78
30 "	0740	48850	221.02	15.88	





CONSOLIDATION TEST

INCR. NO. 5

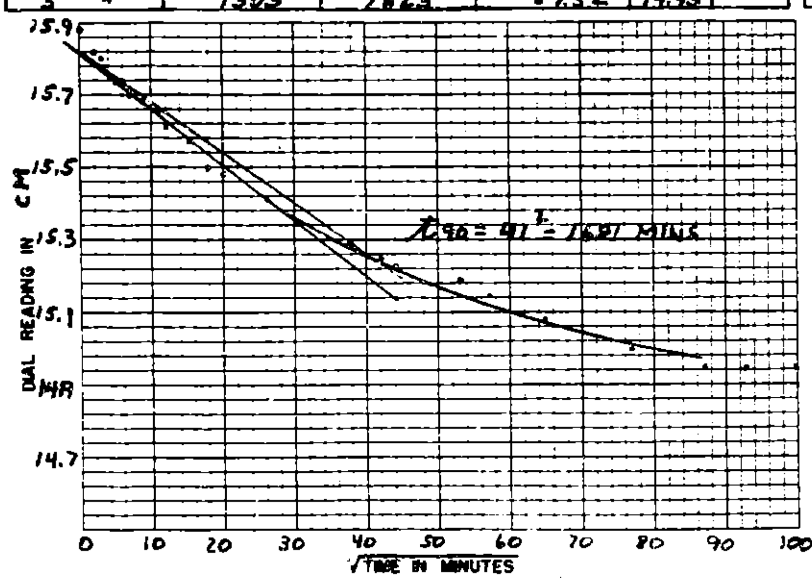
TEST NO. CONSOL #4 TESTED BY JRR PRESSURE INCREMENT
NORALYN COMPOSITE
W/FLOCCULANT

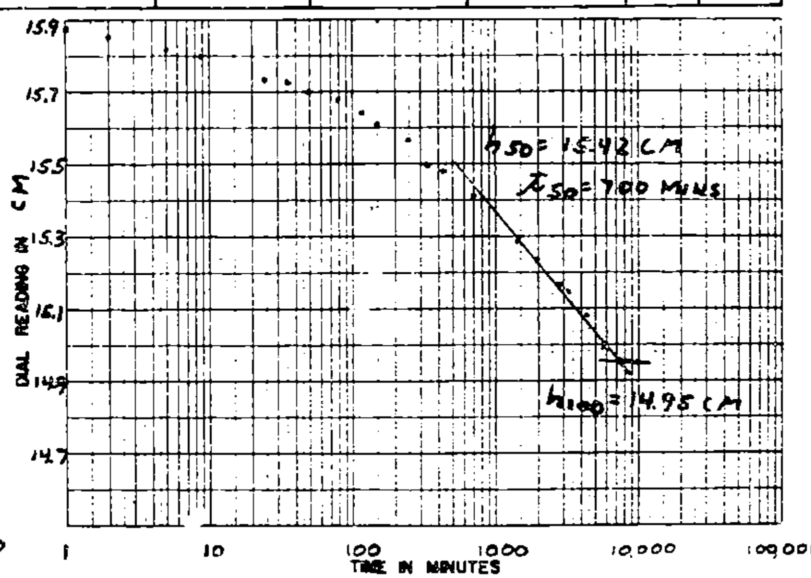
FROM 0.00276 kg/sq. cm. TO 0.00476 kg/sq. cm.

5, 9$_0$

DATE	TIME	ELAPSED TIME, t in min	$\sqrt{t}$ in $\sqrt{min}$	COMPRESSION DIAL in CM	
30 SEPT	0800	0	0	15.88	
	0802	2	1.41	15.85	
	0805	5	2.24	15.82	
	0809	9	3.00	15.80	
	0824	24	4.90	15.74	
	0835	35	5.92	15.73	
	0850	50	7.07	15.70	
	0920	80	8.94	15.68	
	1000	120	10.95	15.65	
	1025	145	12.04	15.61	
	1200	240	15.49	15.57	
	1330	330	18.16	15.50	
	1455	415	20.37	15.48	
	1940	700	26.46	15.41	
1 OCT	0830	1470	38.34	15.29	
	1345	1785	42.25	15.25	
	1640	1960	44.27	15.23	
2 "	0750	2870	53.57	15.17	14.40
	1405	3245	56.96	15.15	
3 "	0750	4310	65.65	15.08	
4 "	1010	5890	76.75	14.99	
5 "	1505	7625	87.32	14.95	

DATE	TIME	ELAPSED TIME, t in min	$\sqrt{t}$ in $\sqrt{min}$	COMPRESSION DIAL in CM	
6 OCT	0810	8650	93.00	14.95	
7 "	0800	10060	100.40	14.95	14.60





CONSOLIDATION TEST

INCR. NO. 6

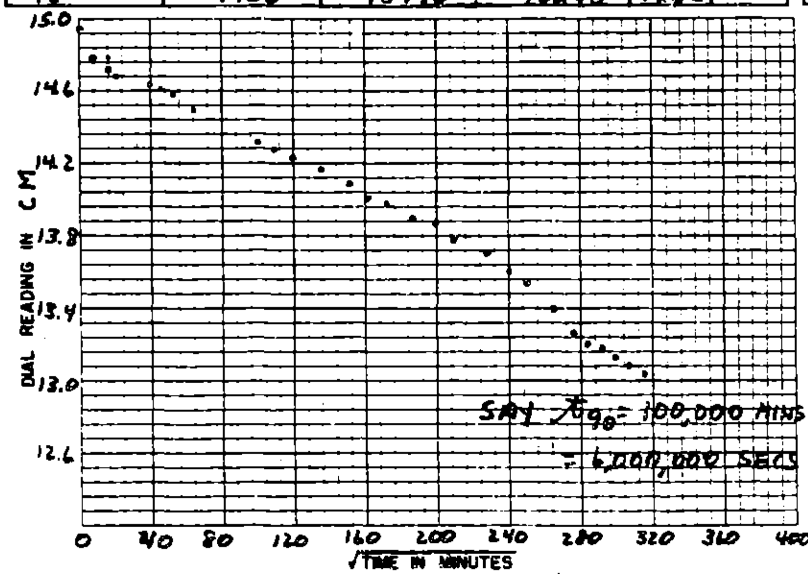
TEST NO. CONSOL #4 TESTED BY JRR PRESSURE INCREMENT FROM 0.00476 kg/sq. cm. TO 0.00876 kg/sq. cm.

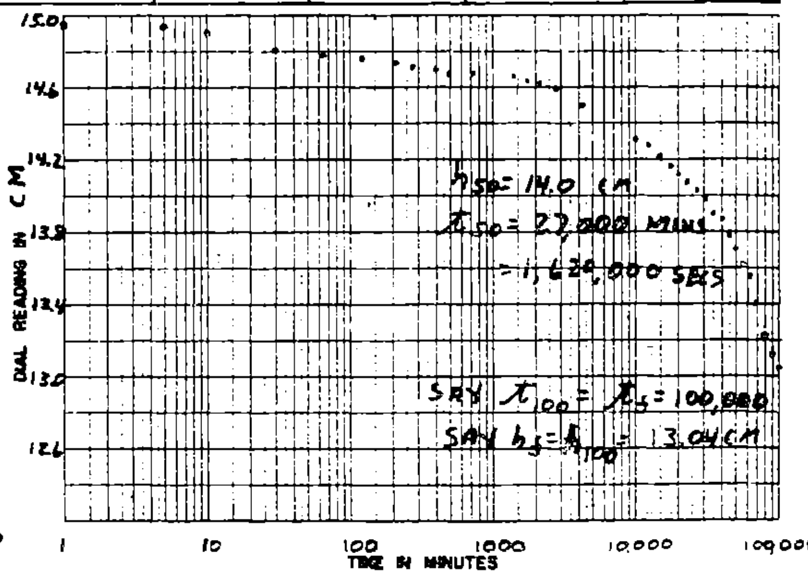
NORALYN COMPOSITE
w/ FLOCCULANT

S, 90

DATE	TIME	ELAPSED TIME, t IN min	$\sqrt{t}$ IN $\sqrt{min}$	COMPRESSION DIAL IN CM	
7 OCT	0830	0	0	14.95	14.60
	0835	5	2.24	14.93	
	0840	10	3.16	14.90	
	0900	30	5.48	14.81	
	0935	65	8.06	14.78	
	1045	135	11.62	14.76	
	1200	210	14.49	14.74	
	1315	285	16.88	14.73	
	1510	400	20.00	14.71	
	1640	490	22.14	14.69	
	2100	750	27.39	14.69	
8 "	0800	1410	37.55	14.67	
	1210	1660	40.74	14.64	
	1415	1785	42.25	14.63	
	2000	2130	46.15	14.62	
9 "	0800	2850	53.38	14.59	
10	0810	4300	65.57	14.50	
14	0750	10040	100.20	14.32	15.18
15	0830	11520	107.33	14.31	
16	0800	12930	113.71	14.28	
17	0825	14395	119.98	14.23	
18	1100	15990	126.45	14.22	

DATE	TIME	ELAPSED TIME, t IN min	$\sqrt{t}$ IN $\sqrt{min}$	COMPRESSION DIAL IN CM	
20 OCT	0810	18700	136.75	14.17	
21 "	0800	20130	141.88	14.14	
23 "	0800	23010	151.69	14.09	15.40
25 "	2300	26790	163.68	14.03	
28 "	0800	30210	173.81	13.98	
31 "	0800	34530	185.82	13.90	
4 NOV	0800	40290	200.72	13.88	
7 "	0800	44610	211.21	13.78	
12 "	0800	51810	227.62	13.70	
16 "	2030	58320	241.50	13.62	
20 "	0830	63360	251.71	13.56	
25 "	0800	70530	265.57	13.40	16.11
29 "	1310	76600	276.77	13.25	
2 DEC	0810	80620	283.94	13.22	
5 "	0730	84900	291.38	13.19	
8 "	0845	89295	298.82	13.13	
11 "	1440	93979	306.54	13.08	16.47
15 "	0800	99330	315.17	13.04	





CONSOLIDATION TEST

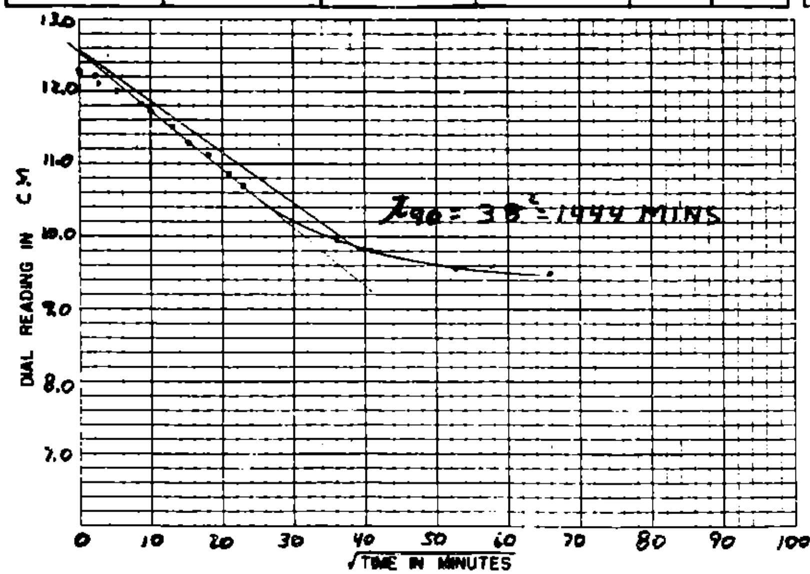
INCR. NO. 7

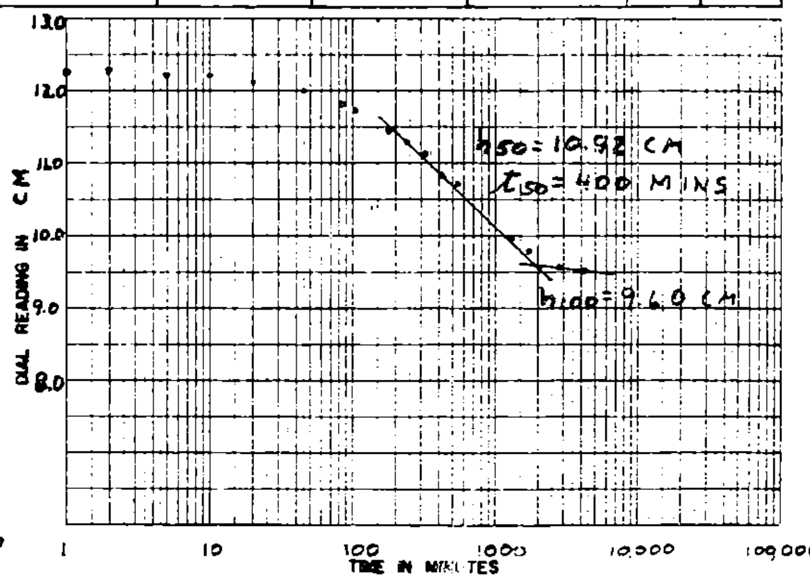
TEST NO. CONSOL #4 TESTED BY JRR PRESSURE INCREMENT
NORALYN COMPOSITE
W/ FLOCCULANT
FROM 0.00876 kg/sq. cm. TO 0.0138 kg/sq. cm.

5,4%

DATE	TIME	ELAPSED TIME, t in min	$\sqrt{t}$ in $\sqrt{min}$	COMPRESSION DIAL IN CM	
15 DEC	1000	0	0	12.25	
	1002	2	1.41	12.25	
	1005	5	2.24	12.22	
	1010	10	3.16	12.20	
	1020	20	4.47	12.12	
	1045	45	6.71	12.00	
	1115	75	8.66	11.82	
	1145	105	10.25	11.72	
	1300	180	13.42	11.48	
	1400	240	15.49	11.30	
	1530	330	18.16	11.10	
	1710	430	20.74	10.87	
	1900	540	23.24	10.70	
16 DEC	0800	1320	36.33	9.98	
	1400	1680	40.99	9.80	
17 "	0800	2760	52.54	9.58	21.67
18 "	1100	4380	66.18	9.53	

DATE	TIME	ELAPSED TIME, t in min	$\sqrt{t}$ in $\sqrt{min}$	COMPRESSION DIAL IN CM	





CONSOLIDATION TEST

INCR. NO. 8

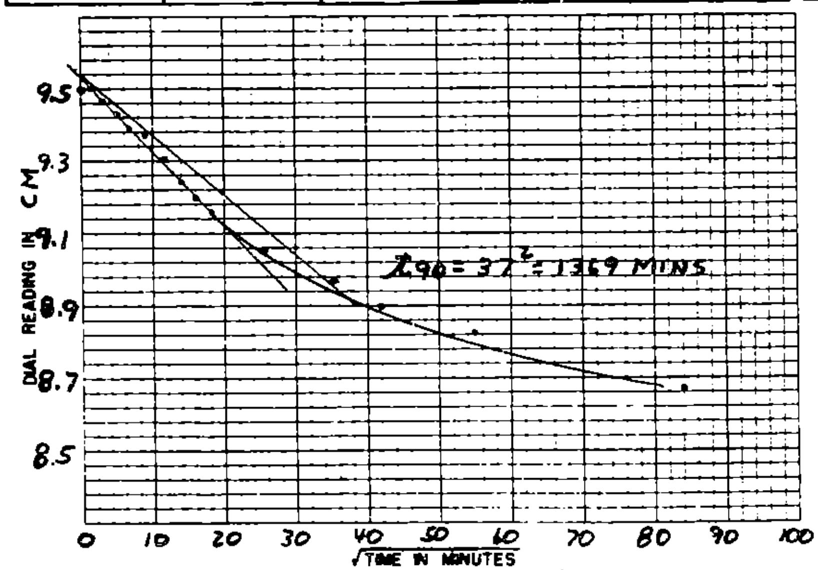
TEST NO. CONSOL #4 TESTED BY JRR PRESSURE INCREMENT FROM 0.0138 kg/sq. cm. TO 0.0192 kg/sq. cm.

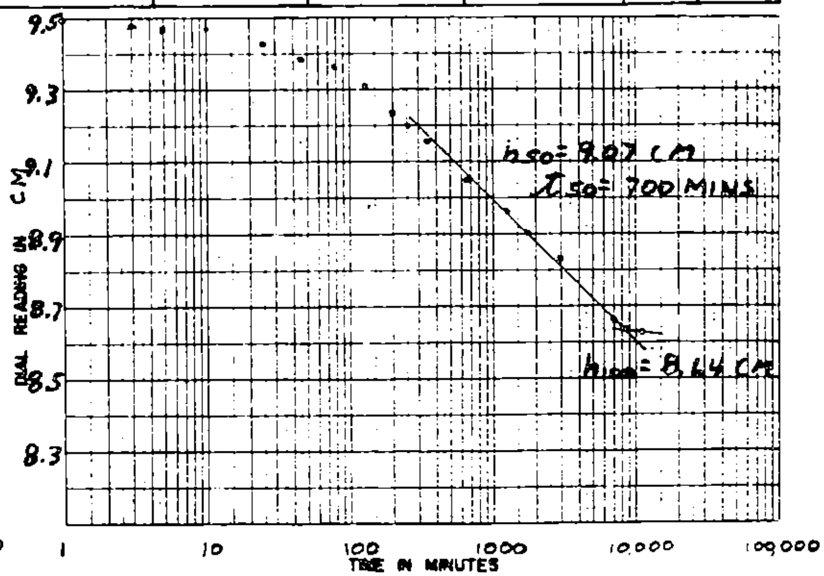
NORALYN COMPOSITE
w/ FLOCCULANT

S, %

DATE	TIME	ELAPSED TIME, t IN min	$\sqrt{t}$ IN $\sqrt{min}$	COMPRESSION DIAL IN CM	
18 DEC	1100	0	0	9.50	
	1101	1	1.00	9.50	
	1103	3	1.73	9.48	
	1105	5	2.24	9.47	
	1110	10	3.16	9.47	
	1125	25	5.00	9.43	
	1145	45	6.71	9.39	
	1220	80	8.94	9.37	
	1310	130	11.40	9.31	
	1420	200	14.14	9.24	
	1515	255	15.97	9.20	
	1750	350	18.71	9.16	
	2200	660	25.69	9.05	
19 DEC	0810	1270	35.64	8.97	
	1545	1725	41.53	8.90	
20 "	1300	3000	54.77	8.83	
21 "	1515	4575	67.64	—	
22 "	1305	5885	76.71	—	
23 "	0815	7035	83.87	8.67	
24 "	1115	8655	93.03	8.64	
26 "	1115	11,535	107.40	8.63	23.20

DATE	TIME	ELAPSED TIME, t IN min	$\sqrt{t}$ IN $\sqrt{min}$	COMPRESSION DIAL IN CM	





CONSOLIDATION TEST

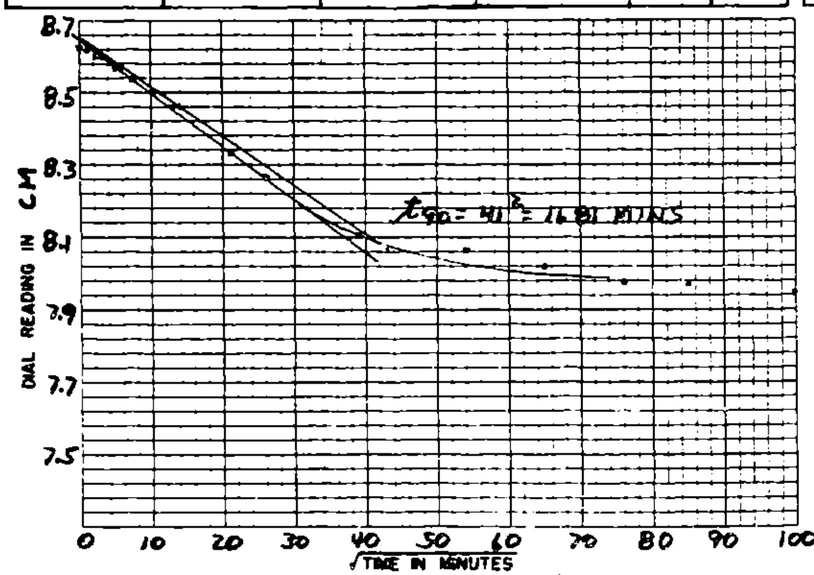
INCR. NO. 9

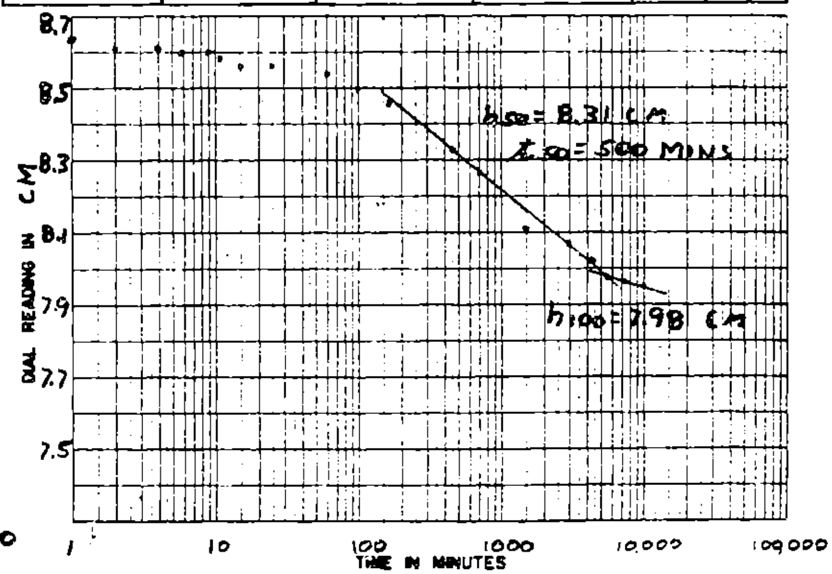
TEST NO. CONSOL #4 TESTED BY JRR PRESSURE INCREMENT
NORALYN COMPOSITE
W/ FLOCCULANT
FROM 0.0192 kg/sq. cm. TO 0.0288 kg/sq. cm.

5,%

DATE	TIME	ELAPSED TIME, t IN min	$\sqrt{t}$ IN $\sqrt{min}$	COMPRESSION DIAL IN CM	
26 DEC	1200	0	0	8.63	
	1201	1	1.00	8.62	
	1202	2	1.41	8.61	
	1204	4	2.00	8.61	
	1206	6	2.45	8.60	
	1209	9	3.00	8.60	
	1216	11	3.32	8.59	
	1225	25	5.00	8.57	
	1300	60	7.74	8.54	
	1340	100	10.00	8.50	
	1445	165	12.84	8.46	
	1930	450	21.21	8.33	
	2330	690	26.27	8.27	
27 DEC	1330	1,530	39.12	8.11	
28 "	1330	2970	54.50	8.07	
29 "	1045	4245	65.15	8.02	25.22
30 "	1200	5760	75.89	7.98	
31 "	1420	7340	85.67	7.97	
2 JAN 76	1130	10050	100.25	7.95	25.40

DATE	TIME	ELAPSED TIME, t IN min	$\sqrt{t}$ IN $\sqrt{min}$	COMPRESSION DIAL IN CM	





CONSOLIDATION TEST

INCR. NO. 10

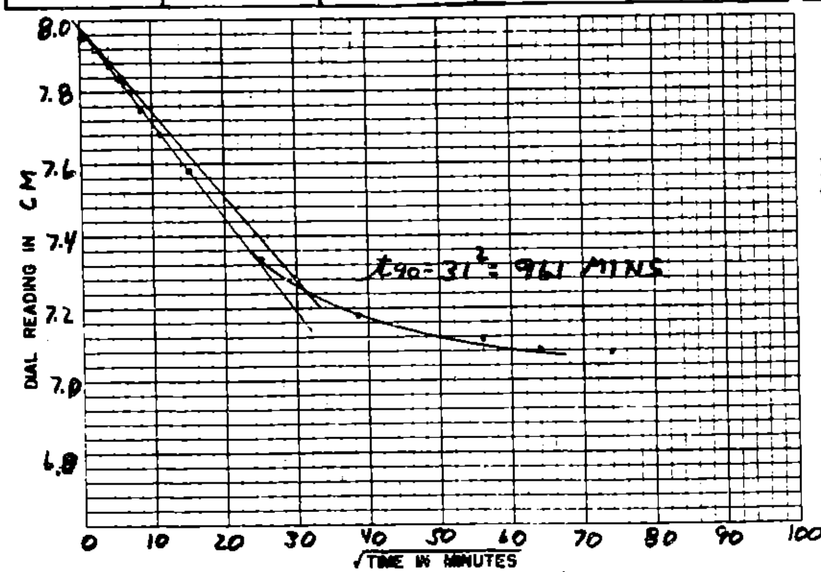
TEST NO. CONSOL #4 TESTED BY JRR PRESSURE INCREMENT FROM 0.0288 kg/sq. cm. TO 0.0488 kg/sq. cm.

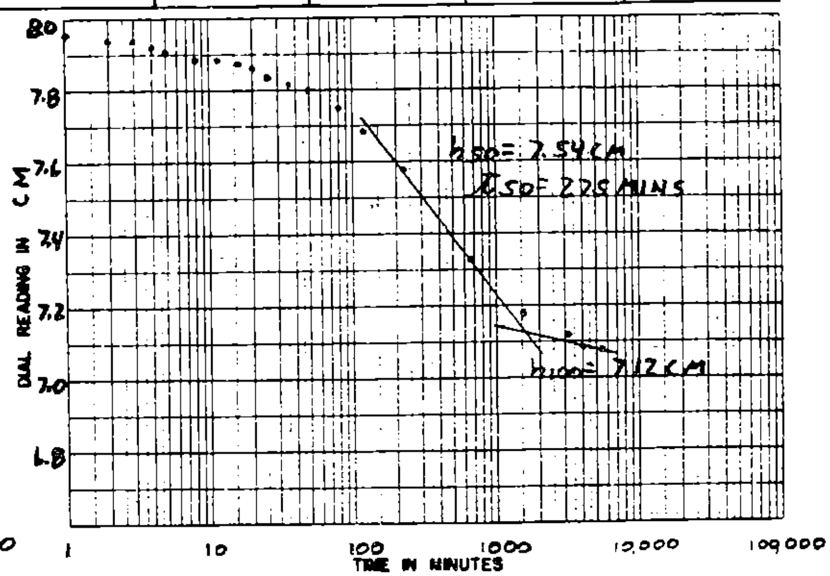
NORALYN COMPOSITE
W/ FLOCCULANT

S, %

DATE	TIME	ELAPSED TIME, t IN min	√t IN √min	COMPRESSION DIAL IN CM	
2 JAN 76	1200	0	0	7.95	
	1201	1	1.00	7.95	
	1202	2	1.41	7.93	
	1203	3	1.73	7.93	
	1204	4	2.00	7.92	
	1205	5	2.24	7.91	
	1208	8	2.83	7.89	
	1212	12	3.46	7.89	
	1216	16	4.00	7.88	
	1220	20	4.47	7.87	
	1225	25	5.00	7.84	
	1236	36	6.00	7.82	
	1250	50	7.07	7.80	
	1320	80	8.94	7.75	
	1400	120	10.95	7.69	
	1550	230	15.16	7.58	
	2230	630	25.10	7.34	
3 JAN	1410	1570	39.62	7.18	
4 "	1600	3120	55.86	7.12	
5 "	0800	4080	63.87	7.09	
6 "	0800	5520	74.30	7.08	27.98

DATE	TIME	ELAPSED TIME, t IN min	√t IN √min	COMPRESSION DIAL IN CM	





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CONSOLIDATION TEST

INCR. NO. 11

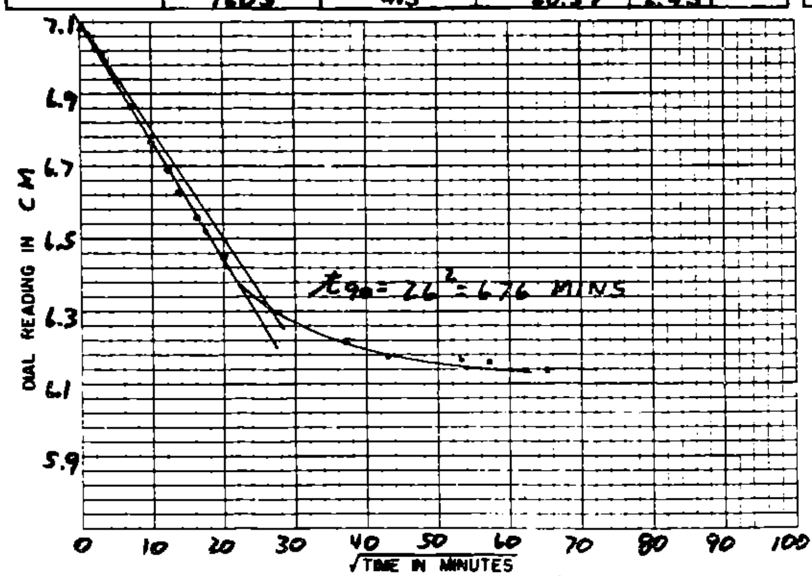
TEST NO. CONSOL #4 TESTED BY JRR PRESSURE INCREMENT FROM 0.0488 kg/sq. cm. TO 0.0888 kg/sq. cm.

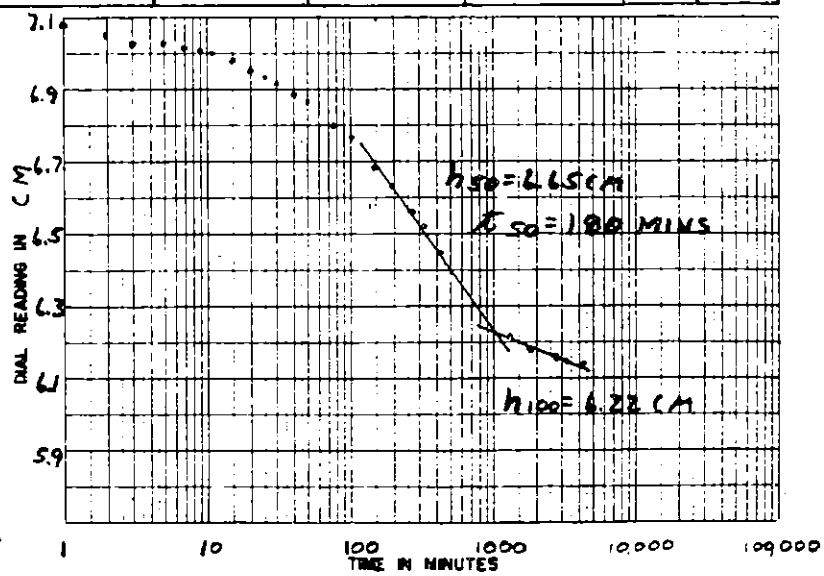
NORALYN COMPOSITE
W/ FLOCCULANT

5,90

DATE	TIME	ELAPSED TIME, t in min	$\sqrt{t}$ in $\sqrt{min}$	COMPRESSION DIAL in CM	
6 JAN	0910	0	0	7.08	
	0911	1	1.00	7.07	
	0912	2	1.41	7.05	
	0913	3	1.73	7.03	
	0914	4	2.00	7.03	
	0915	5	2.24	7.03	
	0917	7	2.64	7.02	
	0919	9	3.00	7.01	
	0921	11	3.32	7.00	
	0925	15	3.87	6.98	
	0930	20	4.47	6.96	
	0935	25	5.00	6.94	
	0940	30	5.48	6.92	
	0950	40	6.32	6.89	
	1000	50	7.07	6.87	
	1025	75	8.66	6.80	
	1050	100	10.00	6.77	
	1135	145	12.04	6.69	
	1220	190	13.78	6.63	
	1335	265	16.28	6.56	
	1420	310	17.61	6.52	
	1605	415	20.37	6.45	

DATE	TIME	ELAPSED TIME, t in min	$\sqrt{t}$ in $\sqrt{min}$	COMPRESSION DIAL in CM	
7 JAN	0810	1380	37.15	6.22	31.09
	1600	1850	43.01	6.18	
8 "	0810	2820	53.10	6.17	
	1630	3320	57.62	6.16	
9 "	0830	4280	65.42	6.14	





CONSOLIDATION TEST

INCR. NO. 12

TEST NO. CONSOL #4 TESTED BY JER PRESSURE INCREMENT

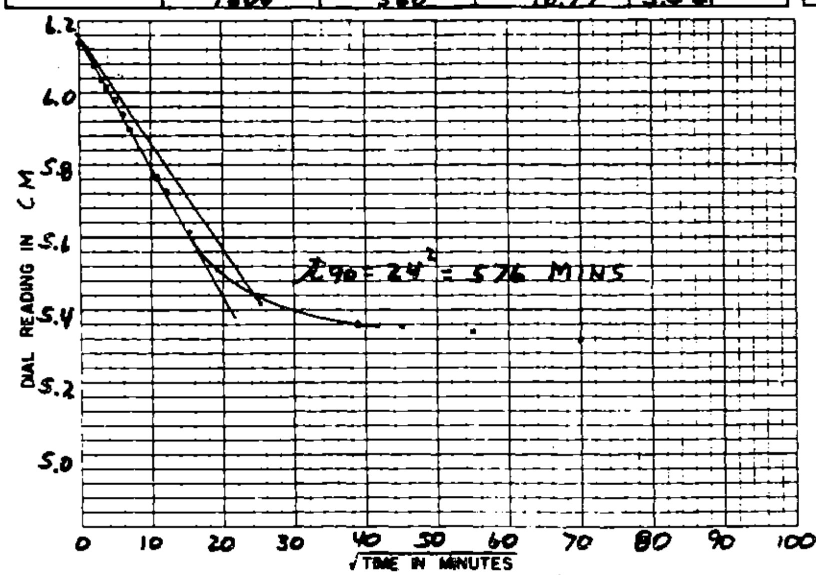
NORALYN COMPOSITE FROM 0.0888 kg/sq. cm. TO 0.1688 kg/sq. cm.

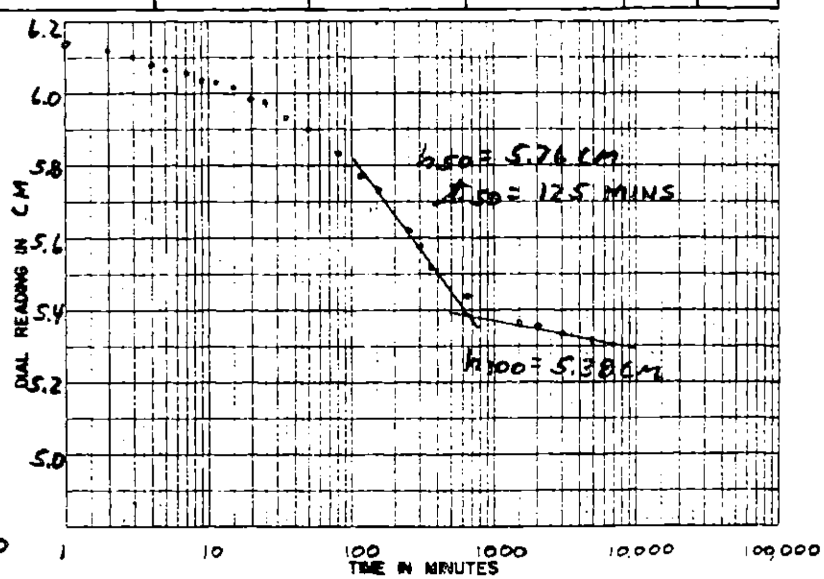
W/ FLOCCULANT

S, %

DATE	TIME	ELAPSED TIME, t in min	$\sqrt{t}$ in $\sqrt{min}$	COMPRESSION DIAL in CM	
9 JAN76	1000	0	0	6.14	31.42
	1001	1	1.00	6.13	
	1002	2	1.41	6.12	
	1003	3	1.73	6.10	
	1004	4	2.00	6.08	
	1005	5	2.24	6.07	
	1006	6	2.45	6.07	
	1007	7	2.64	6.06	
	1008	8	2.83	6.04	
	1009	9	3.00	6.04	
	1012	12	3.46	6.03	
	1015	15	3.87	6.02	
	1020	20	4.47	5.99	
	1025	25	5.00	5.98	
	1035	35	5.92	5.94	
	1050	50	7.07	5.90	
	1120	80	8.94	5.83	
	1200	120	10.95	5.77	
	1235	155	12.45	5.73	
	1410	250	15.81	5.62	
	1500	300	17.32	5.58	
	1600	360	18.97	5.52	

DATE	TIME	ELAPSED TIME, t in min	$\sqrt{t}$ in $\sqrt{min}$	COMPRESSION DIAL in CM	
	2045	645	25.40	5.44	
10 JAN	1120	1520	38.99	5.37	34.93
	2030	2070	45.50	5.36	
11 "	1250	3050	55.23	5.34	
12 "	2000	4920	70.14	5.32	
13 "	0800	5640	75.10	5.32	





CONSOLIDATION TEST

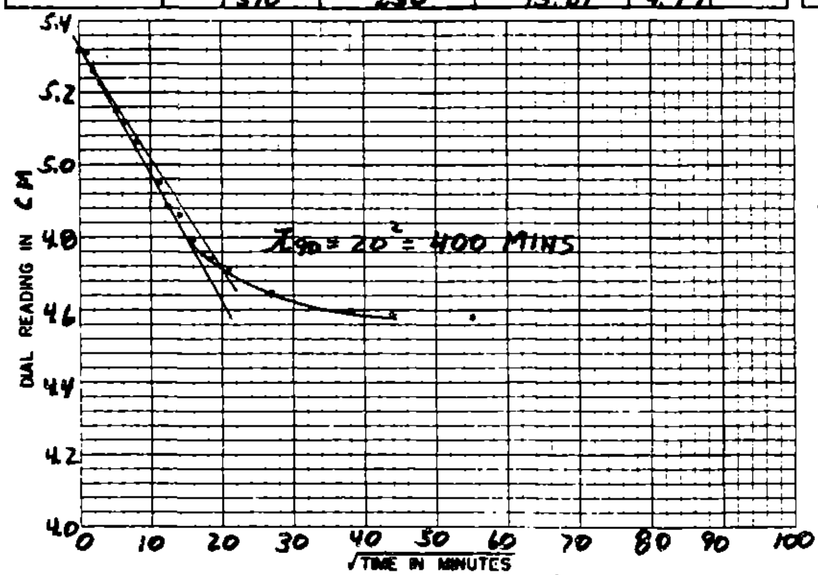
INCR. NO. 13

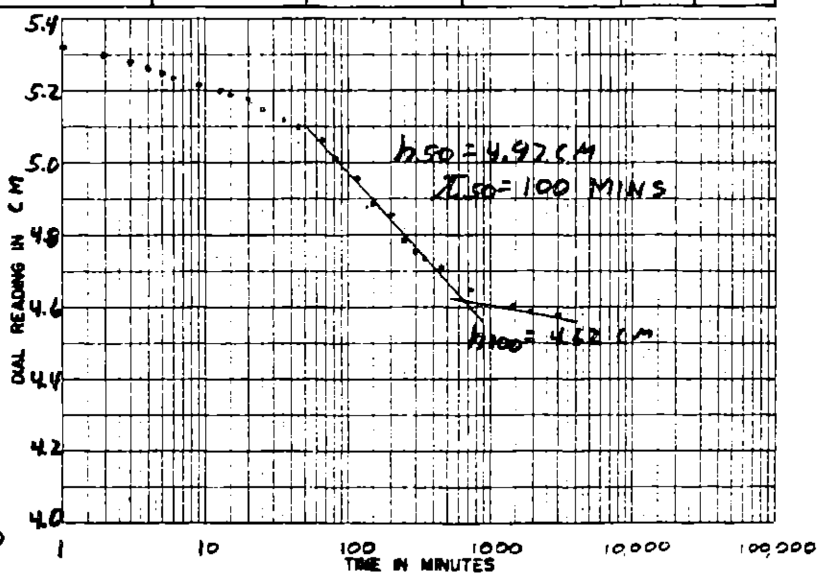
TEST NO. CONSOL #4 TESTED BY JRR PRESSURE INCREMENT
NORALVN COMPOSITE FROM 0.1688 kg/sq. cm. TO 0.3288 kg/sq. cm.
W/ FLOCCULANT

S, %

DATE	TIME	ELAPSED TIME, t in min	$\sqrt{t}$ in $\sqrt{min}$	COMPRESSION DIAL in CM	
13 JAN	0900	0	0	5.32	35.19
	0901	1	1.00	5.31	
	0902	2	1.41	5.30	
	0903	3	1.73	5.28	
	0904	4	2.00	5.26	
	0905	5	2.24	5.25	
	0906	6	2.45	5.24	
	0907	7	2.64	5.23	
	0909	9	3.00	5.22	
	0911	11	3.32	5.21	
	0913	13	3.61	5.20	
	0915	15	3.87	5.19	
	0920	20	4.47	5.18	
	0925	25	5.00	5.15	
	0935	35	5.92	5.12	
	0945	45	6.71	5.10	
	1005	65	8.06	5.06	
	1020	80	8.94	5.01	
	1055	115	10.72	4.95	
	1130	150	12.25	4.89	
	1220	200	14.14	4.86	
	1310	250	15.81	4.79	

DATE	TIME	ELAPSED TIME, t in min	$\sqrt{t}$ in $\sqrt{min}$	COMPRESSION DIAL IN CM	
	1400	300	17.32	4.76	
	1450	350	18.71	4.74	
	1630	450	21.21	4.71	
	2100	720	26.83	4.65	
14 JAN	0845	1425	37.95	4.60	
	1700	1920	43.82	4.59	
15 "	1150	3050	55.23	4.58	39.47





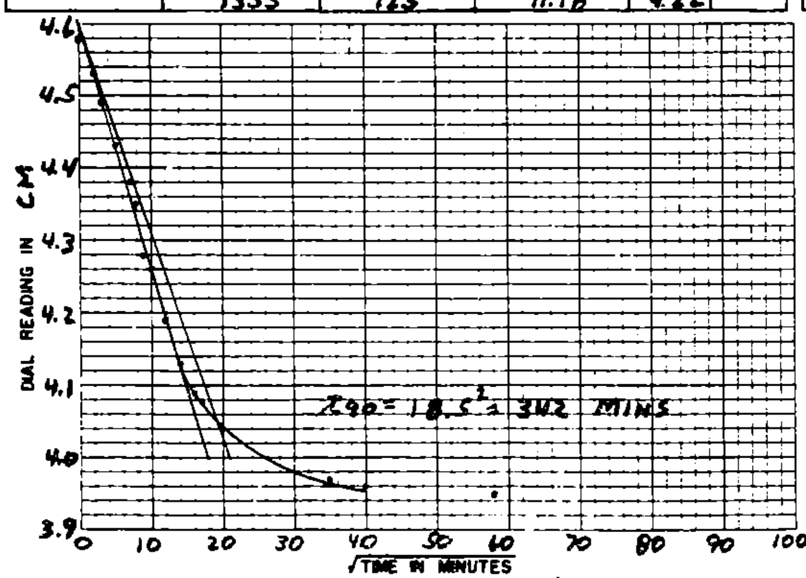
CONSOLIDATION TEST

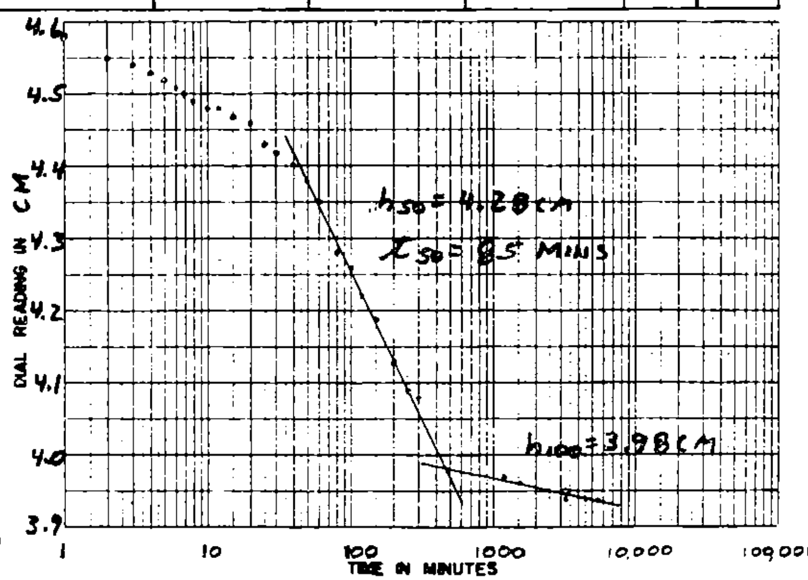
INCR. NO. 14

TEST NO. CONSOL #4 TESTED BY JRR PRESSURE INCREMENT
NORALYN COMPOSITE FROM 0.3288 kg/sq. cm. TO 0.6488 kg/sq. cm.
W/FLOCCULANT

S, $\%_o$

DATE	TIME	ELAPSED TIME, t in min	$\sqrt{t}$ in $\sqrt{min}$	COMPRESSION DIAL IN CM	
15 JAN	1150	0	0	4.58	39.47
	1151	1	1.00	4.58	
	1152	2	1.41	4.55	
	1153	3	1.73	4.54	
	1154	4	2.00	4.53	
	1155	5	2.24	4.52	
	1156	6	2.45	4.51	
	1157	7	2.64	4.50	
	1158	8	2.83	4.49	
	1159	9	3.00	4.49	
	1200	10	3.16	4.48	
	1202	12	3.46	4.48	
	1205	15	3.87	4.47	
	1210	20	4.47	4.46	
	1215	25	5.00	4.43	
	1220	30	5.48	4.42	
	1230	40	6.32	4.40	
	1240	50	7.07	4.38	
	1250	60	7.74	4.35	
	1310	80	8.94	4.28	
	1330	100	10.00	4.26	
	1355	125	11.18	4.22	
	1420	150	12.25	4.19	
	1510	200	14.14	4.13	
	1600	250	15.81	4.09	
	1650	300	17.32	4.08	
16 JAN	0800	1210	34.78	3.97	
	1815	1585	39.81	3.96	43.95
17 "	2000	3370	58.05	3.95	
18 "	1500	4510	67.16	3.94	
19 "	0920	5610	74.90	3.94	44.11





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CONSOLIDATION TEST

INCR. NO. 15

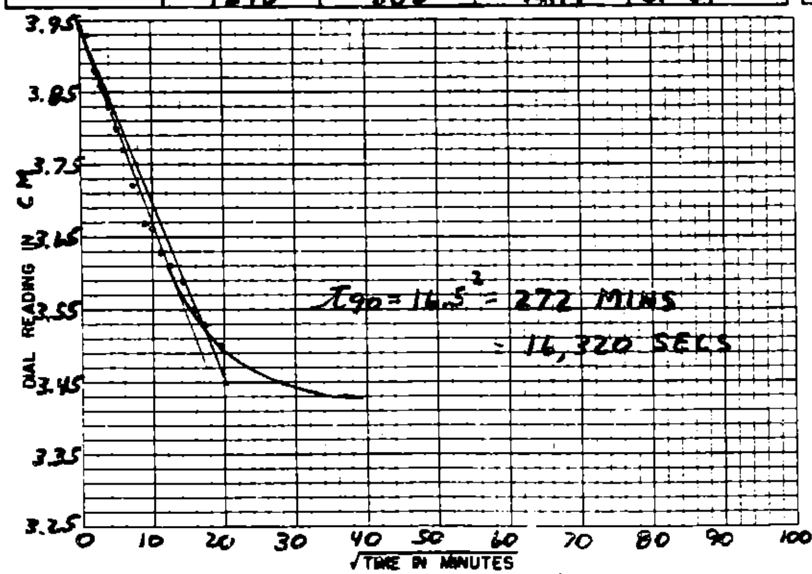
TEST NO. CONSOL #4 TESTED BY JRR PRESSURE INCREMENT FROM 0.6488 kg/sq cm. TO 1.2888 kg/sq cm.

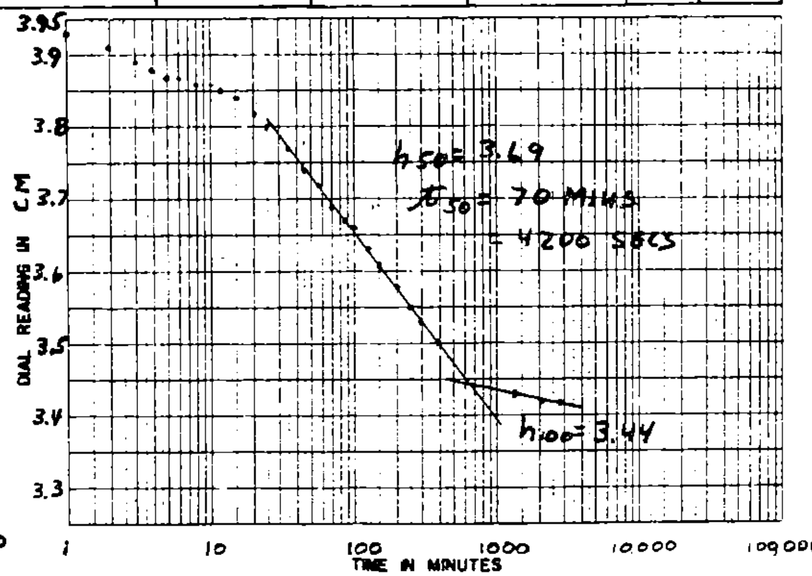
NORALYN
w/ FLOCCULANT

S, %

DATE	TIME	ELAPSED TIME, t IN min	√t IN √min	COMPRESSION DIAL IN CM	
19 JAN	0920	0	0	3.94	44.11
	0921	1	1.00	3.93	
	0922	2	1.41	3.91	
	0923	3	1.73	3.89	
	0924	4	2.00	3.88	
	0925	5	2.24	3.87	
	0926	6	2.45	3.87	
	0928	8	2.83	3.86	
	0930	10	3.16	3.86	
	0932	12	3.46	3.85	
	0935	15	3.87	3.84	
	0940	20	4.47	3.82	
	0945	25	5.00	3.80	
	0955	35	5.92	3.77	
	1005	45	6.71	3.74	
	1015	55	7.42	3.72	
	1030	70	8.37	3.69	
	1045	85	9.22	3.67	
	1100	100	10.00	3.66	
	1125	125	11.18	3.63	
	1150	150	12.25	3.61	
	1240	200	14.14	3.58	

DATE	TIME	ELAPSED TIME, t IN min	√t IN √min	COMPRESSION DIAL IN CM	
	1330	250	15.81	3.55	
	1420	300	17.32	3.53	
	1540	380	19.49	3.50	
20 JAN	0810	1370	37.01	3.43	
	2025	2105	45.88	3.42	
21 "	0820	2820	53.10	3.42	48.77





DETAILS of CONSOLIDATION TEST No. 1 Sheet 1 of 2

SAMPLE: MOBIL #1 BY JRR

INCR.	σ GM/CM² TOTAL	SELF WEIGHT	SEEPAGE	PISTON	HEIGHT, CM H_o	$H_{AVG.}$	H_{100}	H_f	DATE TIME	t FOR C_v, SEC t_{90}	t_{50}	m_v CM²/GM	REMARKS
0	0				28.0				7 MAR 0925				
						25.25				464,640	150,000	0.2550	*
1	0.77	0.77	—	—	28.0		22.5	22.5	10 MAR 1300				
						18.55				365,040	99,000	0.1080	
2	4.02	0.77	3.25	—	22.5		14.6	14.6	18 MAR 1220				
						12.28				238,140	42,000	0.0706	
3	8.52	0.77	5.25	2.50	14.6		10.28	9.96	22 MAR 1250				
						9.305				74,340	17,400	0.0329	
4	12.52	0.77	5.25	6.50	9.96		8.70	8.65	24 MAR 1235				
						8.265				73,800	24,900	0.0254	*
5	16.02	0.77	5.25	10.00	8.65		7.88	7.88	25 MAR 0930				
						7.365				73,500	12,600	0.0135	
6	25.72	0.77	5.25	19.70	7.88		6.86	6.85	26 MAR 0920				
						6.44				45,720	10,800	0.006928	
7	42.92	0.77	5.25	36.90	6.85		6.05	6.03	27 MAR 0920				
						5.565				30,360	7200	0.003899	
8	82.72	0.77	5.25	76.70	6.03		5.11	5.10	28 MAR 1110				
						4.70				14,400	4680	0.001683	
9	176.0	0.77	5.25	170.0	5.10		4.33	4.30	29 MAR 1205				

* t_{90} + t_{100} EXTRAPOLATED

DETAILS of CONSOLIDATION TEST No. 1

Sheet 2 of 2

SAMPLE: MOBIL #1 BY JRR

INCR.	σ GM/CM² TOTAL	SELF WEIGHT	SEEPAGE	PISTON	HEIGHT, CM H_o	$H_{AVG.}$	H_{100}	H_f	DATE TIME	t FOR C_v, SEC t_{90}	t_{50}	m_v CM²/GM	REMARKS
						3.98				13,500	3600	0.000797	
10	363.0	0.77	5.25	357.0	4.30		3.70	3.66	31 MAR 1010				
						3.43				12,098	3360	0.000282	
11	806.0	0.77	5.25	800.0	3.66		3.22	3.20	2 APR 1130				
						2.995				9375	2880	0.000234	
12	1350.0	0.77	5.25	1344.0	3.20		2.83	2.79	7 APR 1230				

DETAILS of CONSOLIDATION TEST No. 2

Sheet 1 of 1

SAMPLE: NORALYN #1 BY JRR

INCR.	σ GM/CM² TOTAL	SELF WEIGHT	SEEPAGE	PISTON	HEIGHT, CM H_o	$H_{ave.}$	H_{100}	H_f	DATE TIME	t for C_v, SEC t_{90}	t_{50}	m_v CM²/GM	REMARKS
0	0				28.0				15 MAY 1323				
						19.20				261,360	13,500	1.96433	
1	0.32	0.32	—	—	28.0		10.60	10.40	22 MAY 1015				
						9.26				132,540	36,000	0.21905	
2	1.32	0.32	1.00	—	10.40		8.30	8.12	27 MAY 1130				
						8.01				7260	16,200	0.01084	
3	3.82	0.32	3.50	—	8.12		7.91	7.90	29 MAY 1253				
						6.675				29,040	18,000	0.06461	
4	8.62	0.32	6.00	2.30	7.90		5.54	5.45	5 JUN 1315				
						4.675				40,560	9840	0.02996	
5	18.12	0.32	7.50	10.30	5.45		4.07	3.90	10 JUN 1020				
						3.73				34,560	9000	0.008403	
6	28.42	0.32	7.50	20.60	3.90		3.63	3.56	11 JUN 1000				
						3.32				20,520	5040	0.006780	
7	48.32	0.32	7.50	40.50	3.56		3.09	3.08	12 JUN 0905				
						2.92				6000	1200	0.002625	
8	88.22	0.32	7.50	80.40	3.08		2.82	2.76	13 JUN 0900				
						2.49				6720	1800	0.002425	
9	168.82	0.32	7.50	161.00	2.76		2.24	2.22	14 JUN 1130				

DETAILS of CONSOLIDATION TEST No. 3

Sheet 1 of 2

SAMPLE NORALYN #2 BY JRR

INCR.	σ GM/CM² TOTAL	SELF WEIGHT	SEEPAGE	PISTON	HEIGHT, CM H_0	$H_{AVG.}$	H_{100}	H_f	DATE TIME	t FOR C_v, SEC t_{90}	t_{50}	m_v CM²/GM	REMARKS
0					28.0				24 JUNE 0850				
						22.165				779,760	21000	0.662	
1	0.63	0.63	—	—	28.0		16.7	16.33	14 JULY 0900				
						15.815				144,060	43,200	0.0630	
2	1.63	0.63	1.00	—	16.33		15.35	15.30	17 JULY 0900				
						15.20				24,000	7800	0.0133	
3	2.63	0.63	2.00	—	15.30		15.10	15.10	18 JULY 1050				
						14.90				277,440	87,000	0.0132	
4	4.63	0.63	4.00	—	15.10		14.70	14.70	21 JULY 0815				*
						14.635				—	—	—	
5	8.63	0.63	8.00	—	14.70		—	14.57	21 JULY 1230				*
						14.26				65,340	15,000	0.00223	
6	27.38	0.63	26.75	—	14.57		13.95	13.95	22 JULY 1055				*
						12.125				201,840	55,800	0.0153	
7	10.33	0.63	7.50	2.20	13.95		10.30	10.30	25 JULY 1030				*
						9.81				208,860	37,800	0.0531	
8	12.13	0.63	7.50	4.00	10.30		9.32	9.32	28 JULY 0945				
						8.825				205,320	45,000	0.0262	
9	16.19	0.63	7.50	8.06	9.32		8.33	8.33	31 JULY 1200				

* H_{100} NOT REACHED

DETAILS of CONSOLIDATION TEST No. 3

Sheet 2 of 2

SAMPLE NORALYN #2 BY JRR

INCR.	$\bar{\sigma}$ GM/CM² TOTAL	SELF WEIGHT	SEEPAGE	PISTON	HEIGHT, CM H_0	$H_{AVE.}$	H_{100}	H_f	DATE TIME	t FOR C_v, SEC t_{90}	t_{50}	m_v CM²/GM	REMARKS
						7.865				126,960	30,000	0.0140	
10	24.13	0.63	7.50	16.0	8.33		7.41	7.40	4 AUG 1315				
						6.955				54,000	15,000	0.00743	
11	40.33	0.63	7.50	32.2	7.40		6.53	6.51	6 AUG 1200				
						6.065				50,460	12,000	0.00430	
12	72.13	0.63	7.50	64.0	6.51		5.62	5.62	8 AUG 1000				
						5.195				39,000	8700	0.00236	
13	136.13	0.63	7.50	128.0	5.62		4.83	4.77	10 AUG 1125				
						4.44				26,460	6900	0.00108	
14	264.13	0.63	7.50	256.0	4.77		4.15	4.11	11 AUG 1315				
						3.91				16320	5400	0.000680	
15	409.13	0.63	7.50	401.0	4.11		3.75	3.71	12 AUG 1300				
						3.445				19,440	4200	0.000357	
16	808.13	0.63	7.50	800.0	3.71		3.21	3.18	14 AUG 0935				
						2.96				13,500	3000	0.000199	
17	1508.13	0.63	7.50	1500.0	3.18		2.81	2.74	18 AUG 0800				

DETAILS of CONSOLIDATION TEST No. 4

Sheet 1 of 2

SAMPLE: NORALYN W/ FLOCCULANT BY JRR

INCR.	$\bar{\sigma}$ GM/CM² TOTAL	SELF WEIGHT	SEEPAGE	PISTON	HEIGHT, CM H_0	$H_{AVG.}$	H_{100}	H_f	DATE TIME	t FOR C_V, SEC t_{90}	t_{50}	m_v CM²/GM	REMARKS
0					28.0				22 AUG 1225				
						24.705				6000	2220	0.30950	
1	0.76	0.76	—	—	28.0		21.70	21.41	25 AUG 0900				
						—				—	—	—	
2	1.26	0.76	0.50	—	21.41		—	—	26 AUG 0900				
						—				—	—	—	
3	1.76	0.76	1.00	—	—		—	—	27 AUG 0930				
						18.645				2,646,000	960,000	0.12911	
4	2.76	0.76	2.00	—	—		15.88	15.88	30 SEPT 0800				
						15.415				100,860	42,000	0.02938	
5	4.76	0.76	4.00	—	15.88		14.95	14.95	7 OCT 0830				
						13.995				6,000,000	1,620,000	0.03195	
6	8.76	0.76	8.00	—	14.95		13.04	13.04	15 DEC 1000				*
						11.285				86,640	24,000	0.05345	
7	13.8	0.76	8.00	5.0	13.04		9.60	9.53	18 DEC 1100				
						9.08				82,140	42,000	0.01746	
8	19.2	0.76	8.00	10.4	9.53		8.64	8.63	26 DEC 1200				
						8.29				100,860	30,000	0.008184	
9	28.8	0.76	8.00	20.0	8.63		7.98	7.95	2 JAN 1200				

H_{100} NOT REACHED

DETAILS of CONSOLIDATION TEST No. 4

Sheet 2 of 2

SAMPLE: NORALYN W/ FLOCCULANT BY JRR

INCR.	$\bar{\sigma}$ GM/CM² TOTAL	SELF WEIGHT	SEEPAGE	PISTON	HEIGHT, CM H_o	$H_{AVE.}$	H_{100}	H_f	DATE TIME	t FOR C_v, SEC t_{90}	t_{50}	m_v CM²/GM	REMARKS
						7.515				57,660	16,500	0.0054817	
10	48.8	0.76	8.00	40.0	7.95		7.12	7.08	6 JAN 0910				
						6.61				40,560	10,800	0.0033271	
11	88.8	0.76	8.00	80.0	7.08		6.22	6.14	9 JAN 1000				
						5.73				34,560	7500	0.0016679	
12	168.8	0.76	8.00	160.0	6.14		5.38	5.32	13 JAN 0900				
						4.95				24,000	6000	0.0008692	
13	328.8	0.76	8.00	320.0	5.32		4.62	4.58	15 JAN 1150				
						4.26				20,520	5100	0.00043269	
14	648.8	0.76	8.00	640.0	4.58		3.98	3.94	19 JAN 0920				
						3.68				16,320	4200	0.00020926	
15	1288.8	0.76	8.00	1280.0	3.94		3.44	3.42	21 JAN 0820				

DETAILS of SEEPAGE TEST No. 2

SAMPLE: MOBIL W/FLOCCULANT BY JRR

INCR.	$\bar{\sigma}$ GM/CM² TOTAL	SELF WEIGHT	SEEPAGE	PISTON	HEIGHT, CM H_o	$H_{AVG.}$	H_{100}	H_f	DATE TIME	t FOR C_v, SEC t_{90}	t_{50}	m_v CM²/GM	REMARKS
0	0				28.00				9 OCT 1200				
						21.71				91,260	31,800	0.67066	
1	0.67	0.67	—	—	28.00		15.90	15.42	20 OCT 1000				
						14.24				3,901,500	480,000	0.15277	
2	1.67	0.67	1.00	—	15.42		13.06	13.06	15 DEC 1015				*
						—				—	—	—	
3	2.67	0.67	2.00	—	13.06		—	—	9 JAN 1000				
						11.28				50,460	9300	0.004328	
4	64.67	0.67	64.00	—	—		10.05	9.50	19 JAN 1200				

* H_{100} NOT REACHED

DETAILS of SEEPAGE TEST No. 1 Sheet 1 of 2

SAMPLE: NORALYN BY JRR

INCR.	$\bar{\sigma}$ GM/CM² TOTAL	SELF WEIGHT	SEEPAGE	PISTON	HEIGHT, CM H_0	$H_{AVG.}$	H_{100}	H_f	DATE TIME	t FOR C_v, SEC t_{90}	t_{50}	m_v CM²/GM	REMARKS
0	0				28.0				6 JUNE 1500				
						18.775				19440	3450	2.27221	
1	0.29	0.29	—	—	28.0		11.0	9.55	25 JUNE 0840				
						9.425				34,560	5400	0.05243	
2	0.79	0.29	0.50	—	9.55		9.30	9.30	26 JUNE 1045				
						8.875				624,240	45,000	0.18278	
3	1.29	0.29	1.00	—	9.30		8.45	8.45	9 JULY 0830				
						8.385				26,460	16,800	0.015205	
4	2.29	0.29	2.00	—	8.45		8.32	8.32	14 JULY 1205				
						8.16				17,340	8400	0.019200	
5	4.29	0.29	4.00	—	8.32		8.00	8.00	15 JULY 0925				
						7.85				15,360	3600	0.0093660	
6	8.29	0.29	8.00	—	8.00		7.70	7.70	16 JULY 0955				
						7.575				12,600	5400	0.0040633	
7	16.29	0.29	16.00	—	7.70		7.45	7.45	17 JULY 0800				
						7.35				34,560	4800	0.0016854	
8	32.29	0.29	32.00	—	7.45		7.25	7.25	18 JULY 1030				
						6.10				8640	2400	0.0099102	
9	64.29	0.29	64.00	—	7.25		4.96	4.95	21 JULY 0720				

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DETAILS of SEEPAGE TEST No. 1 Sheet 2 of 2

SAMPLE: NORALYN BY JRR

INCR.	$\bar{\sigma}$ GM/CM² TOTAL	SELF WEIGHT	SEEPAGE	PISTON	HEIGHT, CM H_0	$H_{AVG.}$	H_{100}	H_f	DATE TIME	t FOR C_v, SEC t_{90}	t_{50}	m_v CM²/GM	REMARKS
0	0				28.00				22 JULY 0850				
						15.65				36,000	9900	0.019721	
10	64.29	0.29	64.00	—	28.00		4.00	3.30	28 JULY 0855				
0	0				28.00				29 JULY 0735				
						18.85				178,200	42,000	2.25355	
11	0.29	0.29	—	—	28.00		11.00	9.70	4 AUG 1320				
						6.80				19,440	7200	0.0093432	
12	64.29	0.29	64.00	—	9.70		4.40	3.90	10 AUG 0815				

DIRECT - SIMPLE SHEAR TEST

PROJECT PHOSPHATES TYPE OF TEST $\overline{CK_0}$UDSS NO. 1 OCR 1

SOIL TYPE ________ TESTED BY JRR DEVICE GEONOR DATE APRIL, 1975

LOCATION FLORIDA - MOBIL PLANT SLIMES

CONSOLIDATION (Stresses in KG/CM²)

$\bar{\sigma}_{vc}$ 3.037 τ_{hc} ______ $\bar{\sigma}_{vm}$ 3.037

t_c(Day) ______ ε_v(%) ______ γ_c(%) ______ t_c(Day) ______

	W,%	e	S,%	H (cm)
Initial	85.3	2.214	97.808	2.687
Preshear		1.919		2.221
Final				

DURING SHEAR

Controlled Strain ✓ Stress ______

Rate (% / Hr.) 4.4

TIME (Hr.)	STRAIN (%)	$\frac{\tau_h}{\bar{\sigma}_{vc}}$	$\frac{\Delta u}{\bar{\sigma}_{vc}}$	$\frac{\bar{\sigma}_v}{\bar{\sigma}_{vc}}$	$\frac{\tau_h}{\bar{\sigma}_v}$	$\frac{\tau_h}{\bar{\sigma}_{vm}}$	$\frac{\bar{\sigma}_v}{\bar{\sigma}_{vm}}$	REMARKS
0800	0.00	0.000	0.000	1.000	0.000	0.000	1.000	
	0.01	0.004	0.000	1.000	0.004	0.004	1.000	
	0.04	0.024	0.000	1.000	0.024	0.024	1.000	
	0.08	0.039	0.004	0.996	0.039	0.039	0.996	
	0.13	0.055	0.007	0.993	0.055	0.055	0.993	
	0.18	0.071	0.010	0.990	0.072	0.071	0.990	
	0.27	0.092	0.014	0.986	0.093	0.092	0.986	
	0.37	0.111	0.023	0.977	0.113	0.111	0.977	
	0.53	0.126	0.031	0.969	0.130	0.126	0.969	
	0.72	0.141	0.048	0.952	0.148	0.141	0.952	
	0.97	0.151	0.075	0.925	0.164	0.151	0.925	
	1.23	0.159	0.093	0.907	0.176	0.159	0.907	
0900	1.57	0.166	0.119	0.881	0.189	0.166	0.881	
	1.82	0.172	0.140	0.860	0.199	0.172	0.860	
	2.14	0.177	0.153	0.847	0.209	0.177	0.847	
	2.50	0.182	0.167	0.833	0.218	0.182	0.833	
	2.86	0.186	0.180	0.820	0.227	0.186	0.820	
	3.22	0.190	0.201	0.799	0.238	0.190	0.799	
	3.64	0.195	0.214	0.786	0.248	0.195	0.786	
	4.03	0.198	0.224	0.776	0.255	0.198	0.776	
	4.42	0.201	0.242	0.758	0.265	0.201	0.758	
	4.78	0.203	0.251	0.749	0.271	0.203	0.749	
	5.16	0.203	0.267	0.733	0.276	0.203	0.733	
	5.53	0.205	0.276	0.724	0.283	0.205	0.724	
1000	5.94	0.207	0.286	0.714	0.290	0.207	0.714	

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REMARKS:

DIRECT - SIMPLE SHEAR (continued)

PROJECT FLORIDA SOIL PHOSPHATES TYPE OF TEST CK_0UDSS NO. 1

TIME (Hr.)	STRAIN (%)	$\frac{\tau_h}{\bar{\sigma}_{vc}}$	$\frac{\Delta u}{\bar{\sigma}_{vc}}$	$\frac{\bar{\sigma}_v}{\bar{\sigma}_{vc}}$	$\frac{\tau_h}{\bar{\sigma}_v}$	$\frac{\tau_h}{\bar{\sigma}_{vm}}$	$\frac{\bar{\sigma}_v}{\bar{\sigma}_{vm}}$	REMARKS
	6.26	0.208	0.296	0.704	0.295	0.208	0.704	
	6.70	0.209	0.303	0.697	0.300	0.209	0.697	
	7.46	0.212	0.316	0.684	0.310	0.212	0.684	
	8.32	0.216	0.322	0.678	0.319	0.216	0.678	
	9.12	0.218	0.337	0.663	0.328	0.218	0.663	
	9.91	0.220	0.354	0.646	0.340	0.220	0.646	
1100	10.71	0.221	0.365	0.635	0.348	0.221	0.635	
	11.51	0.222	0.373	0.627	0.355	0.222	0.627	
	12.33	0.224	0.381	0.619	0.361	0.224	0.619	
	13.23	0.225	0.395	0.605	0.372	0.225	0.605	
	14.03	0.226	0.404	0.596	0.380	0.226	0.596	
	14.86	0.227	0.411	0.589	0.384	0.226	0.589	
1200	15.74	0.227	0.425	0.575	0.394	0.227	0.575	
	16.88	0.227	0.436	0.564	0.402	0.227	0.564	
	17.32	0.227	0.437	0.563	0.403	0.227	0.563	
	18.17	0.226	0.446	0.554	0.408	0.226	0.554	
	19.09	0.226	0.459	0.541	0.417	0.226	0.541	
	19.99	0.225	0.471	0.529	0.426	0.225	0.529	
1300	20.89	0.222	0.486	0.514	0.431	0.222	0.514	
	21.68	0.220	0.493	0.507	0.434	0.220	0.507	
	22.54	0.219	0.502	0.498	0.439	0.219	0.498	
	23.41	0.217	0.513	0.487	0.445	0.217	0.487	
	24.40	0.214	0.533	0.467	0.459	0.214	0.467	
	25.28	0.213	0.544	0.456	0.467	0.213	0.456	
1400	26.18	0.211	0.555	0.445	0.474	0.211	0.445	
	26.96	0.210	0.560	0.440	0.480	0.210	0.440	
1420	27.92	0.207	0.568	0.432	0.481	0.207	0.432	

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REMARKS:

DIRECT - SIMPLE SHEAR TEST

PROJECT FLORIDA 1 **TYPE OF TEST** CKoUDSS **NO.** 2 **OCR** 1

SOIL TYPE PHOSPHATES **TESTED BY** JRR **DEVICE** GEONOR **DATE** JUNE 75

LOCATION NORALYN 1 FROM CONSOL #2

CONSOLIDATION (Stresses in KG/CM²**)**

$\bar{\sigma}_{vc}$ 0.802 τ_{hc} ______ $\bar{\sigma}_{vm}$ 0.802

t_c(Day) ______ ε_v(%) ______ γ_c(%) ______ t_c(Day) ______

	W,%	e	S,%	H ( )
Initial				
Preshear				
Final				

DURING SHEAR

Controlled Strain ✓ Stress ______

Rate (% / Hr.) 4.81

TIME (Hr.)	STRAIN (%)	$\tau_h/\bar{\sigma}_{vc}$	$\Delta u/\bar{\sigma}_{vc}$	$\bar{\sigma}_v/\bar{\sigma}_{vc}$	$\tau_h/\bar{\sigma}_v$	$\tau_h/\bar{\sigma}_{vm}$	$\bar{\sigma}_v/\bar{\sigma}_{vm}$	REMARKS
0000	0.000	0.000	0.000	000	0.000			
	0.121	0.017	0.000	1.000	0.0 7			
	0.332	0.049	0.012	0.988	0.049			
	0.566	0.074	0.012	0.988	0.074			
	0.858	0.096	0.025	0.975	0.096			
	1 89	0.113	0.031	0.969	0.117			
	. 610	0.127	0.050	0.950	0.134			
	2.006	0.132	0.060	0.940	0.141			
	2.427	0.142	0.074	0.926	0.153			
0.945	2.751	0.146	0.099	0.901	0.162			
	3.212	0.151	0.105	0.895	0.168			
	3.568	0.157	0.111	0.889	0.177			
	3.980	0.161	0.122	0.878	0.183			
	4.288	0.166	0.135	0.865	0.192			
	4.716	0.168	0.141	0.859	0.196			
	5.153	0.172	0.155	0.845	0.204			
	5.582	0.175	0.157	0.843	0.207			
	6.140	0.176	0.158	0.842	0.209			
	6. 64	0.189	0.170	0.830	0.228			
	7.119	0.184	0.196	0.804	0.229			
	7.524	0.186	0.202	0.798	0.233			
1050	7.928	0.186	0.203	0.797	0.233			
	8.284	0.189	0.204	0.796	0.238			
	8.656	0.193	0.206	0.794	0.243			
	9.036	0.196	0.207	0.793	0.247			

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REMARKS:

DIRECT - SIMPLE SHEAR (continued)

PROJECT FLORIDA **SOIL** PHOSPHATES **TYPE OF TEST** CK₀UDSS **NO.** 2

TIME (Hr.)	STRAIN (%)	$\frac{\tau_h}{\bar{\sigma}_{vc}}$	$\frac{\Delta u}{\bar{\sigma}_{vc}}$	$\frac{\bar{\sigma}_v}{\bar{\sigma}_{vc}}$	$\frac{\tau_h}{\bar{\sigma}_v}$	$\frac{\tau_h}{\bar{\sigma}_{vm}}$	$\frac{\bar{\sigma}_v}{\bar{\sigma}_{vm}}$	REMARKS
	9.433	0.198	0.211	0.789	0.251			
	9.837	0.200	0.216	0.784	0.25[illegible]			
	10.347	0.202	0.227	0.773	0.261			
	10.654	0.203	0.229	0.771	0.264			
1130	11.148	0.207	0.231	0.769	0.269			
	11.658	0.208	0.244	0.756	0.276			
	11.917	0.204	0.247	0.753	0.272			
	12.386	0.209	0.249	0.751	0.279			
	12.782	0.211	0.251	0.749	0.281			
	13.106	0.212	0.253	0.747	0.284			
	13.526	0.213	0.254	0.746	0.286			
	13.858	0.213	0.257	0.743	0.287			
1210	14.319	0.214	0.269	0.731	0.294			
	14.788	0.214	0.271	0.729	0.294			
	15.177	0.214	0.282	0.718	0.299			
	15.549	0.214	0.284	0.716	0.300			
	16.083	0.214	0.286	0.714	0.300			
	16.479	0.214	0.289	0.711	0.302			
	16.908	0.214	0.292	0.708	0.303			
	17.272	0.214	0.296	0.704	0.304			
	17.717	0.214	0.297	0.703	0.305			
	18.202	0.214	0.299	0.701	0.306			
	18.858	0.216	0.302	0.698	0.309			
	19.739	0.217	0.310	0.690	0.315			
1320	20.225	0.218	0.312	0.688	0.317			
	20.548	0.219	0.314	0.686	0.320			
	20.953	0.221	0.315	0.685	0.322			
	21.786	0.223	0.330	0.670	0.333			
	22.652	0.223	0.333	0.667	0.334			
	23.380	0.224	0.345	0.655	0.343			
	25.241	0.222	0.348	0.652	0.340			
	25.896	0.216	0.358	0.642	0.336			
	26.778	0.208	0.360	0.640	0.326			
	28.541	0.191	0.380	0.620	0.308			
	30.248	0.177	0.383	0.617	0.287			
	32.020	0.167	0.398	0.602	0.277			
1615	34.884	0.153	0.430	0.570	0.269			

SOIL MECHANICS LABORATORY
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MASSACHUSETTS INSTITUTE OF TECHNOLOGY

REMARKS:

DIRECT - SIMPLE SHEAR TEST

PROJECT FLORIDA **TYPE OF TEST** CKoU DSS **NO.** 3 **OCR** 1

SOIL TYPE PHOSPHATES **TESTED BY** JRR **DEVICE** GEONOR **DATE** AUG 75

LOCATION NORALYN
FROM CONSOL. #3

CONSOLIDATION (Stresses in KG/CM²)

$\bar{\sigma}_{vc}$ 2.468 τ_{hc} ______ $\bar{\sigma}_{vm}$ ______

t_c(Day) ______ ε_v(%) ______ γ_c(%) ______ t_c(Day) ______

	W,%	e	S,%	H (CM)
Initial	99.59	2.910	94.099	2.9947
Preshear		2.310		2.5352
Final				

DURING SHEAR

Controlled Strain ✓ Stress ______

Rate (% / Hr.) 2.98

TIME (Hr.)	STRAIN (%)	$\tau_h / \bar{\sigma}_{vc}$	$\Delta u / \bar{\sigma}_{vc}$	$\bar{\sigma}_v / \bar{\sigma}_{vc}$	$\tau_h / \bar{\sigma}_v$	$\tau_h / \bar{\sigma}_{vm}$	$\bar{\sigma}_v / \bar{\sigma}_{vm}$	REMARKS
.40	0.000	0.000	0.000	1.000	0.000			
	0.032	0.019	0.000	1.000	0.019			
	0.087	0.042	0.008	0.992	0.042			
	0.154	0.064	0.020	0.980	0.066			
	0.205	0.086	0.024	0.976	0.088			
	0.256	0.105	0.024	0.9[illegible]	0.108			
	0.363	0.107	0.028	0.9[illegible]	0.110			
	0.560	0.118	0.032	0.968	0.121			
	0.809	0.128	0.040	0.960	0.134			
	1.006	0.136	0.056	0.944	0.144			
1230	1.262	0.142	0.064	0.936	0.151			
	1.558	0.150	0.076	0.924	0.162			
	1.763	0.152	0.076	0.924	0.164			
	2.020	0.157	0.088	0.912	0.172			
	2.327	0.162	0.099	0.901	0.180			
	2.564	0.164	0.107	0.893	0.184			
	2.860	0.168	0.116	0.884	0.191			
	3.061	0.171	0.119	0.88[illegible]	0.194			
	3.302	0.173	0.123	0.877	0.198			
	3.574	0.177	0.131	0.869	0.204			
	3.826	0.179	0.139	0.861	0.208			
	4.071	0.182	0.147	0.853	0.213			
	4.382	0.184	0.151	0.849	0.217			
	5.002	0.189	0.164	0.836	0.226			
1345	5.258	0.192	0.167	0.833	0.231			

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REMARKS:

DIRECT - SIMPLE SHEAR (continued)

PROJECT FLORIDA **SOIL** PHOSPHATES **TYPE OF TEST** CK_oUDSS **NO.** 3

TIME (Hr.)	STRAIN (%)	$\tau_h / \bar{\sigma}_{vc}$	$\Delta u / \bar{\sigma}_{vc}$	$\bar{\sigma}_v / \bar{\sigma}_{vc}$	$\tau_h / \bar{\sigma}_v$	$\tau_h / \bar{\sigma}_{vm}$	$\bar{\sigma}_v / \bar{\sigma}_{vm}$	REMARKS
	5.514	0.194	0.171	0.829	0.235			
	5.798	0.197	0.175	0.825	0.239			
	6.070	0.199	0.183	0.817	0.244			
	6.280	0.201	0.191	0.809	0.248			
	6.599	0.203	0.195	0.805	0.252			
	6.863	0.203	0.203	0.797	0.255			
	7.139	0.205	0.207	0.793	0.258			
1420	7.427	0.205	0.211	0.789	0.260			
	8.015	0.207	0.211	0.789	0.262			
	8.343	0.208	0.218	0.782	0.266			
	8.650	0.209	0.226	0.774	0.270			
	8.934	0.211	0.231	0.769	0.274			
	9.222	0.212	0.235	0.765	0.277			
	9.467	0.214	0.238	0.762	0.280			
	10.015	0.217	0.242	0.758	0.286			
	10.303	0.219	0.246	0.754	0.290			
	10.563	0.220	0.250	0.750	0.293			
	10.828	0.220	0.258	0.742	0.297			MAX c/p
1530	11.407	0.210	0.262	0.738	0.284			STOP SHEAR
	AFTER STOP SHEAR FURTHER CONSOLIDATE SAMPLE							

SOIL MECHANICS LABORATORY
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MASSACHUSETTS INSTITUTE OF TECHNOLOGY

REMARKS:

DIRECT - SIMPLE SHEAR TEST

PROJECT FLORIDA **TYPE OF TEST** CK_oU DSS **NO.** 3 **OCR** 3.983

SOIL TYPE PHOSPHATES **TESTED BY** JRR **DEVICE** GEONOR **DATE** SEPT 75

LOCATION NORALYN
FROM CONSOL #3

CONSOLIDATION (Stresses in KG/CM²**)**

$\bar{\sigma}_{vc}$ 1.254 τ_{hc} ______ $\bar{\sigma}_{vm}$ 3.983

t_c(Day) ______ ε_v(%) ______ γ_c(%) ______ t_c(Day) ______

	W,%	e	S,%	H (CM)
Initial	99.59	2.910	94.099	2.9947
Preshear		2.067		2.3487
Final	79.32			

DURING SHEAR

Controlled Strain ✓ Stress ______

Rate (% / Hr.) 3.49

TIME (Hr.)	STRAIN (%)	$\tau_h / \bar{\sigma}_{vc}$	$\Delta u / \bar{\sigma}_{vc}$	$\bar{\sigma}_v / \bar{\sigma}_{vc}$	$\tau_h / \bar{\sigma}_v$	$\tau_h / \bar{\sigma}_{vm}$	$\bar{\sigma}_v / \bar{\sigma}_{vm}$	REMARKS
0810	0.000	0.000	0.000	1.000	0.000	0.000	0.251	SAMPLE FURTHER
	0.051	0.028	0.000	1.000	0.028	0.007	0.251	CONSOLIDATED
	0.119	0.064	0.000	1.000	0.064	0.016	0.251	AFTER SHEAR
	0.213	0.102	-0.015	1.015	0.100	0.026	0.255	TO MAX c/p
	0.353	0.143	-0.023	1.023	0.140	0.036	0.257	
	0.511	0.174	-0.033	1.033	0.168	0.044	0.259	
	0.749	0.199	-0.057	1.057	0.186	0.050	0.265	
	0.928	0.219	-0.061	1.061	0.207	0.055	0.266	
	1.120	0.242	-0.071	1.071	0.226	0.061	0.269	
	1.358	0.264	-0.084	1.084	0.243	0.066	0.272	
0900	1.592	0.278	-0.093	1.093	0.254	0.070	0.274	
	1.797	0.290	-0.109	1.109	0.262	0.073	0.278	
	2.086	0.305	-0.114	1.114	0.273	0.076	0.280	
	2.325	0.316	-0.124	1.124	0.281	0.079	0.282	
	2.597	0.327	-0.125	1.125	0.290	0.082	0.282	
	2.882	0.340	-0.131	1.131	0.300	0.085	0.284	
	3.117	0.354	-0.147	1.147	0.309	0.089	0.268	
	3.559	0.377	-0.178	1.178	0.320	0.095	0.296	
	3.823	0.390	-0.186	1.186	0.329	0.098	0.298	
	4.066	0.402	-0.194	1.194	0.336	0.101	0.300	
	4.347	0.414	-0.206	1.206	0.343	0.104	0.303	
	4.641	0.424	-0.222	1.222	0.347	0.106	0.307	
	4.909	0.435	-0.226	1.226	0.354	0.109	0.308	
	5.173	0.444	-0.227	1.227	0.362	0.111	0.308	
1015	5.522	0.454	-0.229	1.229	0.370	0.114	0.308	

SOIL MECHANICS LABORATORY
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REMARKS:

DIRECT - SIMPLE SHEAR (continued)

PROJECT FLORIDA **SOIL** PHOSPHATES **TYPE OF TEST** CK_0UDSS **NO.** 3

TIME (Hr.)	STRAIN (%)	$\tau_h/\bar{\sigma}_{vc}$	$\Delta u/\bar{\sigma}_{vc}$	$\bar{\sigma}_v/\bar{\sigma}_{vc}$	$\tau_h/\bar{\sigma}_v$	$\tau_h/\bar{\sigma}_{vm}$	$\bar{\sigma}_v/\bar{\sigma}_{vm}$	REMARKS
	6.003	0.473	-0.252	1.252	0.378	0.119	0.314	
	6.582	0.482	-0.270	1.270	0.379	0.121	0.319	
	7.217	0.486	-0.276	1.276	0.381	0.122	0.320	
	7.749	0.509	-0.281	1.281	0.397	0.128	0.322	
	8.298	0.524	-0.304	1.304	0.402	0.132	0.327	
	8.894	0.537	-0.323	1.323	0.406	0.135	0.332	
	9.456	0.549	-0.328	1.328	0.414	0.138	0.333	
	10.040	0.561	-0.345	1.345	0.417	0.141	0.338	
	10.636	0.576	-0.362	1.362	0.423	0.144	0.342	
	11.172	0.588	-0.374	1.374	0.428	0.148	0.345	
	11.751	0.597	-0.376	1.376	0.434	0.150	0.345	
1215	12.313	0.608	-0.399	1.399	0.435	0.153	0.351	
	12.948	0.617	-0.401	1.401	0.440	0.155	0.352	
	13.582	0.623	-0.405	1.405	0.443	0.156	0.353	
	14.161	0.627	-0.414	1.414	0.443	0.157	0.355	
	14.795	0.632	-0.419	1.419	0.445	0.158	0.356	
	15.072	0.635	-0.424	1.424	0.446	0.160	0.358	
	15.741	0.640	-0.430	1.430	0.448	0.161	0.359	
	16.320	0.644	-0.437	1.437	0.448	0.162	0.361	
	16.980	0.646	-0.438	1.438	0.449	0.162	0.361	
	17.622	0.648	-0.438	1.438	0.451	0.163	0.361	
	18.227	0.652	-0.438	1.438	0.453	0.164	0.361	
1400	18.874	0.655	-0.438	1.438	0.455	0.164	0.361	
	19.496	0.655	-0.438	1.438	0.455	0.164	0.361	
	20.109	0.655	-0.438	1.438	0.455	0.164	0.361	
	20.773	0.656	-0.438	1.438	0.456	0.164	0.361	
	21.442	0.652	-0.430	1.430	0.456	0.164	0.359	
	22.110	0.648	-0.428	1.428	0.453	0.162	0.358	
	22.770	0.643	-0.399	1.399	0.459	0.161	0.351	
	23.528	0.626	-0.381	1.381	0.453	0.157	0.347	
	24.277	0.589	-0.299	1.299	0.454	0.148	0.326	
	25.069	0.557	-0.272	1.272	0.438	0.140	0.319	
	25.802	0.539	-0.241	1.241	0.434	0.135	0.312	
	26.478	0.529	-0.222	1.222	0.432	0.133	0.307	
	27.181	0.518	-0.195	1.195	0.433	0.130	0.300	
	27.845	0.510	-0.171	1.171	0.435	0.128	0.294	
1620	28.518	0.503	-0.132	1.132	0.445	0.126	0.284	END TEST

SOIL MECHANICS LABORATORY
DEPT. OF CIVIL ENGINEERING
MASSACHUSETTS INSTITUTE OF TECHNOLOGY

REMARKS:

TABULATED e-LOG $\bar{\sigma}_v$ CRSC TESTS

1		2		3		4		21	
$\bar{\sigma}_v$	e	$\bar{\sigma}_v$	e	$\bar{\sigma}_v$	e	$\bar{\sigma}_v$	e	$\bar{\sigma}_v$	e
0.090	2.484	0.098	5.174	0.098	5.289	0.118	2.834	0.083	4.739
0.142	2.483	0.217	4.944	0.120	5.225	0.225	2.821	0.225	4.720
0.225	2.478	0.343	4.176	0.170	5.050	0.373	2.795	0.324	4.622
0.297	2.431	0.147	4.217	0.281	4.870	0.513	2.769	0.362	4.114
0.396	2.446	0.066	4.274	0.346	4.652	0.773	2.720	0.481	3.840
0.594	2.405	0.016	4.471	0.384	4.130	1.023	2.671	0.616	3.616
0.793	2.366	0.218	4.310	0.432	3.838	1.370	2.614	0.813	3.219
0.966	2.334	0.392	4.079	0.516	3.686	1.720	2.511	1.093	2.943
1.142	2.302	0.0	3.415	0.650	3.484	2.189	2.380	1.948	2.472
1.428	2.259	1.222	3.068	0.789	3.318	2.648	2.270	2.415	2.353
1.655	2.222	1.625	2.846	0.804	3.259	3.037	2.190	2.855	2.257
1.984	2.156	2.013	2.693	0.734	3.265	3.760	2.071	4.162	2.054
2.292	2.098	2.506	2.547	0.650	3.274	4.369	1.982	4.649	2.001
2.588	2.040	3.009	2.429	0.506	3.295	5.014	1.903	5.164	1.947
3.017	1.963	3.472	2.388	0.436	3.317	5.592	1.844	5.806	1.896
3.336	1.915	3.975	2.258	0.370	3.341	6.496	1.765	6.532	1.844
3.819	1.849	4.704	2.158	0.234	3.389	7.426	1.696	7.181	1.806
4.245	1.803	5.408	2.079	0.197	3.412	8.229	1.647	8.104	1.753
4.724	1.756	6.097	2.029	0.134	3.461	9.303	1.588	9.123	1.701
5.160	1.718	6.677	1.961			10.103	1.550	10.005	1.662
5.500	1.690	7.816	1.913			10.984	1.510	11.365	1.619
5.900	1.662	8.334	1.845			12.404	1.427	12.897	1.562
6.109	1.621	9.892	1.788			11.818	1.429	14.210	1.526
5.778	1.622	11.580	1.686			10.332	1.436	15.453	1.495
5.149	1.624	12.504	1.631			8.435	1.453	15.841	1.469
4.118	1.631	14.076	1.533			6.565	1.476	13.427	1.471
3.251	1.642	8.347	1.645			5.589	1.494	10.790	1.484
2.679	1.654	0.4031	2.045			4.814	1.512	8.950	1.498
2.094	1.671	0.297	2.380			3.825	1.537	6.349	1.526

SH 4/2/

TABULATED e-LOG $\bar{\sigma}_v$ CRSC TESTS CON'T

1		2		3		4		21	
$\bar{\sigma}_v$	e	$\bar{\sigma}_v$	e	$\bar{\sigma}_v$	e	$\bar{\sigma}_v$	e	$\bar{\sigma}_v$	e
1.674	1.687	0.502	2.330			3.033	1.565	4.972	1.548
1.164	1.716	0.968	2.222			2.450	1.595	3.914	1.570
0.619	1.768	1.402	2.141			1.863	1.631	3.057	1.595
0.397	1.799	1.856	2.074			1.281	1.675	2.368	1.622
0.158	1.856	2.537	1.998			0.634	1.752	1.654	1.661
		3.303	1.931			0.176	1.850	1.010	1.707
		3.833	1.896					0.730	1.753
		4.485	1.857					0.541	1.785
		5.227	1.816					0.282	1.821
		5.772	1.792					0.158	1.850
		6.684	1.755						
		7.368	1.730						
		8.464	1.695						
		9.288	1.669						
		4.033	2.820						
		11.986	1.601						
		12.717	1.544						
		11.898	1.548						
		10.058	1.560						
		8.021	1.586						
		6.122	1.621						
		4.782	1.655						
		3.160	1.711						
		1.651	1.814						
		1.163	1.875						
		0.634	1.974						
		0.241	2.087						

SH 2/2