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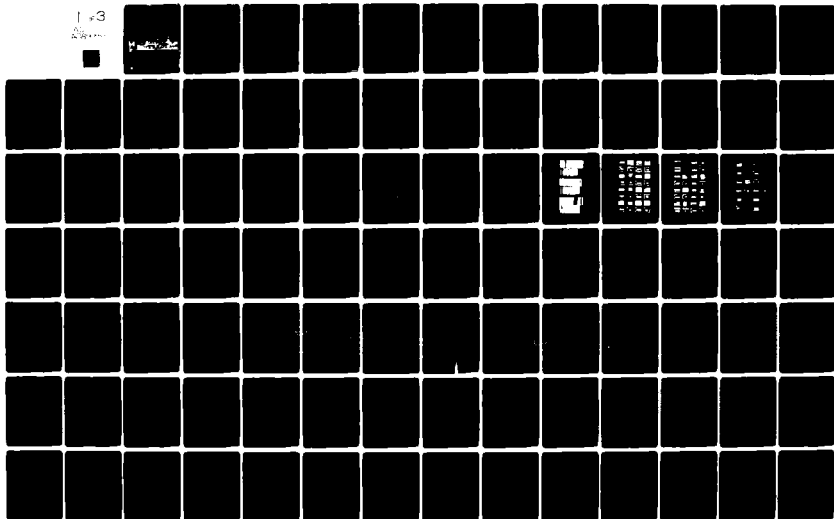
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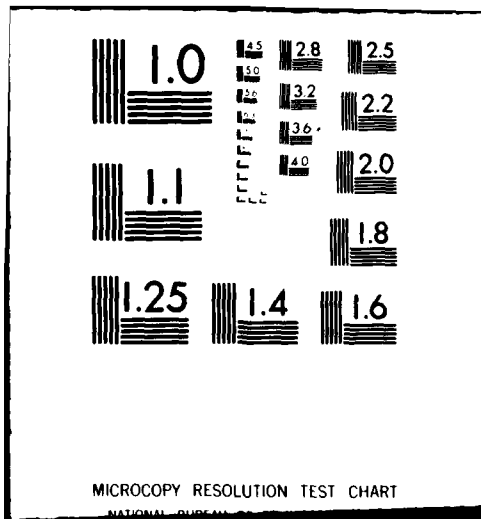
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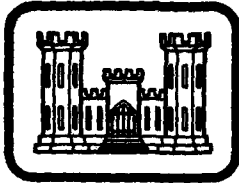
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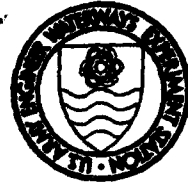


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**INVESTIGATION FOR SOUTH FILL AREA
UNITED STATES MILITARY ACADEMY
WEST POINT, NEW YORK**

by

Hugh M. Taylor, Jr., Jack K. Poplin, Gerald B. Mitchell

**Geotechnical Laboratory
U. S. Army Engineer Waterways Experiment Station
P. O. Box 631, Vicksburg, Miss. 39180**

August 1980

Final Report

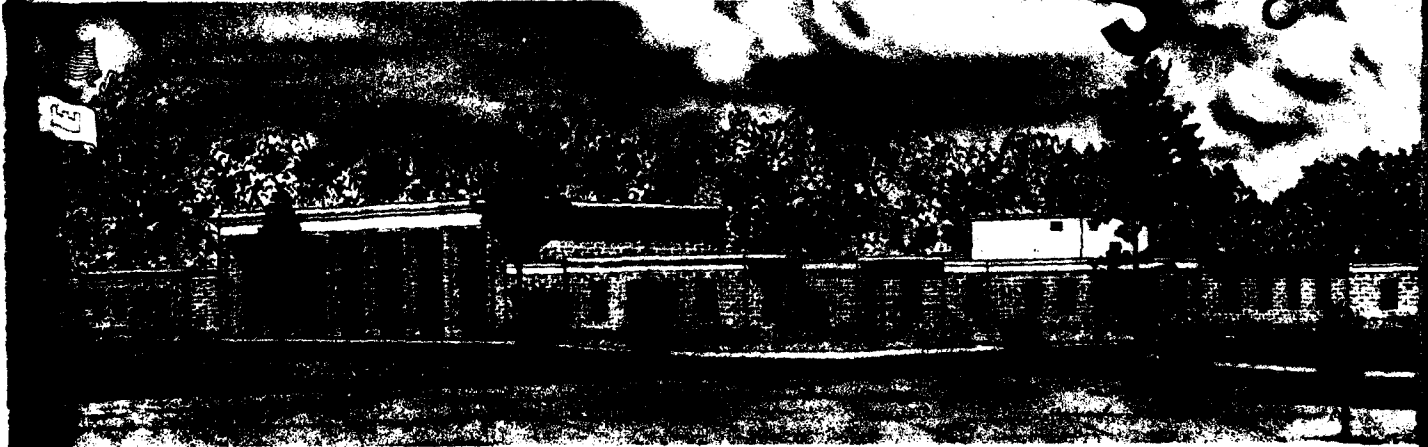
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Prepared for The Directorate of Military Construction
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Washington, D. C. 20314

Under Intra-Army Order No. NYD 78-76(M)

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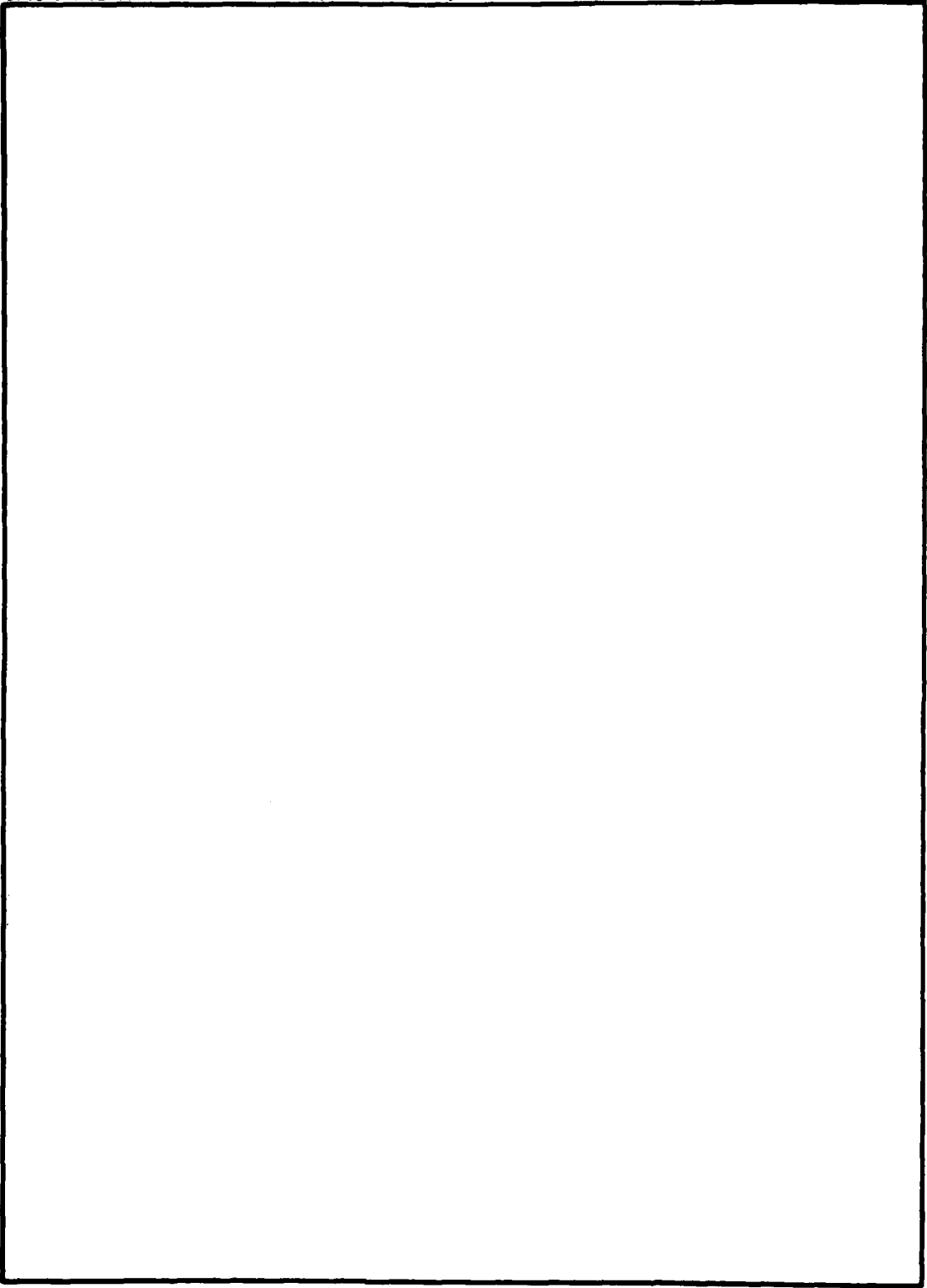
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PREFACE

Authorization for this study was a letter request dated 8 February 1978 to the U. S. Army Engineer Waterways Experiment Station (WES) from the Directorate of Military Construction, Office, Chief of Engineers (OCE), U. S. Army, Washington, D. C., and Intra-Army Order No. NYD 78-76 (M), dated 3 May 1978.

Overall planning, field explorations, soil tests, and analysis for this study were performed by the WES. Data reported in this investigation were collected during the period October 1961 through August 1978 by personnel of the U. S. Army Engineer District, New York, and the WES, and by consultants to the Corps of Engineers. Data from previous publications concerning the South Fill area are repeated for clarity. The September 1979 hydrographs and echo soundings presented in Appendix E were received just prior to publication of this report.

The investigational program under Mr. W. J. Turnbull, former Chief, Soils Division, WES, was directed and reviewed through 1965 by a Board of Consultants consisting of Professors Arthur Casagrande and R. E. Fadum, Dr. P. C. Rutledge, and Messrs. H. B. Zachrison, R. A. Barron (OCE), and C. K. Panish. Review comments for this report from the current active consultants are included in Appendix G. Also contained in this appendix are comments by Dr. P. F. Hadala, Acting Assistant Chief of the Geotechnical Laboratory (GL), WES, concerning the liquefaction potential at the site.

The report was written by Messrs. H. M. Taylor, Jr., and G. B. Mitchell, Soil Mechanics Division (SMD), WES, and Dr. J. K. Poplin, Associate Professor at Louisiana State University, who was employed at the WES for the summer under the Intergovernmental Personnel Act of 1970, under the general supervision of Messrs. C. L. McAnear and J. P. Sale, Chiefs of SMD and GL, respectively. The report was reviewed and approved by OCE prior to its publication.

Directors of the WES during the investigation and preparation of this report were COL John L. Cannon, CE, and COL Nelson P. Conover, CE. Technical Director was Mr. F. R. Brown.

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CONVERSION FACTORS, U. S. CUSTOMARY TO METRIC (SI)
UNITS OF MEASUREMENT

U. S. customary units of measurement used in this report can be converted to metric (SI) units as follows:

<u>Multiply</u>	<u>By</u>	<u>To Obtain</u>
cubic yards	0.7645549	cubic metres
feet	0.3048	metres
inches	25.4	millimetres
kips (force) per square foot	47.88026	kilopascals
pounds (force) per square foot	47.88026	kilograms per cubic metre
pounds (mass) per cubic foot	16.01846	pascals
tons (force) per square foot	95.76052	kilopascals

INVESTIGATION FOR SOUTH FILL AREA,
UNITED STATES MILITARY ACADEMY
WEST POINT, NEW YORK

PART I: INTRODUCTION

Background

1. On 25 August 1961, a large fill area along the west bank of the Hudson River at the U. S. Military Academy (USMA), West Point, New York, subsided suddenly into the river, resulting in considerable property damage and loss. The slide occurred in an estuarine deposit in an area that had been the scene of extensive fill operations in the preceding 14 months. Figure 1 shows the general plan and geology of the West Point area. Field and laboratory investigations were undertaken to determine the cause of the failure and to ascertain the safety of the existing facilities along the failed bank. These investigations were reported in Technical Report No. 3-591 (U. S. Army Engineer Waterways Experiment Station (WES), 1962). In addition, the stability of an existing fill downstream (south) of the failed area was investigated. These investigations indicated that this South Fill area was safe, but with a rather narrow margin.

2. Measurements of horizontal and vertical control points, piezometers, slope indicators, and observations of the telltale walkway at the South Fill area have been made by the U. S. Army Engineer District, New York (NYD), and reported periodically in letter reports to the WES. These data were analyzed by the WES and reported to the Office, Chief of Engineers (OCE), U. S. Army, in letter reports. These analyses indicated that normal rates of movement were observed and that pore pressures were dissipating as expected.

3. In an effort to evaluate conditions for possible future use of the South Fill area, a drilling contract was let by the NYD in 1975. Undisturbed samples of 5- and 3-in.* diameters were taken by a private

* A table of factors for converting U. S. customary units of measurement to metric (SI) units is presented on page 4.

drilling company and sent to the WES for testing. The unconsolidated-undrained (Q) test strengths were equal to or less than the unconfined compression (UC) tests run in 1961. This discrepancy indicating little or no gain in strength was considered unrealistic and probably resulted from problems in sampling and/or testing. The instrumentation in the vicinity of the borings indicated horizontal and vertical movements normally expected due to consolidation. Nothing was indicated by the instrumentation or observed at the site that would account for the little differences in the strengths observed in 1961 and 1975.

4. To determine the stability of the South Fill area, to determine potential uses of the fill, and to reduce the scope of monitoring instrumentation, it was decided that more reliable sampling, testing, and analyses should be undertaken. In 1978, such a program was initiated.

Authorization

5. This investigation of the South Fill area at the USMA, West Point, New York, was conducted in response to a request to the WES in a letter dated 8 February 1978 from the Directorate of Military Construction, OCE, Washington, D. C., subject: West Point Slide Investigation, and Intra-Army Order No. NYD 78-76 (M), dated 3 May 1978.

Previous Studies

Consultants, 1961-1965

6. A board of consultants established to review and direct the investigational program met several times concerning the North Dock failure, the resulting foundation investigations, and the monitoring at the North Dock and the South Fill area. From September 1961 through December 1965, the board rendered judgments on the following items based on visits to the South Fill area and review of laboratory and field data:

- a. Technical procedures in the subsurface investigation.
- b. Vulnerability to further movement.
- c. Security measures.

- d. Program of horizontal and vertical measurements.
- e. Additional loading of the fill.
- f. Regrading and leveling permissible using light equipment.
- g. Installation of piezometers in clay and bedrock.
- h. Review of status reports.
- i. Stability.

WES, 1961

7. The North Dock slide in 1961 prompted the first well-documented investigation (WES, 1962) of subsurface conditions at the South Fill area. A number of general sample borings had been made in the South Fill area in 1941; however, the soil classifications used on the boring logs were somewhat doubtful. Therefore, only the portions of the logs of these borings that indicated the top of rock were reported (WES, 1962).

8. Stability analyses indicated that the South Fill area had a narrow margin of safety. Its stability should increase slowly with time. Piezometer observations indicate that relatively high excess pore pressures existed in the foundation beneath the fill. It was estimated that about 22 percent of the ultimate settlement under the existing fill had occurred as of October 1961.

9. It was recommended, among other items, that no additional fill be placed in the South Fill area, that the South Fill area be reserved for athletic fields, that piezometers and reference points be observed, and that data be evaluated at frequent intervals.

WES, 1973

10. A paper entitled "Performance of Fill Foundation, West Point, New York," was presented to the Fifty-Second Annual Meeting of the Highway Research Board (Sherman and McAnear, 1973). No additional sampling or testing was conducted for this paper. The measurement data reported from instruments installed in 1961 included piezometers, reference points (surface markers), and four slope indicators. Subsequent to the 1961 investigation, the tennis course that had been constructed in the South Fill area afforded a means for tracing the development of surface cracks. The crack pattern reflected the greater settlement of the

thicker portion of the estuarine deposit toward the river. A summary of time plots reported by Sherman and McAnear (1973) of lateral movement and settlement showed that surface settlements were continuing but at a decreasing rate. The lateral distance between reference points indicated continuing extension and, in some instances, compression. The slope indicators demonstrated that through 1969 horizontal movements were continuing and at a decreasing rate with no indication of potential distress.

11. Sherman and McAnear (1973) indicated that strength increases had taken place which significantly increased the stability of the South Fill area with respect to sliding.

USMA, 1974

12. A report entitled "South Fill, West Point, New York," prepared by the Department of Engineering of the USMA (1974) examined the accumulated data through 1973 on the South Fill. The purpose was to compare the anticipated theoretical consolidation behavior of the fill with the actual settlement. Definitive conclusions were not reached concerning the behavior or stability of the South Fill area.

WES, 1976

13. An unpublished letter report prepared by the WES (1976) documented all the field and laboratory data collected, made comparisons of the condition of the fill at various periods of time, and discussed present and future stability. This report first indicated little apparent change in shear strength since 1961 though pore pressure had decreased, indicating an increased degree of consolidation. Because of the limited amount of data and nonuniform site conditions, stability analyses were not possible. Furthermore, because of the excessive costs of the monitoring program and usage requirements of the area, the 1976 study recommended that a Phase II investigation be considered. The proposed investigation consisted of borings and instrumentation at selected strategic locations that would provide the necessary data to make a comprehensive analysis of the entire site. The data would not only provide adequate information to predict the behavior for the whole area but also permit an evaluation of various methods for accelerating the rate of stability improvement.

Purpose and Scope

14. The purpose of this investigation was to assess the current stability (safety) and future settlements of the South Fill area and to provide guidance regarding future use of the area. The results of subsurface investigations since 1961, laboratory and field testing since 1975, and recent (1979) stability analyses are documented. Recommendations are made for guidance in future development, measures to improve stability, and precautions to be observed for changes in usage.

PART II: DESCRIPTION OF SITE

15. The South Fill area is within the alluvial plain of the Hudson River. At West Point, the river occupies a narrow gorge cut through granite and gneiss. The sides of the gorge rise about 200 ft above the alluvial plain. Glaciation has modified the bedrock, plastered it locally with glacial detritus, and otherwise affected the hills overlooking the river where the principal Military Academy buildings are located. Figure 1 shows the general plan and geology of the West Point area. The local and regional geologies are presented in WES Technical Report No. 3-591 (1962).

North Dock Slide Area

16. During construction of a major housing project on the Military Academy grounds in 1960, it was decided to use the excavated material as landfill for athletic fields along the tidal flats in the North Dock area (Figure 1). In June 1960, the fill material, consisting of rock, boulders, and soil excavated for the housing construction area, was hauled in by truck. About 313,000 cu yd of fill were placed shortly before the slide occurred on 25 August 1961. During the fill operation, mud waves, several minor slides, and abrupt settlements occurred, some of which were of major consequence. One severe subsidence caused suspension of work for a week. The North Dock failure resulted in property damage because of wave action and underwater slides, but no loss of life occurred.

South Fill Area

17. Some fill had been placed in the South Fill area in 1941. Additional fill, amounting to 210,000 cu yd, was placed in 1960, the material being of the same type and origin as that used for the North Dock area. The dumped rock fill at the South Fill area accounts for approximately the top 20 to 40 ft in the soil profile.

18. Photographs and records of the fill placement were prepared by the WES (1962). Figure 2 shows the ground surface, underwater surface, and rock surface contours, as well as the riprap shoreline protection placed in 1974.

PART III: FIELD AND LABORATORY INVESTIGATIONS

Soil Borings

19. Subsurface conditions at the South Fill area were determined from soil borings drilled in 1961, 1975, and 1977 at locations indicated in Figure 3. In 1961, four borings (BS-1, BS-2, BS-4, and BS-5) were made in the peripheral areas and split-spoon samples taken. One 5-in. undisturbed boring (BU-2) was made in the central portion of the fill. In 1975, a boring (DH-11) was made in the central area. Six 5-in.-diam undisturbed samples, from 40- to 60-ft depth, and ten 3-in.-diam undisturbed samples, from 70- to 97-ft depth, were obtained. Three additional borings, WS-1, WS-2, and WS-3, were drilled in the same general area in 1977 in a triangular pattern about 15 ft apart.

20. In situ vane shear (VS) tests were conducted in boring WS-2, and undisturbed samples were obtained in borings WS-1 (3-in.-diam) and WS-3 (5-in.-diam). A description of the VS apparatus and the test procedures are presented in WES Miscellaneous Paper No. 3-661 (1964).

Soil Tests

21. All soil tests conducted after 1965 followed standard laboratory procedures (Dept. of the Army, OCE, 1965 (revised in 1970)). Testing prior to 1965 followed procedures outlined in the LMVD report (Dept. of the Army, Mississippi River Commission, 1951).

22. Customary identification and classification tests (specific gravity, Atterberg limits, etc.) for fine-grained soils were conducted on all samples returned to the laboratory for testing. The laboratory results not previously presented are given herein along with engineering properties.

1961

23. Engineering properties tests for the samples taken in 1961 included UC tests on all samples, and slow consolidated drained (S) direct shear tests, consolidated undrained triaxial (R) tests with pore

pressure measurements, and one-dimensional (1D) consolidation tests on selected samples; all were conducted on 5-in.-diam undisturbed samples. The results of these tests were reported in detail by Sherman and McAnear (1973). Selected details are repeated herein when needed for clarity or comparison.

1975

24. Q tests were conducted on most samples collected in 1975, R and 1D tests were run on selected samples from 3- and 5-in.-diam Shelby tubes.

1977

25. The 5-in.-diam undisturbed samples from boring WS-3 (1977) were sealed in the Shelby tube samples and transported to the WES. Since funds were not available for testing, the samples were stored in a humid room until testing was accomplished about 5 months later.

26. Prior to extruding, each sample from boring WS-3 was radiographed to assist in selection of test specimens. Figure 4 shows typical radiographs of samples from boring WS-3. Photographs of sliced sections of the samples in Figure 5 were made to detect evidence of sampling disturbance and nonhomogeneity (Hvorslev, 1948).

27. UC tests were conducted in the field immediately after sampling on duplicate 3-in.-diam specimens from each sample from boring WS-1 (1977). Water contents were measured, and the usual index properties were calculated using specific gravities from boring WS-3. Since only in situ VS tests were run in boring WS-2, no samples were taken and no other tests were conducted.

Soil Profile

28. Boring logs in Figure 6 were taken from borings BU-2, DH-11, WS-3, and WS-1 that were drilled in 1961, 1975, 1977, and 1977, respectively. Figure 7 shows a generalized west to east soil profile developed from the boring logs. The borings indicate a rock fill overlying a thin layer of peat and thick layer of heavy clay down to bedrock, with general agreement as to layering between borings. However, some evidence of nonhomogeneity is noted.

29. Table 1 summarizes the results of laboratory and field tests conducted in 1975 and 1977. Appendixes A, B, C, and D present the results of tests for borings DH-11, WS-1, WS-2, and WS-3, respectively. Table 2 shows the results of in situ VS tests and Appendix C includes the test records. The hydrographs shown in Appendix E were taken adjacent to the South Fill area and were obtained from the NYD.

30. On the plasticity charts (Figure 8), most samples are located above the A-line, indicating fat clay (CH) in upper regions and lean clay (CL) nearer the rock surface. Oven-drying of samples from boring BU-2 caused substantial reduction in both liquid limit (LL) and plasticity index (PI) and resulted in different classifications.

31. Figure 9 shows the distribution of natural water content and Atterberg limits with depth. The decrease in water content with time since 1961 is also consistent with observations of settlement and dissipation of excess pore pressures.

Shear Strength

32. Undrained shear strength was determined from UC, Q, and R tests. Some S tests were conducted on selected samples from boring BU-2 to evaluate drained shear strength during the 1961 investigation. Most tests were conducted from samples taken in the peat or clay layers. No attempt was made to measure the shear strength of the rock fill or the underlying bedrock.

Q test

33. The variation of undrained shear strength with depth is shown in Figure 10 as determined at different times and by various techniques. The shear strength in 1961 shortly after filling was completed, as indicated by UC tests on undisturbed samples from boring BU-2, is low particularly in regions of high pore pressure (to be presented later). Tests on selected remolded samples yield sensitivity ratios from 3 to 11 that signify this soil to be sensitive to extrasensitive.

34. Samples taken in 1975 failed to clearly indicate the expected shear strength increase reflecting the pore pressure dissipation. An

insufficient number of samples were taken, and the test data showed fairly large scatter and inconsistent trends. It was believed at the time that excessive disturbance in drilling and sampling had occurred, and additional borings should be made to more fully assess the conditions of the fill. Three additional borings (WS-1, WS-2, and WS-3), completed in 1977, were used to further assess the shear strength properties. The results of Q tests from WS-3 also failed to demonstrate the expected increase in strength with time and did not agree with UC or VS test results from WS-1 and WS-2. Both the UC and VS tests indicate consistent strengths in relation to the effective overburden stress at the present time, as well as a substantial increase in strength with time.

35. Normally, Q tests in a CH are expected to yield strengths equal to or somewhat greater than the UC test. However, Q test strength is about 50 percent of the UC test strength. Examination of deviator stress versus axial strain curves showed that the UC test exhibited brittle failure, with a peak stress occurring in the range of 5 to 7 percent strain (Appendix B). Q test specimens produced deviator stress-strain curves more typical of remolded clays with stress still increasing at 15 and 20 percent strain in many cases. The discrepancy between the UC and Q tests prompted further testing.

36. The UC tests from WS-1 were run on nominal 3-in.-diam by 6-in.-long samples prepared and tested at the site using a portable testing machine. Very little time elapsed between sampling and testing. While this procedure conceivably could result in greater loss of strength because of sampling disturbance with small diameter tubes, no opportunity for deleterious effects due to storage and handling existed.

37. On the other hand, the samples from WS-3 collected in March 1977 in 5-in.-diam Shelby tubes were sealed at the site and temporarily stored at the USMA, and then later transported to the WES by truck. Since funds were not immediately available, the samples were stored in a humid room at the WES and testing was not done until August 1977, a lapse of about five months. Prior to testing, the samples were extruded full length, using the normal procedure for extruding fresh samples trimmed from quarter sections of 5-in.-diam samples.

38. Half sections of samples 13, 14, 16, and 17 from boring WS-3, which had been waxed and stored, were used to develop supplemental data on the present strength (July 1978), approximately one year after the first tests. Three Q tests and a UC test were run on each section. These check tests show essentially no loss of water, but Q test strengths are almost twice as great as those of one year earlier (Figure 11) and much more in line with UC and VS test strengths yielded in 1977. This observation is further confirmed by a comparison of stress-strain curves for tests at different times from the same depth. Figure 12 shows possible disturbance effects in Q test results in 1975 and 1977, which no longer existed when tested in 1978.

39. The deviant behavior of the Q test results suggests the possibility of sampling disturbance. The probable cause of the loss of strength reflected in the 1977 test was likely a combination of extended storage and delayed extrusion. An investigation of the effects of storage at Louisiana State University show a loss of strength with storage time for both 3- and 5-in.-diam Shelby tube samples of clay, while hand-carved samples lost no strength (Arman and McManis, 1977). However, the tube samples were extruded prior to storage and the findings may not apply here. The disturbance in the extrusion process conceivably increases as the time interval between sampling and extrusion increases because of adhesion of the soil to the tube plus the increased roughness created by corrosion of the inner surface of the tube. However, the apparent regaining of original strength during a one-year storage after extrusion may be attributed to thixotropy, a process in which remolded soils regain strength at a constant water content. Skempton and Northey (1952) observed that clays with sensitivity ratios less than 16 regained a major portion or all of their original strength after remolding as a result of thixotropy. These speculations could adequately explain the erratic results, but other processes may also be involved.

40. For the purposes of this investigation, the Q test strengths are disregarded, and the UC tests backed up by VS tests are deemed to be most representative of the present undrained shear strength of the clay.

R test

41. Two R tests were conducted in 1975 and four in 1977. Table 3 summarizes the results of these tests, and Figure 13 presents the strength envelopes. R tests show apparent cohesion (C) ranging from 0 to 0.24 tsf and angle of internal friction ϕ ranging from 30 to 40 deg.

S test

42. The drained shear strength was determined from three S tests in 1961. Table 3 summarizes the results, and Figure 13 shows the drained shear strength envelopes. S tests in 1961 indicate effective strength envelopes with C equal to zero and ϕ ranging from 29 to 35 deg. Other data presented tend to indicate the clay was either normally consolidated or underconsolidated.

Consolidation Test Data

43. The results of all 1D consolidation tests in Figure 14 are presented in the form of void ratio-log stress curves and coefficient of consolidation-stress curves. Detailed data for tests conducted in 1975 and 1977 are contained in Appendixes A and D.

44. The compression curves from the 1961 borings indicate pre-consolidation stresses p_c approximately equal to the effective overburden stress p_o , hence normally consolidated according to these tests. From the 1975 borings, the samples from el -42.0* displayed a very flat curve with an indicated p_c below the effective p_o . At a greater depth (el -78.5), the curves are more typical of normally consolidated soils, with p_c only slightly greater than p_o .

45. Tests of four samples from the 1977 borings yielded two compression curves typical of insensitive clays and two more typical of sensitive clays in which a large void ratio change occurred as the indicated p_c was exceeded. Interpretation of p_c for the samples from el -24.0 and -45.0 shows values slightly less than p_o , but in reasonable

* All elevations (el) are in feet referred to mean low water (mlw).

agreement, hence normally consolidated. At el -55.0 and -63.0, overconsolidation is indicated since p_c is from two to three times greater than p_{o4} . Coefficients of consolidation ranged from 10×10^{-4} to 60×10^{-4} cm^2/sec .

Groundwater Conditions

46. Piezometers were installed in the same general vicinity as the borings beginning in 1961 to monitor the state of excess pore pressure within the clay. In some cases, the piezometers were installed in the borehole. Readings were taken by personnel of the NYD and the USMA. Table 4 lists the location, date of installation, and inclusive dates of observation. In Figure 15, chronological records of excess hydrostatic pore pressure are presented along with surface movements. Figure 16 shows the dissipation of excess pore pressure with time. The most recent piezometer readings (1978) indicate that approximately 70 percent of the estimated 100 percent consolidation has taken place since 1961.

47. Piezometer P-6, installed in the rock layer beneath the clay at the bottom of boring BU-2, established that drainage was affected to the bottom of the clay layer.

48. Since most of the porous tip piezometers developed heads well above the existing ground level, pressure gages were required; maintenance of the gages against environmental effects and vandalism proved to be a continual problem. Various other difficulties arose, such as crimping of the standpipe tubes, loss of seal, etc., which resulted in inconsistent readings and abandonment of the instruments.

49. The only piezometers presently yielding usable data are 7A, 8A, and 9A, installed in 1969 and used to assess the present excess pore pressure. The gages have been replaced by an adapter furnished by a commercial firm,* which permits readings with a single portable gage, thereby eliminating environmental and vandalism problems previously cited.

* Piezometer Research and Development Corporation, Stamford, Connecticut.

50. Heavy liquid piezometers P-10 through P-13 were intended to overcome some of the operational problems. In principle, pore pressure at the tip causes a liquid heavier than water to rise a lesser height, and only a measurement of the elevation of the column top is required. These piezometers were developed by and installed under the supervision of the same commercial firm previously cited, but no useful data have evolved due to various reasons as noted in Table 4.

51. Discontinuities and erratic readings in piezometer data (Figure 15) were due to problems noted in paragraph 48 in readings. An increase in pore pressure observed from November 1973 to February 1974 caused some alarm regarding the stability but was found to coincide with the installation of riprap along the shoreline. In 1976 and 1977, piezometer 8A indicated higher readings that are unexplained. In view of other malfunctions, these data are considered unreliable.

Surface Movements

52. Markers were placed on the surface for monitoring horizontal and vertical movements. Figure 3 shows the location of these markers, and Table 5 gives the pertinent details of each. The first set of markers was installed in 1961 at intervals along and approximately perpendicular to the baseline traversing the South Fill area. The markers designated East Pin and West Pin have been adequately protected and have yielded consistent data on surface movements. Of the three River Edge Pins installed in 1965, only one remains.

53. At each observation, the elevation was determined for each pin and the horizontal distance from a fixed point to West Pin, from West Pin to East Pin, and from East Pin to River Edge Pin (if still in place). Figure 15 shows a chronological record of observed settlements and changes in horizontal distances along with piezometer readings. Positive lateral movement indicates extension along the line, whereas negative movement indicates shortening or compression. Traverse profiles (approximately parallel to the baseline) of East and West Pins displayed in

Figure 17 at four-year intervals for the last 12 years show the settlement rate is decreasing with time. Also, the largest settlement is in the vicinity of East Pin at sta 4+26, which is located near the soil borings and piezometers. In Figure 18, the combined horizontal and vertical movement is displayed for the same four-year intervals as in Figure 17. These plots indicate an approximately constant ratio of horizontal to vertical displacement, with a slight tendency of decreasing lateral movement recently while settlement continues.

54. Additional horizontal and vertical controls were provided by a telltale asphalt walkway installed in August 1974 extending across the central portion of the area and containing five embedded markers designated as MAC points. It was anticipated that the observable cracking in the walkway would precede the onset of any large mass movement and possibly serve as an early indication of adverse movement. In Figure 19, profiles taken along these points at various times indicate settlement is continuing normally at a decreasing rate. A plot of the horizontal and the vertical movement of MAC points in Figure 20 shows much less lateral movement than vertical settlement.

Inclinometers

55. Measurements of deviations from the vertical were made with inclinometers at the locations shown in Figure 3 and described in Table 6. These devices are used to detect lateral movement below the surface and to indicate any developing mass movement mechanisms. The inclinometer readings were taken and interpreted by the NYD.

56. Considerable difficulties were encountered in maintenance and operation of the inclinometers at the site. Earlier installation utilized aluminum tubing that was subject to corrosion and local buckling, which prevented passage of the sensor device. In later installations, plastic guide tubing was used to alleviate some of the previous problem. However, large vertical deflection continued to create problems with alignment. The exposed tubes were enticing targets of vandalism and were filled with debris many times; they were also subject to accidental dislodgement in maintenance and other operations in the area.

57. The calculated lateral movements with depth in the North-South and East-West directions, as of March 1975, are displayed in Figure 21. Since these inclinometers were installed at different times, these data do not necessarily reflect the total movement along a given vertical line but reflect mass movement tendencies. However, the concentration of large boulders in the rock fill may have induced localized deflections not fully representative of the surrounding area.

58. Near surface movement was greatest for inclinometer station 346A located near the east edge of the old tennis court area. Movements of 3 to 4 in. riverward are consistent with observed cracking patterns that led to the removal of the tennis court surfacing. Within the clay layer, slight movements (less than 0.5 in.) landward were calculated.

59. At inclinometer station 348B located near the river edge, riverward movement is indicated at the surface and at depths in the clay with a maximum of about 0.5 in. at 70 ft. Slight landward movement of less than 0.5 in. occurring around the 20-ft depth could have resulted from riprap placement nearby. Inclinometer station 551B shows movement to south and east near the surface with easterly (riverward) movement increasing to a maximum at about the 60-ft depth and southerly movement diminishing to zero at about the same depth.

60. The lateral movements are indicative of the general riverward creep of the entire mass and do not reveal the development of localized movement that might precede a shear failure along horizontal or inclined surfaces.

PART IV: SETTLEMENT ANALYSES

61. In 1961, a settlement analysis was performed at the location of boring BU-2 in the South Fill area to determine the amount of settlement that had occurred and the amount of settlement that could be expected in the future. The ultimate settlement of the fill at boring BU-2 was computed using void ratio-log pressure curves (Figure 14 (sheet 1 of 3)). The ultimate settlement of the foundation due to the weight of the fill was computed to be 5.2 ft in 1961. Figures 22 and 23 show the predictions of percent consolidation and settlement versus time.

62. As a result of recommendations in WES Technical Report 3-591 (1962), settlements and pore pressures were observed at reference points and piezometers indicated in Figure 3. Based on observed pore pressure and settlements, Figures 22 and 23 also present curves of percent consolidation and predicted settlements dated 1969 based on 1961 test data and field observations through 1969. Since the strength tests performed on 3-in.-diam samples taken in 1975 were considered to be unreliable because of disturbances, the consolidation test results were also doubtful; since only one test was performed on a 5-in.-diam sample, no settlement analysis was made.

63. Another settlement analysis was conducted as a part of this study based on samples taken in 1977. Additional ultimate settlement of 3.5 ft at the location of boring WS-3 is predicted. This predicted settlement, combined with an observed settlement of 3.9 ft (through October 1977) and an estimated settlement (prior to 1961) of 2.2 ft based on observed pore pressures, revises slightly the total ultimate settlement predicted since placement of the fill to 9.6 ft. The predicted total settlements for 1969 and 1978 are compared in Figure 23.

PART V: STABILITY ANALYSES

64. A stability analysis of the South Fill area, from the river edge westward to the parking area, was conducted using the WES computer program 741G9RO-104. This program computes stability by the Modified Swedish Method of circular arcs described in EM 1110-2-1902 (Dept. of the Army, OCE, 1970). The idealized soil profile in Figure 24 was determined from contour maps and boring information obtained from the site since 1961. The stability analyses for this idealized profile used the strength data in Table 7. These values were obtained by assuming the clay normally consolidated ($c/p_o = 0.3$) and subdividing the clay layer into zones of equal overburden stress.

65. The analysis indicates that the factor of safety against sliding increases with distance landward from the edge of the river. The area west of the paved access road (Figure 3) possesses a minimum factor of safety of 2.6. When a 100-psf surcharge load, which simulates congested parking, is imposed on this area, the factor of safety is reduced to 2.4. From the road to the edge of the river, the factor of safety decreases to 1.7 without surcharge, but it is assumed that this particular area will not be utilized for parking since it contains trees and picnic facilities.

66. No strength parameters were determined that would permit analyses of the submerged slope. However, it is assumed that the factor of safety of the submerged slope is at least 1.0 since failure has not occurred. With no failure of the submerged portion, a factor of safety of 1.7 was determined as indicated above. In order to evaluate that portion in the event a failure of the submerged slope did occur, a factor of safety of less than 1.0 (0.98) was assigned to the submerged slope and an analysis performed. The factor of safety of the fill from the road to the river's edge was only reduced from 1.7 to 1.4.

67. Appendix E presents hydrographs and soundings taken adjacent to the South Fill area and extending to the thalweg of the Hudson River. The data indicate that significant erosion has not occurred at the toe of the underwater slope since 1961. Thus, this slope should remain

stable if the upstream and downstream channels remain unaltered. In Figure 24, maximum tide fluctuations for October range from approximately el -0.5 to +4.3.

PART VI: SITE UTILIZATION

Current and Future Use

68. A very low risk of slope failure exists at the South Fill area for continued use for recreational and athletic activities. Parking on athletic fields would not substantially increase risks. If maximum predicted future settlements occur, inundation at tides greater than el 5.0 may occur and thus restrict the use of lowest elevations. Currently, inundation may occur at tides greater than el 8.0.

Future Development Potential

69. Structures on spread footings are likely to develop cracking and distortion due to differential settlements. The use of piles is prohibited; the driving vibration and pile displacement could lead to a liquefaction slide. Hence, the construction of structures on the South Fill area should not be allowed unless measures to improve stability are undertaken.

70. Additional filling in thin soil lifts spread over a period of years to raise the existing area to prevent inundation is permissible with field observations to control placement.

Precautions

71. Other than parking of cars, precautions necessary for changes in use of the South Fill area include:

- a. Storage or stockpile of construction materials, coal, or heavy equipment should not be allowed.
- b. Occupancy by heavy reciprocating or rotating machinery (such as rock crushers, conveyors, pumps, and compressors), which could cause large stresses in the soil due to dynamic amplification, should not be allowed.
- c. More extensive subsurface exploration and testing programs should be required to assess permissible operations.

PART VII: CONCLUSIONS AND RECOMMENDATIONS

Conclusions

72. The South Fill area in its present configuration is stable and should remain stable provided its use is limited to athletic fields, recreational areas, and parking. The factor of safety of the mass landward of the road will continue to increase as the pore pressures dissipate. An assumed failure of the submerged slope and the removal of debris by the river result in a calculated factor of safety for the area between the road and the river of 1.4.

73. Use of the athletic fields (west of gravel road) for concentrated parking will not significantly reduce the stability or affect settlements.

74. Future settlements may cause flooding in lower areas of the site during high tides.

75. Since the South Fill area is stable, and the usage is limited as described above, no further monitoring of movements is necessary. However, periodic sounding should be made of the submerged slope to determine if the river is eroding the toe of the slope.

76. The consultants' review comments concerning this report are presented without comment in Appendix F.

Recommendations

Actions prior to modifying South Fill area

77. In the event that long-range plans of the Military Academy involve altering the use of the South Fill area, the NYD should be notified with sufficient lead time to accommodate the scope of the required foundation investigation.

Further studies

78. The data collected at the South Fill area are unique in that they represent long-term documentation on the behavior of marginally

stable fill on soft clay. Numerical techniques, mainly finite element methods, are being developed to analyze soil masses and predict time-dependent response to loads, and the observations contained in this report would be useful for verification of such techniques. As the Corps of Engineers has a vital interest in the development of numerical techniques for geotechnical purposes, consideration should be given to providing the data to interested academic institutions for use in research studies in this area.

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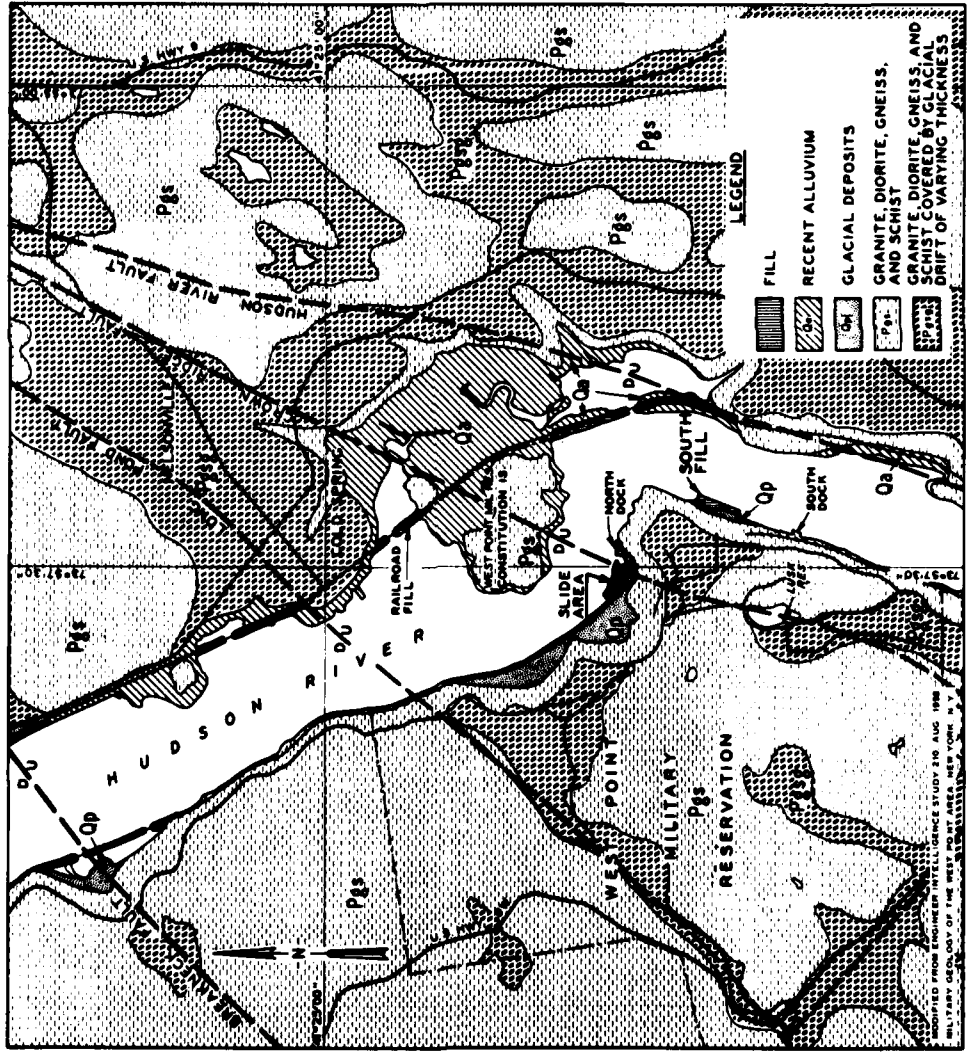
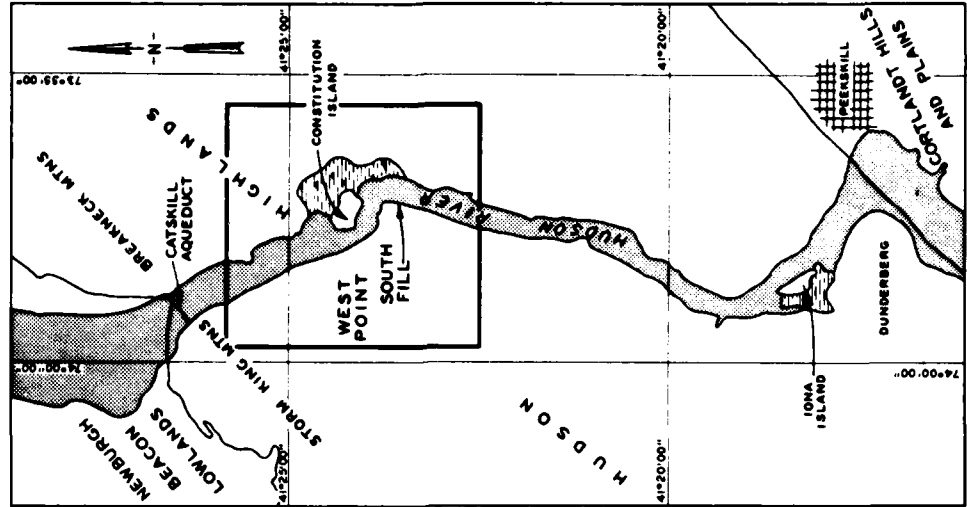


Figure 1. General plan and geology of the West Point, New York, area

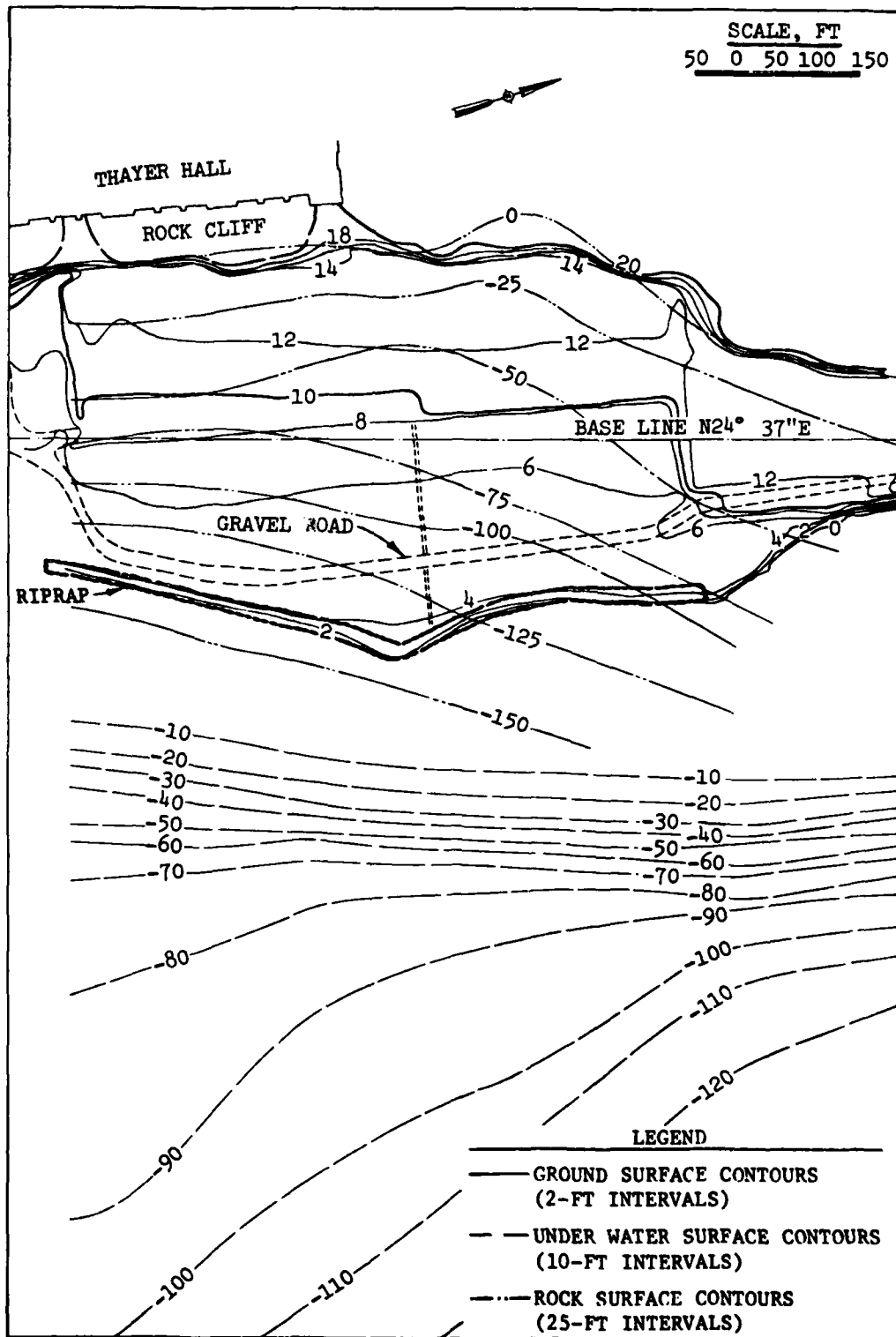


Figure 2. Ground and rock surface contours of the South Fill area, West Point Military Academy, New York

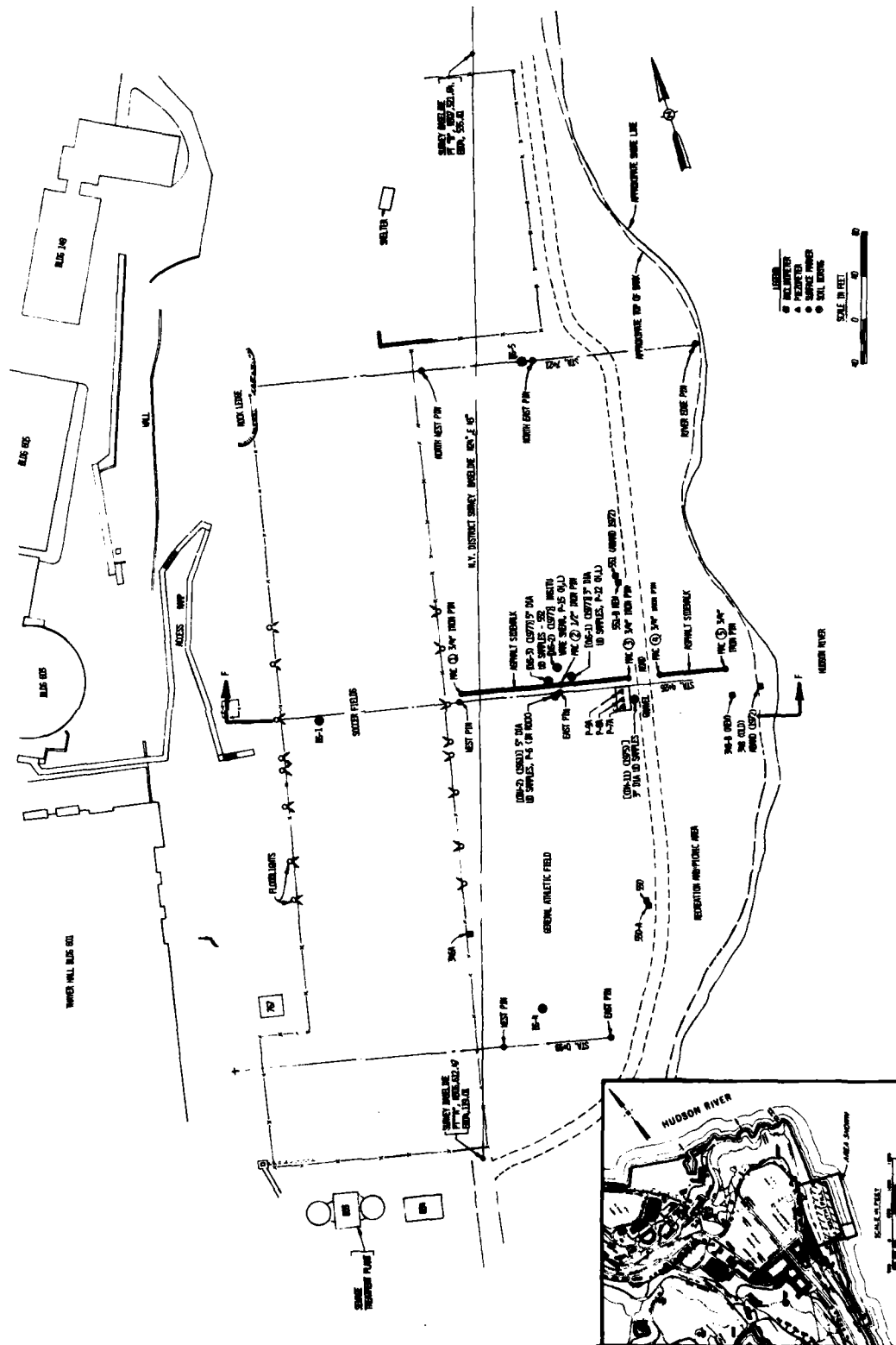


Figure 3. Location of borings and instrumentation for the South Fill area

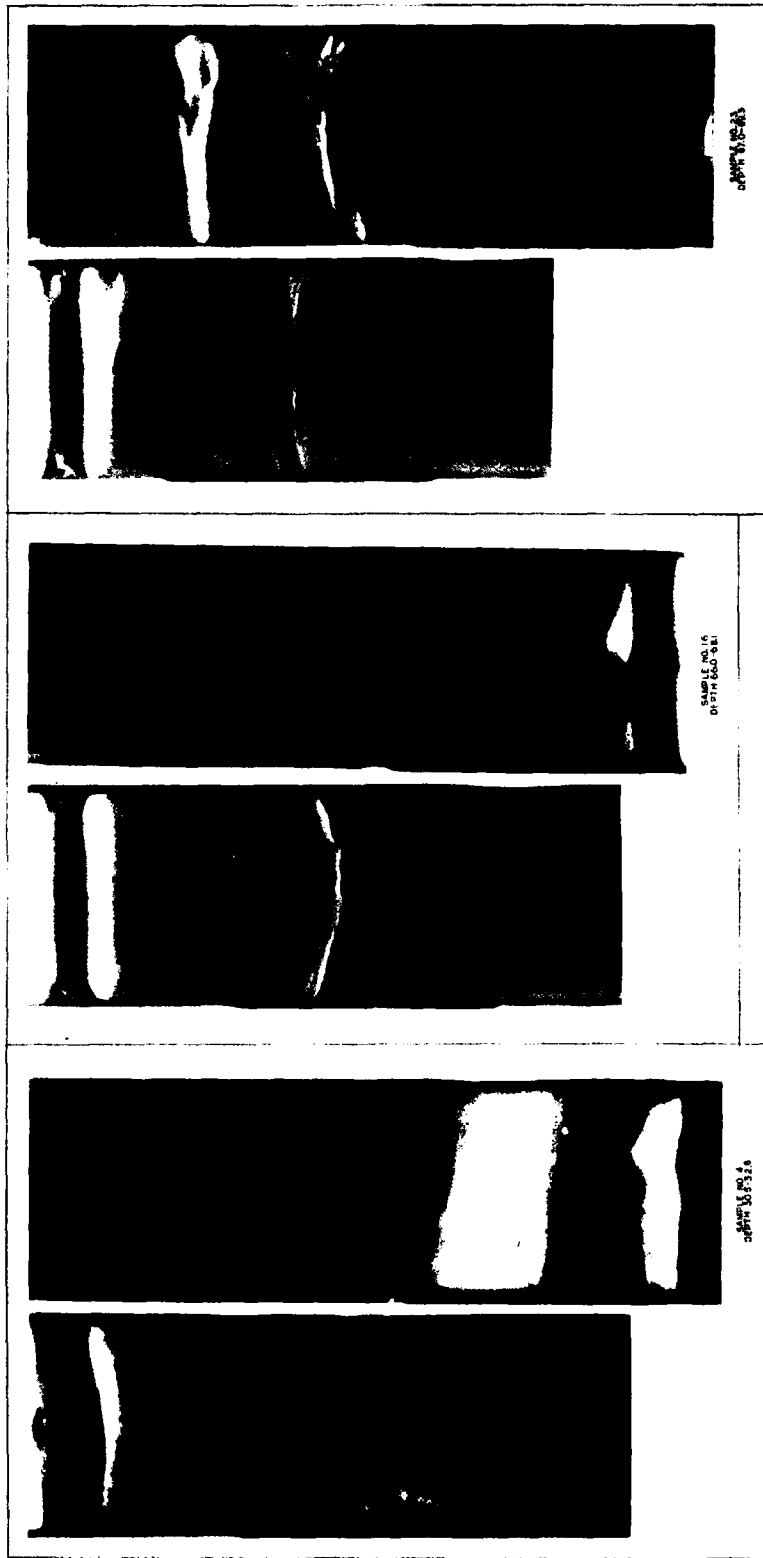


Figure 4. Typical radiographs of representative samples from boring WS-3, South Fill area

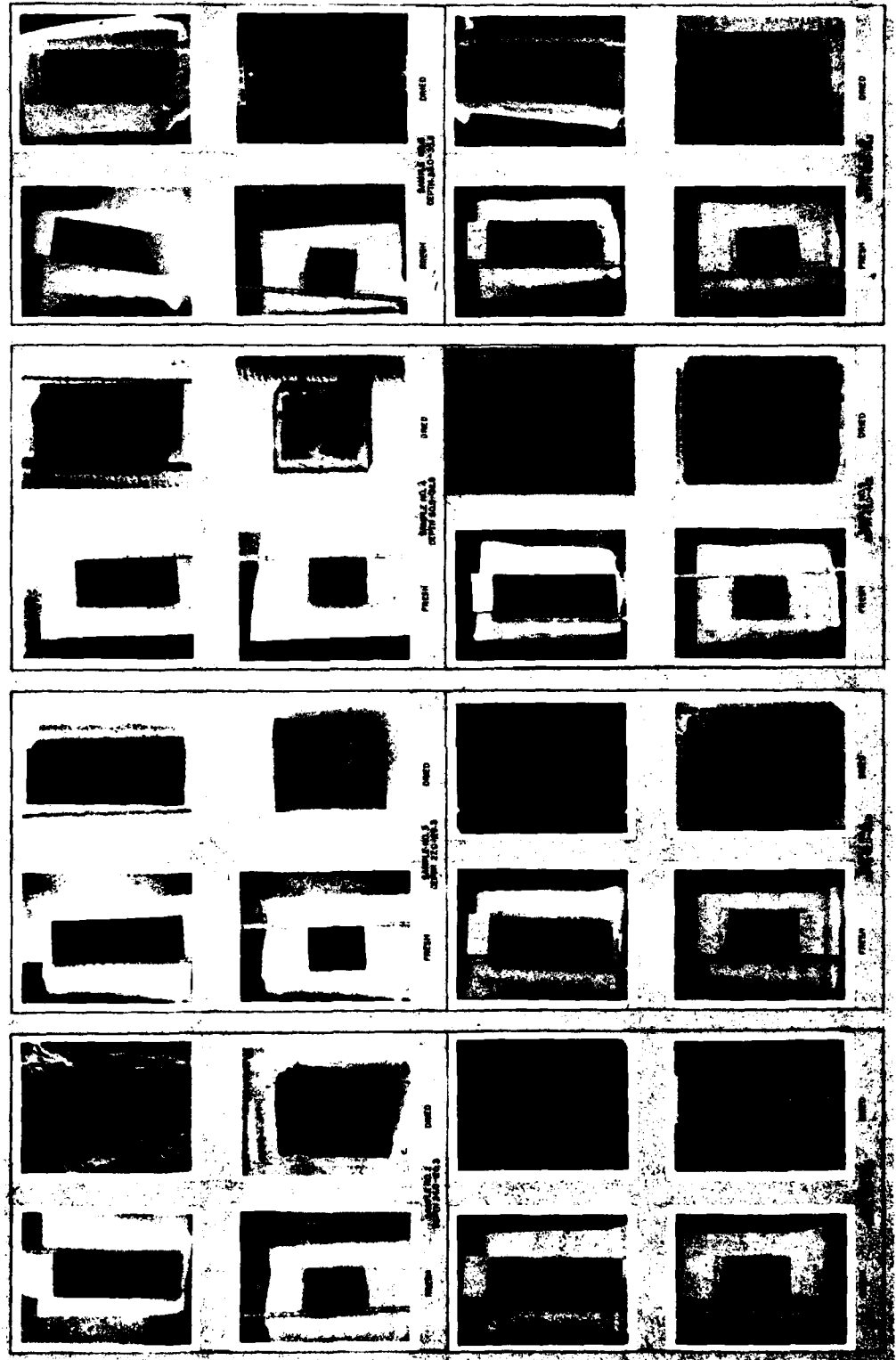


Figure 5. Specimens from boring WS-3, South Fill area, used in the Hvorslev thin-slice examination (Sheet 1 of 3)

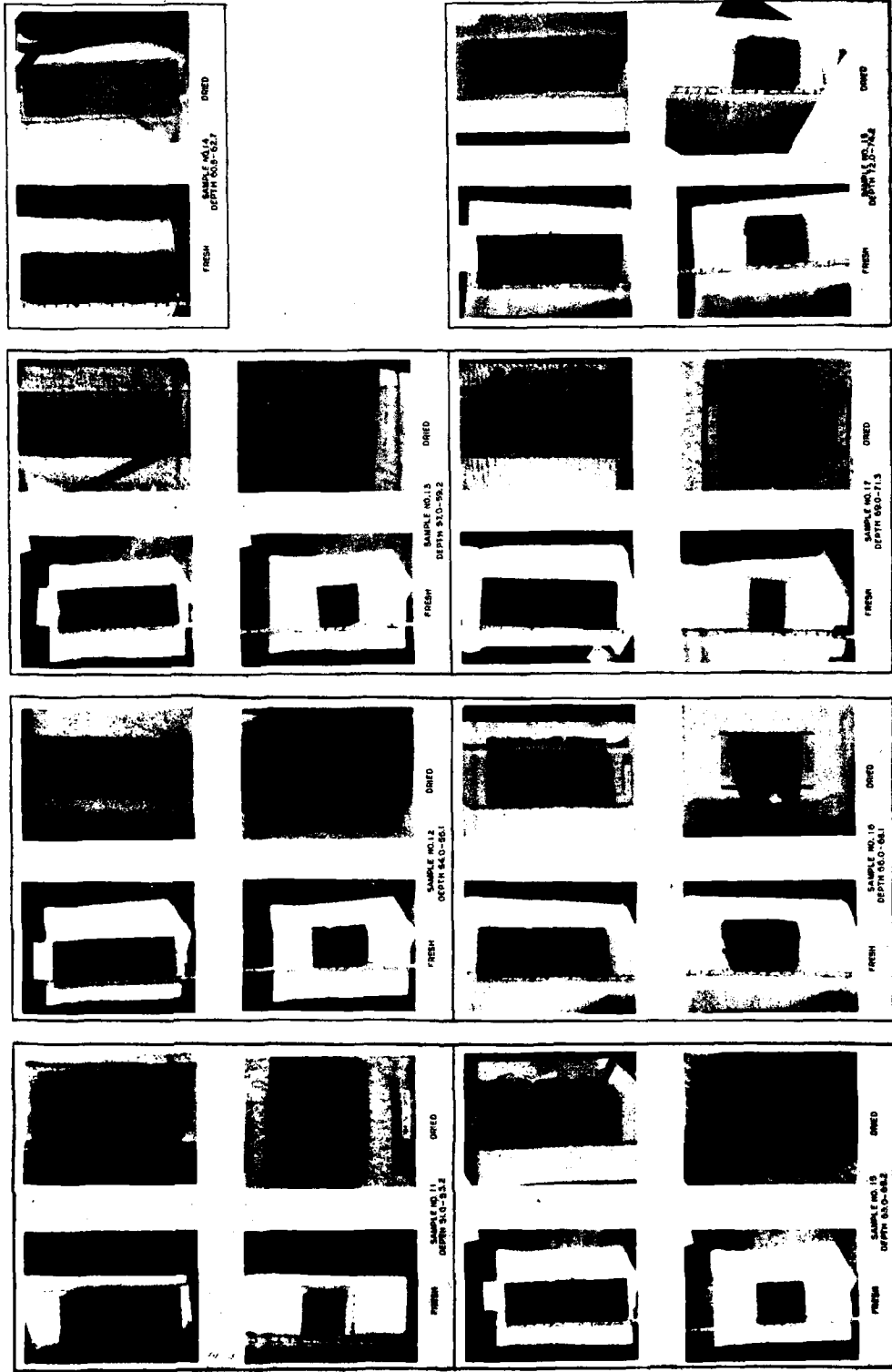


Figure 5 (Sheet 2 of 3)

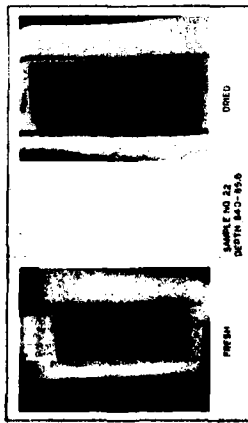
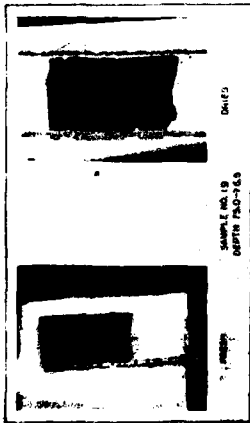
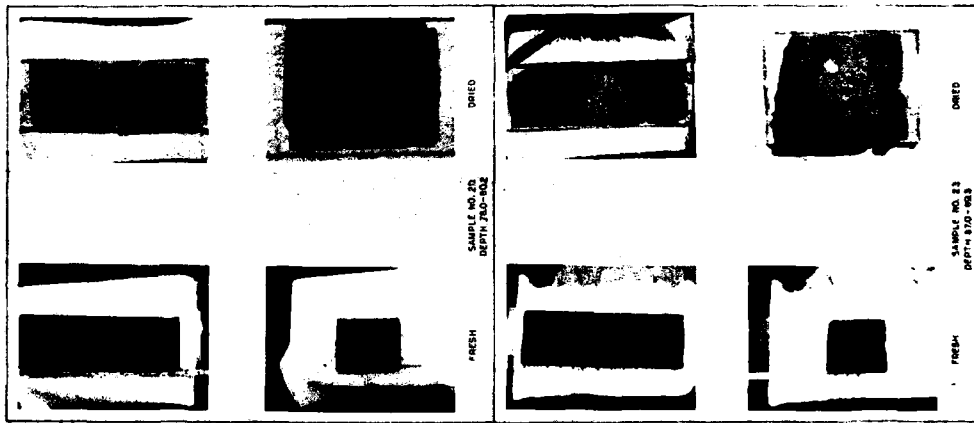
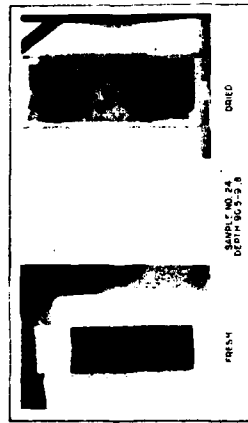
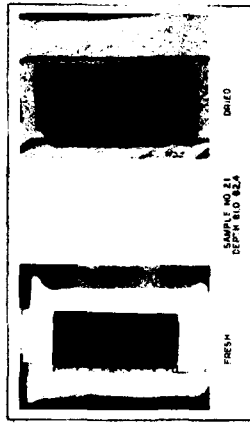


Figure 5 (Sheet 3 of 3)

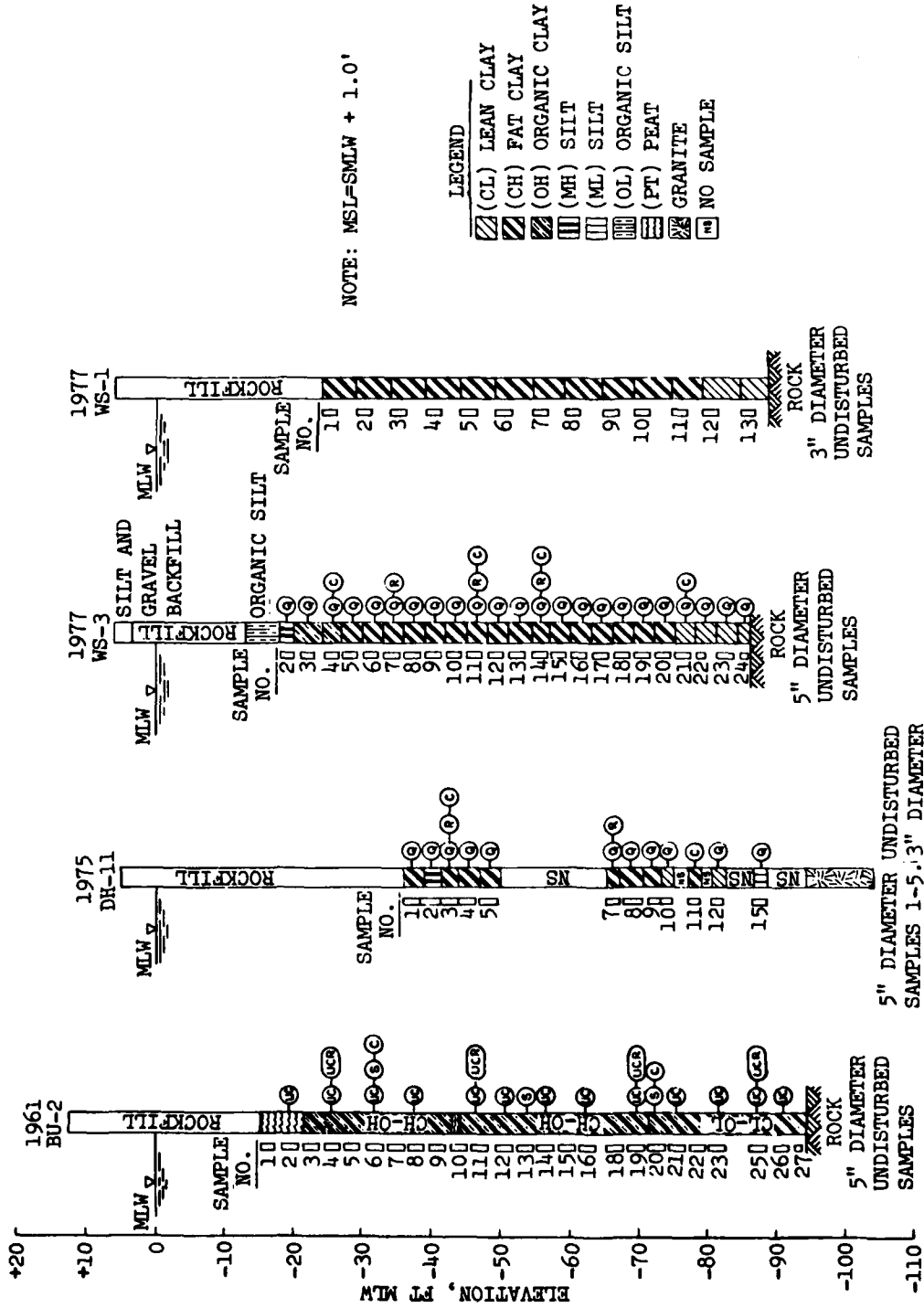


Figure 6. Boring logs from the South Fill area

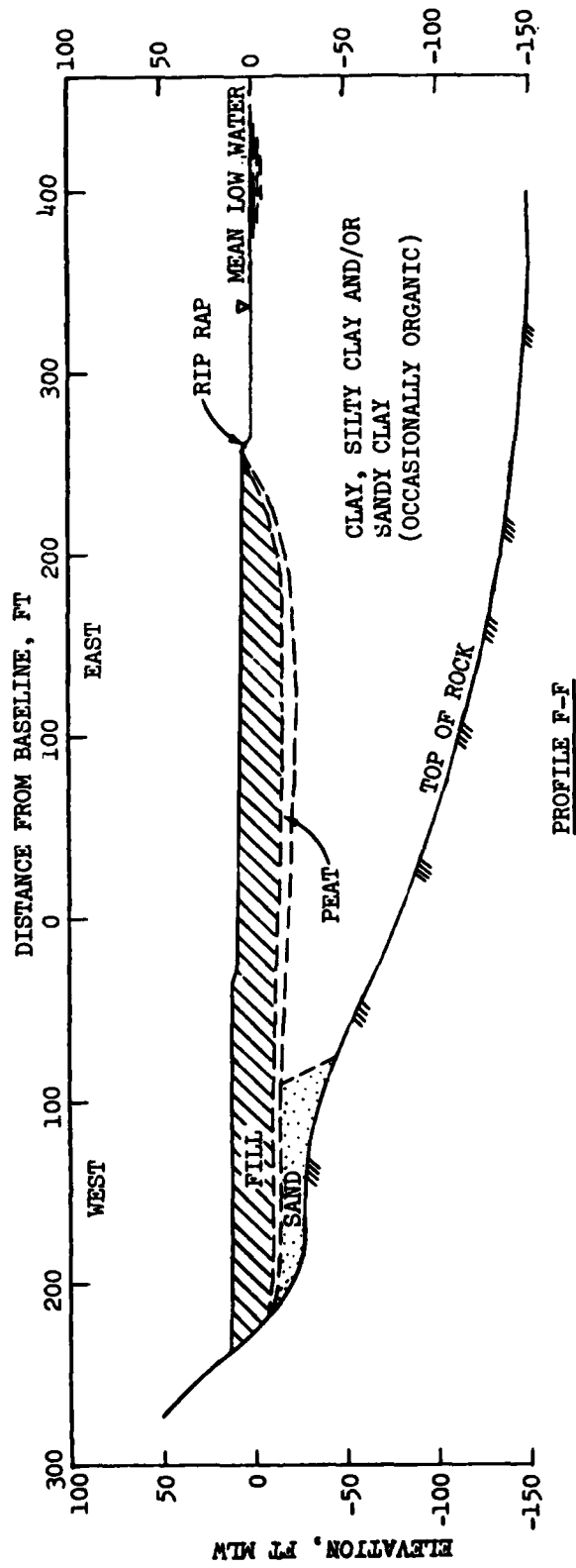


Figure 7. Generalized west to east profile through the South Fill area.

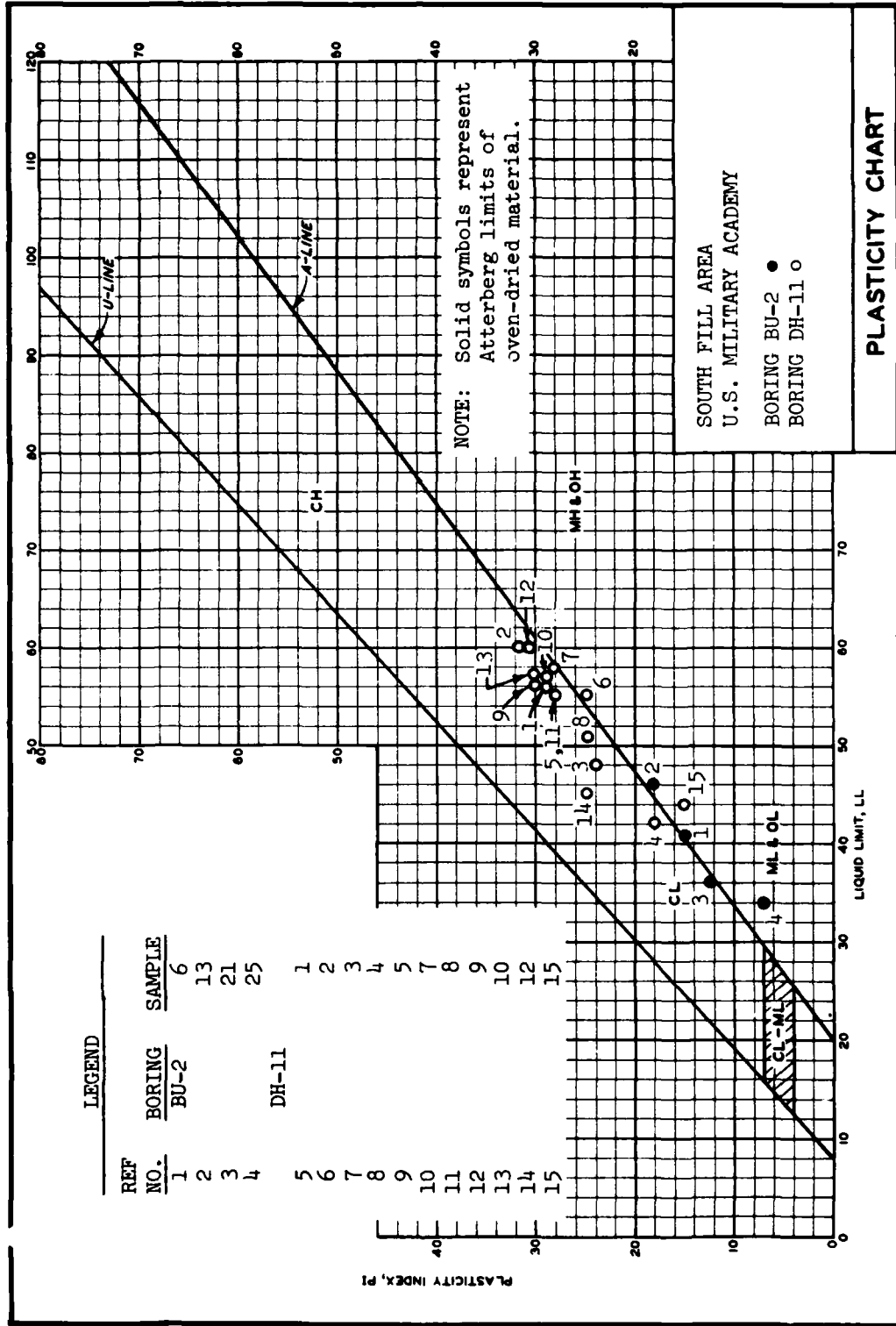
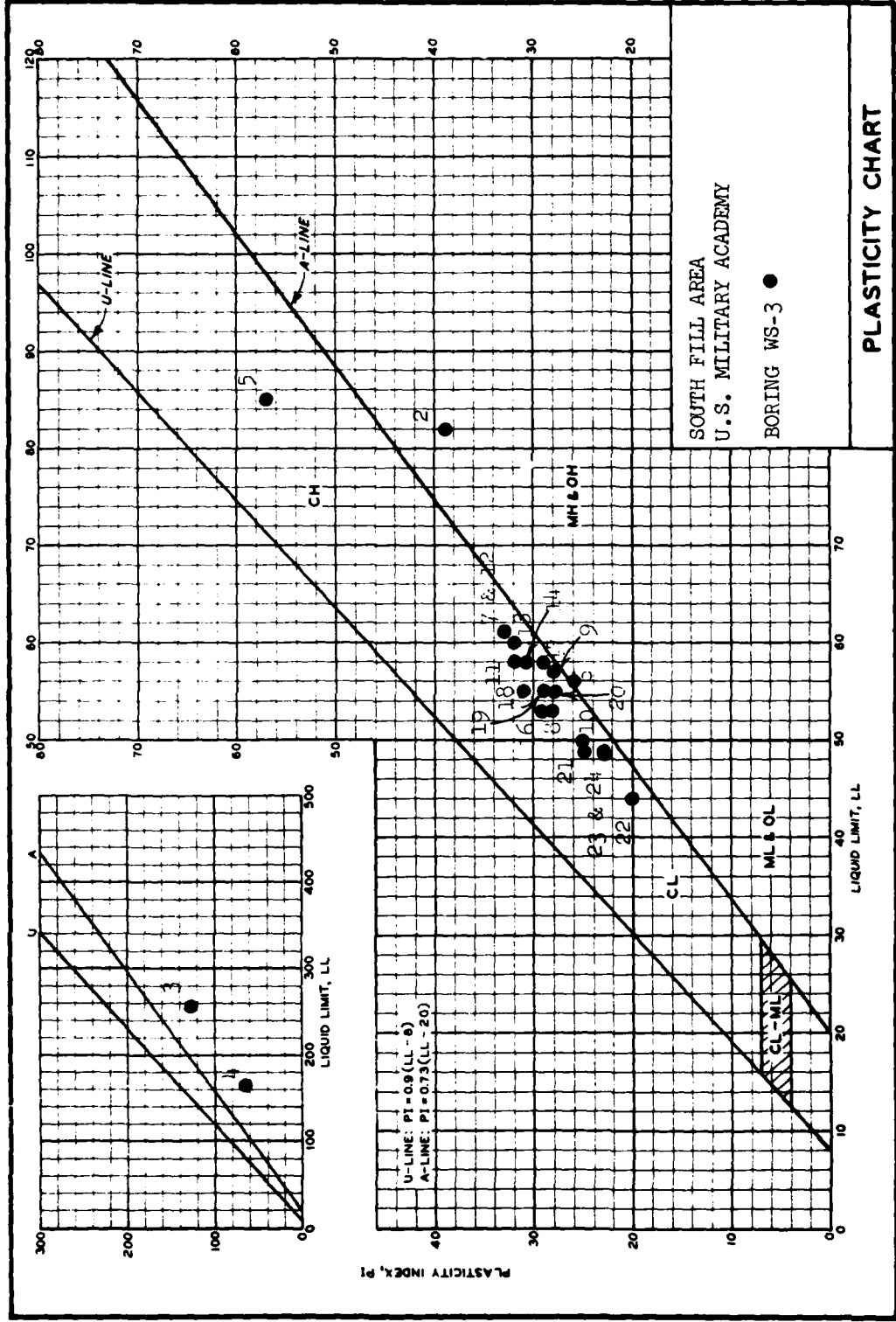


Figure 8. Plasticity chart plotted for South Fill soil samples from borings BU-2, DH-11, and WS-3, (Sheet 1 of 2)



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Figure 8 (Sheet 2 of 2)

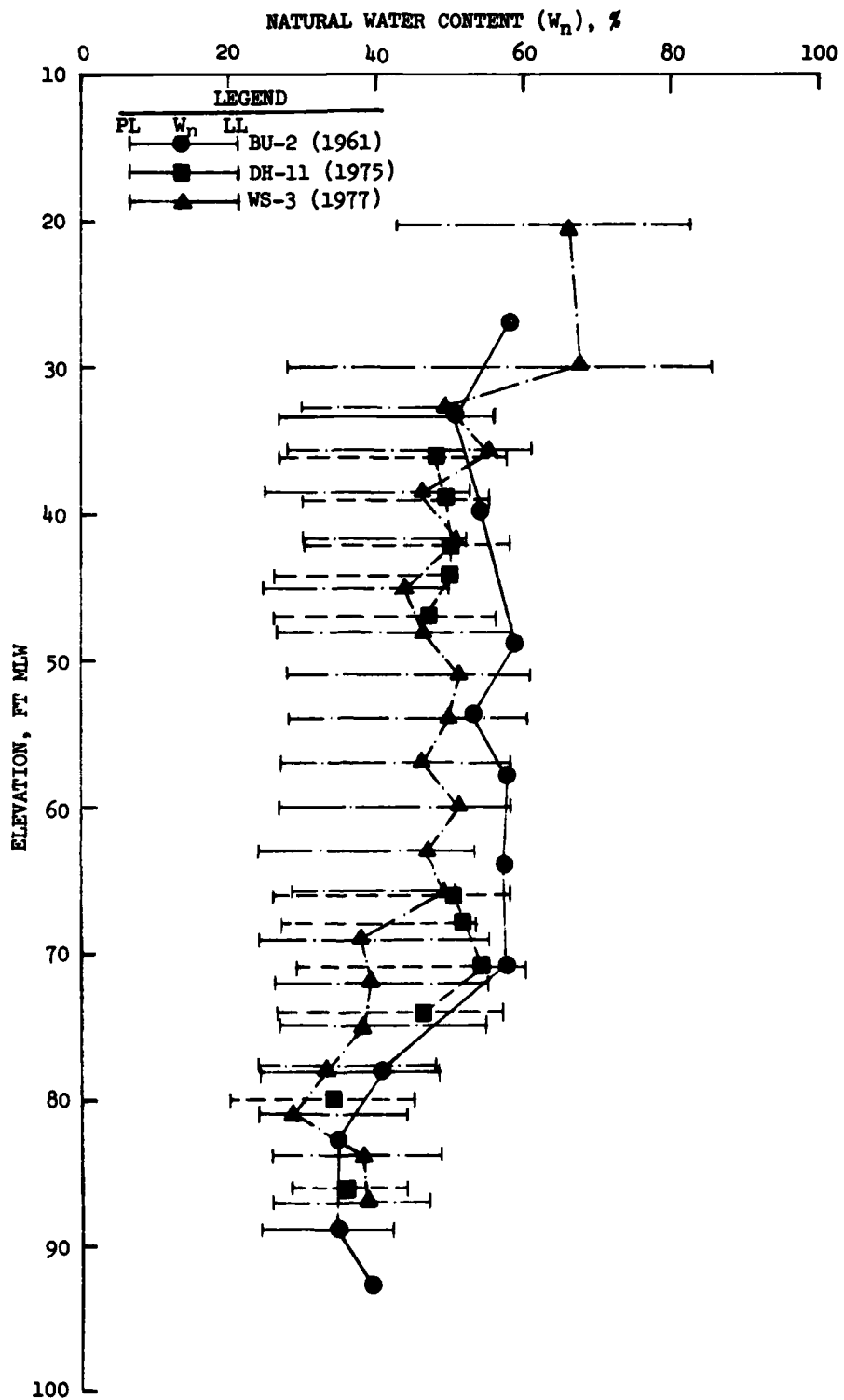


Figure 9. Water content and Atterberg limits distribution for South Fill area

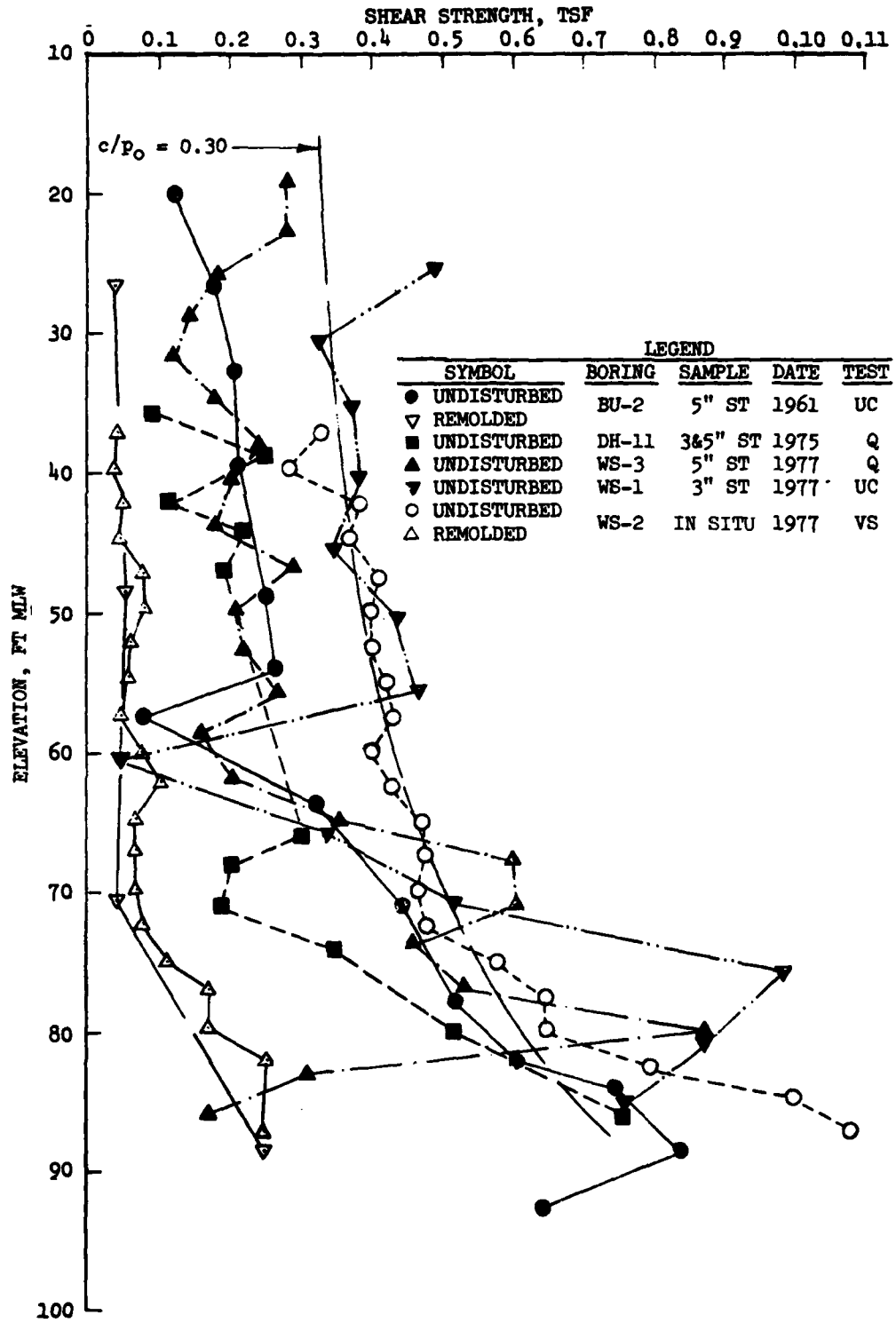


Figure 10. Undrained shear strength versus depth data for borings BU-2, DH-11, WS-1, WS-2, and WS-3, South Fill area (Sheet 1 of 8)

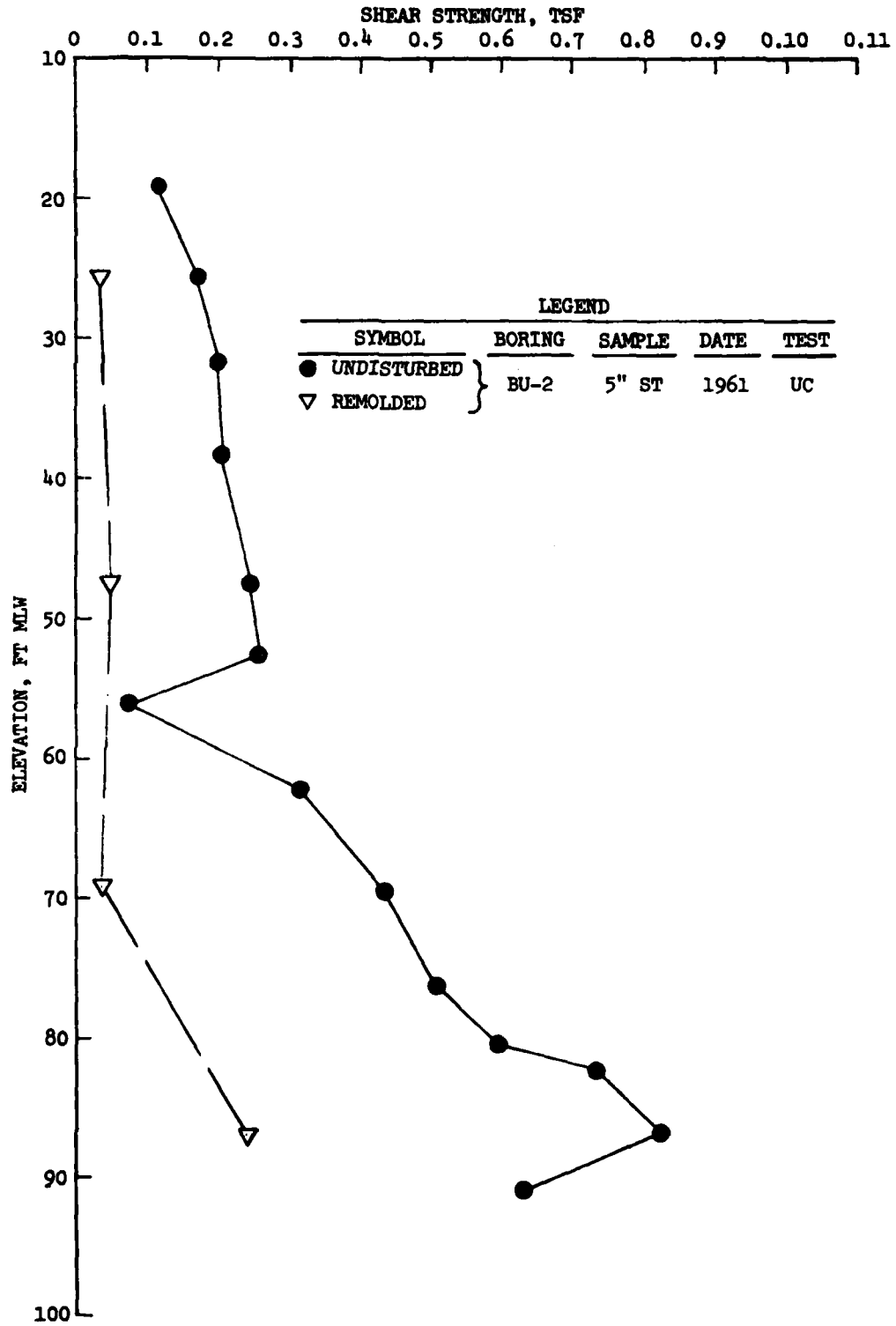


Figure 10 (Sheet 2 of 8)

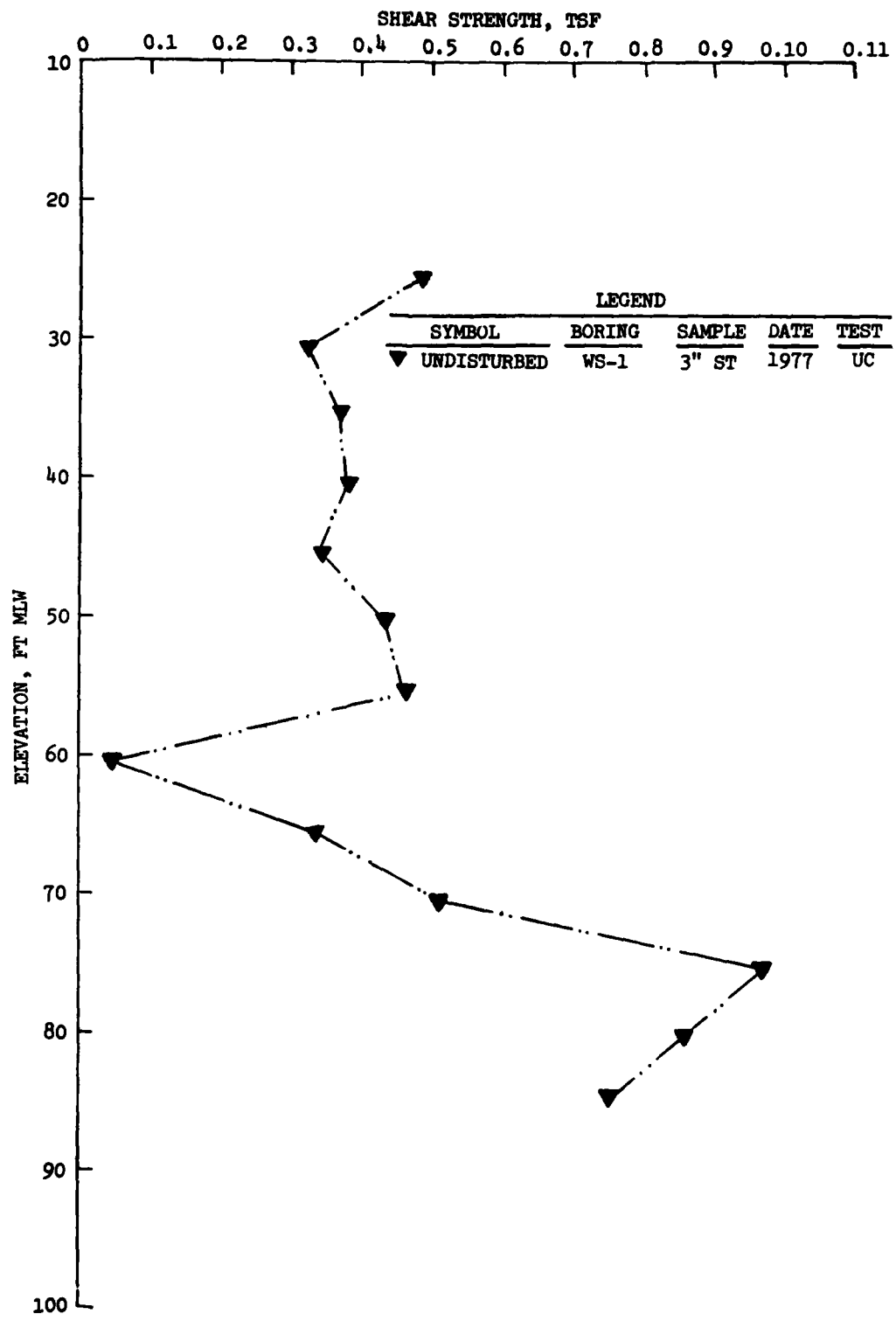


Figure 10 (Sheet 3 of 8)

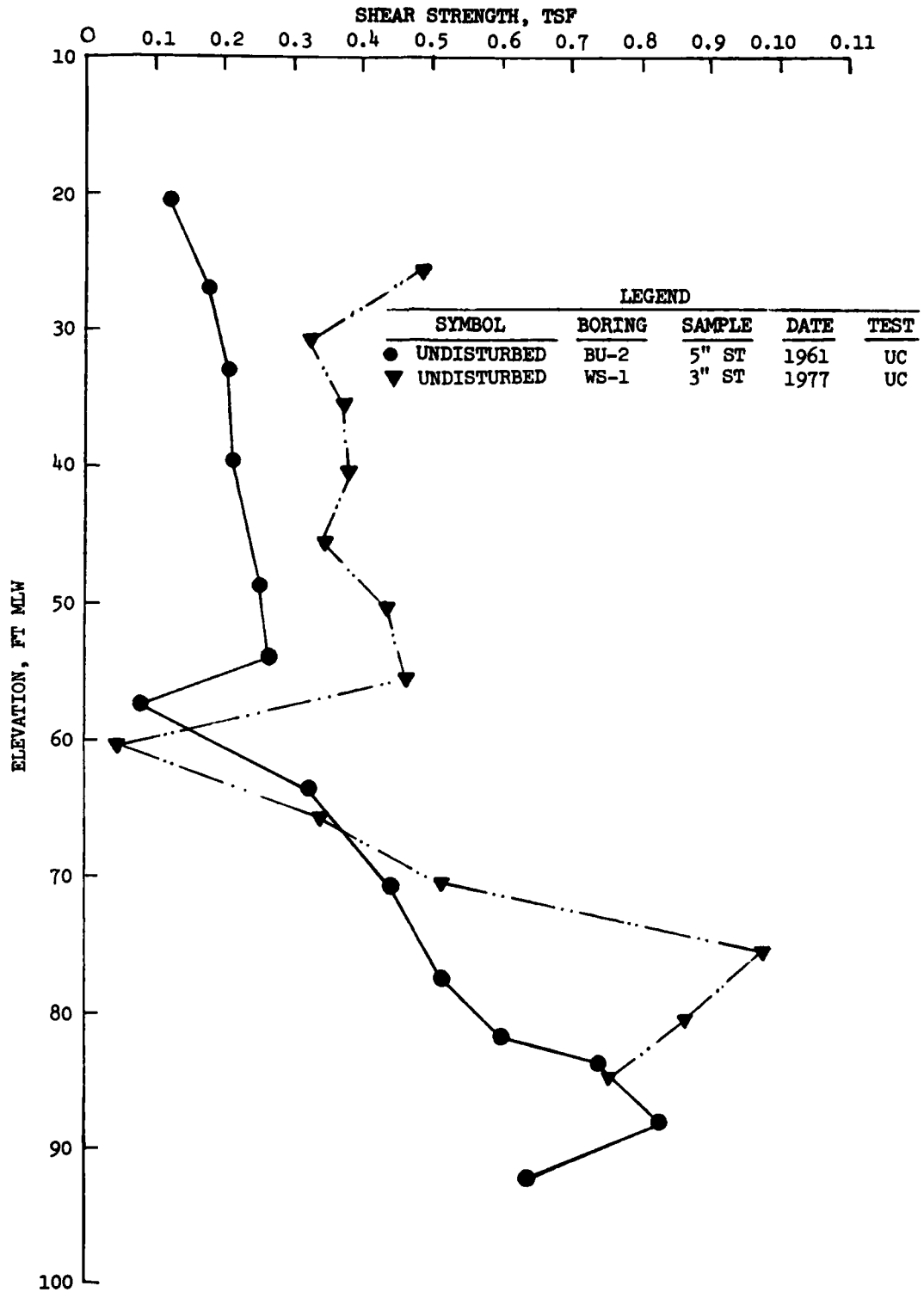


Figure 10 (Sheet 4 of 8)

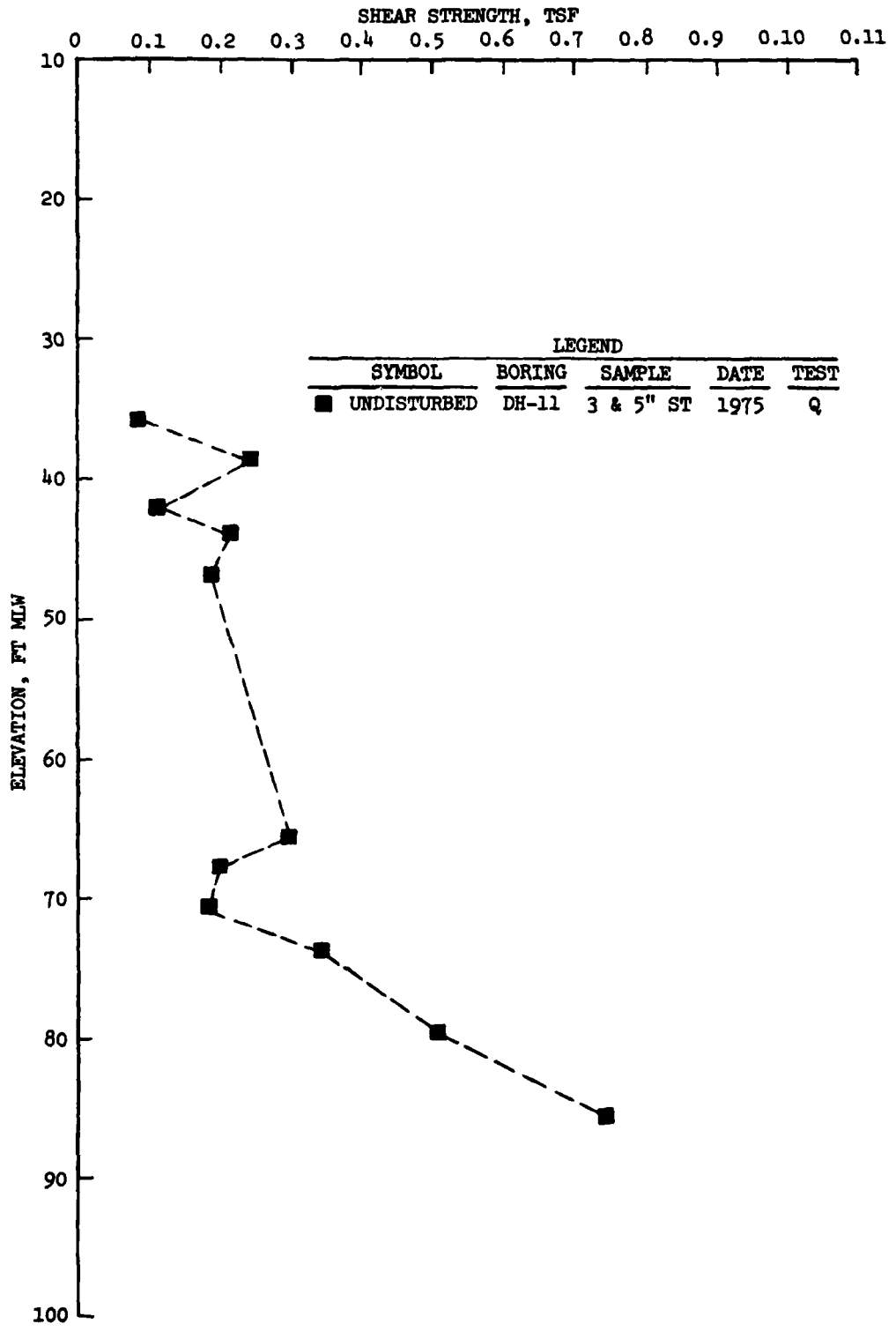


Figure 10 (Sheet 5 of 8)

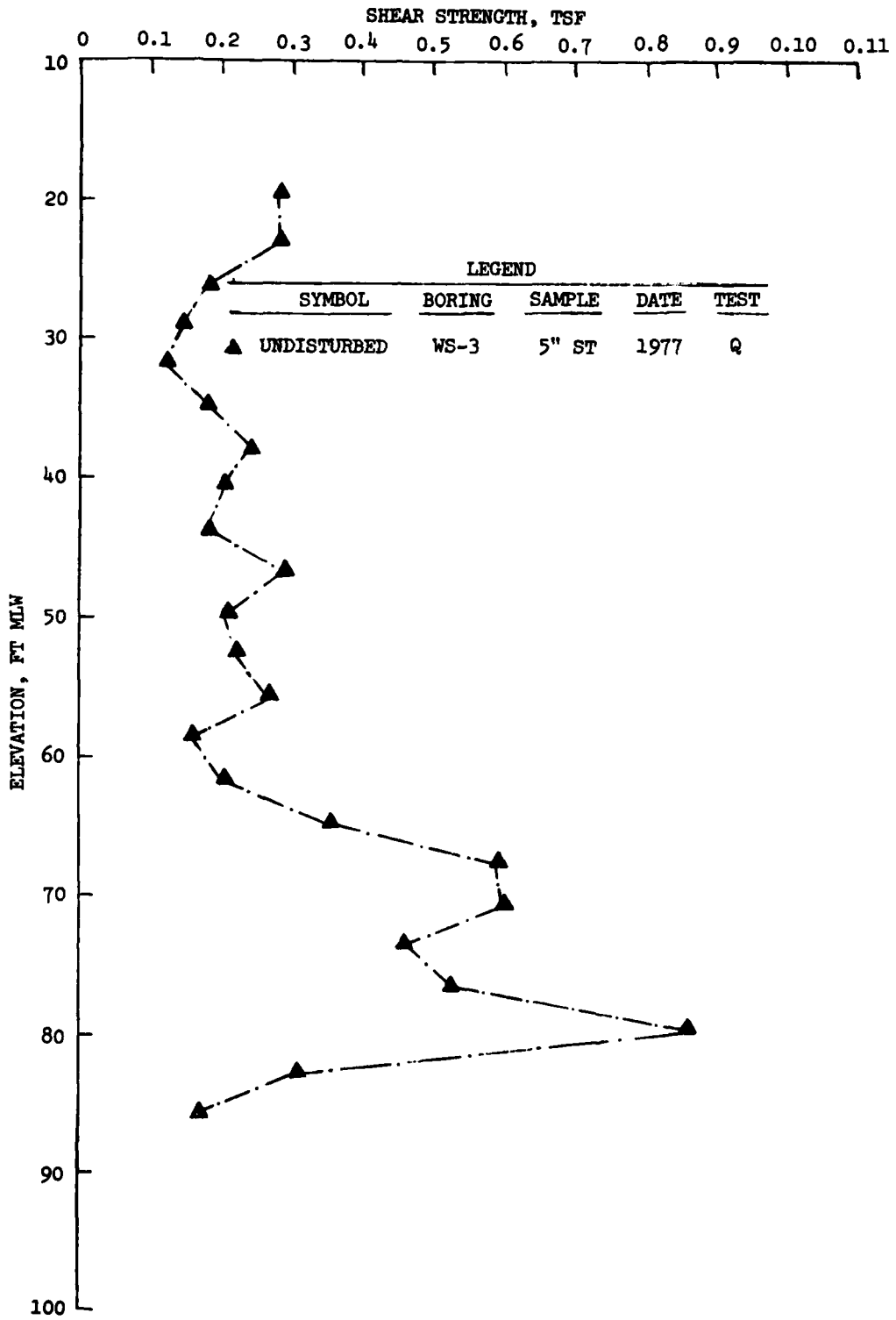


Figure 10 (Sheet 6 of 8)

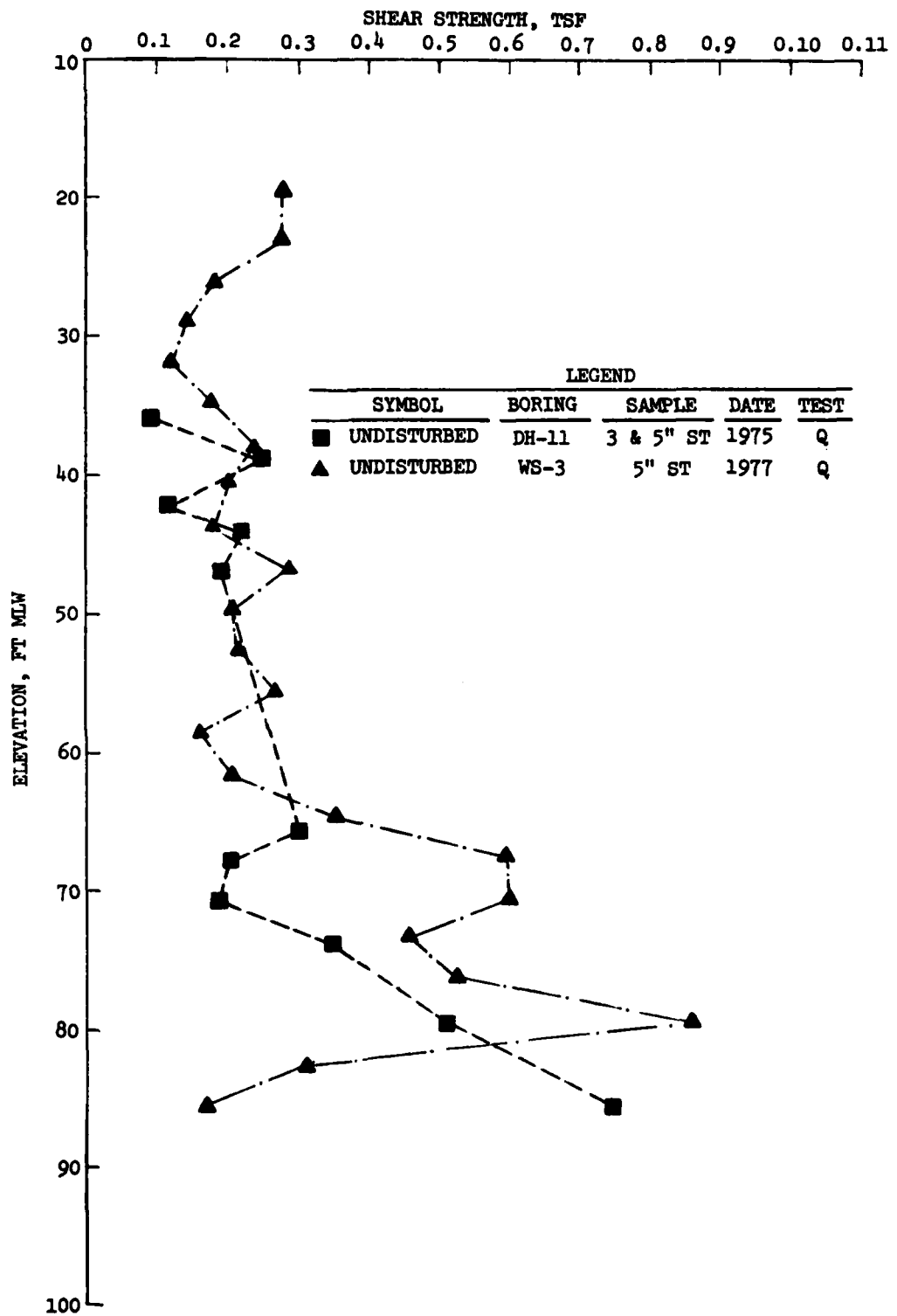


Figure 10 (Sheet 7 of 8)

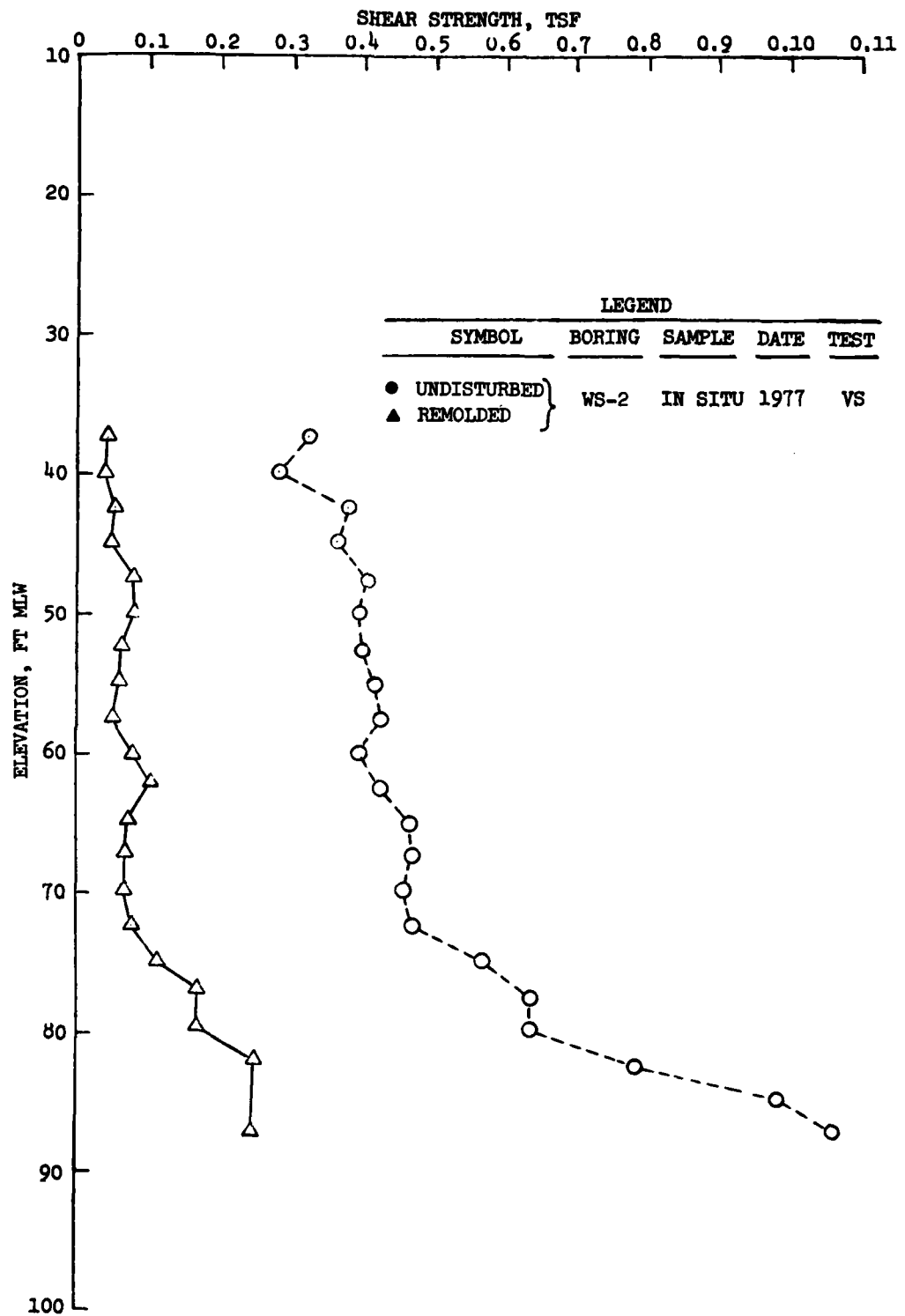


Figure 10 (Sheet 8 of 8)

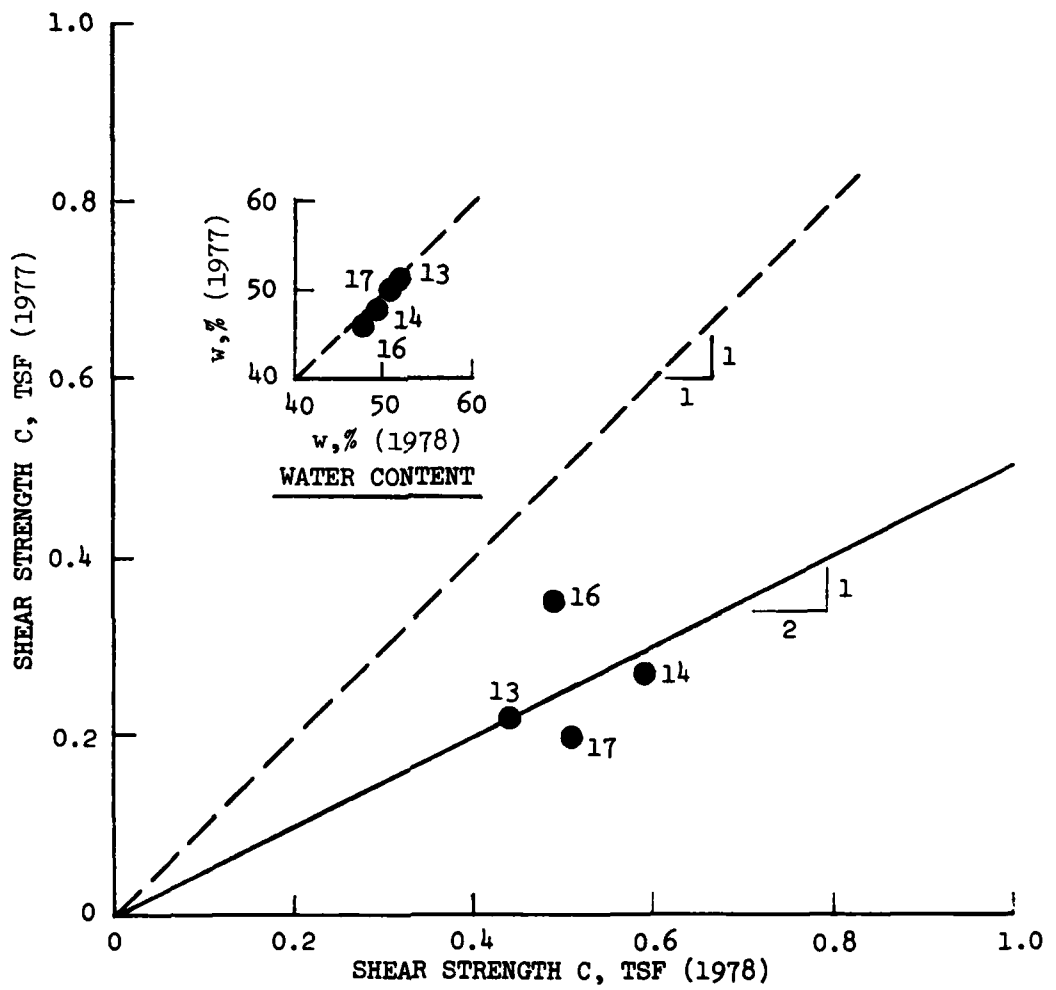


Figure 11. Comparison of Q test shear strengths for samples in storage, South Fill area

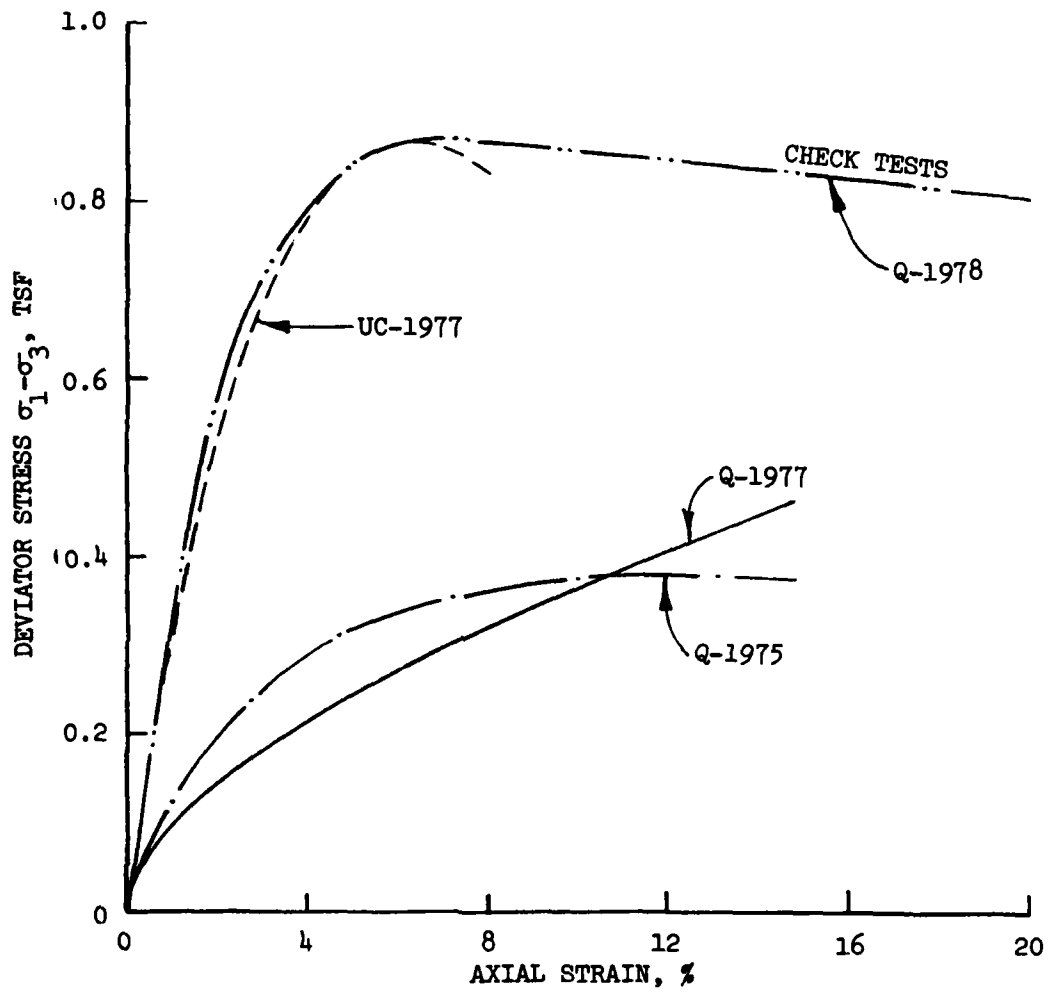


Figure 12. Comparison of stress-strain curves for Q tests at different times from same depth, South Fill area

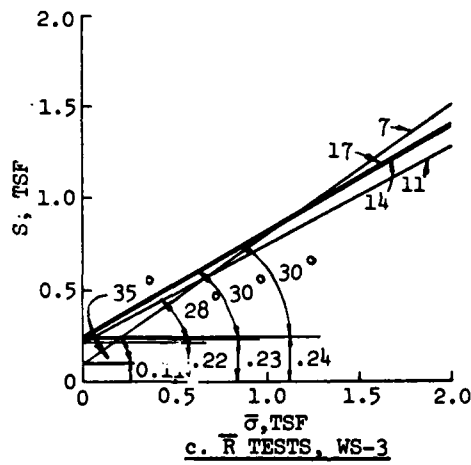
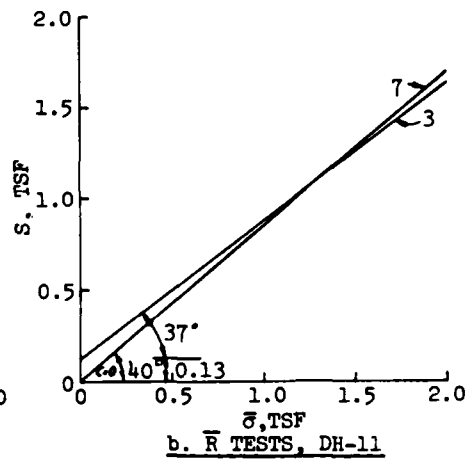
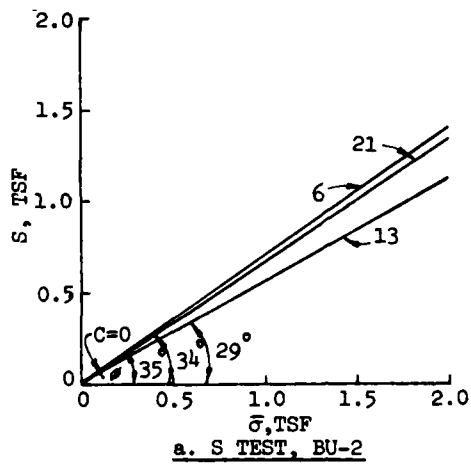


Figure 13. \bar{R} and S test shear strength envelopes for test specimens from South Fill area

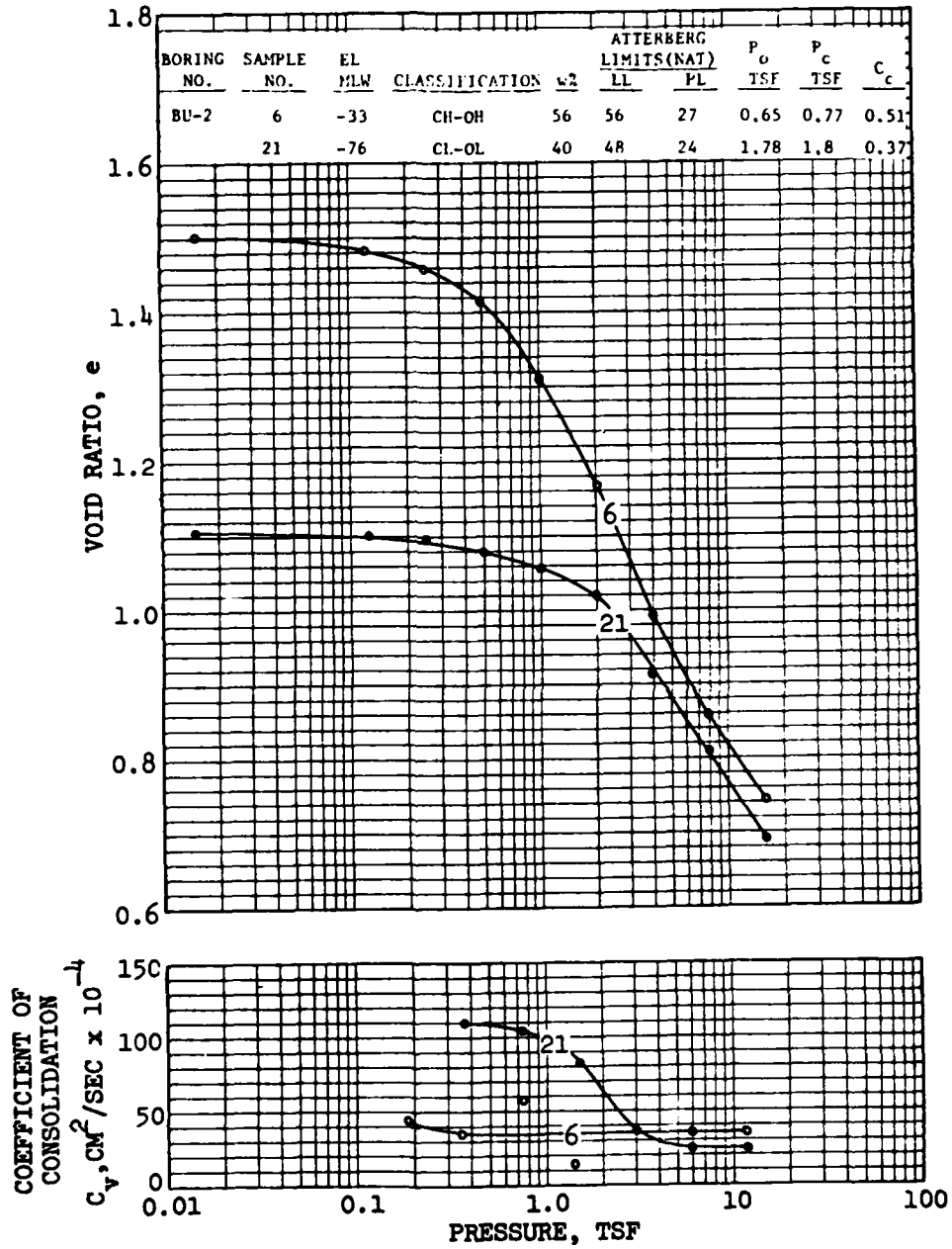


Figure 14. One-dimensional consolidation test results from borings BU-2, WS-3, and DH-11, South Fill area (Sheet 1 of 3)

2.6	BORING SAMPLE		EL	CLASSIFICATION	w%	ATTERBERG LIMITS (NAT)		P _o TSF	P _c TSF	C _c
	NO.	NO.				LL	PL			
	WS-3	4	-24	OH	89	164	99	0.3	1.4	0.58
2.4		11	-45	CH	47	58	26	0.8	1.5	0.52
		14	-55	CH	55	58	27	1.0	4.8	--
2.2		21	-63	CH	37	58	29	1.2	4.0	0.32

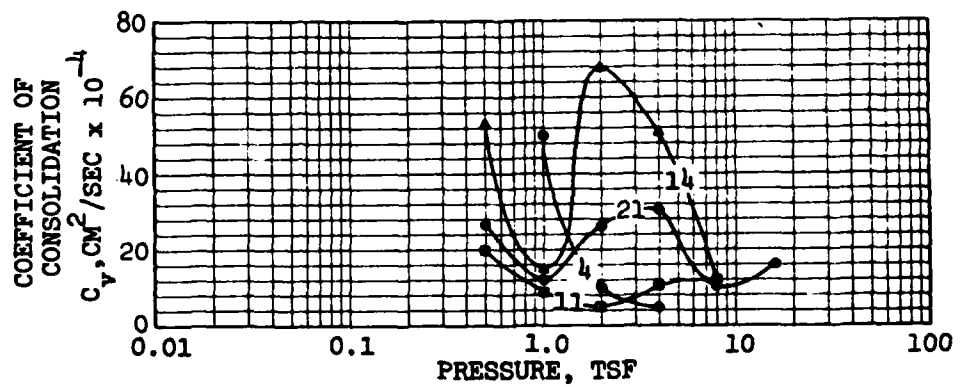
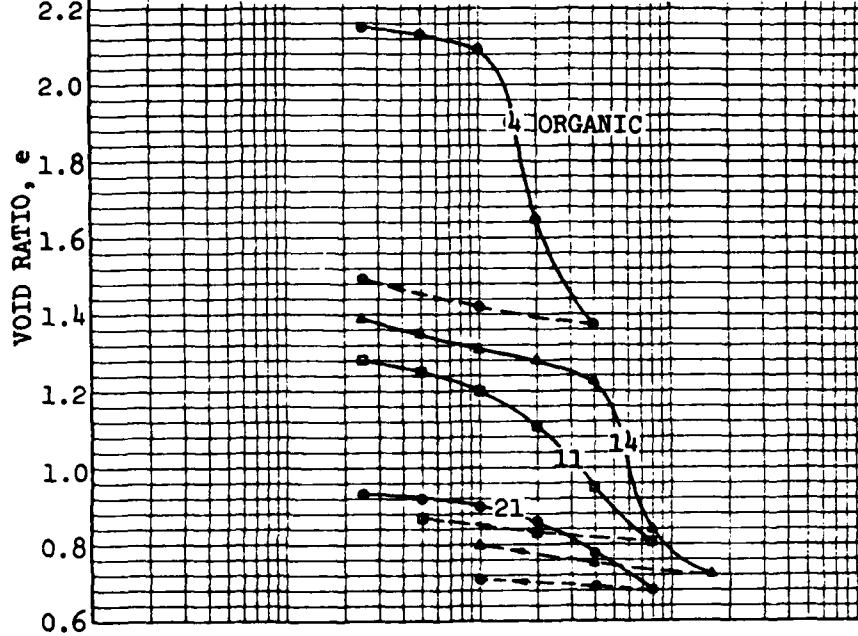


Figure 14 (Sheet 2 of 3)

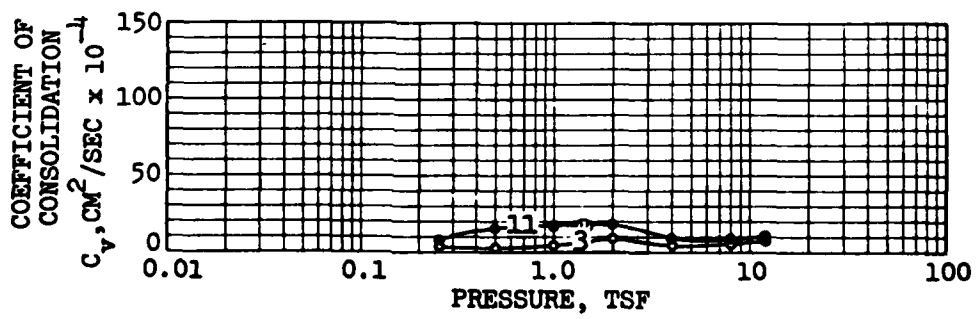
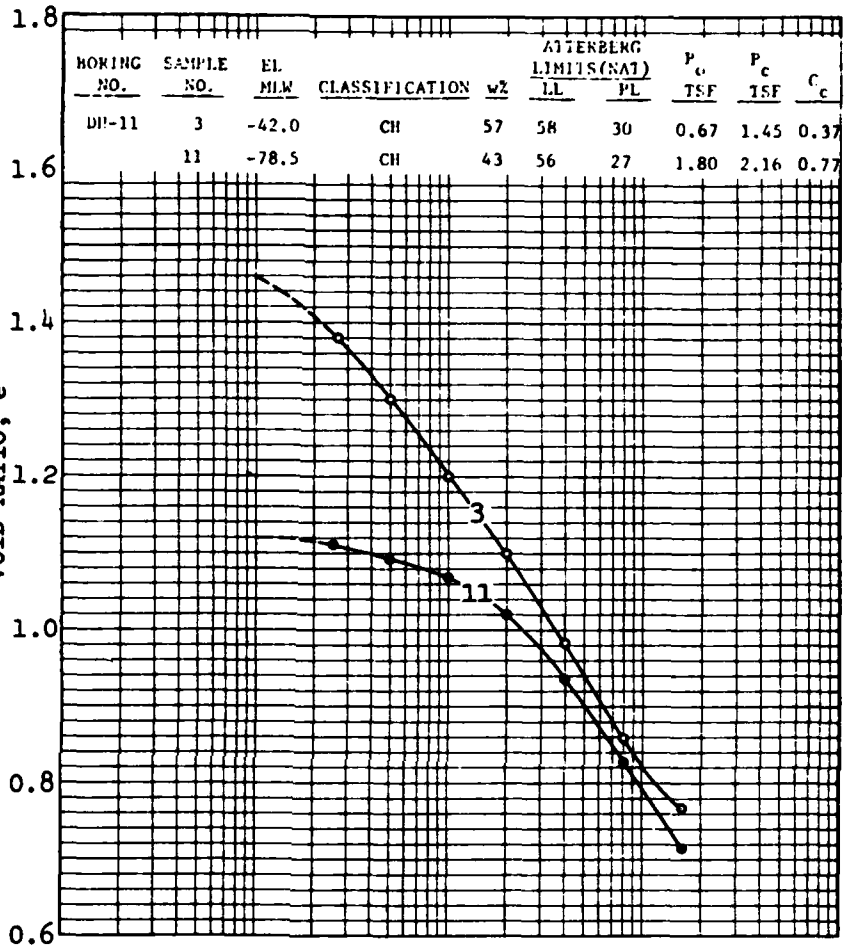
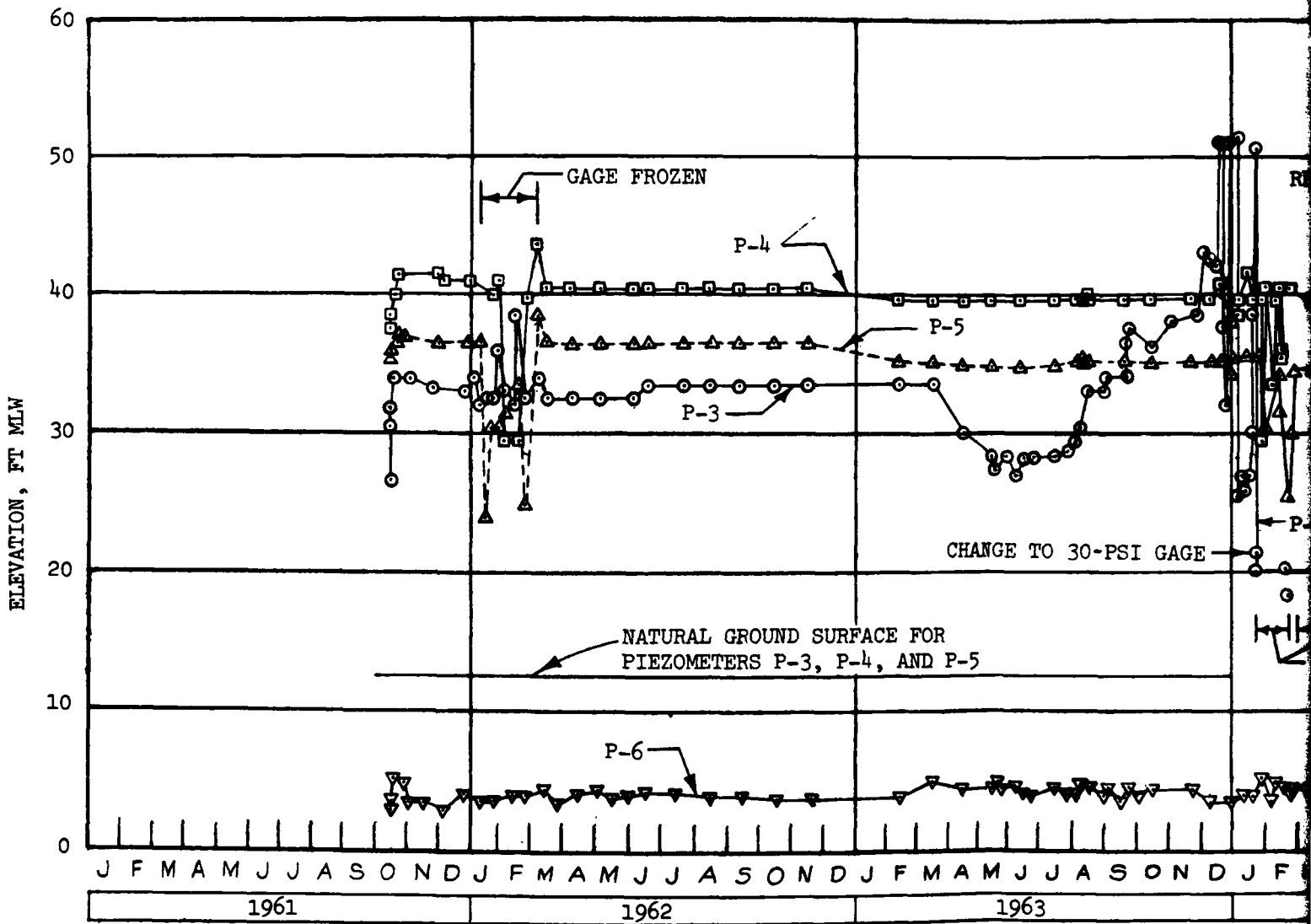


Figure 14 (Sheet 3 of 3)



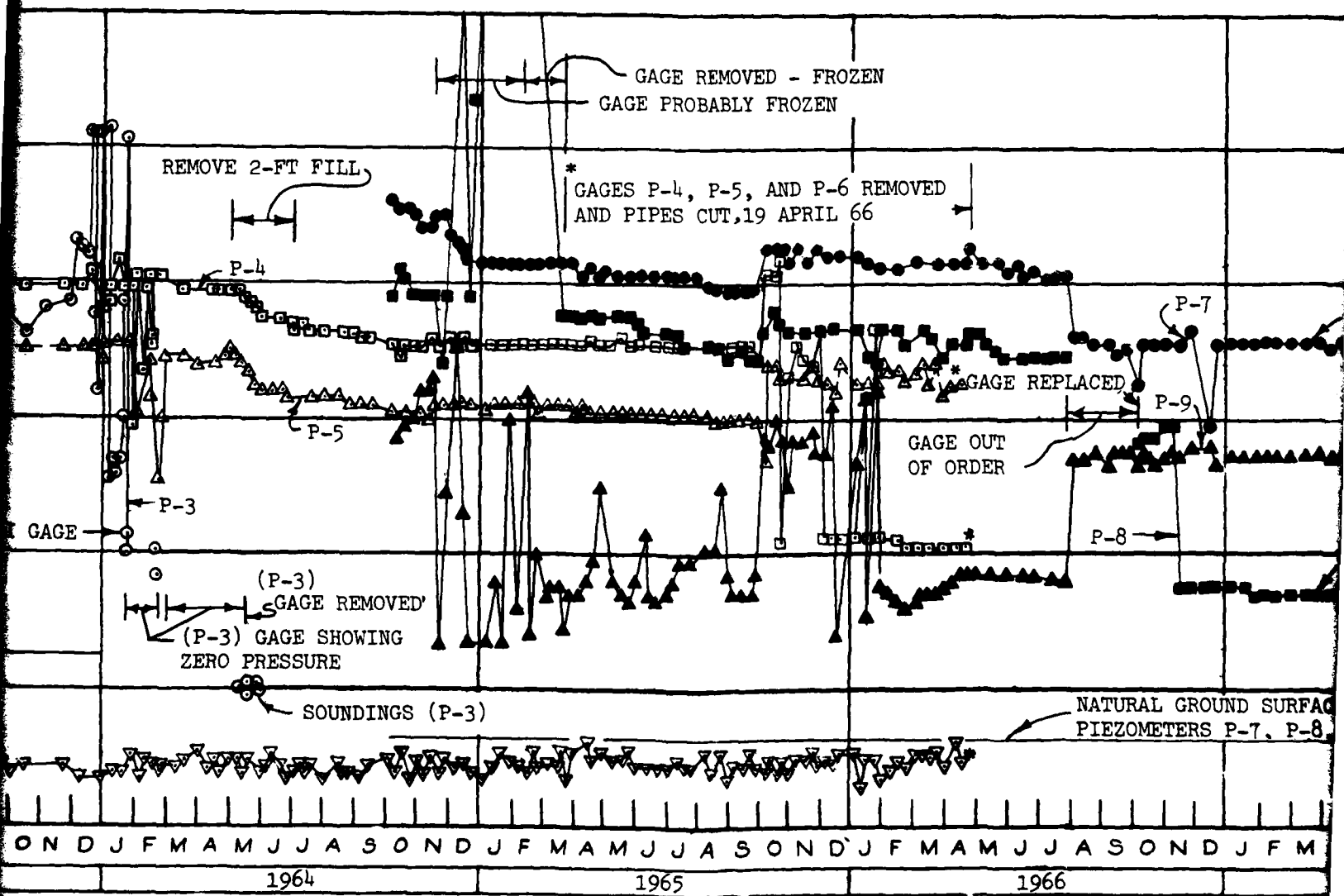
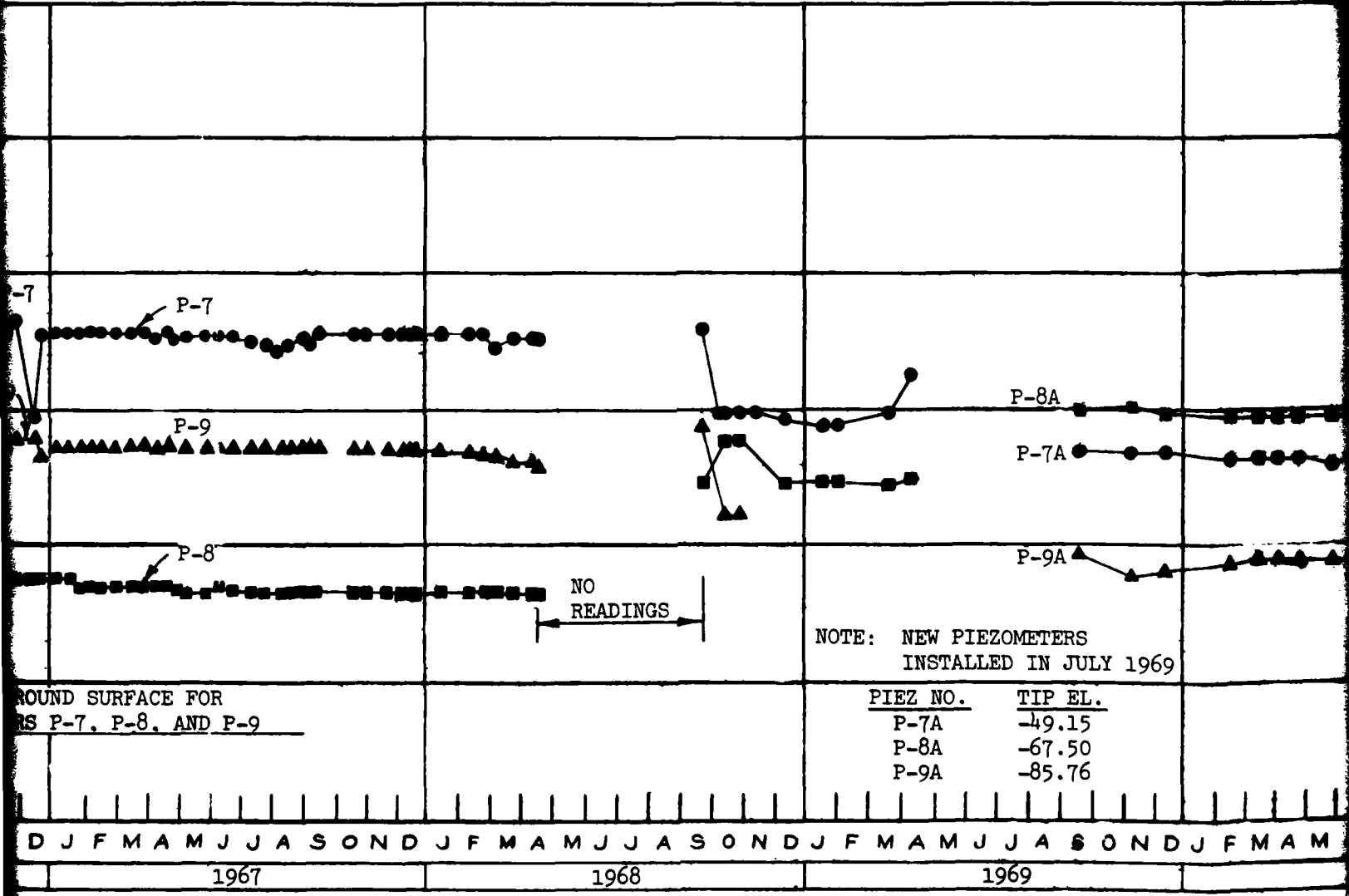


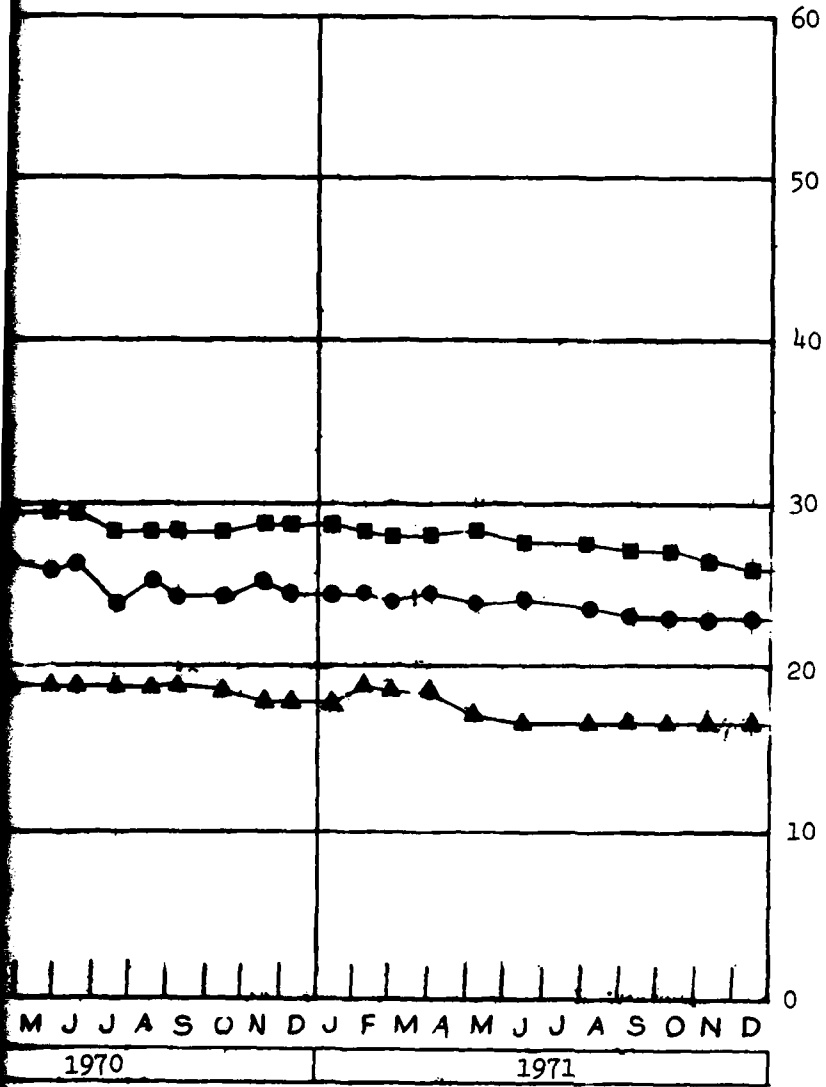
Figure 15. Piezometer, lateral movement, and settlement data, South Fil



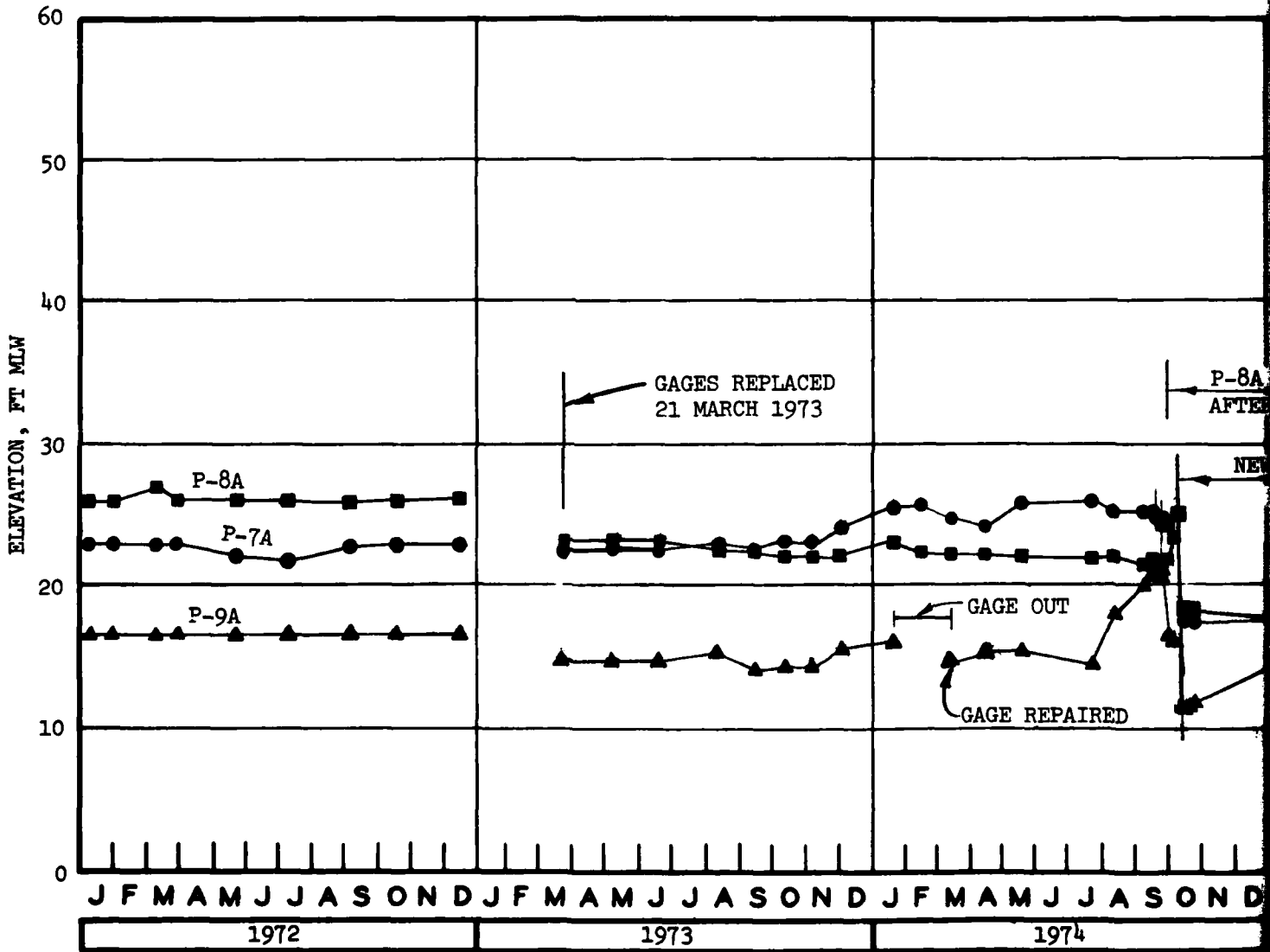
GROUND SURFACE FOR
PIEZOMETERS P-7, P-8, AND P-9

NOTE: NEW PIEZOMETERS
INSTALLED IN JULY 1969

South Fill area (Sheet 1 of 4)



4



1

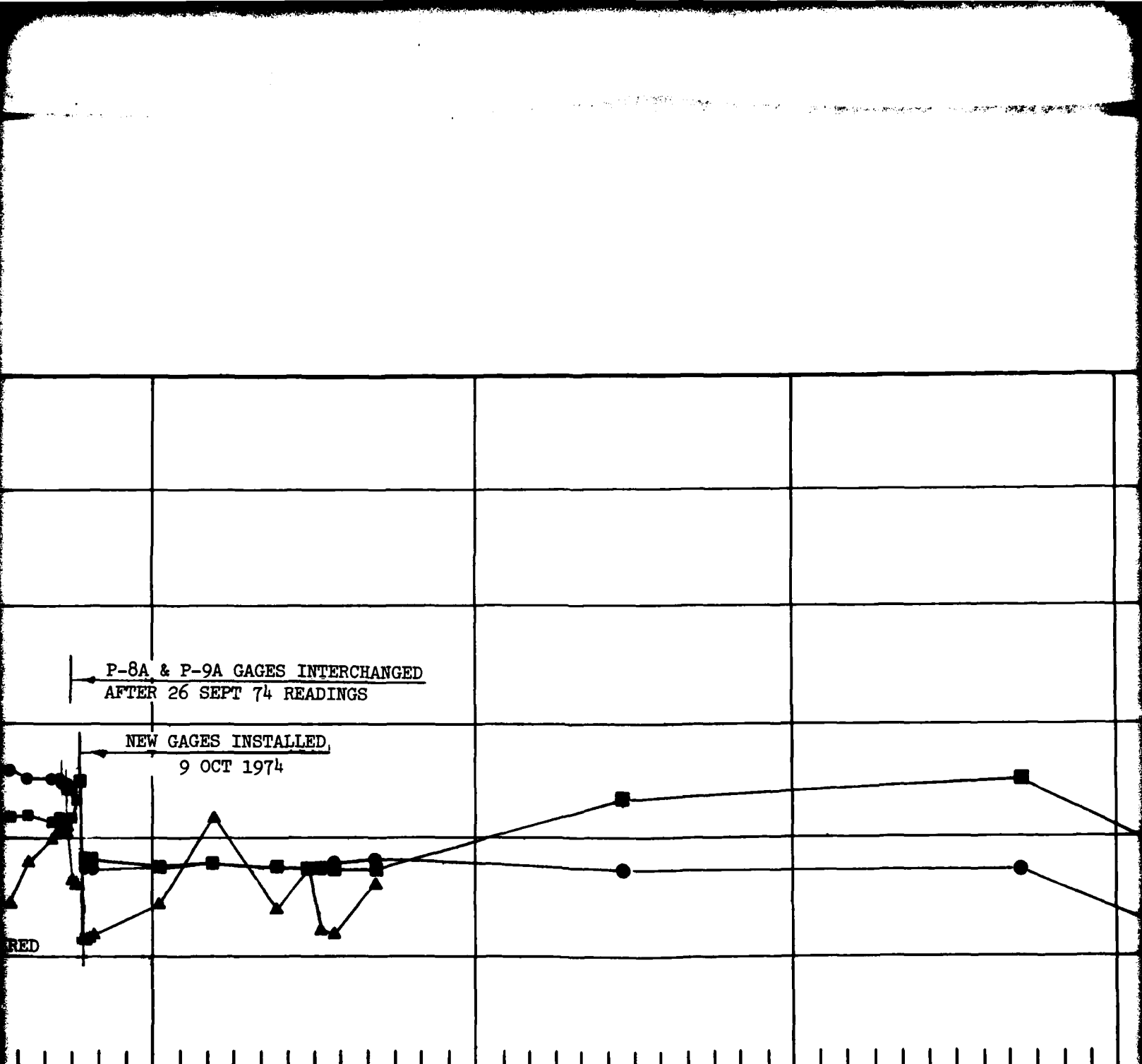
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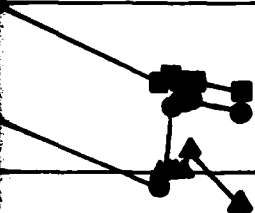
P-8A & P-9A GAGES INTERCHANGED
AFTER 26 SEPT 74 READINGS

NEW GAGES INSTALLED
9 OCT 1974

RED

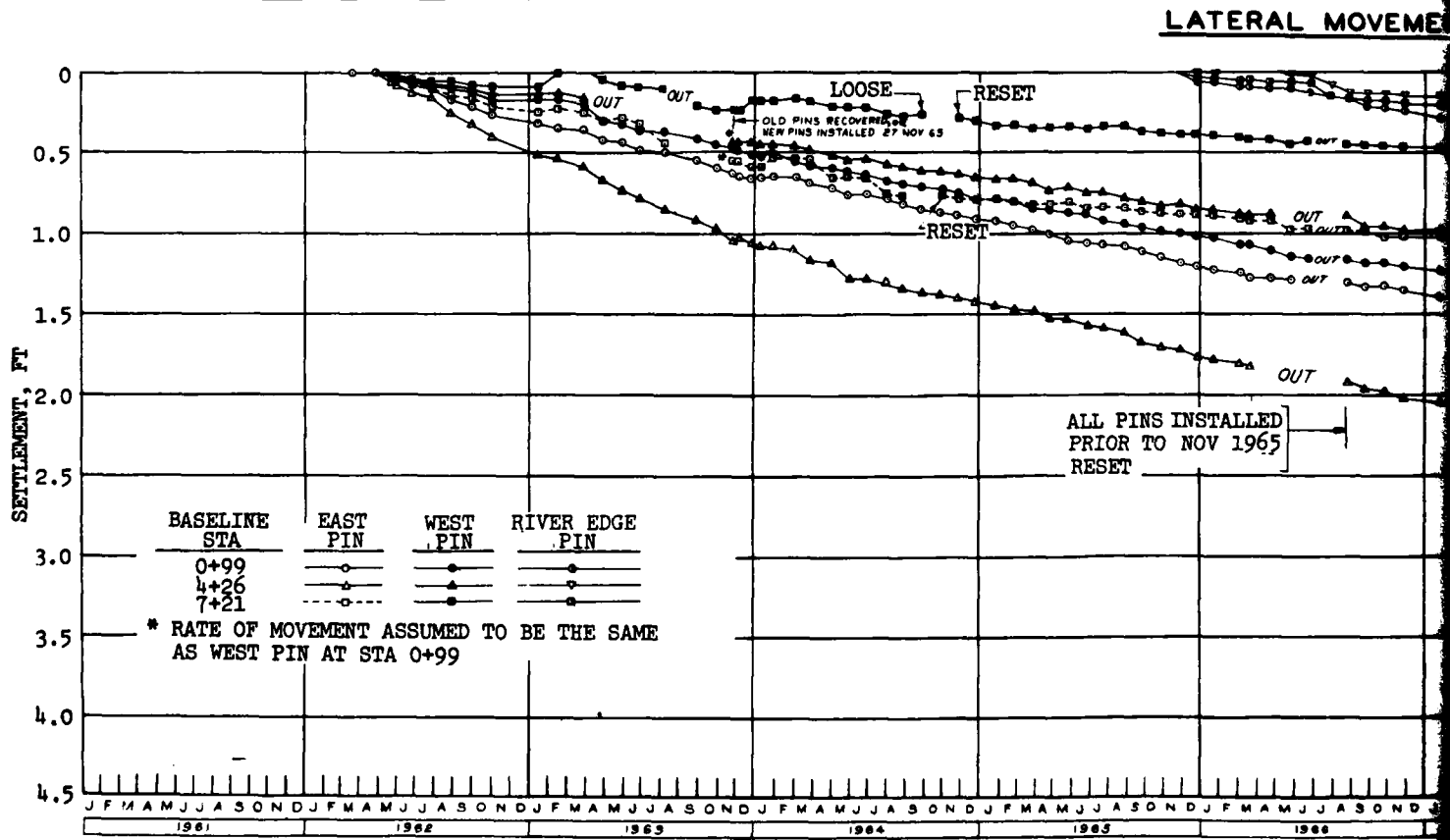
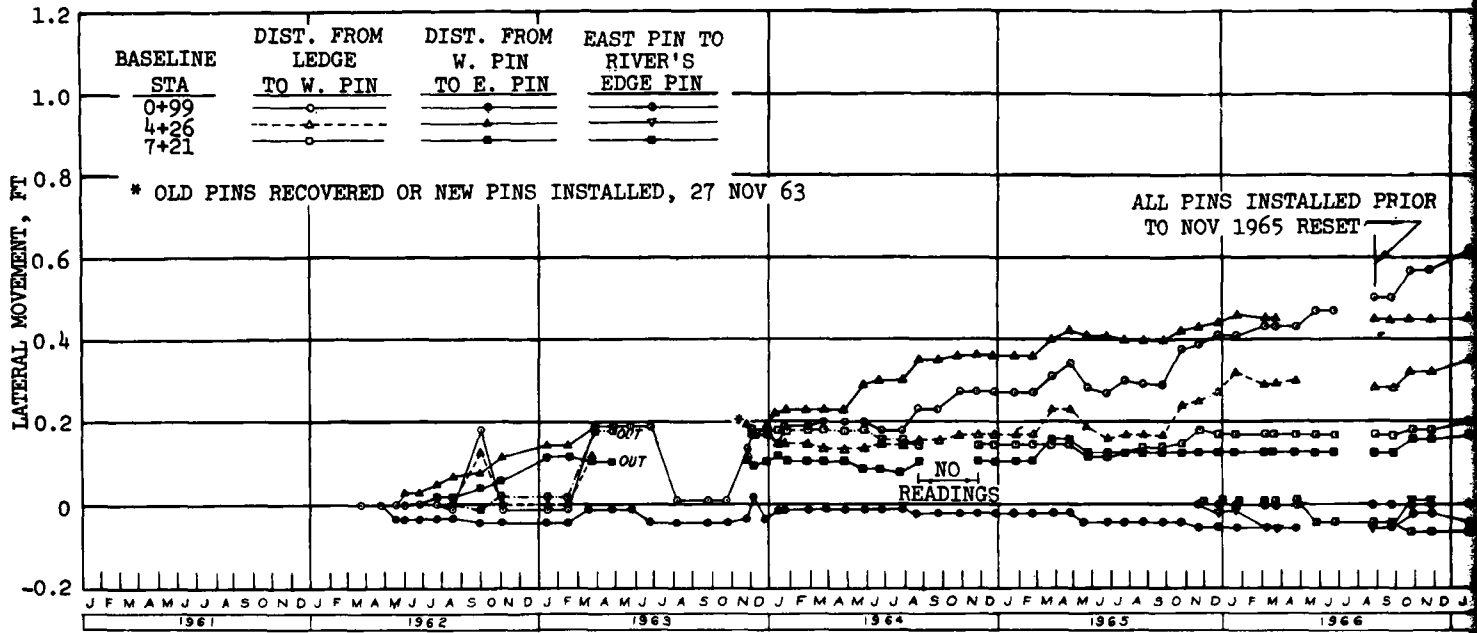
A S O N D J F M A M J J A S O N D J F M A M J J A S O N D J





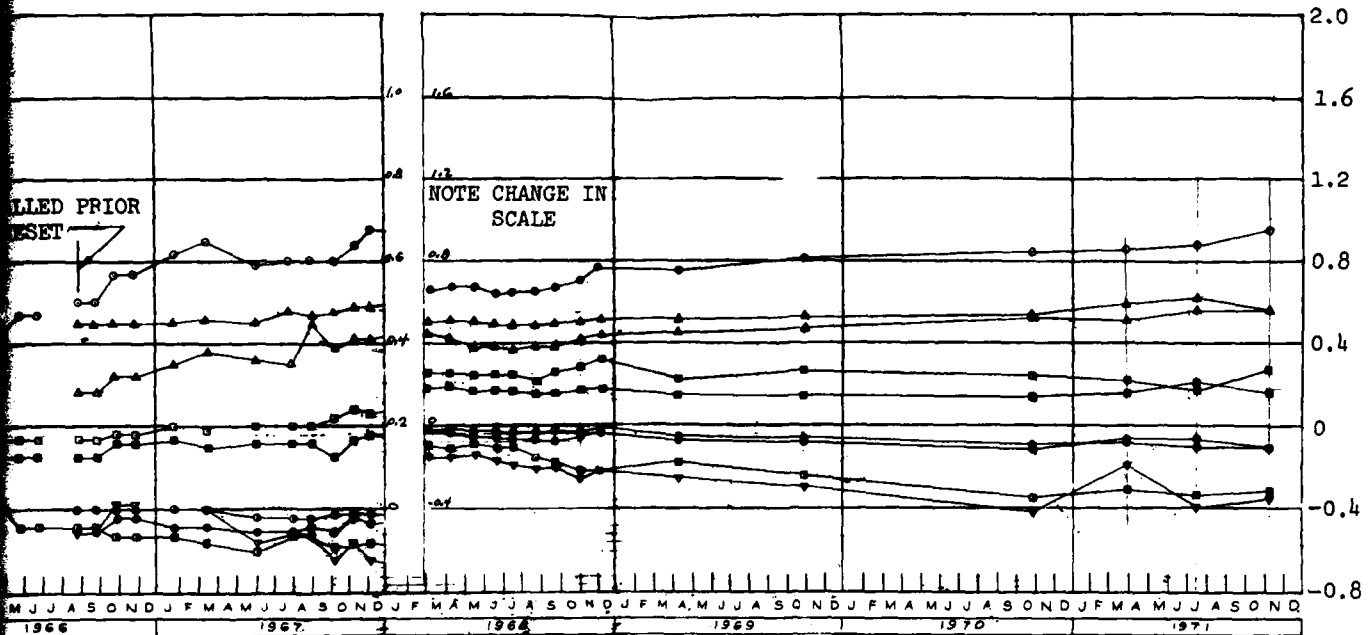
F M A M J J A S O N D J F M A M J J A S O N D J F M A M J J A S O N D J F M A M J J

1978

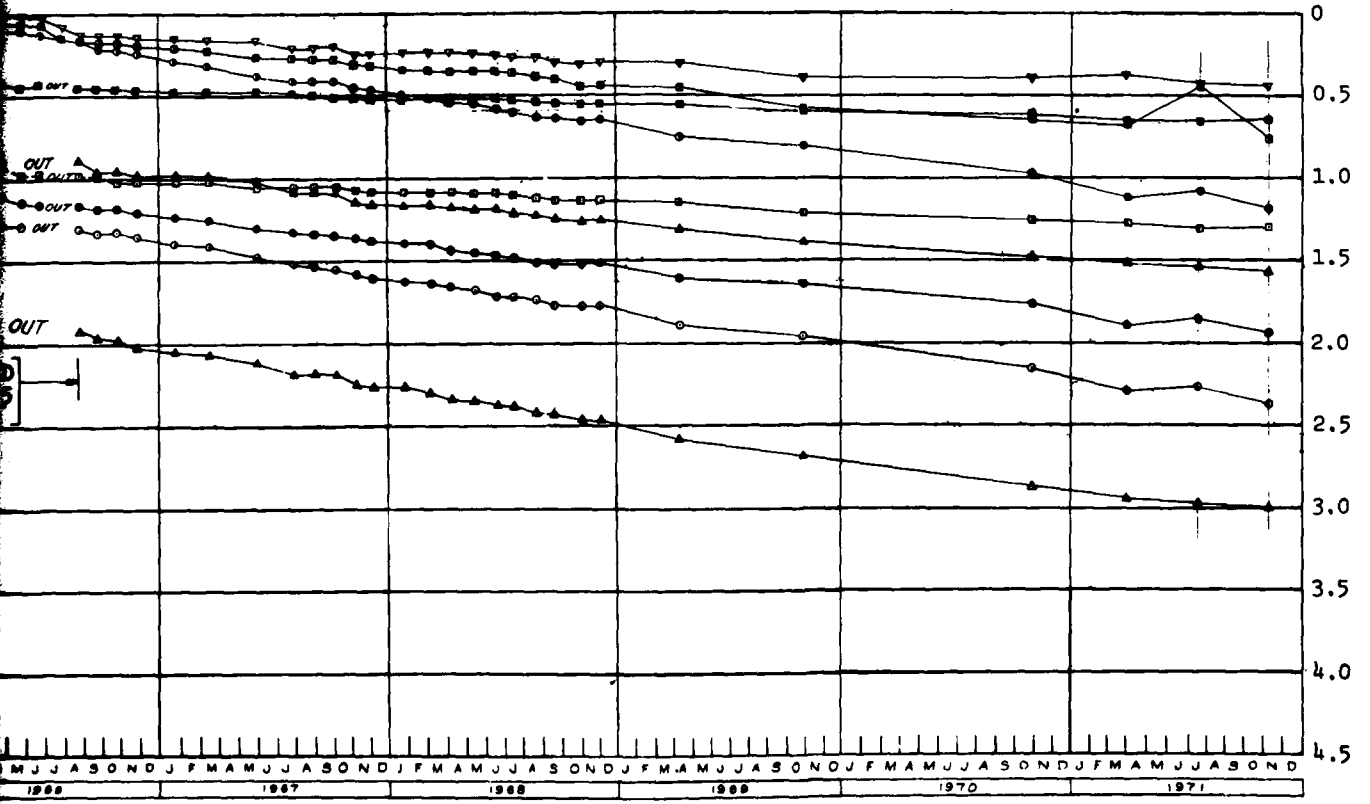


SETTLEMENT

Figure 15 (Sheet 3 of 3)

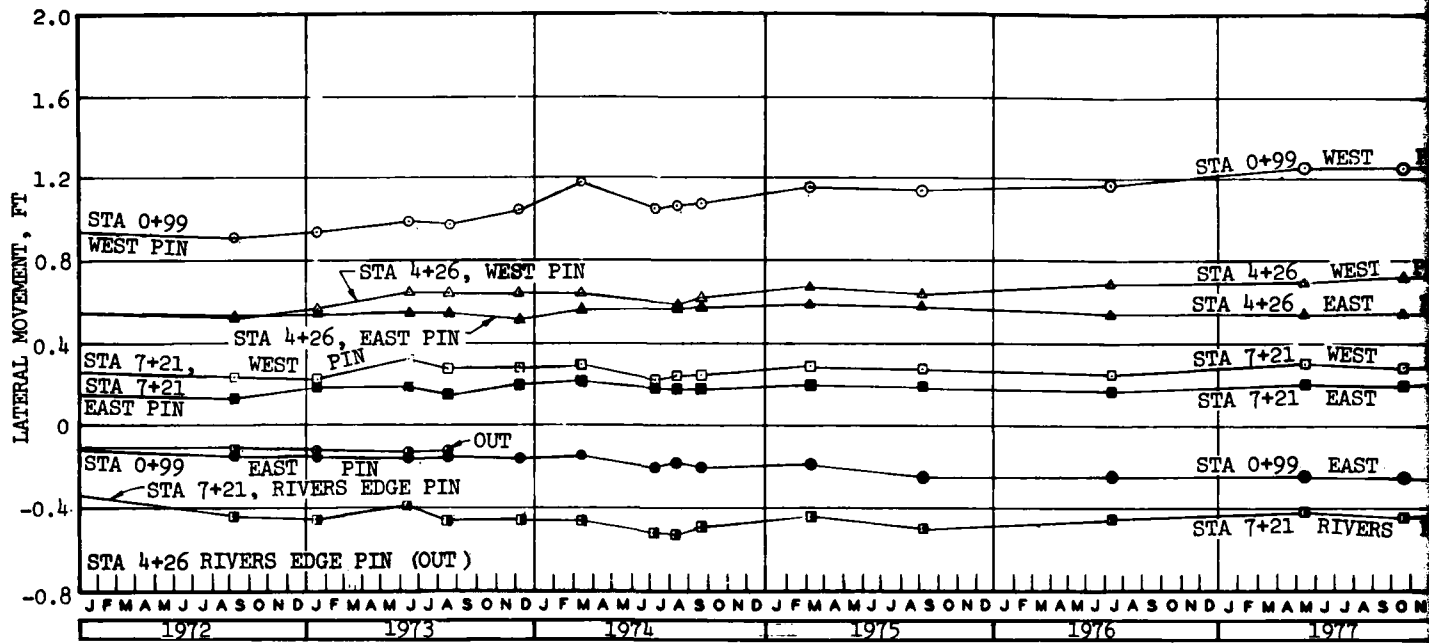


AL MOVEMENT

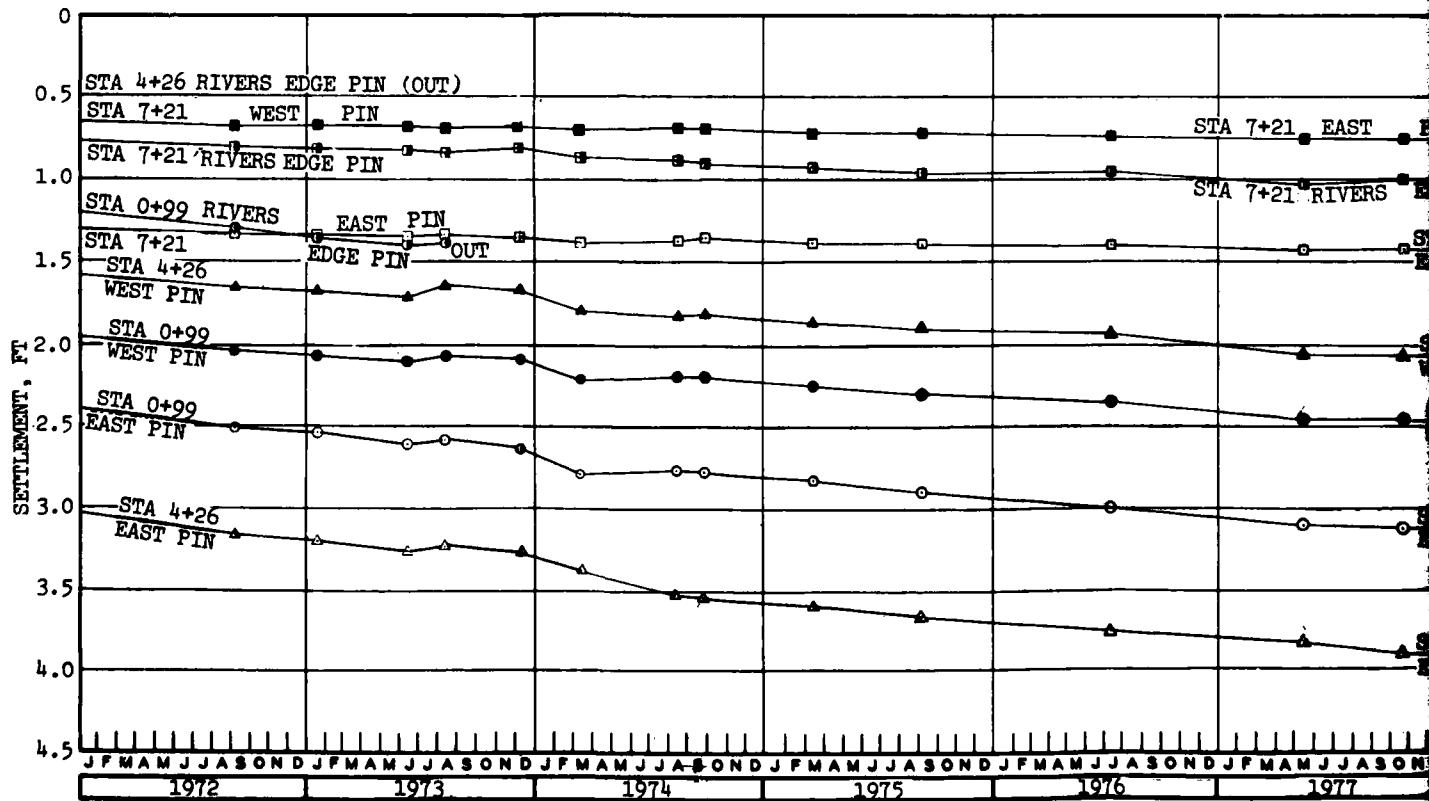


TLEMENT

2

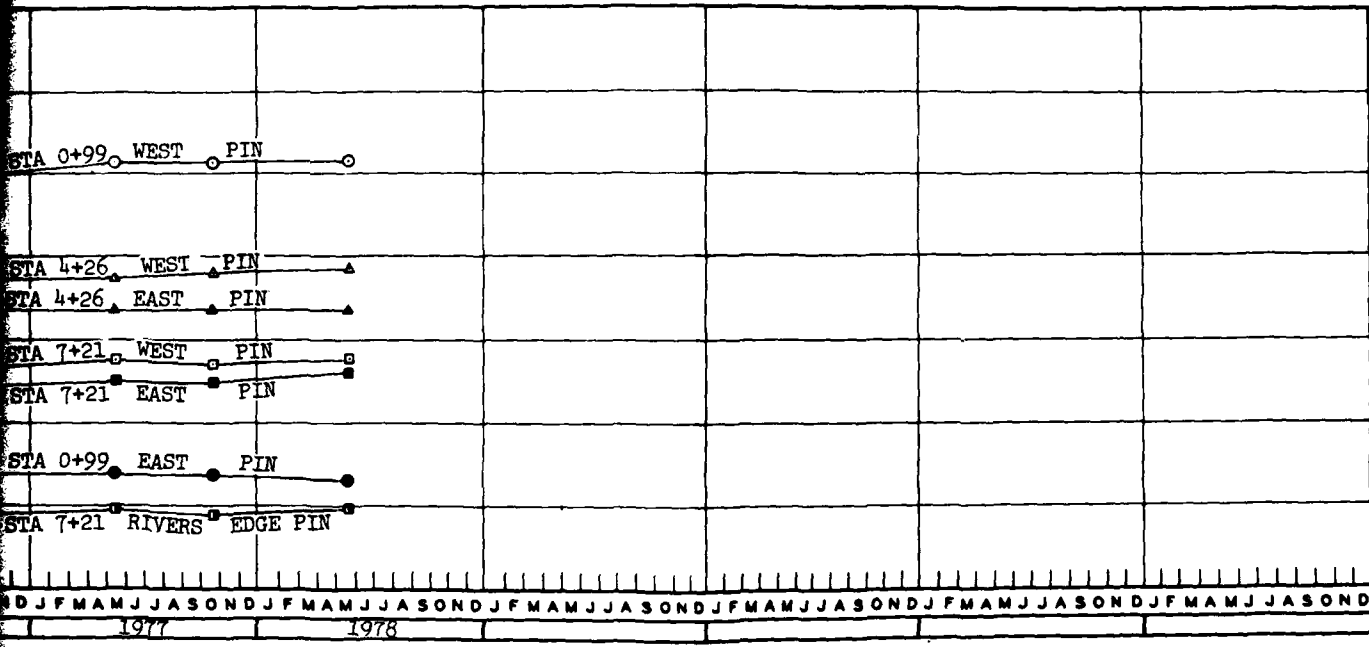


LATERAL MOVEMENT

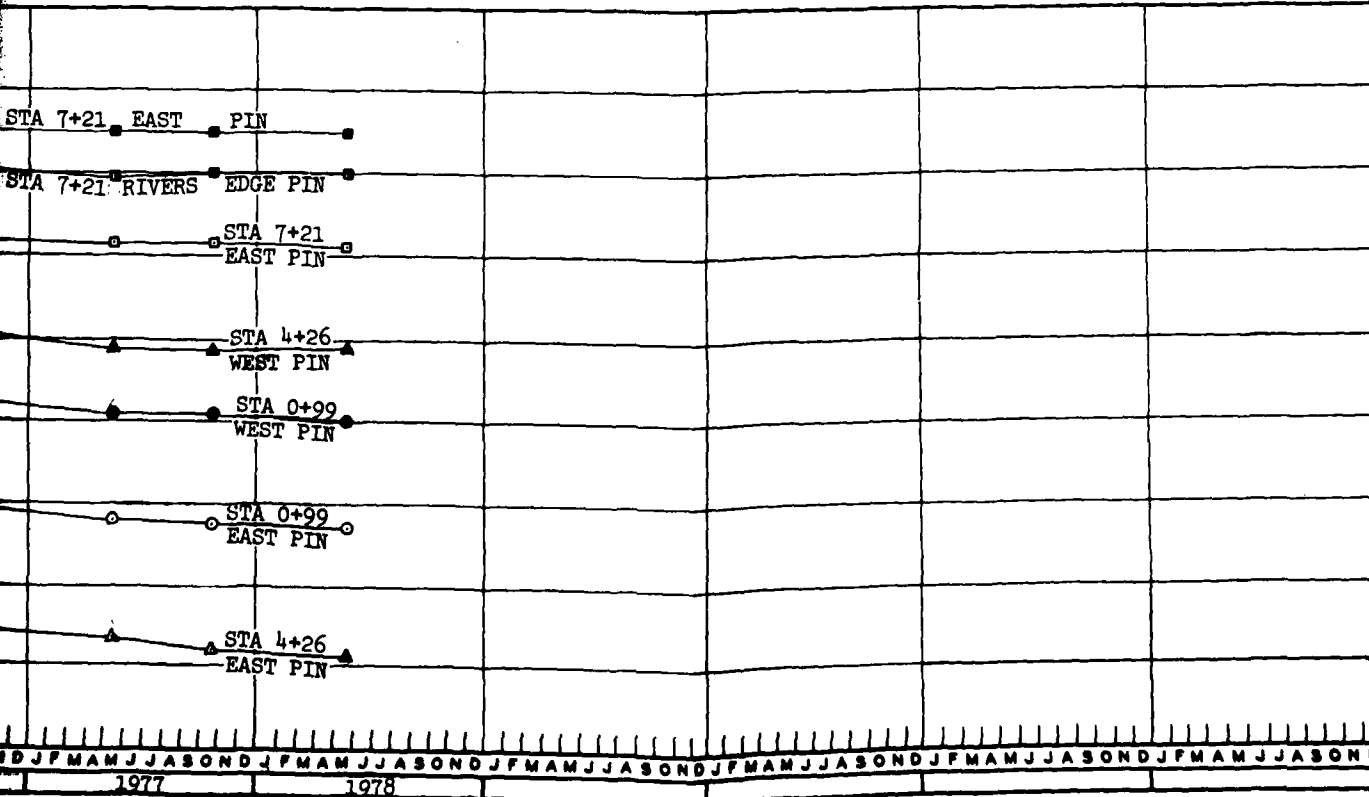


SETTLEMENT

Figure 15 (Sheet 4)



LATERAL MOVEMENT



SETTLEMENT

2

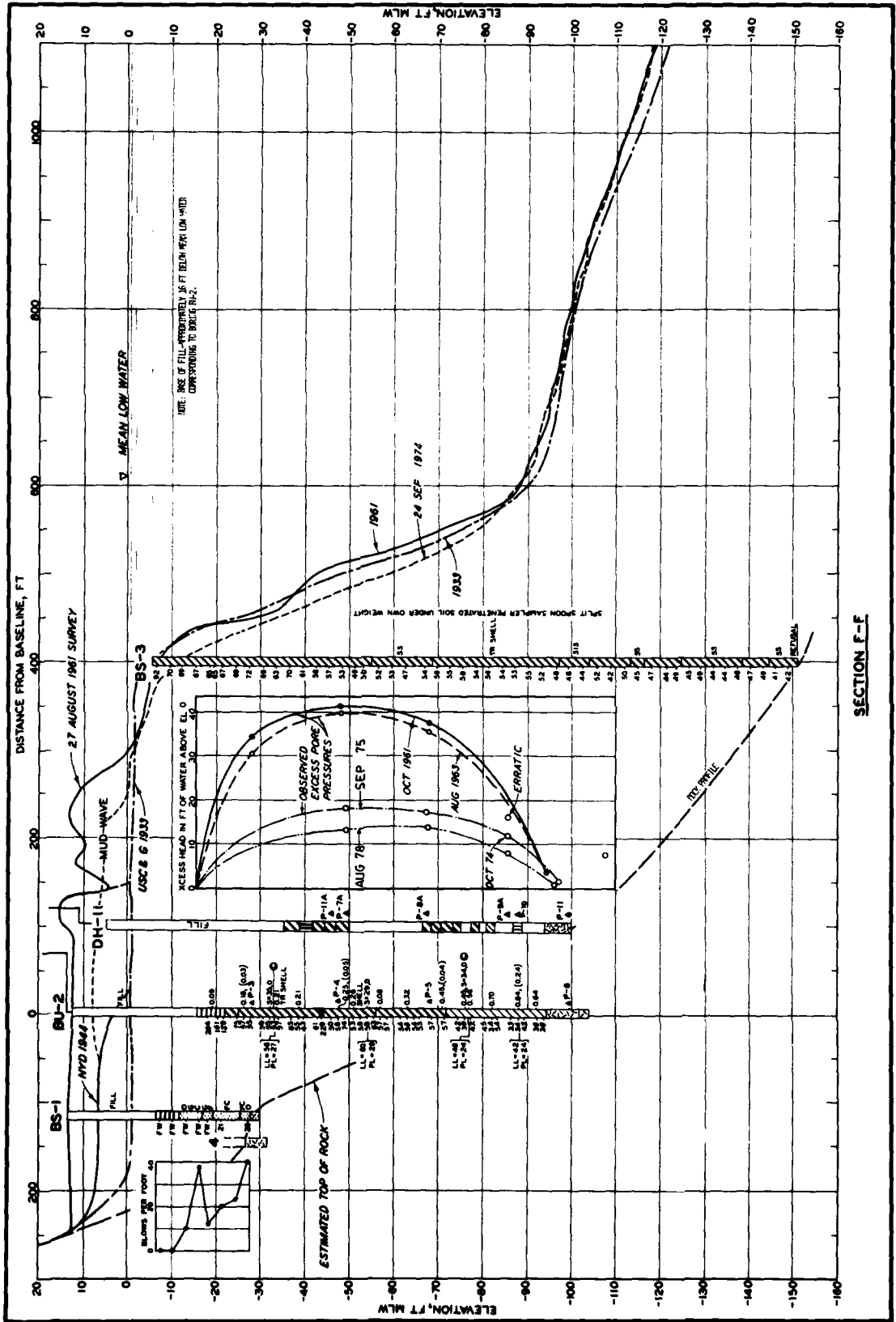


Figure 16. Dissipation of excess pore pressures with time, South Fill area

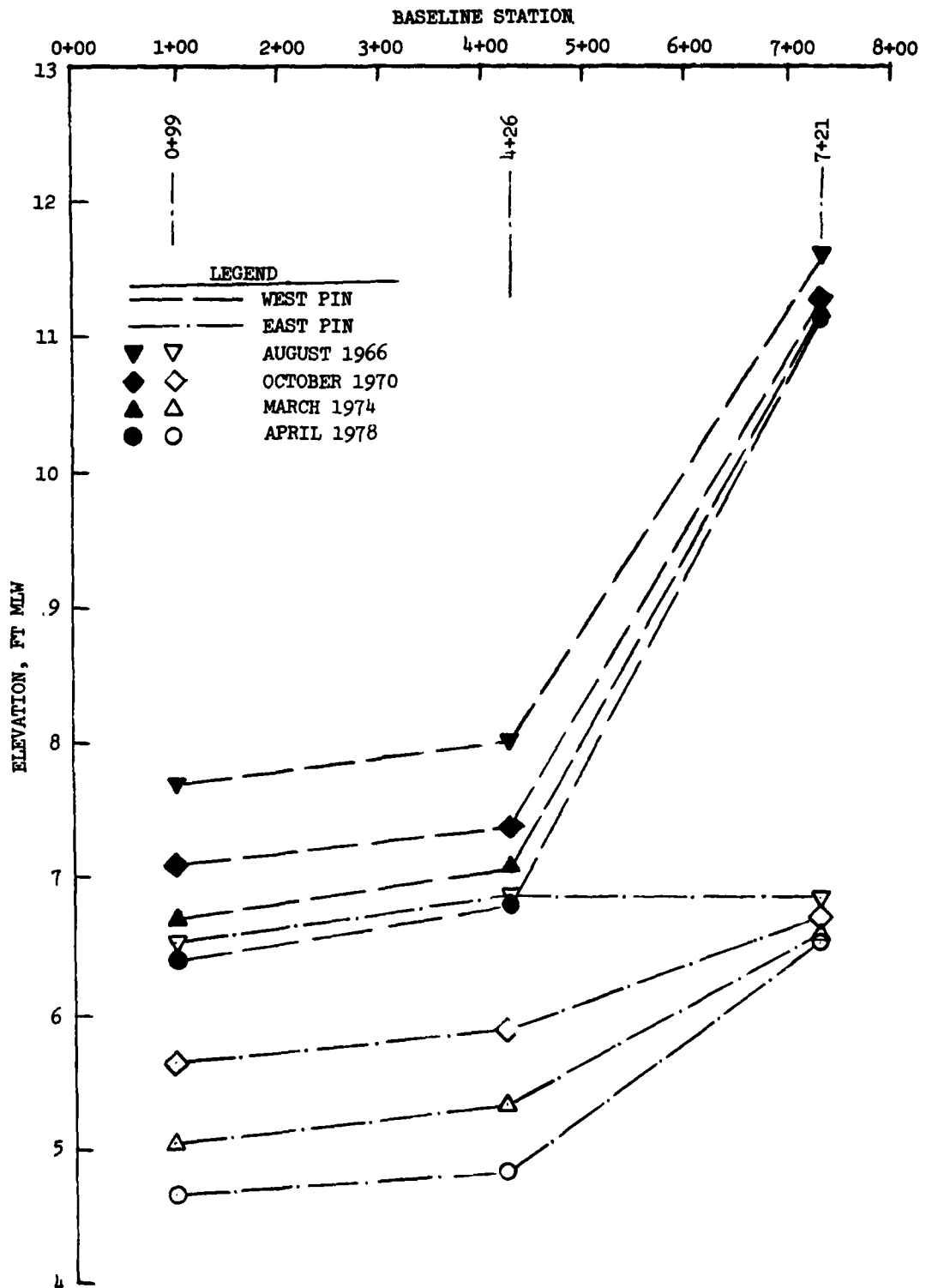


Figure 17. Profiles of the East and West Pins at four-year intervals, South Fill area

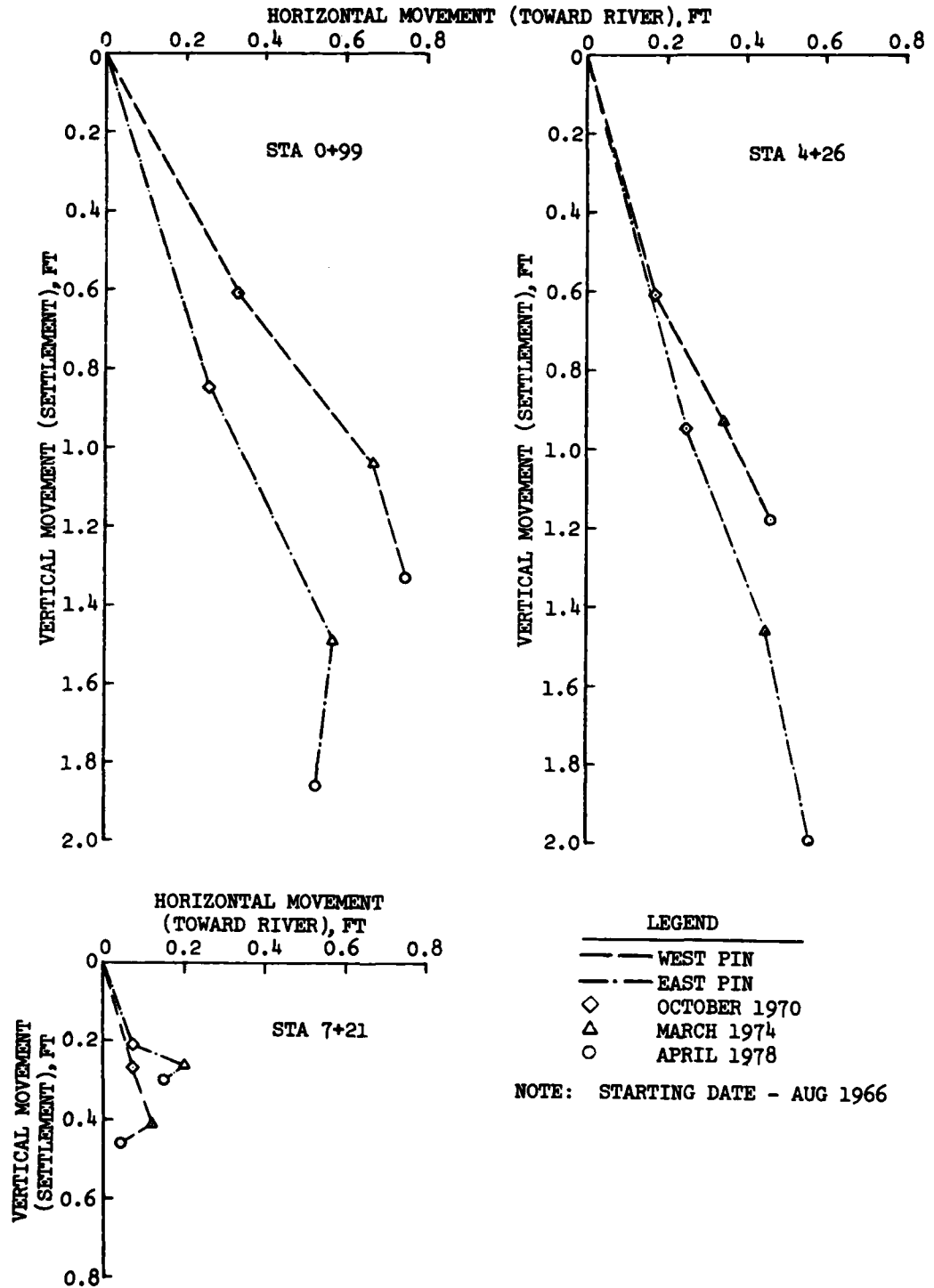


Figure 18. Combined horizontal and vertical movement of surface markers

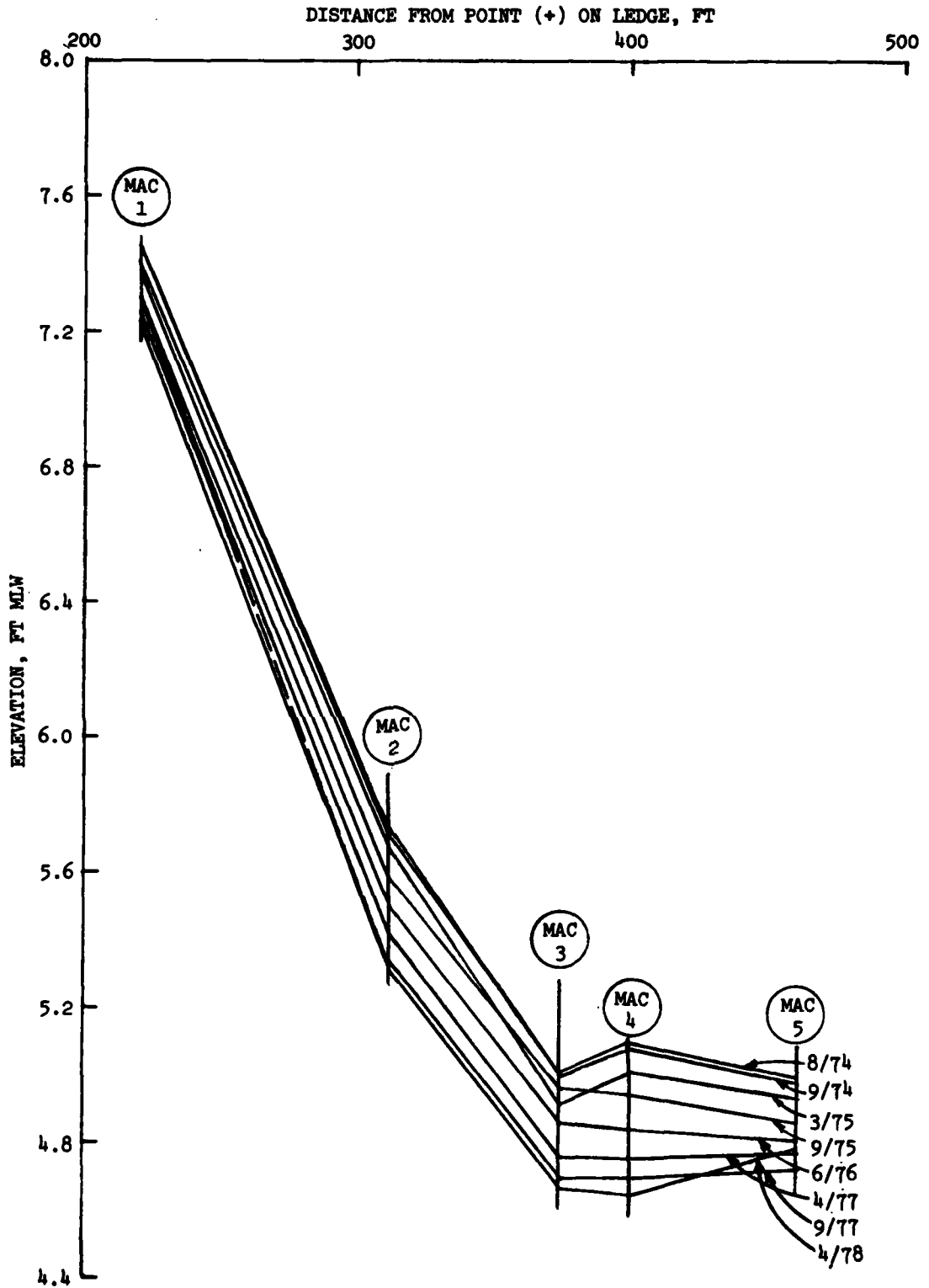


Figure 19. Profiles of MAC points on walkway

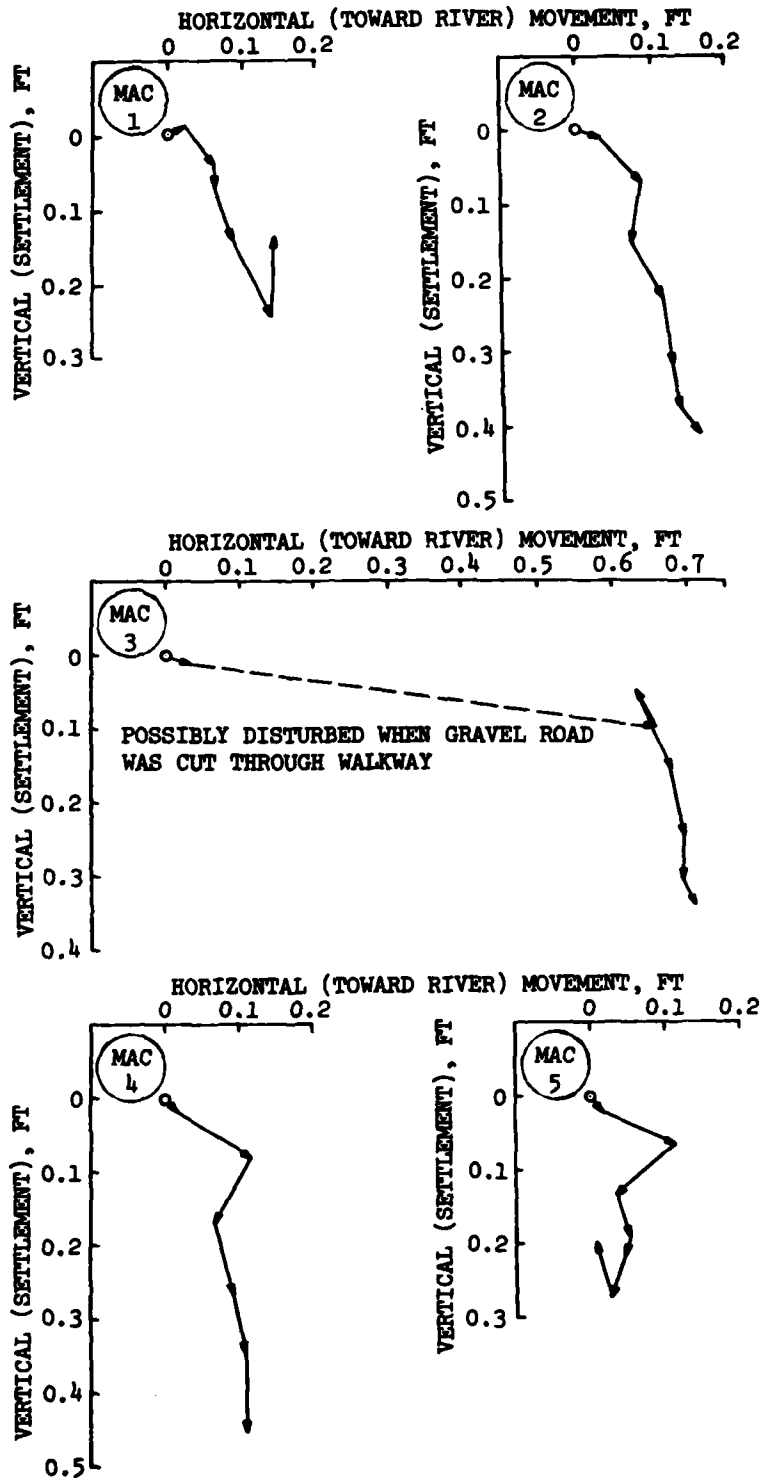
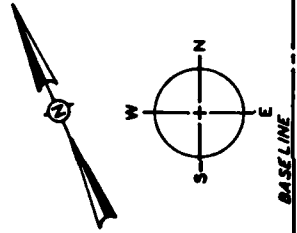
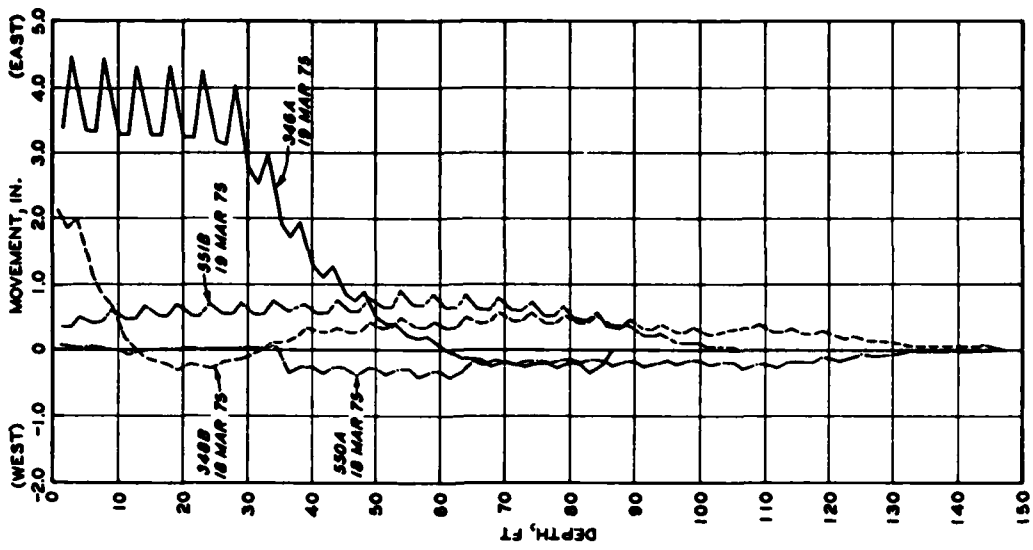


Figure 20. Horizontal and vertical movements of MAC points



ORIENTATION OF SLOPE INDICATORS
348A, 348B, 550A, AND 551B WITH
RESPECT TO BASELINE

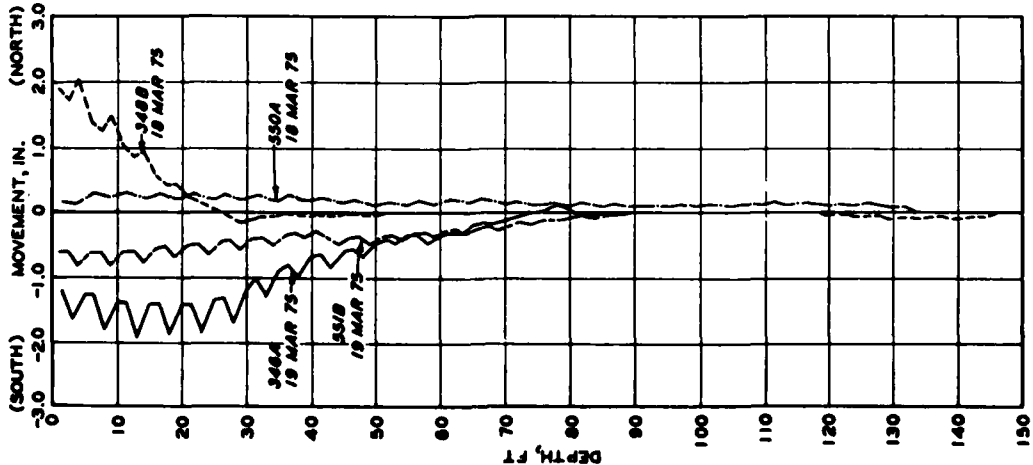


Figure 21. Inclinator data

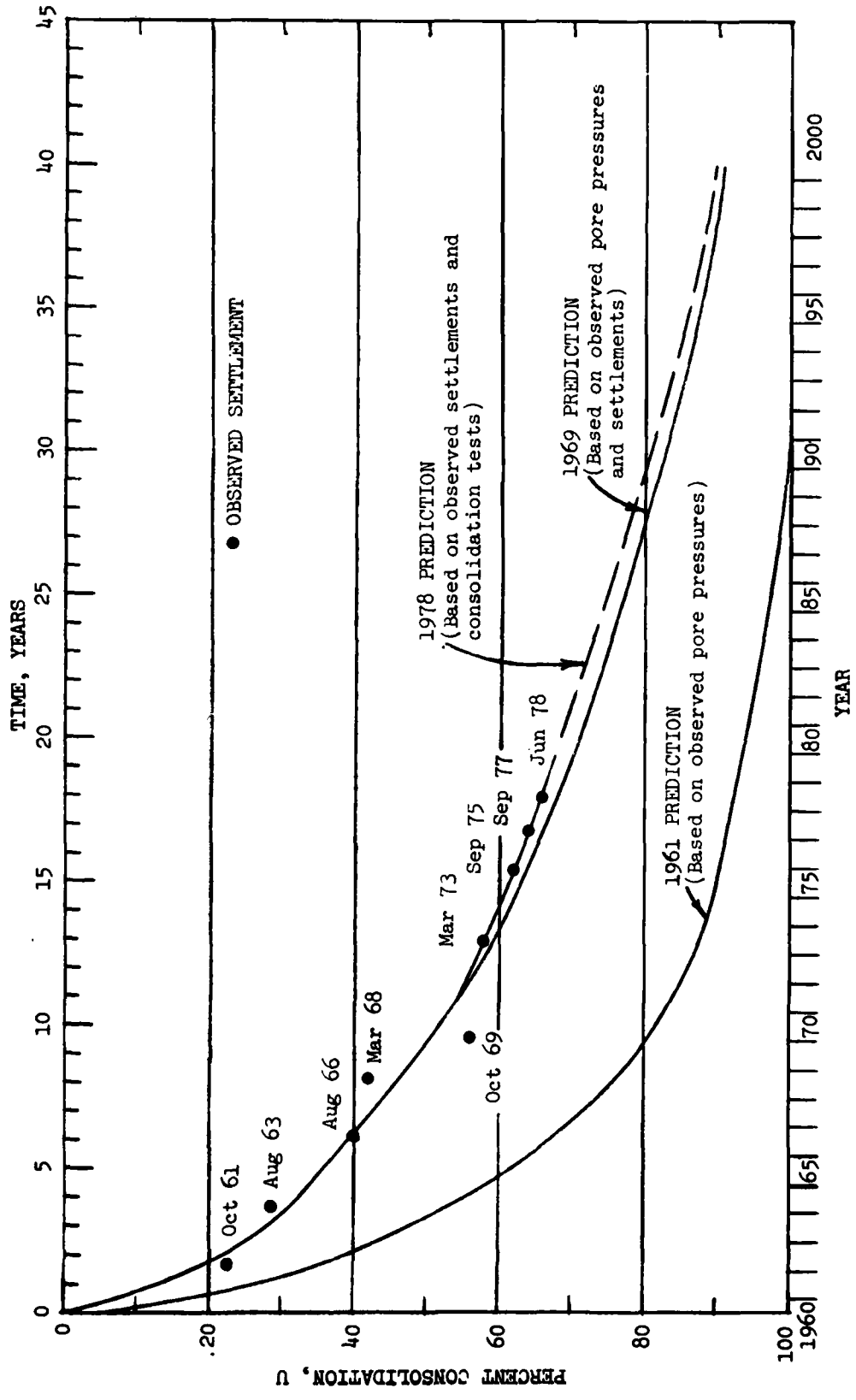


Figure 22. Pore pressure and settlement extrapolations

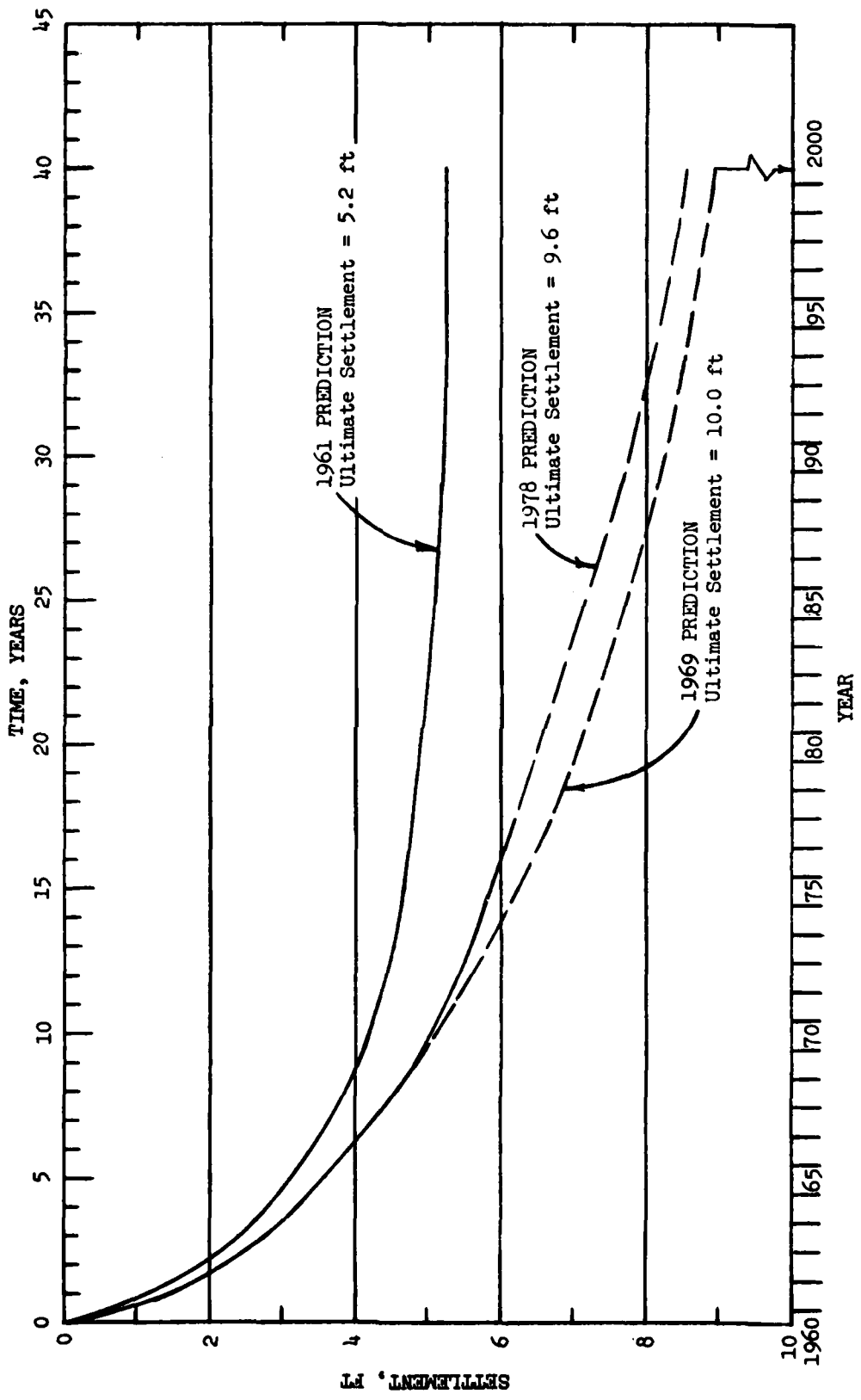
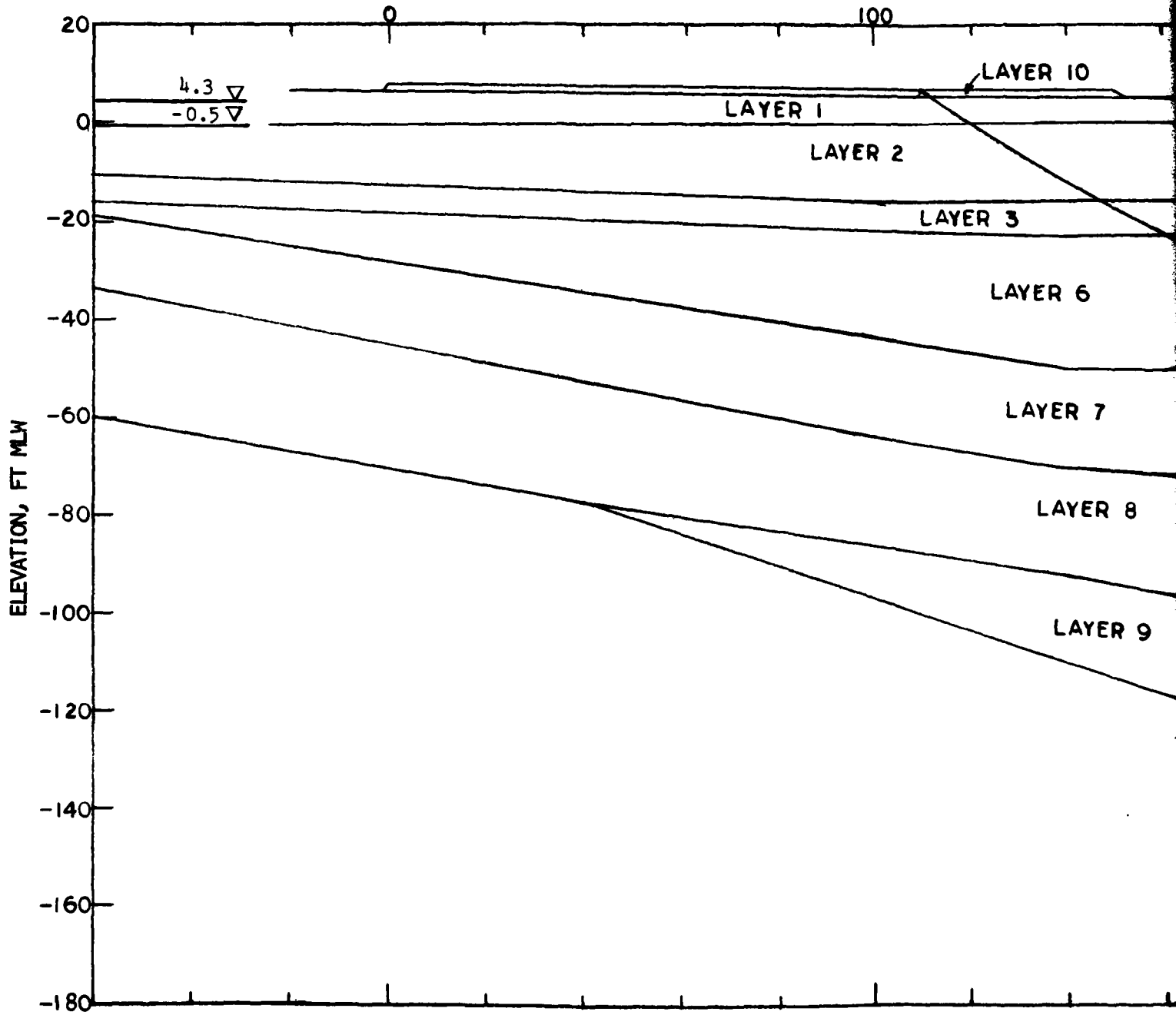


Figure 23. Ultimate settlement predictions



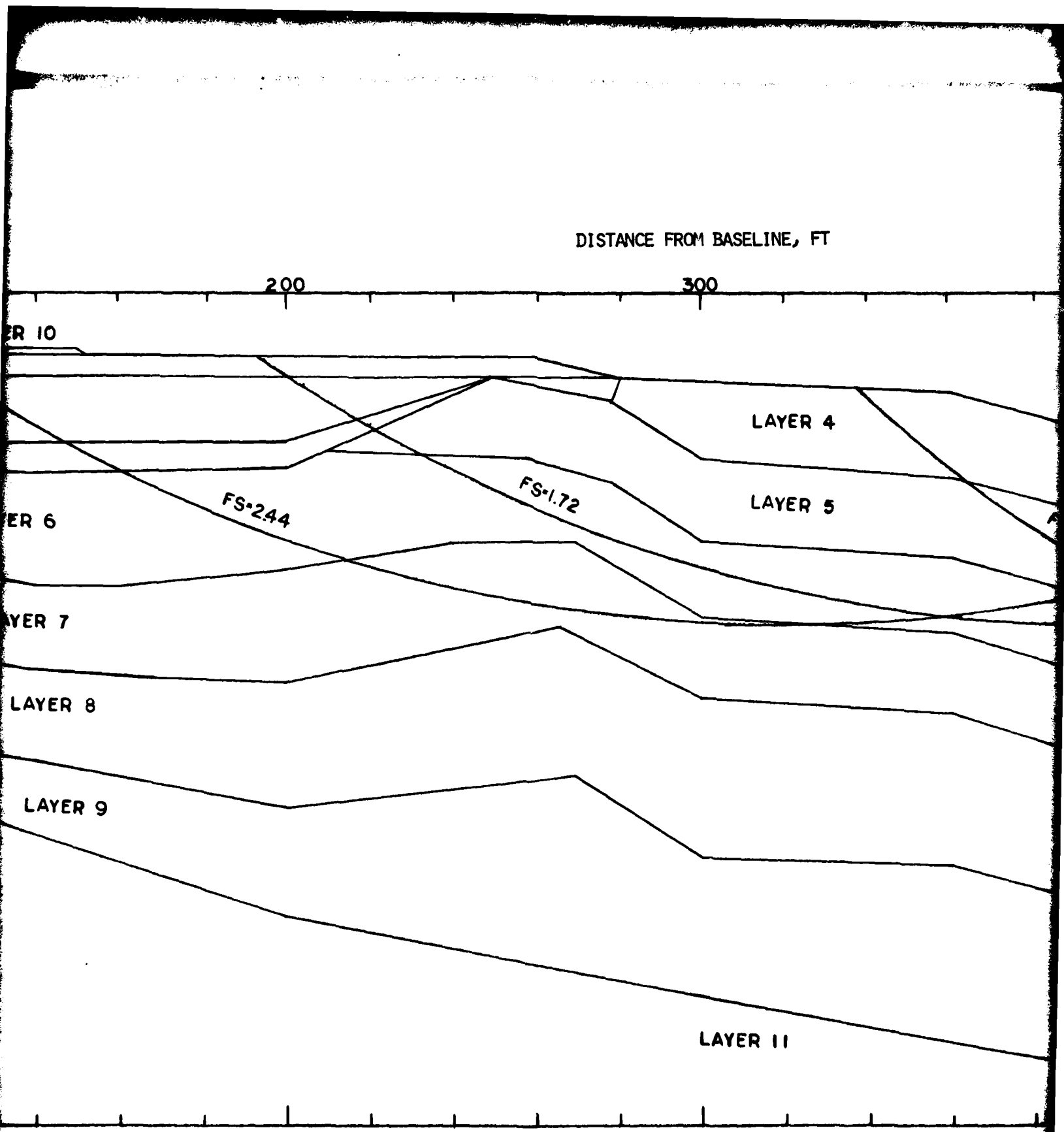


Figure 24. Idealized soil profile for stability analyses

2

400

500

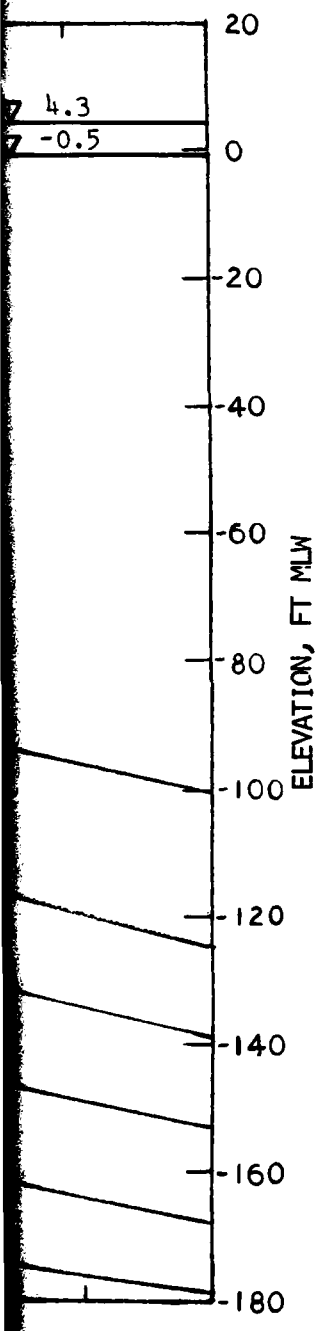
600

▽
▽

NOTE: APPROXIMATE MAXIMUM AND MINIMUM TIDE
LEVELS ARE BASED ON OCTOBER 1961 TIDE
TABLES, U.S. COAST AND GEODETIC SURVEY,
DEPARTMENT OF COMMERCE.

FS-0.98

3



4

Table 1
Summary of Laboratory Tests

Sample No.	Diam in.	Elevation ft mslw	Unified Soils Classification System	Atterberg Limits			Initial			Type Test	UC			R				Consolidation			
				LL %	PL %	PI %	w %	yd pcf	S %		q _u /2 tsf	c tsf	φ deg	c tsf	φ deg	C' tsf	φ' deg	P _o tsf	P _c tsf	C _c	C _v cm ² /sec
<u>Boring DH-11 - 1975</u>																					
1	5	-36	CH	55	27	28	48	72	96	Q		0.09	0								
2	5	-39	MH	55	30	25	49	72	97	Q		0.25	0								
3	5	-42	CH	58	30	28	53	70	98	Q		0.13	0								
							52	70	98	R				0.17	15	0.13	37				
4	5	-44	CH	51	26	25	51	71	97	Q		0.22	0					0.67	1.45	0.37	5
5	5	-47	CH	56	26	30	50	71	96	Q		0.19	0								
7	3	-66	CH	57	28	29	50	70	94	Q		0.30	0								
							50	71	100	R				0.16	13	0	40				
8	3	-68	CH	55	27	28	52	71	100	Q		0.20	0								
9	3	-71	CH	60	29	31	54	68	97	Q		0.29	0								
10	3	-73	CH	57	27	30	46	76	99	Q		0.37	0								
11	3	-78	CH	56	27	29	43	79	100	CONSOL.								1.80	2.16	0.77	15
12		-80	CL	45	20	25	34	88	100	Q		0.52	0								
15		-87	ML	44	29	15	36	86	100	Q		0.86	0								

Boring WS-1 - 1977*

1		-26	OH				125	36			0.50									
							110	48			0.48									
2		-31	CH				50	71			0.32									
							50	71			0.33									
3		-36	CH				47	74			0.39									
							49	72			0.35									
4		-41	CH				49	71			0.39									
							49	71			0.37									
5		-46	CH				48	73			0.32									
							48	73			0.37									
6		-51	CH				52	70			0.44									
							-	70			0.43									
7		-57	CH				50	72			0.52									
							49	72			0.41									
8		-61	CH				51	69			0.05									
							52	73			0.05									
9		-66	CH				51	70			0.30									
							48	74			0.39									

(Continued)

Notes: LL, PL, PI = liquid limit, plastic limit, and plasticity index, respectively.

UC = unconfined compression test.
Q = unconsolidated-undrained triaxial test.

R = consolidated-undrained triaxial test.

CONSOL. = consolidation test.

S % = degree of saturation.

φ = angle of internal friction.

C = cohesion.

yd = unit dry weight.

w % = moisture content.

P_o = effective overburden pressure.

P_c = preconsolidation pressure.

C_c = compression index.

C_v = coefficient of consolidation at P_o.

q_u/2 = compressive strength.

C' and φ' = effective stress parameters from R test.

* All samples of boring WS-1 were 3 diam and were extruded; UC tests were run at site.

Table 1 (Concluded)

Sample No.	Diam. in.	Elevation ft mlv	Unified Soils Classification System	Atterberg Limits			Initial			Type Test	UC			R				Consolidation			
				LL %	PL %	PI %	w %	ys pcf	S %		q _u /2 tsf	C tsf	φ deg	C' tsf	φ' deg	P _o tsf	P _c tsf	C _c	C _v 10 ⁻⁴ cm ² /sec		
<u>Boring WS-1 - 1977 (Continued)</u>																					
10		-71	CL				39	77			0.44										
							43	80			0.60										
11		-76	CL				36	85			0.98										
							35	86			1.00										
12		-81	CL				34	87			0.86										
							34	86			0.88										
13		-86	CL				37	83			0.77										
							34	87			0.76										
<u>Boring WS-3 - 1977 *</u>																					
2	5	-18	MH	82	43	39	66	58	97	Q	0.30	0									
3	5	-21	OH	257	128	129	172	27	100	Q	0.30	0									
4	5	-24.5	OH	164	99	65	119	38	99	Q	0.18	0									
							89	48	99	CONSOL.						0.27	1.38	0.58	16		
5	5	-27	CH	85	28	57	68	58	96	Q	0.16	0									
6	5	-30	MH	56	30	26	50	69	93	Q	0.12	0									
7	5	-33	CH	61	28	33	54	68	96	Q	0.18	0									
							55	67	97	R			0.15	14	0.11	35					
8	5	-36	CH	53	25	28	46	73	96	Q	0.24	0									
9	5	-39	CH	52	29	23	51	69	96	Q	0.20	0									
10	5	-42	CH	50	25	25	44	75	94	Q	0.18	0									
11	5	-45	CH	58	26	32	47	72	95	Q	0.29	0									
							49	72	98	R			0.23	13	0.22	28					
							49	71	96	CONSOL.						0.75	1.50	0.52	5		
12	5	-48	CH	61	28	33	52	68	95	Q	0.21	0									
13	5	-51	CH	60	28	32	52	68	95	Q	0.22	0									
							52	70	100	Q&UC**	0.44	0.44	0								
14	5	-54.5	CH	58	27	31	46	73	96	Q	0.27	0									
							51	74	97	R			0.29	13	0.23	30					
							55	68	100	CONSOL.						0.98	4.8	--	16		
							49	72	98	Q&UC**	0.55	0.59	0								
15		-57	CH	58	27	31	51	68	92	Q	0.16	0									
16		-60	CH	53	24	29	47	72	95	Q	0.20	0									
							49	72	98	Q&UC**	0.52	0.51	0								
17		-63	CH	58	29	29	51	69	95	Q	0.35	0									
							50	71	97	R			0.30	11	0.24	30					
							51	71	98	Q&UC**	0.50	0.49	0								
18		-66	CH	55	24	31	38	81	95	Q	0.60	0									
19		-69	CH	55	26	29	40	82	100	Q	0.60	0									
20		-72	CH	55	27	28	38	79	90	Q	0.46	0									
21		-75	CL	49	24	25	35	84	93	Q	0.53	0									
										CONSOL.						1.16	4.00	0.32	16		
22		-79	CL	44	24	20	29	92	92	Q	0.87	0									
23		-81	CL	49	26	23	39	80	93	Q	0.31	0									
24		-84.5	CL	49	26	23	39	79	94	Q	0.17	3.5									

* All samples from boring WS-3 were sealed in 5-in.-diam Shelby tubes at site and shipped to WES; after 6-month storage, samples were extruded and tested.

** Check tests were made after one-year storage.

Table 2
Vane Shear Tests Data

<u>Elevation</u> <u>ft mlw</u>	<u>Vane Shear Strength, tsf</u>		
	<u>Peaks</u>	<u>Ultimate</u>	<u>Remolded</u>
	<u>Boring WS-2 - 1977</u>		
37.0	0.33	0.24	0.07
39.5	0.29	0.23	0.03
42.0	0.38	0.32	0.05
44.5	0.38	0.31	0.06
47.0	0.41	0.36	0.10
49.5	0.42	0.37	0.09
52.0	0.40	0.29	0.07
54.5	0.44	0.30	0.07
57.0	0.43	0.35	0.05
59.5	0.40	0.29	0.08
62.0	0.42	0.35	0.10
64.5	0.47	0.36	0.08
67.0	0.48	0.36	0.08
69.5	0.45	0.38	0.05
72.0	0.46	0.36	0.08
74.5	0.58	0.52	0.17
77.0	0.65	0.65	0.18
79.5	0.65	0.52	0.17
82.0	0.79	0.98	0.28
84.5	0.99	0.99	--
87.0	1.08	0.78	0.25

* Elevations are in feet referred to mean low water (mlw).

Table 3
Summary of Drained Shear Strength Tests

<u>Boring</u>	<u>Sample No.</u>	<u>Elevation* ft mlw</u>	<u>Class</u>	<u>Type Test**</u>	<u>Total C, tsf</u>	<u>Stress ϕ, deg</u>	<u>Effective C', tsf</u>	<u>Stress ϕ', deg</u>
BU-2	6	-32	CH-OH	S	--	--	0.00	35
	13	-54	CH-OH	S	--	--	0.00	29
	21	-76	CL-OH	S	--	--	0.00	34
DH-11	3	-42	CH	R	0.17	15	0.13	37
	7	-67	CH	R	0.16	13	0.00	40
WS-3	7	-33	CH	R	0.15	14	0.11	35
	11	-45	CH	R	0.23	13	0.22	28
	14	-54	CH	R	0.29	13	0.23	30
	17	-63	CH	R	0.30	11	0.24	30

* Elevations are in feet referred to mean low water (mlw).

** S = consolidated-drained direct shear test; R = consolidated-undrained triaxial test; C = cohesion; ϕ = angle of internal friction.

Table 4
Piezometer Locations and Dates of Operation

No.	Type	Location		Elevation* ft mlw	Date		Reason for Discontinuing Readings	Remarks
		Baseline Sta	Offset ft		Installed	Discontinued		
P-3	Casagrande	4+05	70 R	41.0	Oct 61	June 64	Gage not functioning	
P-4	Casagrande	4+10	70 R	61.0	Oct 61	Apr 66	Gages removed and pipes out	At boring BU-2 in rock No excess pore pressure observed
P-5	Casagrande	4+15	70 R	81.0	Oct 61	Apr 66		
P-6	Casagrande	4+20	70 R	116.0	Oct 61	Apr 66		
P-7					Oct 64	Apr 68	Inconsistent readings	Located in pit with steel plate cover Gages replaced Mar 1973
P-8					Oct 64	Apr 68		
P-9					Oct 64	Apr 68		
P-7A		4+17	130 R	49.2	Aug 69	Still operational		
P-8A		4+17	130 R	67.5	Aug 69			
P-9A		4+17	130 R	85.6	Aug 69			
P-10	Heavy liquid			96.7	Oct 74		Not enough readings to establish reliability	
P-11	Heavy liquid			107.5	Oct 74		} July 78 No casing, reading water table only	
P-11A	Heavy liquid			55.5	Oct 74			
P-12	Heavy liquid			42.8	Feb 77			
P-13	Heavy liquid			63.2	Feb 77			

* Elevations are in feet referred to mean low water (mlw).

Table 5
Horizontal and Vertical Control Surface Movements

Description	Location*		Date	Reason	Remarks
	Baseline Sta	Offset ft			
Sta 0+99 West pin East pin	1+00	18 R	Apr 61 } Apr 61 }	Still in place	All pins are set approximately 6 in. below the surface and protected by a short pipe section and a cover
	1+09	116 R			
River edge pin			Nov 65	Aug 73	Pins are set along lines slightly skewed to baseline
				Lost into river	
Sta 4+26 West pin East pin	4+16	18 L	Apr 61 } Apr 61 }	Still in place	
	4+20	73 R			
River edge pin			Nov 65	Nov 71	Lost into river
Sta 7+21 West pin East pin River edge pin	7+00	48 L	Apr 61 } Apr 61 } Nov 65 }	Still in place	
	7+10	52 R			
	7+25	200 R			
MAC-1 MAC-2 MAC-3 MAC-4 MAC-5	4+22	15 L	Aug 74 } Aug 74 } Aug 74 } Aug 74 } Aug 74 }	Still in place	Iron pins in asphalt walk way traversing center of athletic field and picnic area
	4+30	75 R			
	4+35	134 R			
	4+37	164 R			
	4+44	224 R			

* Approximate location as scaled from Plan No. 4-091, 5/9/78, Office of the Engineers, USMA.

Table 6

Inclinometer Location and Dates of Operation

No.	Location*		Baseline Sta	Offset ft	Elevation** ft mlw	Date		Reason for Discontinuing Rdg's	Remarks
	Installed	Discontinued							
346	2+25	13 L				May 64	Jan 67	Casing became impassable	
346A	2+03	10 L	8.9			Nov 67			Near edge of tennis courts area in leveled off surface of mud wave near river's edge
348	4+28	250 R					Sep 69	Torpedo unable to advance below 88'	
348A	4+26	255 R	--				Nov 71	Replaced by 348B	
348B	4+20	230 R	4.9			Sep 72			Disturbed by construction in July 1974
550	2+28	149 R	--			Jan 66	Sep 67	Casing sheared at 68-ft depth	
550A	2+34	151 R	5.6			Mar 68	July 74	Apparently disturbed by construction	
550B	2+34	151 R	5.6			July 74			Continuation of 550A record after repair
551	5+30	125 R	--			July 66	Dec 69	Casing blocked at 6 ft below surface	
551B	5+23	128 R	5.5			Sep 72			
552	4+35	62 R	--			Apr 77			In borehole WS-3

* Approximate location scaled from Plan No. 4-091, 5/9/78, Office of the Engineer, USMA.

** Elevations are in feet referred to mean low water (mlw) as of Jan 1976.

Table 7
Strength Parameters Used in Stability Analyses

<u>Layer</u>	<u>Submerged* Unit Wt. psf</u>	<u>Cohesion ksf</u>	<u>Tan ϕ</u>
1 - Rock fill	140.0	0	0.577
2 - Saturated rock fill	77.5	0	0.577
3 - Peat	27.5	0.4	0
4 - Clay	42.5	0.12	0
5 - Clay	42.5	0.36	0
6 - Clay	42.5	0.6	0
7 - Clay	42.5	0.84	0
8 - Clay	42.5	1.2	0
9 - Clay	42.5	1.68	0

* Layer 1 of rock fill was not submerged.

APPENDIX A: SOIL DATA, BORING DH-11 (1975),
Q TRIAXIAL, R TRIAXIAL, AND CONSOLIDATION

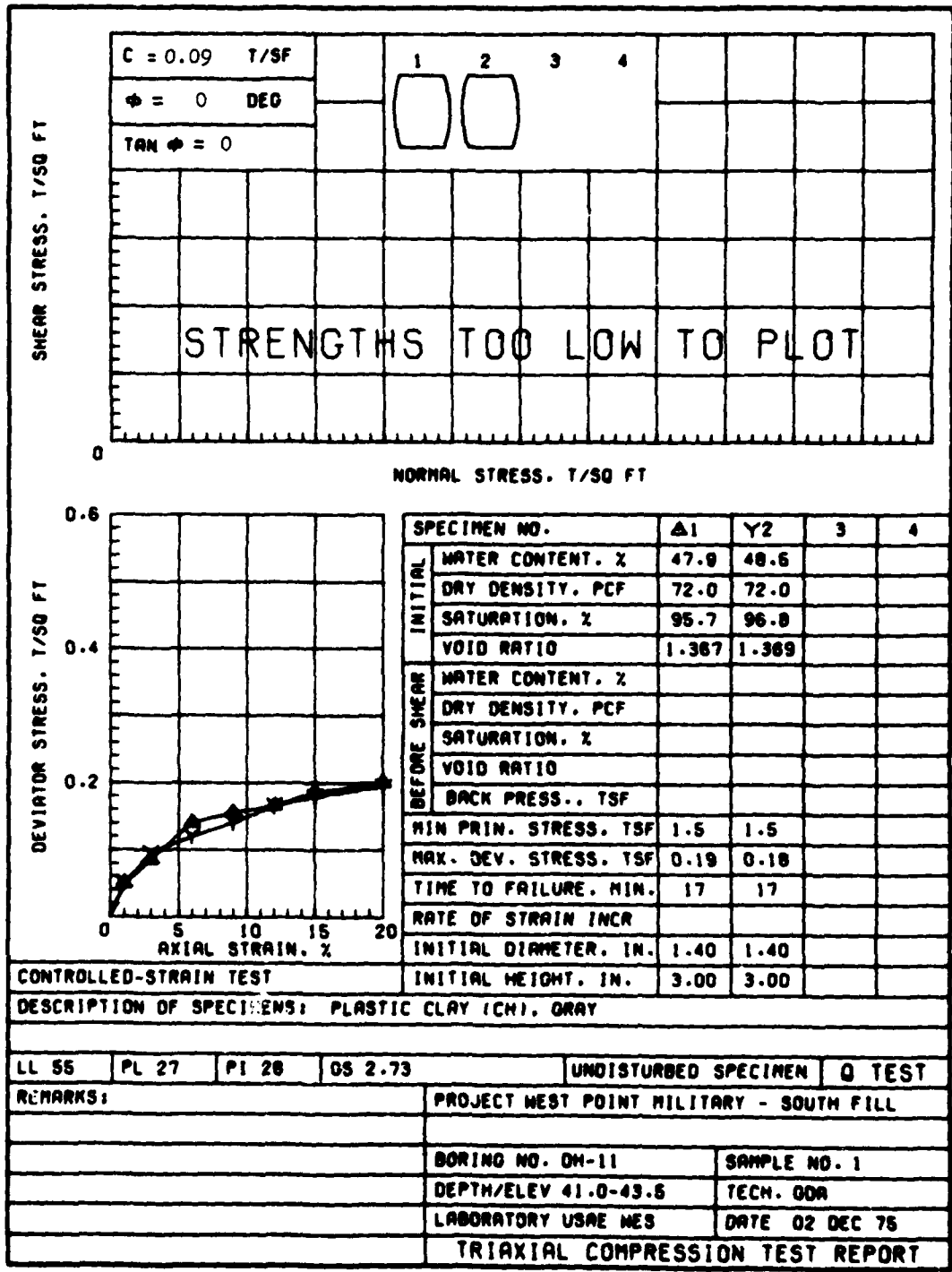


PLATE A1

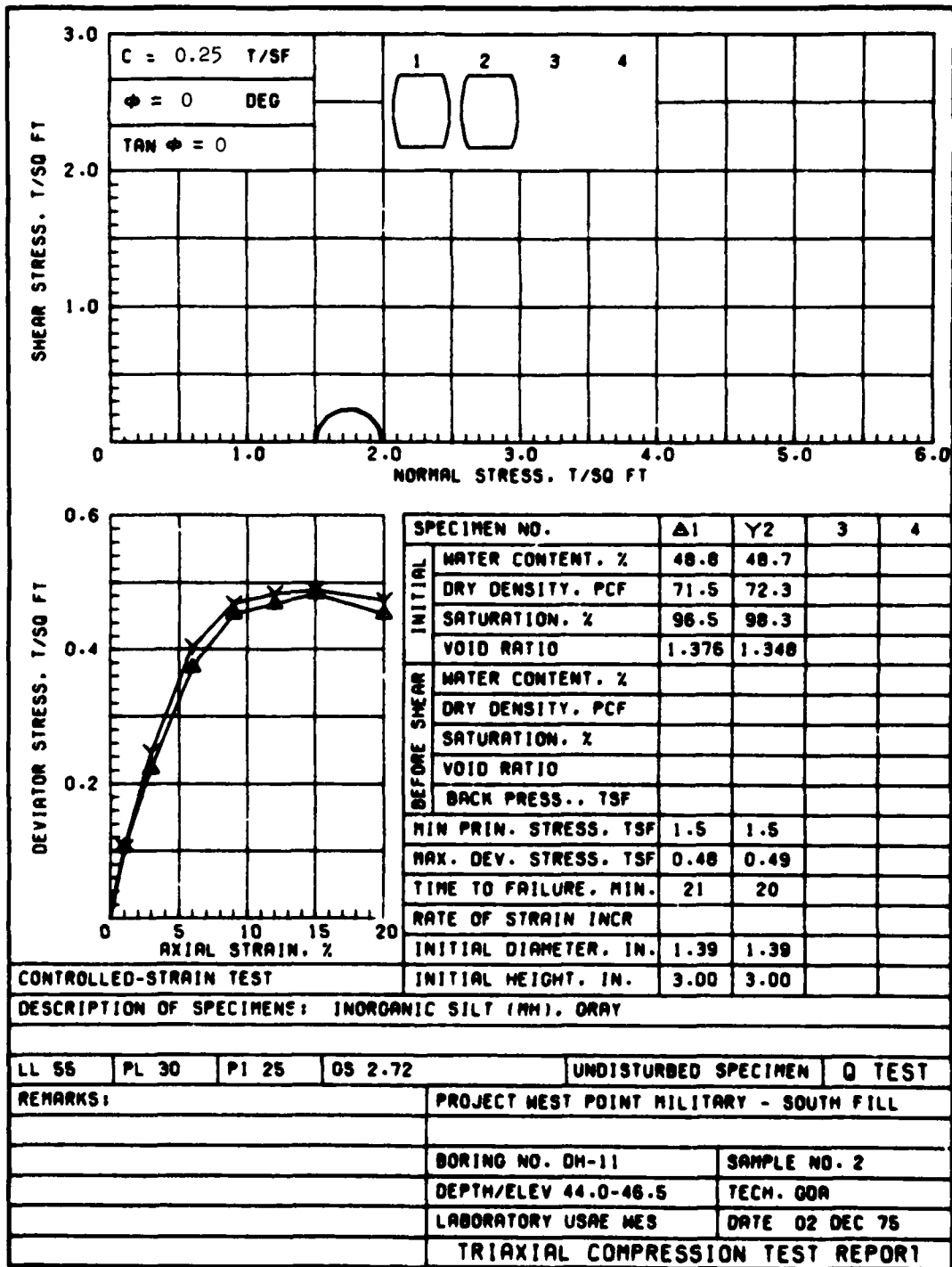
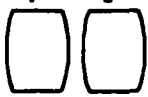
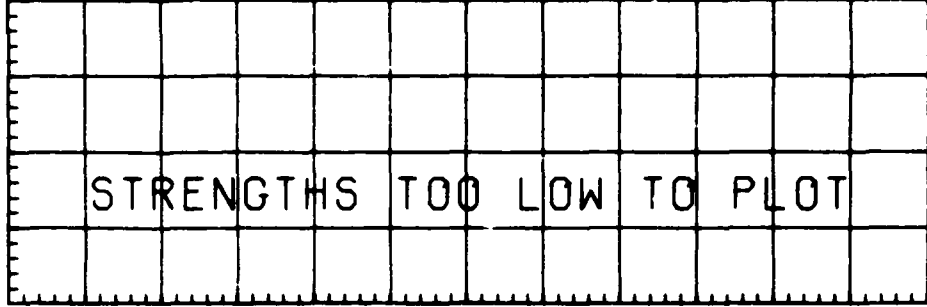


PLATE A2

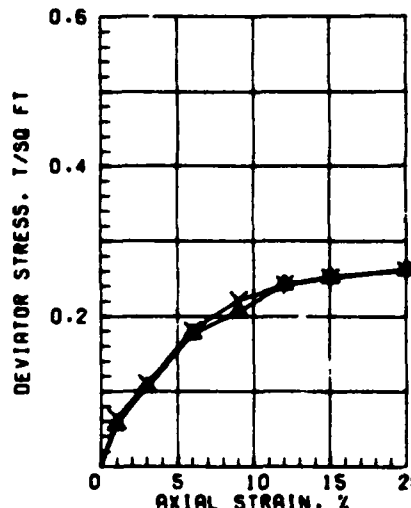
$c = 0.13$ T/SF	1 2 3 4		
$\phi = 0$ DEG			
TAN $\phi = 0$			

SHEAR STRESS. T/SO FT



0

NORMAL STRESS. T/SO FT



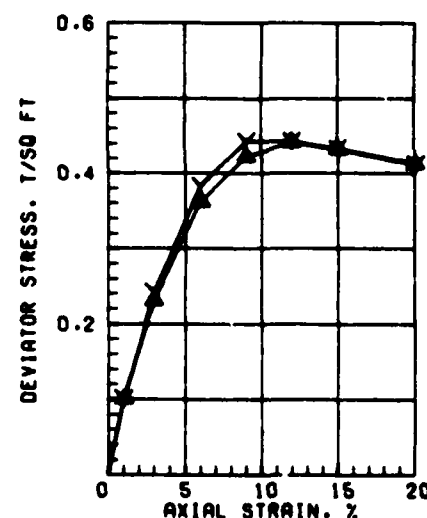
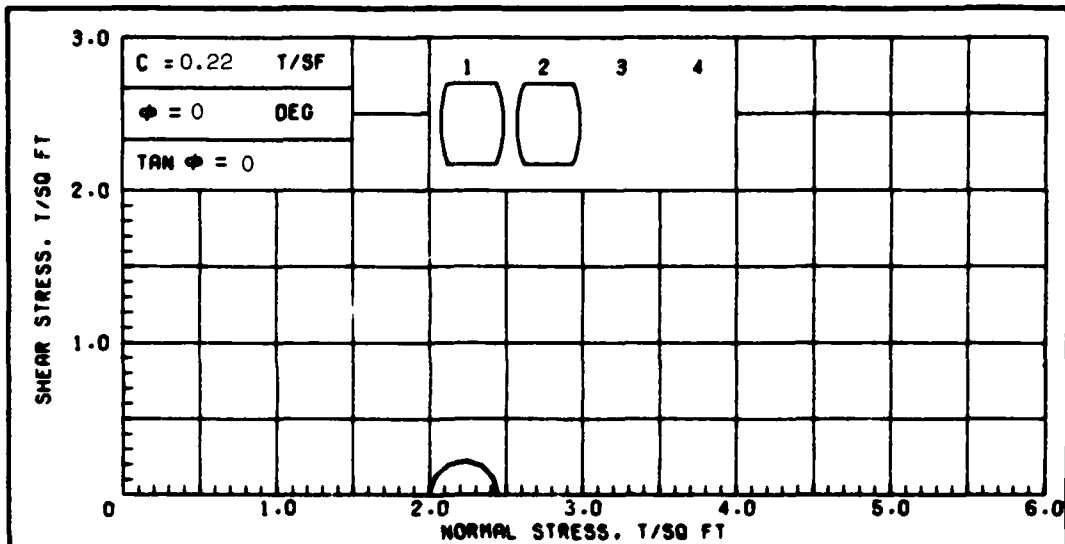
	SPECIMEN NO.	Δ1	Y2	3	4
INITIAL	WATER CONTENT. %	51.0	53.9		
	DRY DENSITY. PCF	70.3	68.0		
	SATURATION. %	98.1	98.2		
	VOID RATIO	1.409	1.488		
BEFORE SHEAR	WATER CONTENT. %				
	DRY DENSITY. PCF				
	SATURATION. %				
	VOID RATIO				
	BACK PRESS.. TSF				
	MIN PRIN. STRESS. TSF	1.5	1.5		
	MAX. DEV. STRESS. TSF	0.25	0.25		
	TIME TO FAILURE. MIN.	21	20		
	RATE OF STRAIN INCR				
	INITIAL DIAMETER. IN.	1.39	1.39		
	INITIAL HEIGHT. IN.	3.00	3.00		

CONTROLLED-STRAIN TEST

DESCRIPTION OF SPECIMENS: PLASTIC CLAY (CH), GRAY

LL 58	PL 30	PI 28	OS 2.71	UNDISTURBED SPECIMEN	Q TEST
REMARKS:				PROJECT WEST POINT MILITARY - SOUTH FILL	
			BORING NO. DM-11		SAMPLE NO. 3
			DEPTH/ELEV 46.5-49.0		TECH. ODA
			LABORATORY USAE MES		DATE 02 DEC 75
TRIAxIAL COMPRESSION TEST REPORT					

PLATE A3



	Δ1	Y2	3	4
SPECIMEN NO.				
INITIAL				
WATER CONTENT, %	51.0	49.9		
DRY DENSITY, PCF	70.0	71.4		
SATURATION, %	96.6	97.7		
VOID RATIO	1.452	1.405		
BEFORE SHEAR				
WATER CONTENT, %				
DRY DENSITY, PCF				
SATURATION, %				
VOID RATIO				
BACK PRESS., TSF				
MIN PRIN. STRESS, TSF	2.0	2.0		
MAX. DEV. STRESS, TSF	0.44	0.44		
TIME TO FAILURE, MIN.	24	11		
RATE OF STRAIN INCR				
INITIAL DIAMETER, IN.	1.40	1.39		
INITIAL WEIGHT, IN.	3.00	3.00		

CONTROLLED-STRAIN TEST

DESCRIPTION OF SPECIMENS: PLASTIC CLAY (CH), DRY

LL 51	PL 26	PI 25	OS 2.75	UNDISTURBED SPECIMEN	Q TEST
REMARKS:				PROJECT WEST POINT MILITARY - SOUTH FILL	
				BORING NO. DM-11	SAMPLE NO. 4
				DEPTH/ELEV 49.0-51.5	TECH. GDA
				LABORATORY USAE MES	DATE 01 DEC 75
TRIAxIAL COMPRESSION TEST REPORT					

PLATE A4

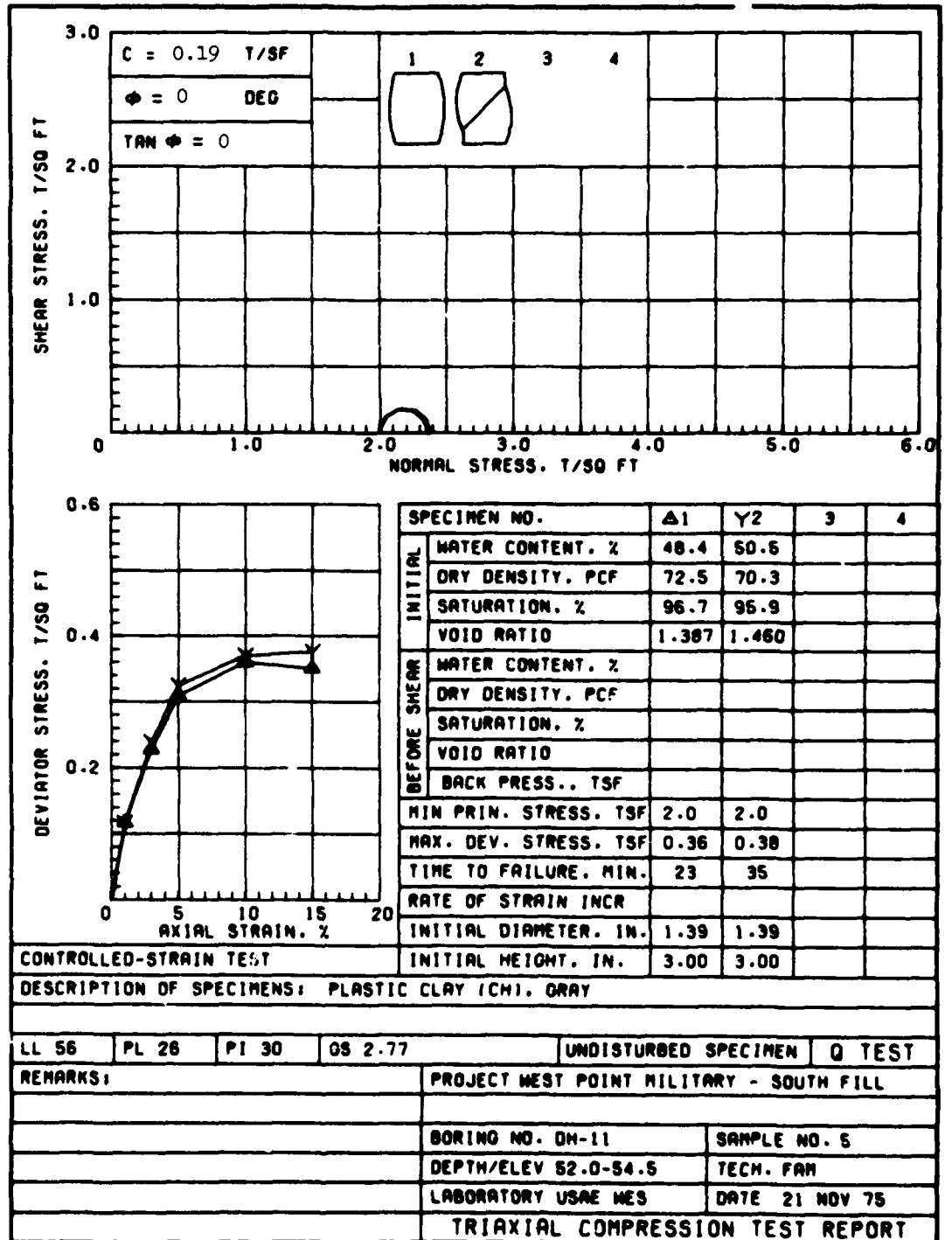


PLATE A5

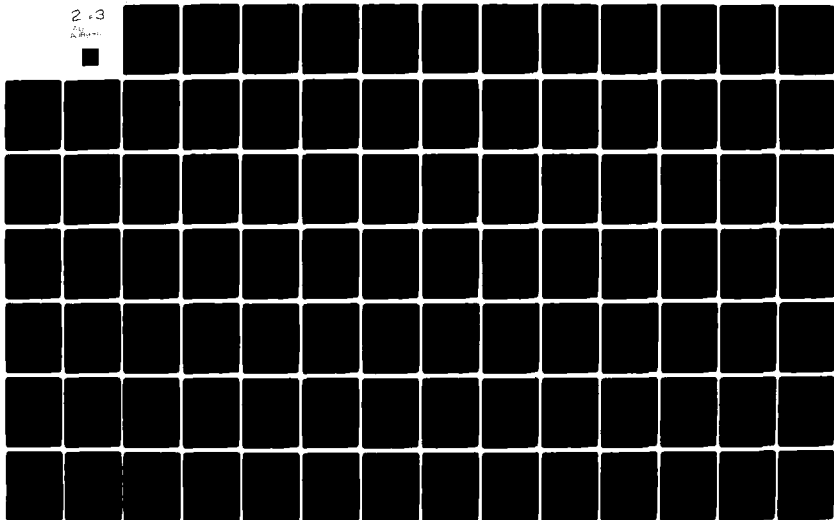
AD-A089 751

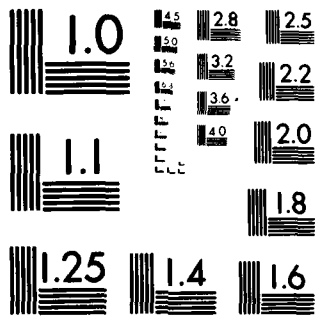
ARMY ENGINEER WATERWAYS EXPERIMENT STATION VICKSBURG--ETC F/G 8/13
INVESTIGATION FOR SOUTH FILL AREA, UNITED STATES MILITARY ACADE--ETC(U)
AUG 80 H M TAYLOR, J K POPLIN, G B MITCHELL IAO-NYD-78-76-(M)
WES/MP/GL-80-7 NL

UNCLASSIFIED

2 of 3

2 of 3





MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

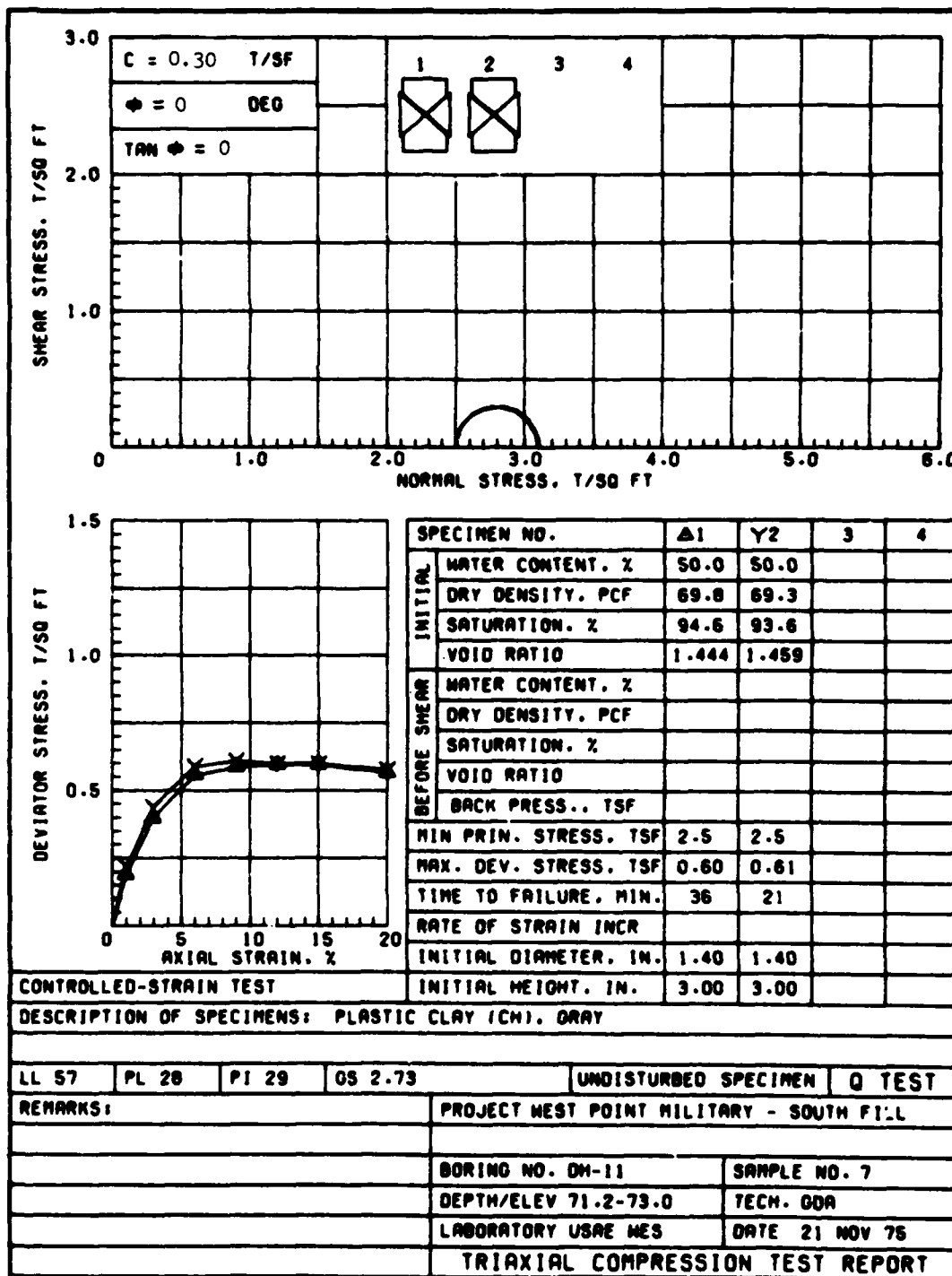


PLATE A6

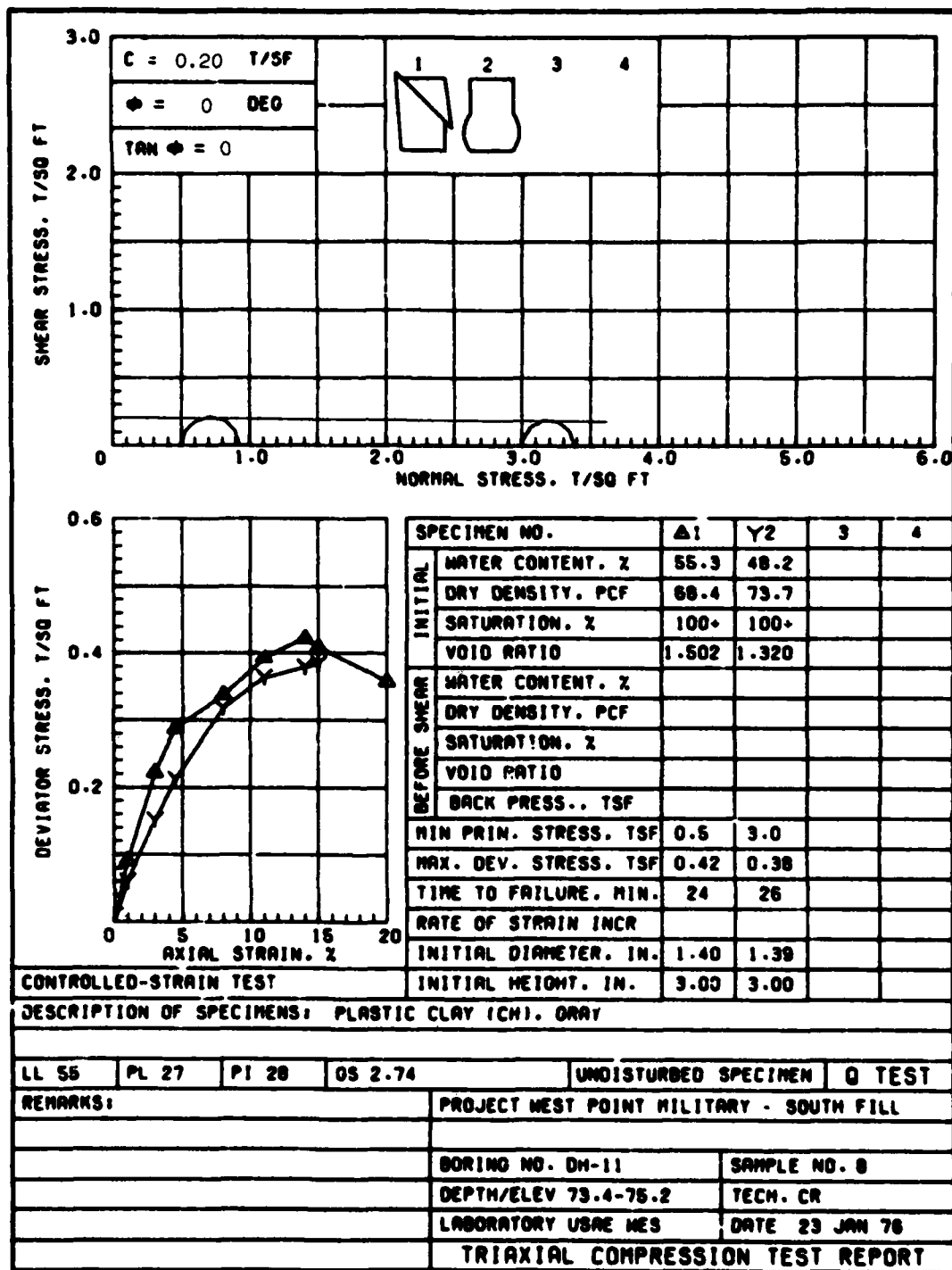


PLATE A7

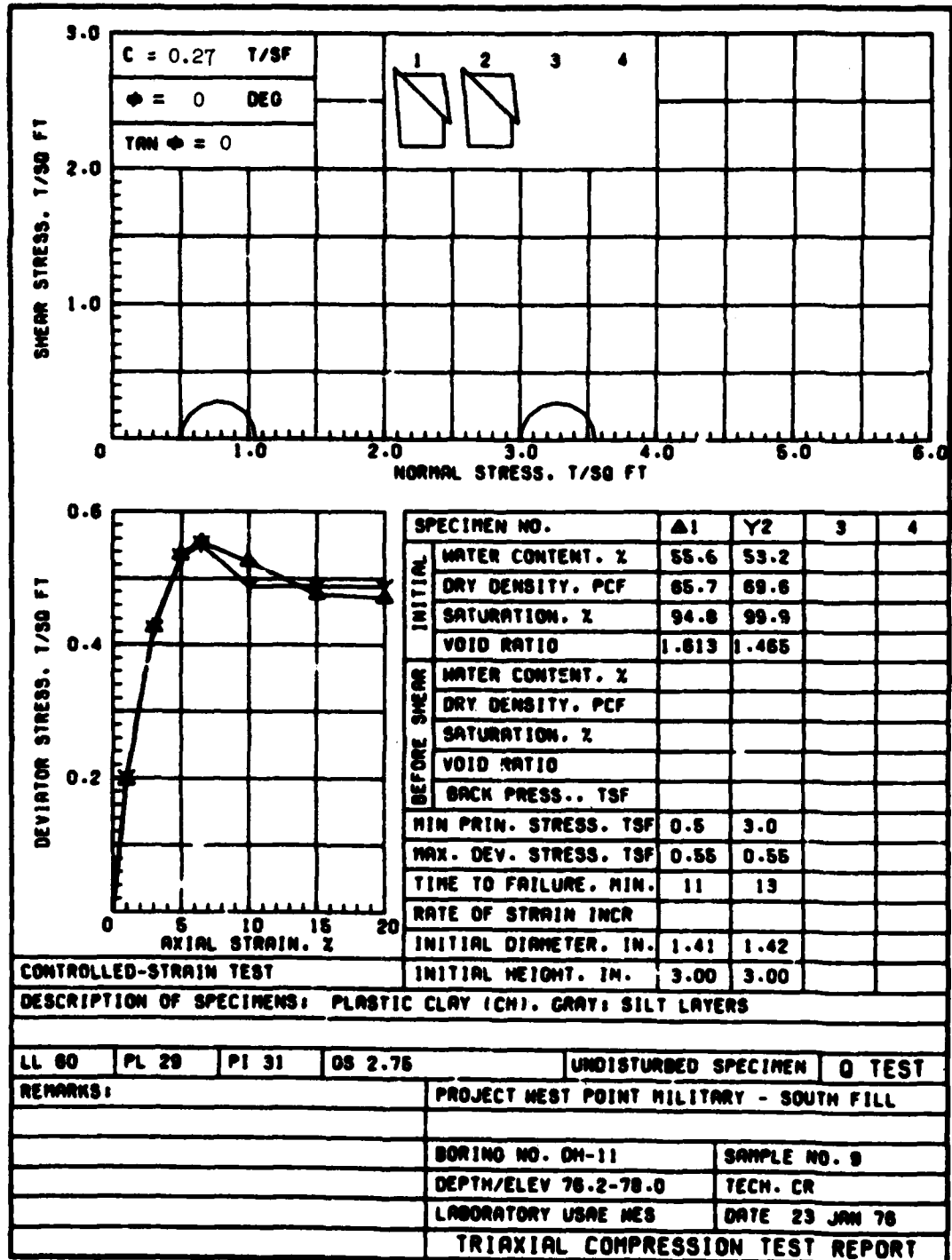


PLATE A8

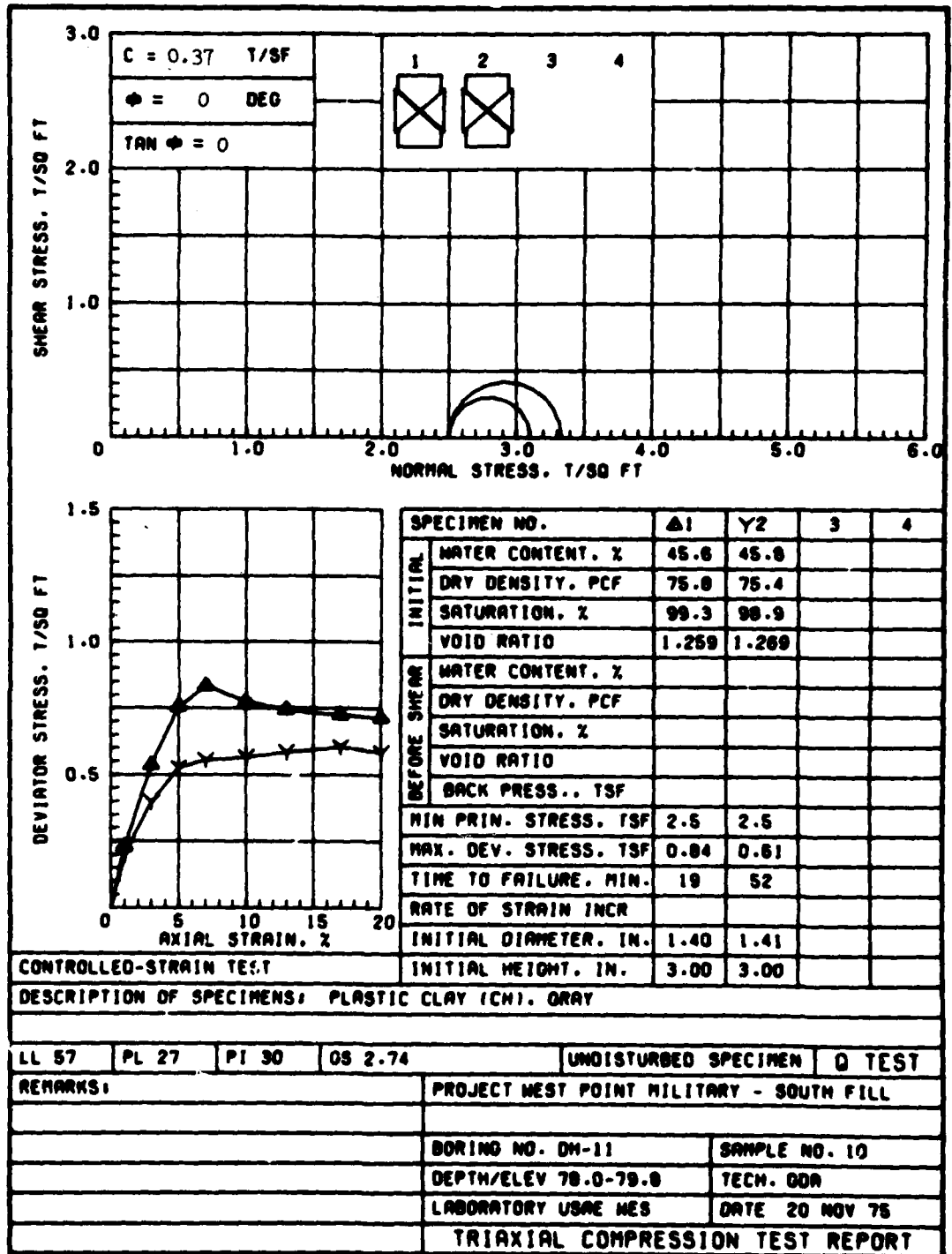


PLATE A9

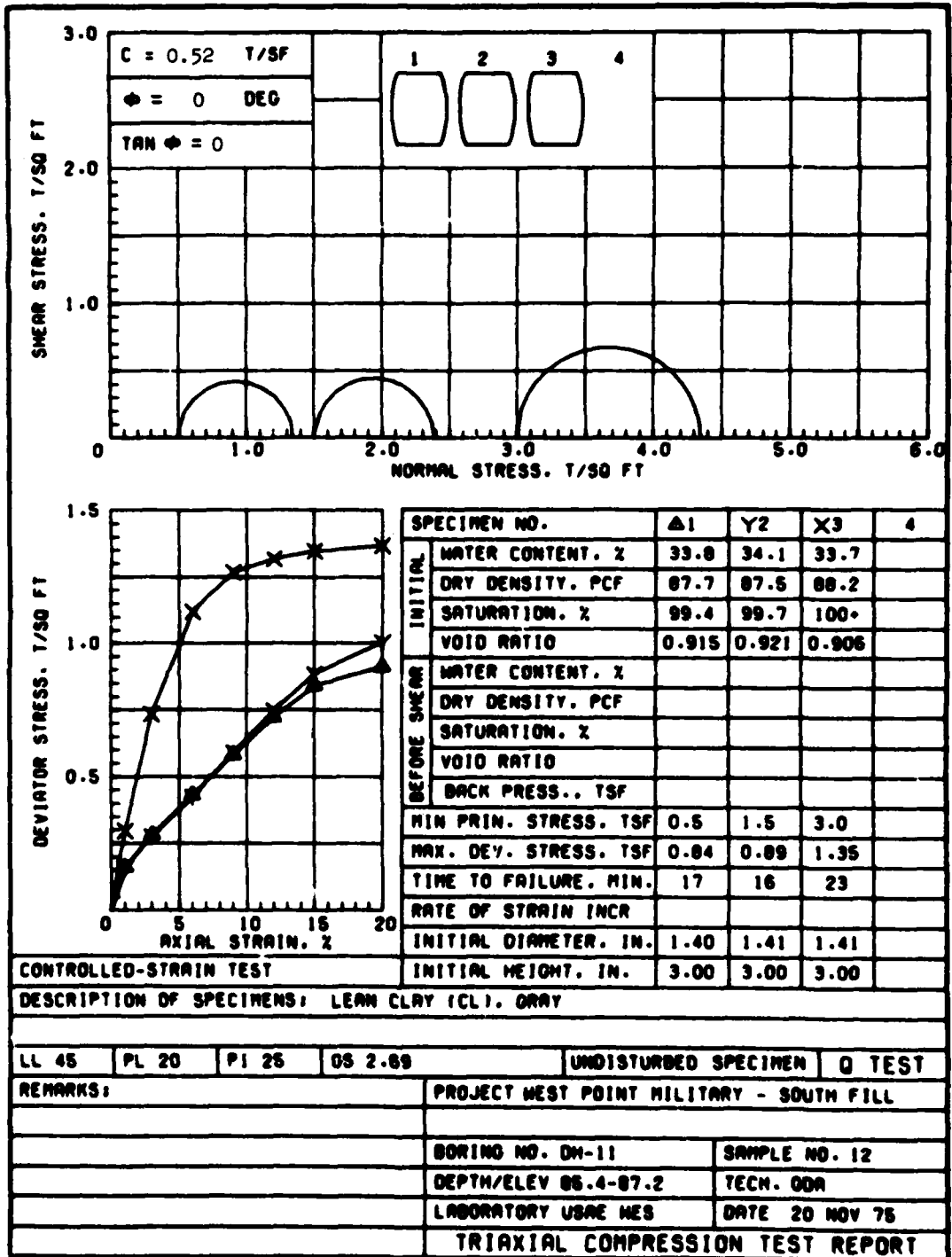
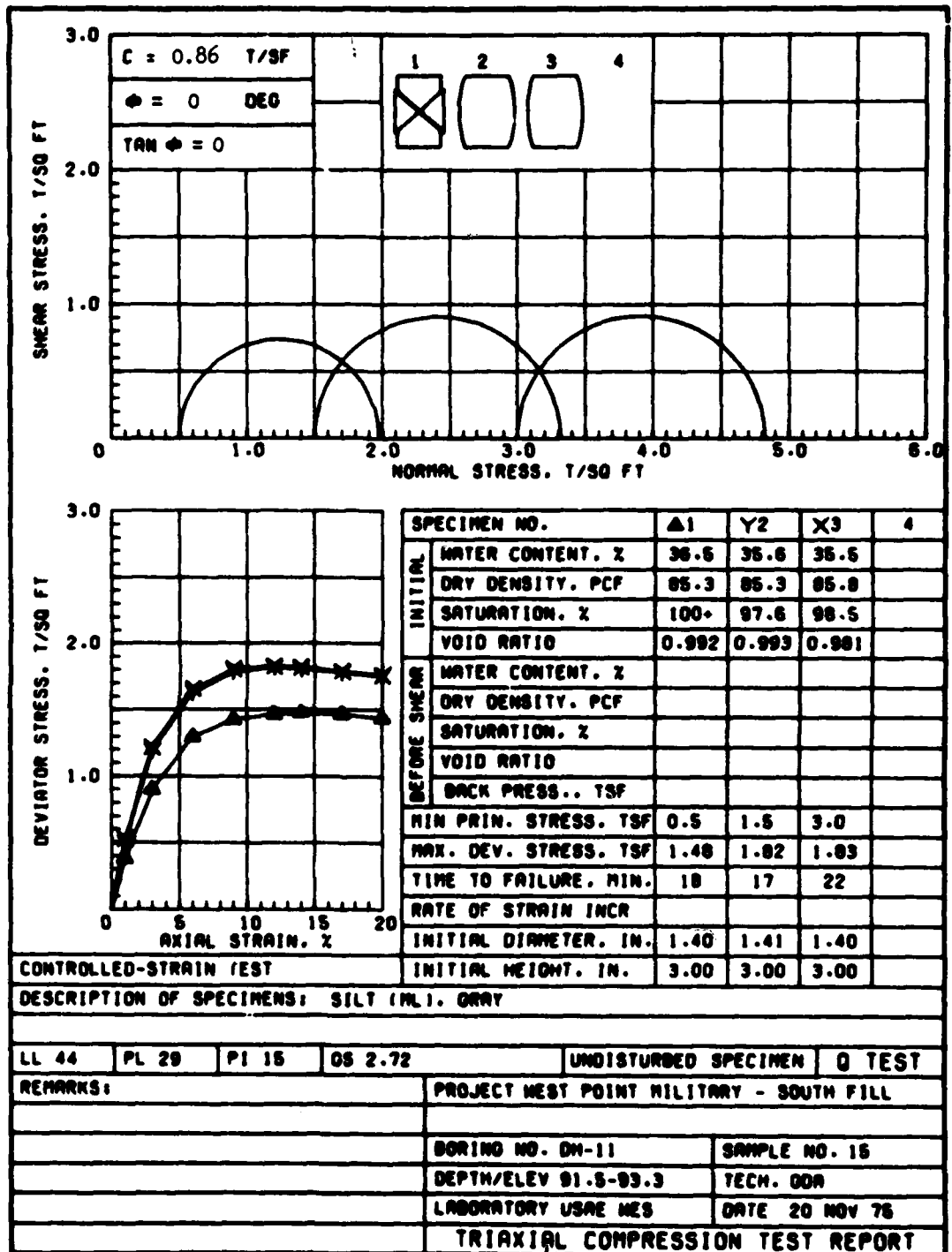
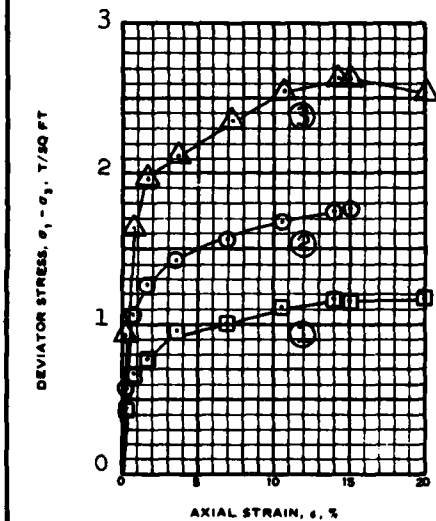
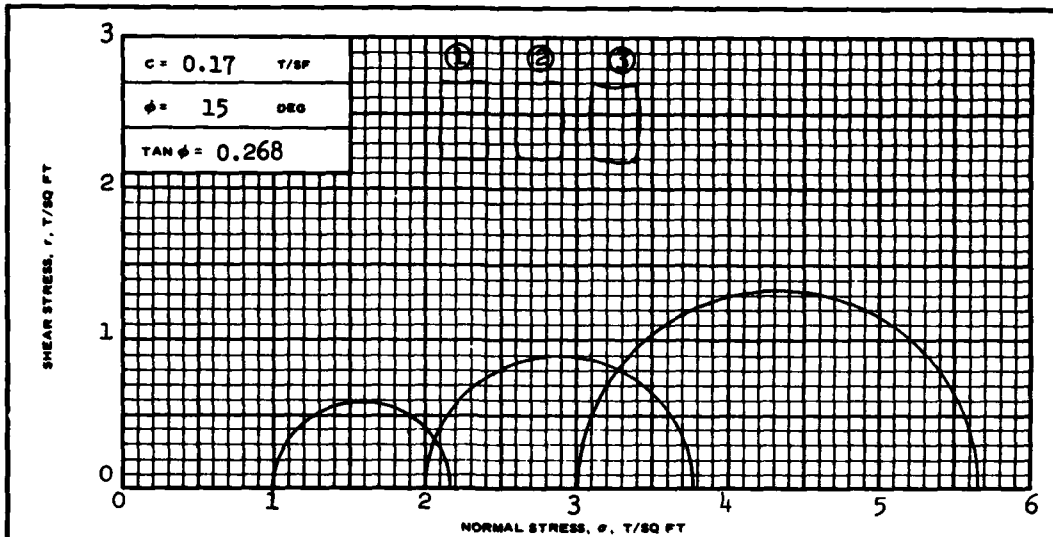


PLATE A10





SPECIMEN NO.		1	2	3
INITIAL	WATER CONTENT, %	w_0 51.5	52.7	51.4
	DRY DENSITY LB/ CU FT	γ_d 69.6	69.4	70.4
	SATURATION, %	s_0 97.1	98.9	98.8
	VOID RATIO	e_0 1.45	1.46	1.42
BEFORE SHEAR	WATER CONTENT, %	w_c 38.6	37.0	33.9
	DRY DENSITY LB/ CU FT	γ_{dc} 79.5	82.7	88.3
	SATURATION, %	s_c *92.2	*95.2	99.4
	VOID RATIO	e_c 1.14	1.06	0.931
FINAL BACK PRESSURE, T/SQ FT		u_0 5.04	5.04	5.04
MINOR PRINCIPAL STRESS, T/SQ FT		σ_3 1.0	2.0	3.0
MAXIMUM DEVIATOR STRESS, T/SQ FT		$(\sigma_1 - \sigma_3)_{MAX}$ 1.17	1.77	2.65
TIME TO $(\sigma_1 - \sigma_3)_{MAX}$, MIN		t_f 1000	1071	1028
ULTIMATE DEVIATOR STRESS, T/SQ FT		$(\sigma_1 - \sigma_3)_{ULT}$		
INITIAL DIAMETER, IN.		D_0 1.38	1.38	1.38
INITIAL HEIGHT, IN.		H_0 3.00	3.00	3.00

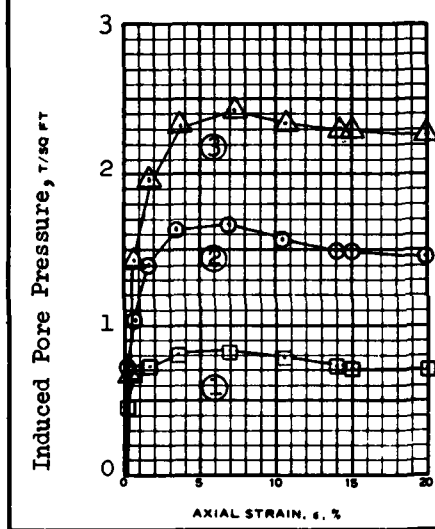
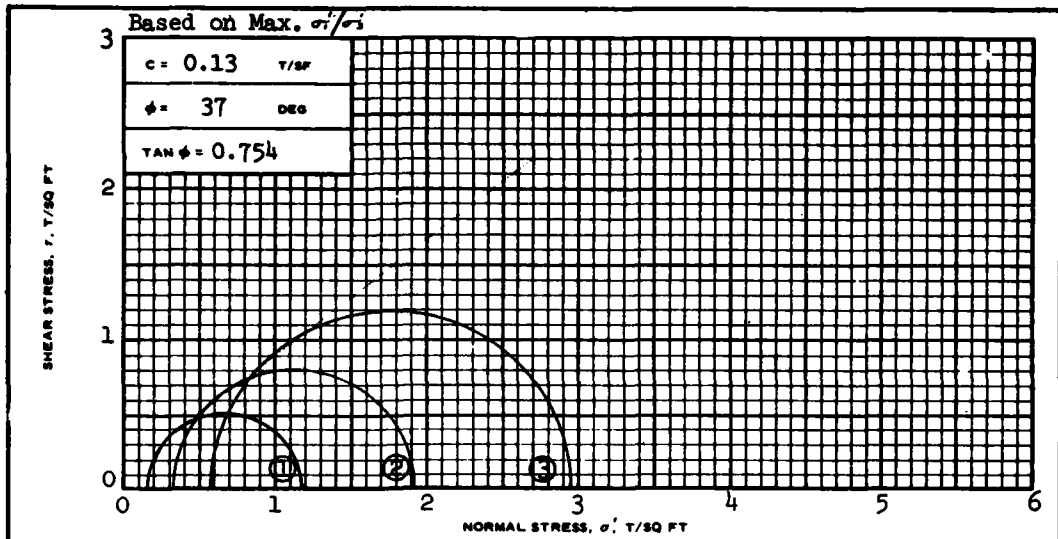
CONTROLLED- strain TEST

DESCRIPTION OF SPECIMENS PLASTIC CLAY(CH), gray

LL -	PL -	PI -	G_s 2.73	TYPE OF SPECIMEN UNDISTURBED	TYPE OF TEST R
REMARKS: See attached sheet for effective values. *Pore pressure response indicated 100% saturation				PROJECT WEST POINT, N.Y.	
				BORING NO. DH-11	SAMPLE NO. 3
				DEPTH/ELEV 46.5-49.0	
				LABORATORY USAEWES	DATE 12 Jan. 1976
Sheet 1 of 2.				JMS TRIAXIAL COMPRESSION TEST REPORT	

ENG FORM NO. 2088 PREVIOUS EDITION IS OBSOLETE TRANSLUCENT (EM 1110-2-1906)

PLATE A12
(SHEET 1 OF 2)



SPECIMEN NO.					
INITIAL	WATER CONTENT, %	w_o			
	DRY DENSITY LB/ CU FT	γ_{d_o}			
	SATURATION, %	s_o			
	VOID RATIO	e_o			
BEFORE SHEAR	WATER CONTENT, %	w_c			
	DRY DENSITY LB/ CU FT	γ_{d_c}			
	SATURATION, %	s_c			
	VOID RATIO	e_c			
	FINAL BACK PRESSURE, T/SQ FT	u_o			
	MINOR PRINCIPAL STRESS, T/SQ FT	σ_3			
	MAXIMUM DEVIATOR STRESS, T/SQ FT	$(\sigma_1 - \sigma_3)_{MAX}$			
	TIME TO $(\sigma_1 - \sigma_3)_{MAX}$, MIN	t_f			
	ULTIMATE DEVIATOR STRESS, T/SQ FT	$(\sigma_1 - \sigma_3)_{ULT}$			
	INITIAL DIAMETER, IN.	D_o			
	INITIAL HEIGHT, IN.	H_o			

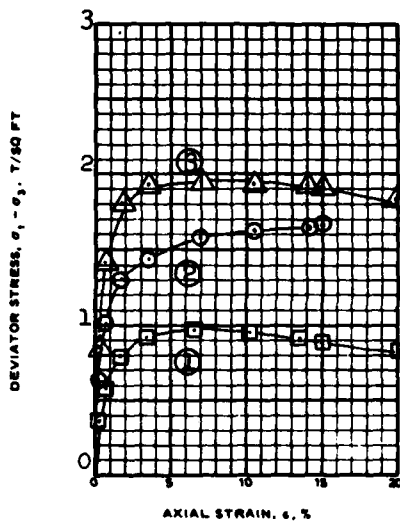
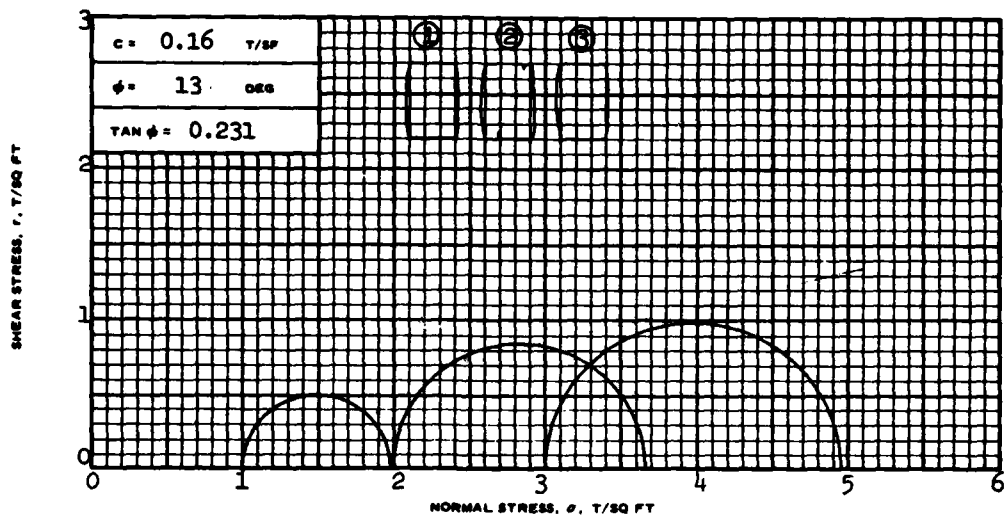
CONTROLLED- TEST

DESCRIPTION OF SPECIMENS

LL	PL	PI	GI	TYPE OF SPECIMEN	TYPE OF TEST \bar{R}
REMARKS:				PROJECT	WEST POINT, N.Y.
				BORING NO.	DH-11
				SAMPLE NO.	3
				DEPTH/ELEV	46.5-49.0
				LABORATORY	USAEWES
				DATE	12 Jan. 1976

Sheet 2 of 2.

JMS TRIAXIAL COMPRESSION TEST REPORT



SPECIMEN NO.		1	2	3
INITIAL	WATER CONTENT, %	w_o 51.6	49.4	50.0
	DRY DENSITY LB/ CU FT	γ_d 70.8	71.2	72.4
	SATURATION, %	s_o 100+	96.8	100+
BEFORE SHEAR	VOID RATIO	e_o 1.41	1.39	1.35
	WATER CONTENT, %	w_c 49.4	43.0	39.2
	DRY DENSITY LB/ CU FT	γ_{dc} 74.1	80.3	82.4
	SATURATION, %	s_c 100+	100+	100
	VOID RATIO	e_c 1.30	1.12	1.07
	FINAL BACK PRESSURE, T/SQ FT	u_o 5.04	5.04	5.04
	MINOR PRINCIPAL STRESS, T/SQ FT	σ_3 1.0	2.0	3.0
	MAXIMUM DEVIATOR STRESS, T/SQ FT	$(\sigma_1 - \sigma_3)_{MAX}$ 0.98	1.66	1.95
	TIME TO $(\sigma_1 - \sigma_3)_{MAX}$, MIN	t_f 486	1071	500
	ULTIMATE DEVIATOR STRESS, T/SQ FT	$(\sigma_1 - \sigma_3)_{ULT}$		
	INITIAL DIAMETER, IN.	d_o 1.40	1.40	1.40
	INITIAL HEIGHT, IN.	h_o 3.00	3.00	3.00

CONTROLLED- strain TEST

DESCRIPTION OF SPECIMENS PLASTIC CLAY(CH), gray

LL - PL - PI - $q = 2.73(Q)$ TYPE OF SPECIMEN UNDISTURBED TYPE OF TEST R

REMARKS: See attached sheet for effective values.

BORING NO. DH-11 SAMPLE NO. 7

DEPTH/ELEV 71.2/73.0

LABORATORY USAEWES DATE 10 Jan. 1976

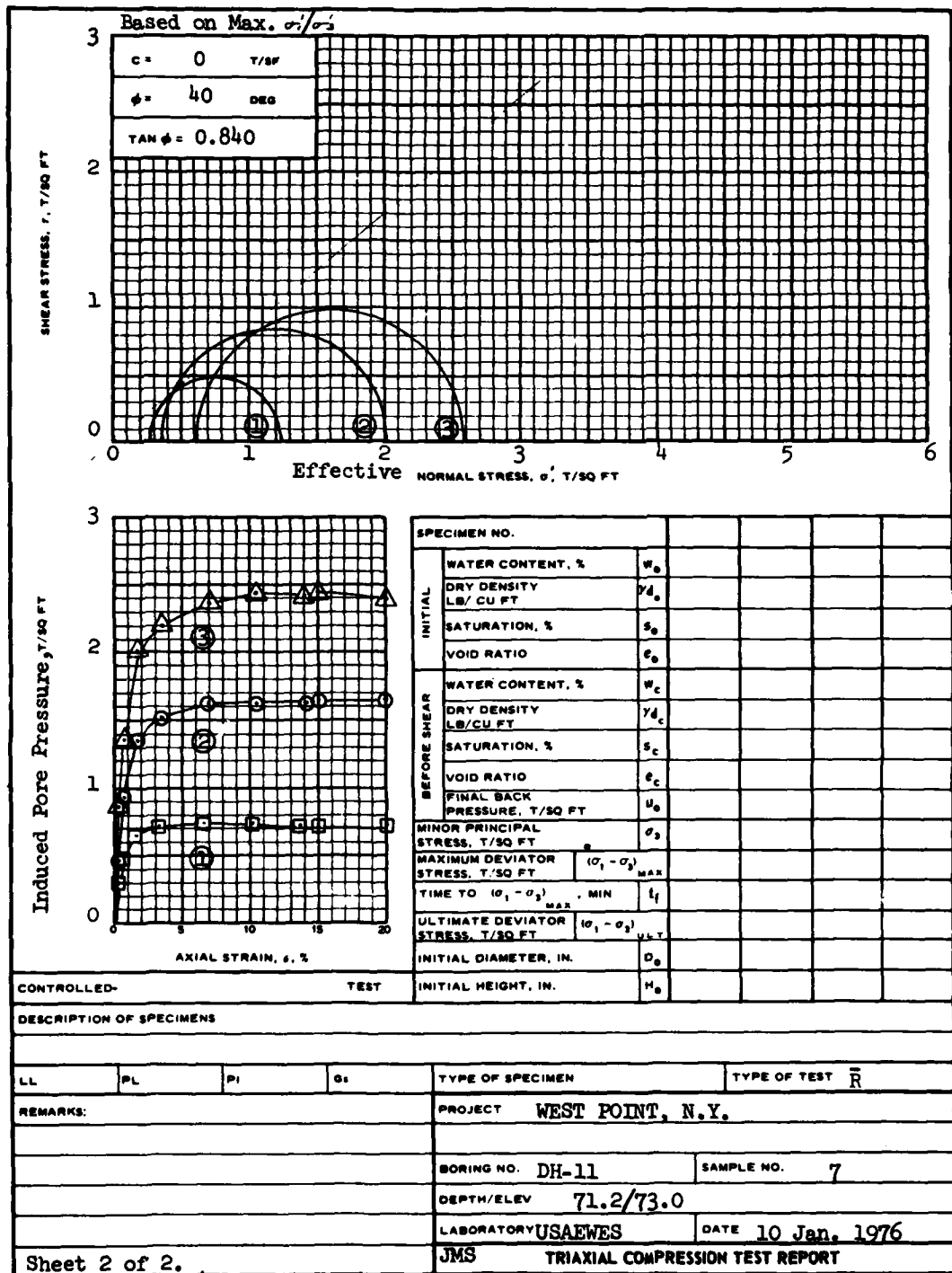
Sheet 1 of 2. JMS TRIAXIAL COMPRESSION TEST REPORT

ENG FORM NO. 2089 REV JUNE 1970 PREVIOUS EDITION IS OBSOLETE

TRANSLUCENT

(EM 1110-2-1906)

PLATE A13
(SHEET 1 OF 2)



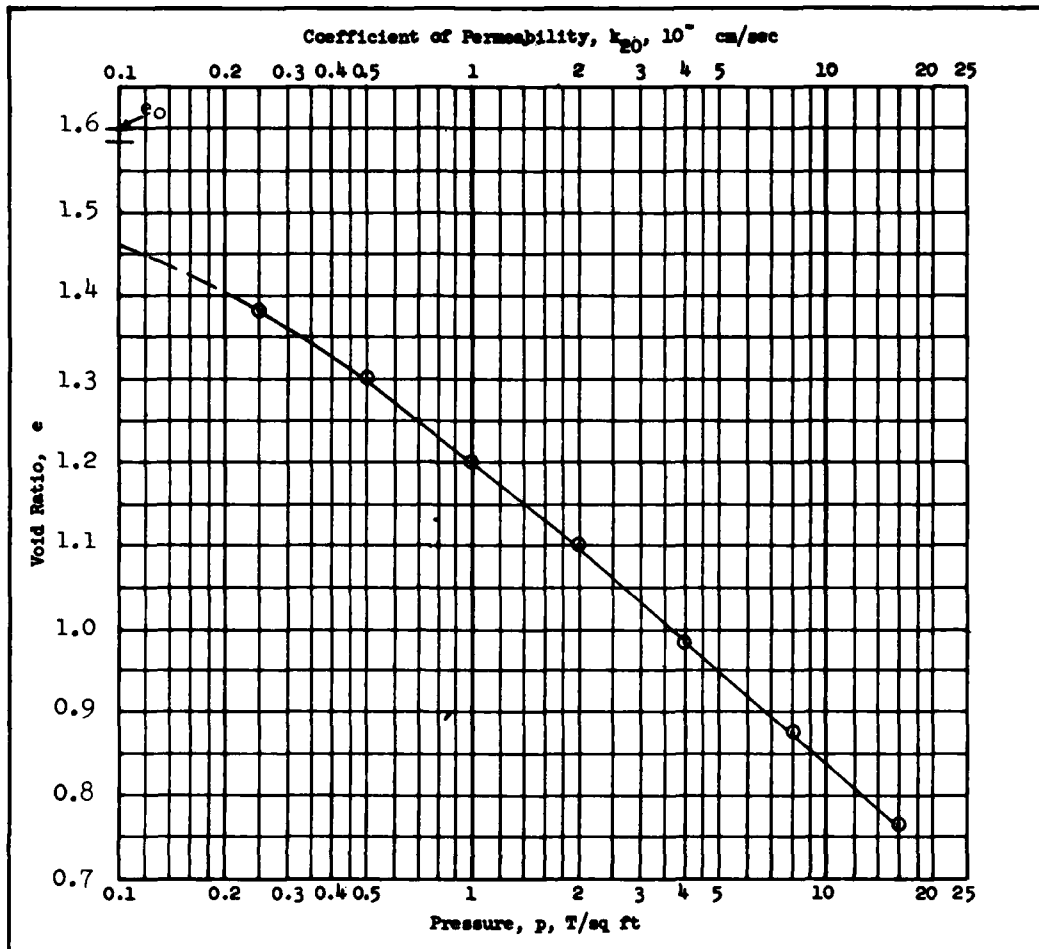
ENG FORM NO. 2089
REV JUNE 1970

PREVIOUS EDITION IS OBSOLETE

TRANSLUCENT

(EM 1110-2-1906)

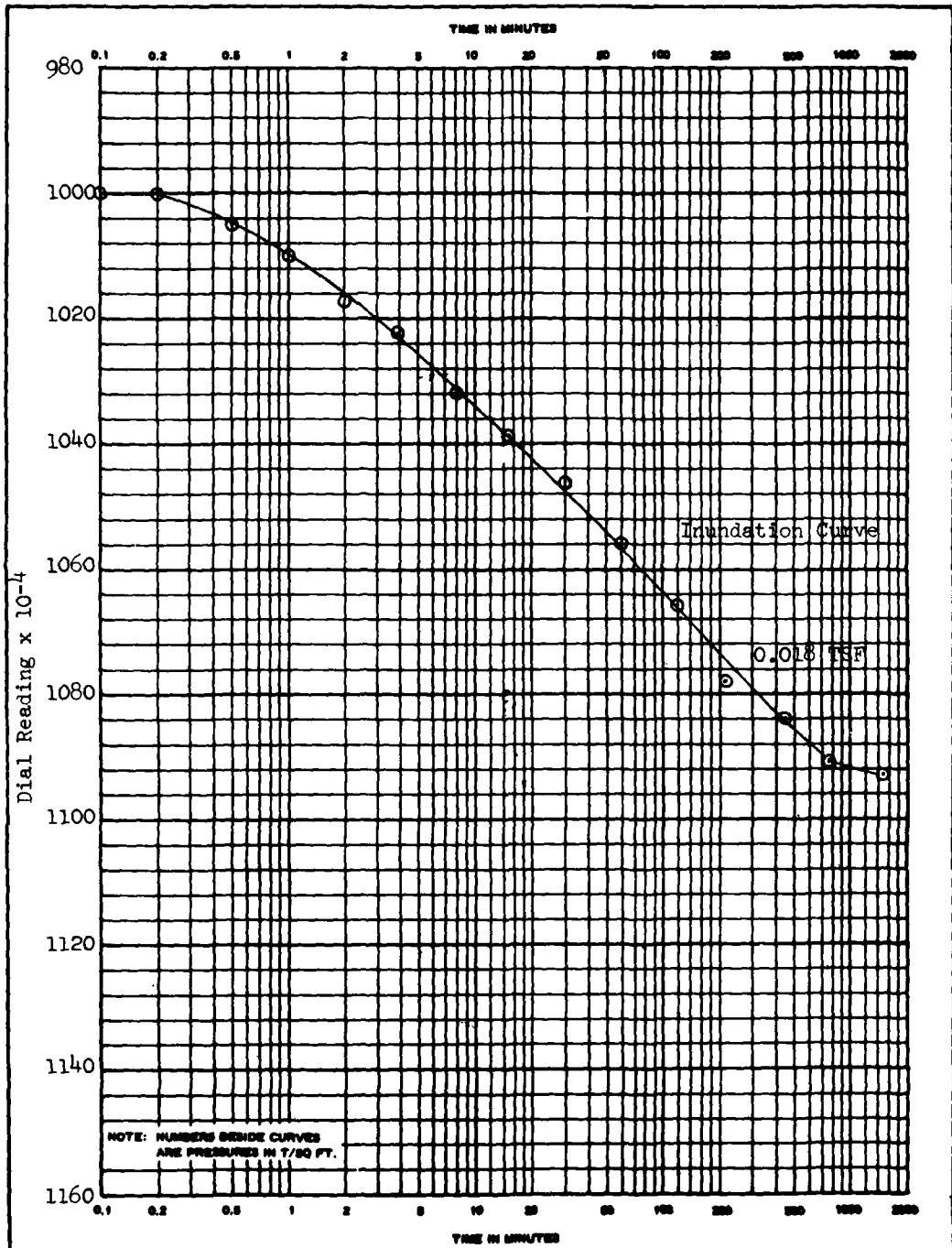
PLATE A13
(SHEET 2 OF 2)



Type of Specimen		UNDISTURBED		Before Test		After Test	
Diam	4.25 in.	Ht	1.1555 in.	Water Content, w_o	57.1 %	w_f	%
Overburden Pressure, P_o	T/sq ft	Void Ratio, e_o	1.60	e_f			
Preconsol. Pressure, P_c	T/sq ft	Saturation, S_o	97.3 %	S_f			%
Compression Index, C_c		Dry Density, γ_d	65.5 lb/ft ³				
Classification	PLASTIC CLAY(CH),*	k_{20} at e_o =		$\times 10^{-}$	cm/sec		
LL	-	G_s	2.73(R)	Project WEST POINT, N. Y.			
PL	-	D_{10}		Area			
Remarks *gray				Boring No.	DH-11	Sample No.	3
Sheet 1 of 5				Depth El	46.5-49.0	Date	14 Jan. 1976
JAL CONSOLIDATION TEST REPORT							

ENS FORM 2090 1 MAY 63 PREVIOUS EDITIONS ARE OBSOLETE. (TRANSLUCENT) 0 9424

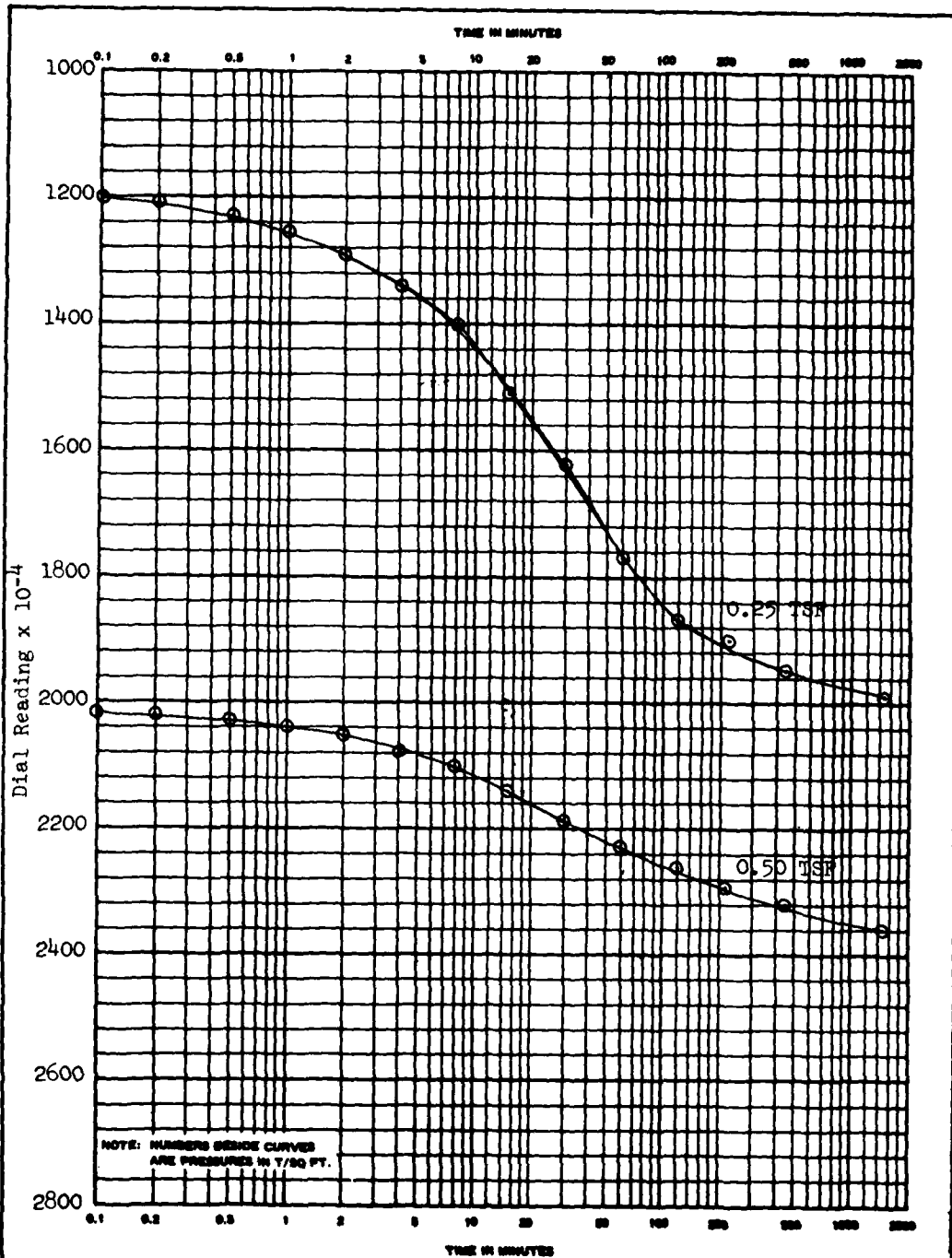
PLATE A14
(SHEET 1 OF 5)



Project WEST POINT, N. Y.			
Area			
Spring No. DH-11	Sample No. 3	Depth ft. 46.5-49.0	Date 14 Jan. 1976
<small>SDS Form 2000 1 MAY 62 PREVIOUS EDITIONS ARE OBSOLETE.</small>			<small>(TRANSLUCENT)</small>

CONSOLIDATION TEST--TIME CURVES

PLATE A14
(SHEET 2 OF 5)



Project WEST POINT, N. Y.

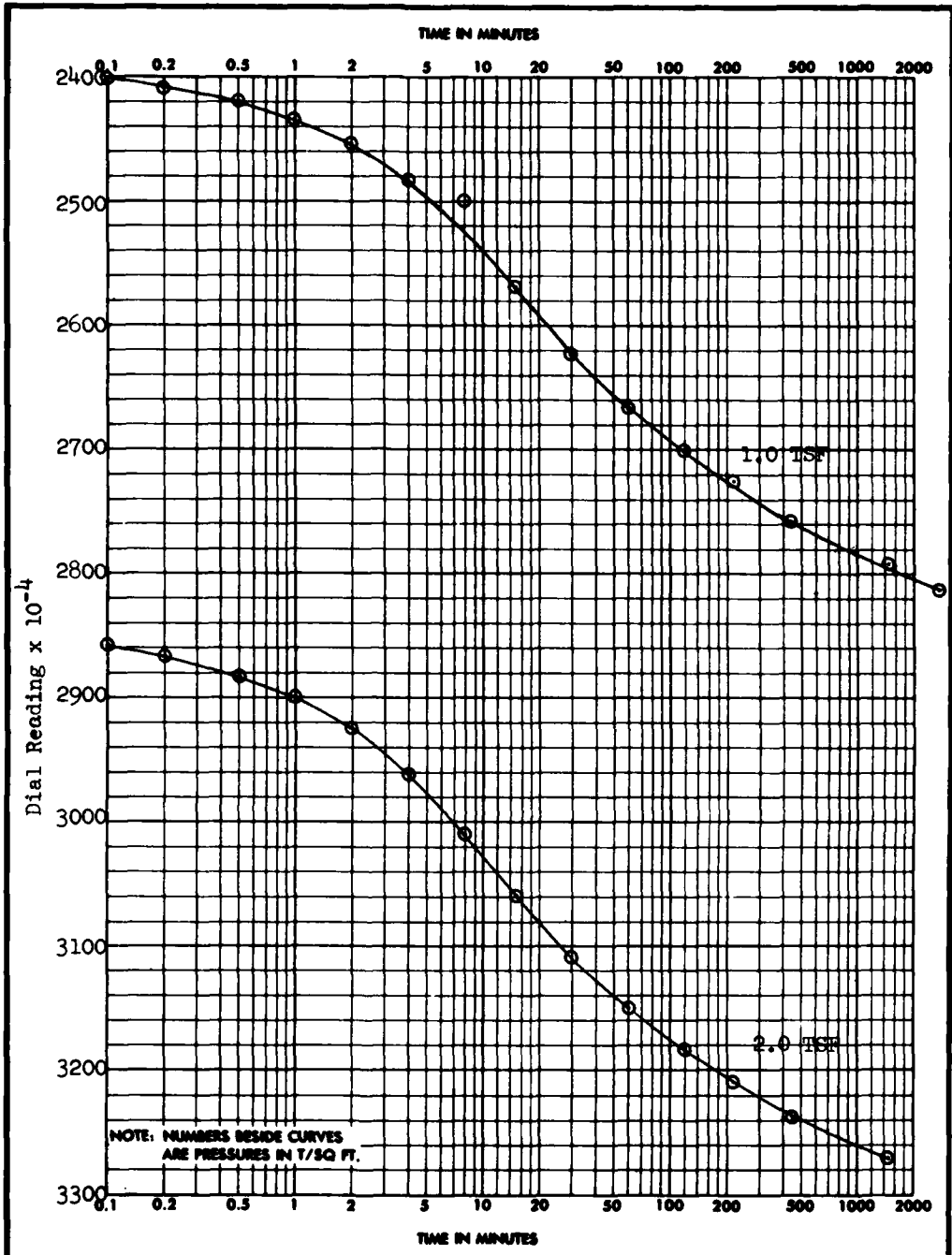
Area

Boring No. DH-11	Sample No. 3	Depth ft. 46.5-49.0	Date 14 Jan. 1976
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ONE FROM 2000
1 MAY 60
PREVIOUS EDITIONS ARE OBSOLETE.

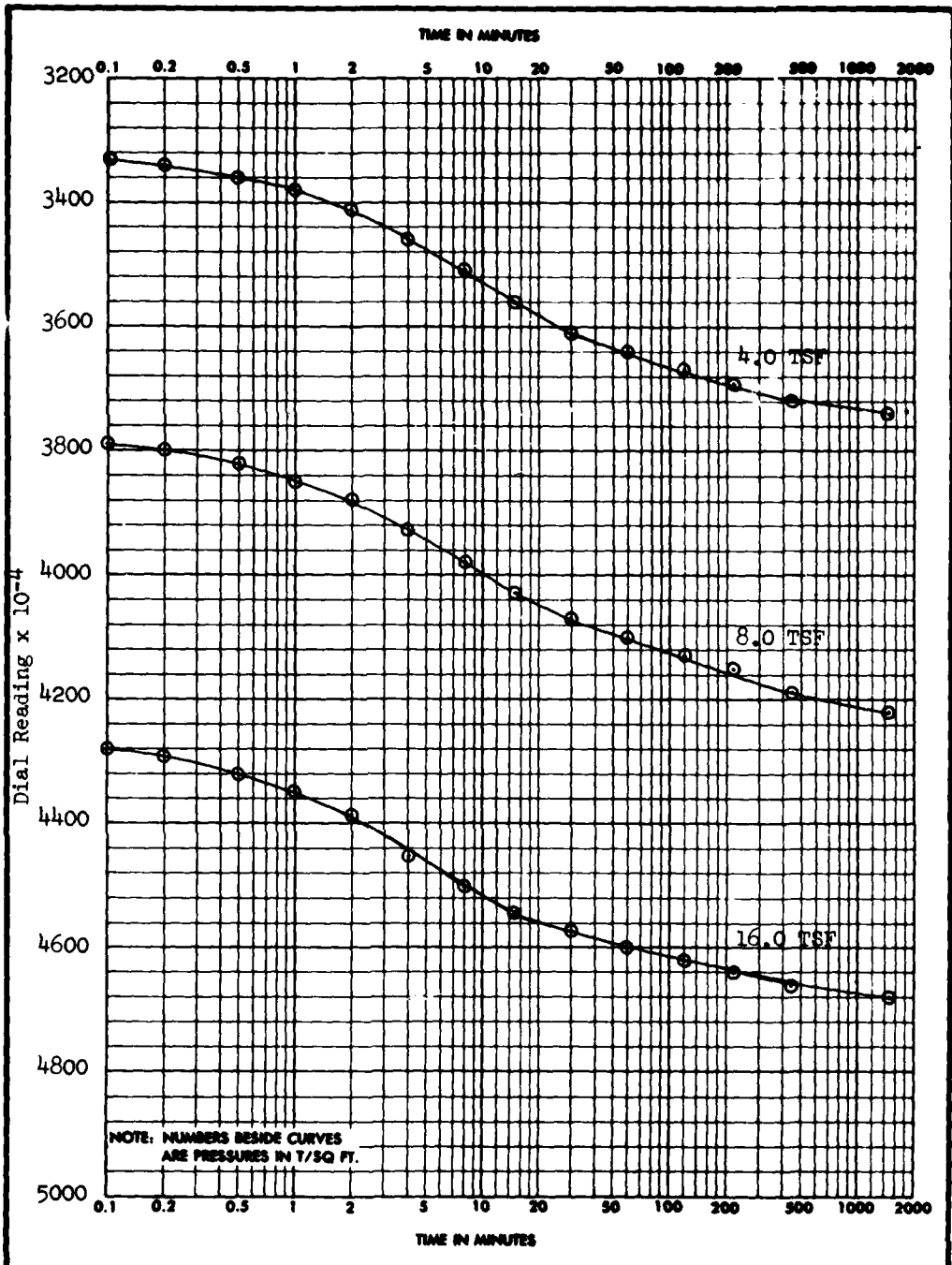
CONSOLIDATION TEST-TIME CURVES (TRANSFORMED)

PLATE A14
(SHEET 3 OF 5)



PROJECT WEST POINT, N. Y.			
AREA			
BORING NO. DH-11	SAMPLE NO. 3	DEPTH EL. 46.5-49.0	DATE 14 Jan. 1976
ENGINEERING FORM 2088 1 MAY 63		PREVIOUS EDITIONS ARE OBSOLETE.	
CONSOLIDATION TEST—TIME CURVES			(TRANSLUCENT)

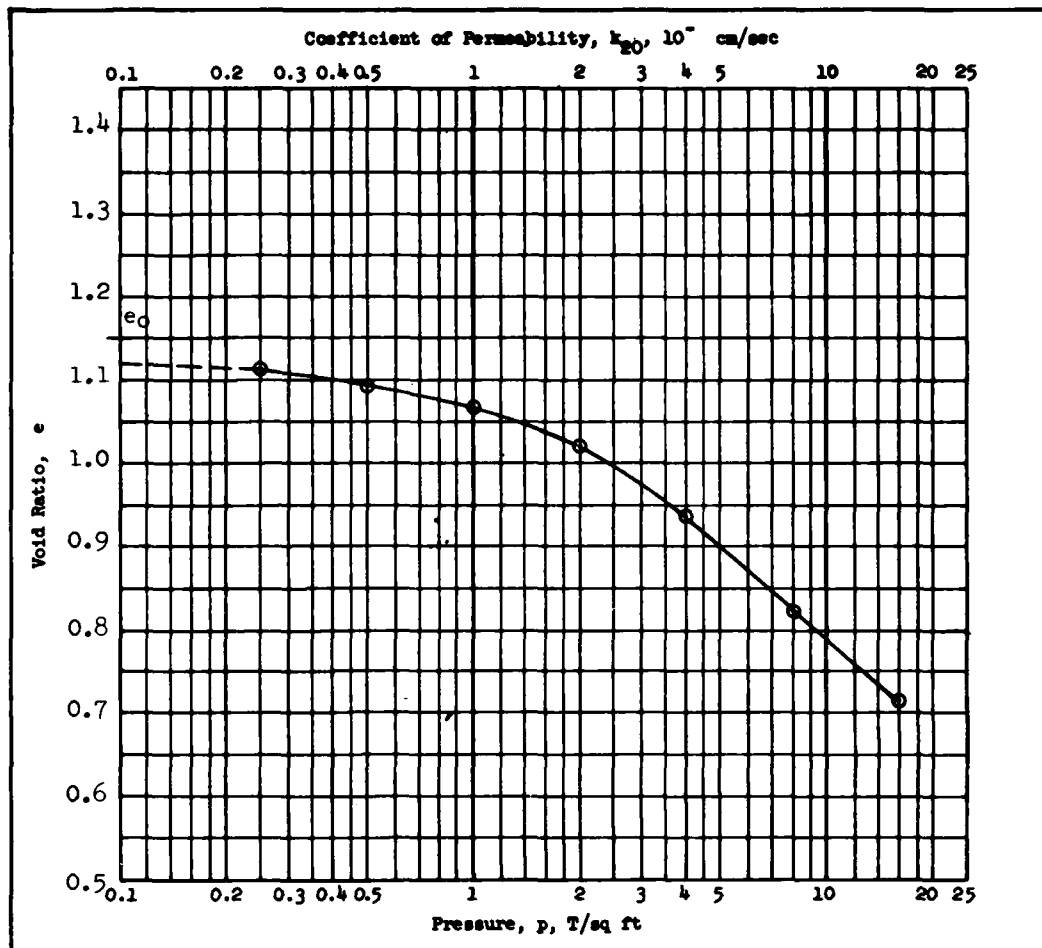
© 1963 : 1004 OF - 710-008
PLATE A14
 (SHEET 4 OF 5)



PROJECT WEST POINT, N. Y.			
AREA			
BORING NO. DH-11	SAMPLE NO. 3	DEPTH EL. 46.5-49.0	DATE 14 Jan. 1976
ENS FORM 2088 1 MAY 63		PREVIOUS EDITIONS ARE OBSOLETE.	CONSOLIDATION TEST—TIME CURVES (TRANSLUCENT)

PLATE A14
(SHEET 5 OF 5)

© GPO : 1964 O-710-008



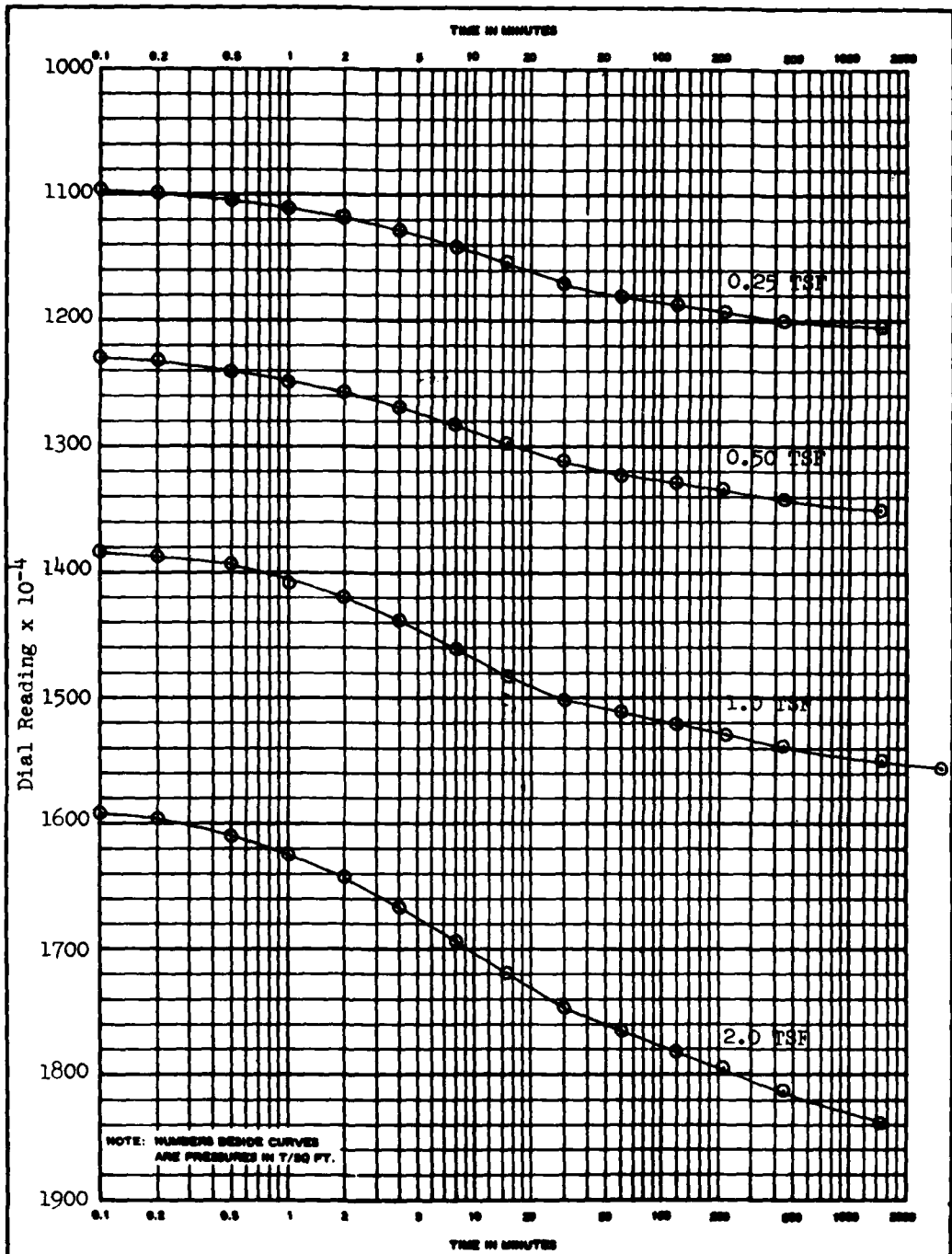
Type of Specimen		UNDISTURBED		Before Test		After Test	
Diam	2.50 in.	Ht	1.4003 in.	Water Content, w_o	43.2 %	w_f	%
Overburden Pressure, P_o	T/sq ft	Void Ratio, e_o	1.15	e_f			
Preconsol. Pressure, P_c	T/sq ft	Saturation, S_o	100+	%	S_f	%	
Compression Index, C_c		Dry Density, γ_d	79.3	lb/ft ³			
Classification	PLASTIC CLAY(CH),*	k_{20} at $e_o =$		$\times 10^{-7}$ cm/sec			
LL	56	G_s	2.73	Project	WEST POINT, N. Y.		
PL	27	D_{10}		Area			
Remarks	Initial void ratio held constant by $p = 0.036$ TSF after inundation. *gray			Boring No.	DH-11	Sample No.	11
				Depth	82.0-83.8	Date	14 Jan. 1976
				El			

CONSOLIDATION TEST REPORT

ENG FORM 2090 1 MAY 65 PREVIOUS EDITIONS ARE OBSOLETE. (TRANSLUCENT)

0 3424

PLATE A15
(SHEET 1 OF 4)



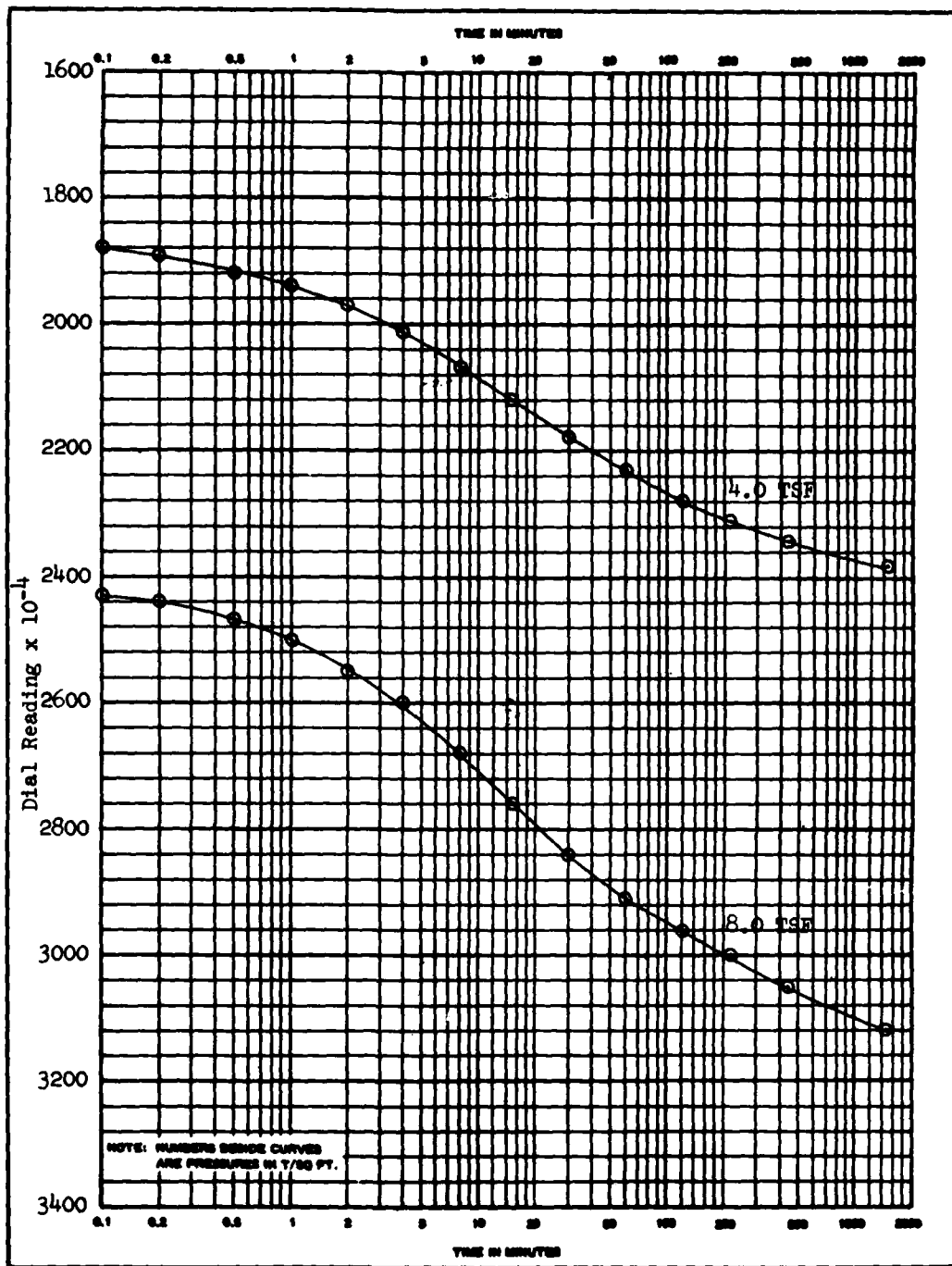
Project WEST POINT, N. Y.

Area

Boring No. DH-11	Sample No. 11	Depth ft. 82.0-83.8	Date 14 Jan. 1976
------------------	---------------	---------------------	-------------------

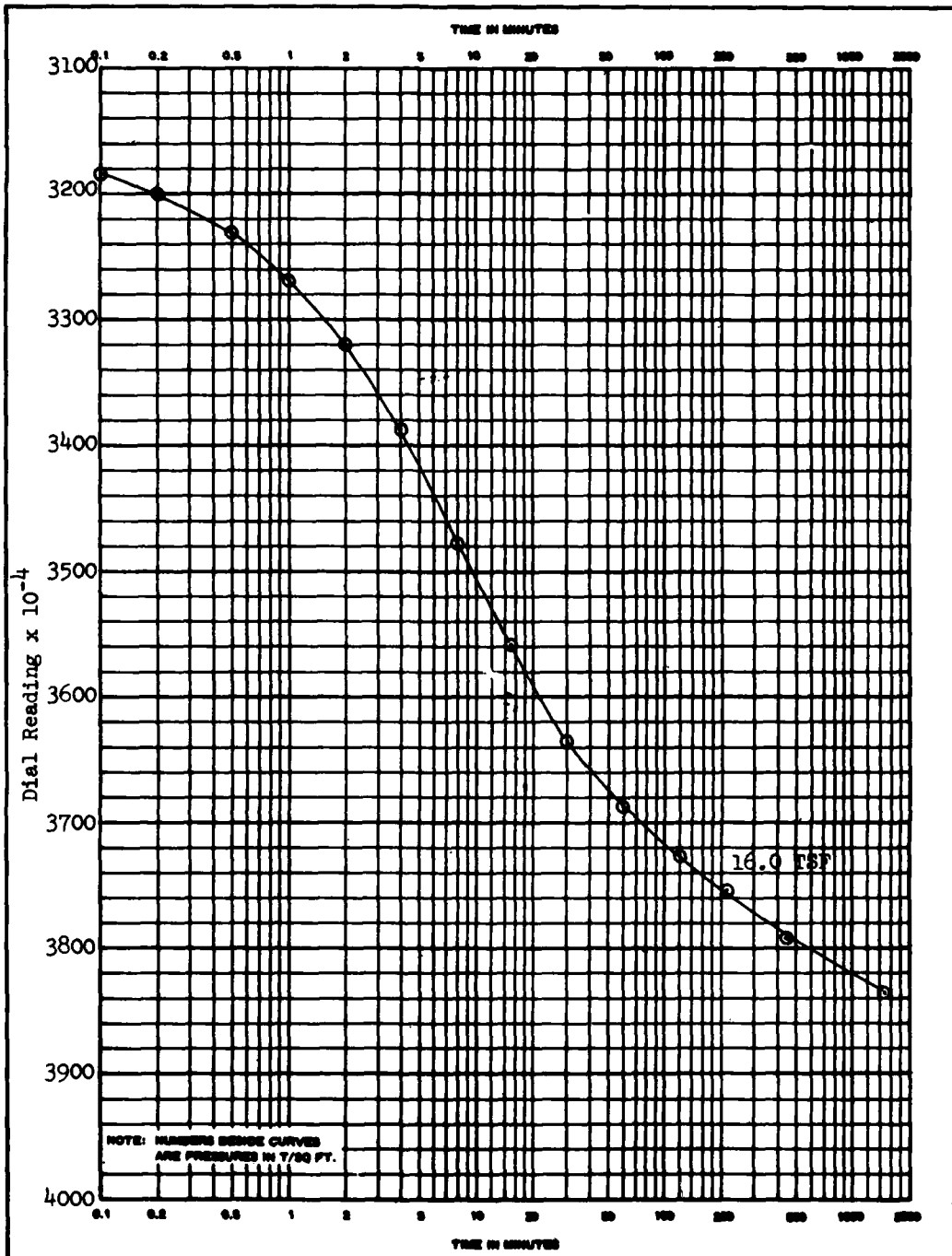
CONSOLIDATION TEST-TIME CURVES

PLATE A15
(SHEET 2 OF 4)



Project WEST POINT, N. Y.			
Area			
Spring No. DH-11	Sample No. 11	Depth 82.0-83.8	Date 14 Jan. 1976
<small>END FORM 2000 1 MAY 60 PREVIOUS EDITIONS ARE OBSOLETE.</small>			CONSOLIDATION TEST-TIME CURVES <small>(TRANSFORMED)</small>

PLATE A15
(SHEET 3 OF 4)



Project WEST POINT, N. Y.			
Area			
Spring No. DH-11	Sample No. 11	Depth 82.0-83.8	Date 14 Jan. 1976
<small>USE FORM 3000 PREVIOUS EDITIONS ARE OBSOLETE.</small>			CONSOLIDATION TEST--TIME CURVES

PLATE A15
(SHEET 4 OF 4)

APPENDIX B: SOILS DATA, BORING WS-1 (1977),
UNCONFINED COMPRESSIVE STRENGTH

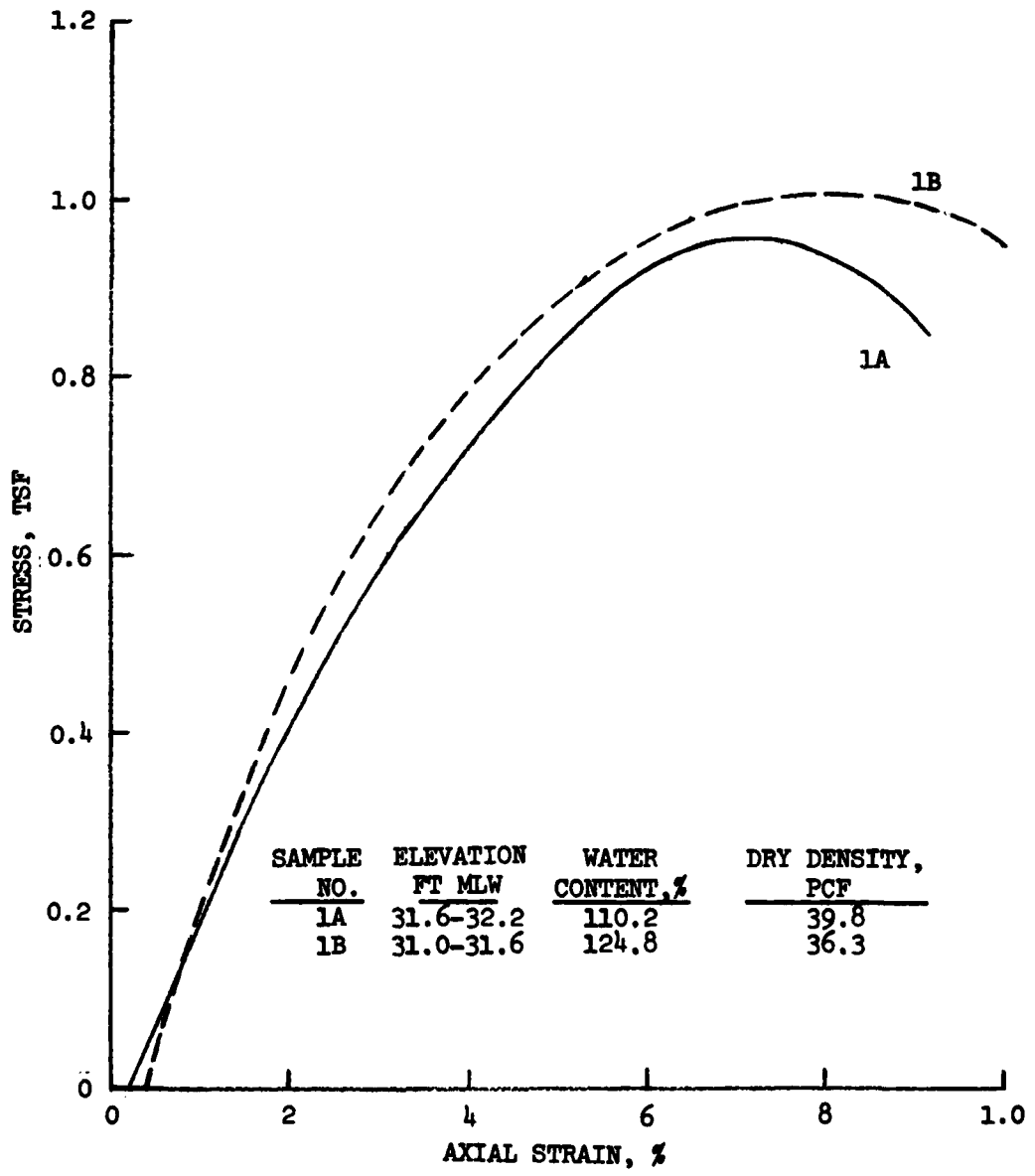


PLATE B1

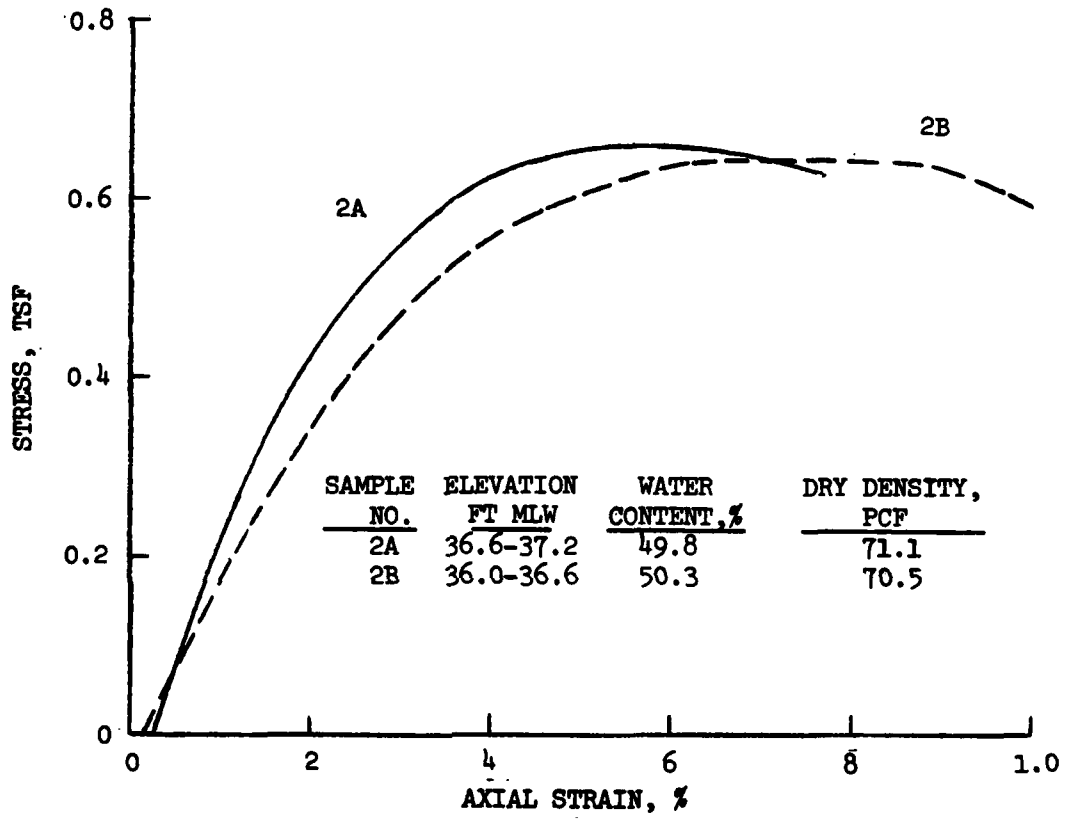


PLATE B2

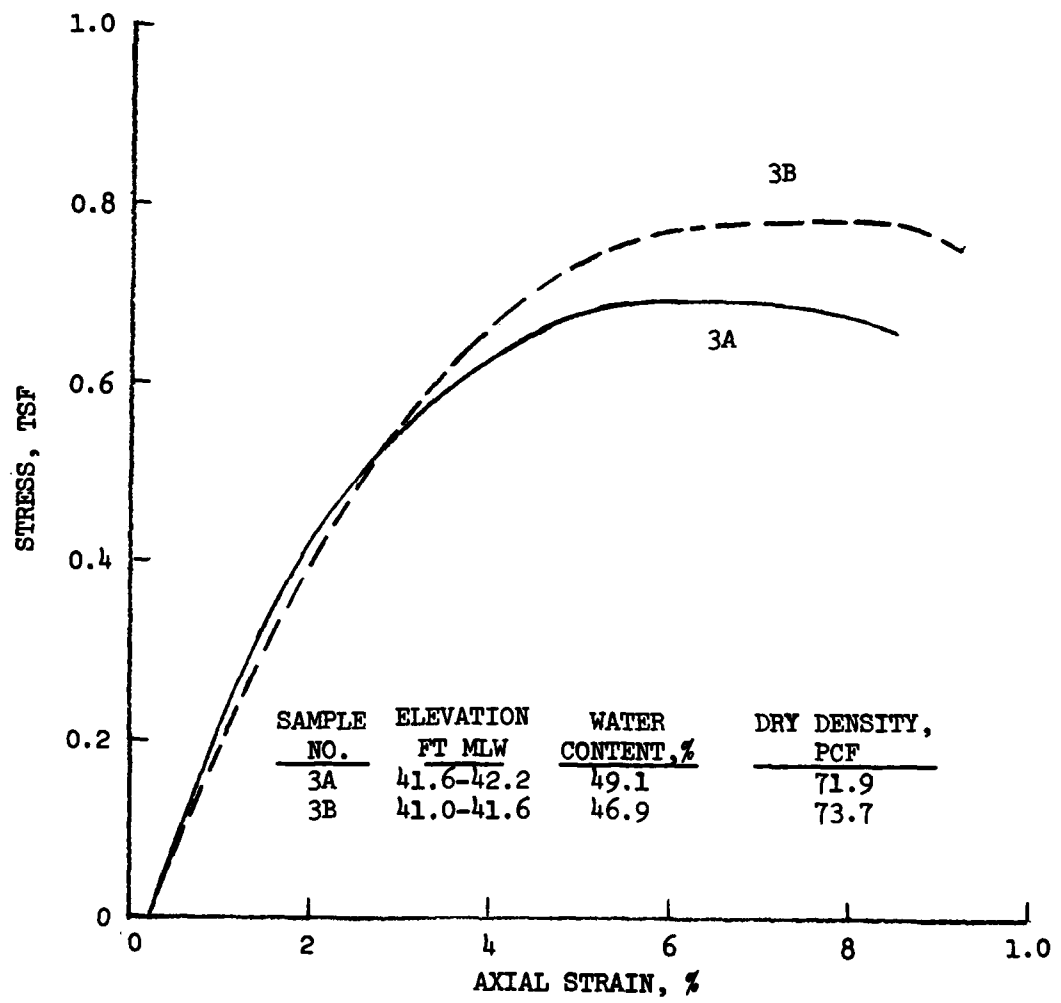


PLATE B3

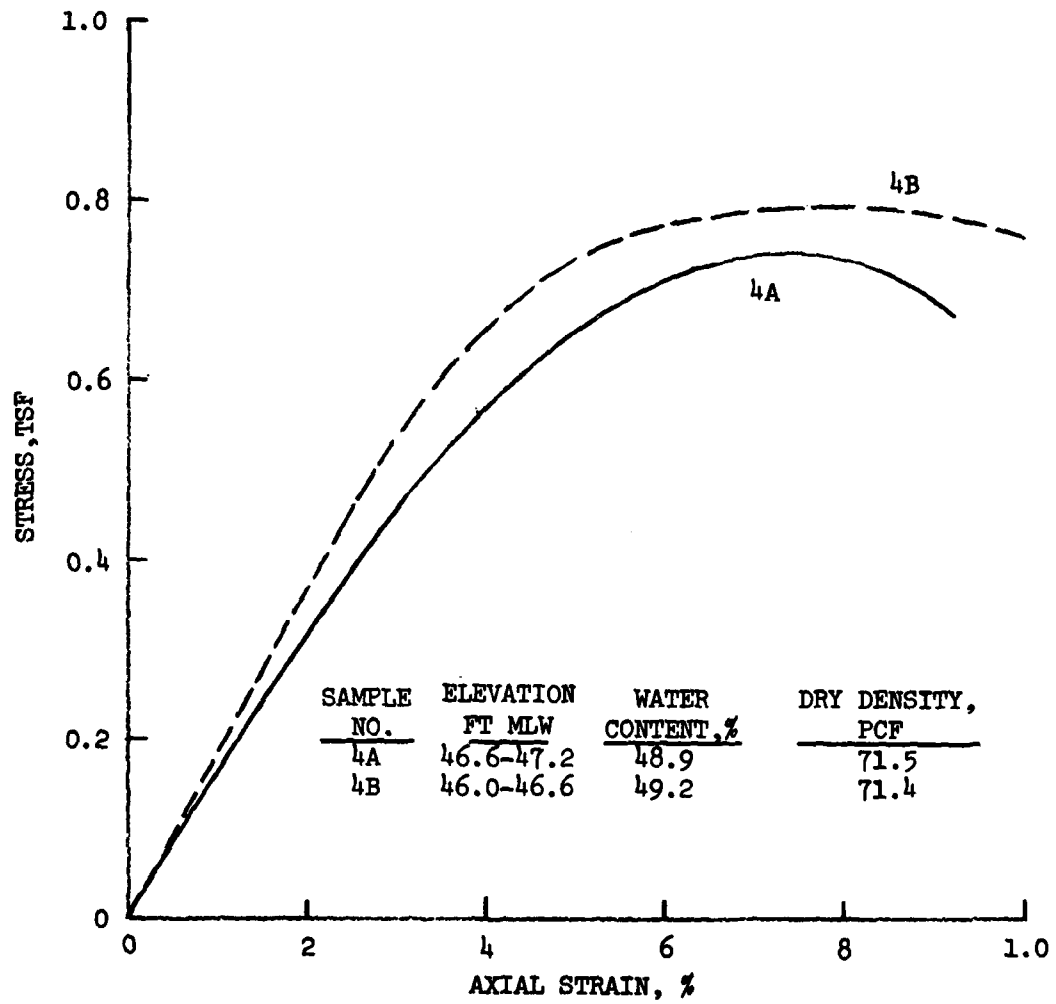


PLATE B4

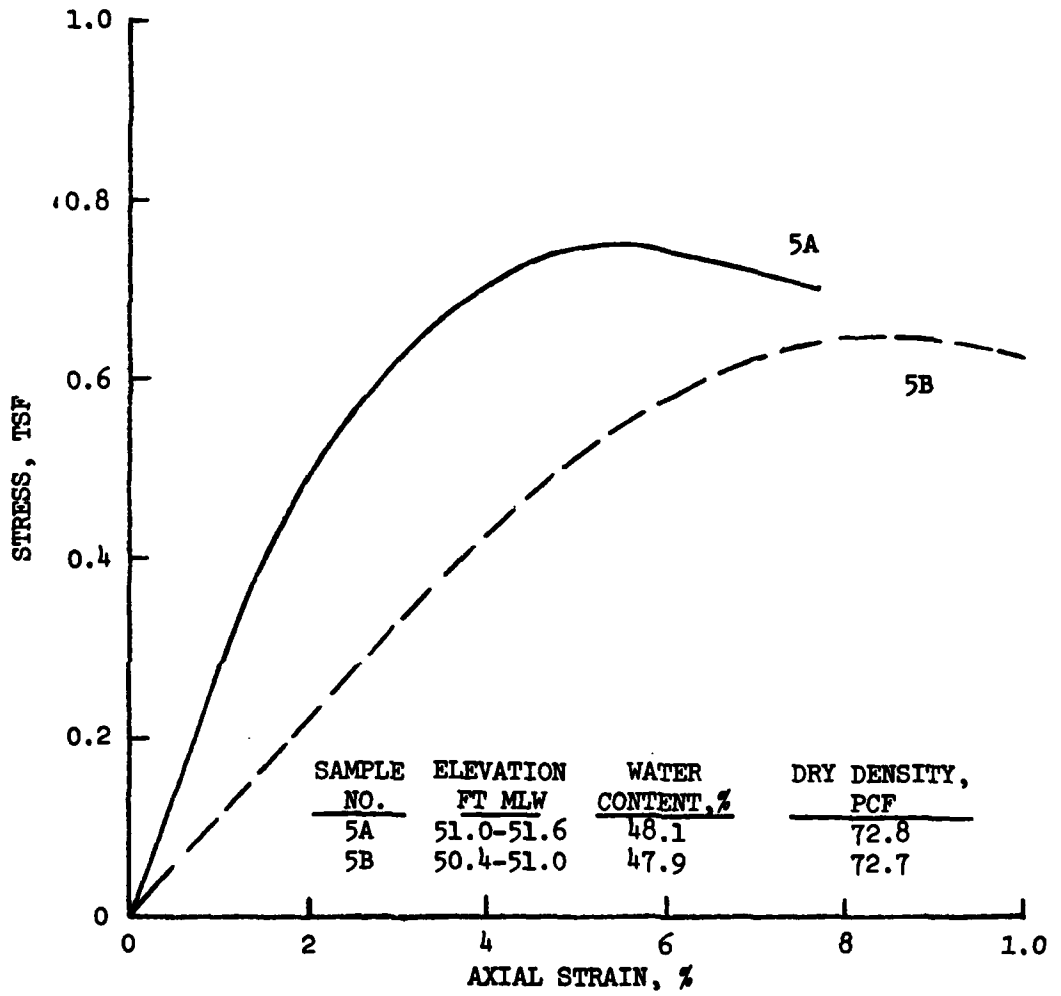


PLATE B5

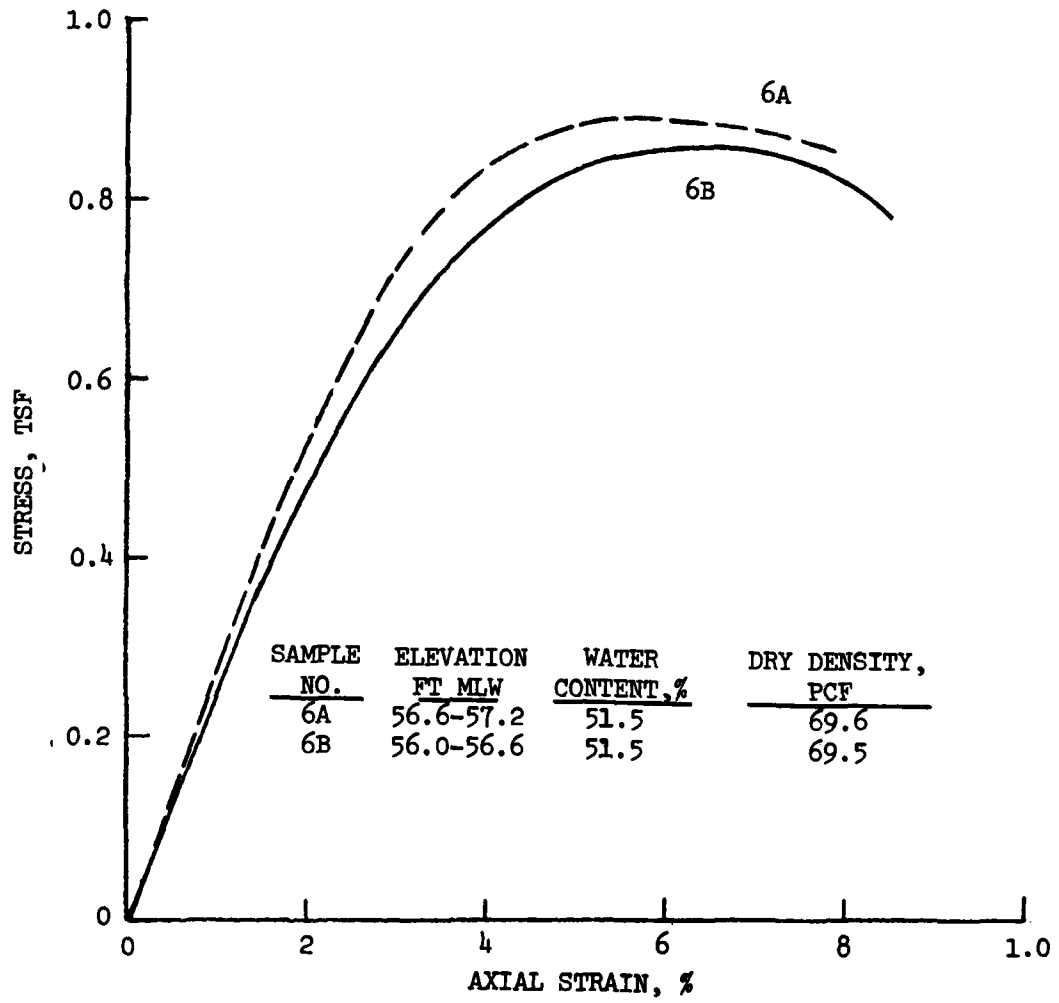


PLATE B6

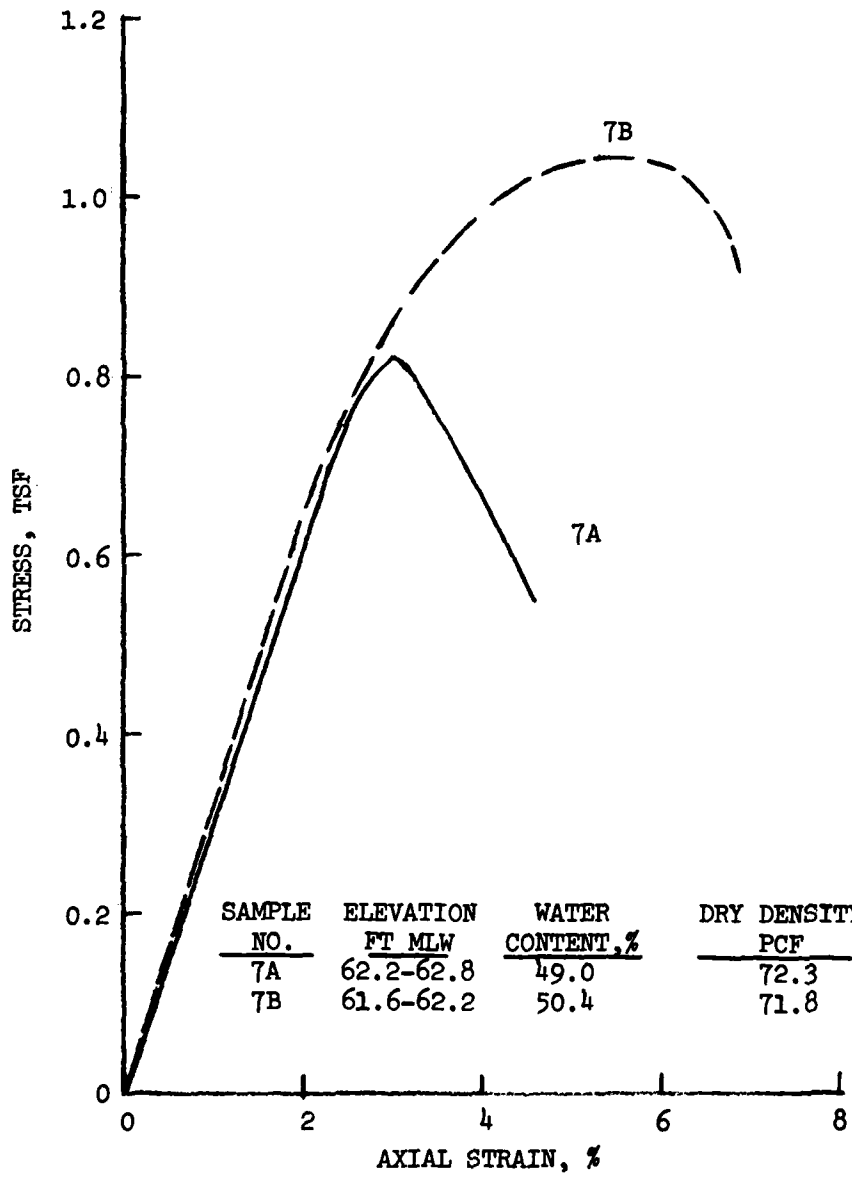
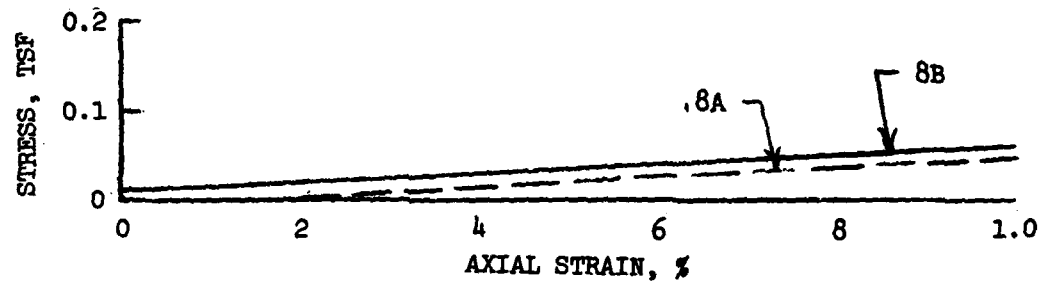


PLATE B7

8A PEAK AT 19.2%
8B PEAK AT 20.0%



SAMPLE NO.	ELEVATION FT MLW	WATER CONTENT, %	DRY DENSITY, PCF
8A	66.4-67.0	51.5	73.2
8B	65.8-66.4	51.1	69.1

PLATE B8

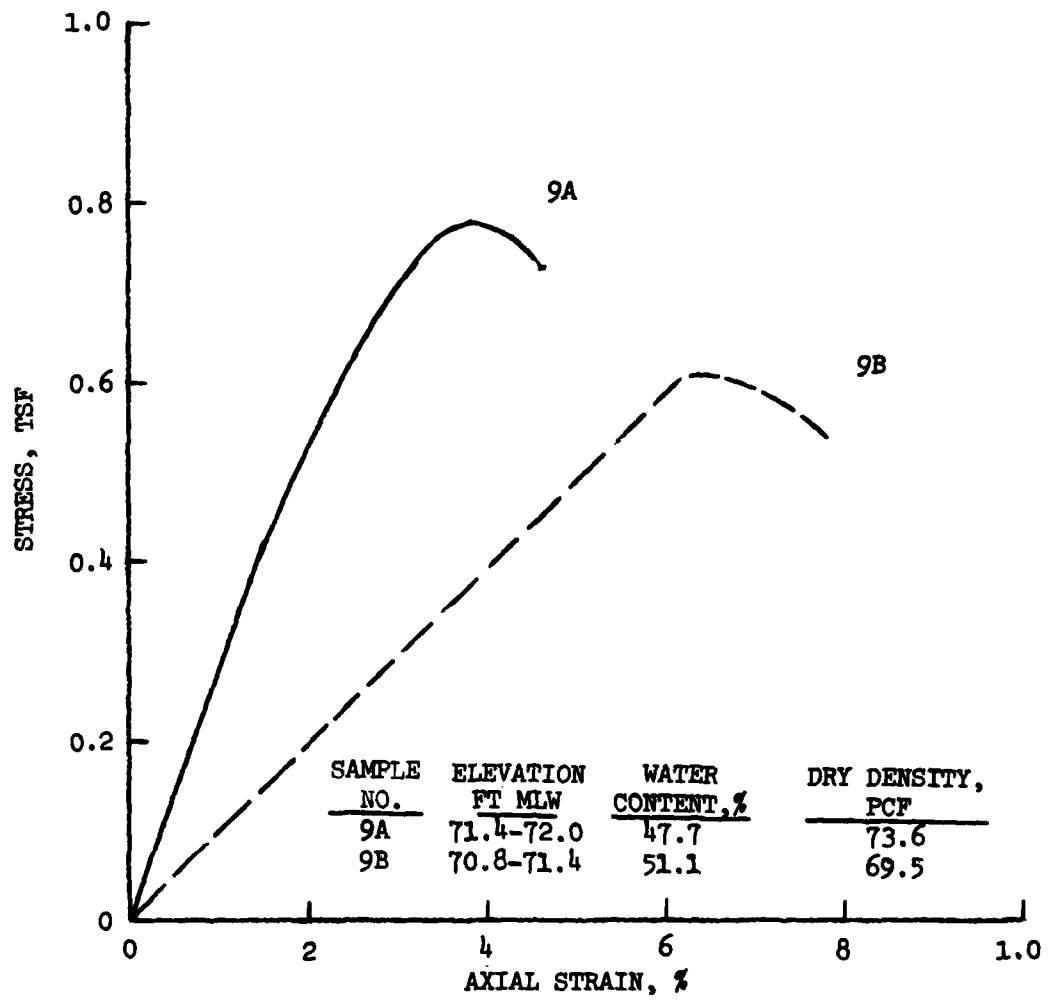


PLATE B9

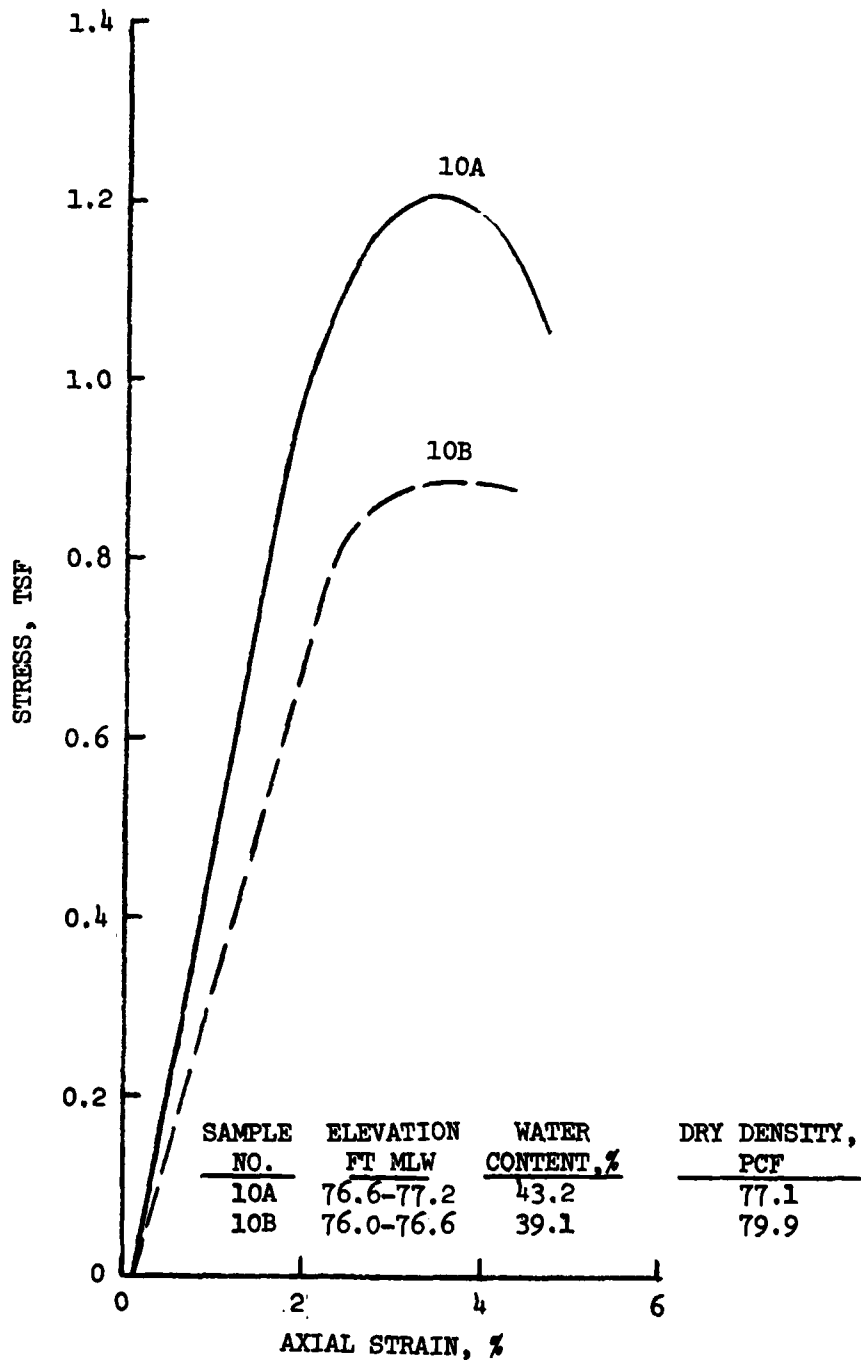


PLATE B10

B12

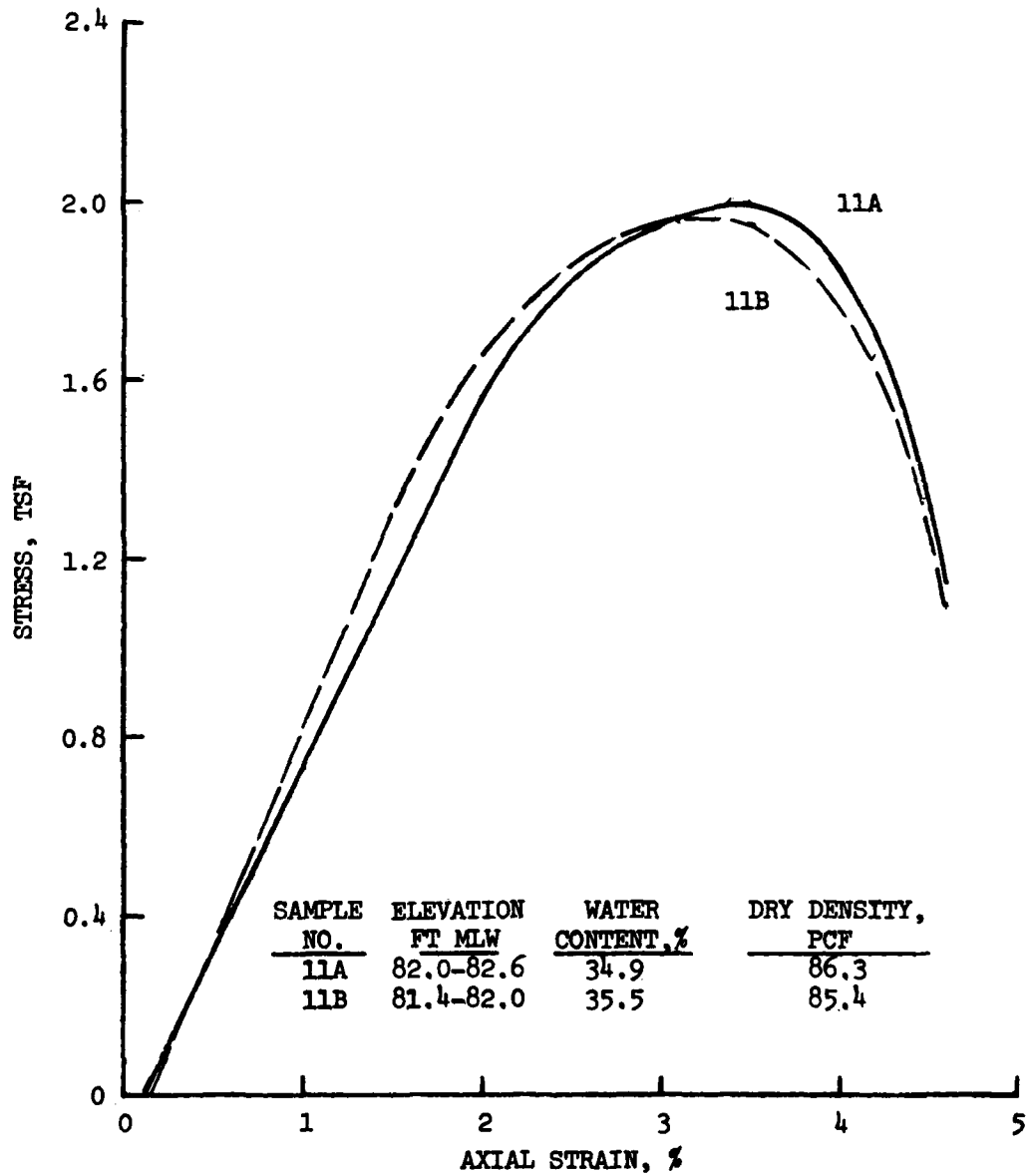


PLATE B11

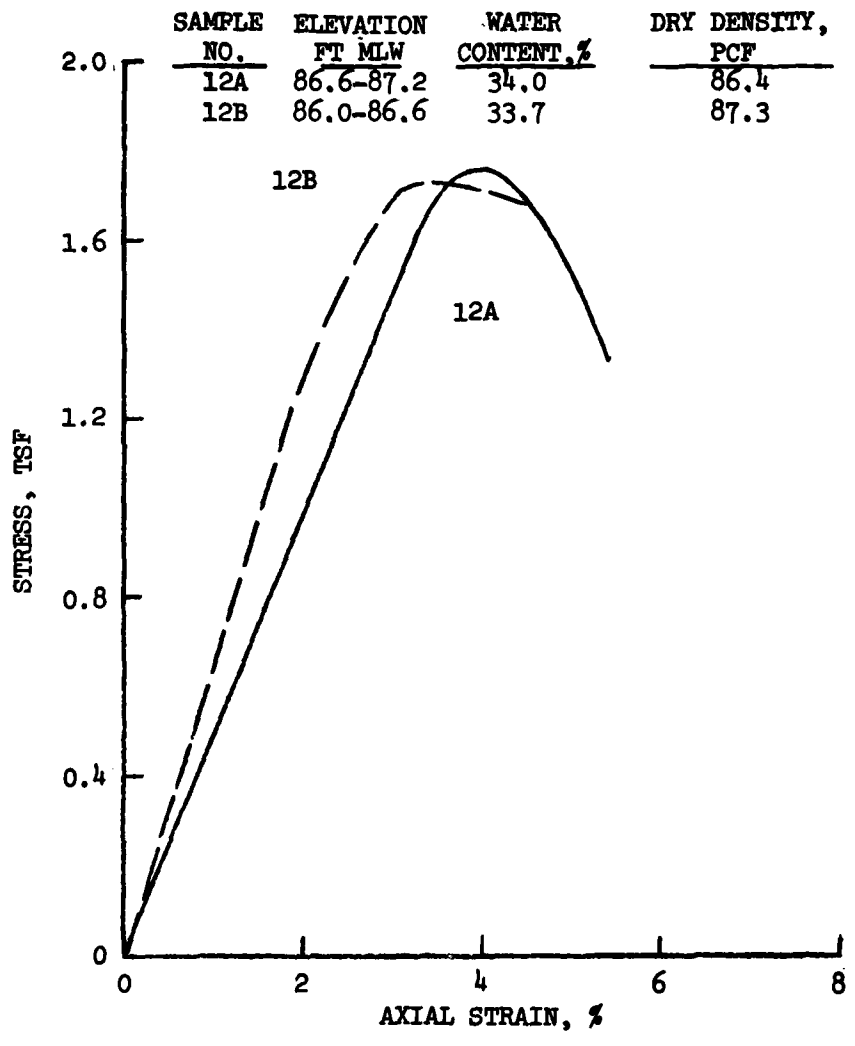


PLATE B12

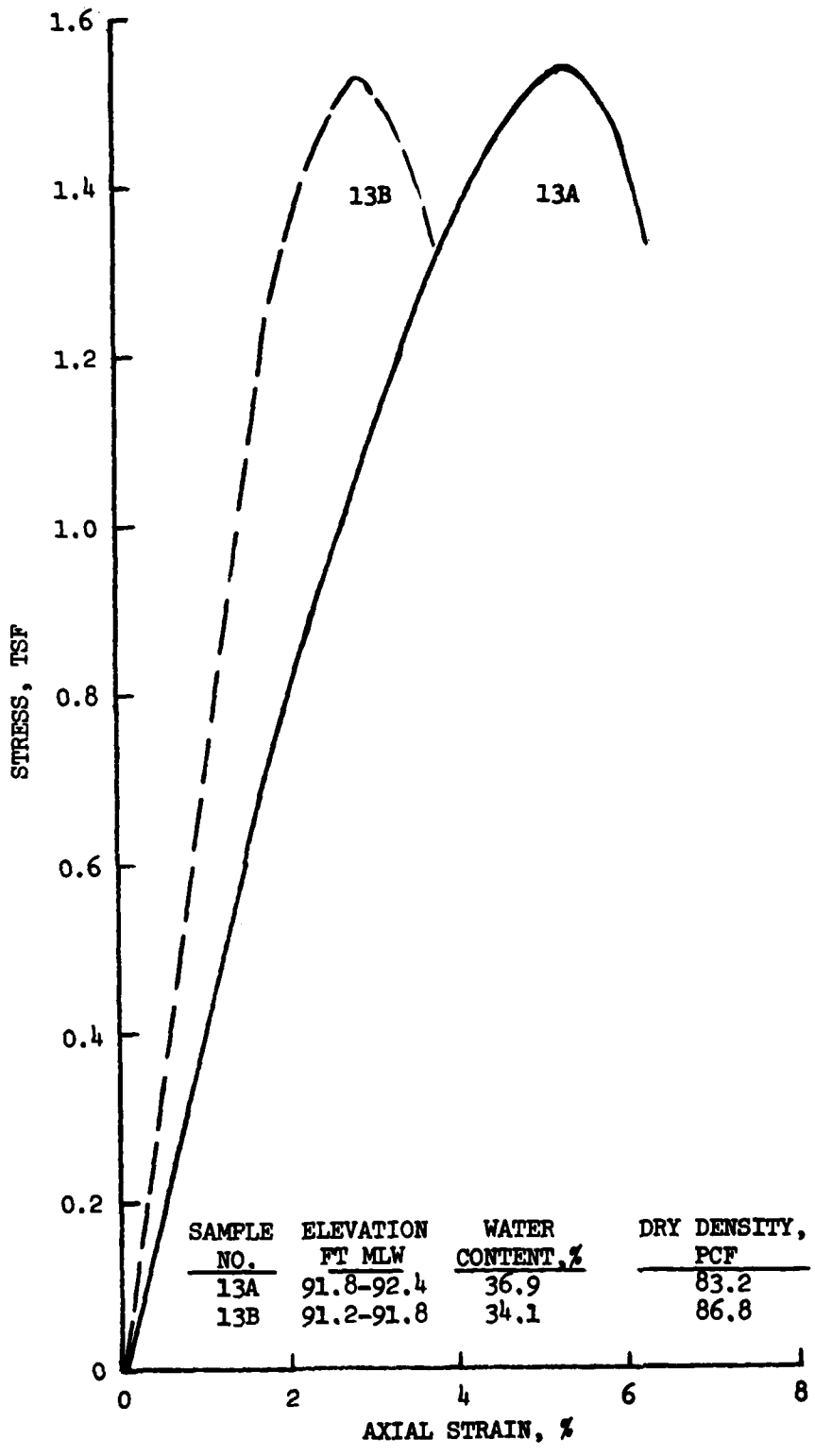


PLATE B13

B15

APPENDIX C: SOILS DATA, BORING WS-2 (1977), VANE SHEAR

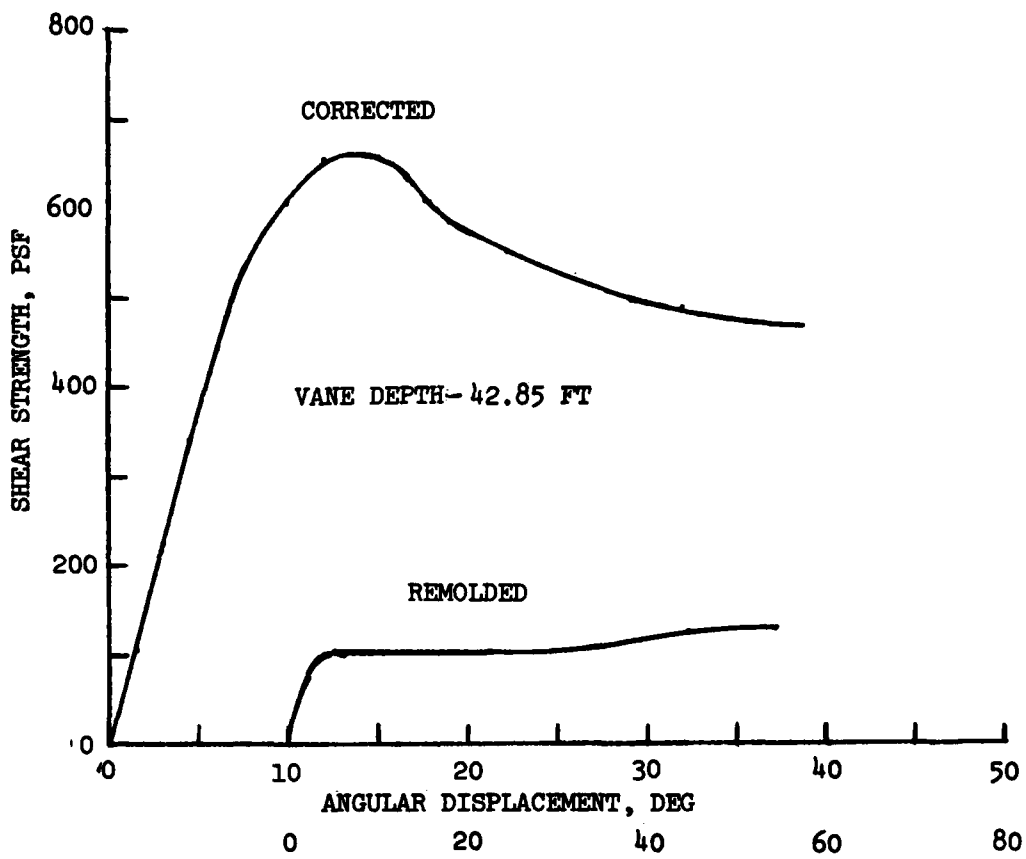


PLATE C1

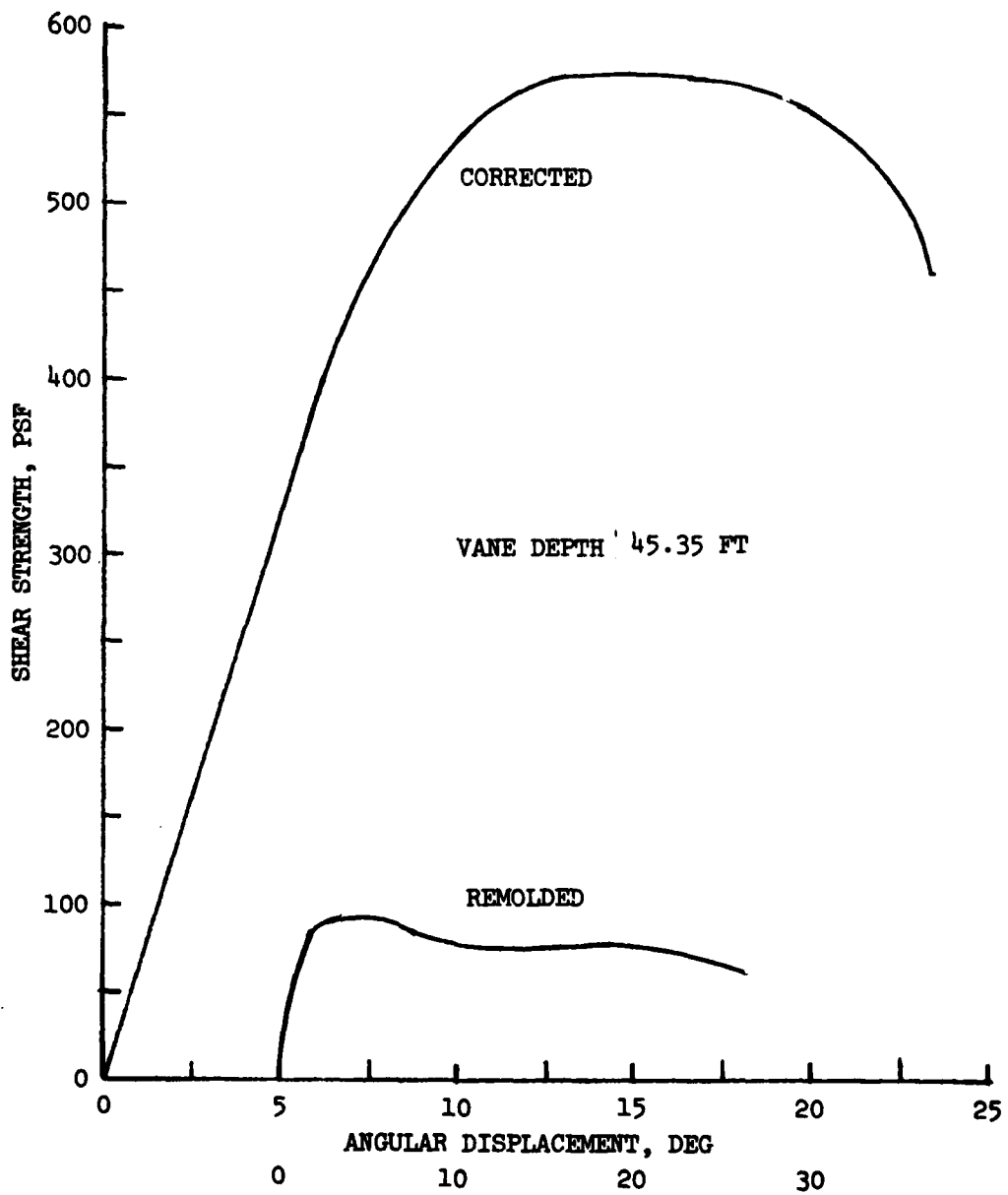


PLATE C2

C4

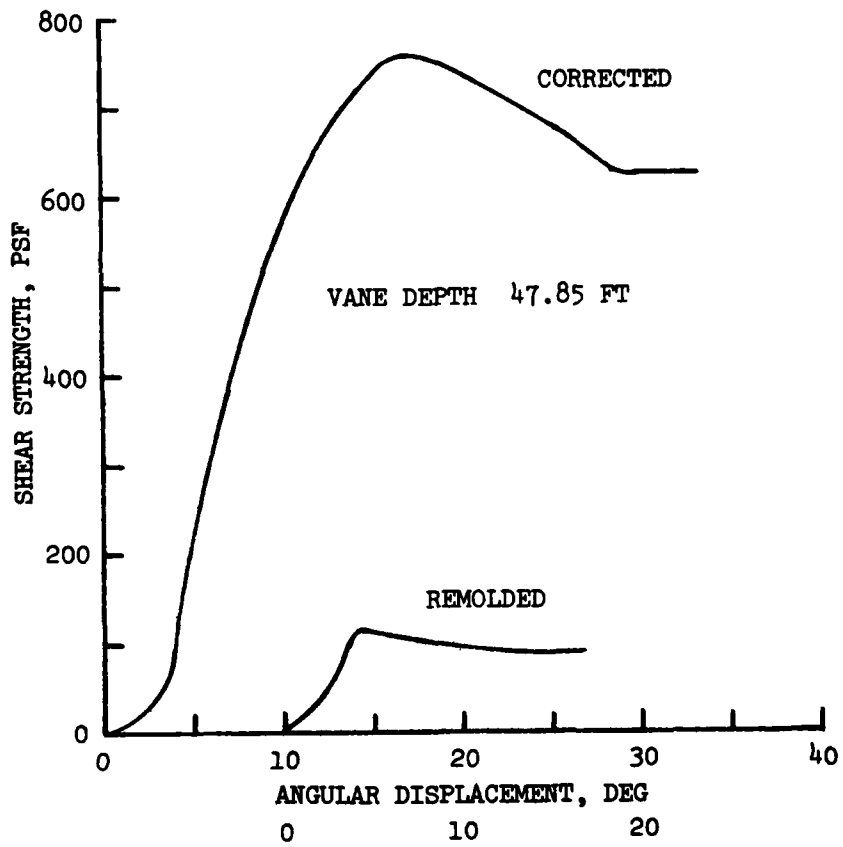


PLATE C3

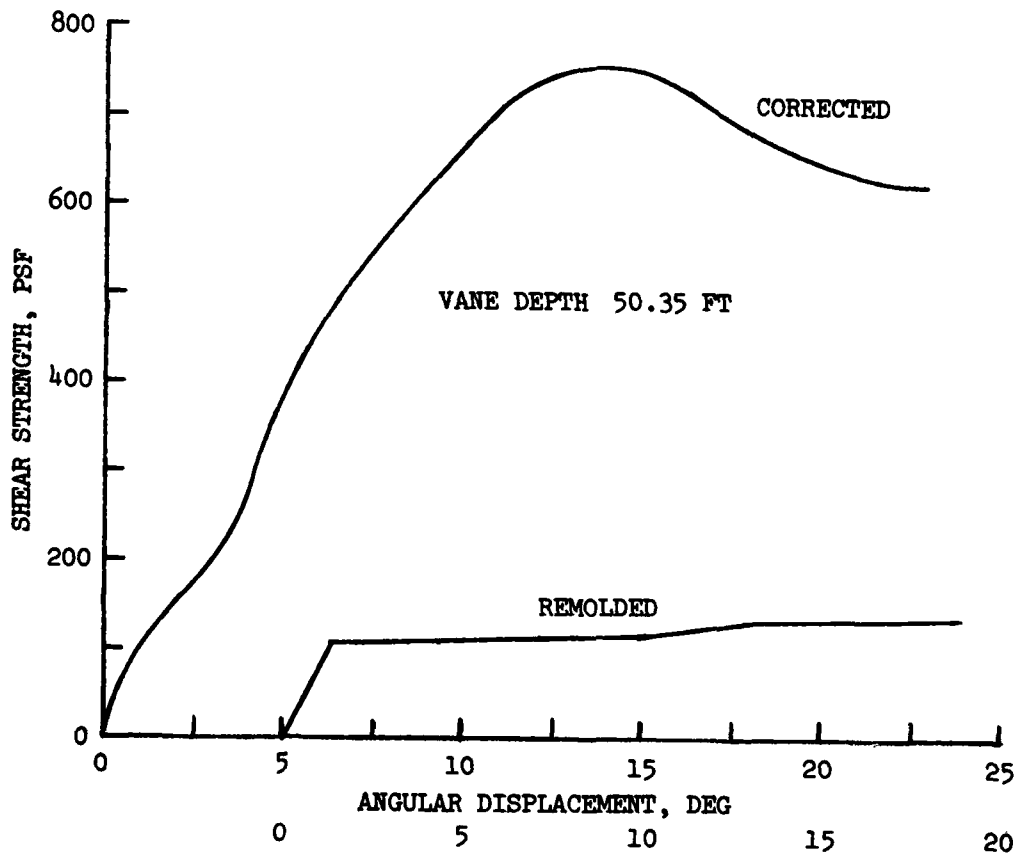


PLATE C4

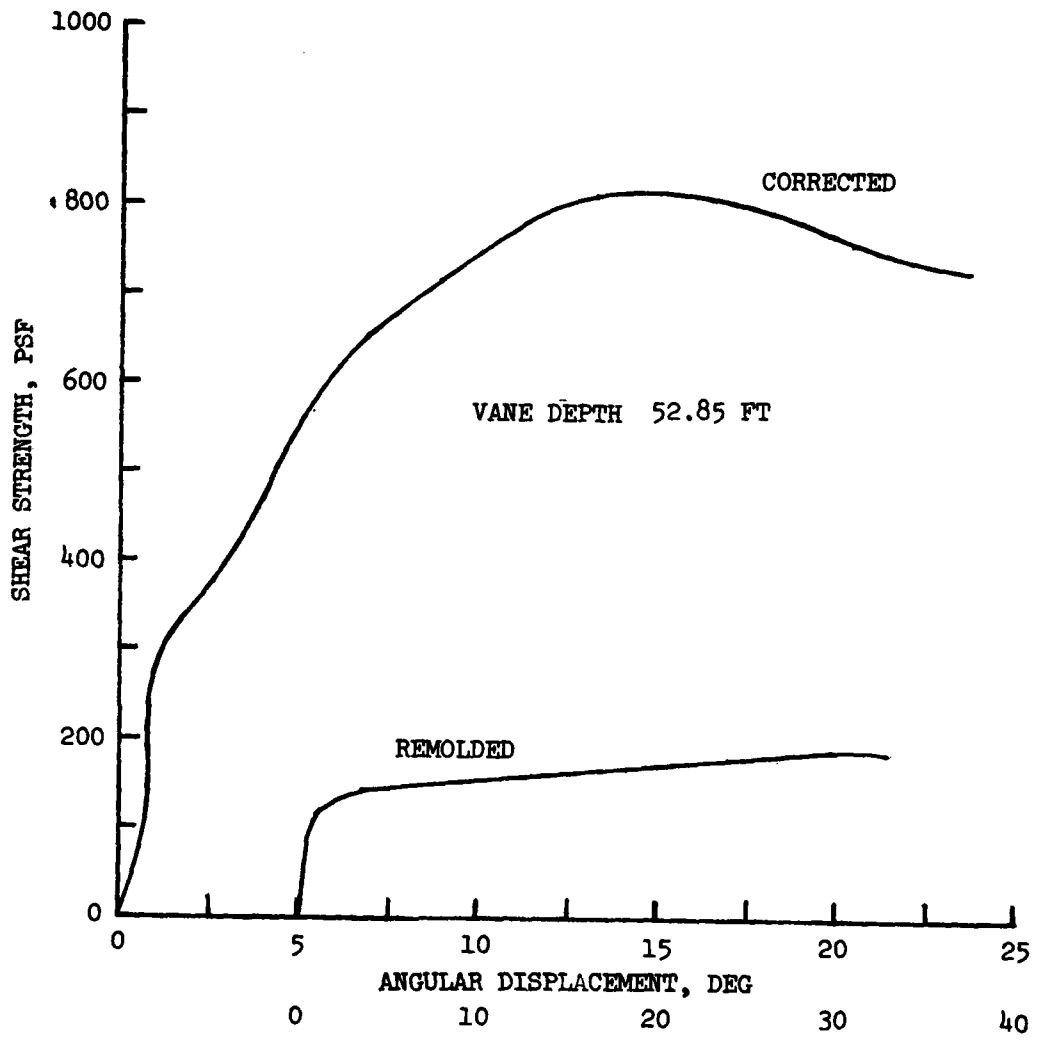


PLATE C5

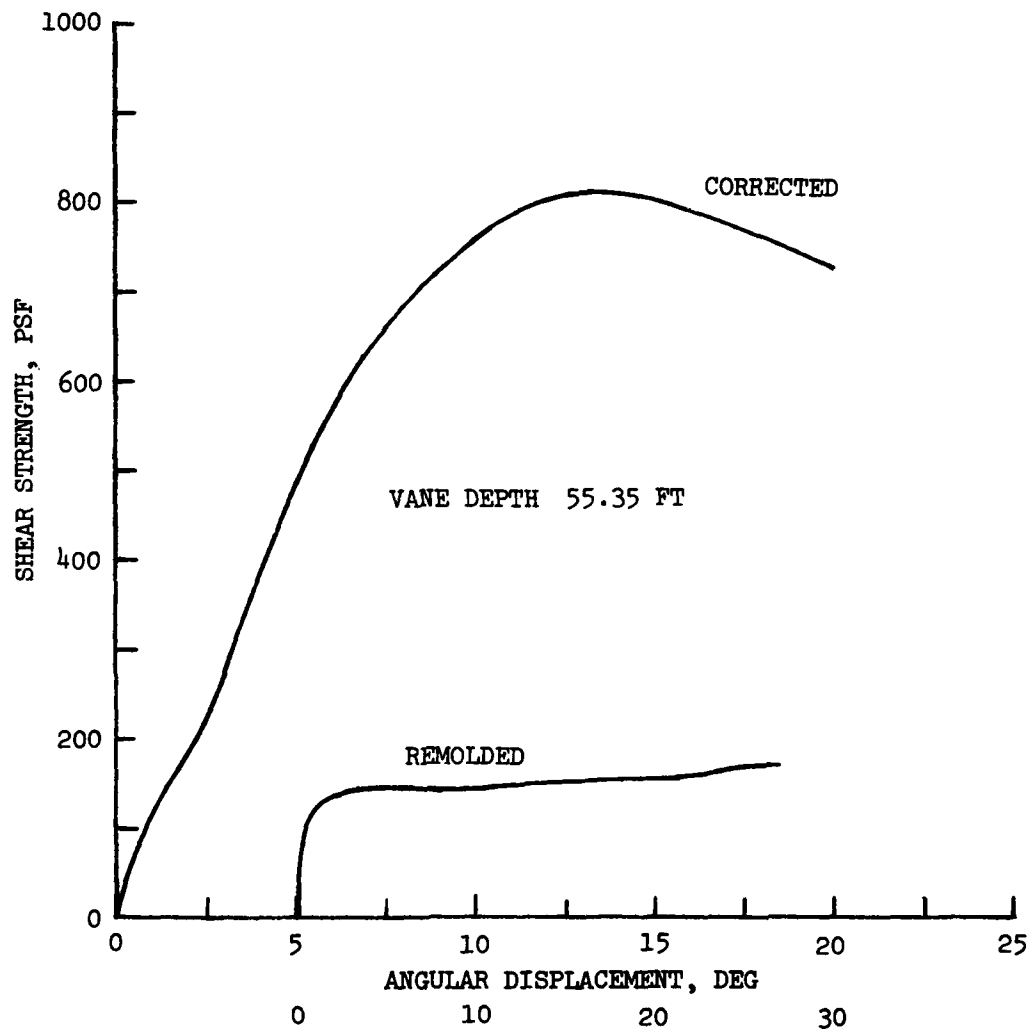


PLATE C6

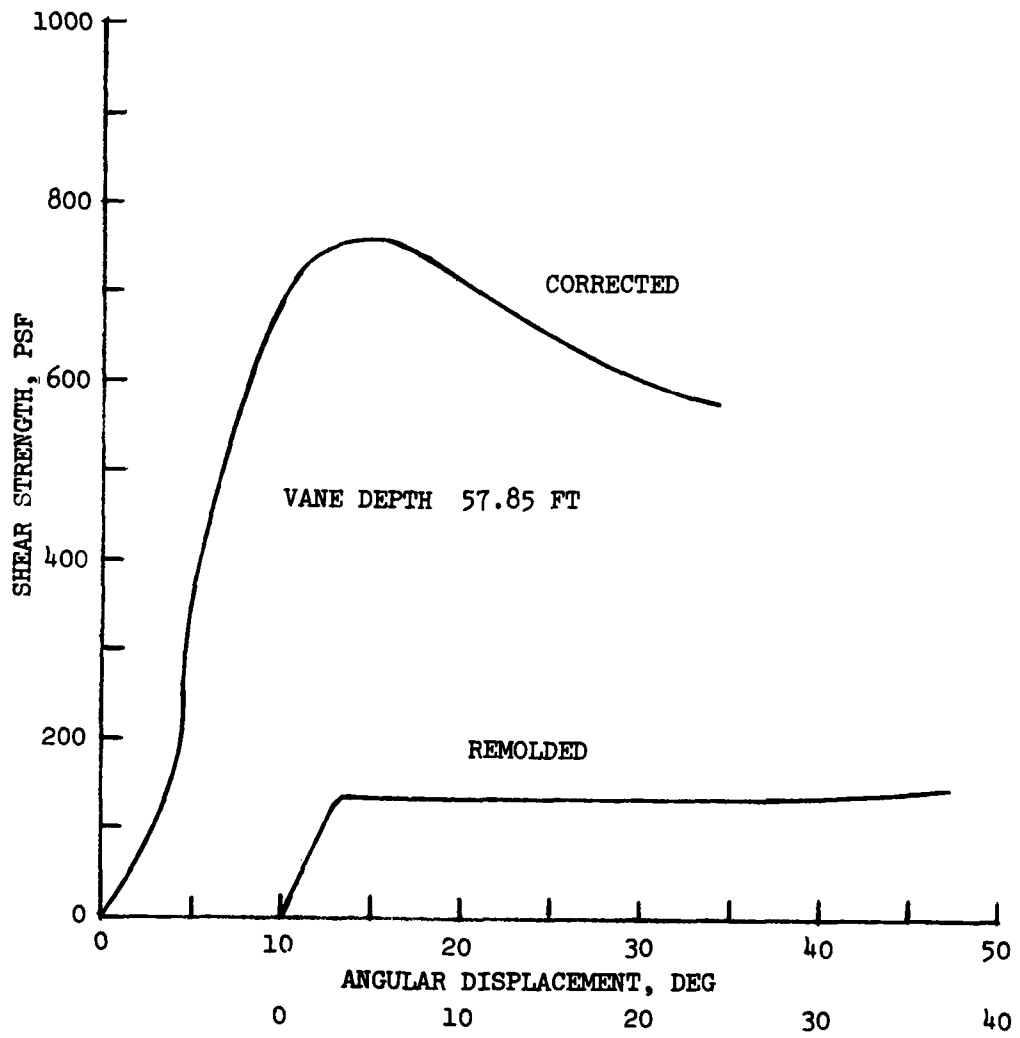


PLATE C7

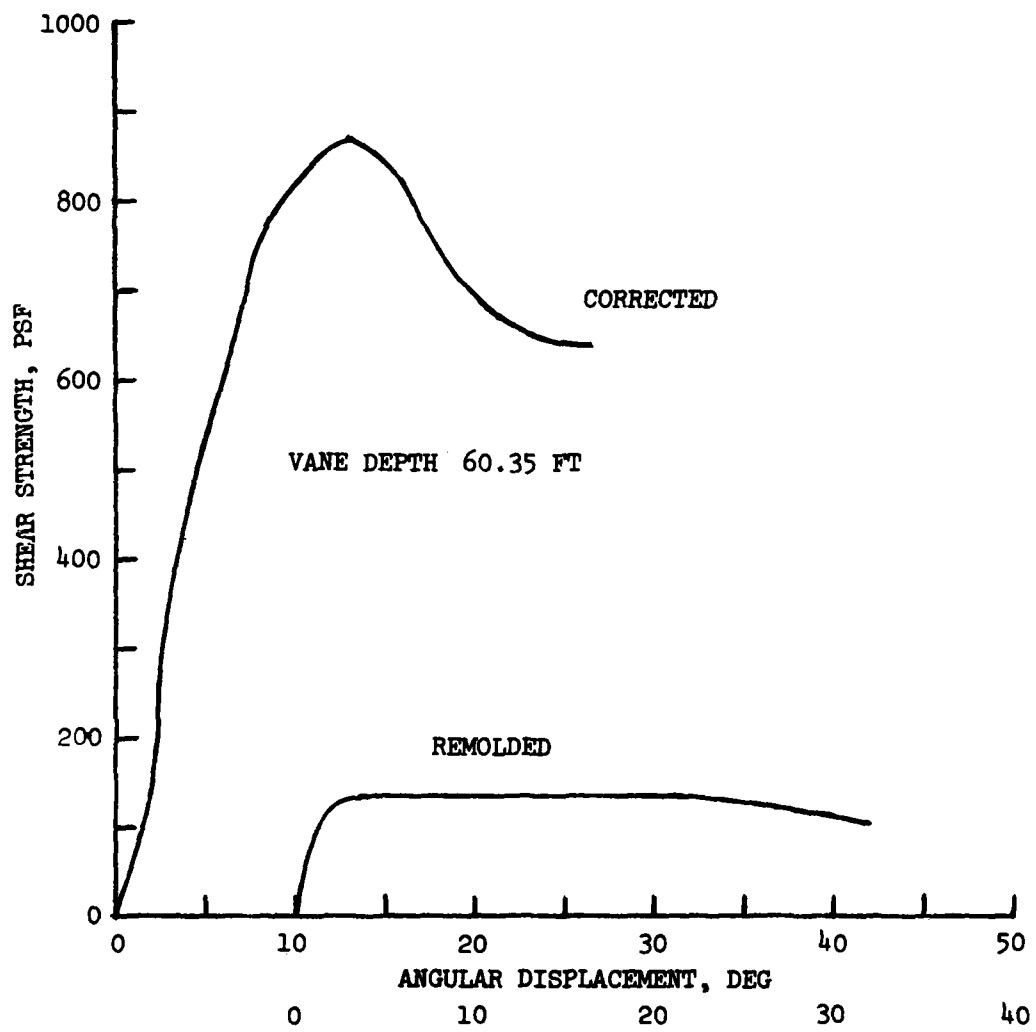


PLATE C8

C10

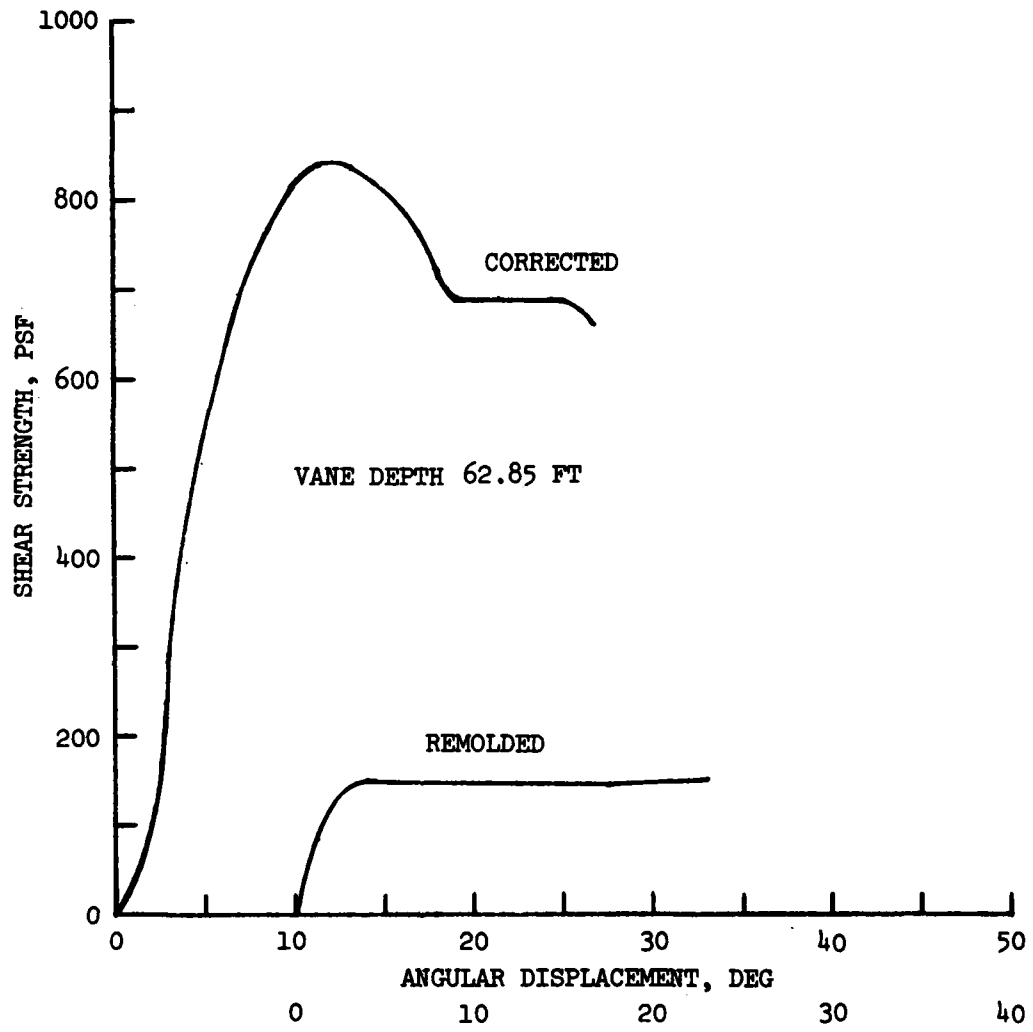


PLATE C9

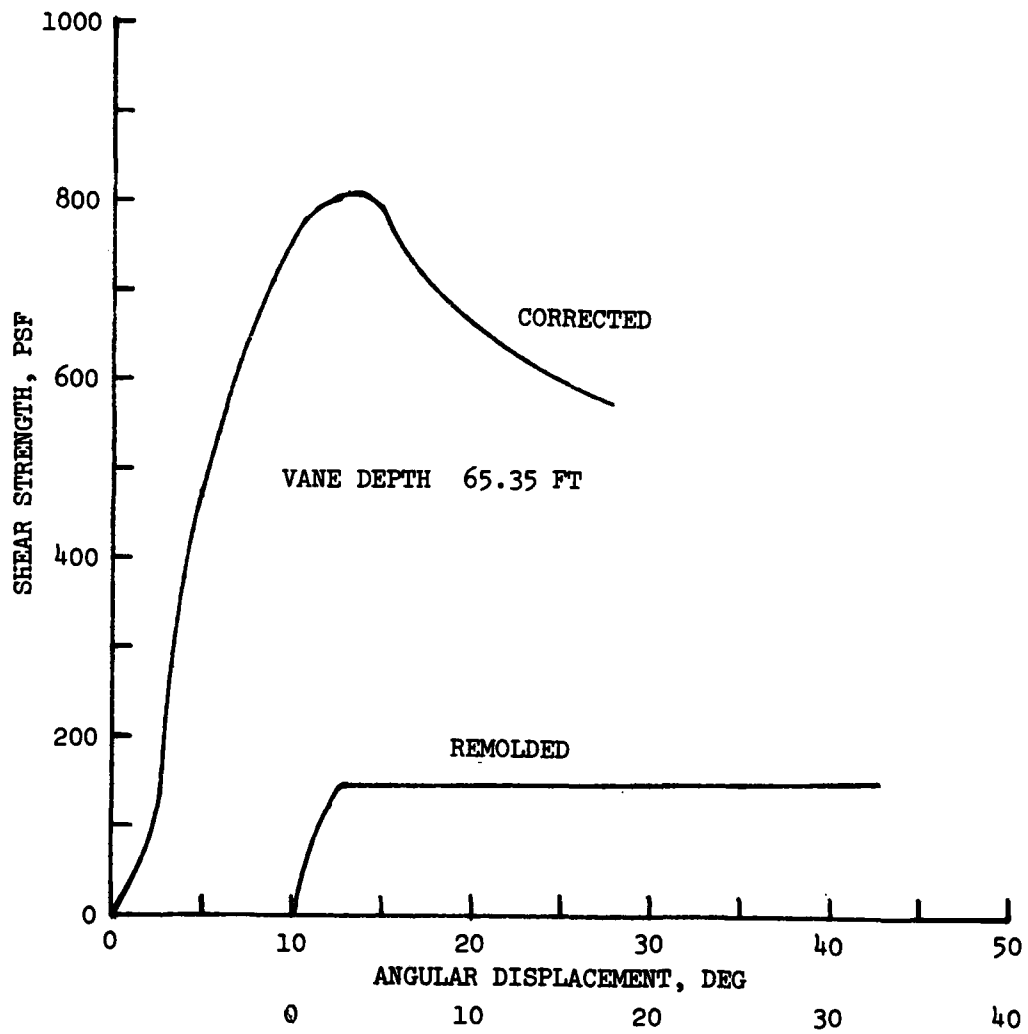


PLATE C10

C12

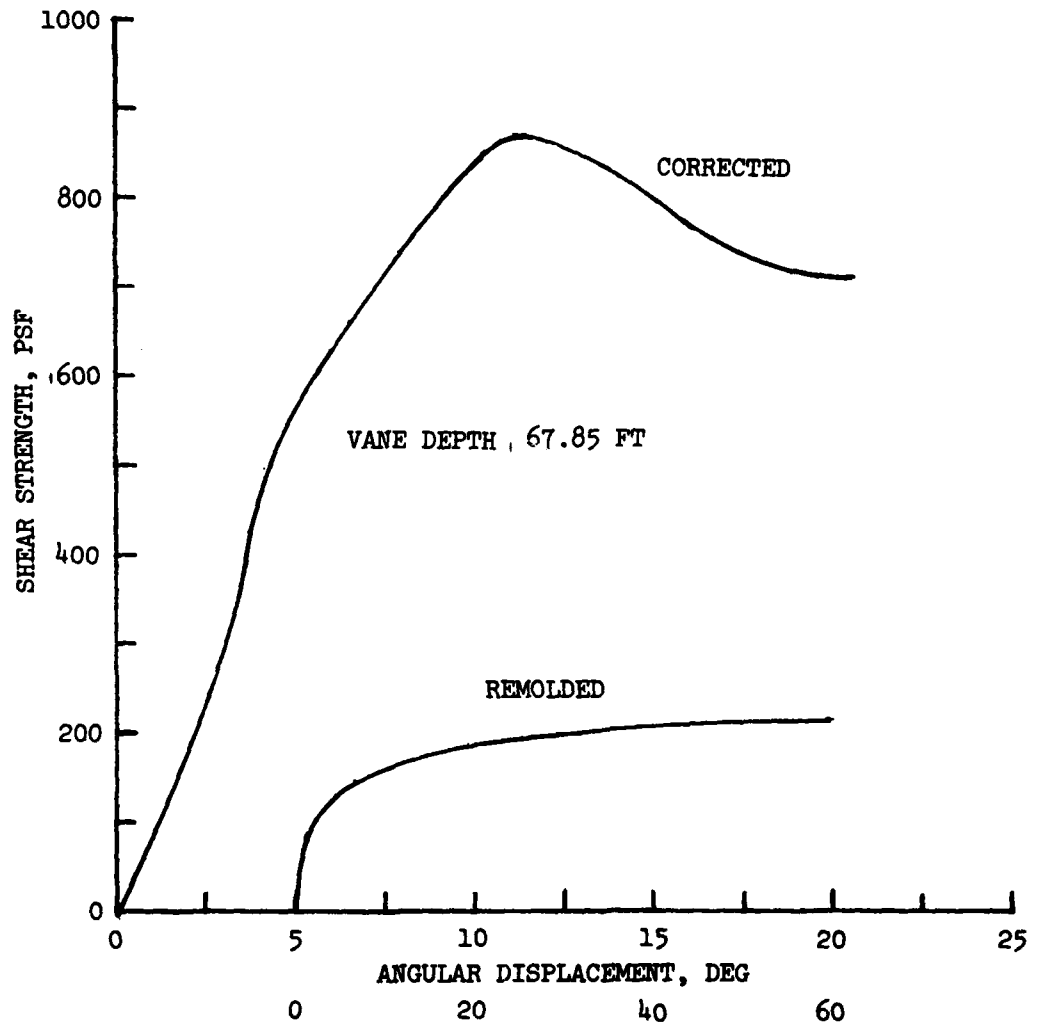


PLATE C11

C13

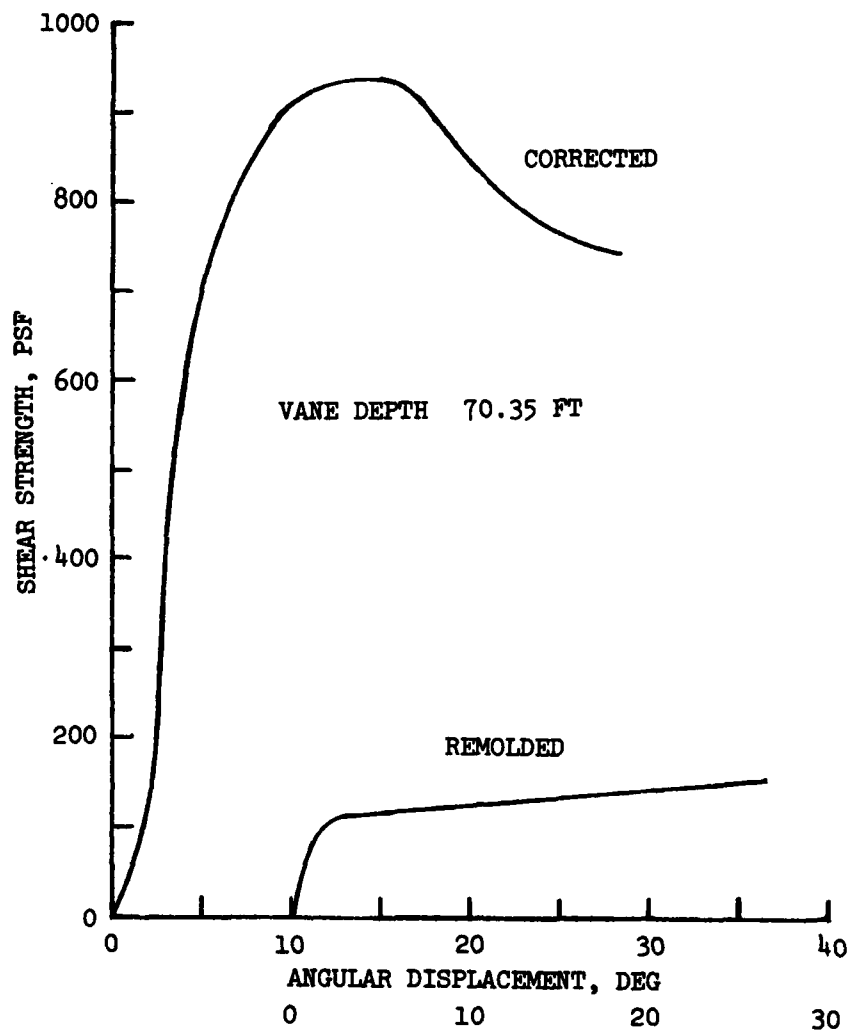


PLATE C12

C14

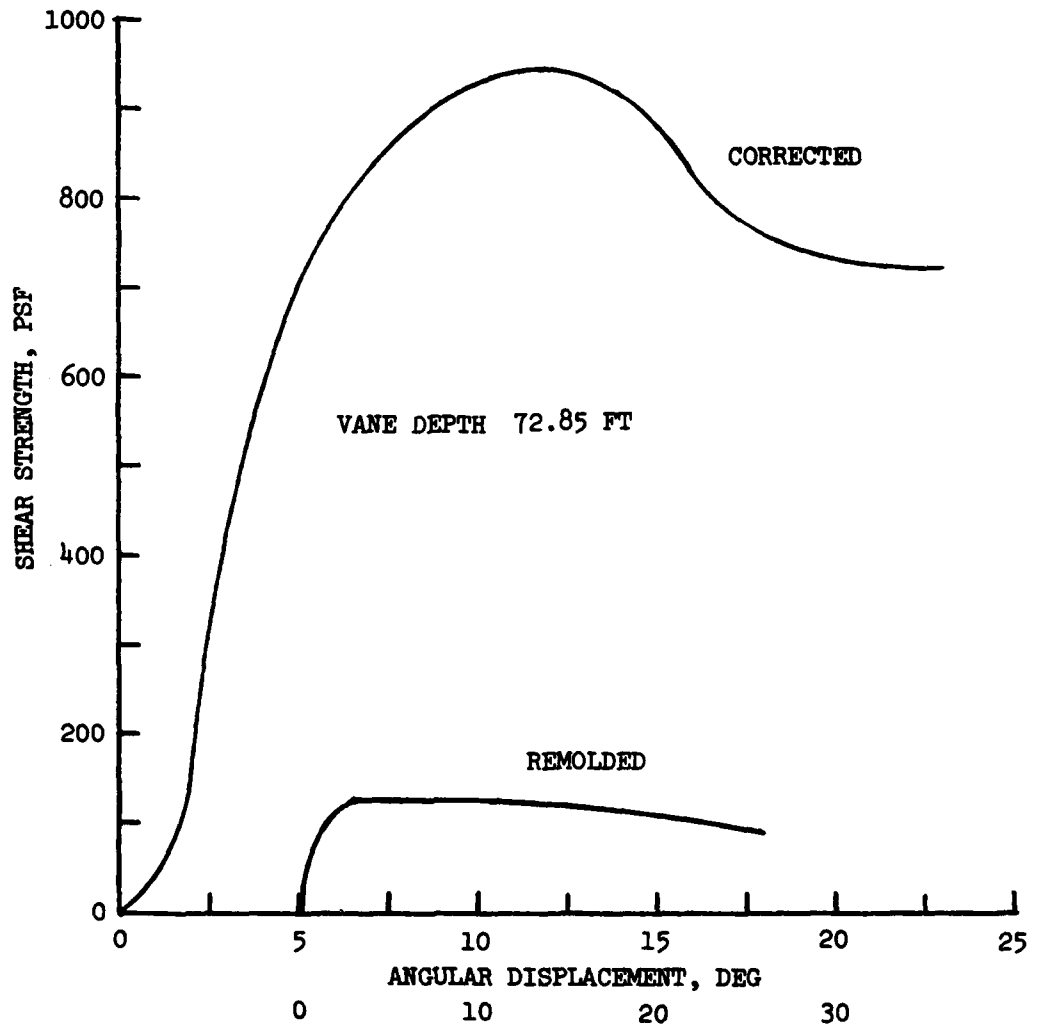


PLATE C13

C15

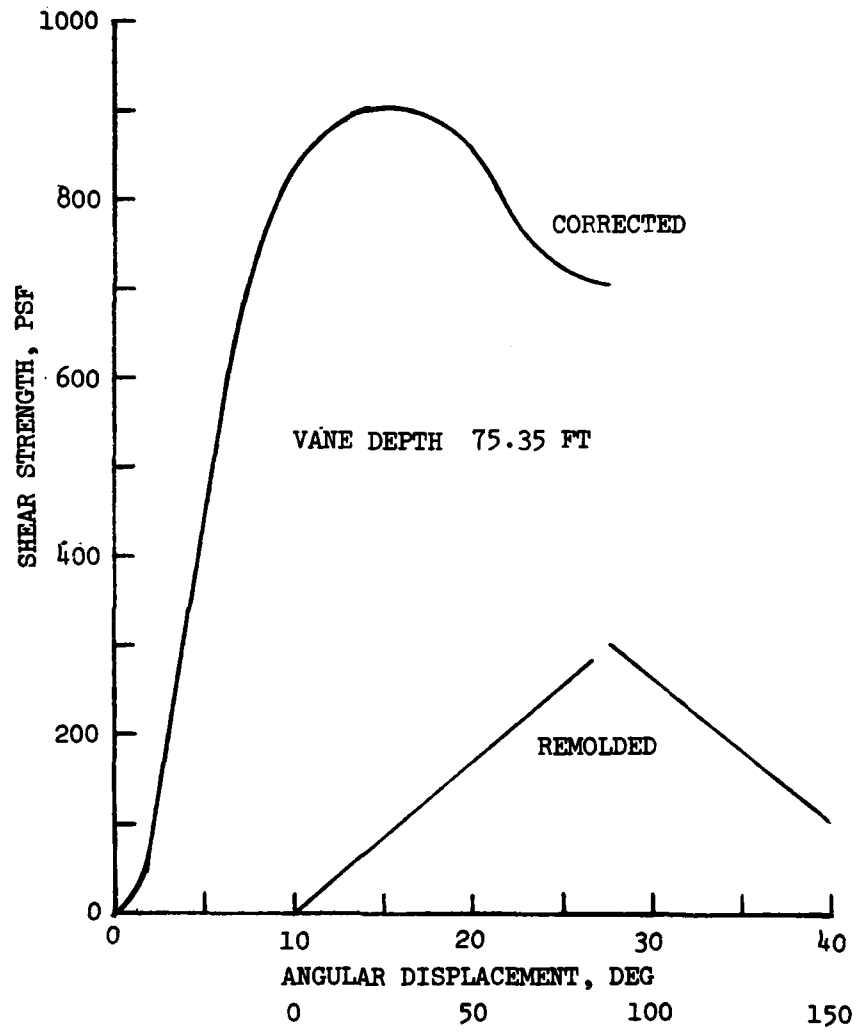


PLATE C14

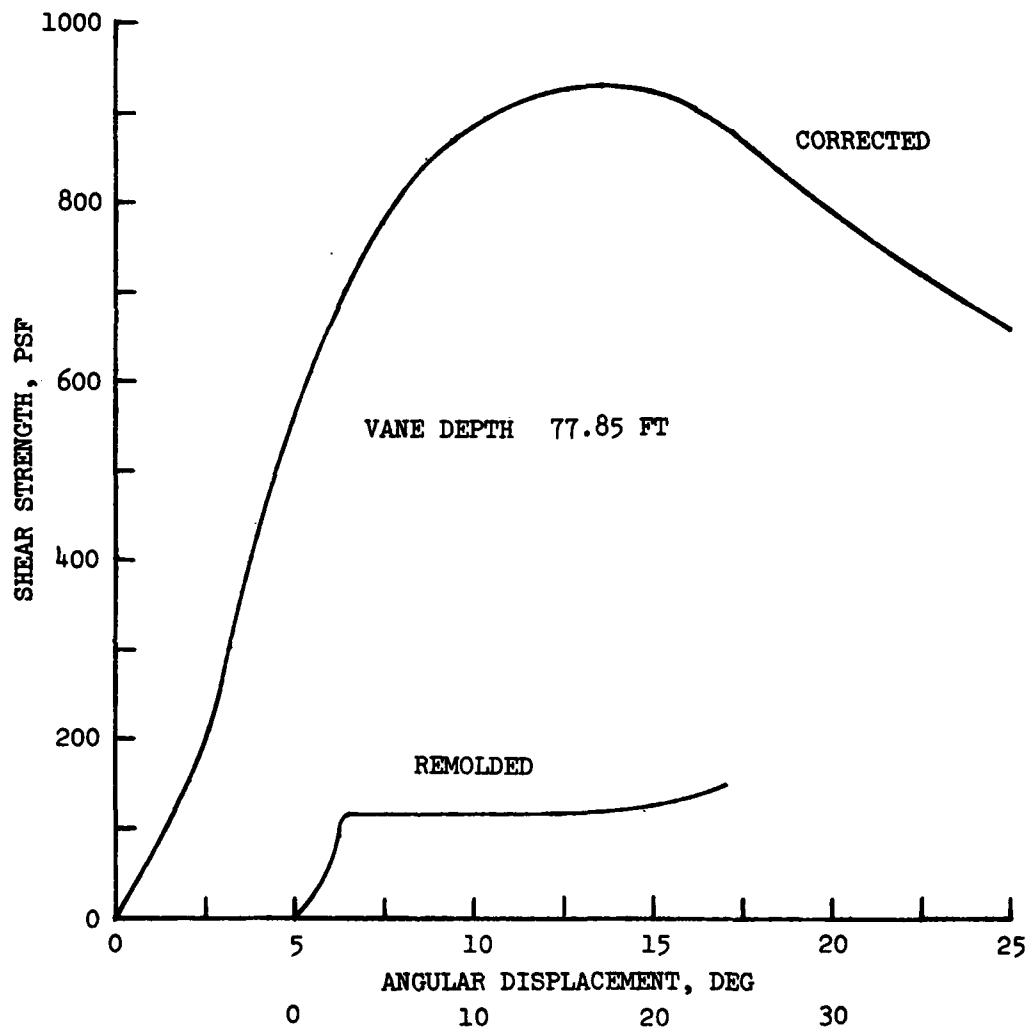


PLATE C15

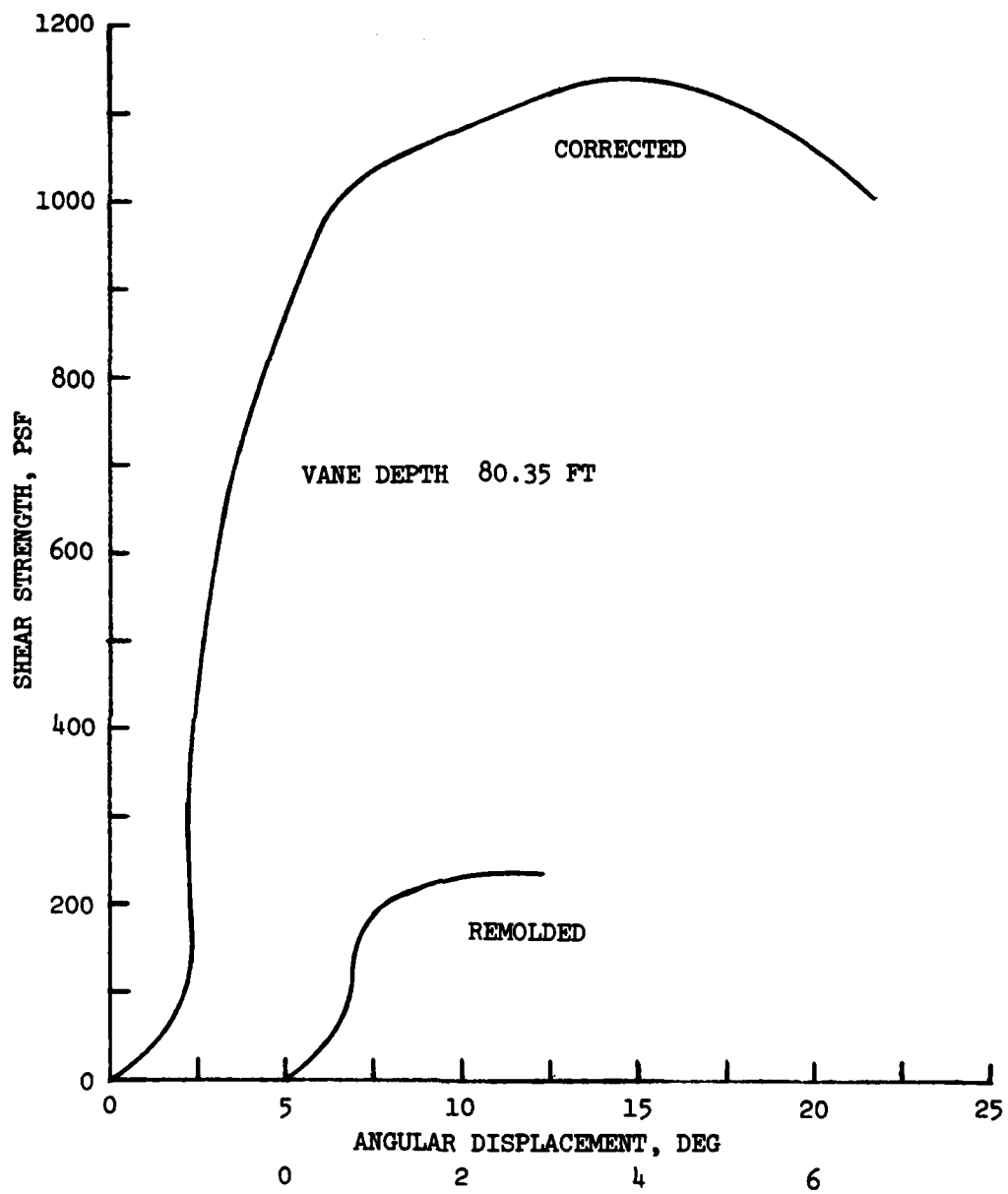


PLATE C16

C18

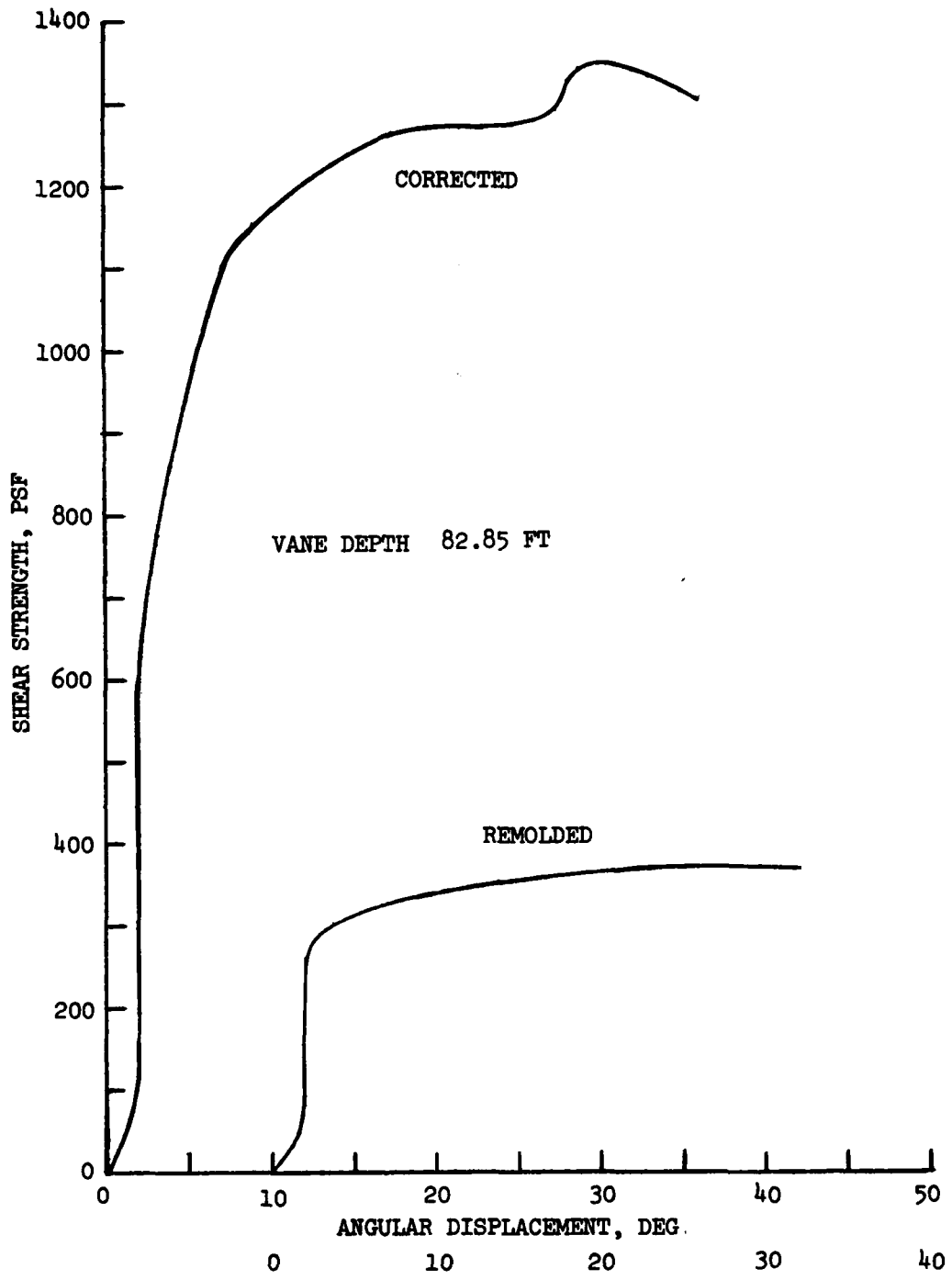


PLATE C17

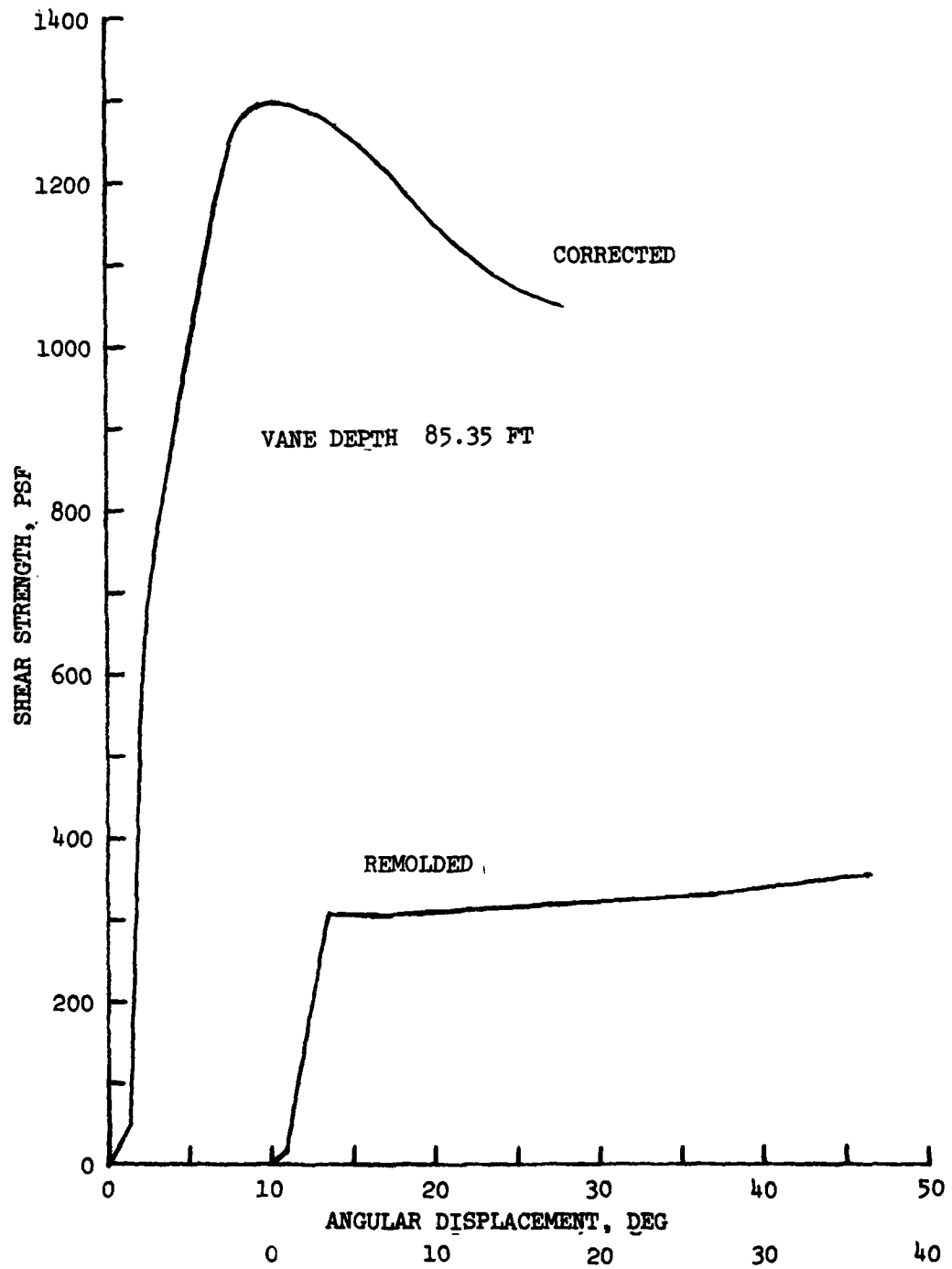


PLATE C18

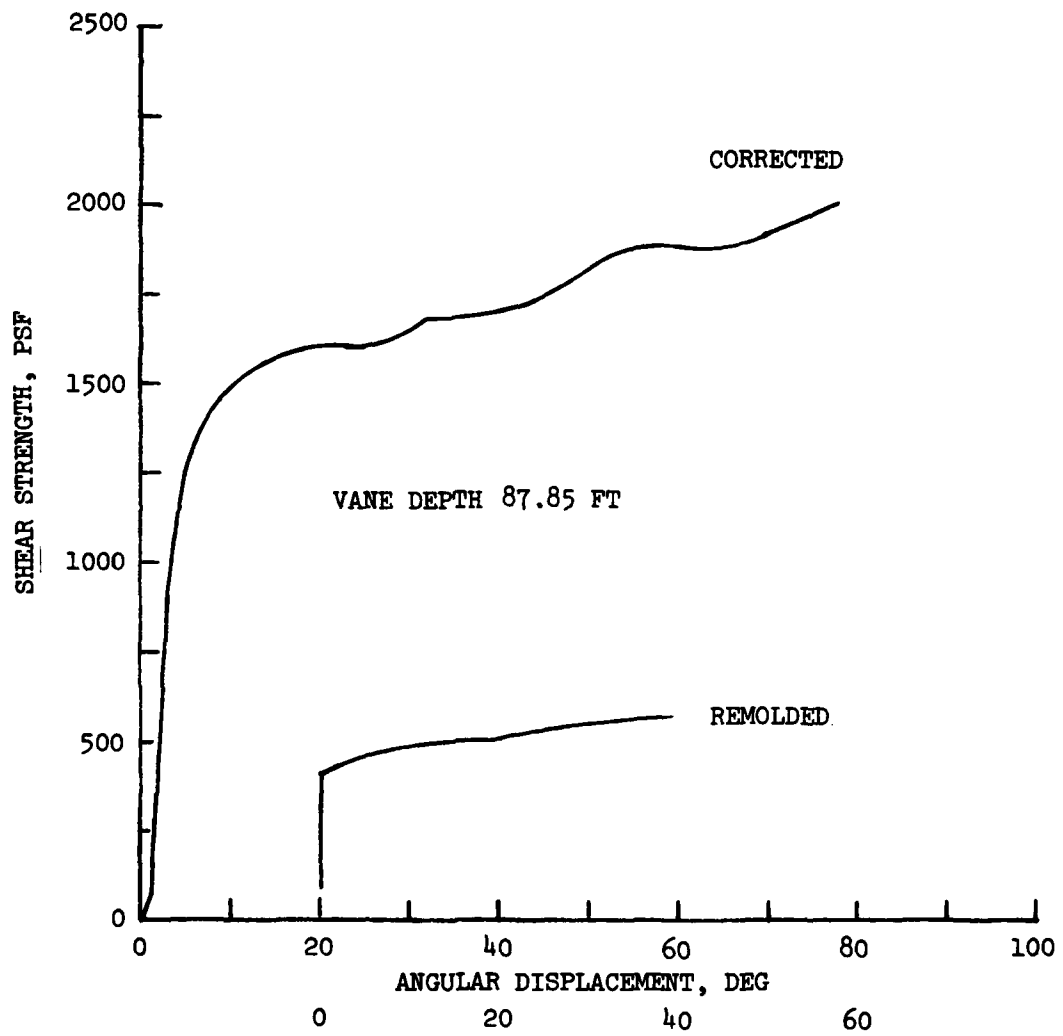


PLATE C19

C21

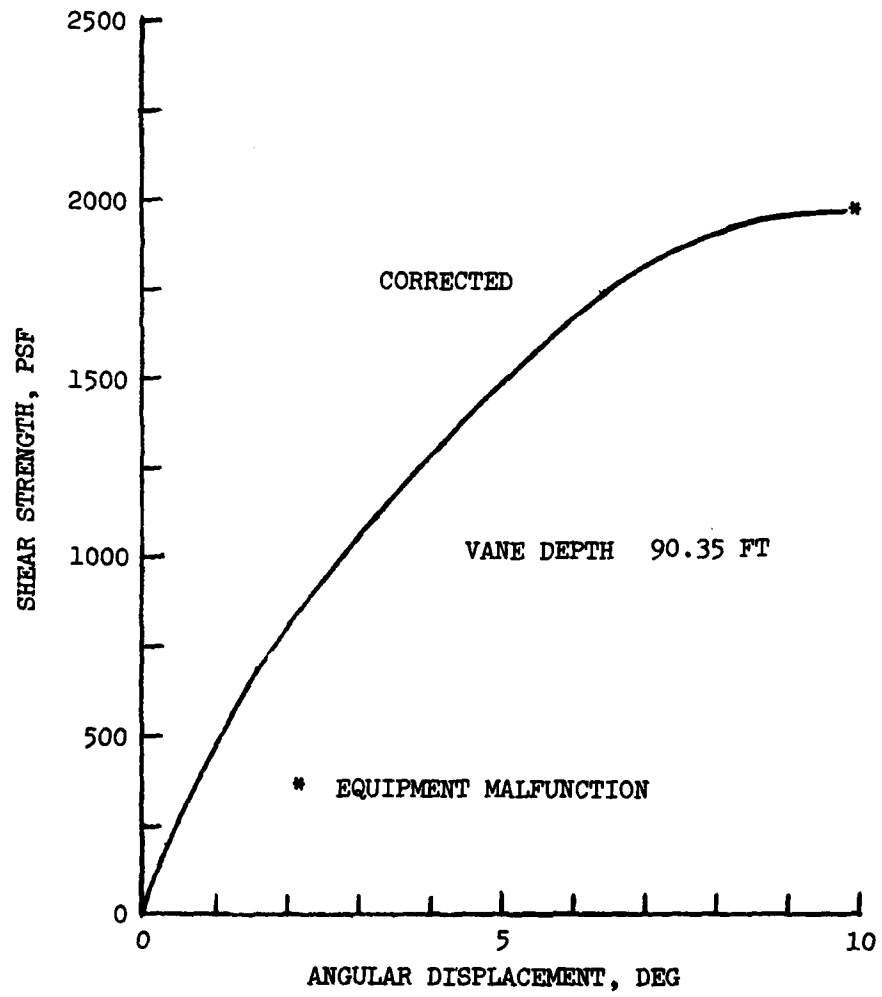


PLATE C20

C22

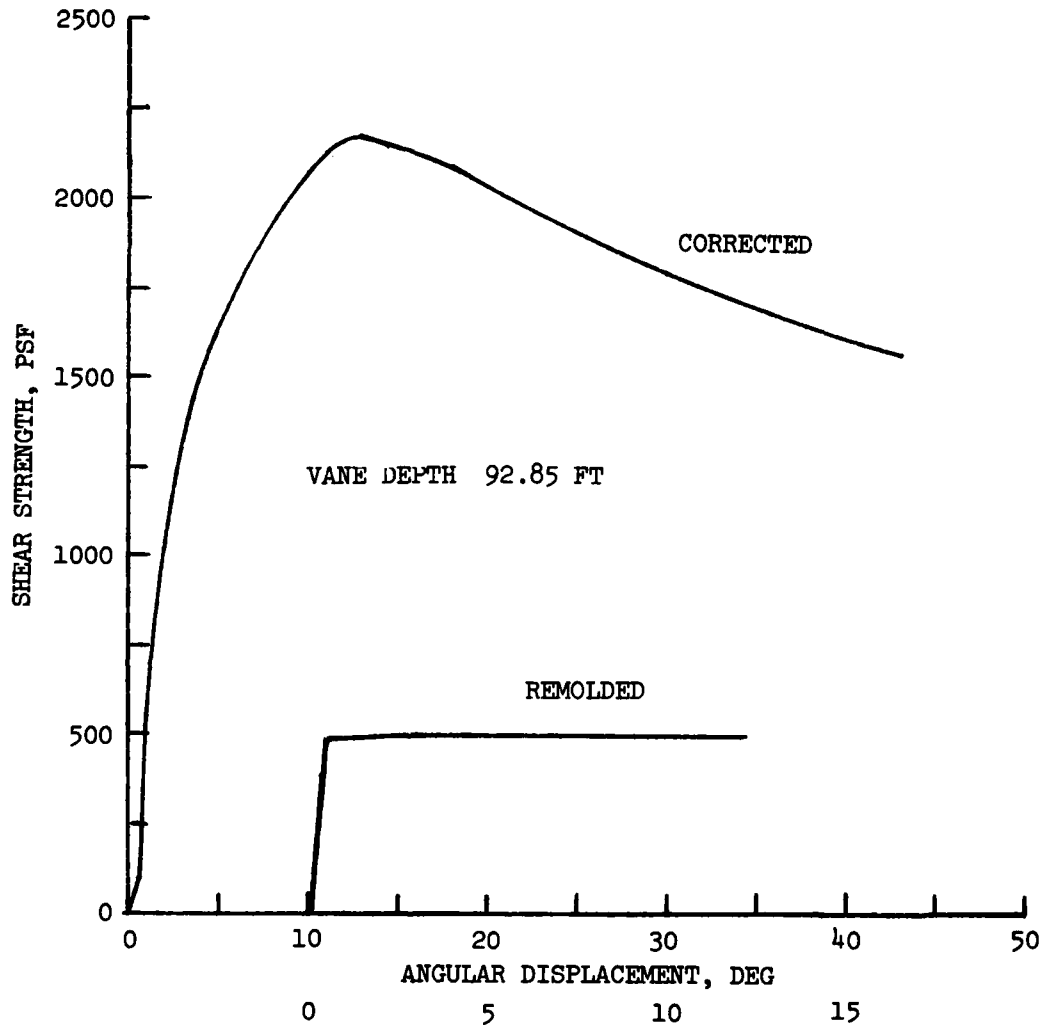
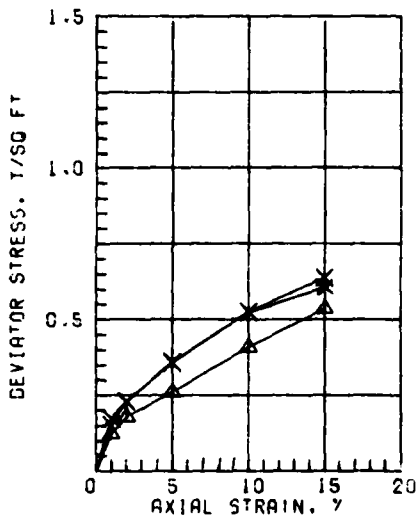
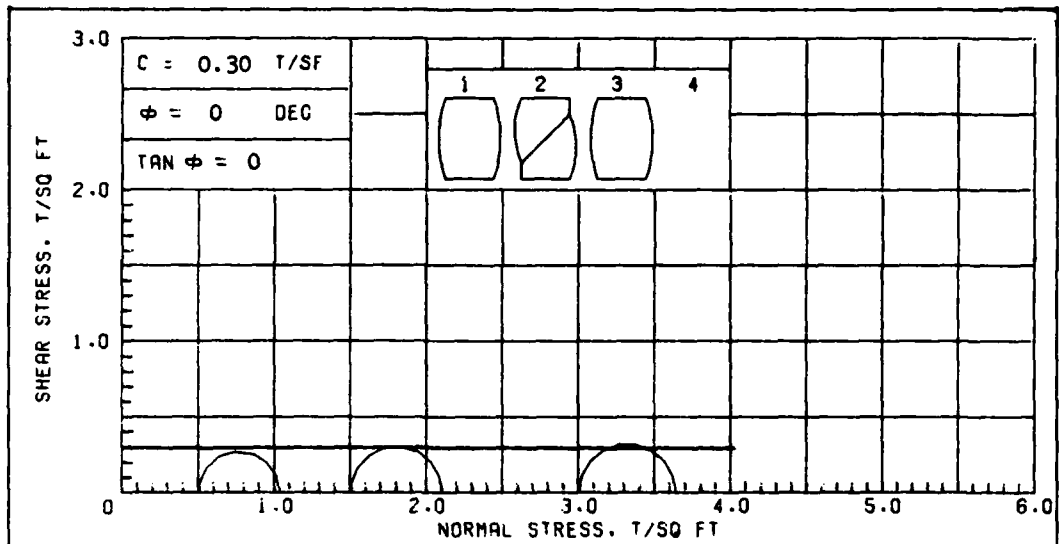


PLATE C21

APPENDIX D: SOILS DATA, BORING WS-3 (1977),
Q TRIAXIAL, R TRIAXIAL, AND CONSOLIDATION



	Δ1	Y2	X3	4
SPECIMEN NO.				
INITIAL				
WATER CONTENT, %	65.7	77.6	66.6	
DRY DENSITY, PCF	58.7	52.4	58.0	
SATURATION, %	97.8	97.1	97.4	
VOID RATIO	1.713	2.038	1.744	
BEFORE SHEAR				
WATER CONTENT, %				
DRY DENSITY, PCF				
SATURATION, %				
VOID RATIO				
BACK PRESS, TSF				
MIN PRIN. STRESS, TSF	0.5	1.5	3.0	
MAX. DEV. STRESS, TSF	0.54	0.61	0.64	
TIME TO FAILURE, MIN.	42	43	32	
RATE OF STRAIN INCR, %				
INITIAL DIAMETER, IN.	1.39	1.39	1.39	
INITIAL HEIGHT, IN.	3.00	3.00	3.00	

CONTROLLED-STRAIN TEST

DESCRIPTION OF SPECIMENS. SILT (MH). DARK GRAY.

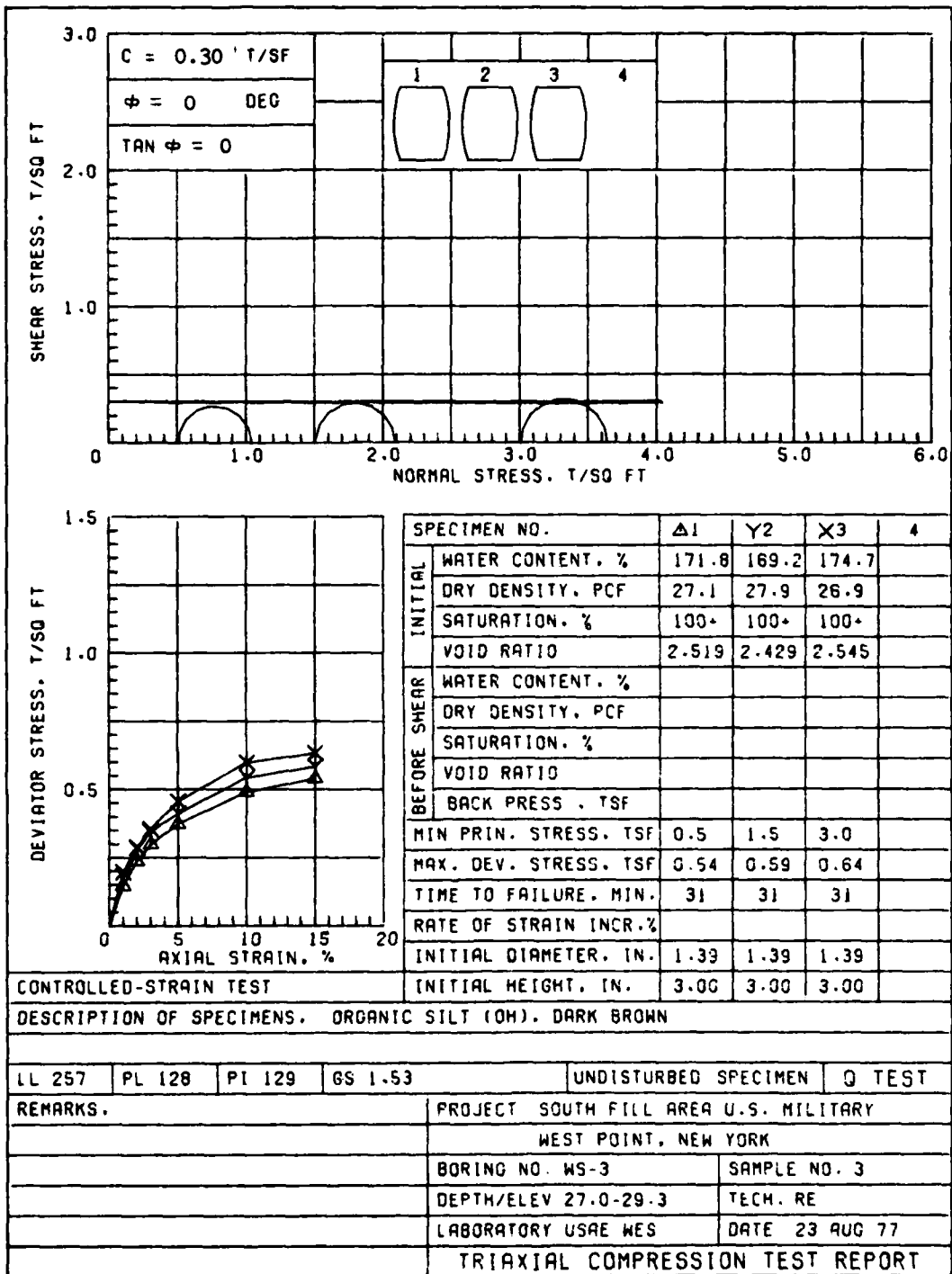
LENSES OF ORGANIC MATTER

LL 82 PL 43 PI 39 GS 2.55 UNDISTURBED SPECIMEN Q TEST

REMARKS.	PROJECT SOUTH FILL AREA U.S. MILITARY
	WEST POINT, NEW YORK
	BORING NO. WS-3 SAMPLE NO. 2
	DEPTH/ELEV 24.0-26.29 TECH. RE
	LABORATORY USAE WES DATE 22 AUG 77
	TRIAXIAL COMPRESSION TEST REPORT

ENG FORM NO. 2089 REV JUNE 1970 PREVIOUS EDITION IS OBSOLETE TRANSLUCENT (EN 1110-2-1906)

PLATE D1



ENG FORM NO. 2089
REV JUNE 1970

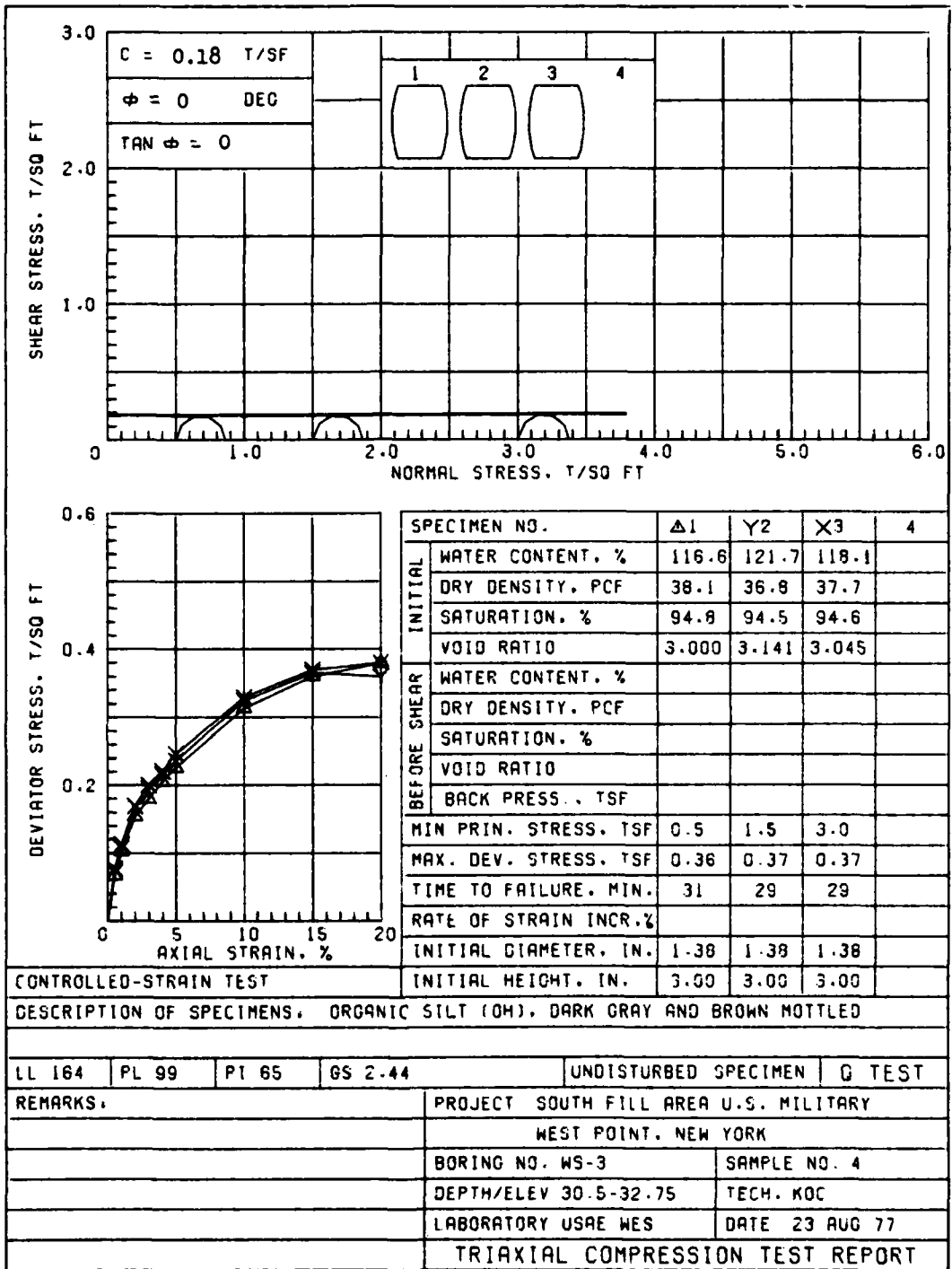
PREVIOUS EDITION IS OBSOLETE

TRANSLUCENT

(EM 1110-2-1906)

PLATE D2

D4



ENG FORM NO. 2089 REV JUNE 1970 PREVIOUS EDITION IS OBSOLETE TRANSLUCENT (EM 1110-2-1906)

PLATE D3

$c = 0.16 \text{ T/SF}$ $\phi = 0 \text{ DEG}$ $\text{TAN } \phi = 0$	<table border="1" style="margin: auto;"> <tr> <td style="width: 20px; height: 20px;">1</td> <td style="width: 20px; height: 20px;">2</td> <td style="width: 20px; height: 20px;">3</td> <td style="width: 20px; height: 20px;">4</td> </tr> </table>	1	2	3	4	
1	2	3	4			
<p style="font-size: 24px; margin: 0;">STRENGTHS TOO LOW TO PLOT</p>						
SHEAR STRESS, T/SO FT 0	NORMAL STRESS, T/SO FT					

	<table border="1" style="width: 100%; border-collapse: collapse;"> <tr> <td style="width: 15%;"></td> <td style="width: 15%;">SPECIMEN NO.</td> <td style="width: 15%;">Δ1</td> <td style="width: 15%;">Y2</td> <td style="width: 15%;">X3</td> <td style="width: 15%;">4</td> </tr> <tr> <td rowspan="4" style="writing-mode: vertical-rl; transform: rotate(180deg);">INITIAL</td> <td>WATER CONTENT, %</td> <td>69.2</td> <td>68.6</td> <td>65.4</td> <td></td> </tr> <tr> <td>DRY DENSITY, PCF</td> <td>57.0</td> <td>57.4</td> <td>59.5</td> <td></td> </tr> <tr> <td>SATURATION, %</td> <td>95.9</td> <td>96.3</td> <td>97.0</td> <td></td> </tr> <tr> <td>VOID RATIO</td> <td>1.926</td> <td>1.902</td> <td>1.800</td> <td></td> </tr> <tr> <td rowspan="4" style="writing-mode: vertical-rl; transform: rotate(180deg);">BEFORE SHEAR</td> <td>WATER CONTENT, %</td> <td></td> <td></td> <td></td> <td></td> </tr> <tr> <td>DRY DENSITY, PCF</td> <td></td> <td></td> <td></td> <td></td> </tr> <tr> <td>SATURATION, %</td> <td></td> <td></td> <td></td> <td></td> </tr> <tr> <td>VOID RATIO</td> <td></td> <td></td> <td></td> <td></td> </tr> <tr> <td></td> <td>BACK PRESS TSF</td> <td></td> <td></td> <td></td> <td></td> </tr> <tr> <td></td> <td>MIN PRIN. STRESS, TSF</td> <td>0.5</td> <td>1.5</td> <td>3.0</td> <td></td> </tr> <tr> <td></td> <td>MAX. DEV. STRESS, TSF</td> <td>0.27</td> <td>0.31</td> <td>0.39</td> <td></td> </tr> <tr> <td></td> <td>TIME TO FAILURE, MIN.</td> <td>30</td> <td>30</td> <td>30</td> <td></td> </tr> <tr> <td></td> <td>RATE OF STRAIN INCR. %</td> <td></td> <td></td> <td></td> <td></td> </tr> <tr> <td></td> <td>INITIAL DIAMETER, IN.</td> <td>1.38</td> <td>1.38</td> <td>1.38</td> <td></td> </tr> <tr> <td></td> <td>INITIAL HEIGHT, IN.</td> <td>3.00</td> <td>3.00</td> <td>3.00</td> <td></td> </tr> </table>		SPECIMEN NO.	Δ1	Y2	X3	4	INITIAL	WATER CONTENT, %	69.2	68.6	65.4		DRY DENSITY, PCF	57.0	57.4	59.5		SATURATION, %	95.9	96.3	97.0		VOID RATIO	1.926	1.902	1.800		BEFORE SHEAR	WATER CONTENT, %					DRY DENSITY, PCF					SATURATION, %					VOID RATIO						BACK PRESS TSF						MIN PRIN. STRESS, TSF	0.5	1.5	3.0			MAX. DEV. STRESS, TSF	0.27	0.31	0.39			TIME TO FAILURE, MIN.	30	30	30			RATE OF STRAIN INCR. %						INITIAL DIAMETER, IN.	1.38	1.38	1.38			INITIAL HEIGHT, IN.	3.00	3.00	3.00	
	SPECIMEN NO.	Δ1	Y2	X3	4																																																																																						
INITIAL	WATER CONTENT, %	69.2	68.6	65.4																																																																																							
	DRY DENSITY, PCF	57.0	57.4	59.5																																																																																							
	SATURATION, %	95.9	96.3	97.0																																																																																							
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	SATURATION, %																																																																																										
	VOID RATIO																																																																																										
	BACK PRESS TSF																																																																																										
	MIN PRIN. STRESS, TSF	0.5	1.5	3.0																																																																																							
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	TIME TO FAILURE, MIN.	30	30	30																																																																																							
	RATE OF STRAIN INCR. %																																																																																										
	INITIAL DIAMETER, IN.	1.38	1.38	1.38																																																																																							
	INITIAL HEIGHT, IN.	3.00	3.00	3.00																																																																																							

CONTROLLED-STRAIN TEST

DESCRIPTION OF SPECIMENS. PLASTIC CLAY (CH), GRAY AND BROWN MOTTLED, DECAYED WOOD

LL 85	PL 28	FI 57	CS 2.67	UNDISTURBED SPECIMEN	Q TEST
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REMARKS. PROJECT SOUTH FILL AREA U.S. MILITARY WEST POINT, NEW YORK

BORING NO. WS-3	SAMPLE NO. 5
DEPTH/ELEV 33.0-35.78	TECH. KOC
LABORATORY USAE WES	DATE 23 AUG 77

TRIAXIAL COMPRESSION TEST REPORT

ENG FORM NO. 2088
REV JUNE 1970

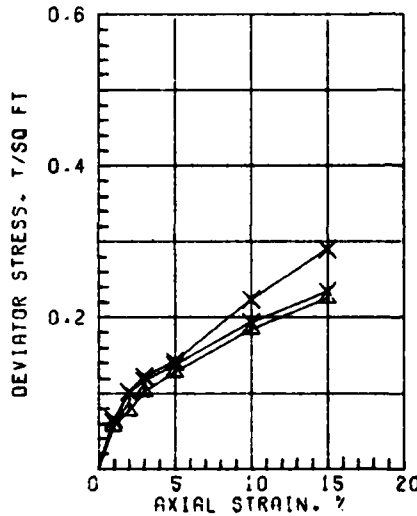
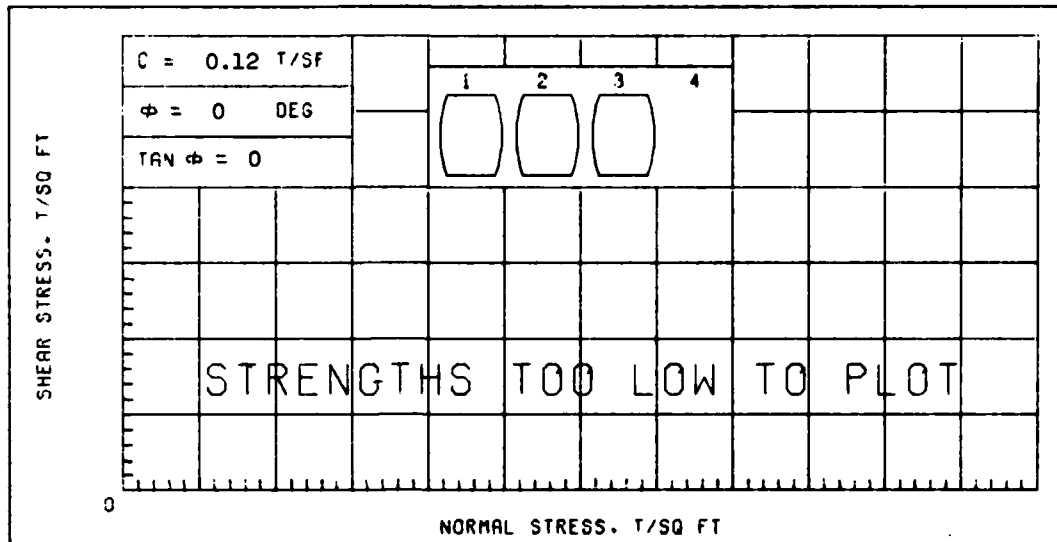
PREVIOUS EDITION IS OBSOLETE

TRANSLUCENT

(EM 1110-2-1906)

PLATE D4

D6



	Δ1	Y2	X3	4
SPECIMEN NO.				
INITIAL WATER CONTENT, %	48.7	51.2	48.8	
INITIAL DRY DENSITY, PCF	69.7	68.0	70.1	
INITIAL SATURATION, %	92.4	93.2	93.5	
INITIAL VOID RATIO	1.428	1.489	1.414	
BEFORE SHEAR WATER CONTENT, %				
BEFORE SHEAR DRY DENSITY, PCF				
BEFORE SHEAR SATURATION, %				
BEFORE SHEAR VOID RATIO				
BEFORE SHEAR BACK PRESS, TSF				
MIN PRIN. STRESS, TSF	0.5	1.5	3.0	
MAX. DEV. STRESS, TSF	0.22	0.23	0.29	
TIME TO FAILURE, MIN.	33	32	33	
RATE OF STRAIN INCR, %				
INITIAL DIAMETER, IN.	1.39	1.39	1.39	
INITIAL HEIGHT, IN.	3.00	3.00	3.00	

CONTROLLED-STRAIN TEST

DESCRIPTION OF SPECIMENS. CLAYEY SILT (MH). DARK GRAY. A FEW SHELLS

LL 56 PL 30 PL 28 65 2.71 UNDISTURBED SPECIMEN Q TEST

REMARKS. PROJECT SOUTH FILL AREA U.S. MILITARY WEST POINT, NEW YORK

BORING NO. WS-3 SAMPLE NO. 6

DEPTH/ELEV 36.0-38.3 TECH. RE

LABORATORY USAE WES DATE 23 AUG 77

TRIAXIAL COMPRESSION TEST REPORT

ENG FORM NO. 2088
REV JUNE 1970

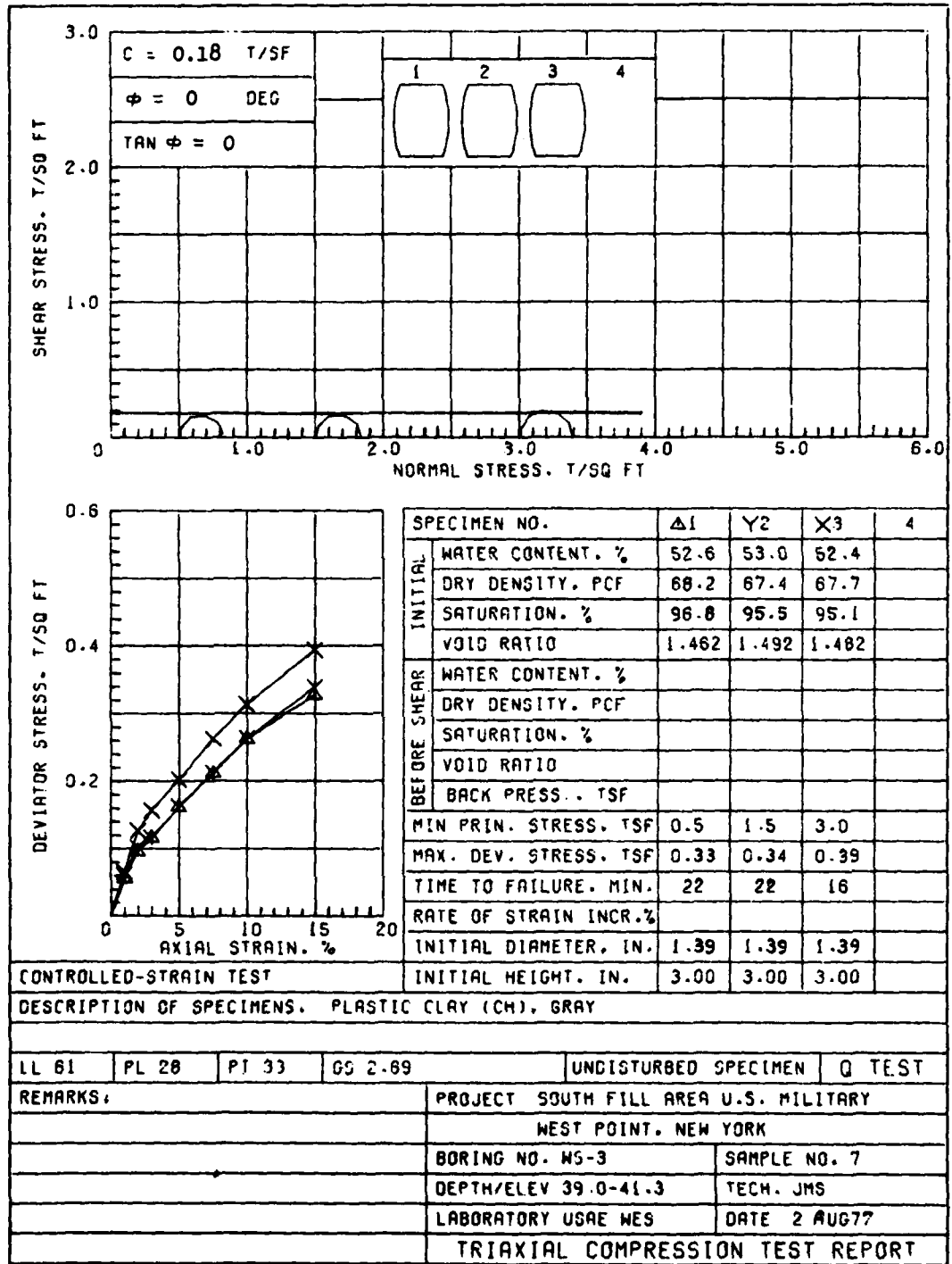
PREVIOUS EDITION IS OBSOLETE

TRANSLUCENT

(EN 1110-2-1906)

PLATE D5

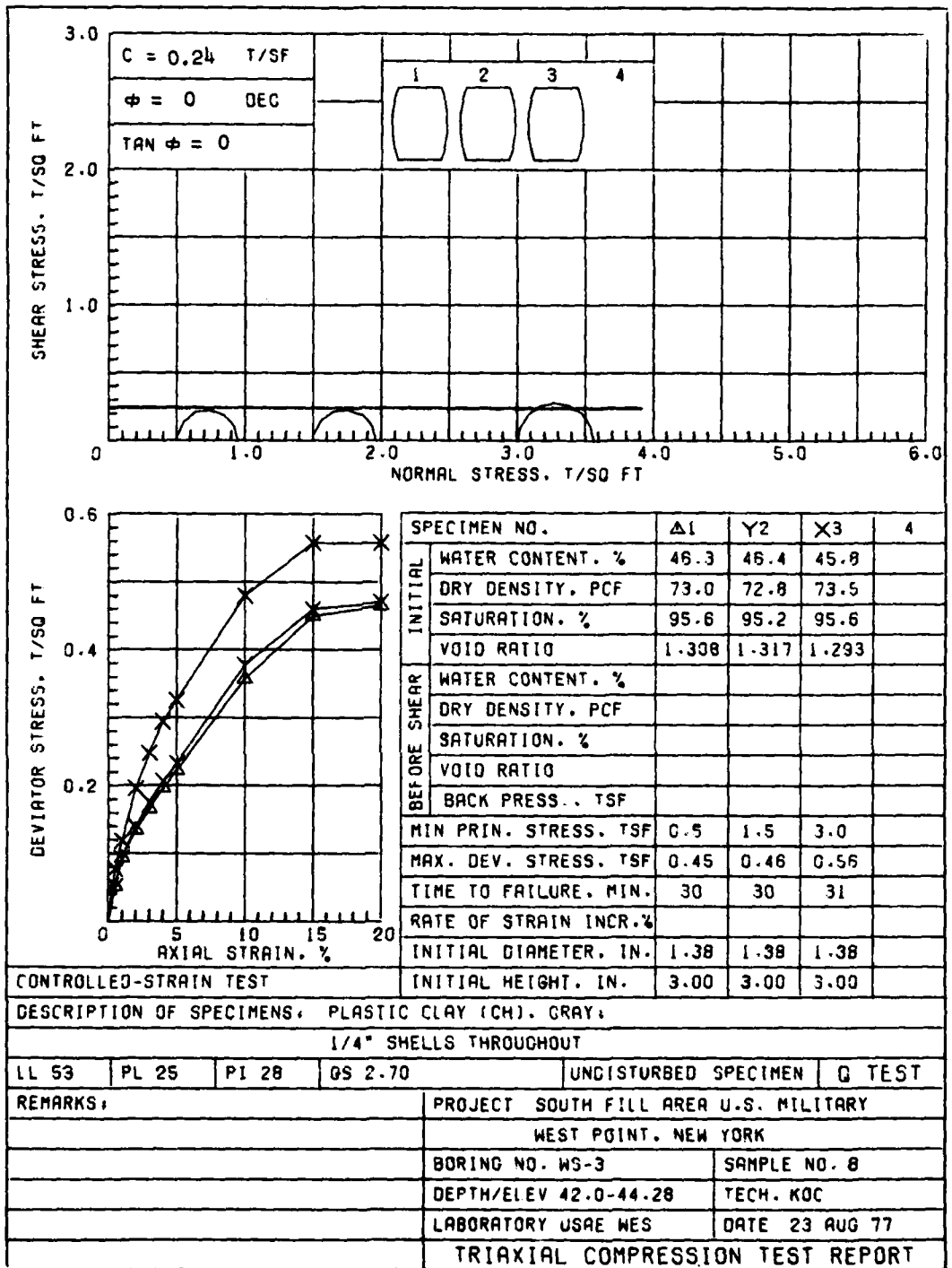
D7



ENG FORM NO. 2080 REV JUNE 1970 PREVIOUS EDITION IS OBSOLETE TRANSLUCENT (EN 1110-2-1906)

PLATE D6

D8



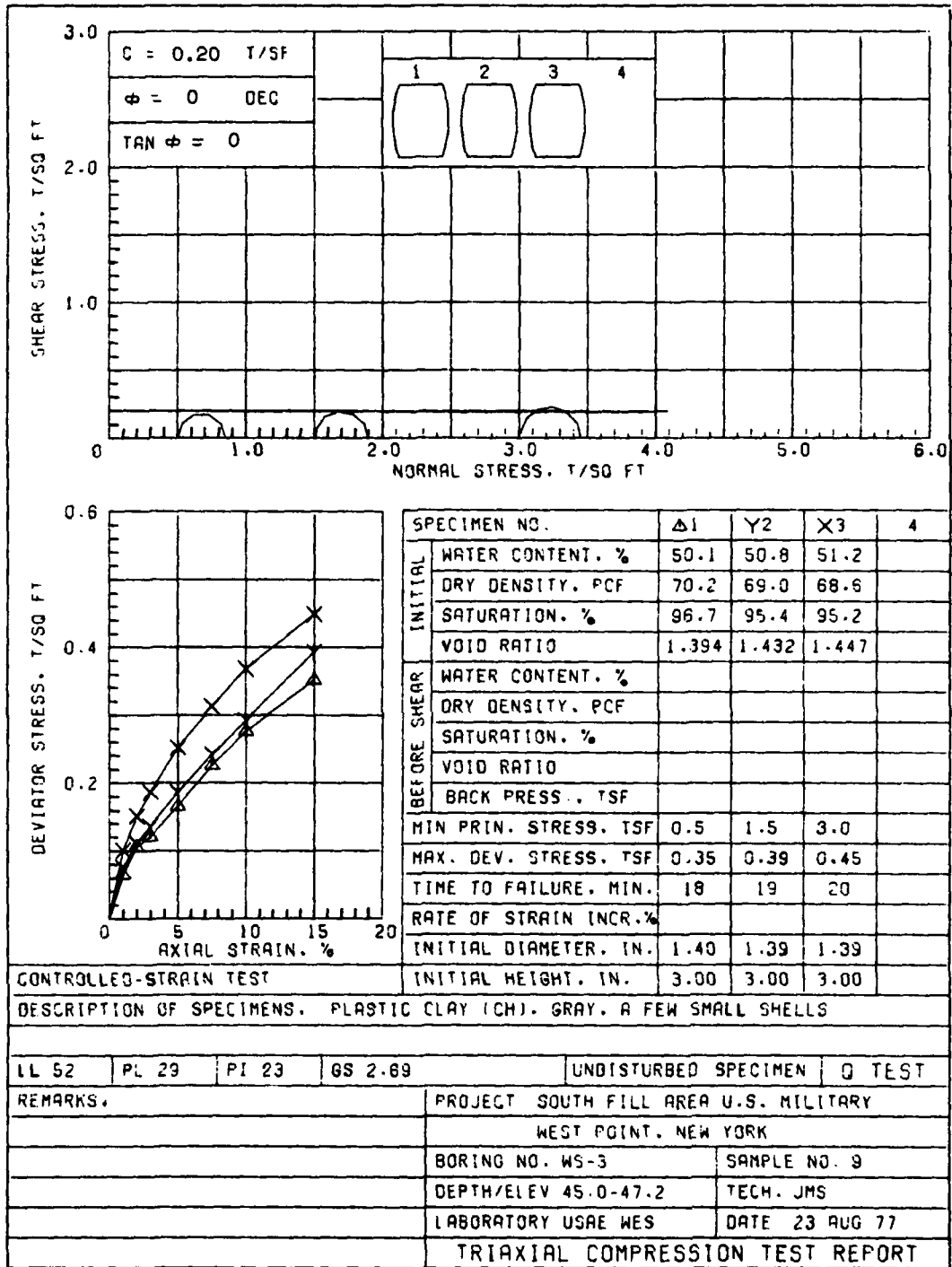
ENG FORM NO. 2088
REV JUNE 1970

PREVIOUS EDITION IS OBSOLETE

TRANSLUCENT

(EM 1110-2-1906)

PLATE D7



ENG FORM NO. 2089
REV JUNE 1970

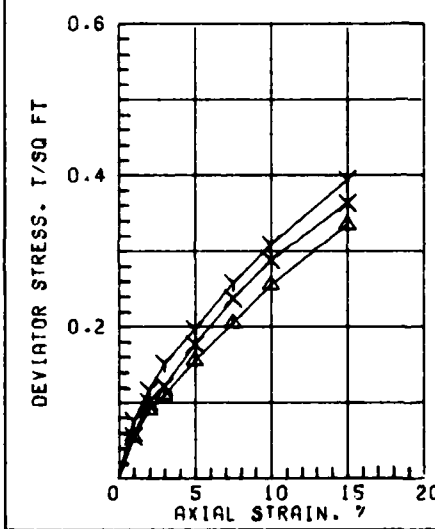
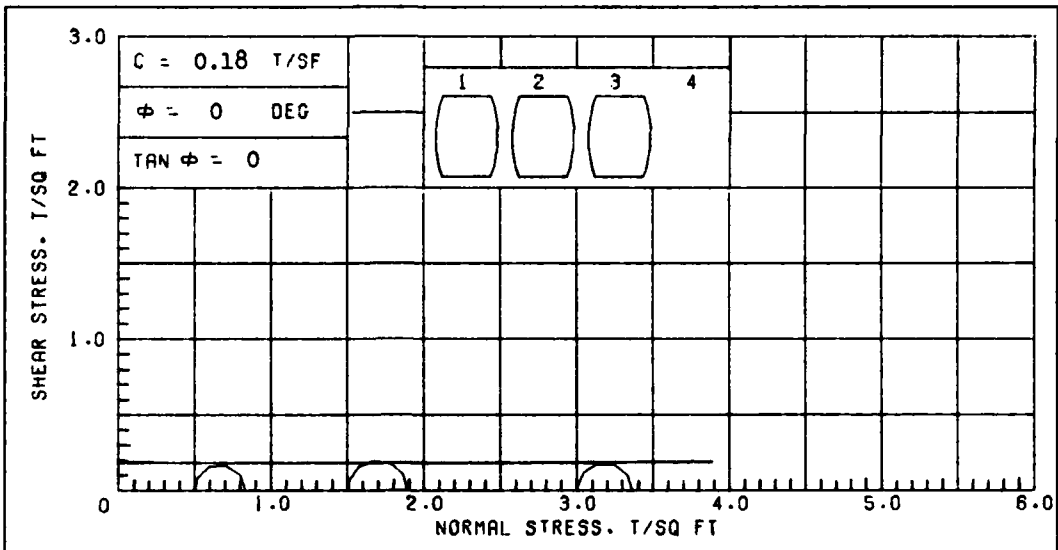
PREVIOUS EDITION IS OBSOLETE

TRANSLUCENT

(EM 1110-2-1906)

PLATE D8

D10



SPECIMEN NO.		Δ1	Y2	X3	4
INITIAL	WATER CONTENT. %	43.3	45.2	44.2	
	DRY DENSITY. PCF	75.7	73.5	74.3	
	SATURATION. %	94.8	93.9	93.5	
	VOID RATIO	1.242	1.309	1.286	
BEFORE SHEAR	WATER CONTENT. %				
	DRY DENSITY. PCF				
	SATURATION. %				
	VOID RATIO				
MIN PRIN. STRESS. TSF		0.5	1.6	3.0	
MAX. DEV. STRESS. TSF		0.33	0.39	0.36	
TIME TO FAILURE. MIN.		17	16	20	
RATE OF STRAIN INCR. %					
INITIAL DIAMETER. IN.		1.40	1.39	1.39	
INITIAL HEIGHT. IN.		3.00	3.00	3.00	

CONTROLLED-STRAIN TEST

DESCRIPTION OF SPECIMENS PLASTIC CLAY (CH). GRAY.
A FEW SHELLS TO 1/4"

LL 50	PL 25	PI 25	GS 2.72	UNDISTURBED SPECIMEN	Q TEST
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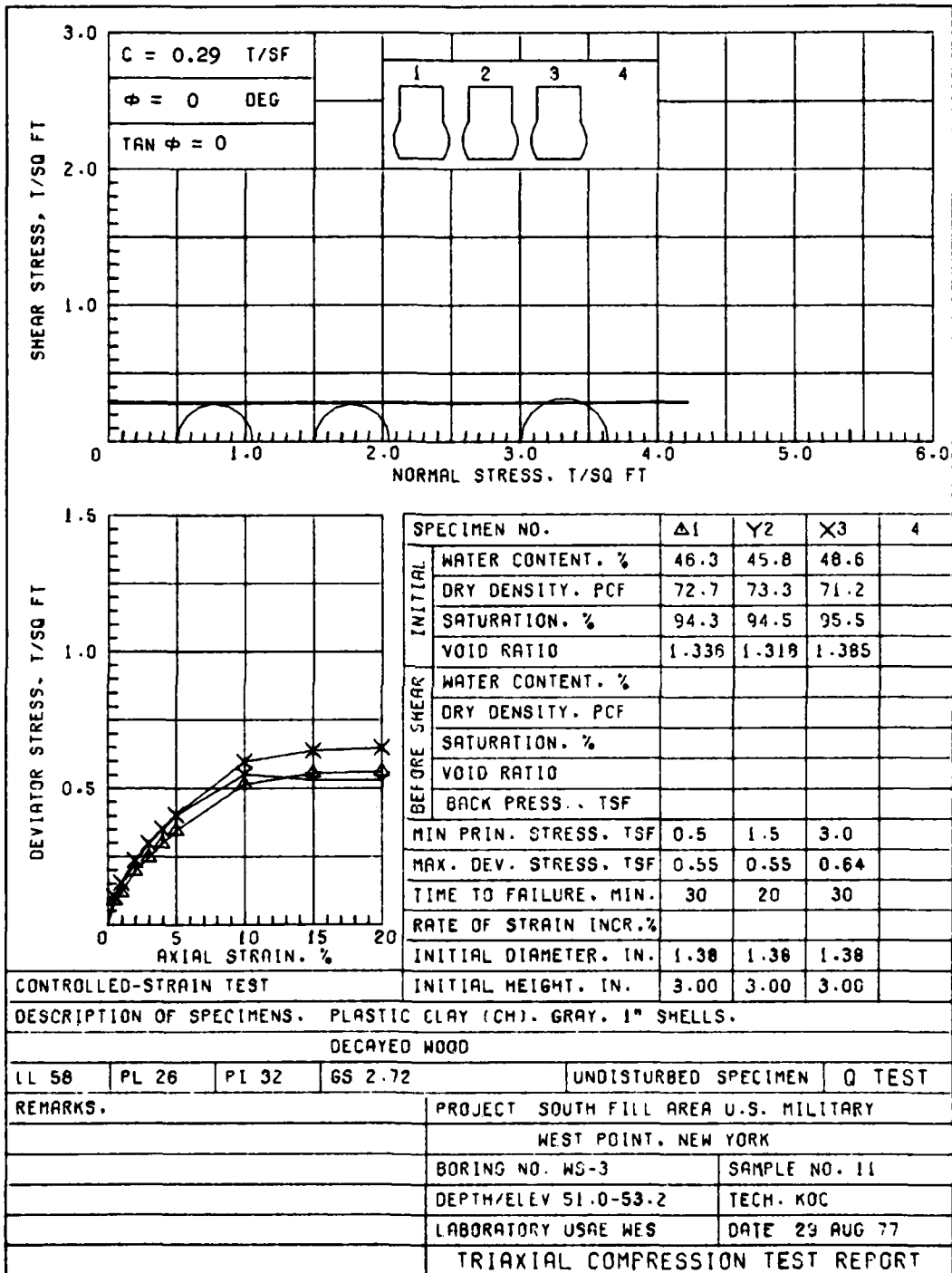
REMARKS. PROJECT SOUTH FILL AREA U.S. MILITARY
WEST POINT. NEW YORK

BORING NO. WS-3	SAMPLE NO. 10
DEPTH/ELEV 48.0-50.2	TECH. JMS
LABORATORY USAE WES	DATE 23 AUG 77

TRIAXIAL COMPRESSION TEST REPORT

ENG FORM NO. 2089 REV JUNE 1970 PREVIOUS EDITION IS OBSOLETE TRANSLUCENT (EM 1110-2-1906)

PLATE D9



ENG FORM NO. 2089
REV JUNE 1970

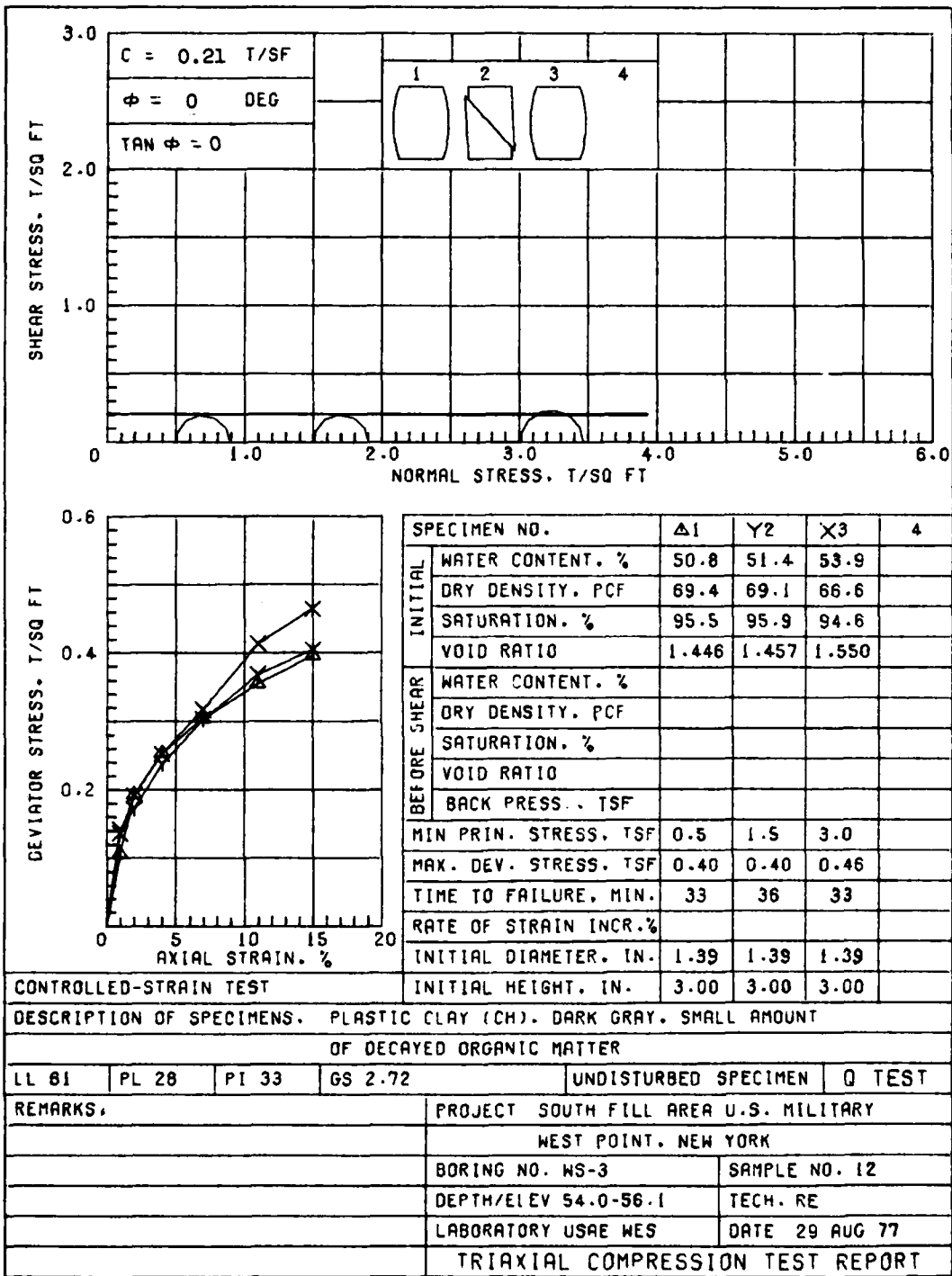
PREVIOUS EDITION IS OBSOLETE

TRANSLUCENT

(EM 1110-2-1906)

PLATE D10

D12



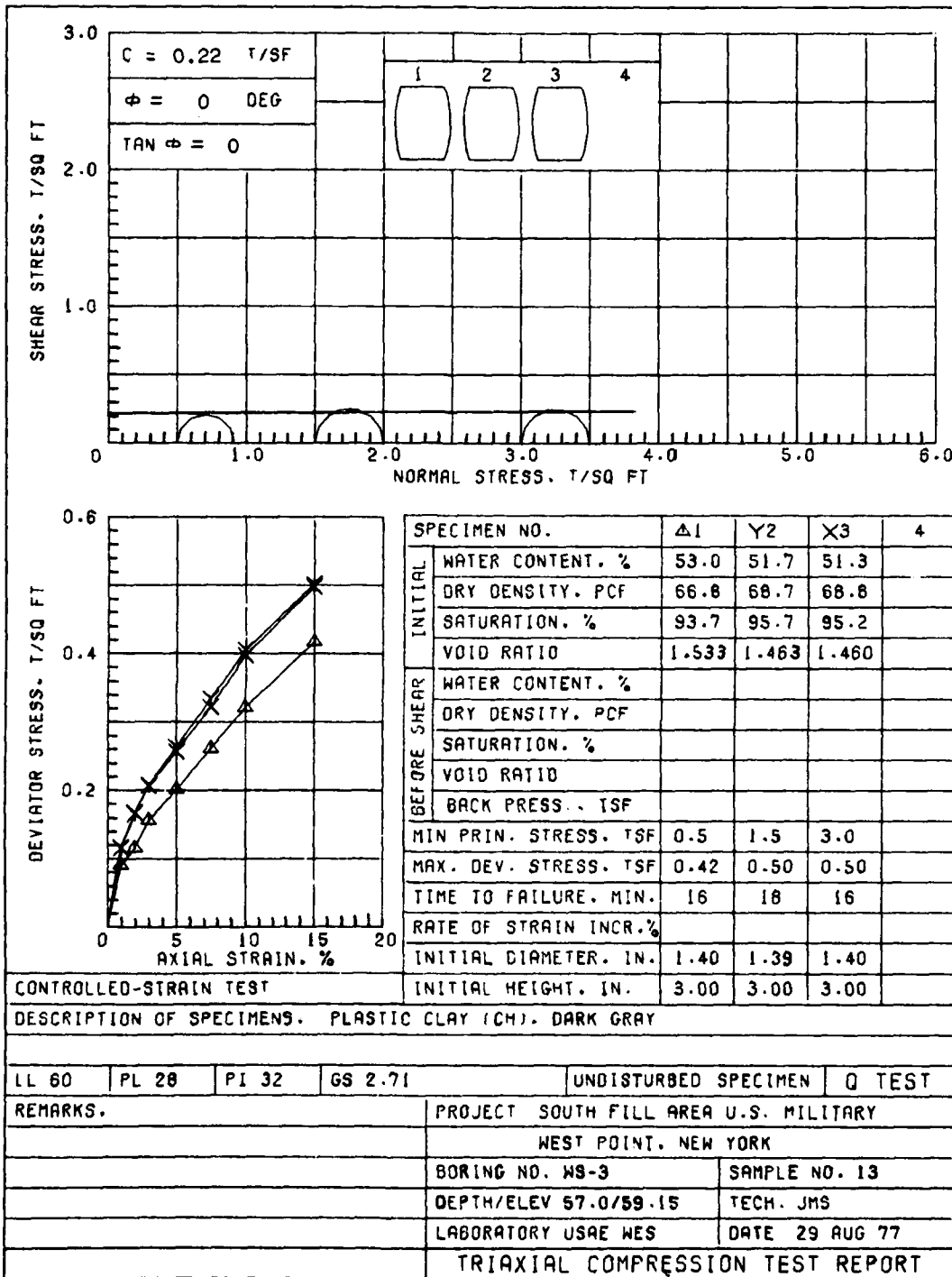
ENG FORM NO. 2089
REV JUNE 1970

PREVIOUS EDITION IS OBSOLETE

TRANSLUCENT

(EM 1110-2-1906)

PLATE D11



ENG FORM NO. 2089
REV JUNE 1970

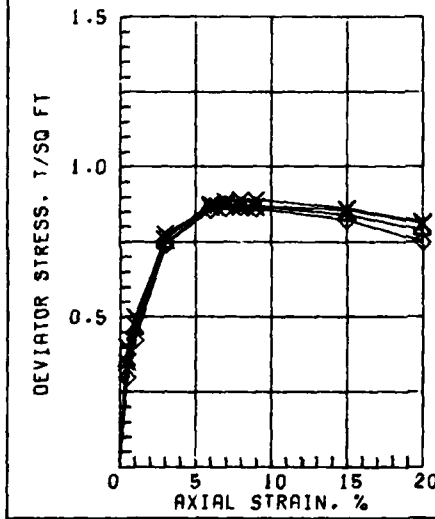
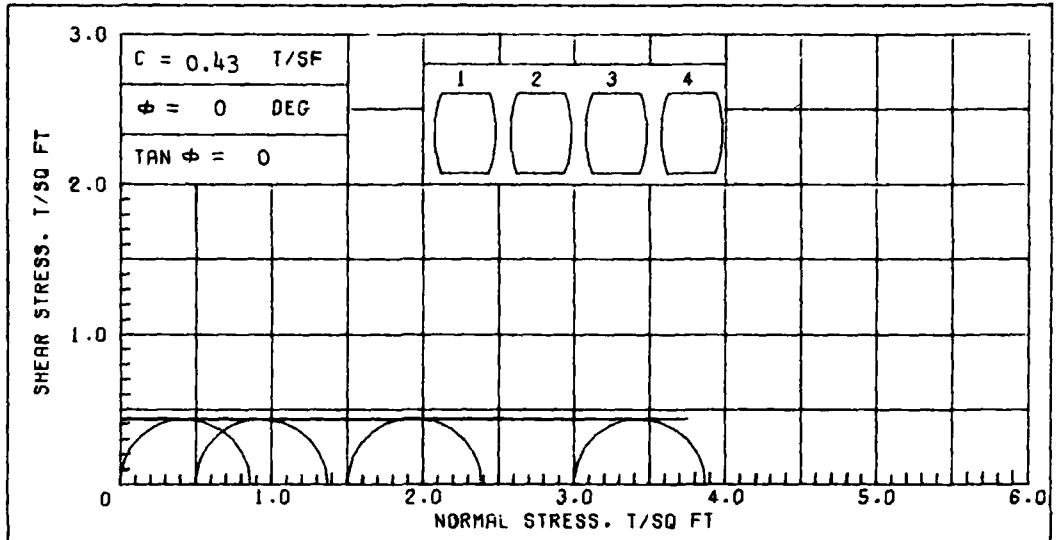
PREVIOUS EDITION IS OBSOLETE

TRANSLUCENT

(EM 1110-2-1906)

PLATE D12

D14



SPECIMEN NO.		Δ1	Y2	X3	◇4
INITIAL	WATER CONTENT. %	52.8	53.0	51.8	51.0
	DRY DENSITY. PCF	69.3	69.2	70.9	70.6
	SATURATION. %	99.4	99.3	100+	99.1
	VOID RATIO	1.440	1.447	1.387	1.395
BEFORE SHEAR	WATER CONTENT. %				
	DRY DENSITY. PCF				
	SATURATION. %				
	VOID RATIO				
		BACK PRESS.. TSF			
MIN PRIN. STRESS. TSF		0.5	1.5	3.0	0.0
MAX. DEV. STRESS. TSF		0.87	0.89	0.87	0.87
TIME TO FAILURE. MIN.		9	11	9	11
RATE OF STRAIN INCR. %					
INITIAL DIAMETER. IN.		1.40	1.40	1.40	1.40
INITIAL HEIGHT. IN.		3.00	3.00	3.00	3.00

CONTROLLED-STRAIN TEST

DESCRIPTION OF SPECIMENS: PLASTIC CLAY (CH). DARK GRAY;
A VERY FEW SILT PARTINGS

LL	PL	PI	OS 2.71	UNDISTURBED SPECIMEN	Q TEST
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REMARKS: CHECK TEST

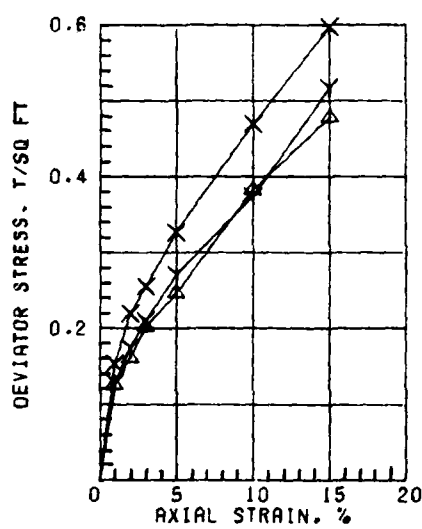
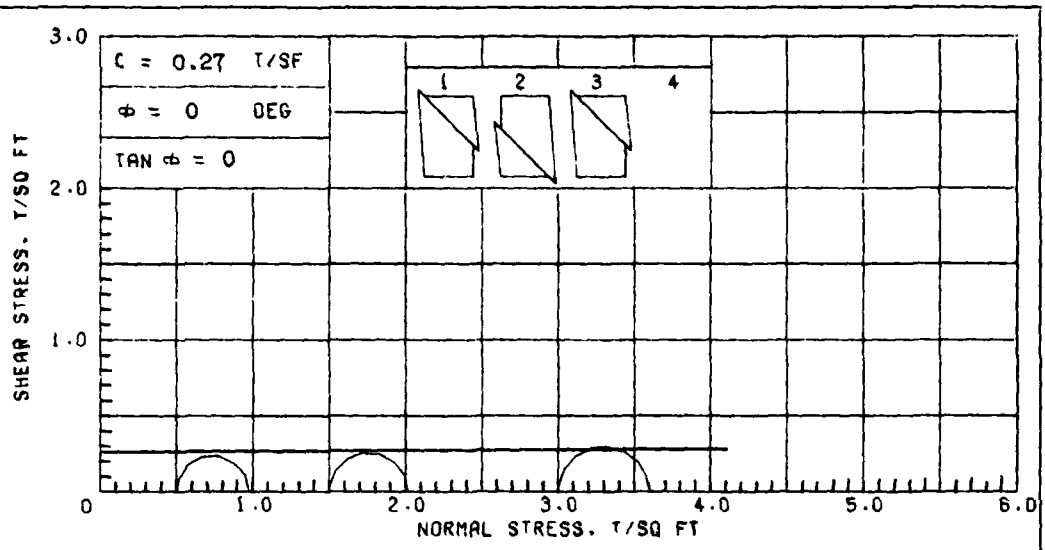
PROJECT SOUTH FILL U.S.
MILITARY ACADEMY

BORING NO. WS-3 SAMPLE NO. 13

DEPTH/ELEV 57.8-58.6 TECH. PJR

LABORATORY USAE WES DATE 19 JUL 78

TRIAXIAL COMPRESSION TEST REPORT



	SPECIMEN NO.	Δ1	Y2	X3	4
INITIAL	WATER CONTENT. %	45.6	46.4	45.9	
	DRY DENSITY. PCF	73.6	72.9	73.9	
	SATURATION. %	95.1	95.3	96.5	
	VOID RATIO	1.299	1.320	1.289	
BEFORE SHEAR	WATER CONTENT. %				
	DRY DENSITY. PCF				
	SATURATION. %				
	VOID RATIO				
	BACK PRESS. TSF				
	MIN PRIN. STRESS. TSF	0.5	1.5	3.0	
	MAX. DEV. STRESS. TSF	0.48	0.52	0.60	
	TIME TO FAILURE. MIN.	34	34	36	
	RATE OF STRAIN INCR. %				
	INITIAL DIAMETER. IN.	1.40	1.38	1.39	
	INITIAL HEIGHT. IN.	3.00	3.00	3.00	

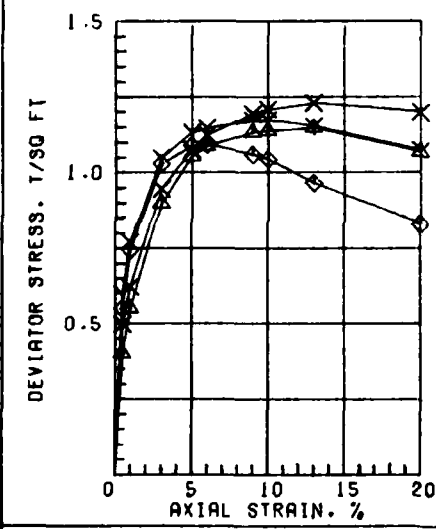
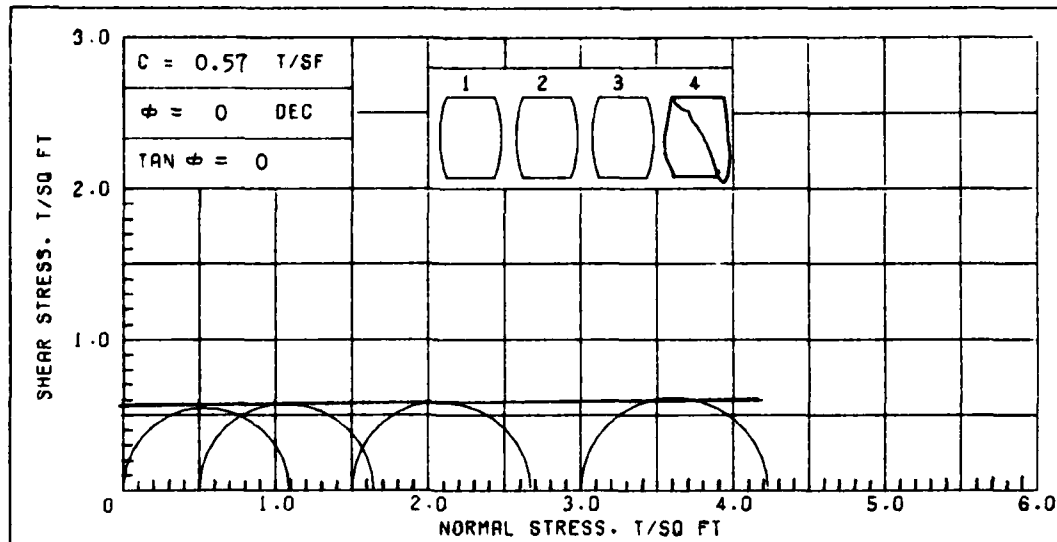
CONTROLLED-STRAIN TEST

DESCRIPTION OF SPECIMENS: PLASTIC CLAY (CH), DARK GRAY

LL 58 | PL 27 | PI 31 | GS 2.71 | UNDISTURBED SPECIMEN | Q TEST

REMARKS: PROJECT SOUTH FILL AREA U.S. MILITARY
 WEST POINT, NEW YORK
 BORING NO. WS-3 | SAMPLE NO. 14
 DEPTH/ELEV 60.5-62.7 | TECH. RE
 LABORATORY USAE WES | DATE 29 AUG 77
 TRIAXIAL COMPRESSION TEST REPORT

REV JUNE 1970 ASCE PREVIOUS EDITION IS OBSOLETE



SPECIMEN NO.		Δ1	Υ2	Χ3	◇4
INITIAL	WATER CONTENT. %	48.7	48.9	46.3	50.4
	DRY DENSITY. PCF	71.7	72.1	73.3	71.2
	SATURATION. %	97.1	98.4	95.8	99.2
	VOID RATIO	1.359	1.346	1.309	1.377
BEFORE SHEAR	WATER CONTENT. %				
	DRY DENSITY. PCF				
	SATURATION. %				
	VOID RATIO				
BACK PRESS.. TSF					
MIN PRIN. STRESS. TSF		0.5	1.5	3.0	0.0
MAX. DEV. STRESS. TSF		1.15	1.17	1.23	1.09
TIME TO FAILURE. MIN.		18	12	19	8
RATE OF STRAIN INCR. %					
INITIAL DIAMETER. IN.		1.40	1.40	1.40	1.40
INITIAL HEIGHT. IN.		3.00	3.00	3.00	3.00

CONTROLLED-STRAIN TEST

DESCRIPTION OF SPECIMENS: PLASTIC CLAY (CH), DARK GRAY,
A FEW SILT PARTINGS

LL	PL	PI	GS 2.71	UNDISTURBED SPECIMEN	Q TEST
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REMARKS: CHECK TEST

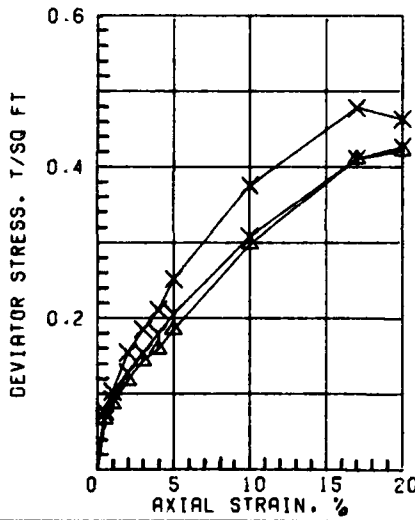
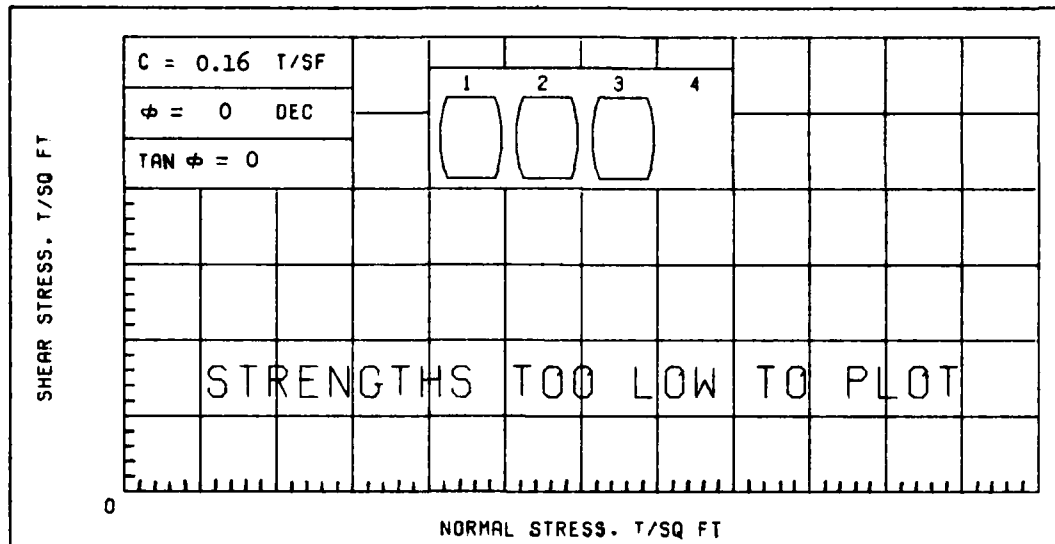
PROJECT SOUTH FILL U.S.
MILITARY ACADEMY

BORING NO. WS-3 SAMPLE NO. 14

DEPTH/ELEV 61.2-62.0 TECH. PJR

LABORATORY USAE WES DATE 19 JUL 78

TRIAXIAL COMPRESSION TEST REPORT

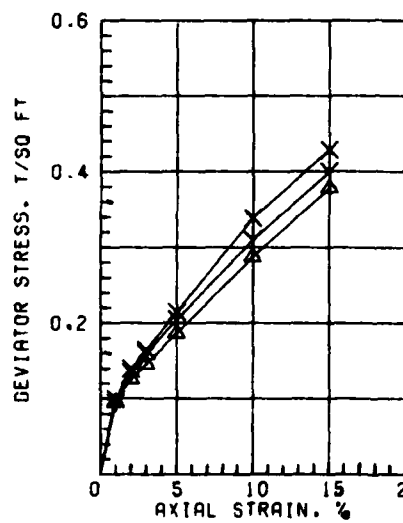
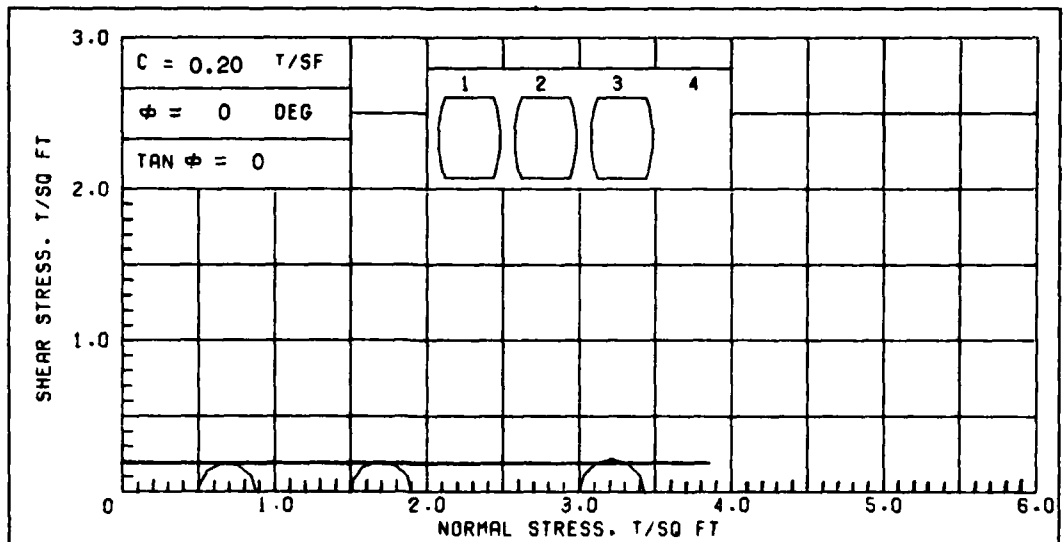


	$\Delta 1$	Y2	X3	4
SPECIMEN NO.				
WATER CONTENT. %	51.1	51.4	51.4	
DRY DENSITY. PCF	67.8	67.8	66.8	
SATURATION. %	92.5	92.9	90.8	
VOID RATIO	1.503	1.504	1.541	
BEFORE SHEAR				
WATER CONTENT. %				
DRY DENSITY. PCF				
SATURATION. %				
VOID RATIO				
BACK PRESS.. TSF				
MIN PRIN. STRESS. TSF	0.5	1.5	3.0	
MAX. DEV. STRESS. TSF	0.30	0.31	0.38	
TIME TO FAILURE. MIN.	20	20	20	
RATE OF STRAIN INCR. %				
INITIAL DIAMETER. IN.	1.38	1.38	1.38	
INITIAL HEIGHT. IN.	3.00	3.00	3.00	

CONTROLLED-STRAIN TEST				
DESCRIPTION OF SPECIMENS: PLASTIC CLAY (CH), GRAY; SEAMS OF SILTY CLAY THROUGHOUT				
LL 58	PL 27	PI 31	GS 2.72	UNDISTURBED SPECIMEN Q TEST
REMARKS:		PROJECT SOUTH FILL AREA U.S. MILITARY		
LIMITS AND SPECIFIC GRAVITY		WEST POINT, NEW YORK		
ON MIXTURE OF MATERIALS.		BORING NO. WS-3	SAMPLE NO. 15	
		DEPTH/ELEV 63.0-65.18	TECH. KOC	
		LABORATORY USAE WES	DATE 29 AUG 77	
TRIAXIAL COMPRESSION TEST REPORT				

ENG FORM NO. 2089 REV JUNE 1970 PREVIOUS EDITION IS OBSOLETE TRANSLUCENT (EM 1110-2-1906)

PLATE D16



SPECIMEN NO.		Δ1	Υ2	Χ3	4
INITIAL	WATER CONTENT, %	47.2	46.9	47.4	
	DRY DENSITY, PCF	72.5	72.2	71.9	
	SATURATION, %	95.7	94.3	94.8	
	VOID RATIO	1.341	1.353	1.361	
BEFORE SHEAR	WATER CONTENT, %				
	DRY DENSITY, PCF				
	SATURATION, %				
	VOID RATIO				
BACK PRESS., TSF					
MIN PRIN. STRESS, TSF		0.6	1.6	3.0	
MAX. DEV. STRESS, TSF		0.38	0.40	0.43	
TIME TO FAILURE, MIN.		17	14	15	
RATE OF STRAIN INCR, %					
INITIAL DIAMETER, IN.		1.39	1.40	1.40	
INITIAL HEIGHT, IN.		3.00	3.00	3.00	

CONTROLLED-STRAIN TEST

DESCRIPTION OF SPECIMENS, PLASTIC CLAY (CH), GRAY

LL 53	PL 24	PT 29	GS 2.72	UNDISTURBED SPECIMEN	Q TEST
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REMARKS. PROJECT SOUTH FILL AREA U.S. MILITARY

WEST POINT, NEW YORK

BORING NO. WS-3	SAMPLE NO. 16
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DEPTH/ELEV 66.0-68.1	TECH. JMS
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LABORATORY USAE WES	DATE 29 AUG 77
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TRIAXIAL COMPRESSION TEST REPORT

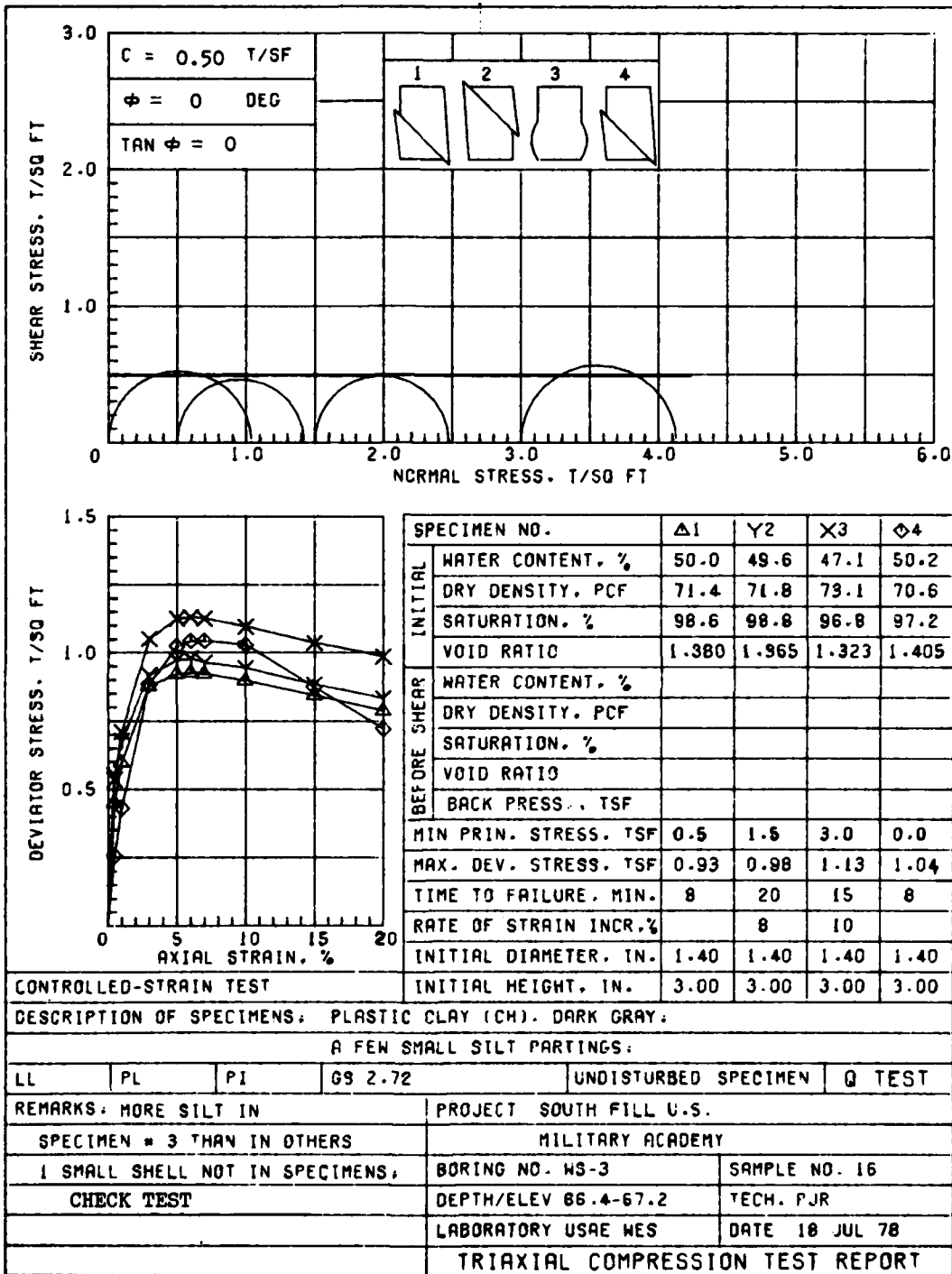
ENG FORM NO. 2089
REV JUNE 1970

PREVIOUS EDITION IS OBSOLETE

TRANSLUCENT

(EM 1110-2-1906)

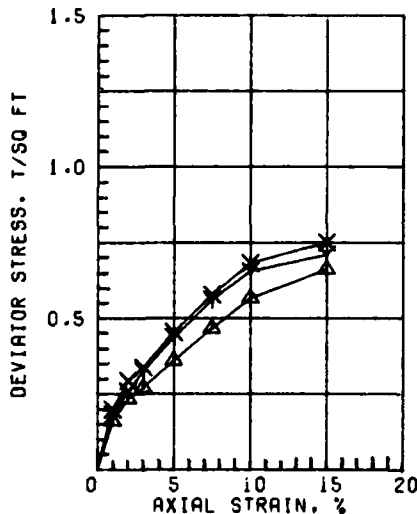
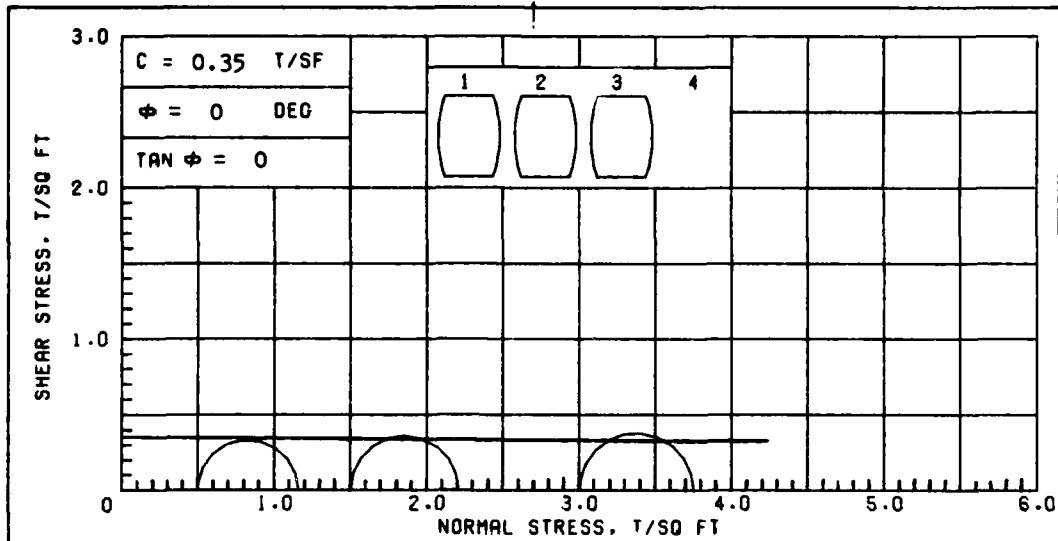
PLATE D17



ENG FORM NO. 2089 PREVIOUS EDITION IS OBSOLETE TRANSLUCENT (EN 1110-2 1965)
 REV JUNE 1970

PLATE D18

D20



SPECIMEN NO.		Δ1	Y2	X3	4
INITIAL	WATER CONTENT, %	51.5	51.4	51.1	
	DRY DENSITY, PCF	69.6	68.5	68.9	
	SATURATION, %	96.8	94.0	94.4	
	VOID RATIO	1.458	1.498	1.482	
BEFORE SHEAR	WATER CONTENT, %				
	DRY DENSITY, PCF				
	SATURATION, %				
	VOID RATIO				
	BACK PRESS., TSF				
	MIN PRIN. STRESS, TSF	0.5	1.5	3.0	
	MAX. DEV. STRESS, TSF	0.66	0.71	0.75	
	TIME TO FAILURE, MIN.	15	16	15	
	RATE OF STRAIN INCR, %				
	INITIAL DIAMETER, IN.	1.40	1.40	1.40	
	INITIAL HEIGHT, IN.	3.00	3.00	3.00	

CONTROLLED-STRAIN TEST

DESCRIPTION OF SPECIMENS, PLASTIC CLAY (CH), DARK GRAY

LL 58 PL 29 PI 29 GS 2.74 UNDISTURBED SPECIMEN Q TEST

REMARKS. PROJECT SOUTH FILL AREA U.S. MILITARY
WEST POINT, NEW YORK

BORING NO. WS-3 SAMPLE NO. 17

DEPTH/ELEV 69.0-71.3 TECH. JMS

LABORATORY USAE WES DATE 29 AUG 77

TRIAXIAL COMPRESSION TEST REPORT

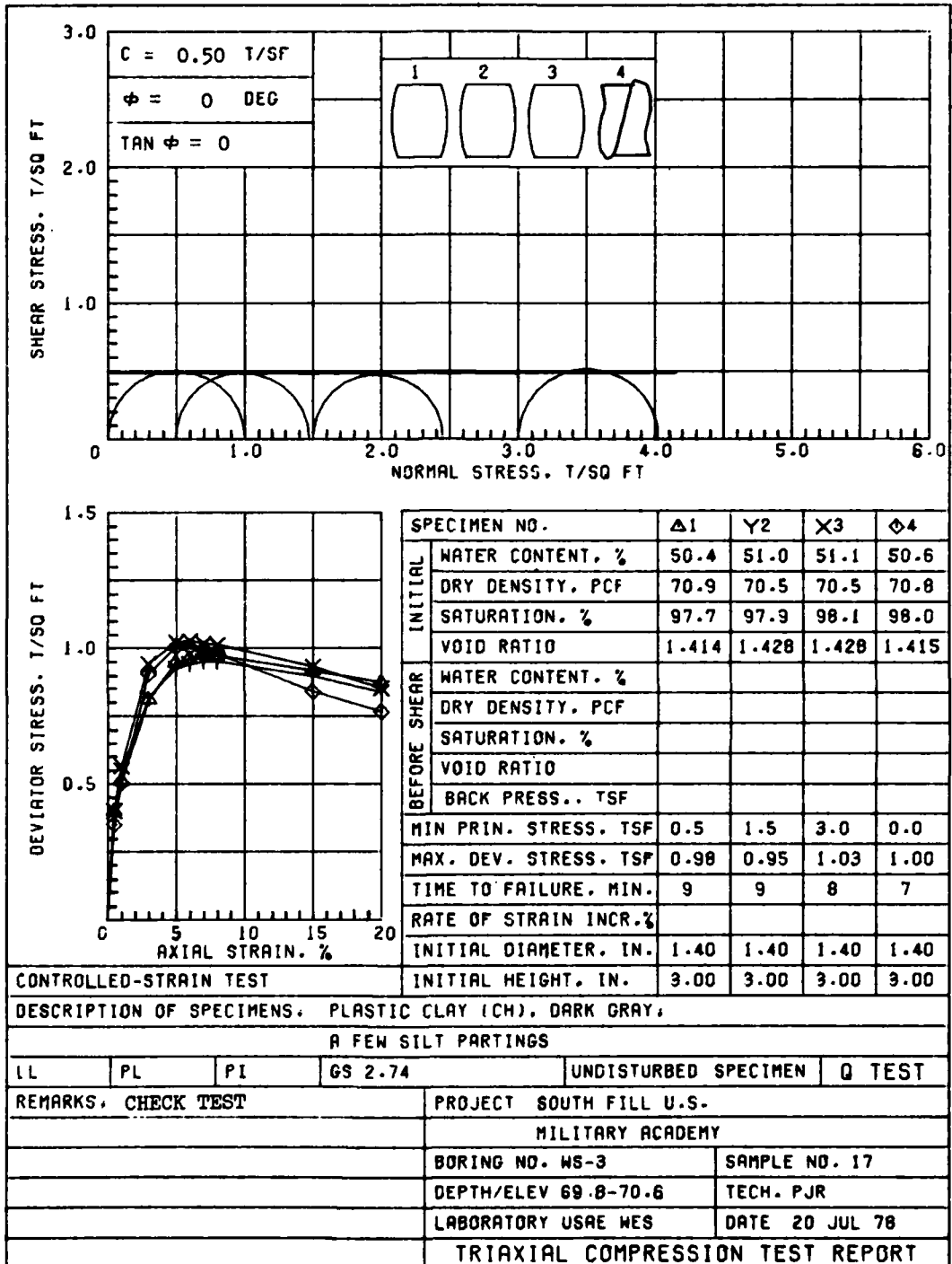
ENG FORM NO. 2089
REV JUNE 1970

PREVIOUS EDITION IS OBSOLETE

TRANSLUCENT

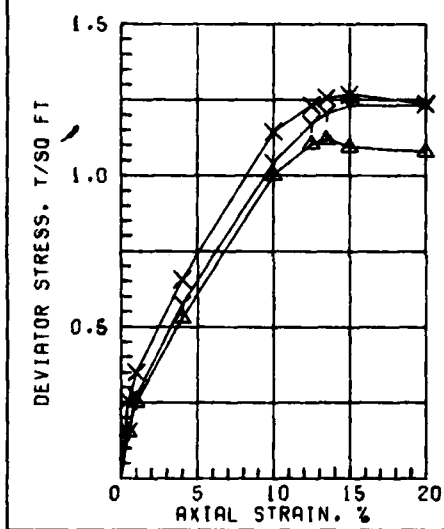
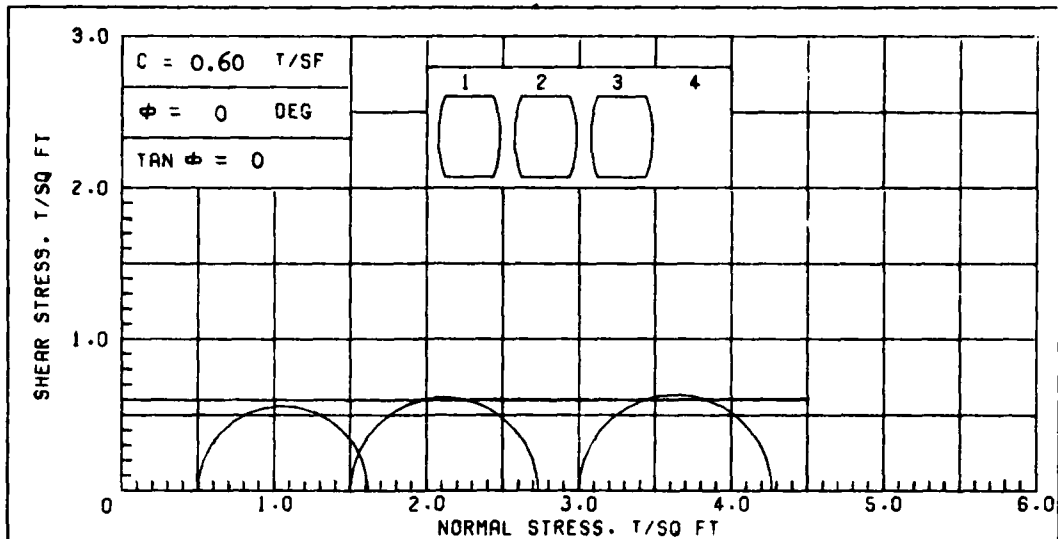
(EM 1110-2-1906)

PLATE D19



ENG FORM NO. 2089 REV JUNE 1970 PREVIOUS EDITION IS OBSOLETE TRANSLUCENT (EM 1110-2-1906)

PLATE D20



	SPECIMEN NO.	Δ1	Y2	X3	4
INITIAL	WATER CONTENT, %	38.5	37.9	38.7	
	DRY DENSITY, PCF	80.7	81.0	80.5	
	SATURATION, %	94.7	94.1	94.9	
BEFORE SHEAR	VOID RATIO	1.105	1.096	1.110	
	WATER CONTENT, %				
	DRY DENSITY, PCF				
	SATURATION, %				
	VOID RATIO				
	BACK PRESS., TSF				
	MIN PRIN. STRESS, TSF	0.5	1.5	3.0	
	MAX. DEV. STRESS, TSF	1.12	1.23	1.27	
	TIME TO FAILURE, MIN.	27	30	30	
	RATE OF STRAIN INCR, %				
	INITIAL DIAMETER, IN.	1.38	1.38	1.38	
	INITIAL HEIGHT, IN.	3.00	3.00	3.00	

CONTROLLED-STRAIN TEST

DESCRIPTION OF SPECIMENS. PLASTIC CLAY (CH), GRAY; SHELLS THROUGHOUT;
IRON OXIDE STAINS

LL 55	PL 24	PI 31	GS 2.72	UNDISTURBED SPECIMEN	Q TEST
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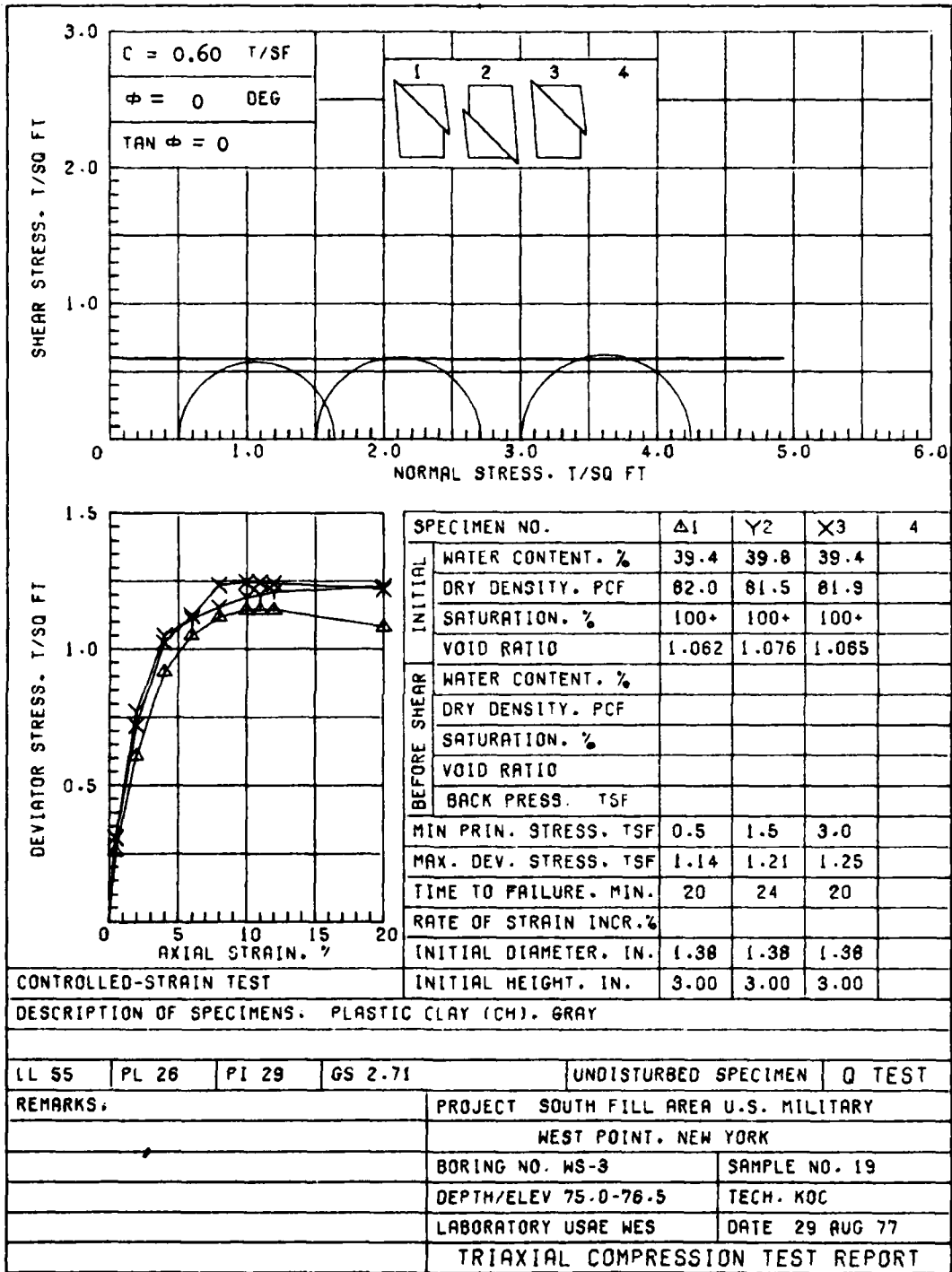
REMARKS:

PROJECT SOUTH FILL AREA U.S. MILITARY	
WEST POINT, NEW YORK	
BORING NO. WS-3	SAMPLE NO. 18
DEPTH/ELEV 72.0-74.2	TECH. KOC
LABORATORY USRE WES	DATE 30 AUG 77

TRIAXIAL COMPRESSION TEST REPORT

ENG FORM NO. 2089 REV JUNE 1970 PREVIOUS EDITION IS OBSOLETE TRANSLUCENT (EM 1110-2-1906)

PLATE D21



ENG FORM NO. 2080
 REV JUNE 1970

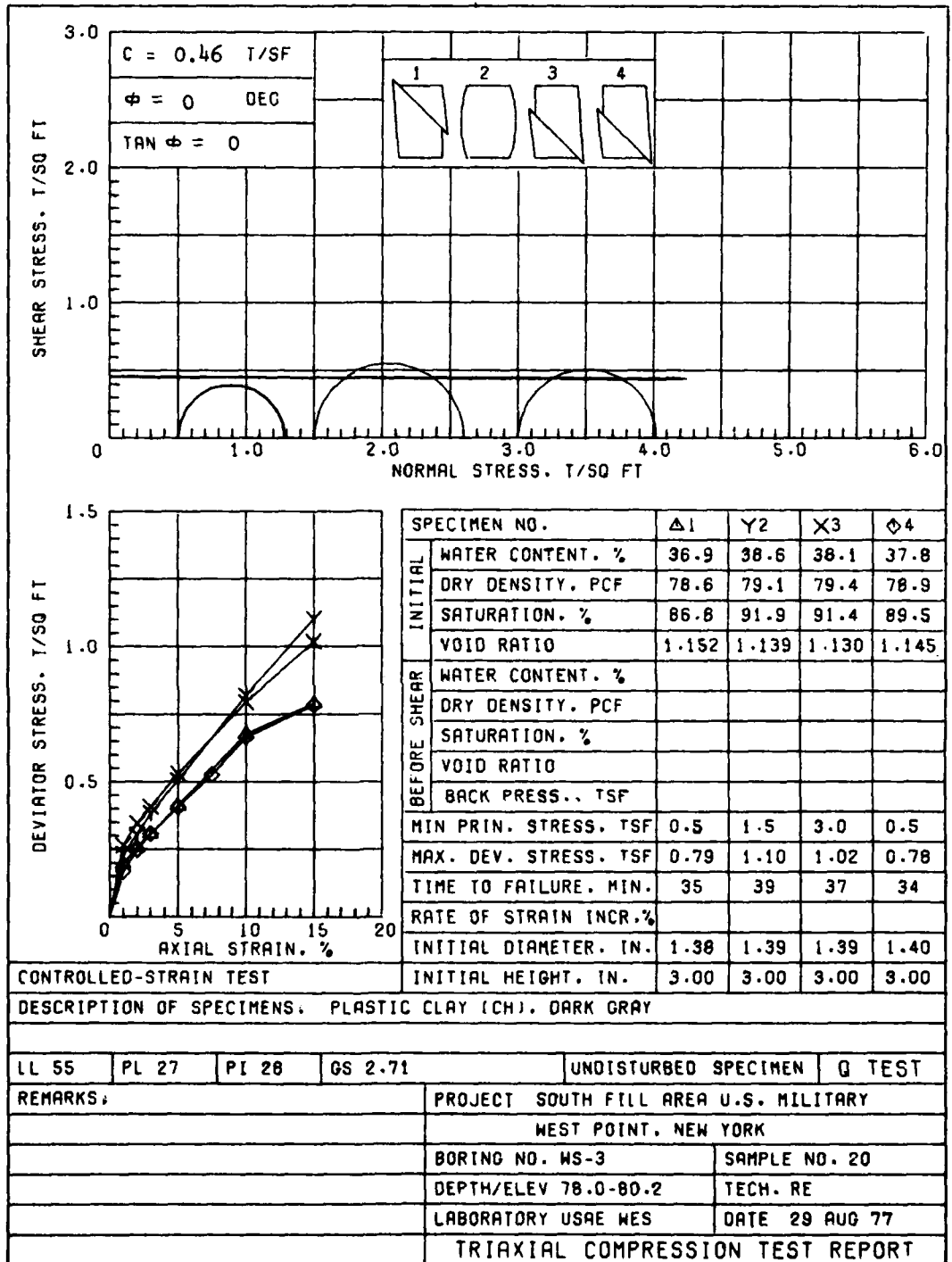
PREVIOUS EDITION IS OBSOLETE

TRANSLUCENT

(EM 1110-2-1906)

PLATE D22

D24



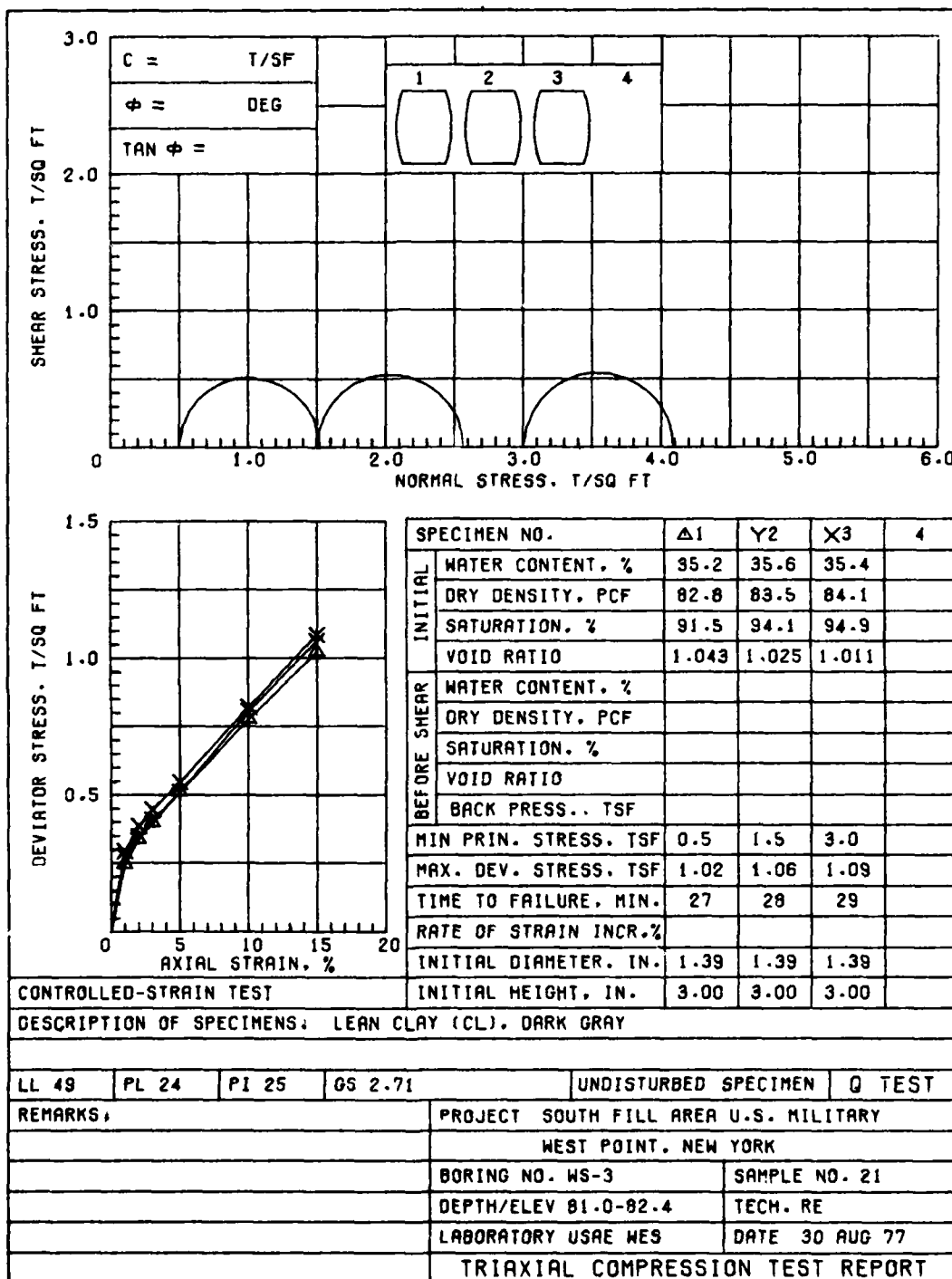
ENG FORM NO. 2089
REV JUNE 1970

PREVIOUS EDITION IS OBSOLETE

TRANSLUCENT

(EN 1110-2-1906)

PLATE D23



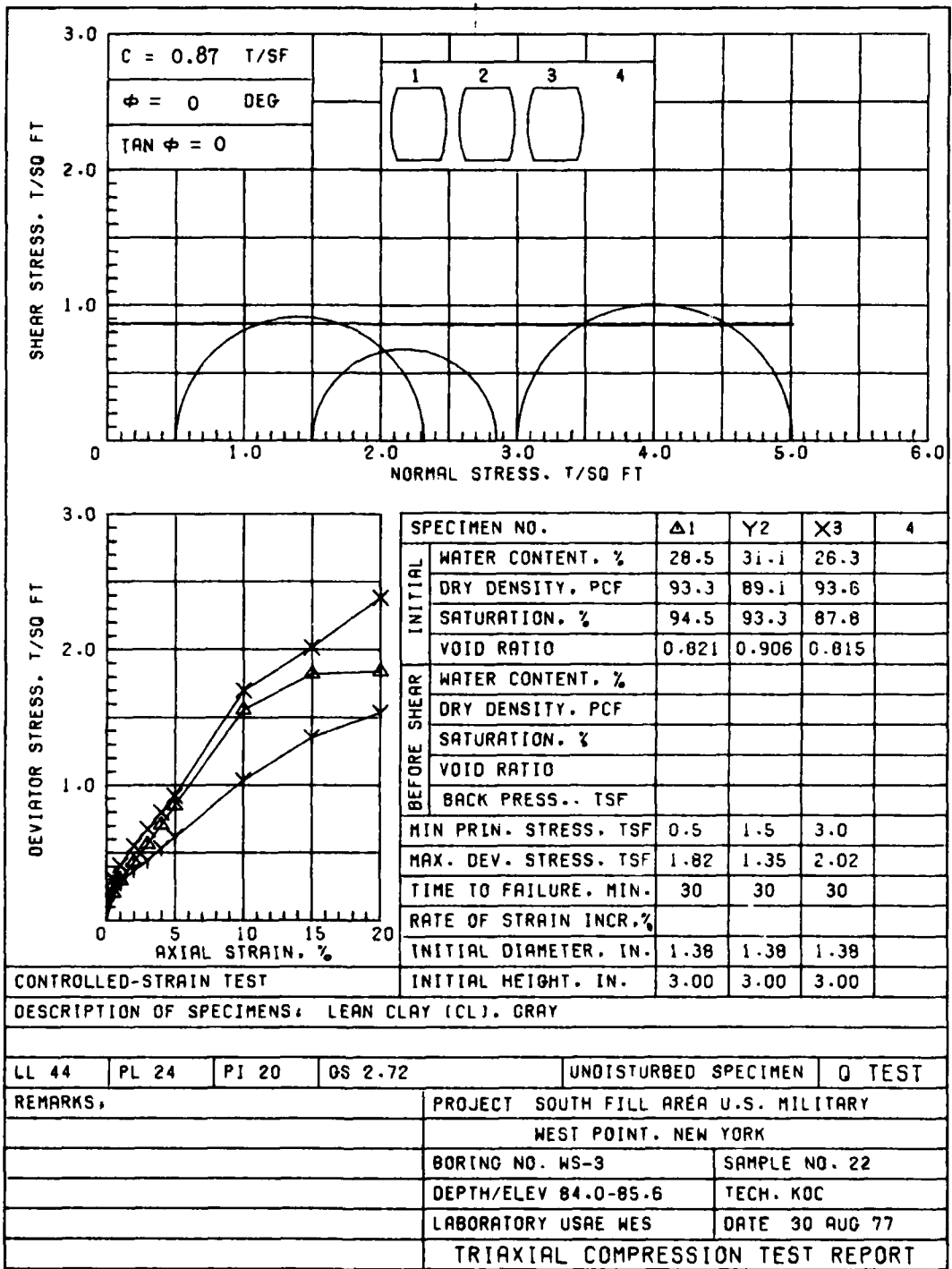
ENG FORM NO. 2089
 REV JUNE 1970

PREVIOUS EDITION IS OBSOLETE

TRANSLUCENT

(EM 1110-2-1906)

PLATE D24



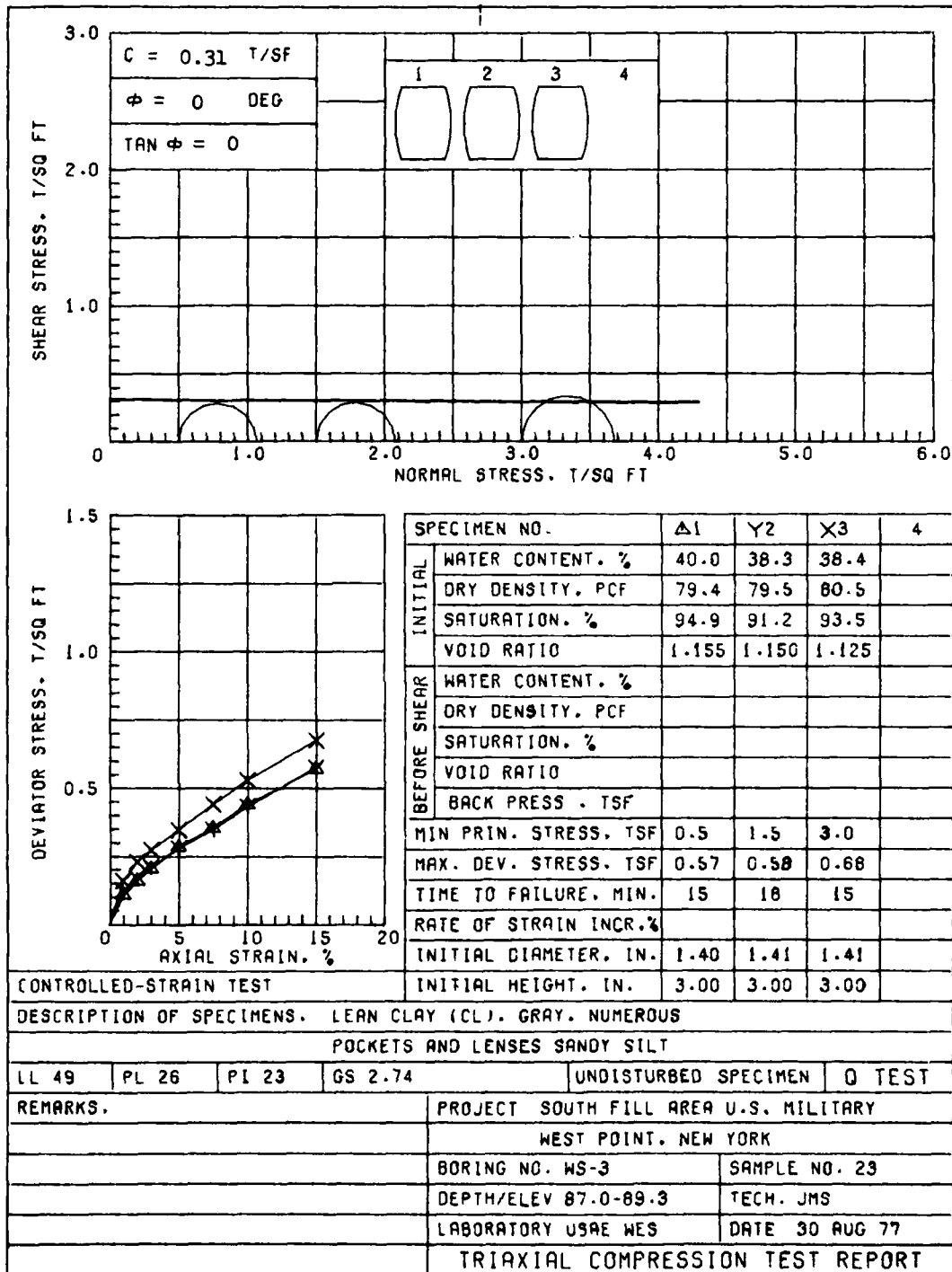
ENG FORM NO. 2089
REV JUNE 1970

PREVIOUS EDITION IS OBSOLETE

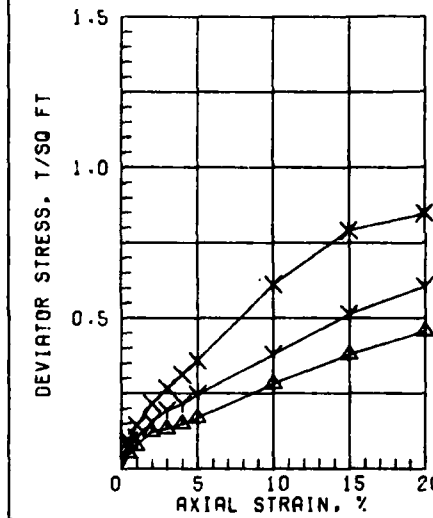
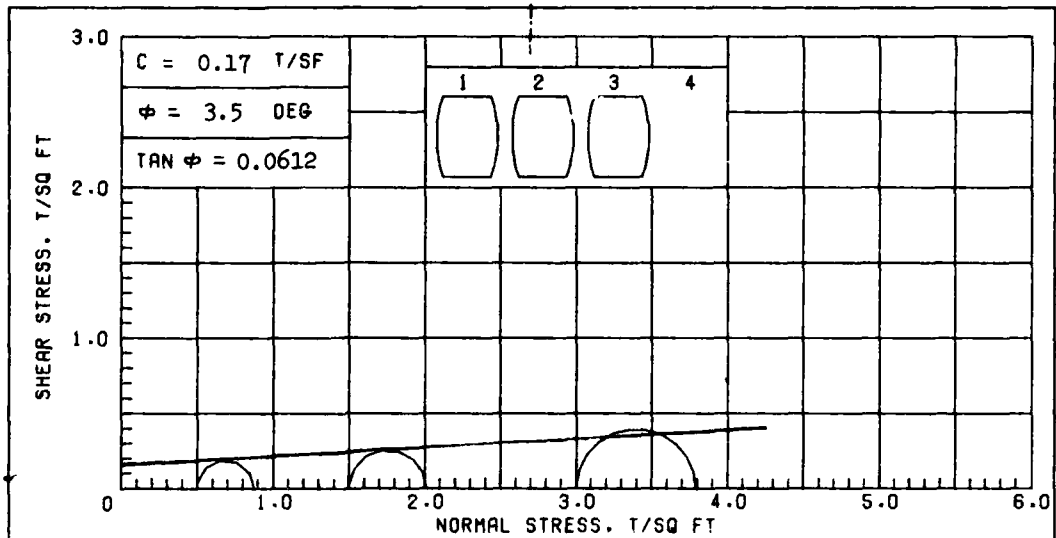
TRANSLUCENT

(EM 1110-2-1906)

PLATE D25



ENG FORM NO. 2089 PREVIOUS EDITION IS OBSOLETE TRANSLUCENT (EM 1110-2-1906)
 REV JUNE 1970
 PLATE D26



SPECIMEN NO.		Δ1	Y2	X3	4
INITIAL	WATER CONTENT, %	39.4	39.0	39.2	
	DRY DENSITY, PCF	79.2	79.5	79.6	
	SATURATION, %	94.0	93.7	94.4	
	VOID RATIO	1.136	1.128	1.125	
BEFORE SHEAR	WATER CONTENT, %				
	DRY DENSITY, PCF				
	SATURATION, %				
	VOID RATIO				
BACK PRESS., TSF					
MIN PRIN. STRESS, TSF		0.5	1.5	3.0	
MAX. DEV. STRESS, TSF		0.38	0.51	0.79	
TIME TO FAILURE, MIN.		30	30	30	
RATE OF STRAIN INCR. %					
INITIAL DIAMETER, IN.		1.38	1.38	1.38	
INITIAL HEIGHT, IN.		3.00	3.00	3.00	

CONTROLLED-STRAIN TEST

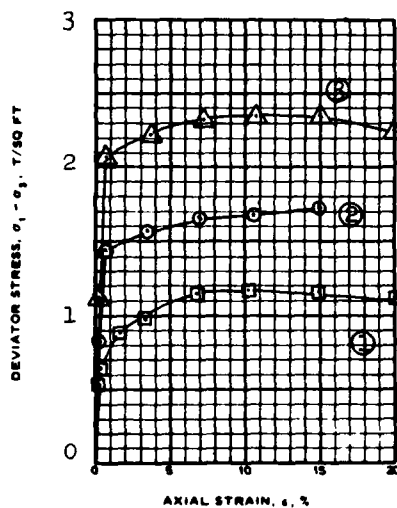
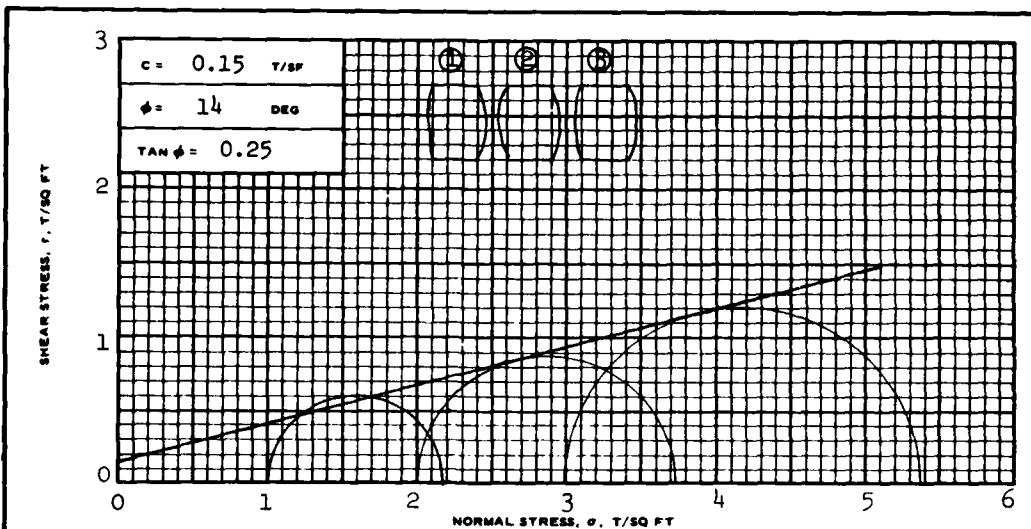
DESCRIPTION OF SPECIMENS, LEAN CLAY (CL), GRAY

LL 49	PL 26	PI 23	GS 2.71	UNDISTURBED SPECIMEN	Q TEST
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REMARKS: PROJECT SOUTH FILL AREA U.S. MILITARY
WEST POINT, NEW YORK

BORING NO. WS-3	SAMPLE NO. 24
DEPTH/ELEV 90.5-91.8	TECH. KOC
LABORATORY USAE WES	DATE 30 AUG 77

TRIAXIAL COMPRESSION TEST REPORT



SPECIMEN NO.		1	2	3
INITIAL	WATER CONTENT, %	w_p 54.0	55.2	55.0
	DRY DENSITY LB/CU FT	γ_d 67.6	66.4	66.1
	SATURATION, %	s_p 98.0	97.1	96.0
	VOID RATIO	e_p 1.48	1.53	1.54
BEFORE SHEAR	WATER CONTENT, %	w_c 46.5	43.7	40.8
	DRY DENSITY LB/CU FT	γ_c 75.6	75.1	78.8
	SATURATION, %	s_c 100+	*95.2	97.0
	VOID RATIO	e_c 1.22	1.23	1.13
FINAL BACK PRESSURE, T/SQ FT		u_0 5.76	5.76	5.76
MINOR PRINCIPAL STRESS, T/SQ FT		σ_3 1.0	2.0	3.0
MAXIMUM DEVIATOR STRESS, T/SQ FT		$(\sigma_1 - \sigma_3)_{MAX}$ 1.18	1.72	2.36
TIME TO $(\sigma_1 - \sigma_3)_{MAX}$, MIN		t_f 736	1071	764
ULTIMATE DEVIATOR STRESS, T/SQ FT		$(\sigma_1 - \sigma_3)_{ULT}$		
INITIAL DIAMETER, IN.		D_0 1.40	1.40	1.40
INITIAL HEIGHT, IN.		H_0 3.00	3.00	3.00

CONTROLLED- strain TEST

DESCRIPTION OF SPECIMENS PLASTIC CLAY(CH), GRAY

LL - PL - PI - σ_c 2.69(Q) TYPE OF SPECIMEN UNDISTURBED TYPE OF TEST R

REMARKS: See attached sheet for effective values. *Pore pressure response indicated 100% saturation

PROJECT SOUTH FILL AREA
U.S. MILITARY ACADEMY

BORING NO. WS-3 SAMPLE NO. 7

DEPTH/ELEV 39.0-41.3

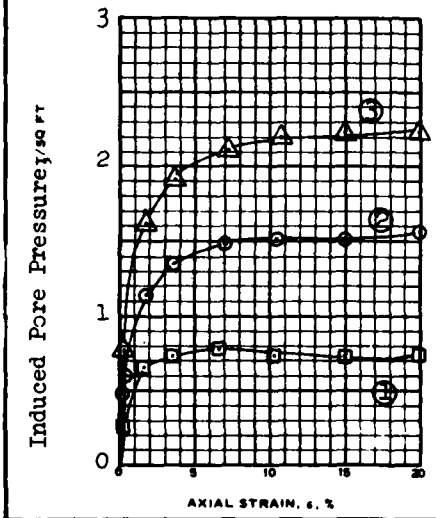
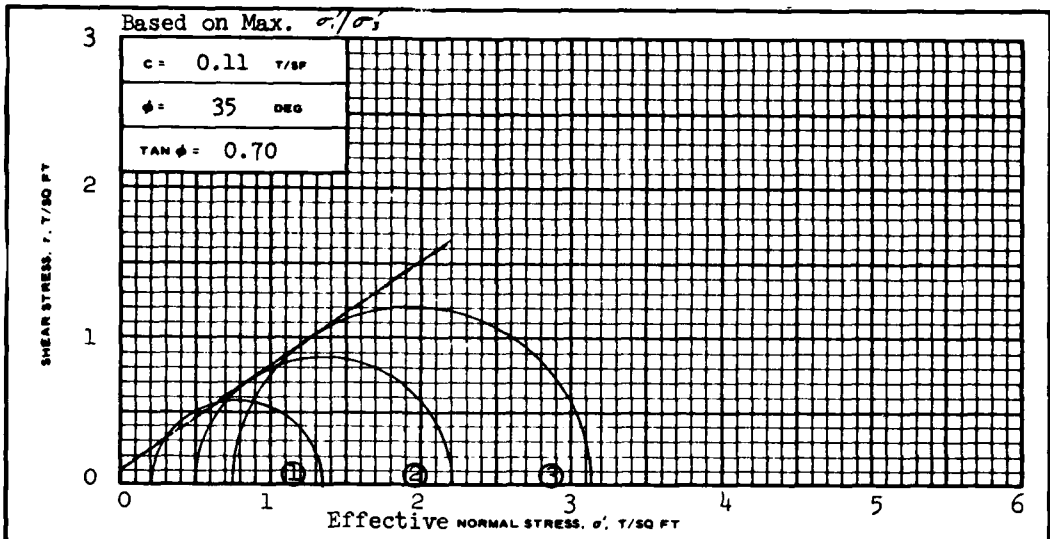
LABORATORY USAEWES DATE 17SEP77

DMS TRIAXIAL COMPRESSION TEST REPORT

ENG FORM NO. 2088 PREVIOUS EDITION IS OBSOLETE
REV JUNE 1970

TRANSLUCENT (EM 1110-2-1906)

PLATE D28

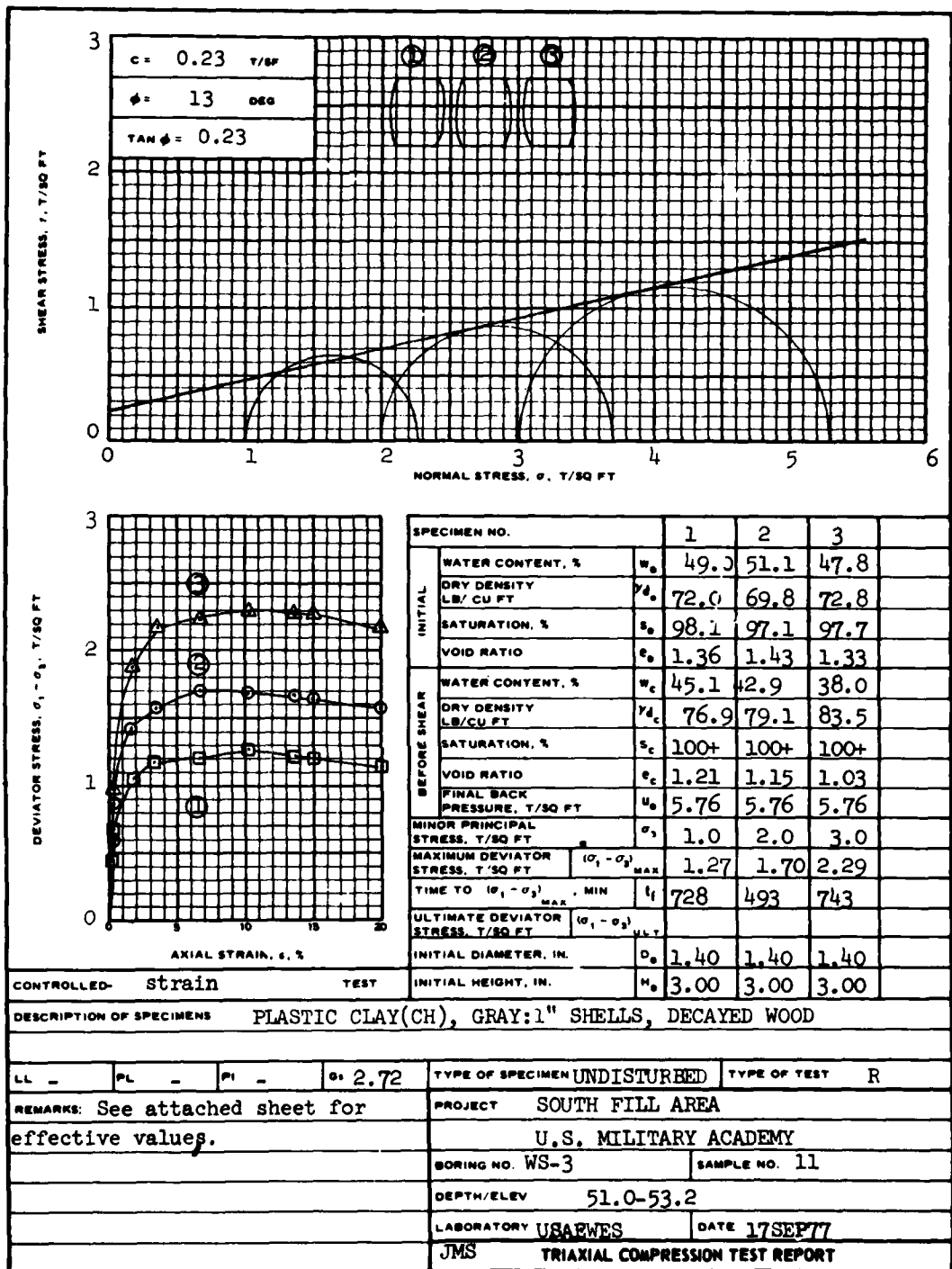


SPECIMEN NO.					
INITIAL	WATER CONTENT, %	w_o			
	DRY DENSITY LB/ CU FT	γ_{d_o}			
	SATURATION, %	s_o			
	VOID RATIO	e_o			
BEFORE SHEAR	WATER CONTENT, %	w_c			
	DRY DENSITY LB/ CU FT	γ_{d_c}			
	SATURATION, %	s_c			
	VOID RATIO	e_c			
	FINAL BACK PRESSURE, T/SQ FT	u_o			
	MINOR PRINCIPAL STRESS, T/SQ FT	σ_3			
	MAXIMUM DEVIATOR STRESS, T/SQ FT	$(\sigma_1 - \sigma_3)_{MAX}$			
	TIME TO $(\sigma_1 - \sigma_3)_{MAX}$, MIN	t_f			
	ULTIMATE DEVIATOR STRESS, T/SQ FT	$(\sigma_1 - \sigma_3)_{ULT}$			
	INITIAL DIAMETER, IN.	D_o			
	INITIAL HEIGHT, IN.	H_o			

CONTROLLED- TEST

DESCRIPTION OF SPECIMENS

LL	PL	PI	q_s	TYPE OF SPECIMEN	UNDISTURBED	TYPE OF TEST	R
REMARKS:				PROJECT	SOUTH FILL AREA U.S. MILITARY ACADEMY		
				BORING NO.	WS-3	SAMPLE NO.	7
				DEPTH/ELEV	39.0-41.3		
				LABORATORY	USA EWES	DATE	17SEP77
				JMS	TRIAxIAL COMPRESSION TEST REPORT		



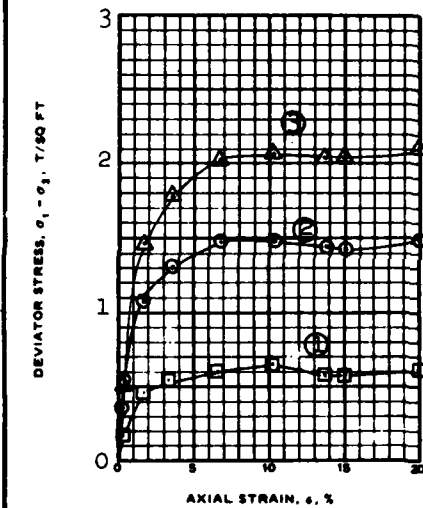
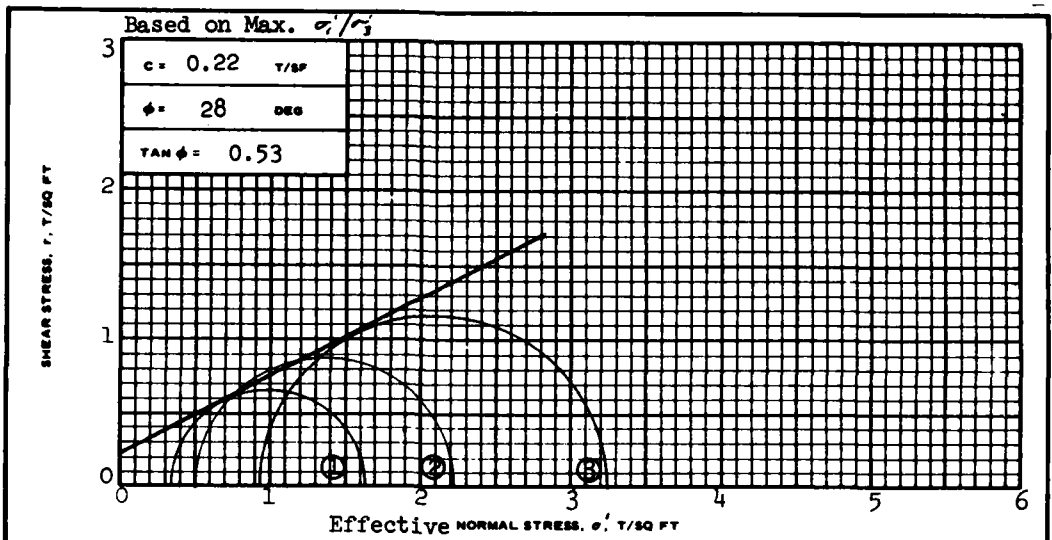
ENG FORM NO. 2089
REV JUNE 1970

PREVIOUS EDITION IS OBSOLETE

TRANSLUCENT

(EM 1110-2-1906)

PLATE D30
(SHEET 1 OF 2)

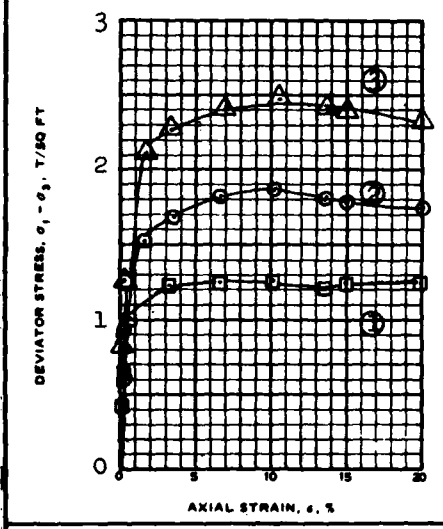
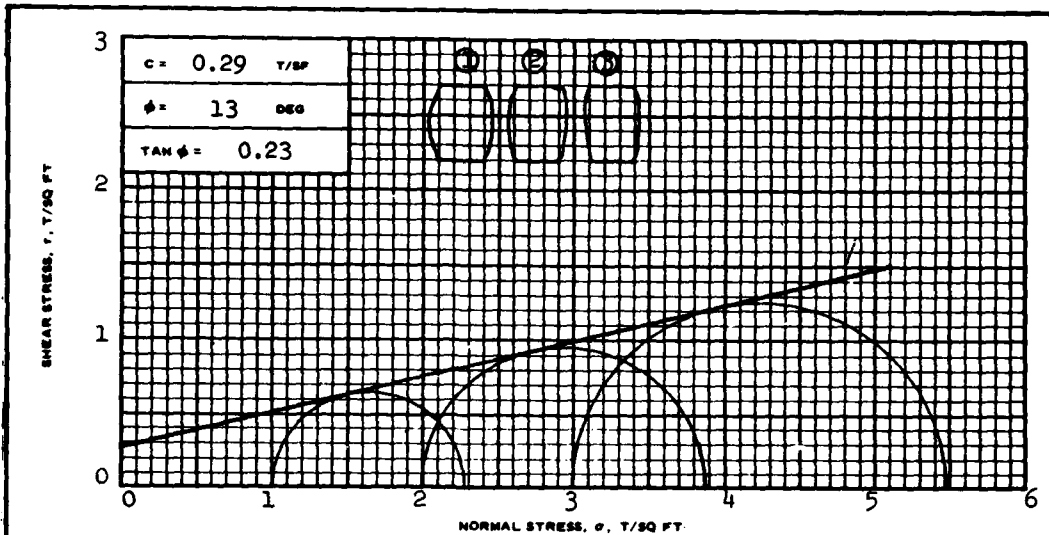


SPECIMEN NO.							
INITIAL	WATER CONTENT, %	w_o					
	DRY DENSITY LB/ CU FT	γ_d_o					
	SATURATION, %	s_o					
	VOID RATIO	e_o					
BEFORE SHEAR	WATER CONTENT, %	w_c					
	DRY DENSITY LB/ CU FT	γ_d_c					
	SATURATION, %	s_c					
	VOID RATIO	e_c					
	FINAL BACK PRESSURE, T/SQ FT	u_o					
	MINOR PRINCIPAL STRESS, T/SQ FT	σ_3					
	MAXIMUM DEVIATOR STRESS, T/SQ FT	$(\sigma_1 - \sigma_3)_{MAX}$					
	TIME TO $(\sigma_1 - \sigma_3)_{MAX}$, MIN	t_f					
	ULTIMATE DEVIATOR STRESS, T/SQ FT	$(\sigma_1 - \sigma_3)_{ULT}$					
	INITIAL DIAMETER, IN.	D_o					
	INITIAL HEIGHT, IN.	H_o					

CONTROLLED- TEST

DESCRIPTION OF SPECIMENS

LL	PL	PI	G _s	TYPE OF SPECIMEN	TYPE OF TEST \bar{R}
REMARKS:				PROJECT	SOUTH FILL AREA
					U.S. MILITARY ACADEMY
				BORING NO.	WS-3
				SAMPLE NO.	11
				DEPTH/ELEV	51.0-53.2
				LABORATORY	USAEWES
				DATE	17SEP77
Sheet 2 of 2.				JMS	TRIAXIAL COMPRESSION TEST REPORT



SPECIMEN NO.		1	2	3
INITIAL	WATER CONTENT, %	w_p 51.8	51.6	50.9
	DRY DENSITY LB/ CU FT	γ_d 69.9	70.3	70.6
	SATURATION, %	s_p 98.8	99.4	98.7
	VOID RATIO	e_p 1.42	1.41	1.40
BEFORE SHEAR	WATER CONTENT, %	w_c 49.9	45.8	41.6
	DRY DENSITY LB/ CU FT	γ_d 73.7	78.7	80.8
	SATURATION, %	s_c 100+	100+	100+
	VOID RATIO	e_c 1.30	1.15	1.09
FINAL BACK PRESSURE, T/SQ FT		u_b 5.76	5.76	5.76
MINOR PRINCIPAL STRESS, T/SQ FT		σ_3 1.0	2.0	3.0
MAXIMUM DEVIATOR STRESS, T/SQ FT		$(\sigma_1 - \sigma_3)_{MAX}$ 1.26	1.87	2.48
TIME TO $(\sigma_1 - \sigma_3)_{MAX}$, MIN		t_f 728	743	750
ULTIMATE DEVIATOR STRESS, T/SQ FT		$(\sigma_1 - \sigma_3)_{ULT}$		
INITIAL DIAMETER, IN.		D_o 1.40	1.41	1.40
INITIAL HEIGHT, IN.		H_o 3.00	3.00	3.00

CONTROLLED- strain TEST

DESCRIPTION OF SPECIMENS PLASTIC CLAY(CH), DARK GRAY

LL - PL - PI - G_s 2.71(G_s) TYPE OF SPECIMEN UNDISTURBED TYPE OF TEST R

REMARKS: See attached sheet for effective values.

PROJECT SOUTH FILL AREA
U.S. MILITARY ACADEMY

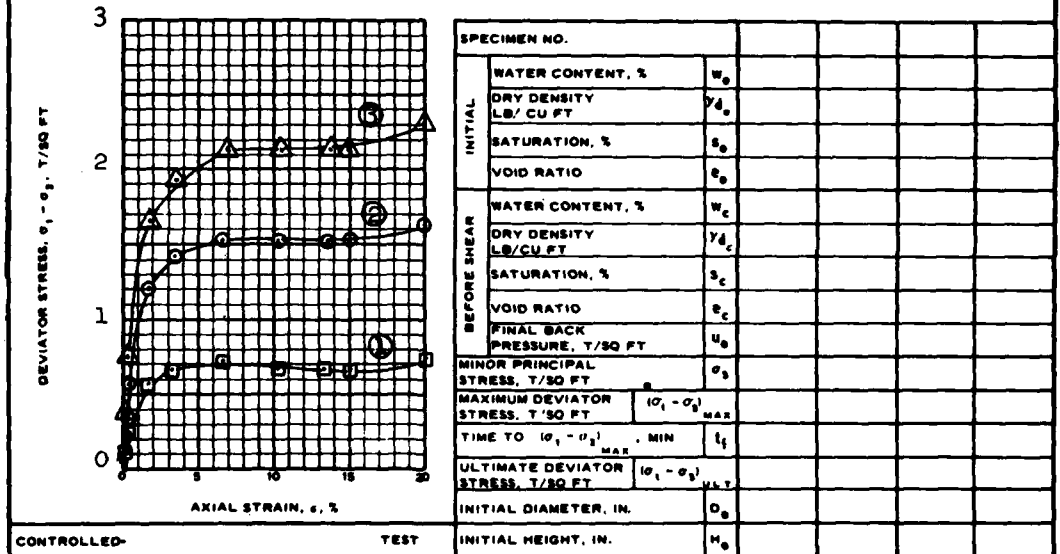
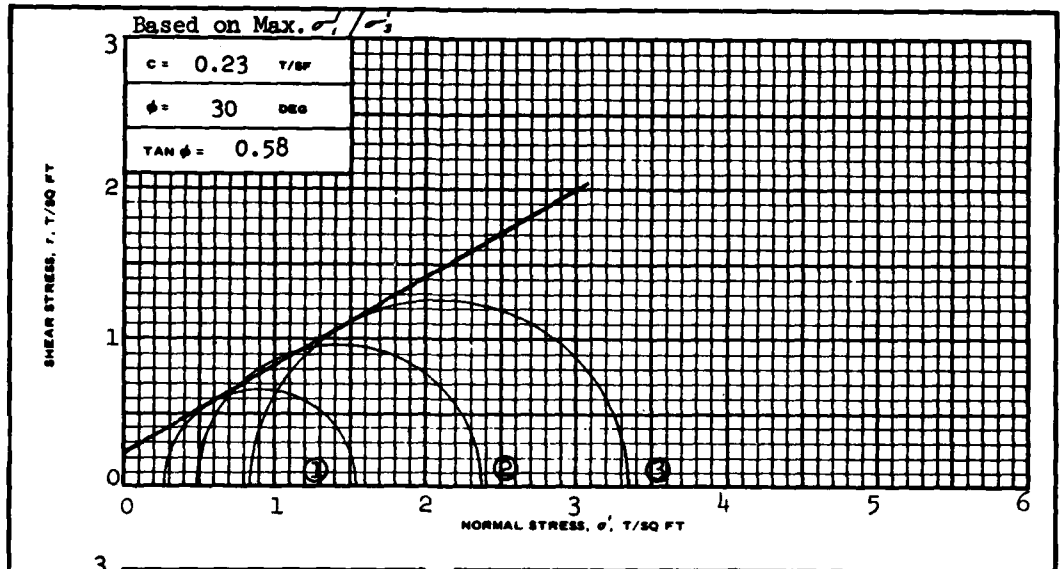
BORING NO. WS-3 SAMPLE NO. 14

DEPTH/ELEV 60.5-62.7

LABORATORY SAEWES DATE 17SEPT77

JMS TRIAXIAL COMPRESSION TEST REPORT

ENG FORM NO. 2089 PREVIOUS EDITION IS OBSOLETE TRANSLUCENT (EM 1110-2-1906)
 REV JUNE 1970
 PLATE D31
 (SHEET 1 OF 2)



CONTROLLED- TEST					
DESCRIPTION OF SPECIMENS					
LL	PL	PI	G _s	TYPE OF SPECIMEN	TYPE OF TEST \bar{R}
REMARKS:				PROJECT SOUTH FILL AREA	
				U.S. MILITARY ACADEMY	
				BORING NO. WS-3	SAMPLE NO. 14
				DEPTH/ELEV 60.5-62.7	
				LABORATORY USAEWES	DATE 17SEP77
				JMS TRIAXIAL COMPRESSION TEST REPORT	

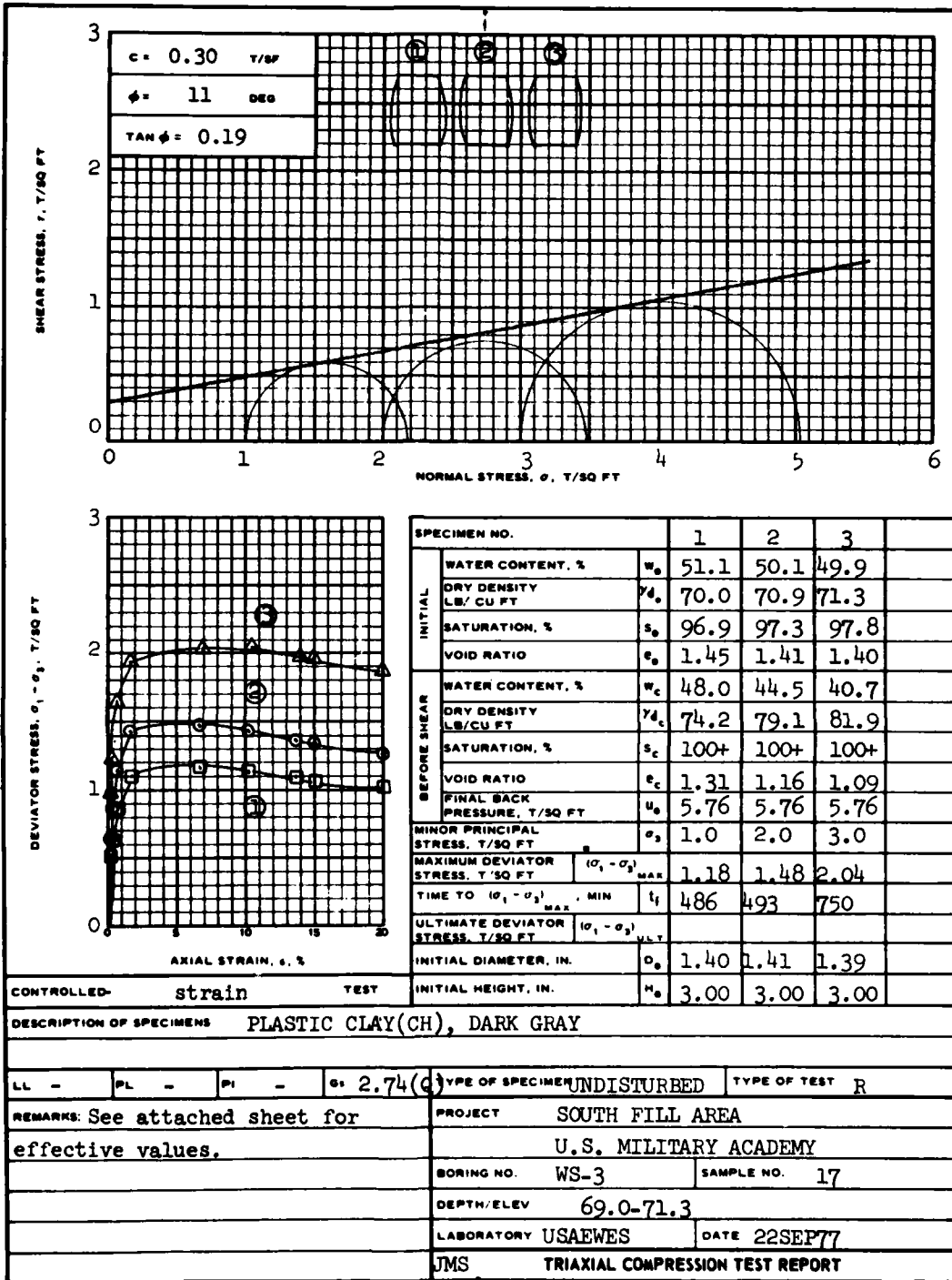
ENG FORM NO. 2088
REV JUNE 1970

PREVIOUS EDITION IS OBSOLETE

TRANSLUCENT

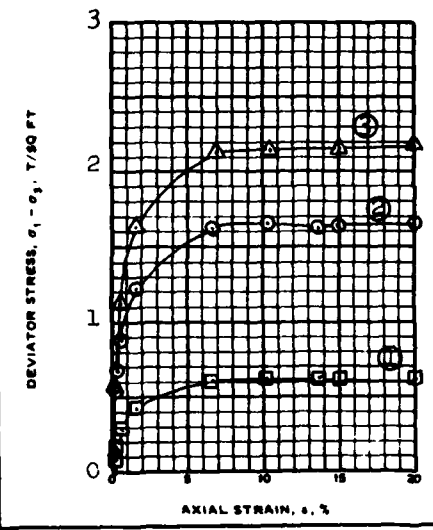
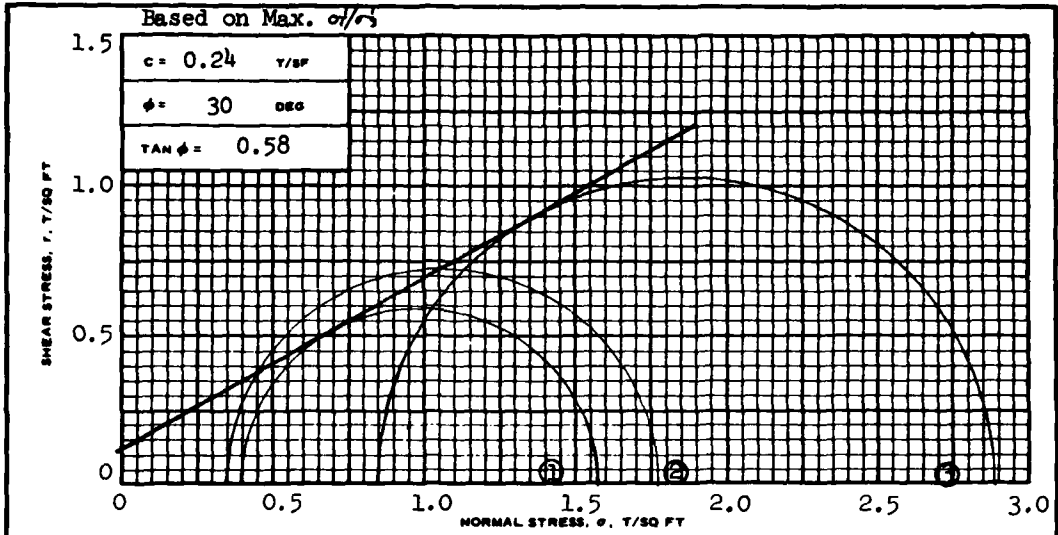
(EM 1110-2-1906)

PLATE D31
(SHEET 2 OF 2)



ENG FORM NO. 2089 PREVIOUS EDITION IS OBSOLETE TRANSLUCENT (EN 1110-2-1906)
 REV JUNE 1970

PLATE D32
 (SHEET 1 OF 2)

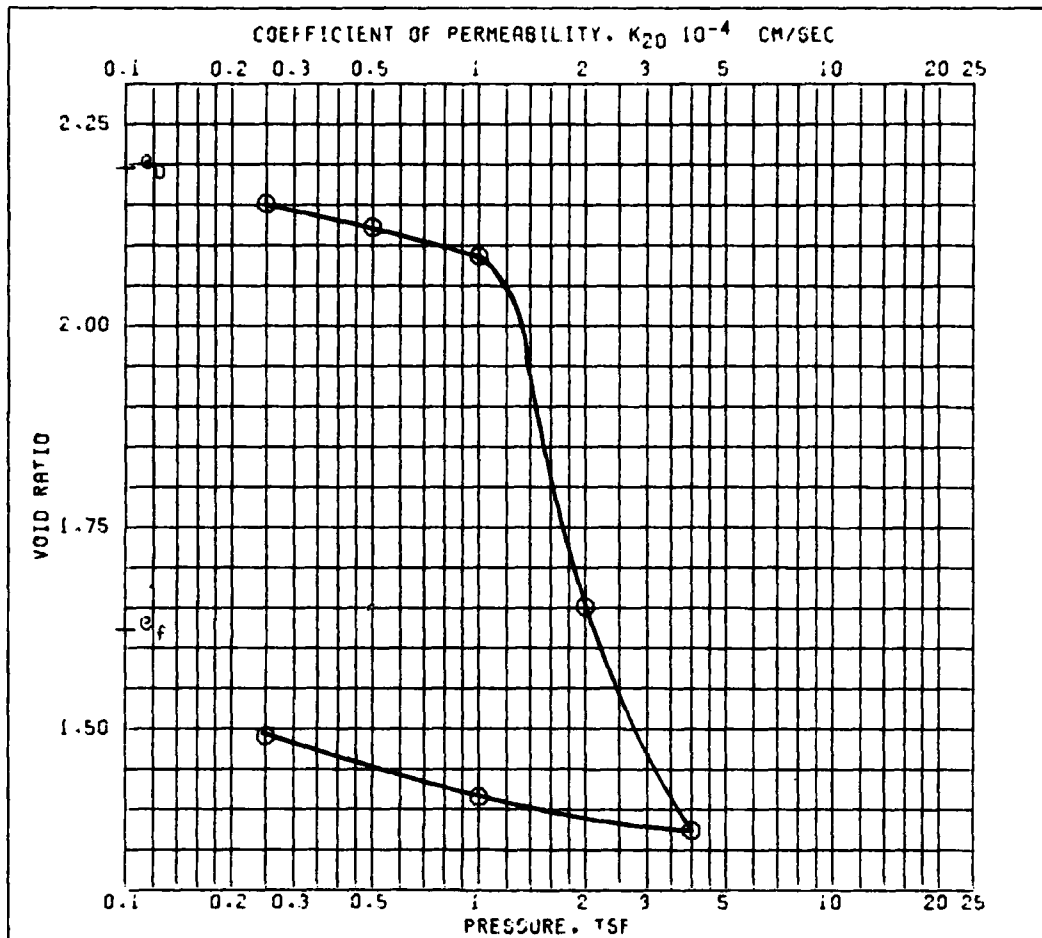


SPECIMEN NO.					
INITIAL	WATER CONTENT, %	w_o			
	DRY DENSITY LB/ CU FT	γ_d_o			
	SATURATION, %	s_o			
	VOID RATIO	e_o			
BEFORE SHEAR	WATER CONTENT, %	w_c			
	DRY DENSITY LB/ CU FT	γ_d_c			
	SATURATION, %	s_c			
	VOID RATIO	e_c			
FINAL BACK PRESSURE, T/SQ FT		u_o			
MINOR PRINCIPAL STRESS, T/SQ FT		σ_3			
MAXIMUM DEVIATOR STRESS, T/SQ FT		$(\sigma_1 - \sigma_3)_{MAX}$			
TIME TO $(\sigma_1 - \sigma_3)_{MAX}$, MIN		t_f			
ULTIMATE DEVIATOR STRESS, T/SQ FT		$(\sigma_1 - \sigma_3)_{ULT}$			
INITIAL DIAMETER, IN.		D_o			
INITIAL HEIGHT, IN.		H_o			

CONTROLLED- TEST

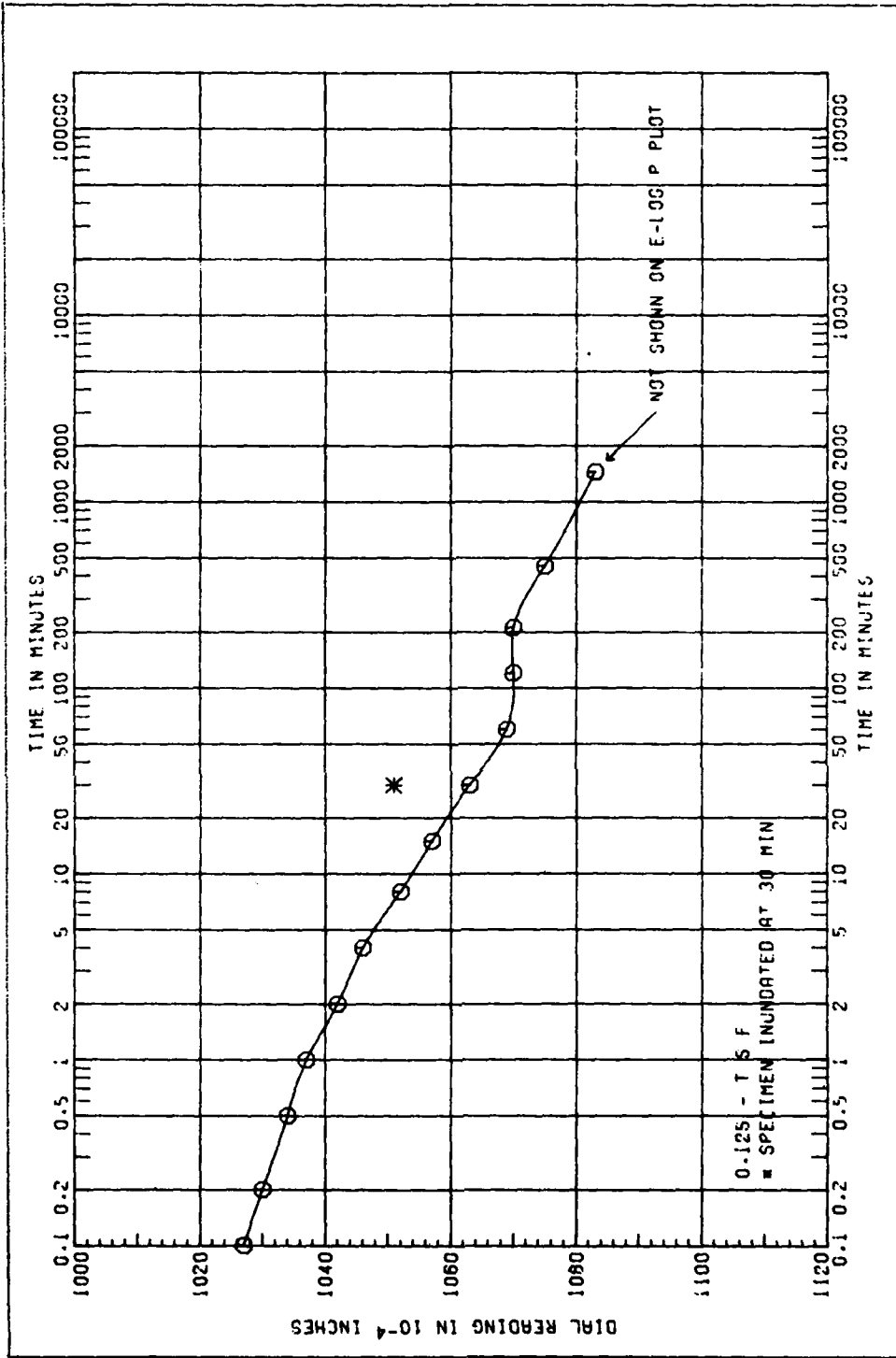
DESCRIPTION OF SPECIMENS

LL	PL	PI	G _s	TYPE OF SPECIMEN	TYPE OF TEST \bar{R}
REMARKS:				PROJECT	SOUTH FILL AREA
					U.S. MILITARY ACADEMY
				BORING NO.	WS-3
				SAMPLE NO.	17
				DEPTH/ELEV	69.0-71.3
				LABORATORY	USAEWES
				DATE	22SEP77
Sheet 2 of 2.				JMS	TRIAxIAL COMPRESSION TEST REPORT



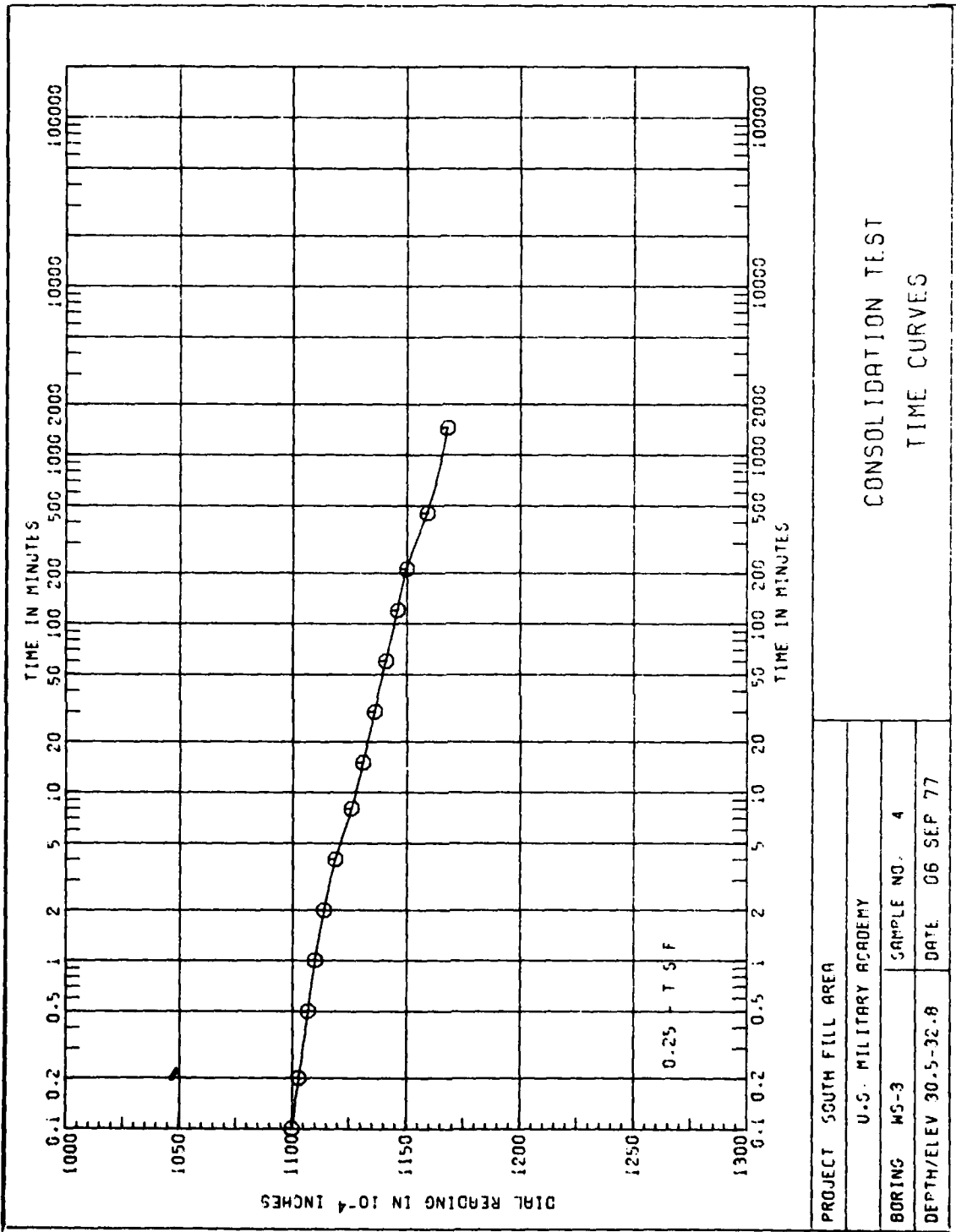
		BEFORE TEST	AFTER TEST
OVERBURDEN PRESSURE, TSF		99.2	67.9
PRECONSOL. PRESSURE, TSF		47.7	59.1
COMPRESSION INDEX		99.3	100 +
TYPE SPECIMEN	UNDISTURBED	VOID RATIO	
		2.194	1.621
DIA. IN 4.44	HT. IN 1.224	BACK PRESSURE, TSF	
CLASSIFICATION ORGANIC SILT(OH). GRAY & BROWN MOTTLED			
LL	PL	PI	PROJECT SOUTH FILL AREA
GS 2.44 (Q)	D ₁₀		U.S. MILITARY ACADEMY
REMARKS		BORING NO. WS-3	SAMPLE NO. 4
		DEPTH/ELEV 30.5-32.0	DATE 06 SEP 77
CONSOLIDATION TEST REPORT			

PLATE D33
(SHEET 1 OF 10)



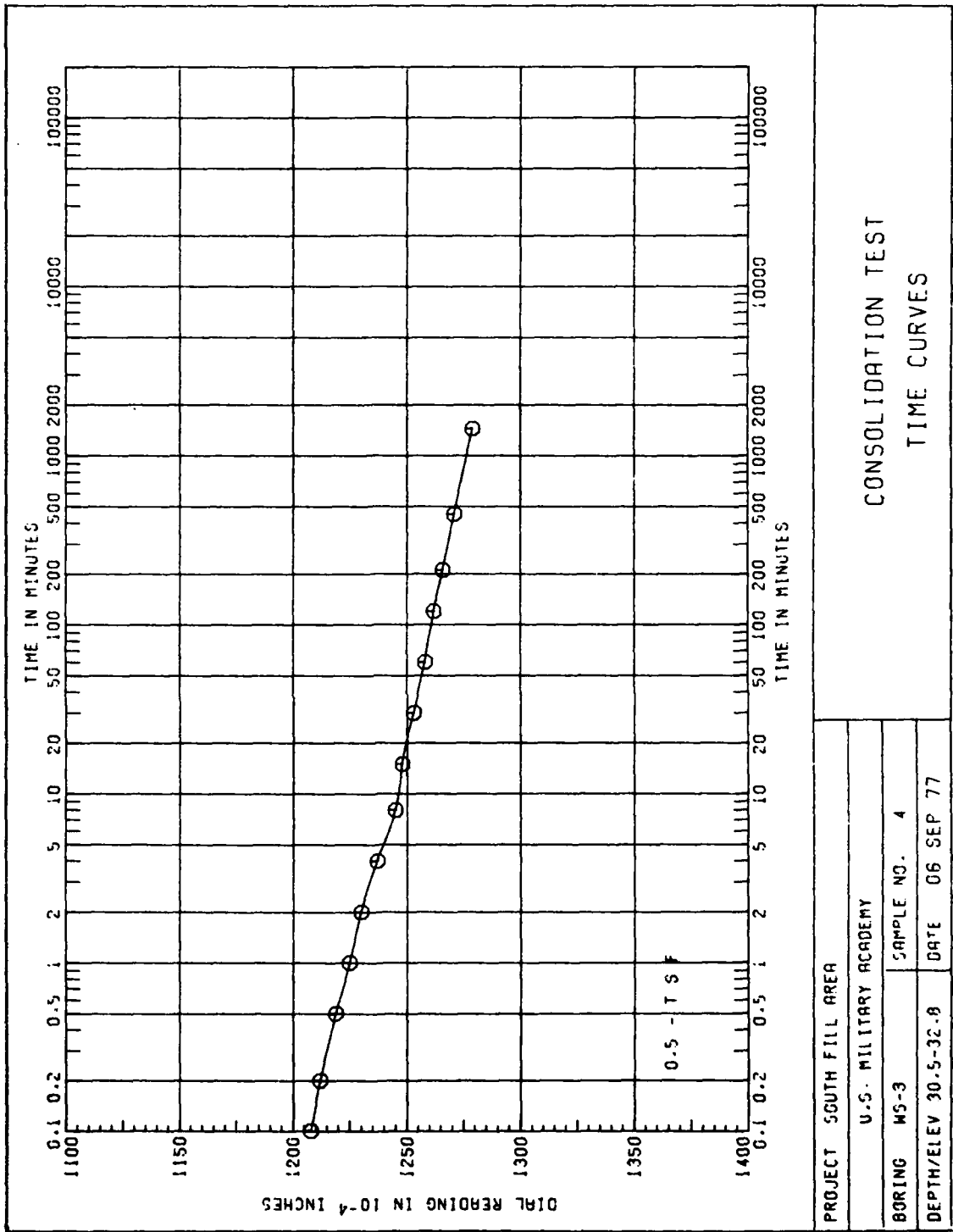
CONSOLIDATION TEST TIME CURVES	
PROJECT SOUTH FILL AREA	U.S. MILITARY ACADEMY
BORING WS-3	SAMPLE NO. 4
DEPTH/ELEV 30.5-32.8	DATE 06 SEP 77

PLATE D33
(SHEET 2 OF 10)



CONSOLIDATION TEST TIME CURVES	
PROJECT SOUTH FILL AREA	
U.S. MILITARY ACADEMY	
BORING WS-3	SAMPLE NO. 4
DEPTH/ELEV 30.5-32.8	DATE 06 SEP 77

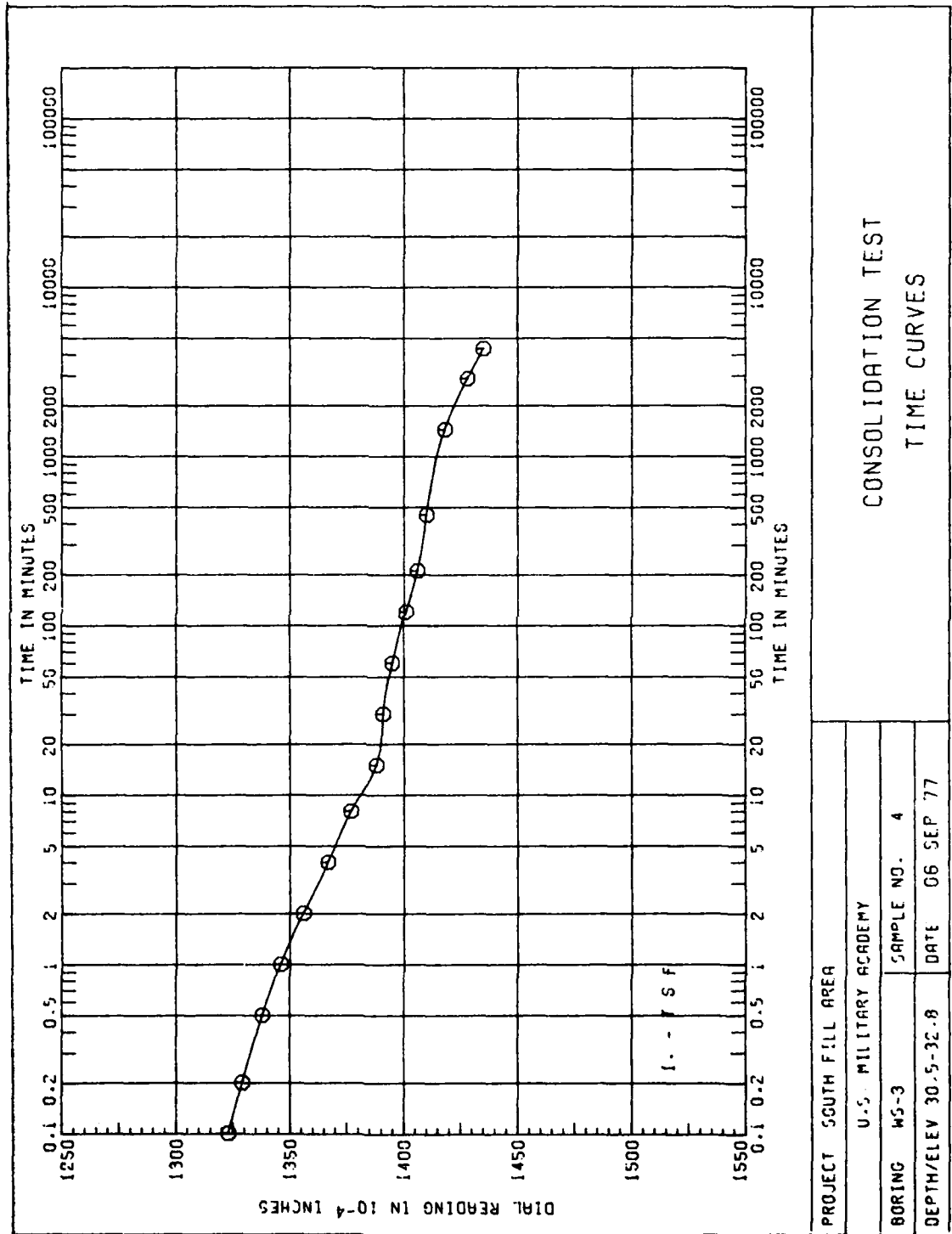
PLATE D33
(SHEET 3 OF 10)



CONSOLIDATION TEST
TIME CURVES

PROJECT SCUTH FILL AREA	
U.S. MILITARY ACADEMY	
BORING MS-3	SAMPLE NO. 4
DEPTH/ELEV 30.5-32.8	DATE 06 SEP 77

PLATE D33
(SHEET 4 OF 10)



CONSOLIDATION TEST
TIME CURVES

PROJECT SOUTH FILL AREA	
U.S. MILITARY ACADEMY	
BORING WS-3	SAMPLE NO. 4
DEPTH/ELEV 30.5-32.8	DATE 06 SEP 77

PLATE D33
(SHEET 5 OF 10)

AD-A089 751

ARMY ENGINEER WATERWAYS EXPERIMENT STATION VICKSBURG--ETC F/6 8/13
INVESTIGATION FOR SOUTH FILL AREA, UNITED STATES MILITARY ACADE--ETC(U)

AUG 80 H M TAYLOR, J K POPLIN, G B MITCHELL IAO-NYD-78-76-(M)

UNCLASSIFIED

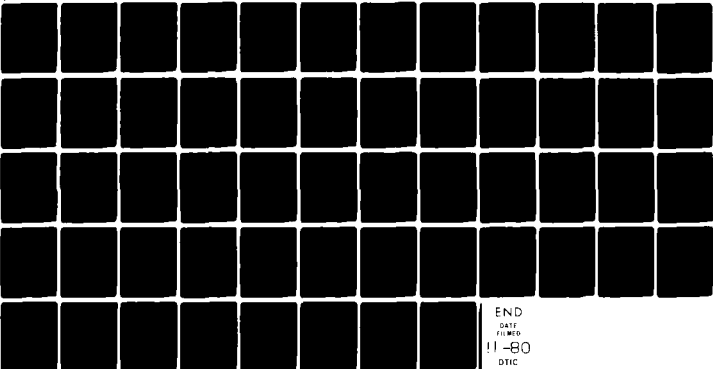
WES/MP/GL-80-7

NL

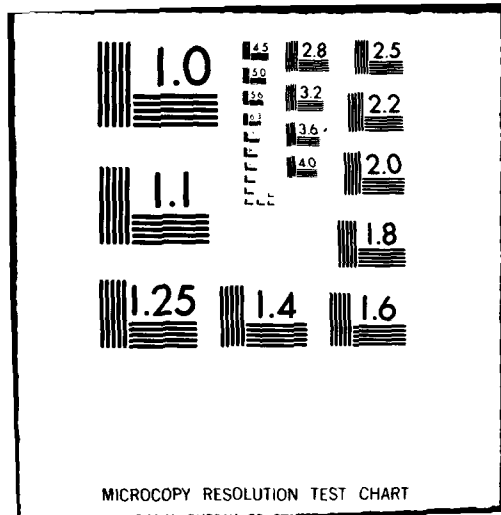
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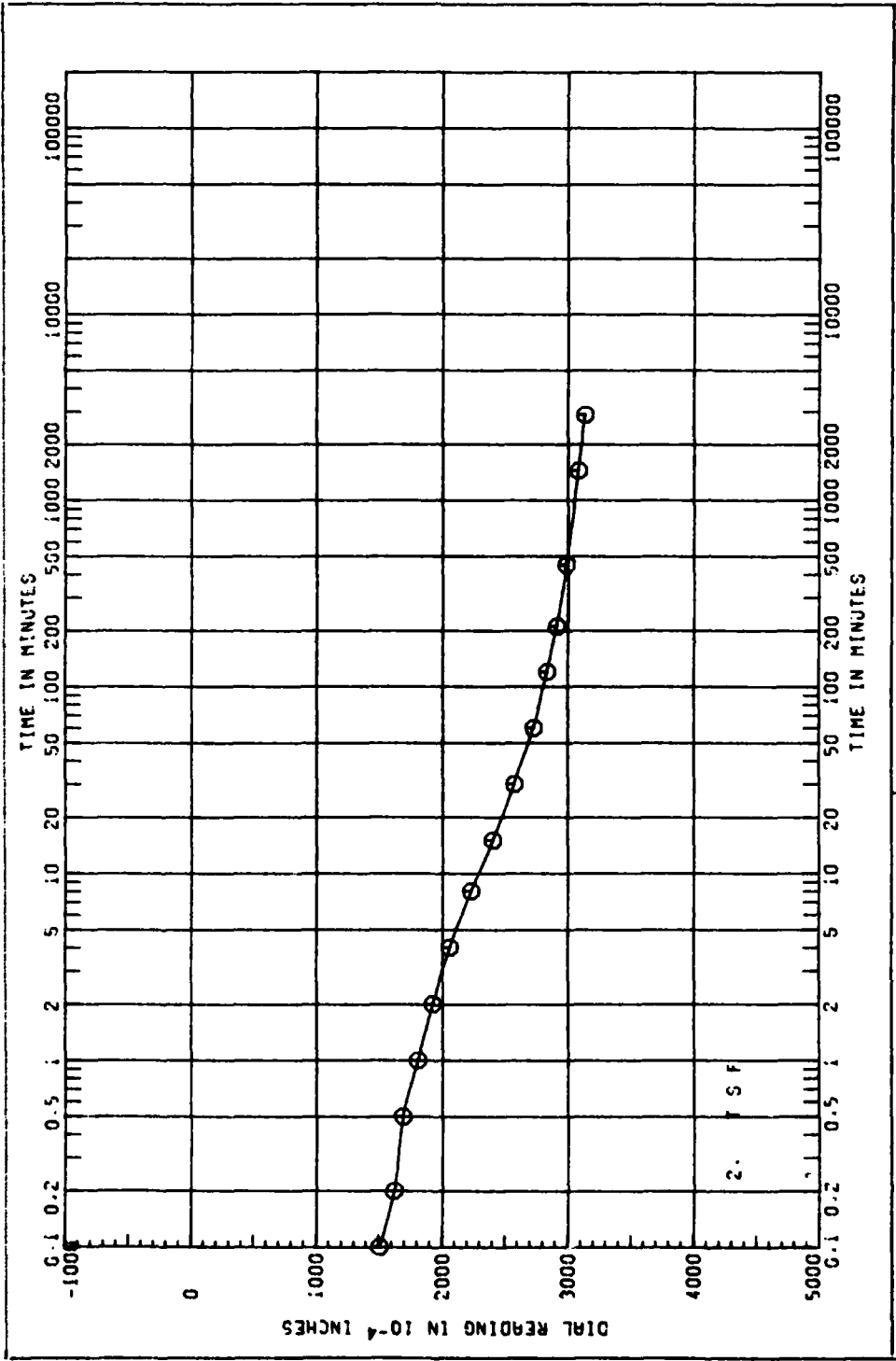
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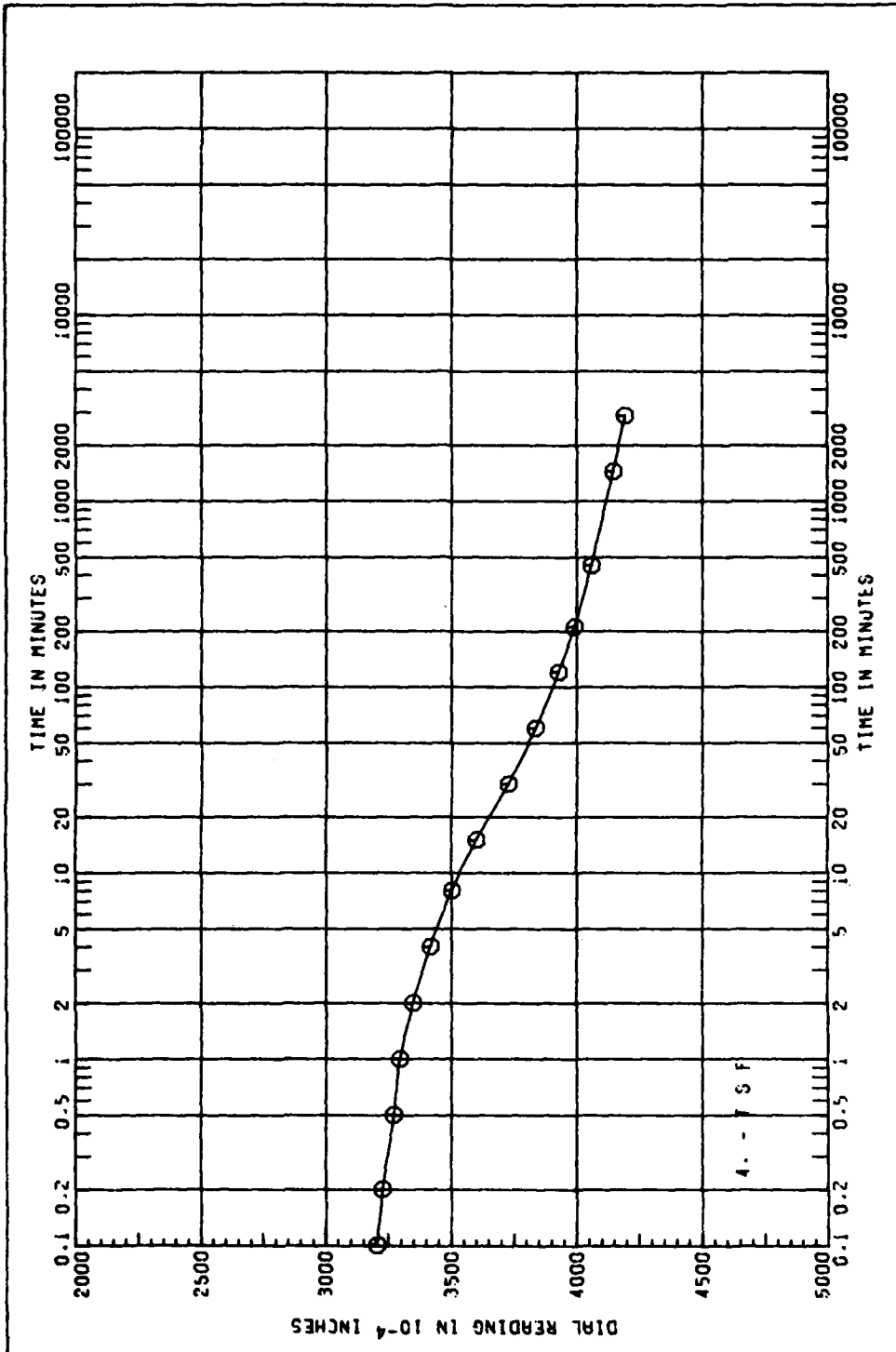
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DATE
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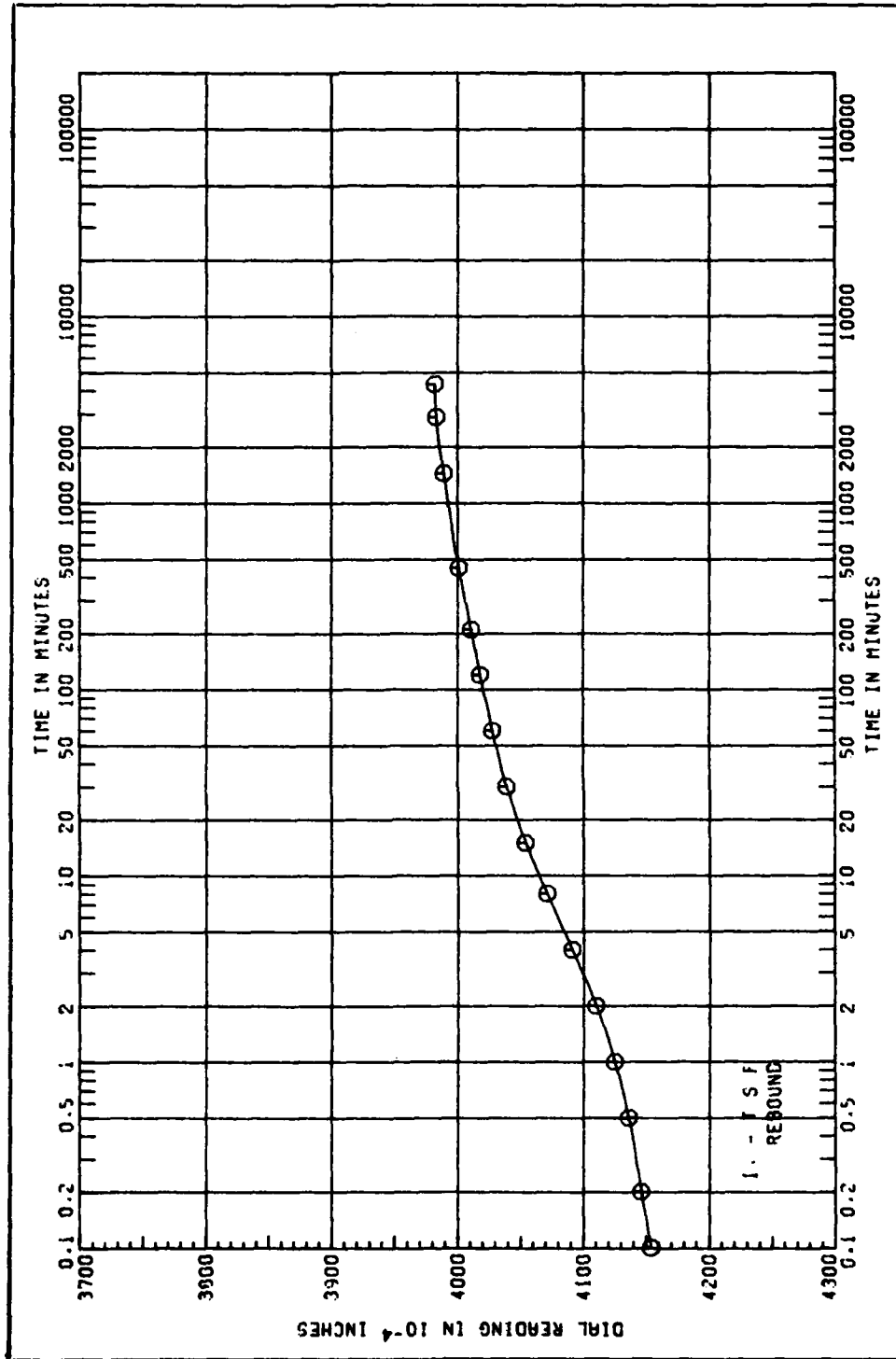
CONSOLIDATION TEST TIME CURVES	
PROJECT SOUTH FILL AREA	
U.S. MILITARY ACADEMY	
BORING M5-3	SAMPLE NO. 4
DEPTH/ELEV 30.5-32.0	DATE 06 SEP 77

PLATE D33
(SHEET 6 OF 10)



CONSOLIDATION TEST TIME CURVES	
PROJECT SOUTH FILL AREA	
U.S. MILITARY ACADEMY	
BORING WS-3	SAMPLE NO. 4
DEPTH/ELEV 30.5-32.8	DATE 06 SEP 77

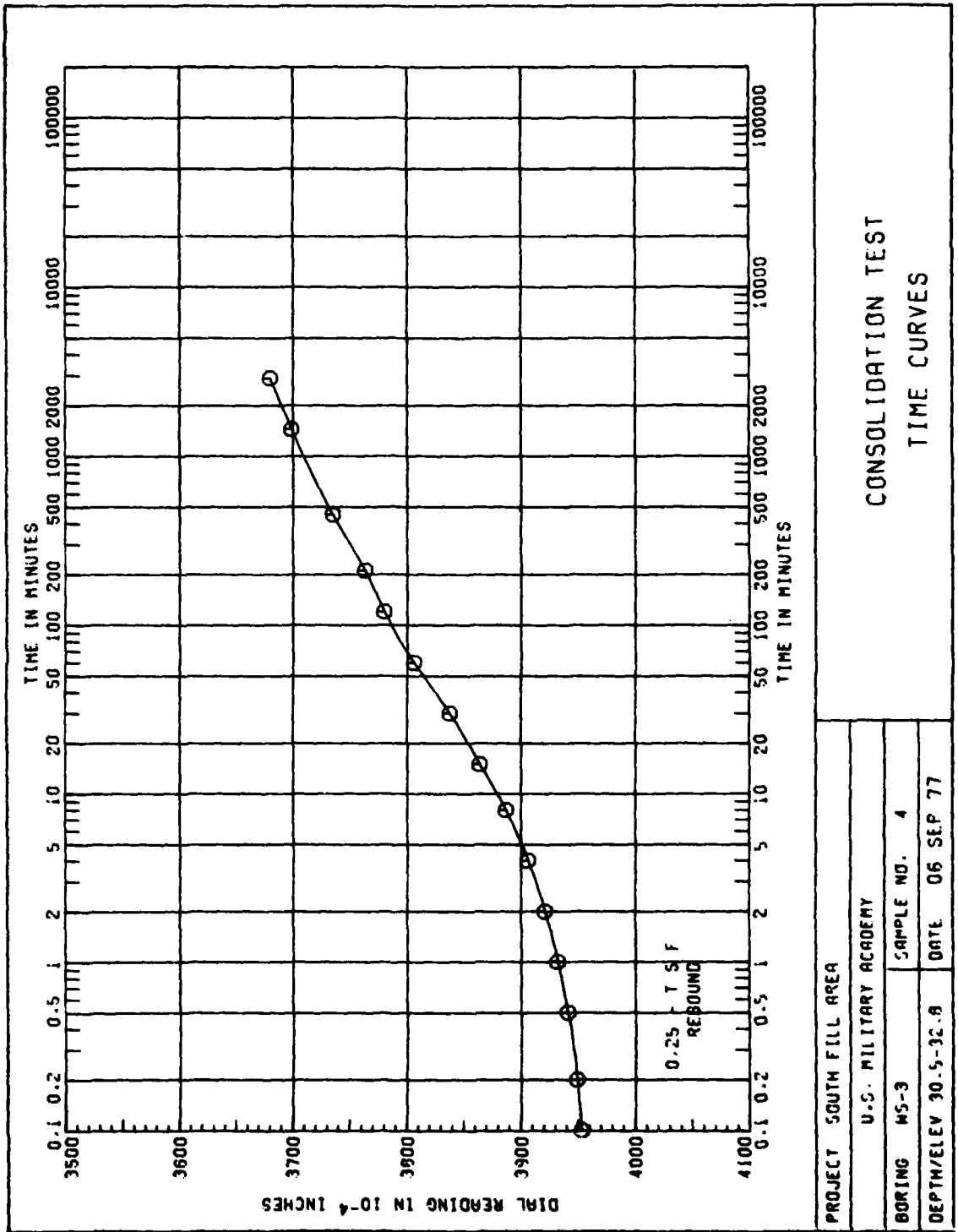
PLATE D33
(SHEET 7 OF 10)



CONSOLIDATION TEST
TIME CURVES

PROJECT SOUTH FILL AREA	
U.S. MILITARY ACADEMY	
BORING WS-3	SAMPLE NO. 4
DEPTH/ELEV 30.5-32.8	DATE 06 SEP 77

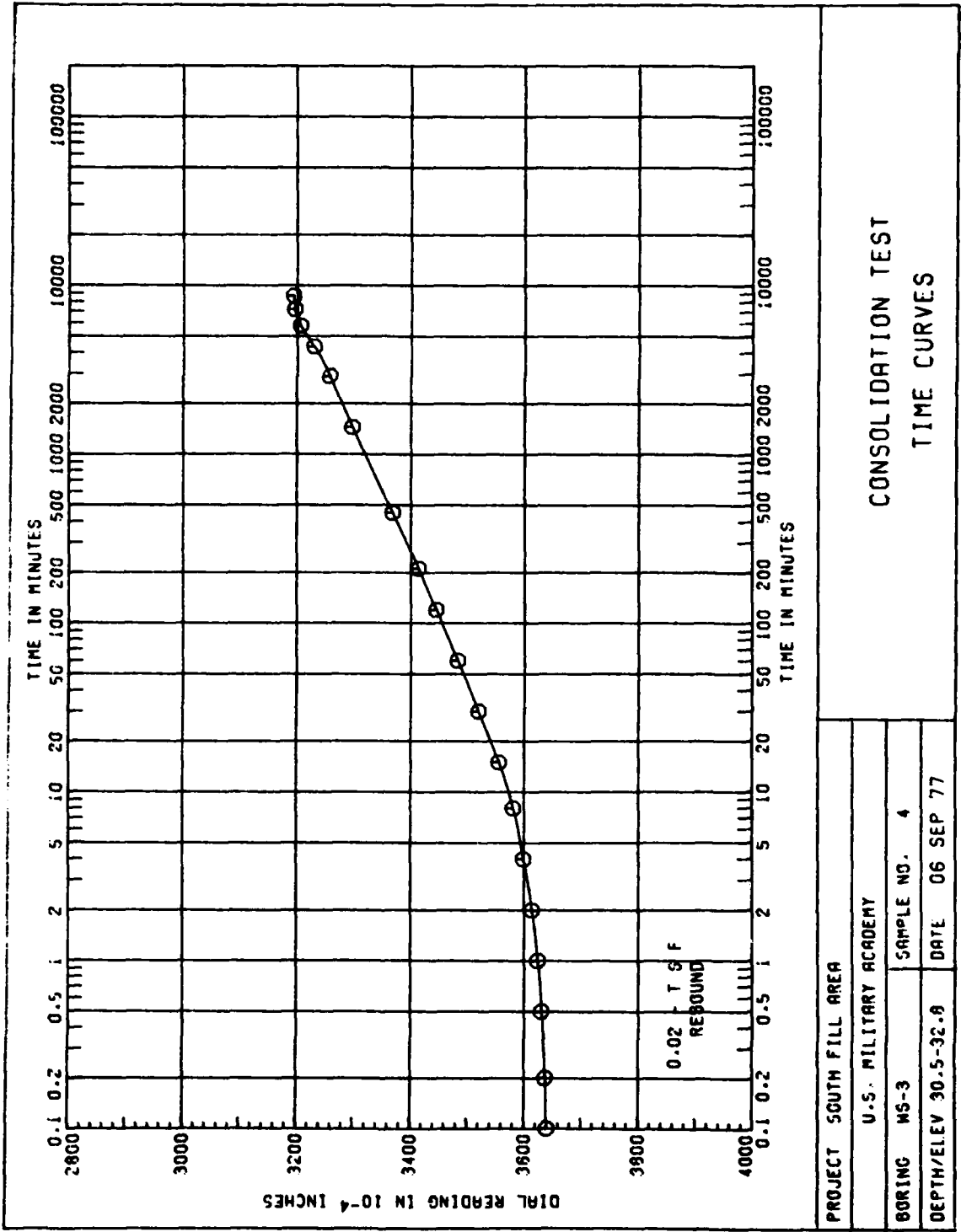
PLATE D33
(SHEET 8 OF 10)



CONSOLIDATION TEST
TIME CURVES

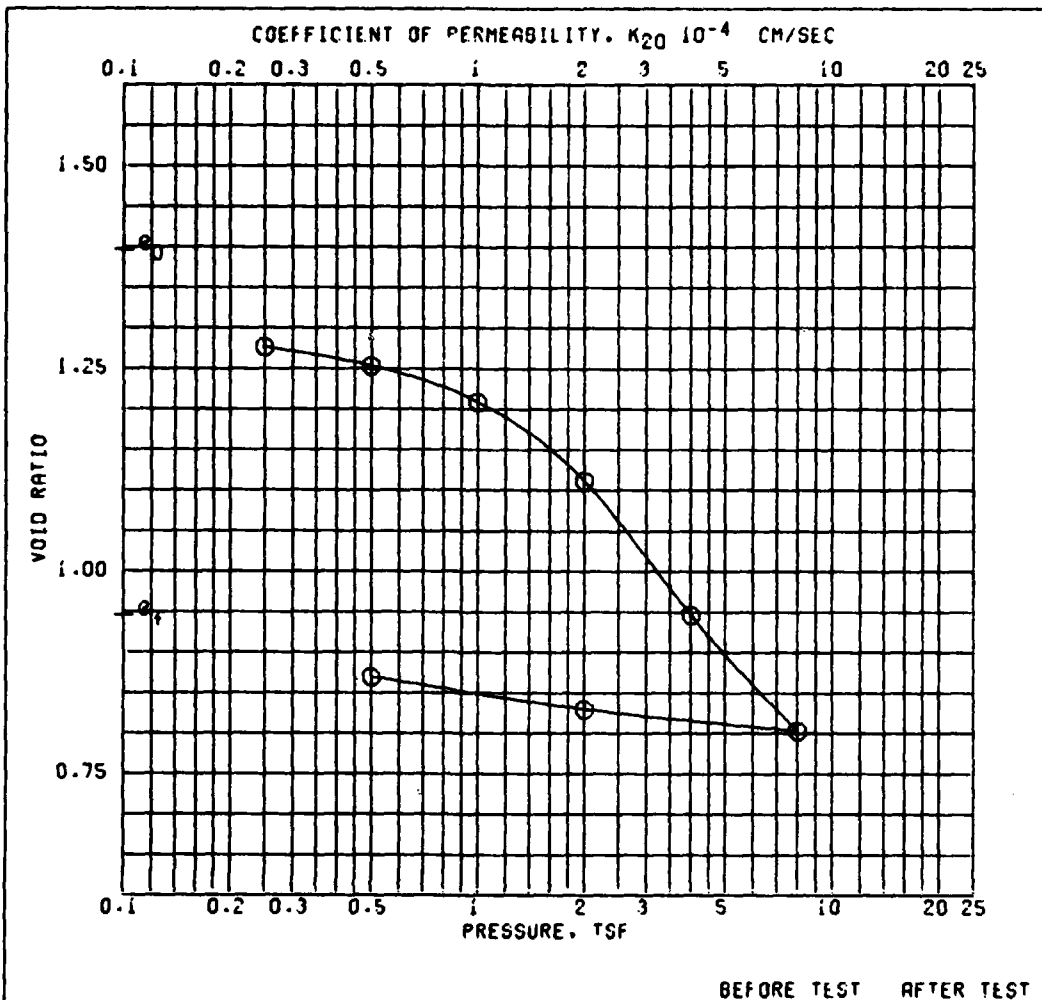
PROJECT SOUTH FILL AREA	
U.S. MILITARY ACADEMY	
BORING MS-3	SAMPLE NO. 4
DEPTH/ELEV 90.5-32.8	DATE 06 SEP 77

PLATE D33
(SHEET 9 OF 10)



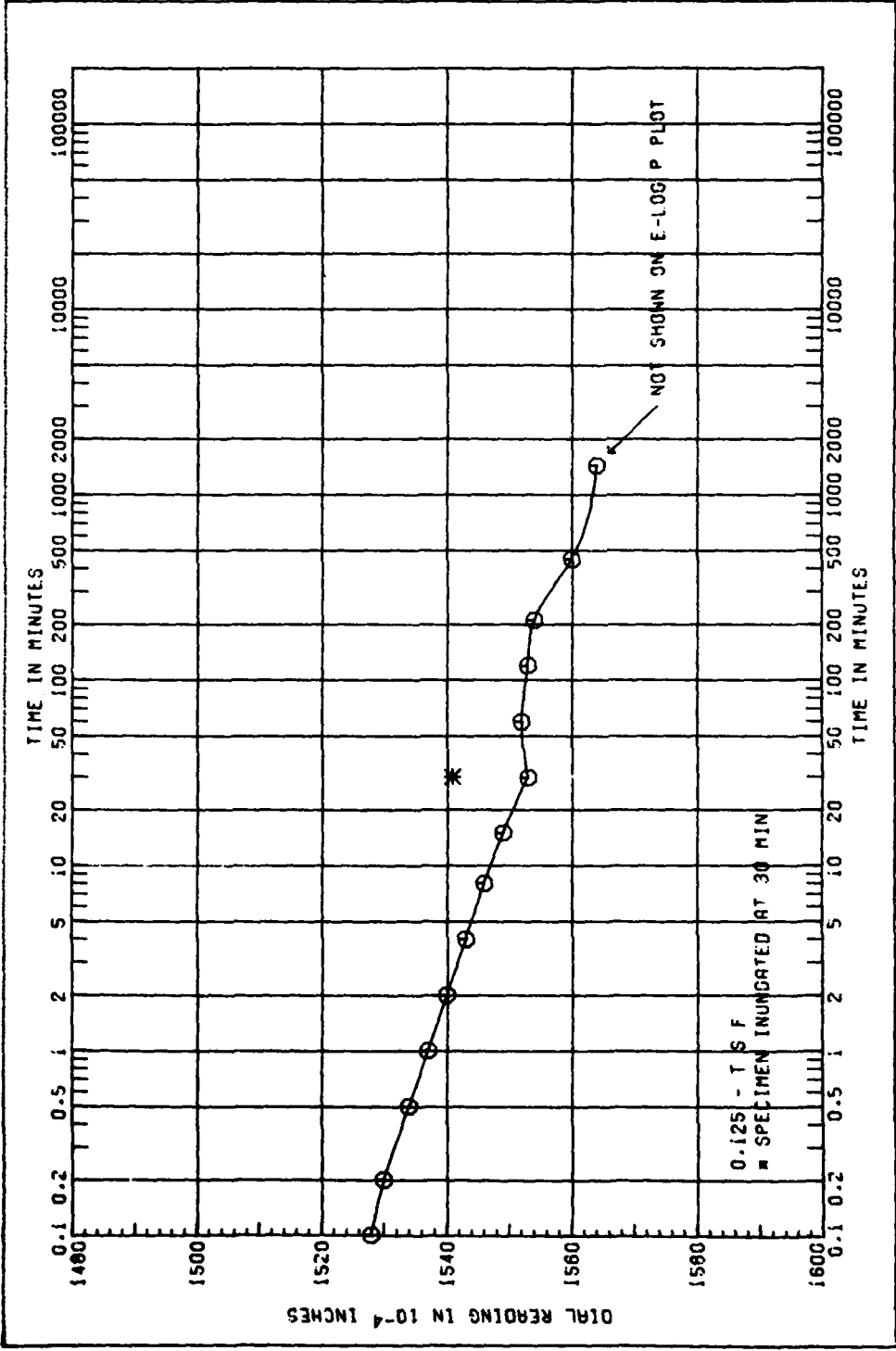
CONSOLIDATION TEST TIME CURVES	
PROJECT SOUTH FILL AREA	
U.S. MILITARY ACADEMY	
BORING MS-3	SAMPLE NO. 4
DEPTH/ELEV 30.5-32.8	DATE 06 SEP 77

PLATE D33
(SHEET 10 OF 10)



		BEFORE TEST	AFTER TEST
OVERBURDEN PRESSURE, TSF			
PRECONSOL. PRESSURE, TSF			
COMPRESSION INDEX			
TYPE SPECIMEN	UNDISTURBED	VOID RATIO	1.395
DIA. IN 4.44	HT. IN 1.251	BACK PRESSURE, TSF	
CLASSIFICATION PLASTIC CLAY (CH), GRAY; 1" SHELLS; DECAYED WOOD			
LL	PL	PI	PROJECT SOUTH FILL AREA
GS 2.72 (0)	D ₁₀		U.S. MILITARY ACADEMY
REMARKS		BORING NO. W5-3	SAMPLE NO. 11
		DEPTH/ELEV 51.0-53.2	DATE 30 AUG 77
CONSOLIDATION TEST REPORT			

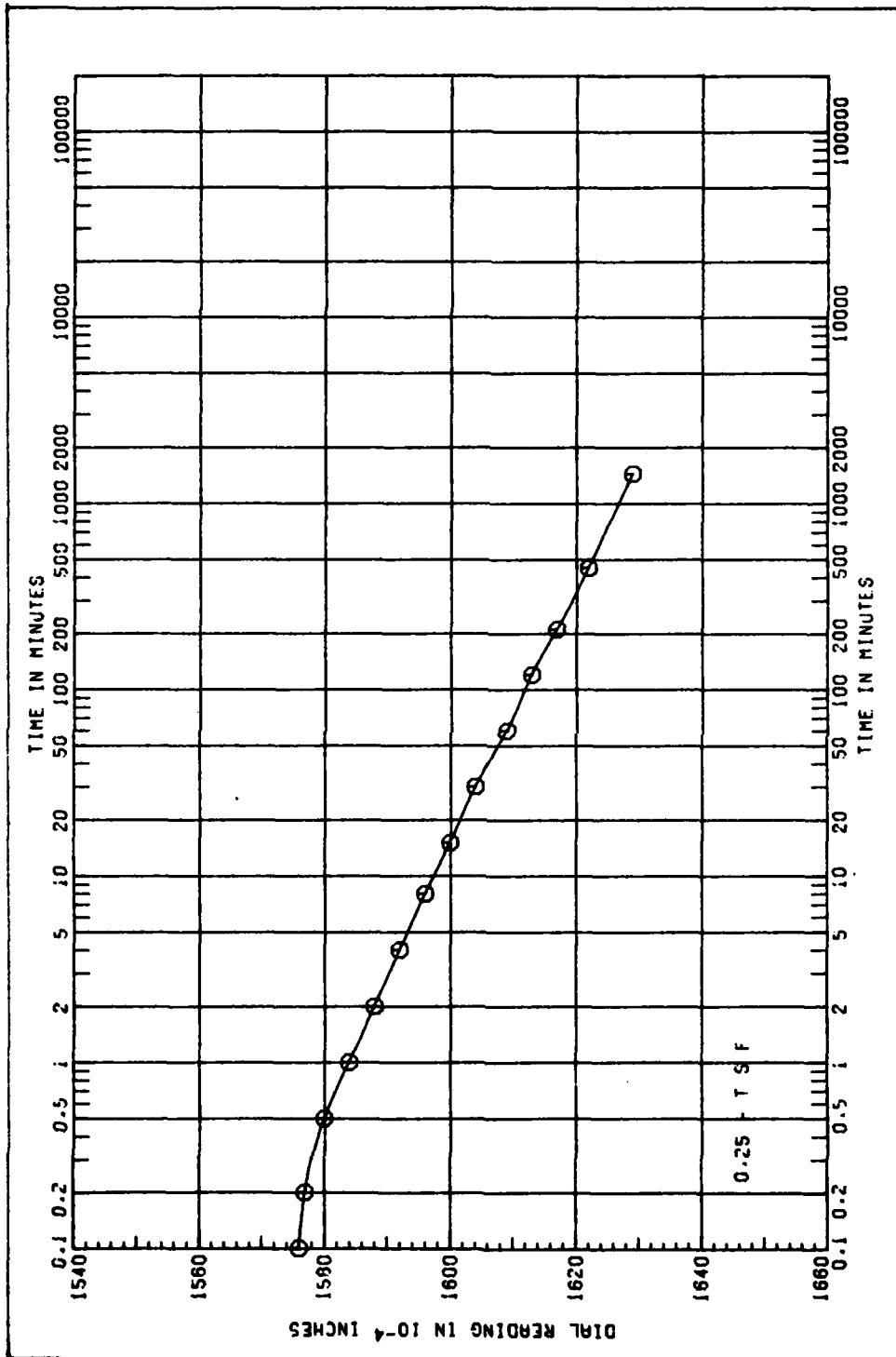
PLATE D34
(SHEET 1 OF 11)



CONSOLIDATION TEST
TIME CURVES

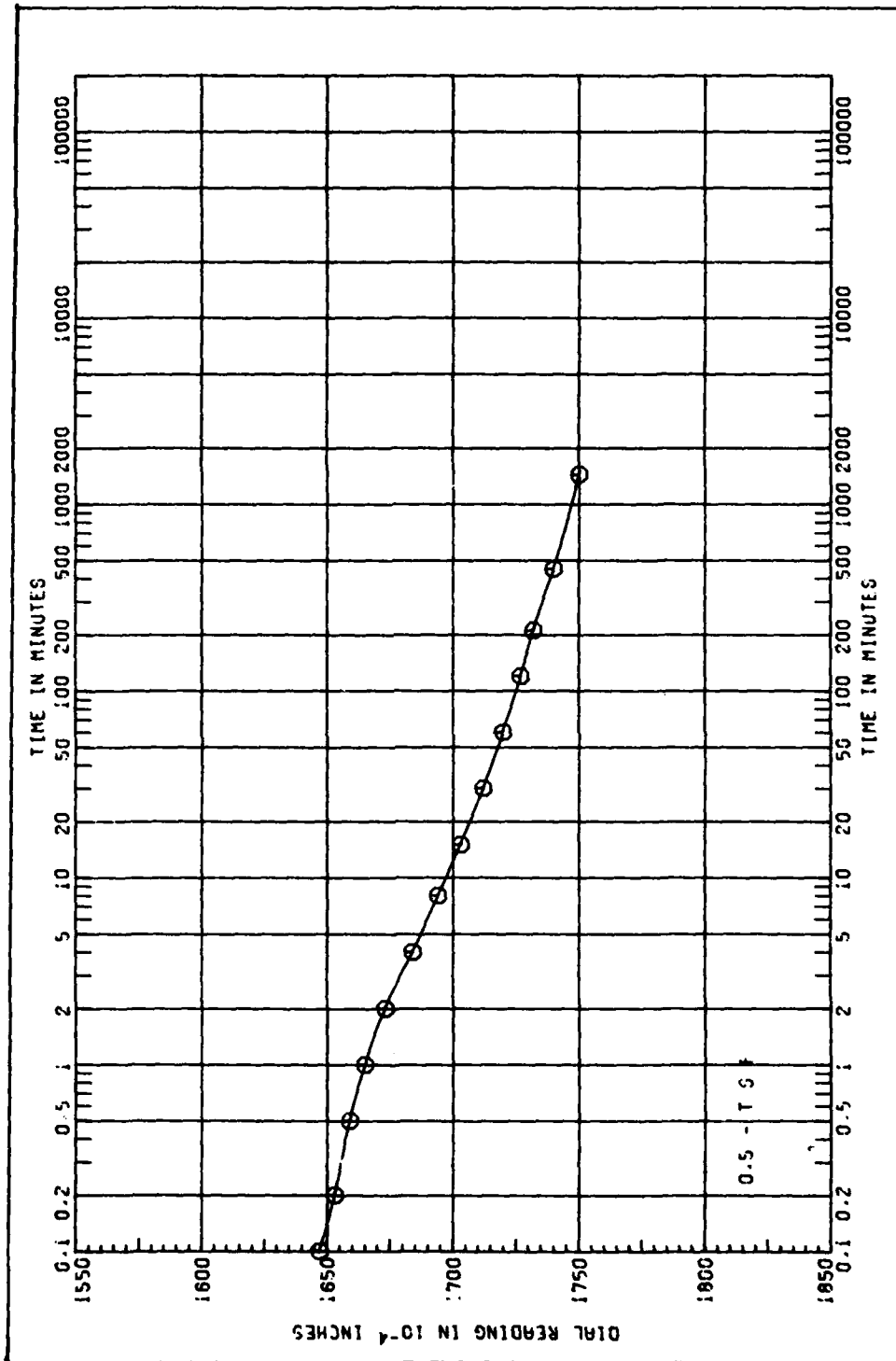
PROJECT SOUTH FILL AREA	
U.S. MILITARY ACADEMY	
BORING MS-3	SAMPLE NO. 11
DEPTH/ELEV 51.0-53.2	DATE 30 AUG 77

PLATE D34
(SHEET 2 OF 11)



PROJECT SOUTH FILL AREA		CONSOLIDATION TEST	
		TIME CURVES	
U.S. MILITARY ACADEMY		BORING MS-3	SAMPLE NO. 11
DEPTH/ELEV 51.0-53.2		DATE 30 AUG 77	

PLATE D34
(SHEET 3 OF 11)



CONSOLIDATION TEST TIME CURVES	
PROJECT SOUTH FILL AREA	
U.S. MILITARY ACADEMY	
BORING WS-3	SAMPLE NO. 11
DEPTH/ELEV 51.0-53.2	DATE 30 AUG 77

PLATE D34
(SHEET 4 OF 11)

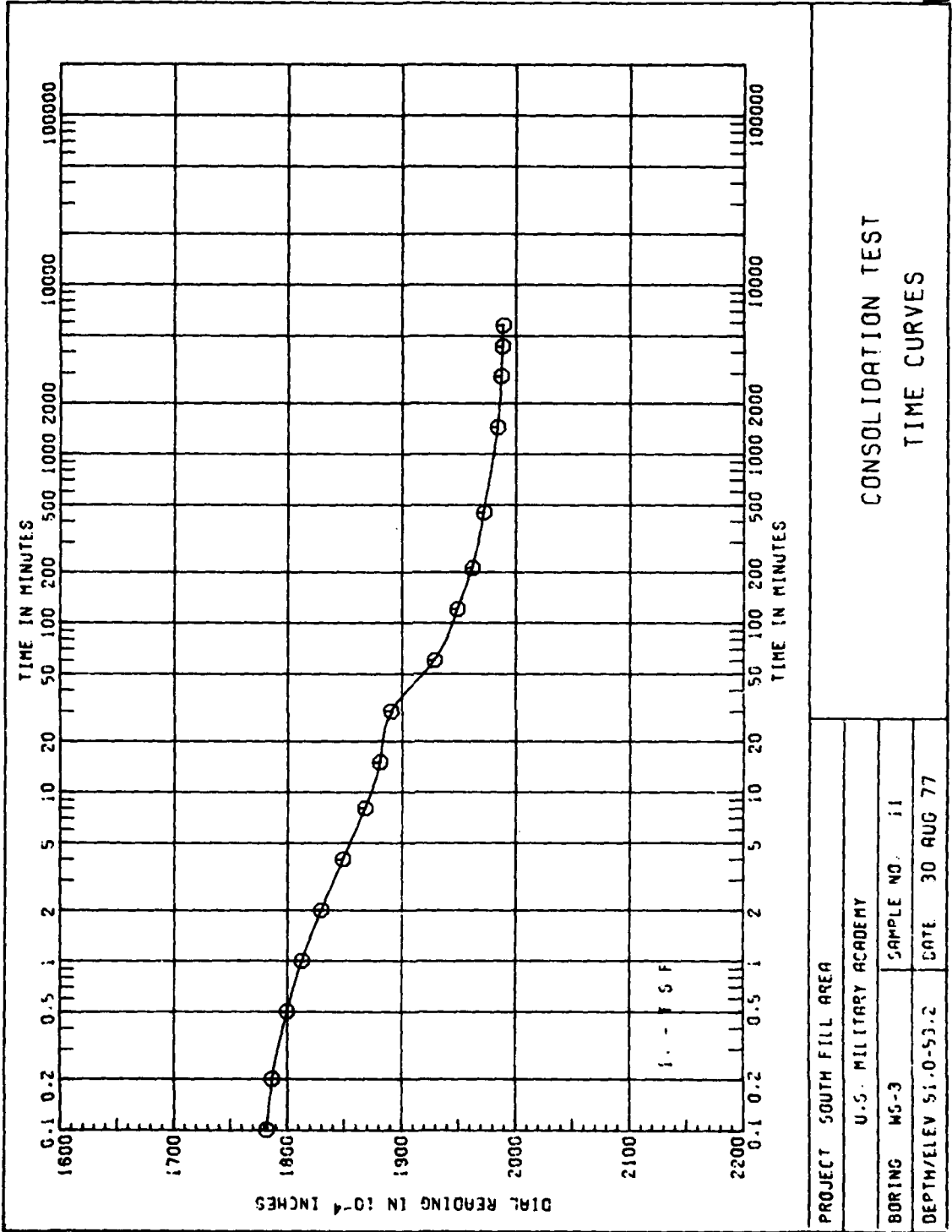
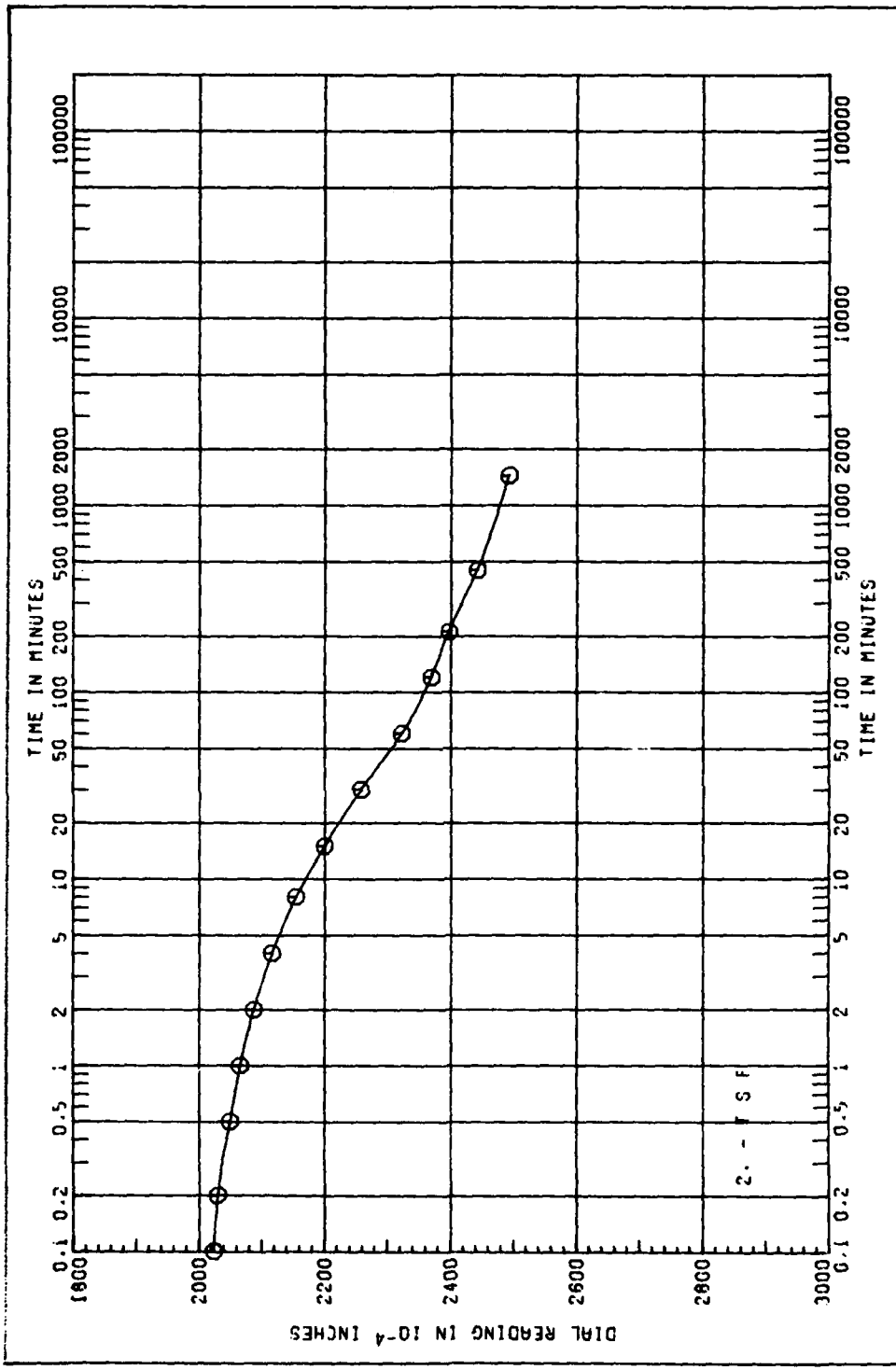


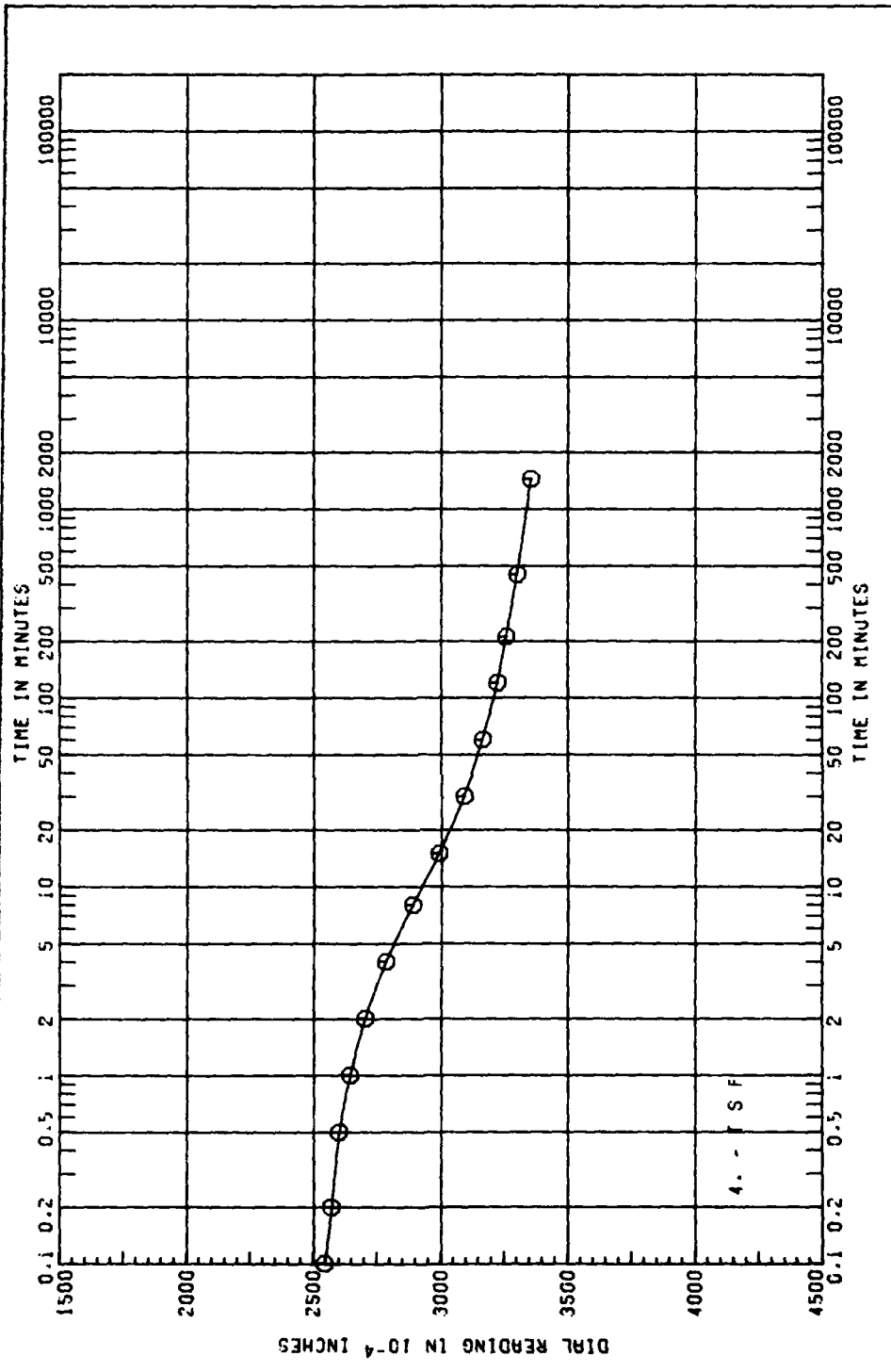
PLATE D34
(SHEET 5 OF 11)

CONSOLIDATION TEST TIME CURVES	
PROJECT	SOUTH FILL AREA
U.S. MILITARY ACADEMY	
BORING	MS-3
SAMPLE NO.	11
DEPTH/ELEV	51.0-53.2
DATE	30 AUG 77



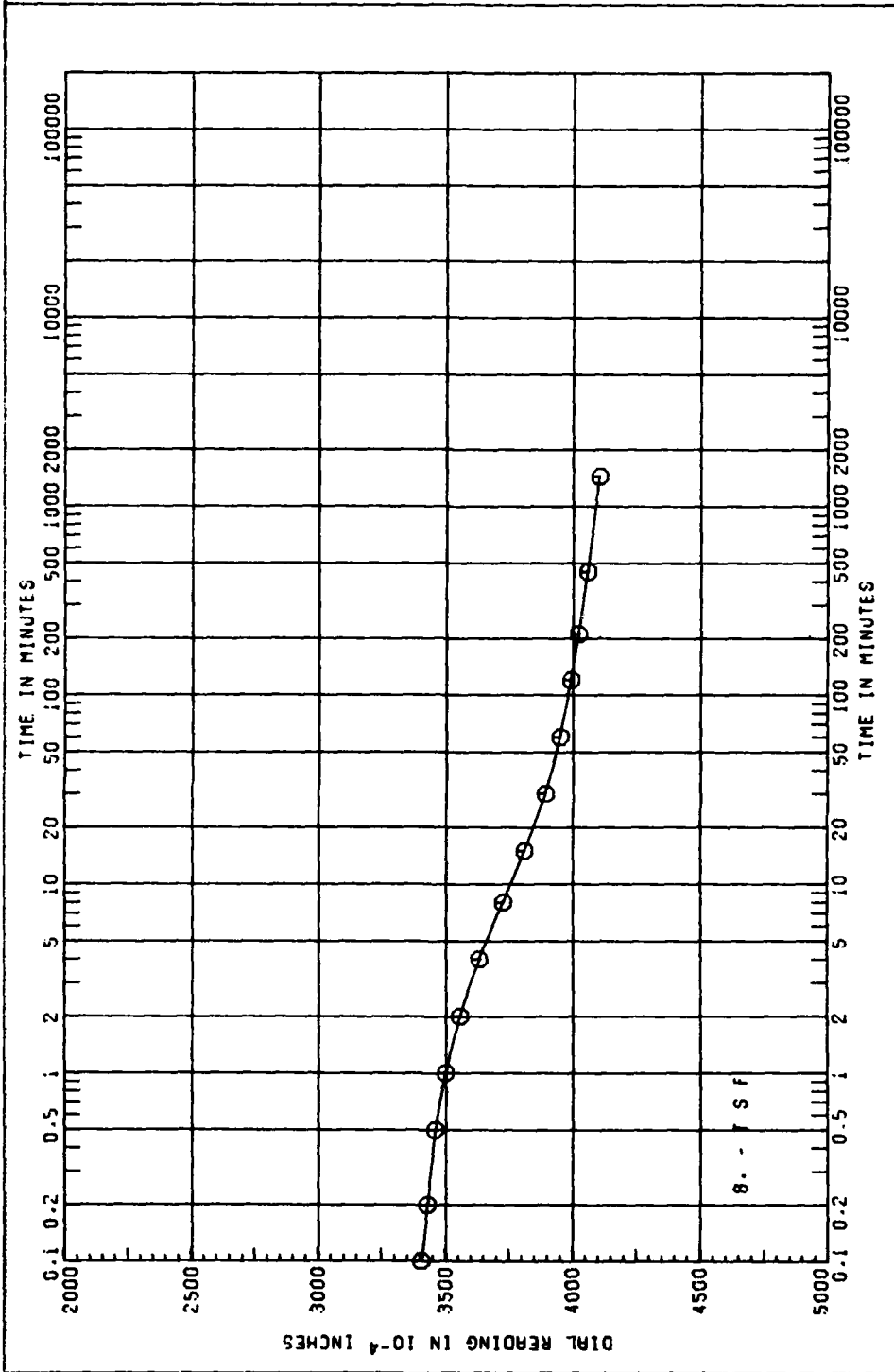
CONSOLIDATION TEST TIME CURVES	
PROJECT	SOUTH FILL AREA
U.S. MILITARY ACADEMY	
BORING	MS-3
DEPTH/ELEV	51.0-53.2
SAMPLE NO.	11
DATE	30 AUG 77

PLATE D34
(SHEET 6 OF 11)



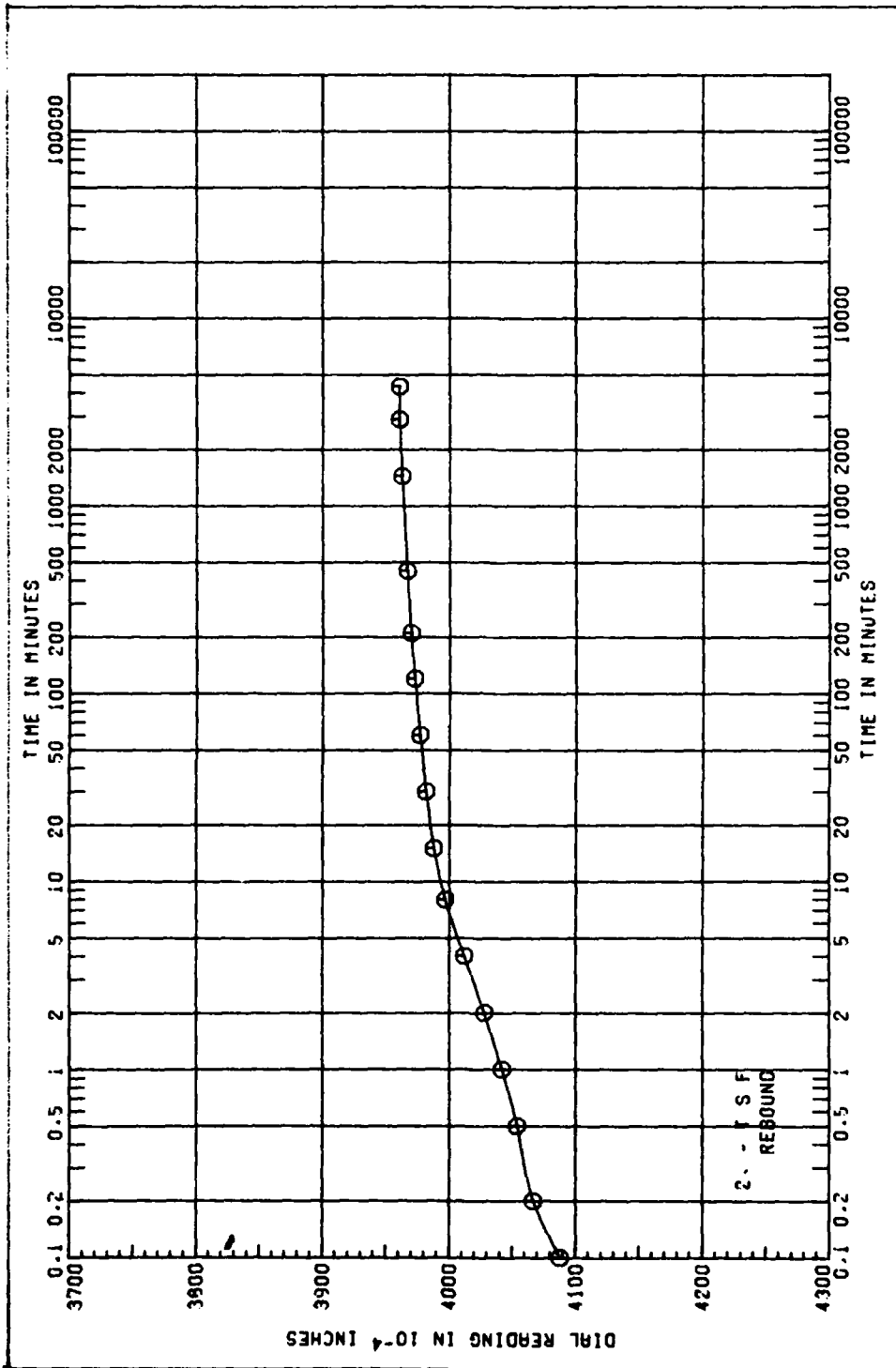
CONSOLIDATION TEST TIME CURVES	
PROJECT SOUTH FILL AREA	
U.S. MILITARY ACADEMY	
BORING W5-3	SAMPLE NO. 11
DEPTH/ELEV 51.0-53.2	DATE 30 AUG 77

PLATE D34
(SHEET 7 OF 11)



CONSOLIDATION TEST TIME CURVES	
PROJECT SOUTH FILL AREA	
U.S. MILITARY ACADEMY	
BORING W5-3	SAMPLE NO. 11
DEPTH/ELEV 51.0-53.2	DATE 30 AUG 77

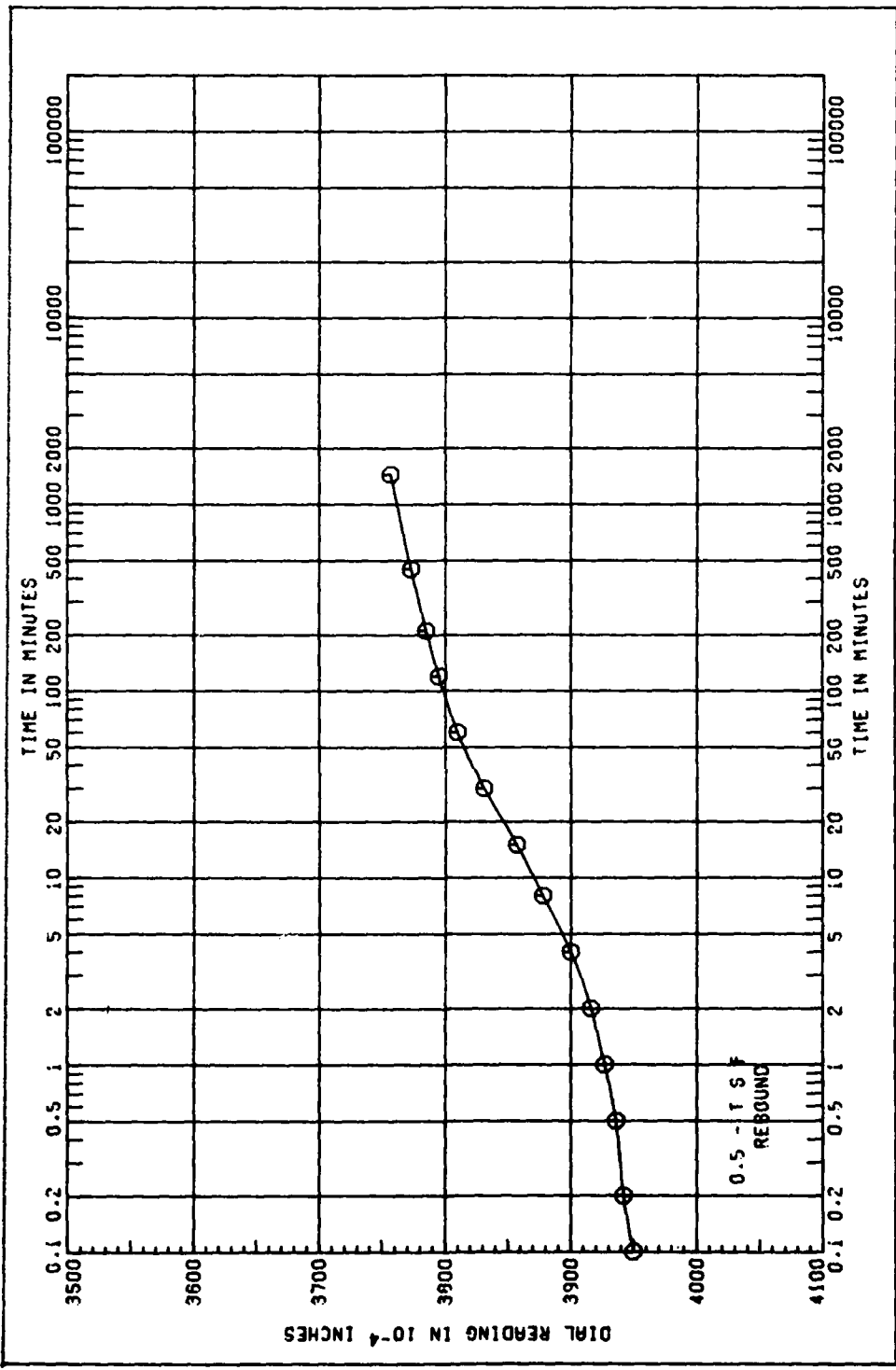
PLATE D34
(SHEET 8 OF 11)



PROJECT SOUTH FILL AREA	
U.S. MILITARY ACADEMY	
BORING M5-3	SAMPLE NO. 11
DEPTH/ELEV 51.0-53.2	DATE 30 AUG 77

CONSOLIDATION TEST
TIME CURVES

PLATE D34
(SHEET 9 OF 11)



CONSOLIDATION TEST TIME CURVES	
PROJECT SOUTH FILL AREA	
U.S. MILITARY ACADEMY	
BORING MS-3	SAMPLE NO. 11
DEPTH/ELEV 51.0-53.2	DATE 30 AUG 77

PLATE D34
(SHEET 10 OF 11)

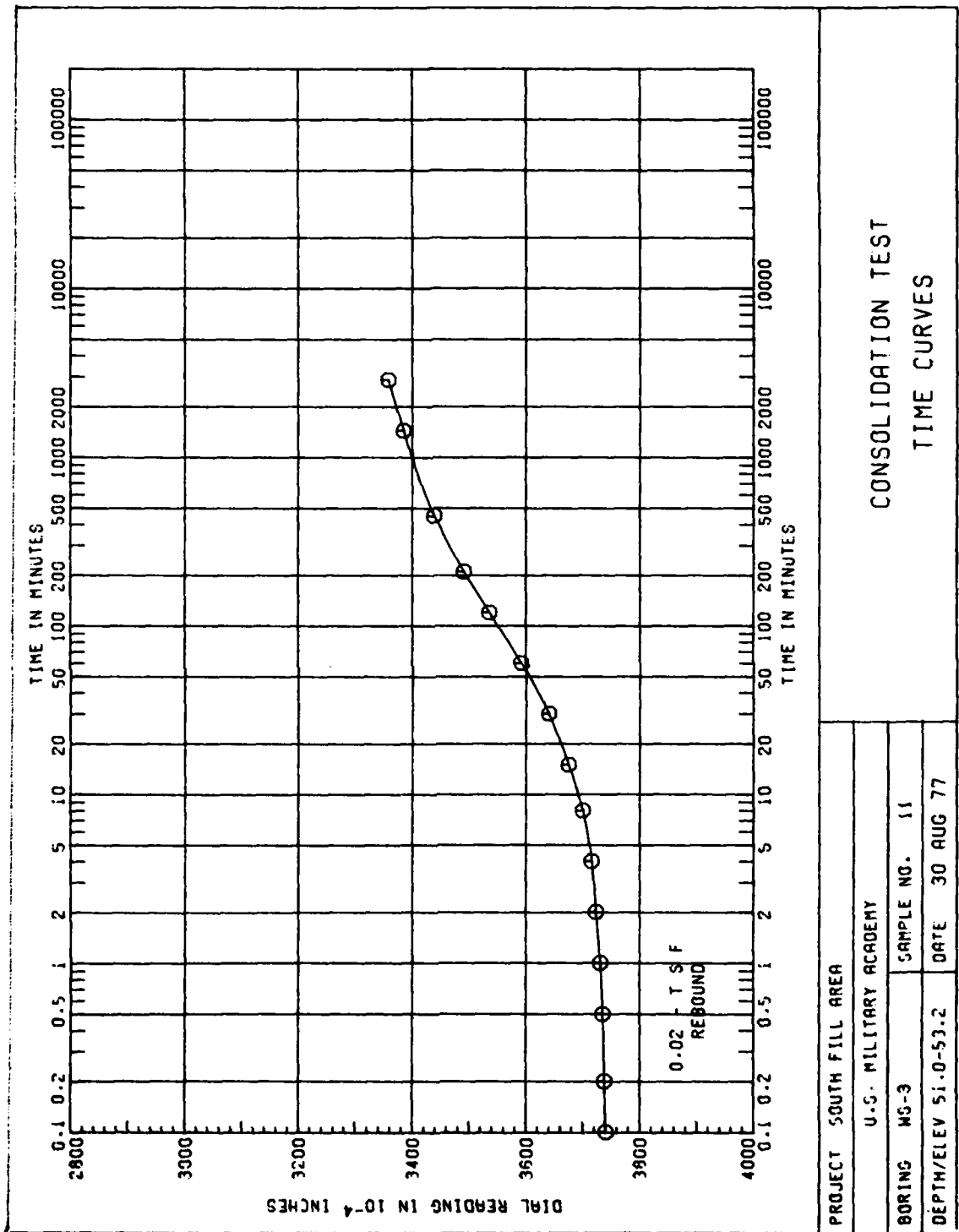
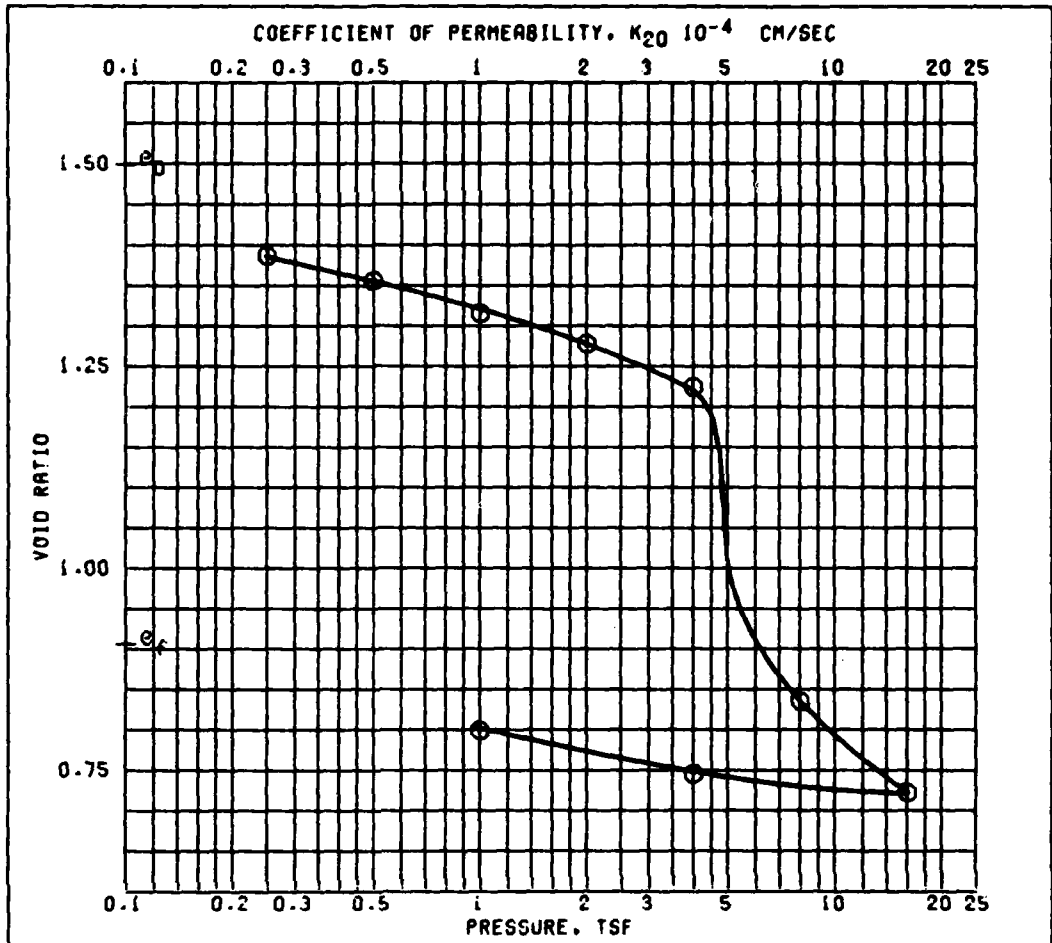


PLATE D34
(SHEET 11 OF 11)

PROJECT SOUTH FILL AREA		CONSOLIDATION TEST TIME CURVES	
BORING	MS-3	SAMPLE NO.	11
DEPTH/ELEV	51.0-53.2	DATE	30 AUG 77



		BEFORE TEST	AFTER TEST
OVERBURDEN PRESSURE, TSF			
PRECONSOL. PRESSURE, TSF			
COMPRESSION INDEX			
TYPE SPECIMEN	UNDISTURBED	WATER CONTENT, %	55.0
DIA. IN 4.44	HT. IN 1.239	DRY DENSITY, PCF	67.7
CLASSIFICATION PLASTIC CLAY (CH), GRAY		SATURATION, %	99.5
LL	PL	VOID RATIO	1.498
OS 2.71 (0)	D ₁₀	BACK PRESSURE, TSF	0.905
REMARKS		PROJECT SOUTH FILL AREA	
		U.S. MILITARY ACADEMY	
		BORING NO. WS-3	SAMPLE NO. 14
		DEPTH/ELEV 60.5-62.7	DATE 30 AUG 77
CONSOLIDATION TEST REPORT			

PLATE D35
(SHEET 1 OF 12)

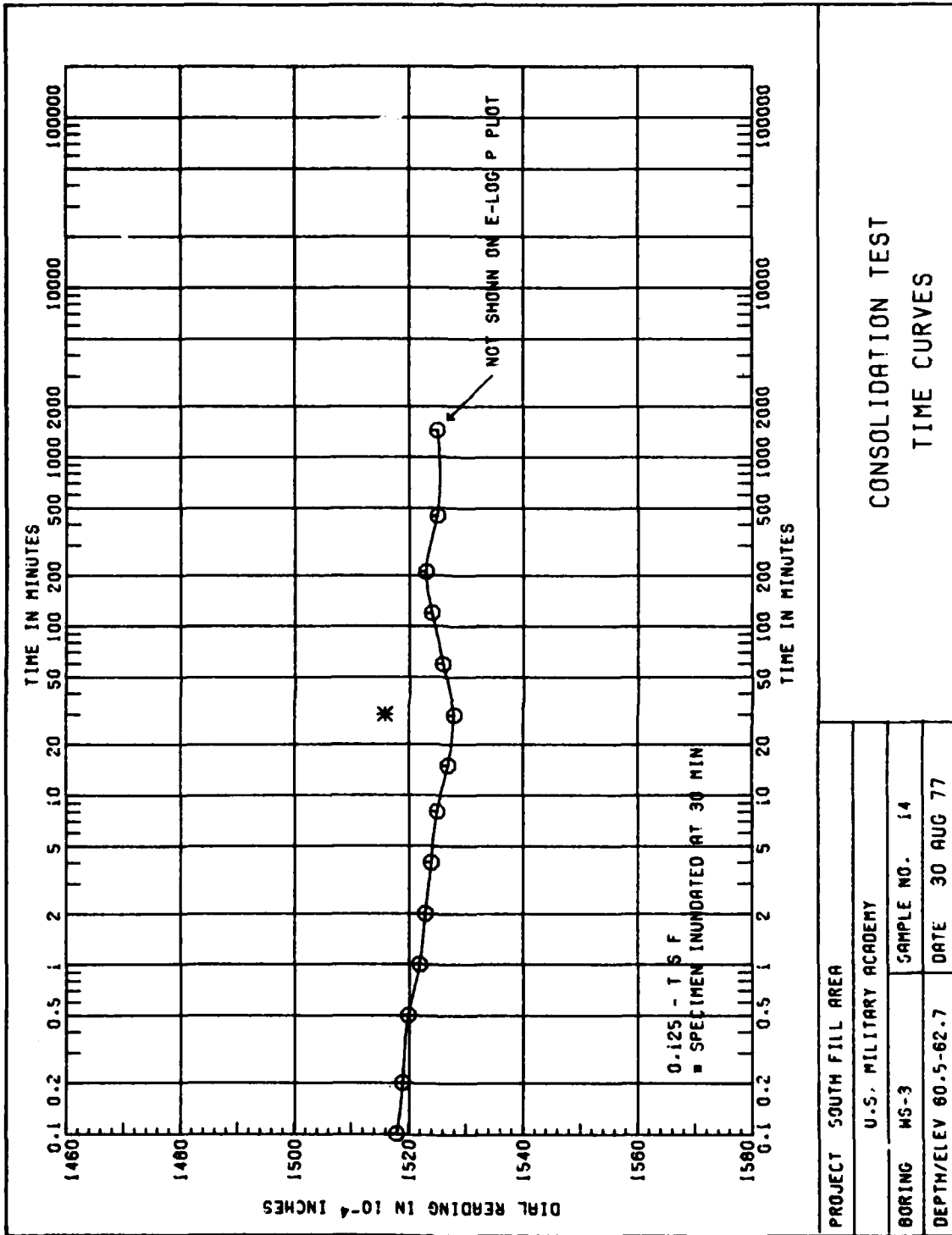
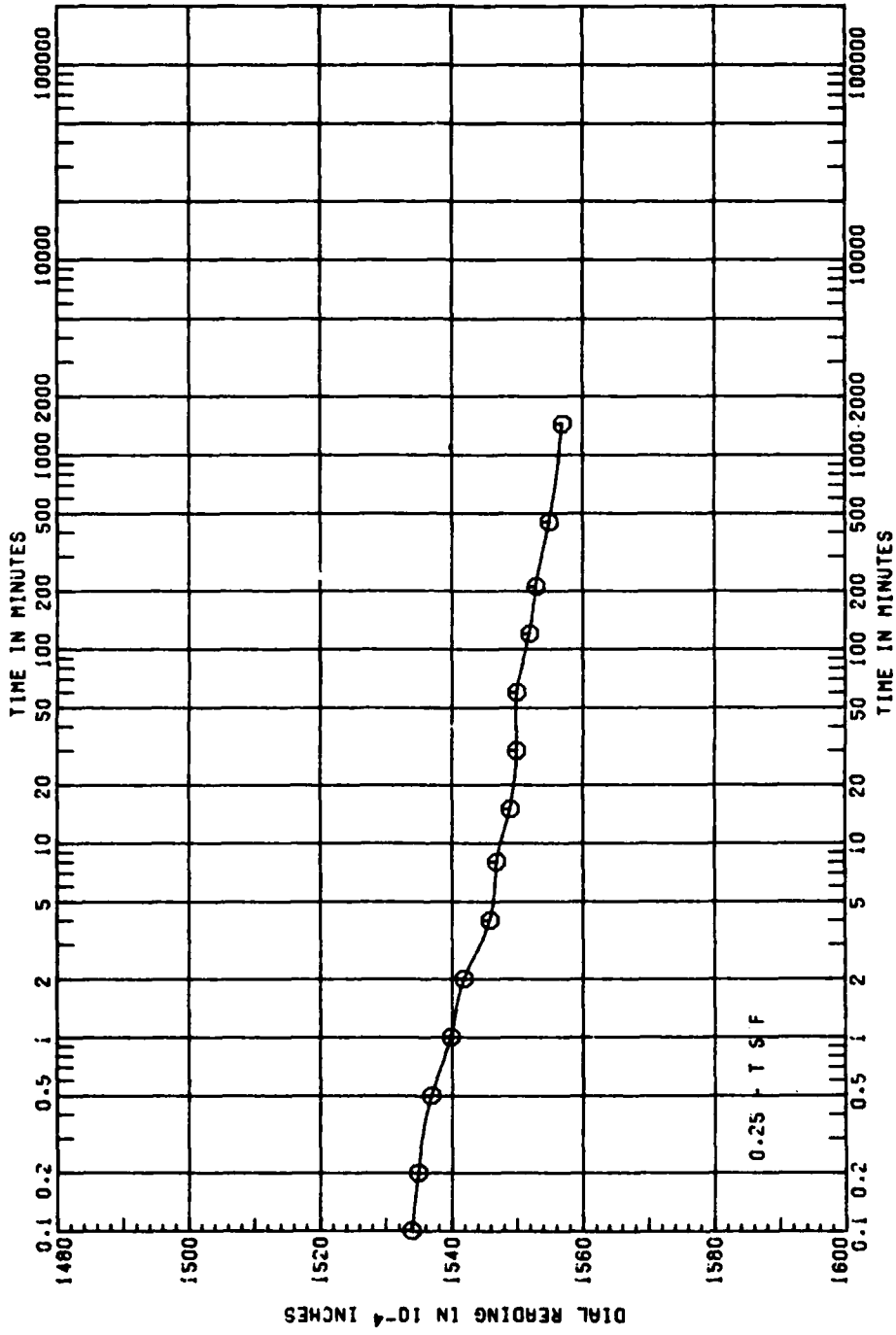


PLATE D35
(SHEET 2 OF 12)

D60

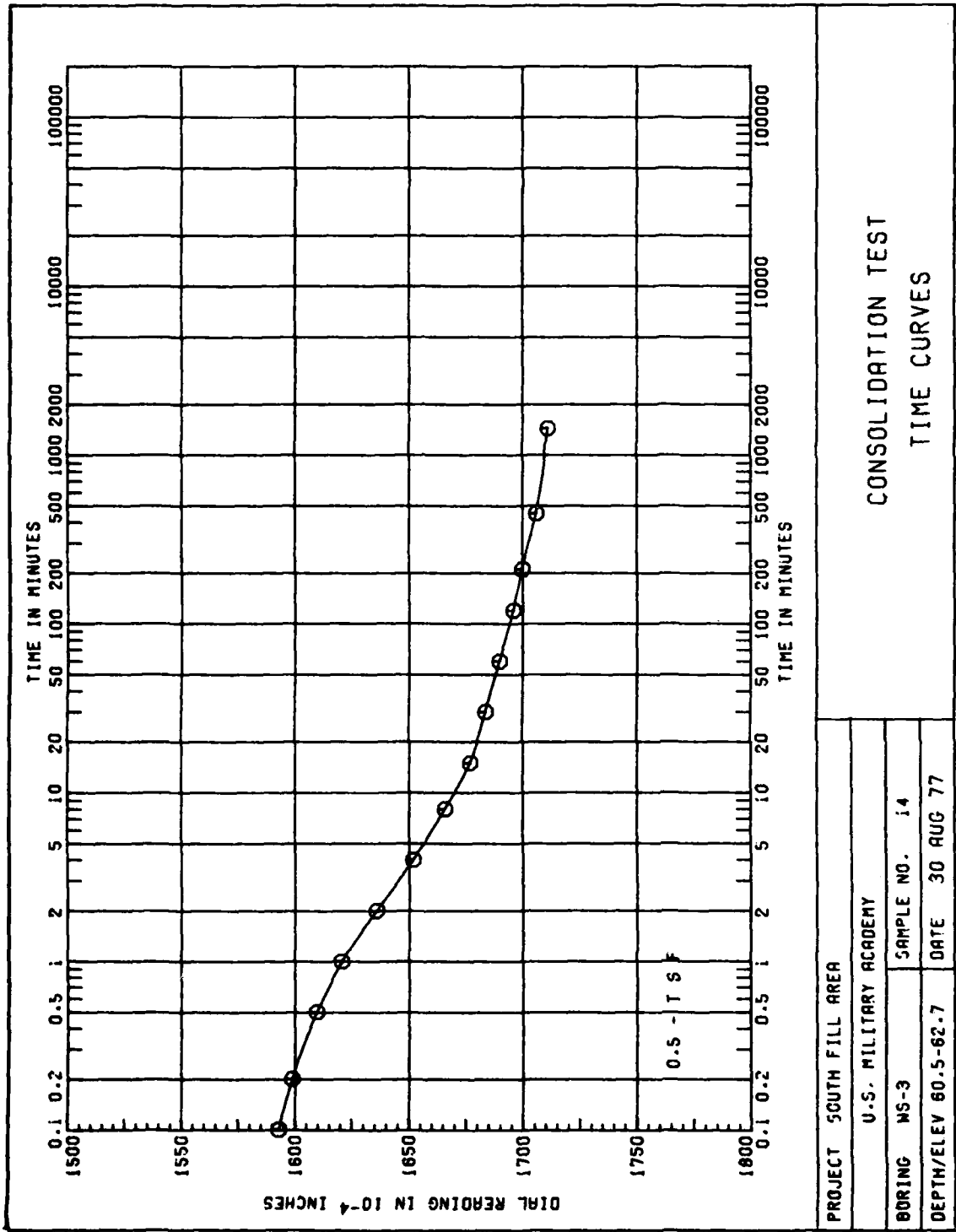
CONSOLIDATION TEST TIME CURVES	
PROJECT SOUTH FILL AREA	
U.S. MILITARY ACADEMY	
BORING MS-3	SAMPLE NO. 14
DEPTH/ELEV 60.5-62.7	DATE 30 AUG 77



CONSOLIDATION TEST
TIME CURVES

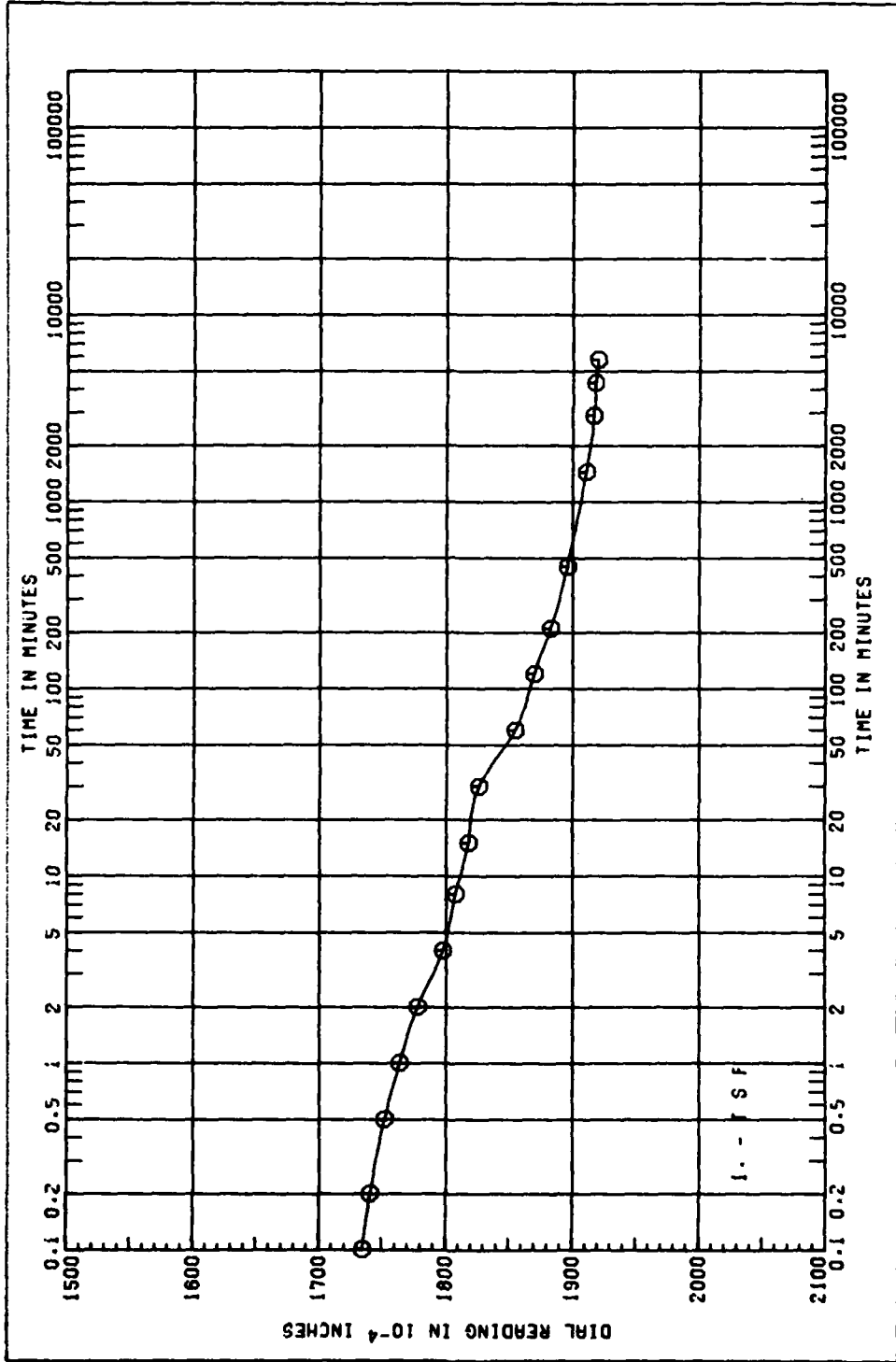
PROJECT SOUTH FILL AREA	
U.S. MILITARY ACADEMY	
BORING MS-3	SAMPLE NO. 14
DEPTH/ELEV 60.5-62.7	DATE 30 AUG 77

PLATE D35
(SHEET 3 OF 12)



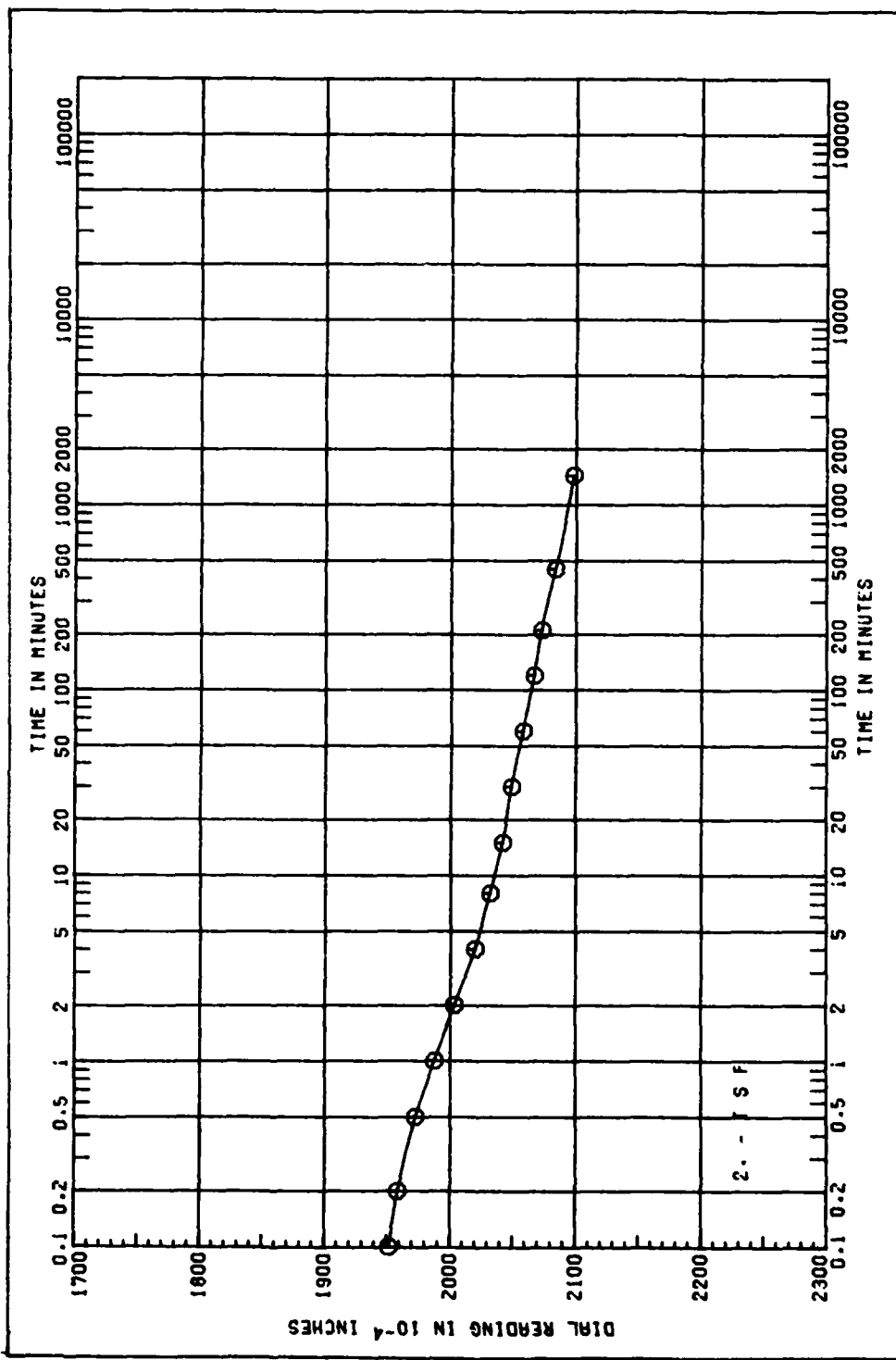
CONSOLIDATION TEST TIME CURVES	
PROJECT	SOUTH FILL AREA
	U.S. MILITARY ACADEMY
BORING	MS-3
DEPTH/ELEV	60.5-62.7
SAMPLE NO.	14
DATE	30 AUG 77

PLATE D35
(SHEET 4 OF 12)



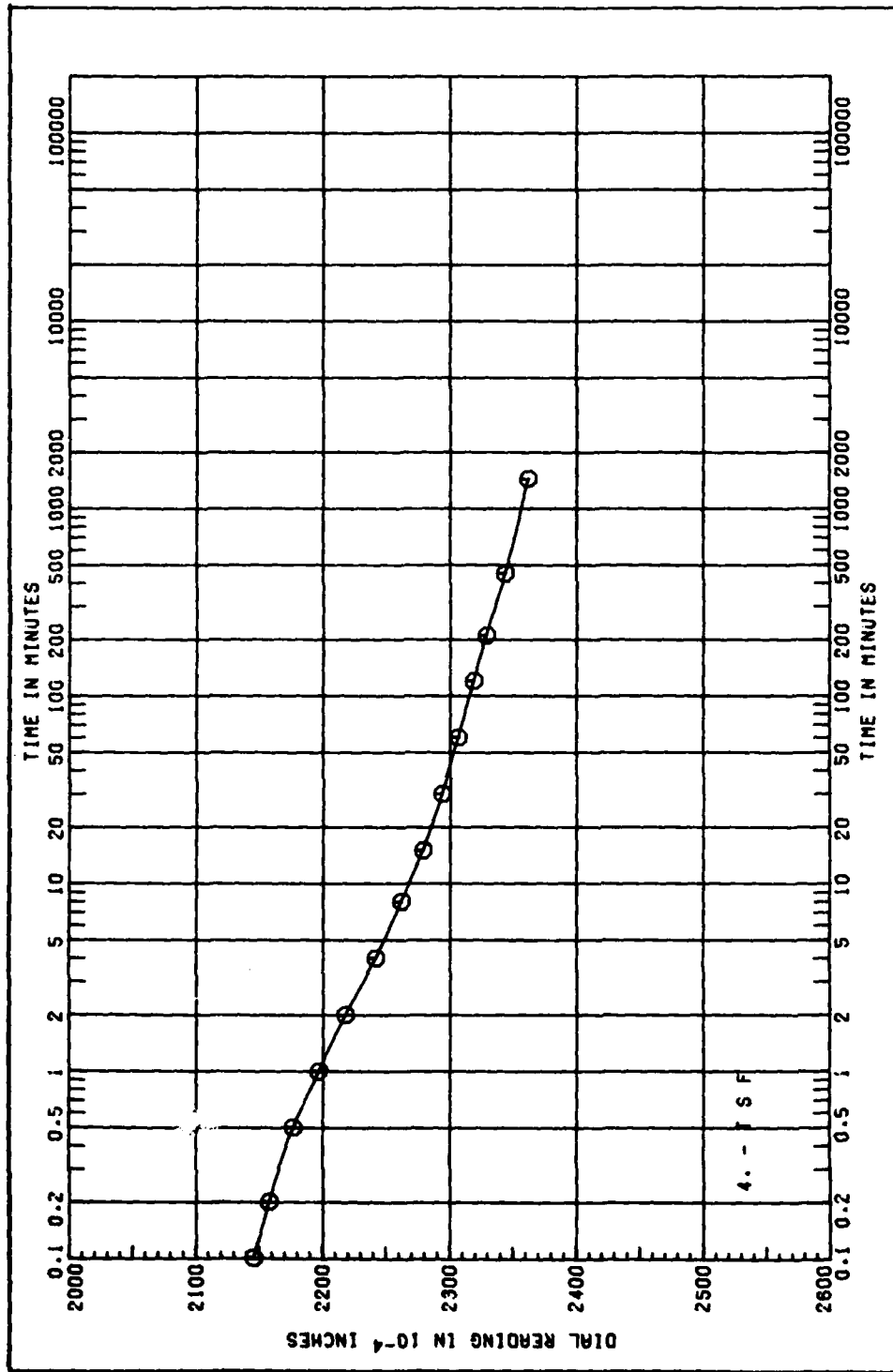
CONSOLIDATION TEST TIME CURVES	
PROJECT	SOUTH FILL AREA
	U.S. MILITARY ACADEMY
BORING	MS-3
DEPTH/ELEV	60.5-62.7
SAMPLE NO.	14
DATE	30 AUG 77

PLATE D35
(SHEET 5 OF 12)



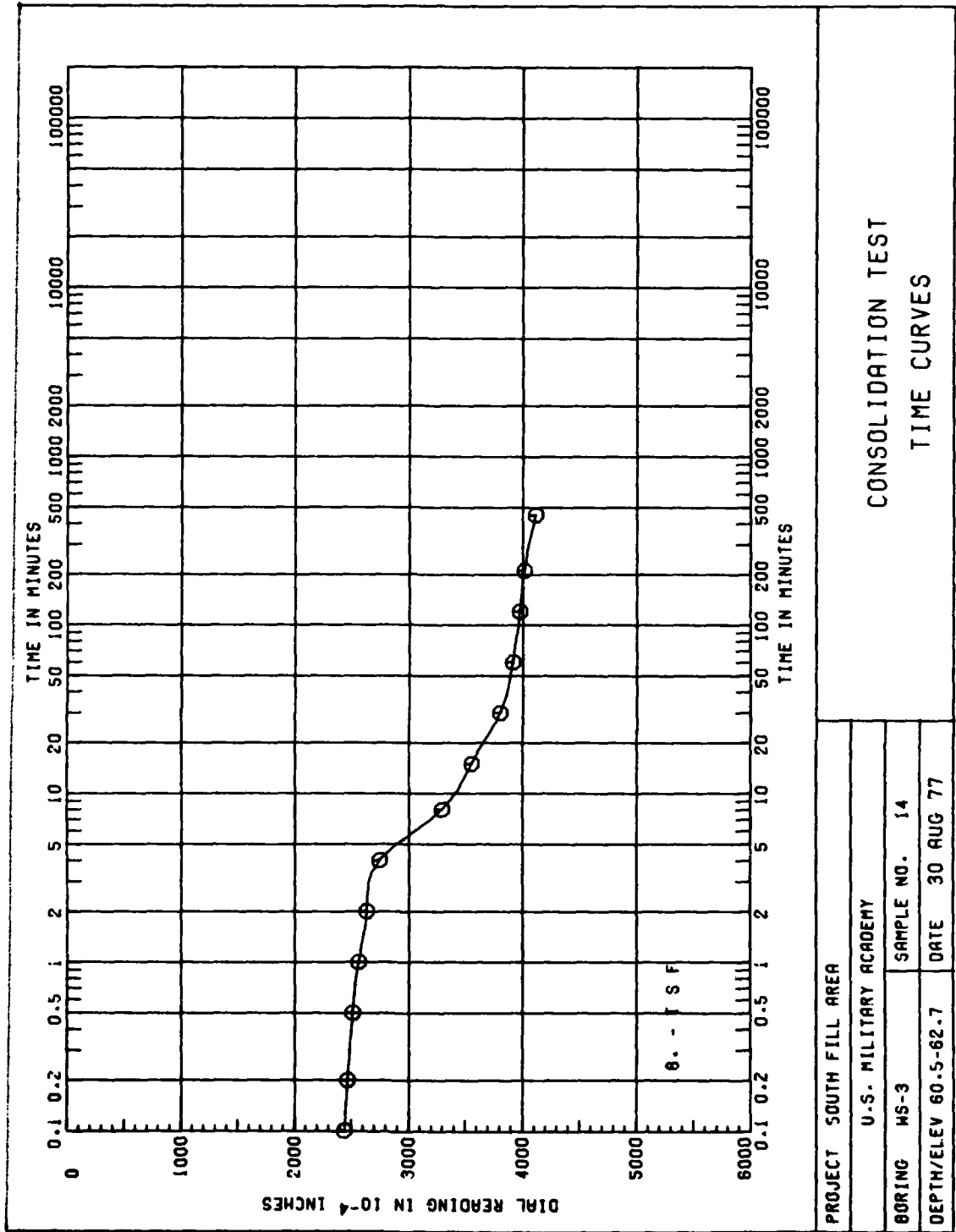
CONSOLIDATION TEST TIME CURVES	
PROJECT SOUTH FILL AREA	
U.S. MILITARY ACADEMY	
BORING MS-3	SAMPLE NO. 14
DEPTH/ELEV 60.5-82.7	DATE 30 AUG 77

PLATE D35
(SHEET 6 OF 12)



CONSOLIDATION TEST TIME CURVES	
PROJECT SOUTH FILL AREA	
U.S. MILITARY ACADEMY	
BORING MS-3	SAMPLE NO. 14
DEPTH/ELEV 60.5-62.7	DATE 30 AUG 77

PLATE D35
(SHEET 7 OF 12)



CONSOLIDATION TEST
TIME CURVES

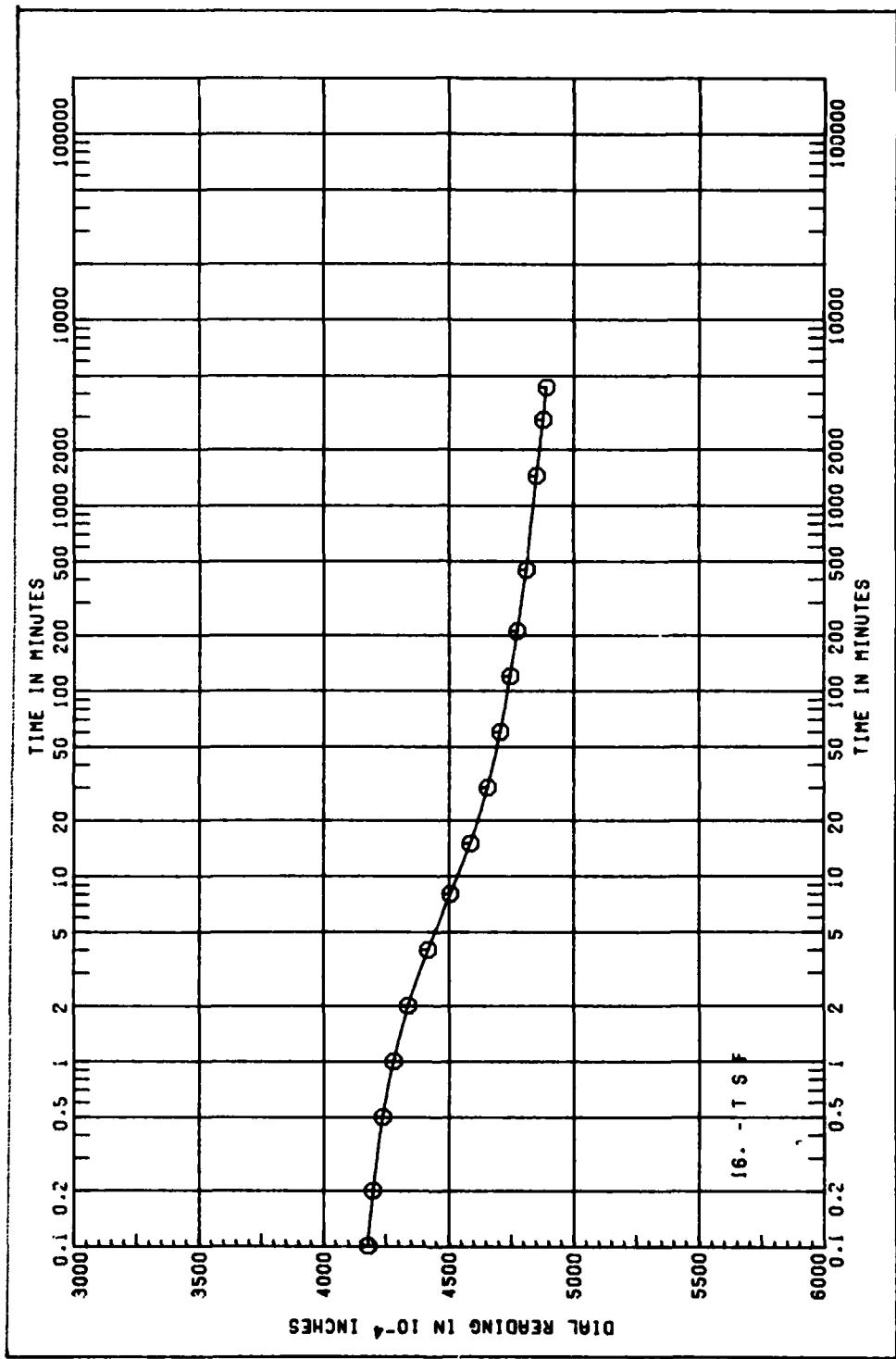
PROJECT SOUTH FILL AREA

U.S. MILITARY ACADEMY

BORING WS-3 SAMPLE NO. 14

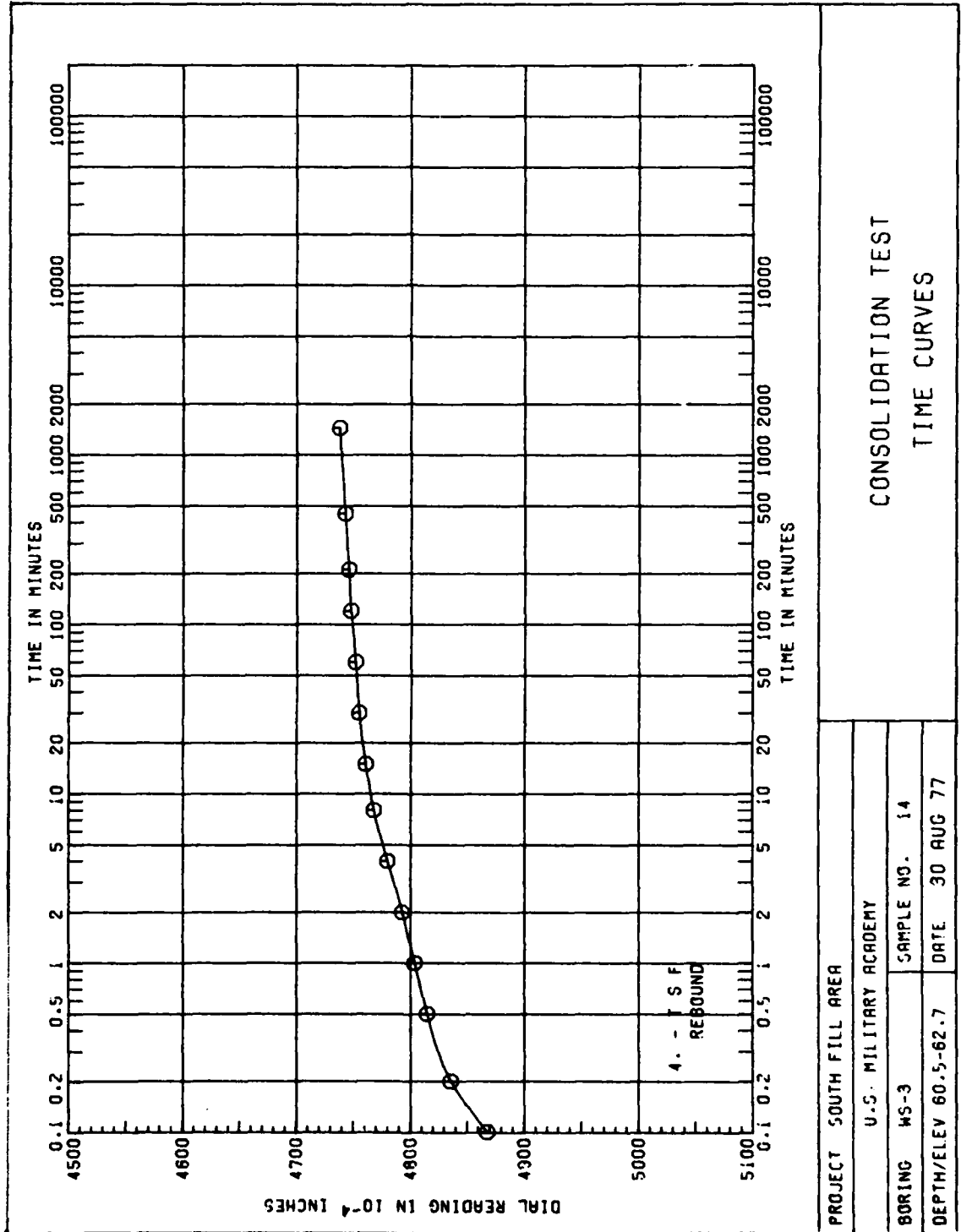
DEPTH/ELEV 60.5-62.7 DATE 30 AUG 77

PLATE D35
(SHEET 8 OF 12)



CONSOLIDATION TEST TIME CURVES	
PROJECT SOUTH FILL AREA	
U.S. MILITARY ACADEMY	
BORING MS-3	SAMPLE NO. 14
DEPTH/ELEV 60.5-62.7	DATE 30 AUG 77

PLATE D35
(SHEET 9 OF 12)



CONSOLIDATION TEST
TIME CURVES

PROJECT SOUTH FILL AREA	
U.S. MILITARY ACADEMY	
BORING WS-3	SAMPLE NO. 14
DEPTH/ELEV 60.5-62.7	DATE 30 AUG 77

PLATE D35
(SHEET 10 OF 12)

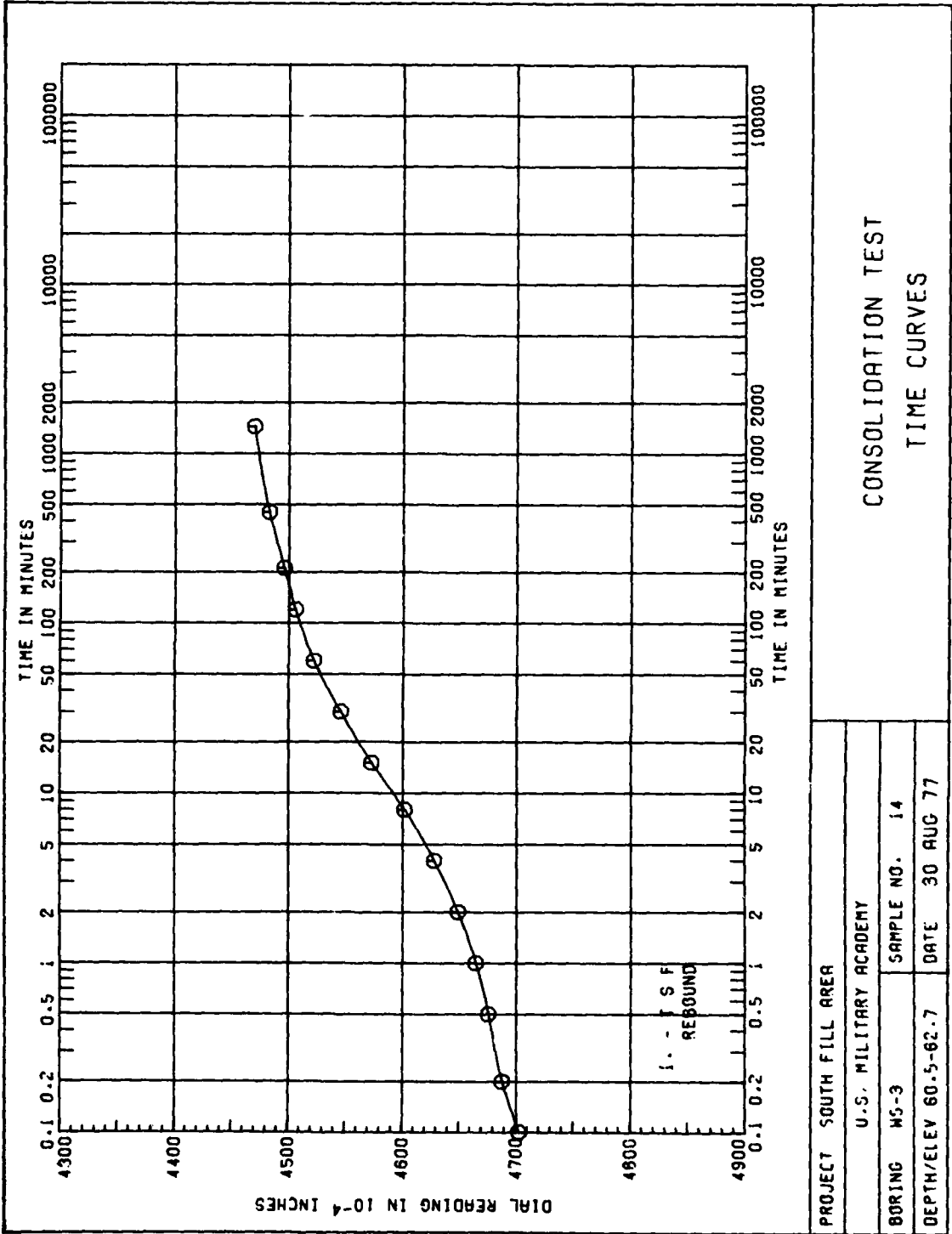
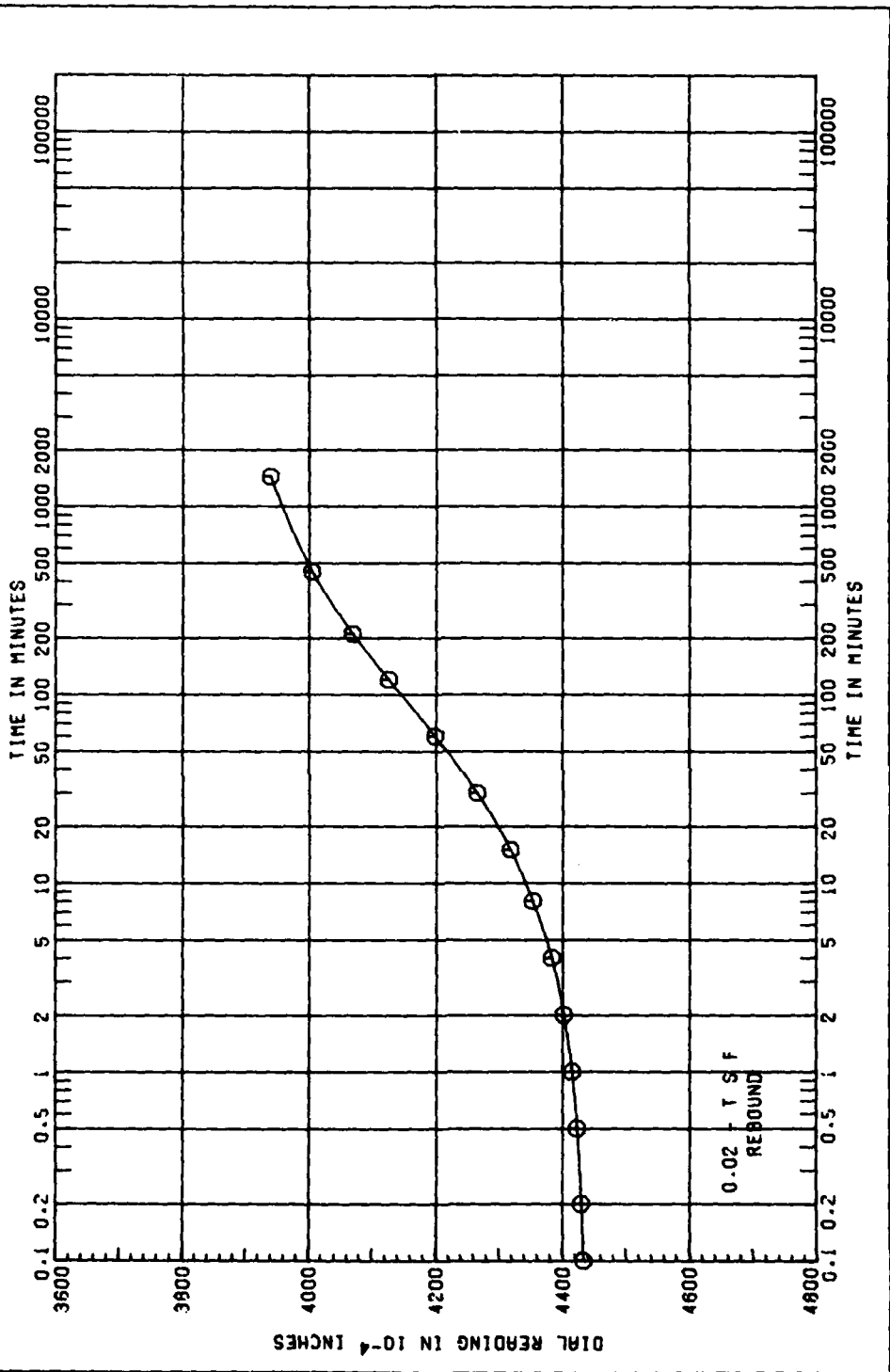


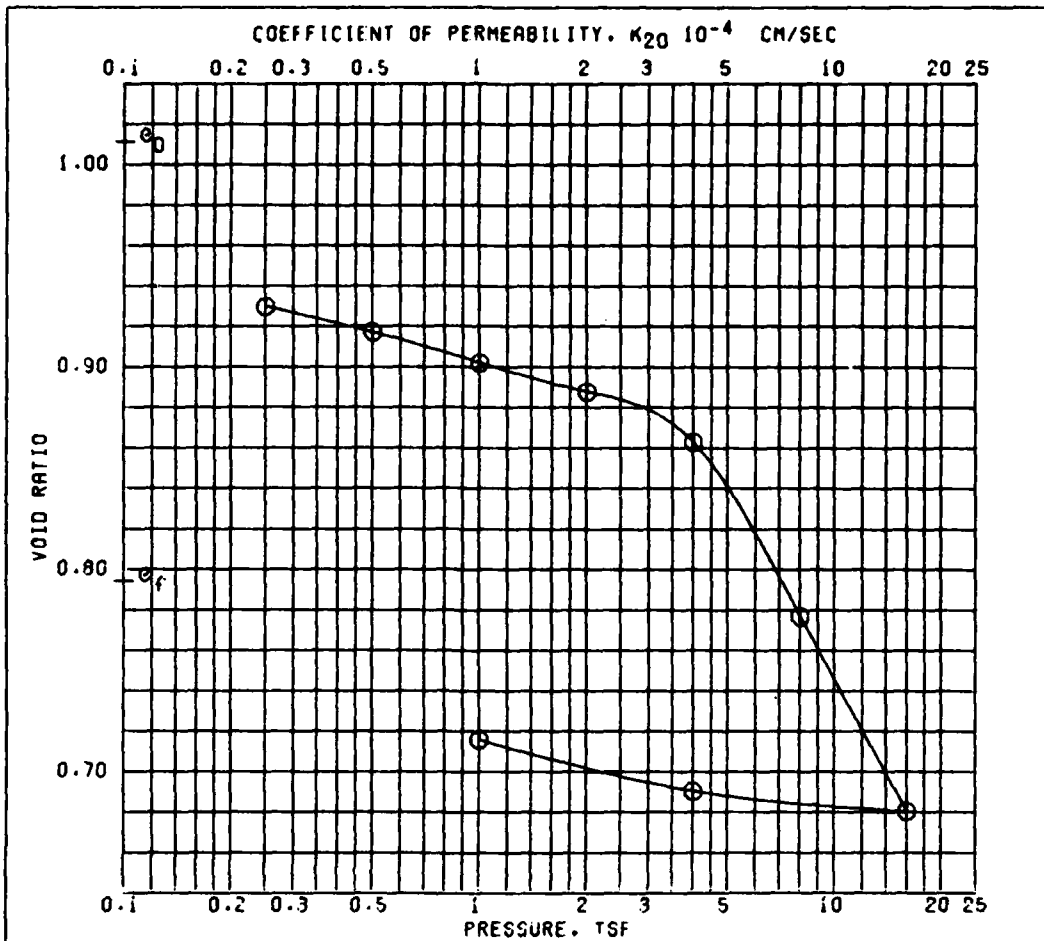
PLATE D35
(SHEET 11 OF 12)



PROJECT SOUTH FILL AREA	
U.S. MILITARY ACADEMY	
BORING WS-3	SAMPLE NO. 14
DEPTH/ELEV 60.5-62.7	DATE 30 AUG 77

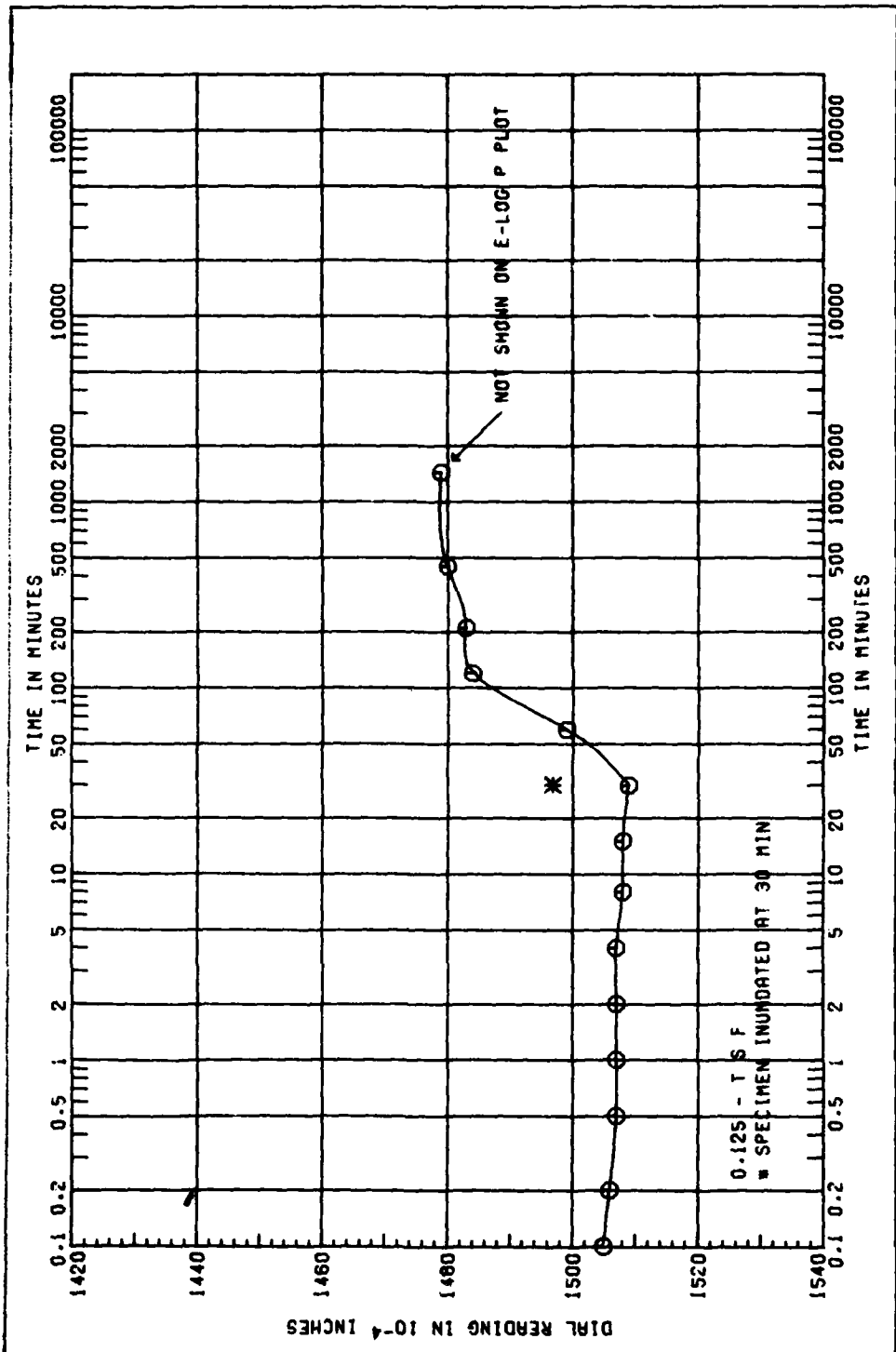
CONSOLIDATION TEST
TIME CURVES

PLATE D35
(SHEET 12 OF 12)



		BEFORE TEST	AFTER TEST
OVERBURDEN PRESSURE, TSF			
PRECONSOL. PRESSURE, TSF			
COMPRESSION INDEX			
TYPE SPECIMEN	UNDISTURBED	WATER CONTENT, %	36.7
DIA. IN 4.44	HT. IN 1.241	DRY DENSITY, PCF	84.1
		SATURATION, %	98.4
		VOID RATIO	1.011
		BACK PRESSURE, TSF	0.793
CLASSIFICATION LEAN CLAY (CL), DARK GRAY			
LL	PL	PI	PROJECT SOUTH FILL AREA
GS 2.71 (Q)	D ₁₀		U.S. MILITARY ACADEMY
REMARKS		BORING NO. WS-3	SAMPLE NO. 21
		DEPTH/ELEV 81.0-82.4	DATE 30 AUG 77
CONSOLIDATION TEST REPORT			

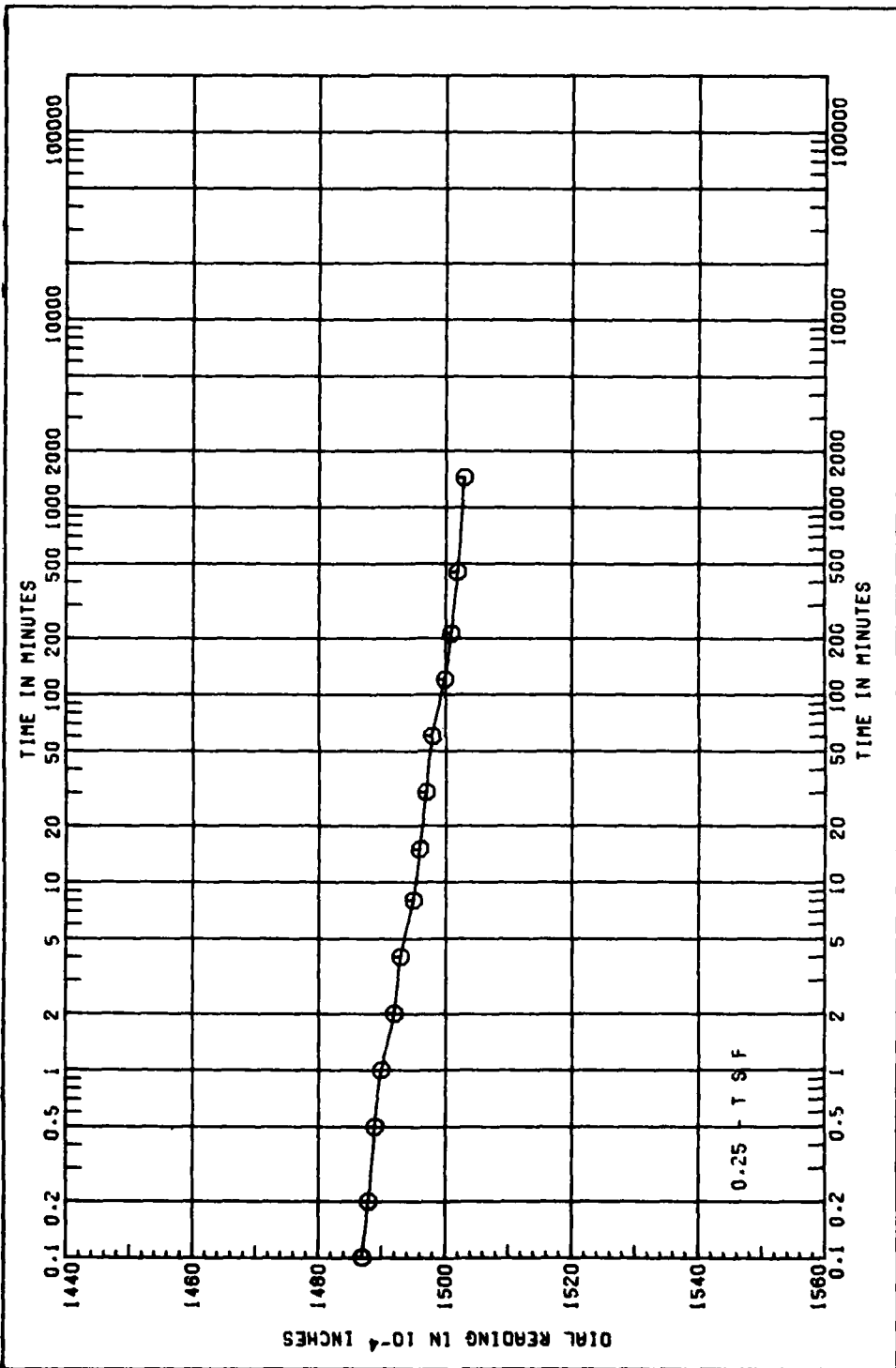
PLATE D36
(SHEET 1 OF 12)



CONSOLIDATION TEST
TIME CURVES

PROJECT SOUTH FILL AREA	
U.S. MILITARY ACADEMY	
BORING MS-3	SAMPLE NO. 21
DEPTH/ELEV 81.0-82.4	DATE 30 AUG 77

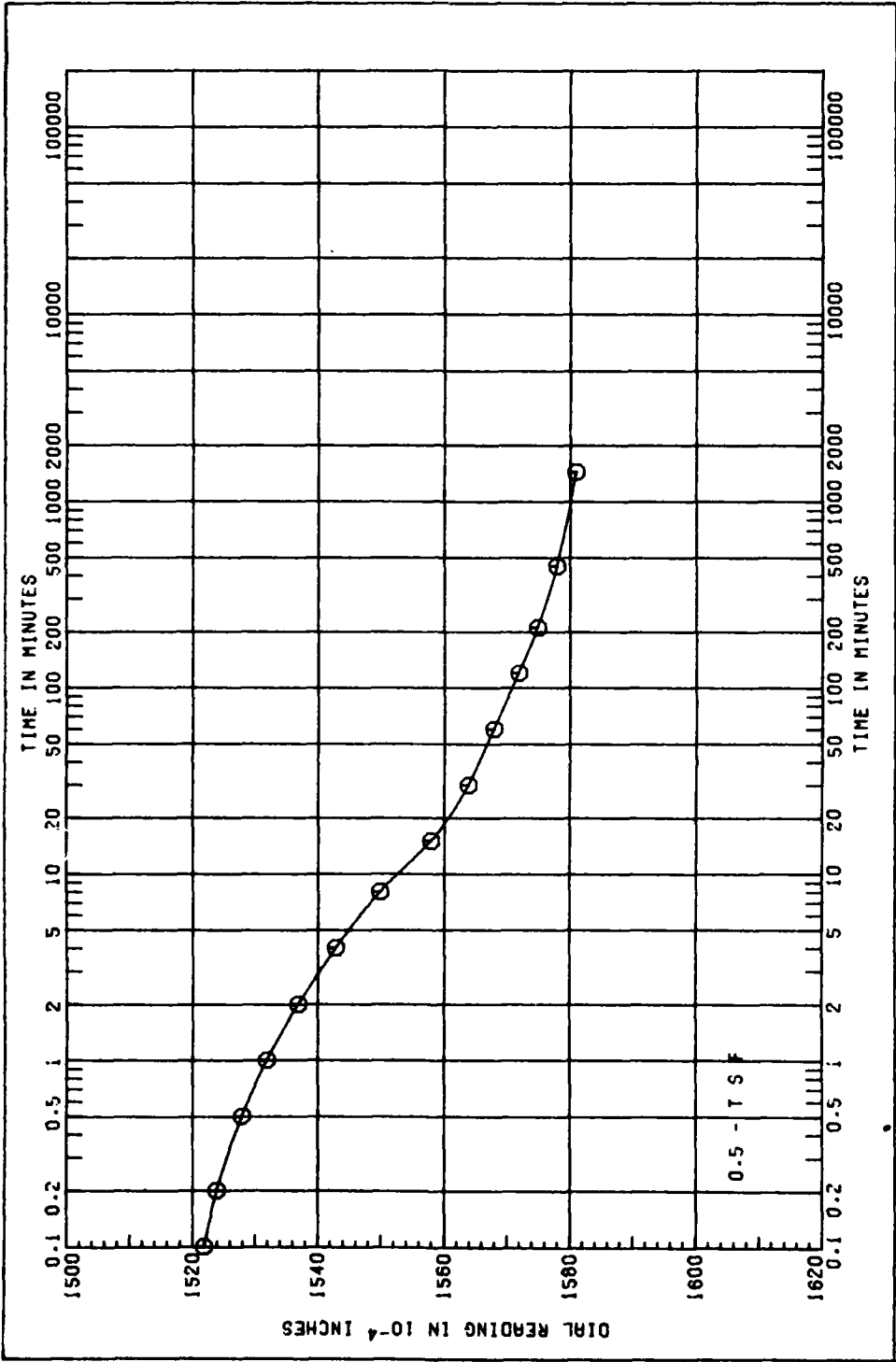
PLATE D36
(SHEET 2 OF 12)



CONSOLIDATION TEST
TIME CURVES

PROJECT SOUTH FILL AREA	
U.S. MILITARY ACADEMY	
BORING WS-3	SAMPLE NO. 21
DEPTH/ELEV 01.0-82.4	DATE 30 AUG 77

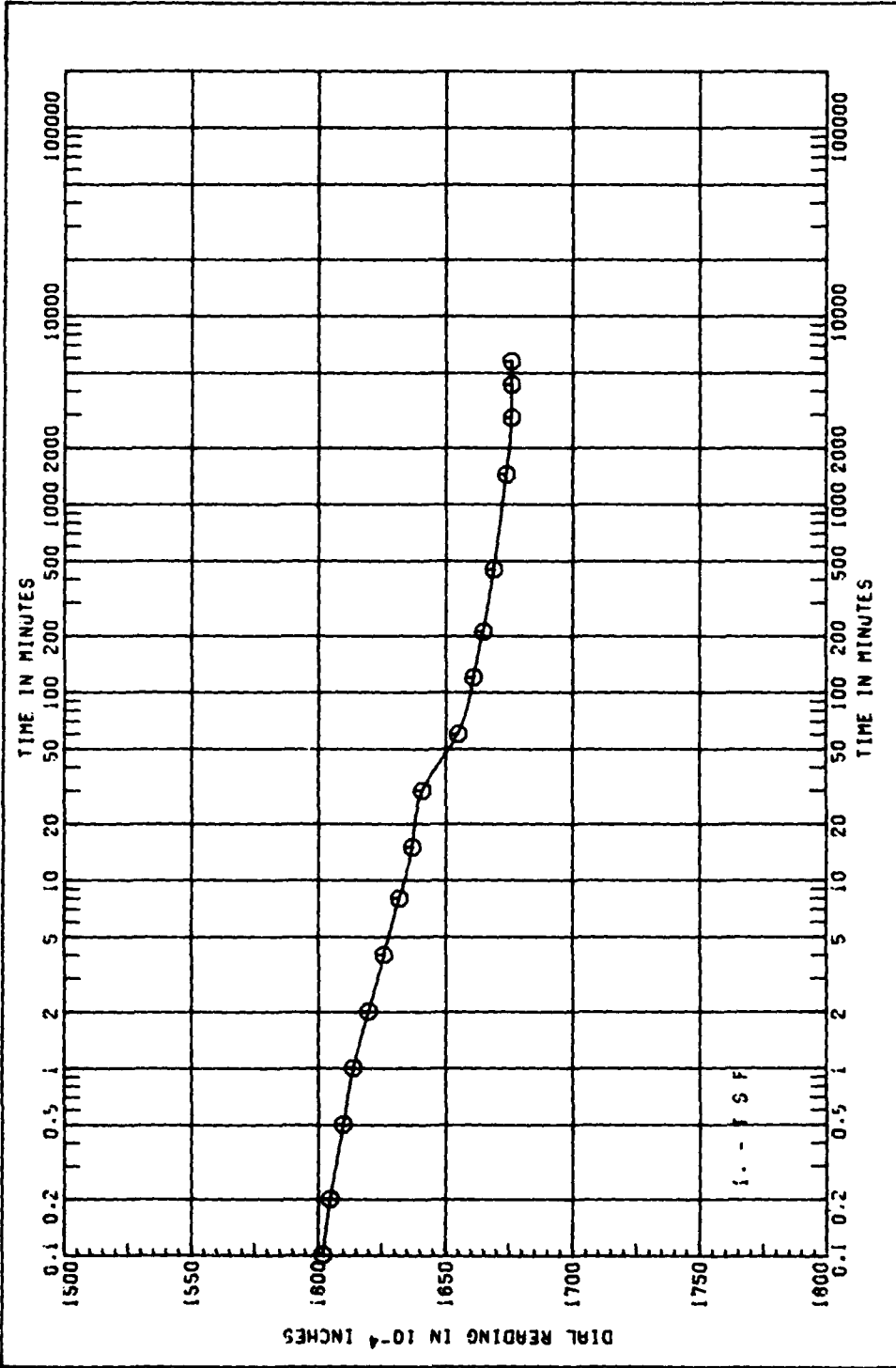
PLATE D36
(SHEET 3 OF 12)



CONSOLIDATION TEST
TIME CURVES

PROJECT SOUTH FILL AREA	
U.S. MILITARY ACADEMY	
BORING M5-3	SAMPLE NO. 21
DEPTH/ELEV 81.0-82.4	DATE 30 AUG 77

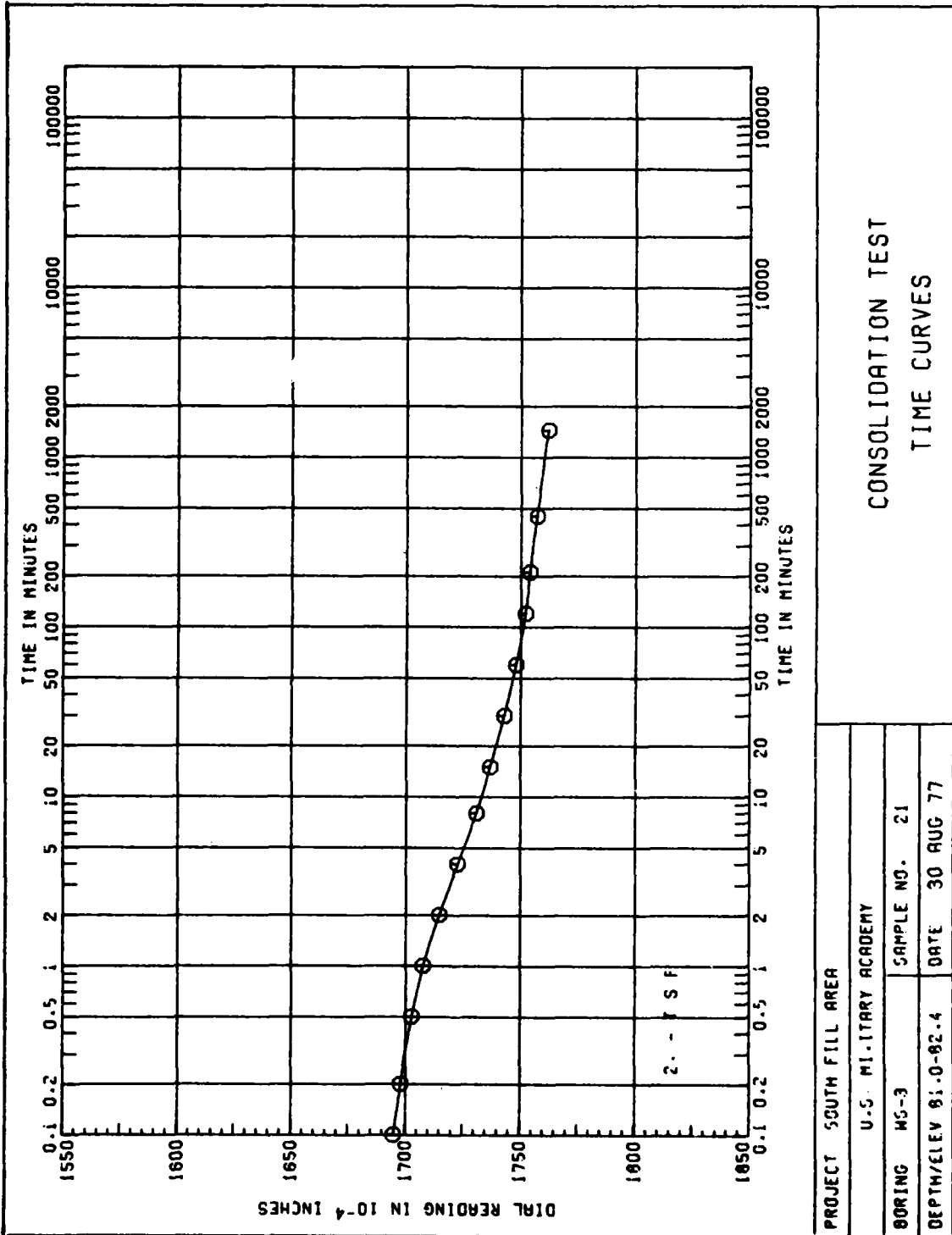
PLATE D36
(SHEET 4 OF 12)



**CONSOLIDATION TEST
TIME CURVES**

PROJECT SOUTH FILL AREA	
U.S. MILITARY ACADEMY	
BORING WS-3	SAMPLE NO. 21
DEPTH/ELEV 81.0-82.4	DATE 30 AUG 77

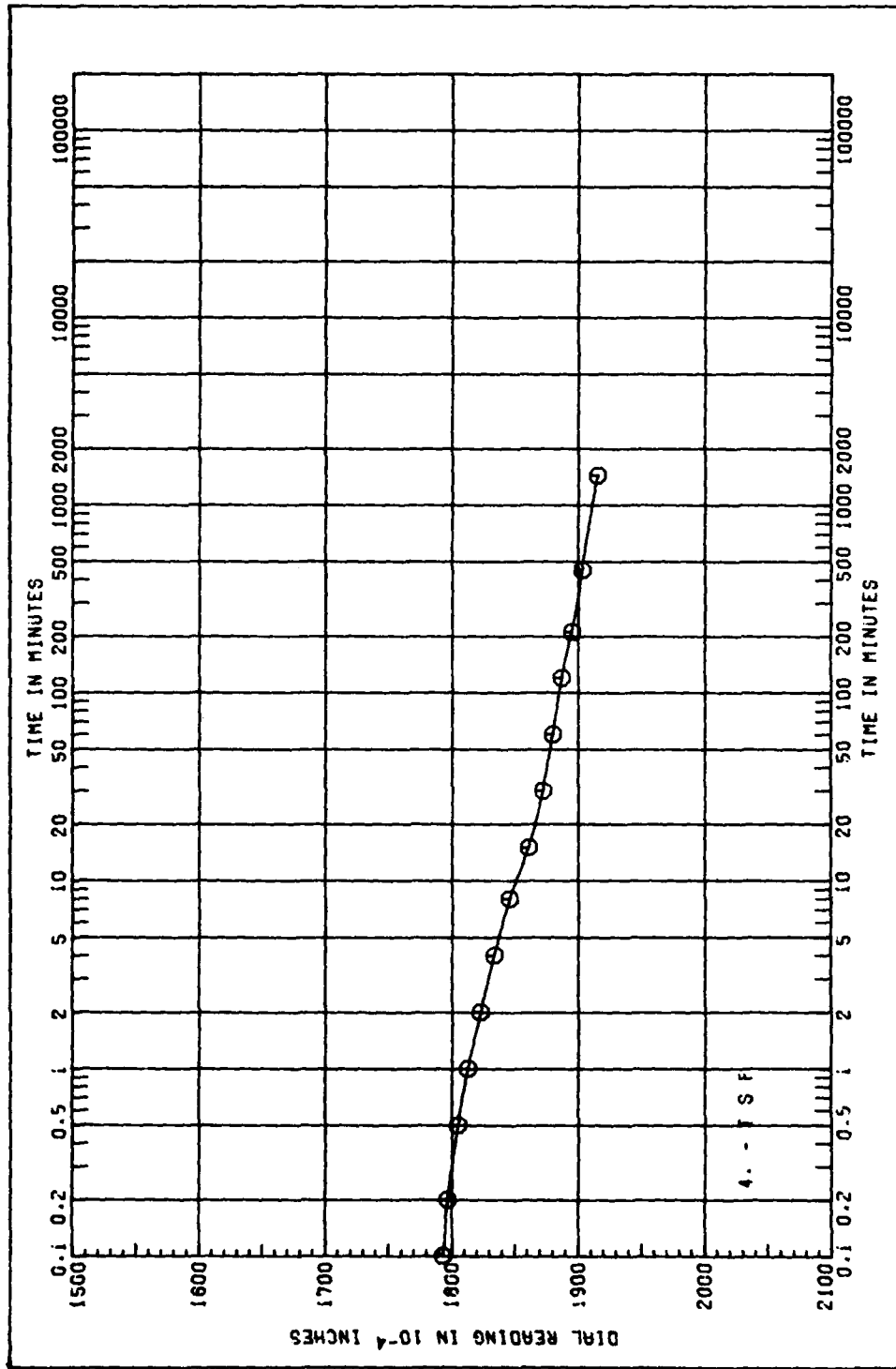
**PLATE D36
(SHEET 5 OF 12)**



PROJECT SOUTH FILL AREA	
U.S. MILITARY ACADEMY	
BORING MS-3	SAMPLE NO. 21
DEPTH/ELEV 81.0-82.4	DATE 30 AUG 77

CONSOLIDATION TEST
TIME CURVES

PLATE D36
(SHEET 6 OF 12)

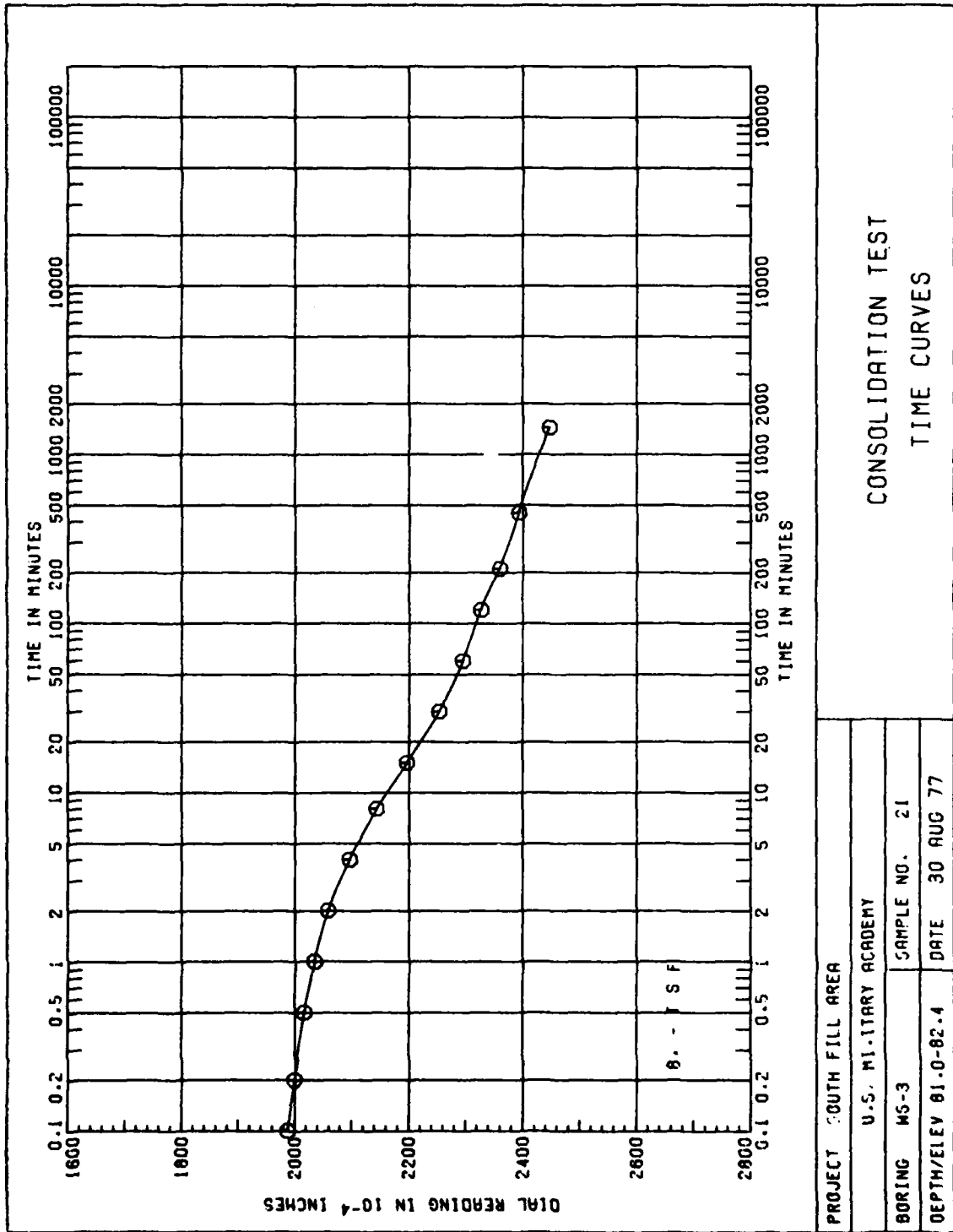


CONSOLIDATION TEST
TIME CURVES

PROJECT SOUTH FILL AREA	
U.S. MILITARY ACADEMY	
BORING MS-3	SAMPLE NO. 21
DEPTH/ELEV 91.0-82.4	DATE 30 AUG 77

PLATE D36
(SHEET 7 OF 12)

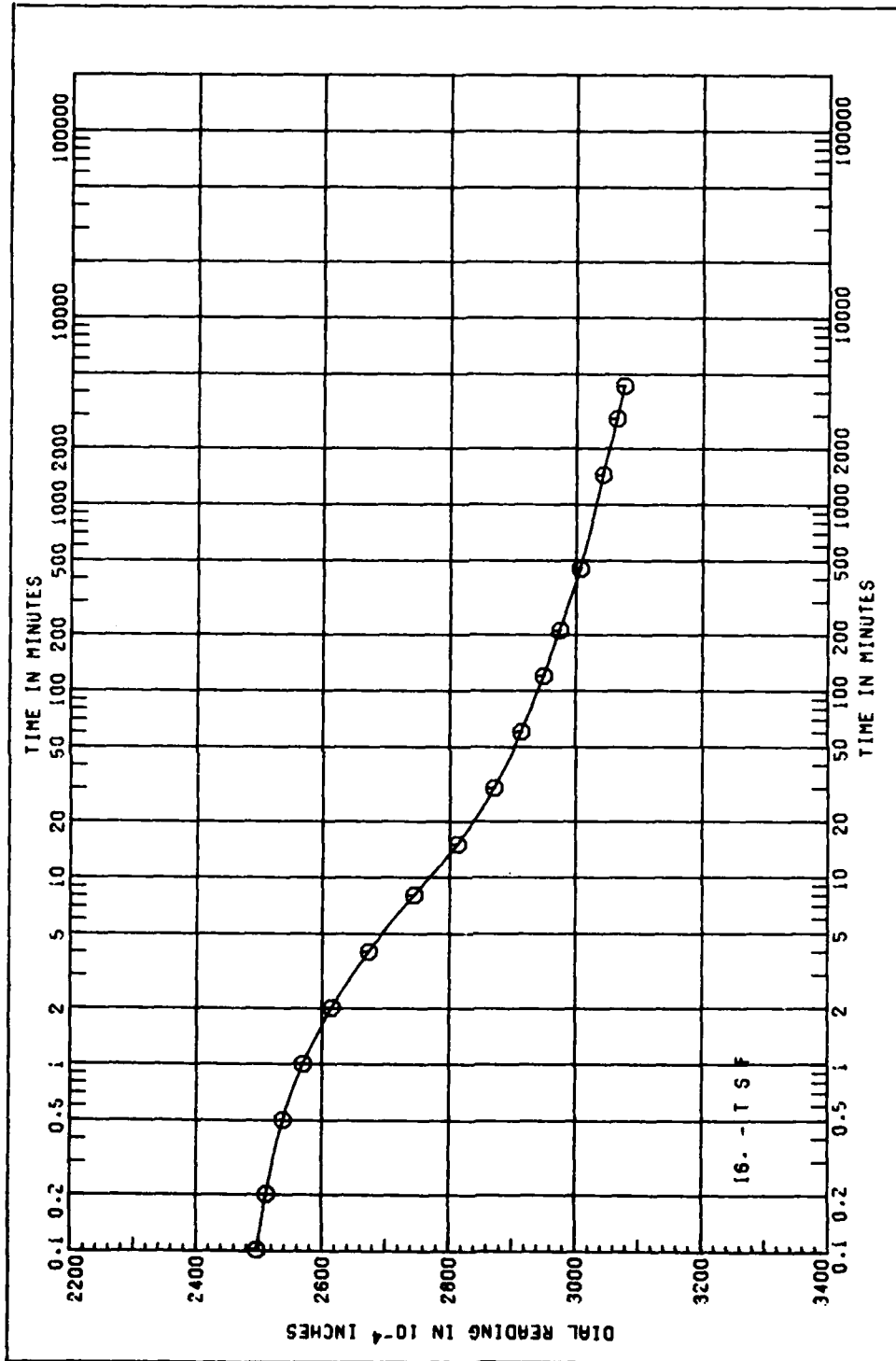
D77



CONSOLIDATION TEST
TIME CURVES

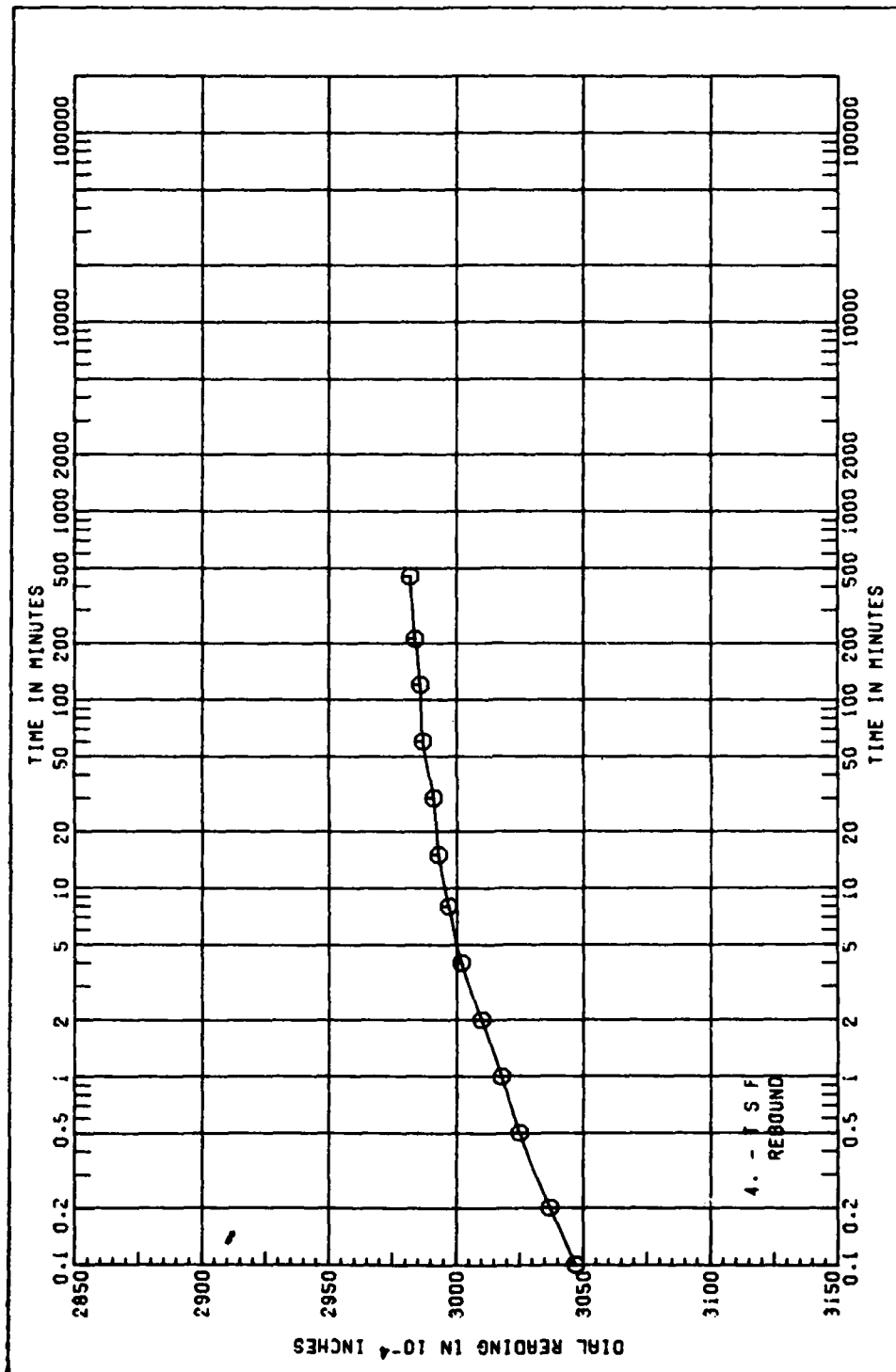
PROJECT	SOUTH FILL AREA	
	U.S. MILITARY ACADEMY	
BORING	MS-3	SAMPLE NO. 21
DEPTH/ELEV	81.0-82.4	DATE 30 AUG 77

PLATE D36
(SHEET 8 OF 12)



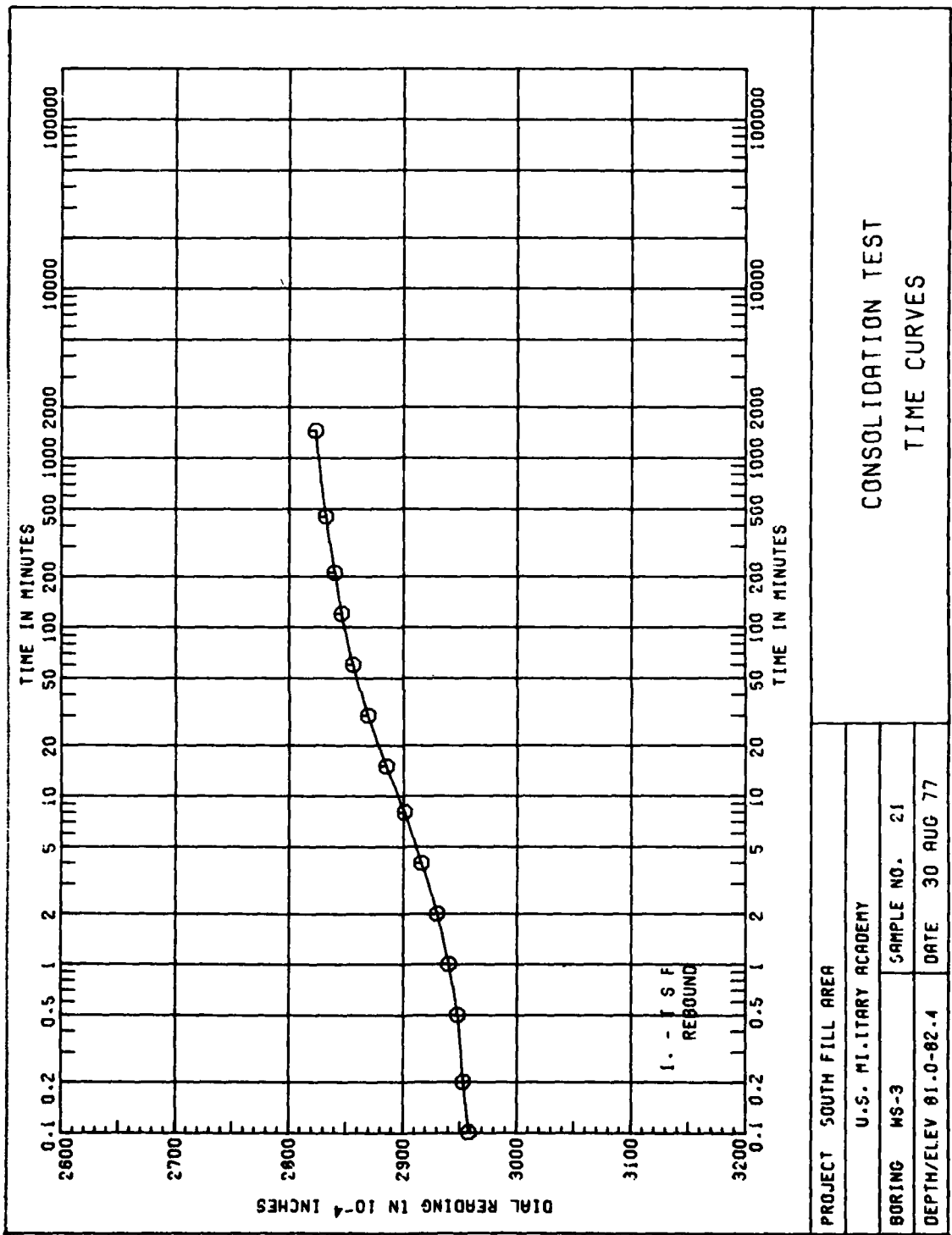
CONSOLIDATION TEST TIME CURVES	
PROJECT SOUTH FILL AREA	
U.S. MILITARY ACADEMY	
BORING WS-3	SAMPLE NO. 21
DEPTH/ELEV 81.0-82.4	DATE 30 AUG 77

PLATE D36
(SHEET 9 OF 12)



CONSOLIDATION TEST TIME CURVES	
PROJECT SOUTH FILL AREA	
U.S. MILITARY ACADEMY	
BORING MS-3	SAMPLE NO. 21
DEPTH/ELEV 81.0-82.4	DATE 30 AUG 77

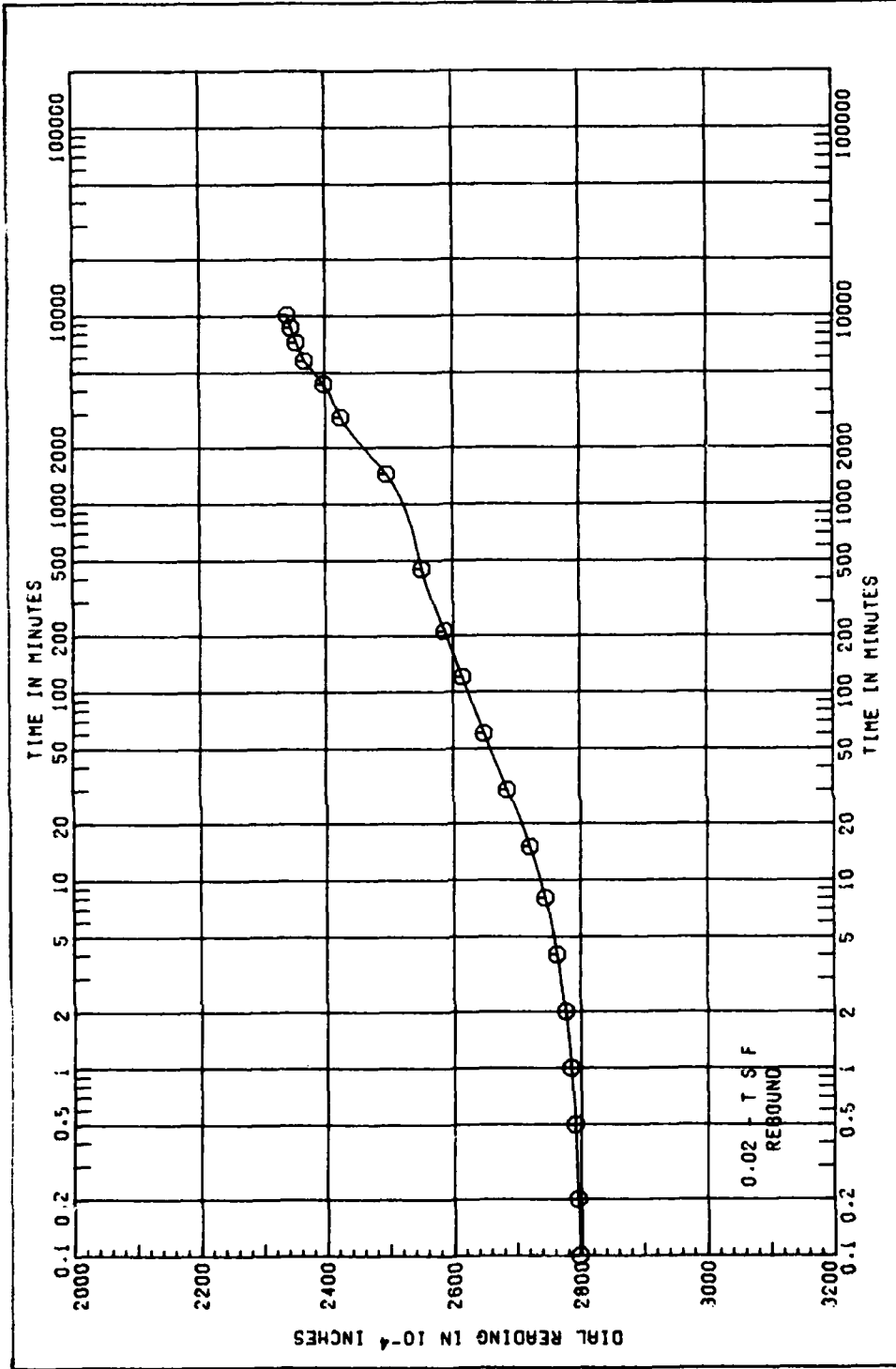
PLATE D36
(SHEET 10 OF 12)



CONSOLIDATION TEST
TIME CURVES

PROJECT SOUTH FILL AREA	
U.S. MILITARY ACADEMY	
BORING WS-3	SAMPLE NO. 21
DEPTH/ELEV 61.0-82.4	DATE 30 AUG 77

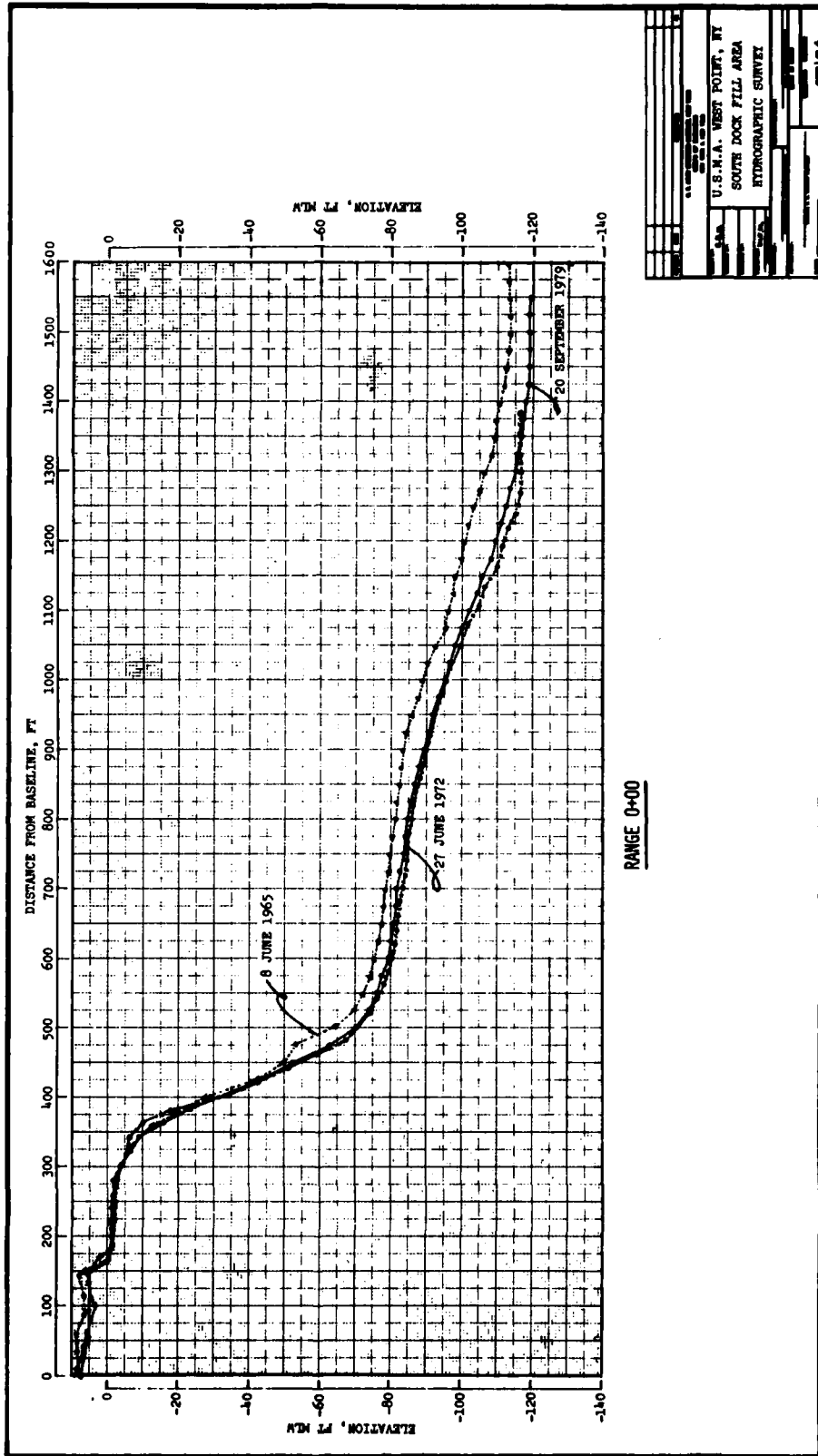
PLATE D36
(SHEET 11 OF 12)



CONSOLIDATION TEST TIME CURVES	
PROJECT	SCUTH FILL AREA
BORING	MS-3
DEPTH/ELEV	81.0-82.4
SAMPLE NO.	21
DATE	30 AUG 77

PLATE D36
(SHEET 12 OF 12)

APPENDIX E: SEPTEMBER 1979 HYDROGRAPHIC SURVEYS
AND ECHO SOUNDINGS, SOUTH DOCK,
U. S. MILITARY ACADEMY, WEST POINT, NEW YORK



RANGE 0+00

PLATE E1
(SHEET 1 OF 4)

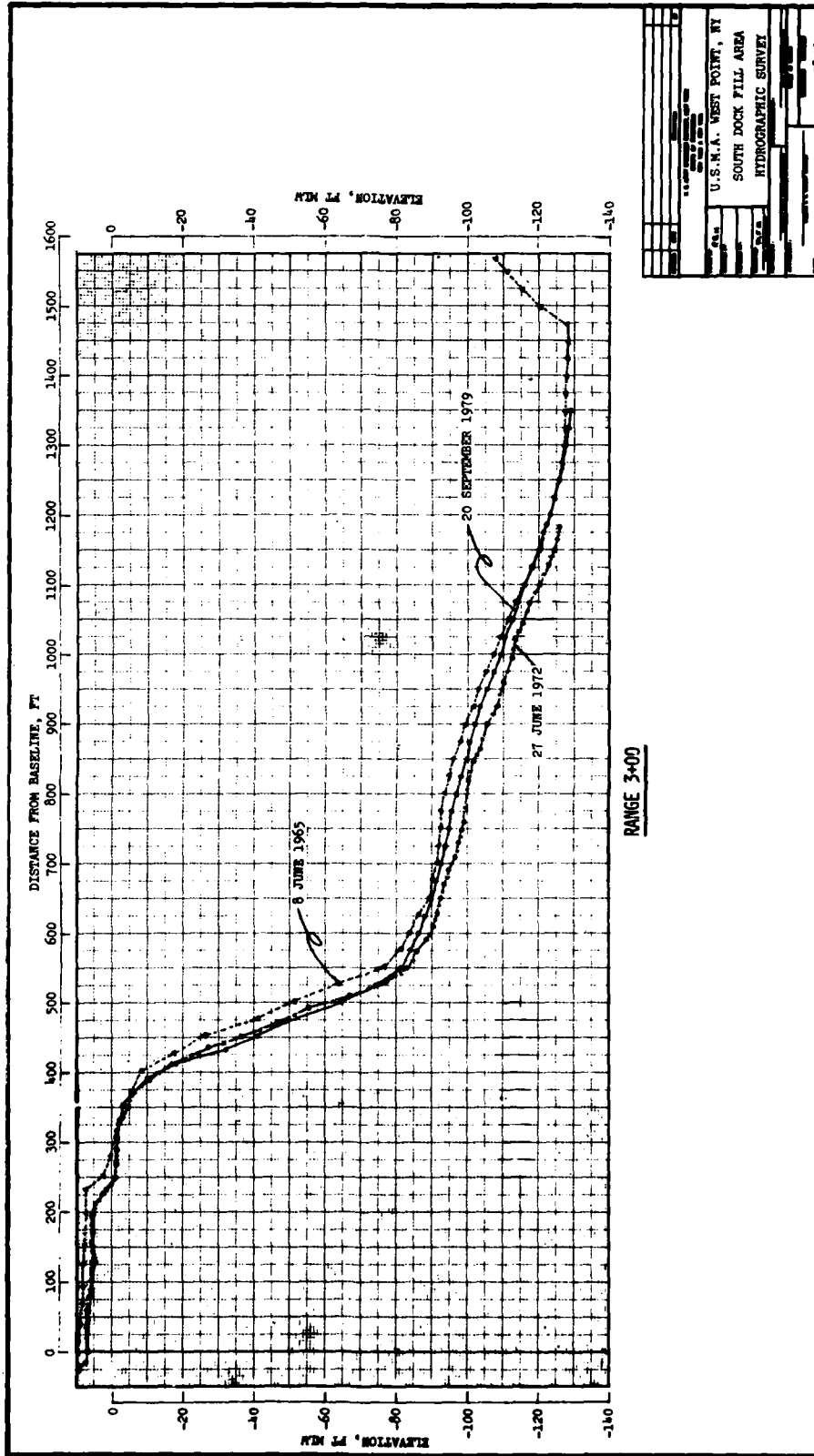
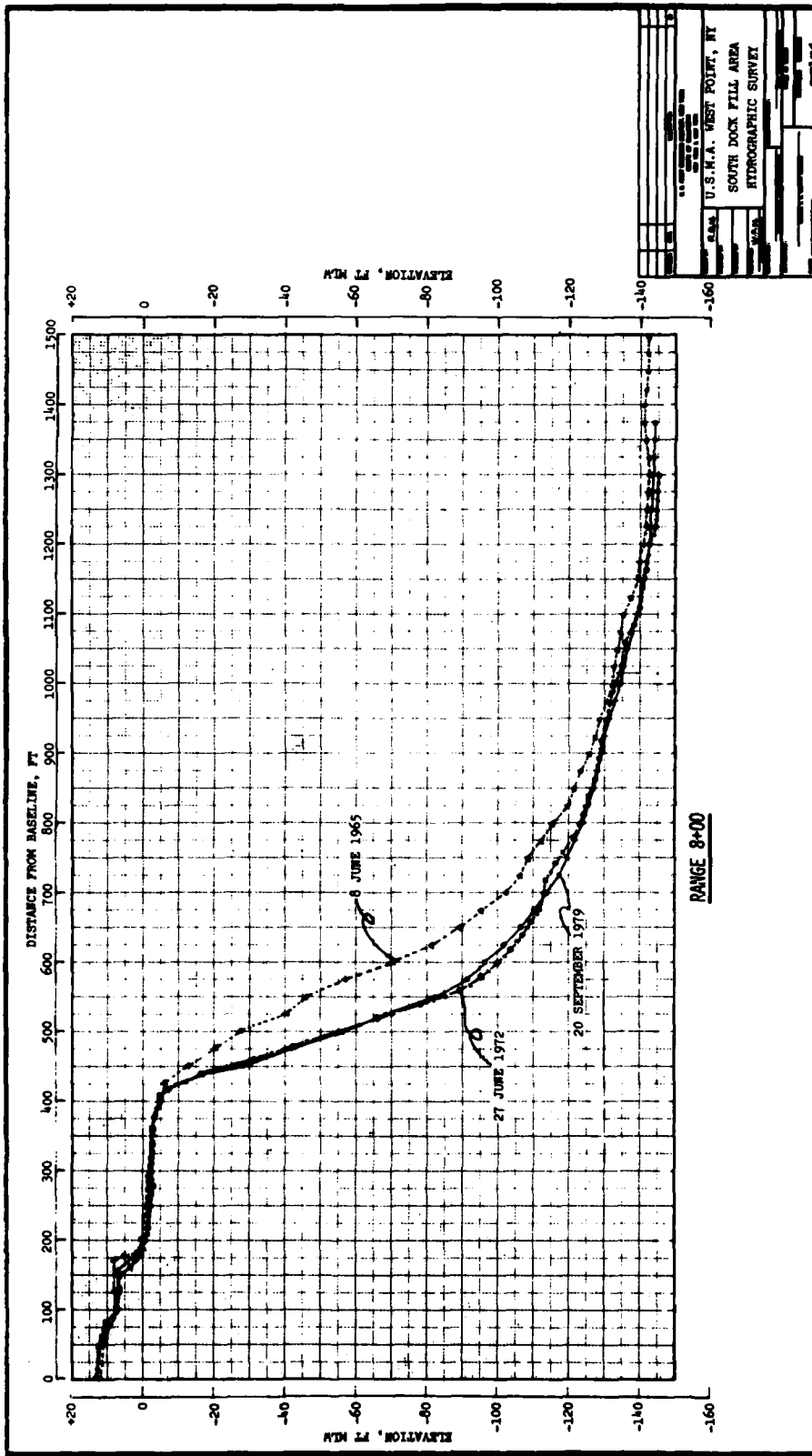


PLATE E1
(SHEET 2 OF 4)

E4



E5

PLATE E1
(SHEET 3 OF 4)

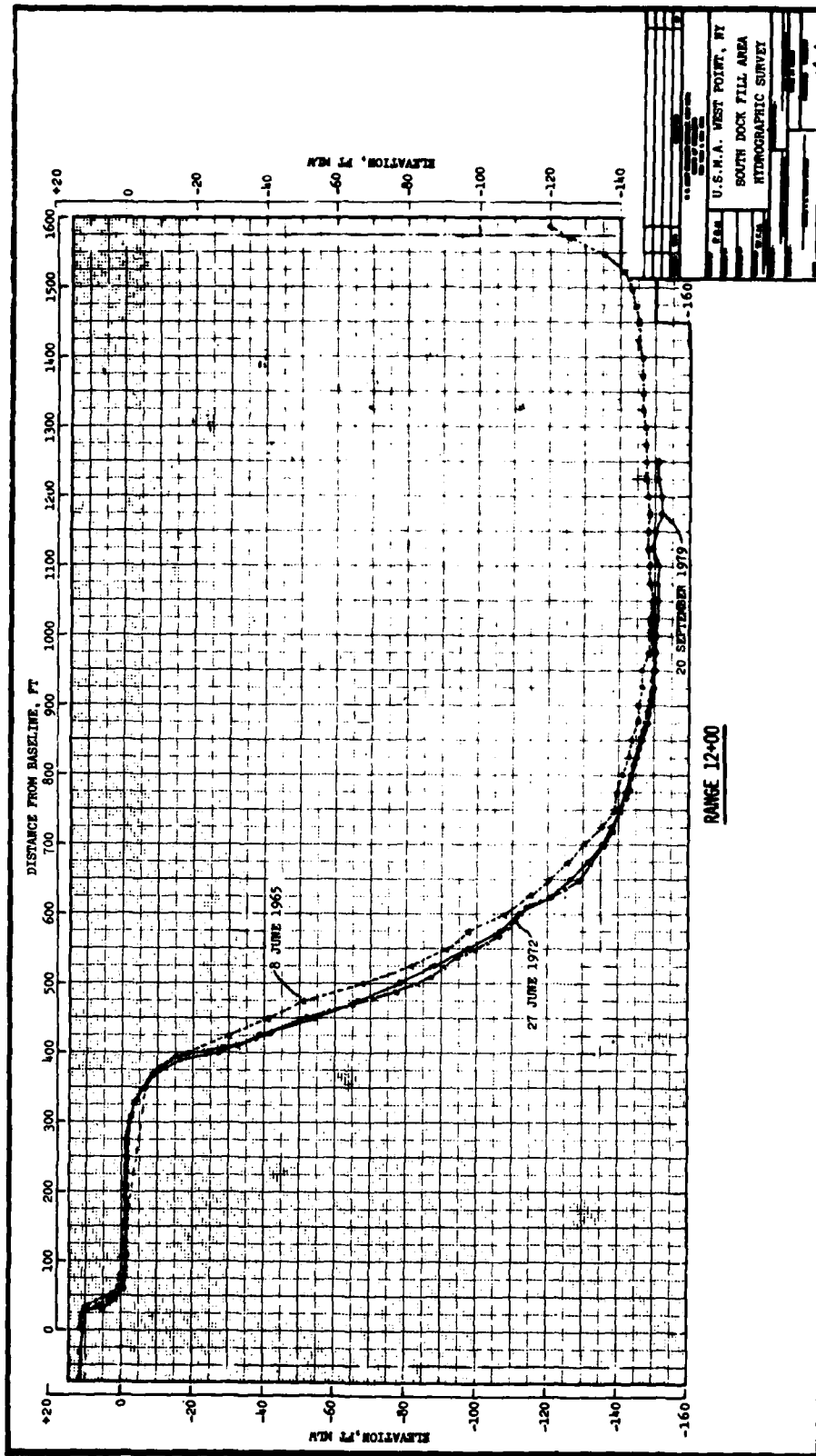
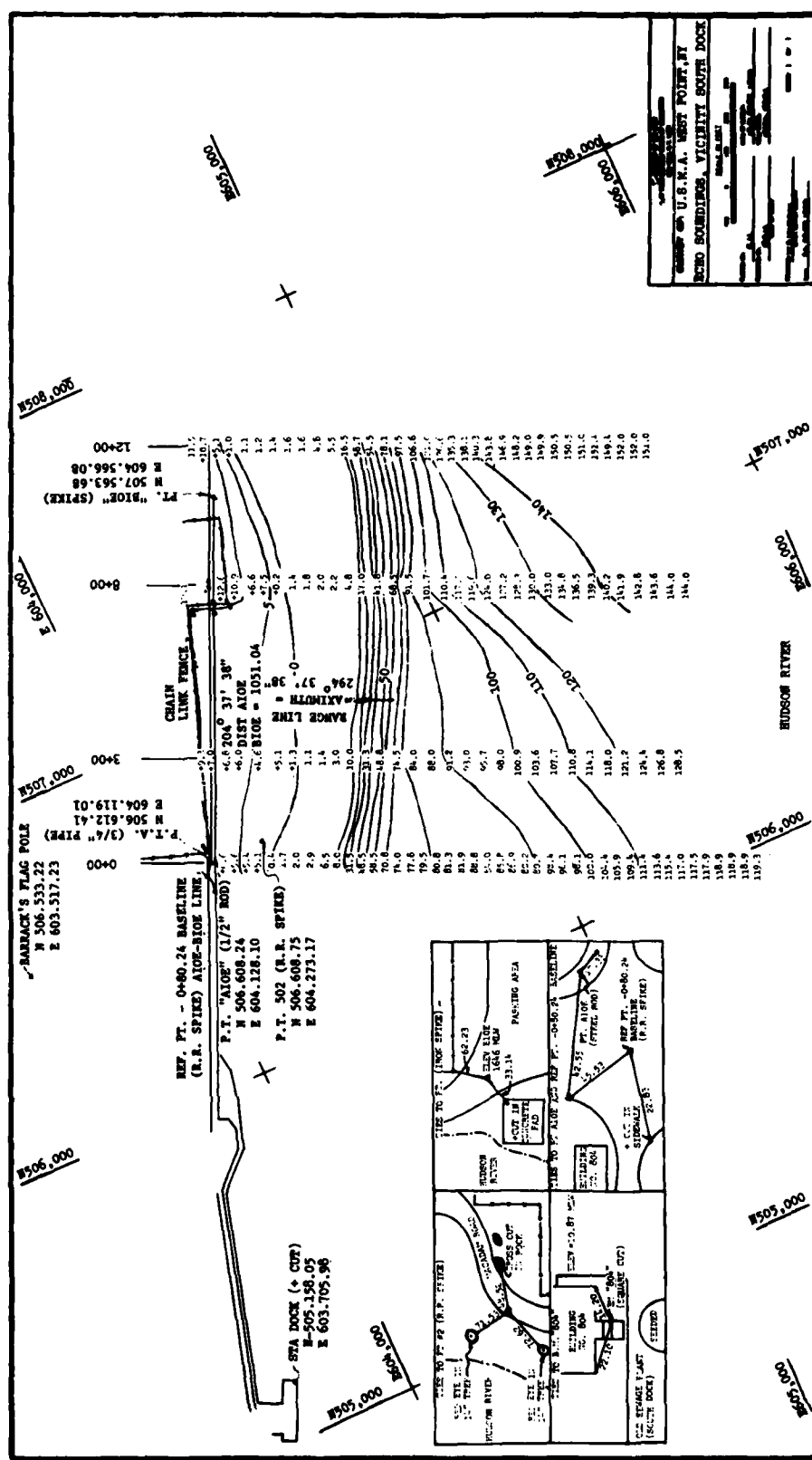


PLATE E1
 (SHEET 4 OF 4)

CONF ON U.S.N.A. WEST POINT, BY
ECHO BOARDING, VICINITY SOUTH DOCK
1943



E 604,100

E 604,100

E 606,000

E 606,000

12+00
E 604,566.08
N 507,563.68

8+00
E 604,119.01
N 506,612.41

0+00
E 603,517.23
N 506,533.22

E 606,000

E 606,000

E 606,000

HUDSON RIVER

E 605,000

E 605,000

E 605,000

E 606,000

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E 605,000

E 605,000

E 605,000

E 605,000

E 7

PLATE E2

APPENDIX F: REVIEW COMMENTS BY CONSULTANTS

(Note: A draft report was provided to the consultants for review comments, concurrently with other in-house reviews. The other reviews resulted in the addition or deletion of certain paragraphs; consequently, the item identification, such as page and paragraph numbers and the appendixes, referred to in the consultants' comments may be different from the printed report.)

17 August 1979

To: Mr. C. LeRoy McAnear
Chief, Soil Mechanics Division
Geotechnical Laboratory
Waterways Experiment Station
P.O. Box 631
Vicksburg, Miss. 39180

From: Reginald A. Barron, P.E.
62 Horseshoe Road
Guilford, Conn. 06437

Subject: Review of Report, "Investigations
of South Fill Area, U.S. Military
Academy, West Point, New York."

1. This report is in accordance with a letter from Mr. C. LeRoy McAnear, W.E.S., to R.A. Barron dated 13 August 1979 and purchase order DACA39-79-M-0162, dated 8/10/79.

2. Comments are as follows:

- A. Preface states that the report was written by Taylor and Poplin but title page also cites G.B. Mitchell.
- B. Page 21, end of paragraph 65, Fig. 19 should read 21.
- C. Page 23, paragraph 70. Use of piles should be prohibited. The driving vibration and pile displacement could lead to a liquefaction slide.
- D. Page 23, paragraph 71. It should be possible to raise the site level by use of thin soil lifts spread out over a number of years without measures to improve stability; field observations should be used to control placement.
- E. Page 23, paragraph 72. If sand drains are used to improve stability, they should be installed, if possible, by an auger method. No displacement mandrills should be permitted. See comment C.
- F. Page 23, paragraph 73. a, b, & c, suggest use of "should" in lieu of "must".

Mr. C. LeRoy McAvery
Chief, Soil Mechanics Division
Page 2

- G. Page 24. Recommend that periodic soundings be made of the submerged slope to determine if the river is eroding the slope which could induce a flow slide involving the South Fill Area.
3. This is an excellent report. It illustrates the difficulties involved in the sampling and testing a very sensitive soil. (It is very possible that transportation of the samples from West Point to WES damaged the samples.) It also illustrates the need to keep field instrumentations simple and the requirement that all field devices be thoroughly protected against vandals.



Reginald A. Barron, P.E.

ARTHUR CASAGRANDE

September 21, 1979

*Pierce Hall
Harvard University
Cambridge, Mass. 02138*

Mr. C. L. McAnear, Chief
Soil Mechanics Division
Waterways Experiment Station
P.O. Box 631
Vicksburg, MS 39180

Subject: Review of Draft Report dated May 1979, on
INVESTIGATIONS FOR SOUTH FILL AREA
U.S. Military Academy, West Point, N.Y.

Dear Mr. McAnear:

In accordance with the request in your letter of 13 August 1979, and on the basis of our telephone conversation on 19 September, I submit herewith my comments on the subject report.

In my opinion, the most important results of these investigations are summarized in Fig. 14, which illustrates clearly that consolidation of the very soft clay stratum has well advanced; and that, therefore, the strength of the clay and the stability of this area have substantially increased as compared to the conditions in 1961.

On page 17, the last sentence in the first paragraph may not clearly convey the results shown in Fig. 14, by referring to "...70% of the total consolidation has taken place since 1961." To prevent misunderstandings, I suggest expressing this as follows: "...70% of the estimated 100% consolidation has taken place since 1961." Perhaps this thought could be expressed even clearer. See note (x) on p. 4.

On page 21, in the second paragraph the authors conclude that a settlement analysis would have been of doubtful value

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Residence Tel. (617) 484-4081, 16 Rockmont Rd., Belmont, Mass. 02178*

because the samples may have been disturbed. In my experience, "undisturbed samples" of sensitive clays taken in borings are hardly ever sufficiently undisturbed to permit reasonably reliable strength investigations. However, for normally consolidated clays the virgin-compression curve is not changed much by minor straining of sensitive specimens, ~~but which always causes major reduction in strength~~, as reflected by the shape of the e-p curves in Appendix F. Furthermore, the combination of reliable settlement and piezometer observations would serve as a good basis for settlement analyses.

The last paragraph on page 22 is not clearly written. I assume that the authors refer in the first line to "total strength parameters", not "effective strength parameters". I estimate that the effective friction angle of this clay, and also of the peat, is at least 25 degrees, perhaps as high as 30 degrees. In combination with the degree of consolidation, it would be possible to carry out fairly reliable stability analyses using an effective friction angle and zero cohesion.

In the table of CONTENTS and the title page for APPENDIX F are listed "S TRIAXIAL COMPRESSIVE STRENGTH" tests, but I could not find any. Such tests, if carefully conducted, would have yielded reliable effective friction angles. A number of \bar{R} tests are included in APPENDIX F. Unfortunately none of these tests were consolidated under a sufficiently high all-around pressure so that the effective confining pressure would be well above the effective normal stress in situ. For soft, sensitive clays the consolidation pressure should be at least 8 kg/sq cm. This would have resulted in an effective normal stress of at least 2.5 kg/sq cm which would have been sufficiently high to go safely beyond the preconsolidation pressure. The maximum confining pressure used in all \bar{R} series was 3 kg/sq cm, and thus the maximum Effective Minor Principal Stress was only between 0.70

and 0.93 kg/sq cm. By the way, in some of the "Sheet 2" of Figs. F29, 20, 21 and 32, I found missing the adjective "effective" in the caption of the horizontal axis in the Mohr Diagram. Also, on some of these sheets, next to TYPE OF TEST, the designation \bar{R} is missing, or the bar over the R is missing. From the effective stress circles for all \bar{R} tests there is no doubt in my mind that within a range of effective normal stress greater than the in situ effective stress the strength envelope would show zero cohesion and an effective friction angle not exceeding 30 degrees.

On page 23, in paragraph 71, the authors recommend against raising the existing surface level "without providing measures to improve stability". However, in my judgment, it would be perfectly safe to raise the surface by one foot without endangering the stability. On the basis of reliable piezometer observations it would then be possible to raise the surface by additional small increments. In paragraph 72, sand drains are recommended to improve the stability of the south fill. In my experience, installation of sand drains in highly sensitive clays can do more harm than good.

On page 24, in paragraph 77, the statement that "no further monitoring of movements is necessary", without any reference to piezometer observations, could be interpreted to mean that also piezometer observations could be discontinued. In my opinion, and also because of the authors' appropriate emphasis in the first sentence of paragraph 79, it would be unfortunate if the piezometer observations were not continued. I believe that continuation of piezometer observations, and their utilization by means of conventional stability and settlement analyses, would be much more productive of useful results on

September 21, 1979

this project than the use of "numerical techniques, mainly finite element methods", as suggested in paragraph 79.

Sincerely yours,



AC:wc

P.S.: After completing this letter-report, I discovered that S tests, although not included in Appendix F, are briefly mentioned on page 16 and are summarized in Table 3. Unfortunately this table does not include the confining pressure under which these test specimens were consolidated. Also, I would want to know much more about these S test specimens because of the excessive range of 29 to 35 degrees. An effective friction angle of 29 degrees would, in my experience, be reasonable for such clays; but 34 and 35 degrees are far too high.

As I glanced again through pages 13 to 16, it occurred to me that the reader would be helped by appropriate sub-headings, as follows:

On page 13, change "Undrained" to "Undrained (Q) Tests"

On page 16, insert before the 4th line from bottom, the subheading "Consolidated-Undrained (\bar{R}) Tests".

Top of page 16, change "Drained" to "Drained (S) Tests".

Note (x)- As compared to 1961, the factor of safety has greatly increased not only because about 70% of the excess hydrostatic pressures have dissipated as of August 1978, but also because the 6 ft settlement of the area (Fig. 21) has also greatly decreased the overturning moment.

RALPH E. FADUM
CONSULTING ENGINEER
BOX 8818
RALEIGH, N. C. 27607

August 20, 1979

Commander and Director
U. S. Army Waterways Experiment Station
Corps of Engineers
P.O. Box 631
Vicksburg, Miss. 39180

Re: Investigation for South Fill Area
United States Military Academy
West Point, New York

Dear Sir:

In conformity with my agreement with the Waterways Experiment Station, I have carefully reviewed a draft copy of the above-referred-to report by H. M. Taylor, J. K. Poplin, and G. B. Mitchell dated May 1979 and am pleased to offer the following comments concerning it.

I do agree that it is highly desirable to compile the data obtained for this project into a comprehensive case history. The report provides data for an 18 year period of record that should prove to be of interest to future students as well as of value for the future planning of the Academy.

I concur with the conclusions and recommendations as stated in the report. The measurements of all of the parameters reflect improvements in the stability of the South Fill. There has been a significant decrease in moisture content of the foundation soil during the period 1961-1977 as shown in Fig. 7. During this period the shearing strength as measured by unconfined compression tests has also increased appreciably as shown in Fig. 8a. Piezometer measurements shown in Fig. 14 indicate that the percent consolidation has increased from approximately 20% in 1961 to 70% in 1978. These measurements consistently show that the stability of the South Fill has increased significantly during the observation period, and thus justify the conclusions as stated in the report.

I am pleased also to concur with the observations and recommendations concerning site utilization. I do, however, have the following additional comments to offer relating to them.

With respect to settlements, it is to be noted (p. 21), that an additional maximum settlement of 3.5 ft. is to be anticipated. As this settlement develops,

Commander and Director
U. S. Army Waterways Experiment Station
August 20, 1979
Page Two

greater and greater portions of the fill area will be subjected to periodic inundation. There will, therefore, be a greater temptation to place additional fill in such areas. Before proceeding with any additional filling, the admonition stated in the recommendations (paragraph 78) should be followed.

With respect to future threats to the stability of the South Fill, an undercutting of the riverward edge of the fill is perceived to be the most serious. Profiles shown in Fig. 14 for 1933, 1961 and 1974 give little indication that undercutting is occurring. Nonetheless, should any major changes in river flow take place it would be well to determine whether any undercutting has resulted therefrom.

Finally, I wish to commend the Corps of Engineers for the diligence with which it has undertaken this investigation. The "lessons learned" will make a significant contribution to our understanding of the stability of sensitive clays.

Sincerely yours,


Ralph E. Fadum
Consulting Engineer

DISPOSITION FORM

For use of this form, see AR 340-12, the proponent agency is TAGCEN.

REFERENCE OR OFFICE SYMBOL	SUBJECT
WESGH	Evaluation of "Liquefaction Potential" at South Fill

TO	FROM	DATE	CMT 1
H. M. Taylor, Jr., SMD	P. F. Hadala, C/EEGD	10 Sep 79	

Background

1. Mr. Taylor asked me to review the draft report entitled "Investigation for South Fill Area, United States Military Academy, West Point, New York," and comment on letter reports by Consultants W. J. Turnbull and R. A. Barron, who, in their reviews of the same report, raised the subject of liquefaction.

Synopsis of Consultants' Comments on Liquefaction

2. Mr. Turnbull expressed the opinion that the North Fill failed by liquefaction rather than progressive shear and cited several causative factors which were present as well as the short time in which the mass movement occurred. Mr. Barron recommended prohibition of pile driving on the South Fill because it could lead to a liquefaction slide. Consultants R. E. Fadum and P. C. Rutledge did not mention liquefaction in their letter reports.

Comment

3. Liquefaction is a much misunderstood word and people do not agree on its meaning. I will comment on the potential for a flow slide in the South Fill as a result of dynamic excitation. There are two materials of interest in the South Fill. The first is a zone of cohesionless material of glacial origin which underlies the fill near its western edge (see Figure 5 of the report). The only data available on this material are given on Plate 15 of WES Technical Report 3-591. The material is below the water table. It is a fine, sometime: gravelly or clayey sand. Standard penetration tests in this material made in 1962 (Boring BS-1) range from 0 to 40 blows/ft. Low blow counts (less than 12 blows/ft) were encountered between elevations -7 and -15 ft below mlw. The zero blow counts are highly unusual for sands (even if loose) as the effective overburden stress in this depth range is at least 1 tsf. At any rate, even if this material was very loose and could lose all of its shear strength as a result of sustained shaking, it has nowhere to go. It is contained on one side by the rock and on the other by the clay. So long as the guidance in Parts VI and VII of the draft report is followed regarding surface construction and usage of the site, no damage can result from possible loss of strength in the sand as a result of dynamic loadings.

4. The other material is a highly plastic marine clay which (a) is sometimes organic and/or silty, (b) was deposited in an estuary condition, (c) was normally consolidated prior to construction, and (d) is about 70 percent consolidated under its present loading. The material in the top 40 ft of this deposit had, in 1977, an undrained shear strength of about 0.4 to 0.5 tsf and sensitivity ratios of about 4 to 10. \bar{R} tests on this material indicated positive pore pressure response in shear.

DA FORM 2496
1 FEB 62

REPLACES DD FORM 96, WHICH IS OBSOLETE.

GPO-1975-686-422/1083

WESGH

10 Sep 79

SUBJECT: Evaluation of "Liquefaction Potential" at South Fill

The literature was examined to try to find data on the cyclic test performance of such materials. France and Sangrey (1977) tested sedimented normally consolidated illite specimens in undrained cyclic triaxial tests. However, the sensitivities of these materials were quite low (approximately 2). They found that for cyclic loading at stress levels below two-thirds of the maximum deviator stress in monotonic loading, the material eventually reached a stable hysteresis loop. Lee (1979) conducted cyclic tests on undisturbed samples of very sensitive preconsolidated Champlain clay which classified as CL. Two different materials were tested. Soil A had a Q shear strength of approximately 2 tsf and a sensitivity of 300. Soil B had a Q strength of about 0.6 tsf and a sensitivity of 35. Large strains developed rapidly after about 30 cycles of loading at stress levels which were about two-thirds of the static strength. The failure mode was the remolding of a thin zone about one or two well-defined failure planes. Seed and Wilson (1967) report cyclic test data for Bootlegger Cove clay. This is a sensitive marine silty clay which classifies as a CL material and had a Q shear strength of from 0.45 to 1.00 tsf. After 30 cycles of stress at deviator stresses of 55 percent of the static strength, failures of the test specimens occurred. The mechanism of the Turnagin Heights slide in the 1964 Alaska earthquake is discussed by Seed and Wilson. They indicate that the Bootlegger Cove clay did fail in the latter stages of the slide. This slide also occurred quite rapidly.

5. The laboratory or field performance of these three cohesive soils suggest that a substantial amount of shaking at stress levels above one-half of the static Q strength can produce large strains or failure but that small amplitude shaking will not. The West Point area is in seismic zone 1 on the Algermission map, and strong earthquake excitation is extremely unlikely. The only situation in which one should be concerned about dynamic loads is one where the static factor of safety is very close to 1.0 (as it was in the North Fill area). Since the static factor of safety of the South Fill is 1.7 or more and will increase with time, dynamic excitation from earthquake or machine vibrations are unlikely to cause any distress at all.

6. Prohibition of pile driving as recommended by Barron and prohibition of machine operation as recommended in the report are both safe courses of action but are probably not necessary. I would personally delete item b in paragraph 73 of the report. Rather than prohibit pile driving, I would require pore pressure observations during any pile driving and close control of the operation by geotechnical engineers.


HADALA

CF:
McAnear
Mitchell

PHILIP C. RUTLEDGE
Consulting Engineer
~~XXXXXXXXXX~~
~~XXXXXXXXXXXXXXXXXXXXXXXXXXXX~~
P.O.Box 347
Norfolk, Connecticut 06058

203-542-5008

August 24, 1979

Commander and Director
U.S. Army Engr., WES, CE
P.O.Box 631
Vicksburg, Mississippi 39180

Re: South Fill Area, U.S.M.A., West Point, N.Y.
Your Reference WESGE

Dear Sir:

In accordance with the request in a letter dated 13 August 1979 by Mr. C.L. McAnear and as authorized by Purchase Order No. DACA 39-79-M-0161 the writer has reviewed the draft dated May 1979 of the report "Investigation for South Fill Area, United States Military Academy, West Point, New York" and submits herein the following comments and recommendations. Because I no longer have my file on the several inspections and meetings of the Board of Consultants readily available, some of the dates of observations and recommendations by the consultants are not well defined in these comments.

I have been most interested in the surface manifestations of the condition of the South Fill. A brief note at the bottom of p. 6 indicates that the tennis courts in the area now shown as Soccer Fields on Fig. 3 were constructed some time after December 1961. The cracks in the surfacing of these tennis courts were the first definite evidence observed showing continuing deformation of the South Fill well inland from its river front. At that time it was not clear whether the cracks, which showed little vertical displacements, were the result of settlements of the fill or a slow creeping of the fill toward the river. Paragraph 60 on p. 20 indicates that the movements were primarily riverward and that the tennis court surfacing was removed at some date not stated because of the continued cracking.

A brief statement at the bottom of p. 6 indicates the surface reference points were installed in 1961. However, Table 5 and pp. 54 on page 18 state that these were installed in April 1962 and the measured motions are discussed in pp. 55. The horizontal and vertical displacements are shown on Figs. 15 and 16 but it is not clear why these plots begin for August 1966 whereas Fig. 13 Sheet 3 of 4 shows measurements beginning in

April 1962. It would seem that the motions relative to consolidation settlements would be more useful beginning at the earlier date. The plots do indicate that both settlements and horizontal motions are continuing at decreasing time rates. This could be shown more clearly by a simplified plot of settlements and horizontal motions against time since April 1962.

An interesting and possibly significant study would be a geometric analysis of the settlements and riverward lateral movements to determine if the lateral movements are compatible with the consolidation settlements of the increasing thickness of the alluvial clay stratum toward the river or are partially a riverward creep of the entire mass. Paragraph 62 indicates that the authors believe it is a riverward creep. Some university might be interested in making such an analysis.

Paragraph 56 states that an asphalt walkway extending west to east across the central portion of the fill area was installed in August 1974. It is my recollection that such a walkway was recommended by the Board of Consultants at or prior to its last meeting in December 1965 as a simple warning device for horizontal motions that might indicate danger of an impending slide. I also remember inspecting the sewage treatment plant at the extreme south end of the South Fill where there were indications of settlement effects. This is not mentioned in the report.

It is unfortunate but understandable under the condition of large settlements that so much difficulty was encountered with the inclinometers installed at various times thru the South Fill. I note that the inclinometers for which data are plotted in Fig. 19 were installed at different times varying from Nov. 1967 and March 1968 to Sept. 1972. Hence the motions to March 1975 are not directly comparable. This should be noted on the figure.

The piezometers also encountered difficulties requiring discontinuation of readings or replacements. However, enough readings have been obtained to produce an excellent plot of the dissipation of excess pore water pressures with time at one location shown on Fig. 14. The excess pore water pressures after 1973 apparently are shown only by piezometers P-7A, P-8A, P-9A and P-11. It would be helpful to the reader of this report if the specific location, depth to rock and reason for showing zero excess head of water at about Elev. -16 were stated on the figure or in the report in the section of Groundwater Conditions.

I have read the sections on soil tests, paragraphs 22 thru 47, but have not attempted to evaluate the results because of the many uncertainties in interpretations of the results as

mentioned in the text. I leave comments on this portion of the report to someone more competent in this subject than I am.

The settlement analysis results described in pp's 63, 64 and 65 are interesting and instructive and would seem to indicate that the interpretations of consolidation test results are good. However, because of the large variation in thickness of the clayey alluvium, from about 30 ft. on the west side of the fill area to about 140 ft. near its east edge, the plotted results on Fig. 20 obviously apply to only one location. The writer was unable to determine this location because he was not able to read boring locations on the reproduction of Fig. 3. It would be helpful if the location for the data on Fig. 20 were described by the depth to rock, the thickness of the fill and the thickness of the clayey stratum. It would help in determining the applicability of Fig. 20 to other portions of the fill area if a plot were made of the total settlements from 1962 to 1978 based on the surveys of the marker pins vs. the thickness of the clayey stratum. Incidentally the reference at the end of pp. 65 should be Fig. 21 and not Fig. 19.

The stability analyses and results described in pps. 66 and 68 appear reasonable with the single exception that the ratio $c/p_o = 0.3$ is for normally, or completely, consolidated clay whereas Fig. 20 would indicate that the clay stratum is only about 70% consolidated. It would be useful if the stability analyses were also made using a smaller c/p_o ratio based on this degree of consolidation and if a plot were made comparing the assumed shear strengths with the most reliable of the test strengths shown on Figs. 8a thru 8 h.

I agree with the precautions in the site utilization and the conclusions and recommendations in the concluding sections of the report, perhaps for reasons somewhat different from those of the authors of the report. The surface settlements obviously indicate that there has been consolidation and accompanying gain in strength of the alluvial clay stratum since 1962 and the fill has been standing in place since that time. I do believe that it would be desirable to protect the surface markers installed in 1962 and to make survey measurements of them at two to five year intervals to verify the interpretations made at this time.

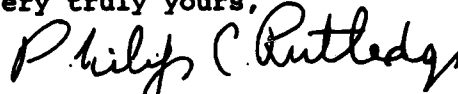
In addition to the specific recommendations made concerning several items in this report I have one general suggestion. I believe that this report would be more coherent and easier to follow if Part II - Description of Site were to include pps. 22 and 23 on the borings made and p. 31 presenting the generalized soil profile. The next major section should be Field Observations including surface movements, groundwater conditions and inclinometer measurements. This could be followed by Laboratory Investigations and then the Settlement and Stability Analyses

-4-

based on the laboratory tests and the field observations. The concluding sections would then follow.

I trust that this review will prove useful to you and that you will consider seriously the recommendations and suggestions made herein.

Very truly yours,

A handwritten signature in cursive script that reads "Philip C. Rutledge".

Philip C. Rutledge

PCR/cht

F16

WILLARD J. TURNBULL
CONSULTING ENGINEER
8 BRIARWOOD PLACE
VICKSBURG, MISSISSIPPI 39180

TELEPHONE (601) 636-3425

19 September 1979

Mr. C. L. McAnear
Chief of Laboratories
Civil Works
Waterways Experiment Station
U. S. Army Corps of Engineers
Vicksburg, Miss. 39180

Re: Investigation of South Fill Area
United States Military Academy
West Point, New York

Dear Mr. McAnear:

This letter replaces my letter of 21 August 1979, in that, the comments in this letter concern entirely the South Fill area and specifically are directed to the draft report dated May 1979.

As a general comment, I consider that this report describes a study which is an example of basic errors in conducting an important field and laboratory research study. It illustrates very graphically the need for preciseness of procedures, timing, selection of instruments and method of conducting field and laboratory work. Further, it would be better to use fewer types of tests and more of them to get statistically sound data. Particular reference is made to the shear strength testing. In the reverse, this study (with all its shortcomings) represents a classical example of follow-through in the conduct of an important study.

The following comments are specifically directed to the report as written.

P-9, paragraph 19. The railroad was damaged by underwater slides.

P-11. Fig 3 is reduced to such an extent that I have to use a magnifying glass but still cannot read all of it.

P-12. Many of the pictures in Appendix B are unclear.

P-15. I feel that P-15 may be quite hypothetical and it might be better to simply say that certain irregularities occurred which undoubtedly affected the test results. The word "irratc" in last line of paragraph 42 should be "erratic".

A study of Figs 8d and 8f tends to indicate a peculiar weakness of the soil at about elev 60. Nothing is said about this in the text.

P-16, 3rd line in paragraph 45. Remove hyphen in "coefficient". In paragraph 47 no attempted explanation is given as to why the soil from elevation -55 to -63

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is highly overconsolidated (presumably representative of deeper material also) and yet that which is higher in the soil profile is normally consolidated.

P-17, paragraph 52. This remark is not intended as criticism but again the unreliability of "salesmanship" is demonstrated. Piezometers ordinarily should be one of our more reliable field instruments.

P-18. The surface movement data as expressed by the pins and asphalt walkway are very good.

P-19. Considering the difficulties encountered with the inclinometers and the difficulty of installing these instruments (particularly through the rock), I consider the data obtained reasonably good and logical.

P-21. The actual and predicted settlements appear reasonable. In last line change "1977" to "1978" (see Fig 20) and "Fig 19" to "Fig 20".

P-23. I personally feel that measures to improve the stability of the area would be too costly to justify. Further filling the area for construction purposes to keep off future floodwaters could be dangerous. If it is desired to restrict flooding it should be done by low and steep sided grassed-over levees. No heavy construction should be allowed.

I am in agreement with paragraph 73.

P-24. I am in agreement with "Conclusions and Recommendations".

I conclude by making the following comments.

- a. Something should have been said about the sinkhole development which was an independent phenomenon.
- b. Also something should be said about the potamology of the river. Namely, while the thalweg of the river will deepen during flood stages it will tend to pull further away from the South Fill area toward the opposite concave bank. This tends to reduce erosion of the underwater toe during flood flows.

Sincerely yours,


W. J. TURNBULL, P. E.
Consultant

In accordance with letter from DAEN-RDC, DAEN-ASI dated 22 July 1977, Subject: Facsimile Catalog Cards for Laboratory Technical Publications, a facsimile catalog card in Library of Congress MARC format is reproduced below.

Taylor, Hugh Madison

Investigation for South Fill area, United States Military Academy, West Point, New York / by Hugh M. Taylor, Jack K. Poplin, Gerald B. Mitchell. Vicksburg, Miss. : U. S. Waterways Experiment Station ; Springfield, Va. : available from National Technical Information Service, 1980.

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References: p.28.

1. Field tests. 2. Fills. 3. Settlement. 4. Slope stability.
5. Soil tests (Laboratory). 6. Subsurface investigations.
7. United States Military Academy. I. Poplin, Jack Kenneth, joint author. II. Mitchell, Gerald B., joint author.
III. United States Army Corps of Engineers. IV. Series: United States Waterways Experiment Station, Vicksburg, Miss. Miscellaneous paper ; GL-80-7.
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