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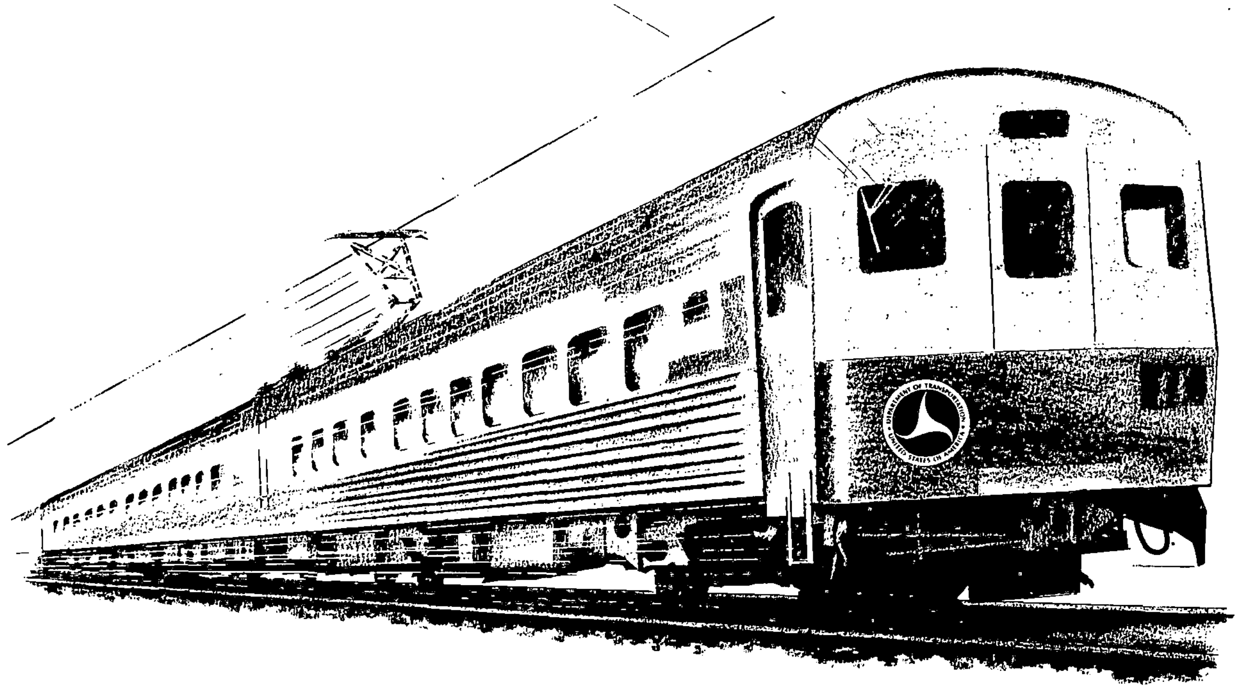
EMBANKMENT SUPPORT FOR A RAILROAD TEST TRACK

CONSTRUCTION REPORT



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16. Abstract

This report discusses the construction of three non-conventional railroad track support structures. These non-conventional structures, which include a continuously reinforced concrete slab, twin cast-in-place concrete beams and twin precast concrete beams, are part of a program to develop practical, low maintenance, high quality track structures for conventional and advanced rail vehicles. The design of these test structures is discussed in a separate report, "The Kansas Test Track, Non-Conventional Track Structures--Design Report."

The report which follows documents the construction phase of the Kansas Test Track. It includes as-built drawings, field test data on the embankment and details of instrumentation. The information provided on instrumentation outlines the system configuration, components, shop drawings, installation details and calibration data. The field data obtained on the embankment during construction are summarized and interpreted.

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HIGH SPEED TEST EMBANKMENT
AIKMAN-CHELSEA, KANSAS

INTRODUCTION

Background

The United States Department of Transportation (DOT) and The Atchison, Topeka and Santa Fe Railway Company (ATSF) are jointly sponsoring an investigation into methods of providing more stable railroad track structures for present and future operating conditions with high speed trains and heavily loaded cars. ATSF is providing support services for the investigation and is establishing a test embankment on a main line of its system. Earlier studies had located the test embankment between Aikman and Chelsea, Kansas, on the ATSF main line. The site selection was influenced by the presence of abundant rail traffic, a long straight tangent section, uniform and relatively flat grades, a good performance record under main line traffic conditions and other factors. The test segment was considered to be reasonably typical of much of the country's railways, and the uniform soil conditions and gentle terrain were suitable for construction of a uniform test embankment at reasonable cost.

The project consists of an embankment and track structures constructed adjacent to and offset 30 feet from the existing ATSF main line. The test embankment is nearly two miles long on a slight grade, and transition sections at each end will divert main line traffic onto it and then back to the main line. The embankment has nine test sections and each section will have a unique track support system. The support systems include concrete ties at four different spacings, a concrete slab, a continuous concrete beam, a precast beam, stabilized ballast, and a control section typical of conventional ATSF construction. Each test section has identical embankment instrumentation. An access road along the test embankment provides easy access for periodically reading the instrumentation and observing the test track.

Scope

Shannon & Wilson, Inc. was engaged to design the embankment for the test structures, observe construction, and instrument the embankment to provide soils data for evaluation of the various test track structures. Specifically the work included 1) design of the embankment; 2) preparation of construction plans and specifications; 3) observation of construction; and 4) design, fabrication and/or procurement, calibration, and installation of embankment instrumentation. Track support structures and reading of the instrumentation were not within the scope of this contract.

A previous report "High Speed Test Embankment - Design Studies", (Ref. 1) January 1971, by Shannon & Wilson, Inc. covered the embankment design portion of the project. It contained the "pilot" geophysical measurements, field investigations, laboratory test results, and embankment and instrumentation design considerations that led to the preparation of construction plans and specifications. The plans and special provisions to the specifications were contained as as appendix to that report.

This report documents the construction phase of the project. It includes as-built drawings, field test data on the embankment, and details of instrumentation. The information on instrumentation includes details on system configuration, components, shop drawings, installation details, and calibration data. The field data obtained on the embankment during construction are summarized and interpreted.

Volume II of this report contains manuals of the Schaevitz LVDT Readout Box, moisture-temperature cells, and the weather station instruments. Also included are instrument wiring hookup lists.

Authorization

Contract authority for Shannon & Wilson, Inc. is provided by ATSF Contract No. 134753 which is pursuant to Task Order No. 2 of their contract with the U.S. Department of Transportation.

SITE DESCRIPTION

The test track is located between railroad mile posts 161 and 163 approximately 11.3 miles northeast of El Dorado, Kansas on State Route 177 or 7.2 miles southwest of Cassoday, Kansas. The railway-designated locations of Aikman and Chelsea are to the northeast and southwest, respectively of the site. The existing ATSF track lies parrallel to State Route 177 and is offset 134 feet south in the vicinity of the test embankment. The test embankment lies between the highway and existing track at a constant distance of 30 feet from the track. A vicinity map is included as Fig. 1 and a plan and profile of the test embankment are included as Fig. 2.

The terrain of the site area is gently rolling with drainage to the south. The existing track grade is about 0.4 percent and drops about 35 feet along the section from northeast to southwest. The average site elevation is about 1,400 feet MSL. The track passes through minor cut and fill zones, and spoil piles are adjacent to the track in cut sections.

CONSTRUCTION OBSERVATIONS

General

On the construction site, Shannon & Wilson, Inc. was responsible for continuously observing embankment construction, testing the embankment materials, providing technical advice to ATSF, and furnishing and installing embankment instrumentation. ATSF was responsible for administering the contractor's contract, day to day construction control, and providing field engineering services.

The criteria for embankment placement was developed in "High Speed Test Embankment-Design Studies", Ref. 1. The criteria for placing embankment materials were revised after submittal of Ref. 1 and this is discussed below. It was also decided to lime stabilize the upper six inches of the embankment; conditions leading to this decision, laboratory tests, and field control are discussed below. Other modifications are shown in the as-built plans contained in Appendix A.

The original project schedule from the Shannon & Wilson, Inc. contract is shown in Fig. 3 along with the actual schedule. The embankment design and writing of plans and specifications proceeded on schedule and bid invitations and award of contract, likewise, followed on schedule. However, embankment placement during the fall of 1970 was minimal and most of it was accomplished during spring and summer 1971. Circumstances leading to postponement of embankment placement are discussed below. As shown on Fig. 3, Shannon & Wilson, Inc. was represented at the site in October and November 1970 and from April to October 1971. The contractor, L.A. Knebler Construction Company, worked at the site continuously from October 1970 to November 1971.

Final earthwork quantities were as follows:

Item	Quantity, yd^3
Common Excavation	154,270.2
Rock Excavation	40,652.4
Embankment Fill	71,944.1

Construction Progress

Shannon & Wilson, Inc. mobilized personnel, field equipment, and laboratory equipment at the site in early October 1970, see Fig. 3. The contractor placed a test fill from October 20 to 24, 1970. It was apparent that the unseasonal wet weather would not allow the clay to dry sufficiently to permit efficient placement of high quality embankment. It was decided to terminate embankment placement until 1971 but to continue removing overburden from rock, stockpiling suitable embankment materials, and excavating rock through the winter at a reduced level of activity. All but one Shannon & Wilson, Inc. employee left the site in late October. One engineer remained until November 19, 1970, when overburden removal and stockpiling was complete. The contractor continued rock excavation until early April 1971 under the control of ATSF.

Shannon & Wilson, Inc. was directed to remobilize at the site on April 15, 1971, and the contractor began placing fill on April 19. Embankment placement in April and May was delayed by frequent rains. The embankment was completed to grade on August 2, 1971. Lime stabilization of the upper six inches of embankment was accomplished in late August and gravel for the service road was delivered from late September through November. Shannon & Wilson, Inc. demobilized all equipment and personnel from the site by October 16, 1971.

Rock Excavation

Rock excavation was accomplished by drilling and blasting although thicknesses less than two feet could occasionally be ripped. Drilling was accomplished with a rotary pneumatic drill. Spacing of explosive charges varied from four to 12 feet on centers depending upon the desired depth of rock excavation and hardness of the rock. The rock was typically ripped with a single ripper tooth mounted on a crawler tractor following drilling and blasting. The rock was then loaded into trucks and wasted along the north side of the existing mainline embankment both east and west of the construction site.

Embankment Placement

Placement criteria. The main construction objective was to build a uniform embankment of good quality using locally available materials, methods, and equipment. Suitable embankment materials included some gray to brown silty clay (CL) and a larger amount of reddish brown clay (CH). The design criterion for the embankment specified a minimum unconfined compressive strength of 4.0 tsf. Laboratory tests performed during the design studies showed that this strength could be achieved with a minimum dry density of 92 percent relative compaction (modified AASHO, ASTM D1557) at a moisture content not exceeding two percentage points above optimum water content. Based on seven compaction curves obtained during the design studies, optimum water content was 19.1 percent and maximum dry density was 107.4 pcf. It was anticipated that the average embankment dry density would be 100 pcf, and the water content 21 to 22 percent. The test fill placed in late October 1970, produced two different qualities of embankment depending upon the source of the borrow material as shown in Fig. 4. One material, designated as undisturbed borrow in Fig. 4, was original undisturbed soil below a depth of one to one and a half feet. Its water content had not been increased by the fall rains and it was placed during drying weather. In-place densities of this material averaged about 102 pcf, thereby exceeding the anticipated embankment density.

On the other hand, borrow that was stockpiled or borrow from the upper one and one half feet of original soil had increased by about two percentage points to water contents of 24 to 26 percent due to the fall rains. These materials could not be placed at the specified density at the existing water content and it was not practical to dry the material due to frequent rains and continuous high humidity and low temperatures. The materials that were placed and accepted required an extraordinary amount of time for conditioning and compaction. A large portion of the material required reworking before acceptable densities were achieved. Due to these circumstances and because it was not practical to attain an acceptable rate of production, Shannon & Wilson, Inc. recommended the embankment placement be postponed until the following spring. The decision was made to defer embankment placement and a revised schedule was worked out with the contractor.

Embankment placement resumed on April 19, 1971. Much of the available borrow material had been stockpiled in haul roads and its water content had increased by about two percentage points, similar to the material placed in the test fill. Spring rains permitted little opportunity to dry the material. When drying weather occurred, it was discovered that the material could not be dried uniformly. The contractor's equipment was not adequate to work a full six-inch lift to facilitate uniform drying. A layering effect was introduced by working and overdrying the top of a lift without significantly affecting the excessively moist bottom of the lift. Furthermore, it was not possible to place lifts thinner than about six inches due to the high plasticity and toughness of the materials using conventional scrapers for excavation, hauling, and spreading. The uniform drying of the embankment material was also complicated by the initial nonuniform water content at the stockpiled borrow sources and the very limited work area available for borrow and placement. Repeated disking of the embankment produced a surface layer of hardened clay chunks that could not be compacted together into a homogeneous, void free mass. It became clear that it was not feasible to place the material uniformly at optimum plus two percentage points of moisture. The material would have to be placed at a higher water content to achieve the desired uniformity.

The compaction criteria was revised to provide that the clay be placed at a water content of 24 to 25 percent at a relative compaction of at least 90 percent. This water content was considered to be the lowest at which it was feasible to place a uniform embankment of reasonable quality using available equipment and methods. The average as-placed moisture contents and densities of each test section are plotted in Fig. 4 as well as the overall embankment average of 90.1 percent relative compaction at a water content of 24.3 percent.

Testing compaction. Primary embankment density control was accomplished with a Troxler Model 1401 Nuclear Moisture-Density Gauge. The gauge was factory-inspected and recalibrated in early April 1971 prior to the bulk of embankment placement. The nuclear device had the ability to provide immediate densities and water contents without having to wait for oven drying. Backup density control equipment included a sand cone, a Rainhart Densometer, and Corps of Engineers surface samplers.

The continuous observations of embankment placement provided by Shannon & Wilson, Inc. included spot-checking excavation of materials at the borrow areas so that undesirable materials would not reach the embankment. The spreading, leveling, and disking of material at the embankment was observed. When the material was at the proper moisture content for compaction, the contractor was informed, and compaction began with a sheepsfoot tamper, also under observation. The lift was wheel rolled with loaded scrapers to seal the surface and reduce the adverse effects of drying. Then, density tests were performed. The rule of thumb for testing frequency was to perform one test for each 300 feet of six-inch lift placed. The tests were generally taken at random although suspected poorer areas were given priority for testing.

Use of the nuclear moisture density gauge followed ASTM D2922-71. Method A, Backscatter, was used for water content and Method B, Direct Transmission, was used for wet density. When performing a density test, about six inches of material were removed with a motor grader so that the second lift from the surface could be tested. A standard probe depth of six inches was used for the direct transmission wet density portion of the test although four-inch probes were used for thin lifts or to avoid striking rock in the first lift. Water content samples were frequently taken for a check on the nuclear device. Corps of Engineers-type surface samples were taken as a check on density and to permit strength testing. Density, water content, and strength data are summarized in Table 1. For the most part, tests on soil that was subsequently reworked are not included.

Laboratory compaction tests were performed in a field laboratory in El Dorado, Kansas. Modified AASHO compaction tests were conducted until a correlation was established between Harvard miniature and modified AASHO compaction. Harvard miniature tests were conducted after that because they were much easier to perform and because the adopted Harvard miniature compaction energy more closely approximated the field compaction energy on this project. The Harvard miniature compaction method consisted of compacting the soil in five layers with 35 tamps from a 0.5-inch diameter tamper having a spring pressure of 33 lbs. In order to obtain modified AASHO parameters from Harvard miniature, subtract three percentage points from the Harvard miniature optimum moisture content and divide Harvard miniature maximum dry density by 0.936. Results of the compaction tests are summarized in Table 2.

The frequency of laboratory and field testing as planned and actual are summarized below:

Test	Anticipated No. of Tests	Actual No. of Tests	Approx. Test Frequency Cu Yd/Test
Moisture Content	620	647+	100
Field Density	310	647	100
Laboratory Compaction*	62	53	200

* The anticipated number of tests were not required because of the uniformity of borrow materials.

Lime Stabilization

Background. Typical new embankment construction on ATSF lines specifies that the upper one foot of subgrade be stabilized with five percent lime. Lime stabilization was considered during the design studies but it was decided not to complicate interpretation of embankment performance by introducing a relatively stiff layer directly beneath the ballast. It was assumed that ballast would be placed over the completed embankment as a protective layer before winter.

Circumstances leading to lime stabilization. About three feet of embankment had been placed as a test fill in late October 1970 for about a 400-foot strip south of the county road crossing at 8597. The surface of the fill was sloped to drain at a gradient of about 0.5 foot over the 30-foot width. When Shannon & Wilson, Inc. returned to the site in mid April 1971, it was observed that the surface of the test fill was extremely soft. Corps of Engineers surface samples were taken to define the depth of softened soil at two locations in the test fill. Water content, dry density, and unconfined compressive strengths were determined on these samples and are plotted in Fig. 5. Water content had increased from about 24 to 25 percent at a depth of one foot to 32 percent at 0.2 feet below the ground surface. The increase in water content produced an increase in volume, a decrease in dry unit weight and a decrease in strength. Unconfined compressive strength fell as low as 0.43 tsf at a depth of 0.2 feet. This softening of the embankment was caused by combined freezing and thawing during the winter and repeated wetting during spring rains.

The effects of weather on the embankment would have been greatly diminished by ballast rock cover but would not have been eliminated entirely. At that time, Spring 1971, it appeared that a portion of the ballast and track structures would be placed before winter and that it was probable that the embankment would remain in a variable condition of exposure over the winter of 1971-1972. The delay in track structure construction could have resulted in track structures being placed on subgrade with initial properties that varied significantly. Shannon & Wilson, Inc. recommended that the subgrade be treated to minimize differential softening of the embankment. The added complication of adding a stabilized layer of uniform but different physical properties appeared to be less important than the prospect of non-uniform softening of the subgrade prior to track construction. Authority was given to proceed with stabilization studies.

Lime stabilization was adopted as it appeared the most attractive from the standpoint of cost and physical properties. The thickness of the stabilized layer was to be kept as thin as possible to avoid a high strength pavement. Six inches of stabilized material was selected through discussions with Professor Marshall Thompson, Consultant to Shannon & Wilson, Inc. Prof. Thompson had experience with six-inch thick lime-stabilized secondary roads on highly plastic clay which have experienced several winters satisfactorily. The strength of the lime-soil mixture should be just great enough to provide at least four tons per square foot unconfined compressive strength under severe weathering. A spray coat of bituminous material was also recommended to seal the stabilized layer.

Laboratory tests. Laboratory tests were conducted in Shannon & Wilson, Inc.'s El Dorado, Kansas field laboratory. Three typical site soils were selected. Atterberg limits were determined on the untreated soil and also at several different lime contents. Lime was mixed with the soils, the water content was raised to about 30 percent, and the mixture was allowed to cure for one hour before performing the Atterberg limits. The plot of plasticity index versus lime content in Fig. 6 shows that about three percent of lime by weight reduced plasticity index by half.

Harvard miniature compaction tests were then performed on untreated soils A and B and on these soils with three, five, and seven percent lime. The soil was raised to its desired compaction water content, mixed with lime, and allowed to cure for one hour in a sealed container before being compacted. Each compaction specimen was extruded from the Harvard miniature mold and wrapped with an air-tight covering. Each specimen was then placed in a 120°F oven for 48 hours; Professor Thompson has found that this curing simulates a 30-day field cure. After the oven cure, the compaction specimens were failed in unconfined compression. Unconfined compressive strength versus compaction water content are plotted in Fig. 7 for soils A and B. Increasing lime percentage increased strength. Compaction test results are presented in Fig. 7. Increasing lime percentages increased the optimum water content and decreased the maximum dry density. Compaction specimens containing lime and having water contents of about 20 percent or lower did not fit the curve established by the higher water contents. There probably was not enough free water available to hydrate the lime at these low water contents, so the soil was not modified to the extent of the lime's potential.

The effect of free water on the strength of lime stabilized soil was determined by strengths of soaked and unsoaked specimens with different lime contents. A water content of 25 percent was selected as it was about optimum water content for lime treated soils in the earlier studies. Soil and lime were allowed an initial cure of one hour at 25 percent water content before being compacted into a Harvard miniature mold. Duplicate samples were made at each lime content. All specimens were extruded, wrapped air-tight, and cured in a 120°F oven for 48 hours. One set of samples was tested in unconfined compression and the results are shown in Fig. 8. Another set was unwrapped and submerged in water for 96 hours. These specimens were then failed in compression and their strengths are also shown in Fig. 8. Soaking reduced strength of the specimens. The specimens without lime treatment exhibited essentially negligible strength after soaking.

The soaking conditions described above are considered overly severe as compared to field conditions A strength of four tons per square foot was desired under all conditions, and from Fig. 8

it is seen that three percent lime is the minimum lime percentage satisfying the strength criteria.

Professor Thompson conducted CBR and freeze-thaw studies on materials A and C with two, three, and four percent lime. CBR's of specimens with three percent lime soaked for 96 hours remained very high. Unconfined compressive strength of specimens with three percent lime increased to 20.2 tsf after eight freeze-thaw cycles. Drying of the samples during cycling acccounts for the increase in strengths. The test results are included in Appendix B.

Based on the above laboratory tests, a lime percentage of three percent was selected at a water content of about 25 percent. Four percent lime appeared to provide excessive strength and two percent lime after soaking had marginal strengths. Laboratory strengths would be about eight tons per square foot and field strengths were expected to be from 65 to 75 percent of laboratory values, i.e. 5.2 to 6.0 tsf.

Construction and field control. "ATSF Supplemental Specifications, Section 2, Lime Stabilized Roadway", January 1970, were utilized for the construction of the lime stabilized layer. The exceptions to the ATSF Specification were that the stabilized layer was to be six inches thick, three percent lime was to be used, and the compaction was to be at least 90 percent of modified AASHO maximum density. The roadway was roughly to grade before the lime operations began. The upper six inches were scarified and pulverized and then the lime was spread with distributor trucks. The lime and soil were mixed with water until the mixing was relatively uniform, the water content was about 30 percent, and the maximum lump size was two inches. The mixture was then compacted lightly and allowed to cure for at least 48 hours while the surface was kept moist by sprinkling. Final mixing consisted of pulverization until all of the material passed a one-inch screen and 60 percent passed a No. 4 sieve. The water content was adjusted to 25 percent and compaction began. The floury texture of the material at this water content did not allow good compaction, so the water content was raised to 28 to 30 percent. The compaction equipment was more effective at this increased water content. The water content and dry density were determined on the compacted material at 300-foot intervals along the length of the embankment; these data are tabulated in Table 1.

The increased water content required by the lime treated soil was a result of up to ten-day delays between the initial mixing of lime and compaction. Extended curing time has the effect of moving the compaction curve lower and to the right. Consequently the material had to be compacted at a water content slightly higher than anticipated, thereby slightly reducing the strength of the stabilized layer.

Just after final mixing and before beginning compaction, grab samples were taken of the lime-soil mixture at 300-foot intervals. A Harvard miniature compaction specimen was made of each material. The specimens were wrapped in air-tight containers, cured in a 120°F oven for 48 hours and then failed in unconfined compression. The results are presented in Table 3. The average strength of the 33 specimens was 6.3 tsf. If a reduction factor of 65 percent is assumed for applying laboratory strengths to the field, then the average field strength after 30 days of curing would be about 4.1 tsf.

After lime stabilization and final grading, the surface of the embankment was kept moist until a bituminous seal coat was spread at the approximate rate of 0.2 gallons per square yard.

<u>Service Road Gravel</u>

Numerous sieve analyses were performed on gravel for the service road. The test results and a brief discussion are contained in Appendix C.

EMBANKMENT PROPERTIES

Water Content, Density, and Strength

Water contents and dry densities were determined for compaction control as discussed earlier. These data are tabulated in Table 1 with the location of the test referenced to stationing along the main line track and distance below base of rail. The nuclear moisture-density meter was most commonly used for compaction testing, but frequently a Corps of Engineers surface sample would be obtained at the location of the nuclear test. The volume of the samplers was a standard 0.01 cubic foot, so dry density and water content were easily determined by drying the samples. These values are presented also in Table 1 denoted as test type T; nuclear moisture-density test results are denoted as test type N.

Unconfined compressive strengths were determined from the Corps of Engineers samples by sawing through the soil around the inside of the sampling tubes so that the samples would slide out. The samples were then trimmed to 1.4-inch diameter and failed in unconfined compression. The length of the samples was 2.65 inches. The strength values are also tabulated in Table 1. Additional strength tests were obtained with a hand-held Pocket Penetrometer. Equivalent unconfined compressive strengths were determined with this device at the nuclear moisture-density test locations; these test results are also shown in Table 1.

The locations of the water content, dry density, and strength tests are shown in section in Fig. 9. The embankment has arbitrarily been divided into four layers for data summation purposes, and these are shown in Fig. 9. Layer A is the 0.5-foot thick lime stabilized layer. Layer B extends from the bottom of the lime stabilized layer to a depth below rail of 3.5 feet. Layer B is 1.5 feet thick where the subgrade is 1.5 feet below base of rail and 1.0-foot thick where subgrade is 2.0 feet below base of rail. Layer C extends from 3.5 to 5.5 feet below base of rail. Layer D is 5.5 to 7.5 feet below base of rail or to the greatest depth where data were available. The dry densities, water contents, and strength for each layer of each test section have been averaged and are shown in Table 4. The number of tests producing the averages are also presented. Finally, the overall average for each test section are listed.

An overall statistical study of the test embankment properties has also been conducted. Frequency distribution curves have been developed from dry density, water content, and unconfined compressive strength data. Only densities and water contents determined by the nuclear densometer are included; tests in lime-treated soil are omitted. Also, strengths determined with the Pocket Penetrometer are omitted. The test results versus the number of occurrences are plotted in each instance in Fig. 10, and they give an overall summary of the data. The average dry density based on 225 nuclear densometer tests averaged 97.2 pcf and had a standard deviation of 3.2 pcf. The standard deviation is a significant measure of data spread; 68.27 percent of the tests had densities lying within plus or minus one standard deviation from the average. The average of 223 water contents was 24.3 percent and the standard deviation was 2.93 percentage points. The average of 85 unconfined compressive strengths was 2.89 tsf and the standard deviation was 1.00 tsf.

Plate Load Tests

One hundred and twenty plate load tests were conducted on the embankment during construction. Fifteen of the tests were on the completed lime stabilized upper surface of the embankment. The tests were conducted according to ASTM Method D1195-64 with a six-inch diameter plate. A mechanical jack assembly was mounted on the back of a 3/4-ton truck having sand ballast in its bed. The truck springs were tied down to increase rigidity of the loading platform. An eight-foot long reference beam supported three dial gages spaced equally around the plate diameter. Load was measured with a proving ring.

The testing surface was prepared by removing six inches of the upper material with a motor grader and placing a small amount of fine dry sand beneath the plate for bedding. The plate was seated by loading it so that the average deflection was 0.01 inch. The load was released to half that of the seating pressure and the deflection dials were zeroed. The plate was then loaded to five tons per square foot in increments of one ton per square foot. The load was reduced to the starting pressure, raised to five tons per square foot, reduced to the starting pressure again, and then unloaded. Each load was held until each deflection dial moved less than 0.001-inch per minute for three consecutive minutes. Following the test, a moisture content sample was taken from the ground surface to a depth of about four inches.

Typical plate pressure versus soil deformation curves from the plate tests are presented in Fig. 11. Two typical tests on soil and another on lime stabilized soil are shown. Also shown is an average loading curve from 104 tests on the embankment and an average curve from 15 tests on top of the lime stabilized layer. The modulus of a test on the surface of the six-inch lime treated layer is about twice that of the untreated embankment.

Seating pressures and deflections at 1.0 tsf, 3.0 tsf, and 5.0 tsf are listed in Table 5 for all plate load tests. Stationing and depth below base of rail are also shown. Deflections at 5.0 tsf are also summarized in Table 3 for each layer of each test section. Deformations at 5.0 tsf are shown in a frequency distribution plot in Fig. 10; four tests having deformations greater than 0.5-inch were not included. The location of each test is plotted in profile on Fig. 9. Load deformation curves were prepared for all plate load tests for analysis purposes but are not presented in this report due to the volume of data.

INSTRUMENTATION

General

The response and performance of the track structures will be influenced by subgrade performance. Therefore, it is necessary to observe the embankment behavior in order to evaluate track structure performance. The instrumentation was developed for this purpose. The embankment instrumentation was designed to measure dynamic and static embankment strain. Limited stress and moisture-temperature instrumentation was also provided.

Identical embankment instrumentation was placed in each of nine test sections. Each section has one principal instrument array including vertical extensometers, horizontal tubing embedded in the embankment for insertion of portable horizontal extensometers, pressure cells, and moisture-temperature cells. With the exception of the moisture-temperature cells, the instrumentation was designed specifically for this project. Shannon & Wilson, Inc. established performance criteria and in cooperation with the Slope Indicator Company, developed conceptual designs. Slope Indicator Company accomplished detailed design and fabricated instrument prototypes. Following testing and approval of the prototypes, the project instruments were fabricated. After fabrication, the instruments were calibrated and shipped to the site.

Embankment instrumentation design concepts and performance criteria are presented in "High Speed Test Embankment-Design Studies", Ref. 1. Typical details of the instrumentation are shown in Fig. 12 and an explanation of the instrument numbering scheme is given in Table 6. Discussions of the instrumentation design, fabrication, and installation are presented below. Instruction manuals for use and data analysis of the vertical extensometers, portable extensometers, and pressure cells are contained in Appendix D. Volume II contains instruction manuals for the moisture-temperature cells, the Schaevitz Readout Box, and wiring hookup schedules for all the instrumentation.

Vertical Extensometers

General. Vertical embankment strains relative to the surface of the subgrade will be measured with vertical extensometers anchored in rock and at intermediate points within the embankment. All permanent strains will be referenced to the extensometers anchored in rock. Vertical holes were drilled through the embankment and into rock following embankment construction. Anchors were inserted into the hole and fixed in position by grouting in rock and by hydraulically expanding prong anchors into the soil forming the sides of the drill hole. A Schaevitz type 1000HR LVDT transducer with displacement ranges of ± 1.0 inch was positioned immediately above the anchor point and a brass riser rod was extended to a fixed point in a terminal box at the embankment surface. Three anchors were placed within the embankment as shown in Fig. 12, and if the rock was present within 12 inches of the embankment base, the lowest embankment anchor was eliminated. Only Sections 4,6, and 9 had the lower embankment anchor installed.

Three multi-position extensometers were placed in each main instrument array. One was placed under the center of the track, the second underlays the outboard rail, and the third was placed at the side of the embankment four feet from the rail. All three lie in the same embankment cross-section. Four single-position extensometers were also installed in each test section, all beneath the track centerline. Three were spaced at 100-foot (nominal) intervals uptrack (east) of the main array and one was placed 100 feet downtrack (west) of the main array. The spacings were adjusted slightly so that each extensometer would lie directly beneath a tie. Stationing of the instruments within the test section was determined by placing the furthest west vertical extensometer in each section a distance of 84 feet from the section end. This criterion was established by DOT so that if a different track response developed beyond the end of the test section, the longest rail car, 84 feet, would not transmit vibrations back through the car to the extensometer.

A detail of the extensometer installation is shown in Fig. 13. An instruction manual written by Slope Indicator Company is contained in Appendix D and an instruction manual for the Schaevitz TR-100 Readout Box is enclosed in Volume II.

Flexible steel conduit from the extensometer terminal boxes was extended across the embankment to eight-inch diameter steel terminal pipes. Multi-pin connectors were mounted on panels at the top of the pipes to which the electrical leads were terminated. The terminal pipes were fitted with locked caps. Each single position extensometer has a 2.5-inch steel terminal pipe placed at the side of the embankment and electrical leads were terminated at a multi-pin connector mounted at the top of the pipe. These pipes also have locked caps. The top of the terminal pipes for the multi-position and single-position extensometers are shown in Fig. 14 and 15, respectively.

Installation of vertical extensometers. The locations of the vertical extensometers were surveyed and staked. As discussed above, single-position extensometers were placed at the even tie spacings from the main array which were closest to the 100-foot spacing originally recommended. Holes in the embankment were drilled by subcontract to Layne-Western Corporation of Kansas City, Missouri. A 6.5-inch diameter auger with a rock bit was used. Holes were extended through the embankment and sufficiently far into rock to provide two feet of open hole in rock. This usually required about one foot of overdrill to accomodate cuttings. The drilling was terminated at a depth of 20 feet if rock had not been encountered. The holes were covered temporarily with plywood panels and secured with spikes.

The next step was to grout anchors in the bottoms of the holes. The 0.75-inch PVC anchor rod casing was cemented to an adapter which screwed to a steel anchor ring 2.5 inches in diameter. Any water that had seeped into the hole was bailed out, the anchor rod casing was lowered, and cement grout was poured down a tremie pipe to fill the two-foot deep hole in rock. The upper ends of the PVC casings were temporarily plugged with rubber stoppers.

In the multi-position extensometers at the main arrays, expandable prong anchors were cemented to 0.75-inch PVC pipe, the anchors were coated with water pump grease, hydraulic lines were attached to the anchor, the anchor was lowered to the desired level, and the anchor prongs were expanded with a hydraulic pump from the ground surface. The oil level in a reservoir on the jack was monitored to verify that the anchor prongs were fully expanded. The anchor was visually observed during this process to check that the anchor remained centered in the hole and did not change vertical position.

After the anchors were in place, the holes were backfilled to within about one foot from subgrade with polyurethane foam. One inch PVC pipe was coated with water pump grease and inserted over each 0.75-inch PVC anchor rod casing. The two liquid components of the foam, polyol and isocyanate, were mixed in the ratio of 1.5 to 1.0 respectively, and poured into the hole where they expanded to about 30 times their initial volumes. The foam was placed in about two to three separate pours allowing cooling between each pour. The cooling was essential to prevent overheating of the PVC pipe. When foaming was complete, the one-inch PVC pipe was pulled leaving an annular space between the foam and the 0.75-inch PVC pipe. Laboratory tests on the foam produced unit weights of 1.9 pcf, unconfined compressive strengths of 1.0 tsf and modulus of elasticity of 277 psi. The water pump grease was found to be a very effective parting agent between the foam and the PVC.

Initial preparation for placing the terminal box on top of the hole included removing the soil to an average depth of 1.5 inches below the 16-inch diameter flange of the box and placing a mortar leveling course. The terminal box was seated and leveled on the mortar and then removed. When the mortar had set, final installation of the terminal box began. The 0.75-inch PVC extending above the polyurethane foam, see Fig. 16, was coated with water pump grease to maintain a separation with the next stage of foaming. A thick ring of chassis grease was placed around the top of the PVC pipe to allow relative movement between the slip coupling and the PVC pipe after installation. A six-inch deep trench was dug from the edge of the embankment to the terminal location for electrical leads and the slip coupling was cemented to the terminal box. Then a carefully measured amount of foam was poured in the hole and the terminal box and slip coupling were quickly placed in position with the flanges seated on the mortar and the slip coupling on the PVC riser. Lag bolts were driven in holes in the mortar to secure the box to the subgrade after foaming was complete. Eight holes in the flange for bolting down the box cover permitted observation of the foam expansion. If the foam did not extrude through these holes, additional foam was poured through the holes, thus verifying complete confinement by the foam.

With the terminal boxes in place and the anchor rod casing installed, all that remained was placing the LVDT and anchor rod and final hookup. The LVDT's had a PVC adapter on their base which permitted them to be threaded onto the end of an installation rod, lowered into place, and threaded into the anchor by tightening left hand threads. The installation rod was removed and replaced with a 0.25-inch brass anchor rod having an LVDT core installed at the bottom. Sections of the rod were tightened before installation and Lock-Tite compound was placed on all threads. The core was approximately centered in the LVDT core and the rod was cut to length.

Flex-tite conduit was placed between terminal boxes at the top of the extensometers and the main terminal pipe housing set in concrete at the side of the embankment. LVDT leads were pulled through the conduit and soldered to multi-pin connectors at the main terminal. The Schaevitz readout box was connected to the leads for each LVDT and the core was given a one-inch deflection to check wiring and scale. The LVDT core was precisely placed in a null or center position, within the coil, and the anchor rod was secured to the anchor support. Silicone seal was injected about two inches into the flex-tite conduit from the terminal box to form a seal. The terminal box and PVC pipe LVDT rod assembly were filled with transformer oil and the cover was bolted into place. The trench for the electrical leads was backfilled using a Wacker. The conduit was buried at least one foot deep on the slopes of the embankment. This completed installation of the vertical extensometers. A final reading of LVDT's was then taken with the project readout box, and the static (initial) readings are presented in Table 6. The stationing of each extensometer and the as-built anchor depths are included in this table.

Redrill of extensometer holes. A rain following drilling of the vertical extensometer holes caused water to enter several holes from seepage through rock at the bottom of the hole and from surface runoff at the top, even though the holes were covered. Before the water was discovered and pumped out, three of the holes had sloughed to diameters of 18 inches at two feet below the top of the embankment. The holes that caved were numbers 2504, 3501, and 3502. New holes were drilled about ten feet east of the original holes and the original holes were backfilled with compacted sand to within four feet of the ground surface and with compacted clay for the remaining distance. Hand tamping was used for depths greater than three feet and a Wacker tamper was used for the upper three feet. Lime treated soil was used for the upper six inches.

During the first usages of the polyurethane foam, it was discovered that the exothermic foam reaction produced sufficient heat to soften PVC pipe. The heat was a function of quantity of components mixed and temperature of the components. When the one-inch PVC pipe was pulled from the foam, the pulling resistance and softening caused it to stretch, neck down, and lock onto the 3/4-inch PVC pipe it was protecting. Further pulling also necked the 3/4-inch PVC so that the LVDT could not be placed. This necking occurred for extensometer numbers 6503 and 8504. The original locations were abandoned, and the installations were relocated about ten feet east. The original holes were dug out to one-foot diameter and filled with concrete from the foam level at a depth of one foot to a depth of six inches. A six-inch layer of lime stabilized soil was compacted over the concrete.

Horizontal Tubing and Dynamic Extensometers

Horizontal tubing. At each main instrument array, horizontal four-inch diameter ADS #451 corrugated, non-perforated, polyethelene tubing was placed at four levels in the embankment during construction as shown in Fig. 12. The tubing has specially machined three-inch diameter Schedule 80 PVC couplings at 2.5 and 5.0-foot spacings which were anchored in the embankment. The couplings were attached to the tubing with PVC cement and pop rivets. A three-foot length of four-inch diameter Class 160 PVC pipe was attached to the open side of the embankment and one-foot was allowed to protrude from the embankment side. The tubing and couplings were shop assembled leaving two to three field connections. Tubing and coupling details are shown in Fig. 17. Protective enclosures around the ends of the tubing where they protruded from the embankment were furnished by ATSF.

The PVC couplings provide the reference points for measuring static and dynamic embankment strains. These couplings are coupled to the embankment by friction and are expected to conform to the free-field embankment deformation. The thin gauge corrugated tubing provides a flexible connection between couplings.

Strain rods with a hooking device to engage the couplings will be used to measure the static horizontal deformation of the embankment. No absolute reference is provided, and all measurements will be relative to the end of the tubing. A schematic of the strain rods and hooking point is shown in Fig. 18.

Dynamic horizontal deformation of the embankment will be measured with portable extensometers that will lock into the couplings; these will be discussed later. The horizontal tubing also provides openings in the embankment which are available for insertion of other types of instrumentation if desired at some future date.

Installation of horizontal tubing. The instrumentation was designed so that horizontal tubing and moisture cells would be placed at four common levels in the embankment with pressure cells being placed in the two upper levels only. When embankment construction reached about 16 inches above the centerline of a proposed installation, construction was diverted elsewhere and two six-inch wide trenches were dug across the embankment with a ditching machine after leveling the area with a motor grader. One of the trenches was dug for the tubing and the second was dug for moisture cells or both moisture cells and pressure cells. The trenches were positioned two tie spacings apart as shown in Fig. 16. Tie spacing was taken as 19.5 inches for Test Sections 4, 5, and 7, which have concrete structures instead of ties. The trenches were dug to grade and the bottoms were compacted with a Wacker whose tamping foot was modified to fit the six-inch wide trench.

The trench for the horizontal tubing was carefully surveyed and dug so as to be straight and level. Final hand work adjustments to the trench produced by the ditching machine were usually necessary. The bottom of the trench was compacted with a Wacker and checked with a level. An approximate 0.5 inch sand leveling course was placed and compacted with a vibratory compactor. The sand was leveled to $\pm$ 0.02 foot using a surveyor's level and the tubing was laid into the trench. A line was then stretched over the proposed tubing centerline and a tubing centering device was used to horizontally align each coupling to $\pm$ 0.01 foot as two ten-inch long by 0.25-inch square steel anchor pins were driven in machined grooves in the couplings. The distances of the couplings from the embankment centerline was also controlled to within ± 0.01 foot.

Dried uniform sand passing the No. 40 sieve but retained on the No. 20 sieve was placed around the tubing as shown in Fig. 16 and vibrations were imparted to the tubing with a combination vibrator and tubing hold-down device. Vertical alignment was verified by shooting levels on top of the couplings. Sufficient dry sand was placed to cover the tubing and then damp sand was placed to 1.5 to 2.0 inches above the tubing; this was compacted with a vibratory plate tamper. The soil which was excavated from the trench was wetted by sprinkling to replace water lost by evaporation and recompacted in about three-inch compacted lifts until the trench was backfilled.

<u>Coupling survey</u>. Periodically after installation, the distances of the tubing couplings from the ends of the PVC pipe at the end of the tubing were carefully measured with aluminum gaging rods having a hook on the end. The hooked end would be slid past a coupling and then withdrawn until the hook caught against the far side of the coupling. A measurement would be made to the nearest 0.001 foot through use of a precise scale, 0.1 foot marks scribed on the rod, and a special end cap for the PVC pipe. A length to the far tubing end cap was also measured. Readings obtained during construction are listed in Table 7.

A spare set of rods made from steel was also furnished. A carrying and storage case was provided that will accomodate both sets of rods. Wrench flats on the aluminum rods allow them to be tightened identically each time they are assembled.

The repeatability of readings is estimated to be ± 0.002 foot. Thermal strains are more significant. It is estimated that the temperature in the tubing will range from about 30° to 70°F during readings. If 50°F is taken as standard, the temperature will vary ± 20°F from the standard. For a 30-foot length of aluminum rod, the overall length change would be ± 0.008 foot from the standard length at 50°F; the corresponding length change for the steel rods would be ± 0.004 foot. In future readings, temperatures should be recorded.

Portable extensometers. Three portable extensometers were provided for measuring the change in distance between two tubing couplings under dynamic loading conditions. The gage length of the portable extensometers can be adjusted to 2.5 or 5.0 feet. Expandable anchor feet at the ends of the extensometer extend and lock into tubing couplings. A Schaevitz type 500 HR LVDT at one end of the extensometer will sense dynamic deformations caused by passing rail traffic. The available displacement range for this LVDT is ± 0.5 inch.

The three portable extensometers with cases and hydraulic jack with manifolds are furnished to the project. A schematic of the device is shown in Fig. 18. An instruction manual for use of the instrument and analysis of data is presented in Appendix D. The instruments are compatible with many different dynamic data recording systems.

Tubing constriction. Several weeks after placement, it was observed that the lower horizontal tubing in Test Section 9 had developed a constriction just past the centerline coupling. Attempts were made to expand the constriction with a jacking device, but they were generally unsuccessful. At the completion of embankment instrument installation in October 1971, the lower tubing in Test Section 9 still had the constriction. The portable extensometer could be locked into the center coupling but could not be extended past the coupling. The joint survey can not be extended past the centerline coupling.

Pressure Cells

General. Three pressure cells were placed in the upper portions of the embankment in each main array to measure stresses. The cells have two six-inch diameter pressure diaphragms welded to 0.5-inch thick rings. The cells are oil-filled and applied pressure is transmitted directly to a diaphragm in the attached Schaevitz PT-7 LVDT pressure transducer. The diaphragm moves a magnetic core within the transducer whose output has been calibrated with pressure. A cavity on the back side of the pressure diaphragm is connected to a tubing which vents to the atmosphere in the eight-inch pipe terminal at the side of each main array.

The cells were provided with three different pressure transducers having ranges of zero to 25 psi, 50 psi, or 100 psi. The assignment of different transducer ranges depended upon position of the cell with respect to the rail, depth below subgrade, and the support area of the particular track structure. The cell assignments, calibration data, and initial readings after the embankment had been completed are listed in Table 8. A schematic of a pressure cell is shown in Fig. 19. Instructions for use of the pressure cells and for data analysis are presented in Appendix D.

Placement of pressure cells. Pressure cells were prepared for installation by kneading soil around the cells with a moisture content higher than the surrounding embankment. This water content was generally about 30 percent, and it was generally the lowest water content at which the material could be easily molded around the cells without leaving voids. The cells were placed in the bottom of the trenches and electrical leads were strung along the trench to the embankment edge. Soil was compacted two to three inches above the cells by hand tamping. The trench was then backfilled with the soil that was removed. The material was wetted by sprinkling to replace water lost by evaporation. It was compacted in about three-inch lifts compacted with the Wacker tamper until the trench was backfilled. These placement details are shown in Fig. 16.

Moisture - Temperature Cells

Description. Soiltest MC-300A Moisture Meter and Soil Cells were used for determining moisture content of the embankment. Thirteen soil cells were buried during the embankment construction at each of the nine main arrays. A soil cell consists of screen electrodes with fiberglass wrapping encased in a thin stainless steel case which is 1.0 in. x 1.3 in. A small thermister for sensing temperature is also contained in the case. The readout box is a self-powered alternating current ohmmeter. Further details on the cell and meter are contained in the Soil Moisture Meter Instruction Manual, Volume II.

Operation. Readout box readings are converted into resistance with the readout box calibration chart; the chart for box number 549 is contained in Volume II. The temperature resistance is multiplied times the gage temperature calibration factor and the resulting resistance is used with Figure 4 of the Instruction Manual (Volume II) to obtain temperature.

Moisture cell resistance is corrected for temperature using Figure 5 of the Instruction Manual (Volume II) and the temperature corrected resistance is used with the moisture cell calibration to determine water content. The calibration is developed below.

Calibration. Three Soiltest MC-313 Soil Cell Calibration Boxes and three soil cells were used to develop moisture calibration curves for the High Speed Test Track soils. A cell was placed in each box and soil was packed around it to the approximate field density. The box was soaked in water and then placed in a tightly closed container for sufficient time for the water content to equalize throughout the box. Uniformity of water content was indicated when there was no further change in cell reading; this generally took a period of about one week for the highly plastic site soils. Water content was calculated and plotted against cell resistance. The box was soaked more and the procedure was repeated until the highest water content of interest was reached. Then the soil was air-dried in increments until data were collected on lower water contents. The wetting and drying cycles were repeated several times.

Cell No. 91 data have been plotted in Fig. 20. The cell was initially placed in highly plastic clay (CH) to develop a curve and then was placed in a low plasticity clay (CL). The cell was in the calibration phase from September 1970 to December 1971. The cell was removed from the calibration box and given a "quick" calibration by placing it in soil samples at specified water contents and allowing it to reach equilibrium. Calibration points determined in this manner are shown in Fig. 20 and numbered in sequence; readout box readings versus time are also shown. A low plasticity clay with a plasticity index of 47 was used for the quick calibration.

Data from Cell No. 99 are plotted in Fig. 20. A highly plastic clay (CH) was used from January to December 1971. Then the cell was removed from the calibration box and given a "quick" calibration with the same soil and procedures mentioned above. The "quick" calibration and readout box reading versus time are also shown.

Cell No. 91A was placed in soil treated with three percent lime. The data points developed with this cell are shown in Fig. 20.

From the time versus micro-amps plot in Fig. 20, it is apparent that higher soil water contents require longer times for the cell readings to stabilize. For water contents in the low thirties, it appears that at least one day is required.

The calibration data do not define a unique calibration curve because of data scatter. Several calibration curves are presented on page 17 of the Instruction Manual. The curves for different soils are essentially the same shape but are shifted in the direction of higher water content for higher plasticity materials. The calibration curve for the Altamont clay was taken from the Instruction Manual and shifted in the direction of higher water content until a best fit was obtained. This curve generally fits the data, but the scatter is quite large. There are several reasons to account for the data scatter. Any nonuniformity of moisture in the calibration box would affect the data. Upon dismantling the calibration boxes, drying cracks were noticed in the soil. These cracks could have developed during an earlier drying cycle and affected uniformity adversely from then on. Furthermore, manufacturing variances in the cells preclude a unique calibration curve for all cells.

In order to eliminate, as far as possible, differences between cells and also differences in plasticity of the soil around each cell, the following procedures were adopted for interpreting readout box data of installed cells.

1. A water content determination was made on the soil placed around the cell during installation.

2) The first cell reading after one day in place, to avoid time effects, was assumed to indicate the installed water content.

3) The initial point of water content versus resistance was plotted and the Altamont clay calibration curve was shifted laterally to fit through the initial point. This became the calibration curve for that cell: the technique is demonstrated in Fig. 20 for Cell 1 of Test Section 1.

The temperature calibration factor was provided by the manufacturer. The factor was checked for each cell at room temperature and was generally found to give temperatures within 1°F. The calibration factor was checked for several cells at temperatures in the thirties and also in the nineties (°F) and was found to be reasonably accurate over this temperature range.

Fabrication of moisture cell leads. The electrical leads as furnished for the cells were six feet long. The leads were extended by connecting the leads of adjacent cells to a shielded direct-burial multi-conductor cable. The splice was potted in epoxy to reduce the possibility of electrical shorts caused by moisture. The cell leads were strung through one-quarter inch diameter nylon tubing sealed at the ends with silicone seal for added protection while compacting soil over the leads. The wiring was accomplished in the Shannon & Wilson, Inc. shop at El Dorado, Kansas. The factory temperature calibration of all cells was confirmed and the circuitry of all moisture cells was checked.

Installation. Moisture cells were installed similarly to the pressure cells, see Fig. 16. Moist soil with a water content of about 30 percent was kneaded around the cells and a water content sample was taken from the surrounding soil for each cell. The cells were placed in the bottom of the trenches and soil was compacted two to three inches above the cells by hand tamping. The trench was then backfilled in three-inch compacted lifts with a Wacker tamper. Electrical leads were connected to multi-pin connectors in the main array eight-inch diameter terminal pipes. Field readings of installed soil cells and the oven-determined water content are listed in Table 9. These data represent the "initial" point which is the basis for establishing each cell's calibration curve. A limited amount of additional readings for some cells were obtained but are not presented in this report.

Weather Station

Shannon & Wilson, Inc. was requested to purchase and install an on-site weather station. Electrical hookups were to be furnished by ATSF as well as weekly changing of records and maintenance. The following shelters and instruments were selected and purchased from Weather Measure Corporation, Sacramento, California.

Model No.	Item
IS-1	2 Instrument Shelters
P511-E	Remote Recording Heated Rain/Snow Gage
P521	Event Recorder for the Rain/Snow Gage
E-801	Recording Evaporimeter
M701	Meteograph (records temperature, humidity, and barometric pressure)

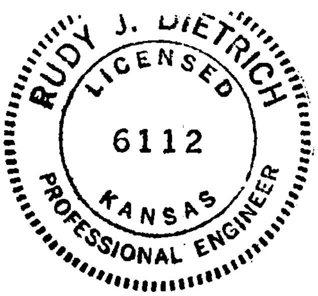
The instruments provide continuous recordings on charts attached to revolving drums making one revolution every seven days. The drums are geared to clock works which are driven by 1.5-volt D cell batteries. The event recorder signal is provided by a six-volt battery. The rain/snow gage requires 110-volt AC current for heating. Operating manuals for the instruments are contained in Volume II.

The two meteorological instrument shelters were installed at Station 8566+60 on the south side of the tracks on November 16-18, 1970. A six-inch thick concrete slab was founded at a depth of one-foot and the metal legs of the shelters were bolted to the slab. The slab was then covered with a six-inch layer of crushed rock. The rain/ snow gage was installed about 50 feet east, adjacent to the existing track, on a 12-inch square by three-foot long concrete pedestal embedded two feet.

The evaporimeter and meteorograph were stolen in November 1970 while being calibrated in the construction trailer. Electric power was not provided until early summer 1970, so no weather records were obtained over the 1970-1971 winter. The stolen instruments were replaced, calibrated, and fully operational by August 21, 1971.

After several days of operation during the summer, it became apparent that the evaporimeter's water reservoir would run dry after two to three days because of the prevailing very high evaporation rate. In order to extend servicing to the normal seven-day interval, the evaporating surface area was reduced with a stainless steel disk machined to have a 0.75 inch opening. This reduced the available evaporation area to 34.5 percent of the original, and it was installed on August 31, 1971.

Weekly record changes have been provided by ATSF and the records are in their possession.



SHANNON & WILSON, INC.

Rudy J. Dietrich

J. Ronald Salley

REFERENCE

1. "High Speed Test Embankment - Design Studies", by Shannon & Wilson, Inc. for the Atchison, Topeka, and Santa Fe Railway Company and the United States Department of Transportation, Office of High Speed Ground Transportation, January, 1971.

TABLE I, FIELD DENSITY & STRENGTH TESTS

Date	Test No.	Test Type	Stationing	Depth Below Rail Base, feet	Unconfined Strength, tsf.		Water Content, %		Dry Density, pcf.		Est. Mod. AASHO pcf.	% Comp.
					Qu	Pp	Nuc.	Oven	Nuc.	Other		
10-20-70	1	N	8598+50	8.5			21.0		102.5		107.0	96
		T	"	"				26.2		96.7	107.0	90
	2	N	8598+50	8.5			19.3		103.5		107.0	97
		T	"	"				24.6		96.3	107.0	90
	3	N	8601+10	7.5			18.9		104.7		107.0	98
	4	N	8598+82	6.7			22.5		100.0		107.0	93
		T	"	"				24.3		98.1	107.0	92
	5	N	8601+75	7.5			22.9		100.5		107.0	94
		T	"	"				23.1		97.5	107.0	91
10-21-70	6	N	8598+60	7.0			19.0		110.5		107.0	103
		T	"	"				25.8		95.6	107.0	89
	7	N	8600+25	7.0			21.4		98.5		107.0	92
		T	"	"				30.7		90.2	107.0	84
	8	N	8599+66	7.0			21.1	26.2	99.5		107.0	93
	9	N	8599+68	7.0			20.3	23.5	99.3		107.0	93
	11	N	8599+00	6.5			18.8	22.9	104.0		107.0	97
	12	N	8598+30	6.5			22.0	22.0	100.8		107.0	94
10-22-70	13	N	8599+00	6.5			20.8		103.5		107.0	98
		T	"	"				20.7		103.2	107.0	96
	14	N	8600+00	6.5			21.0		102.5		107.0	97
		T	"	"				21.3		101.4	107.0	95
	15	N	8599+25	5.0			22.1		99.5		107.0	93
		T	"	"				21.2		102.1	107.0	95
	16	N	8600+80	5.0			20.4		100.5		107.0	94
		T	"	"				20.8		101.6	107.0	94
10-23-70	17	N	8600+50	5.1			20.9		98.0		107.0	92
		T	"	"				24.4		98.6	107.0	93
	18	N	8602+80	5.8			20.8		98.1		107.0	92
		T	"	"				21.1		102.3	107.0	96
11- 6-70	19	R	8515+20	4.0				30.0		92.3	107.0	83
	20	R	8516+60	3.3				15.8		111.0	117.6	92

Date	Test No.	Test Type	Stationing	Depth Below Rail Base, feet	Unconfined Strength, tsf.		Water Content, %		Dry Density, pcf.		Est. Mod. AASHO pcf.	% Comp.
					Qu	Pp	Nuc.	Oven	Nuc.	Other		
11- 6-70	21	R	8513+20	4.3				18.1		102.6	112.0	92
11- 7-70	22	R	8515+20	1.8				21.8		96.3	112.0	86
	23	R	8517+00	1.9				18.3		109.0	117.6	93
	24	R	8513+10	3.6				19.9		106.0	117.6	90
	25	R	8516+15	1.9				15.6		102.0	117.6	87
	26	R	8515+00	1.4				18.5		105.4	114.1	92
	27	R	8514+20	1.3				19.6		106.0	114.1	93
11-10-70	28	R	8511+30	1.3				17.0		109.4	117.6	93
	29	R	8512+60	1.6				17.9		109.0	112.0	97
	30	R	8517+00	1.2				18.9		106.5	112.0	95
4-19-71	101	N	8596+40	8.0			22.8		101.7		111.5	91
	102	N	8595+95	7.7				16.9	104.2		111.5	94
	101	T	"	"				16.9		106.5	111.5	96
	102	T	"	"				14.2		104.0	111.5	94
	103	N	8595+66	7.6				16.8	106.8		111.5	96
	103	T	"	"				16.8		106.0	111.5	96
	104	T	8595+33	7.7				18.8		99.0	111.5	89
4-21-71	104	N	8596+00	7.5			22.9	20.7	103.5		109.0	95
	105	N	8592+40	7.8			22.9		101.2		109.0	93
	105	T	"	"				20.2		101.6	109.0	93
	106	N	8588+25	8.0			20.8	19.4	104.3		109.0	96
	107	N	8585+85	8.7			25.2		96.2		109.0	88
	106	T	"	"				25.2		97.8	109.0	90
4-22-71	109	N	8570+50	7.5			12.1		111.9		109.0	103
	110	N	8573+ 5	7.5			21.8		100.2		109.0	92
	107	T	"	"				21.3		100.1	109.0	92
	111	N	8578+00	7.5			24.6		100.8		109.0	93
	108	T	"	"				23.9		100.0	109.0	92

Date	Test No.	Test Type	Stationing	Depth Below Rail Base, feet	Unconfined Strength, tsf.		Water Content, %		Dry Density, pcf.		Est. Mod. AASHO pcf.	% Comp.
					Qu	Pp	Nuc.	Oven	Nuc.	Other		
4-30-71	112	N	8591+20	7.3			25.4		98.9		109.0	91
	109	T	"	"				24.0		99.8	109.0	92
	113	N	8600+64	5.3			25.1		100.6		109.0	92
	110	T	"	"				23.8		101.0	109.0	92
	111	T	"	"				24.9		98.9	109.0	91
	112	T	"	"				23.3		100.8	109.0	92
	114	N	8600+66	5.3			25.0		100.2		109.0	92
	113	T	"	"				24.1		101.3	109.0	93
	114	T	"	"				23.7		101.2	109.0	93
	115	T	"	"				23.5		101.2	109.0	93
5- 3-71	115	N	8598+72	5.7			24.0		100.3		109.0	92
	126	T	"	"	2.7			23.3		99.3	109.0	91
	227	T	"	"	2.4			24.0		99.8	109.0	92
	116	N	8598+84	5.7			23.7		102.1		109.0	94
	128	T	"	"	2.2			24.4		100.2	109.0	92
	129	T	"	"	2.2			24.2		98.7	109.0	91
	117	N	8592+62	6.8			13.2		104.4		109.0	96
	130	T	"	"				13.4				
	118	N	8595+10	6.0			13.4		97.0		109.0	89
	119	N	8588+75	7.8			14.3		96.6		109.0	89
	119	N	"	"			14.3		91.9		109.0	84
	119	N	"	"			14.3		94.3		109.0	87
5- 4-71	120	N	8589+80	6.8			19.4		93.3		109.0	86
	121	N	8570+60	7.3			26.0		95.9		109.0	89
	121	N	"	"			26.4		94.6		109.0	87
	122	N	8573+55	6.7			23.2		95.6		109.0	88
	122	N	"	"			23.6		93.9		109.0	86
	123	N	8576+50	6.4			23.6		96.8		109.0	87
	124	N	8554+95	8.3			24.2		93.7		109.0	86
	125	N	8560+90	7.2			25.5		95.1		109.0	87
	126	N	"	"			19.7		94.3		109.0	87
	127	N	8567+55	7.0			22.3		95.0		109.0	87
	134	T	"	"				20.4		102.6	109.0	94
	128	N	8565+35	7.0			21.5		93.7		109.0	86
	135	T	"	"				20.4		96.7	109.0	89

Date	Test No.	Test Type	Stationing	Depth Below Rail Base, feet	Unconfined Strength, tsf.		Water Content, %		Dry Density, pcf.		Est. Mod. AASHO pcf.	% Comp.
					Qu	Pp	Nuc.	Oven	Nuc.	Other		
5- 4-71	129	N	8565+39	7.0			18.6		96.0		109.0	88
5- 5-71	130	N	8571+50	7.0			19.8	20.8	90.0		109.0	83
	131	N	"	"					95.7		109.0	88
	132	N	8575+00	6.5			23.6	17.6	93.9		109.0	86
	133	N	"	"			22.3		99.6		109.0	92
	134	N	8578+44	6.5			19.3	15.1	93.8		109.0	86
5- 6-71	135	N	8594+50	6.6			18.7		100.1		109.0	92
	136	T	"	"				23.8		99.0	109.0	91
	136	N	8591+85	7.3			19.5	16.8	95.9		109.0	88
	137	N	8588+20	7.6			15.1	19.2	96.3		109.0	88
	138	N	8584+45	6.8			25.8		92.6		109.0	85
	137	T	"	"				29.4		96.6	109.0	89
	139	N	8577+75	6.5			17.3	17.7	93.9		109.0	86
	140	N	8575+00	6.0			23.2	25.8	96.5		109.0	89
	141	N	8572+45	6.5			20.2	20.5	96.3		109.0	88
	142	N	8570+00	6.2			20.5	19.3	100.1		109.0	92
	143	N	8565+45	5.6			23.9	25.0	91.2		109.0	84
	144	N	8567+80	5.7			21.6	20.9	90.8		109.0	83
	145	N	8561+35	6.9			28.4	29.5	76.6		109.0	70
5- 7-71	146	N	8594+65	6.0			23.1	27.1	94.3		109.0	87
	146	N	"	"			22.7		96.0		109.0	88
	147	N	8589+45	6.4			22.4	25.6	95.2		109.0	87
	147	N	"	"			21.5		100.9		109.0	93
	148	N	8586+00	6.9			23.6	23.1	94.2		109.0	86
	148	N	"	"			22.0		100.9		109.0	93
	149	N	8584+25	7.2			24.4	24.5	95.3		109.0	87
	149	N	"	"			23.4		99.2		109.0	91
	150	N	8559+15	7.0			23.2	21.9	96.2		109.0	88
	150	N	"	"			22.7		98.3		109.0	90

TABLE I, FIELD DENSITY & STRENGTH TESTS

Date	Test No.	Test Type	Stationing	Depth Below Rail Base, feet	Unconfined Strength, tsf.		Water Content, %		Dry Density, pcf.		Est. Mod. AASHO pcf.	% Comp.
					Qu	Pp	Nuc.	Oven	Nuc.	Other		
5- 7-71	151	N	8553+40	6.0			21.5	22.2	100.4		109.0	92
5-17-71	152	N	8593+30	5.7			18.2	19.3	102.6		109.0	94
	152	N	"	"			19.2		97.6		109.0	90
	153	N	8595+50	6.0			21.6	21.1	91.9		109.0	84
	153	N	"	"			21.0		95.0		109.0	87
5-18-71	154	N	8595+95	5.5			19.5		103.0		109.0	95
	138	T	"	"	2.5			22.7		95.3	109.0	87
	155	N	8593+40	5.5			23.7		97.0		109.0	89
	139	T	"	"	3.2			22.5		104.9	109.0	96
5-19-71	156	N	8588+30	6.0			25.5		96.0		109.0	88
	140	T	"	"	3.0			18.9		90.0	109.0	83
	157	N	8591+ 8	5.7			21.7		102.7		109.0	94
	141	T	"	"	5.0			21.9		98.6	109.0	91
	158	N	8568+87	7.0			17.7	19.3	90.6		109.0	83
	159	N	8568+87	6.7			23.6		97.5		109.0	90
	160	N	"	"			24.3		98.8		109.0	91
	142	T	"	"	2.5			24.4		100.0	109.0	92
	161	N	8568+67	5.8			28.4	20.4	97.6		109.0	90
	162	N	8568+86	5.8			26.5	22.8	95.8		109.0	88
	163	N	8593+99	5.1			28.8	29.6	85.3		109.0	78
	164	N	"	"			24.6	29.6	100.2		109.0	92
	165	N	"	"			24.7	29.6	99.6		109.0	91
	143	T	"	"	1.3			29.5		91.4	109.0	84
	144	T	"	"	4.1			20.9		104.4	109.0	96
	166	N	8590+00	5.8			26.8	24.7	97.7		109.0	90
	145	T	"	"	2.1			25.2		97.4	109.0	89
5-20-71	167	N	8568+10	4.8			20.3	19.4	104.6		109.0	96
	168	N	8568+68	4.0			22.0	23.4	101.4		109.0	93
	169	N	8585+25	7.0			22.1	23.6	102.4		107.0	96
	146	T	"	"	3.8			23.6		105.9	107.0	99
	170	N	8582+ 8	6.1			24.7	21.4	95.4		107.0	89
	147	T	"	"	4.3			21.2		101.9	107.0	95
	171	N	8563+18	6.6			24.1	20.4	91.3		107.0	85
5-21-71	172	N	8595+65	5.0			27.8		95.4		107.0	89
	148	T	"	"	2.1			26.4		94.5	107.0	88
	173	N	8591+92	5.4			23.8	20.1	93.7		107.0	92
	174	N	8589+20	5.5			26.9		94.8		107.0	89
	149	T	"	"	2.6			31.3		90.0	107.0	84
	175	N	8563+20	6.8			19.9	23.5	103.0		107.0	96
	176	N	8577+10	6.1			21.1	19.1	94.4		107.0	88
	177	N	8573+30	6.0			23.6	24.9	99.8		107.0	93
	178	N	8562+90	7.3			25.5	25.0	93.5		107.0	88
	179	N	"	"			25.1	25.0	94.6		107.0	89
5-27-71	180	N	8576+00	4.3			25.8	24.6	99.0		107.0	92
	181	N	"	"			26.0		98.2		107.0	92
	150	T	"	"	2.6			23.7		101.1	107.0	95
	182	N	8578+53	5.0			26.2	26.1	97.5		107.0	91
	183	N	"	"			26.0	23.9	98.5		107.0	92
	151	T	"	"	3.7			23.9		99.3	107.0	93
	185	N	8569+90	4.7			25.4	24.8	94.8		107.0	89
	186	N	"	"			27.2	24.1	88.4		107.0	83
	187	N	8572+80	4.7			24.3	22.9	91.4		107.0	85
	188	N	"	"			24.9	23.8	89.1		107.0	83
	189	N	8574+70	4.9			24.9	25.0	95.6		107.0	89
	190	N	"	"			24.6	26.5	96.6		107.0	90
	191	N	8570+10	4.6			25.2	24.7	96.6		107.0	90
	192	N	"	"			25.6	24.7	95.2		107.0	89
	193	N	8572+90	5.0		2.8	26.9		91.3		107.0	85
	194	N	"	"		2.8	25.8		95.0		107.0	89
	152	T	"	"	3.8			24.7		98.6	107.0	92
	195	N	8584+70	6.0		2.6	28.8		95.0		107.0	89
	153	T	"	"	1.7			29.3		92.6	107.0	86
	196	N	8582+25	6.6			28.5		95.5		107.0	89
	154	T	"	"	1.6			27.9		95.2	107.0	90
	197	N	8587+00	5.0		1.5	26.0		95.5		107.0	89
	155	T	"	"	1.8			26.1		97.8	107.0	92
5-27-71	198	N	8590+15	4.7			26.4		98.0		107.0	92
	156	T	"	"	2.5			25.3		97.5	107.0	91
5-28-71	199	N	8582+45	6.0			25.3		98.3		107.0	92
	157	T	"	"	2.7			25.2		96.9	107.0	91
	200	N	8585+40	5.5		2.5	25.9		94.5		107.0	88
	158	T	"	"	2.0			26.2		96.8	107.0	91
	201	N	8588+35	4.5		2.6	25.2		97.4		107.0	91
	159	T	"	"	2.6			25.4		97.6	107.0	91
	202	N	8591+62	4.4		2.3	27.3		92.3		107.0	86
	160	T	"	"	1.6			27.4		95.6	107.8	89
	203	N	8596+45	4.7		2.8	24.7		99.2		107.0	93
	161	T	"	"	2.9		24.6			99.2	107.0	92
	204	N	8593+90	4.0		2.3	26.8		93.7		107.0	88
	162	T	"	"	1.4		26.4			95.0	107.0	89
	205	N	8590+25	5.9		2.5	26.2		98.5		107.0	92
6- 1-71	209	N	8577+00	3.5			25.3		96.9		100.0	97
	164	T	"	"	3.6			24.6		97.4	100.0	97
	210	N	8574+85	3.6			25.6		94.3		100.0	94
	165	T	"	"	1.2			26.7		95.5	100.0	95
	211	N	8581+70	5.8			26.0		99.2		107.0	93
	166	T	"	"	2.6			25.2		98.2	107.0	92
	212	N	8584+82	4.8			23.6		101.6		107.0	95
	167	T	"	"	4.7			22.0		105.2	107.0	98
6- 2-71	213	N	8575+85	2.9		4.0	22.5		107.1		107.0	100
	214	N	8573+53	3.8		2.7	25.6		98.5		107.0	92
	215	N	8567+50	5.6		3.7	22.8		99.9		107.0	93
	168	T	"	"	3.4			22.5		100.0	107.0	94
	216	N	8566+30	5.8			27.8		94.9		107.0	89
	169	T	"	"	1.5			27.5		93.6	107.0	88
6- 7-71	217	N	8573+54	3.6		3.6	25.7		99.4		107.0	93
	170	T	"	"				23.7		101.6	107.0	95
	218	N	8575+36	3.0		3.0	25.8		97.0		107.0	91
	171	T	"	"				26.9		97.4	107.0	91
6- 7-71	219	N	8576+77	3.2		2.0	27.0		96.3		107.0	90
	172	T	"	"	2.3			27.7		94.7	107.0	89
	220	N	8578+60	3.3		3.3	24.4		97.4		107.0	91
	221	N	8581+56	5.4		3.0	25.5		100.0		107.0	93
	173	T	"	"	3.1			25.3		97.0	107.0	91
	222	N	8583+50	4.5		2.5	25.1		97.8		107.0	92
	223	N	8588+58	3.9		3.6	27.1		94.0		100.0	94
	174	T	"	"				27.9		97.2	100.0	97
	224	N	8594+24	3.0		2.8	26.4		91.0		100.0	91
	225	N	8591+10	3.3		2.6	26.2		94.1		100.0	94
6- 8-71	225	N	8580+54	4.8			26.2		93.5		100.0	93
	226	N	8580+40	2.2			26.3		95.0		100.0	95
6- 9-71	227	N	8580+76	2.9		2.9	25.0		98.0		107.0	91
	228	N	8578+71	2.8		3.4	24.9		101.3		107.0	95
	229	N	8577+ 5	2.7		4.2	23.8		100.0		107.0	93
	175	T	"	"	3.9			24.1		99.0	107.0	92
	230	N	8575+12	2.7		4.5	21.0		102.0		107.0	95
	176	T	"	"	4.1			24.5		102.5	107.0	96
	231	N	8573+47	2.6		4.5	24.7		98.3		107.0	91
	177	T	"	"	4.1			23.3		100.6	107.0	94
	232	N	8571+65	4.0		3.5	23.7		98.6		107.0	91
	178	T	"	"				22.8		100.4	107.0	94
	233	N	8569+75	4.3		4.5	22.8		100.8		107.0	94
	234	N	8582+75	4.5		3.2	24.0		101.2		107.0	95
	235	N	8585+86	3.8		3.4	24.8		100.6		107.0	94
	179	T	"	"	3.9			23.4		101.4	107.0	95
	236	N	8587+ 6	3.4		2.9	24.2		100.4		107.0	94
	180	T	"	"	2.7			23.3		101.4	107.0	95
6-15-71	237	N	8588+70	2.5			24.8		98.9		107.0	92
	181	T	"	"	2.0			24.8		99.2	107.0	93
	181	T	"	"	1.6			25.2		100.0	107.0	93

TABLE I, FIELD DENSITY & STRENGTH TESTS

Date	Test No.	Test Type	Stationing	Depth Below Rail Base, feet	Unconfined Strength, tsf.		Water Content, %		Dry Density, pcf.		Est. Mod. AASHO pcf.	% Comp.
					Qu	Pp	Nuc.	Oven	Nuc.	Other		
6-15-71	181	T	8588+70	2.5	2.3			23.8		100.9	107.0	94
	181	T	"	"	2.4			23.6		102.3	107.0	96
6-16-71	238	N	8591+66	3.3		3.3	23.6		100.7		107.0	94
	182	T	"	"	4.0			20.7		103.8	107.0	97
	239	N	8594+ 3	2.8		2.6	26.2		97.5		107.0	91
	183	T	"	"	3.1			22.7		101.5	107.0	95
	240	N	8596+60	3.8		2.6	27.9		93.3		107.0	[illegible]
	184	T	"	"	2.4			24.4		99.1	107.0	93
	241	N	8582+95	3.6		2.6	24.9	26.0	96.7		107.0	90
	242	N	8586+97	2.3		3.3	23.6		100.7		107.0	94
	185	T	"	"	3.2			22.4		103.0	107.0	96
	243	N	8589+56	2.0		3.0	24.2		98.5		107.0	92
	186	T	"	"	2.6			23.1		99.1	107.0	93
	244	N	8592+50	2.2		2.7	24.5		98.9		107.0	92
	187	T	"	"	2.5			22.1		101.1	107.0	95
	245	N	8595+ 6	2.3		3.0	24.4		99.3		107.0	93
	188	T	"	"	3.5			21.1		104.0	107.0	97
	246	N	8596+62	3.0			24.8	25.1	94.9		105.0	90
	247	N	8583+00	3.5		2.5	21.5		101.3		107.0	95
	189	T	"	"	2.8			21.7		100.2	107.0	94
	248	N	8586+48	1.9			23.7		100.6		107.0	94
	190	T	"	"	2.9			22.4		101.2	107.0	95
6-17-71	249	N	8590+50	2.0		3.0	24.3	22.9	96.0		107.0	90
	250	N	8593+40	1.8		2.5	24.4	24.7	101.6		107.0	95
	251	N	8583+47	2.5			25.0	23.3	97.4		107.0	91
6-18-71	252	N	8578+40	2.5		1.8	26.1		98.1		107.0	92
	191	T	"	"	3.0			24.7		99.2	107.0	93
	253	N	8575+50	2.4		2.6	27.6	25.8	96.8		107.0	90
	254	N	8573+40	2.4		4.2	24.0		101.6		107.0	95
	192	T	"	"	3.6			22.9		93.0	107.0	87
	255	N	8570+50	3.9			23.0	17.9	100.8		107.0	94

Date	Test No.	Test Type	Stationing	Depth Below Rail Base, feet	Unconfined Strength, tsf.		Water Content, %		Dry Density, pcf.		Est. Mod. AASHO pcf.	% Comp.
					Qu	Pp	Nuc.	Oven	Nuc.	Other		
6-18-71	256	N	8566+42	4.8		2.0	23.2		98.4		107.0	92
	193	T	"	"	1.3			25.9		96.9	107.0	91
	257	N	8564+28	5.5		1.5	27.2		96.0		107.0	90
	194	T	"	"	3.0			23.0		96.0	107.0	90
6-21-71	258	N	8572+50	3.0			28.5		96.8		107.0	90
	195	T	"	"	3.3			23.8		98.1	107.0	92
	259	N	8569+65	3.5		2.0	26.2		97.5		107.0	91
	196	T	"	"	2.2			24.9		97.5	107.0	91
	260	N	8567+42	5.0		1.8	28.5	31.1	96.5		107.0	90
	261	N	8564+80	5.1		2.6	24.9		99.3		107.0	93
	197	T	"	"	3.4			24.1		99.0	107.0	93
	262	N	8571+68	2.5		3.0	25.4		97.3		107.0	91
	198	T	"	"	2.7			22.9		100.2	107.0	94
	263	N	8569+50	2.8		2.0	28.7		94.7		107.0	[illegible]
	199	T	"	"	1.3			27.4		94.5	107.0	[illegible]
6-22-71	264	N	8566+92	4.3			28.6		94.9		107.0	89
	200	T	"	"				27.8		98.4	107.0	92
	265	N	8564+80	5.2		3.5	22.9		100.8		107.0	94
	201	T	"	"				21.1		103.6	107.0	97
	266	N	8577+00	2.0		2.5	26.2		97.1		107.0	91
	202	T	"	"				27.8		95.1	107.0	89
	267	N	8574+74	2.3		2.7	24.6		98.7		107.0	92
	203	T	"	"	2.4			24.6		100.0	107.0	93
	268	N	8568+15	3.0		2.3	24.5		99.1		107.0	93
	204	T	"	"	2.2			25.9		96.5	107.0	90
	269	N	8572+30	2.2		2.6	25.4		99.3		107.0	93
	205	T	"	"	3.0			23.6		100.2	107.0	94
	270	N	8561+21	5.5		2.0	26.3		96.5		107.0	90
	206	T	"	"	1.7			24.9		98.4	107.0	92
	271	N	8559+40	6.5		2.7	25.6		96.5		107.0	90
	207	T	"	"	1.6			25.2		97.2	107.0	91
6-23-71	272	N	8564+27	4.5			25.0	22.3	99.0		107.0	93
6-24-71	273	N	8542+17	7.5			24.2	24.2	100.2		105.0	95

Date	Test No.	Test Type	Stationing	Depth Below Rail Base, feet	Unconfined Strength, tsf.		Water Content, %		Dry Density, pcf.		Est. Mod. AASHO pcf.	% Comp.
					Qu	Pp	Nuc.	Oven	Nuc.	Other		
6-24-71	275	N	8536+93	7.5		3.5	27.1	24.6	97.9		105.0	93
	278	N	8548+16	7.7		1.9	28.4	28.2	92.9		100.0	93
	279	N	8542+00	6.8		2.6	30.6	25.3	90.7		100.0	91
	280	N	8552+00	7.7		3.7	25.3	23.5	94.4		100.0	94
	281	N	8542+90	6.4		1.8	28.6	26.5	96.8		105.0	92
	282	N	8539+00	6.9			30.7	30.2	92.1		100.0	92
	283	N	8536+00	6.8		2.5	25.7	24.1	95.5		105.0	91
	284	N	8532+00	7.0			28.9	31.1	93.0		100.0	93
6-25-71	285	N	8555+20	6.3		2.0	28.4		94.4		100.0	94
	208	T	"	"				29.0		92.7	100.0	93
	286	N	8551+95	7.0		1.8	24.6		98.6		105.0	94
	209	T	"	"				21.1		99.5	105.0	94
	287	N	8548+80	6.5		1.8	30.5		91.6		100.0	92
	210	T	"	"	1.9			27.6		93.7	100.0	94
	288	N	8559+00	6.0		2.7	25.7		97.5		107.0	91
	211	T	8560+42	6.1				23.5		100.9	107.0	94
	212	T	8562+25	5.0				21.6		101.8	107.0	95
	213	T	8567+82	3.8				22.2		90.3	107.0	84
	214	T	8567+84	3.8	2.7			23.5		97.9	107.0	91
	215	T	8530+00	6.8				29.8		90.4	105.0	86
	216	T	8533+00	6.5				24.4		97.3	105.0	93
	217	T	8536+00	6.5				25.1		94.9	105.0	90
	218	T	8539+00	6.3	2.8			25.2		95.8	105.0	91
	219	T	8542+00	6.2	2.3			30.1		91.2	105.0	87
	220	T	8545+00	7.0				29.2		92.8	105.0	88
	221	T	8527+00	6.0				28.5		93.0	105.0	89

Date	Test No.	Test Type	Stationing	Depth Below Rail Base, feet	Unconfined Strength, tsf.		Water Content, %		Dry Density, pcf.		Est. Mod. AASHO pcf.	% Comp.
					Qu	Pp	Nuc.	Oven	Nuc.	Other		
6-28-71	289	N	8560+60	5.7			26.3	23.6	99.5		107.0	93
	290	N	8567+10	2.8		3.6	21.1	20.6	102.8		107.0	96
	291	N	8552+24	6.5		2.9	26.9	25.6	95.5		107.0	91
	292	N	8565+ 9	3.3		4.0	23.7	21.8	98.9		107.0	92
	293	N	8561+ 6	3.1		3.1	22.6	22.6	102.0		107.0	95
6-29-71	294	N	8525+56	6.8		2.8	26.8		95.2		105.0	91
	295	N	8522+76	6.5		4.5	22.5		101.0		105.0	96
	223	T	8560+35	5.3	1.5			23.7		98.1	107.0	92
	224	T	8560+38	5.3	1.7			21.9		102.5	107.0	96
	225	T	8560+34	5.3				21.3		103.2	107.0	96
6-30-71	296	N	8604+74	5.5		3.3	20.7		100.7		107.0	94
	226	T	"	"				17.2		107.3	107.0	100
	297	N	8606+83	5.8		4.5	20.8	19.1	102.9		107.0	96
	298	N	8602+79	4.8		1.8	25.7		100.5		107.0	94
	227	T	"	"	2.7			20.6		103.2	107.0	96
	299	N	8605+88	4.8		3.6	20.6	20.4	104.4		107.0	97
	300	N	8608+68	5.3		1.5	21.5	26.0	102.4		107.0	96
	228	T	8567+81	2.0				19.0		106.7	107.0	100
	229	T	8567+80	2.0				22.4		102.8	107.0	96
	230	T	8567+79	2.0				18.9		103.5	107.0	97
7- 1-71	301	N	8598+50	5.3		3.3	21.0		101.2		107.0	95
	234	T	"	"				17.8		105.6	107.0	99
	302	N	8600+50	5.0		2.5	23.4		101.7		107.0	95
	235	T	"	"	3.5			16.8		106.0	107.0	99
	303	N	8603+00	3.8		3.3	26.6		96.5		107.0	90
	236	T	"	"				18.6		103.4	107.0	97
	304	N	8605+36	3.8		3.2	22.9		101.7		107.0	95
	237	T	"	"				19.9		104.4	107.0	98

TABLE I, FIELD DENSITY & STRENGTH TESTS

Date	Test No.	Test Type	Stationing	Depth Below Rail Base, feet	Unconfined Strength, tsf. Qu	Unconfined Strength, tsf. Pp	Water Content, % Nuc.	Water Content, % Oven	Dry Density, pcf. Nuc.	Dry Density, pcf. Other	Est. Mod. AASHO pcf.	% Comp.
7- 1-71	231	T	8602+56	4.1				22.2		101.8	107.0	95
	232	T	8605+56	4.5		1.8		23.3		99.8	107.0	93
	233	T	8609+18	5.0				22.1		99.8	107.0	93
7- 2-71	305	N	8601+ 1	4.0		2.0	26.0		99.7		107.0	93
	238	T	"	"	2.4			23.6		99.7	107.0	93
	306	N	8599+60	4.1		2.0	23.4		99.8		107.0	93
	239	T	"	"				22.9		99.9	107.0	93
	307	N	8598+21	4.4		2.5	25.0		100.5		107.0	94
	240	T	"	"	2.1			23.1		100.6	107.0	94
	308	N	8602+31	3.3		2.4	22.2		100.2		107.0	94
	241	T	"	"				19.0		101.7	107.0	95
	310	N	8608+00	4.3		3.3	23.3		99.1		107.0	93
	243	T	"	"				21.0		99.8	107.0	93
	312	N	8589+88	3.7		2.2	27.4		96.1		107.0	90
	244	T	"	"				24.9		95.2	107.8	89
	313	N	8600+26	3.8		2.4	23.7		99.4		107.0	93
	245	T	"	"	2.6			22.7		100.1	107.0	93
	314	N	8602+50	2.7		3.3	25.3	20.8	97.8		107.0	91
7- 6-71	315	N	8599+88	3.0			26.1	25.6	97.8		107.0	91
7- 7-71	317	N	8603+40	2.3		2.0	24.3		99.0		107.0	92
	245	T	"	"				24.1		98.8	107.0	92
	319	N	8599+60	2.5		4.4	24.1		98.7		107.0	92
	247	T	"	"				18.6		107.3	107.0	100
	320	N	8603+30	1.7			23.4	27.8	100.3		107.0	94
	323	N	8603+80	1.6		2.0	24.1	19.8	101.8		107.0	95
7- 8-71	324	N	8521+55	5.6		1.6	25.9	27.0	99.3		107.0	93
	325	N	8523+00	5.6		4.5	18.3	18.1	105.3		107.0	98
	326	N	8525+86	5.7		2.7	21.6	18.3	92.5		107.0	91
7- 9-71	328	N	8531+00	5.5			19.9	19.3	91.3		100.0	91
	328	N	"	"			19.6	19.3	92.8		100.0	93
7- 9-71	329	N	8534+75	6.4			24.8	26.0	97.8		100.0	98
	330	N	8536+ 6	5.6			25.0	18.5	96.0		100.0	96
	331	N	8543+00	5.6			23.4	20.3	98.5		100.0	98
	332	N	8524+95	5.6			23.0	21.5	100.0		100.0	100
	333	N	8523+00	5.5			22.0	22.3	97.9		100.0	98
	335	N	8530+ 5	5.5			20.1	24.7	92.0		100.0	92
	336	N	8535+00	5.0			24.2	29.2	91.8		100.0	92
	337	N	8540+ 5	5.5			23.6	22.2	93.8		100.0	94
	338	N	8545+10	5.3			24.1	19.6	95.5		100.0	96
7-12-71	339	N	8555+30	5.0			22.9		90.3		100.0	90
	250	T	"	"				17.5		97.9	100.0	98
	340	N	8558+18	5.0		2.6	25.7		97.5		100.0	98
	251	T	"	"	2.6			26.0		95.6	100.0	96
	341	N	8561+00	4.5		2.8	25.2		97.0		100.0	97
	252	T	"	"				25.1		96.3	100.0	96
	342	N	8531+15	5.0			28.2		93.8		100.0	94
	253	T	"	"	8.9			23.6		98.5	100.0	98
	343	N	8536+12	5.0		3.3	29.6		93.5		100.0	94
	254	T	"	"				26.2		95.5	100.0	96
	344	N	8541+ 5	5.0		4.2	26.3		92.8		100.0	93
	255	T	"	"				21.4		97.9	100.0	98
	345	N	8545+00	5.0		2.6	22.5		98.2		100.0	98
	256	T	"	"				20.6		100.0	100.0	100
	346	N	8551+ 3	5.2		3.9	24.3	20.4	96.9		100.0	97
	347	N	8523+ 6	5.0		3.5	24.0		96.4		100.0	96
	257	T	"	"	3.3			24.0		98.1	100.0	98
7-13-71	348	N	8520+15	5.0		3.0	26.1		96.0		100.0	96
	266	T	"	"				24.0		97.3	100.0	97
7-13-71	349	N	8521+76	5.0		4.2	25.7		94.3		100.0	94
	267	T	"	"	4.2			25.3		96.9	100.0	97
	350	N	8526+00	4.5			22.3		94.9		100.0	95
	268	T	"	"				15.4		104.4	100.0	104
	351	N	8547+00	5.0		4.5	24.7		98.1		105.0	94
	269	T	"	"				20.7		100.2	105.0	95
	352	N	8551+00	4.8		2.5	23.8		100.1		105.0	95
	270	T	"	"	2.1			23.0		98.8	105.0	94
	353	N	8556+00	4.3	3.6		24.5		96.0		105.0	91
	271	T	"	"				20.7		97.2	105.0	93
	259	T	8562+00	3.3	3.9	3.9		24.2		98.4	105.0	93
	260	T	8561+00	4.1		3.5		23.0		94.9	105.0	90
	261	T	8560+36	3.9	3.3	4.0		21.1		97.9	105.0	93
	262	T	8559+00	4.0		3.1		22.0		99.4	105.0	95
	263	T	8552+35	5.5		3.8		21.6		99.2	105.0	95
	264	T	8552+36	5.5	2.7	3.1		23.6		98.7	105.0	94
	265	T	8552+37	5.5		4.2		21.7		96.5	105.0	92
7-14-71	354	N	8546+80	4.8		4.5	22.0		100.1		105.0	95
	272	T	"	"				19.0		105.1	105.0	100
	355	N	8548+95	4.9		4.5	23.4		97.1		105.0	92
	273	T	"	"	7.6			20.7		104.6	105.0	100
	356	N	8551+00	4.7		2.8	25.7		97.4		105.0	93
	274	T	"	"				22.3		100.5	105.0	96
	357	N	8553+ 5	4.5		4.5	19.8		101.0		105.0	96
	275	T	"	"				18.7		97.9	105.0	93
	358	N	8556+00	3.7		2.5	26.7		95.9		105.0	91
	276	T	"	"	2.3			25.1		97.6	105.0	93
	359	N	8532+00	4.5		2.6	24.8		99.3		105.0	94
	277	T	"	"	2.7			23.7		98.2	105.C	94
	360	N	8537+ 6	4.1			25.6		101.3		105.0	96
	278	T	"	"				24.3		96.7	105.0	92
7-14-71	361	N	8542+00	4.5			27.1		92.0		100.0	92
	279	T	"	"	4.6			23.0		98.9	100.0	99
	362	N	8529+15	4.4			27.7		94.8		100.0	95
	280	T	"	"				26.0		95.9	100.0	96
7-15-71	363	N	8548+00	3.5		3.5	25.8		95.0		105.0	90
	281	T	"	"	2.8			27.3		94.8	105.0	90
	364	N	8551+18	3.6		3.0	24.7		95.4		105.0	91
	282	T	"	"				19.9		100.9	105.0	96
	365	N	8554+00	3.4			24.1		95.9		105.0	91
	283	T	"	"	6.0			22.0		100.0	105.0	95
	368	N	8536+11	3.7		3.0	26.5		95.4		100.0	95
	288	T	"	"	2.8			25.8		95.4	100.0	95
	369	N	8540+85	3.6		3.2	26.5		95.3		100.0	95
	289	T	"	"	2.6			27.2		94.7	100.0	95
	370	N	8521+85	3.9		2.0	26.1		95.2		100.0	95
	290	T	"	"				25.6		94.6	100.0	95
	371	N	8526+ 8	3.4			24.5	23.6	98.0		100.0	98
	285	T	8521+90	4.4		3.0		26.8		89.9	105.0	85
	286	T	8524+90	4.5	2.8	3.0		26.9		93.5	105.0	89
7-16-71	372	N	8542+00	3.6		3.5	23.3		94.5		105.0	90
	291	T	"	"				21.4		101.3	105.0	96
	373	N	8540+ 9	3.3		3.5	25.6		98.3		105.0	93
	292	T	"	"	3.1			25.8		97.4	105.0	93
	374	N	8541+00	3.4		2.5	25.4		97.7		105.0	93
	293	T	"	"				24.4		98.8	105.0	94
	375	N	8539+00	3.6		3.0	25.7		94.3		105.0	90
	294	T	"	"	1.4			29.5		92.1	105.0	88
	376	N	8537+90	3.4		3.0	24.1		99.8		105.0	95
	295	T	"	"	2.7			25.3		97.7	105.0	93
	377	N	8537+10	3.6		2.1	23.6		96.8		105.0	92
	296	T	"	"				26.4		94.9	105.0	90
	378	N	8536+00	3.3		3.1	26.1		94.0		105.0	90
	297	T	"	"				24.9		93.4	105.0	89

TABLE I, FIELD DENSITY & STRENGTH TESTS

Date	Test No.	Test Type	Stationing	Depth Below Rail Base, feet	Unconfined Strength, tsf. Qu	Unconfined Strength, tsf. Pp	Water Content, % Nuc.	Water Content, % Oven	Dry Density, pcf. Nuc.	Dry Density, pcf. Other	Est. Mod. AASHO pcf.	% Comp.
7-16-71	379	N	8534+00	3.0		2.8	24.4		99.2		105.0	94
	298	T	"	"	2.9			26.2		95.0	105.0	91
	380	N	8533+00	3.4		3.3	26.9		95.8		105.0	91
	299	T	"	"				25.3		96.4	105.0	92
	381	N	8532+00	3.4		3.1	2c 7		92.2		105.0	88
	300	T	"	"	4.3			25.6		94.4	105.0	90
	382	N	8531+00	3.7		2.3	25.1		95.1		105.0	90
	301	T	"	"				23.9		99.0	105.0	94
	383	N	8530+00	3.8		4.0	24.7		97.7		105.0	93
	302	T	"	"				24.1		95.2	105.0	91
	384	N	8529+15	3.7		2.6	23.5		98.0		105.0	93
	303	T	"	"				20.6		99.0	105.0	94
	385	N	8526+ 3	3.1		4.2	23.3		97.6		105.0	93
	304	T	"	"	4.0			21.9		98.4	105.0	94
	386	N	8525+00	3.3		2.8	23.3		99.2		105.0	94
	305	T	"	"				23.6		100.9	105.0	96
	387	N	8524+10	3.2		3.5	24.7		95.4		105.0	90
	306	T	"	"				22.0		97.1	105.0	93
	388	N	8523+ 6	3.7		4.1	23.8		97.6		105.0	93
	307	T	"	"				24.0		94.6	105.0	90
7-19-71	389	N	8556+00	2.9		4.2	21.7		102.7		105.0	98
	312	T	"	"				18.4		107.1	105.0	102
	390	N	8554+00	2.8			23.3	20.8	98.2		105.0	94
	391	N	8550+59	3.4		3.6	25.8		95.6		105.0	91
	313	T	"	"	3.6			25.0		97.7	105.0	93
	392	N	8547+00	3.2		3.1	24.7		98.1		105.0	93
	314	T	"	"				24.4		99.7	105.0	95
	308	T	8566+39	1.9		2.5		27.1		94.3	105.0	90
	309	T	8563+95	2.5	5.0	4.4		22.8		99.9	105.0	95
	310	T	8561+50	2.5				23.8		99.5	105.0	95
	311	T	8558+47	2.4	5.3			22.1		99.6	105.0	95
7-20-71	393	N	8562+10	2.0		2.7	23.0	18.1	94.6		100.0	95
	394	N	8561+00	2.3		4.0	22.1		100.7		105.0	96
	315	T	"	"				23.4		100.0	105.0	95
	395	N	8559+95	2.1		3.8	26.4		98.8		105.0	94
	316	T	"	"	3.1			25.8		97.4	105.0	92
	396	N	8557+60	2.1		2.5	25.5		96.3		105.0	92
	317	T	"	"				22.6		99.2	105.0	94
	397	N	8554+96	2.2			25.0		95.6		105.0	91
	318	T	"	"				22.7		95.4	105.0	91
	398	N	8552+00	2.3		3.0	24.1		90.6		100.0	91
	319	T	"	"				18.4		105.2	100.0	105
	399	N	8550+00	2.2		4.0	27.4	26.0	92.2		100.0	92
	400	N	8547+00	2.2		2.1	25.8	19.7	95.4		100.0	95
	401	N	8531+00	3.2		3.9	28.7	27.3	92.0		100.0	92
7-21-71	402	N	8532+31	3.3			24.3		99.0		105.0	94
	320	T	"	"	7.8			21.6		105.2	105.0	100
	403	N	8533+95	3.0			19.1		104.3		105.0	99
	321	T	"	"				22.7		100.7	105.0	95
	404	N	8537+00	3.0			23.7		100.2		105.0	95
	322	T	"	"	4.5			27.3		93.0	105.0	89
	406	N	8543+00	2.3		3.3	25.0		98.8		105.0	94
	324	T	"	"				20.1		104.7	105.0	100
	407	N	8531+33	2.7		3.0	23.8		99.5		105.0	95
	325	T	"	"	2.8			27.7		94.4	105.0	90
	408	N	8534+55	2.3		2.6	25.0		94.2		105.0	90
	326	T	"	"				21.9		100.2	105.0	95
	409	N	8537+ 9	2.5		3.2	25.1		96.7		105.0	92
	327	T	"	"	2.0			25.5		97.2	105.0	92
	410	N	8540+ 5	2.0		3.1	26.2		98.4		105.0	93
	328	T	"	"				20.1		99.2	105.0	94
	411	N	8543+16	2.0			23.0		94.5		105.0	90
	329	T	"	"				27.3		100.5	105.0	96
7-22-71	412	N	8530+00	2.7		4.2	24.1		101.0		105.0	96
	330	T	"	"	1.7			27.9		93.2	105.0	88
	413	N	8533+00	1.9		1.6	27.8		94.4		105.0	90
	331	T	"	"				24.1		98.8	105.0	94
	414	N	8536+00	1.9		2.6	25.2		99.9		105.0	95
	332	T	"	"	2.8			24.7		97.4	105.0	93
	415	N	8526+00	2.4		2.2	25.2		98.6		105.0	94
	333	T	"	"				22.6		102.0	105.0	96
	416	N	8522+18	2.8		2.0	23.7		99.8		105.0	95
	334	T	"	"	1.9			27.6		94.4	105.0	90
7-27-71	417	N	8521+76	2.6		4.5	25.6	23.7	93.2		100.0	93
	418	N	8525+00	2.4		2.0	23.1		96.5		105.0	92
	335	T	"	"				23.1		93.0	105.0	89
	420	N	8523+00	2.0		2.8	25.5		98.8		105.0	94
	338	T	"	"	2.1			25.5		96.9	105.0	92
	336	T	8527+00	1.8	4.4			22.7		98.5	105.0	94
8- 2-71	421	N	8521+48	1.9			24.1		99.4		105.0	95
	334	T	"	"	1.9			27.6		94.4	105.0	90
8- 3-71	422	N	8527+40	1.5			26.3		95.6		105.0	91
	339	T	"	"	2.4			28.5		94.8	105.0	91
	424	N	8522+88	1.5			24.9		98.6		105.0	94
	341	T	"	"	2.7			26.8		98.3	105.0	93
	425	N	8519+18	1.5			25.0		97.6		105.0	93
	342	T	"	"				24.7		98.0	105.0	93
8- 6-71	426	N	8513+ 6	1.5			24.5	20.8	95.6		105.0	91
	427	N	8515+30	1.5			21.2	19.4	103.5		105.0	99
8-12-71	428	N	8597+75	1.5			25.9		98.5		105.0	94
8-24-71	1	L	8605+ 6	1.5			27.3	29.3	91.8		100.0	92
	2	L	8602+00	1.5			26.6	27.6	92.3		100.0	92
	3	L	8599+00	1.5			28.3	30.8	92.6		100.0	93
	4	L	8596+00	1.5			30.2	30.3	89.7		100.0	90

TABLE I, FIELD DENSITY & STRENGTH TESTS

Date	Test No.	Test Type	Stationing	Depth Below Rail Base, feet	Unconfined Strength, tsf.		Water Content, %		Dry Density, pcf.		Est. Mod. AASHO pcf.	% Comp.
					Qu	Pp	Nuc.	Oven	Nuc.	Other		
8-24-71	5	L	8593+00	1.5			28.9	29.0	90.6		100.0	91
	6	L	8590+00	1.5			28.3	29.1	86.0		100.0	86
	7	L	8587+00	1.9			28.6	27.2	87.8		100.0	88
	8	L	8584+00	1.9			26.8	26.9	91.5		100.0	92
	9	L	8581+00	1.9			26.9	31.0	88.3		100.0	88
8-26-71	13	L	8578+00	2.0			30.2	30.7	86.8		100.0	87
	14	L	8575+00	2.0			29.7	32.9	90.2		100.0	90
	15	L	8572+00	2.0			29.9	25.7	89.3		100.0	89
	16	L	8569+00	1.5			27.3	34.8	92.4		100.0	92
8-27-71	17	L	8566+00	1.5			28.6	32.2	87.3		100.0	87
	18	L	8564+00	1.5			27.4	31.3	93.7		100.0	94
	19	L	8560+00	2.0			28.3		92.6		100.0	93
	20	L	8556+85	2.0			28.3		92.1		100.0	92
	21	L	8553+90	2.0			30.8		86.0		100.0	86
	22	L	8550+90	2.0			29.0		91.5		100.0	92
	23	L	8547+85	2.0			30.5		87.7		100.0	88
	24	L	8545+85	1.5			31.1		88.1		100.0	88
8-28-71	25	L	8542+91	1.5			28.5		93.0		100.0	93
	26	L	8539+90	1.5			31.9		90.2		100.0	90
	27	L	8536+90	1.5			31.7		88.1		100.0	88
	28	L	8533+90	1.5			32.7		88.1		100.0	88
	29	L	8530+90	1.5			33.3		87.3		100.0	87
8-30-71	30	L	8527+77	1.5			26.5		93.1		100.0	93
	31	L	8525+00	1.5			29.4		89.1		100.0	89
	32	L	8521+00	1.5			26.9		91.0		100.0	91
	33	L	8518+00	1.5			25.5		93.3		100.0	93
8-30-71	34	L	8515+00	1.5			29.2		84.7		99.0	85
	35	L	8512+00	1.5			27.3		87.6		99.0	88

TABLE 2

COMPACTION TESTS

Date	Test No.	Location	Mat'l. Color	Test Method	Optimum Water Content,%	Maximum Dry Density,pcf
4/19/71	101	1st Lift	Brn	Mod.AASHO	16.9	112.8
4/19/71	102	2nd Lift	Red	Mod.AASHO	19.6	108.7
4/21/71	103	Sta.8578+00 HR	Red Brn	Mod.AASHO	17.7	109.7
	104	Sta.8565+00 HR	Red,Brn + Blk	Mod.AASHO	17.7	106.4
	105	Sta.8582+00E/ML	Red,Brn	Mod.AASHO	18.5	107.4
4/28/71	106	Sta.8543+16 HR	Brn+Red-Brn	Mod.AASHO	16.5	108.0
4/29/71	107	Sta.8574+00 HR	Brn+Red-Brn	Mod.AASHO	19.5	105.0
4/30/71	108	Sta.8573+00 HR	Dk.Red-Brn	Mod.AASHO	18.7	107.4
5/1/71	109	Sta.8533+00 HR	Motled Red.Brn. Blk.	Mod.AASHO	19.6	106.5
5/4/71	110	Sta.8524+00 HR	Brn-Gry	Mod.AASHO	18.8	105.3
5/6/71	111	Sta.8549+00 HR	Red.Brn-Gry	Mod.AASHO	21.5	104.6
5/18/71	112	Sta.8595+00 E	Red.Brn	Harv.Mini	21.5	102.5
6/1/71	113		Red Gry	Harv.Mini	19.2	105.2
6/1/71	114	Sta.8572+40 E	Red-Brn	Harv.Mini	19.2	107.0
6/1/71	115	Sta.8577+00 E	Red-Brn,Brn	Harv.Mini	18.7	107.9
6/3/71	116	Sta.8577 E/ML	Dk.Brn-Blk	Harv.Mini	18.5	108.2
6/3/71	117	Sta.8572 E/ML	Dk.Brn-Blk	Harv.Mini	19.7	106.9
6/7/71	118	E.side Area F	Orange-Red	Harv.Mini	18.5	111.1

Note: Harvard miniature compaction results have been adjusted to their Modified AASHO equivalent.

TABLE 2 (Contd.)

COMPACTION TESTS

Date	Test No.	Location	Mat'l Color	Test Method	Optimum Water Content,%	Maximum Dry Density,pcf
6/8/71	119	NE end Bor.Area E		Harv.Mini	19.5	107.2
6/9/71	120	NE end Bor.Area F	Red	Harv.Mini	17.5	112.2
	121	Top NE Area E	Red	Harv.Mini	21.6	102.0
	122	Top NE Area E	Blk.Red	Harv.Mini	20.2	104.7
7/2/71	123	Top N.C.Area G	Dk.Brn	Harv.Mini	16.9	108.8
	124	Top N.Area G	Brn	Harv.Mini	16.4	110.6
	125	N.C,Top 2" Area G	Brn	Harv.Mini	20.0	106.9
7/12/71	C-126	NE Area E	Red CH,Gry Silt	Harv.Mini	17.3	111.9
7/13/71	C-127	No.C.Top 1 Area G	Brn	Harv.Mini	23.0	101.7
7/15/71	C-128	Hill on G (B)	Red, Gry	Harv.Mini	17.3	112.6
7/14/71	C-129	Hill on G (A)	Red Gry	Harv.Mini	18.6	108.7
7/19/71	C-130	(N-359)(T-277)	Brn	Harv.Mini	18.8	109.1
7/26/71	C-131	(N-360)(T-278)	Brn Gry	Harv.Mini	18.9	108.8
7/26/71	C-132	(N-361)(T-279)	Brn	Harv.Mini	20.5	105.0
7/26/71	C-133	(N-375)(T-294)	Red CH & CH	Harv.Mini	20.7	106.3
7/29/71	C-134	(N-375)(T-295)	Brn,Red,Blk	Harv.Mini	17.7	111.0
7/27/71	C-135	(N-391)	Brn.Gry	Harv.Mini	16.9	111.9
8/4/71	C-136		Brn Red	Harv.Mini	18.4	110.0

Note: Harvard miniature compaction results have been adjusted to their Modified AASHO equivalent.

TABLE 3

LIME STRENGTH TESTS

Station	Unconfined Compressive strength tsf	Water content %	Dry density, pcf
8512	13.6	29.7	85.8
8515	5.7	35.4	78.9
8518	3.8	29.4	90.5
8521	6.2	26.8	87.3
8524	4.7	27.2	90.5
8527	5.9	28.4	89.5
8530	2.9	35.2	83.1
8533	4.2	32.1	87.2
8536	5.0	30.2	89.3
8539	3.0	33.9	84.8
8542	4.1	32.3	87.1
8545	6.2	34.3	83.3
8548	3.6	30.8	89.0
8551	1.2	32.8	85.8
8554	1.7	31.0	88.0
8557	3.1	30.4	88.9
8560	3.5	31.0	88.5
8563	4.1	29.6	89.5
8566	8.4	22.3	85.4
8569	6.0	20.6	90.3
8572	7.2	24.1	89.5
8575	12.8	26.6	84.9
8578	13.7	30.5	79.6
8581	10.3	26.7	88.7*
	9.0	26.6	88.7
8584	8.9	24.8	92.3
8587	8.9	27.9	85.2
8590	9.1	28.3	89.6
8593	8.2	29.4	85.7
8596	8.9	26.6	86.0
8599	7.1	23.8	91.8
8602	4.4	20.3	92.0
8605	5.2	17.7	90.1

* lab mix

Note: Just prior to field compaction of the lime-soil mixture, grab samples were taken at the above locations and Harvard miniature compaction specimens were made without allowing a change in water content. The specimens were sealed, cured in a 120° F oven for 48 hours, and failed in unconfined compression.

TABLE 4

SUMMARY OF FIELD TESTS

Section	Level	Dry Density, pcf		Water Content, %		Unconfined Compressive Strength, tsf	*Plate Load Test Δ in. @ 5 tsf
		Nuclear	Tube	Nuclear	Oven		
1	A(Lime)	90.1 (2)		28.1 (2)			0.065 (1)
	B	97.5 (9)	97.5 (7)	24.3 (9)	23.7 (9)	2.7 (3)	0.103 (1)
	C	95.7 (6)	96.2 (8)	24.7 (6)	24.0 (8)	3.8 (2)	0.138 (2)
	D	98.7 (7)	93.0 (1)	22.9 (7)	22.6 (6)		0.136 (3)
	Average	97.4	96.6	24.0	23.5	3.1	0.122
2	A(Lime)	87.8 (3)		32.6 (3)			0.057 (1)
	B	97.4(11)	96.6(10)	24.8(11)	25.3(11)	3.2 (5)	0.244 (2)
	C	95.5 (9)	97.1 (8)	26.0 (9)	25.3 (9)	2.7 (2)	0.192 (2)
	D	94.9 (7)	94.2 (3)	24.5 (7)	24.8(10)		0.293 (3)
	Average	96.1	96.4	25.1	25.1	3.1	0.226
3	A(Lime)	91.6 (2)		30.2 (2)			0.078 (1)
	B	97.7 (7)	99.4 (7)	24.9 (7)	23.4 (7)	2.6 (3)	0.225 (1)
	C	95.7 (8)	97.1 (8)	25.1 (8)	24.2 (8)	2.9 (3)	0.161 (2)
	D	95.4 (6)	93.3 (3)	26.8 (6)	25.9 (9)	2.6 (2)	0.111 (3)
	Average	96.3	97.3	25.5	24.6	2.7	0.137

*ASTM, Method D 1195-64, 6" Dia. Plate
( ) No. of Tests

Notes:
1. See Fig. 9 for the locations of levels.
2. Averages do not include the lime stabilized layer, Level A.
3. Dry density and water content were determined with a nuclear densometer and from samples taken with a Corps of Engineers surface sampler (tube).

TABLE 4 (Contd.)

SUMMARY OF FIELD TESTS

Section	Level	Dry Density, pcf		Water Content, %		Unconfined Compressive Strength, tsf	*Plate Load Test Δ in. @ 5 tsf
		Nuclear	Tube	Nuclear	Oven		
4	A(Lime)	88.4 (3)		30.1 (3)			0.064 (1)
	B	97.0 (4)	99.1 (3)	24.5 (4)	23.1 (4)	4.8‡ (2)	0.069 (3)
	C	97.9 (9)	100.4 (8)	23.8 (9)	21.3 (9)	2.8 (1)	0.130 (3)
	D	95.6 (6)	97.5 (5)	26.2 (6)	23.9 (9)	2.3 (2)	0.131 (3)
	Average	97.0	99.2	24.7	22.7	3.4‡	0.105
5	A(Lime)	95.4 (2)		28.3 (2)			0.090 (1)
	B	102.3 (2)	101.7 (3)	22.2 (2)	22.3 (4)	3.9 (1)	0.050 (3)
	C	95.3 (5)	98.5 (12)	25.0 (5)	22.4 (12)	2.3 (5)	0.159 (3)
	D	96.3 (8)	97.3 (4)	25.2 (8)	24.5 (8)	1.6 (2)	0.339 (2)
	Average	96.8	98.8	24.7	23.1	2.3	0.155
6	A(Lime)	90.5 (2)		28.0 (2)	31.8 (2)		0.059 (1)
	B	100.3 (3)	98.2 (2)	23.1 (3)	22.8 (4)	3.6 (2)	0.109 (6)
	C	99.1 (7)	97.7 (6)	24.8 (7)	24.2 (9)	2.5 (3)	0.166 (3)
	D	95.4 (11)	97.8 (5)	23.5 (11)	22.6 (11)	2.6 (3)	0.107 (4)
	Average	97.3	97.8	23.9	23.2	2.8	0.117

*ASTM, Method D 1195-64, 6" Dia. Plate
( ) No. of Tests
‡ Contains unusually high number
See first page for notes.

TABLE 4 (Contd.)

SUMMARY OF FIELD TESTS

Section	Level	Dry Density, pcf		Water Content, %		Unconfined Compressive Strength, tsf	*Plate Load Test Δ in. @ 5 tsf
		Nuclear	Tube	Nuclear	Oven		
7	A(Lime)	86.3 (6)		29.1 (6)	29.1 (6)		0.064 (1)
	B	99.1 (9)	98.9 (7)	24.8 (9)	24.6 (9)	3.4 (6)	0.182 (2)
	C	96.6(10)	99.1 (6)	25.1(10)	23.7(10)	2.5 (3)	0.074 (3)
	D	97.4(14)	100.0 (2)	21.4(14)	21.8(14)		0.110 (2)
	Average	97.6	99.1	23.4	23.1	3.1	0.109
8	A(Lime)	89.7 (2)		27.7 (2)	27.1 (2)		0.058 (2)
	B	98.9 (3)	100.7 (6)	24.7 (3)	24.0 (7)	2.1 (4)	0.157 (2)
	C	98.6(10)	99.5 (7)	24.8(10)	24.6(10)	3.1 (6)	0.148 (2)
	D	97.0(15)	97.2(10)	23.6(15)	24.2(14)	2.7 (8)	0.124 (3)
	Average	97.8	98.8	24.1	24.3	2.7	0.122
9	A(Lime)	88.8 (3)		29.1 (3)	29.5 (3)		0.040 (2)
	B	96.8 (9)	101.9(5)	25.0 (9)	23.2 (9)	3.1 (5)	0.122 (2)
	C	95.7 (9)	96.7 (8)	25.9 (9)	25.0 (9)	2.4 (7)	0.148 (4)
	D	99.4(21)	99.7(11)	21.5(19)	21.4(20)	3.0 (5)	0.148 (3)
	Average	97.9	99.2	23.4	22.7	2.8	0.124

*ASTM, Method D 1195-64, 6" Dia. Plate
( ) No. of Tests
See first page for notes.

TABLE 5

PLATE LOAD TESTS

Date 1971	Test No.	Stationing	Depth Below Rail Base, feet	Offset from ℄ ML, feet	Water Content, %	Seating Pressure, tsf	Deflection, inches		
							@1 tsf	@3 tsf	@5 tsf
5- 5	1	8574+99	6.5	35	-	1.0	.001	.017	.042
5- 5	2	8598+65	5.5	35	24.0	.2	.037	.092	.177
5- 6	3	8591+85	7.3	30	19.1	.2	.015	.048	.079
5- 6	4	8569+95	6.0	32	17.6	.6	.018	.082	.133
5- 6	5	8565+52	6.0	34	20.1	.8	.007	.038	.067
5- 7	6	8576+00	6.0	30	19.9	.6	.020	.064	.110
5- 7	7	8572+91	6.5	28	19.8	.5	.020	.064	.110
5-17	8	8567+32	6.3	27	24.0	.6	.020	.055	.096
5-17	9	8563+59	6.7	31	18.0	.6	.013	.075	.142
5-18	10	8575+50	6.0	32	27.5	.4	.044	.341	Fail.
5-18	11	8593+40	5.8	25	21.1	.4	.014	.047	.104
5-19	12	8588+22	6.3	24	25.5	.5	.020	.095	.265
5-20	13	8594+80	5.3	42	24.1	.7	.008	.047	.118
5-20	14	8585+38	7.7	45	20.7	.4	.009	.035	.064
5-21	15	8581+50	8.3	39	22.5	.9	.004	.026	.068
5-21	16	8591+92	5.5	29	25.4	.5	.019	.100	.260
5-27	17	8576+02	4.6	30	22.1	1.1	.004	.040	.101
5-27	18	8570+11	4.5	21	24.0	1.0	.006	.044	.163
5-28	19	8574+45	4.7	23	26.0	.5	.014	.039	.079
6- 1	20	8586+05	4.8	34	26.7	.5	.018	.063	.123
6- 1	21	8595+37	4.2	21	26.1	.4	.025	.096	.302
6- 2	22	8581+06	6.0	23	25.1	1.0	.004	.027	.059
6- 4	23	8593+33	4.3	27	25.1	1.4	.002	.021	.056
6- 7	24	8596+36	4.8	19.5	26.2	1.0	.005	.033	.116
6- 7	25	8565+36	5.8	30	24.8	1.0	.006	.058	.122
6- 9	26	8588+18	4.3	32	25.6	.7	.015	.063	.174
6- 9	27	8578+66	2.8	16.5	22.0	1.0	.003	.028	.057
6- 9	28	8577+09	3.0	27	19.6	1.1	.002	.027	.059
6-15	29	8570+42	4.2	21	22.0	1.3	.002	.022	.042
6-16	30	8586+98	2.5	30	22.2	.5	.015	.077	.180
6-16	31	8595+00	2.3	17	21.9	.4	.015	.078	.177
6-17	32	8588+07	1.8	15	20.8	.5	.024	.114	.198
6-21	33	8583+18	2.3	18	25.8	.9	.006	.041	.135
6-21	34	8591+24	2.4	18	24.1	.6	.015	.057	.725
6-22	35	8593+62	1.8	18	21.0	1.0	.004	.032	.068

TABLE 5 (Contd.)

PLATE LOAD TESTS

Date 1971	Test No.	Stationing	Depth Below Rail Base, feet	Offset from ℄ ML, feet	Water Content, %	Seating Pressure, tsf	Deflection, inches		
							@1 tsf	@3tsf	@5 tsf
6-22	36	8567+26	3.8	18	23.0	.5	.033	.121	.261
6-22	37	8559+30	6.5	33	25.1	.4	.029	.122	.323
6-23	38	8570+37	2.3	15	26.5	.7	.013	.099	.305
6-24	39	8564+06	5.2	18	24.2	.6	.014	.068	.149
6-24	40	8566+40	3.9	20	23.7	.5	.013	.047	.087
6-24	41	8560+48	5.3	27	25.1	.3	.022	.080	.183
6-25	42	8551+99	7.0	33	23.6	.5	.019	.072	.144
6-25	43	8557+93	6.9	24	29.0	.3	.032	.127	.356
6-28	44	8530+06	6.3	24	22.8	.3	.044	.136	.249
6-28	45	8533+05	6.3	24	29.0	.7	.009	.062	.197
6-29	46	8535+07	6.3	21	27.1	.5	.024	.122	.434
6-29	47	8567+62	2.1	15	26.7	.5	.014	.054	.113
6-29	48	8565+39	2.8	21	21.6	.3	.036	.094	.161
6-30	49	8563+87	3.0	15	24.1	.5	.022	.084	.206
6-30	50	8550+06	5.8	21	26.3	.7	.010	.058	.132
6-30	51	8547+80	5.8	24	23.1	.6	.014	.052	.117
7- 2	52	8538+11	6.1	27	22.3	.7	.007	.047	.124
7- 2	53	8541+18	6.3	24	23.7	.3	.020	.060	.129
7- 2	54	8543+12	6.1	24	25.9	1.1	.005	.037	.081
7- 8	55	8598+31	1.8	15	24.6	.7	.011	.066	.164
7- 8	56	8602+87	2.0	12	23.3	.6	.015	.068	.159
7- 8	57	8608+02	1.8	13	33.1	.8	.011	.090	.358
7- 9	58	8521+09	6.0	24	22.1	.6	.013	.060	.113
7-12	59	8523+53	6.0	33	23.5	.3	.013	.077	.184
7-12	60	8526+61	6.0	33	24.2	.3	.019	.058	.111
7-12	61	8551+34	5.1	18	25.8	.6	.015	.085	.219
7-13	62	8530+16	5.2	33	24.1	.7	.014	.098	.279
7-13	63	8523+83	4.7	30	26.0	.7	.009	.070	.216
7-16	64	8559+35	4.0	27	26.3	.7	.012	.079	.164
7-16	65	8557+60	4.0	24	27.1	.8	.008	.046	.130
7-16	66	8547+54	4.3	27	24.8	1.1	.003	.024	.049
7-16	67	8550+36	4.6	28	25.5	.5	.017	.060	.122
7-17	68	8534+03	3.3	18	26.0	.6	.019	.099	.251
7-17	69	8535+97	3.5	24	22.3	.8	.008	.036	.106

TABLE 5 (Contd.)

PLATE LOAD TESTS

Date 1971	Test No.	Stationing	Depth Below Rail Base, feet	Offset from ℄ ML, feet	Water Content, %	Seating Pressure, tsf	Deflection, inches		
							@1 tsf	@3tsf	@5 tsf
7-17	70	8543+10	3.7	16	24.7	.5	.021	.079	.136
7-19	71	8541+33	3.4	15	23.6	.7	.011	.062	.186
7-19	72	8537+97	3.3	16	24.5	.6	.017	.105	.237
7-19	73	8526+73	3.3	18	24.1	.6	.009	.037	.103
7-19	74	8521+22	3.5	18	22.4	1.5	.001	.026	.061
7-21	75	8551+94	2.3	24	23.2	.7	.006	.030	.074
7-21	76	8554+85	2.3	16	23.0	1.3	.001	.018	.038
7-21	77	8558+33	2.4	15	22.8	1.9	.0003	.007	.020
7-21	78	8561+56	2.4	16	22.6	.4	.010	.051	.093
7-22	79	8549+10	2.4	24	26.7	.7	.014	.105	.654
7-22	80	8553+53	2.5	15	23.2	1.1	.005	.031	.075
7-27	81	8568+54	2.0	21	20.9	1.1	.003	.021	.037
7-27	82	8566+43	1.8	21	22.8	1.0	.005	.034	.077
7-27	83	8563+99	1.8	20	22.0	.8	.006	.031	.062
8- 3	84	8543+43	1.5	25	25.3	1.3	.0035	.033	.085
8- 3	85	8541+99	1.6	27	25.5	.8	.009	.054	.143
8- 3	86	8540+01	1.3	15	23.3	1.2	.003	.028	.066
8- 3	87	8538+05	1.9	18	23.4	1.0	.008	.079	.225
8- 4	88	8519+92	1.6	27	25.2	.6	.014	.069	.187
8- 4	89	8522+84	1.6	18	24.7	.5	.018	.058	.143
8- 4	90	8525+47	1.4	21	22.4	1.4	.003	.019	.046
8- 4	91	8526+98	1.5	21	23.2	.8	.008	.042	.080
8- 5	92	8536+25	1.7	24	23.6	1.0	.005	.029	.060
8- 5	93	8534+00	1.7	24	24.2	1.0	.006	.057	.166
8- 5	94	8531+91	1.7	25	26.1	.6	.012	.039	.073
8- 5	95	8529+06	1.7	22	22.7	1.0	.005	.031	.060
8- 6	96	8547+01	2.3	18	22.9	1.1	.002	.024	.058
8- 6	97	8555+94	2.5	18	26.5	.5	.036	.227	1.002
8-10	98	8575+09	2.0	27	20.3	1.7	.001	.011	.022
8-10	99	8572+82	2.0	24	23.6	1.4	.002	.020	.052
8-10	100	8568+27	1.9	27	22.5	1.3	.002	.025	.059
8-10	101	8558+88	2.0	29	21.7	.5	.019	.073	.172
8-11	102	8588+46	2.0	27	24.1	1.5	.002	.018	.041
8-11	103	8593+06	1.7	18	26.6	.8	.011	.081	.221

TABLE 5 (Contd.)

PLATE LOAD TESTS

Date 1971	Test No.	Stationing	Depth Below Rail Base, feet	Offset from ℄ ML, feet	Water Content, %	Seating Pressure, tsf	Deflection, inches		
							@1 tsf	@3tsf	@5 tsf
8-11	104	8561+45	1.7	18	20.5	.8	.008	.039	.065
8-11	105	8513+85	1.5	16	22.1	1.4	.002	.028	.078
8-30	L-1	8604+00	1.5	21	24.1	.8	.005	.027	.047
8-30	L-2	8598+94	1.5	30	23.3	1.4	.001	.012	.023
8-31	L-3	8594+00	1.5	25	27.7	1.1	.0005	.017	.036
8-31	L-4	8591+04	1.5	30	20.2	.9	.004	.024	.045
8-31	L-5	8588+46	1.9	32	24.5	.8	.005	.028	.047
9- 9	L-6	8583+18	1.9	30	22.7	.3	.013	.041	.069
9- 9	L-7	8575+09	2.0	30	23.8	.5	.017	.058	.083
10- 2	L-8	8568+27	1.5	30	21.6	.6	.007	.034	.059
10- 2	L-9	8558+88	1.5	30	19.2	.4	.019	.058	.090
10- 2	L-10	8543+43	1.5	31	19.9	.6	.011	.045	.078
10- 2	L-11	8553+53	2.0	30	19.1	.6	.008	.037	.064
10- 4	L-12	8535+00	1.5	30	18.4	.5	.009	.034	.057
10- 4	L-13	8525+15	1.5	30	21.8	.4	.011	.039	.065
10- 4	L-14	8513+00	1.5	21	20.6	.6	.009	.037	.062
10- 4	L-15	8512+73	1.5	21	17.0	.6	.009	.038	.061

TABLE 6

VERTICAL EXTENSOMETER DATA

LEGEND

1. Instrument number

   Example: 2401 - 2

   - 2 — Anchor number
   - 01 — The number of that particular instrument in the test section.
   - 4 — Instrument type:
     1. Horizontal tubing
     2. Pressure cells
     3. Moisture-temperature cells
     4. Multi-position extensometers
     5. Single-position extensometers
   - 2 — Test section, 1 - 9

2. Anchor depths and depth to top of rock are referenced to top of subgrade.

3. Initial readings were taken with the project Schaevitz TR-100 Readout Box set to the 0.003 scale. The L or R with the initial readings denotes if the reading was on the left or right side of the scale. A load placed over the terminal box would produce a lesser reading on the left scale or an increased reading on the right scale.

4. Initial readings were taken before placement of ballast and track structures.

TABLE 6

VERTICAL EXTENSOMETER DATA

Inst. No.	Station	LVDT Serial No.	Sensitivity MV/V/in.x10	Anchor Depth, ft.	Depth to Top of Rock, ft.	Initial Reading
1501	8522+68	1056	3817	9.6	7.4	0.4 L
1502	8523+68	1051	3790	8.2	6.0	1.2 L
1503	8524+68	1063	3703	8.9	6.4	1.2 L
1401-1	8525+68	1035	3743	1.3	6.5	0.7 L
-2		1015	3805	3.5		0.3 L
-4		949	3778	9.3		1.2 L
1402-1		930	3740	1.3	6.4	0.8 L
-2		933	3780	3.5		1.5 L
-4		947	3813	9.2		0.6 L
1403-1		928	3790	1.3	6.4	0.5 L
-2		1008	3778	3.5		0.5 L
-4		934	3788	8.9		1.3 L
1504	8526+68	1003	3773	9.0	6.6	1.2 L
2501	8532+16.75	1088	3800	11.2	8.6	0.9 L
2502	8533+15.75	931	3773	10.3	7.3	1.7 L
2503	8534+17	929	3767	9.1	6.8	1.0 L
2401-1	8535+16	1027	3823	1.3	7.5	0.6 L
-2		1040	3782	3.5		1.4 L
-4		1067	3723	10.0		0.8 L
2402-1		1052	3792	1.3	7.4	0.4 L
-2		1001	3790	3.5		1.2 L
-4		1048	3812	9.9		1.3 L
2403-1		1038	3793	1.3	7.3	0.4 L
-2		1057	3775	3.5		0.8 L
-4		1068	3790	10.2		0.7 L
2504	8536+06	919	3798	8.7	7.4	0.5 L

TABLE 6 (Contd.)

VERTICAL EXTENSOMETER DATA

Inst. No.	Station	LVDT Serial No.	Sensitivity MV/V/in.x10	Anchor Depth, ft.	Depth to Top of Rock, ft.	Initial Reading
3501	8540+06	1031	3825	8.8	7.4	1.1 L
3502	8541+06	1039	3763	9.6	8.0	0.8 L
3503	8542+16	943	3827	10.7	8.0	0.5 L
3401-1	8543+16	1024	3813	1.3	8.0	0.9 L
-2		1050	3803	3.5		1.4 L
-4		1058	3810	10.1		1.1 L
3402-1		1066	3775	1.3	8.0	0.1 R
-2		1059	3770	3.5		0.2 L
-4		1017	3770	10.8		0.7 L
3403-1		1072	3800	1.4	8.0	0.5 L
-2		1004	3774	3.6		0.9 L
-4		1016	3760	10.8		1.0 L
3504	8544+16	1091	3740	10.5	7.7	0.8 L
4501	8549+36	1082	3760	13.0	9.7	0.9 L
4502	8550+36	1094	3793	11.5	9.0	0.9 L
4503	8551+36	1032	3790	14.1	11.4	1.1 L
4401-1	8552+36	995	3775	1.3	11.4	0.4 L
-2		1000	3798	3.4		1.0 L
-3		1006	3770	5.4		0.5 L
-4		927	3818	14.5		0.3 L
4402-1		1012	3778	1.3	11.7	0
-2		1083	3793	3.5		0.6 L
-3		1084	3760	5.5		0.4 L
-4		1078	3820	14.1		0.2 L
4403-1		1085	3740	1.3	12.1	0.8 L
-2		996	3765	3.5		1.5 L
-3		1011	3783	5.5		2.1 L
-4		948	3720	14.7		0.8 L
4504	8553+36	1073	3658	11.8	8.7	0.2 L

TABLE 6 (Contd.)

VERTICAL EXTENSOMETER DATA

Inst. No.	Station	LVDT Serial No.	Sensitivity MV/V/in.x10	Anchor Depth, ft.	Depth to Top of Rock, ft.	Initial Reading
5501	8557+36	993	3792	9.3	7.1	0.6 L
5502	8558+36	1054	3807	9.0	6.3	1.1 L
5503	8559+36	1033	3817	8.2	5.9	1.2 L
5401-1	8560+36	1026	3778	1.3	5.6	0.5 L
-2		1096	3757	3.5		0.7 L
-4		1002	3823	8.6		0.9 L
5402-1		1044	3792	1.3	6.4	0.8 L
-2		1093	3745	3.5		1.3 L
-4		1007	3777	9.1		0.7 L
5403-1		1034	3792	1.3	6.4	0.7 L
-2		1074	3787	3.5		1.0 L
-4		1086	3792	8.4		0.7 L
5504	8561+36	1045	3810		6.5	0.6 L
6501	8564+79.38	915	3793	9.3	6.4	0.9 L
6502	8565+80.12	917	3743	13.6	10.5	0.6 L
6503	8566+69.50	946	3793	8.6	6.8	0.7 L
6401-1	8567+80	1037	3815	1.3	8.4	0.2 L
-2		1092	3775	3.5		1.1 L
-3		1049	3763	5.5		1.1 L
-4		1046	3777	10.1		0.6 L
6402-1		1025	3805	1.3	7.8	0.7 L
-2		1036	3810	3.5		1.2 L
-3		1087	3745	5.5		1.3 L
-4		1070	3688	10.3		1.4 L
6403-1		1071	3682	1.3	7.2	0.6 L
-2		994	3805	3.5		1.3 L
-3		1005	3802	5.5		1.3 L
-4		1013	3750	9.8		1.5 L
6504	8568+30.38	914	3708	10.4	7.5	0.5 L

TABLE 6 (Contd.)

VERTICAL EXTENSOMETER DATA

Inst. No.	Station	LVDT Serial No.	Sensitivity MV/V/in.x10	Anchor Depth, ft.	Depth to Top of Rock, ft.	Initial Reading
7501	8573+41	916	3595	10.1	7.0	1.1 L
7502	8574+41	1042	3800	8.6	6.0	1.2 L
7503	8575+41	1047	3807	8.6	5.9	1.3 L
7401-1	8576+41	1090	3777	1.3	7.4	3.4 L
-2		1009	3780	3.5		4.1 L
-4		1014	3758	10.1		5.0 L
7402-1		1010	3800	1.3	7.7	1.5 L
-2		998	3742	3.5		3.0 L
-4		1065	3773	10.0		5.0 L
7403-1		1061	3798	1.3	7.0	1.0 L
-2		1018	3740	3.5		2.6 L
-4		992	3787	8.9		3.5 L
7504	8577+41	991	3772	7.8	5.5	0.9 L
8501	8584+33.75	989	3767	10.2	7.2	0.6 L
8502	8585+32.75	1080	3785	10.0	7.7	1.0 L
8503	8586+34	1069	3762	10.2	8.0	0.9 L
8401-1	8587+33	997	3773	1.3	7.5	0.8 L
-2		1055	3798	3.5		0.8 L
-4		1043	3782	10.2		0.9 L
8402-1		944	3763	1.3	7.5	0.6 L
-2		1041	3817	3.5		0.9 L
-4		1053	3815	9.9		0.9 L
8403-1		918	3717	1.3	7.5	0.1 R
-2		1030	3808	3.5		0.7 L
-4		942	3705	9.3		0.8 L
8504	8588+23	935	3810	8.0	6.9	0.4 L

TABLE 6 (Contd)

VERTICAL EXTENSOMETER DATA

Inst. No.	Station	LVDT Serial No.	Sensitivity MV/V/in.x10	Anchor Depth, ft.	Depth to Top of Rock, ft.	Initial Reading
9501	8592+32.38	945	3713	9.1	7.1	0.5 L
9502	8593+33.12	1095	3763	9.9	6.3	0.2 R
9503	8594+32.25	1079	3687	17.1	15.8	0.6 L
9401-1	8595+33	999	3773	1.3	19.0	0.9 L
-2		990	3802	3.5		3.0 L
-3		941	3773	5.5		1.6 L
-4		1081	3765	19.0		1.8 L
9402-1		1075	3728	1.3	19.5	0.8 L
-2		1028	3763	3.5		2.2 L
-3		1029	3810	5.5		1.6 L
-4		1077	3740	19.0		1.8 L
9403-1		1064	3792	1.3	19.5	0.7 L
-2		1076	3758	3.5		1.0 L
-3		1062	3705	5.4		1.7 L
-4		932	3780	19.2		1.1 L
9504	8596+33.75	1089	3772	10.0	8.2	0

TABLE 7

TUBE COUPLING SURVEY DATA

Test Section	Level	Date	Distances from End of Tubing to Back Edge of Coupling (feet)								
			Open End	Varies	Varies	5.0'	2.5'	℄ 2.5'	2.5'	2.5'	5.0' Closed End
1	1	8-18-71	3.329	5.360	10.339	15.357	17.866	20.355	22.847	25.365	30.356
		9-11-71	3.327	5.362	10.342	15.362	17.872	20.364	22.856	25.375	30.367
		10-13-71	3.326	5.366	10.350	15.372	17.883	20.376	22.867	25.387	30.381
	2	8-18-71		3.325	7.617	12.609	15.119	17.606	20.101	22.595	27.616
		9-11-71		3.321	7.622	12.618	15.129	17.613	20.110	22.603	27.630
		10-13-71		3.320	7.630	12.626	15.138	17.628	20.124	22.618	27.646
	3	8-18-71		3.325	5.531	10.539	13.037	15.539	18.037	20.535	25.531
		9-11-71		3.123	5.530	10.542	13.039	15.548	18.042	20.538	25.537
		10-13-71		3.321	5.543	10.552	13.051	15.558	18.054	20.552	25.551
	4	9-11-71			3.323	8.325	10.823	13.327	15.819	18.313	23.179
		10-13-71			3.323	8.326	10.828	13.330	15.825	18.324	

Survey data was obtained with the aluminum strain rods.
Measurements were made to a reference cap at the open end of the tubing

TABLE 7 (Contd.)

TUBE COUPLING SURVEY DATA

Test Section	Level	Date	Distances from End of Tubing to Back Edge of Coupling (feet)								
			Varies Open End	Varies	5.0'	2.5'	2.5'	℄ 2.5'	2.5'	5.0'	Closed End
2	1	8-19-71	3.325	5.324	10.343	15.319	17.835	20.316	22.814	25.304	30.335
		9-11-71	3.325	5.324	10.346	15.322	17.840	20.320	22.820	25.308	30.340
		10-13-71	3.321	5.326	10.350	15.326	17.845	20.326	22.826	25.314	30.345
	2	8-19-71		3.326	7.633	12.647	15.134	17.648	20.154	22.650	27.652
		9-11-71		3.325	7.636	12.653	15.140	17.655	20.157	22.656	27.655
		10-13-71		3.322	7.644	12.663	15.150	17.666	20.170	22.668	27.666
	3	8-19-71		3.328	5.547	10.534	13.035	15.553	18.048	20.553	25.546
		9-11-71		3.326	5.552	10.538	13.041	15.559	18.056	20.560	25.554
		10-13-71		3.324	5.561	10.550	13.055	15.571	18.068	20.572	25.565
	4	9-11-71			3.317	8.291	10.802	13.300	15.804	18.310	23.302
		10-13-71			3.313	8.298	10.809	13.309	15.812	18.319	23.311

See first sheet for notes.

TABLE 7 (Contd.)

TUBE COUPLING SURVEY DATA

Test Section	Level	Date	Distances from End of Tubing to Back Edge of Coupling (feet)								
			Open End	Varies	Varies	5.0'	2.5'	2.5' ℄	2.5'	2.5'	5.0' Closed End
3	1	8-19-71	3.326	5.338	10.364	15.376	17.874	20.363	22.860	25.378	30.382
		9-13-71	3.234	5.340	10.368	15.380	17.877	20.377	22.866	25.384	30.417
		10-12-71	3.322	5.341	10.368	15.379	17.876	20.367	22.864	25.382	30.385
	2	8-19-71		3.251	7.445	12.434	14.963	17.451	19.958	22.460	27.455
		9-13-71		3.249	7.458	12.441	14.969	17.457	19.964	22.467	27.476
		10-12-71		3.249	7.462	12.445	14.972	17.458	19.967	22.469	27.478
	3	8-19-71		3.326	5.576	10.568	13.084	15.574	18.058	20.562	25.572
		9-13-71		3.322	5.477	10.572	13.088	15.580	18.063	20.568	25.577
		10-12-71		3.322	5.581	10.578	13.094	15.583	18.069	20.571	25.580
	4	9-13-71			3.319	8.326	10.821	13.328	15.828	18.337	23.332
		10-12-71			3.320	8.330	10.824	13.331	15.833	18.340	23.335

See first sheet for notes.

TABLE 7 (Contd.)

TUBE COUPLING SURVEY DATA

Test Section	Level	Date	Open End	Varies	Varies	5.0'	2.5'	2.5' ℄	2.5'	2.5'	5.0' Closed End
			Distances from End of Tubing to Back Edge of Coupling (feet)								
4	1	8-19-71	3.322	5.305	10.308	15.303	17.814	20.318	22.823	25.328	30.334
		9-13-71	3.320	5.304	10.312	15.308	17.818	20.322	22.828	25.332	30.340
		10-12-71	3.319	5.306	10.312	15.306	17.818	20.322	22.828	25.331	30.338
	2	8-19-71		3.322	8.240	13.234	15.727	18.233	20.703	23.212	28.223
		9-13-71		3.318	8.243	13.239	15.736	18.239	20.710	23.220	28.232
		10-12-71		3.318	8.248	13.243	15.742	18.243	20.713	23.223	28.236
	3	8-19-71		3.321	6.305	11.292	13.788	16.317	18.822	21.343	26.295
		9-13-71		3.319	6.322	11.311	13.808	16.310	18.814	21.320	26.318
		10-12-71		3.321	6.325	11.316	13.812	16.312	18.818	21.322	26.321
	4	9-13-71		3.322	4.059	9.054	11.552	14.052	16.546	19.057	24.045
		10-12-71		3.321	4.059	9.058	11.555	14.057	16.550	19.062	24.049

See first sheet for notes.

TABLE 7 (Contd.)

TUBE COUPLING SURVEY DATA

Test Section	Level	Date	Distances from End of Tubing to Back Edge of Coupling (feet)								
			Varies Open End	Varies	5.0'	2.5'	2.5' ℄	2.5'	2.5'	5.0'	Closed End
5	1	8-19-71	3.325	5.339	10.348	15.335	17.841	20.339	22.821	25.314	30.308
		9-13-71	3.322	5.339	10.352	15.336	17.845	20.342	22.826	25.318	30.311
		10-12-71	3.322	5.343	10.357	15.341	17.850	20.348	22.830	25.321	30.316
	2	8-19-71		3.328	8.382	13.384	15.883	18.377	20.885	23.384	28.383
		9-13-71			8.387	13.387	15.887	18.382	20.890	23.389	28.388
		10-12-71		3.325	8.390	13.393	15.892	18.387	20.894	23.394	28.394
	3	8-19-71		3.325	6.313	11.288	13.806	16.297	18.799	21.307	26.293
		9-13-71			6.322	11.300	13.809	16.310	18.814	21.319	26.307
		10-12-71		3.324	6.326	11.302	13.822	16.312	18.818	21.320	26.312
	4	9-13-71		3.318	4.052	9.046	11.536	14.052	16.542	19.042	24.037
		10-12-71		3.317	4.052	9.051	11.542	14.061	16.549	19.048	24.045

See first sheet for notes.

TABLE 7 (Contd.)

TUBE COUPLING SURVEY DATA

Test Section	Level	Date	Distances from End of Tubing to Back Edge of Coupling (feet)								
			Varies, Open End	Varies	5.0'	2.5'	2.5'	℄ 2.5'	2.5'	5.0'	Closed End
6	1	8-19-71	3.324	5.305	10.357	15.357	17.857	20.371	22.885	25.387	30.391
		9-13-71	3.348	5.307	10.360	15.361	17.859	20.372	22.859	25.391	30.394
		10-12-71	3.346	5.308	10.366	15.370	17.872	20.384	22.899	25.404	30.410
	2	8-19-71		3.325	7.519	12.527	15.035	17.527	20.033	22.529	27.501
		9-13-71		3.324	7.521	12.529	15.037	17.529	20.036	22.533	27.507
		10-12-71		3.322	7.523	12.535	15.046	17.539	20.046	22.544	27.521
	3	8-19-71		3.320	5.539	10.534	13.049	15.539	18.045	20.530	25.543
		9-13-71		3.320	5.544	10.541	13.056	15.546	18.053	20.538	25.554
		10-12-71		3.318	5.548	10.548	13.066	15.557	18.066	20.550	25.566
	4	9-13-71			3.321	8.321	10.816	13.296	15.791	18.292	23.282
		10-12-71			3.320	8.326	10.822	13.300	15.798	18.298	23.291

See first sheet for notes.

TABLE 7 (Contd.)

TUBE COUPLING SURVEY DATA

Test Section	Level	Date	Distances from End of Tubing to Back Edge of Coupling (feet): Open End (Varies)	Varies	5.0'	2.5'	2.5'	℄ 2.5'	2.5'	5.0'	Closed End
7	1	8-20-71	3.325	5.336	10.360	15.353	17.865	20.372	22.854	25.385	30.383
		9-13-71	3.322	5.337	10.371	15.352	17.864	20.369	22.850	25.380	30.376
		10-11-71	3.319	5.339	10.366	15.357	17.870	20.376	22.858	25.390	30.387
	2	8-20-71		3.319	8.253	13.348	15.869	18.355	20.862	23.353	28.323
		9-13-71		3.320	8.355	13.359	15.869	18.354	20.862	23.350	28.321
		10-11-71		3.318	8.360	13.365	15.875	18.362	20.868	23.357	28.329
	3	8-20-71		3.319	6.290	11.315	13.799	16.299	18.807	21.318	26.315
		9-13-71		3.327	6.296	11.317	13.802	16.301	18.810	21.320	26.311
		10-11-71		3.318	6.297	11.322	13.805	16.307	18.818	21.328	26.324
	4	9-13-71		3.323	4.053	9.042	11.547	14.033	16.520	19.019	24.009
		10-11-71		3.320	4.055	9.048	11.553	14.042	16.531	19.030	24.016

See first sheet for notes.

TABLE 7 (Contd.)

TUBE COUPLING SURVEY DATA

Test Section	Level	Date	Distances from End of Tubing to Back Edge of Coupling (feet)								
			Varies Open End	Varies	5.0'	2.5'	2.5'	2.5' ℄	2.5'	5.0'	Closed End
8	1	8-20-71	3.321	5.325	10.342	15.343	17.825	20.342	22.827	25.329	30.151
		9-13-71	3.320	5.325	10.340	15.341	17.821	20.336	22.822	25.319	30.298
		10-11-71	3.317	5.325	10.341	15.344	17.824	20.340	22.825	25.328	30.306
	2	8-20-71		3.321	8.384	13.389	15.893	18.396	20.901	23.399	28.403
		9-13-71		3.320		13.387	15.892	18.396	20.898	23.398	28.399
		10-11-71		3.320	8.387	13.391	15.936	18.439	20.943	23.443	28.406
	3	8-20-71		3.323	6.303	11.302	13.797	16.295	18.799	21.298	26.278
		9-13-71		3.323	6.304	11.304	13.797	16.297	18.798	21.301	26.275
		10-11-71		3.362	6.305	11.305	13.799	16.298	18.803	21.303	26.281
	4	9-13-71		3.320	4.062	9.051	11.550	14.063	16.568	19.066	24.075
		10-11-71		3.317	4.060	9.055	11.555	14.068	16.573	19.072	24.082

See first sheet for notes.

TABLE 7 (Contd.)

TUBE COUPLING SURVEY DATA

Test Section	Level	Date	Distances from End of Tubing to Back Edge of Coupling (feet): Varies, Open End	Varies	5.0'	2.5'	2.5'	2.5'	2.5' ℄	5.0'	Closed End
9	1	8-18-71	3.320	5.311	10.321	15.334	17.838	20.315			
		9-13-71	3.319	5.312	10.322	15.336	17.836				
		10-11-71	3.320	5.312	10.328	15.342	17.845	20.320			
	2	8-18-71		3.315	7.545	12.568	15.097	17.597	20.107	22.617	27.623
		9-13-71		3.314	7.547	12.570	15.100	17.600	20.108	22.615	27.623
		10-11-71		3.111	7.548	12.573	15.105	17.602	20.112	22.622	27.632
	3	8-18-71		3.329	5.562	10.549	13.039		18.035	20.523	25.534
		9-13-71		3.326	5.562	10.551	13.042	15.546	18.038	20.524	25.536
		10-11-71		3.324	5.562	10.555	13.046	15.550	18.041	20.529	25.544
	4	9-13-71			3.321	8.310	10.806	13.316	15.826	18.316	23.308
		10-11-71			3.319	8.312	10.808	13.319	15.830	18.322	23.315

See first sheet for notes.

TABLE 8

PRESSURE CELL DATA

Test Section	Cell Number	Cell Range psi	Manufacturer's Number	Sensitivity MV/V/psi	Initial Reading
1	1201	25	060	8.680	0
	1202	50	141	4.740	1.2 L
	1203	100	095	2.000	2.0 R
2	2201	25	044	8.667	0.1 L
	2202	50	073	4.263	1.8 R
	2203	100	096	2.225	0.2 R
3	3201	25	051	10.220	1.8 R
	3202	50	070	4.203	0.7 R
	3203	100	093	2.040	1.1 R
4	4201	50	081	4.223	0.2 L
	4202	50	064	2.947	0.4 L
	4203	50	078	4.263	0.2 L
5	5201	50	076	2.440	0.1 L
	5202	50	068	3.020	0.2 R
	5203	50	074	4.206	0.4 R
6	6201	25	049	8.793	4.2 L
	6202	50	080	4.316	0
	6203	100	087	2.216	0.9 L

See notes on following sheet.

TABLE 8 (Contd.)

PRESSURE CELL DATA

Test Section	Cell Number	Cell Range psi	Manufacturer's Number	Sensitivity MV/V/psi	Initial Reading
7	7201	50	065	3.120	0.6 R
	7202	50	079	4.303	0.4 R
	7203	100	099	1.802	0.4 L
8	8201	25	053	9.360	9.1 L
	8202	50	067	3.100	0.2 R
	8203	100	094	2.000	0.5 R
9	9201	25	047	8.693	2.8 R
	9202	50	077	4.086	1.3 R
	9203	100	090	2.000	1.0 R

Notes:

1. Refer to the Legend for Table 6 for an explanation of cell numbering.
2. Initial readings were obtained with the project Schaevitz Readout Box set at the 0.003 scale. The L or R denotes the side of the scale read. Loading the cell caused a decrease in reading on the right scale or an increase on the left scale.
3. Initial readings were taken before placement of ballast and track structures.

TABLE 9

MOISTURE CELL DATA

Section Number	Cell Number	Temperature Calibration Factor	Date (1971) *Inst.	Read	Temperature °F	Temperature Corrected Resistance after 1 day, $\Omega \times 10^5$	Water Content %
1	1	1.07	7-12	7-22	76	1.65	26
	2	1.05	7-12	7-22	78	2.40	29
	3	1.09	7-14	7-22	78	1.55	29
	4	1.03	7-14	7-22	79	3.40	30
	5	1.04	7-14	7-22	89	4.10	28
	6	1.06	7-14	7-22	77	3.05	31
	7	0.94	7-17	7-22	80	1.28	35
	8	0.91	7-17	7-22	80	3.70	32
	9	1.04	7-17	7-22	78	2.80	33
	10	0.93	7-17	7-22	80	2.60	32
	11	1.04	9-10	10-13	59	9.60	31
	12	1.02	9-10	10-13	60	3.00	34
	13	1.03	9-10	10-13	68	0.50	30
2	1	1.08	7-13	7-22	76	3.40	32
	2	1.05	7-13	7-22	77	1.25	31
	3	0.98	7-17	7-22	80	0.27	31
	4	1.00	7-17	7-22	79	1.08	31
	5	0.98	7-17	7-22	78	4.40	32
	6	1.04	7-17	7-22	75	8.40	35
	7	1.00	8-2	8-18	77	2.70	30
	8	1.02	8-2	8-18	77	4.30	36
	9	1.03	8-2	8-18	75	3.40	35
	10	0.99	8-2	8-18	77	2.05	34
	11	1.08	9-8	9-11	69	4.30	36
	12	1.06	9-8	9-11	77	1.16	39
	13	1.03	9-8	9-11	78	2.85	31

* Date installed.

TABLE 9 (Contd.)

MOISTURE CELL DATA

Section Number	Cell Number	Temperature Calibration Factor	Date (1971) Inst.	Read	Temperature °F	Temperature Corrected Resistance after 1 day, Ω x 10^5	Water Content %
3	1	1.06	7-13	7-22	75	2.80	32
	2	1.07	7-13	7-22	76	3.60	29
	3	1.05	7-17	7-22	77	2.20	29
	4	1.06	7-17	7-22	75	2.30	27
	5	0.96	7-19	7-22	76	1.55	32
	6	1.03	7-17	7-22	73	3.90	28
	7	1.03	7-27	8-3	72	4.45	32
	8	1.07	7-27	8-3	72	2.55	30
	9	0.93	7-27	8-3	71	3.20	30
	10	1.07	7-27	8-3	72	3.30	27
	11	1.00	9-8	9-13	76	3.65	33
	12	1.06	9-8	9-13	74	5.60	34
	13	0.99	9-8	9-13	81	4.20	32
4	1	1.09	7-12	7-22	75	3.10	27
	2	1.00	7-12	7-22	76	2.30	26
	3	0.98	7-15	7-22	78	6.00	33
	4	1.08	7-15	7-22	76	3.10	32
	5	1.02	7-15	7-22	78	4.70	30
	6	1.04	7-15	7-22	79	36.0	33
	7	1.09	7-21	7-22	74	1.85	27
	8	1.07	7-21	7-22	76	1.75	30
	9	1.07	7-21	7-22	77	4.50	30
	10	1.05	7-21	8-3	74	10.0	32
	11	1.01	9-7	9-13	75	4.50	32
	12	0.97	9-7	9-13	77	3.50	34
	13	1.05	9-7	9-13	73	2.55	30

TABLE 9 (Contd.)

MOISTURE CELL DATA

Section Number	Cell Number	Temperature Calibration Factor	Date (1971) Inst.	Date (1971) Read	Temperature °F	Temperature Corrected Resistance after 1 day, $\Omega \times 10^5$	Water Content %
5	1	1.05	6-28	7-1	75	2.30	22
	2	1.02	6-28	7-1	75	2.40	22
	3	1.02	7-15	7-22	76	4.20	26
	4	1.05	7-15	7-22	77	4.20	26
	5	1.06	7-15	7-22	78	1.40	24
	6	1.03	7-15	7-22	74	2.50	26
	7	1.02	7-20	7-22	70	3.80	32
	8	1.09	7-20	7-22	73	2.10	30
	9	1.08	7-20	7-22	72	1.30	29
	10	0.93	7-20	7-22	77	2.20	27
	11	1.03	9-3	9-13	77	12.8	42
	12	1.00	9-3	9-13	75	10.5	37
	13	1.01	9-3	9-13	78	13.0	33
6	1	1.02	5.27	6-4	63	1.90	32
	2	1.03	5-27	6-4	66	5.80	26
	3	0.93	6-25	7-1	73	4.20	22
	4	0.98	6-25	7-1	75	2.50	24
	5	0.97	6-25	7-1	77	1.90	24
	6	1.05	6-25	7-1	72	1.90	25
	7	0.97	6-30	7-7	81	1.10	30
	8	1.05	6-30	7-7	79	4.20	30
	9	0.99	6-30	7-7	80	5.50	31
	10	1.06	6-30	7-7	78	6.00	30
	11	1.02	9-3	9-13	93	11.0	33
	12	1.05	9-3	9-13	80	3.20	36
	13	1.07	9-3	9-13	81	0.011	28

TABLE 9 (Contd.)

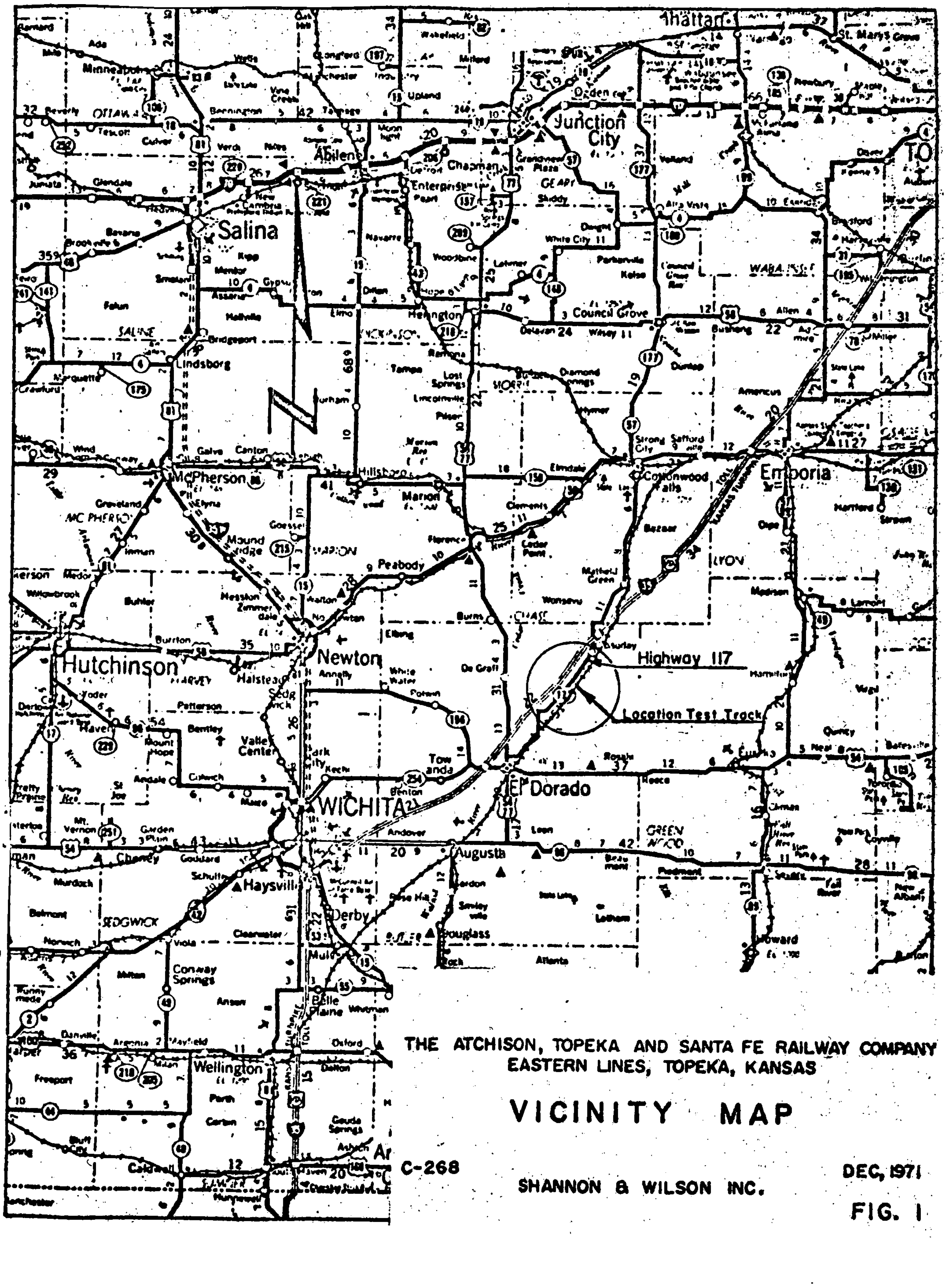
MOISTURE CELL DATA

Section Number	Cell Number	Temperature Calibration Factor	Date (1971) Inst.	Date (1971) Read	Temperature °F	Temperature Corrected Resistance after 1 day, $\Omega \times 10^5$	Water Content %
7	1	1.05	5-8	6-4	62	11.5	26
	2	1.01	5-8	6-4	64	6.00	29
	3	0.99	5-28	6-4	65	4.60	35
	4	1.02	5-28	6-4	64	6.80	34
	5	0.99	5-28	6-4	65	4.40	33
	6	1.00	5-28	6-4	64	8.80	31
	7	1.05	6-16	6-23	76	5.30	29
	8	1.09	6-16	6-23	74	2.90	24
	9	0.92	6-16	6-23	78	12.0	30
	10	1.04	6-16	6-23	75	2.70	24
	11	1.05	9-2	9-13	89	7.20	32
	12	1.02	9-2	9-13	79	8.00	31
	13	1.09	9-2	9-13	77	0.415	30
8	1	0.91	5-21	5-27	63	2.10	-
	2	0.96	5-21	5-27	63	4.80	-
	3	1.03	6-2	6-4	65	1.15	35
	4	1.02	6-2	6-16	68	0.115	35
	5	1.03	6-2	6-4	67	2.20	36
	6	1.09	6-2	6-4	67	2.70	32
	7	1.04	6-25	7-1	79	2.80	22
	8	1.02	6-25	7-1	78	2.70	26
	9	1.09	6-25	6-28	79	2.80	34
	10	1.09	6-25	7-1	75	5.20	26
	11	1.03	9-1	9-13	93	8.40	26
	12	1.02	9-1	9-13	86	7.10	25
	13	1.07	9-1	9-13	79	3.05	26

TABLE 9 (Contd.)

MOISTURE CELL DATA

Section Number	Cell Number	Temperature Calibration Factor	Date (1971) Inst. Read	Temperature °F	Temperature Corrected Resistance after 1 day, $\Omega \times 10^5$	Water Content %
9	1	0.97	5-14 6-23	65	9.60	31
	2	1.00	5-14 6-23	64	11.5	34
	3	0.98	6-2 6-4	65	4.60	31
	4	1.04	6-2 6-4	64	7.00	29
	5	1.09	6-2 6-16	70	0.012	34
	6	1.06	6-2 6-4	67	8.20	32
	7	0.98	7-21 8-3	73	2.25	32
	8	1.04	7-21 8-3	75	4.60	36
	9	1.02	7-21 8-3	75	6.50	30
	10	1.06	7-21 8-3	74	1.22	33
	11	1.08	8-31 9-13	91	9.80	33
	12	1.07	8-31 9-13	83	7.80	35
	13	0.96	8-31 9-13	82	2.25	24



THE ATCHISON, TOPEKA AND SANTA FE RAILWAY COMPANY
EASTERN LINES, TOPEKA, KANSAS

VICINITY MAP

C-268

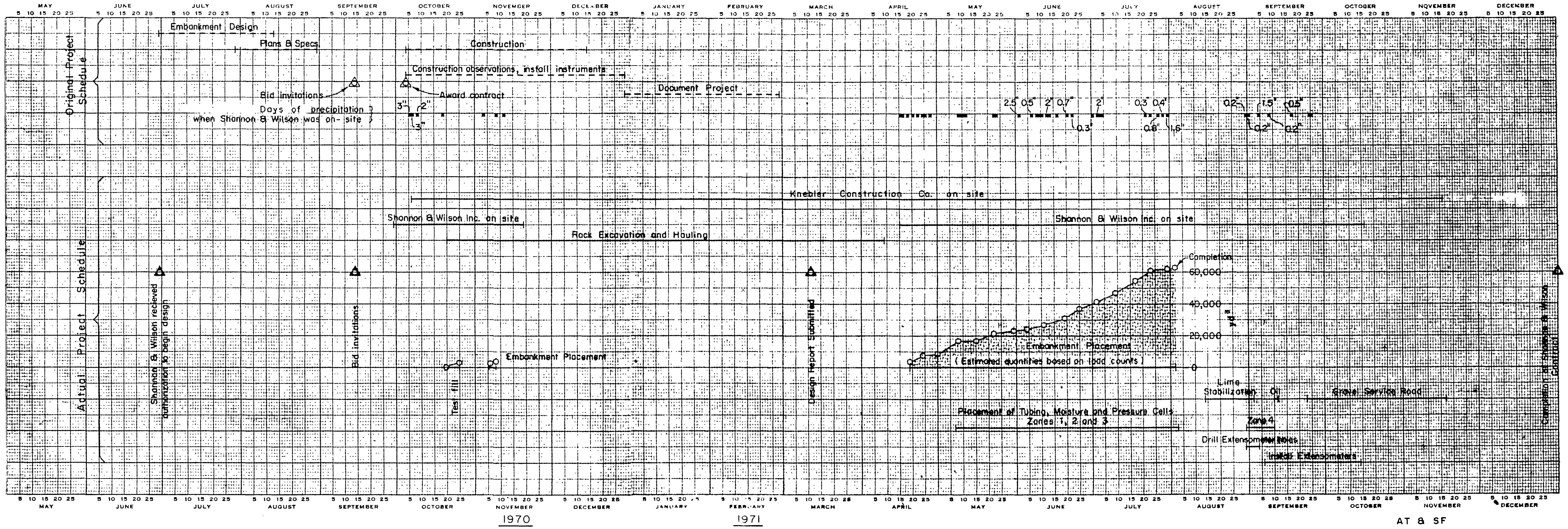
SHANNON & WILSON INC.

DEC, 1971

FIG. I


LEGEND:
Main instrumentation array.
Single-position extensometer
Boring {B-1-B-16 Hemphill Corp, April 1969 / B-21-B-30 Shannon & Wilson Inc, July 1970
Test pit {TP-1-TP-24, July 1970 / TP-25-TP-27, Sept 1970
Note: 1. Stationing for Main Line and Test Track are identical in tangent section only.
2. Subsurface conditions between indicated borings or test pits may vary from that shown.
3. All elevations are based on AT & SF datum.
RAILROAD WEST
RAILROAD EAST
Section 1 – Concrete Ties 30" OC. 10" Ballast 800'
Existing ground line at ℄ of test track
Designed base of rail
Subgrade
Red-brown CLAY (CH)
Rock
Pale yellow, clayey SILT
Bottom of embankment - Design
As-built
ELEVATION IN FEET
THE ATCHISON, TOPEKA AND SANTA FE RAILWAY COMPANY
EASTERN LINES, TOPEKA, KANSAS
DATED Sept. 18, 1970
APPROVED
Chief Engineer
U.S. DEPARTMENT OF TRANSPORTATION
EXPERIMENTAL TEST TRACK
EMBANKMENT
PLAN AND PROFILE OF
TEST TRACK
EMBANKMENT
SHANNON & WILSON INC.

FIG. 2.



AT & SF

CONSTRUCTION PROGRESS

C-268

DEC, 1971

FIG. 3

SUMMARY OF FIELD & LABORATORY COMPACTION TESTS

SHANNON & WILSON

☐ STANDARD AASHO (AASHO T 99-57, ASTM D698-58T)
■ MODIFIED AASHO (AASHO T180-57, ASTM D1557-58T)
☐ OTHER ____________

PROJECT AT & SF KANSAS
JOB NO. C-268 DATE ____
SAMPLE NO. ____
DEPTH ____

MAX. DRY DENSITY LBS./CU. FT. ____
OPTIMUM W.C., % ____
NATURAL W.C., % ____

HAMMER WT., LBS. ____
DROP, IN. ____
NO. LAYERS ____
NO. BLOWS/LAYER ____
DIA. MOLD., IN. ____
HEIGHT MOLD., IN. ____
VOL. MOLD., CU. FT. ____
COMPACTIVE EFFORT-FT. LBS/CU. FT. ____
SAMPLE CLASSIFICATION ____

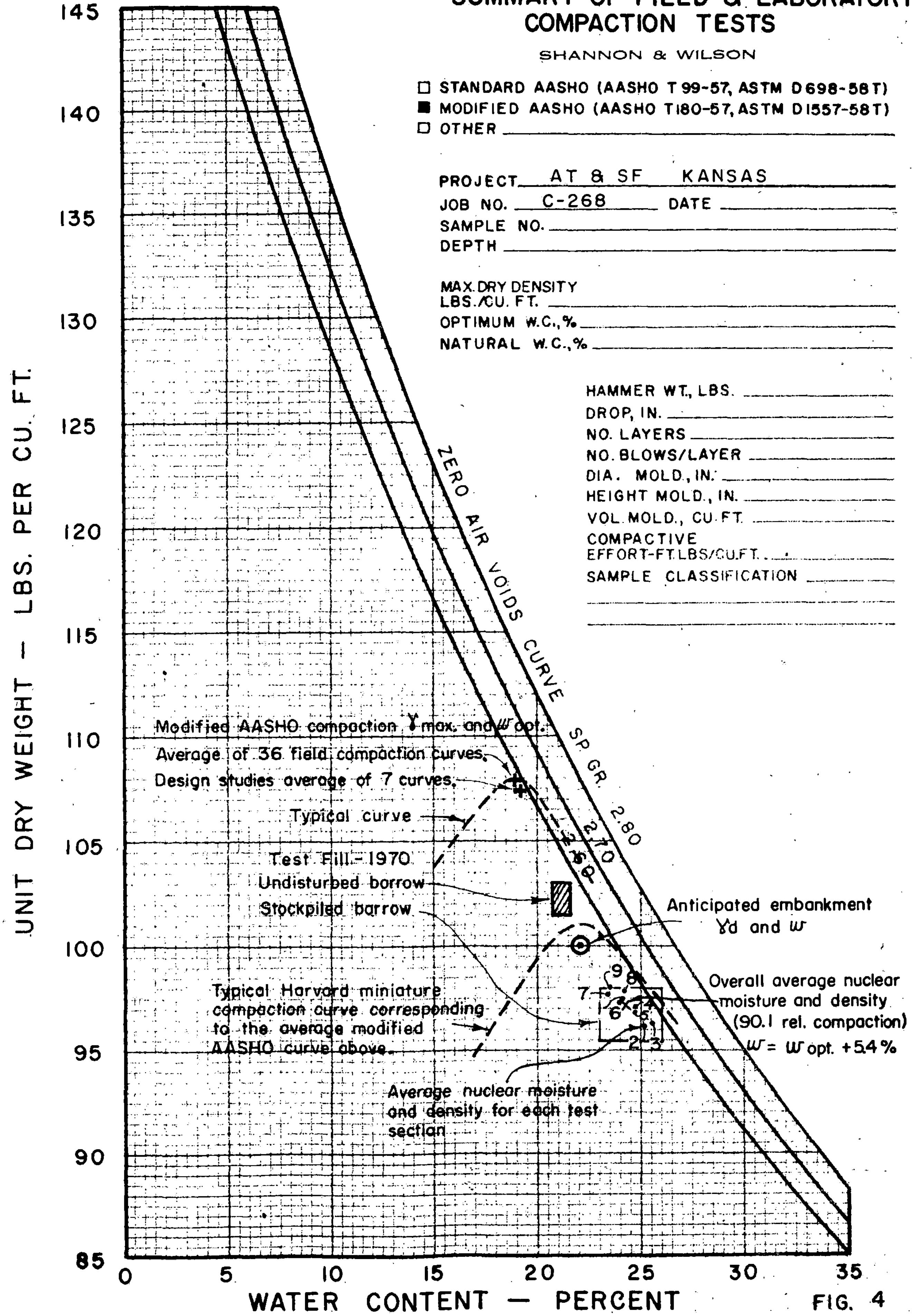
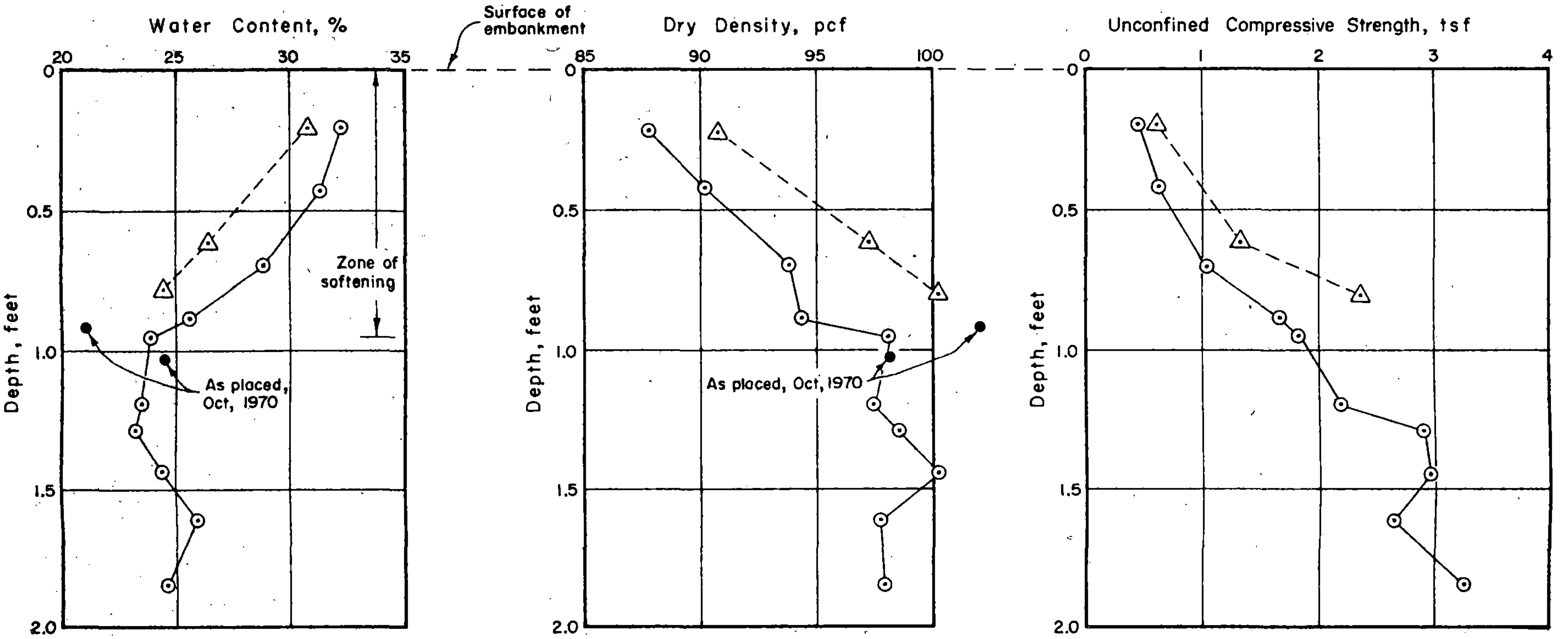


FIG. 4



⊙ Embankment surface 4.1' below base of rail at Sta. 8600+62.

△ Embankment surface 4.7' below base of rail at Sta. 8598+73.

● Tests on embankment during placement, October 1970.

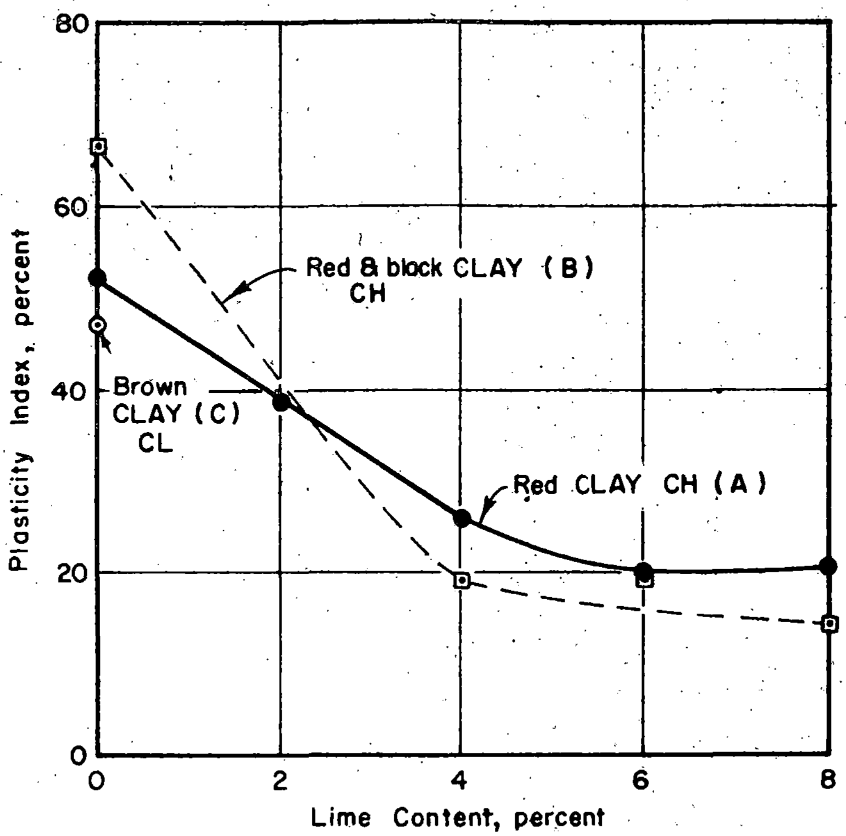
AT & SF

EMBANKMENT SOFTENING, EXPOSED ONE WINTER

C-268 DEC, 1971

SHANNON & WILSON, INC.
SOIL MECHANICS & FOUNDATION ENGINEERS

FIG. 5



Sample	PL	LL	PI	Color
A	18	70	52	Red
B	18	85	67	Red & Black
C	17	64	47	Brown

Samples were cured 1 hr. in lime before performing the Atterberg limits.

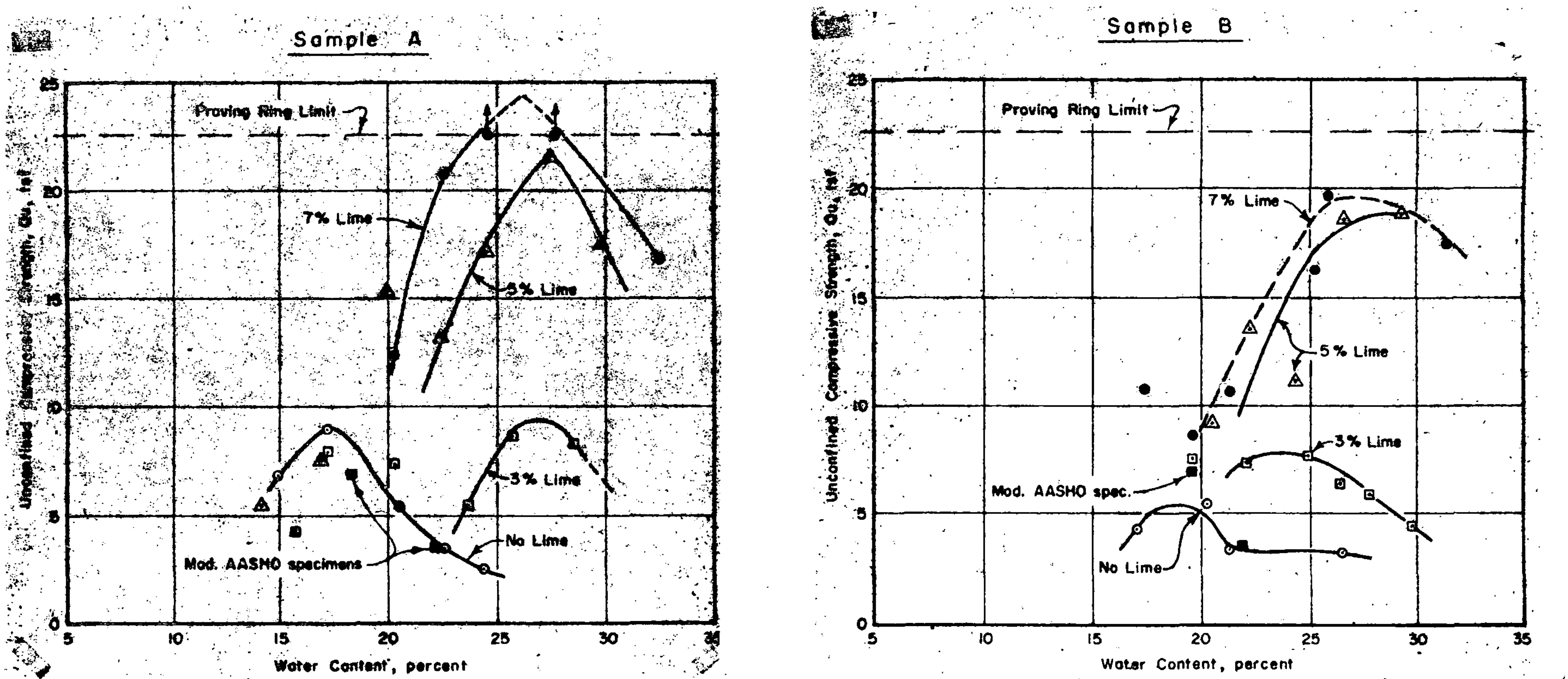
AT & SF

LIME CONTENT vs. PLASTICITY INDEX

C-268 DEC, 1971

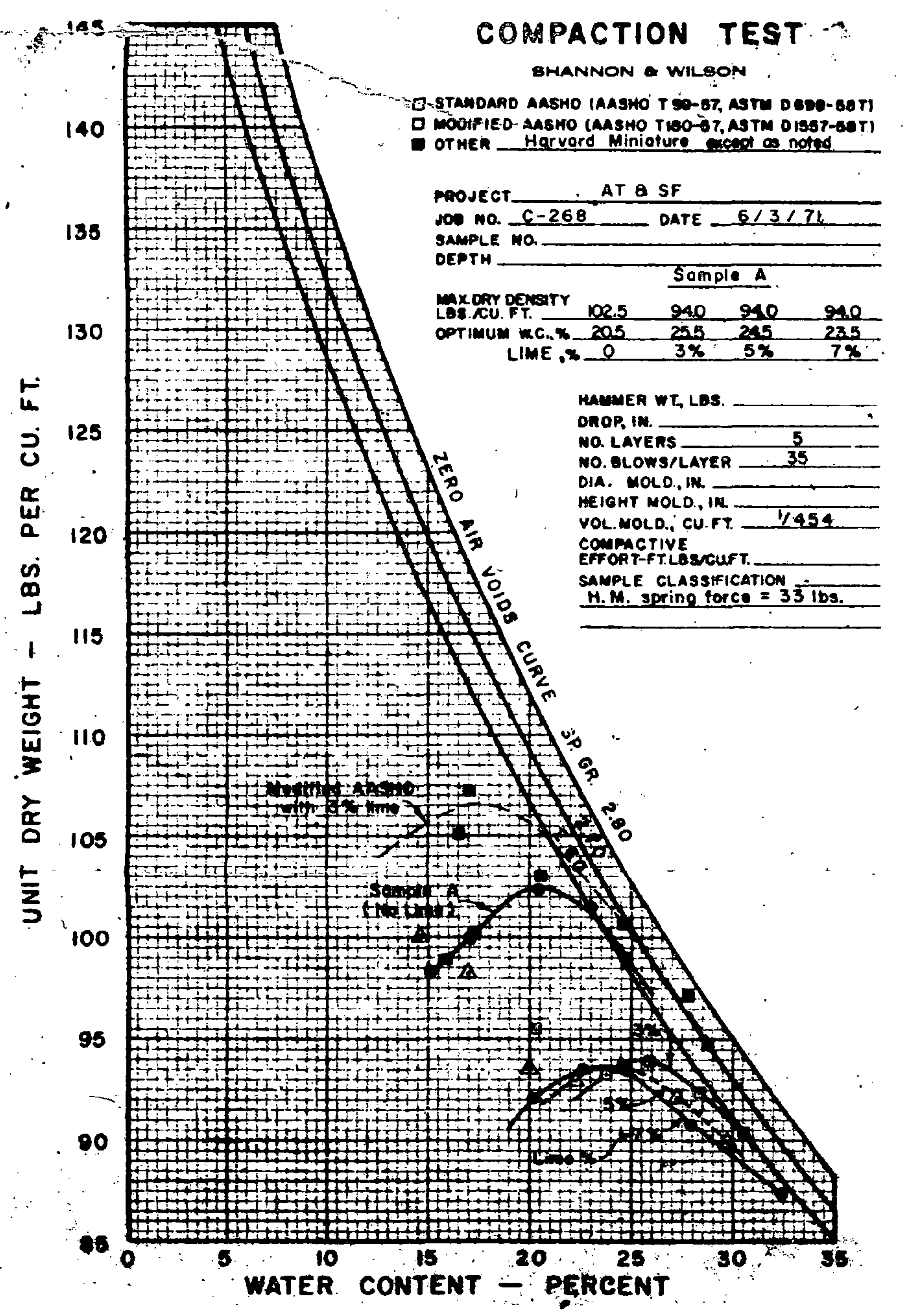
SHANNON & WILSON
SOIL MECHANICS & FOUNDATION ENGINEERS

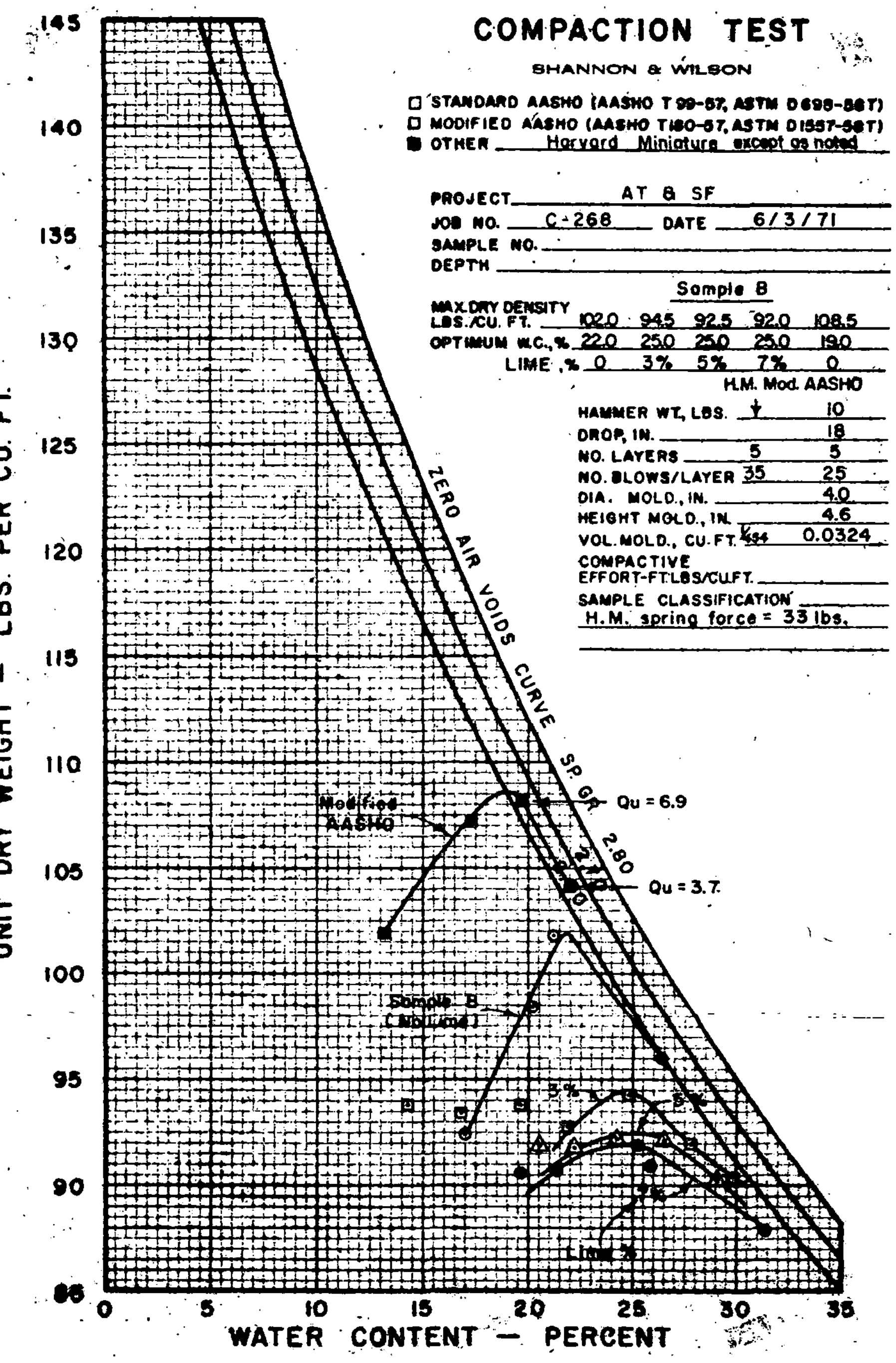
FIG. 6



Samples were Harvard miniature compaction specimens. Samples were sealed and cured in a 120° F oven for 48 hours. } Lime treated specimen

All water contents are after oven-curing; water loss was negligible.





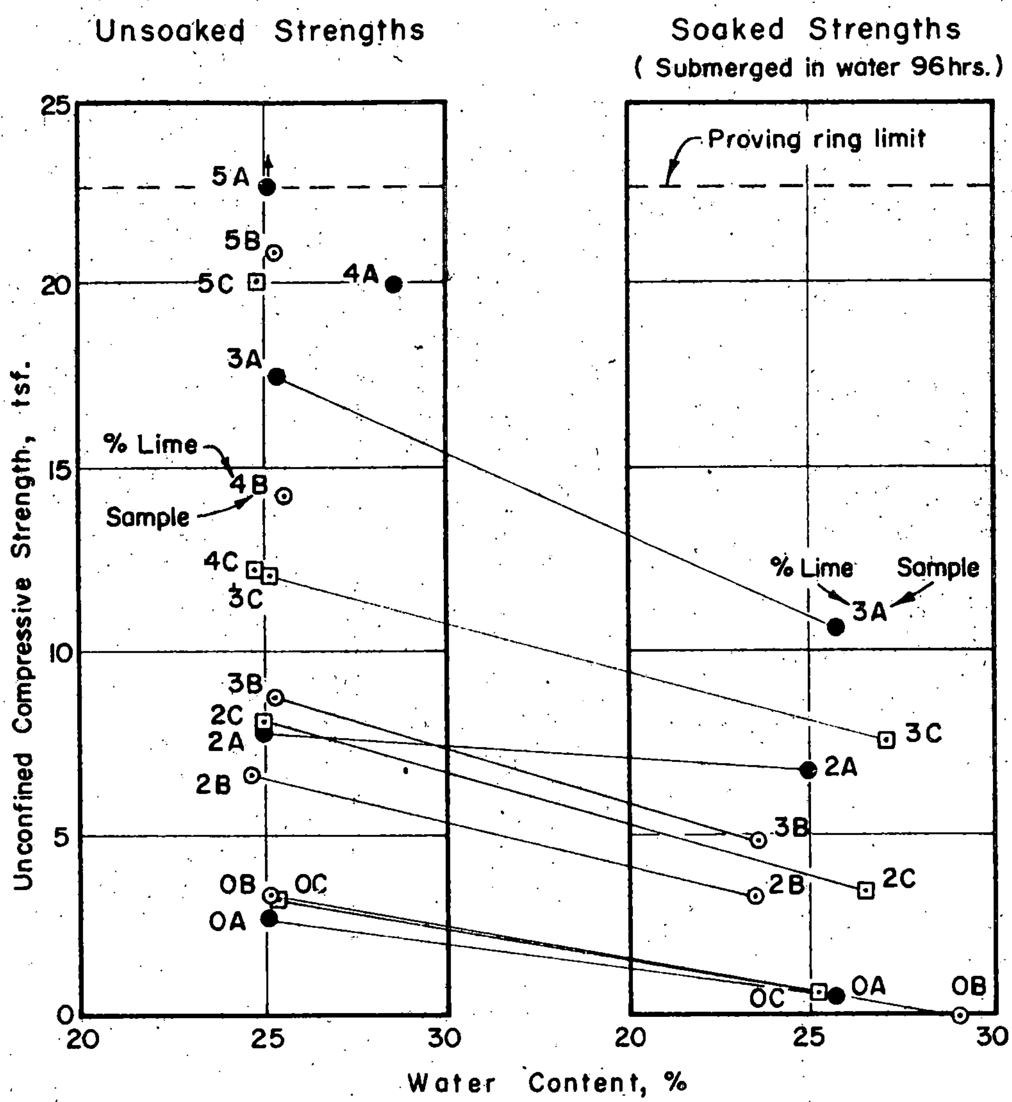
AT & SF

STRENGTH AND COMPACTION OF LIME - TREATED SOILS

C-268 DEC, 1971

SHANNON & WILSON
SOIL MECHANICS & FOUNDATION ENGINEERS

FIG. 7



NOTES:

1. Water content shown is that before soaking.

2. Specimens were formed by compacting soil into a Harvard miniature mold in five layers using 35 tamps with a spring pressure of 33 lbs.

3. All specimens were wrapped to maintain a constant water content while being cured for 48 hours in a 120° F oven.

AT & SF

SOAKED vs. UNSOAKED LIME STRENGTHS

C-268 DEC, 1971

SHANNON & WILSON
SOIL MECHANICS & FOUNDATION ENGINEERS

FIG. 8

0 100' 200' 300'
Horiz. Scale

0 1' 2' 3'
Vert. Scale

LEGEND:

△ Plate Load Test

□ Nuclear density and Water content tests

■ Density, Water content, and Unconfined compressive strength tests.

T Corps of Engineer Tube Sample. Tube samples at the same location as nuclear tests are not plotted.

R Tests using Rainhart Densometer.

All tests shown within Layer A were conducted before it was lime stabilized.

♦ Tests on top of subgrade conducted before lime stabilization.

Tests were located by stationing and depth below base of rail; distances from centerline vary.

Refer to Table I for test results.

AT-8 SF

LOCATION OF FIELD TESTS

C-268

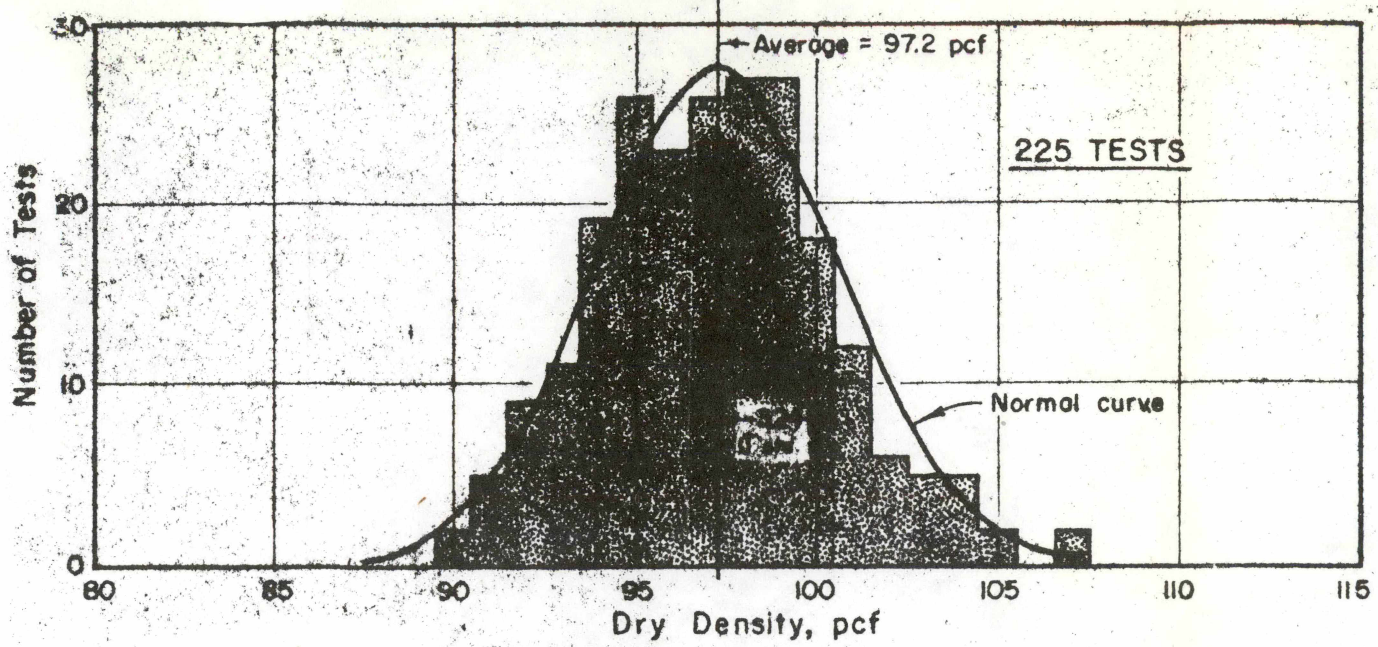
SHANNON & WILSON

SOIL MECHANICS & FOUNDATION ENGINEERS

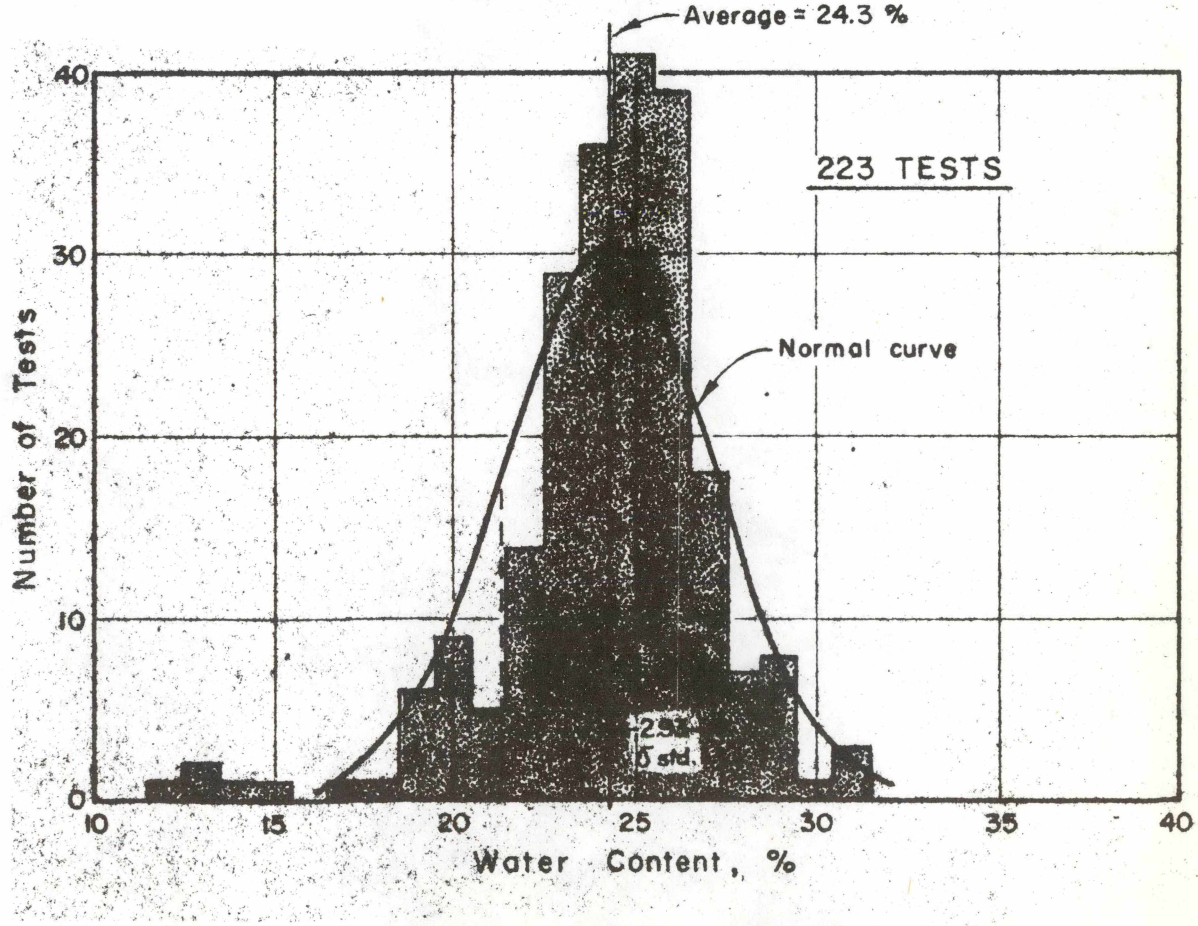
DEC. 1971

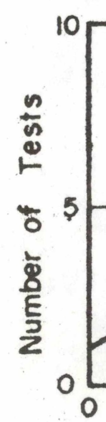
FIG. 9

FIELD DENSITY (nuclear only)

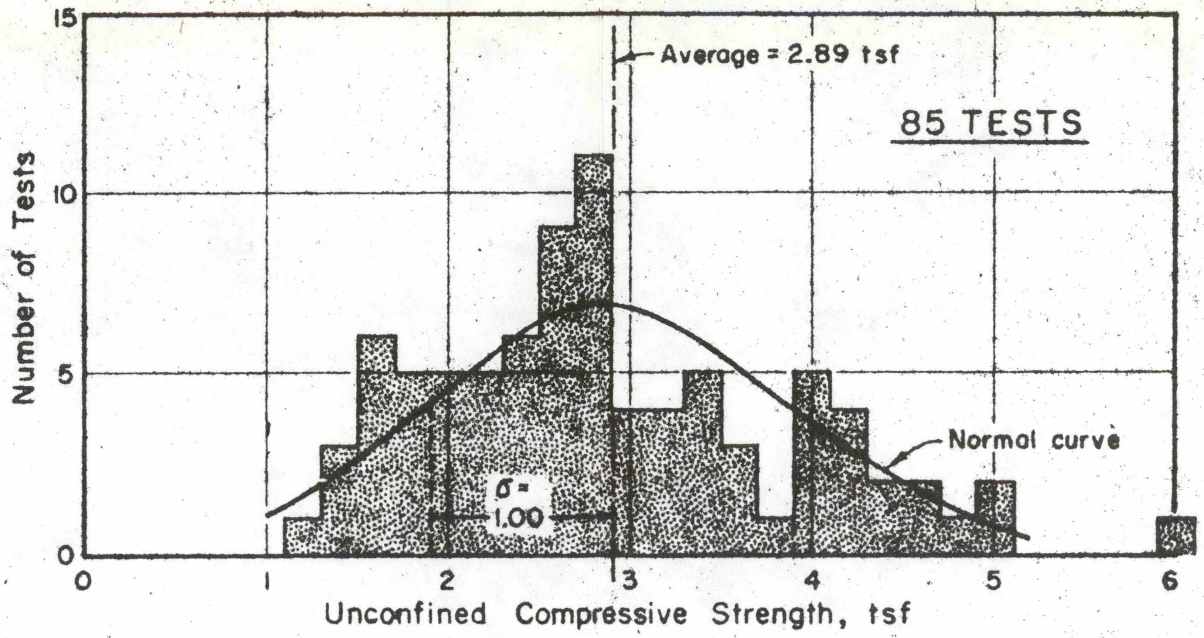


FIELD WATER CONTENT (nuclear only)





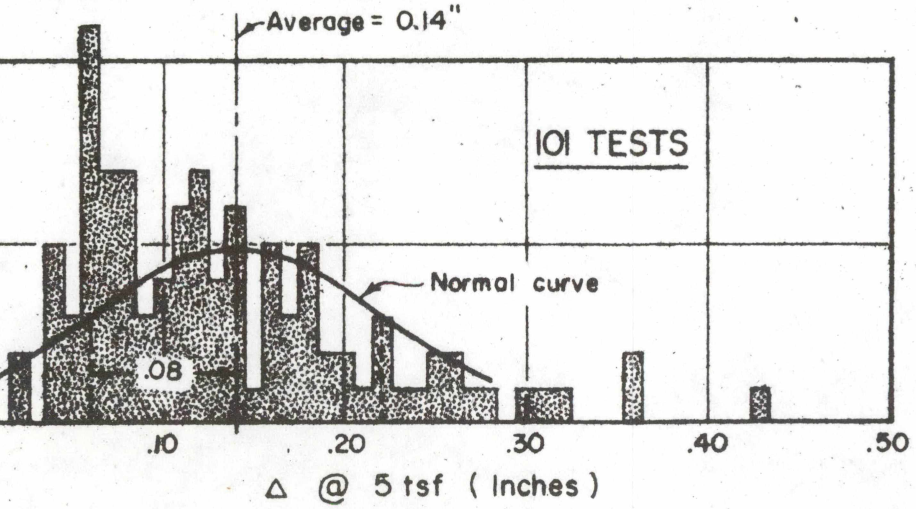
STRENGTH



σ = Standard deviation

Tests on lime-treated soil are not included.

PLATE LOAD DEFLECTION @ 5 tsf



AT & SF

FREQUENCY DISTRIBUTION OF TEST DATA

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SHANNON & WILSON, INC.
SOIL MECHANICS & FOUNDATION ENGINEERS

FIG. 10

PLATE BEARING TEST

Test No. 47 Tested by: J. L. B.
Day Tues. Date 6-29-71 Time
Location: Station 8567+62 ; ℄ Offset 15'
Depth Below Base of Rail; -2.1
Seating Pressure 0.5 tsf @ Plate Defl.= 0.01"

Modulus ═══ @ Defl.
Remarks: Moisture = 26.7 % 0-4" below test point.

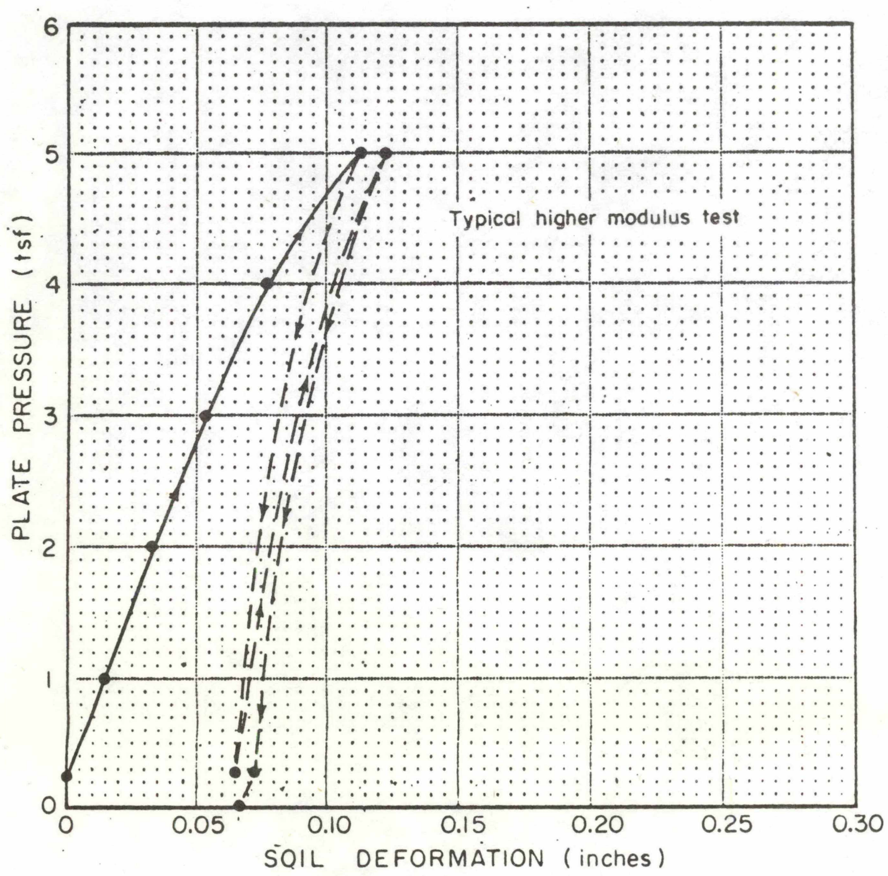


PLATE BEARING TEST

Test No. 101 Tested by: J. L. B.
Day Tues. Date 8-10-71 Time
Location: Station 8558+88 ; ℄ Offset 29'
Depth Below Base of Rail; -2.0
Seating Pressure 0.5 tsf @ Plate Defl.= 0.01"

Modulus ═══ @ Defl.
Remarks: Moisture = 21.7 % 0-4" below test point.

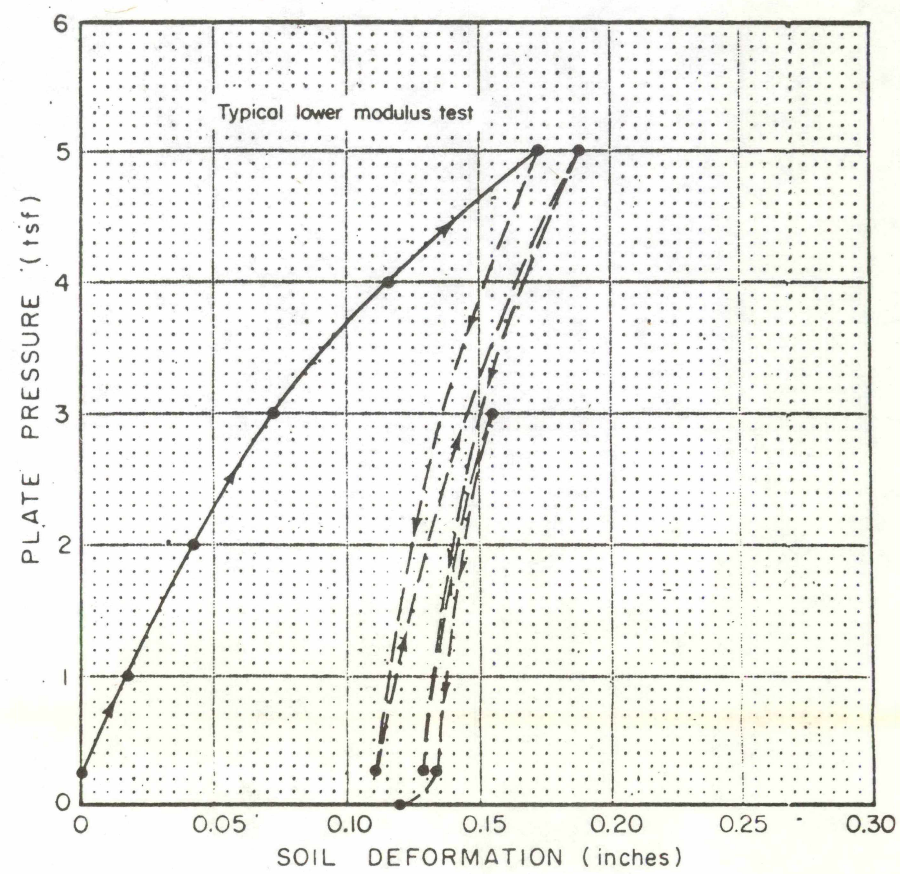
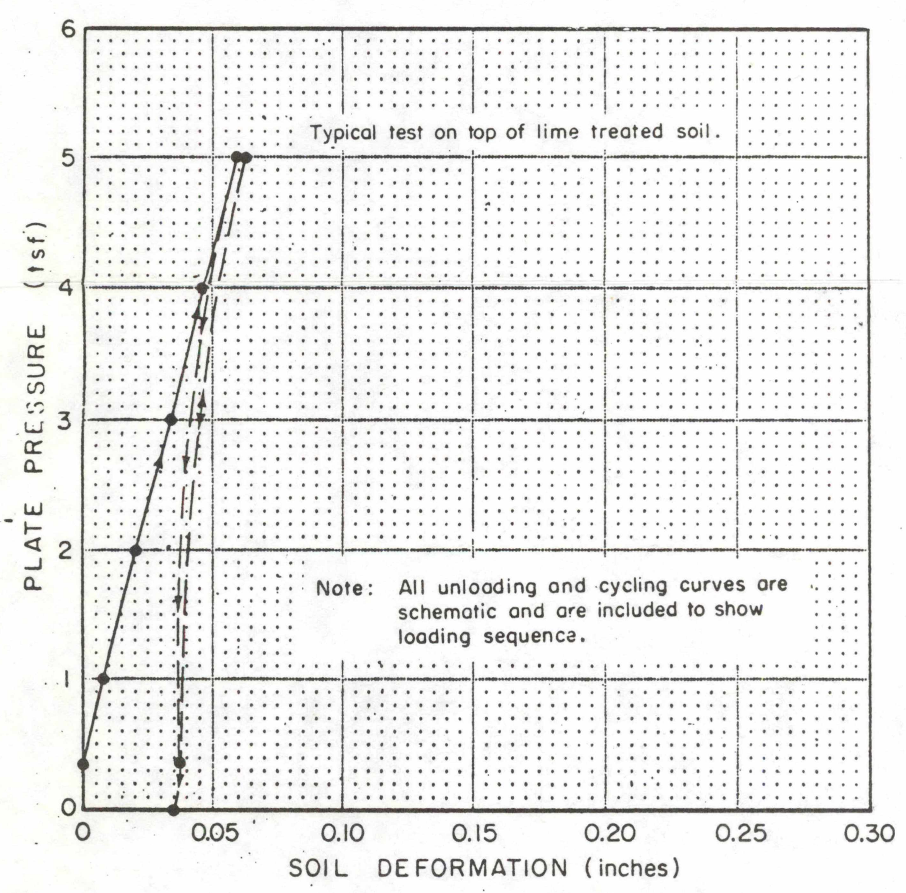
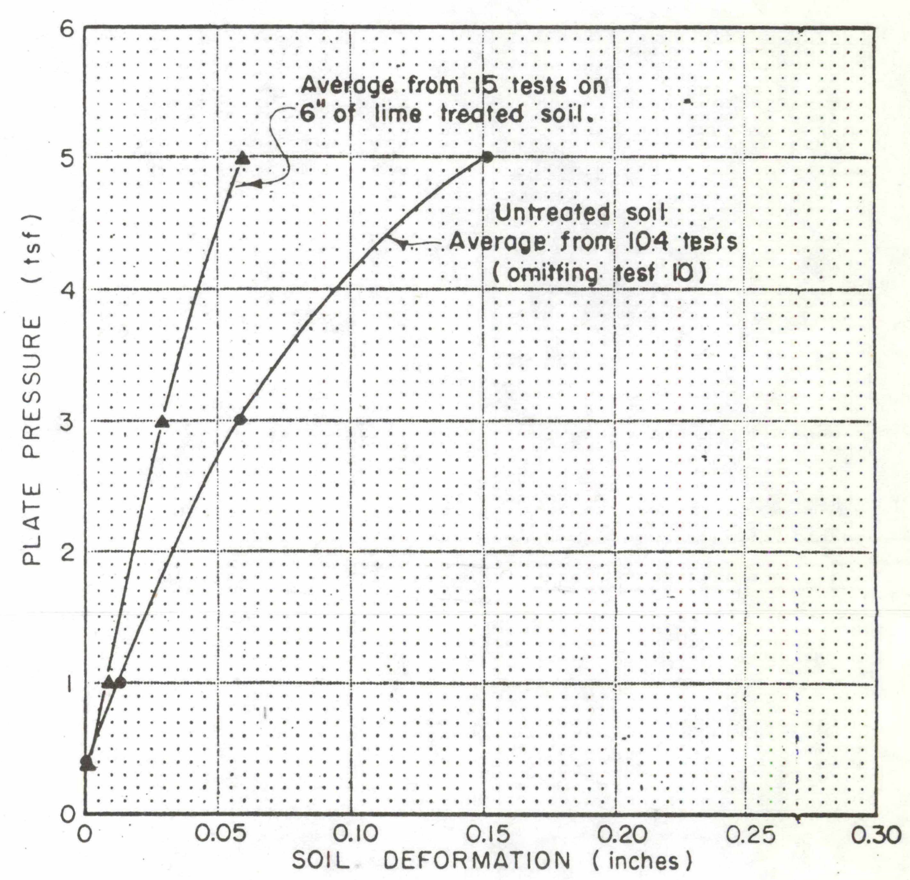


PLATE BEARING TEST

Test No. L-8 Tested by: R. A.
Day Sat. Date 10-2-71 Time 9:00 A.M.
Location: Station 8568+27 ; ℄ Offset 30'
Depth Below Base of Rail; 1.5'
Seating Pressure .0034 @ Plate Defl.=

Modulus ═══ @ Defl.
Remarks: Limed CH - Cut away bituminus seal and set plate ~½" deep.





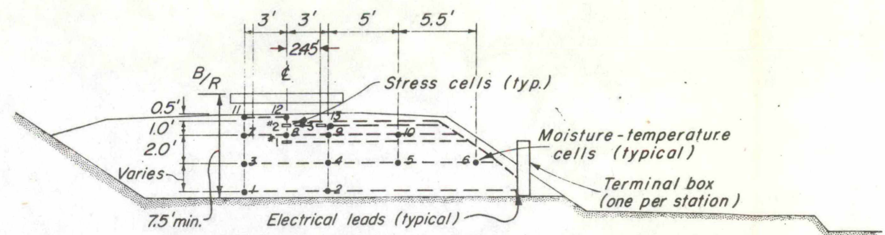
AT & SF

PLATE BEARING TEST TYPICAL RESULTS & SUMMARY

C-268 DEC, 1971

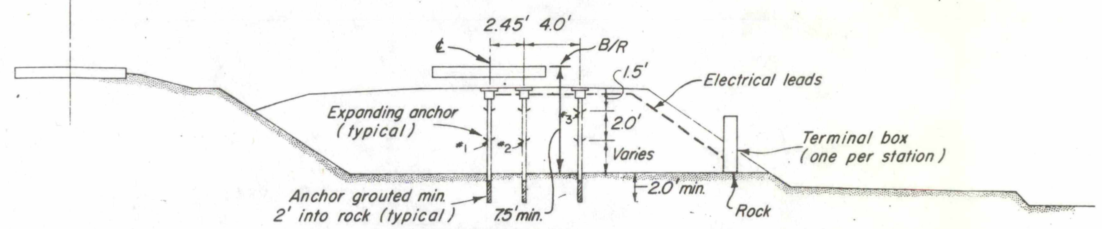
SHANNON & WILSON
SOIL MECHANICS & FOUNDATION ENGINEERS

FIG. 11



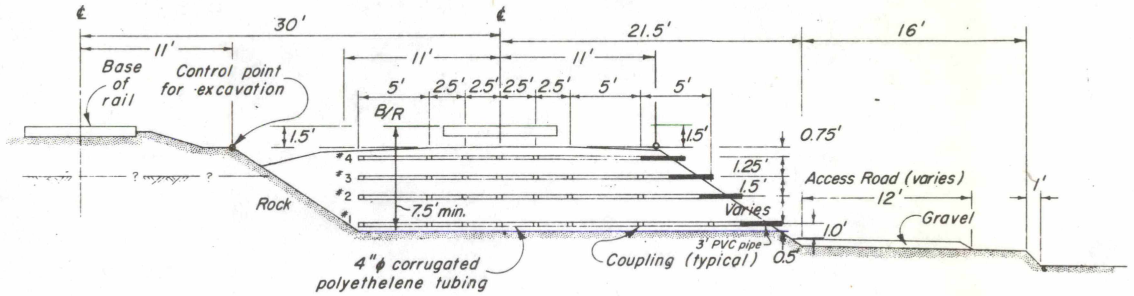
MOISTURE-TEMPERATURE CELLS AND STRESS CELLS — MAIN ARRAY

(To be installed as embankment is constructed)



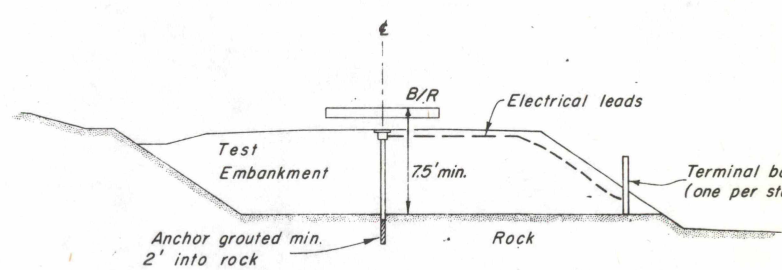
VERTICAL EXTENSOMETERS - MAIN ARRAY

(To be installed after completion of embankment)



HORIZONTAL TUBING - MAIN ARRAY

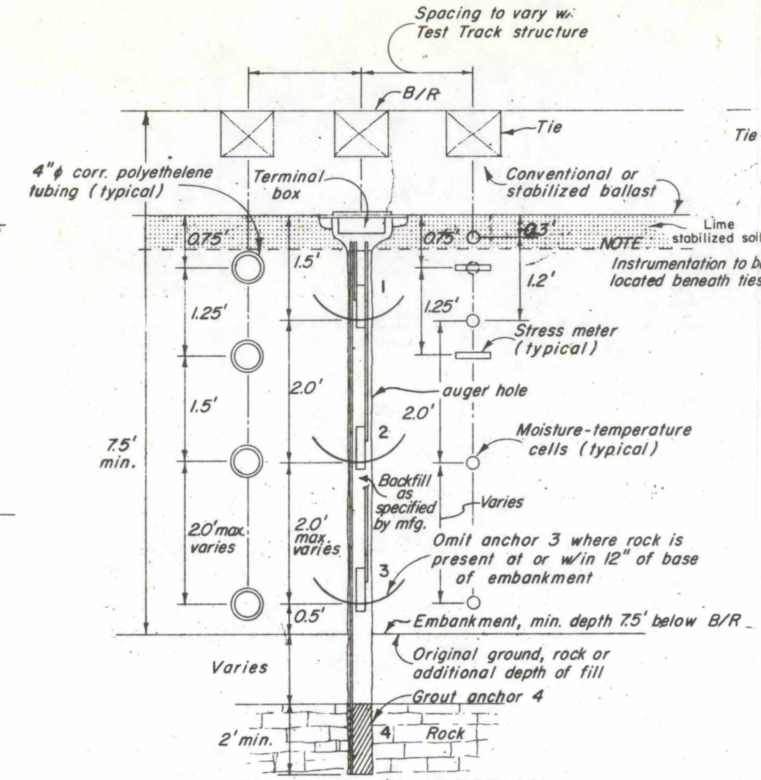
(To be installed as embankment is constructed)



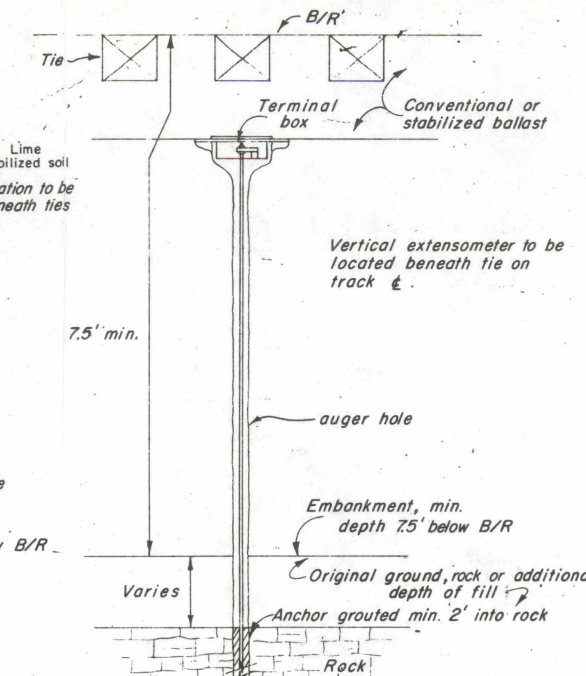
SINGLE-POSITION EXTENSOMETER

(To be installed after completion of embankment)

0 5 10 15
Scale – feet

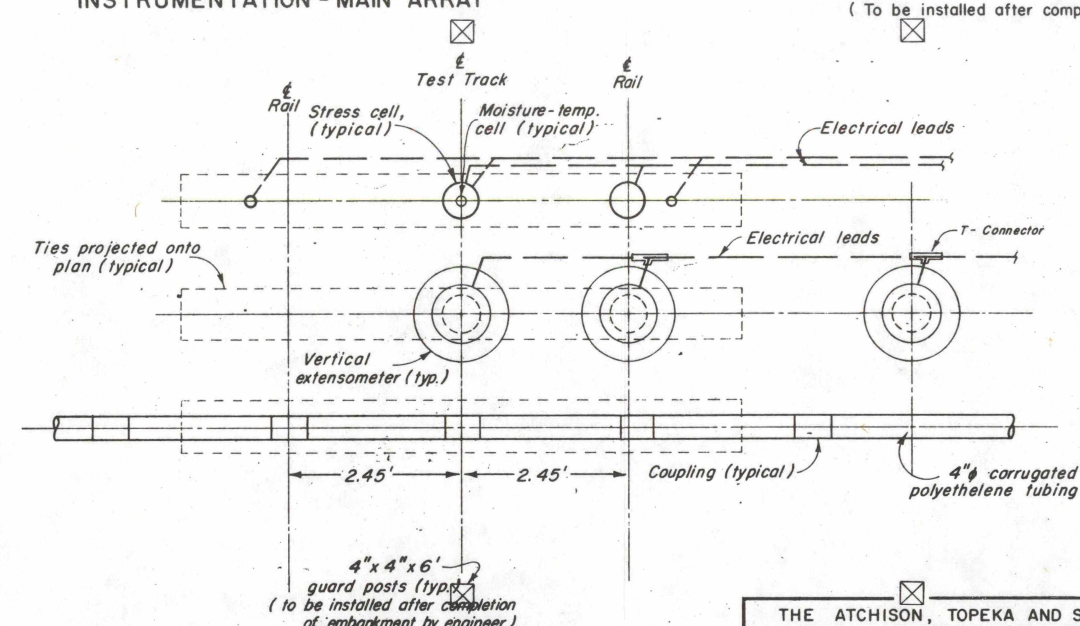


LONGITUDINAL SECTION
INSTRUMENTATION - MAIN ARRAY



LONGITUDINAL SECTION
SINGLE - POSITION EXTENSOMETER

(To be installed after completion of embankment)



PLAN
INSTRUMENTATION - MAIN ARRAY

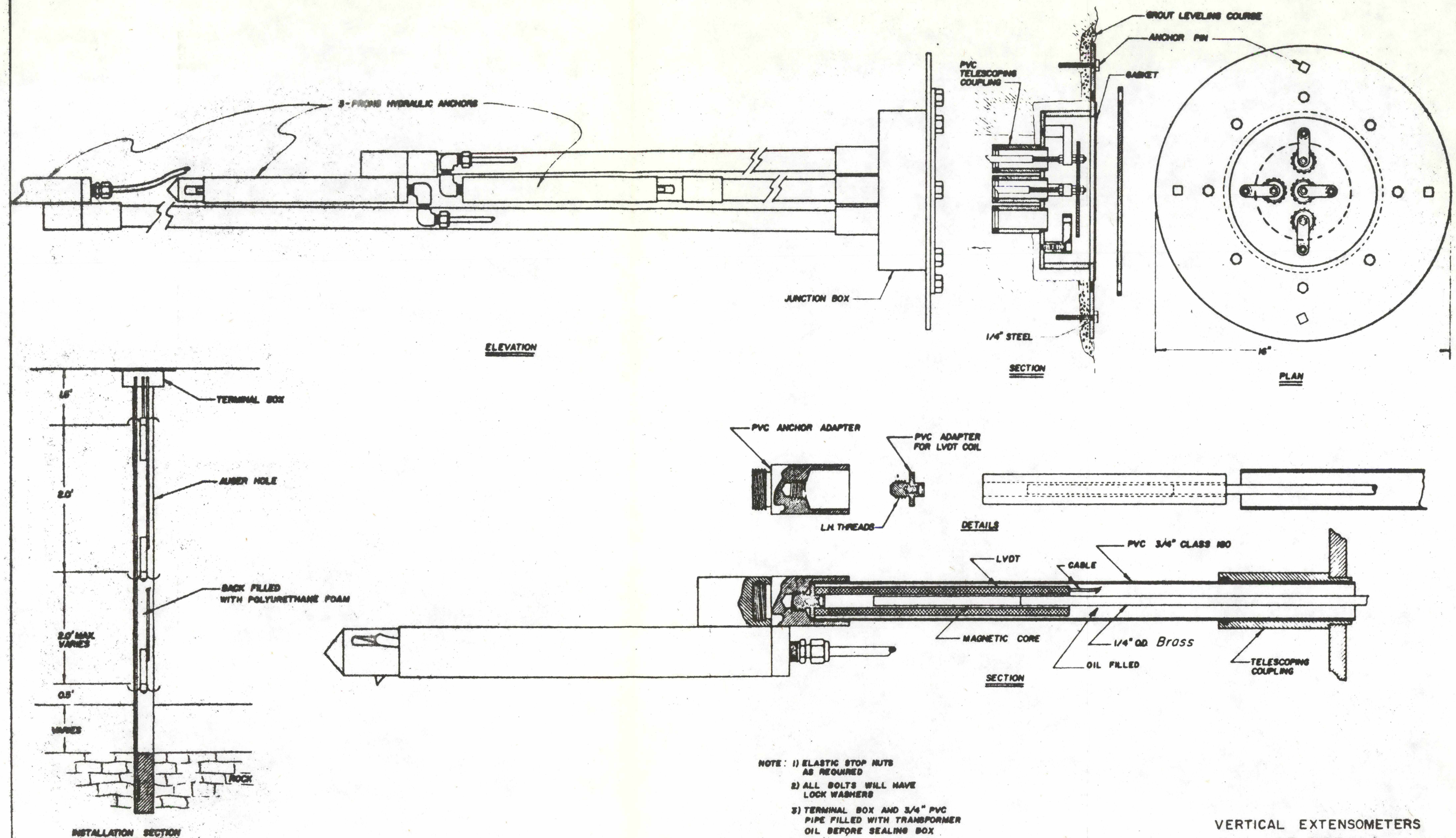
0 10 20 30 40
Scale – feet

NOTES:

1. All instrumentation to be furnished and installed by the engineer.
2. Moisture-temperature cells, stress cells and horizontal tubing to be installed as the embankment is placed. Extensometers (vertical) to be installed after embankment is completed.

THE ATCHISON, TOPEKA AND SANTA FE RAILWAY COMPANY EASTERN LINES, TOPEKA, KANSAS DATED Sept 14, 1970 APPROVED [signature] Chief Engineer	
U. S. DEPARTMENT OF TRANSPORTATION EXPERIMENTAL TEST TRACK EMBANKMENT	
TYPICAL INSTRUMENTATION DETAILS	
Shannon and Wilson **Soil mechanics and foundation engineers**	Rev. As-built Dec. 1, 1971 8 8

FIG. 12

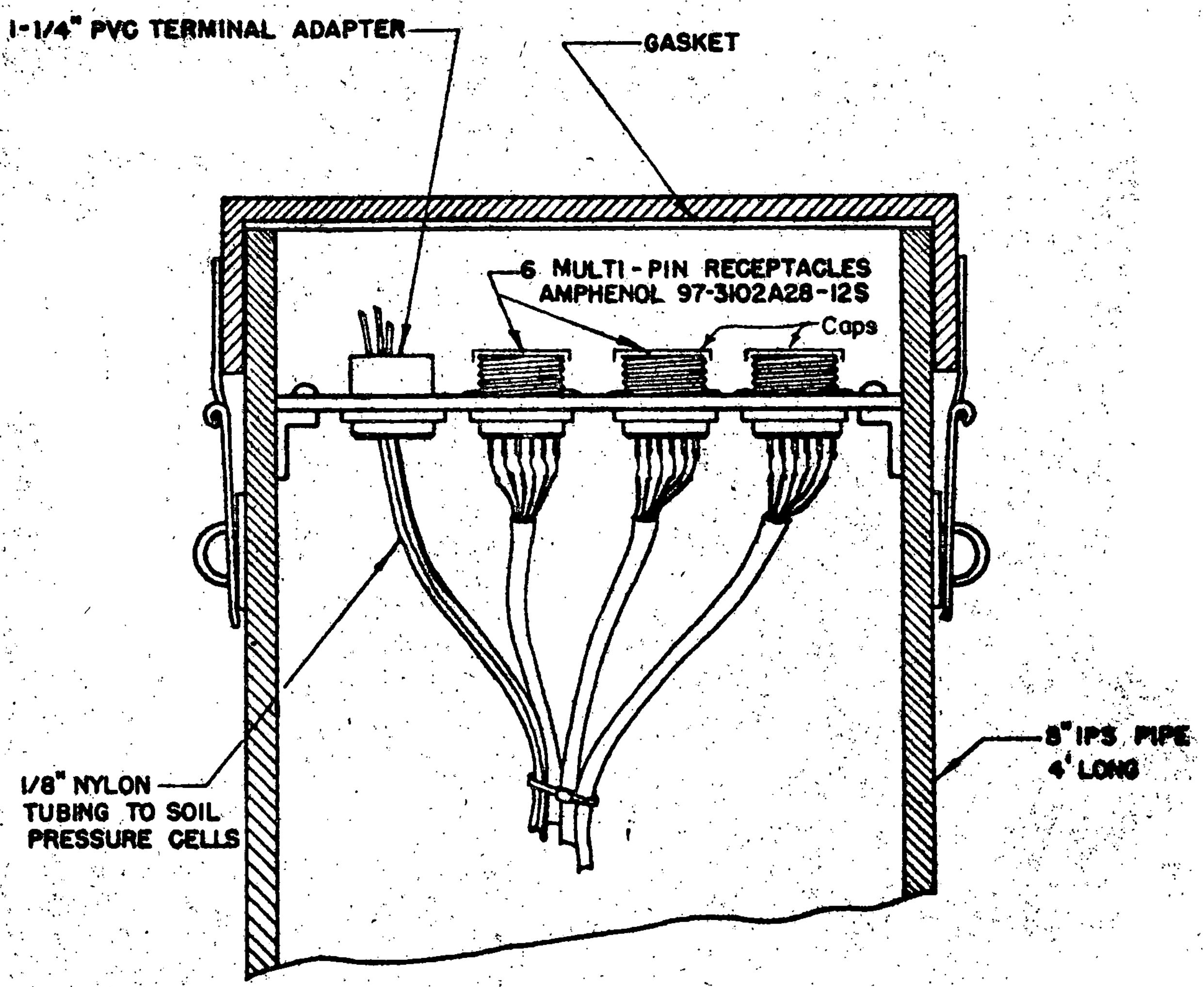


NOTE: 1) ELASTIC STOP NUTS AS REQUIRED
2) ALL BOLTS WILL HAVE LOCK WASHERS
3) TERMINAL BOX AND 3/4" PVC PIPE FILLED WITH TRANSFORMER OIL BEFORE SEALING BOX

VERTICAL EXTENSOMETERS
A.T. & S.F
EXPERIMENTAL TEST TRACK

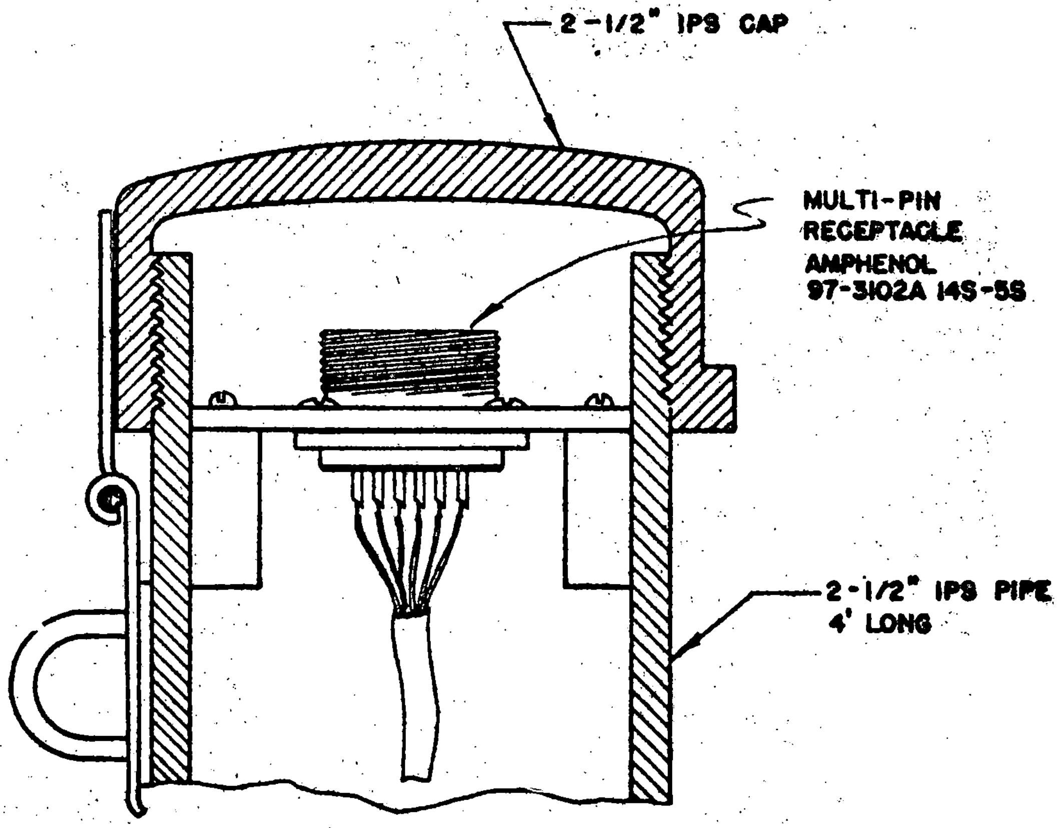
SLOPE INDICATOR CO. SEATTLE, WASHINGTON

FIG. 13



UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES	MAIN ARRAY TERMINAL PIPE
TOLERANCES ON FRACTIONS ± .010, DECIMALS ± .005, ANGLES ± ½°	A.T. & S.F. EXPERIMENTAL TEST TRACK
CHAMFER OR RAD ON ALL CORNERS OR EDGES .005 TO .010. REMOVE ALL BURRS	SLOPE INDICATOR CO. SEATTLE, WASHINGTON
MATERIAL	
FINISH	
SCALE 1:2 · DR'N A.S. · APP'D	REV · DATE 7-21-71 · SHT 1 OF 1

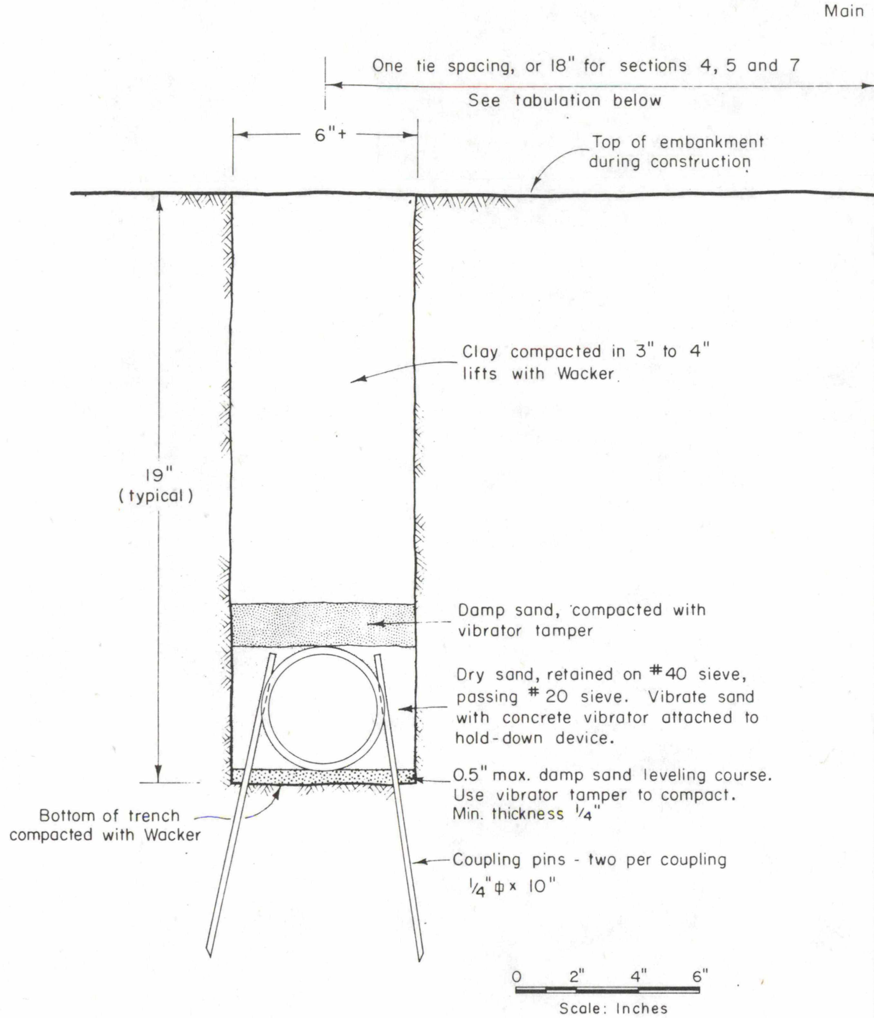
FIG. 14



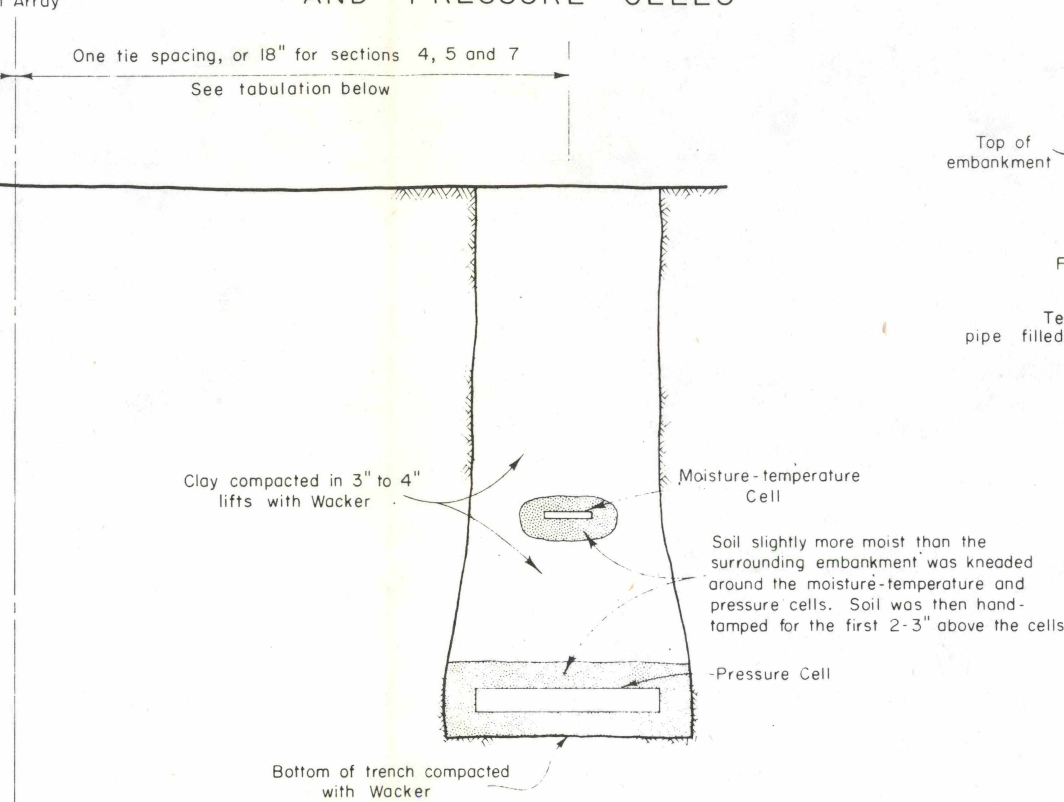
UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES TOLERANCES ON FRACTIONS ± .010 DECIMALS ± .005 ANGLES ± ½° CHAMFER OR RAD ON ALL CORNERS OR EDGES .005 TO .010 REMOVE ALL BURRS	SINGLE POSITION TERMINAL PIPE A.T.&S.F. EXPERIMENTAL TEST TRACK
MATERIAL FINISH	SLOPE INDICATOR CO. SEATTLE, WASHINGTON
SCALE 1:1 DR'N A.S. APP'D	REV DATE 7-21-71 SHT 1 OF 1

FIG. 15

HORIZONTAL TUBING



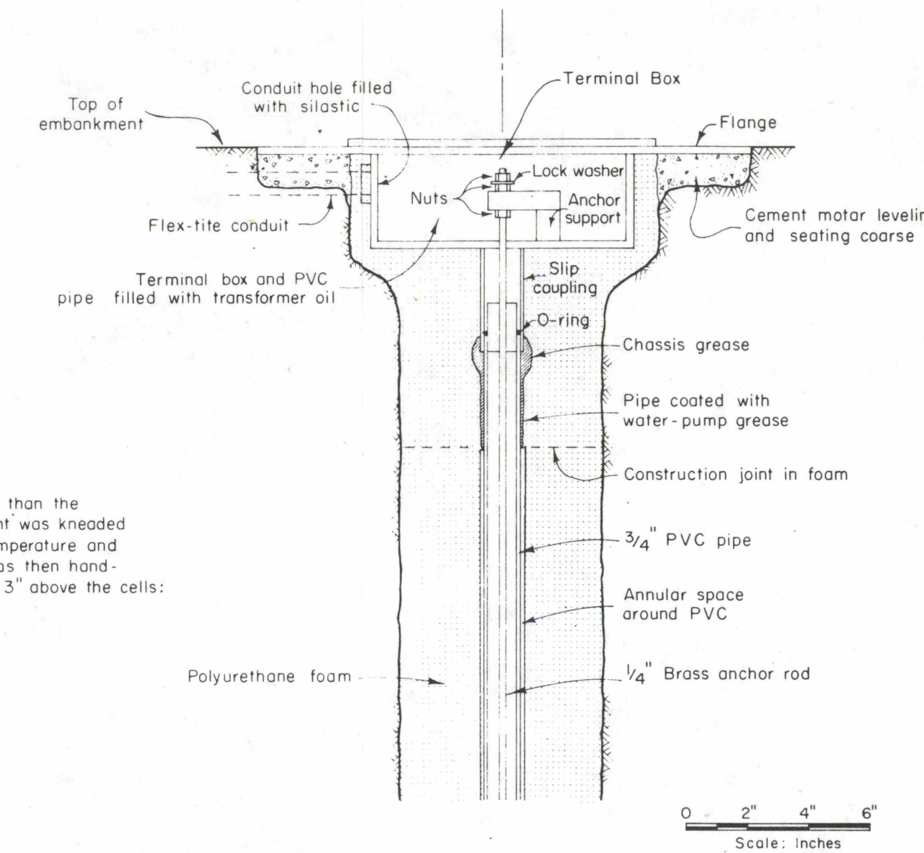
MOISTURE - TEMPERATURE AND PRESSURE CELLS



Test Section	Tie Spacing, in.
1	30
2	27
3	24
4	19.5*
5	19.5*
6	19.5
7	19.5*
8	27
9	19.5

* No ties in test section, but spacing was taken as 19.5" for instrument installation purposes.

VERTICAL EXTENSOMETER



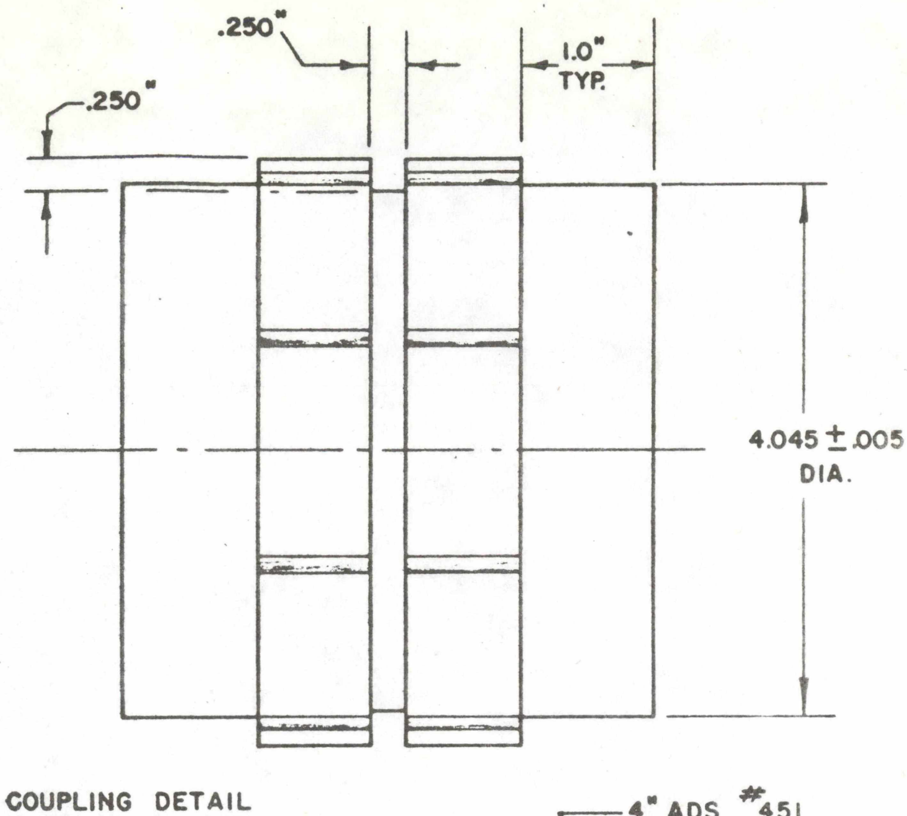
AT & SF

INSTRUMENT INSTALLATION DETAILS

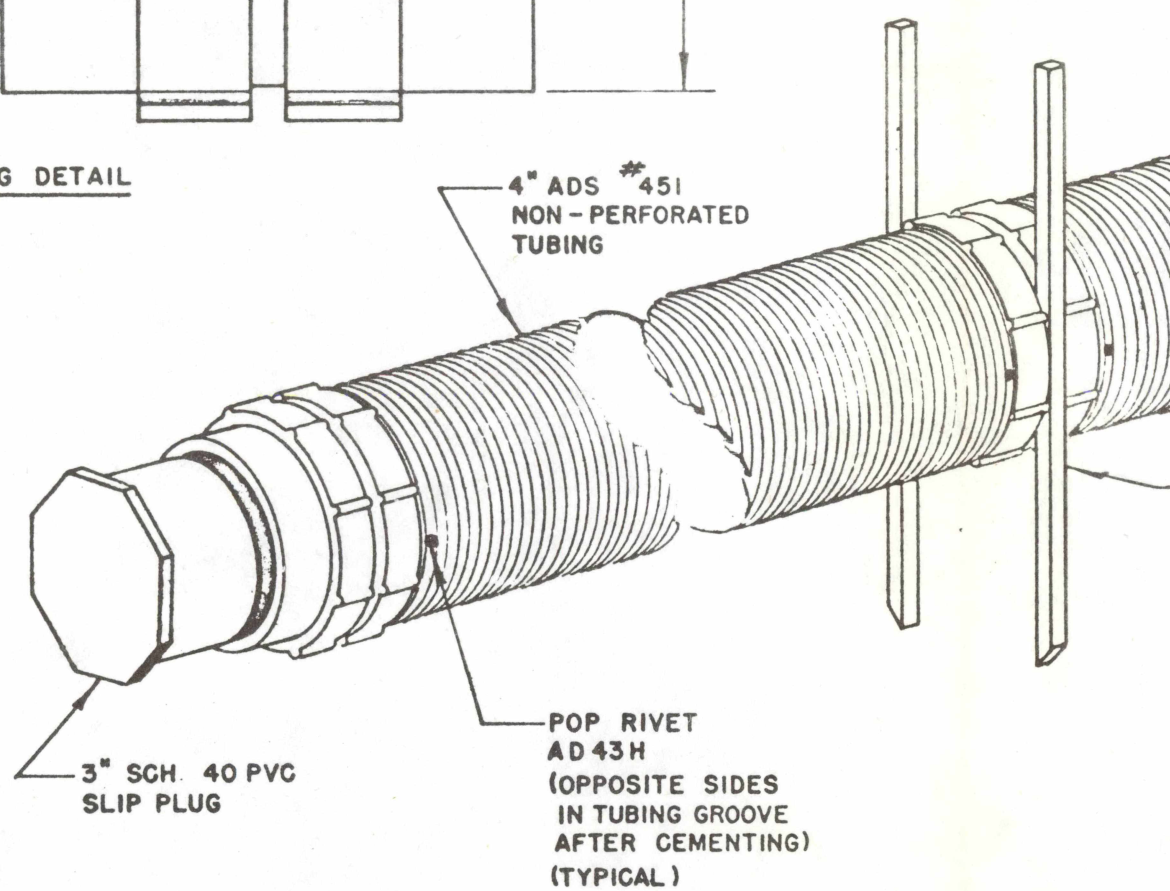
C-268 DEC, 1971

SHANNON & WILSON
SOIL MECHANICS & FOUNDATION ENGINEERS

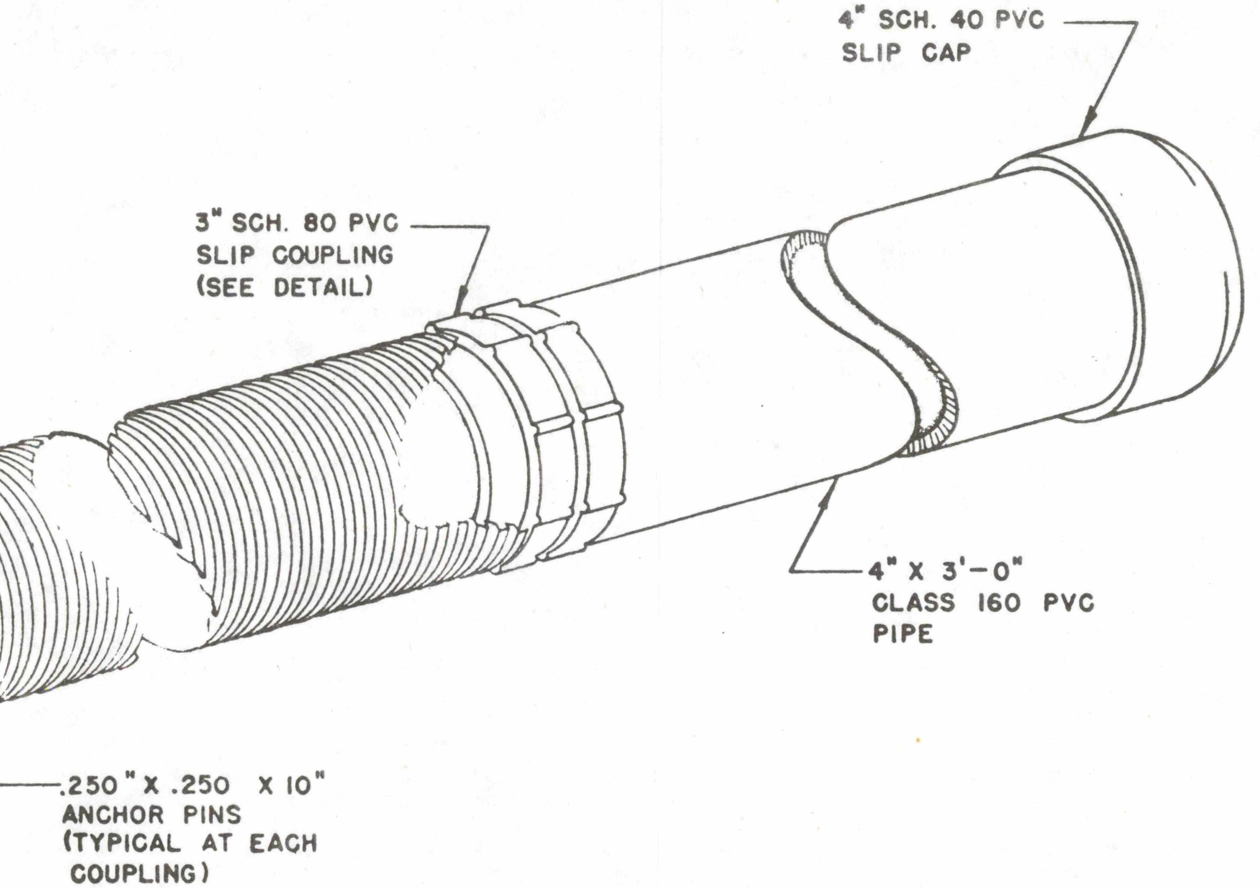
FIG. 16



.250"
.250"
1.0"
TYP.
4.045 ± .005
DIA.
COUPLING DETAIL



4" ADS #451
NON-PERFORATED
TUBING
POP RIVET
AD 43 H
(OPPOSITE SIDES
IN TUBING GROOVE
AFTER CEMENTING)
(TYPICAL)
3" SCH. 40 PVC
SLIP PLUG



UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES
TOLERANCES ON
FRACTIONS ± .010 — DECIMALS ± .005 — ANGLES ± ½°
CHAMFER OR RAD ON ALL CORNERS OR EDGES .005 TO .010
REMOVE ALL BURRS

MATERIAL

FINISH

SCALE — DR'N AS. — APP'D

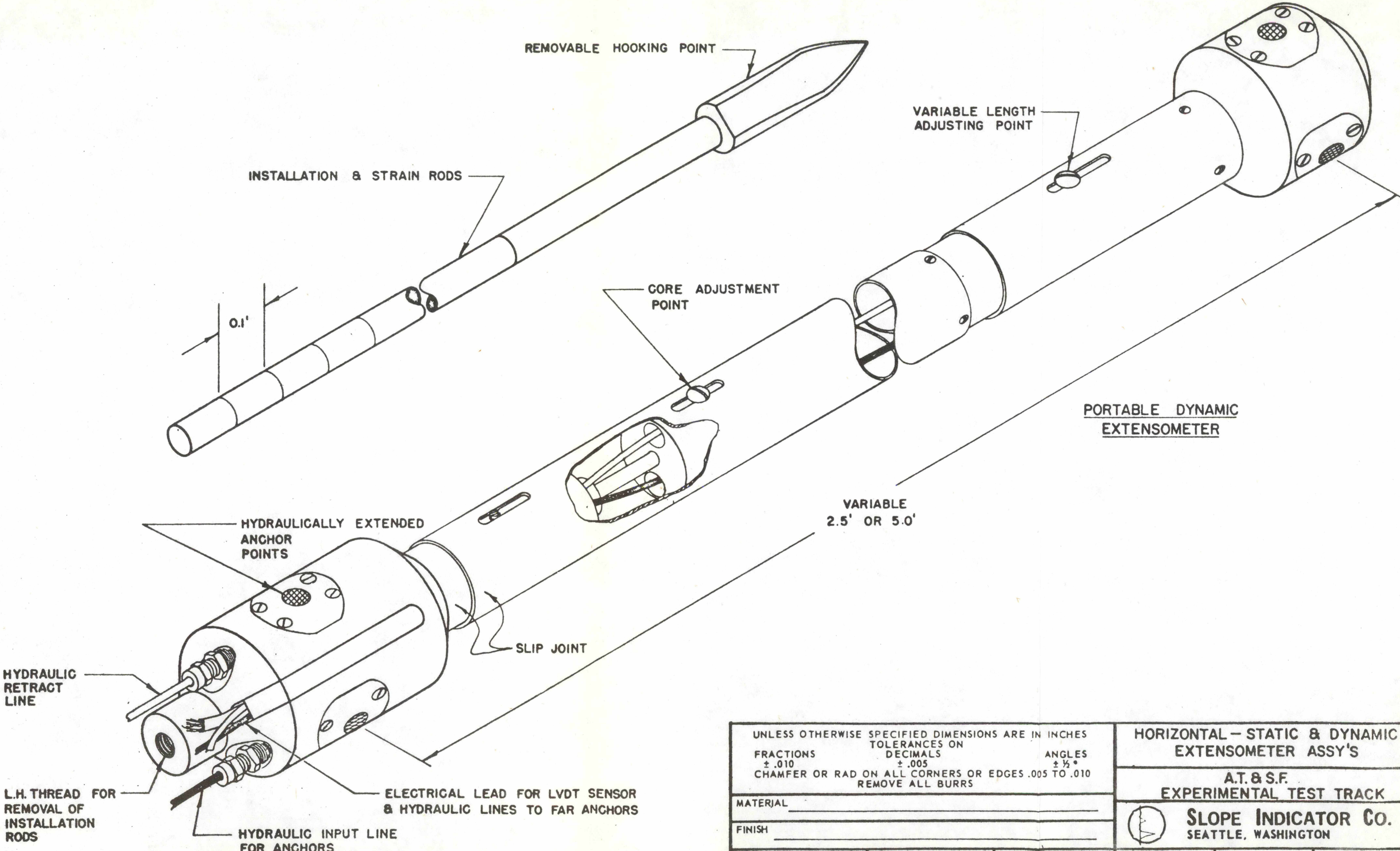
HORIZONTAL EXTENSOMETER
TUBING ASSEMBLY -- 51844

EXPERIMENTAL TEST TRACK
THE ATCHISON, TOPEKA AND SANTA FE RAILWAY CO.

SLOPE INDICATOR CO.
SEATTLE, WASHINGTON

REV — DATE 10-8-70 — SHT 1 OF 1

FIG. 17



UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES
TOLERANCES ON
FRACTIONS ± .010 | DECIMALS ± .005 | ANGLES ± ½°
CHAMFER OR RAD ON ALL CORNERS OR EDGES .005 TO .010
REMOVE ALL BURRS

MATERIAL

FINISH

SCALE | DR'N A.S. | APP'D

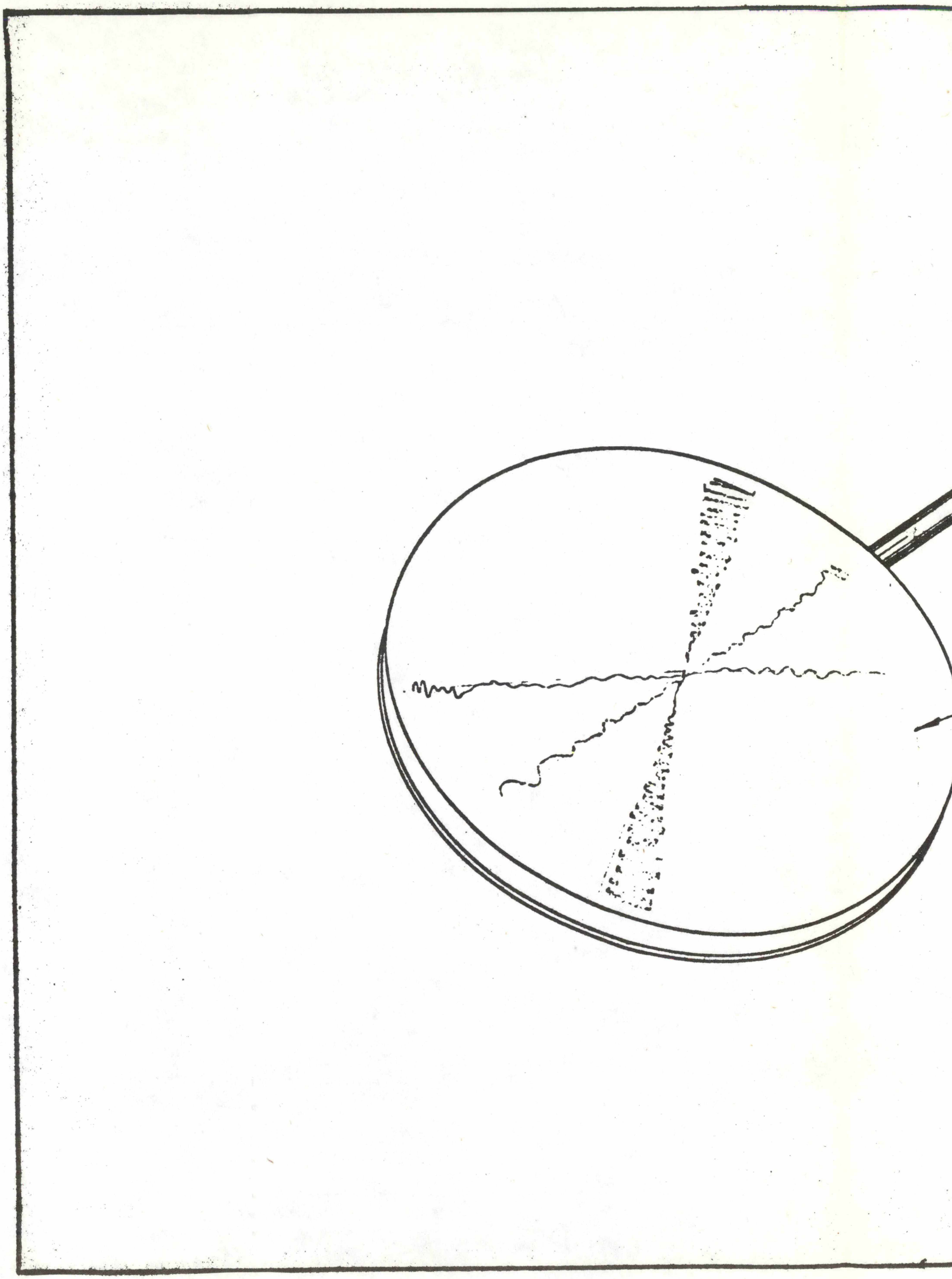
HORIZONTAL – STATIC & DYNAMIC EXTENSOMETER ASSY'S

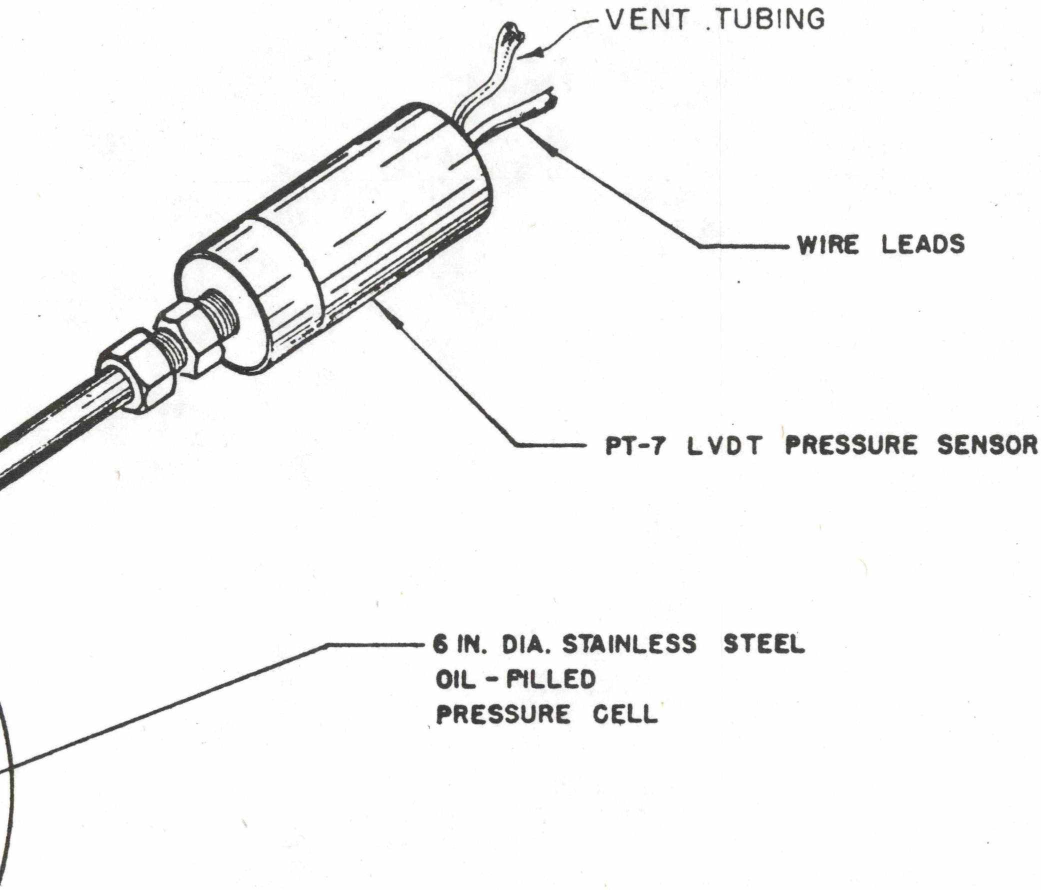
A.T. & S.F. EXPERIMENTAL TEST TRACK

SLOPE INDICATOR CO.
SEATTLE, WASHINGTON

REV | DATE | SHT | OF

FIG. 18



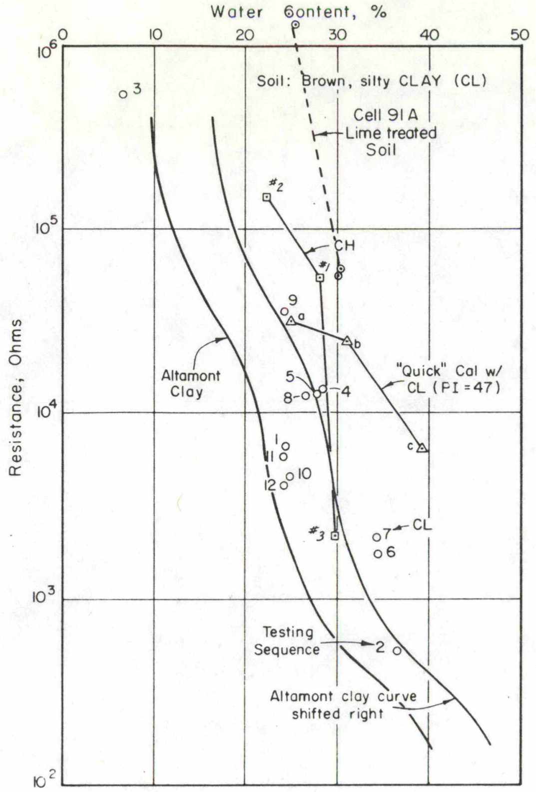


UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES TOLERANCES ON FRACTIONS ± .010 · DECIMALS ± .005 · ANGLES ± ½° CHAMFER OR RAD ON ALL CORNERS OR EDGES .005 TO .010 REMOVE ALL BURRS	SOIL PRESSURE CELL
MATERIAL	
FINISH	SLOPE INDICATOR CO. SEATTLE, WASHINGTON

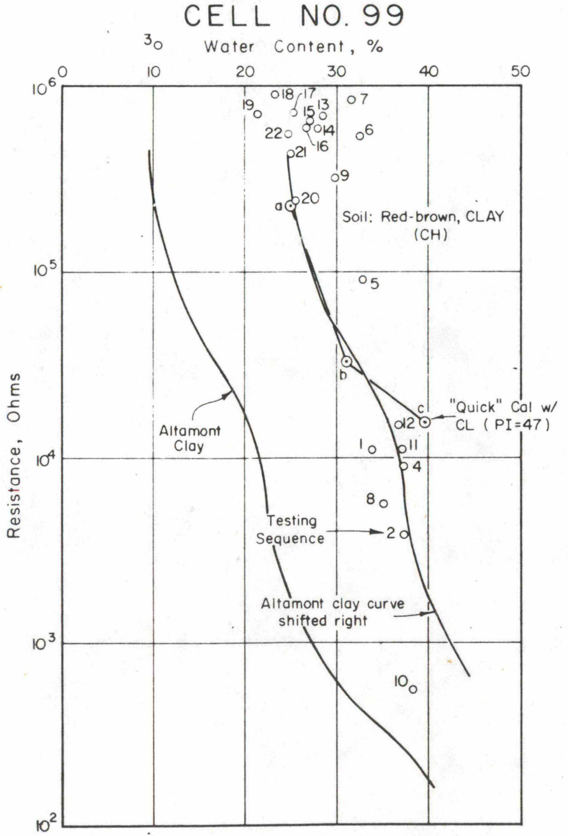
SCALE	DR'N	APP'D	REV	DATE	SHT	OF
	A.S.			12-17-71	1	1

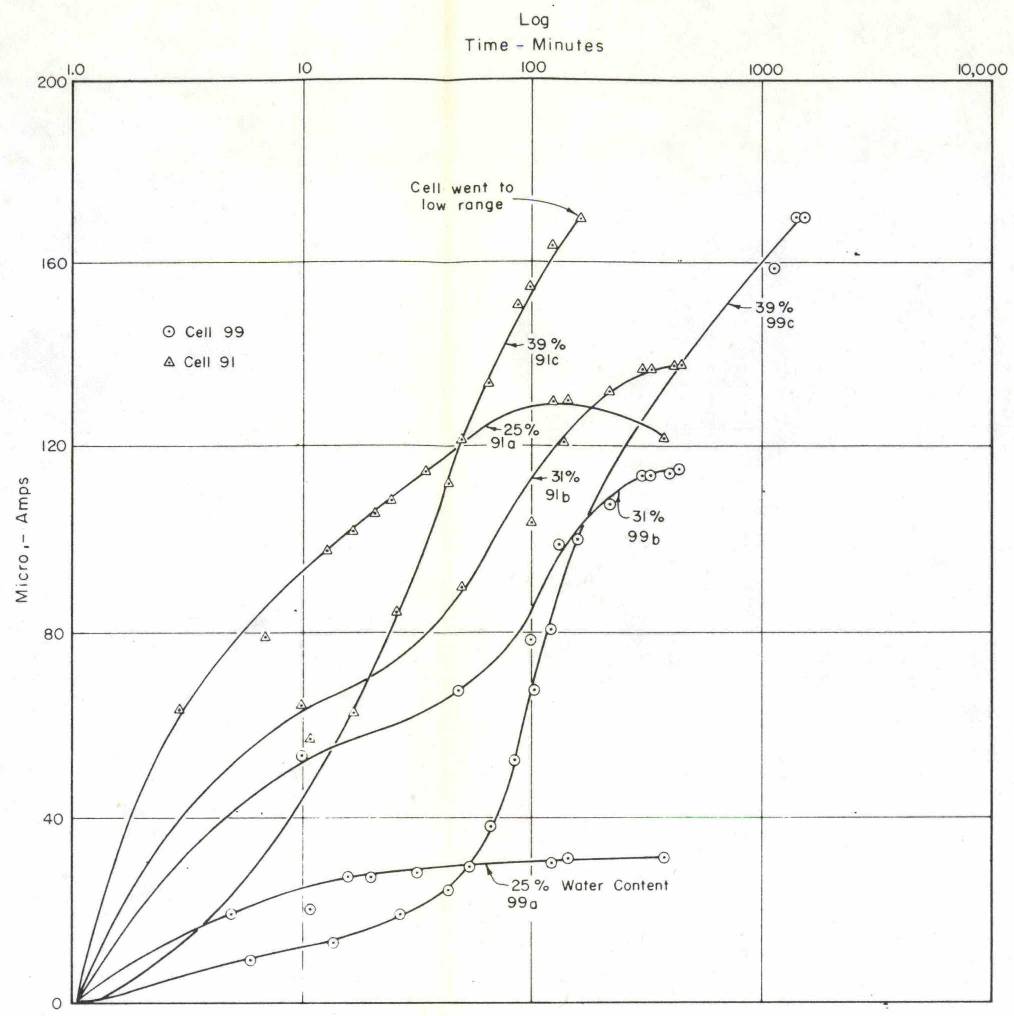
FIG. 19

CALIBRATION OF CELL NO. 91

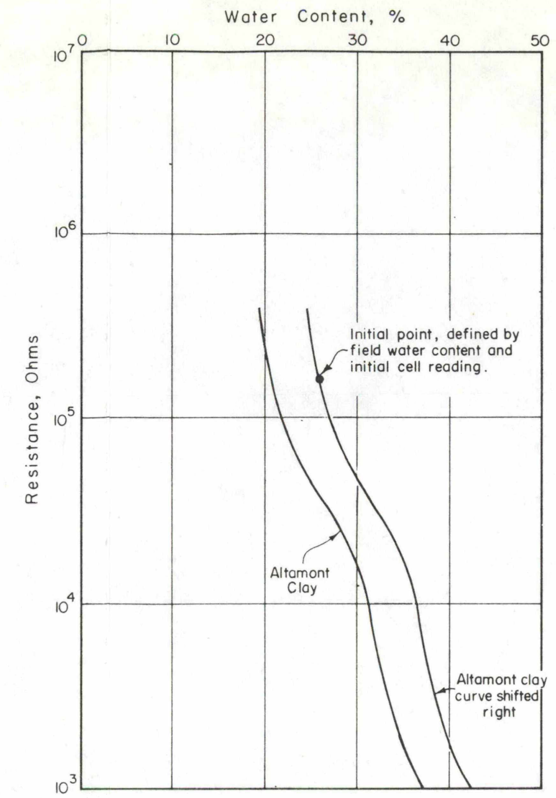


CALIBRATION OF CELL NO. 99





MOISTURE CELL RESPONSE TIME



CALIBRATION CURVE FOR CELL # 1 OF TEST SECTION # 1

AT & SF

MOISTURE CELL CALIBRATION DATA

C-268 DEC, 1971

SHANNON & WILSON
SOIL MECHANICS & FOUNDATION ENGINEERS

FIG. 20

APPENDIX A

AS-BUILT DRAWINGS

U. S. DEPARTMENT OF TRANSPORTATION

EXPERIMENTAL TEST TRACK EMBANKMENT

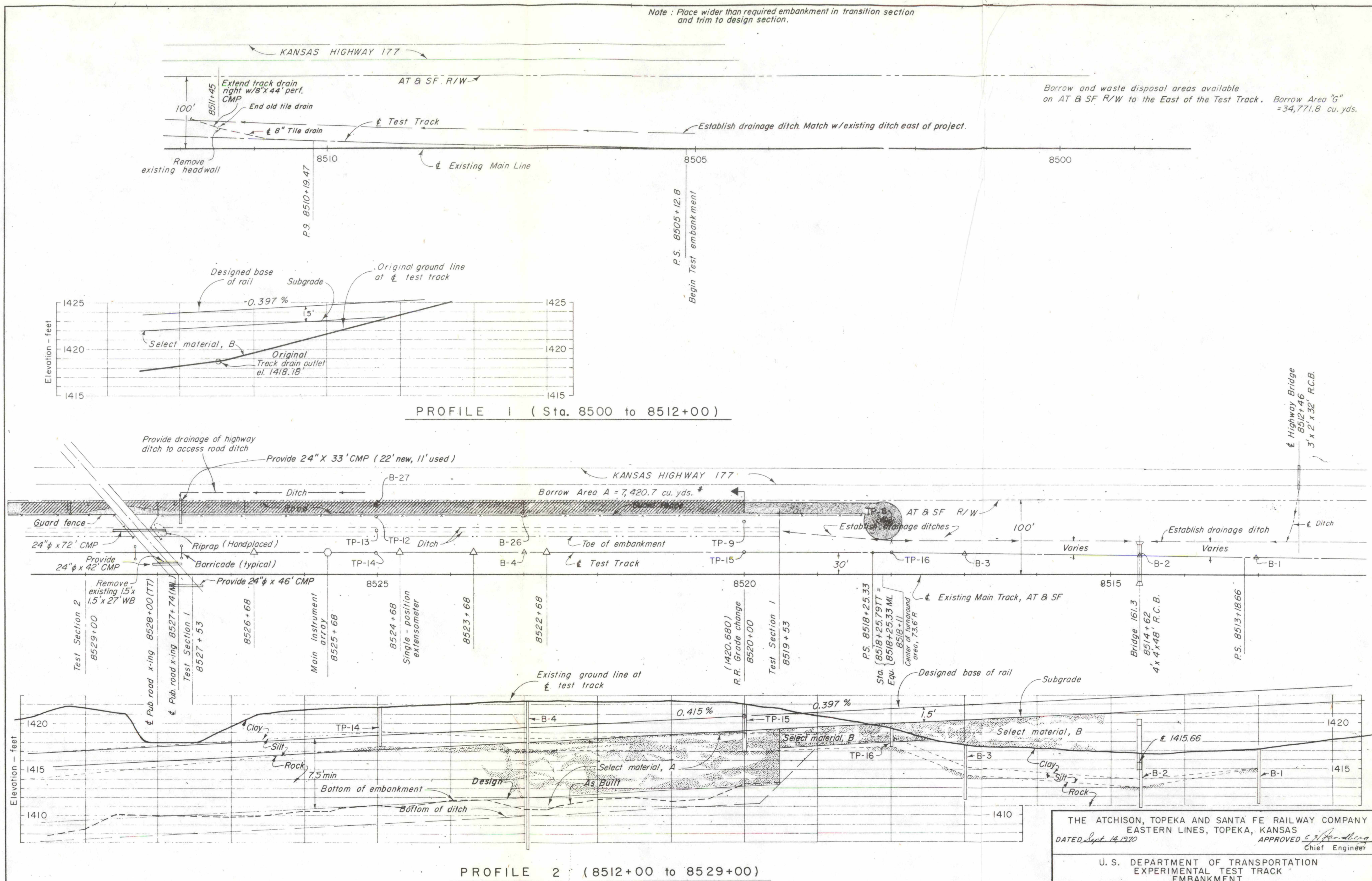
THE ATCHISON, TOPEKA AND SANTA FE RAILWAY COMPANY
EASTERN LINES, TOPEKA, KANSAS

INDEX OF DRAWINGS

1. TITLE SHEET
2. PLAN - PROFILE (1" = 200')
3. PROFILE 1 AND 2
4. PROFILE 3 AND 4
5. PROFILE 5 AND 6
6. PROFILE 7
7. TYPICAL EXCAVATION AND EMBANKMENT SECTIONS
8. TYPICAL INSTRUMENTATION DETAILS


RAILROAD WEST
RAILROAD EAST
LEGEND:
Main instrumentation array.
Single-position extensometer
Boring {B-1-B-16 Hemphill Corp, April 1969 / B-21-B-30 Shannon & Wilson Inc, July 1970
Test pit {TP-1-TP-24, July 1970 / TP-25-TP-27, Sept 1970
Note: 1. Stationing for Main Line and Test Track are identical in tangent section only.
2. Subsurface conditions between indicated borings or test pits may vary from that shown.
3. All elevations are based on AT & SF datum.
Section 9 - Control Section 800'
Section 8 - Concrete Ties 27" OC. 15" ballast 800'
Section 7 - Precast Beam 800'
Section 6 Stabilized Ballast 548'
Section 5 - Concrete Slab 800'
Section 4 - Continuous Concrete Beam 800'
Section 3 - Concrete Ties 24" OC. 10" Ballast 800'
Section 2 - Concrete Ties 27" OC 10" Ballast 800'
Section 1 - Concrete Ties 30" OC. 10" Ballast 800'
Mile Post 163
Mile Post 162
Mile Post 161
Proposed Test Track
Existing Main Track
Kansas Highway 177
Borrow Area I
Borrow Area B Sta. 8563 to 8568
Borrow Area C Sta. 8572 to 8575+40
Borrow Area D Sta. 8579+40 to 8591+40
Borrow Areas E, F Sta. 8581 to 8590
Borrow Area A Sta. 8520 to Sta. 8538
Borrow Area G
Borrow Area H
Scale - feet
ELEVATION IN FEET
Existing ground line of ℄ of test track
Designed base of rail
Subgrade
Bottom of 6" embankment - Design - As-built
Bottom of embankment - Design
As-built
Red-brown CLAY (CH)
Pale yellow, clayey SILT
Rock
R.R. Grade change 8598+00
R.R. Grade change 8583+00
R.R. Grade change 8536+00
R.R. Grade change 8520+00
THE ATCHISON, TOPEKA AND SANTA FE RAILWAY COMPANY
EASTERN LINES, TOPEKA, KANSAS
DATED Sept. 14, 1970 APPROVED Chief Engineer
U.S. DEPARTMENT OF TRANSPORTATION
EXPERIMENTAL TEST TRACK
EMBANKMENT
PLAN AND PROFILE OF TEST TRACK EMBANKMENT
SHANNON & WILSON INC.

FIG. 2



NOTES:

1. Subsurface conditions between indicated borings or test pits may vary from that shown.
2. All stationing relative to main line (ML) stationing.
3. Track drains between Sta. 8488+20 and 8511+48 and between Sta. 8517+50 and 8545+67 are not to be disturbed.
4. Indicated borrow quantities represent estimates of usable borrow.
5. * Quantity includes stockpiled material that overlaid rock in test embankment area.

0 50 100 150 200
Scale - feet
Horizontal

THE ATCHISON, TOPEKA AND SANTA FE RAILWAY COMPANY
EASTERN LINES, TOPEKA, KANSAS
DATED *Sept. 14, 1970* APPROVED *[signature]*
Chief Engineer

U. S. DEPARTMENT OF TRANSPORTATION
EXPERIMENTAL TEST TRACK
EMBANKMENT

PROFILES 1 & 2

Shannon and Wilson
Soil mechanics and foundation engineers

Rev. As-built Dec. 1, 1971

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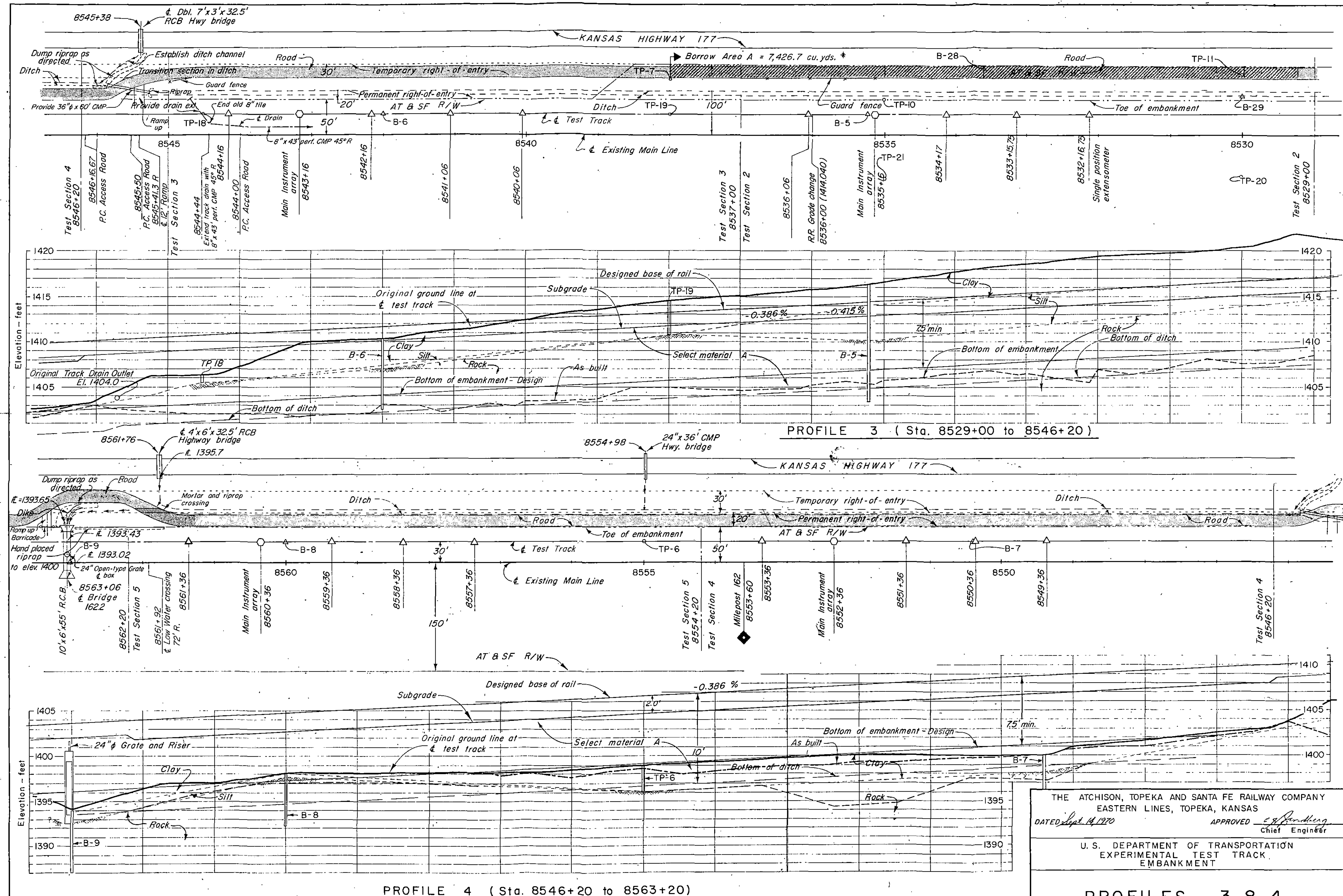

* Quantity includes stockpiled material that overlaid rock in test embankment area.

NOTE : 1. Refer to drawing No. 3 for general notes.
2. Track drains between Sta. 8517+50 and 8545+67 are not to be disturbed.

0 50 100 150 200
Horiz. Scale - feet

THE ATCHISON, TOPEKA AND SANTA FE RAILWAY COMPANY
EASTERN LINES, TOPEKA, KANSAS

DATED Sept. 14, 1970 APPROVED [signature] Chief Engineer

U. S. DEPARTMENT OF TRANSPORTATION
EXPERIMENTAL TEST TRACK
EMBANKMENT

PROFILES 3 & 4

Shannon and Wilson
Soil mechanics and foundation engineers

Rev. As-built Dec. 1, 1971

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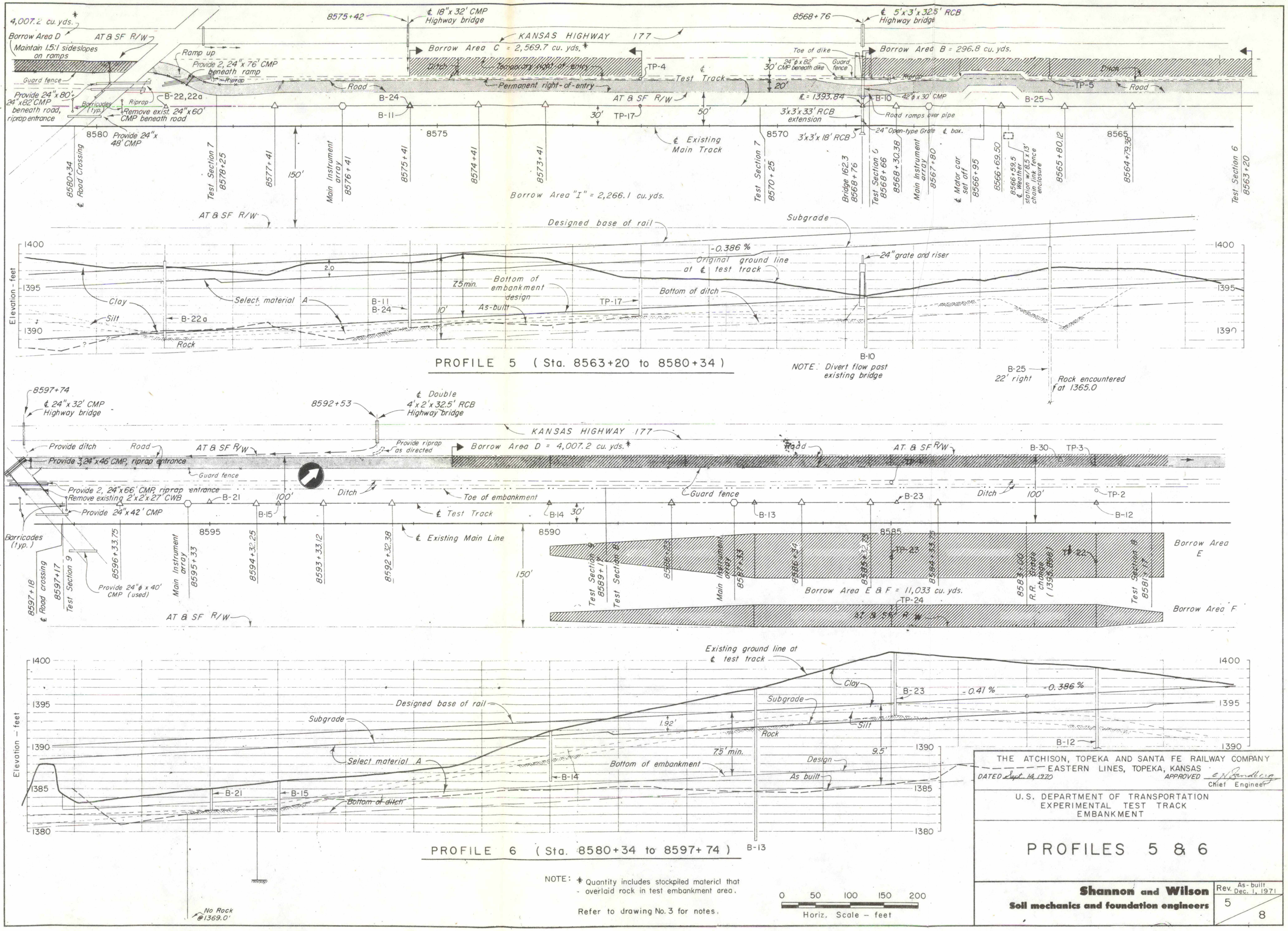

NOTE: * Quantity includes stockpiled material that overlaid rock in test embankment area.

Refer to drawing No. 3 for notes.

THE ATCHISON, TOPEKA AND SANTA FE RAILWAY COMPANY
EASTERN LINES, TOPEKA, KANSAS

DATED Sept. 14, 1970 — APPROVED [signature] Chief Engineer

U.S. DEPARTMENT OF TRANSPORTATION
EXPERIMENTAL TEST TRACK
EMBANKMENT

PROFILES 5 & 6

Shannon and Wilson
Soil mechanics and foundation engineers

Rev. As-built Dec. 1, 1971

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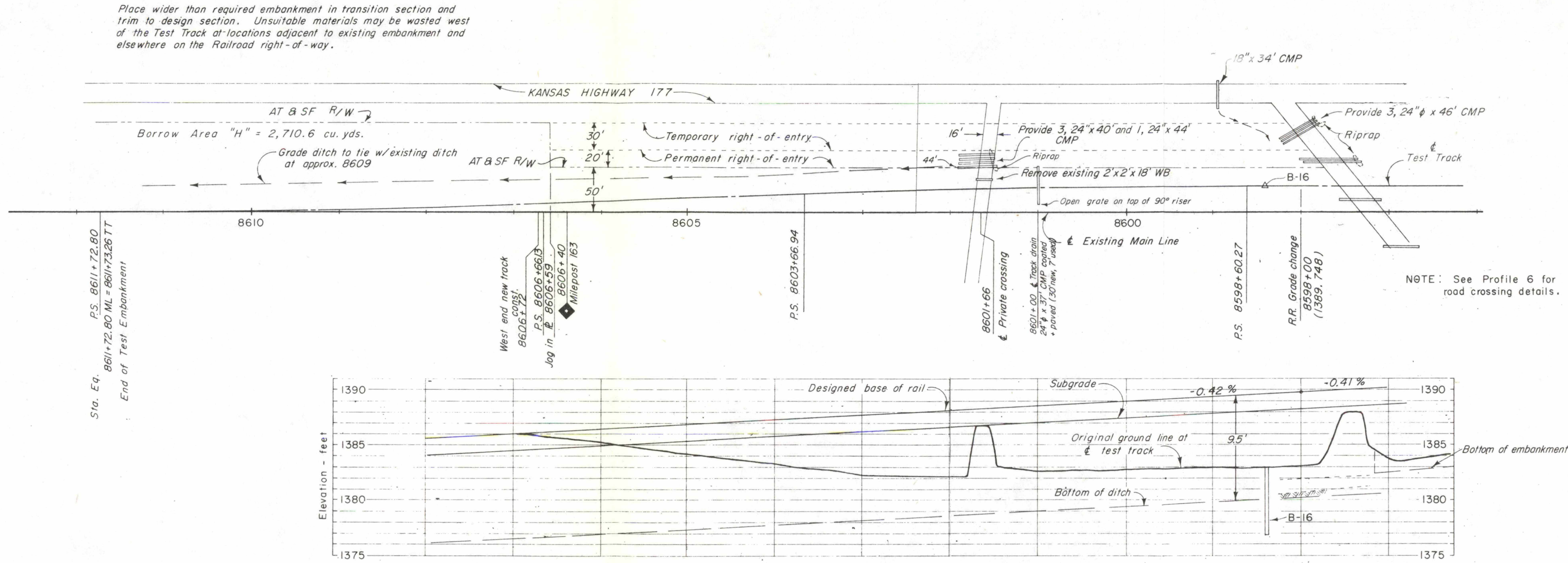
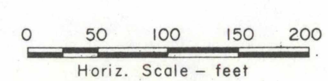


PROFILE 7 (Sta. 8597+74 to 8611+72.80)



NOTE: Refer to drawing No. 3 for notes.

THE ATCHISON, TOPEKA AND SANTA FE RAILWAY COMPANY
EASTERN LINES, TOPEKA, KANSAS
DATED Sept. 14, 1970 APPROVED C. J. Sandberg, Chief Engineer

U.S. DEPARTMENT OF TRANSPORTATION
EXPERIMENTAL TEST TRACK
EMBANKMENT

PROFILE 7

Shannon and Wilson
Soil mechanics and foundation engineers

Rev. As-built Dec. 1, 1971

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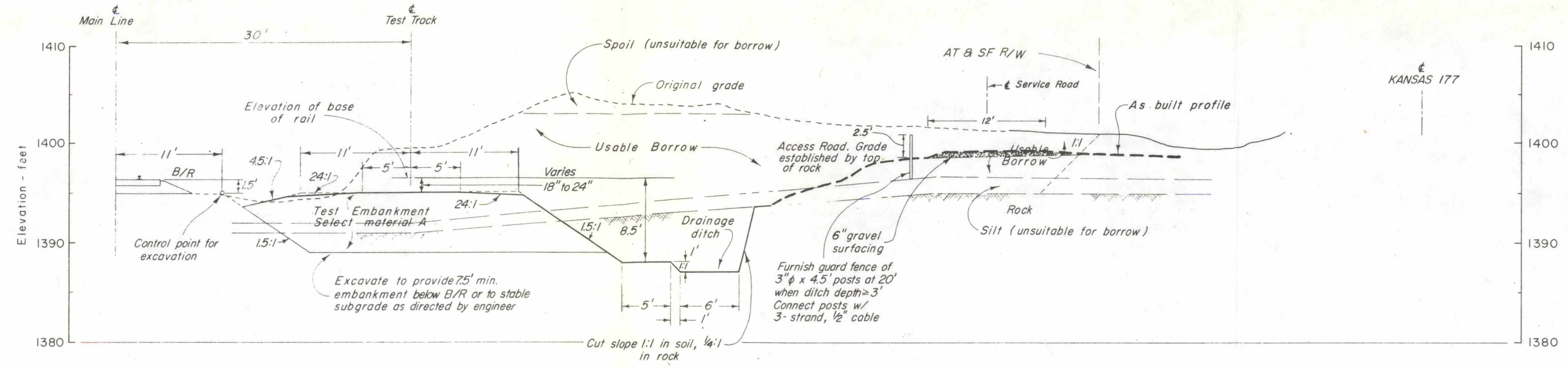
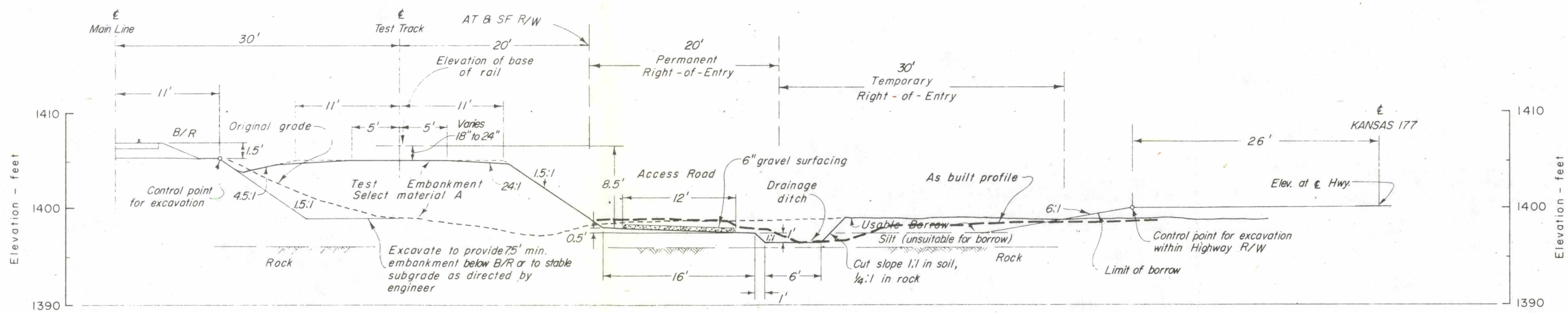


TYPICAL EXCAVATION SECTION
(STA. 8582+00)



TYPICAL EMBANKMENT SECTION
(STA. 8555+00)

0 5 10 15 20
Horiz. Scale - feet

THE ATCHISON, TOPEKA AND SANTA FE RAILWAY COMPANY
EASTERN LINES, TOPEKA, KANSAS
DATED Sept. 14, 1970 APPROVED [signature] Chief Engineer

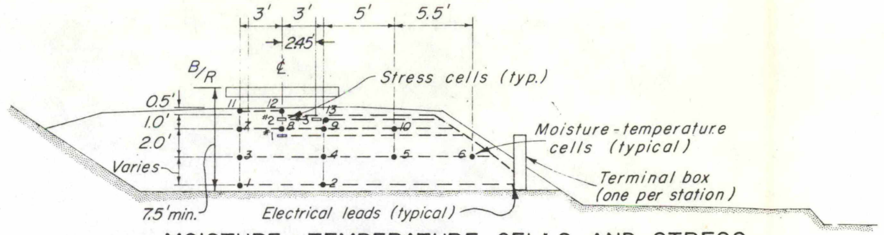
U. S. DEPARTMENT OF TRANSPORTATION
EXPERIMENTAL TEST TRACK
EMBANKMENT

TYPICAL EXCAVATION & EMBANKMENT SECTIONS

Shannon and Wilson
Soil mechanics and foundation engineers

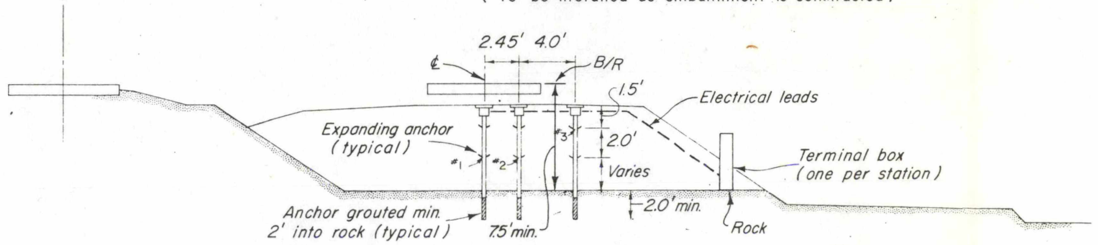
Rev. As-built Dec. 1, 1971

7 / 8



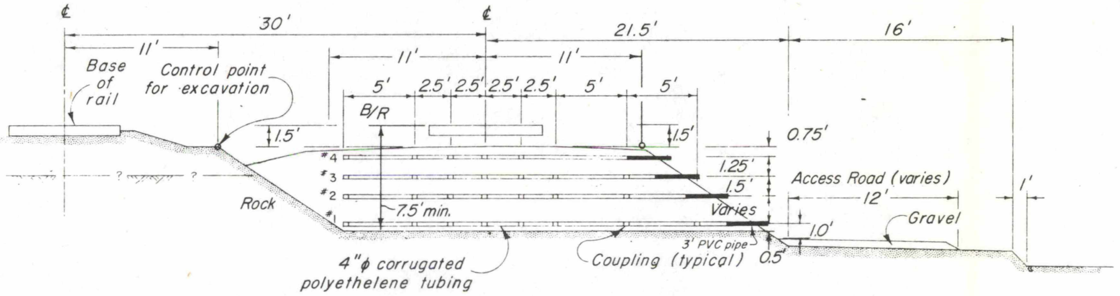
MOISTURE - TEMPERATURE CELLS AND STRESS CELLS — MAIN ARRAY

(To be installed as embankment is constructed)



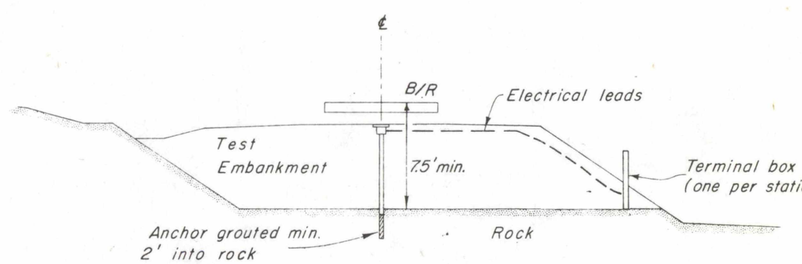
VERTICAL EXTENSOMETERS - MAIN ARRAY

(To be installed after completion of embankment)



HORIZONTAL TUBING - MAIN ARRAY

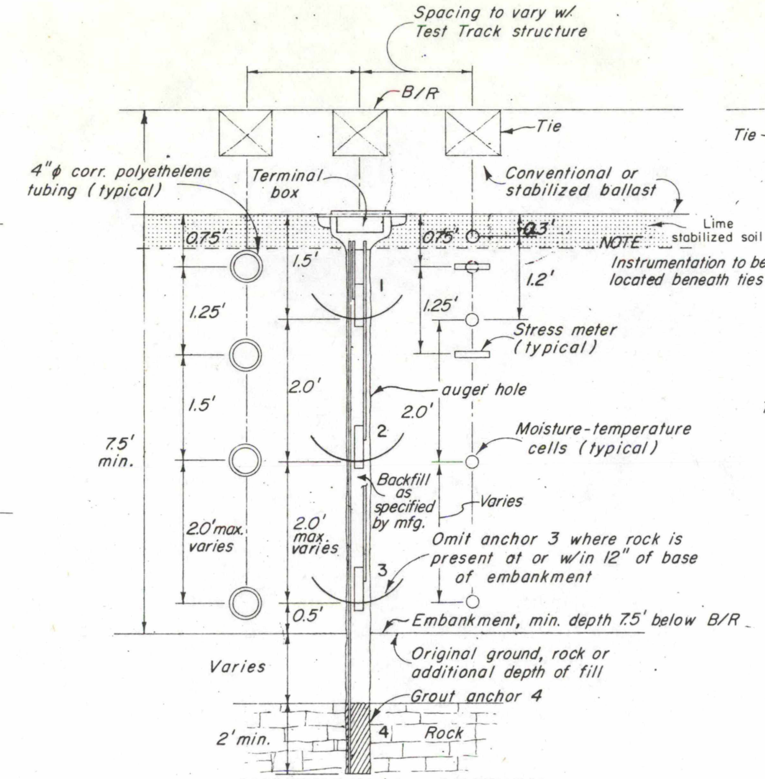
(To be installed as embankment is constructed)



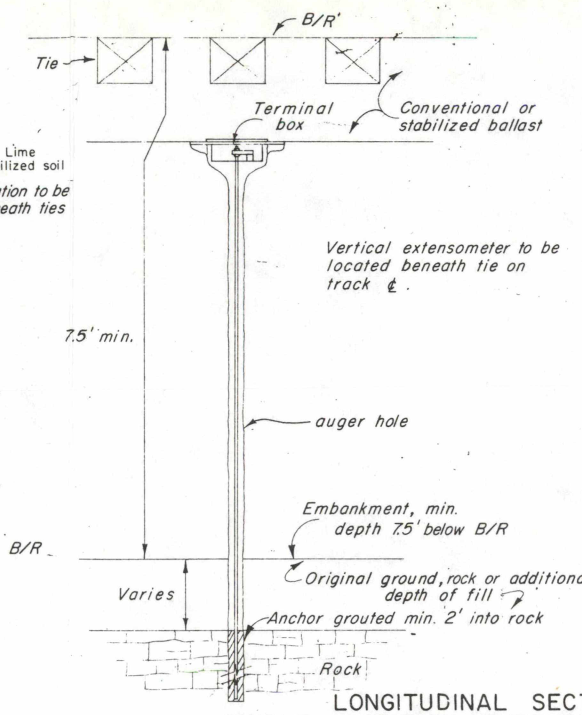
SINGLE - POSITION EXTENSOMETER

(To be installed after completion of embankment)

0 5 10 15
Scale - feet

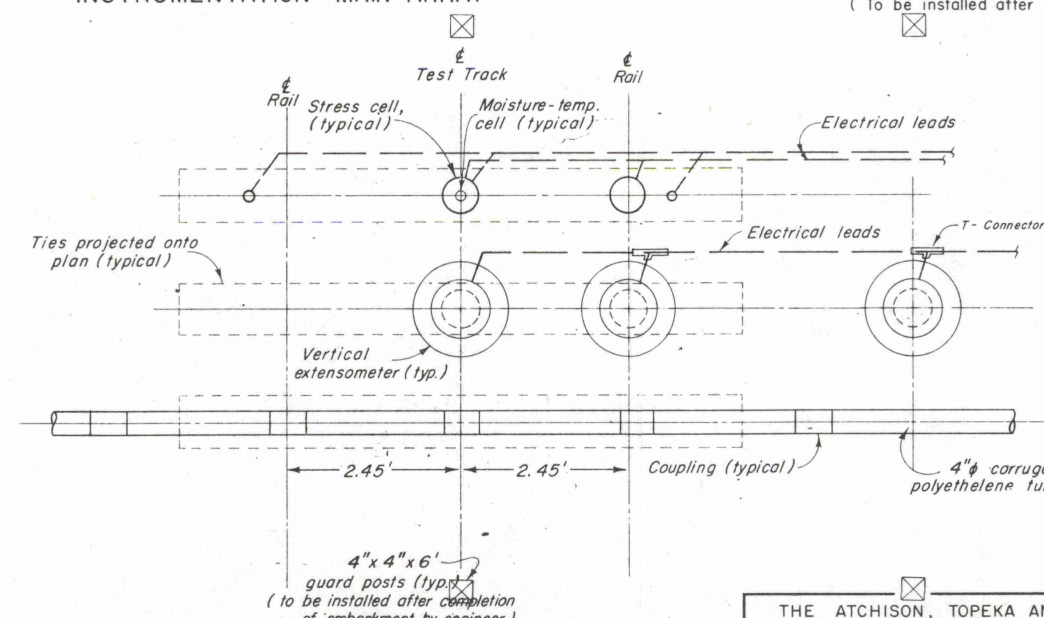


LONGITUDINAL SECTION
INSTRUMENTATION - MAIN ARRAY



LONGITUDINAL SECTION
SINGLE - POSITION EXTENSOMETER

(To be installed after completion of embankment)



PLAN
INSTRUMENTATION - MAIN ARRAY

0 10 20 30 40
Scale - feet

NOTES:

1. All instrumentation to be furnished and installed by the engineer.
2. Moisture - temperature cells, stress cells and horizontal tubing to be installed as the embankment is placed. Extensometers (vertical) to be installed after embankment is completed.

THE ATCHISON, TOPEKA AND SANTA FE RAILWAY COMPANY EASTERN LINES, TOPEKA, KANSAS DATED Sept. 14, 1970 APPROVED [signature] Chief Engineer
U. S. DEPARTMENT OF TRANSPORTATION EXPERIMENTAL TEST TRACK EMBANKMENT
TYPICAL INSTRUMENTATION DETAILS
Shannon and Wilson Soil mechanics and foundation engineers — Rev. As-built Dec. 1, 1971 — 8 / 8

FIG. 12

APPENDIX B

CBR AND FREEZE-THAW STUDY

By

MARSHALL R. THOMPSON, P.E.

GENERAL COMMENTS - CBR DATA

1. The immediate CBR's are high for both lime-treated soils. Although CBR data is not available for the natural soil at 25% moisture content, the immediate CBR's are undoubtedly substantially higher.
2. Curing for 48 hrs. at 120F effected the lime-soil pozzolanic reaction and further CBR increases were obtained.
3. Soaking (complete water immersion) for 96 hrs. in general caused a slight decrease in CBR. The swell values for the lime-soil mixtures ranged from 0.10 to 0.20%, a substantial reduction from the 5%+ natural soil data reported by Shannon and Wilson in the "Design Studies Report."
4. Only nominal water content increases were noted in the CBR specimens during the 96-hr. soaking period. The lime treatment effectively restrained the swell and softening effects that typically accompany such moisture content increases.
5. The design lime content of 3% effectively modifies both the Kansas A and Kansas C soils. Stability is greatly improved and swelling properties are substantially reduced.

FREEZE-THAW TEST PROCEDURE

Apparatus:

The apparatus consisted of the following:

1. A commercial wide mouth vacuum flask with an internal diameter of about 3 in. and depth of about 6 in.
2. A specimen holder of low thermal conductivity lucite for holding the cylindrical specimen inside the vacuum flask. The base of the specimen holder was perforated.
3. A supply of rubber membrane cut into 4-in. lengths.
4. A comparator with a dial guage having an accuracy of .0001 in. and fitted with 1/4 in. ball bearing seats.
5. A freezer maintained at 22 F $\pm$ 2 F.
6. Loading machine with a deformation rate of 0.05 in./min.

Test Procedure:

1. 1/4-in. ball bearings were epoxy glued to each end of the specimens. The ball bearings acted as reference points for the length change measurements made during cycles of freezing and thawing.
2. The specimens were encased in thin rubber membranes leaving the tops and bottoms of the specimens exposed.
3. The tops of the specimens were "painted" with an RC liquid asphalt to serve as a "seal".
4. The lengths of the specimens were measured by the comparator to determine the initial lengths (0 cycles freeze-thaw).

5. The holders containing the specimens were then placed in the vacuum flasks.

6. The vacuum flasks and specimens were placed in the freezer (22 F ± 2 F) for 16 hours.

7. After the 16 hour freezing period the vacuum flasks were removed from the freezer. The specimens were removed from the flasks and allowed to thaw for 8 hours at 77 ± 2 F in a container covered with a moist towel to prevent drying. Sixteen hours freezing and 8 hours thawing represented one freeze-thaw cycle.

8. Step 7 was repeated to develop the desired number of cycles of freezing and thawing.

9. Length change and compressive strengths were evaluated for series of specimens subjected to 4 or 8 freeze-thaw cycles. Moisture samples were taken from the top, middle, and bottom of the specimens after they had been tested in compression.

FREEZE-THAW DATA SUMMARY

Eldorado, Kansas DOT Project

Soil	% Lime	Molding[1] w,%	Molding[1] γ_D,pcf	# F-T Cycles	Q_u,psi[2]	ΔL,%[3]	Water Content,%[4] Top	Middle	Bottom
Kansas A	2	25.1	92.7	0	152	0	-	22.5	-
				4	229	-0.6	17.8	17.6	17.6
				8	239	-1.0	18.0	17.0	16.6
	3	26.0	92.1	0	262	0	-	21.4	-
				4	336*	-0.8	19.0	18.6	17.5
				8	309*	-1.3	18.8	17.3	17.0
	4	25.5	90.6	0	272	0	-	21.8	-
				4	262	-0.6	19.8	19.4	18.9
				8	254	-0.9	18.9	17.4	16.9
Kansas C	2	25.2	92.8	0	132	0	-	22.2	-
				4	180	-0.1	19.5	19.0	18.8
				8	210	-0.7	16.1	16.5	16.2
	3	24.1	94.1	0	231	0	-	21.4	-
				4	248	-0.3	18.8	17.9	17.4
				8	280	-0.6	19.1	18.1	17.3
	4	24.8	91.7	0	276	0	-	22.2	-
				4	293	-0.3	19.1	18.7	18.6
				8	349	-0.6	18.6	18.2	17.6

* Only one specimen was available for testing.

NOTES

1. 2-inch diameter by 4-inch specimens were prepared in 3 layers with each layer being compacted using a 4-lb. hammer with a 12-inch drop. Compaction effort was adjusted to provide dry densities of approximately 92-94 pcf for Kansas A and 90-92 pcf for Kansas C. Molding moisture contents for the mixtures were to be approximately 25%.

2. Strengths are the average of 3 specimens for 0 F-T cycles and 2 specimens for 4 and 8 F-T cycles. The specimens were tested at a constant deformation rate of 0.05 in./min. All specimens were cured in sealed containers for 48 hrs. at 120F.

3. +, swell; -, shrink.

4. Following cyclic freeze-thaw, moisture samples were taken from the top, middle, and bottom of the compressive strength specimens.

APPENDIX C

SERVICE ROAD GRAVEL

APPENDIX C
SERVICE ROAD GRAVEL

Specifications for the service road gravel stated that the rock should be crushed limestone and that the wear loss should not exceed 45 percent under the Los Angeles Abrasion Test. Material passing the No. 200 sieve by washing should not exceed three percent. If it does, the contractor must furnish 1.5 percent additional material at no cost for each percentage point over three. In no case should the minus sieve 200 material plus other deleterious substances exceed ten percent. For payment, deductions should be made for moisture content. Gradation after removal of fines should conform to the following:

Size	Percent Retained
1 inch	0-45
3/8 inch	45-100
#30 Sieve	95-100

Shannon & Wilson, Inc. visited the intended source of gravel at a quarry near Florence, Kansas and obtained a sample of the proposed gravel. This material, Sample A, had 8.2 percent passing the No. 200 sieve as shown in Fig. C1. The fines were excessive and the contractor was informed. A Los Angeles Abrasion Test performed on Sample A had 34.8 percent loss, so the soundness of the gravel was adequate. The test results are attached.

The contractor then had a washed sample delivered to the jobsite with less than one percent fines, Sample B; the contractor was informed that the material was acceptable. When the contractor began hauling in quantity, it became clear that the delivered gravel was similar to Sample A, not the approved Sample B. The contractor was informed and fifteen grain size curves were performed during placement of about 80 percent of the material. The last samples were taken on October 16, 1971, the last day Shannon & Wilson, Inc. was on site. Gravel continued to be hauled in small quantities until completion on November 16, 1971.

Gradation curves for three samples of production delivered gravel are shown in Fig. C1. Percentages passing the No. 200 sieve and percent water content are listed in Table C1. For the production deliveries, the average percent passing the No. 200 sieve was **9.6** percent and the average water content was 7.6 percent. With this moisture content, 93.0 percent of the total material weight was dry gravel. Allowing three percent permissible fines, 6.6 percent of the fines was excessive. Compensating for 7.4 percent at the rate of 1.5 to 1.0 extends to 9.9 percent that the contractor should provide at no extra cost; in other words, the contractor should be paid for 90.1 percent. Combining the moisture deduction with that for excessive fines, 0.93 x 0.901, shows that the contractor should be paid for only 83.7 percent of the weight delivered. Adjustments should be made if the gravel delivered improved or lost quality between October 16 and November 16, 1971, when testing was not conducted.

The gravel was compacted under the observation of ATSF.

WICHITA TESTING LABORATORIES
Materials Engineers
TELEPHONE (316) 264-4328
1428 N. MOSLEY AVE. • WICHITA, KANSAS 67214

KARL R. HORNER, P.E.
MANAGER

August 23, 1971

Shannon Wilson, Inc.
P.O. Box 744
ElDorado, Kansas 67042

ATTENTION: Mr. Ron Salley

REFERENCE: Los Angeles Abrasion Test

Gentlemen:

In accordance with your request we have performed a Los Angeles Abrasion test on a sample of crushed rock submitted to our laboratory. The test was performed in accordance with the procedures as outlined in ASTM C131-69 Grading B. The results of this test is as follows.

	Sample Size	Sample Wt.
Before Test	3/4 - 1/2	2500
	1/2 - 3/8	2500
After Test	(Ret. on No. 12)	3262

$$\text{Percent Loss} = \frac{1738}{5000} \times 100 = 34.8\%$$

Respectfully submitted,

WICHITA TESTING LABORATORIES

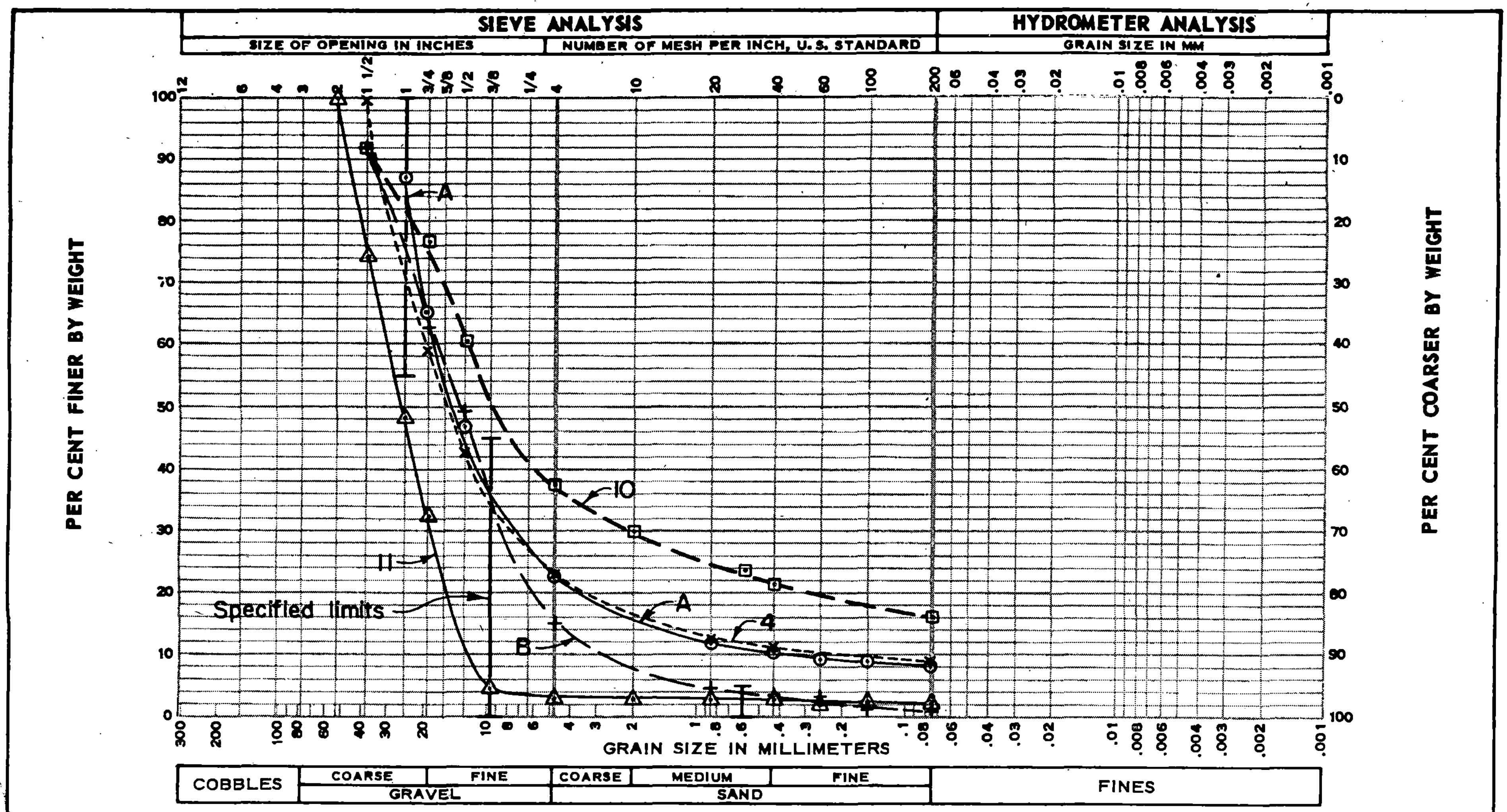
By Richard L. Luke
Richard L. Luke
Geologist

RLL:ja
3 Copies

TABLE C 1

SERVICE ROAD GRAVEL TESTS

Sample		Dumping Date	Water Content %	Passing No. 200 Sieve, %	Remarks
A	PLR @ Florence	8/10/71	7.2	8.2	Told Cont. too fine
B	Special sample	9/16/71	6.2	0.9	Sample load brought to site
	1	10/9/71 0850	7.5	11.5	940 tons placed
	2	10/9/71 0900	8.2	12.8	
	3	10/9/71 0940	8.8	6.4	
	4	10/9/71 1000	8.3	9.2	
	5	10/9/71 1345	8.1	14.3	
	6	10/9/71 1400	7.5	7.6	
	7	10/9/71 1715	6.4	13.0	
	8	10/12/71 1540	7.2	3.9	~150 tons placed
	9	10/12/71 1548	7.5	7.8	
	10	10/12/71 1600	7.7	16.0	
	11	10/13/71 1505	7.1	2.2	~150 tons placed
	12	10/13/71 1515	8.3	12.5	
	13	10/16/71 0930	-	7.3	@ 8536;~500 tons placed
	14	10/16/71 1200	7.3	11.9	@ 8545
	15	10/16/71 1400	6.5	7.1	@ 8558



SAMPLE NO.	DEPTH -FT.	U.S.C.	CLASSIFICATION	NAT. W.C. %	LL	PL	PI
A	Surface	GW	Light tan GRAVEL, some sand, trace silt.	7.2			
B	"	GW	Light tan GRAVEL, some sand, trace silt.	6.2			
4	"	GW	Light tan GRAVEL, some sand, trace silt.	8.3			
10	"	GM	Light tan GRAVEL, some silty sand.	7.7			
11	"	GW	Light tan GRAVEL, trace sand and silt.	7.1			

AT & SF

GRAIN SIZE CLASSIFICATION

SERVICE ROAD GRAVEL

C-268 DEC, 1971

SHANNON & WILSON
SOIL MECHANICS & FOUNDATION ENGINEERS

FIG. C-1

APPENDIX D

INSTRUMENTATION MANUALS

By

THE SLOPE INDICATOR COMPANY

D-1 Instructions - LVDT Extensometer

D-2 Instructions - Dynamic Extensometer

D-3 Instructions - Soil Pressure Cell

Instructions

LVDT EXTENSOMETER

GENERAL INFORMATION

1. INTRODUCTION

The LVDT extensometer is an instrument for measuring the change in distance between two points under dynamic loading conditions. The device is embedded within boreholes drilled in earthfill embankments. It provides an electrical signal to a remote point for one to four anchor points.

2. DESCRIPTION

Sensing Element The extensometer contains an electrical sensing element for measuring the linear displacement and transmitting a proportional signal to a remote point through a shielded cable. This element is a linear-variable-differential-transformer (LVDT). It consists of a body which is the transformer windings and the magnetic core which is movable within the windings. The LVDT is a Schaevitz type 1000HR.

Anchors The anchors are hydraulic types which also have an attached housing for mounting the LVDT body. Hydraulic oil under pressure is used to force three steel prongs out of the anchor body into the soil.

LVDT Housing This consists of standard 3/4 in. PVC pipe with adapter to attach the lower end to the anchor. The upper end is terminated within a PVC slip-joint. The LVDT body is inserted by means of an adapter attached to the lower end which has left hand threads. The insertion rod passes through the body of the LVDT and screws into the adapter with right hand threads. The LVDT is removable due to the opposing threads.

Junction Box At the upper end of the extensometer, a steel, waterproof box provides support for the brass rods. These rods support the magnetic LVDT core attached at the lower end. Relative movement between the magnetic core and the LVDT produces the electrical signal. The rod position is adjustable by means of two jam nuts at either side of the rod support bar.

The sensitivity of each LVDT is slightly different for each unit and this must be taken into account when making static measurements with the TR-100 or when making dynamic measurements with oscillographic recorders. The LVDT sensitivity has been measured using the procedure described in that section of this manual. It is expressed in terms of millivolts output per volt input per inch displacement. Sensitivities of all LVDT's are listed in the table.

1. MEASURING STATIC DISPLACEMENTS

To make readings of the static displacement indicated by several LVDTs using a Schaevitz TR-100 portable indicator, it is necessary to standardize the instrument. To do this, it is necessary to have on hand a Schaevitz, Model 1000HR as a standard LVDT. This LVDT must be calibrated using the procedure described in this manual to determine its sensitivity in terms of output millivolts per input volt per inch of displacement.

Connect the standard LVDT to the indicator. Using the calibration device, Schaevitz Model PMP2000T, apply a known displacement, preferably one inch. Adjust the indicator scale factor and span (amplifier gain) controls so that the reading of the indicator is at full scale (100 on the Schaevitz TR-100). Tighten the lock nut on the span control.

Connect the LVDT to be measured and record the scale reading. Note that these instructions do not preclude those instructions given in the TR-100 instruction manual. After once standardizing the span adjustment on the TR-100, do not change this setting while reading other LVDTs.

To convert the scale readings obtained for the measuring LVDTs, it is necessary to apply the sensitivity for each LVDT determined by previous calibrations as follows:

$$D_m = R_m \times \frac{S_m}{S_s} \times K_s$$

where, D_m = static displacement of the measuring LVDT in inches

R_m = scale reading of indicator from measuring LVDT

S_s = sensitivity of standard LVDT

S_m = sensitivity of measuring LVDT

K_s = scale factor of indicator established with standard LVDT

As an example let, $Ks = \frac{1}{100}$ in./scale unit

$Rm = 70$ scale units

$Ss = 3708$ MV/V/inch

$Sm = 3813$ MV/V/inch

then: $D_m = \frac{70}{100} \times \frac{3813}{3708} = 0.72$ inches

As an alternate method, the equipment and circuit described in the calibration section of this manual may be used. In this case, however, the position of the LVDT core is unknown. Following the calibration procedure given, measure the AC millivolt output and the AC input volts. Since the sensitivity of the measuring LVDT is known from previous calibration (see table), the actual static displacement is measured. Static displacement is determined as follows:

$$D_m = \frac{\text{MV out}}{\text{V in}} \times \frac{10}{S_m}$$

where, D_m = Unknown static displacement of LVDT core in inches

MV out = AC millivolts output from LVDT

V in = AC volts input to LVDT

S_m = sensitivity of LVDT

As an example let, MV out = 1133 millivolts AC

V in = 6 volts AC

S_m = 3813 MV/V/inch X 10 (from chart)

then: $D_m = \frac{1133}{6} \times \frac{10}{3813} = 0.5$ inches

2. MEASURING DYNAMIC DISPLACEMENTS

Since the oscillograph and signal conditioning equipment is undetermined, this procedure covers only the general approach to be used. The equipment and circuit described in the calibration section are used to set up each oscillograph channel.

E. Record output voltage from LVDT with Fluke 887AB in millivolts AC.

F. Record primary excitation voltage to LVDT with Fluke 887AB in volts.

G. Record primary excitation frequency to LVDT with Eldorado counter.

H. Position core of LVDT with micrometer to minus (-) 0.5 in. (toward cable). See drawing of displacement direction.

I. Repeat E.

J. Repeat F.

K. Repeat G.

L. Position core of LVDT with micrometer to minus (-) 1.0 in. (toward cable). See drawing of displacement direction.

M. Repeat E, F, and G.

N. Reposition core of LVDT to zero.

O. Repeat E, F, and G.

P. Position core of LVDT to +0.5 in. (toward red spot).

Q. Repeat E, F, and G.

R. Position core of LVDT to +1.0 in. (toward red spot).

S. Repeat E, F, and G.

T. Calculate and record sensitivity at +1.0 in.

$$\text{Sensitivity} = 10 \times \frac{\text{Secondary Output Voltage at +1.0 in.}}{\text{Primary excitation voltage}}$$

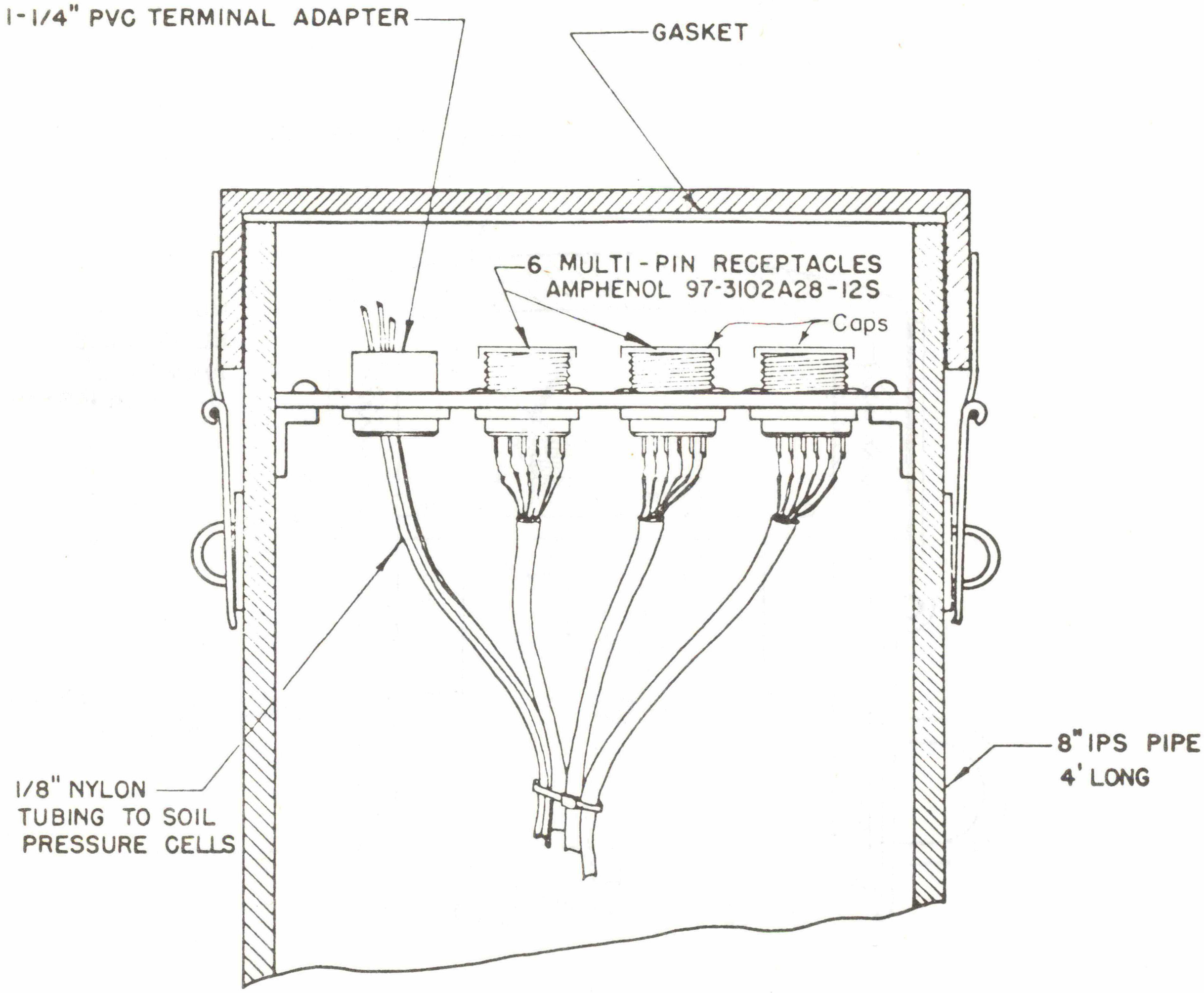
$$= 10 \times \frac{\text{AC Millivolts output at 1.0 in.}}{\text{AC Volts excitation}}$$

U. Enter deviation from linearity for 0.5 in.

V. Check measured sensitivity against value given on manufacturer's card.

SENSITIVITY OF LVDT FOR
AT & SF EXTENSOMETERS
(Schaevitz 1000HR)

Serial Number	Sensitivity MV/V/in.X10	Serial Number	Sensitivity MV/V/in.X10	Serial Number	Sensitivity MV/V/in.X10
914	3708	1007	3777	1054	3807
915	3793	1008	3778	1055	3798
916	3595	1009	3780	1056	3817
917	3743	1010	3800	1057	3775
918	3717	1011	3783	1058	3810
919	3798	1012	3778	1059	3770
927	3818	1013	3750	1061	3798
928	3790	1014	3758	1062	3705
929	3767	1015	3805	1063	3703
930	3740	1016	3760	1064	3792
931	3773	1017	3770	1065	3773
932	3780	1018	3740	1066	3775
933	3780	1024	3813	1067	3723
934	3788	1025	3805	1068	3790
935	3810	1026	3778	1069	3762
941	3773	1027	3823	1070	3688
942	3705	1028	3763	1071	3682
943	3827	1029	3810	1072	3800
944	3763	1030	3808	1073	3658
945	3713	1031	3825	1074	3787
946	3793	1032	3790	1075	3728
947	3813	1033	3817	1076	3758
948	3720	1034	3792	1077	3740
949	3778	1035	3743	1078	3820
989	3767	1036	3810	1079	3687
990	3802	1037	3815	1080	3785
991	3772	1038	3793	1081	3765
992	3787	1039	3763	1082	3760
993	3792	1040	3782	1083	3793
994	3805	1041	3817	1084	3760
995	3775	1042	3800	1085	3740
996	3765	1043	3782	1086	3792
997	3773	1044	3792	1087	3745
998	3742	1045	3810	1088	3800
999	3773	1046	3777	1089	3772
1000	3798	1047	3807	1090	3777
1001	3790	1048	3812	1091	3740
1002	3823	1049	3763	1092	3775
1003	3773	1050	3803	1093	3745
1004	3774	1051	3790	1094	3793
1005	3802	1052	3792	1095	3763
1006	3770	1053	3815	1096	3757



UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES
TOLERANCES ON

FRACTIONS	DECIMALS	ANGLES
± .010	± .005	± ½°

CHAMFER OR RAD ON ALL CORNERS OR EDGES .005 TO .010
REMOVE ALL BURRS

MATERIAL

FINISH

MAIN ARRAY TERMINAL PIPE

A.T. & S.F.
EXPERIMENTAL TEST TRACK

SLOPE INDICATOR CO.
SEATTLE, WASHINGTON

SCALE	DR'N	APP'D	REV	DATE	SHT	OF
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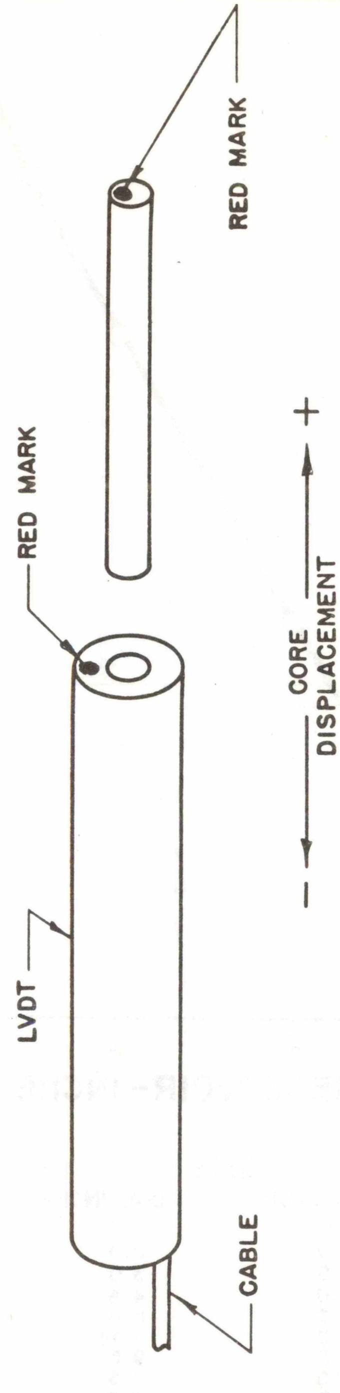


UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES
TOLERANCES ON

FRACTIONS	DECIMALS	ANGLES
± .010	± .005	± ½ °

CHAMFER OR RAD ON ALL CORNERS OR EDGES .005 TO .010
REMOVE ALL BURRS

MATERIAL

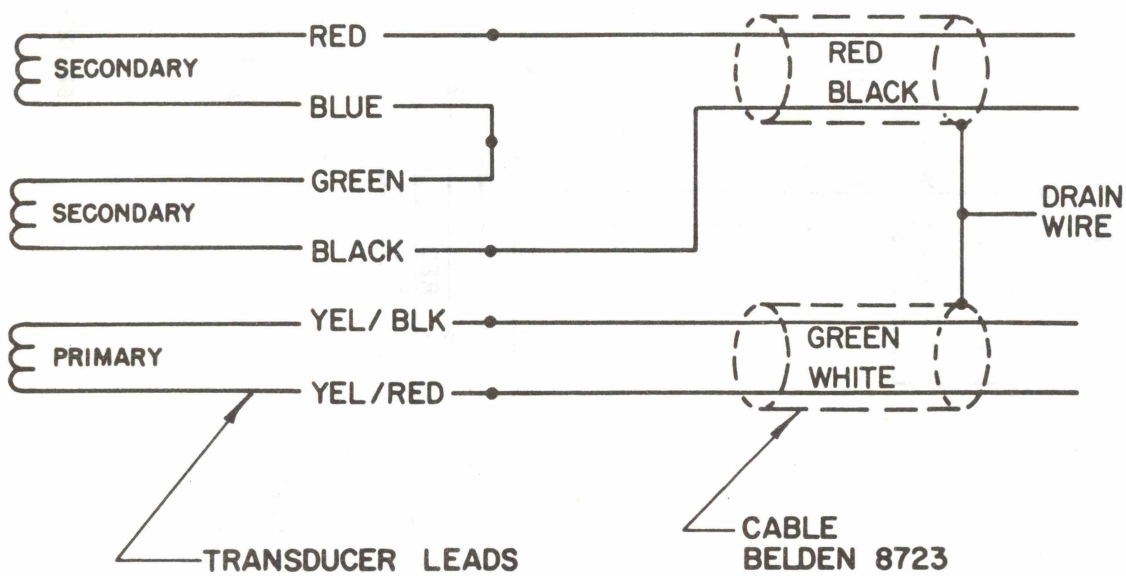
FINISH

DIRECTION OF DISPLACEMENT
SCHAEVITZ 1000 HR LVDT

AT & SF
EXPERIMENTAL TEST TRACK

SLOPE INDICATOR CO.
SEATTLE, WASHINGTON

SCALE	DR'N A.S.	APP'D	REV	DATE 12-15-71	SHT 1 OF 1



UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES
TOLERANCES ON

FRACTIONS	DECIMALS	ANGLES
± .010	± .005	± ½ °

CHAMFER OR RAD ON ALL CORNERS OR EDGES .005 TO .010
REMOVE ALL BURRS

WIRING FOR 1000 HR LVDT
FOR SINGLE & MULTI-POSITION
EXTENSOMETER

MATERIAL

FINISH

SLOPE INDICATOR CO.
SEATTLE, WASHINGTON

SCALE	DR'N	APP'D	REV	DATE	SHT	OF
	A.S.			3-4-71	1	1

<u>Displacement Range.</u> The LVDT's measure displacement of the two anchor heads linearly over a range of ± 0.5 inches.

<u>Linearity.</u> The output signal from the LVDT is a linear function of displacement to within ± 1% of full range.

<u>Installation Rods</u>. In order to locate the instrument within the tubing, special rods are used. These rods consist of a hook and graduated scale for locating each coupling. The hook is removed and the rods are used to install the extensometer at the proper point.

<u>Displacement Indicator</u>. For adjusting and checking the instrument and measurement of very slow displacement, a portable Schaevitz TR-100 indicator is used.

<u>Hydraulic Pump</u>. A small hydraulic hand pump, Enerpac type P-14 is used to extend and retract the anchor pistons.

<u>AC Voltage Source</u>. The Schaevitz TR-100 Indicator operates from any standard 60 cps power source, 105 to 130 volts, single phase at 8 watts.

<u>Operating Temperature</u>

LVDT	-65F to + 180F
TR-100 Indicator	OF to + 130F
Hydraulic Oil	-50F (pour Point)

<u>OPERATING INSTRUCTIONS</u>

1. <u>LOCATING COUPLINGS</u>

Attach hooking point to far end of first installation rods. Add sections of rod until hook is near coupling to be measured. Use graduated rod to measure distance.

Withdraw the rods. Remove the hooking point. Connect rod to extensometer near anchor head.

2. <u>ADJUST EXTENSOMETERS</u>

Adjust the extensometer to the correct length using variable length adjusting point as shown on the drawing. Allow about half of an inch of the slip joint to show.

Adjust the core to the desired reading on the LVDT.

3. HYDRAULIC CONNECTION

Attach valves to black hydraulic lines.

Operate hydraulic anchor points to determine the near and far anchor points.

Retract pistons by opening valves and pushing on pistons.

4. INSTALLATION

Push the extensometer through the tube with the rods until the required depth is reached. This is shown on the drawing.

Expand the far anchor points. (after expanding the anchor points, the valve must be closed until time to retract)

Pull back on the extensometer until the desired LVDT reading is obtained.

Expand the near anchor points and close the valve.

Unscrew the installation rods and remove (left hand thread)

5. REMOVAL

Disconnect the valve from the black lines, and attach to the white lines.

Retract the anchor points.

Remove extensometer from tubing by pulling back on rope or cable attached to the eye bolt,

6. MEASURING STATIC DISPLACEMENTS

For electrical wiring and hookup to the LVDT extensometers, refer to the electrical wiring diagram.

For operation using the Schaevitz TR-100 indicator, refer to the instruction manual for that instrument.

As an example let,

$$D_s = 0.5 \text{ inch}$$

$$S_s = 6676 \text{ MV/V/inch}$$

$$S_m = 6750 \text{ MV/V/inch}$$

$$K_m = 100 \text{ scale units per inch}$$

then, $C_m = 0.5 \times \frac{6676}{6750} \times 100$

$= 49$ scale units

Adjust the signal conditioning amplifier gain of the oscillograph so that deflection of the oscillograph is 49 scale units.

CALIBRATION PROCEDURE

The procedure described in this section is that used to calibrate the Schaevitz 500 HR LVDTs used in the extensometers. The sensitivity values determined by this means are listed below.

s/n 484	6676	millivolts	per	volt	per	inch	X	10	
s/n 505	6750	"	"	"	"	"	"	"	"
s/n 506	6780	"	"	"	"	"	"	"	"

1. EQUIPMENT

AC Voltmeter	-Fluke, AC/DC Differential Voltmeter, Model 887AB, S/N 1629
Excitation Generator	-Wavetek, VCG Generator, Model 131A, S/N 71206
Frequency Counter	-Eldórado, Model 224
Displacement Device	-Schaevitz, Model PMP-2000T

2. MECHANICAL SETUP

Mount the core of the LVDT in the micrometer spindle so that the red spot on the end corresponds to the red spot on the end of the LVDT body.

3. CIRCUIT

See schematic diagram. Note that both shields are grounded through the Wavetek generator.

4. PROCEDURE

A. Set core of 500HR LVDT at zero with micrometer of PMP2000T displacement device.

B. Adjust primary excitation from Wavetek 131A to 6.000 volts AC.

C. Adjust primary frequency from Wavetek 131A to 2500 Hz.

D. Position 500HR LVDT body over core (core stationary at zero displacement) for minimum output.

E. Record output voltage from LVDT with Fluke 887AB in millivolts AC.

F. Record primary excitation voltage to LVDT with Fluke 887AB in volts.

G. Record primary excitation frequency to LVDT with Eldorado counter.

H. Position core of LVDT with micrometer to minus (-) 0.25 in. (toward cable). See drawings of displacement direction.

I. Repeat E.

J. Repeat F.

K. Repeat G.

L. Position core of LVDT with micrometer to minus (-) 0.5 in. (toward cable). See drawing of displacement direction.

M. Repeat E, F, and G.

N. Reposition core of LVDT to zero.

O. Repeat E, F, and G.

P. Position core of LVDT to + 0.25 in. (toward red spot).

Q. Repeat E, F, and G.

R. Position core of LVDT to + 0.5 in. (toward red spot).

S. Repeat E, F, and G.

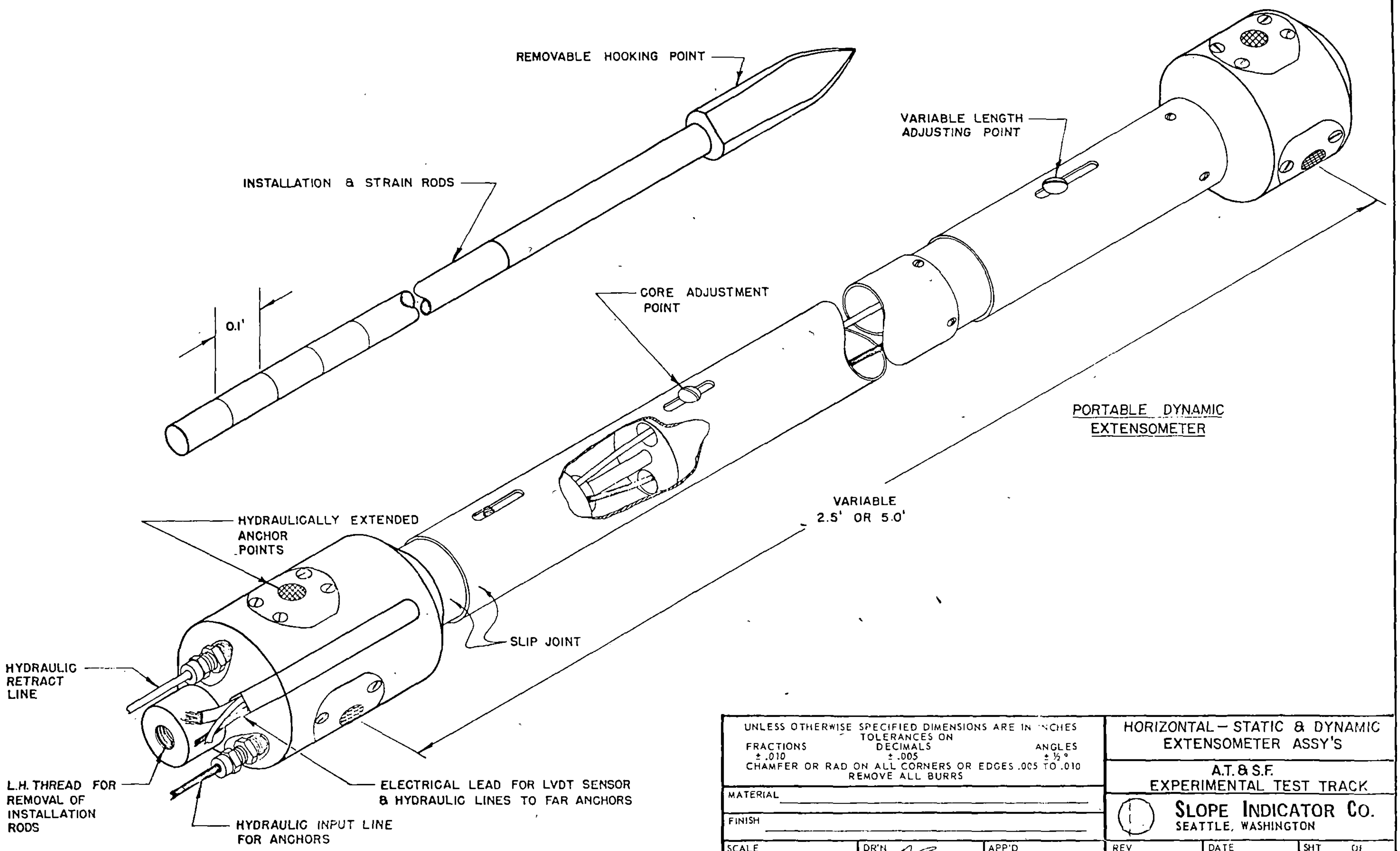
T. Calculate and record sensitivity at + 0.5 in.

$$\text{Sensitivity} = 20 \times \frac{\text{Secondary Output Voltage at + 0.5 in.}}{\text{Primary excitation voltage}}$$

$$= 20 \times \frac{\text{AC Millivolts output at + 0.5 in.}}{\text{AC Volts excitation}}$$

U. Enter deviation from linearity for 0.25 in.

V. Check measured sensitivity against value given on manufacturer's card.



UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES
TOLERANCES ON

FRACTIONS	DECIMALS	ANGLES
± .010	± .005	± ½°

CHAMFER OR RAD ON ALL CORNERS OR EDGES .005 TO .010
REMOVE ALL BURRS

MATERIAL

FINISH

SCALE | DR'N A.S. | APP'D

HORIZONTAL – STATIC & DYNAMIC EXTENSOMETER ASSY'S

A.T. & S.F.
EXPERIMENTAL TEST TRACK

SLOPE INDICATOR CO.
SEATTLE, WASHINGTON

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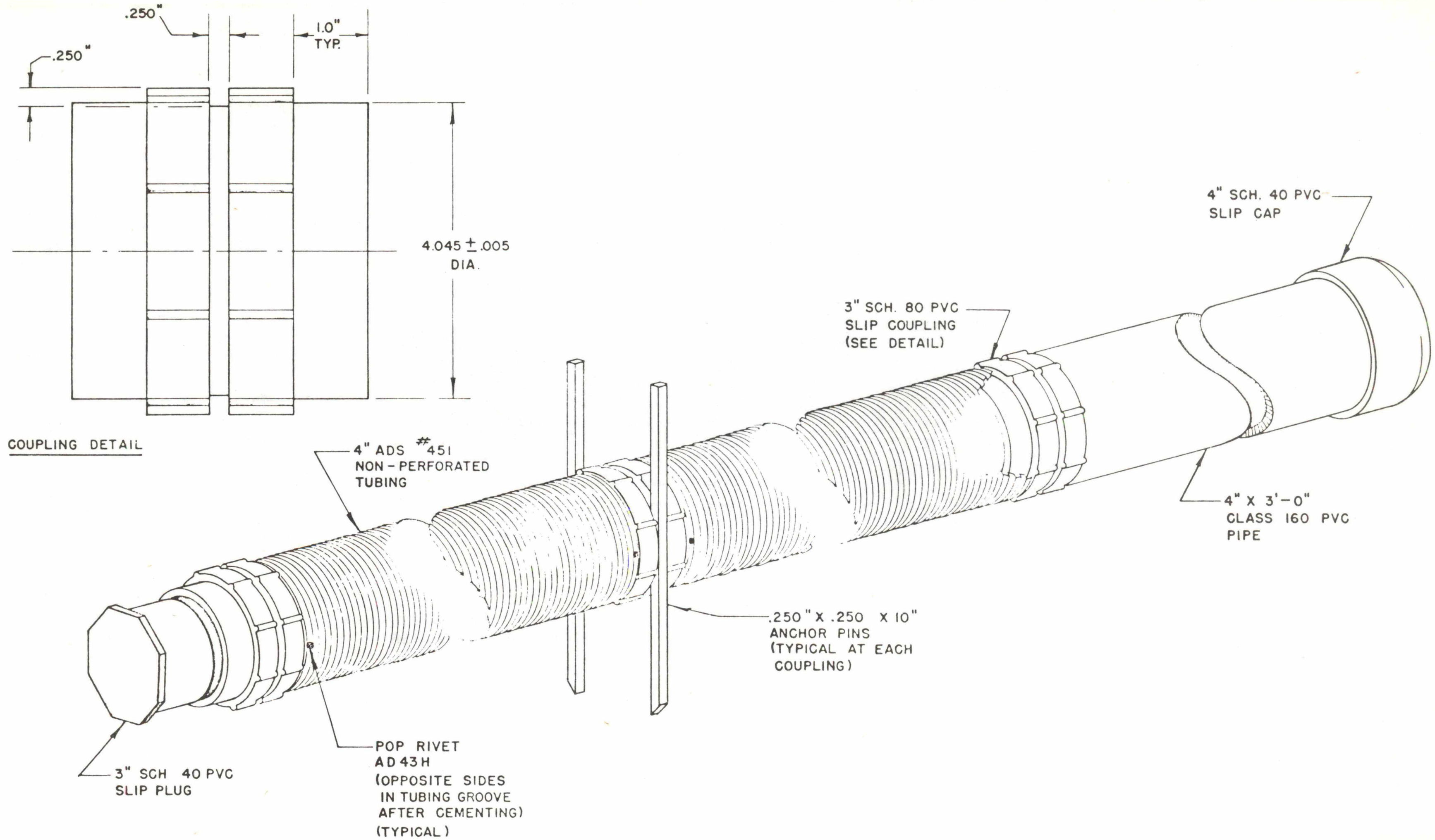


UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES
TOLERANCES ON
FRACTIONS ± .010 | DECIMALS ± .005 | ANGLES ± ½°
CHAMFER OR RAD ON ALL CORNERS OR EDGES .005 TO .010
REMOVE ALL BURRS

MATERIAL

FINISH

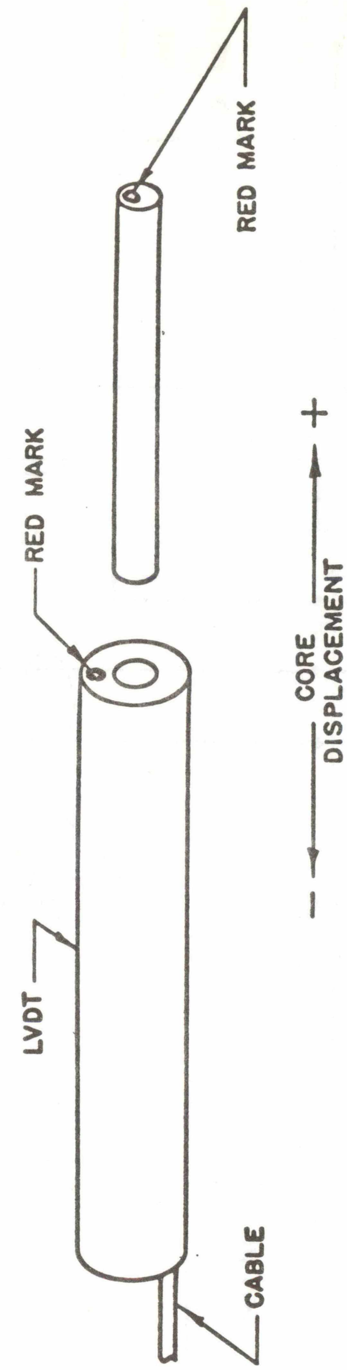
SCALE | DRN AS. | APP'D

HORIZONTAL EXTENSOMETER
TUBING ASSEMBLY -- 51844

EXPERIMENTAL TEST TRACK
THE ATCHISON, TOPEKA AND SANTA FE RAILWAY CO.

SLOPE INDICATOR CO.
SEATTLE, WASHINGTON

REV | DATE 10-8-70 | SHT 1 OF 1



UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES
TOLERANCES ON

FRACTIONS	DECIMALS	ANGLES
± .010	± .005	± ½°

CHAMFER OR RAD ON ALL CORNERS OR EDGES .005 TO .010
REMOVE ALL BURRS

MATERIAL

FINISH

DIRECTION OF DISPLACEMENT
SCHAEVITZ 500 HR LVDT

AT & SF
EXPERIMENTAL TEST TRACK

SLOPE INDICATOR Co.
SEATTLE, WASHINGTON

SCALE	DR'N	APP'D	REV	DATE	SHT	OF
	A.S.			12-17-71	1	1

APPENDIX D3

Instructions

SOIL-PRESSURE CELL

Instructions

SOIL-PRESSURE CELL

GENERAL INFORMATION

1. INTRODUCTION

The soil-pressure cell is an instrument for measuring the total stress in earth structures and foundations under dynamic loading conditions. It is embedded within earth-fill embankments and provides an electrical signal to a remote point.

2. DESCRIPTION

Sensing Element. The instrument contains an electrical sensing element for measuring the total pressure applied to the surface of the instrument. It provides an electrical signal proportional to this pressure. The electrical signal is generated by a linear-variable-differential-transformer (LVDT) pressure transducer, Schaevitz PT-7. The soil pressure cell has two 6 in. diameter pressure diaphragms welded to a ring. The cell is oil-filled and the applied pressure is transmitted directly to the diaphragm in the pressure transducer. This diaphragm moves a magnetic core within the transformer windings. Because the transducer measures gauge pressure the cavity on the backside of the diaphragm is connected to a 1/8 in. nylon tube. The tube is led along with the electrical cable to the terminal station where it is open to the atmosphere.

Terminal Station. The electrical cable of the soil-pressure cell is terminated to the side of the embankment at an 8-in. diameter steel pipe. The cable is terminated within the pipe at a multi-pin connector mounted on a panel. The terminal pipe is fitted with a water-proof, dust-proof, and lockable steel cap.

then: $P_m = \frac{70}{100} \times \frac{4.086}{4.740} = 60$ psi

As an alternate method, the equipment and circuit described in the calibration section of this manual may be used. In this case, however, the pressure is unknown. Following the calibration procedure given, measure the AC millivolt output and the AC input volts. Since the sensitivity of the measuring LVDT is known from previous calibration (see table), the actual static pressure is measured. Static pressure is determined as follows:

$$D_m = \frac{\text{MV out}}{\text{V in}} \times \frac{1}{S_m}$$

where, D_m = Unknown static pressure in psi

MV out = AC millivolts output from LVDT

V in = AC volts input to LVDT

S_m = sensitivity of LVDT

As an example let, MV out = 600 millivolts AC

V in = 6 volts AC

S_m = 2.000 MV/V/psi (from chart)

then: $D_m = \frac{600}{6} \times \frac{1}{2.000} = 50$ psi

2. MEASURING DYNAMIC DISPLACEMENTS

Since the oscillograph and signal conditioning equipment is undetermined, this procedure covers only the general approach to be used.

Connect the standard PT-7 LVDT pressure transducer used for static measurements to each oscillograph channel. Apply a known pressure of approximately full scale pressure. Adjust the signal conditioning amplifier gain so that the oscillograph chart deflection equals a value determined by the ratio of the LVDT sensitivities. The chart deflection is determined as follows:

$$C_m = P_s \times \frac{S_s}{S_m} \times K_m$$

where, C_m = Chart deflection

K_m = Chart scale factor to be used

S_s = Sensitivity of standard LVDT

S_m = Sensitivity of measuring LVDT

P_s = Pressure applied to standard LVDT

As an example let,

P_s = 40 psi

S_s = 4.470 MV/V/psi

S_m = 4.086 MV/V/psi

K_m = 1 scale units per psi

then, $C_m = 40 \text{ X } \frac{4.740}{4.086}$

$= 46$ scale units

Adjust the signal conditioning amplifier gain of the oscillograph so that deflection of the oscillograph is 46 scale units.

CALIBRATION PROCEDURE

The procedure described in this section is that used to calibrate the Schaevitz PT-7 pressure transducers. The sensitivity values determined by this means are listed in the table versus serial number. The sensitivity is given in the following units: millivolts per volt per psi.

1. EQUIPMENT

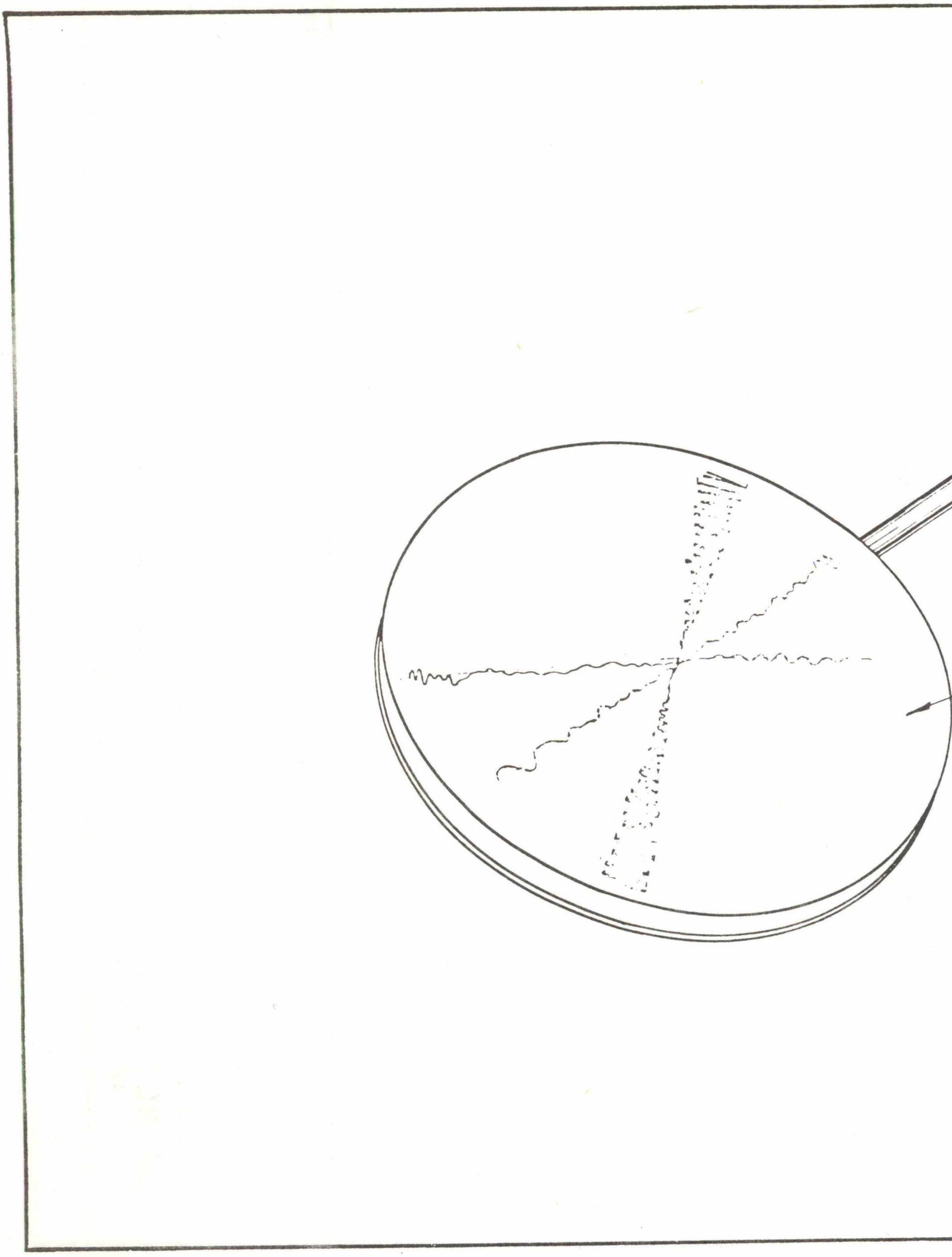
AC Voltmeter	-Fluke, AC/DC Differential Voltmeter, Model 887AB, S/N 1629
Excitation Generator	-Wavetek, VCG Generator, Model 131A, S/N 71206
Frequency Counter	-Eldorado, Model 224
Pressure Gauge	-Heise, Model CMM

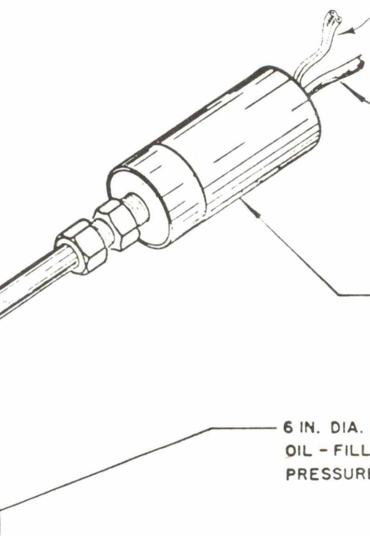
SENSITIVITY OF AT & SF SOIL PRESSURE CELLS

(Schaevitz PT-7 Pressure Transducer)

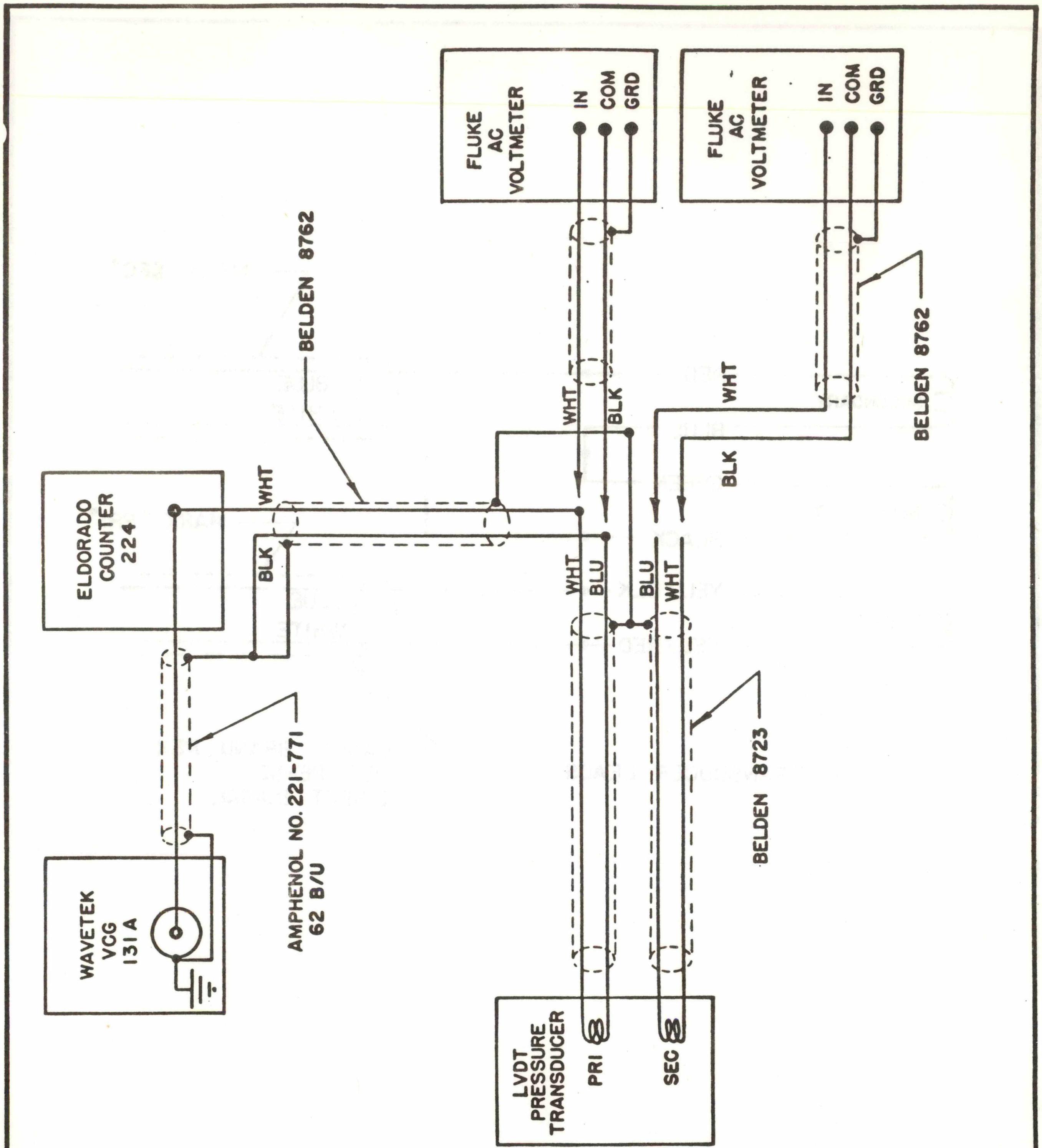
Serial No.	Sensitivity Millivolts/volts/psi
25-044	8.667
25-047	8.693
25-049	8.793
25-051	10.220
25-053	9.360
25-060	8.680
50-064	2.947
50-065	3.120
50-067	3.100
50-068	3.020
50-070	4.203
50-073	4.263
50-074	4.206
50-076	2.440
50-079	4.086
50-078	4.263
50-079	4.303
50-080	4.316
50-081	4.223
50-141	4.740
100-087	2.216
100-090	2.000
100-093	2.040
100-094	2.000
100-095	2.000
100-096	2.225
100-099	1.802

NOTE: First number in serial number indicates full scale pressure in psi.





UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES TOLERANCES ON FRACTIONS ± .010 DECIMALS ± .005 ANGLES ± ½° CHAMFER OR RAD ON ALL CORNERS OR EDGES .005 TO .010 REMOVE ALL BURRS			SOIL PRESSURE CELL		
MATERIAL					
FINISH			SLOPE INDICATOR CO. SEATTLE, WASHINGTON		
SCALE	DR'N A.S.	APP'D	REV	DATE 12-17-71	SHT 1 OF 1



UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES
TOLERANCES ON

FRACTIONS	DECIMALS	ANGLES
± .010	± .005	± ½°

CHAMFER OR RAD ON ALL CORNERS OR EDGES .005 TO .010
REMOVE ALL BURRS

CALIBRATION SET-UP FOR SCHAEVITZ PT-7 LVDT PRESSURE TRANSDUCER
AT & SF EXPERIMENTAL TEST TRACK

MATERIAL

FINISH

SLOPE INDICATOR CO.
SEATTLE, WASHINGTON

SCALE	DR'N	APP'D	REV	DATE	SHT	OF
	A.S.			12-17-71	1	1

Embankment Support for a Railroad Test Track: Construction Report, 1972
FRA, Office of High Speed Ground Transportation