SUBSURFACE INVESTIGATION
PROPOSED HALAWA VALLEY BUS
MAINTENANCE FACILITY
HALAWA, OAHU, HAWAII
FOR
THE CITY & COUNTY OF HONOLULU

DAMES & MOORE JOB NO. 4402-079-11

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February 27, 1976

Daniel, Mann, Johnson & Mendenhall of Hawaii
210 Ward Avenue, Suite 212
Honolulu, Hawaii 96814

Attention: Mr. Robert W. Kemp

Gentlemen:

Submitted herewith are nine copies of our report entitled "Subsurface Investigation, Proposed Halawa Valley Bus Maintenance Facility, Halawa, Oahu, Hawaii, for The City & County of Honolulu".

The general scope of our work was presented in our revised proposal dated January 13, 1976. Our findings and recommendations are presented in the body of the report. For your convenience, a brief summary is provided on the first page.

Soil samples not utilized during testing will be retained for a period of six months for possible future examination by you or your contractor. They will be discarded at that time unless you request otherwise.

We have appreciated the opportunity to perform this work for you. Should you have any questions regarding this report, please contact us.

Yours very truly,

DAMES & MOORE

Mei-Ban Lo

Mei-Ban Lo

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March 2, 1976

Daniel, Mann, Johnson & Mendenhall of Hawaii
210 Ward Avenue, Suite 212
Honolulu, Hawaii 96814

Attention: Mr. Robert W. Kemp

Gentlemen:

Addendum 1 to Report
Subsurface Investigation
Proposed Halawa Valley Bus
Maintenance Facility
Halawa, Oahu, Hawaii
<u>For City & County of Honolulu</u>

This letter is written to clarify questions from the civil and structural engineers for this project regarding our excavation recommendations.

1. <u>Excavation Limits</u> - For simplicity, in our report we recommend excavating ten feet beyond the building lines. More explicitly, we recommend that the excavation limits be determined by extending a plane at 60 degrees to the horizontal downward from the building lines to the fill and topsoil -- recent alluvium interface. At its deepest point, the limit of excavation as determined by this method is expected to be approximately ten feet from the building lines.

2. <u>Excavation Slope</u> - The slope of the excavations should be determined such that the State and Federal OSHA Regulations are satisfied.

Should there be any further questions regarding the contents of our report, please contact us.

Yours very truly,

DAMES & MOORE

Mei-Ban Lo

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March 11, 1976

Daniel, Mann, Johnson & Mendenhall of Hawaii
210 Ward Avenue, Suite 212
Honolulu, Hawaii 96814

Attention: Mr. Robert W. Kemp

Gentlemen:

Addendum 2 to Report
Subsurface Investigation
Proposed Halawa Valley Bus
Maintenance Facility
Halawa, Oahu, Hawaii
For City & County of Honolulu

As discussed during a meeting at your office on March 9, 1976, we have evaluated an additional alternative scheme for the proposed bus maintenance building. The scheme involves excavating the dumped fill from beneath the building site and replacing it with a compacted fill, as for the previously proposed single mat foundation. The foundation would consist of spread footings and tie beams.

During our discussions, we considered proportioning footings for different allowable pressures in order to equalize the settlement under each column. Based on the results of additional testing and analysis, it is our opinion that due to the variability of the soil conditions and the small differential settlements anticipated, the concept of proportioning different footings for different bearing pressures may not be warranted.

We recommend that a bearing pressure of 3,000 pounds per square foot be used to proportion all footings. Settlement of about 1 inch under interior columns and about 3/4-inch under exterior columns is anticipated. About 1/2-inch of differential settlement between columns on cut and columns on fill is expected. These estimates are based on the revised loads provided us during the recent meeting, i.e. 435 kips for interior columns and about 250 kips for exterior columns.

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The fill material for the five feet of compacted fill immediately below the footings should be the decomposed alluvium rather than the recent alluvium, which would exhibit less desirable stress-strain characteristics and would tend to expand if inundated. Foundation soils for footings in the recent alluvium should be prepared as discussed on Page 14 of our original report in the section entitled "Servicing Facilities".

The scheme presently under consideration includes a slab-on-grade. The fill material between the footing foundation elevation and the bottom of the slab should be either the decomposed alluvium or a nonplastic imported material. Use of the recent alluvial material for this application is not recommended. The slab should be the last major item to be constructed in order to minimize possible slab damage due to differential settlement between column and midspan locations.

We feel strongly that all critical earthwork should be inspected by a qualified soils and foundation engineer, and that we should be given the opportunity to review all the plans and specifications pertinent to earthwork and foundation construction.

If there are any further questions regarding the contents of our report and its addenda, please contact us.

Respectfully submitted,

DAMES & MOORE

Mei-Ban Lo

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(Nine copies submitted)

SUBSURFACE INVESTIGATION

PROPOSED HALAWA VALLEY

BUS MAINTENANCE FACILITY

HALAWA, OAHU, HAWAII

FOR

THE CITY & COUNTY OF HONOLULU

SUMMARY

Foundation support can be mobilized using a single mat under the maintenance building provided the fill materials under one end of the building are replaced with compacted fill. Bearing pressures under 1000 pounds per square foot are anticipated. Total settlements on the order of one inch and differential settlements on the order of ½-inch are anticipated.

Servicing facilities can be supported on spread foundations a minimum of 24 inches wide. Allowable bearing pressures of 3000 pounds per square foot can be used for proportioning footings.

Retaining walls can be designed with an active equivalent fluid pressure of 40 pounds per square foot per foot of depth, a passive pressure of 300 pounds per square foot per foot of depth and a sliding friction factor of 0.3. Maximum allowable bearing pressures should be 3000 pounds per square foot in recent alluvium and 5000 pounds per square foot in decomposed alluvium. Footings should be at least 24 inches wide.

For pavement design, a CBR of 4 can be used for compacted fill and recent alluvium; a CBR of 10 can be used for decomposed alluvium.

Detailed discussions and recommendations follow in subsequent sections of this report.

INTRODUCTION

This report presents the results of our subsurface investigation for the proposed Halawa Valley Bus Maintenance Facility in Halawa, Oahu, Hawaii. The general location of the site is shown on the Map of Area, Plate 1.

The purpose of our investigation was to explore subsurface conditions at the site to determine the engineering characteristics of the materials encountered. In particular, we aimed at defining the areal extent, thickness, and engineering properties of the surficial fill materials known to exist at the site and to evaluate the stability of the steep slope adjoining Halawa Stream. Based on our analyses, recommendations including those for foundation and pavement design are presented for the proposed development.

Also included in our investigation was a percolation test in the fill, designed to assist in determining the suitability of the site for use of septic tanks. The results of this test are also presented in the report.

PROJECT CONSIDERATIONS

We understand that the proposed bus maintenance facility will consist of a maintenance building and its appurtenant facilities, retaining walls up to 30 feet in height and extensive paving. The Plot Plan, Plate 2 presents the general configuration of the site showing the proposed structure locations.

The maintenance building is to be a single-story structure with rooftop parking approximately 180 feet by 320 feet in plan dimension. It is to be located at the northeast end of the site. It is our understanding that the building will be supported on columns with maximum column loads of about 550 kips. Finished floor elevation is understood to be at 132 feet (unless otherwise noted, all elevations in this report refer to Mean Sea Level (MSL) datum), requiring as much as 20 to 25 feet of excavation below the existing grade in the upper portion of the site. X?

Servicing facilities are to be located nearby and will include refueling, lubricating and washing provisions. Underground storage tanks for fuel and lubricants will be approximately 12 feet in diameter, 30 feet long and will lie on concrete slabs about 3½ feet thick. Bearing pressures on the order of 700 pounds per square foot are anticipated. The tanks are not believed to be settlement-sensitive, but piping connections may be. The wash rack is essentially a 12-foot high wall with no roof.

Free standing retaining walls are to be located along the northeast boundary of the site. We understand that these walls may be as high as 30 feet. The remainder of the site is to be used as a parking area for buses and employees' vehicles.

SITE CONDITIONS

SURFACE CONDITIONS

The site occupies an 11-acre area on the northwest side of Halawa Stream opposite the Halawa Quarry. It is roughly trapezoidal in shape and is bounded on the southeast and southwest sides by Halawa Stream. A steep slope, about 20 feet in height, descends from the project area to the stream. The major portion of the site is relatively level, rising gently from an elevation of 118 feet at the southwest end to 132 feet at the northeast end. The north quarter of the site is terraced into two sections. The first rise lies approximately 250 feet from the top of the stream bank at an elevation of about 140 feet. The second rise lies approximately 380 feet back from the stream bank at an elevation of roughly 148 to 150 feet. Both rises parallel the stream, and appear to be man-made rather than natural topographic features. The maximum site elevation occurs at the north end of the site at approximately 160 feet.

Much of the lower portion of the site is presently being used to cultivate turf. Along the upper boundary, some stripping and grading has taken place resulting in an uneven terrain of dessicated adobe and boulders.

SUBSURFACE CONDITIONS

Subsurface conditions at the site were first explored by drilling nine borings to depths ranging from 26.5 feet to 61.5 feet. Fourteen test pits were then excavated to further delineate the extent of the materials encountered. Boring and test pit locations are shown on the Plot Plan, Plate 2.

Materials encountered during our investigation can be divided into three basic categories. The first type is the dumped fill material consisting of cobbles, boulders, gravel, concrete rubble, red-brown and brown clayey silts and some coral sand. The fill is generally medium dense with voids among the debris. Settlement in the fill is expected to be highly variable and may be considerable.

The second type of material encountered consists of geologically recent alluvial deposits made up of cobbles, gravels, boulders and sandy silts. Sandy silts encountered near the water table are soft to medium stiff; the other materials, particularly the gravels and cobbles are generally dense. Boulders occur frequently, in some areas making up most of the recent alluvial deposit in thicknesses up to 13 feet. Thin seams of silt generally less than six inches thick lie between the boulders.

Decomposed alluvium classified as silt underlies the recent alluvial deposits and makes up the third category of material encountered. These soils retain a relict texture of the material they weathered from; i.e. the gravels, cobbles and sand particles are visually discernible while having the physical characteristics of a silt. Decomposed alluvium encountered near the surface is generally hard but becomes variable in consistency as it nears the water table. The original gravels and cobbles remain as a hard silt while the matrix silt they are embedded in becomes saturated and soft to medium stiff.

Areal distribution and thickness of these three categories of material is variable due to the extensive excavation, backfilling and regrading that has occurred at the site. Two generalized cross-sections of the subsurface conditions based on geologic interpretation of the boring and test pit data are presented on Plates 3 and 4. Although a relatively thin layer of fill covers much of the site to a depth of two to four feet, the extensive thicknesses of dumped fill are localized into two areas. The first area is located in the lower portion of the site forming the bank of the stream and extending back towards the valley wall at the northeast end of the site where it abuts the first rise. The fill in this area is generally 20 to 25 feet in depth along the stream bank and over most of its extent, wedging out sharply against the first rise. The second area containing considerable amounts of fill lies in the northeast half of the first rise immediately above the first area described. Here, the fill is a maximum of 10 feet thick wedging out to the southwest and against the second rise. The fill in this area lies above the elevation of anticipated excavation and should not constitute a problem.

A layer of gray-brown clayey silt with organic material several feet thick marks the interface of the fill and the natural ground. This material appears to be a partially saturated to saturated adobe.

Alluvial deposits 7 to 13 feet thick including numerous boulders underlie the fill and adobe in the lower area. This in turn is underlain by decomposed alluvium to the depths explored. As the decomposed alluvium lies near or beneath the water table in this area, it exhibits the variable consistency described above.

In the upper filled area, recent alluvial deposits underlying the fill are probably quite thin and grade quickly to decomposed alluvium.

The southwest half of the first rise has less than two feet of fill overlying two feet of alluvium. Decomposed alluvium varying from medium stiff to very stiff underlies the recent alluvium to the depths explored. It is possible that much of the recent alluvial material in this area has been removed.

The remainder of the site is characterized by 10 to 15 feet of generally dense recent alluvium containing many boulders, overlain by 0 to 4 feet of very stiff red to brown silt fill material. Decomposed alluvium lies beneath the alluvium and ranges from very stiff to hard with the matrix having a variable consistency.

Along the upper boundary of the site approximately five feet of hard dessicated adobe containing some boulders, occurs at the surface, overlying the alluvium. This material is highly expansive and should not be mixed with other on-site materials for use in later site grading.

The water level was measured in several of the borings and was observed at an approximate elevation of +98 feet.

GEOLOGY

The geology of Halawa Valley is characteristic of an alluvial valley carved from the surrounding rocks by the rapid downcutting action of a stream and filled with the resulting alluvial material. Alluvial deposits ranging from boulders to silts, derived from the surrounding volcanic rocks of the Koolau Range were deposited by an older version of the present Halawa Stream as it traversed the valley in relatively recent geological history. Episodes of subsidence and later emergence formed terraced deposits as the stream cut through earlier deposited materials reworking and redepositing them and bringing in newly eroded material from higher elevations in the valley. This results in a layer of older, decomposed alluvial materials overlain by more recent, slightly weathered and fresh alluvial deposits.

The generally large particle size of the alluvial materials is an indication of the high competence of the ancient stream. The extensive boulder trains found throughout the site may have been carried down the stream in periods of flooding or may be the result of landslides and mudflows carrying debris from the surrounding valley walls across the valley. Most probably they are a combination of the two.

The alluvial deposits reach considerable depths in the middle of the valley but wedge out near the valley walls. Bedrock of the Koolau Volcanic Series underlies the alluvium. It should be noted that the topography of the site does not reflect the underlying geology with any degree of accuracy due to the considerable excavation, filling and grading that has occurred within the last few years.

DISCUSSIONS AND RECOMMENDATIONS

EXCAVATION AND GRADING

The proposed construction involves a considerable volume of earthmoving. In the northwestern two-thirds of the maintenance building site, up to 25 feet of excavation will be required. Most of the material to be removed is expected to be recent alluvium, though some fill and decomposed alluvium will also be removed.

Based on the materials encountered in the borings and test pits, we believe all the required excavation can be accomplished with conventional earthmoving equipment. Some ripping may be required in deep cut areas adjacent to the valley walls. Blasting should not be required.

The fill material excavated should be wasted. The recent alluvium and the decomposed alluvium are both suitable for use in compacted fills where pervious materials are not required. However, the recent alluvium is expected to contain numerous cobbles and boulders. Cobbles and boulders larger than six inches in their greatest dimension should not be used in compacted fills. Recent alluvial materials should be placed and compacted in such a fashion that the cobbles do not become nested, creating interstitial voids, as soil may migrate into them at a later date and result in undesirable settlement. Fills should be placed and compacted in horizontal lifts. Although both the recent and decomposed alluvial materials may be used as fill, they should be handled separately and not be allowed to be mixed. This is required to ensure uniform performance of the fills and to facilitate control of fill placement and compaction. The adobe materials and the gray-brown organic silt at the fill-alluvium contact should be wasted or used as landscaping or general fill. They should be used only where the low strength and shrink-swell properties of these soils will not affect the performance of the facilities. Compaction recommendations are included in the appropriate paragraphs.

MAINTENANCE BUILDING

Several foundation schemes were considered and analyzed for this structure. Loading configurations and anticipated performance characteristics were discussed with the architect and the structural engineer in several meetings.

Considerable effort was expended to arrive at practical solutions to the problems presented by the large building area, high column loads, highly variable soil conditions under the building site, and the stringent performance requirements set by the architect. The schemes considered are discussed briefly below:

1. Spread Footings - The use of spread footings under the entire building was initially considered. Where the building site would be underlain by the debris fill, a compacted earth mat was considered. A slab-on-grade would be used in the garage area.

2. Mats - Three variations were considered:

   a) Two partial mats with a construction joint through the building to accomodate the differential performance of the mats on different soil conditions;

   b) A single mat under the portion of the building on fill, with the portion of the building in the cut area being founded on spread foundations; and

   c) A single mat under the entire building. The debris fill and the original topsoil would be excavated, wasted and replaced with compacted fill. At the present time, we understand this is the scheme which has been adopted.

3. Drilled Piers - High capacity drilled, cast-in-place piers founded in the decomposed alluvium were considered.

4. Friction Piles - Prestressed concrete piles driven into the decomposed alluvium were considered. Several pile sizes, shapes, cluster configurations, lengths, and capacities were analyzed. The piles would have to be predrilled through the fill and recent alluvium to minimize breakage.

Estimated performance characteristics and pertinent comments are tabulated below for the various foundation schemes considered:

FOUNDATION SCHEME	ESTIMATED SETTLEMENT (inches) MAXIMUM TOTAL	MAXIMUM DIFFERENTIAL	NOTES
1. Spread Foundations	4	3	Between columns on decomposed alluvium & columns on fill
		1½	Between columns on decomposed alluvium & slab-on-grade at midspan.
2. Mats			
a. Two partial mats	2½	2	Between construction joint and end of building on fill.
b. Combined mat & footings	--	--	Discussed but not analyzed; performance expected similar to each component's as tabulated above.
c. Single mat	1	½	Assumes flexible mat.
3. Drilled Piers (4-foot diameter shaft & 12-foot diameter bell; 1 per column)	2	1	Total & differential settlement estimates do not include compression of cuttings in bottom of pier. Possible difficulty in maintaining stable bell below ground water level.

4. Friction Piles

12" sq.,55-60 ft. long	2	1	30-ton capacity
16½" oct.,50 ft. long	2½	1½	50-ton capacity
16½" oct.,75 ft. long	6	2-3	100-ton capacity

As this report is being written, our present understanding is that a single mat is proposed for the entire building. Bearing pressures less than 1000 pounds per square foot are expected. The fill material and any original topsoils encountered are to be excavated and replaced with compacted fill. The excavation should be inspected to ensure that all compressible soils and debris fill have been removed. The area of excavation should extend about ten feet beyond the building lines in the fill area and to the decomposed alluvium on the uphill side. The excavation should be maintained free of rainfall, runoff or groundwater seepage during backfill placement and compaction. Backfill should be compacted to a minimum of 90 percent of the ASTM D-1557 maximum dry density (all compaction recommendations refer to this standard unless otherwise noted). Placement moisture content should be within 10 percent of optimum for ease of compaction and for stiffness characteristics similar to the undisturbed soils which will underlie the remainder of the building. Some moisture conditioning will be necessary. This will be accomplished in part by the removal of oversize cobbles and boulders. However, additional drying and discing may be necessary to lower the moisture content. After the backfill is completed, trenches may be excavated with a backhoe and the mat concrete poured neat. For uniformity of foundation performance, contact pressures should be kept under 3000 pounds per square foot; the ultimate bearing capacity of the soil is actually quite higher.

SERVICING FACILITIES

Servicing and washing facilities may be founded on spread or continuous footings. The foundation soils will be recent alluvium if the facilities are constructed as planned at this time. Due to the variable density of the soil, one foot of soil beneath the footings should be scarified and compacted to 90 percent of its maximum dry density to ensure uniform performance of the footings. Due to the high natural moisture content of the soil, it may be preferable to overexcavate one foot, and replace it with non-expansive preconditioned material. The minimum footing width should be 24 inches. Footings should be proportioned using a maximum allowable bearing pressure of 3000 pounds per square foot. Footings may be placed neat.

Foundation soils for the slabs to support the fuel and oil tanks should be prepared as described in the previous paragraph. Settlement should be insignificant as the tanks represent a net unloading of the underlying soil. Piping and connections should be placed in properly prepared and compacted bedding to prevent damage due to loads imposed from above.

RETAINING WALLS

For the design of the retaining walls, we recommend that the active soil pressure be calculated using an equivalent fluid pressure of 40 pounds per square foot per foot of depth. This value is recommended if the backslope is horizontal and there are no surcharge loads on the soil behind the wall.

Passive pressures may be calculated using 300 pounds per square foot per foot of depth. The first foot of depth should be neglected for mobilizing passive resistance. The recommended pressure could be increased by recompacting the soil in front of the footing. A friction coefficient of 0.3 should be used for resistance to sliding.

An allowable bearing pressure of 5000 pounds per square foot may be used for proportioning footings founded in decomposed alluvium and 3000 pounds per square foot in recent alluvium. Footings should be at least 24 inches wide. Footings founded in the recent alluvium, e.g. those in the west corner of the site, should be prepared as described in the section entitled "Servicing Facilities".

PAVEMENT

A major portion of the site is to be paved for use as bus parking, service roads or maneuvering areas. The asphalt concrete pavement sections for the various areas are to be designed by the civil engineer.

Much of the site is underlain by at least nominal thicknesses of dumped, uncompacted fill which includes considerable amounts of debris and interstitial voids. To minimize settlement during the design life of the facility, we recommend that the heavy earthmoving equipment required to make the deep cuts for this project be routed over as much of the areas to be paved as possible. This is particularly important within 50 to 75 feet of the stream edge of the fill where the depths are greatest. Construction traffic will have the beneficial effect of densifying the fill due to the vehicle weight and vibration.

For use in pavement design, a California Bearing Ration (CBR) of 4 should be used for fill and recent alluvial materials, and a CBR of 10 could be used for the decomposed alluvium. In order to use these recommended CBR values, subgrade materials should be compacted to at least 90 percent of the maximum dry density to a minimum depth of 24 inches. Compaction moisture content should be within 10 percent of optimum. Excessive overcompaction should be avoided to minimize pavement damage in the event the soils become inundated, as all the recompacted alluvial soils are moderately expansive. All areas to be paved should be proof-rolled after subgrade compaction, prior to base course placement.

Pavement areas should be set back at least four feet from the edge of the slope. However, compaction of the subgrade and base course should extend at least 18 inches past the edge of the pavement.

INSPECTION

It is recommended that the construction plans and specifications be reviewed by us to verify that the intent of these recommendations is included. The excavation for the maintenance building should be inspected to ensure that all soft soils and debris have been removed. Footing excavations should also be inspected before any rebar or concrete is placed. Backfill placement and compaction and proofrolling operations should also be inspected. All inspection should be performed by a qualified soils and foundation engineer.

LIMITATIONS

The soils and foundation engineer has prepared this report for the use of Daniel, Mann, Johnson & Mendenhall of Hawaii for design purposes in accordance with generally accepted soils and foundation engineering practices. No other warranty, expressed or implied, is made as to the professional advice included in this report. The report has not been prepared for use by parties other than Daniel, Mann, Johnson & Mendenhall of Hawaii or the City & County of Honolulu. It may not contain sufficient information for purposes of other parties or other uses. Trenches and foundation excavations should be inspected to verify that overall soil conditions are similar to those encountered in the investigation. Should other soil conditions be encountered, the foundation engineer must be consulted immediately and appropriate construction modifications developed and implemented.

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The following Plates and Appendix are attached and complete this report.

Plate 1	Map of Area
Plate 2	Plot Plan
Plate 3	Generalized Subsurface Cross-Section A-A
Plate 4	Generalized Subsurface Cross-Section B-B
Appendix	Field Exploration and Laboratory Testing

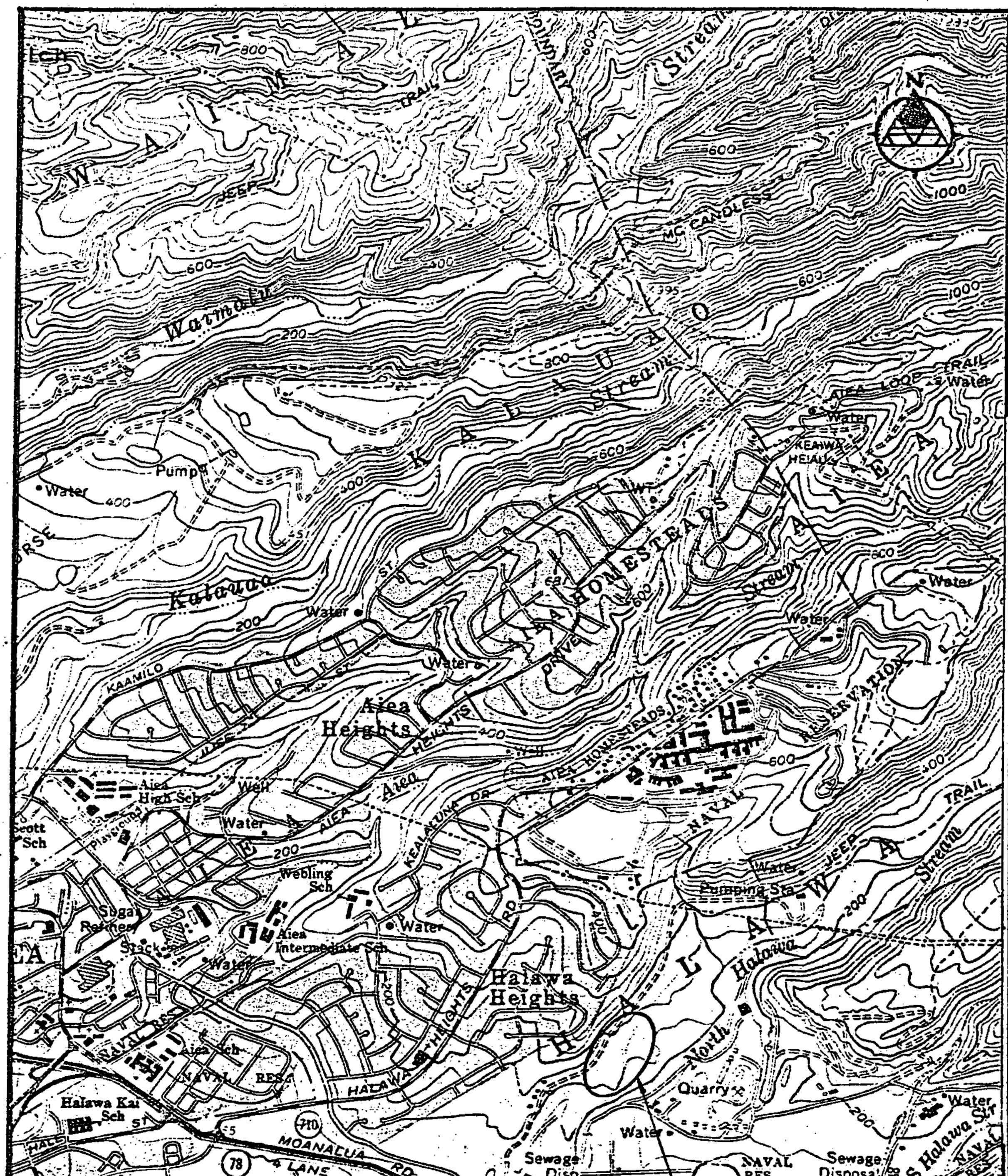
Respectfully submitted,

DAMES & MOORE

Mei-Ban Lo

MEI-BAN LO
REGISTERED
PROFESSIONAL
ENGINEER
No. 2547
HAWAII, U.S.A.

THIS WORK WAS PREPARED BY
ME OR UNDER MY SUPERVISION.



GENERAL LOCATION OF SITE AS SHOWN ON PLOT PLAN

MAP OF AREA

SCALE 1:24000

1 ½ 0 1 MILE

1000 0 1000 2000 3000 4000 5000 6000 7000 FEET

1 .5 0 1 KILOMETER

REFERENCE:
U.S.G.S. TOPOGRAPHIC MAP
WAIPAHU, HAWAII
DATED 1968

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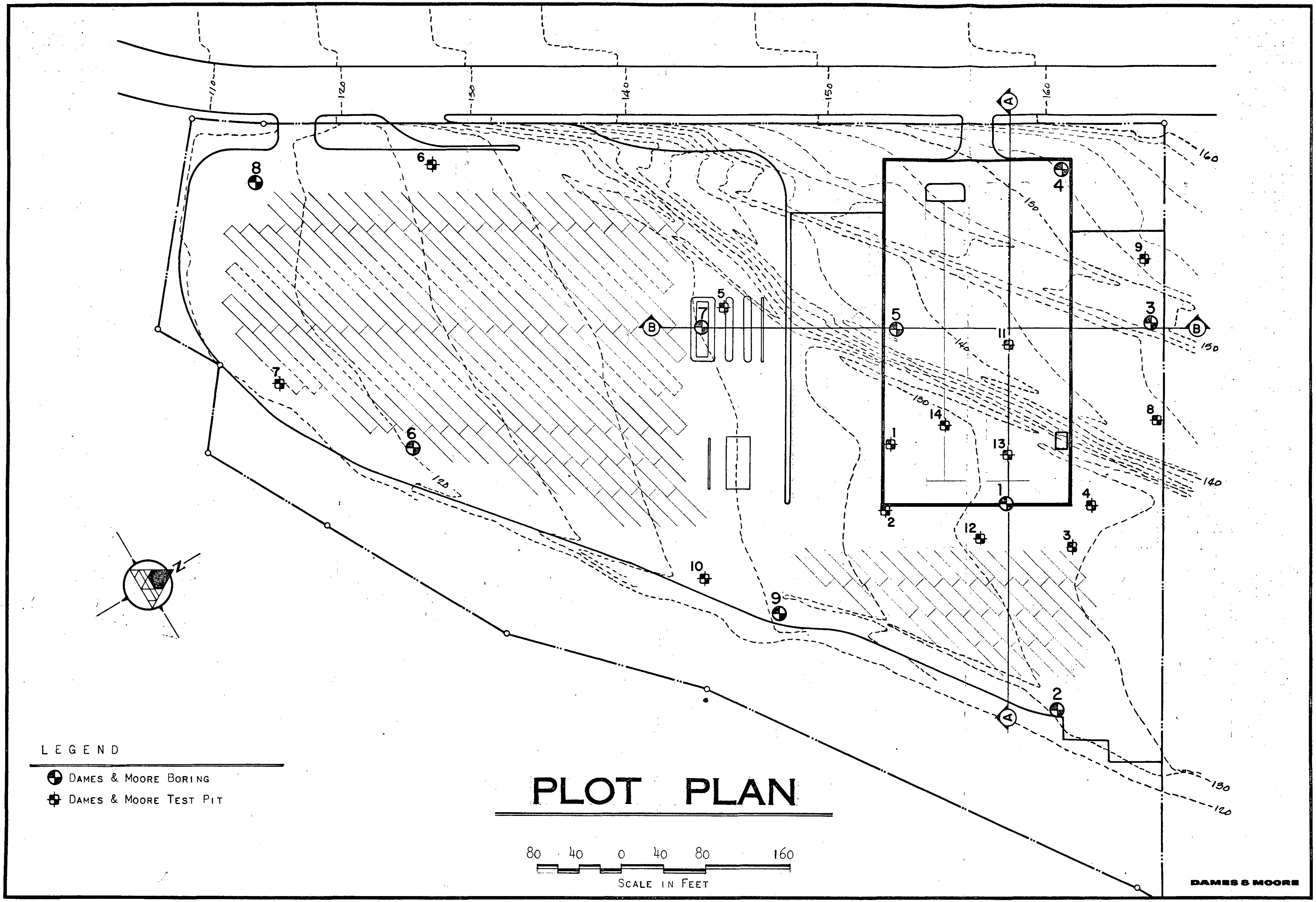
PLATE 1

REVISIONS BY DATE

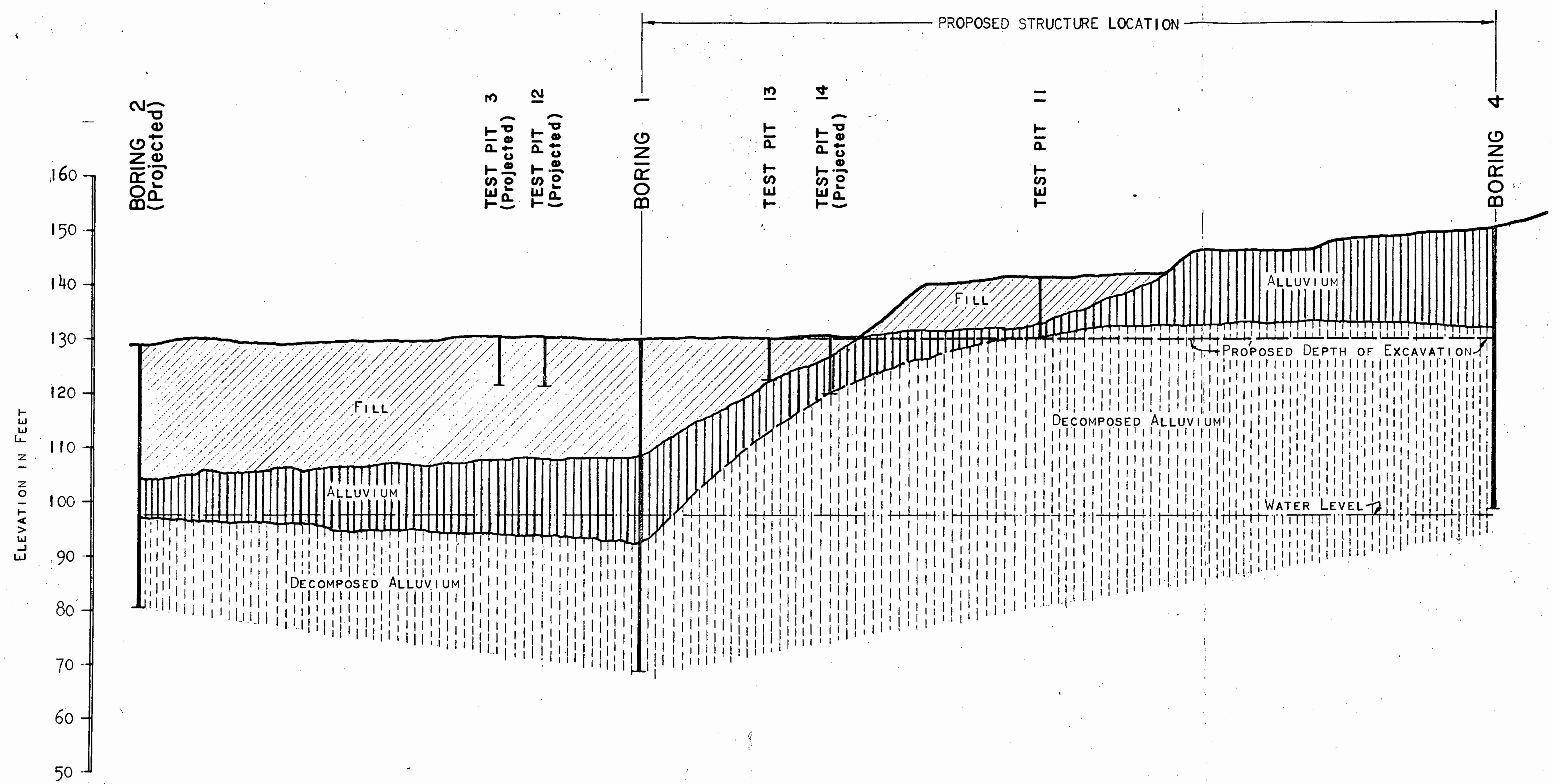
FILE

CHECKED BY DATE



PLOT PLAN

PLATE 2



GENERALIZED SUBSURFACE CROSS-SECTION A-A

NOTE: THE CONDITIONS ILLUSTRATED BETWEEN BORINGS ARE BASED ON GEOLOGICAL INTERPRETATIONS. WHILE THESE ARE BELIEVED TO BE GENERALLY CORRECT, THE CONDITIONS MAY VARY LOCALLY FROM THOSE INDICATED.

HORIZONTAL SCALE: 40 20 0 20 40 80 FEET

VERTICAL SCALE: 20 10 0 10 20 40 FEET

(2 : 1 VERTICAL EXAGGERATION)

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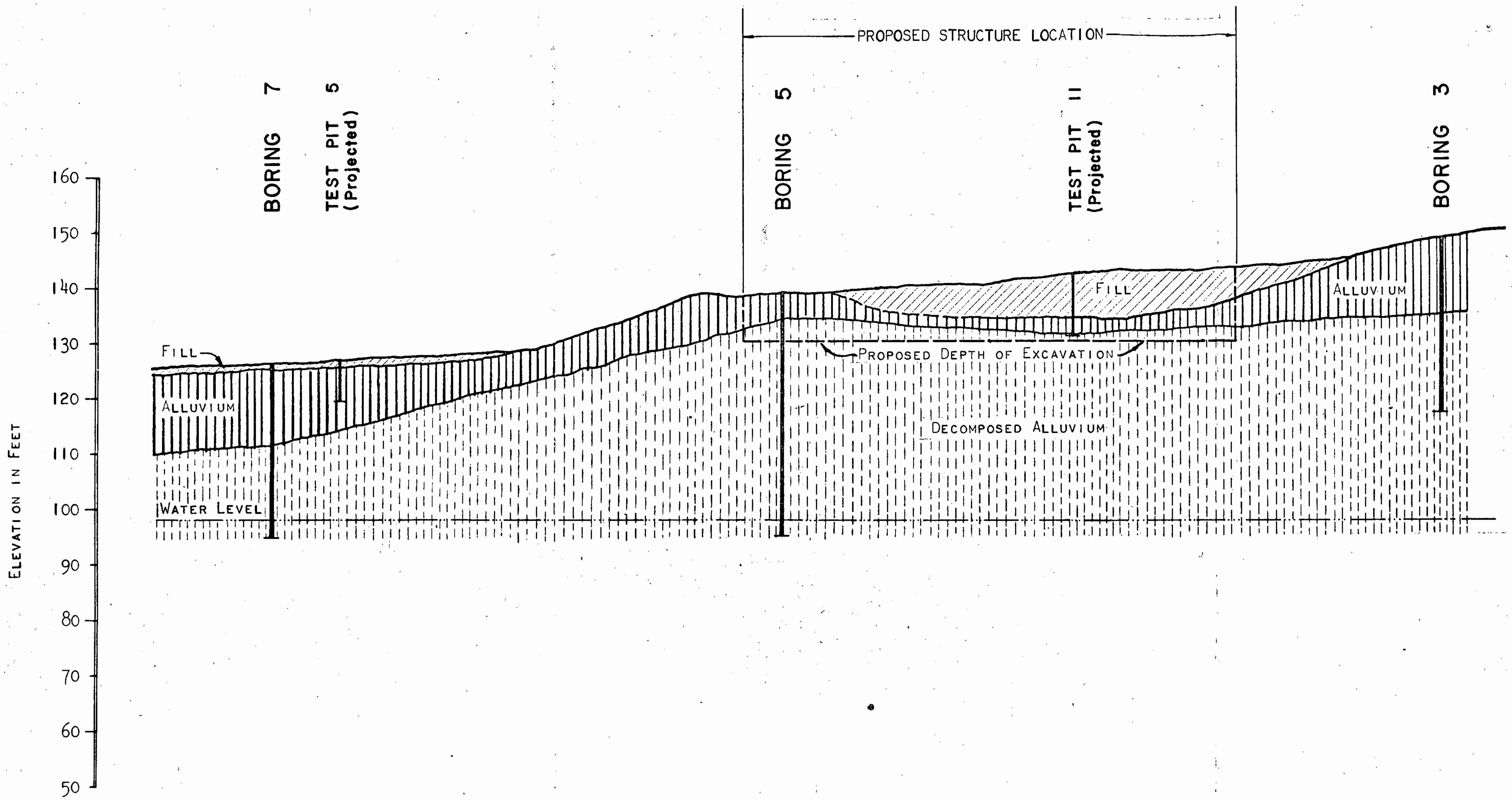
PLATE 3



GENERALIZED SUBSURFACE CROSS-SECTION B-B

NOTE: THE CONDITIONS ILLUSTRATED BETWEEN BORINGS ARE BASED ON GEOLOGICAL INTERPRETATIONS. WHILE THESE ARE BELIEVED TO BE GENERALLY CORRECT, THE CONDITIONS MAY VARY LOCALLY FROM THOSE INDICATED.

HORIZONTAL SCALE: 40 20 0 20 40 80 FEET

VERTICAL SCALE: 20 10 0 10 20 40 FEET

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PLATE 4

APPENDIX

FIELD EXPLORATION AND LABORATORY TESTING

FIELD EXPLORATION

Field exploration for this project consisted of drilling nine borings and excavating fourteen test pits to determine subsurface conditions at the site. In addition, a percolation test was run to determine the suitability of the subsurface fill materials for a septic tank.

The borings ranged in depth from 26.5 feet to 61.5 feet with a total footage of 383.5 feet. Drilling was done by our subcontractor, Continental Drilling of Hawaii using two truck-mounted drilling rigs. Borings were drilled using augers and casing and rotary-wash drilling equipment. Test pits were excavated with a backhoe.

One of our engineers and one of our geologists were present during drilling operations and excavation of the test pits to assist in obtaining samples of subsurface materials and to make detailed observations of the site. Our engineer and geologist also maintained a continuous log of the borings and test pits. The Log of Borings and Test Pits is shown on Plates A-1A through A-1M, attached to this Appendix.

Relatively undisturbed and a few disturbed samples of the subsurface materials were recovered by means of the Dames & Moore Type U Soil Sampler shown on Exhibit A-1. Soil samples were classified according to the Unified Soil Classification System presented on Plate A-2.

Water level readings were taken in Borings 2 and 5 during or shortly after drilling. As the water level may not have had time to fully stabilize, these readings may not be entirely accurate. Extended readings over a period of time could not be measured as the borings tended to cave in at or above the water table, shortly after they were completed. Measurements were not made in the remainder of the borings that extended below the presumed water table for the same reason.

One percolation test was performed at the site at a location chosen by a representative of Chung Dho Ahn & Associates, the civil engineer. The test was conducted in a test pit excavated four feet below the surface into a brown sandy silt. The dimensions of the pit were 6.4 feet by 2.5 feet at the top and 4.5 feet by 2.5 feet at the bottom. Two inches of base course material was placed at the bottom of the hole to facilitate drainage. Fourteen inches of water was placed in the hole and left to saturate overnight. The next day, the hole was refilled with water to a depth of 6 inches and the rate of water drop was measured at half hour intervals over a period of four hours. The water level was restored to six inches after each reading. Water level drop ranged from 0.04 feet per 30 minutes to 0.02 feet per 30 minutes. The percolation rate was calculated to be about 0.72 inch per hour.

LABORATORY TESTING

General - Laboratory tests were conducted on selected samples of soils obtained during our drilling program to determine their physical properties and engineering characteristics. These tests include moisture-density determinations, unconsolidated-undrained triaxial compression tests, a consolidated-drained triaxial compression test, consolidation tests, compaction tests, and California Bearing Ratio tests.

Moisture-Density Tests - Determinations of natural moisture content and dry density were made for selected samples. The results of these tests are shown on the Log of Borings, Plates A-1A through A-1L, at the appropriate sample depths.

Triaxial Compression Tests - Unconsolidated-undrained and consolidated-drained triaxial compression tests were performed on selected samples to determine their strength characteristics. The test procedure is described on Exhibit A-2. Results are presented in the following table.

STRENGTH TEST RESULTS - TRIAXIAL COMPRESSION TESTS

Boring No.	Depth (ft.)	Type of Test*	Confining Pressure(PCF)	Peak Shear Strength(PCF)	Axial Strain%	Soil Type
1	23.7	UU	2000	1300	5.0	Brown & Gray Clayey Silt
5	15.5	UU	1500	1460	6.7	Mottled Tan & Gray Silt
5	20.5	UU	2000	1695	5.0	Mottled Tan & Gray Silt
7	15.5	UU	1000	1990	3.7	Mottled Brown & Gray Silt
8	12.5	UU	1000	4040	1.2	Mottled Brown, Tan & Gray Silt
**8	20.5	CD	2500	3240	10.0	Mottled Red & Black Silt

*UU - Unconsolidated-undrained Triaxial Compression Test.
CD - Consolidated-drained Triaxial Compression Test.
**Failure for this sample was defined to be at 10% axial strain.

<u>Consolidation Tests</u> - Consolidation tests were performed to determine the compressibility characteristics of some of the samples recovered. Results were used in the calculation of anticipated settlement of the proposed structure for foundation design. The method of performing the tests is presented on Exhibit A-3. The test results are presented on Plates A-3 and A-4.

<u>Compaction Tests</u> - These tests were conducted on bulk samples of selected near-surface materials obtained from the test pits to determine their suitability for backfill and subgrade purposes. Maximum dry densities and optimum

moisture contents for the materials were derived in accordance with ASTM test designation D1557-70, Method "C" or "D". The results are as follows:

Test Pit No.	Depth (ft.)	Test Method	Maximum Dry Density (PCF)	Optimum Moisture Content%	Soil Type
2	1.0	C	99	25	Red Brown Sandy Clayey Silt
9	3.0	D	91	26	Mottled Brown Silt w/Decomposed Gravel
10	4.0	C	103	22	Brown Sandy Clayey Silt w/Tuff & Coral Fragments
12	5.0	C	105	20	Brown Clayey Silt & Tuff & Coral Fragments

<u>California Bearing Ratio Test (CBR)</u> - The CBR test is performed on a recompacted soil sample which has been soaked for four days. The test procedure involves measuring the resistance of the soil to a standard three square-inch plunger which has penetrated 0.1 inch and 0.2 inches. The ratio of this resistance to the corresponding resistance in crushed rock is the CBR value.

The CBR tests were performed on bulk samples of material obtained from Test Pits 2 and 9. The results are tabulated below.

Test Pit No.	Depth (ft.)	Moisture Content%	Dry Density(PCF)	CORRECTED CBR VALUE Penetration 0.1 Inch	0.2 Inch	Soil Type
2	3.0+	27	92	4	4	Red Brown Clayey Silt
9	3.0+	18	76	4	6	Mottled Brown Silt
9	3.0+	22	82	9	11	Mottled Brown Silt

The following Plates and Exhibits are attached and complete this Appendix.

Plate A-1A	Log of Borings and Test Pits, Boring 1
Plate A-1B	Log of Borings and Test Pits, Boring 2
Plate A-1C	Log of Borings and Test Pits, Boring 3
Plate A-1D	Log of Borings and Test Pits, Boring 4
Plate A-1E	Log of Borings and Test Pits, Boring 5
Plate A-1F	Log of Borings and Test Pits, Boring 6
Plate A-1G	Log of Borings and Test Pits, Boring 7
Plate A-1H	Log of Borings and Test Pits, Boring 8
Plate A-1J	Log of Borings and Test Pits, Boring 9
Plate A-1K	Log of Borings and Test Pits, Test Pits 1-6
Plate A-1L	Log of Borings and Test Pits, Test Pits 7-12
Plate A-1M	Log of Borings and Test Pits, Test Pits 13-14
Plate A-2	Unified Soil Classification System
Plate A-3	Consolidation Test Data
Plate A-4	Consolidation Test Data
Exhibit A-1	Dames & Moore Soil Sampler, Type U
Exhibit A-2	Method of Performing Triaxial Compression Tests
Exhibit A-3	Method of Performing Consolidation Tests

BORING 1

SURFACE ELEVATION 131 ± FEET
MSL DATUM

Moisture Content in %	Dry Density in PCF	Blows/Ft. on Sampler	Core and % Recovery	Samples and/or Cores	Depth in Feet	Letter Symbol	Description
						MH	RED - BROWN SILT WITH WOOD SHAVINGS (TOPSOIL)
						MH	RED-BROWN CLAYEY SILT WITH SOME COARSE SAND AND GRAVEL, VERY STIFF - HARD, WITH LOOSE POCKETS (FILL)
		24		▩			
					5		
		95/8"		▩			GRADES TO COBBLES, BOULDERS AND CONCRETE RUBBLE WITH SOME BROWN CLAYEY SILT, LOOSE - MEDIUM DENSE, WITH LARGE VOIDS
		16/4"		▩			
		7		⊠	10		
		7		⊠			
		3/4"		☐	15		CONCRETE RUBBLE
					20		
							(END OF FILL)
42	78	13		▩		MH	DARK GRAY BROWN CLAYEY SILT WITH A TRACE OF SAND AND ROOTS, STIFF (ADOBE)
					25		HIGHLY WEATHERED TO WEATHERED COBBLES AND BOULDERS (ALLUVIUM)
		50/2"		☐	30		
		110		▩		MH	LAYER OF BROWN AND GRAY SILTY WEATHERED SAND, GRAVEL AND COBBLES, DENSE
					35		
						MH	BROWN SILT WITH A TRACE OF SAND, MEDIUM STIFF
		34		⊠			
		30		▩	40		GRADES TO BROWN, TAN AND GRAY MOTTLED SILT, HARD (DECOMPOSED GRAVELS AND COBBLES) IN BROWN MEDIUM STIFF SILT MATRIX (DECOMPOSED ALLUVIUM)
		25		▩	45		MATRIX GRADES SOFT
		38		▩	50		GRADES WITH A LITTLE MATRIX
		47		▩	55		
		49		▩	60		

BORING COMPLETED AT 61.5 FEET ON 1-19-76
WATER LEVEL NOT RECORDED

LOG OF BORINGS

NOTES:
▩ -DEPTH AT WHICH UNDISTURBED SAMPLE WAS TAKEN
⊠ -DEPTH AT WHICH DISTURBED SAMPLE WAS TAKEN
☐ -DEPTH AT WHICH SAMPLE WAS LOST DURING EXTRACTION
I -DEPTH AND LENGTH OF CORE RUN
DRIVING ENERGY- 300 -LB WEIGHT DROPPING 30 INCHES

PLATE A-1A

466.12 (4-64)

FILE 4401-079
BY AB DATE 2-3-76
CHECKED BY JCC DATE 2-11-76

REVISIONS
BY ___ DATE ___
BY ___ DATE ___
PLATE ___ OF ___

BORING 2

SURFACE ELEVATION 130 ± FEET
MSL DATUM

Moisture Content in %	Dry Density in PCF	Blows/Ft. on Sampler	Core and % Recovery	Samples and/or Cores	Depth in Feet	Graph Symbol	Letter Symbol	Description
					0		MH	Brown clayey silt with occasional gravel, loose (fill - topsoil)
		17		■				grades very stiff - hard, with boulders, some small voids and loose pockets (fill)
		10		■	5			
								grades to cobbles, boulders and concrete rubble with some brown clayey silt, medium dense - dense
		88		□	10			
							MH	Gray brown clayey silt, stiff (fill)
		9		■	15			
		8		■	20			
								grades with boulders and concrete rubble
								(end of fill)
					25		GM	Brown silty sandy gravel with some cobbles and boulders, medium dense - dense (alluvium)
		58/11"		□				
		55		■				
					30			
		39/7"		■				Water level at 1220 hours on 1-16-76
							MH	Brown silt, hard (decomposed gravel) in medium stiff silt matrix (decomposed alluvium)
		30		■	35			
		32		■	40			
		30		■	45			
								grades with decomposed boulders
		29		■				

Boring completed at 49.5 feet on 1-16-76

LOG OF BORINGS

NOTES:
- ■ -DEPTH AT WHICH UNDISTURBED SAMPLE WAS TAKEN
- ☒ -DEPTH AT WHICH DISTURBED SAMPLE WAS TAKEN
- □ -DEPTH AT WHICH SAMPLE WAS LOST DURING EXTRACTION
- I -DEPTH AND LENGTH OF CORE RUN

DRIVING ENERGY- 300 -LB WEIGHT DROPPING 30 INCHES

DAMES & MOORE

PLATE A-1B

466.12 (4-64)

FILE 4402-079
BY AD DATE 2-3-76
CHECKED BY ?CC DATE 2-11-76

REVISIONS
BY ___ DATE ___
BY ___ DATE ___
PLATE ___ OF ___

BORING 3

SURFACE ELEVATION 149 ± FEET
MSL DATUM

Moisture Content in %	Dry Density in PCF	Blows/Ft. on Sampler	Core and % Recovery	Samples and/or Cores	Depth in Feet	Graph Symbol	Letter Symbol	Description
							MH	BROWN CLAYEY SILT WITH BOULDERS (ALLUVIUM)
		24/8"		■				GRADES RED BROWN WITH GRAVEL, HARD
								WEATHERED BASALT BOULDERS AND COBBLES WITH THIN SEAMS OF SILT, DENSE
		25/2"		■	5			
		25/2"		■	10			
								BROWN AND GRAY MOTTLED, VERY HIGHLY WEATHERED SILTY GRAVEL, HARD
		53		■				
							MH	BROWN AND TAN MOTTLED SILT, HARD (DECOMPOSED GRAVEL AND SAND) IN BROWN MEDIUM STIFF SILT MATRIX (DECOMPOSED ALLUVIUM)
					15			
		26		■				
					20			
		27		■				GRADES TO BROWN AND GRAY MOTTLED UNIFORM SILT, HARD
					25			
		26		■				GRADES TO BROWN AND GRAY SILT, HARD (DECOMPOSED GRAVEL) IN MEDIUM STIFF SILT MATRIX
		23		■	30			MATRIX GRADES STIFF

BORING COMPLETED AT 31.0 FEET ON 1-19-76
NO WATER ENCOUNTERED

LOG OF BORINGS

NOTES:
- ■ -DEPTH AT WHICH UNDISTURBED SAMPLE WAS TAKEN
- ☒ -DEPTH AT WHICH DISTURBED SAMPLE WAS TAKEN
- ☐ -DEPTH AT WHICH SAMPLE WAS LOST DURING EXTRACTION
- I -DEPTH AND LENGTH OF CORE RUN

DRIVING ENERGY- 300 -LB WEIGHT DROPPING 30 INCHES

DAMES & MOORE

PLATE A-1C

466.12 (4-64)

FILE 4402-079
BY ___ DATE 2-3-76
CHECKED BY ___ DATE 2-11-76

REVISIONS
BY ___ DATE ___
BY ___ DATE ___
PLATE ___ OF ___

BORING 4

SURFACE ELEVATION 154 ± FEET
MSL DATUM

Moisture Content in %	Dry Density in PCF	Blows/Ft. on Sampler	Core and % Recovery	Samples and/or Cores	Depth in Feet	Letter Symbol	Description
					0	MH	Dark gray-brown clayey silt, hard, with some boulders at the surface (adobe)
		17		▩			
					5	MH	Red-brown and tan mottled clayey silt with relict texture of small gravels, hard
		40		▩			grades to weathered gravel and cobbles with some gray brown clayey silt, dense - hard (alluvium)
		25/3"		▩	10		
		47		▩	15		grades to gray brown silt with very highly weathered gravel, cobbles and some relict gravel texture, hard (partially decomposed alluvium)
						MH	Gray brown silt, hard (decomposed gravel) in stiff brown silt matrix (decomposed alluvium)
		29		▩	20		
		53		▩	25		grades with trace of matrix
		19		▩	30		grades with some medium stiff matrix
						MH	Dark gray silt, medium stiff
83	51	9		▩	35		
							Brown silt, hard (decomposed gravel), in brown silt matrix
		61		▩	40		matrix grades stiff
		61		▩	45		
		55		▩	50		grades with partially decomposed cobbles

Boring completed at 51.5 feet on 1-19-76
No water encountered

LOG OF BORINGS

NOTES:
▩ -DEPTH AT WHICH UNDISTURBED SAMPLE WAS TAKEN
☒ -DEPTH AT WHICH DISTURBED SAMPLE WAS TAKEN
☐ -DEPTH AT WHICH SAMPLE WAS LOST DURING EXTRACTION
I -DEPTH AND LENGTH OF CORE RUN
DRIVING ENERGY- 300 -LB WEIGHT DROPPING 30 INCHES

DAMES & MOORE

466.12 (4-64)

FILE A402-079
BY AB DATE 2-3-76
CHECKED BY JCC DATE 2-11-76

REVISIONS
BY ______ DATE ______
BY ______ DATE ______
PLATE ______ OF ______

BORING 6

SURFACE ELEVATION 120 ± FEET
MSL DATUM

Moisture Content in %	Dry Density in PCF	Blows/Ft. on Sampler	Core and % Recovery	Samples and/or Cores	Depth in Feet	Letter Symbol	Description
					0	MH	RED BROWN CLAYEY SILT WITH SAND, GRAVEL AND COBBLES, STIFF - HARD, WITH LOOSE POCKETS AND SMALL VOIDS (FILL)
		19/9"		⊠			
					5		
		14		▩			
					10		
		21		▩			GRADES TO COBBLES AND BOULDERS WITH SOME SILT, MEDIUM DENSE - DENSE, WITH VOIDS
					15		
		4		▩	20		GRADES TO BROWN CLAYEY SILT WITH SAND, GRAVEL AND COBBLES, SOFT - MEDIUM STIFF
							(END OF FILL)
		11		▩	25	MH	GRAY BROWN CLAYEY SILT, VERY STIFF - HARD (ADOBE)
						GM	BROWN SANDY SILT, SOFT (ALLUVIUM)
45	75	14		▩			
					30		GRADES WITH GRAVEL AND COBBLES, DENSE
		15/6"		⊠			
					35		
		25/6"		▩			
							RED BROWN SILT, HARD (DECOMPOSED GRAVEL AND COBBLES) WITH A TRACE OF SOFT SILT MATRIX (DECOMPOSED ALLUVIUM)
		32		▩	40		
		42/9"		▩	45		GRADES WITH SOME MEDIUM STIFF MATRIX
		13		⊠	50		

BORING COMPLETED AT 50.0 FEET ON 1-21-76
WATER LEVEL NOT RECORDED

LOG OF BORINGS

NOTES:
▩ -DEPTH AT WHICH UNDISTURBED SAMPLE WAS TAKEN
⊠ -DEPTH AT WHICH DISTURBED SAMPLE WAS TAKEN
☐ -DEPTH AT WHICH SAMPLE WAS LOST DURING EXTRACTION
I -DEPTH AND LENGTH OF CORE RUN
DRIVING ENERGY- 300 -LB WEIGHT DROPPING 30 INCHES

DAMES & MOORE

PLATE A-1F

466.12 (4-64)

FILE 4402-079
BY AG DATE 2-3-76
CHECKED BY JCC DATE 2-11-76

REVISIONS
BY ____ DATE ____
BY ____ DATE ____
PLATE ____ OF ____

BORING 7

SURFACE ELEVATION 126 ± FEET
MSL DATUM

Moisture Content in %	Dry Density in PCF	Blows/Ft. on Sampler	Core and % Recovery	Samples and/or Cores	Depth in Feet	Graph Symbol	Letter Symbol	Description
								Red silt with gravel, very stiff (topsoil)
							MH	Gray brown mottled clayey silt with gravel and cobbles, hard
		10/6"		■				
								(end of fill)
								Weathered basalt cobbles and boulders with seams of silty gravel, medium dense - dense (alluvium)
		50/8"		■	5			
					10			
		50/6"		☒				
							MH	Brown and gray mottled silt, hard, with relict sand, gravel and cobble texture, very stiff (decomposed alluvium)
51	71	15		■	15			
		16		■	20			grades hard
		28		■	25			
		39		■	30			

Boring completed at 31.5 feet on 1-20-76
Water level not recorded

LOG OF BORINGS

NOTES:
■ -Depth at which undisturbed sample was taken
☒ -Depth at which disturbed sample was taken
☐ -Depth at which sample was lost during extraction
I -Depth and length of core run
Driving Energy- 300 -lb weight dropping 30 inches

DAMES & MOORE

PLATE A-1G

BORING 8

Surface Elevation 120 ± Feet
MSL Datum

Moisture Content in %	Dry Density in PCF	Blows/Ft. on Sampler	Core and % Recovery	Samples and/or Cores	Depth in Feet	Letter Symbol	Description
		68		■		MH	Tan, brown and gray mottled silt with coarse sand, gravel and cobbles, hard, with loose pockets (fill) (end of fill)
					5, 10		Weathered basalt boulders and cobbles with thin seams of silt (alluvium)
44	77	57		■		MH	Brown, tan and gray mottled silt with relict texture of a few gravels, hard (decomposed alluvium)
		18		■	15		grades with more decomposed gravel
76	52	8		■	20		grades red and black mottled with relict sand texture, very stiff - hard
		67/ 11"		■	25		grades with decomposed cobbles and very highly weathered boulder

Boring completed at 26.5 feet on 1-20-76
No water encountered

LOG OF BORINGS

NOTES:

■ -DEPTH AT WHICH UNDISTURBED SAMPLE WAS TAKEN
⊠ -DEPTH AT WHICH DISTURBED SAMPLE WAS TAKEN
□ -DEPTH AT WHICH SAMPLE WAS LOST DURING EXTRACTION
I -DEPTH AND LENGTH OF CORE RUN
DRIVING ENERGY -300 -LB WEIGHT DROPPING 30 INCHES

DAMES & MOORE
PLATE A-1H

REVISIONS BY ____ DATE ____
FILE 2462-079
DATE 2/11/76
BY ____ CHECKED BY ____
946.7 (REV. 6-71)

466.12 (4-64)

FILE 4402-079
BY [illegible] DATE 2-5-76
CHECKED BY [illegible] DATE 2-11-76

REVISIONS
BY ____ DATE ____
BY ____ DATE ____
PLATE ____ OF ____

BORING 9

SURFACE ELEVATION 128 ± FEET
MSL DATUM

Moisture Content in %	Dry Density in PCF	Blows/Ft. on Sampler	Core and % Recovery	Samples and/or Cores	Depth in Feet	Letter Symbol	Description
					0		GRAY SMALL GRAVEL (BASE COURSE)
						MH	RED BROWN CLAYEY SILT WITH SAND AND GRAVEL, STIFF, WITH SMALL VOIDS (FILL)
		10		▩	5		
							GRADES TO COBBLES AND BOULDERS AND SEAMS OF RED BROWN CLAYEY SILT
					10		
		24/ 10"		▩			
					15		
							(END OF FILL)
						MH	GRAY BROWN CLAYEY SILT WITH SAND, A FEW GRAVEL AND A TRACE OF ROOTS, STIFF (ALLUVIUM)
		22		▩			GRADES WITHOUT ROOTS
					20		
		10/ 15"		▩			GRADES WITH BOULDERS
					25		
		22/7"		⊠		MH	GRAY SILT WITH SMALL GRAVEL, HARD
					30	MH	RED, BROWN AND GRAY SILT, HARD (DECOMPOSED SAND AND GRAVEL) IN MEDIUM STIFF TO STIFF SILT MATRIX (DECOMPOSED ALLUVIUM)
		39		▩			
					35		
		23		▩	40		MATRIX GRADES SOFT

BORING COMPLETED AT 40.0 FEET ON 1-21-76
WATER LEVEL NOT RECORDED

LOG OF BORINGS

NOTES:
▩ -DEPTH AT WHICH UNDISTURBED SAMPLE WAS TAKEN
⊠ -DEPTH AT WHICH DISTURBED SAMPLE WAS TAKEN
☐ -DEPTH AT WHICH SAMPLE WAS LOST DURING EXTRACTION
I -DEPTH AND LENGTH OF CORE RUN
DRIVING ENERGY- 300 -LB WEIGHT DROPPING 30 INCHES

DAMES & MOORE

TEST PIT 1

Surface Elevation
129 ± Feet
MSL Datum

Depth in Feet	Letter Symbol	Description
	MH	Red brown clayey silt (topsoil)
	MH	Interlayered red-brown and brown clayey silt (fill)
		grades with coral and basalt gravel and cobbles
5	MH	Brown mottled silt (decomposed alluvium)

Test pit completed at 6.0 feet on 1-22-76
No water encountered

TEST PIT 2

Surface Elevation
129 ± Feet
MSL Datum

Depth in Feet	Letter Symbol	Description
	MH	Red-brown clayey silt (topsoil)
	MH	Brown clayey silt with gravels and cobbles (fill)
5	MH	Brown mottled silt (alluvium)
	GM	Cobbles and gravels with brown silt

Test pit completed at 6.5 feet on 1-22-76
No water encountered

TEST PIT 3

Surface Elevation
132 ± Feet
MSL Datum

Depth in Feet	Letter Symbol	Description
	MH	Red-brown clayey silt (topsoil - fill)
	MH	Brown clayey silt with basalt boulders and cobbles (fill)
5		

Test pit completed at 8.5 feet on 1-22-76
No water encountered

TEST PIT 4

Surface Elevation
131 ± Feet
MSL Datum

Depth in Feet	Letter Symbol	Description
	MH	Red-brown clayey silt (topsoil - fill)
	MH	Brown clayey silt with basalt boulders and cobbles (fill)
5		

Test pit completed at 8.0 feet on 1-22-76
No water encountered

TEST PIT 5

Surface Elevation
127 ± Feet
MSL Datum

Depth in Feet	Letter Symbol	Description
	MH	Red-brown clayey silt (topsoil)
	MH	Brown clayey silt (fill)
	MH	Brown mottled silt
	GM	grades to cobbles and gravels with some silt (alluvium)
5		

Test pit completed at 7.0 feet on 1-22-76
No water encountered

TEST PIT 6

Surface Elevation
122 ± Feet
MSL Datum

Depth in Feet	Letter Symbol	Description
	MH	Red-brown clayey silt (topsoil)
	MH	Red-brown to brown clayey silt (fill)
5	GM	Cobbles and gravels with brown silt (alluvium)

Test pit completed at 6.0 feet on 1-22-76
No water encountered

LOG OF TEST PITS

Dames & Moore

PLATE A-1K

466-12 (4-64)

4402-079

LOG OF TEST PITS

TEST PIT 7

Surface Elevation
119 ± Feet
MSL Datum

Depth in Feet	Letter Symbol	Description
	MH	Red-brown clayey silt (topsoil)
5	SM	Gray-brown silty sand with some cobbles and gravels (fill)

Test pit completed at 9.0 feet on 1-22-76
No water encountered

TEST PIT 8

Surface Elevation
143 ± Feet
MSL Datum

Depth in Feet	Letter Symbol	Description
	MH	Brown clayey silt with cobbles (fill)
		Layer of red-brown clayey silt (fill)
5		Brown clayey silt with basalt boulders (fill)
	MH	Gray-brown clayey silt (adobe) grades with cobbles

Test pit completed at 8.0 feet on 1-22-76
No water encountered

TEST PIT 9

Surface Elevation
153 ± Feet
MSL Datum

Depth in Feet	Letter Symbol	Description
	MH	Gray-brown clayey silt (adobe)
	MH	Brown mottled silt with gravel, cobbles and boulders (alluvium)

Test pit completed at 3.0 feet on 1-22-76
No water encountered

TEST PIT 10

Surface Elevation
125 ± Feet
MSL Datum

Depth in Feet	Letter Symbol	Description
	MH	Red-brown clayey silt (fill)
		Pocket of gray-brown silt (adobe - fill)
5	MH	Brown sandy silt (fill)

Test pit completed at 9.0 feet on 1-22-76
No water encountered

TEST PIT 11

Surface Elevation
141 ± Feet
MSL Datum

Depth in Feet	Letter Symbol	Description
	MH	Brown clayey silt with gravel and cobbles (fill)
		Grades with basalt boulders
5		Grades to red-brown clayey silt
	MH	Gray-brown clayey silt (adobe - fill)
10	MH	Gray-brown clayey silt with organics (adobe) grades without organics

Test pit completed at 11.0 feet on 1-23-76
No water encountered

TEST PIT 12

Surface Elevation
130 ± Feet
MSL Datum

Depth in Feet	Letter Symbol	Description
	MH	Red-brown clayey silt with seams of brown clayey silt (fill)
5	MH	Brown clayey silt with basalt cobbles and boulders (fill)

Test pit completed at 9.0 feet on 1-23-76
No water encountered

DAMES & MOORE

PLATE A-11

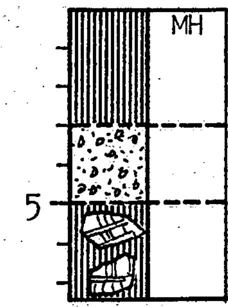
File 4402-079

466.12 (4-64)

TEST PIT 13

SURFACE ELEVATION
131 ± FEET
MSL DATUM

DEPTH IN FEET | GRAPH SYMBOL | LETTER SYMBOL | DESCRIPTION



RED-BROWN CLAYEY SILT (FILL)

GRADES BROWN

LAYER OF TAN AND WHITE CORAL SAND AND GRAVEL (FILL)

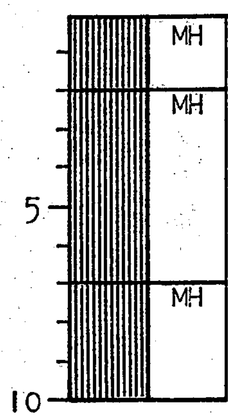
GRADES TO BROWN CLAYEY SILT WITH BASALT COBBLES AND BOULDERS (FILL)

TEST PIT COMPLETED AT 7.5 FEET ON 1-23-76
NO WATER ENCOUNTERED

TEST PIT 14

SURFACE ELEVATION
130 ± FEET
MSL DATUM

DEPTH IN FEET | GRAPH SYMBOL | LETTER SYMBOL | DESCRIPTION



RED-BROWN CLAYEY SILT (TOPSOIL - FILL)

BROWN MOTTLED SILT WITH GRAVEL AND COBBLES (FILL)

BROWN MOTTLED SILT WITH GRAVEL AND COBBLES (ALLUVIUM)

TEST PIT COMPLETED AT 10.0 FEET ON 1-23-76
NO WATER ENCOUNTERED

LOG OF TEST PITS

DAMES & MOORE

PLATE A-1M

REVISIONS BY ____ DATE ____

FILE 4402-079

BY ____ DATE ____

CHECKED BY ____ 3-11-76

946.7 (REV. 6-61)

SOIL CLASSIFICATION CHART

MAJOR DIVISIONS			GRAPH SYMBOL	LETTER SYMBOL	TYPICAL DESCRIPTIONS
COARSE GRAINED SOILS	GRAVEL AND GRAVELLY SOILS	CLEAN GRAVELS (LITTLE OR NO FINES)		GW	WELL-GRADED GRAVELS, GRAVEL-SAND MIXTURES, LITTLE OR NO FINES
				GP	POORLY-GRADED GRAVELS, GRAVEL-SAND MIXTURES, LITTLE OR NO FINES
	MORE THAN 50 % OF COARSE FRACTION RETAINED ON NO. 4 SIEVE	GRAVELS WITH FINES (APPRECIABLE AMOUNT OF FINES)		GM	SILTY GRAVELS, GRAVEL-SAND-SILT MIXTURES
				GC	CLAYEY GRAVELS, GRAVEL-SAND-CLAY MIXTURES
	SAND AND SANDY SOILS	CLEAN SAND (LITTLE OR NO FINES		SW	WELL-GRADED SANDS, GRAVELLY SANDS, LITTLE OR NO FINES
MORE THAN 50 % OF MATERIAL IS LARGER THAN NO. 200 SIEVE SIZE				SP	POORLY-GRADED SANDS, GRAVELLY SANDS, LITTLE OR NO FINES
	MORE THAN 50% OF COARSE FRACTION PASSING NO. 4 SIEVE	SANDS WITH FINES (APPRECIABLE AMOUNT OF FINES)		SM	SILTY SANDS, SAND-SILT MIXTURES
				SC	CLAYEY SANDS, SAND-CLAY MIXTURES
FINE GRAINED SOILS	SILTS AND CLAYS	LIQUID LIMIT LESS THAN 50		ML	INORGANIC SILTS AND VERY FINE SANDS, ROCK FLOUR, SILTY OR CLAYEY FINE SANDS OR CLAYEY SILTS WITH SLIGHT PLASTICITY
				CL	INORGANIC CLAYS OF LOW TO MEDIUM PLASTICITY, GRAVELLY CLAYS, SANDY CLAYS, SILTY CLAYS, LEAN CLAYS
				OL	ORGANIC SILTS AND ORGANIC SILTY CLAYS OF LOW PLASTICITY
	SILTS AND CLAYS	LIQUID LIMIT GREATER THAN 50		MH	INORGANIC SILTS, MICACEOUS OR DIATOMACEOUS FINE SAND OR SILTY SOILS
MORE THAN 50 % OF MATERIAL IS SMALLER THAN NO. 200 SIEVE SIZE				CH	INORGANIC CLAYS OF HIGH PLASTICITY, FAT CLAYS
				OH	ORGANIC CLAYS OF MEDIUM TO HIGH PLASTICTY, ORGANIC SILTS
HIGHLY ORGANIC SOILS				PT	PEAT, HUMUS, SWAMP SOILS WITH HIGH ORGANIC CONTENTS

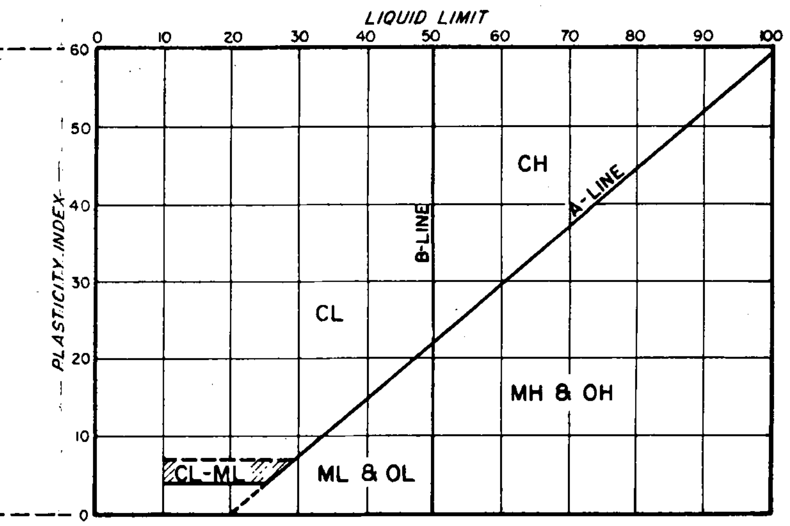
FOR LABORATORY CLASSIFICATION OF FINE-GRAINED SOILS

GRADATION CHART

MATERIAL SIZE	PARTICLE SIZE			
	LOWER LIMIT		UPPER LIMIT	
	MILLIMETERS	SIEVE SIZE✱	MILLIMETERS	SIEVE SIZE✱
SAND				
FINE	.074	#200✱	0.42	#40✱
MEDIUM	0.42	#40✱	2.00	#10✱
COARSE	2.00	#10✱	4.76	#4✱
GRAVEL				
FINE	4.76	#4✱	19.1	3/4"•
COARSE	19.1	3/4"•	76.2	3"•
COBBLES	76.2	3"•	304.8	12•
BOULDERS	304.8	12•	914.4	36"

✱ U.S. STANDARD • CLEAR SQUARE OPENINGS

PLASTICITY CHART



NOTES:

1. DUAL SYMBOLS ARE USED TO INDICATE BORDERLINE CLASSIFICATIONS.
2. WHEN SHOWN ON THE BORING LOGS, THE FOLLOWING TERMS ARE USED TO DESCRIBE THE CONSISTENCY OF COHESIVE SOILS AND THE RELATIVE COMPACTNESS OF COHESIONLESS SOILS.

COHESIVE SOILS	(APPROXIMATE SHEARING STRENGTH IN KSF)	COHESIONLESS SOILS	
VERY SOFT	LESS THAN .25	VERY LOOSE	THESE ARE USUALLY BASED ON AN EXAMINATION OF SOIL SAMPLES, PENETRATION RESISTANCE, AND SOIL DENSITY DATA.
SOFT	0.25 TO 0.5	LOOSE	
MEDIUM STIFF	0.5 TO 1.0	MEDIUM DENSE	
STIFF	1.0 TO 2.0	DENSE	
VERY STIFF	2.0 TO 4.0	VERY DENSE	
HARD	GREATER THAN 4.0		

SAMPLES

■ INDICATES UNDISTURBED SAMPLE
☒ INDICATES DISTURBED SAMPLE
□ INDICATES SAMPLING ATTEMPT WITH NO RECOVERY

I INDICATES LENGTH OF CORING RUN

NOTE:
DEFINITIONS OF ANY ADDITIONAL DATA REGARDING SAMPLES ARE ENTERED ON THE FIRST LOG ON WHICH THE DATA APPEAR.

UNIFIED SOIL CLASSIFICATION SYSTEM

DAMES & MOORE

746.1

DATE

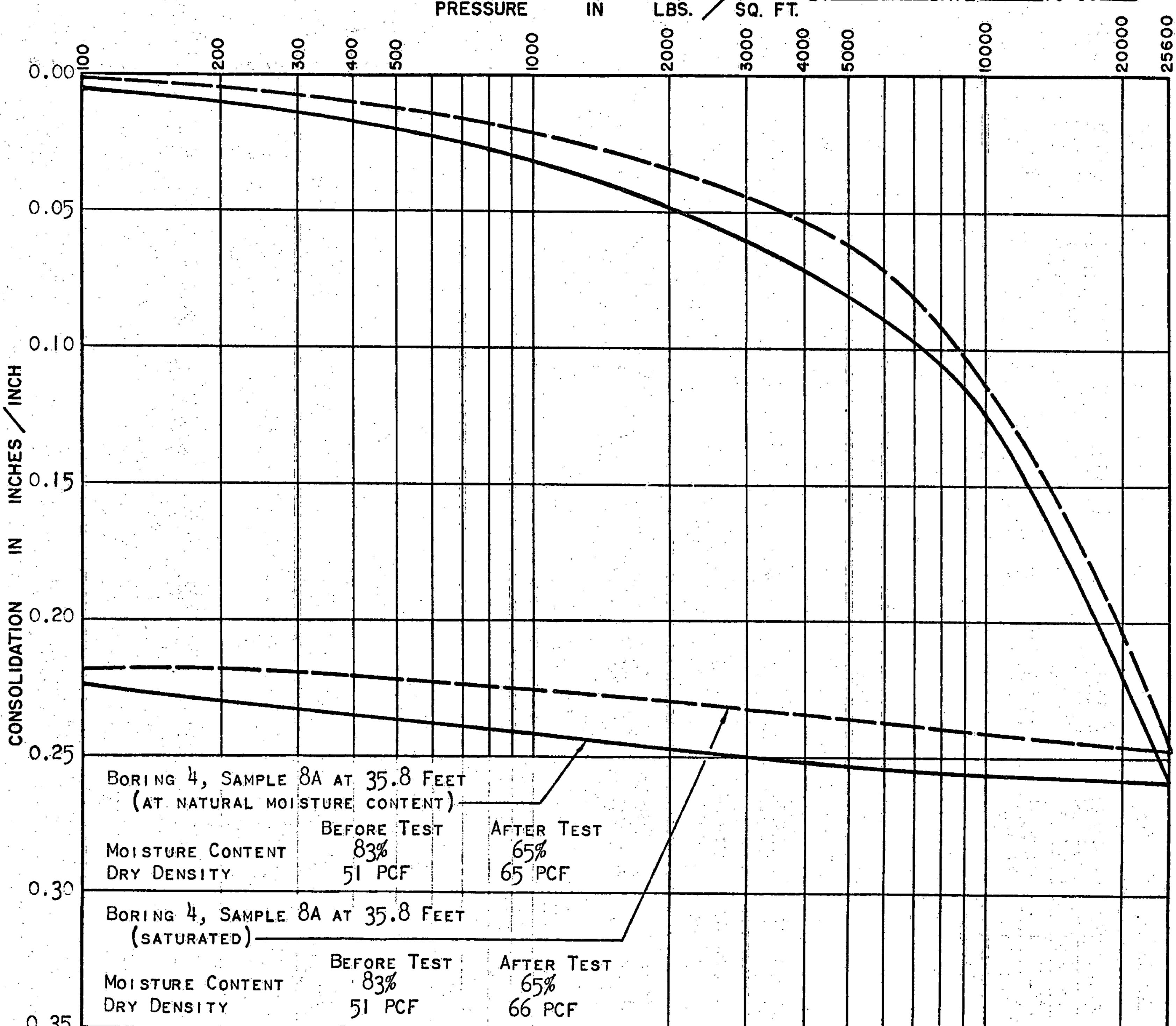
CHECKED BY

COPY TO GO

REVISIONS

BY ______ DATE ______ TO GO ____

BY ______ DATE ______ TO GO ____



CONSOLIDATION TEST DATA

DAMES & MOORE

PLATE A-3

BY Ab DATE ...76

CHECKED BY JC 7/23/76 FILE 4402-079

6.2 (REV. 3-65)

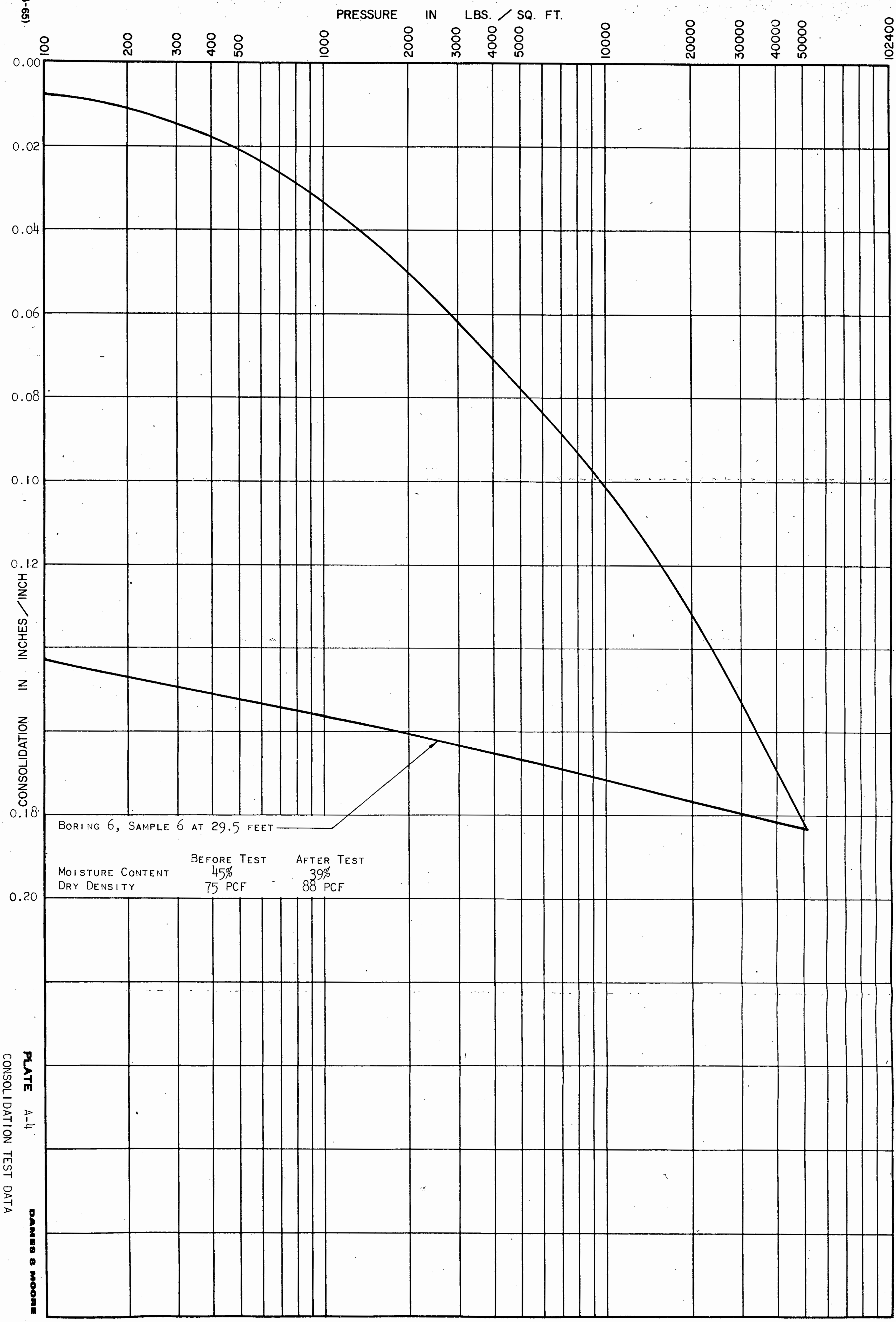


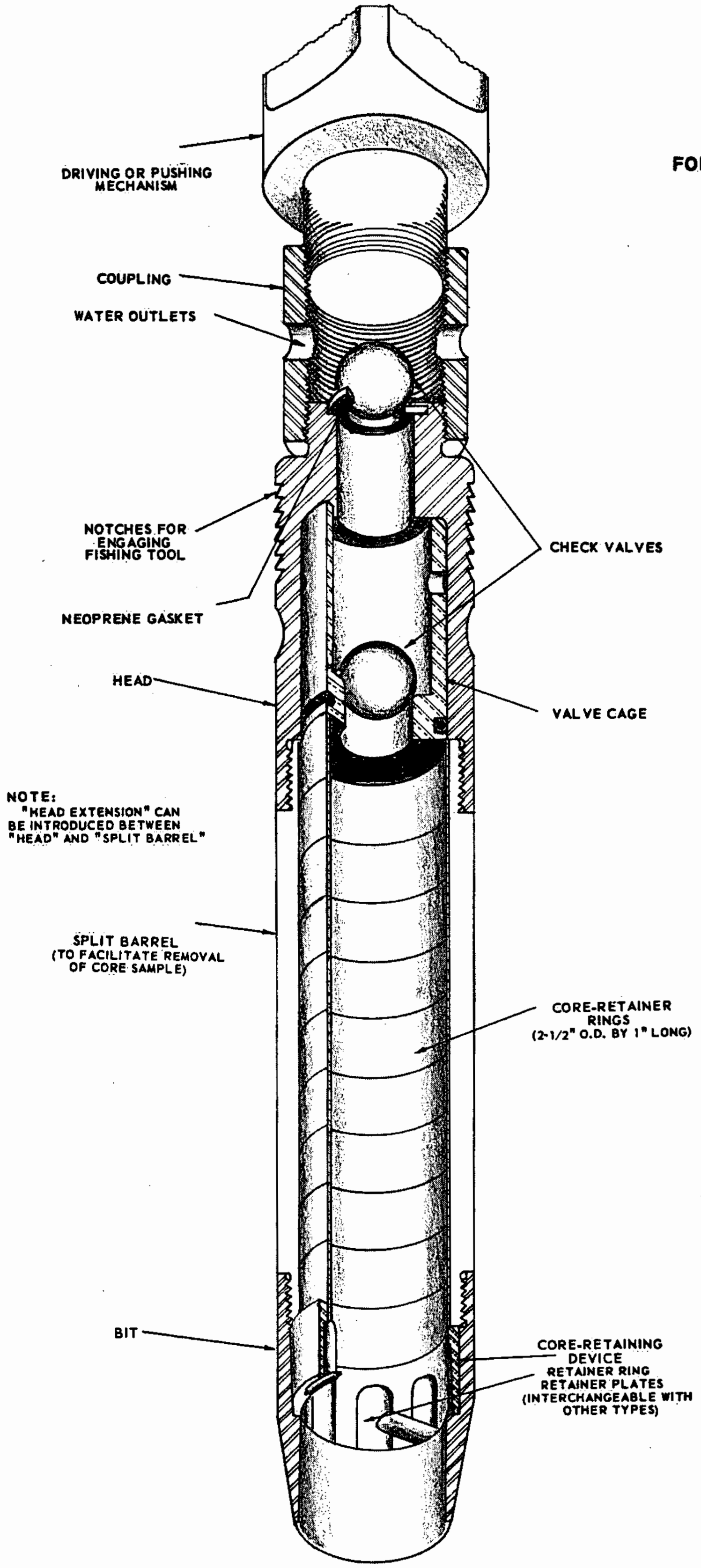
PLATE A-4

CONSOLIDATION TEST DATA

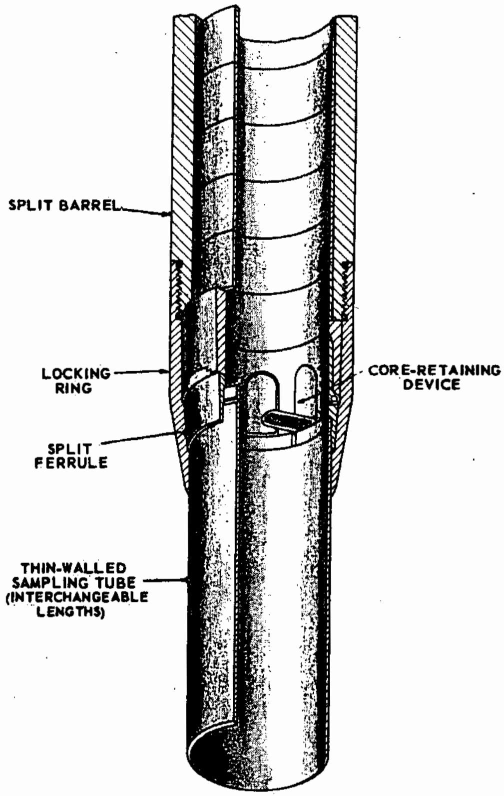
DAMES & MOORE

SOIL SAMPLER TYPE U

FOR SOILS DIFFICULT TO RETAIN IN SAMPLER



ALTERNATE ATTACHMENTS



417.9 (5-68)

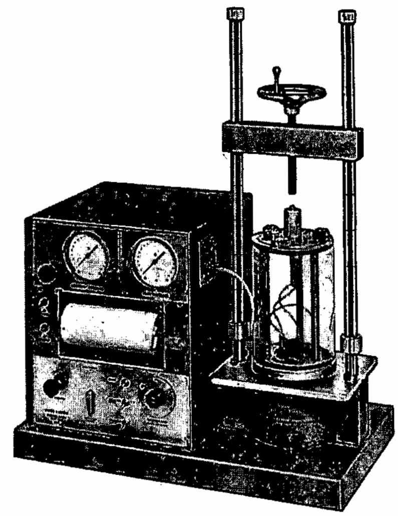
DAMES & MOORE

EXHIBIT A-1

METHODS OF PERFORMING UNCONFINED COMPRESSION AND TRIAXIAL COMPRESSION TESTS

THE SHEARING STRENGTHS OF SOILS ARE DETERMINED FROM THE RESULTS OF UNCONFINED COMPRESSION AND TRIAXIAL COMPRESSION TESTS. IN TRIAXIAL COMPRESSION TESTS THE TEST METHOD AND THE MAGNITUDE OF THE CONFINING PRESSURE ARE CHOSEN TO SIMULATE ANTICIPATED FIELD CONDITIONS.

UNCONFINED COMPRESSION AND TRIAXIAL COMPRESSION TESTS ARE PERFORMED ON UNDISTURBED OR REMOLDED SAMPLES OF SOIL APPROXIMATELY SIX INCHES IN LENGTH AND TWO AND ONE-HALF INCHES IN DIAMETER. THE TESTS ARE RUN EITHER STRAIN-CONTROLLED OR STRESS-CONTROLLED. IN A STRAIN-CONTROLLED TEST THE SAMPLE IS SUBJECTED TO A CONSTANT RATE OF DEFLECTION AND THE RESULTING STRESSES ARE RECORDED. IN A STRESS-CONTROLLED TEST THE SAMPLE IS SUBJECTED TO EQUAL INCREMENTS OF LOAD WITH EACH INCREMENT BEING MAINTAINED UNTIL AN EQUILIBRIUM CONDITION WITH RESPECT TO STRAIN IS ACHIEVED.



TRIAXIAL COMPRESSION TEST UNIT

YIELD, PEAK, OR ULTIMATE STRESSES ARE DETERMINED FROM THE STRESS-STRAIN PLOT FOR EACH SAMPLE AND THE PRINCIPAL STRESSES ARE EVALUATED. THE PRINCIPAL STRESSES ARE PLOTTED ON A MOHR'S CIRCLE DIAGRAM TO DETERMINE THE SHEARING STRENGTH OF THE SOIL TYPE BEING TESTED.

UNCONFINED COMPRESSION TESTS CAN BE PERFORMED ONLY ON SAMPLES WITH SUFFICIENT COHESION SO THAT THE SOIL WILL STAND AS AN UNSUPPORTED CYLINDER. THESE TESTS MAY BE RUN AT NATURAL MOISTURE CONTENT OR ON ARTIFICIALLY SATURATED SOILS.

IN A TRIAXIAL COMPRESSION TEST THE SAMPLE IS ENCASED IN A RUBBER MEMBRANE, PLACED IN A TEST CHAMBER, AND SUBJECTED TO A CONFINING PRESSURE THROUGHOUT THE DURATION OF THE TEST. NORMALLY, THIS CONFINING PRESSURE IS MAINTAINED AT A CONSTANT LEVEL, ALTHOUGH FOR SPECIAL TESTS IT MAY BE VARIED IN RELATION TO THE MEASURED STRESSES. TRIAXIAL COMPRESSION TESTS MAY BE RUN ON SOILS AT FIELD MOISTURE CONTENT OR ON ARTIFICIALLY SATURATED SAMPLES. THE TESTS ARE PERFORMED IN ONE OF THE FOLLOWING WAYS:

UNCONSOLIDATED-UNDRAINED: THE CONFINING PRESSURE IS IMPOSED ON THE SAMPLE AT THE START OF THE TEST. NO DRAINAGE IS PERMITTED AND THE STRESSES WHICH ARE MEASURED REPRESENT THE SUM OF THE INTERGRANULAR STRESSES AND PORE WATER PRESSURES.

CONSOLIDATED-UNDRAINED: THE SAMPLE IS ALLOWED TO CONSOLIDATE FULLY UNDER THE APPLIED CONFINING PRESSURE PRIOR TO THE START OF THE TEST. THE VOLUME CHANGE IS DETERMINED BY MEASURING THE WATER AND/OR AIR EXPELLED DURING CONSOLIDATION. NO DRAINAGE IS PERMITTED DURING THE TEST AND THE STRESSES WHICH ARE MEASURED ARE THE SAME AS FOR THE UNCONSOLIDATED-UNDRAINED TEST.

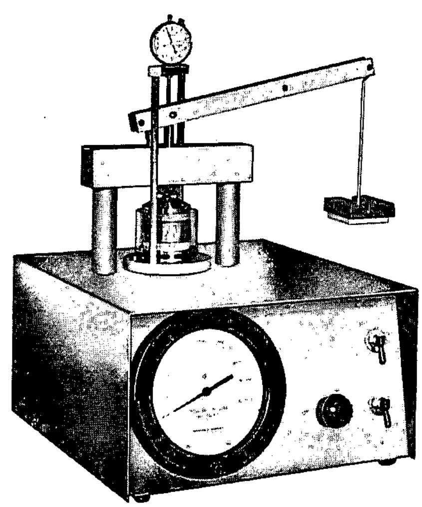
DRAINED: THE INTERGRANULAR STRESSES IN A SAMPLE MAY BE MEASURED BY PERFORMING A DRAINED, OR SLOW, TEST. IN THIS TEST THE SAMPLE IS FULLY SATURATED AND CONSOLIDATED PRIOR TO THE START OF THE TEST. DURING THE TEST, DRAINAGE IS PERMITTED AND THE TEST IS PERFORMED AT A SLOW ENOUGH RATE TO PREVENT THE BUILDUP OF PORE WATER PRESSURES. THE RESULTING STRESSES WHICH ARE MEASURED REPRESENT ONLY THE INTERGRANULAR STRESSES. THESE TESTS ARE USUALLY PERFORMED ON SAMPLES OF GENERALLY NON-COHESIVE SOILS, ALTHOUGH THE TEST PROCEDURE IS APPLICABLE TO COHESIVE SOILS IF A SUFFICIENTLY SLOW TEST RATE IS USED.

AN ALTERNATE MEANS OF OBTAINING THE DATA RESULTING FROM THE DRAINED TEST IS TO PERFORM AN UNDRAINED TEST IN WHICH SPECIAL EQUIPMENT IS USED TO MEASURE THE PORE WATER PRESSURES. THE DIFFERENCES BETWEEN THE TOTAL STRESSES AND THE PORE WATER PRESSURES MEASURED ARE THE INTERGRANULAR STRESSES.

METHOD OF PERFORMING CONSOLIDATION TESTS

CONSOLIDATION TESTS ARE PERFORMED TO EVALUATE THE VOLUME CHANGES OF SOILS SUBJECTED TO INCREASED LOADS. TIME-CONSOLIDATION AND PRESSURE-CONSOLIDATION CURVES MAY BE PLOTTED FROM THE DATA OBTAINED IN THE TESTS. ENGINEERING ANALYSES BASED ON THESE CURVES PERMIT ESTIMATES TO BE MADE OF THE PROBABLE MAGNITUDE AND RATE OF SETTLEMENT OF THE TESTED SOILS UNDER APPLIED LOADS.

EACH SAMPLE IS TESTED WITHIN BRASS RINGS TWO AND ONE-HALF INCHES IN DIAMETER AND ONE INCH IN LENGTH. UNDISTURBED SAMPLES OF IN-PLACE SOILS ARE TESTED IN RINGS TAKEN FROM THE SAMPLING DEVICE IN WHICH THE SAMPLES WERE OBTAINED. LOOSE SAMPLES OF SOILS TO BE USED IN CONSTRUCTING EARTH FILLS ARE COMPACTED IN RINGS TO PREDETERMINED CONDITIONS AND TESTED.



DEAD LOAD-PNEUMATIC CONSOLIDOMETER

IN TESTING, THE SAMPLE IS RIGIDLY CONFINED LATERALLY BY THE BRASS RING. AXIAL LOADS ARE TRANSMITTED TO THE ENDS OF THE SAMPLE BY POROUS DISKS. THE DISKS ALLOW DRAINAGE OF THE LOADED SAMPLE. THE AXIAL COMPRESSION OR EXPANSION OF THE SAMPLE IS MEASURED BY A MICROMETER DIAL INDICATOR AT APPROPRIATE TIME INTERVALS AFTER EACH LOAD INCREMENT IS APPLIED. EACH LOAD IS ORDINARILY TWICE THE PRECEDING LOAD. THE INCREMENTS ARE SELECTED TO OBTAIN CONSOLIDATION DATA REPRESENTING THE FIELD LOADING CONDITIONS FOR WHICH THE TEST IS BEING PERFORMED. EACH LOAD INCREMENT IS ALLOWED TO ACT OVER AN INTERVAL OF TIME DEPENDENT ON THE TYPE AND EXTENT OF THE SOIL IN THE FIELD.