SITE INVESTIGATION

PROPOSED HAWAII LOA COLLEGE CAMPUS
KAILUA, HAWAII

FOR

HAWAII LOA COLLEGE
William L. Pereira & Associates
5657 Wilshire Boulevard
Los Angeles, California 90036

Attention: Mr. Harrison Lewis Whitney

Gentlemen:

Three copies of our report, "Site Investigation, Proposed Hawaii Loa College Campus, Kailua, Hawaii, for Hawaii Loa College," are herewith submitted.

The scope of our work was defined in discussions with Mr. Whitney of your office and Messrs. Haines and Young of Belt, Lemmon & Lo, and was described in our proposal dated May 19, 1965.

In general, the site is suitable for its intended use. Some existing structures and other construction features may be necessary. We recommend that buildings be supported on spread foundations in natural soils. Adequate drainage should be provided for surface runoff from the site and for water passing through natural drainages.

We trust this report will be useful to you. If there are points not clear, please feel free to discuss with us.

Yours very truly,

DAMES & MOORE

DCL RLL CU

cc: Belt, Lemmon & Lo (3)
SITE INVESTIGATION
PROPOSED HAWAII LOA COLLEGE CAMPUS
KAILUA, HAWAII
FOR
HAWAII LOA COLLEGE

INTRODUCTION

GENERAL

Presented in this report are the results of engineering and geologic studies performed during a site investigation for a proposed Hawaii Loa College campus to be constructed near Kailua, Hawaii. The site is located on the windward side of the Island of Oahu just north of the intersection of Kalanianaole and Kamehameha Highways as shown on the Map of Area, Plate 1.

The proposed initial campus will be about 100 acres in size and will be comprised of several structures together with athletic fields, lagoons and other appurtenant construction. Proposed locations of buildings are shown on the Plot Plan, Plate 2. Buildings will be about four stories high, constructed of 40-foot modular units. Column loads will be high, with a maximum load of about 900 kips.

Scope

In a letter to William L. Pereira and Associates, dated May 19, 1965,* Dames & Moore proposed that the site investigation be conducted in two phases. The work performed in connection with the first phase of the investigation is described in this report and includes the following:

*Proposal, Site Investigation, Proposed Hawaii Loa College Campus near Kailua, Hawaii.

DAMES & MOORE
1. Nature and location of potential natural hazards to aid in siting (such natural hazards would include unstable slopes and potential slides, areas easily eroded by surface runoff, areas of adobe or similar expansive soils, areas of weak soils and unsuitable fill materials),

2. Recommendations for suitable foundation types,

3. Grading requirements for site preparation, and

4. Recommendations for additional investigations of subsurface conditions as the second phase of the site investigation.

Sequence of Studies

Initially, available soils and geologic literature and aerial photographs were studied. A site reconnaissance was performed by an engineering geologist. A total of 15 borings were drilled at the site at locations shown on Plate 2, Plot Plan. Undisturbed samples were taken from five of the borings. Information from borings, site reconnaissance, and other observations were used in the preparation of this report. A detailed description of the exploration is presented with the log of borings in Appendix A, Field Exploration and Laboratory Testing.

Laboratory tests were performed on selected soil samples obtained at the site. Certain soil properties to be used in analyses were evaluated, and interpretations of analyses was used to formulate the discussions and recommendations presented in this report. Descriptions of the tests performed and their results are presented in Appendix A of this report.
SITE CONDITIONS

GENERAL

The site is located in an area of varying relief ranging from lowlands and terraces to sharp, narrow ridges flanked by V-shaped valleys.

Vegetation is heavy with thick tree and vine growth in valleys and lowlands and heavy grass growth on ridges.

The area is underlain by rocks of the Kailua Volcanic Series, consisting mainly of basaltic dikes. Rocks are usually overlain by residual soils or by alluvial soils of varying age.

SURFACE CONDITIONS

Topography: Elevations within the general area of investigation vary from about 250 feet to about 500 feet. Sharp ridges plunge westward into the site area from a higher spine located to the east. A low drainage area, flanked by terraces, runs from southeast to northwest through the lower portion of the property.

Slopes in the area are moderately steep ranging from about 2:1 to 1½:1. A curved slope at the edge of the terrace in the vicinity of Boring 3 may be an ancient slide scarp that has subsequently been eroded. This scarp is approximately 90 feet high and slopes upward at about 1½:1. The approximate location of the scarp is shown on Plate 3, Map of Surface Geology and Features.

The site appears to have been used as a military camp in the past and minor grading has been done for roads, quarters sites and rifle ranges. Areas previously graded are denuded and have undergone moderately rapid erosion of soils with perhaps 12 to 18 inches of erosion occurring over the past 20 years.
HYDROLOGY: No detailed drainage studies of the site have been made. No permanent streams flow in the site area, but the drainages are water courses for runoff water from surrounding areas. The presence of gravel- and cobble-size rock fragments and other debris in the drainages indicate intermittent heavy and rapid water flows. The water table was encountered in one boring only, at a depth of 17.5 feet in Boring 2.

GEOLGY: Three geologic units were observed at the site. Their distribution was indicated by topographic expression and by observations in cuts, valleys and borings. These distinct units are respectively:

1. Residual soil and decomposed rock formed on top of and directly overlying basaltic rock,
2. Older alluvium forming terraces and low ridges adjacent to low land, and
3. Recent alluvium found in drainage bottoms.

The approximate distribution of these geologic units are shown on Plate 3. A more complete discussion of the geology is presented in Appendix B of this report.

SUBSURFACE CONDITIONS

As mentioned in the previous paragraph, three geologic units were noted and mapped in the area of investigation. Borings drilled at the site penetrated into all geologic units. No great variation in soil type was noted between the different units. Soils consisted mainly of moderately firm to firm clayey silt with varying amounts of decomposed or weathered rock fragments. Soils have been derived from the weathering and decomposition of the Kailua basalts. The residual soils and decomposed rock often retain relict
STRUCTURE FROM THE ROCK, OCCASIONALLY SHOWING SOME WEAKNESS ALONG OLD JOINTS. OLDER ALLUVIAL SOILS CONTAIN ABUNDANT CONGLOMERATE LENSES COMPOSED OF GRAVEL-SIZE FRAGMENTS OF DECOMPOSED BASALT. RECENT ALLUVIAL SOILS OFTEN CONTAIN FRAGMENTS OF SOUND ROCK AND ALSO OCCASIONALLY DISPLAY SHRINKAGE CRACKS UPON DRYING. EXPANSIVE SOILS OR SOILS WHICH ARE EXCESSIVELY WEAK OR COMPRESSIBLE WERE NOT FOUND IN THE BORINGS NOR OBSERVED DURING SITE RECONNAISSANCE.

BORINGS INDICATED THAT THE OLDER ALLUVIUM WAS THIN WHERE TERRACES ABUTTED THE SHARP RIDGES BUT THICKENED RAPIDLY AWAY FROM THE RIDGES.

DECOMPOSED BASALT WAS ENCOUNTERED IN BORINGS 1, 2 AND 4. NO SOUND ROCK WAS ENCOUNTERED WITHIN THE DEPTHS DRILLED.

DISCUSSIONS AND RECOMMENDATIONS

GENERAL

THE SITE SELECTED FOR THE PROPOSED HAWAI'I LOA COLLEGE DEVELOPMENT IS SUITABLE FOR THE INTENDED USE, PROVIDED CARE IS EXERCISED IN THE LOCATION OF STRUCTURES UPON THE SITE. BUILDINGS MAY BE SUPPORTED ON SPREAD FOUNDATIONS IN NATURAL SOILS. SITE PREPARATION SHOULD PROVIDE FOR ADEQUATE DRAINAGE OF SURFACE RUNOFF FROM THE SITE AND OF WATER PASSING THROUGH NATURAL DRAINAGES. RESITING OF THE PRESENTLY PROPOSED LOCATIONS OF SOME STRUCTURES AND OTHER CONSTRUCTION FEATURES MAY BE NECESSARY.

NATURAL HAZARDS

SLOPES. NATURAL SLOPES APPEAR STABLE, BUT CARE SHOULD BE TAKEN IN SITING AND SITE GRADING TO INSURE THAT NO GREAT CHANGES IN NATURAL CONDITIONS OCCUR THAT MIGHT CAUSE THE SLOPES TO BECOME UNSTABLE. SUCH CHANGES WOULD INCLUDE EXTENSIVE CUTTING AT THE BASE OF A SLOPE* OR THE CONSIDERABLE RAISING

* EAST OF THE HAWAI'I LOA COLLEGE SITE, A HIGH CUT HAS BEEN MADE IN A NATURAL SLOPE OF SIMILAR SOILS AS THOSE AT THE SITE. THIS CUT SLOPE IS PRESENTLY FAILING ALONG A DEEP-SEATED SLIDE SURFACE. THIS CUT IS APPROXIMATELY 100 FEET HIGH AND IS CONSTRUCTED ON A SLOPE OF ABOUT 1:4:1.
OF THE WATER TABLE. IT IS POSSIBLE THAT THE SLOPE OF THE ANCIENT SLIDE SCARP
HAS A LOW FACTOR OF SAFETY AGAINST SLIDING. ALSO THE NEAR-SURFACE SOILS ON
THIS SLOPE MAY HAVE BEEN WEAKENED BY THE ACTION OF THE ORIGINAL SLIDE.

**Erosion.** Continuing erosion is occurring at denuded areas shown on
Plate 3. These areas and new cuts which will be made in natural soils will
not erode extremely rapidly; however, they should be protected from erosional
deterioration by planting and by directing drainage away from the slopes.

**Expansive Soils.** Observations made in borings and during site recon-
naissance did not reveal the presence of expansive soils within the site
area; however, the recent alluvial soils observed were usually damp so that
evidence of shrinkage and swelling was not apparent. It is possible that, in
some areas, these soils will experience large volume change upon drying and
wetting.

**Unsuitable Fill Material.** Residual and old alluvial soils were found
to be satisfactory for use as compacted fill. The recent alluvial soils are
variable and weaker and may be usable for landscaping fills, but they should
not be considered for fill to support structures unless the material from a
particular borrow area is investigated and found to be acceptable.

**Flooding.** Valleys and lowlands are subject to flooding during periods
of heavy rainfall. The areas that may be inundated are assumed to be the
same as areas occupied by recent alluvial soils, but more exact boundaries
must be determined by a drainage study.

**Foundation Support**

It is recommended that structures be supported on spread foundations
in the natural soils. The undisturbed residual and older alluvial soils are
SUITABLE FOR SUPPORT OF SPREAD FOUNDATIONS, AND THEIR LOCATIONS ARE DELINEATED ON PLATE 3. GENERALLY, SPREAD FOUNDATIONS MAY BE PLACED ABOVE ELEVATION 300 WITHOUT ADDITIONAL INVESTIGATION EXCEPT IN CERTAIN VALLEYS. SPECIFIC FOUNDATION INVESTIGATIONS SHOULD BE MADE FOR STRUCTURES TO BE FOUNDED ON RECENT ALLUVIAL SOILS.

A BEARING PRESSURE OF 4000 POUNDS PER SQUARE FOOT MAY BE USED IN PROPORTIONING FOOTINGS TO BE PLACED IN NATURAL RESIDUAL AND OLDER ALLUVIAL SOILS. FOOTINGS SHOULD BE PLACED A MINIMUM DEPTH OF THREE FEET BELOW THE LOWEST ADJACENT GRADE. FOR THE MAXIMUM COLUMN LOAD SUPPORTED ON AN INDIVIDUAL SPREAD FOUNDATION, THE SETTLEMENT IS ESTIMATED TO BE ABOUT ONE AND ONE-HALF INCHES OCCURRING OVER A PERIOD OF A FEW MONTHS. A LOWER BEARING PRESSURE, ON THE ORDER OF 2000 POUNDS PER SQUARE FOOT, MAY BE USED WHEN FOUNDATIONS ARE PLACED IN FILL COMPACTED TO 95% OF THE MAXIMUM DENSITY AS DETERMINED BY THE STANDARD A.A.S.H.O. METHOD OF COMPACTION TEST. SETTLEMENTS OF FOUNDATIONS ON FILLS WILL BE HIGHER THAN THOSE ON NATURAL SOILS. IF THE FILL IS LIABLE TO BECOME SATURATED, THE BEARING PRESSURE SHOULD BE REDUCED TO 1500 POUNDS PER SQUARE FOOT AND THE ANTICIPATED SETTLEMENT WOULD BE GREATER.

IN GENERAL, STRUCTURES SHOULD BE LOCATED SO THAT THEY ARE FOUNDED TOTALLY UPON NATURAL SOILS OR UPON FILL SOILS. IF IT IS NECESSARY TO PLACE A STRUCTURE PARTLY IN CUT AND PARTLY IN FILL, TWO ALTERNATE FOUNDATION SCHEMES MAY BE CONSIDERED. IT MAY BE ADVISABLE TO SUPPORT ONE PORTION ON SPREAD FOUNDATIONS PLACED IN NATURAL SOILS AND TO SUPPORT THE OTHER PORTION ON DRIVEN PILES OR DRILLED PIERS EXTENDING THROUGH THE FILL TO THE NATURAL SOILS. IT IS LIKELY THAT THE SETTLEMENT WOULD BE MORE UNIFORM. OR, IT IS POSSIBLE TO OVEREXCAVATE THE AREA TO BE OCCUPIED BY THE STRUCTURE AND PLACE ALL FOUNDATIONS IN FILL. IN THIS MANNER, THE SETTLEMENT OF THE FOUNDATIONS
WOULD TEND TO BE MORE UNIFORM, ALTHOUGH THE MAGNITUDE WOULD BE GREATER, THAN IF THE STRUCTURE IS PARTLY ON NATURAL SOILS AND PARTLY IN FILL. ADDITIONAL INVESTIGATION AND ANALYSES WOULD BE REQUIRED IF EXTREME DIFFERENCES IN FOUNDATION ELEVATION ARE ENCOUNTERED.

**Facility Siting and Site Preparation**

THE LIBRARY AND OTHER BUILDINGS TO BE PLACED ABOVE THE SLOPE OF THE SLIDE SCARP SHOWN ON PLATE 3 SHOULD BE LOCATED AWAY FROM THE FACE OF THE SLOPE. IT IS RECOMMENDED THAT THE LIBRARY BE MOVED BACK THREE BAYS FROM ITS PRESENT LOCATION OR SHIFTED TO THE RIDGE WHICH LIES TO THE SOUTH. BUILDINGS TO BE LOCATED IN THE LOW AREAS OR VALLEYS SHOULD BE PLACED SO THAT THEY WILL NOT BE INUNDATED OR OTHERWISE DAMAGED DURING PERIODS OF FLOOD.

A PORTION OF THE LOW LYING AREA IS TO BE DEVELOPED AS A LAGOON THAT WILL OCCUPY PART OF A NATURAL TRUNK DRAINAGE. FOR THIS REASON, THE LAGOON SHOULD HAVE SUFFICIENT CAPACITY TO HOLD DESIGN STORM WATERS OR BE DESIGNED SO THAT STORM WATERS COULD PASS OVER OR THROUGH A RETENTION EMBANKMENT WITHOUT DAMAGING IT. THE LAGOON WILL BE LOCATED ON RECENT ALLUVIAL SOILS OF LOW PERMEABILITY SO THAT NO GREAT WATER LOSS THROUGH PERCOLATION IS ANTICIPATED.

WATER FROM THE LAGOON WILL SATURATE ADJACENT SLOPES, POSSIBLY WEAKENING THE SOILS AND INCREASING THE POSSIBILITY OF THE SLOPES BECOMING UNSTABLE. IT IS RECOMMENDED THAT THE LAGOON BE AS SHALLOW AS PRACTICAL SO THAT THE LEAST AMOUNT OF SATURATION OCCURS.

ONLY OLDER ALLUVIAL SOILS WERE INVESTIGATED AS POSSIBLE SOURCES OF COMPACTED FILL MATERIAL BECAUSE THESE SOILS ARE THE PREDOMINANT TYPE IN THE AREAS WHERE MOST STRUCTURES WILL BE LOCATED. RESIDUAL SOILS ARE SIMILAR IN CHARACTER TO THE OLDER ALLUVIAL SOILS AND MAY BE USED AS A SOURCE FOR FILL.

Compaction to greater densities would require that the material be dried prior to compaction, but it is expected that this would be a slow and difficult process. Fill slopes of moderate heights, not exceeding 1:2:1, should be stable if (1) soil is compacted to reasonable specifications, (2) the fill is keyed properly into natural slopes, and (3) adequate drainage of the slopes is provided for. If very high embankments are contemplated, detailed stability analyses should be performed to assure that the fill slope would be stable. Drains should be provided through fill placed over natural drainages. These drains should be of sufficient capacity to prevent excessive ponding of water behind the fills.

Additional Investigations

Only general foundation recommendations have been made in this report. Separate investigations should be made for structures to be placed on the recent alluvial soils or outside of the initial area of investigation.
THE FOLLOWING PLATES AND APPENDICES ARE ATTACHED AND COMPLETE THIS REPORT:

**PLATE 1** - Map of Area
**PLATE 2** - Plot Plan
**PLATE 3** - Map of Surface Geology and Features
**APPENDIX A** - Field Exploration and Laboratory Testing
**APPENDIX B** - Site Geology.

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RESPECTFULLY SUBMITTED,

DAMES & MOORE

DAVID C. LIU

DCL RLL GU

[Signature]

DAVID C. LIU
REGISTERED PROFESSIONAL ENGINEER
HAWAII, U.S.A.

THIS WORK WAS PREPARED BY ME OR UNDER MY SUPERVISION.

[Signature]

DAMES & MOORE
MAP OF AREA

Scale: 1 inch = 2000 feet

This map is a portion of USGS Kāne‘ohe Quadrangle, 1959.
APPENDICES
APPENDIX A

FIELD EXPLORATION AND LABORATORY TESTING

FIELD EXPLORATION

Fifteen borings averaging 30 feet in depth were drilled at the locations shown on Plate 2. The drilling was done under the direction of Dames & Moore by Nat Whiton Drilling Company using tripod wash rig and anger rig. A Dames & Moore engineer was present during the drilling of Borings 1 through 5, and he observed the drilling of the other borings on an intermittent basis. Undisturbed samples for testing and visual examination were obtained from Borings 1 through 5 with equipment which is described on Page A-2. Materials encountered in the borings were examined and classified, and they are described on the Log of Borings, Plates A-1A through A-1Q. The soils were classified according to the Unified Soil Classification System, Plate A-2.

A general site reconnaissance was performed by an engineering geologist who observed surface geology, land forms, vegetation distribution, drainage patterns and other natural features that might be possible hazards to construction. Some surface samples of the alluvial deposits were taken.

LABORATORY TESTS

Direct shear tests were performed on selected undisturbed samples to determine their strength characteristics. The method of performing this test is described on Page A-3. The results of these tests are tabulated below:
NOTE:
"HEAD EXTENSION" CAN BE INTRODUCED BETWEEN "HEAD" AND "SPLIT BARREL"

ALTERNATE ATTACHMENTS

CORE-RETAINING DEVICE
RETAINER RING
RETAINER PLATES (INTERCHANGEABLE WITH OTHER TYPES)
THIN-WALLED SAMPLING TUBE (INTERCHANGEABLE LENGTHS)

SOIL SAMPLER TYPE U
FOR SOILS DIFFICULT TO RETAIN IN SAMPLER
U. S. PATENT NO. 2,318,062
METHOD OF PERFORMING DIRECT SHEAR AND FRICTION TESTS

Direct shear tests are performed to determine the shearing strengths of soils. Friction tests are performed to determine the frictional resistances between soils and various other materials such as wood, steel, or concrete. The tests are performed in the laboratory to simulate anticipated field conditions.

Each sample is tested within three 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 tool 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.

Direct Shear Tests

A three-inch length of the sample is tested in direct double shear. A constant pressure, appropriate to the conditions of the problem for which the test is being performed, is applied normal to the ends of the sample through porous stones. A shearing failure of the sample is caused by moving the center ring in a direction perpendicular to the axis of the sample. Transverse movement of the outer rings is prevented.

The shearing failure may be accomplished by applying to the center ring either a constant rate of load, a constant rate of deflection, or increments of load or deflection. In each case, the shearing load and the deflections in both the axial and transverse directions are recorded and plotted. The shearing strength of the soil is determined from the resulting load-deflection curves.

Friction Tests

In order to determine the frictional resistance between soil and the surfaces of various materials, the center ring of soil in the direct shear test is replaced by a disk of the material to be tested. The test is then performed in the same manner as the direct shear test by forcing the disk of material from the soil surfaces.
<table>
<thead>
<tr>
<th>BORING</th>
<th>DEPTH (FT)</th>
<th>NORMAL PRESSURE (PSF)</th>
<th>SHEARING STRENGTH (PSF)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>5.0</td>
<td>750</td>
<td>900</td>
</tr>
<tr>
<td>2</td>
<td>5.5</td>
<td>600</td>
<td>1000</td>
</tr>
<tr>
<td>3</td>
<td>1.0</td>
<td>500</td>
<td>1200</td>
</tr>
<tr>
<td>3</td>
<td>15.5</td>
<td>1500</td>
<td>1600</td>
</tr>
<tr>
<td>4</td>
<td>2.0</td>
<td>800</td>
<td>1200</td>
</tr>
<tr>
<td>4</td>
<td>10.5</td>
<td>750</td>
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</tr>
<tr>
<td>4</td>
<td>10.5</td>
<td>1500</td>
<td>1500</td>
</tr>
<tr>
<td>5</td>
<td>1.0</td>
<td>500</td>
<td>1400</td>
</tr>
</tbody>
</table>

Unconfined compression tests were performed on two undisturbed samples and a sample of the old alluvial soil that had been compacted to 92% of the maximum dry density as determined by the Standard A.A.S.H.O. method of compaction test at a moisture content of 43%. The method of performing this test is described on Page A-5. The results of these tests are shown below:

<table>
<thead>
<tr>
<th>BORING</th>
<th>DEPTH (FT)</th>
<th>UNCONFINED COMPRESSIVE STRENGTH (PSF)</th>
</tr>
</thead>
<tbody>
<tr>
<td>4</td>
<td>5.5</td>
<td>1600</td>
</tr>
<tr>
<td>5</td>
<td>10.5</td>
<td>2870</td>
</tr>
<tr>
<td>Compacted Sample</td>
<td>1900</td>
<td></td>
</tr>
</tbody>
</table>

Consolidation tests were performed on samples of older alluvial soils from Boring 3. The tests were performed in accordance with the procedure described on Page A-6 and the results are presented as a range of possible consolidation on Plate A-3. An expansion test was performed on a sample of recent alluvial soil taken from a depth of one foot in Boring 2. This test was performed in the same manner as a consolidation test. The sample expanded 0.54 percent when saturated under a load of 100 pounds per square foot.

A percolation test was performed on a sample of recent alluvial soil taken from a depth of about 9" below the low drainage area at the site. The test was performed in accordance with the procedure described on Page A-7.
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.

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 a brass ring 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 tool 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.

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.

Soils saturated in the field are tested submerged in water. The effect of increased moisture content on partially saturated soils is determined by adding water to the sample during the test.
The quantity and the velocity of flow of water which will escape through an earth structure or percolate through soil are dependent upon the permeability of the earth structure or soil. The permeability of soil has often been calculated by empirical formulas but is best determined by laboratory tests, especially in the case of compacted soils.

A one-inch length of the core sample is sealed in the percolation apparatus, placed under a confining load, or surcharge pressure, and subjected to the pressure of a known head of water. The percolation rate is computed from the measurements of the volume of water which flows through the sample in a series of time intervals. These rates are usually expressed as the velocity of flow in feet per year under a hydraulic gradient of one and at a temperature of 20 degrees Centigrade. The rate so expressed may be adjusted for any set of conditions involving the same soil by employing established physical laws. Generally, the percolation rate varies over a wide range at the beginning of the test and gradually approaches equilibrium as the test progresses.

During the performance of the test, continuous readings of the deflection of the sample are taken by means of micrometer dial gauges. The amount of compression or expansion, expressed as a percentage of the original length of the sample, is a valuable indication of the compression of the soil which will occur under the action of load or the expansion of the soil as saturation takes place.
The sample was saturated under a surcharge of 500 pounds per square foot and the percolation rate was determined to be $5.6 \times 10^{-8}$ cm/sec.

Moisture content and density determinations were performed on a number of samples and on samples upon which other tests had been performed. The results are shown on the Log of Borings, Plates A-IA through A-1Q.

Atterberg limit determinations were made on selected soil samples. Results were as follows:

<table>
<thead>
<tr>
<th></th>
<th>Boring 1 at 1 ft.</th>
<th>Boring 3 at 1 ft.</th>
<th>Compaction Sample of Older Alluvium</th>
</tr>
</thead>
<tbody>
<tr>
<td>Liquid Limit</td>
<td>60%</td>
<td>80%</td>
<td>89%</td>
</tr>
<tr>
<td>Plastic Limit</td>
<td>51%</td>
<td>65%</td>
<td>78%</td>
</tr>
<tr>
<td>Plasticity Index</td>
<td>9%</td>
<td>15%</td>
<td>11%</td>
</tr>
<tr>
<td>Unified Soil</td>
<td>MH</td>
<td>MH</td>
<td>MH</td>
</tr>
<tr>
<td>Classification</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

A compaction test was performed on a sample of older alluvium, classified as a clayey silt, taken from a terrace east of the low drainage area. The test was performed in accordance with the Standard A.A.S.H.O. Method of performing a compaction test as shown on Page A-9. The material was found to have a maximum dry density of 73 pounds per cubic foot at an optimum moisture content of 48 percent.
METHOD OF PERFORMING COMPACTION TESTS
(STANDARD AND MODIFIED A.A.S.H.O. METHODS)

It has been established that when compacting effort is held constant, the density of a rolled earth fill increases with added moisture until a maximum dry density is obtained at a moisture content termed the "optimum moisture content," after which the dry density decreases. The compaction curve showing the relationship between density and moisture content for a specific compacting effort is determined by experimental methods. Two commonly used methods are described in the following paragraphs.

For the "standard A.A.S.H.O." (A.S.T.M. D698-58T & A.A.S.H.O. T99-57) method of compaction a portion of the soil sample passing the No. 4 sieve is compacted at a specific moisture content in three equal layers in a standard compaction cylinder having a volume of 1/30 cubic foot, using twenty-five 12-inch blows of a standard 5-1/2 pound rammer to compact each layer.

In the "modified A.A.S.H.O." (A.S.T.M. D-1557-58T & A.A.S.H.O. T 180-57) method of compaction a portion of the soil sample passing the No. 4 sieve is compacted at a specific moisture content in five equal layers in a standard compaction cylinder having a volume of 1/30 cubic foot, using twenty-five 18-inch blows of a 10-pound rammer to compact each layer. Several variations of these compaction testing methods are often used and these are described in A.A.S.H.O. & A.S.T.M. specifications.

For both methods, the wet density of the compacted sample is determined by weighing the known volume of soil; the moisture content, by measuring the loss of weight of a portion of the sample when oven dried; and the dry density, by computing it from the wet density and moisture content. A series of such compactions is performed at increasing moisture contents until a sufficient number of points defining the moisture-density relationship have been obtained to permit the plotting of the compaction curve. The maximum dry density and optimum moisture content for the particular compacting effort are determined from the compaction curve.
A-10

The following plates are attached and complete this appendix:

- **PLATE A-1A** - Log of Borings, Boring 1
- **PLATE A-1B** - Log of Borings, Boring 2
- **PLATE A-1C** - Log of Borings, Boring 3
- **PLATE A-1D** - Log of Borings, Boring 4
- **PLATE A-1E** - Log of Borings, Boring 5
- **PLATE A-1F** - Log of Borings, Boring 6
- **PLATE A-1G** - Log of Borings, Boring 7
- **PLATE A-1H** - Log of Borings, Boring 8
- **PLATE A-1I** - Log of Borings, Boring 9
- **PLATE A-1J** - Log of Borings, Boring 10
- **PLATE A-1K** - Log of Borings, Boring 11
- **PLATE A-1L** - Log of Borings, Boring 12
- **PLATE A-1M** - Log of Borings, Boring 13
- **PLATE A-1N** - Log of Borings, Boring 14
- **PLATE A-1O** - Log of Borings, Boring 15
- **PLATE A-2** - Unified Soil Classification System
- **PLATE A-3** - Consolidation Test Data
LOG OF BORINGS

M - DEPTH AT WHICH UNDISTURBED SAMPLE WAS TAKEN
D - DEPTH AT WHICH DISTURBED SAMPLE WAS TAKEN
O - DEPTH AT WHICH SAMPLE WAS LOST DURING EXTRACTION
P - SAMPLER PUSHED INTO SOIL

DRIVING ENERGY = 140-LB WEIGHT DROPPING 30 IN.
<table>
<thead>
<tr>
<th>Depth in Ft</th>
<th>Symbol</th>
<th>Letter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>40</td>
<td></td>
<td>MH</td>
<td>RED-BROWN CLAYEY SILT, SOME FINE ROOTS TO 9&quot;, FIRM</td>
</tr>
<tr>
<td>29</td>
<td></td>
<td></td>
<td>GRADING TO VERY FIRM</td>
</tr>
<tr>
<td>15</td>
<td></td>
<td></td>
<td>LENS OF YELLOW BROWN SANDY SILT</td>
</tr>
<tr>
<td>18</td>
<td></td>
<td></td>
<td>INCLUSIONS OF DECOMPOSED ROCK FRAGMENTS</td>
</tr>
<tr>
<td>10</td>
<td></td>
<td></td>
<td>MOTTLED TO YELLOW BROWN</td>
</tr>
<tr>
<td>5</td>
<td></td>
<td></td>
<td>BORING COMPLETED 6-23-65</td>
</tr>
</tbody>
</table>

**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
- P - SAMPLER PUSHED INTO SOIL

**Driving Energy:** 140-LB WEIGHT DROPPING 30 IN.
### 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
- P - Sampler pushed into soil

Driving energy = 140-lb weight dropping 30 in.

---

<table>
<thead>
<tr>
<th>Depth in Ft</th>
<th>Symbol</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>10</td>
<td>MH</td>
<td>RED-BROWN TO PURPLE DECOMPOSED ROCK, FRIABLE, FIRM</td>
</tr>
<tr>
<td>15</td>
<td></td>
<td>MOTTLED WITH YELLOWISH BROWN</td>
</tr>
<tr>
<td>30</td>
<td></td>
<td>RED-BROWN CLAYEY SILT, MOD. FIRM</td>
</tr>
</tbody>
</table>

BORING COMPLETED 6-22-65
No WATER ENCOUNTERED
### Log of Borings

**BORING 5  SURFACE ELEV. 530.6'**

<table>
<thead>
<tr>
<th>SAMPLES</th>
<th>Blows/ft on Sampler</th>
<th>Depth in ft</th>
<th>Symbol</th>
<th>Letter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>41</td>
<td>82</td>
<td>20</td>
<td>■</td>
<td>5</td>
<td>MH</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>49</td>
<td>75</td>
<td>30</td>
<td>■</td>
<td>10</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>55</td>
<td>65</td>
<td>20</td>
<td>■</td>
<td>19</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>28</td>
<td>25</td>
<td>19</td>
<td>■</td>
<td>19</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>78</td>
<td>56</td>
<td>16</td>
<td>■</td>
<td>39</td>
<td></td>
</tr>
</tbody>
</table>

**NOTES:**
- ■ - Depth at which undisturbed sample was taken
- □ - Depth at which disturbed sample was taken
- ○ - Depth at which sample was lost during extraction
- P - Sampler pushed into soil

Driving energy = 140-LB weight dropping 30 in.

**Small inclusions of decomposed rock fragments**

Boring completed 7-1-65
No water encountered
<table>
<thead>
<tr>
<th>SYMBOL</th>
<th>LETTER</th>
<th>DESCRIPTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>M</td>
<td>H</td>
<td>BROWN CLAYEY SILT, FIRM</td>
</tr>
</tbody>
</table>

MOTTLED TO RED BROWN
GRADING SOME DECOMPOSED ROCK FRAGMENTS

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
- P - SAMPLER PUSHED INTO SOIL

DRIVING ENERGY = 140-LB WEIGHT DROPPING 30 IN.
BORING 7  SURFACE ELEV. 358.1'

<table>
<thead>
<tr>
<th>SAMPLES</th>
<th>DEPTH IN FT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Blows/ft on Sampler</td>
<td>Depth in ft</td>
</tr>
<tr>
<td>Dry Density in PCF</td>
<td>Symbol</td>
</tr>
<tr>
<td>Moisture Content in %</td>
<td>Letter</td>
</tr>
<tr>
<td>Description</td>
<td></td>
</tr>
</tbody>
</table>

- Red-brown clayey silt, firm

Grading some decomposed rock fragments

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
- P - Sampler pushed into soil
- Driving energy = 140-lb weight dropping 30 in.
BORING 8  SURFACE ELEV. 308.6'

- Samples
  - Blows/Ft on Sampler
  - Dry Density in PCF
  - Moisture Content in %

- Depth in Ft
  - Symbol
  - Letter

- Description

Brown clayey silt, mod. firm
Grading to firm
Mottled to yellow-brown
Grading to mod. firm, some decomposed rock fragments

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
- P - Sampler pushed into soil

Driving Energy = 140-lb weight dropping 30 in.
BORING 9  SURFACE ELEV. 309.2'

<table>
<thead>
<tr>
<th>Samples</th>
<th>Depth in ft</th>
<th>Symbol</th>
<th>Letter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Blows/ft on Sampler</td>
<td>5</td>
<td>MH</td>
<td></td>
<td>Brown clayey silt, firm</td>
</tr>
<tr>
<td>Dry Density in PCF</td>
<td></td>
<td></td>
<td></td>
<td>Grading to very firm</td>
</tr>
<tr>
<td>Moisture Content in %</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Notes:
- ■ - Depth at which undisturbed sample was taken
- ◦ - Depth at which disturbed sample was taken
- □ - Depth at which sample was lost during extraction
- P - Sampler pushed into soil

Driving Energy = 140-lb weight dropping 30 in.
**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
- □ - Sampler pushed into soil
- **Driving energy** = 140-lb weight dropping 30 in.

**Boring 10**

**Surface ELEV.** 379.9'

<table>
<thead>
<tr>
<th>Depth in FT</th>
<th>Symbol</th>
<th>Letter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td></td>
<td>MH</td>
<td>Brown clayey silt, firm</td>
</tr>
<tr>
<td>10</td>
<td></td>
<td></td>
<td>MOTTLED TO LIGHT GRAY, SOME DECOMPOSED ROCK FRAGMENTS, MOD. FIRM</td>
</tr>
<tr>
<td>15</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>20</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>25</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>30</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Samples**

- Blows/FT on Sampler
- Dry Density in PCF
- Moisture content in %
BORING II  SURFACE ELEV. 370.3'

<table>
<thead>
<tr>
<th>SAMPLES</th>
<th>Blow/ft on Sampler</th>
<th>Dry Density in PCF</th>
<th>Moisture Content in %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Depth in Ft</td>
<td>Symbol</td>
<td>Letter</td>
<td>Description</td>
</tr>
<tr>
<td>5</td>
<td></td>
<td></td>
<td>Brown clayey silt, firm</td>
</tr>
<tr>
<td>10</td>
<td></td>
<td></td>
<td>MOTTLED TO YELLOW-BROWN</td>
</tr>
<tr>
<td>15</td>
<td></td>
<td></td>
<td>MH GrADING TO MODERATELY FIRM</td>
</tr>
<tr>
<td>20</td>
<td></td>
<td></td>
<td>Grading to firm</td>
</tr>
<tr>
<td>25</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>30</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

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
- P - Sampler pushed into soil

Driving energy = 140-lb weight dropping 30 in.
BORING 13  SURFACE ELEV. 368.8'

<table>
<thead>
<tr>
<th>Depth in ft</th>
<th>Symbol</th>
<th>Letter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td></td>
<td></td>
<td>BROWN CLAYEY SILT, FIRM</td>
</tr>
<tr>
<td>10</td>
<td></td>
<td></td>
<td>BROWN WEATHERED ROCK (BOULDER?)</td>
</tr>
<tr>
<td>15</td>
<td></td>
<td></td>
<td>BROWN CLAYEY SILT, FIRM</td>
</tr>
<tr>
<td>20</td>
<td></td>
<td></td>
<td>BROWN WEATHERED ROCK (BOULDER?)</td>
</tr>
<tr>
<td>25</td>
<td></td>
<td></td>
<td>BROWN TO RED BROWN CLAYEY SILT WITH SOME DECOMPOSED ROCK FRAGMENTS, FIRM</td>
</tr>
<tr>
<td>30</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

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
P - SAMPLER PUSHED INTO SOIL

DRIVING ENERGY = 140-LB WEIGHT DROPPING 30 IN.
## Log of Boring 14

**Surface Elev. 267.8'**

### Depth in Ft

<table>
<thead>
<tr>
<th>Depth</th>
<th>Symbol</th>
<th>Letter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>MH</td>
<td></td>
<td>Brown Clayey Silt, Mod. Firm</td>
</tr>
<tr>
<td>10</td>
<td></td>
<td></td>
<td>Grading to Firm, Some Decomposed Rock Fragments</td>
</tr>
<tr>
<td>15</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>20</td>
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<td></td>
<td></td>
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<tr>
<td>25</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>30</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Boring Completed 7-1-65**

### Notes:
- **■** - Depth at which undisturbed sample was taken
- **□** - Depth at which disturbed sample was taken
- **☐** - Depth at which sample was lost during extraction
- **P** - Sampler pushed into soil

**Driving Energy = 140-lb weight dropping 30 in.**
BORING 15  SURFACE ELEV. 262.1'  

**Samples**  
Blows/ft on Sampler  
Dry Density in PCF  
Moisture Content in %  

**Depth in Ft**  
Symbol  
Letter  
Description  

- Red-brown clayey silt, firm  
- Grading some decomposed rock fragments  

BORING COMPLETED 7-1-65  

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  
- P - Sampler pushed into soil  

Driving energy = 150-Lb weight dropping 30 in.
### Unified Soil Classification System

#### Major Divisions

<table>
<thead>
<tr>
<th>Major Divisions</th>
<th>Graph Symbol</th>
<th>Letter Symbol</th>
<th>Typical Descriptions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coarse Grained Soils</td>
<td>GW</td>
<td>Well-graded gravel, gravel-sand mixtures, little or no fines</td>
<td></td>
</tr>
<tr>
<td>More than 50% of coarse fraction retained on No. 200 sieve</td>
<td>GP</td>
<td>Poorly-graded gravel, gravel-sand mixtures, little or no fines</td>
<td></td>
</tr>
<tr>
<td>Gravel and gravelly soils</td>
<td>GM</td>
<td>Silty gravel, gravel-sand-silt mixtures</td>
<td></td>
</tr>
<tr>
<td>More than 50% of coarse fraction passing No. 4 sieve</td>
<td>GC</td>
<td>Clayey gravel, gravel-sand-clay mixtures</td>
<td></td>
</tr>
<tr>
<td>Sand and sandy soils</td>
<td>SW</td>
<td>Well-graded sands, gravelly sands, little or no fines</td>
<td></td>
</tr>
<tr>
<td>More than 50% of coarse fraction passing No. 4 sieve</td>
<td>SP</td>
<td>Poorly-graded sands, gravelly sands, little or no fines</td>
<td></td>
</tr>
<tr>
<td>Sands with fines (appreciable amount of fines)</td>
<td>SM</td>
<td>Silty sands, sand-silt mixtures</td>
<td></td>
</tr>
<tr>
<td>Silty and clayey soils</td>
<td>SC</td>
<td>Clayey sands, sand-clay mixtures</td>
<td></td>
</tr>
<tr>
<td>Fine Grained Soils</td>
<td>ML</td>
<td>Inorganic silts and very fine sands, rock flour, silty or clayey fine sands or clayey silt, with slight plasticity</td>
<td></td>
</tr>
<tr>
<td>Silts and clays</td>
<td>CL</td>
<td>Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays</td>
<td></td>
</tr>
<tr>
<td>More than 50% of material is smaller than No. 200 sieve size</td>
<td>OL</td>
<td>Organic silts and organic silt clays of low plasticity</td>
<td></td>
</tr>
<tr>
<td>Silts and clays</td>
<td>MH</td>
<td>Inorganic silts, micaceous or diatomaceous fine sand or silty soils</td>
<td></td>
</tr>
<tr>
<td>Highly Organic Soils</td>
<td>CH</td>
<td>Inorganic clays of high plasticity, fat clays</td>
<td></td>
</tr>
<tr>
<td></td>
<td>OH</td>
<td>Organic clays of medium to high plasticity, organic silts</td>
<td></td>
</tr>
<tr>
<td></td>
<td>PT</td>
<td>Peat, humus, swamp soils with high organic contents</td>
<td></td>
</tr>
</tbody>
</table>

**Note:** Dual symbols are used to indicate borderline soil classifications.
APPENDIX B

SITE GEOLOGY

The site is located in the general area of the former Koolau Volcano caldera. The caldera was probably formed in late Tertiary times by the collapse of the top of the volcano over its vents. Subsequently, the caldera was filled with thick, horizontal basalt flows that were later intruded by basaltic dikes. These dikes were feeder channels for later basalt flows. The site area is underlain by this dike complex which is the fire pit area of the original caldera. This complex is considered to be a member of the Kailua Volcanic Series of rocks.

The caldera was deeply eroded during early and middle Pleistocene times. The fire pit area was left standing as a prominent ridge complex.

Changes in the stand of the sea occurred during middle and late Pleistocene times and the caldera area may have been submerged as much as 1200 feet. A thick range of sediments was deposited at this time by marine and fluvial agents. These sediments lapped up on the fire pit ridges in the area of the site. Here the alluvium appears to be fluvial in origin, composed mainly of silt and clay derived from the decomposition of the basaltic rocks. Often conglomerate lenses are present which consist of gravel to cobble-size fragments of soft and friable decomposed basalt in a matrix of fine-grained material. These deposits dip away from the ridges toward the lowlands.

During late Pleistocene or recent times, stream baselines were lowered and the older alluvial deposits were eroded and dissected by down-cutting streams. In the site area, a fairly well-incised drainage system has been cut into the older alluvium. More recent alluvial deposits have been laid down.
April 18, 1972

Belt, Collins & Associates, Ltd.
745 Fort Street
Suite 514
Honolulu, Hawaii 96813

Attention: Mr. Jerry H. Nunogawa

Gentlemen:

Letter No. 2
Consultation re Site Grading
Proposed College Addition
Hawai‘i Loa College
Kailua, Oahu, Hawaii

In our previous letter dated April 12, 1972, regarding site grading at the proposed college addition, we presented our opinion that the grading shown on your plans would perform satisfactorily. We stated that 1.5 horizontal to 1 vertical cut slopes and 2 horizontal to 1 vertical fill slopes would perform adequately. We did not, however, specifically mention the non-compliance of your plans with the grading ordinance of the City and County of Honolulu, which requires benches in cut slopes greater than 15 feet in height. We wish to express our opinion at this time that the proposed cut slopes, which are a maximum of 20 feet in height, will perform satisfactorily without benches.

We trust this letter clarifies our previous one. If you have any further questions or require additional consultation, please feel free to contact us.

Yours very truly,

DAMES & MOORE

[Signature]

DCL ES mw
(four copies submitted)
Belt, Collins & Associates, Ltd.
745 Fort Street
Suite 514
Honolulu, Hawaii 96813

Attention: Mr. Jerry H. Nunogawa

Gentlemen:

Consultation re Site Grading
Proposed College Addition
Hawaii Loa College
Kailua, Oahu, Hawaii

April 12, 1972

Following our discussion with you on March 30, 1972, we reviewed the drainage and grading plans, Sheets C-4, C-5 and C-15, for the proposed addition to Hawaii Loa College, and we made a site inspection on April 11, 1972. Based on our site inspection and the date from our earlier report*, we believe that the proposed grading shown on your plans would perform satisfactorily.

In general, the soils encountered at the site may safely be cut at 1.5 horizontal:1 vertical slopes as planned. When properly compacted, these same soils will also perform satisfactorily at the planned fill slopes of 2:1. In areas where the fill slopes are constructed on natural slopes steeper than 4:1, we recommend cutting a bench 8 feet wide into the natural slope for every 15 feet of fill height. The bench will help key the fill into the existing slope.

If during the earthwork operations, subsurface soils encountered are dissimilar from those anticipated from our report or any seepage in the slopes is discovered, we would want to reappraise the situation in order to suggest some modification in the grading plans.

*See our report, "Site Investigation, Proposed Hawaii Loa College Campus, Kailua, Hawaii, for Hawaii Loa College", dated July 30, 1965.
We trust this letter is sufficient. If you have any questions or require additional consultation, please feel free to contact us.

Yours very truly,

DAMES & MOORE

David C. Liu

(four copies submitted)
Belt, Lemmon & Le
1402 Kapiolani Boulevard
Honolulu, Hawaii 96814

Attention: Mr. Robert Sarae

Gentlemen:

Benches on Cut Slopes
Hawaii Loa College Campus
Kaneohe, Oahu, Hawaii

This letter is written to confirm our discussions with you regarding the need for benches on cut slopes at the Hawaii Loa College campus in Kaneohe, Oahu, Hawaii. Our previous work at this site was described in our report, "Site Investigation, Proposed Hawaii Loa College Campus, Kailua, Hawaii, for Hawaii Loa College," July 30, 1965.

We reviewed the preliminary grading plan you prepared, which showed benches on the cut slopes near the library buildings. It is our opinion that benches are normally used for slope maintenance and for trapping falling rocks.

We generally would like to see benches every 15 feet in elevation in order to assist in slope maintenance work. However, in view of the existing topography, and the probable better maintenance on a college campus, it is believed that the spacing of benches at 25 feet in elevation, as you indicated on your grading plan, is permissible. Therefore, we are in accord with your plans on this matter.

Very truly yours,

DAMES & MOORE

DCL mw
(three copies submitted)

cc: William L. Pereira & Associates (1)
October 16, 1969

Belt, Collins & Associates Ltd.
1402 Kapiolani Boulevard
Honolulu, Hawaii 96814

Attention: Mr. Masao Nakamura

Gentlemen:

Review of Grading
Proposed Library
Hawaii Loa College
Kaneohe, Oahu, Hawaii

We have reviewed your drawing titled "Library Grading & Drainage Plan, Hawaii Loa College, Kaneohe, Oahu, Hawaii, Sheet C-1.4," dated September 10, 1969. The grading design is generally in conformance to our soils report* for the proposed college and should be satisfactory if performed under adequate field earthwork inspection.

Yours very truly,

DAMES & MOORE

JRS HAS mw
(three copies submitted)

*"Site Investigation, Proposed Hawaii Loa College Campus, Kailua, Hawaii for Hawaii Loa College" dated July 30, 1965.