SOILS INVESTIGATION

PROPOSED UNIT 12, MILILANI TOWN
WAIPIO, EWA, OAHU, HAWAI'I

FOR
MILILANI TOWN, INC.

MUNICIPAL REFERENCE RECORDS CENTER
City & County of Honolulu
City Hall Annex, 655 S. King Street
Honolulu, Hawaii 96813

DAMES & MOORE NO. 4425-020-11
APRIL 12, 1968

MILILANI TOWN, Inc.,
Post Office Box 2780
HONOLULU, HAWAII 96803

ATTENTION: Mr. Eugene Ferguson

GENTLEMEN:

Six copies of our report, "SOILS INVESTIGATION, PROPOSED UNIT 12, MILILANI TOWN, WAIPIO, EWA, OAHU, HAWAII, FOR MILILANI TOWN, INC.," are herewith submitted.

The scope of this investigation was defined in discussions with Mr. Ferguson of your office and is essentially the same as that applied to previous investigations at Mililani Town.

Our investigation indicates that the site is suitable for the proposed construction. No unusual problems in earthwork are anticipated and shallow foundations are recommended for the planned structures.

It has been a pleasure to perform this investigation for you. Should any questions arise concerning the contents of this report, please contact us.

Yours very truly,

DAMES & MOORE

[Signature]

DCL RHW MW
SOILS INVESTIGATION
PROPOSED UNIT 12, MILILANI TOWN
WAIPIO, EWA, OAHU, HAWAII
FOR
MILILANI TOWN, INC.

INTRODUCTION

This report presents the results of a soils investigation performed at Unit 12, Mililani Town for Mililani Town, Inc.

Unit 12 contains 20.1 acres and is part of a 3,000 acre planned development. A preliminary study was conducted for the larger area during September, 1965.* The Map of Area, Plate 1, shows the location of the site with respect to its surroundings and this area is shown in detail on the Plot Plan, Plate 2.

The purpose of this investigation was to explore the subsurface conditions at the site and to provide data and recommendations for foundation design and earthwork operations for the proposed construction. It is understood that the planned earthwork will result in heights of fills and depths of cuts of less than six feet and that the planned slopes will be 2:1. It is further understood that the site is to be used for single unit housing.

SITE CONDITIONS

THE SITE IS LOCATED APPROXIMATELY 3400 FEET EAST AND 3500 FEET NORTH OF THE INTERSECTION OF KAMEHAMEHA HIGHWAY AND WAHOLE DITCH. ELEVATIONS VARY FROM ABOUT 732 FEET TO 703 FEET ABOVE SEA LEVEL AND DRAINAGE IS GENERALLY FROM NORTHEAST TO SOUTHWEST. THE SITE IS NOW BEING USED FOR PINEAPPLE CULTIVATION AND IS DISECTED BY NUMEROUS ACCESS ROADS, WITH THE PRINCIPLE DRAINAGE PATTERN FOLLOWING THESE ROADS.


THE SUBSURFACE CONDITIONS ENCOUNTERED AT UNIT 12 ARE COLLABORATED BY SEVERAL OTHER INVESTIGATIONS IN THE IMMEDIATE VICINITY.

APPENDIX A TO THIS REPORT CONTAINS THE LOG OF BORINGS AND A MORE DETAILED DESCRIPTION OF THE FIELD EXPLORATION OPERATIONS.

DISCUSSIONS AND RECOMMENDATIONS

BUILDING SUPPORT

BASED ON THE RESULTS OF THIS INVESTIGATION IT IS OUR OPINION THAT THE SITE IS SUITABLE FOR THE PLANNED CONSTRUCTION AND THAT ALL STRUCTURES CAN BE SATISFACTORILY SUPPORTED ON SHALLOW FOOTINGS OR SLAB-ON-GRADE TYPE FOUNDATIONS. IT IS RECOMMENDED THAT FOUNDATIONS BE PROPORTIONED ON THE BASIS OF
Maximum allowable bearing pressures of 2,000 and 3,000 pounds per square foot for properly compacted fill and undisturbed soil, respectively. Footings should have a minimum dimension of 12 inches and should be located at least 12 inches below adjacent grades, and a 4-inch thick drainage fill should be placed beneath all on-grade foundations.

The on-site soils display negligible expansion and compression characteristics under the conditions to be imposed by the planned structures. However, the wetting of all exposed surfaces before the placement of foundations is recommended in order to reduce the absorption of moisture by the soil.

Earthwork

Our studies indicate that the material present at the site is suitable for use as compacted fill, but its compaction characteristics may require that considerable control over moisture content be exercised during compaction.

Clearing of the site should be accompanied by removal of all significant organic matter from the surface soils. Stripping or grubbing operations could be used with the depth of removal to be controlled at the site. Due to the variable depth to which significant organic matter was observed, one dimension cannot be applied to the entire site. However, it is felt that six inches may be used for estimate purposes.

Any natural material which is to have fill placed upon it should be scarified to six inches and recompacted prior to the placement of fill. During the recompaction process any soft spots revealed should be repaired by compaction or replacement.

Placement of fill should be in uncompacted lifts not in excess of eight inches and all fill material should be compacted to 90 percent of the maximum dry density as determined by the Modified AASHO compaction procedure.
TEST DESIGNATION T-180-57. The compaction test results for on-site soil are presented in Appendix A. Erosion and the undue addition of moisture to the fill can be reduced if the fill, including slopes, is sealed by rolling when earthwork operations are not in process. No slope stability problems are expected, providing fill slopes are properly compacted; however, recent experience in the units now under construction indicates that the slopes may display considerable erosion, regardless of the fill quality.

Some variation in the strength of material encountered in deep excavations is anticipated and the presence of boulders should be expected in the deeper trenches. Furthermore, minor blasting may be required if concentrations of unweathered rock are exposed.

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THE FOLLOWING PLATES AND APPENDIX ARE ATTACHED AND COMPLETE THIS REPORT:

Plate 1 - Map of Area
Plate 2 - Plot Plan
Appendix A - Field Exploration and Laboratory Testing

- 000 -

Respectfully submitted,
DAMES & MOORE

[Signature]
David C. Liu

[Seal]
DCL RHW MW

THIS WORK WAS PREPARED UNDER MY SUPERVISION.

[Signature]
DAMES & MOORE
MAP OF AREA

SCALE

REFERENCE:
U.S.G.S. MAP, WAIPAHU QUADRANGLE
DATED: 1959
REFERENCE:
MILILANI TOWN, PLAN, SANITARY SEWAGE SYSTEM
PLATE C-5, DATED MAR. 1968, BY C. BOERNER

- BORING LOCATIONS

200  0  200'
FEET
APPENDIX

FIELD EXPLORATION AND LABORATORY TESTING

FIELD EXPLORATION

To investigate the subsurface conditions, five borings were drilled at the site as shown on the Plot Plan, Plate 2. Borings were advanced using auger type drilling methods. All field explorations were conducted under the constant supervision of one of our engineers. The materials encountered were sampled using the equipment shown on Exhibit A-1 and were recorded on the Log of Borings, Plates 1-A1 through 1-AC. Classification of the soils penetrated is in accordance with the Unified Soil Classifications System, described on Plate A-2.

LABORATORY TESTING

Four unconfined compression tests were conducted on selected samples to evaluate the strength properties of the materials found at the site. The procedure used to perform these tests is described on Exhibit A-2. The unconfined compression test results are shown below:

<table>
<thead>
<tr>
<th>Boring</th>
<th>Depth ft.</th>
<th>Peak Compressive Stress lbs./sq. ft.</th>
</tr>
</thead>
<tbody>
<tr>
<td>26</td>
<td>7</td>
<td>19,800</td>
</tr>
<tr>
<td>28</td>
<td>4</td>
<td>8,400</td>
</tr>
<tr>
<td>28</td>
<td>14(\frac{1}{2})</td>
<td>3,000</td>
</tr>
<tr>
<td>29</td>
<td>14(\frac{1}{2})</td>
<td>9,000</td>
</tr>
</tbody>
</table>
The expansive nature of the soils at the site was investigated by conducting two expansion tests on material extracted from the borings. The tests were performed by applying a pressure of 100 pounds per square foot to the sample, saturating the soils and observing the linear volumetric increase which took place. The results of the expansion tests conducted are shown below:

<table>
<thead>
<tr>
<th>Boring</th>
<th>Depth ft.</th>
<th>Expansion %</th>
</tr>
</thead>
<tbody>
<tr>
<td>27</td>
<td>2</td>
<td>.38</td>
</tr>
<tr>
<td>29</td>
<td>11</td>
<td>.15</td>
</tr>
</tbody>
</table>

Three Atterberg limits were performed, the results of which are tabulated below:

<table>
<thead>
<tr>
<th>Boring</th>
<th>Depth ft.</th>
<th>Plastic Limit %</th>
<th>Liquid Limit &amp;</th>
</tr>
</thead>
<tbody>
<tr>
<td>26</td>
<td>7</td>
<td>46</td>
<td>65</td>
</tr>
<tr>
<td>27</td>
<td>2</td>
<td>*</td>
<td>63</td>
</tr>
<tr>
<td>28</td>
<td>9½</td>
<td>*</td>
<td>62</td>
</tr>
</tbody>
</table>

* Test in progress

Numerous moisture and density tests were conducted, results of which are shown on the Log of Borings.

A compaction test was conducted using the Modified AASHO Procedure as described on Exhibit A-4. The results from this test are presented on Plate A-3.
THE FOLLOWING EXHIBITS AND PLATES ARE ATTACHED AND COMPLETE THIS APPENDIX:

EXHIBIT A-1 - SOIL SAMPLER, TYPE D
EXHIBIT A-2 - METHOD OF PERFORMING UNCONFINED COMPRESSION AND TRIAXIAL COMPRESSION TESTS
EXHIBIT A-3 - METHOD OF PERFORMING COMPACTION TESTS
PLATE A-1A - LOG OF BORINGS, BORINGS 26, AND 27
PLATE A-1B - LOG OF BORINGS, BORINGS 28, 29 AND 30
PLATE A-2 - UNIFIED SOIL CLASSIFICATION SYSTEM
PLATE A-3 - COMPACTION TEST DATA
EXHIBIT A-I

SOIL SAMPLER TYPE D

FOR SOILS EASY TO RETAIN IN SAMPLER

DRIVING OR PUSHING MECHANISM

COUPLING

WATER OUTLETS

CHECK VALVE

NEOPRENE SEAT

HEAD

NOTCHES FOR ENGAGING FISHING TOOL

HEAD EXTENSION (OPTIONAL)

SPACE TO RECEIVE DISTURBED SOIL

CORE-RETAINER RINGS

(2 1/2" O.D. BY 1" LONG)

ALTERNATE ATTACHMENTS

BARREL

BARREL COUPLING

SAMPLING TUBE COUPLING

SPLIT FERRULE LOCKING RING

THIN-WALLED SAMPLING TUBE

(6" AND 12" TUBES INTERCHANGEABLE)

NOTE:
SAMPLE IS EXTRUDED INTO CORE RETAINER RINGS IMMEDIATELY UPON COMPLETION OF SAMPLING OPERATION.
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.
EXHIBIT A-3

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.
### Boring 26

**Surface Elevation:** 730 Feet

<table>
<thead>
<tr>
<th>Sample</th>
<th>Blows/Feet</th>
<th>Dry Density in PCF</th>
<th>Moisture Content in %</th>
<th>Type of Core and Percent Recovery</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>33.6</td>
<td>87</td>
<td>69</td>
<td></td>
<td>Red-Brown Silt, Slightly Clayey (Dense)</td>
<td>Grading to brown and very dense</td>
</tr>
<tr>
<td>33.9</td>
<td>92</td>
<td>91</td>
<td></td>
<td></td>
<td>Grading to lighter color and less dense</td>
</tr>
<tr>
<td>35.0</td>
<td>84</td>
<td>47</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Boring Completed at 15' on 3/21/68
No water encountered*

### Boring 27

**Surface Elevation:** 720 Feet

<table>
<thead>
<tr>
<th>Sample</th>
<th>Blows/Feet</th>
<th>Dry Density in PCF</th>
<th>Moisture Content in %</th>
<th>Type of Core and Percent Recovery</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>32.2</td>
<td>50</td>
<td></td>
<td></td>
<td>Red-Brown Silt, Slightly Clayey (Dense)</td>
<td>Grading to lighter color and very dense</td>
</tr>
<tr>
<td>35.4</td>
<td>85</td>
<td>15</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Boring Completed at 15' on 3/21/68
No water encountered*

**Notes:**
- **M** = Depth at which undisturbed sample was taken.
- **H** = Depth at which disturbed sample was taken.
- **L** = Depth at which sample was lost.
- **D** = Depth and length of coring run.
- **E** = Driving energy - 140 -lb weight dropping 30 inches.
- **P** = Sampler pushed into the soil.
BORING 28  
SURFACE ELEVATION 730 FEET

<table>
<thead>
<tr>
<th>Blows/Ft on Sampler</th>
<th>Dry Density in PCF</th>
</tr>
</thead>
<tbody>
<tr>
<td>37.4 82 44</td>
<td></td>
</tr>
<tr>
<td>39.2 84 83</td>
<td></td>
</tr>
<tr>
<td>32.1 92 43</td>
<td></td>
</tr>
</tbody>
</table>

Moisture Content in %

- 5
- 10
- 15

Type of Core and Percent Recovery

- Red-Brown Silt, Slightly Clayey (Dense)
- Grading to lighter color and very dense

Boring Completed at 15' on 3/21/68
No water encountered

BORING 29  
SURFACE ELEVATION 731 FEET

<table>
<thead>
<tr>
<th>Blows/Ft on Sampler</th>
<th>Depth in Feet</th>
</tr>
</thead>
<tbody>
<tr>
<td>29.7 92 60</td>
<td>5</td>
</tr>
<tr>
<td>30.4 85 58</td>
<td>10</td>
</tr>
</tbody>
</table>

Moisture Content in %

- 5
- 10
- 15

Type of Core and Percent Recovery

- Red-Brown Silt, Slightly Clayey (Dense)
- Grading to lighter color
- Some rock structure at 11'

Boring Completed at 15' on 3/21/68
No water encountered

BORING 30  
SURFACE ELEVATION 712 FEET

<table>
<thead>
<tr>
<th>Blows/Ft on Sampler</th>
<th>Depth in Feet</th>
</tr>
</thead>
<tbody>
<tr>
<td>37.4 80 57</td>
<td>5</td>
</tr>
<tr>
<td>34.7 88 10</td>
<td></td>
</tr>
</tbody>
</table>

Moisture Content in %

- 5
- 10

Type of Core and Percent Recovery

- Red-Brown Silt, Slightly Clayey (Dense)
- Grading to very dense
- Grading to brown

Boring Completed at 110' on 3/21/68
No water encountered

- Depth at which undisturbed sample was taken.
- Depth at which disturbed sample was taken.
- Depth at which sample was lost.
- Depth and length of coring run.
- Driving energy - 150 lb weight dropping 30 inches.
- Sampler pushed into the soil.
MAJOR DIVISIONS | GRAPH SYMBOL | LETTER SYMBOL | TYPICAL DESCRIPTIONS
--- | --- | --- | ---
COARSE GRAINED SOILS

Gravel and Gravelly Soils

More than 50% of coarse fraction retained on No. 4 Sieve

Gravel and 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

GM

Silts gravels, gravel-sand-silt mixtures

GC

Clayey gravels, gravel-sand-clay mixtures

SW

Well-graded sands, gravelly sands, little or no fines

SP

Poorly-graded sands, gravelly sands, little or no fines

SM

Silty sands, sand-silt mixtures

SC

Clayey sands, sand-clay mixtures

FINE GRAINED SOILS

Silt and Clays

Liquid limit less than 50

ML

Inorganic silts and very fine sands, rock flour, silty or clayey fine sands or clays, 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

MH

Inorganic silts, micaceous or diatomaceous fine sand or silty soils

CH

Inorganic clays of high plasticity, fat clays

OH

Organic clays of medium to high plasticity, organic silts

PT

Peat, humus, swamp soils with high organic contents

HIGHER ORGANIC SOILS

NOTE: DUAL SYMBOLS ARE USED TO INDICATE BORDERLINE SOIL CLASSIFICATIONS.

SOIL CLASSIFICATION CHART

UNIFIED SOIL CLASSIFICATION SYSTEM

DAMES & MOORE
Moisture Content (%)

S.G. = 2.8

Zero Air Voids

Optimum Moisture = 26.5%
Maximum Dry Density = 97.5 lbs/cu ft

Compaction Test Data

Performed in Accordance with the Modified AASHO Test Procedure
Designation T 180-57
DATE: June 26, 1969

TO: Mr. Hung Joong Young
Chief, Division of Engineering
Department of Public Works
City and County of Honolulu
Honolulu, Hawaii 96813

ATTENTION: Mr. William Tokushige

SUBJECT: Millilani Town, Soils Reports

WE ARE TRANSMITTING: THE FOLLOWING:

X Herewith
Under Separate Cover

REMARK:

One (1) copy each of the soils report for Units 6, 7, 10 & 12.