Waiau Gardens Kai

# SOIL AND FOUNDATION INVESTIGATION
# LOWER WAIAU APARTMENTS
# WAIAU, OAHU, HAWAII

HML&A Job No. 3904,004.06

Prepared for

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700 Bishop Street, Suite 1112
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by

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October 22, 1971

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# LIST OF ILLUSTRATIONS

# I INTRODUCTION

This report presents the results of the soil and foundation investigation we performed for the Lower Waiau Apartments, Waiau, Oahu, Hawaii.

The development, shown on the Site Plan, Plate 1, is an 80-acre parcel, located north of Interstate Highway H-1, and southeast of Waiau Ridge Estates, Unit 1A. We understand the site will be developed for multiple-family, two-story apartment buildings. Roads, parking areas, and recreation facilities are also planned.

The site is characterized by low, rolling hills of volcanic origin. Grading plans have not yet been developed; however, we anticipate that grading will be limited to cut and fill slopes less than about 25 feet high.

The scope of our investigation was described in our proposal dated April 6, 1971. The object of our work was to explore subsurface conditions at the site and to develop conclusions and recommendations covering

1. Site preparation and grading, including
   a. Excavation difficulties, if any
   b. Proper placement of fill material and required degree of compaction
   c. Maximum slopes and slope-heights
2. Subsurface drainage
3. Building foundation support, including
   a. Recommended foundation types
   b. Soil criteria necessary for foundation design

4. Settlement behavior of fills and foundations

5. Roadway and parking area pavement designs

Federal Housing Authority financing is planned for the project and our report reflects their requirements.

# II SUMMARY

1. The site is blanketed by a layer of stiff to very stiff clayey silt underlain by basalt bedrock at shallow depths (5 to more than 20 feet below the existing surface). The silt surface soil exhibits high strength, low compressibility, and low expansion potential.

2. The silt surface soil can be excavated with conventional equipment; however, numerous large, basalt boulders in the silt will be difficult to remove and transport. Excavations which extend more than about five feet into the bedrock will require ripping and perhaps localized blasting. For this reason, depths of excavation should be minimized, if possible.

3. Cut and fill slopes should be not steeper than two horizontal to one vertical (2:1). Slopes greater than 15 feet in vertical height should be provided with an intermediate bench eight feet wide. Slopes should be planted and protected from surface runoff to retard erosion.

4. Low-rise buildings can be supported on shallow spread foundations. Settlement of fills and foundations should be small (less than one inch); post construction settlement should be negligible.

5. Flexible pavements have been designed using the State of California Method 301-F. Recommended pavement thicknesses, assuming the clayey silt is the subgrade material, are presented in the table on page 10.

## III FIELD EXPLORATION AND LABORATORY TESTS

We explored subsurface conditions at the site by drilling 25 test borings, 13 to 30 feet deep. The field work was performed between August 31, and September 9, 1971. The borings were drilled with truck-mounted flight auger equipment and were logged by our engineer, who obtained core samples from them for laboratory tests. The logs of the borings are presented on Plates 2 through 26. The soils have been classified in accordance with the Unified Soil Classification System presented on Plate 27.

The soils were re-examined in our laboratory to verify the field classifications and selected samples were tested to determine certain physical characteristics. The following table indicates the laboratory tests which were run, and the plate numbers where test data are presented. An explanation of the various test methods is included in Appendix A.

| Laboratory Tests | Test Data Presented On |
|---|---|
| Moisture Content/Dry Density | Boring Logs |
| Shear Strength (TX-UU) | Boring Logs |
| Shrink-Swell | Plate 28 |
| Consolidation | Plate 29 |
| Atterberg Limits | Plate 30, Boring Logs |
| Compaction (moisture content versus maximum dry density) | Plate 31 |
| Resistance Value | Plate 32 |

NOTE: The manner in which test data is presented on the boring logs is indicated on the Key to Test Data, Plate 27.

## IV SITE AND SOIL CONDITIONS

The site is characterized by low rolling hills of volcanic origin. Most of the site is currently covered with second-growth sugar cane. Concrete-lined ditches used to irrigate the cane still remain. Haul roads and contractor's temporary storage yards have been constructed at the site.

The borings indicate that the site is blanketed by red, clayey silt ranging in depth from 5 to more than 20 feet. The silt is strong, has a low compressibility, and a low shrink-swell potential. The test borings encountered numerous large basalt boulders in the silt; during the grading for adjacent projects, boulders more than five feet in maximum dimension have been common.

Basalt bedrock in various stages of weathering was encountered below the red silt. The rock is generally porous, but varies in hardness and strength.

Free water was not encountered in the borings.

# V CONCLUSIONS AND RECOMMENDATIONS

## A. Site Preparation and Grading

### 1. Stripping and Recompaction

Areas to be graded should be stripped of vegetation and organic debris. The second-growth cane should be cleared and the top three or four inches of soil containing roots and organic matter should be stripped and removed. Deeper stripping (say up to 18 inches) may be required in localized areas to remove pockets of loose or soft soils.

After stripping, the upper soils which are dry and cracked should be scarified, moisture conditioned to a moisture content suitable for compaction, and compacted to 90 percent relative compaction (ASTM D1557-70(C) test method). We estimate the required depth of scarification to be about eight inches.

### 2. Excavation

The red silt should be excavatable with conventional grading equipment (bulldozers, scrapers, etc.); however, the large basalt boulders in the silt may be costly to remove and haul away. Excavations which extend into the basalt bedrock will require light to heavy ripping. Cuts which extend more than about five feet into the bedrock may encounter heavy ripping and/or localized blasting.

Excavated material, with the exception of rocks and boulders greater than six inches in maximum dimension, will be suitable for reuse as fill. Rocks or boulders larger than six inches

and less than two feet in maximum dimension can be used below a depth of four feet from finished grade or below the maximum utility trench depth, whichever is greater (FHA approval will be required in order to use material larger than six inches in maximum dimension).

3. Fill Placement and Compaction

Fill material should be placed in thin lifts, moisture conditioned to a moisture content suitable for compaction, and compacted to 90 percent relative compaction. If boulders are used in the fill they should be placed in rows so that fill can be compacted on all sides of them. Boulders should not be piled or allowed to nest so that voids are created which can not be filled with compacted material.

Fills placed on slopes greater than five horizontal to one vertical should be started on a level bench cut into natural ground. Subsequent fill lifts should also be benched into natural material.

We expect that little shrinkage will take place during fill placement since the expected compacted densities of the fill material are generally the same as the in-place densities of the natural soil. When determining cut and fill quantities, material lost due to site-stripping should be considered.

4. Slopes

Cut and fill slopes should be no steeper than two horizontal to one vertical. Where cut and fill slopes exceed a vertical height of 15 feet, they should be provided with an eight-foot

bench at mid-height. To retard erosion, cut and fill slopes should be planted as soon as possible after construction. Surface water should be diverted away from slope faces by interceptor ditches or other means.

5. Specifications

Recommended specifications covering site preparation and grading are included in Appendix B.

B. Subsurface Drainage

Since the site is underlain by porous rock at relatively shallow depths, an extensive subdrainage system beneath fills will not be required. Subdrains may be necessary in localized areas, depending upon the actual grading scheme. When a grading plan has been developed, we should review it in order to determine where subdrains should be placed, if required.

C. Foundation Support

Spread foundations for low-rise, residential structures can be designed using the following criteria:

| | |
|---|---|
| Bearing Pressures | |
| Dead loads | 2000 psf |
| Total design loads, including wind and seismic forces | 3500 psf |
| Resistance to Lateral Loads | |
| Friction on the bottom of footings (times vertical dead load) | 0.3 |
| Passive soil resistance (due to stiff natural soil or properly compacted fill on base of footing) | 1000 psf* |

*Where footings are not confined on all sides by slabs or pavements, passive resistance in the top foot should be neglected.

Footings should be at least 12 inches wide and should be bottomed at least 12 inches below lowest adjacent grade.

D. Slab-on-Grade Floors

Slab floor subgrades should be rolled to provide a firm, non-yielding surface. Slab floors should be underlain by at least four inches of free-draining, crushed rock, to provide a capillary moisture break. The rock should conform to the following gradation:

| Sieve Size | Percent Passing |
|---|---|
| 3/4-inch | 100 |
| No. 4 | 0 - 10 |
| No. 200 | 0 - 3 |

Where penetration of moisture vapor through the slab would be detrimental, an impervious membrane should be placed between the rock and the slab.

E. Flexible Pavement Design

We have designed pavement sections for three traffic conditions:

a. Automobile parking areas not subjected to truck traffic

b. Access roads and cul-de-sacs subjected to some truck traffic

c. Collector streets subjected to appreciable car and truck traffic

Pavement sections for these areas were designed according to the State of California method. We assumed traffic indices for the three conditions of 3.5, 4.5 and 7.0, respectively. A minimum subgrade R-value of 14 was used for design; this value

is based on a resistance value (stabilometer) test run in our laboratory on a representative sample of surface soil from the site. The quality of subgrade soil should be checked after grading has been completed in the roadway areas.

Design pavement sections for the three traffic conditions are given in the following table:

| Pavement Area | Design Traffic Index | Asphalt Concrete Surface (ins.) | Aggregate Base (ins.) | Aggregate Subbase (ins.) |
|---|---|---|---|---|
| a. Automobile Parking Areas | | | | |
| Alternative 1 | 3.5 | 1-1/2 | 7-1/2 | --- |
| Alternative 2 | 3.5 | 1-1/2 | 4 | 4 |
| b. Access Roads and Cul-de-sacs | 4.5 | 2 | 6 | 6 |
| c. Collector Roads | 7.0 | 3 | 6 | 10 |

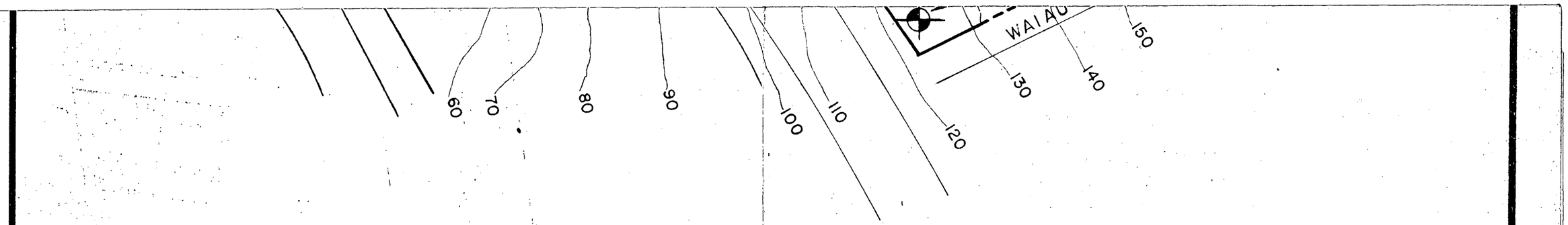
Before pavement components are placed, the subgrade surface should be scarified to a depth of six inches, moisture conditioned to a moisture content slightly above optimum, and compacted with smooth-wheeled rollers to provide a dense, nonyielding surface, compacted to at least 95 percent relative compaction.

Aggregate base and subbase courses should also be placed in thin lifts, moisture conditioned to a moisture content suitable for compaction and compacted to at least 95 percent relative compaction. Aggregate base and subbase should conform to the requirements in the "Standard Specifications for Public Works Construction", November, 1968, Department of Public Works, City and County of Honolulu.

## VI REVIEW OF PLANS AND CONSTRUCTION INSPECTION

We suggest that we review the plans and specifications for compliance with the intent of our recommendations. We recommend that the site preparation, placement and compaction of fill, and foundation installation be performed under our soil engineering inspection. This inspection would permit us to detect unanticipated field conditions that could require special treatment or modification of our recommendations.

# VII ILLUSTRATIONS




Reference : "Preliminary Subdivison Plans", by Community Planning, Inc., No Date.

200' 0' 200' 400'

GRAPHIC SCALE

Job No 3904.00406
Designed D.L.S
Drawn E.J.H
Checked
Approved
Date 10-21-71
Scale 1" = 4000'

**HARDING, MILLER, LAWSON & ASSOCIATES**

*Consulting Engineers*

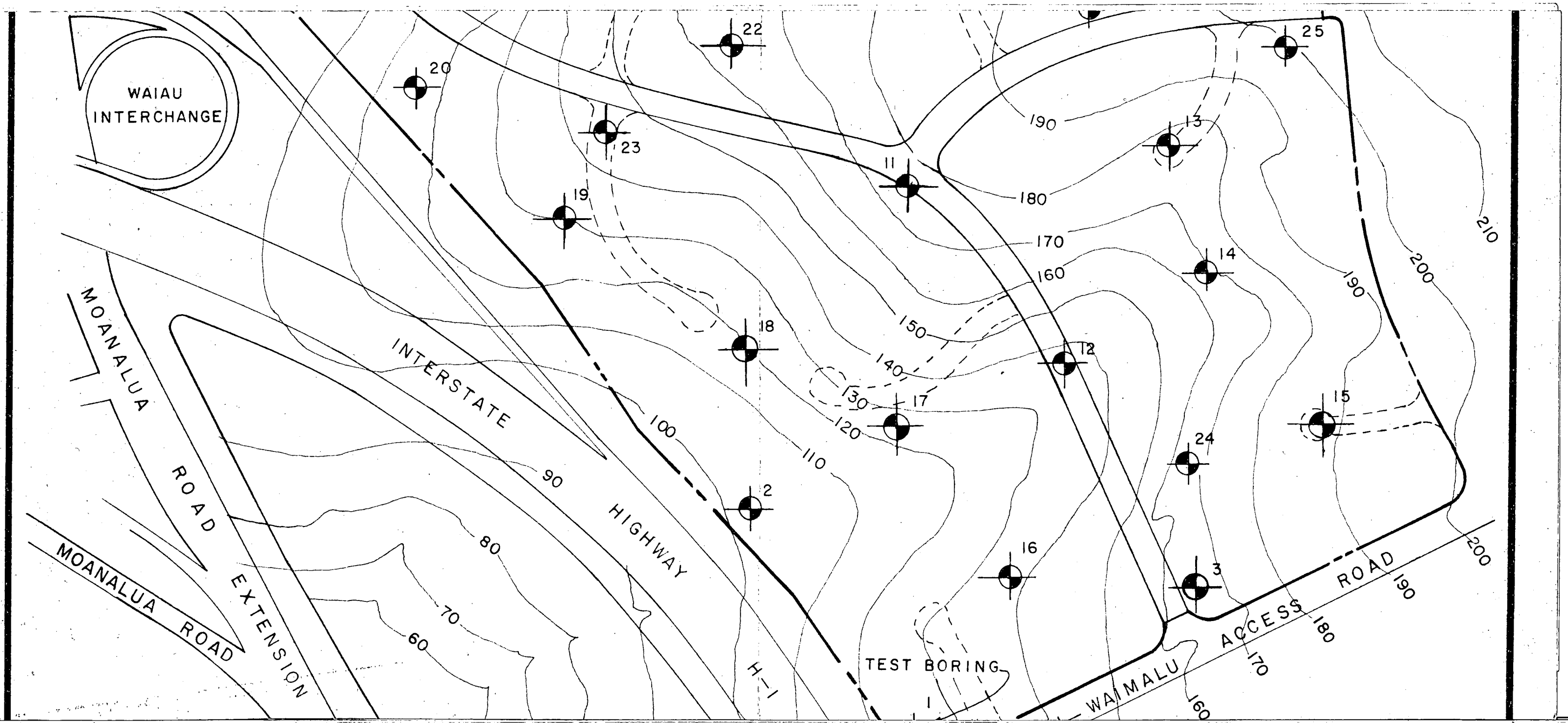
# SITE PLAN

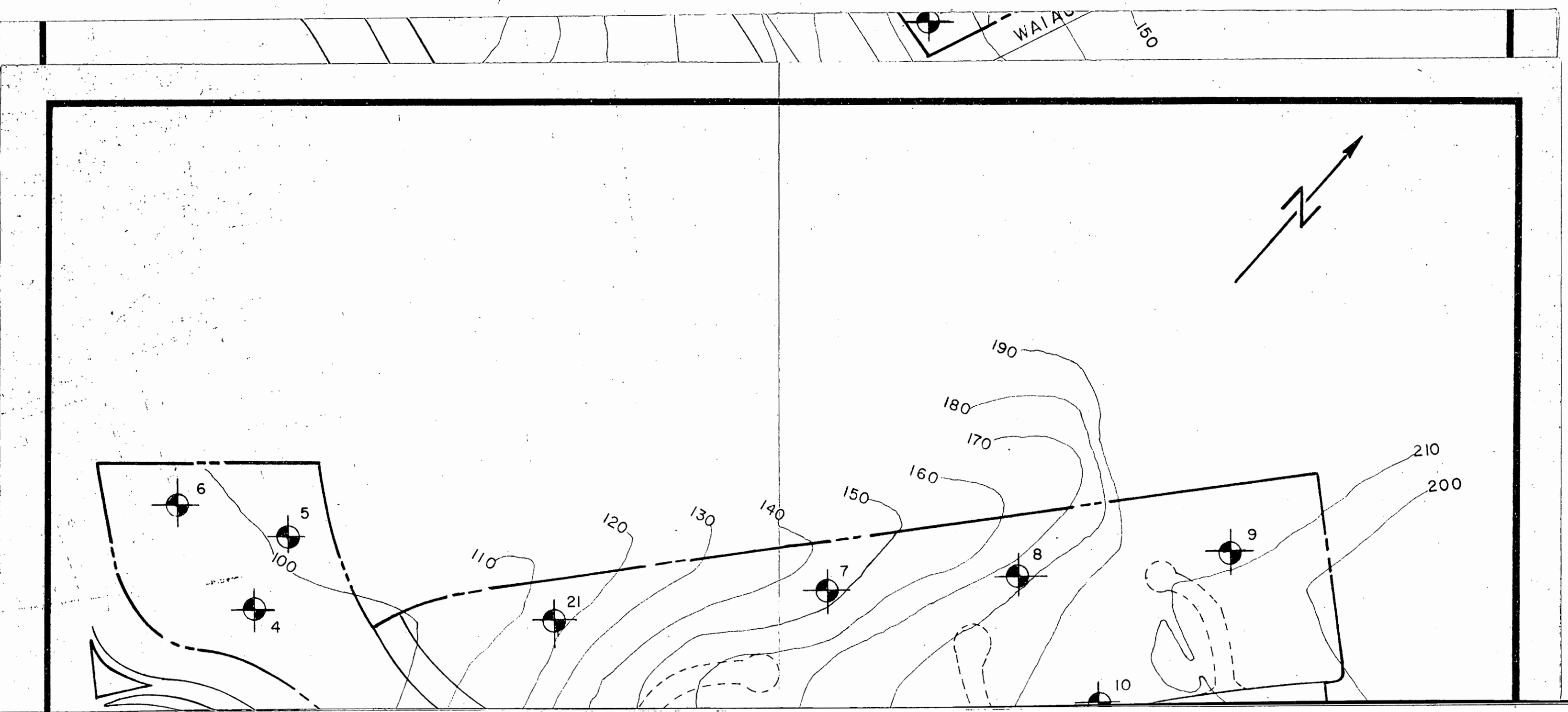
## LOWER WAIAU APARTMENTS

WAIAU OAHU, HAWAII

PLATE

**1**

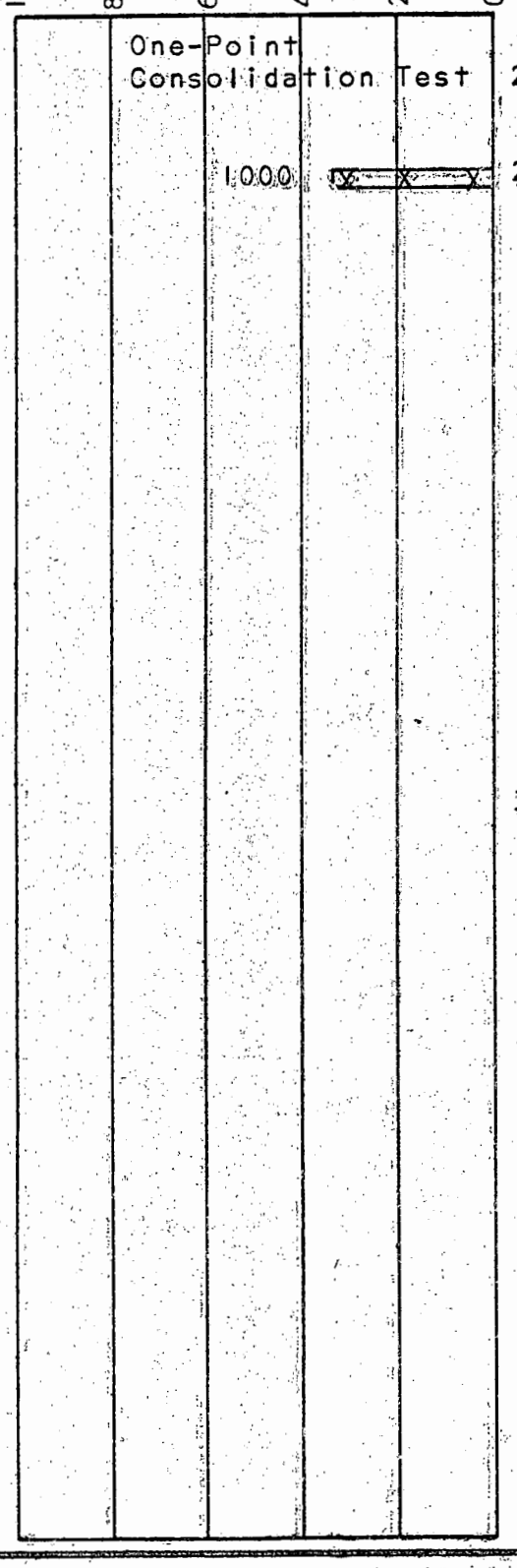

WAIAU
INTERCHANGE
MOANALUA ROAD
MOANALUA ROAD EXTENSION
INTERSTATE HIGHWAY H-1
WAIMALU ACCESS ROAD
TEST BORING
1
2
3
11
12
13
14
15
16
17
18
19
20
22
23
24
25
60
70
80
90
100
110
120
130
140
150
160
170
180
190
200
210


WAIA
150
190
180
170
160
150
140
130
120
110
100
210
200
6
5
4
21
7
8
9
10

# LOG OF BORING 1

Equipment 4" Flight Auger

Elevation 125 Date 8/31/71




| Moisture Content (%) | Dry Density (pcf) | Depth (ft) | Sample | |
|---|---|---|---|---|
| 22.0 | 90 | 0 | | RED CLAYEY SILT (ML) stiff, dry |
| 25.2 | 99 | 5 | | |
| | | 9 | | moist at 9' |
| | | 10 | | |
| | | 13 | | MOTTLED GRAY AND RED BASALT moderate hardness, weak, moderately weathered, slightly porous |
| | | 15 | | |
| | | 19 | | highly weathered, soft between 19' and 20' |
| 38.7 | 79 | 20 | | |
| | | 25 | | |
| | | 30 | | (no free water encountered) |
| | | 35 | | |
| | | 40 | | |

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*Consulting Engineers*

Job No: 3904.4 Appr: ns /gs Date 9/21/71

LOG OF BORING 1
Lower Waiau Apartments
Waiau, Oahu, Hawaii

PLATE 2

# LOG OF BORING 2

Equipment 4" Flight Auger

Elevation 102 Date 8/31/71

| Shear Strength (lbs/sq ft) | Moisture Content (%) | Dry Density (pcf) | Depth (ft) | Sample | |
|---|---|---|---|---|---|
| | | | 0 | | RED CLAYEY SILT (ML) very stiff, dry |
| Shrink-Swell Test<br>Liquid Limit = 42<br>Plastic Limit = 29<br>Plasticity Index = 12 | 23.9 | 89 | | | moist at 4' |
| | | | 5 | | |
| | | | 10 | | |
| Consolidation Test<br>Liquid Limit = 36<br>Plastic Limit = 28<br>Plasticity Index = 8 | 29.6 | 96 | | | |
| | | | 15 | | |
| | | | 20 | | (no free water encountered) |
| | | | 25 | | |
| | | | 30 | | |
| | | | 35 | | |
| | | | 40 | | |

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LOG OF BORING 2

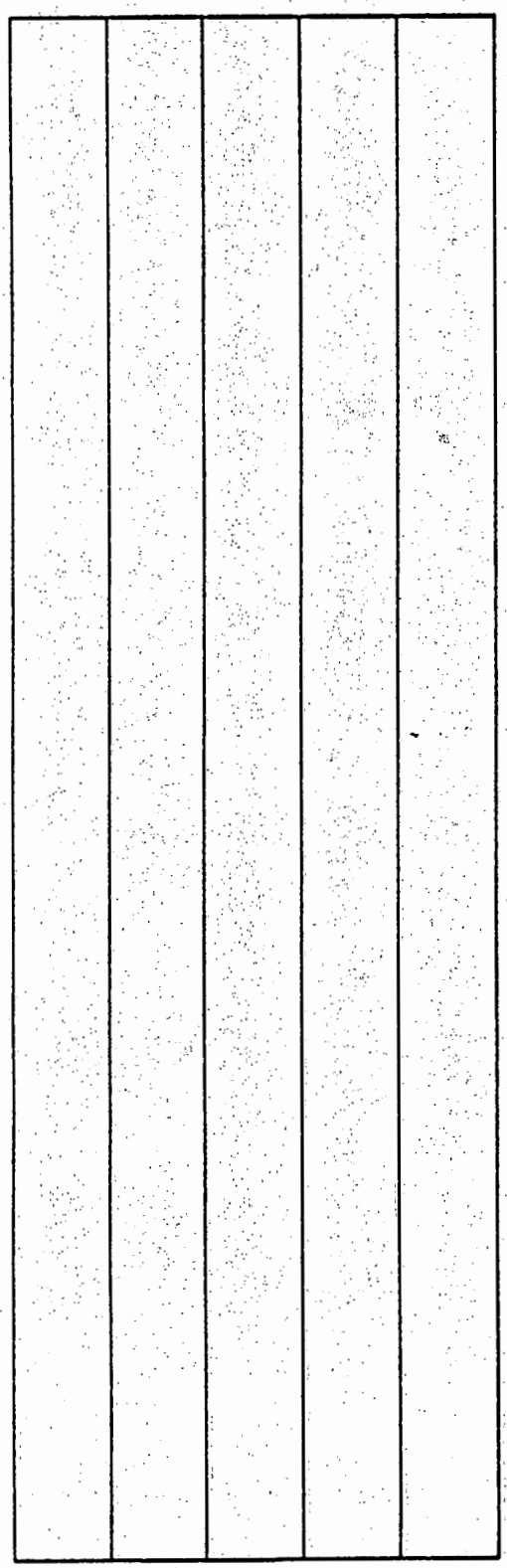
Lower Waiau Apartments
Waiau, Oahu, Hawaii

PLATE 3

# LOG OF BORING 3

Equipment 4" Flight Auger

Elevation 165 Date 8/31/71



| Depth (ft) | Sample | Moisture Content (%) | Dry Density (pcf) | Shear Strength (lbs/sq ft) |
|---|---|---|---|---|
| 0 | | | | |
| 5 | | 23.9 | 100 | |
| 10 | | | | |
| 15 | | | | |
| 20 | | | | |
| 25 | | | | |
| 30 | | | | |
| 35 | | | | |
| 40 | | | | |

RED CLAYEY SILT (ML)
very stiff, dry

moist at 10'

MOTTLED ORANGE AND GRAY GRAVELLY SANDY SILT (ML)
stiff, moist
very deeply weathered basalt

(no free water encountered)

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LOG OF BORING 3

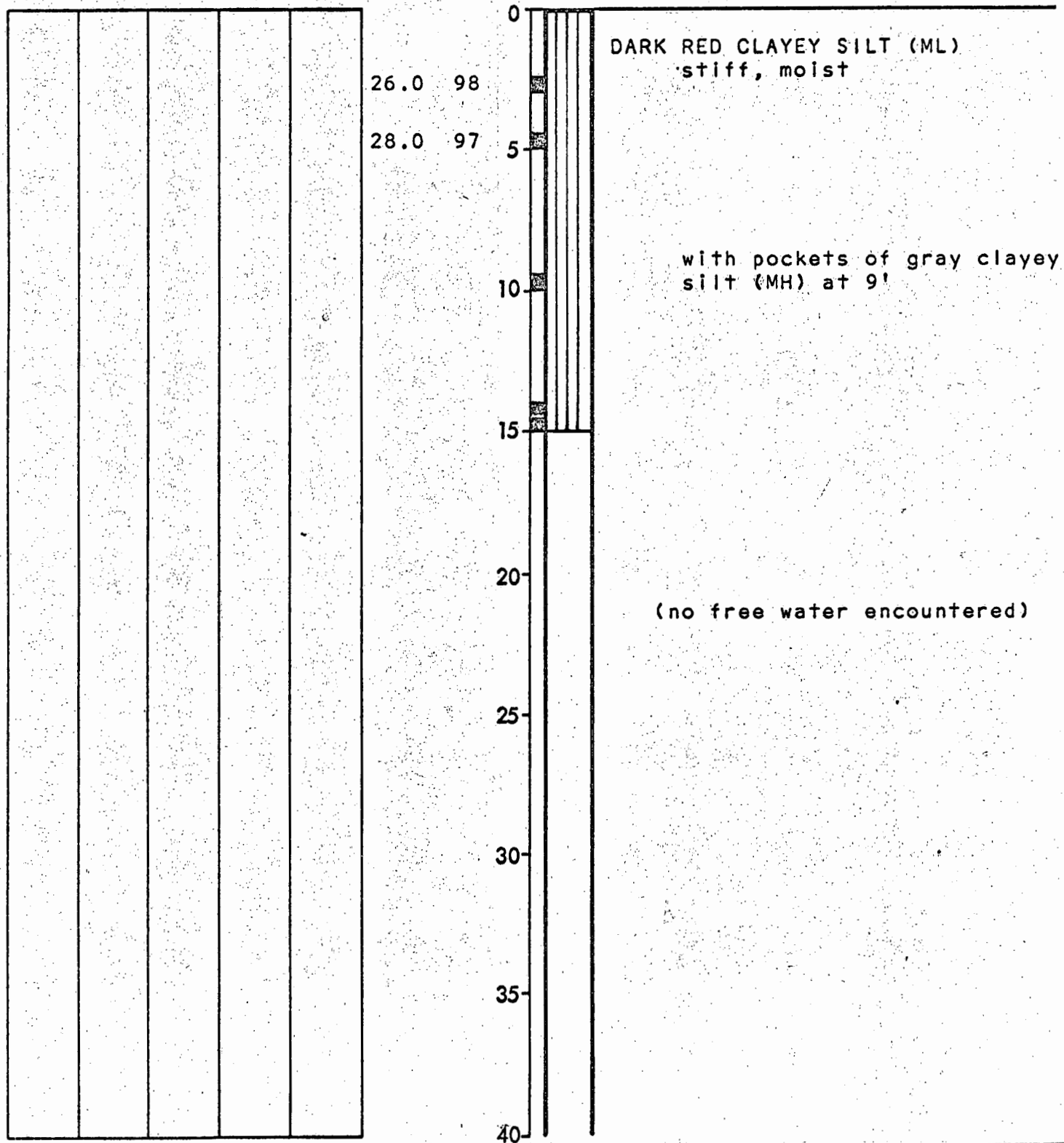
Lower Waiau Apartments
Waiau, Oahu, Hawaii

PLATE 4

# LOG OF BORING 4

Equipment 4" Flight Auger

Elevation 95 Date 9/1/71

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LOG OF BORING 4

Lower Waiau Apartments

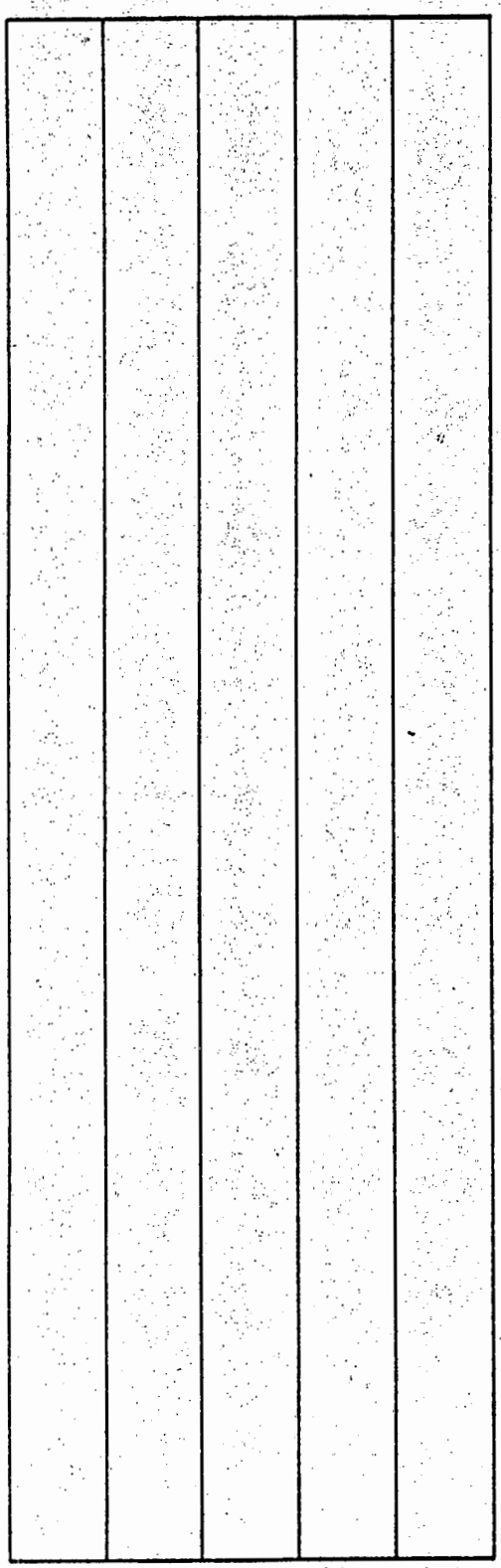
Waiau, Oahu, Hawaii

PLATE 5

# LOG OF BORING 5

Equipment 4" Flight Auger

Elevation 103 Date 9/1/71



| Depth (ft) | Sample | Moisture Content (%) | Dry Density (pcf) | Shear Strength (lbs/sq ft) |
|---|---|---|---|---|
| 0 | | | | |
| | | 25.2 | 100 | |
| 5 | | | | |
| 10 | | | | |
| | | 38.3 | 72 | |
| 15 | | | | |
| 20 | | | | |
| 25 | | | | |
| 30 | | | | |
| 35 | | | | |
| 40 | | | | |

RED CLAYEY SILT (ML)
stiff, dry
GRAY BASALT BOULDER

RED CLAYEY SILT (ML)
very stiff, moist

MOTTLED GRAY AND RED CLAYEY SILT (ML)
medium stiff, moist
with abundant basalt boulders
GRAY AND ORANGE BASALT
moderately hard, weak, moderately weathered, porous

(no free water encountered)

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LOG OF BORING 5

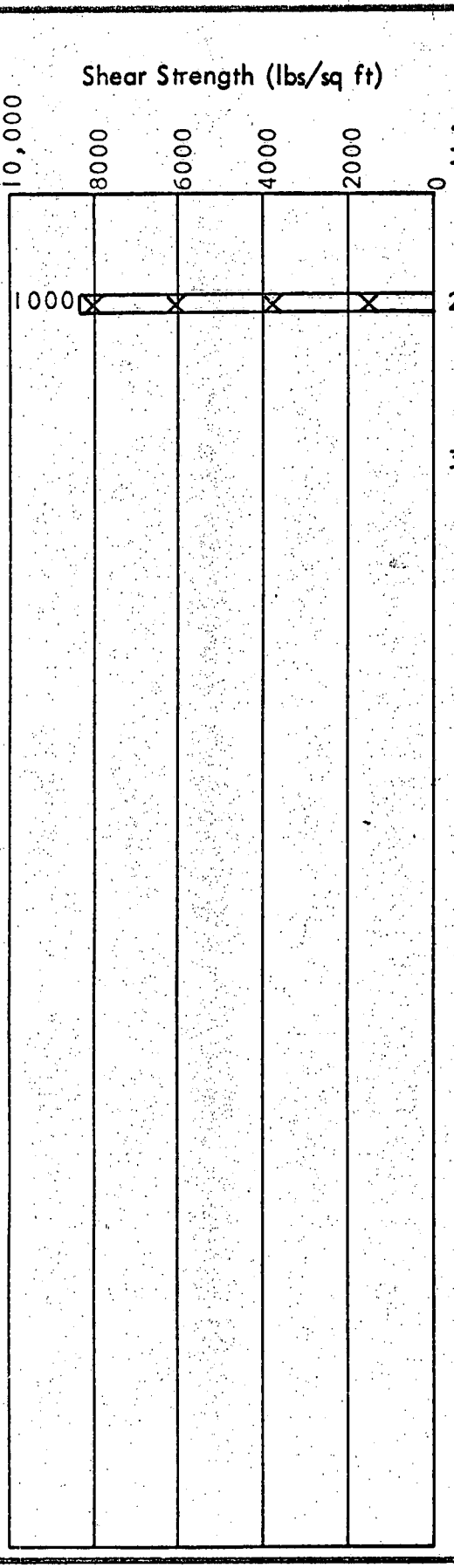
Lower Waiau Apartments
Waiau, Oahu, Hawaii

PLATE 6

# LOG OF BORING 6

Equipment 4" Flight Auger

Elevation 90 Date 9/1/71




| Depth (ft) | Sample | Moisture Content (%) | Dry Density (pcf) | |
|---|---|---|---|---|
| 0 | | | | RED-BROWN CLAYEY SILT (ML) stiff, dry |
| 3.5 | | 24.2 | 100 | moist at 3.5' |
| 5 | | | | |
| 8 | | 31.2 | 89 | |
| 10 | | | | MOTTLED ORANGE AND BROWN SILT (ML) stiff, moist |
| 13 | | | | RED CLAYEY SILT (ML) stiff, moist |
| 15 | | | | |
| 20 | | | | (no free water encountered) |
| 25 | | | | |
| 30 | | | | |
| 35 | | | | |
| 40 | | | | |

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LOG OF BORING 6

Lower Waiau Apartments

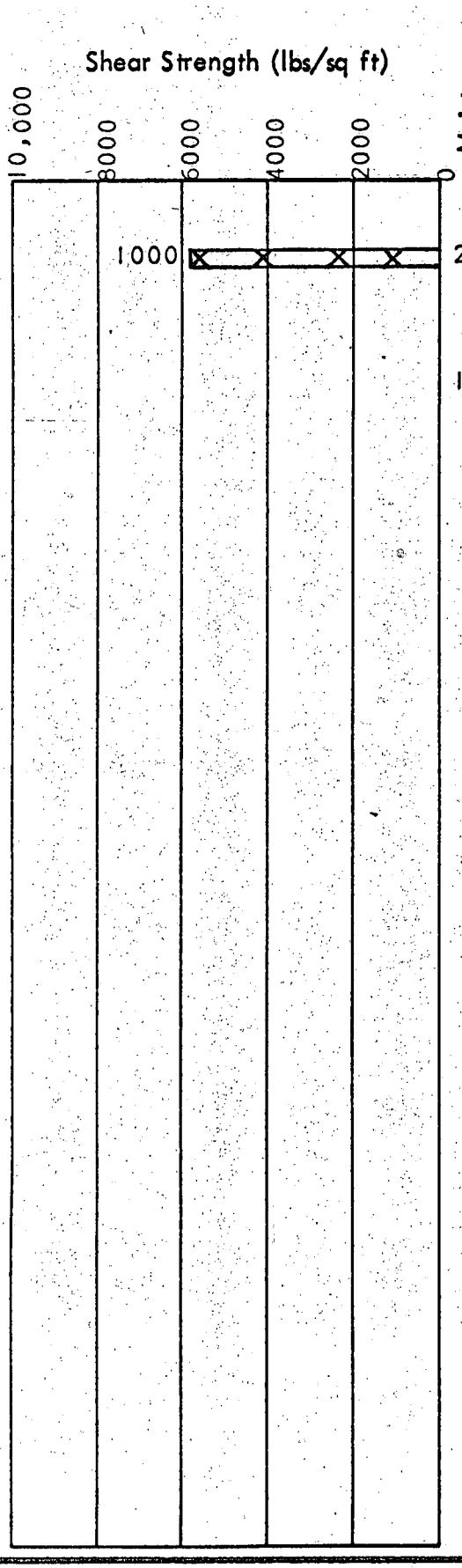
Waiau, Oahu, Hawaii

PLATE 7

# LOG OF BORING 7

Equipment 4" Flight Auger

Elevation 147 Date 9/1/71




| Depth (ft) | Moisture Content (%) | Dry Density (pcf) |
|---|---|---|
| 2.5 | 24.8 | 96 |
| 5 | 18.0 | 105 |

RED CLAYEY SILT (ML)
very stiff, dry
moist at 2.5'

BASALT BOULDER

BROWN AND GRAY SILT (ML).
stiff, moist
with rock fragments

RED SILT (ML)
stiff, moist

BASALT BOULDER

(no free water encountered)

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LOG OF BORING 7

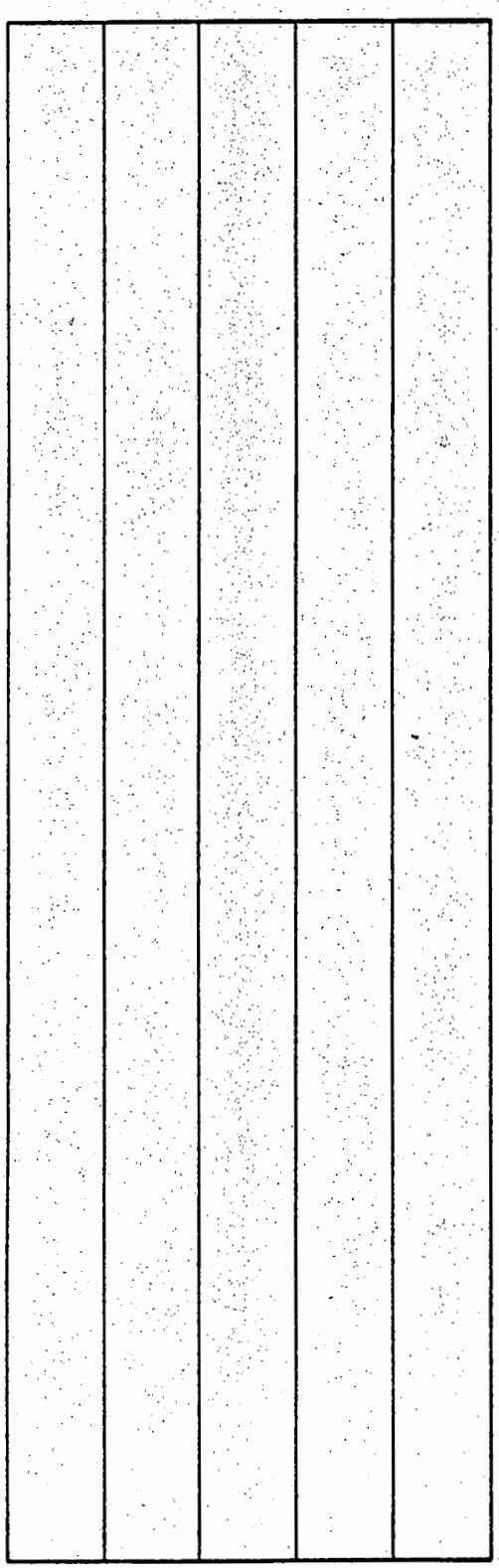
Lower Waiau Apartments
Waiau, Oahu, Hawaii

PLATE 8

# LOG OF BORING 8

Equipment 4" Flight Auger

Elevation 175 Date 9/1/71




RED CLAYEY SILT (ML)
very stiff, dry
moist at 2'

BROWN SILT (ML)
stiff, moist

ORANGE AND GRAY BASALT
low hardness, friable, weak
deeply weathered
with silt layers

(no free water encountered)

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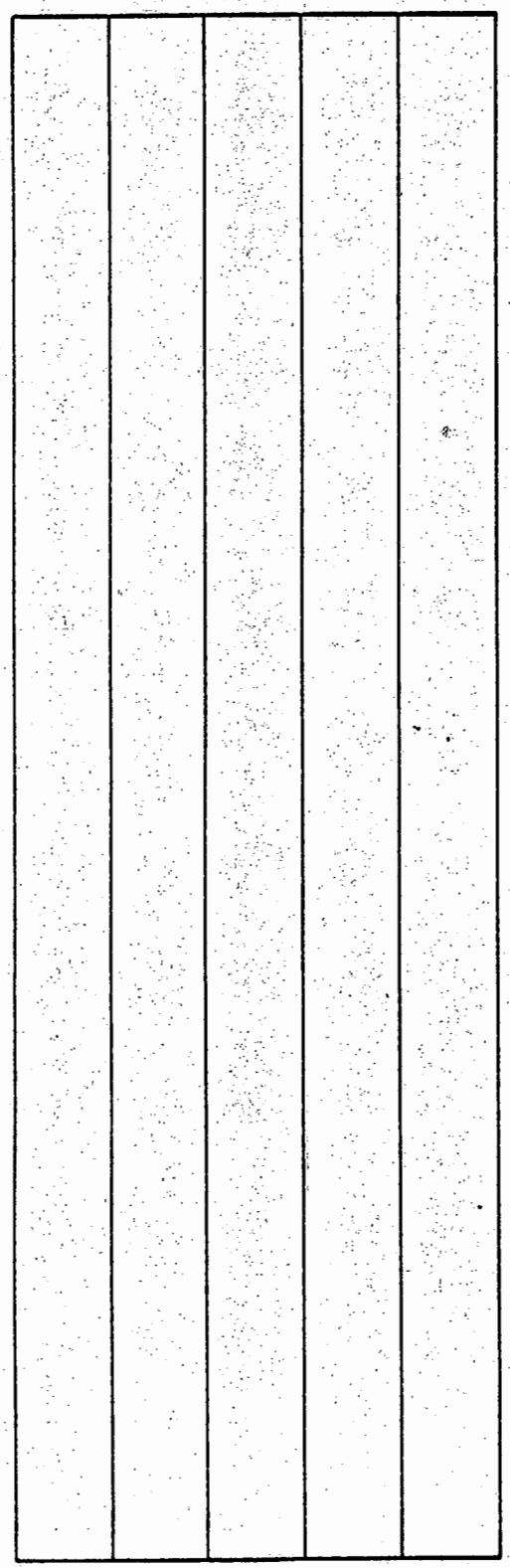
LOG OF BORING 8
Lower Waiau Apartments
Waiau, Oahu, Hawaii

PLATE 9

# LOG OF BORING 9

Equipment 4" Flight Auger

Elevation 198 Date 9/2/71




| Moisture Content (%) | Dry Density (pcf) | Depth (ft) | Sample |
|---|---|---|---|
| 30.2 | 91 | 0 | |
| | | 5 | |
| | | 10 | |
| | | 15 | |
| | | 20 | |
| | | 25 | |
| | | 30 | |
| | | 35 | |
| | | 40 | |

RED CLAYEY SILT (ML)
stiff, dry

moist at 4'

gray-brown in color at 14'

MOTTLED ORANGE AND GRAY SILT (ML)
stiff, moist
very deeply weathered basalt

with rock fragments at 24'

(no free water encountered)

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LOG OF BORING 9

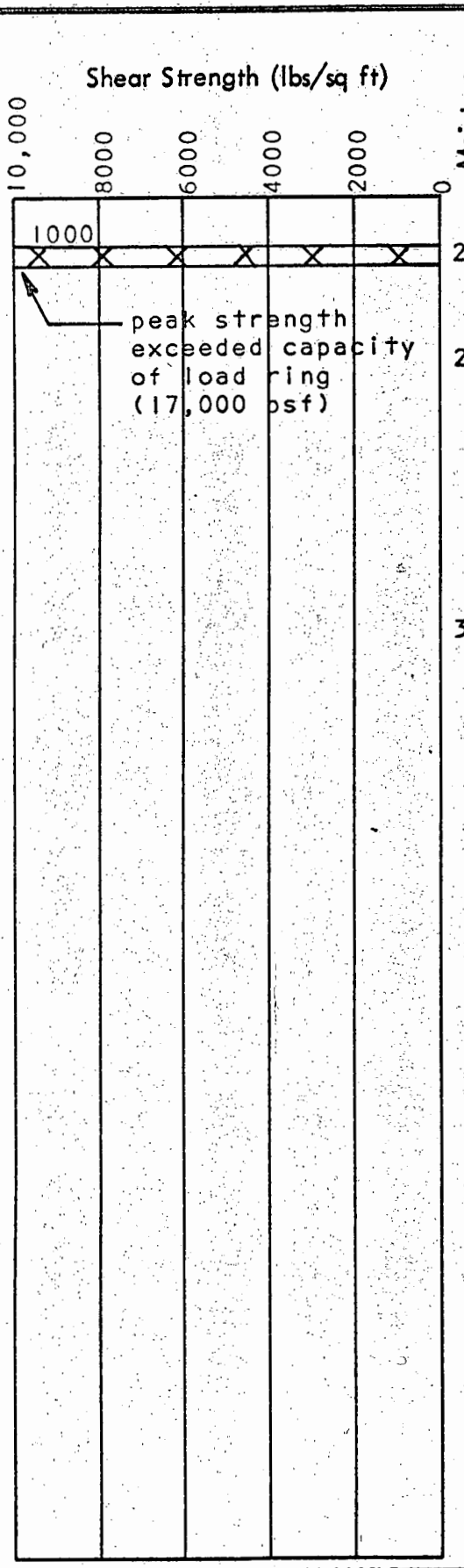
Lower Waiau Apartments
Waiau, Oahu, Hawaii

PLATE 10

# LOG OF BORING 10

Equipment 4" Flight Auger

Elevation 195 Date 9/2/71




| Moisture Content (%) | Dry Density (pcf) | Depth (ft) | Sample |
|---|---|---|---|
| 22.2 | 100 | 0 | |
| 27.2 | 98 | 5 | |
| 35.5 | 86 | 10 | |
| | | 15 | |
| | | 20 | |
| | | 25 | |
| | | 30 | |
| | | 35 | |
| | | 40 | |

RED CLAYEY SILT (ML)
stiff, dry

mottled brown and red in color at 4'

LIGHT BROWN SANDY SILT (ML)
stiff, moist
with weathered rock fragments

GRAY BASALT
low hardness, friable, moderately weathered, moderately porous

moderate hardness, moderately strong, little weathering at 22'

(no free water encountered)

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*Consulting Engineers*

Job No: 3904.4 Appr: ds /gs Date 9/21/71

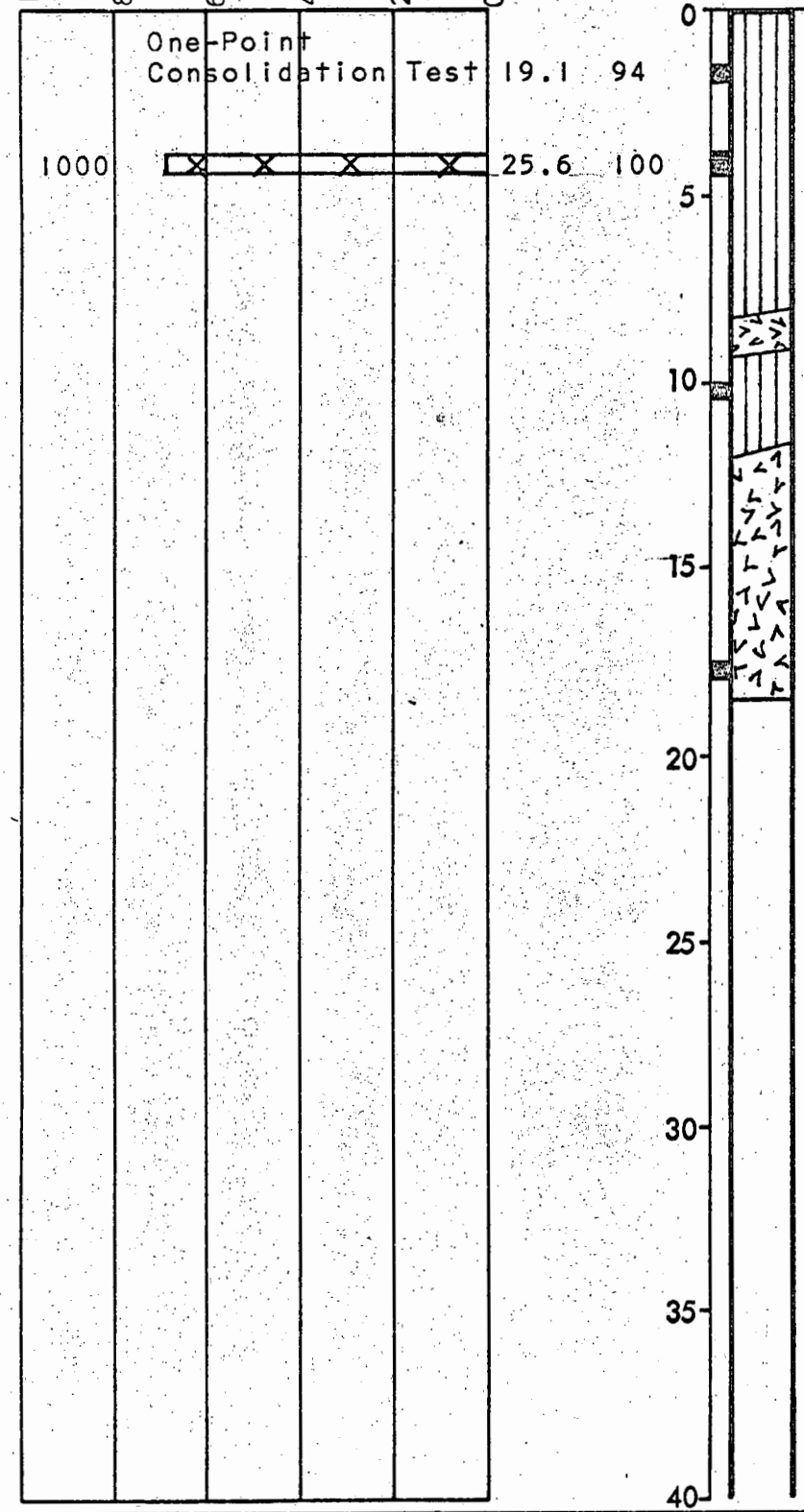
LOG OF BORING 10
Lower Waiau Apartments
Waiau, Oahu, Hawaii

PLATE 11

# LOG OF BORING II

Equipment 4" Flight Auger

Elevation 175 Date 9/2/71




RED CLAYEY SILT (ML)
stiff, dry

brown in color at 4!

BASALT BOULDER

RED SILT (ML)
stiff, moist

GRAY BASALT
moderate hardness, weak to moderately strong, moderately porous

(no free water encountered)

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*Consulting Engineers*

Job No: 3904.4 Appr: HS /gs Date 9/21/71

LOG OF BORING II
Lower Waiau Apartments
Waiau, Oahu, Hawaii

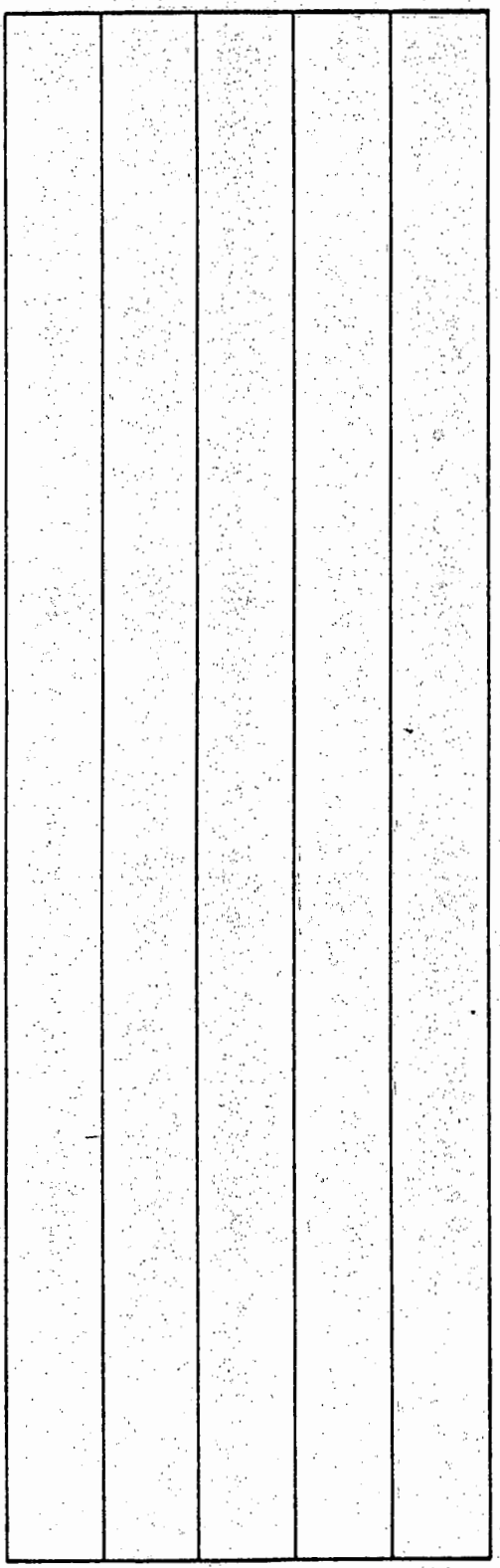
PLATE 12

# LOG OF BORING 12

Equipment 4" Flight Auger

Elevation 138 Date 9/2/71

Shear Strength (lbs/sq ft) | Moisture Content (%) | Dry Density (pcf) | Depth (ft) | Sample



0

RED CLAYEY SILT (ML)
very stiff, moist

5

mottled gray and red in color at 5'

10

15

GRAY BASALT
moderate hardness, porous

20

(no free water encountered)

25

30

35

40

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LOG OF BORING 12

Lower Waiau Apartments
Waiau, Oahu, Hawaii

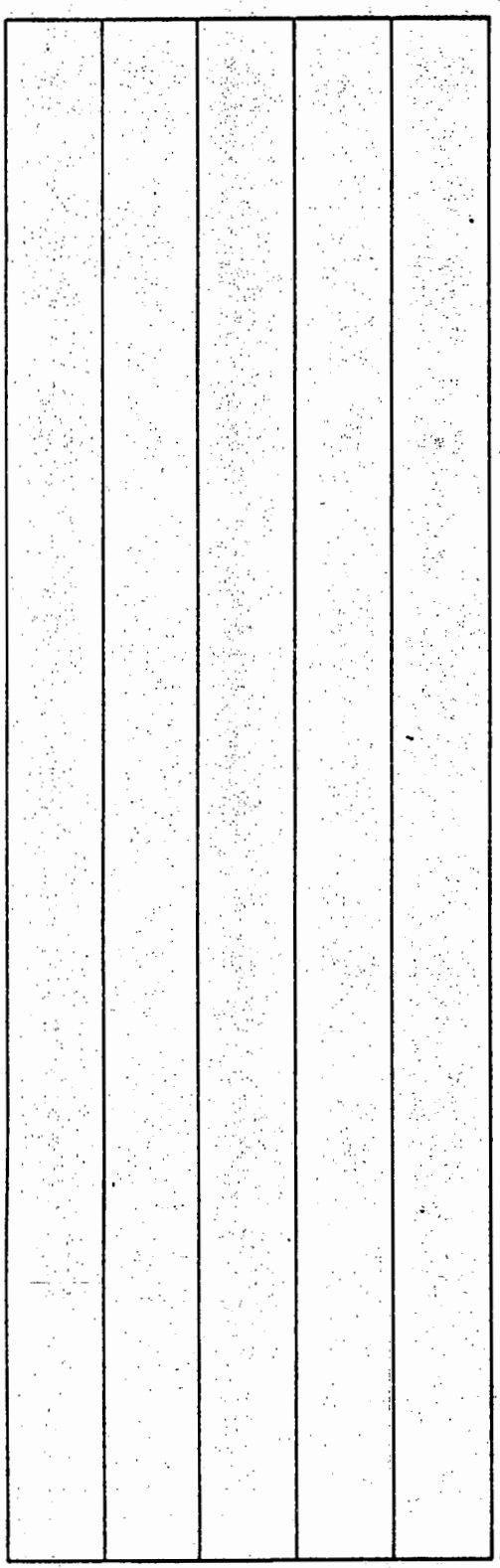
PLATE 13

RF11

# LOG OF BORING 13

Equipment 4" Flight Auger

Elevation 178 Date 9/2/71




| Moisture Content (%) | Dry Density (pcf) | Depth (ft) | Sample |
|---|---|---|---|
| 21.8 | 92.5 | 0 | |
| | | 5 | |
| | | 10 | |
| | | 15 | |
| | | 20 | |
| | | 25 | |
| | | 30 | |
| | | 35 | |
| | | 40 | |

RED CLAYEY SILT (ML)
very stiff, dry

GRAY BASALT
moderate hardness, moderately strong, moderately weathered

little weathering at 14'

(no free water encountered)

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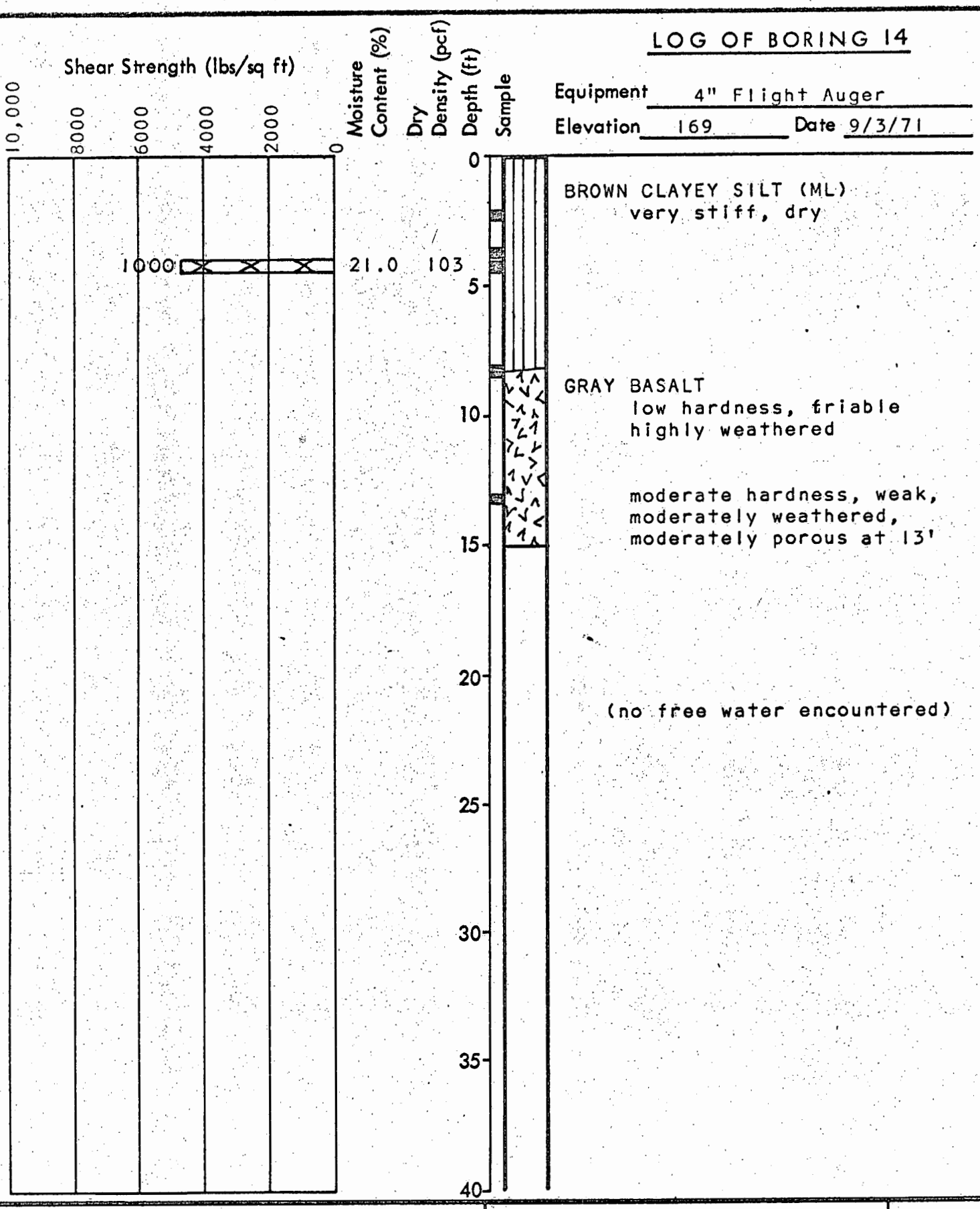
LOG OF BORING 13
Lower Walau Apartments
Waiau, Oahu, Hawaii

PLATE 14

# LOG OF BORING 14

Equipment 4" Flight Auger

Elevation 169 Date 9/3/71




BROWN CLAYEY SILT (ML)
very stiff, dry

GRAY BASALT
low hardness, friable
highly weathered

moderate hardness, weak,
moderately weathered,
moderately porous at 13'

(no free water encountered)

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LOG OF BORING 14

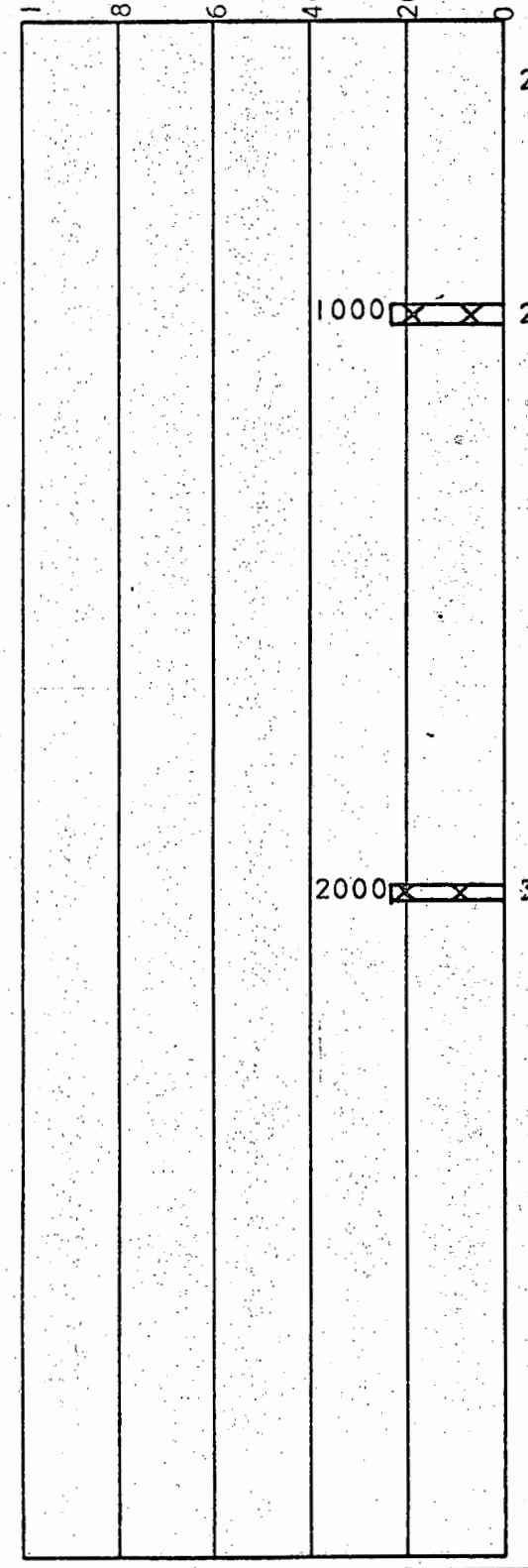
Lower Waiau Apartments
Waiau, Oahu, Hawaii

PLATE 15

# LOG OF BORING 15

Equipment 4" Flight Auger

Elevation 188 Date 9/3/71




| Moisture Content (%) | Dry Density (pcf) | Depth (ft) | Sample |
|---|---|---|---|
| 23.0 | 93.5 | 0 | |
| 27.0 | 97 | 5 | |
| | | 10 | |
| | | 15 | |
| 36.2 | 86 | 20 | |
| | | 25 | |
| | | 30 | |
| | | 35 | |
| | | 40 | |

RED CLAYEY SILT (ML)
very stiff, dry

moist at 4'

orange in color at 7'

GRAY BASALT
low hardness, friable, very highly weathered

(no free water encountered)

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LOG OF BORING 15

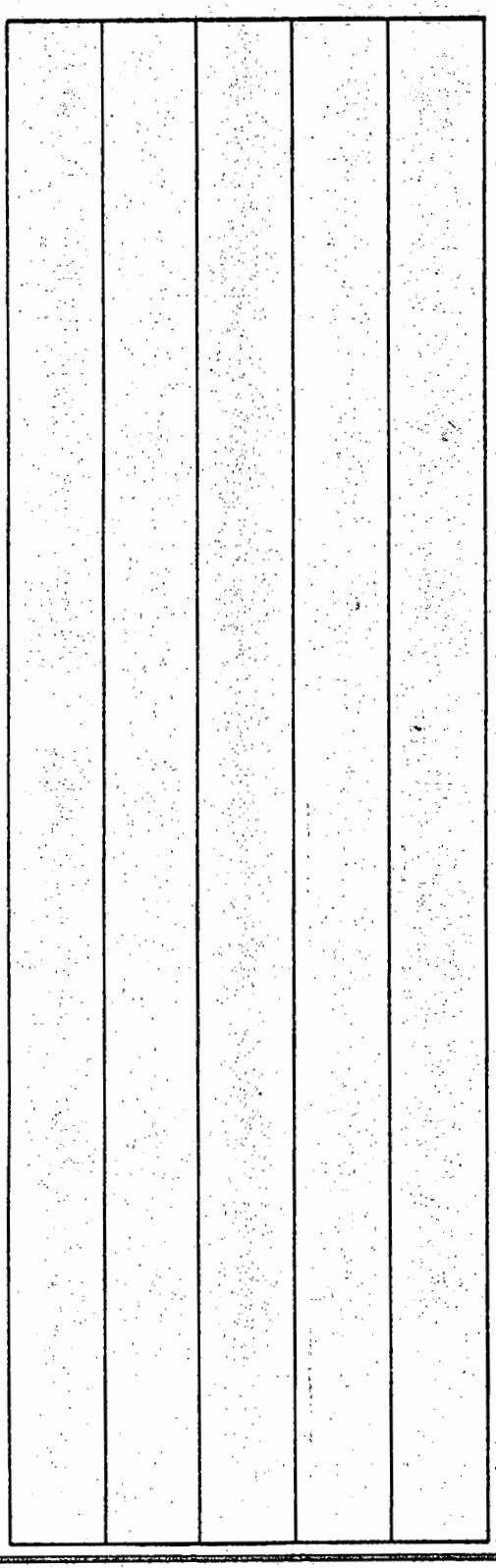
Lower Waiau Apartments
Waiau, Oahu, Hawaii

PLATE 16

# LOG OF BORING 16

Equipment 4" Flight Auger

Elevation 135 Date 9/7/71



| Depth (ft) | Moisture Content (%) | Dry Density (pcf) | Sample |
|---|---|---|---|
| 0 | | | |
| 5 | 20.4 | 102 | |
| 10 | | | |
| 15 | 42.7 | 80 | |
| 20 | | | |
| 25 | | | |
| 30 | | | |
| 35 | | | |
| 40 | | | |

RED CLAYEY SILT (ML)
very stiff, dry

stiff, moist at 9'

BASALT BOULDER

MOTTLED ORANGE, BROWN AND GRAY BASALT
low hardness, friable, deeply weathered

GRAY BASALT
moderate hardness, weak, slightly weathered, slightly porous

(no free water encountered)

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Job No: 3904.4 Appr: DLS /gs Date 9/21/71

LOG OF BORING 16
Lower Waiau Apartments
Waiau, Oahu, Hawaii

PLATE 17

# LOG OF BORING 17

Equipment 4" Flight Auger

Elevation 125 Date 9/7/71

| Shear Strength (lbs/sq ft) | Moisture Content (%) | Dry Density (pcf) | Depth (ft) | Sample | |
|---|---|---|---|---|---|
| Shrink-Swell Test<br>Liquid Limit = 45<br>Plastic Limit = 31<br>Plasticity Index = 14 | 20.3 | 104 | 0 | | RED CLAYEY SILT (ML)<br>very stiff, dry |
| | | | 5 | | |
| | 20.4 | 93 | | | GRAY BASALT<br>moderate hardness, weak, moderately weathered<br>little weathering at 12' |
| | | | 10 | | |
| | | | 15 | | (no free water encountered) |
| | | | 20 | | |
| | | | 25 | | |
| | | | 30 | | |
| | | | 35 | | |
| | | | 40 | | |

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Job No: 3904.4 Appr: DS /gs Date 9/21/71

LOG OF BORING 17

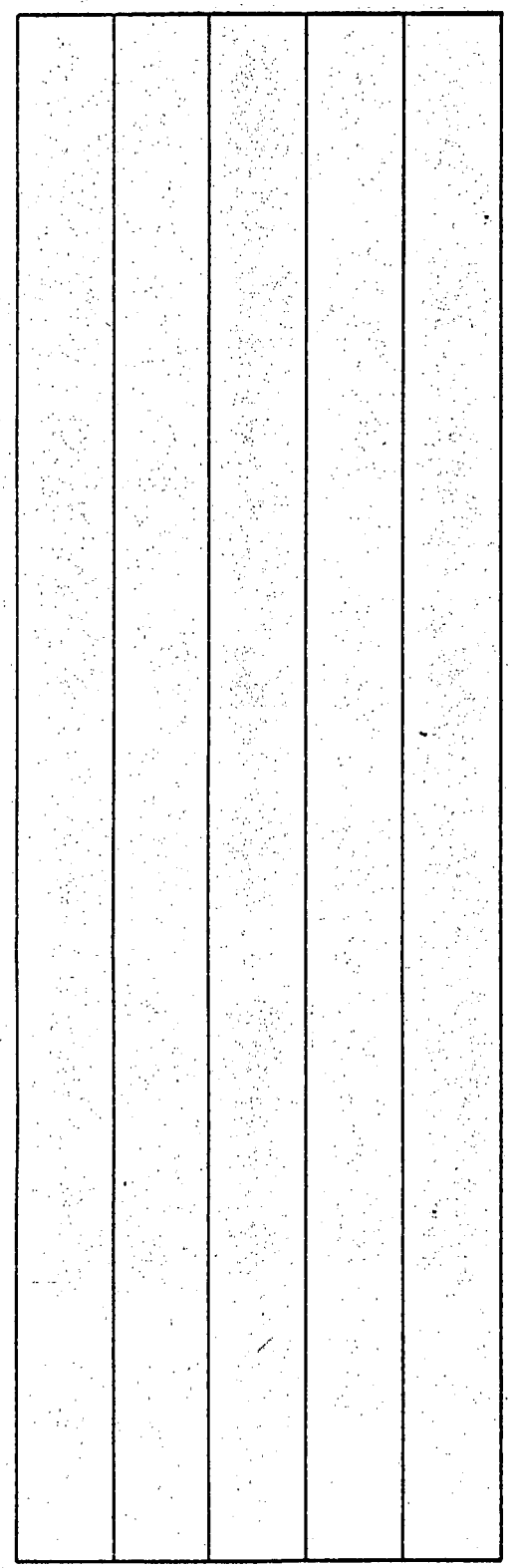
Lower Waiau Apartments
Waiau, Oahu, Hawaii

PLATE 18

# LOG OF BORING 18

Equipment 4" Flight Auger

Elevation 120 Date 9/7/71




| Moisture Content (%) | Dry Density (pcf) | Depth (ft) | Sample |
|---|---|---|---|
| 18.5 | 106 | 0 | |
| 22.8 | 100 | 5 | |
| | | 10 | |
| | | 15 | |
| | | 20 | |
| | | 25 | |
| | | 30 | |
| | | 35 | |
| | | 40 | |

RED CLAYEY SILT (ML)
very stiff, dry

brown in color, moist at 9'

GRAY BASALT
moderate hardness, weak

(no free water encountered)

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Job No: 3904.4 Appr: DS /gs Date 9/21/71

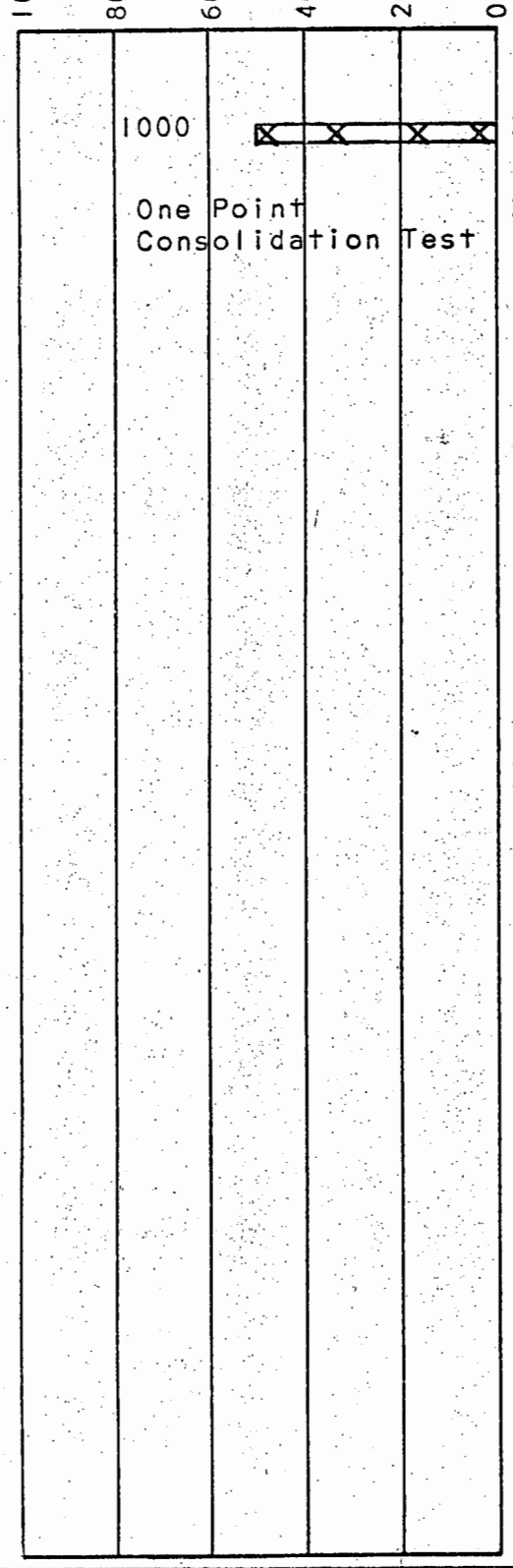
LOG OF BORING 18
Lower Waiau Apartments
Waiau, Oahu, Hawaii

PLATE 19

# LOG OF BORING 19

Equipment 4" Flight Auger

Elevation 130 Date 9/7/71




| Moisture Content (%) | Dry Density (pcf) | Depth (ft) | Sample |
|---|---|---|---|
| 21.9 | 98 | 0 | |
| 26.6 | 93 | 5 | |
| | | 10 | |
| 33.9 | 90 | 15 | |
| | | 20 | |
| | | 25 | |
| | | 30 | |
| | | 35 | |
| | | 40 | |

RED CLAYEY SILT (ML)
very stiff, dry

stiff, moist at 7'

BASALT BOULDER

MOTTLED GRAY AND ORANGE SILT (ML)
stiff, moist

(no free water encountered)

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Job No: 3904.4 Appr: NS /gs Date 9/21/71

LOG OF BORING 19

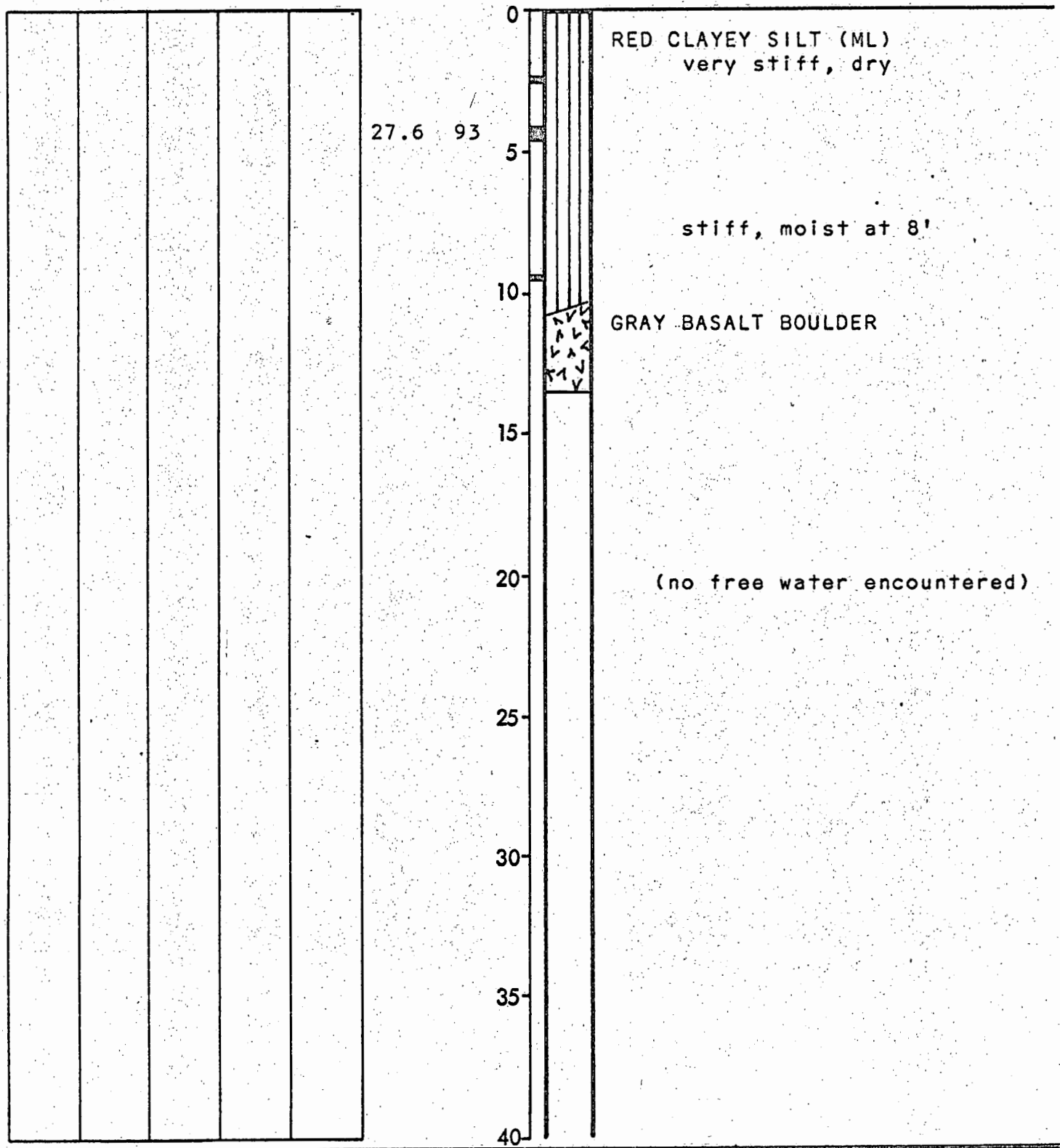
Lower Waiau Apartments
Waiau, Oahu, Hawaii

PLATE 20

# LOG OF BORING 20

Equipment 4" Flight Auger

Elevation 115 Date 9/8/71

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*Consulting Engineers*

Job No: 3904.4 Appr: pls /gs Date 9/21/71

LOG OF BORING 20

Lower Waiau Apartments
Waiau, Oahu, Hawaii

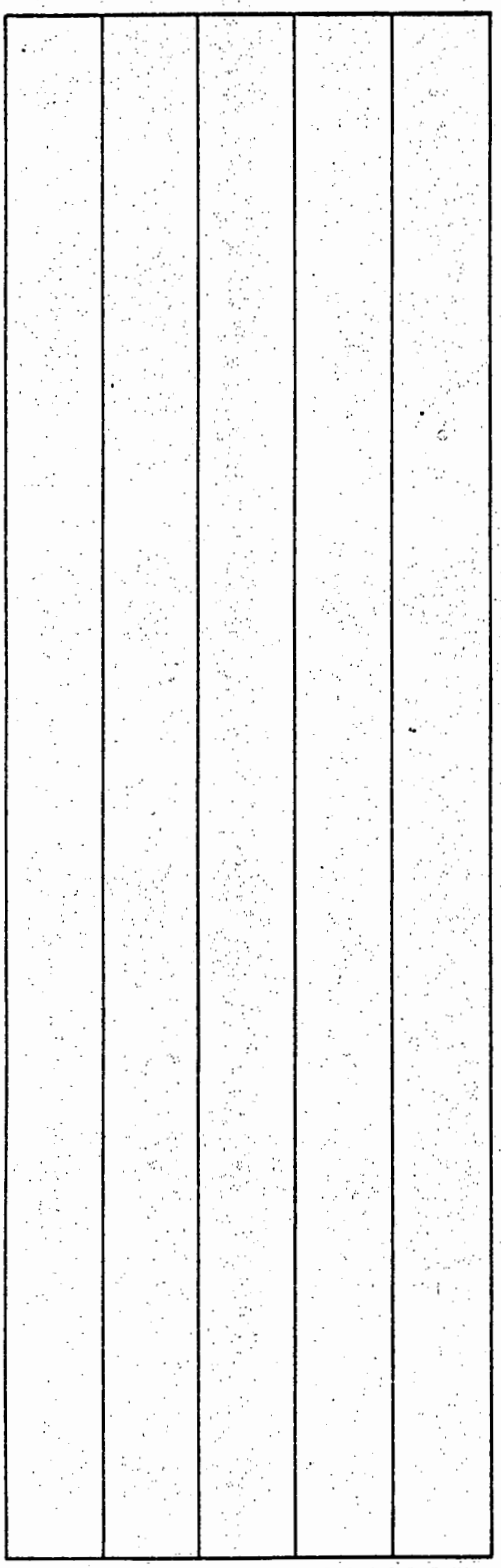
PLATE 21

RF11

# LOG OF BORING 21

Equipment 4" Flight Auger

Elevation 116 Date 9/8/71




| Moisture Content (%) | Dry Density (pcf) | Depth (ft) | Sample |
|---|---|---|---|
| 22.8 | 87 | 0 | |
| | | 5 | |
| 24.2 | 90 | 10 | |
| | | 15 | |
| | | 20 | |
| | | 25 | |
| | | 30 | |
| | | 35 | |
| | | 40 | |

RED CLAYEY SILT (ML)
very stiff, dry

stiff, moist at 3'

GRAY BASALT
deeply weathered
moderately weathered, moderate hardness to hard, moderately strong, porous at 7'

(no free water encountered)

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Job No: 3904.4 Appr: DLS /gs Date 9/21/71

LOG OF BORING 21
Lower Waiau Apartments
Waiau, Oahu, Hawaii

PLATE 22

RF11

# LOG OF BORING 22

Equipment 4" Flight Auger

Elevation 163 Date 9/8/71

| Shear Strength (lbs/sq ft) | Moisture Content (%) | Dry Density (pcf) | Depth (ft) | Sample | |
|---|---|---|---|---|---|
| | | | 0 | | RED CLAYEY SILT (ML) very stiff, dry |
| | | | 5 | | moist at 3' |
| | | | 10 | | GRAY BASALT moderate hardness, friable |
| | 25.0 | 102 | | | |
| | | | 15 | | |
| | | | 20 | | (no free water encountered) |
| | | | 25 | | |
| | | | 30 | | |
| | | | 35 | | |
| | | | 40 | | |

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Job No: 3904.4 Appr: DLS /gs Date 9/21/71

LOG OF BORING 22

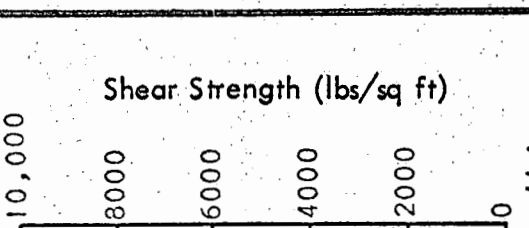
Lower Waiau Apartments
Waiau, Oahu, Hawaii

PLATE 23

# LOG OF BORING 23

Equipment 4" Flight Auger

Elevation 145 Date 9/8/71




| Depth (ft) | Sample | Shear Strength (lbs/sq ft) | Moisture Content (%) | Dry Density (pcf) |
|---|---|---|---|---|
| 0 | | | | |
| | | 1000 | 25.7 | 100 |
| 5 | | 1000 | 29.0 | 99 |
| 10 | | | 31.5 | 92 |
| 15 | | | 39.8 | 82 |
| 20 | | | | |
| 25 | | | | |
| 30 | | | | |
| 35 | | | | |
| 40 | | | | |

RED CLAYEY SILT (ML)
very stiff, dry

moist at 4'

brown in color at 11'

MOTTLED GRAY AND RED SANDY SILT (ML)
stiff, moist
very deeply weathered basalt

(no free water encountered)

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Job No: 3904.4 Appr: DLS /gs Date 9/21/71

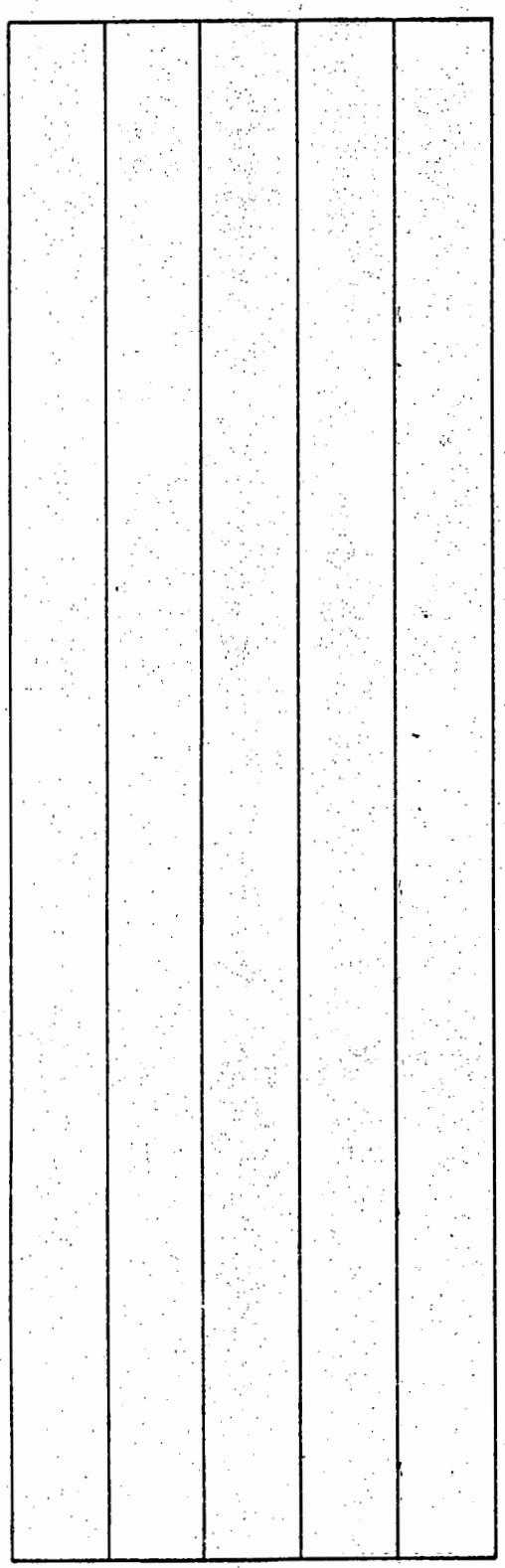
LOG OF BORING 23
Lower Waiau Apartments
Waiau, Oahu, Hawaii

PLATE 24

# LOG OF BORING 24

Equipment 4" Flight Auger

Elevation 165 Date 9/9/71




RED CLAYEY SILT (ML)
very stiff, dry

brown in color at 3.5'

BASALT BOULDER

DARK BROWN SILT (ML)
very stiff, moist

GRAY BASALT
moderately weathered

(no free water encountered)

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*Consulting Engineers*

Job No: 3904.4 Appr: NS /gs Date 9/21/71

LOG OF BORING 24
Lower Waiau Apartments
Waiau, Oahu, Hawaii

PLATE 25

# LOG OF BORING 25

Shear Strength (lbs/sq ft)

Moisture Content (%)

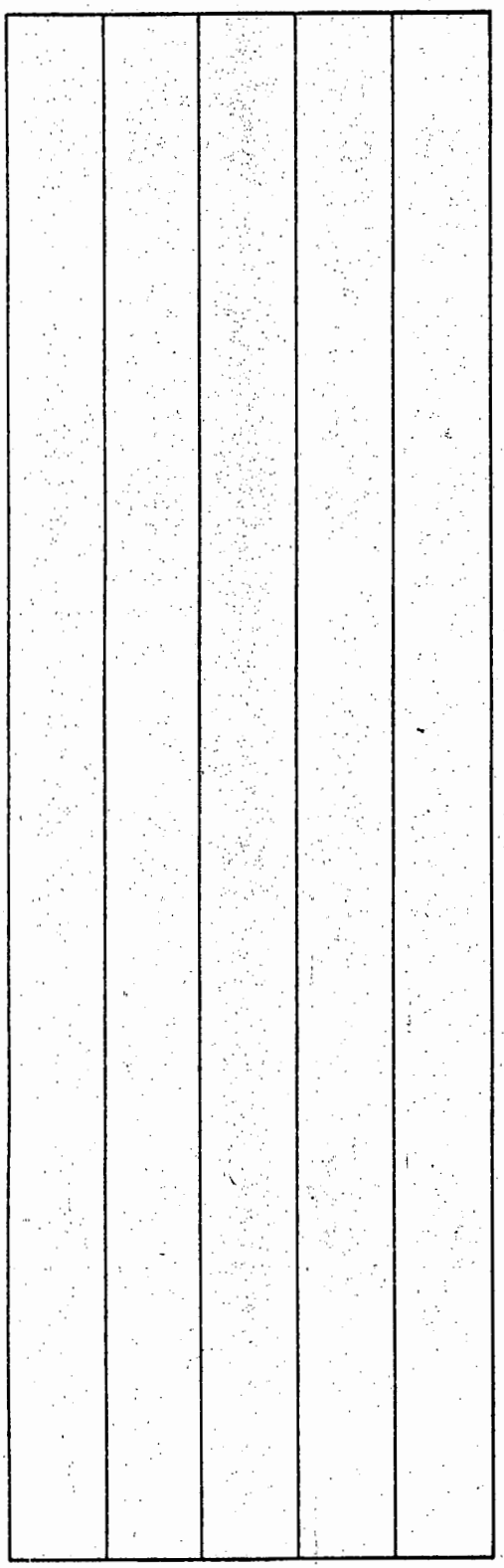
Dry Density (pcf)

Depth (ft)

Sample

Equipment 4" Flight Auger

Elevation 200 Date 9/9/71



0

5

10

15

20

25

30

35

40

RED CLAYEY SILT (ML)
very stiff, dry

moist at 5'

gray in color at 9'

MOTTLED GRAY AND RED SANDY SILT (ML)
stiff, moist
very deeply weathered basalt

GRAY BASALT
moderate hardness, moderately strong, little weathering

(no free water encountered)

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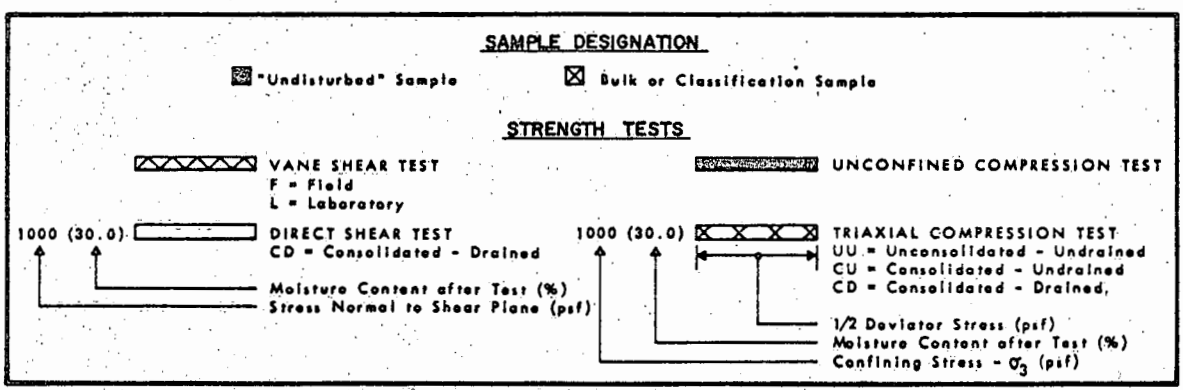
Job No: 3904.4 Appr: DLS /gs Date 9/21/71

LOG OF BORING 25
Lower Waiau Apartments
Waiau, Oahu, Hawaii

PLATE 26

| MAJOR DIVISIONS | | | | TYPICAL NAMES |
|---|---|---|---|---|
| COARSE GRAINED SOILS (MORE THAN HALF IS LARGER THAN #200 SIEVE) | GRAVELS (MORE THAN HALF COARSE FRACTION IS LARGER THAN NO. 4 SIEVE SIZE) | CLEAN GRAVELS WITH LITTLE OR NO FINES | GW | WELL GRADED GRAVELS, GRAVEL - SAND MIXTURES |
| | | | GP | POORLY GRADED GRAVELS, GRAVEL - SAND MIXTURES |
| | | GRAVELS WITH OVER 12% FINES | GM | SILTY GRAVELS, POORLY GRADED GRAVEL - SAND - SILT MIXTURES |
| | | | GC | CLAYEY GRAVELS, POORLY GRADED GRAVEL - SAND - CLAY MIXTURES |
| | SANDS (MORE THAN HALF COARSE FRACTION IS SMALLER THAN NO. 4 SIEVE SIZE) | CLEAN SANDS WITH LITTLE OR NO FINES | SW | WELL GRADED SANDS, GRAVELLY SANDS |
| | | | SP | POORLY GRADED SANDS, GRAVELLY SANDS |
| | | SANDS WITH OVER 12% FINES | SM | SILTY SANDS, POORLY GRADED SAND - SILT MIXTURES |
| | | | SC | CLAYEY SANDS, POORLY GRADED SAND - CLAY MIXTURES |
| FINE GRAINED SOILS (MORE THAN HALF IS SMALLER THAN #200 SIEVE) | 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 CLAYS AND ORGANIC SILTY CLAYS OF LOW PLASTICITY |
| | SILTS AND CLAYS LIQUID LIMIT GREATER THAN 50 | | MH | INORGANIC SILTS, MICACEOUS OR DIATOMACIOUS FINE SANDY OR SILTY SOILS, ELASTIC SILTS |
| | | | CH | INORGANIC CLAYS OF HIGH PLASTICITY, FAT CLAYS |
| | | | OH | ORGANIC CLAYS OF MEDIUM TO HIGH PLASTICITY, ORGANIC SILTS |
| HIGHLY ORGANIC SOILS | | | Pt | PEAT AND OTHER HIGHLY ORGANIC SOILS |

## UNIFIED SOIL CLASSIFICATION SYSTEM




## KEY TO TEST DATA

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Job No: 3904.4 Appr: DLS /gs Date: 10/19/7

SOIL CLASSIFICATION CHART AND KEY TO TEST DATA

Lower Waiau Apartments

PLATE 27

| | | Volume Change (Percent) | | |
|---|---|---|---|---|
| Boring | Depth | Air Dry* to Saturated | Air Dry* to Oven Dry | Total |
| 2 | 2.0 | 5 | 1 | 6 |
| 17 | 2.0 | 3 | 2 | 5 |

*Air dry is at low humidity condition

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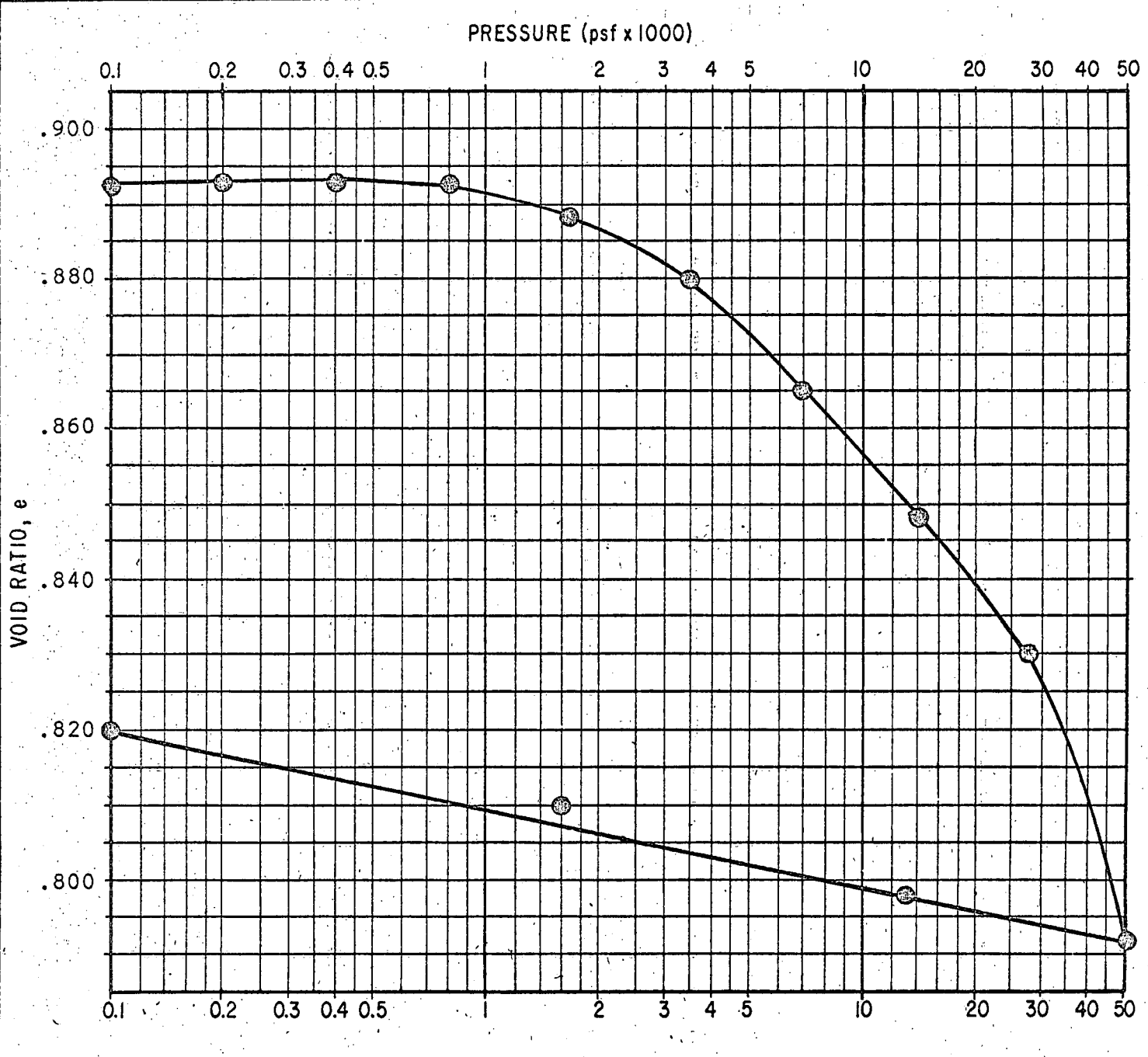
SHRINK-SWELL TEST DATA

Lower Waiau Apartments
Waiau, Oahu, Hawaii

PLATE 28

RF-30




| Type of Specimen | | | Before Test | | | After Test | |
|---|---|---|---|---|---|---|---|
| Diameter (in.) 2.43 | Height (in.) 0.8 | | Moisture Content | $w_o$ | 29.6 % | $w_f$ | 28.3 % |
| Overburden Press., $P_o$ | 1500 psf | | Void Ratio | $e_o$ | .895 | $e_f$ | .820 |
| Preconsol. Press., $P_c$ | psf | | Saturation | $S_o$ | 96 % | $S_f$ | 100 % |
| Compression Index, $C_c$ | 0.120 | | Dry Density | $\gamma_d$ | 96 pcf | $\gamma_d$ | 101 pcf |

| LL 36 | PL 28 | PI 8 | $G_s$ 2.90 (assumed) |
|---|---|---|---|

Classification RED CLAYEY SILT (ML)

Source Boring 2 at 12.5'

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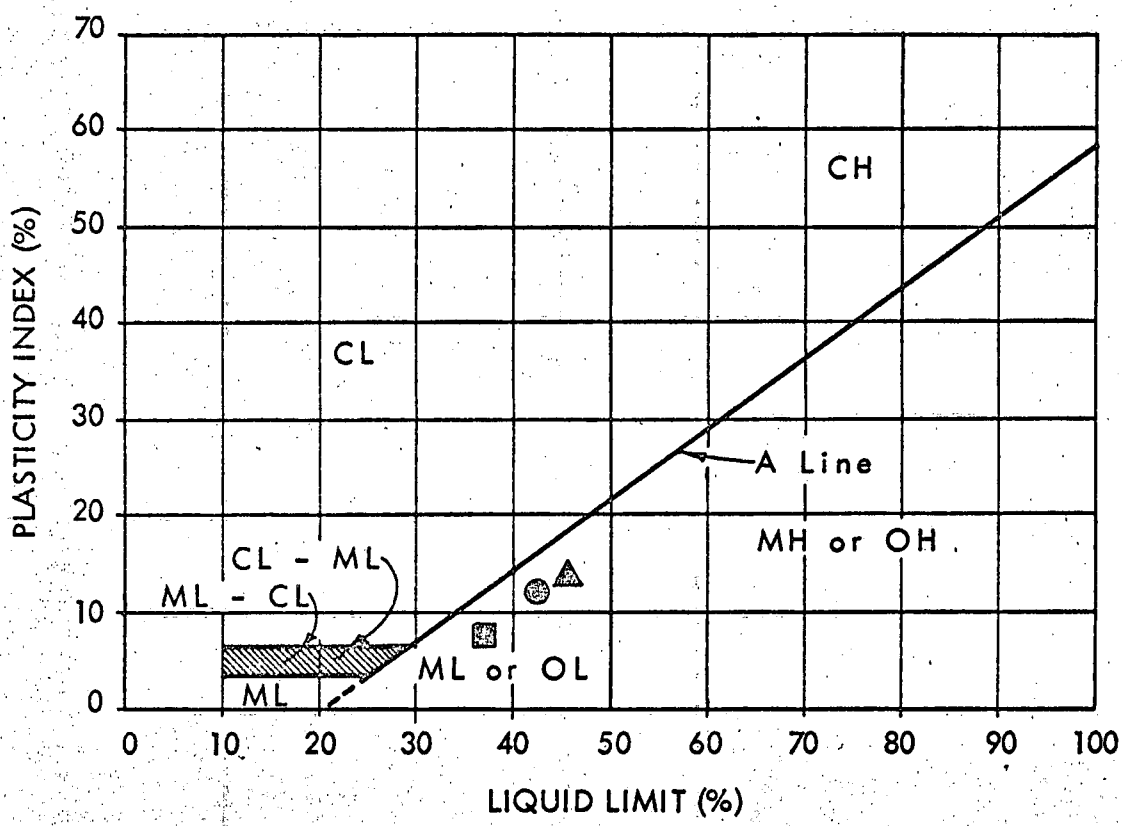
Job No: 3904.4 Appr: DS /gs Date: 10/19/71

CONSOLIDATION TEST REPORT

Lower Waiau Apartments
Waiau, Oahu, Hawaii

PLATE 29




| Symbol | Classification and Source | Liquid Limit (%) | Plastic Limit (%) | Plasticity Index (%) | % Passing #200 Sieve |
|---|---|---|---|---|---|
| ⊗ | RED CLAYEY SILT (ML) Boring 2 at 2.0' | 42 | 29 | 12 | --- |
| ▲ | RED CLAYEY SILT (ML) Boring 17 at 2.0' | 45 | 31 | 14 | --- |
| ▣ | RED CLAYEY SILT (ML) Boring 2 at 12.5' | 36 | 28 | 8 | --- |

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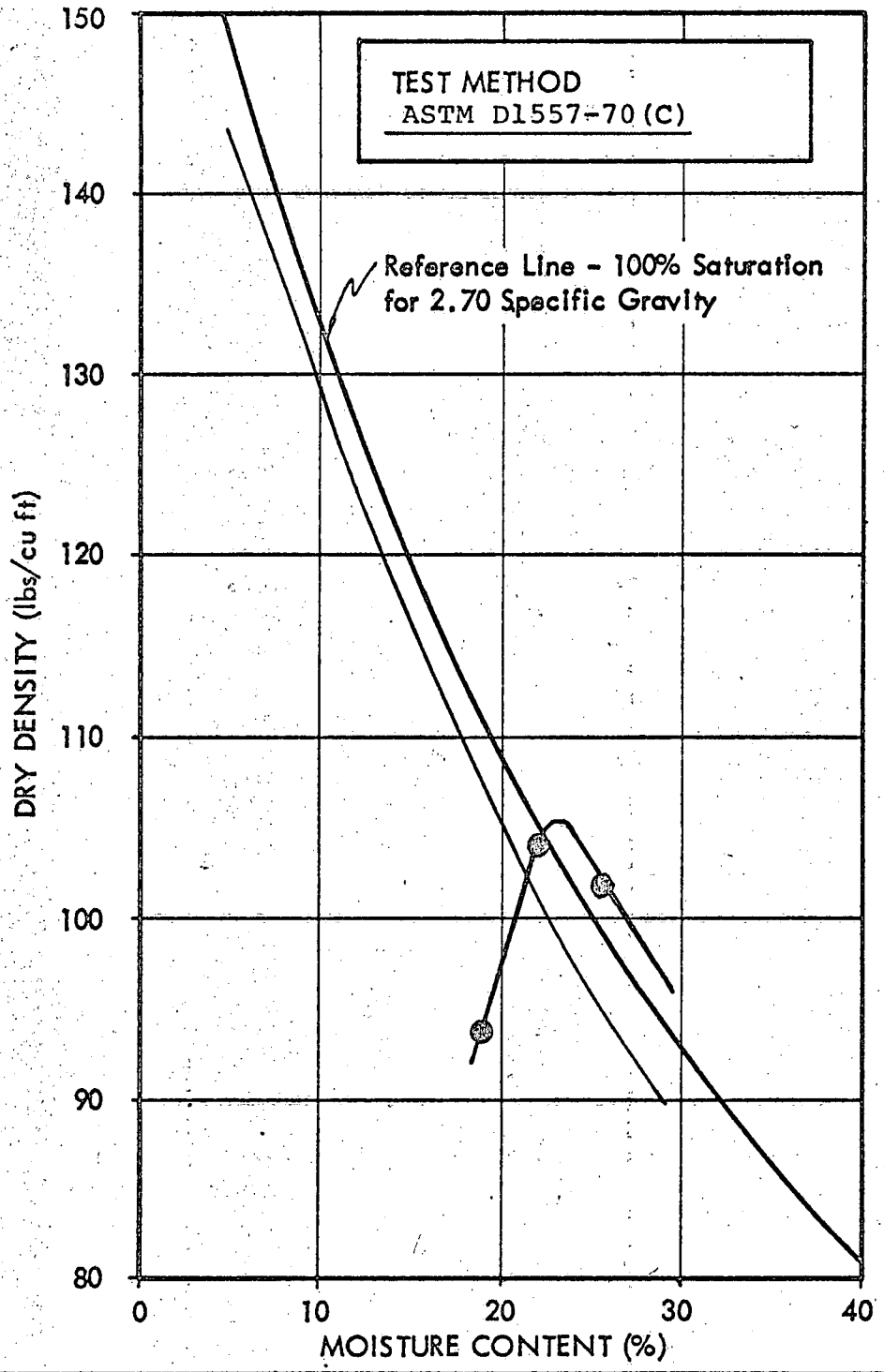
Job No: 3904.4 Appr: DLS /gs Date 10/19/71

PLASTICITY CHART

Lower Waiau Apartments
Waiau, Oahu, Hawaii

PLATE 30




| Symbol | Sample Source | Classification | Optimum Moisture (%) | Maximum Dry Density (pcf) |
|---|---|---|---|---|
| ● | Near Boring 17 | RED CLAYEY SILT (ML) | 23.0 | 106 |

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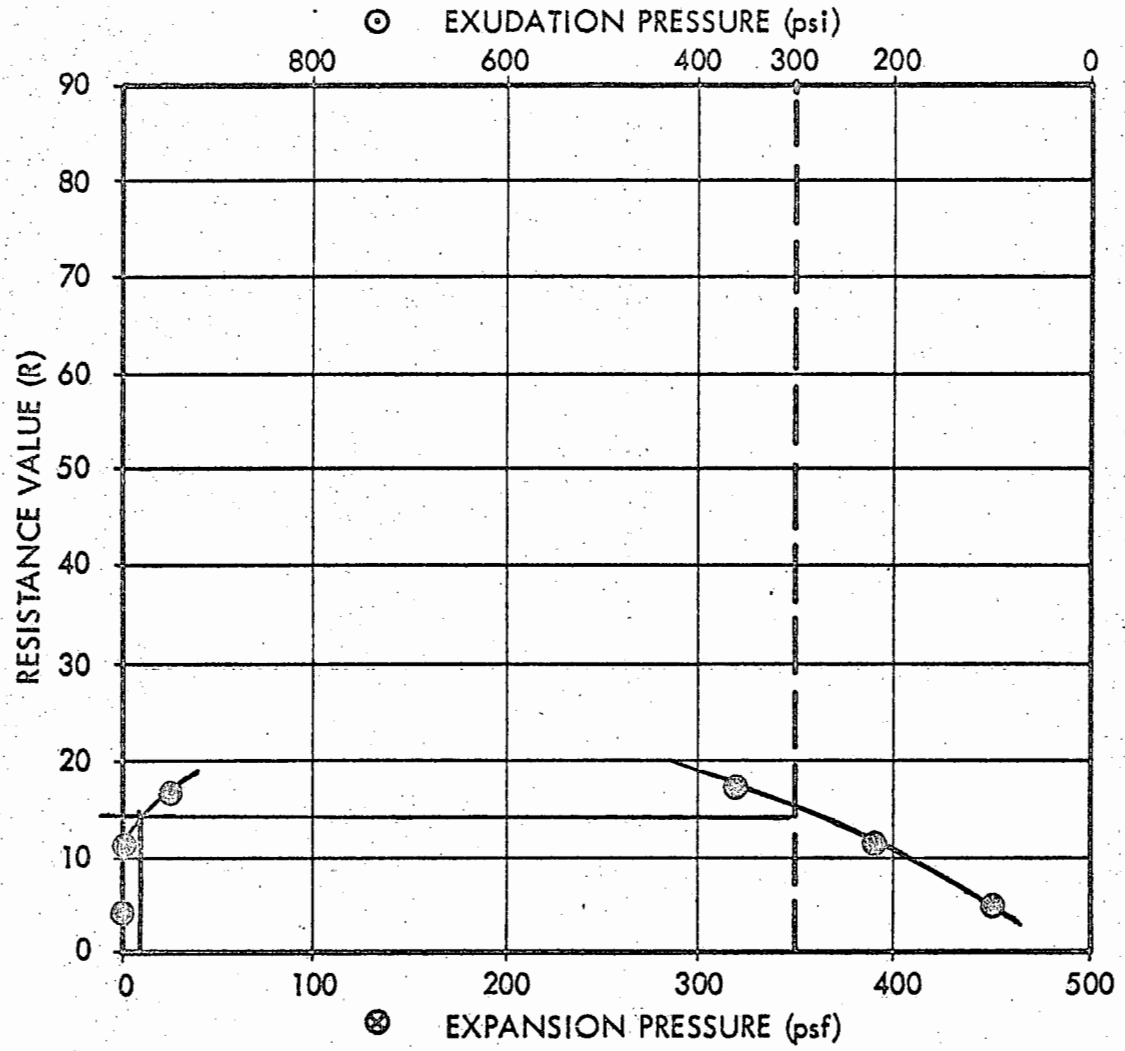
Job No: 3904.4 Appr: ds / gs Date: 10/21/71

COMPACTION TEST DATA

Lower Waiau Apartments
Waiau, Oahu, Hawaii

PLATE 31




| Specimen No. | 1 | 2 | 3 | |
|---|---|---|---|---|
| Moisture Content (%) | 28.0 | 30.6 | 34.2 | |
| Dry Density (psf) | 97.4 | 92.3 | 88.7 | |
| Exudation Pressure (psi) | 360 | 220 | 95 | |
| Expansion Pressure (psf) | 26 | 0 | 0 | |
| Resistance Value (R) | 17 | 11 | 5 | |

## TEST DATA

| Sample Source | Classification | Sand Equivalent | Expansion Pressure | R value |
|---|---|---|---|---|
| Representative of Surface Soils | RED CLAYEY SILT (ML) | 10 | 10 | 14 |

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RESISTANCE VALUE TEST DATA

Lower Waiau Apartments
Waiau, Oahu, Hawaii

Job No: 3904.4 Appr: bls / gs Date: 10/21/71

PLATE 32

# Appendix A

# LABORATORY TEST METHODS

## LABORATORY TEST METHODS

### Moisture Content/Dry Density Determinations

Generally, the wet density of the sample was determined on the basis of the entire sample volume. The loss of weight upon drying was used for determining moisture content.

### Atterberg Limits Determinations

Liquid limit tests were performed in accordance with the method of test for liquid limit, ASTM designation D423-66, with the exception that before testing, the material was not allowed to dry to a moisture content lower than the natural moisture content. Plastic limit and plasticity index results are in accordance with the standard method of test, ASTM designation D424-59.

### Strength Tests

Controlled strain, unconsolidated-undrained triaxial compression tests were performed at a strain rate of one percent per minute. Strength test procedures were generally in accordance with those presented in "Soil Testing for Engineers" by T. W. Lambe, 1951.

### Shrink-Swell Tests

Shrink-swell tests were performed in pneumatic consolidometers on samples 0.5 inches in height and 2.43 inches diameter. Initially, samples were allowed to reach equilibrium under a surcharge load of 100 psf. The sample was then saturated and

again allowed to reach equilibrium. The sample was then removed from the consolidometer and allowed to air dry; sample dimensions were recorded when sample weight reached equilibrium. The sample was then oven-dried and sample dimensions again recorded. The percent volume change was computed as the sum of the volume changes from natural moisture content to saturation and from natural moisture content to oven-dried.

Consolidation Test

The consolidation test generally conformed to the standard method of test ASTM designation D2435-65T. Each load increment of the test was double the previous load and was applied through a period of approximately 24 hours. Specimen height was 0.80 inches. The sample was loaded to approximately overburden prior to inundation to reduce swell effects. Time rate of compression readings were taken at two load increments above the preconsolidation pressure of the sample.

Compaction Test

A compaction test was run in accordance with ASTM designation D1557-70(C) test method, with the exception that samples compacted wet of field moisture were not allowed to dry below field moisture prior to adding water.

Resistance Value Test

A resistance value test was run in conformance with the standard California test method, No. 301.

# Appendix B

## EARTHWORK SPECIFICATIONS
## LOWER WAIAU APARTMENTS

# EARTHWORK SPECIFICATIONS
# LOWER WAIAU APARTMENTS

## 1.0 GENERAL

1.1 Scope - The work done under these specifications shall include clearing, stripping and removal of unsuitable materials, preparation of natural soils and the excavation, placement and compaction of on-site and imported fill materials as shown on the plans.

1.2 Percent Compaction - As referred to in these specifications, "relative compaction" is the in-place dry density of the soil expressed as a percentage of the maximum dry density of the same material determined in accordance with the ASTM D1557-70(C) test method.

1.3 Dust Abatement - The Contractor shall furnish, transport and apply water as required to minimize dust.

1.4 Erosion - The Contractor shall remove soil and debris eroded from the site and deposited on/in roads, drainage facilities and adjacent property.

## 2.0 SITE PREPARATION

2.1 Clearing - The areas to be graded shall be cleared of all cane, brush, trees, and debris. This material shall be removed from the site.

2.2 Stripping - The upper two to four inches of natural soils containing grass, roots and other vegetation shall be stripped from all areas to be graded and removed from the site. This material is not to be reused as compacted fill.

2.3 Overexcavation - In areas to be filled, localized overexcavation of soft, loose or cracked soils may be required as directed by the Soil Engineer. Generally, the excavated material will be suitable for reuse as compacted fill.

2.4 Scarification and Recompaction - After stripping, surfaces to receive fills shall be scarified to a depth of eight inches, moisture conditioned to a moisture content suitable for compaction and compacted to 90 percent relative compaction.

2.5 Approval - After stripping and overexcavation and before placing or replacing fill, the Contractor shall obtain the Soil Engineer's approval of the site preparation in each area to be filled.

## 3.0 FILL MATERIAL

3.1 On-Site Material - On-site soil can be used for fill material provided it is free of debris, organic material and rocks over six inches in maximum dimension. Unsuitable material encountered in excavations shall be removed from the site.

3.2 Imported Material - Imported material shall be free from organic matter and debris and shall conform to the following gradation:

| Sieve Size | Percent Passing |
|---|---|
| 4 inches | 100 |
| 1-1/2 inches | 60 - 100 |

The Contractor shall submit a representative sample of import material to the Soil Engineer for laboratory tests, at least

two days prior to hauling. All import material must be approved by the Soil Engineer prior to hauling to the site.

## 4.0 COMPACTED FILL

4.1 Placement and Compaction - Approved fill material shall be placed in layers eight inches or less in loose thickness and moisture conditioned as necessary to achieve a moisture content suitable for compaction. Fill material shall be compacted with sheepsfoot rollers or other suitable equipment to obtain at least 90 percent relative compaction.

4.2 Recompaction - Where test results or performance of the fill indicate that the moisture content is not suitable, or insufficient compaction has been obtained, the fill shall be reconditioned and recompacted to the required density prior to placing additional fill material. The Contractor shall be responsible for placing and compacting approved fill material in accordance with these specifications. If the Contractor fails to meet the compaction requirements, he shall stop hauling or reduce his rate of haul, furnish additional spreading, watering and/or compaction equipment, or make any other adjustments necessary to produce a satisfactory compacted fill. When the work is stopped by rain, filling shall not resume until the Soil Engineer has verified that the moisture content and density of the fill surface are satisfactory.

4.3 Benching - Where fill is placed on slopes steeper than five horizontal to one vertical the fill shall be started on a level bench excavated at the toe of the slope. As the fill progresses, it shall be continuously keyed into the natural slope by excavating a series of level benches and compacting the fill in them.

4.4 Drainage - During construction, all fill surfaces shall be sloped to provide positive surface drainage and to prevent ponding of water. If it appears that rainy weather is imminent, the Contractor shall roll the surface with smooth rollers or rubber-tired equipment to seal the surface against excessive infiltration of water. Temporary surface drains and ditches shall be provided by the Contractor as necessary to expedite runoff and/or prevent erosion.

5.0 SLOPES AND FINAL GRADING

5.1 Final Slopes - Upon completion of the compacted fill, all loose material shall be removed from the slopes and the slopes shall be trimmed or compacted to expose a dense, uniform surface.

5.2 Final Grading - All fill surfaces shall be graded to uniform slopes in accordance with the grades shown on the drawings so as to drain readily. All surfaces should be graded smooth, low spots filled in and rolled with rubber-tired equipment to seal the surface against infiltration of water.

## 6.0 STRUCTURAL AND UTILITY TRENCH BACKFILL

6.1 Backfill Material - Backfill material shall conform to the requirements for general site fill as specified in Section 3.0.

6.2 Compaction - Backfill material shall be placed in horizontal, uniform layers six inches or less in loose thickness, moisture conditioned to a moisture content suitable for compaction, and compacted to at least 90 percent relative compaction. Flooding or jetting methods of compaction shall not be used.

## 7.0 PAVEMENT SUBGRADE

At the completion of all utility trench backfilling, and prior to placing aggregate base material, the subgrade surface shall be scarified to a depth of six inches, moisture conditioned to a moisture content suitable for compaction and compacted to 95 percent relative compaction. The subgrade surface shall be approved by the Soil Engineer prior to placing aggregate base material.

## 8.0 AGGREGATE BASE AND SUBBASE

Aggregate base and subbase shall be placed in accordance with the City and County of Honolulu's "Standard Specifications for Public Works Construction", November, 1968.

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