SOILS AND FOUNDATION INVESTIGATION

PROPOSED KAONOHI RIDGE DEVELOPMENT
PEARL CITY, OAHU, HAWAII

FOR

KAONOHI RIDGE PARTNERS

Dames & Moore Job No. 4431-014-11
September 19, 1973

Kaonohi Ridge Partners
c/o Amfac Financial Corporation
700 Bishop Street, 16th Floor
Honolulu, Hawaii 96813

Attention: Mr. Teney K. Takahashi

Gentlemen:

Submitted herewith are four copies of our report entitled "Soils and Foundation Investigation, Proposed Kaonohi Ridge Development, Pearl City, Oahu, Hawaii, For Kaonohi Ridge Partners."

The scope of our work was outlined in our proposal dated June 12, 1973, and our work has been conducted accordingly.

The subsurface soil and rock samples obtained from the field exploration are being stored at our office for possible future examination. These samples will be discarded after a period of six months from the date of this report unless otherwise instructed.

If you have any questions regarding the content of this report, please contact us.

Yours very truly,

DAMES & MOORE

W. E. Estes

WEE:RGH:PWC:my
SOILS AND FOUNDATION INVESTIGATION
PROPOSED KAONOHI RIDGE DEVELOPMENT
PEARL CITY, OAHU, HAWAII
FOR
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INTRODUCTION

GENERAL

This report presents the results of our soils and foundation investigation for the proposed condominium development at Kaonohi Ridge.

The investigation consisted of a geologic reconnaissance, subsurface borings, laboratory testing, and engineering analyses as outlined in our proposal dated June 12, 1973.

The purpose of this report is to provide foundation design information based on the existing site conditions and the proposed development.

PROJECT CONSIDERATIONS

The site is located on approximately 5.5 acres of land on the eastern slope of Kaonohi Ridge at the end of Iho Street, Pearl City, Oahu, Hawaii, Tax Map...
Key 9-8-11, Parcel 42. The property is bounded by an existing dirt and paved access road leading to a Board of Water Supply pump station. The general location of the site is shown on the Map of Area, Plate 1.

The proposed development has been revised during our work on the project. Initially, 265 units in 6 main buildings and associated parking structures were planned. The buildings were to be 4-, 6-, and 7-story with three 12-story units along the lower portion of the property.

Present plans call for 5 buildings having 8, 9, 13, 14, and 15 stories, and 3 parking structures having 2, 3, and 4 levels. It is our understanding that the taller structures will be along the lower position of the site.

The condominium structures are planned to be supported on continuous spread wall footings having a maximum load which will not exceed 40 kips per lineal foot for the 3 tallest structures, and 25 kips per lineal foot for the 2 smaller structures. The parking structures will be supported on exterior continuous wall footings and interior individual column footings. The parking structures will have relatively light loads.

Generally, site grading will be minimal, consisting of cuts less than 10 feet (vertical), with 2
horizontal to 1 vertical slopes. However, a vertical cut approximately 20 feet high is proposed for the parking structure access ramp.

Fills for the project is limited to backfill behind walls and retaining structures.

SITE CONDITIONS

SURFACE CONDITIONS

Generally, the site slopes downward to the southeast, ranging in elevation from approximately 290 feet to 150 feet (MSL Datum). The average existing slope is approximately 2 horizontal to 1 vertical.

A service road beginning at the cul-de-sac on Iho Street and extending to the Kalauao Pump Station forms the north, west and south property boundaries. The site is covered with moderate to dense groves of Hale Koa trees and other brush and tall grass. Loose boulders to four feet in diameter and almost vertical rock outcrops were observed.

Uphill and to the north of the property, an existing reservoir is being reconditioned. The reservoir is constructed on alluvial silt deposits which occur near the ridge top.
GEOLOGY

The regional geology of the site is dominated by the basalt flows of the Koolau Volcanic Series, which have been dissected by stream erosion. Grey, dense, vesicular basalt varying from fresh to highly weathered makes up the base rock at the site.

The site is located on the southeast flank of the ridge, formed by a valley which has been cut into the basalt by Kalauao Stream. Basalt and residual soils occur on the surface throughout most of the site. At the lower (northeast) end of the site, stream deposits were observed. These deposits included highly weathered boulders in a clay-silt matrix, which shows some evidence of desication.

The basalt flows underlying the proposed structures consist of both Aa and Pahoehoe with possibly some interlayering of the two types. The flows generally vary in thickness from approximately 2 feet to more than 20 feet.

Subtropical conditions have caused on-site weathering of the basalt flows. At the surface, the weathering is complete, as expressed by the red silt soils which cover the basalt over much of the site. The thickness of this weathered zone varied from
approximately one to three feet; however, numerous rock outcrops were observed.

A Surface Geologic Map is presented on Plate 3.

**SUBSURFACE CONDITIONS**

The subsurface exploration program indicated that the site is covered by a thin veneer of red silt with some boulders, and is underlain by layered basalt rock and uncemented clinker material derived from a series of lava flows. The basalt rock is predominantly Aa lava, which characteristically has a dense core of hard grey vesicular basalt overlain and underlain by relatively uncemented clinker material. The clinker zones varied considerably in thickness from approximately 1 foot to 13 feet, while the hard grey basalt core varied from approximately 2 feet to more than 20 feet in thickness.

The Pahoehoe lava rock was generally deposited in wider flows, with varying thicknesses due to ponding in lower areas. Thickness from approximately 3 feet to over 20 feet were encountered. The Pahoehoe flows consisted of hard, dense, vesicular, unweathered to moderately weathered basalt.

Groundwater was not encountered in any of the borings during our exploration program. Some water was observed in the downhill holes; however, this was due to...
the drilling water used during coring. After drilling was completed, the holes were checked again and all were dry.

A summary of our field investigation and the boring logs are presented in Appendix A. The approximate boring locations are shown on the Site Plan, Plate 2. General subsurface conditions are illustrated on the cross-section presented on Plates 3, 4 and 5.

ENGINEERING RECOMMENDATIONS

Based on the results of the field investigation, laboratory testing and engineering analyses, the following conclusions and recommendations are presented.

GENERAL

The exploration program disclosed generally highly variable subsurface conditions across the site; however, competent basalt layers were encountered at reasonably shallow depths in all borings. From a soils and foundation engineering viewpoint, the site is suitable for the proposed development, provided our recommendations are followed. With proper site preparation and construction methods, continuous wall footings may be utilized for the condominium structures, and individual column spread footing may be utilized for the lightly loaded parking structures.
It is our opinion that the underlying basalts encountered on the site are capable of supporting the proposed structures.

SITE GRADING

1) **Clearing and Grubbing** - All deleterious material, i.e., vegetation, topsoil, existing fill, etc., should be removed from the construction areas.

2) **Unsupported Fills** - Unsupported fills are not recommended due to the relative steepness of the existing slopes.

3) **Fill Material** - Generally, the on-site soils are not suitable for compacted fill behind walls and retaining structures. Imported fill material should be free draining, granular material with less than 5 percent passing the No. 200 mesh sieve. All imported fill material should be tested and approved by the soils engineer prior to use.

4) **Structural Fill Placement** - Structural fills should consist of approved fill material placed in maximum 8-inch lifts, and compacted to 90 percent relative compaction using ASTM D-1557-70 as a standard. All lifts must be placed in horizontal layers, or slightly dipping into the hillside.
5) **Excavations** - Permanent cuts having the following maximum slope may be utilized:

<table>
<thead>
<tr>
<th>Material</th>
<th>Maximum Slope</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hard grey basalt (Unweathered)</td>
<td>1/2 horizontal : 1 vertical</td>
</tr>
<tr>
<td>Moderately soft basalt (moderately weathered)</td>
<td>1 horizontal : 1 vertical</td>
</tr>
<tr>
<td>Clinker material and natural soil</td>
<td>2 horizontal : 1 vertical</td>
</tr>
</tbody>
</table>

All cuts which have a clinker or soil layer over a basalt layer should have a minimum horizontal bench of three feet at the toe of the clinker layer.

Benches for drainage terraces for erosion control are not necessary, provided the proposed drainage system can handle the runoff from the slope. If drainage terraces are not utilized, the exposed cinder layers should be gunited; however, sufficient weepholes or other means to prevent hydrostatic pressure build-up should be provided.

6) **Drainage** - Provisions for well designed and maintained site drainage, both during and after completion of the construction, should be implemented. Water should not be allowed to pond in the excavations.

7) **Inspection** - A site inspection by an engineering geologist from our firm should be made as soon as the site is cleared and grubbed, so that the surface geology may be more thoroughly mapped.
Inspection and testing during grading should also be performed under the supervision of the soils engineer.

**FOUNDATIONS**

Continuous wall footings may be utilized for the proposed 8- to 15-story condominium structures. Spread and/or continuous footings may be used for the proposed parking structures. All footings must be founded in hard grey basalt, and must meet all the following criteria:

<table>
<thead>
<tr>
<th>Design Criteria</th>
<th>13 to 15 story structures</th>
<th>8 and 9 story structures</th>
<th>2 and 4 story parking structures</th>
</tr>
</thead>
<tbody>
<tr>
<td>Minimum footing embedment (below adjacent ground or slab surface)</td>
<td>36 inches</td>
<td>36 inches</td>
<td>24 inches</td>
</tr>
<tr>
<td>Minimum socket into hard grey basalt</td>
<td>18 inches</td>
<td>12 inches</td>
<td>6 inches</td>
</tr>
<tr>
<td>Minimum thickness of basalt beneath footing base</td>
<td>5 feet</td>
<td>3 feet</td>
<td>3 feet</td>
</tr>
<tr>
<td>Minimum width of footing</td>
<td>36 inches</td>
<td>24 inches</td>
<td>18 inches</td>
</tr>
<tr>
<td>Minimum horizontal distance from slope face</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(measured at base of footing)</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

A maximum allowable bearing capacity of 14 kips per square foot may be used for design. This value may be increased by 1/3 for short duration wind or seismic loading conditions.
Step footings may be utilized with the following restrictions. The step must be poured monolithically for a minimum distance of three feet on the lower footing, and five feet on the upper footing. Step footings which start in one basalt flow and step up to another flow must have a minimum footing length of 10 feet between steps. Footings which step up within the same homogeneous basalt flow may have a horizontal to vertical ratio varying from 2 horizontal : 1 vertical to 4 horizontal : 1 vertical.

The above requirements are illustrated on Plate 7, Footing Design Criteria. Drainage should be designed in such a manner that surface water is diverted away from footing areas.

Total settlements for the structures should not exceed 1 inch, and differential settlements should be less than 3/4 inch. All buildings should be structurally separated since they will be bearing on different basalt layers.

Lightly loaded miscellaneous structures, i.e., low retaining walls, may have footings founded on dense cinder material. These footings may be designed for a maximum allowable bearing pressure of 3000 pounds per square foot. The footings must be at least 24 inches below adjacent ground or slab surfaces, and at least 12
Inches into the dense cinder material. The footings should have a minimum width of 18 inches, and should be set back at least 5 feet from the slope face at the base of the footing. Footings for the proposed building and parking structures cannot be founded on the cinder material. The on-site silts and clays are not suitable for structural support.

All footing excavations must be inspected during construction, and approved by the soils engineer or his representative in order to evaluate the existing conditions and to verify that our recommendations are being carried out, and to make revisions where appropriate. Footing elevations will have to be determined during construction based on actual field conditions. The importance of inspection during the foundation construction phase of this project cannot be overemphasized.

LATERAL EARTH PRESSURE

Retaining walls with horizontal backfill should be designed for an equivalent fluid pressure of 35 pounds per cubic foot, provided only moderate compaction of the backfill is required. If a high degree of backfill compaction is necessary (e.g., adjacent roadway, etc.), or the walls cannot yield slightly during placement of
backfill, an equivalent fluid pressure of 75 pounds per cubic foot should be used for design. These values assume a minimum of three feet (horizontal) of free draining, granular backfill behind the walls.

Surcharge due to adjacent footings, hydrostatic pressure, construction equipment, etc., must be added to the above values. We recommend that an efficient drainage system be designed for all walls to prevent any hydrostatic pressure build-up.

Resistance to lateral movement can be obtained by passive pressures and frictional resistance. An equivalent fluid pressure of 250 pounds per cubic foot may be used for design; however, the upper 18 inches of material must not be included in the calculations. A friction coefficient of 0.4 may be used between concrete and basalt, and 0.3 may be used between concrete and clinker material.

Any retaining structures having a vertical height greater than 15 feet should be analyzed on an individual basis.

SLOPE STABILITY

Generally, slope stability is not considered to be a problem at this site, provided that all our recommendations are followed. The existing slopes consist
of relatively horizontal lava flows, and rise at an approximate average slope of 2 horizontal to 1 vertical, and are considered to be stable.

There is some danger of individual loose surface boulders rolling down the slopes. These boulders should be removed during the clearing and grubbing operation.

ADDITIONAL ENGINEERING SERVICES

Design Review - Grading, foundation and retaining wall plans, with design data, should be forwarded to the soils engineer for review and comments prior to finalizing the design.

Additional Investigation - After the site has been cleared and graded, additional investigation consisting of probing to determine depths to and thickness of the basalt may be advantageous. A more accurate delineation of the bearing surface elevations could affect substantial construction cost savings.

Construction Inspection - It is our opinion that a comprehensive construction inspection program, under the supervision of the soils engineer, is necessary during the grading, foundation, and retaining wall construction portions of the project.
The following Plates and Appendices are attached and complete this report.

Plate 1 - Map of Area
Plate 2 - Site Plan
Plate 3 - Surface Geologic Map
Plate 4 - Generalized Subsurface Cross-section A-A
Plate 5 - Generalized Subsurface Cross-section B-B
Plate 6 - Generalized Subsurface Cross-section C-C
Plate 7 - Footing Design Criteria
Appendix A - Field Exploration
Appendix B - Laboratory Testing

Respectfully submitted,

DAMES & MOORE

[Signature]
W. E. Estes

[Stamp: W. E. ESTES]
[Stamp: REGISTERED PROFESSIONAL ENGINEER]
[Stamp: No. 2171]
[HAWAII, U.S.A.]

THIS WORK WAS PREPARED BY ME OR UNDER MY SUPERVISION

[Signature]
MAP OF AREA
CONTINUOUS FOOTING DESIGN CRITERIA

NOT TO SCALE

This section must be poured monolithically

<table>
<thead>
<tr>
<th></th>
<th>13, 14 &amp; 15 Story Bldg.</th>
<th>8 &amp; 9 Story Bldg.</th>
<th>2, 3 &amp; 4 Level Parking Structure</th>
</tr>
</thead>
<tbody>
<tr>
<td>Footing Imbedment</td>
<td>36 in.</td>
<td>36 in.</td>
<td>24 in.</td>
</tr>
<tr>
<td>Footing Socketing</td>
<td>18 in.</td>
<td>12 in.</td>
<td>6 in.</td>
</tr>
<tr>
<td>Footing Setback SB</td>
<td>5 ft.</td>
<td>5 ft.</td>
<td>5 ft.</td>
</tr>
<tr>
<td>Basalt Thickness</td>
<td>5 ft.</td>
<td>3 ft.</td>
<td>3 ft.</td>
</tr>
<tr>
<td>Footing Length L</td>
<td>10 ft.</td>
<td>8 ft.</td>
<td>-</td>
</tr>
<tr>
<td>Vertical Step D</td>
<td>Var.</td>
<td>Var.</td>
<td>-</td>
</tr>
</tbody>
</table>

For step footings within a uniform layer of gray basalt a ratio of L/D = 2 to 4 may be used.
For step footings which traverse from one basalt layer to another, the minimum length (L) criteria is applicable.
APPENDIX A

FIELD EXPLORATION

The field exploration program consisted of a geologic site reconnaissance and subsurface boring program. Twenty borings ranging in depth from 23.5 to 50.0 feet were drilled between July 19 and August 23, 1973. Two of the borings originally proposed, B-17 and B-21, were omitted. The drilling was accomplished using two CP-15 air mobile skid-type drill rigs. Rotary drilling equipment with NX and four-inch diameter core barrels with diamond and carbide bits were used to advance the hole. Due to the poor access to boring location, the drill rigs were moved by helicopter lifts.

The drilling operation was performed under the continuous supervision of an engineer or geologist from our firm. Our field representative maintained a log of boring, and made observations of pertinent conditions affecting the proposed construction.

The approximate boring locations are shown on the Site Plan, Plate 2. The Logs of Borings, including a description of the material encountered and

DAMES & MOORE
other pertinent information, are presented on Plates A-1 through A-20.

All samples were classified according to the Unified Soil Classification System. Rock cores were described by geologic nomenclature commonly used for volcanic rocks. Samples obtained were crated and returned to our laboratory for inspection and testing.

Datum for elevations is Mean Sea Level (MSL).
The following Plates are attached and complete this Appendix.

Plate A-1 - Log of Borings, Boring No. 1
Plate A-2 - Log of Borings, Boring No. 2
Plate A-3 - Log of Borings, Boring No. 3
Plate A-4 - Log of Borings, Boring No. 4
Plate A-5 - Log of Borings, Boring No. 5
Plate A-6 - Log of Borings, Boring No. 6
Plate A-7 - Log of Borings, Boring No. 7
Plate A-8 - Log of Borings, Boring No. 8
Plate A-9 - Log of Borings, Boring No. 9
Plate A-10 - Log of Borings, Boring No. 10
Plate A-11 - Log of Borings, Boring No. 11
Plate A-12 - Log of Borings, Boring No. 12
Plate A-13 - Log of Borings, Boring No. 13
Plate A-14 - Log of Borings, Boring No. 14
Plate A-15 - Log of Borings, Boring No. 15
Plate A-16 - Log of Borings, Boring No. 16
Plate A-17 - Log of Borings, Boring No. 18
Plate A-18 - Log of Borings, Boring No. 19
Plate A-19 - Log of Borings, Boring No. 20
Plate A-20 - Log of Borings, Boring No. 22
BORING 1

SURFACE ELEVATION 179 FEET
MSL Datum

<table>
<thead>
<tr>
<th>MOISTURE CONTENT in %</th>
<th>DENSITY IN PC</th>
<th>CORE &amp; % RECOVERY</th>
<th>SAMPLES AND % RECOVERY</th>
<th>DEPTH IN FEET</th>
<th>LETTER SYMBOL</th>
<th>DESCRIPTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>158</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>GRAY VESICULAR BASALT, HARD, MODERATELY JOINTED (FRESH AA CORE)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>GRADING TO SEVERELY JOINTED</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>RED-BROWN CLINKER, MODERATELY HARD, SEVERELY JOINTED, SEVERELY WEATHERED</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>GRADING WITH MUCH SILT</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>GRAY VESICULAR BASALT, HARD, SLIGHTLY JOINTED, FRESH (AA CORE WITH ZONES OF SEVERE WEATHERING)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>GH</td>
<td>BROWNISH GRAY BASALT GRAVEL, DENSE (DERIVED FROM SEVERELY WEATHERED CLINKERS CONTAINING RED INTERSTICIAL SILT)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>GRAY VESICULAR BASALT, HARD, MODERATELY JOINTED, FRESH (AA CORE)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>15% VESICLES</td>
</tr>
</tbody>
</table>

Boring completed at 40.5 feet on 7-19-73
No water encountered

LOG OF BORINGS

NOTES:
- Depth at which undisturbed sample was taken
- Depth at which disturbed sample was taken
- Depth at which sample was lost during extraction
- Depth and length of core run
- Driving energy: 300 lb weight dropping 30 inches
BORING 2

SURFACE ELEVATION 175 FEET
MNL DATUM

DESCRIPTION

MORISH RED OILY SILT, CONTAINS OCCASIONAL BASALT COBBLES, STIFF

DARK BROWN SILT CLAY, HARD

BROWN AND GRAY CLINKERS, HARD, MODERATELY JOINTED, MODERATELY WEATHERED

GRAY MASSIVE BASALT, VERY HARD, SLIGHTLY JOINTED (FRESH AA CORE)

GRADING TO MODERATELY JOINTED
GRADING TO MASSIVE

GRADING WITH 4" DECOMPOSED BEAM AT 15.5 FEET

RED AND GRAY CLINKERS, MODERATELY HARD, SEVERELY JOINTED, SEVERELY WEATHERED

GRADING TO MODERATELY WEATHERED

GRADING TO FRESH

GRADING TO SEVERELY WEATHERED

GRAY MODERATELY VESICULAR BASALT, HARD, MODERATELY JOINTED (FRESH AA CORE)

BORING COMPLETED AT 35.0 FEET ON 7-18-73
NO WATER ENCOUNTERED

LOG OF BORINGS

NOTES:

- DEPTH AT WHICH UNDISTURBED SAMPLE WAS TAKEN
- DEPTH AT WHICH DISTURBED SAMPLE WAS TAKEN
- DEPTH AT WHICH SAMPLE WAS LOST DURING EXTRACTION
- DEPTH AND LENGTH OF CORE RUN

DRIVING ENERGY- 300 -LB WEIGHT DROPPING 30 INCHES
### BORING 3

**Surface Elevation**: 180 Feet  
**MSL Datum**

<table>
<thead>
<tr>
<th>Depth in Feet</th>
<th>Letter Symbol</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>MH</td>
<td>Dark brown clayey silt with some gravel and boulders, stiff</td>
</tr>
<tr>
<td>10</td>
<td>RQD 72% NX 86%</td>
<td>Gray and brown slightly vesicular basalt, hard, slightly jointed, moderately weathered (AA core) grading to hard 1&quot; brown silt seam</td>
</tr>
<tr>
<td>15</td>
<td>RQD 87% NX 100%</td>
<td>Gray basaltic sandy gravel, dense (derived from very severely weathered clinkers)</td>
</tr>
<tr>
<td>20</td>
<td>RQD 50% NX 80%</td>
<td>Gray massive basalt, hard, moderately jointed, weathered, fresh (AA core)</td>
</tr>
<tr>
<td>20</td>
<td>RQD 65% NX 95%</td>
<td>Brownish gray clinkers, moderately jointed, moderately weathered</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Gray slightly vesicular basalt, moderately hard, moderately jointed, slightly weathered (AA core)</td>
</tr>
</tbody>
</table>

Boring completed at 23.5 feet on 7-23-73  
No water encountered

### LOG OF BORINGS

- **□**: Depth at which undisturbed sample was taken  
- **◆**: Depth at which disturbed sample was taken  
- **◯**: Depth at which sample was lost during extraction  
- **I**: Depth and length of core run

**Driving Energy**: 300-lb weight dropping 30 inches
<table>
<thead>
<tr>
<th>Depth (ft)</th>
<th>Material Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>25</td>
<td>Red silt, stiff</td>
</tr>
<tr>
<td></td>
<td>Grading with some sand and gravel</td>
</tr>
<tr>
<td></td>
<td>Derived from basalt lava</td>
</tr>
<tr>
<td>166</td>
<td>Gray massive basalt, hard, moderately jointed, slightly weathered (AA core)</td>
</tr>
<tr>
<td></td>
<td>Red vesicular clinkers, severely jointed, severely weathered</td>
</tr>
<tr>
<td>25%</td>
<td>Grading to moderately jointed and weathered</td>
</tr>
<tr>
<td>25%</td>
<td>Grading to highly vesicular</td>
</tr>
<tr>
<td>63%</td>
<td>Gray massive slightly vesicular basalt, very hard (Pahoehoe core)</td>
</tr>
<tr>
<td>100%</td>
<td>Grading with 10% vesicles</td>
</tr>
<tr>
<td>100%</td>
<td>Grading with a trace of vesicles</td>
</tr>
</tbody>
</table>

Boring completed at 26.0 feet on 7-23-73
No water encountered

**NOTES:**
- Depth at which undisturbed sample was taken
- Depth at which disturbed sample was taken
- Depth at which sample was lost during extraction
- Depth and length of core run
- Driving energy - 300-lb weight dropping 30 inches
NOTES:

- Depth at which undisturbed sample was taken
- Depth at which disturbed sample was taken
- Depth and length of core run
- Driving energy
- Depth at which water encountered
- No water encountered

LOG OF BORINGS

Boring completed at 29.5 feet on 7-30-73
No water encountered

Moisture content in %

Dry density in PCF

Blows/ft. on sampler

Core and % recovery

Samples and/or cores

Depth in feet

Graph symbol

Letter symbol

BORING

Surface elevation: 208 feet

M B B.Datum

1. SURFACE ELEVATION: 208 FEET
2. CORE AND % RECOVERY
3. SAMPLES AND/OR CORES
4. DEPTH IN FEET
5. GRAPH SYMBOL
6. LETTER SYMBOL

Boring completed at 29.5 feet on 7-30-73
No water encountered

Gray dense basalt, massive, fresh (AA core)

Reddish brown silty sandy gravel, dense (derived from weathered clinker)

Brownish gray vesicular basalt, hard

Reddish gray gravel, medium dense (derived from decomposed AA basalt)

Gray vesicular basalt, hard

Reddish gray clinker, slightly jointed, moderately weathered

Brown-gray vesicular basalt, hard, slightly jointed, moderately weathered

Reddish gray clinker, severely weathered

Brown-gray vesicular basalt, hard, severely weathered

Reddish gray clinker, severely weathered

Brown-gray silty gravel, medium dense (derived from weathered clinker)

Boring completed at 29.5 feet on 7-30-73
No water encountered

Description

Moisture content in %

Dry density in PCF

Blows/ft. on sampler

Core and % recovery

Samples and/or cores

Depth in feet

Graph symbol

Letter symbol

BORING

Surface elevation: 208 feet

M B B.Datum

1. SURFACE ELEVATION: 208 FEET
2. CORE AND % RECOVERY
3. SAMPLES AND/OR CORES
4. DEPTH IN FEET
5. GRAPH SYMBOL
6. LETTER SYMBOL

Boring completed at 29.5 feet on 7-30-73
No water encountered

Gray dense basalt, massive, fresh (AA core)

Reddish brown silty sandy gravel, dense (derived from weathered clinker)

Brownish gray vesicular basalt, hard

Reddish gray gravel, medium dense (derived from decomposed AA basalt)

Gray vesicular basalt, hard

Reddish gray clinker, slightly jointed, moderately weathered

Brown-gray vesicular basalt, hard, slightly jointed, moderately weathered

Reddish gray clinker, severely weathered

Brown-gray vesicular basalt, hard, severely weathered

Reddish gray clinker, severely weathered

Brown-gray silty gravel, medium dense (derived from weathered clinker)
<table>
<thead>
<tr>
<th>Depth (ft)</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-5</td>
<td>Reddish brown clayey silt with a trace of basalt gravel, medium stiff</td>
</tr>
<tr>
<td>5-15</td>
<td>Red-brown slightly vesicular basalt, medium hard, slightly jointed, moderately weathered (pahoehoe lava)</td>
</tr>
<tr>
<td>15-20</td>
<td>Grading to moderately vesicular and slightly weathered</td>
</tr>
<tr>
<td>20-25</td>
<td>Grading to massive and hard</td>
</tr>
<tr>
<td>25-30</td>
<td>Red and gray clinker, severely jointed, severely weathered</td>
</tr>
<tr>
<td>30-35</td>
<td>Gray slightly vesicular basalt, moderately hard, moderately jointed, moderately weathered (a core)</td>
</tr>
<tr>
<td>35-40</td>
<td>Gray slightly vesicular clinker, moderately jointed, moderately weathered</td>
</tr>
<tr>
<td>40</td>
<td>Grading to severely jointed</td>
</tr>
<tr>
<td>40-45</td>
<td>Gray vesicular basalt gravel, dense (derived from aa clinker)</td>
</tr>
<tr>
<td>45-50</td>
<td>Grading with some sand and silt</td>
</tr>
<tr>
<td>50-55</td>
<td>Brownish gray very vesicular basalt, medium hard, severely jointed, severely weathered (pahoehoe lava)</td>
</tr>
<tr>
<td>55-60</td>
<td>30% vesicles</td>
</tr>
<tr>
<td>60</td>
<td>Brownish gray vesicular basalt gravel, dense, containing a trace of silt and sand (derived from pahoehoe lava)</td>
</tr>
<tr>
<td>60-65</td>
<td>Brown very vesicular basalt, moderately hard, severely jointed, severely weathered (pahoehoe lava)</td>
</tr>
</tbody>
</table>

Boring completed at 40.0 feet on 7-26-73. No water encountered.

**LOG OF BORINGS**

NOTES:
- ☐ Depth at which undisturbed sample was taken
- ☐ Depth at which disturbed sample was taken
- ☐ Depth at which sample was lost during extraction
- ☐ Depth and length of core run
- Driving Energy: 300-lb weight dropping 30 inches
<table>
<thead>
<tr>
<th>Depth in Feet</th>
<th>Core and/or Core Recovery</th>
<th>MHW</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>REDDISH BROWN CLAYEY SILT WITH SOME GRAVEL, MEDIUM STIFF</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>GRAY SLIGHTLY VESICULAR BASALT, VERY HARD, MASSIVE (FRESH AA CORE)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>GRADING TO SEVERELY JOINTED</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>GRADING TO MODERATELY JOINTED AND WEATHERED</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>GRADING TO MASSIVE AND FRESH</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>GRADING TO SEVERELY JOINTED</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>GRADING TO MODERATELY JOINTED</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>REDDISH GRAY AA CLINKERS, SEVERELY BROKEN, SEVERELY WEATHERED, WITH MODERATE AMOUNTS OF GRAVEL-SIZED PIECES</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>GRADING TO RED</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>ORANGE GRAY VESICULAR AA CLINKER, SEVERELY BROKEN, SEVERELY WEATHERED</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>GRADING WITH MANY GRAVEL-SIZED PIECES</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>ORANGE AND GRAY SANDY GRAVEL, MEDIUM DENSE, SEVERELY WEATHERED (DERIVED FROM AA CLINKER)</td>
</tr>
</tbody>
</table>

Boring completed at 46.8 feet on 7-26-73
No water encountered

LOG OF BORINGS

NOTES:
- Depth at which undisturbed sample was taken
- Depth at which disturbed sample was taken
- Depth at which sample was lost during extraction
- Depth and length of core run
Driving energy: 300-lb weight dropping 30 inches
## BORING 8

<table>
<thead>
<tr>
<th>Depth in Feet</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 - 5</td>
<td>REDDISH BROWN CLAYEY SILT, MEDIUM STIFF (DERIVED FROM WEATHERED BASALT)</td>
</tr>
<tr>
<td>5 - 10</td>
<td>GRAY SLIGHTLY VESICULAR BASALT, HARD, MODERATELY JOINTED, FRESH (AA CORE)</td>
</tr>
<tr>
<td>10 - 15</td>
<td>GRADING WITH A TRACE OF WEATHERING IN JOINTS</td>
</tr>
<tr>
<td>15 - 20</td>
<td>GRAYISH RED CLINKERS, JOINTED, MODERATELY WEATHERED</td>
</tr>
<tr>
<td>20 - 25</td>
<td>GRADING TO SEVERELY JOINTED</td>
</tr>
<tr>
<td>25 - 30</td>
<td>REDDISH GRAY SANDY GRAVEL, DENSE, SEVERELY WEATHERED (VERY SEVERELY BROKEN CLINKERS)</td>
</tr>
<tr>
<td>30 - 35</td>
<td>GRAY MASSIVE VESICULAR BASALT, HARD, JOINTED, FRESH (AA CORE)</td>
</tr>
<tr>
<td>35 - 40</td>
<td>GRADING TO SEVERELY JOINTED, MODERATELY WEATHERED</td>
</tr>
<tr>
<td>40 - 45</td>
<td>GRADING TO MODERATELY JOINTED</td>
</tr>
<tr>
<td>45 - 50</td>
<td>REDDISH GRAY SANDY GRAVEL, DENSE (DERIVED FROM SEVERELY WEATHERED CLINKERS)</td>
</tr>
<tr>
<td>50 - 55</td>
<td>GRAY VESICULAR BASALT, MODERATELY JOINTED, SLIGHTLY WEATHERED (AA LAVA)</td>
</tr>
<tr>
<td>55 - 60</td>
<td>GRADING TO MODERATELY WEATHERED</td>
</tr>
<tr>
<td>60 - 65</td>
<td>GRADING TO SEVERELY JOINTED</td>
</tr>
<tr>
<td>65 - 70</td>
<td>REDDISH BROWN SILTY GRAVEL (DERIVED FROM WEATHERED CLINKERS)</td>
</tr>
<tr>
<td>70 - 75</td>
<td>BROWNISH GRAY VESICULAR BASALT, MODERATELY HARD, MODERATELY JOINTED, MODERATELY WEATHERED (AA LAVA)</td>
</tr>
</tbody>
</table>

### LOG OF BORINGS

- **Surface Elevation**: 210 Feet
- **MSL Datum**: 210 Feet

<table>
<thead>
<tr>
<th>Moisture Content in %</th>
<th>Blows/ft. on Sampler</th>
<th>Core and % Recovery</th>
<th>Depth in Feet</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>RQD 50%</td>
<td>NX 81%</td>
<td>10</td>
<td>0</td>
<td>REDDISH BROWN CLAYEY SILT, MEDIUM STIFF (DERIVED FROM WEATHERED BASALT)</td>
</tr>
<tr>
<td>RQD 60%</td>
<td>NX 100%</td>
<td>10</td>
<td>5</td>
<td>GRAY SLIGHTLY VESICULAR BASALT, HARD, MODERATELY JOINTED, FRESH (AA CORE)</td>
</tr>
<tr>
<td>RQD 40%</td>
<td>NX 96%</td>
<td>10</td>
<td>10</td>
<td>GRADING WITH A TRACE OF WEATHERING IN JOINTS</td>
</tr>
<tr>
<td>RQD 30%</td>
<td>NX 56%</td>
<td>10</td>
<td>15</td>
<td>GRAYISH RED CLINKERS, JOINTED, MODERATELY WEATHERED</td>
</tr>
<tr>
<td>RQD 95%</td>
<td>NX 100%</td>
<td>10</td>
<td>20</td>
<td>GRADING TO SEVERELY JOINTED</td>
</tr>
<tr>
<td>RQD 4%</td>
<td>NX 100%</td>
<td>10</td>
<td>25</td>
<td>REDDISH GRAY SANDY GRAVEL, DENSE (DERIVED FROM SEVERELY WEATHERED CLINKERS)</td>
</tr>
<tr>
<td>RQD 17%</td>
<td>NX 100%</td>
<td>10</td>
<td>30</td>
<td>GRAY VESICULAR BASALT, MODERATELY JOINTED, SLIGHTLY WEATHERED (AA LAVA)</td>
</tr>
<tr>
<td>RQD 72%</td>
<td>NX 100%</td>
<td>10</td>
<td>35</td>
<td>GRADING TO MODERATELY WEATHERED</td>
</tr>
<tr>
<td>RQD 9%</td>
<td>NX 75%</td>
<td>10</td>
<td>40</td>
<td>GRADING TO SEVERELY JOINTED</td>
</tr>
<tr>
<td>RQD 84%</td>
<td>NX 75%</td>
<td>10</td>
<td>45</td>
<td>REDDISH BROWN SILTY GRAVEL (DERIVED FROM WEATHERED CLINKERS)</td>
</tr>
<tr>
<td>RQD 0%</td>
<td>NX 75%</td>
<td>10</td>
<td>50</td>
<td>BROWNISH GRAY VESICULAR BASALT, MODERATELY HARD, MODERATELY JOINTED, MODERATELY WEATHERED (AA LAVA)</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**
- **-DEPTH AND LENGTH OF CORE RUN**

**Driving Energy**: 300 - LB WEIGHT DROPPING 30 INCHES
BOURING 9

SURFACE ELEVATION 216 Feet
MSL Datum

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

LOG OF BORINGS

<table>
<thead>
<tr>
<th>Depth in Feet</th>
<th>Graph Symbol</th>
<th>Letter Symbol</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td></td>
<td>NX 100%</td>
<td>REDDISH BROWN CLAYEY SILT, MEDIUM STIFF</td>
</tr>
<tr>
<td>5</td>
<td></td>
<td>NX 100%</td>
<td>GRAY VESICULAR BASALT, HARD, MODERATELY JOINTED, FRESH (AA CORE)</td>
</tr>
<tr>
<td>10</td>
<td></td>
<td>NX 100%</td>
<td>REDDISH BROWN CLINKERS, JOINTED, SEVERELY WEATHERED</td>
</tr>
<tr>
<td>15</td>
<td></td>
<td>NX 60%</td>
<td>GRAY HIGHLY VESICULAR PAHOEHOE BASALT, MODERATELY JOINTED, MODERATELY WEATHERED</td>
</tr>
<tr>
<td>20</td>
<td></td>
<td>NX 100%</td>
<td>REDDISH BROWN CLINKERS, SEVERELY JOINTED, SEVERELY WEATHERED</td>
</tr>
<tr>
<td>25</td>
<td></td>
<td>NX 100%</td>
<td>GRAY DENSE SLIGHTLY VESICULAR BASALT, HARD, MODERATELY JOINTED, FRESH (AA CORE)</td>
</tr>
<tr>
<td>30</td>
<td></td>
<td>NX 93%</td>
<td>GRADING TO SEVERELY FRACUTURED</td>
</tr>
<tr>
<td>35</td>
<td></td>
<td>NX 91%</td>
<td>REDDISH BROWN CLINKERS, SEVERELY JOINTED, SEVERELY WEATHERED</td>
</tr>
<tr>
<td>40</td>
<td></td>
<td>NX 67%</td>
<td>GRAY DENSE BASALT, HARD, MODERATELY JOINTED, MODERATELY TO SEVERELY WEATHERED</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>GRADING TO SLIGHTLY JOINTED AND FRESH</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>GRADING TO MODERATELY WEATHERED</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>GRYISH BROWN CLINKERS, SEVERELY JOINTED, MODERATELY WEATHERED</td>
</tr>
<tr>
<td>35</td>
<td></td>
<td></td>
<td>REDDISH BROWN SILT SEAM, SOFT</td>
</tr>
<tr>
<td>40</td>
<td></td>
<td></td>
<td>GRAY VESICULAR BASALT, HARD, SEVERELY JOINTED, SLIGHTLY WEATHERED</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>GRADING TO MODERATELY WEATHERED</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>GRADING TO MODERATELY JOINTED</td>
</tr>
</tbody>
</table>

Boring completed at 39.0 feet on 8-3-73
No water encountered

NOTES:
-DEPTH AT WHICH UNDISTURBED SAMPLE WAS TAKEN
-DEPTH AT WHICH DISTURBED SAMPLE WAS TAKEN
-DEPTH AT WHICH SAMPLE WAS LOST DURING EXTRACTION
I-DPETH AND LENGTH OF CORE RUN
DRIVING ENERGY - 300 -LB WEIGHT DROPPING 30 INCHES
**BORING 10**

**SURFACE ELEVATION**: 195 feet

**MSL Datum**: 0

**LOG OF BORINGS**

<table>
<thead>
<tr>
<th>M.O.I.</th>
<th>Recovery %</th>
<th>Sample &amp; Core</th>
<th>Depth in Feet</th>
<th>Graph Symbol</th>
</tr>
</thead>
<tbody>
<tr>
<td>RQD 81%</td>
<td>NX 90%</td>
<td>5</td>
<td>100%</td>
<td></td>
</tr>
<tr>
<td>RQD 89%</td>
<td>100%</td>
<td>100%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>RQD 100%</td>
<td>76%</td>
<td>15</td>
<td></td>
<td></td>
</tr>
<tr>
<td>RQD 81%</td>
<td>NX 93%</td>
<td>20</td>
<td></td>
<td></td>
</tr>
<tr>
<td>RQD 62%</td>
<td>NX 93%</td>
<td>25</td>
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<td></td>
</tr>
<tr>
<td>RQD 91%</td>
<td>NX 100%</td>
<td>30</td>
<td></td>
<td></td>
</tr>
<tr>
<td>RQD 90%</td>
<td>NX 90%</td>
<td>35</td>
<td></td>
<td></td>
</tr>
<tr>
<td>RQD 40%</td>
<td>NX 52%</td>
<td>40</td>
<td></td>
<td></td>
</tr>
<tr>
<td>RQD 82%</td>
<td>NX 93%</td>
<td>45</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**DESCRIPTION**

- **Reddish Brown Clayey Silt, Soft**
  - Grading to Slightly Jointed
  - (Occasional Small Silt-Filled Open Joints)

- **Gray Massive Slightly Vesicular Basalt, Hard, Moderately Jointed**
  - Grading to Slightly Jointed

- **Gray Clay Filled Joint at 45°**

- **Gray Clinkers**
  - Grading to Severely Jointed and Weathered with Some Reddish
  - Silt
  - Grading with Much Clayey Silt
  - Gray Vesicular Basalt, Hand, Moderately Jointed, Fresh (LA Core)
  - Gray Vesicular Clinkers, Moderately Jointed, Severely Weathered

- **Reddish Gray Moderately Vesicular Basalt, Moderately Hard, Severely Jointed, Severely Weathered (Pahoehoe Lava)**
  - Grading to Moderately Jointed and Slightly Weathered

**Boring Completed at 32.5 Feet on 8-3-73**

**No Water Encountered**

**NOTES:**

[ ] = Depth at which undisturbed sample was taken
[ ] = Depth at which disturbed sample was taken
[ ] = Depth at which sample was lost during extraction
[ ] = Depth and length of core run

**Driving Energy**: 300 lb weight dropping 30 inches
### BORING 11

**Surface Elevation** 197 Feet  
M.S.L Datum

<table>
<thead>
<tr>
<th>Depth in Feet</th>
<th>Graph Symbol</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>H</td>
<td>Reddish brown clayey silt, stiff</td>
</tr>
<tr>
<td>10</td>
<td>G</td>
<td>Brown and gray vesicular basalt, severely jointed, severely weathered grading to fresh</td>
</tr>
<tr>
<td>15</td>
<td>M</td>
<td>Grading to severely jointed</td>
</tr>
<tr>
<td>20</td>
<td>Q</td>
<td>Gray slight vesicular basalt, hard, moderately jointed, fresh (AA core) contains iron stained vesicles</td>
</tr>
<tr>
<td>25</td>
<td>M</td>
<td>Reddish brown clinkers, moderately jointed, severely weathered</td>
</tr>
<tr>
<td>30</td>
<td>G</td>
<td>Reddish brown silty gravel, hard (very severely weathered clinkers)</td>
</tr>
<tr>
<td>35</td>
<td>M</td>
<td>Gray massive slightly vesicular basalt, hard, slightly jointed, fresh (AA core)</td>
</tr>
<tr>
<td>40</td>
<td>G</td>
<td>Grading to vesicular</td>
</tr>
<tr>
<td>45</td>
<td>M</td>
<td>Brownish gray clinkers, hard, severely jointed, severely weathered</td>
</tr>
<tr>
<td>50</td>
<td>G</td>
<td>Reddish brown vesicular basalt, moderately jointed, moderately weathered (pahoehoe lava) pinhole vesicles grading to 1&quot; diameter vesicles</td>
</tr>
<tr>
<td>55</td>
<td>M</td>
<td>Boring completed at 34.0 feet on 8-7-73 No water encountered</td>
</tr>
</tbody>
</table>

**LOG OF BORINGS**

- Depth at which undisturbed sample was taken
- Depth at which disturbed sample was taken
- Depth at which sample was lost during extraction
- Depth and length of core run

Driving energy: 300-lb weight dropping 30 inches

**NOTES:**
Boring 12

Surface Elevation 205 Feet
MSL Datum

Description

Gray sand and gravel with red interstitial silt, dense (derived from clinkers)
Grading to yard

Gray massive very slightly vesicular basalt, hard, slightly jointed, fresh (A core)
Grading to moderately jointed
Grading to massive and very hard
Grading to moderately jointed

Red and gray clinkers, severely jointed, severely weathered contains some silt seams
Grading to moderately jointed and weathered

Gray vesicular basalt, hard, moderately jointed, slightly weathered, (A core)
Grading to moderately vesicular
Grading to dense

Red and gray clinkers, severely jointed, severely weathered
Grading to moderately jointed and weathered
Brownish gray vesicular basalt, hard, slightly jointed, slightly weathered (Pahoehoe lava)
20% pinhole vesicles
Grading to 2" vesicles

Boring completed at 31.5 feet on 8-7-73
No water encountered

Log of Boring

Notes:
- Depth at which undisturbed sample was taken
- Depth at which disturbed sample was taken
- Depth at which sample was lost during extraction
- Depth and length of core run

Driving Energy: 300-lb weight dropping 30 inches
### BORING 13

**Surface Elevation**: 247 Feet
**ML Datum**: 

<table>
<thead>
<tr>
<th>Depth in Feet</th>
<th>Core and/or Cores</th>
<th>Swirl</th>
<th>Diameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-5</td>
<td>NX</td>
<td>55%</td>
<td></td>
<td>Gray vesicular basalt, hard, moderately jointed, moderately weathered (Pahoehoe Lava) grading to severely jointed, 5% vesicles, grading to severely weathered</td>
</tr>
<tr>
<td>5-10</td>
<td>NX</td>
<td>50%</td>
<td></td>
<td>Brown sandy silty gravel, dense, severely weathered grading with much coarse sand grading to loose grading with much silt</td>
</tr>
<tr>
<td>10-15</td>
<td>NX</td>
<td>50%</td>
<td></td>
<td>Red and gray vesicular clinkers, moderately hard, moderately jointed, severely weathered Gray slightly vesicular basalt, severely jointed fresh AA core</td>
</tr>
<tr>
<td>15-20</td>
<td>NX</td>
<td>50%</td>
<td></td>
<td>Gray vesicular clinker, severely jointed, severely weathered at joints</td>
</tr>
<tr>
<td>20-25</td>
<td>NX</td>
<td>50%</td>
<td></td>
<td>Reddish gray highly vesicular basalt, moderately hard, moderately jointed, moderately weathered (Pahoehoe Lava) 20% vesicles grading with 6&quot; silty gravel zone grading with 6&quot; silty gravel zone grading with 5% vesicles grading to dense grading to brownish gray, severely jointed and severely weathered grading to gray, dense, massive and hard</td>
</tr>
<tr>
<td>25-30</td>
<td>NX</td>
<td>50%</td>
<td></td>
<td>Gray vesicular basalt grading to brown and severely weathered</td>
</tr>
</tbody>
</table>

**Boring Completed at 50.0 feet on 8-13-73**
**No water encountered**

### LOG OF BORINGS

- **Notes:**
  - Depth at which undisturbed sample was taken
  - Depth at which disturbed sample was taken
  - Depth at which sample was lost during extraction
  - Depth and length of core run
  - Driving energy: 300-lb weight dropping 30 inches
BORING 14

SURFACE ELEVATION 250 FEET
MSL Datum

DESCRIPTION

1. RED-BROWN SANDY SILT, STIFF
   GRAY CLINKERS, SEVERELY JOINTED, SEVERELY WEATHERED, MUCH Silt IN JOINTS
   GRAY SLIGHTLY VESICULAR MASSIVE BASALT, HARD, SLIGHTLY JOINTED
   (FRESH AA CORE)
   GRADING TO MODERATELY JOINTED
   GRADING TO SLIGHTLY JOINTED

2. RED-BROWN VESICULAR BASALT, MODERATELY HARD, MODERATELY JOINTED,
   MODERATELY WEATHERED (PAHOEHOE LAVA)
   GRADING WITH 20% VESICLES
   GRADING TO GRAY AND SLIGHTLY WEATHERED
   GRADING WITH 1" VESICLES
   GRADING WITH ½" VESICLES
   12" SEVERELY JOINTED ZONE
   GRADING TO FRESH AND WITH 5% VESICLES

3. RED-BROWN SILTY GRAVEL, DENSE, SEVERELY WEATHERED (DERIVED FROM PAHOEHOE CLINKERS)

Boring completed at 37.0 feet on 8-9-73
No water encountered

LOG OF BORINGS

NOTES:
- Depth at which undisturbed sample was taken
- Depth at which disturbed sample was taken
- Depth at which sample was lost during extraction
- Depth and length of core run
Driving energy - 300 - 150 lb weight dropping 30 inches
### BORING 15

**Surface Elevation**: 225 Feet  
**MSL Datum**

<table>
<thead>
<tr>
<th>Depth in Feet</th>
<th>Letter Symbol</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>S</td>
<td>REDDISH BROWN CLAYEY SILT AND BOUCERS, STIFF</td>
</tr>
<tr>
<td>10</td>
<td></td>
<td>REDDISH BROWN CLINKERS, SEVERELY WEATHERED</td>
</tr>
<tr>
<td>15</td>
<td>SM</td>
<td>GRAY HIGHLY VESICULAR BASALT, HARD, MODERATELY JOINTED, FRESH (Pahoehoe Lava) 20% VESICLES</td>
</tr>
<tr>
<td>20</td>
<td></td>
<td>RED AND GRAY CLINKERS, SEVERELY JOINTED, SEVERELY WEATHERED</td>
</tr>
<tr>
<td>25</td>
<td></td>
<td>GRAY HIGHLY VESICULAR BASALT, SEVERELY JOINTED, FRESH (Pahoehoe Lava) (DERIVED FROM CLINKERS)</td>
</tr>
<tr>
<td>30</td>
<td></td>
<td>GRAY Slightly Vesicular Basalt, Hard, Slightly Jointed, Fresh (Pahoehoe Lava) GRADING TO SEVERELY WEATHERED</td>
</tr>
<tr>
<td>35</td>
<td></td>
<td>GRAY VESICULAR BASALT, MODERATELY JOINTED, FRESH (AA CORE)</td>
</tr>
<tr>
<td>40</td>
<td></td>
<td>GRAY CLINKER, SEVERELY JOINTED, SLIGHTLY WEATHERED</td>
</tr>
<tr>
<td>45</td>
<td>SM</td>
<td>GRAY VESICULAR BASALT, MODERATELY WEATHERED, HIGHLY FRACTURED (AA CORE) GRADING TO MODERATELY JOINTED AND FRESH</td>
</tr>
<tr>
<td>50</td>
<td></td>
<td>REDDISH BROWN CLINKER, SEVERELY JOINTED, SEVERELY WEATHERED</td>
</tr>
<tr>
<td>55</td>
<td></td>
<td>GRAY SLIGHTLY VESICULAR BASALT, MODERATELY HARD, SEVERELY JOINTED, MODERATELY WEATHERED</td>
</tr>
<tr>
<td>60</td>
<td></td>
<td>GRAY SILTY Silt, Dense (DERIVED FROM SEVERELY WEATHERED CLINKERS)</td>
</tr>
<tr>
<td>65</td>
<td></td>
<td>GRAY CLINKER, MODERATELY JOINTED, MODERATELY WEATHERED GRADING TO SEVERELY JOINTED</td>
</tr>
<tr>
<td>70</td>
<td>SM</td>
<td>GRAY VESICULAR BASALT, MODERATELY JOINTED, FRESH (AA CORE)</td>
</tr>
<tr>
<td>75</td>
<td></td>
<td>GRADING TO MODERATELY WEATHERED</td>
</tr>
</tbody>
</table>

**Notes**:  
- Boring completed at 50.0 feet on 8-16-73  
- No water encountered

### Log of Borings

- Depth at which undisturbed sample was taken
- Depth at which disturbed sample was taken
- Depth at which sample was lost during extraction
- Depth and length of core run
- Driving energy: 300 lb weight dropping 30 inches
**BORING 16**

**SURFACE ELEVATION** 228 FEET

**MSL DATUM**

<table>
<thead>
<tr>
<th>MOISTURE CONTENT IN %</th>
<th>DRY DENSITY IN PCF</th>
<th>BLOWS/FT.-ON SAMPLER</th>
<th>CORE AND % RECOVERY</th>
<th>SAMPLES AND OR CORES</th>
<th>DEPTH IN FEET</th>
<th>GRAPH SYMBOL</th>
<th>LETTER SYMBOL</th>
</tr>
</thead>
<tbody>
<tr>
<td>RQD 100%</td>
<td>NX 100%</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>M1</td>
<td></td>
</tr>
<tr>
<td>RQD 83%</td>
<td>NX 55%</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>RQD 45%</td>
<td>NX 70%</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>RQD 28%</td>
<td>NX 43%</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>RQD 0%</td>
<td>NX 0%</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>RQD 30%</td>
<td>NX 50%</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>RQD 33%</td>
<td>NX 75%</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**DESCRIPTION**

REDISH BROWN CLAYEY SILT AND BOULDERS, STIFF

GRAY VESICULAR BASALT, JOINTED, SLIGHTLY WEATHERED (PAHOEHOE SPATTER)

GRAY VESICULAR BASALT, MODERATELY JOINTED, MODERATELY WEATHERED (PAHOEHOE LAVA) 80% VESICLES

GRADING TO SLIGHTLY WEATHERED AND 10% VESICLES

GRADING TO HIGHLY VESICULAR

GRADING TO SEVERELY FRAC TRURED

GRADING TO HIGHLY WEATHERED

GRADING TO MASSIVE, DENSE AND FRESH

GRADING TO VESICULAR AND 8% VESICLES

REDISH BROWN CLINKERS, SEVERELY WEATHERED

GRAY VESICULAR BASALT, JOINTED, SLIGHTLY WEATHERED (A A CORE)

GRADING TO SEVERELY WEATHERED

Boring completed at 33.0 FEET on 8-16-73
No water encountered

**LOG OF BORINGS**

**NOTES:**

- Depth at which undisturbed sample was taken
- Depth at which disturbed sample was taken
- Depth at which sample was lost during extraction
- Depth and length of core run
- Driving Energy - 300 - lb weight dropping 30 inches
### BORING 18

**Surface Elevation** 236 Feet

**MSL Datum**

<table>
<thead>
<tr>
<th>Depth in Feet</th>
<th>Core and % Recovery</th>
<th>Graph Symbol</th>
<th>Letter Symbol</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>RQD 100% NX 100%</td>
<td></td>
<td></td>
<td>Red Silt and Boulders, Soft</td>
</tr>
<tr>
<td>5</td>
<td>RQD 83% NX 30%</td>
<td></td>
<td></td>
<td>Gray Clinker, Well Cemented, Hard</td>
</tr>
<tr>
<td>10</td>
<td>RQD 50% NX 100%</td>
<td></td>
<td></td>
<td>Gray Vesicular Basalt, Hard, Massive, Fresh (AA Core)</td>
</tr>
<tr>
<td>10</td>
<td>RQD 50% NX 100%</td>
<td></td>
<td></td>
<td>Red and Gray Clinker Containing Some Silt, Severely Jointed, Severely Weathered</td>
</tr>
<tr>
<td>10</td>
<td>RQD 50% NX 100%</td>
<td></td>
<td></td>
<td>Red Silty Sandy Gravel, Medium Dense (Derived from Very Severely Jointed and Weathered Clinker)</td>
</tr>
<tr>
<td>15</td>
<td>RQD 0% NX 10%</td>
<td></td>
<td></td>
<td>Red gravelly Silt, Stiff (Derived from Decomposed Clinkers)</td>
</tr>
<tr>
<td>20</td>
<td>RQD 0% NX 10%</td>
<td></td>
<td></td>
<td>Gray Moderately Vesicular Basalt, Hard, Slightly Jointed, Fresh (AA Core)</td>
</tr>
<tr>
<td>25</td>
<td>RQD 0% NX 10%</td>
<td></td>
<td></td>
<td>Grading to Severely Jointed and Moderately Weathered</td>
</tr>
<tr>
<td>30</td>
<td>RQD 0% NX 10%</td>
<td></td>
<td></td>
<td>Grading to Slightly Weathered</td>
</tr>
<tr>
<td>35</td>
<td>RQD 0% NX 67%</td>
<td></td>
<td></td>
<td>Red and Gray Clinkers, Severely Decomposed</td>
</tr>
</tbody>
</table>

**Log of Borings**

Boring completed at 36.5 feet on 8-22-73
No water encountered

**Notes:**

- Depth at which undisturbed sample was taken
- Depth at which disturbed sample was taken
- Depth at which sample was lost during extraction
- Depth and length of core run

Driving energy: 300-lb weight dropping 30 inches
**BORING 19**

**SURFACE ELEVATION** 243 FEET  
**MSL DATUM**

<table>
<thead>
<tr>
<th>Depth in Feet</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>Red Silt and Boulders, Stiff</td>
</tr>
<tr>
<td>10</td>
<td>Reddish Brown Vesicular Clinkers, Severely Weathered</td>
</tr>
<tr>
<td>15</td>
<td>Gray Vesicular Basalt, Hard, Moderately Jointed, Fresh (AA Core)</td>
</tr>
<tr>
<td>20</td>
<td>Gray Clinkers, Moderately Jointed, Fresh</td>
</tr>
<tr>
<td>25</td>
<td>Gray Dense Basalt, Hard, Slightly Jointed, Fresh (AA Core)</td>
</tr>
<tr>
<td>30</td>
<td>2* Severely Jointed Zone</td>
</tr>
<tr>
<td></td>
<td>2* Severely Jointed Zone</td>
</tr>
<tr>
<td></td>
<td>Grading to Very Severely Jointed (Brittle)</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
- Depth and length of core run
- Driving energy - 300 Lb weight dropping 30 inches

Boring completed at 30.5 feet on 8-22-73
No water encountered
<table>
<thead>
<tr>
<th>Depth in Feet</th>
<th>Core and $^3$ Recovery Samples and/or Cores</th>
<th>Moisture Content in %</th>
<th>Dry Density in PCF</th>
<th>Blow/ft. on Sampler</th>
<th>Graph Symbol</th>
<th>Letter Symbol</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>RED SILT AND BOULDERS, STIFF</td>
</tr>
<tr>
<td>5</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>RED AND GRAY CLINKERS, SLIGHTLY JOINTED, MODERATELY WEATHERED</td>
</tr>
<tr>
<td>10</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>GRADING TO GRAY AND MASSIVE</td>
</tr>
<tr>
<td>15</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>GRAY BASALT, HARD, SLIGHTLY JOINTED, FRESH (AA CORE)</td>
</tr>
<tr>
<td>20</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>8&quot; SEVERELY JOINTED ZONE</td>
</tr>
<tr>
<td>25</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>GRADING TO MODERATELY JOINTED WITH TRACES OF SILT IN JOINTS</td>
</tr>
<tr>
<td>30</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>RED SILTY GRAVEL, DENSE (DERIVED FROM CLINKERS)</td>
</tr>
<tr>
<td>35</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>GRADING TO GRAY BASALT, HARD</td>
</tr>
<tr>
<td>40</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>GRAY VESICULAR BASALT, HARD, MODERATELY JOINTED, FRESH (AA CORE)</td>
</tr>
</tbody>
</table>

Boring completed at 31.0 feet on 8-24-73
No water encountered

LOG OF BORINGS

NOTES:
- DEPTH AT WHICH UNDISTURBED SAMPLE WAS TAKEN
- DEPTH AT WHICH DISTURBED SAMPLE WAS TAKEN
- DEPTH AT WHICH SAMPLE WAS LOST DURING EXTRACTION
- DEPTH AND LENGTH OF CORE RUN
DRIVING ENERGY = 300-LB WEIGHT DROPPING 30 INCHES
BORING  22

SURFACE ELEVATION  213 FEET

MOL DATUM

LOG OF BORINGS

MOISTURE CONTENT IN %

DRY DENSITY IN PT.

BORING/FT. OF SAMPLER

CORES AND % RECOVERY

SAMPLES AND/OR CORES

DEPTII IN FEET

GRAPH SYMBOL

LETTER SYMBOL

DESCRIPTION

50/3'
RQD
NX
100%

RED SILT AND BOULDERS, SOFT
GRADING TO STIFF
GRADING TO HARD (DECOMPOSED ROCK WITH CLAY)
GRADING WITH SOME GRAVEL

Red and Gray Clinkers, Moderately Jointed, Severely Weathered
GRADING WITH SOME SILT AND CLAY

50/3'
RQD
NX
100%

GRAY SLIGHTLY VESICULAR BASALT, HARD, SLIGHTLY JOINTED, FRESH (AA CORE)

8" SEVERELY JOINTED ZONE
GRADING WITH 15% - 8" PARTIALLY INTERCONNECTED VESICLES
GRADING TO SEVERELY JOINTED

RQD
NX
100%

GRADING TO RED
RED AND GRAY CLINKERS WITH ZONES OF RED SANDY GRAVEL, GENSE
SEVERELY WEATHERED

RQD
NX
100%

REDDISH GRAY HIGHLY VESICULAR BASALT, HARD, MODERATELY JOINTED,
MODERATELY WEATHERED (Pahoehoe Lava)
GRADING TO GRAY AND 20% VESICLES, SLIGHTLY JOINTED

RQD
NX
100%

GRADING TO MODERATELY JOINTED

DRIVING ENERGY- 300 LB. WEIGHT DROPPING 30 INCHES

Boring completed at 36.3 feet on 8-24-73
No water encountered

NOTES:

• Depth at which undisturbed sample was taken
• Depth at which disturbed sample was taken
• Depth at which sample was lost during extraction
• Depth and length of core run

PLATE

A-50

Page: 466.12 (1-64)
APPENDIX B

LABORATORY TESTING

Selected representative samples of the subsurface materials recovered in the field were subjected to various laboratory tests to evaluate their engineering properties, and to provide necessary information for classification and correlation of various soil and rock types. The testing procedures and test results are presented below.

Moisture Content and Dry Density - The moisture content and dry density of selected samples of the subsurface materials were determined. The results of these tests are presented on the Log of Borings at the appropriate depths of the samples tested.

Atterberg Limits - Liquid and plastic limits were determined for selected samples for the purpose of classification, and to evaluate the plasticity of the materials. The results are as follows.

<table>
<thead>
<tr>
<th>Boring No.</th>
<th>Sample No.</th>
<th>Depth (ft.)</th>
<th>Dry Density (pcf)</th>
<th>Field Moisture %</th>
<th>Liquid Limit %</th>
<th>Plastic Limit %</th>
<th>Plasticity Index</th>
<th>USC</th>
</tr>
</thead>
<tbody>
<tr>
<td>11</td>
<td>1</td>
<td>2</td>
<td>84</td>
<td>23</td>
<td>63</td>
<td>36</td>
<td>27</td>
<td>MH</td>
</tr>
<tr>
<td>22</td>
<td>2</td>
<td>3</td>
<td>82</td>
<td>28</td>
<td>60</td>
<td>40</td>
<td>20</td>
<td>MH</td>
</tr>
</tbody>
</table>
Unconfined Compression Tests - Nine unconfined compression tests were performed on various core samples. The testing was performed in accordance with ASTM D-2938-71a. The results of the testing are presented in the following table.

<table>
<thead>
<tr>
<th>Boring No.</th>
<th>Depth (ft.)</th>
<th>Diameter (in.)</th>
<th>Height (in.)</th>
<th>Density (pcf)</th>
<th>Unconfined Compressive Strength (psi)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>6</td>
<td>2.125</td>
<td>4.625</td>
<td>158</td>
<td>9,160</td>
</tr>
<tr>
<td>1</td>
<td>33</td>
<td>2.125</td>
<td>4.560</td>
<td>136</td>
<td>10,010</td>
</tr>
<tr>
<td>1</td>
<td>30</td>
<td>2.062</td>
<td>4.500</td>
<td>181</td>
<td>12,810</td>
</tr>
<tr>
<td>2</td>
<td>12</td>
<td>2.125</td>
<td>4.060</td>
<td>192</td>
<td>11,800</td>
</tr>
<tr>
<td>2</td>
<td>24</td>
<td>2.062</td>
<td>3.000</td>
<td>120</td>
<td>490</td>
</tr>
<tr>
<td>2</td>
<td>32</td>
<td>2.125</td>
<td>4.625</td>
<td>171</td>
<td>10,290</td>
</tr>
<tr>
<td>3</td>
<td>20</td>
<td>2.125</td>
<td>4.500</td>
<td>164</td>
<td>10,010</td>
</tr>
<tr>
<td>4</td>
<td>17</td>
<td>2.188</td>
<td>4.125</td>
<td>166</td>
<td>11,800</td>
</tr>
<tr>
<td>5</td>
<td>10</td>
<td>2.125</td>
<td>4.125</td>
<td>157</td>
<td>10,600</td>
</tr>
</tbody>
</table>

Consolidation Test - A consolidation test was performed on an undisturbed representative sample of the cinder material to determine the compressibility, and evaluate potential settlements of the structure. Consolidation test procedures are presented in Exhibit B-1. The test results are presented on Plate B-1.

Direct Shear Tests - Two direct shear tests were performed on samples of the cinder material to
determine shear strength parameters, and to evaluate bearing capacity. The test method is described on Exhibit B-2. The test results are presented on Plate B-2.

---

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

Exhibit B-1 - Method of Performing Consolidation Tests
Exhibit B-2 - Method of Performing Direct Shear and Friction Tests
Plate B-1 - Consolidation Test Data
Plate B-2 - Shear Strength Test Data
EXHIBIT B-1

METHOD OF PERFORMING CONSOLIDATION TESTS

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

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

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.
EXHIBIT B-2

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 device in which the samples were obtained. Loose samples of soils to be used in constructing earth fills are compacted in rings to predetermined conditions and tested.

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.
SHEARING STRENGTH IN Lbs/Sq. Ft.

1. Boring 8, Sample 1, at 11 Feet
   - Dry Density = 101 PCF
   - Moisture Content = 22%
   - Cohesion $c = 2400$ PSF
   - Frictional Resistance $\phi = 31^\circ$

2. Boring 22, Sample 2, at 2 Feet
   - Dry Density = 82 PCF
   - Moisture Content = 28%
   - Cohesion $c = 3000$ PSF
   - Frictional Resistance $\phi = 46^\circ$

SHEAR STRENGTH TEST DATA