G.P. #5685

SOILS AND GEOLOGIC INVESTIGATION

KAMEHAME RIDGE SUBDIVISION

OAHU, HAWAII

W. O. 285-10 - AUGUST 25, 1971

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GEOLABS-HAWAII, INC.

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August 25, 1971

W. O. 285-10

Grant Company of Hawaii
P. O. Box 7631
Honolulu, Hawaii 96821

Attention: Mr. Calvin Chun

Subject: Soils and Geologic Investigation
Kamehame Ridge Subdivision
Oahu, Hawaii

Gentlemen:

Presented in this report are the results and recommendations of a detailed soils and geologic investigation completed at the site for the proposed development of the Kamehame Ridge in the Hawaii-Kai area, Oahu, Hawaii. A site plan showing the project limit and the field test locations is enclosed as Figure No. 1. The site plan was derived from the topographic survey prepared by VTN-Pacific.

The report presents the results of our work during June, July and August 1971. Soil and rock types are delineated and are shown on Figure 1. Laboratory test results are presented in the Appendices.

SUMMARY OF SITE CONDITIONS

1. Kamehame Ridge lies north of Koko Crater and rises from Elevation 200 to Elevation 950. The south two-third of the project is made up of two ridges with an intervening valley. The ridges come together above Elevation 630 and form a narrow ridge for the north one-third of the project.

The project area is accessible by a narrow paved road that follows up the ridge through the project to a U.S. Government Niki site about 1/2 mile beyond the project.

2. Almost the entire Kamehame Ridge is composed of basaltic lava flows. The southern one-third of the ridge is capped by volcanic tuff similar to that exposed on the slopes of Koko Crater from which it originated.

3. There is practically no soil cover on this project. There are small areas, generally less than 50 feet across, scattered along the ridge tops where some soil has developed in the upper 4 to 12 inches.

4. In general, the source for embankment fill will be derived from the material in place excavated from the cut sections. Most of the volcanic tuff will break down to rock sizes less

than 6 inches. The same will hold true for most of the weathered basalt above Elevation 700. Occasionally there will be some harder rocks up to 2 and 3 feet across which will need special processing.

The basalt below Elevation 350 on the west ridge and Elevation 580 on the east ridge becomes much less weathered and may offer resistance to ripping with D-9 Cats. It is estimated that up to 50 percent of this material will require special processing for embankment fill, as outlined in the report.

5. The following slope ratios may be used on the project:

1/2H:1V for cut slopes in hard, relatively unweathered basalt (Area 1).

1H:1V for cut slopes in moderately weathered basalt (Area 2).

1-1/2H:1V for cut slopes in Tuff (Area 4).

2H:1V for all other cut and fill slopes.

6. Foundations which are placed in the in-place rock material should be designed to withstand a total loading (DL+LL) of 6,000 PSF for hard basalt, 5,000 PSF for moderately weathered

basalt, 4,000 PSF for Tuff and 3,000 PSF for moderately soft basalt. Foundations placed in the compacted onsite soil material should be designed for 2,000 PSF (DL+LL).

FIELD EXPLORATION

A detailed geologic reconnaissance was made of the project area and the approximate limits of the tuff, the weathered and relatively unweathered basalt were determined. These limits and their explanations are shown on the attached plan Figure No.1.

Test pits were excavated at three widely spaced intervals to obtain representative samples of material to be excavated and used for fill. These samples were returned to the laboratory for a more detailed analyses. Due to difficulty in excavating, no attempt was made to obtain samples of the harder, relatively unweathered basalt or tuff. Log of test pits are shown on Table I.

The soil and rock material encountered in the test pits does not necessarily represent subsurface conditions at other points on the site; however, mapping and sampling procedures are believed to be representative.

It should be pointed out that the soil material which exists on the site is generally the result of residual weathering.

There are boulders along the stream wash in the lower central portion of the site.

LABORATORY TESTING

Various laboratory tests were performed on disturbed and remolded samples to determine the necessary soil parameters.

Laboratory maximum density and laboratory CBR tests were performed on the onsite soil material. The CBR tests were performed in accordance with the City and County of Honolulu standard specifications, for the purpose of determining the street sections required in the soil areas. Results of CBR tests are shown on Table II and laboratory compaction tests are shown on Plates 1 through 2.

The soil material was remolded in the laboratory to 90% of the maximum density at optimum moisture content and subjected to expansion tests to determine the influence of disturbance and recompaction on the swell properties. Results of expansion tests are shown on Table III.

Direct shear tests were also performed on the remolded samples to determine the Coulomb shear strength parameters; cohesion and angle of internal friction. The shear test results are shown on Plate 3.

GEOLOGY AND SITE CONDITIONS

Kamehame Ridge lies north of Koko Crater and rises from Elevation 200 on the south to Elevation 950 on the north. The south two-third of the project is made up of two ridges with an intervening valley. The ridges come together near Elevation 630 and form one ridge for the north one-third of the project.

Kamehame Ridge drops off steeply on the west into Kamiloiki Valley and on the east into Kalama Valley. The ridge is covered with brush. Some scattered trees are found in the lower portion.

The rocks which outcrop on Kamehame Ridge are composed of interlayered lavas which, according to geologic reports*, are part of the Koolau volcanic series and volcanic tuff which came from Koko Crater.

The lavas are separated into flows of varying thicknesses. The predominate rock-type that is exposed is classified as basalt with layers of Aa and clinker beds. The flows generally dip in a southerly direction at an angle of about 10 degrees. Differential erosion of the varying lava types has caused vertical cliffs which are composed of the harder, more resistant basalt material.

* "Geology and Groundwater Resources of the Island of Oahu, Hawaii" H. T. Stearns and K. H. Vaksvik.

GENERAL DISCUSSION

The subject site has been divided into areas that delineate the tuff, the harder lava rock, the moderately weathered lavas and the more deeply weathered rocks. The approximate limits of these areas are shown on the site plan, Figure 1 (in pocket).

Area 1- Relatively Hard Basalt

This formation underlies the tuff (Area 4) and outcrops on both sides of Kamehame Ridge as well as along the ridge itself as described in detail on page 6.

The formation is generally too hard for the D-9 rippers but can be ripped by the new HD41 which is being used successfully in the Kaluanui Ridge under construction. Large slabs of hard rock will result from the excavation and these will have to be broken up or placed in deep fills as recommended in section dealing with "Oversize Rock".

Area 2 - Moderately Weathered Basalt

Above Elevation 350 on the west ridge and 580 on the east ridge, the basalt becomes increasingly more weathered and somewhat softer. Most of this area can probably be ripped with D-9 Cats.

There will be layers of relatively hard basalt which will produce large slabs of hard rock which will need to be handled separately as "Oversize Rock". This material is represented by TP-2 shown on Figure 1.

Area 3 - Deeply Weathered Basalt

Generally above Elevation 700, the basalt is deeply weathered with only an occasional layer of hard rock. The formation can be easily ripped with D-9 Cats. Locally there are small areas of red Silty CLAY. This material is represented by TP-1 on Figure 1.

Area 4 - TUFF

The tuff overlies the basalt flows below Elevation 350 on the west ridge and below Elevation 400 on the east ridge. The tuff generally dips 10 to 25 degrees to the north but locally it shows dips in other directions. The tuff is a thin-bedded formation consisting of volcanic ash blown out from Koko Crater and deposited in layers as it settled out of the atmosphere. Later it became indurated into moderately hard rock. This formation generally has a green gray color when fresh or unweathered and its color change to brown, tan and red brown when weathered. The tuff often contains fragments of hard basalt and layers of black sand. The tuff will rip moderately easy with a D-9 ripper but is hard to dig with a backhoe except where it is deeply weathered.

RECOMMENDATIONS

General

1. The soil and rock material as encountered throughout the site will function satisfactorily as a foundation base both for structures and embankment fills.

2. Where the bottom of the footings will be in compacted soil or soil material occurring in the cut lots, the footings should be placed a minimum depth of 12 inches from finished rough grade.

3. Where the bottom of the footings, in a cut lot, occur in soil material, the soil should be inspected by a soils engineer to verify the parameters used in this report.

4. All onsite soil material may be used for embankment fills providing it is processed and compacted in accordance with the enclosed earthwork specifications.

5. All soil material in the building and street areas should be compacted to 90% of the laboratory maximum density and in

accordance with the enclosed earthwork specifications.

6. Where the natural ground slopes at 5:1 or steeper, the fill material should be keyed and benched into firm bedrock or firm material approved by the soils engineer (See Plates GS-1 through GS-3 for graphic details).

7. Where excavations will be along the top of the steep slopes above Kamiloiki Valley on the west and above Kalama Valley in the east, catchment fences will be necessary at various intervals along the slope to protect residential houses that are planned for these valley areas.

Area 1 - Relatively Hard Basalt

1. In this area, it is estimated that the major portion of the excavation will require the use of the heavy rippers now employed at Kaluanui Ridge. Some blasting may be required in heavy cuts. The use of D-9 Cats and backhoes may not be practical for rock excavation or utility line installation.

✓2. Cut slopes for in-place hard basalt may be constructed at 1/2H:1V.

3. Footings founded on in-place hard basalt, an allowable bearing value (DL+LL) of 6,000 PSF may be utilized.

4. Where footings will be founded in rock on the side slopes, the footings should be bolted or seated into the rock material.

5. It is recommended that footings be placed either entirely in rock or entirely in fill material. In no case should the footings for one structure be partially in rock and partially in fill.

6. For buildings on rock side slopes, the construction should consist of a post and beam type with the post or column footings being seated and/or bolted into the in-place rock.

Area 2 - Moderately Weathered Basalt

1. In this area, it is estimated that most of the excavation can be made with the use of D-9 Cats or their equivalent. There may be portions that will require use of the heavy rippers.

2. Cut slopes in this area can generally be made at 1:1.

3. For footings founded in this material, an allowable bearing value (DL+LL) of 5,000 PSF may be utilized.

4. Where footings will be founded in rock on the side slopes, the footings should be bolted or seated into the rock material.

5. It is recommended that footings be placed either entirely in rock or entirely in fill material. In no case should the footings for one structure be partially in rock and partially in fill.

6. For buildings on rock side slopes, the construction should consist of a post and beam type with the post or column footings being seated and/or bolted into the in-place rock.

Area 3 - Moderately Soft Basalt

1. Most of this area can be easily ripped and much of the material can be moved with large scrapers.

2. Cut slopes should be made at 2:1 or flatter.

3. For footings founded in this material, an allowable bearing value (DL+LL) of 3,000 PSF may be utilized. All footings on side slopes should be inspected by the soils engineer.

Area 4 - Moderately Hard Tuff

1. In this area, it is estimated that most of the excavation can be made with the use of D-9 Cats except where hard basalt underlies the tuff at shallow depths.

2. Cut slopes in this area can generally be made at 1-1/2:1. Where the tuff is weathered, the slopes will need to be flatter.

3. For footings founded in this material, an allowable bearing value (DL+LL) of 4,000 PSF may be utilized. Footings founded in weathered Tuff should be designed for 2,000 PSF. No footings should be placed in loose Tuff.

Oversized Rock

All rock material larger than 8 inches in diameter that has been excavated from the site may be used in the deeper fills provided it is windrowed in fill areas in the following manner:

1. The windrows should not be over five (5) feet in width and not closer than equipment width (15 feet) between the windrows. The height of the windrows should not exceed three (3) feet.

2. The maximum size rock acceptable within the windrow should not exceed four (4) feet in the greatest dimension. Rock over this size should be broken down or disposed of in areas other than fill.

3. The resultant rock configuration in the windrows will offer considerable void space between the rocks. The more granular

Tuff or lava materials should be used for fill along and over the rock windrows and thoroughly watered and consolidated so that all the void spaces in the rocks are filled with soil. Successive lifts may be made; however, the windrows should be staggered horizontally and have a vertical distance of at least four (4) feet between the top of the lower windrow and bottom of the next windrow.

4. No windrows may be made within thirteen (13) feet of the finished pad grade.

5. The approximate location of windrows should be noted on the "as-built" grading plan. The approximate elevation of the higher windrows should be noted on the plan.

6. All rock burial should be placed under the supervision of the soils engineer for the project.

The above details are shown graphically on Plate GS-3.

Expansive Soils

The very limited amount of Silty CLAY soils encountered on the site are considered expansive. This soil should be buried in the deeper fills or should be well blended with the onsite granular soils so that it will not pose any problems to footings. All other onsite materials are considered non-expansive.

Pavement Design

The following recommended pavement sections are based on the CBR Values given in Table I.

Pavement Thickness (inches)	Base Course (inches)
2	6

Inspection

It is recommended that all footings and slab areas be inspected by the soils engineer prior to placing forms, concrete or steel. The excavations should be trimmed neat, level, and square and be free of sloughed soils at the time of inspection.

Design Review

The grading plans should be forwarded to the soils engineer for review and comments prior to finalizing the design.

Additional analysis and/or investigation should be made where conditions different from the basic assumptions indicated herein are used or are encountered.

We appreciate this opportunity to be of service. Should you have any questions or need additional clarification regarding the report, please do not hesitate to call.

Very truly yours,

GEOLABS-HAWAII, INC.

Stanley N. Mitchell, P.E.

STANLEY N. MITCHELL REGISTERED PROFESSIONAL ENGINEER No. 2174 HAWAII, U.S.A.

Peter S. C. Chan
Vice President

xc: (5) Addressee

APPENDIX A

LOGS OF TEST PITS

TABLE I

LOGS OF TEST PITS

Pit No.	Depth Feet	Description
1	0.0 - 1.0	Silty CLAY (MH), dark red, dry, stiff.
	1.0 - 4.0	BASALT, deeply weathered, red, tan, brown, and gray.
2	0.0 - 6.0	BASALT, moderately weathered, gray, green and tan.
3	0.0 - 2.0	TUFF, weathered, brown, tan, black and red brown.

APPENDIX B

LABORATORY DATA

TABLE II

SUMMARY OF CBR DATA

Test No.	Depth Feet	USCS	Dry Density (pcf)	Moisture (%)	CBR (%)	Expansion (%)
TP2	0 - 6	Moderately Weathered BASALT	83.7	33.0	2.9	5.1
TP3	0 - 2	TUFF	86.6	26.7	49.0	0.3

TABLE III

SUMMARY OF EXPANSION TESTS

REMOLDED

Test Pit No.	Depth (ft)	Percent Swell Under 100 PSF Surcharge Air Dry to Saturation	USCS
TP1	0 - 1.0	10.6	MH
TP1	2.0 - 4.0	8.9	Weathered BASALT

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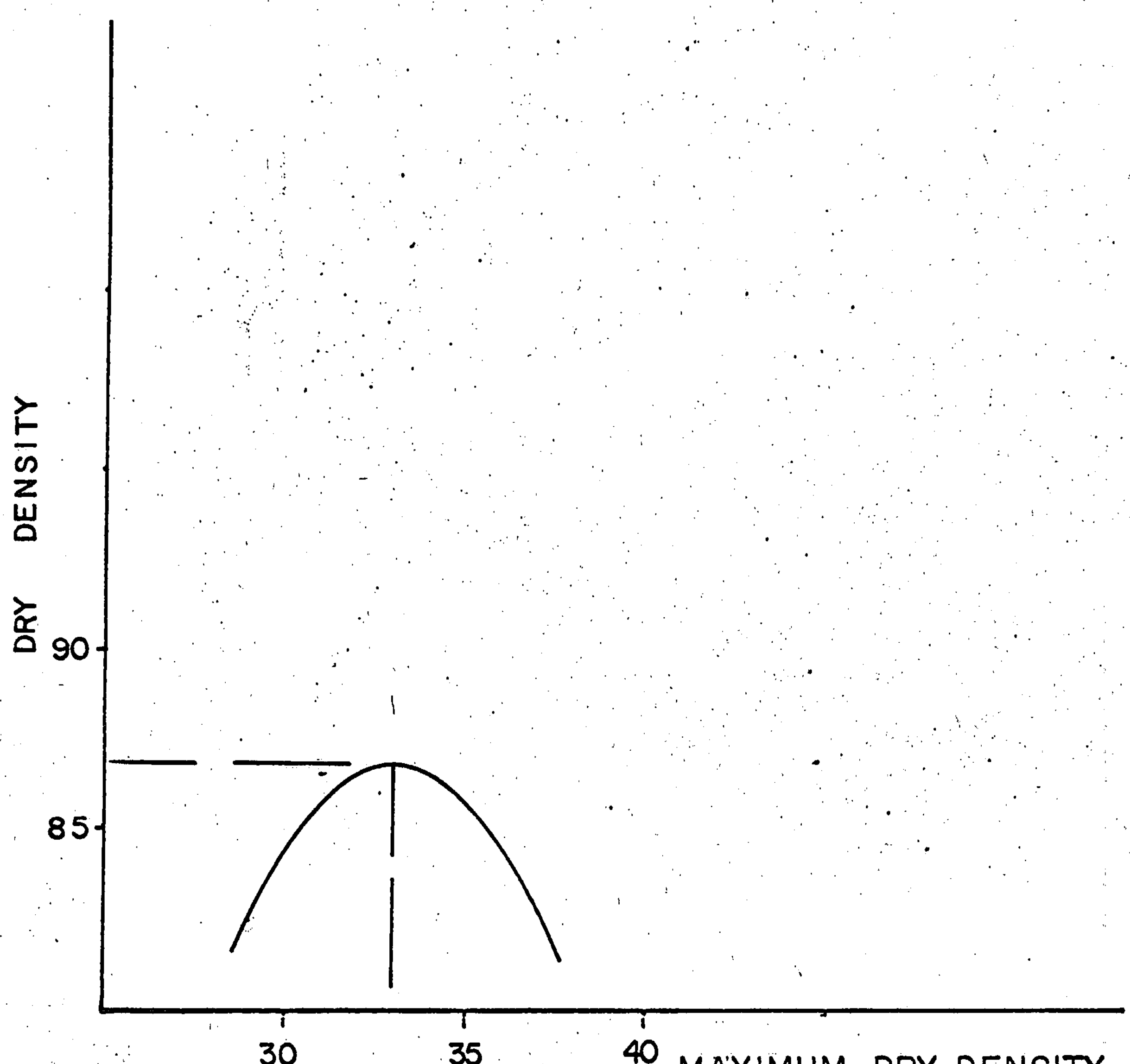

MAXIMUM DRY DENSITY 87.0PCF
OPTIMUM MOISTURE 33 %

LOCATION TP.#1
DEPTH 0' TO 1'
SOIL CL

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PLATE 1

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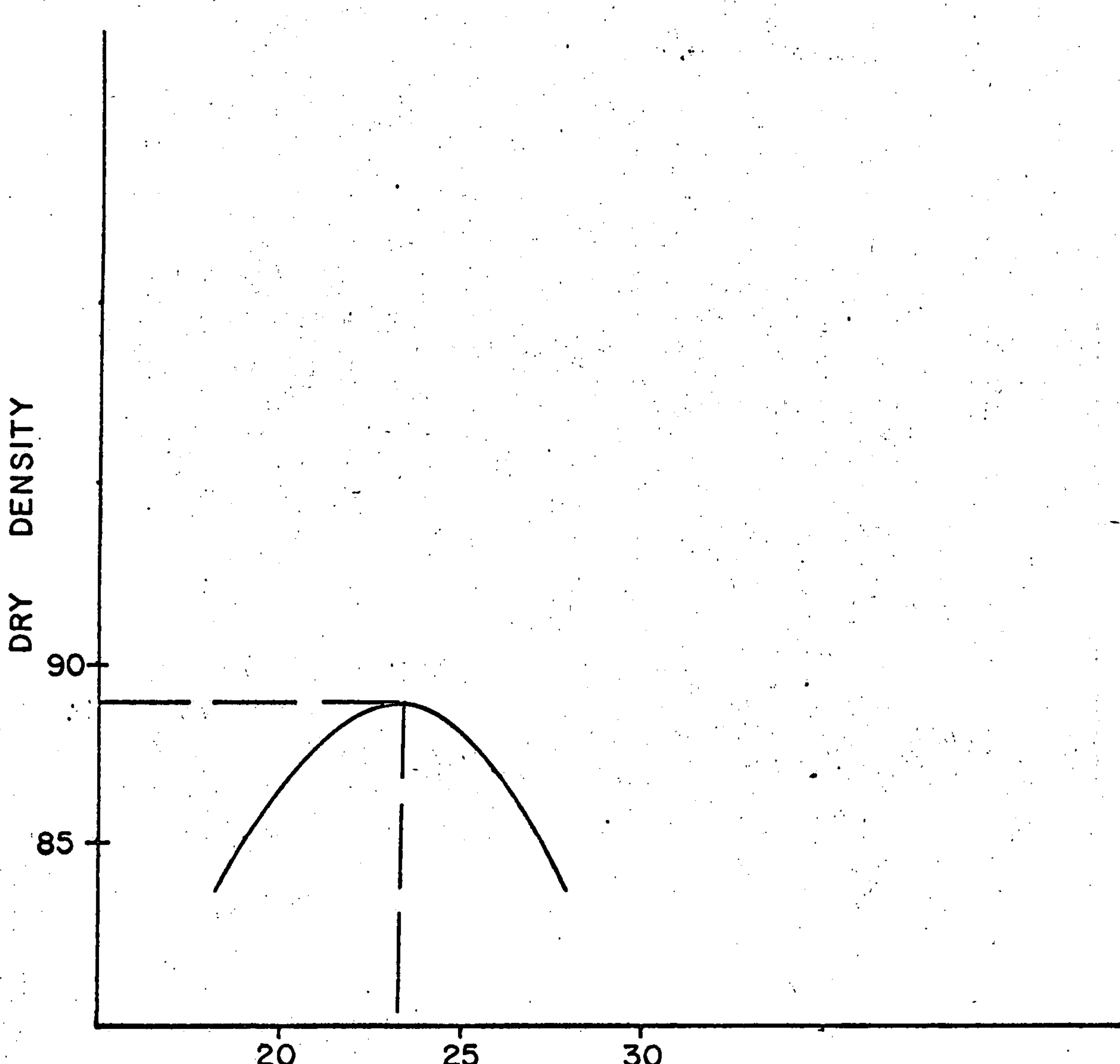

MAXIMUM DRY DENSITY 89.0 PCF
OPTIMUM MOISTURE 23 %

LOCATION TP*1

DEPTH 2′ TO 4′

SOIL Weathered Basalt

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PLATE 2

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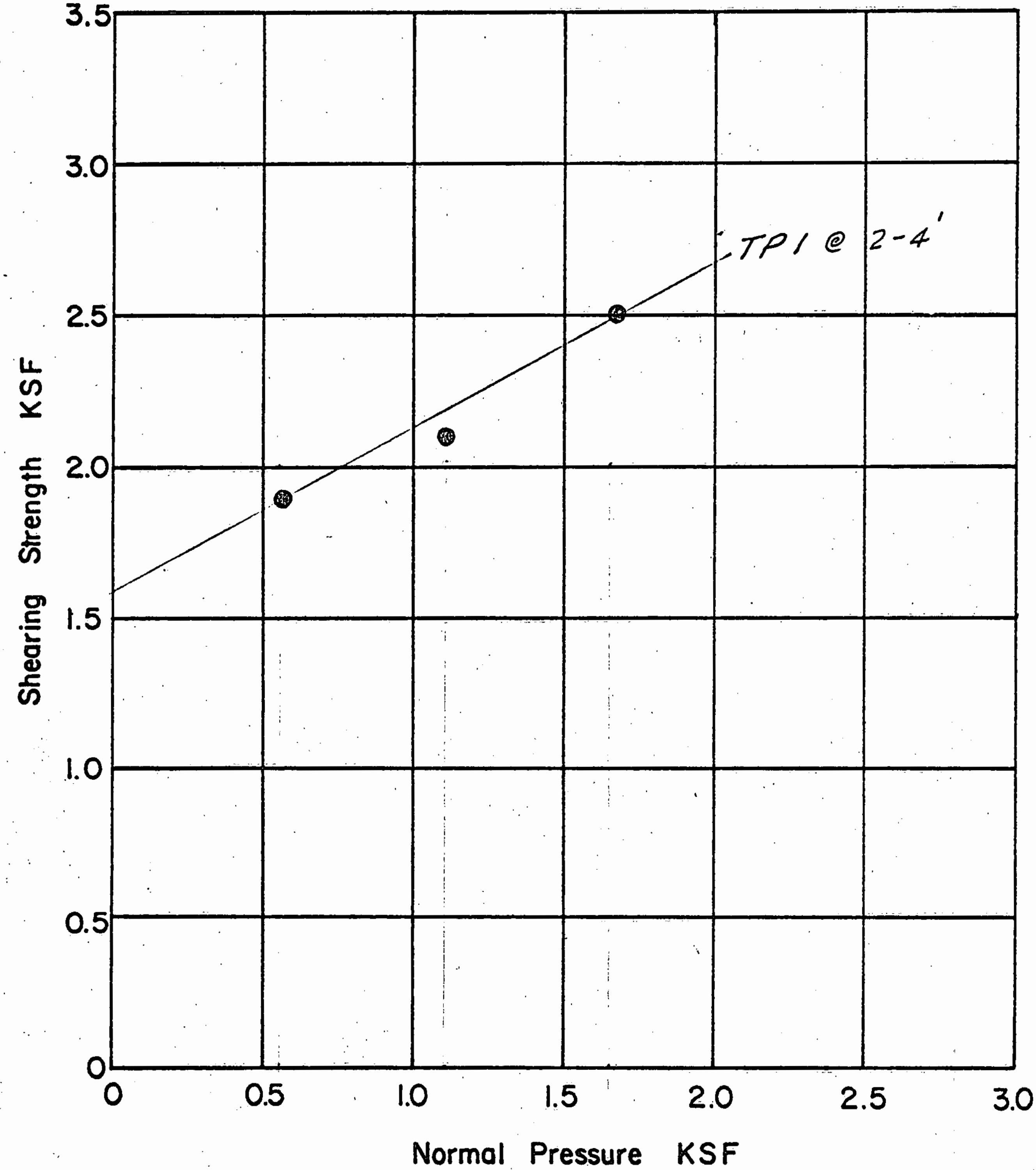
SHEAR TEST DIAGRAM



REMOLDED SAMPLES
90% @ OPT. MOISTURE

Key:

- ○ Tests at field moisture content.
- ◉ Tests at saturated moisture content.

PLATE 3

A P P E N D I X   C

FIELD AND LABORATORY SPECIFICATIONS

FIELD AND LABORATORY SPECIFICATIONS

EXPLORATORY DRILLING AND SAMPLING

Method for soil investigation and sampling by auger borings (Tentative)	ASTM Designation: D 1452-63T
Method for penetration test and split barrel sampling of soils (Tentative)	ASTM Designation: D 1586-64T

LABORATORY TESTING

Grain Size Analysis

Grain size analysis of soil ±200	ASTM Designation: D 422-63

ATTERBERG LIMITS

Determining the liquid limit of soils. Tests conducted from natural moisture content unless otherwise noted.	ASTM Designation: D 423-61
Determining the plastic limit and plasticity index of soils.	ASTM Designation: D 424-59
Direct Shear (Q Test) Consolidation Tests	"Soil Testing for Engineers" by T. William Lambe

SPECIFIC GRAVITY

Specific gravity of soils Modified as follows: Le Chatelier Flask	ASTM Designation: D 854-58

CBR TESTS

Expansion test and California Bearing Ratio (CBR)	ASTM Designation: D 1883-61T ASTM Designation: D 1557-64T

PROCTOR Test

Moisture-Density relations of soils using a 10# hammer and an 18" drop	AASHO Designation: T 180-57 ASTM Designation: D 1557-64T

UNIFIED SOIL CLASSIFICATION

Suggested Method by A. A. Wagner - ASTM Committee D-18

A P P E N D I X D

EARTHWORK SPECIFICATIONS

AND

GENERAL GRADING DETAILS

EARTHWORK SPECIFICATIONS
KAMEHAME RIDGE SUBDIVISION
OAHU, HAWAII

The work under this section includes:

1. Clearing and grubbing of site
2. Preparation of natural ground
3. Preparation of fill areas
4. Placement and control of fill operations
5. Compaction equipment
6. Removal and backfill of underground structures
7. Supervision of earthwork
8. Seasonal requirements

1. Clearing

All areas within contract limit lines shall be cleared of trash, debris and organic matter, and such material shall be burned and removed from the site.

2. Preparation of Natural Ground

In areas where the bottom of footings are designed on or below existing natural ground, the soils shall be scarified to a depth as determined by the soils engineer until the material is free of all uneven features and shall be precompacted as outlined in the following Section #4b.

3. Preparation of Fill Areas

All areas upon which fill is to be placed after clearing, as outlined in Section #1 of these specifications, shall be scarified until free of uneven features to a depth as determined by the soils engineer, and watered and compacted according to Section #4 of these specifications.

4. Placement of Fill

a. Material for fill shall consist of onsite soils. Fill material shall be free of all organic matter and other deleterious material, and shall not contain rocks or lumps in excess of four inches (4") in diameter.

b. Compaction of Fill

After the base for the fill has been prepared as described above, it shall be brought to the proper moisture content and compacted to not less than 90% of maximum density in accordance with Test ASTM D-1557-70.

c. Depth of Fill

Fill shall be placed in horizontal layers which, when compacted, will not exceed six inches (6").

5. Compaction Equipment

The soils engineer shall determine the type of compacting equipment which will attain the specified results in the most efficient manner. Sheepsfoot, vibratory, or pneumatic tire rollers may be used in the test section and the equipment which produces the specified results in the most expedient manner as determined by the soils engineer shall be employed by the contractor. The equipment used in rolling shall be in good working condition, fully ballasted, and self cleaning. Fill material placed in an unsatisfactory condition and not within the enclosed specifications shall be rejected by the soils engineer and the contractor shall rework the fill placed such that the specifications are followed.

6. Removal and Backfill of Underground Structures

Any underground structures such as cesspools, cisterns, septic tanks, wells, pipe lines, etc. shall be removed under the direction of the soils engineer. Backfill of the excavation shall be in accordance with these specifications.

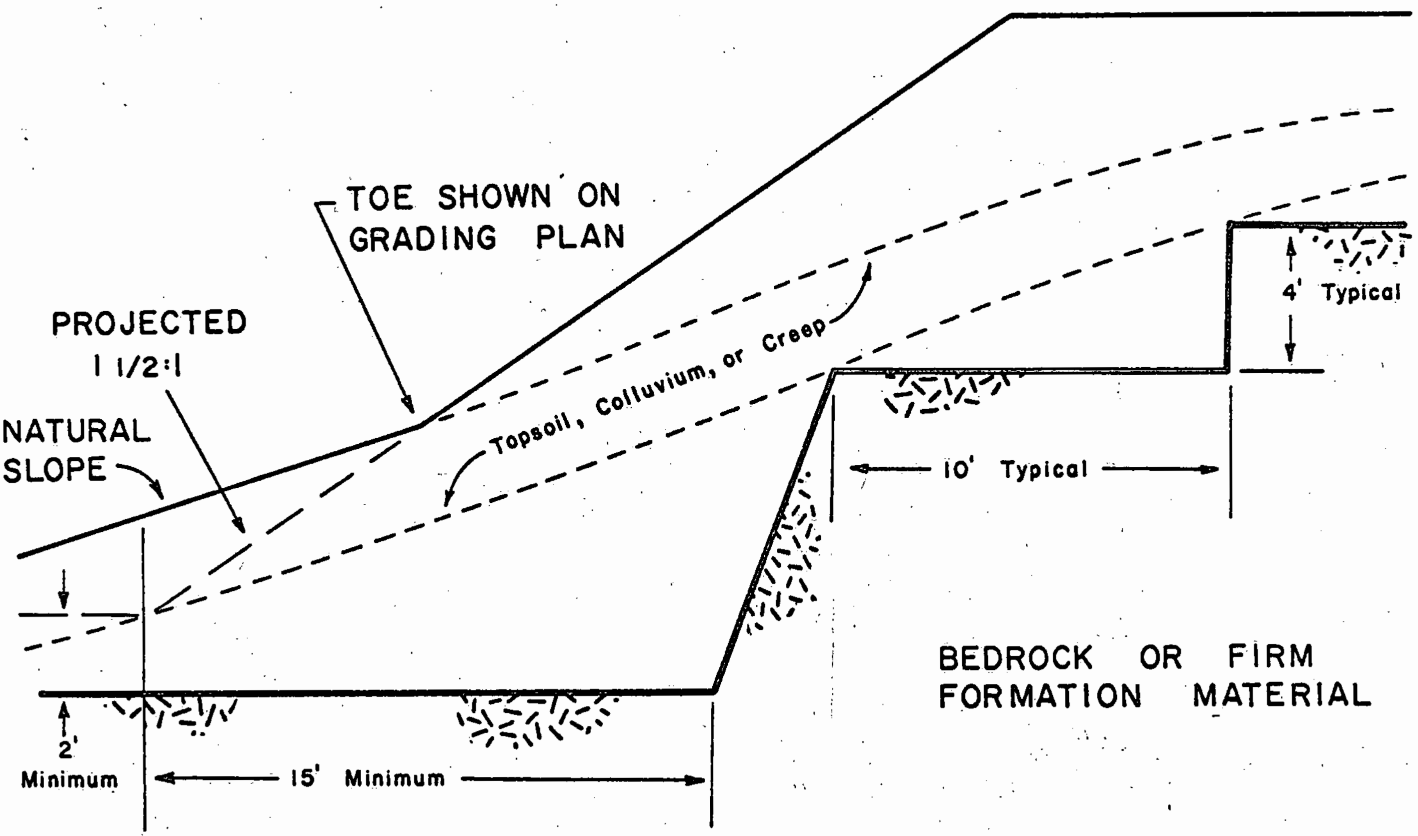
7. Supervision of Earthwork

Field density tests shall be made by the soils engineer during the earthwork operation such that he may certify that the fill was placed according to accepted specifications. In the event that field density tests of a layer or any portion thereof is less than the required density, the particular layer or portion shall be reworked until the required density is obtained.

8. Seasonal Requirements

No fill shall be placed during unfavorable weather conditions as determined by the soils engineer. After interruption of work due to heavy rain, the soils engineer shall approve previously placed fill before resumption of earthmoving operations.

TYPICAL FILL OVER NATURAL SLOPE



NOTE: WHERE NATURAL SLOPE GRADIENT IS 5:1 OR LESS BENCHING IS NOT NECESSARY, UNLESS STRIPPING DID NOT REMOVE ALL COMPRESSIBLE MATERIAL.

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DATE 8-25-71 BY P.C.
SCALE NONE W.O. 285-10

PLATE GS-1

TYPICAL FILL OVER CUT SLOPE

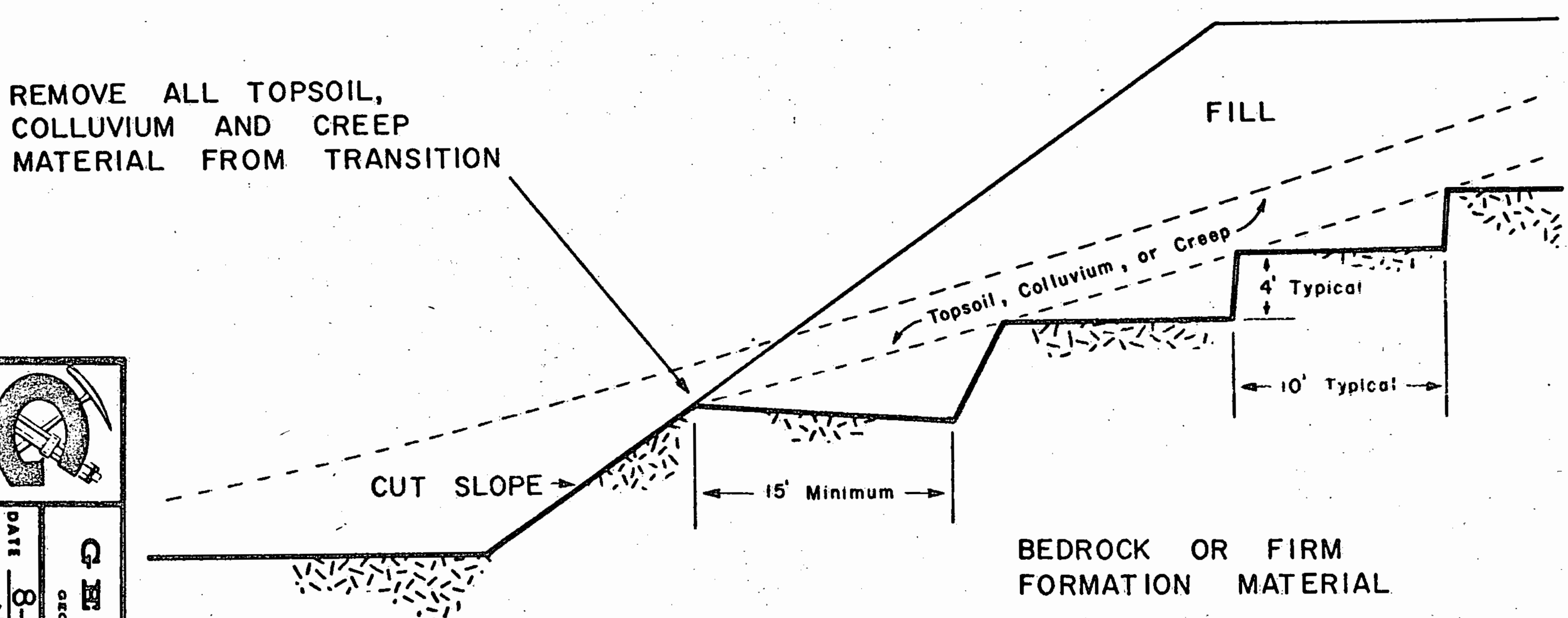

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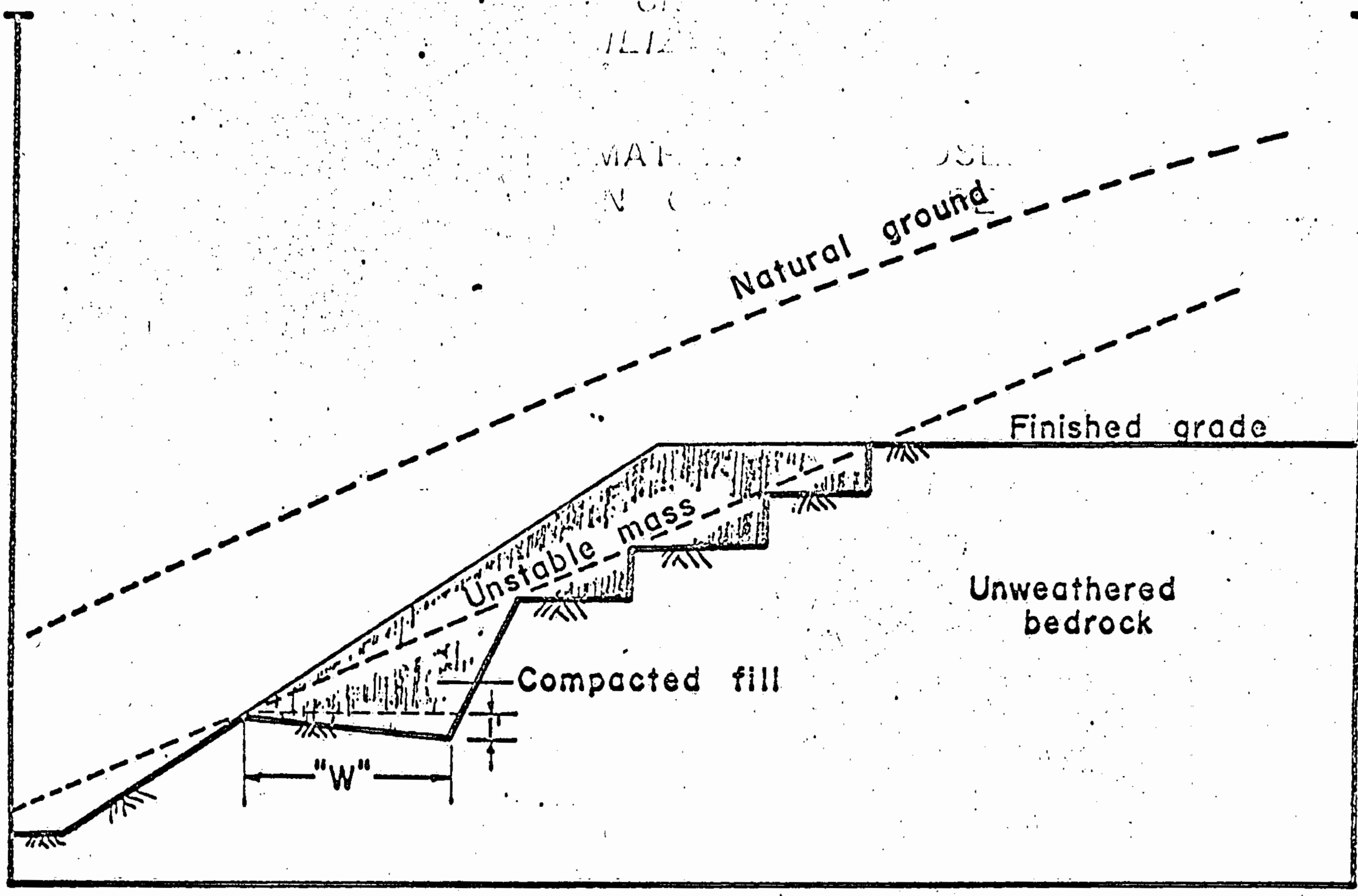
PLATE GS-2

SELECTIVE GRADING DETAIL FOR STABILIZATION FILL

UNSTABLE MATERIAL EXPOSED IN PORTION OF CUT SLOPE



NOTE: 1. Subdrains not required unless specified.

2. "W" shall be equipment width (15') for slope heights less than 40 feet. For slopes greater than 40 feet "W" shall be determined by the project soils engineer.

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STABILATION FILL

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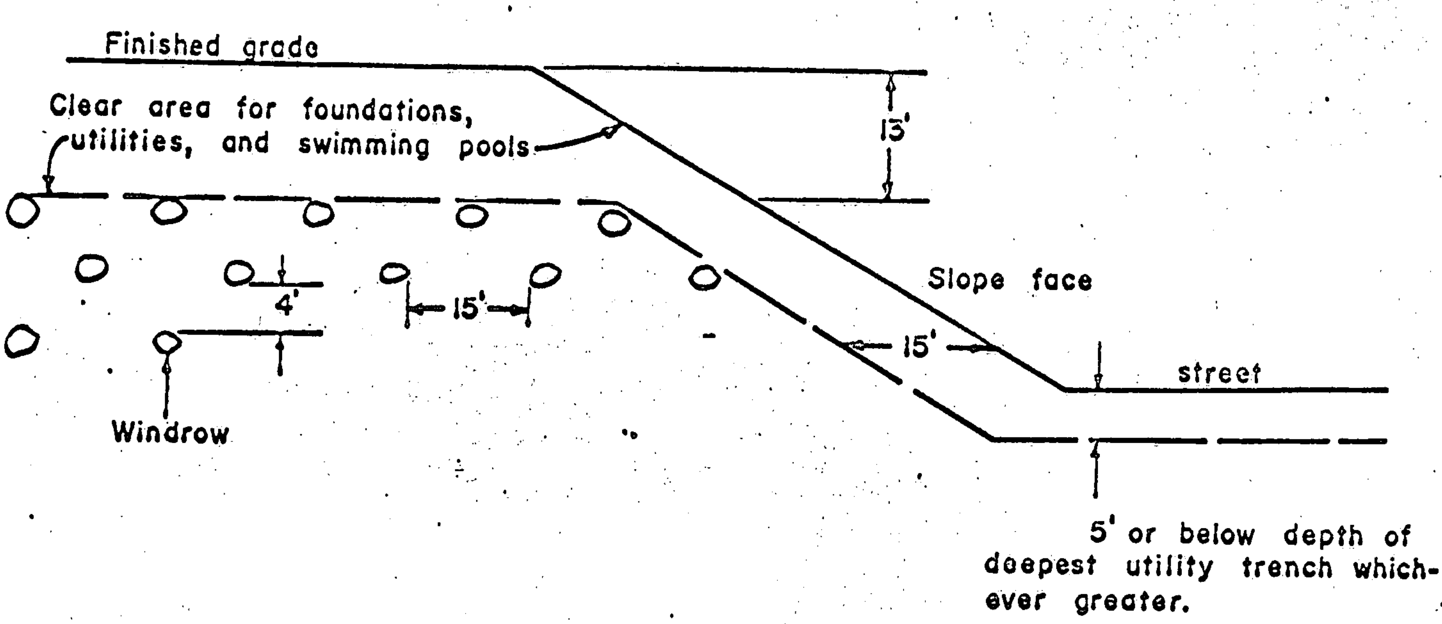
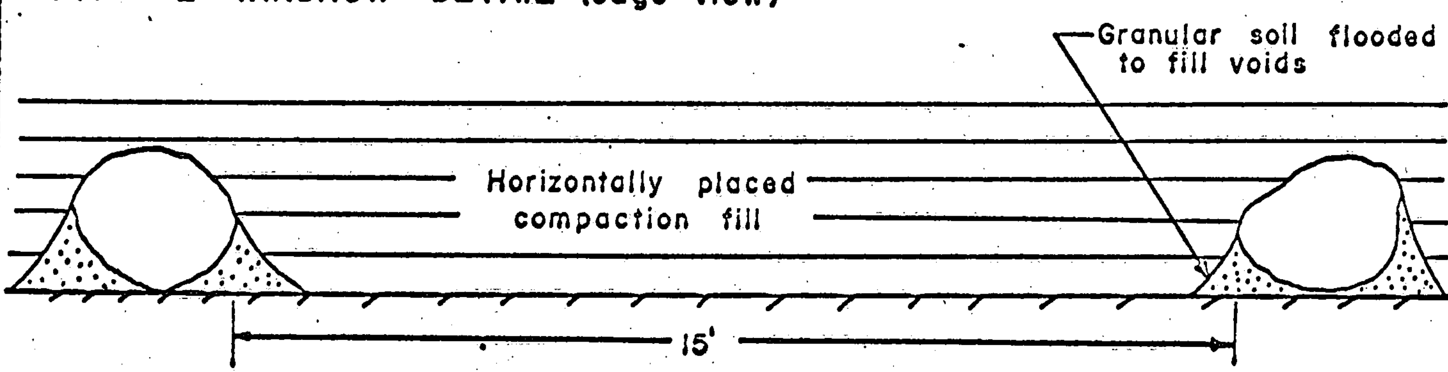
ROCK DISPOSAL DETAIL

BUILDING



TYPICAL WINDROW DETAIL (edge view)



PROFILE VIEW