ATTACHMENT #5

HECO STANDARDS

LETTER OF TRANSMITTAL

Hawaiian Electric Co.,Inc. An HEI Company

October 9, 2003

MK Engineers, Ltd.
286 Kalihi Street
Honolulu, HI 96819

Attention: Paul Uyeda

Subject: Mamala Substation

Enclosed are the following:

COPIES	DESCRIPTION
1	HECO specs. for thermal concrete and fluidized thermal backfill
1	Standard drawing 26919 for 4'X6' MH

These are transmitted as checked below:

_____	As requested.
x	For your information/files.
_____	For your review and comments.
_____	Please provide comments by _____.

Remarks:

Note that the thermal concrete and fluidized thermal backfill can be obtained from Ameron. On standard drawing 26919, revision 4 has not been impleted yet. These are precast and may be obtained from various suppliers.

Sincerely,

Tanay Panalal

Tanay Panalal
Engineering Department

(D) HECO's thermal concrete for ductbank as noted on drawings shall meet the following requirements.

(1) The proportions for the following mix designs shall be in accordance with the guidelines of ACI 211 and ASTM C94 "Standard Specification for Ready Mix Concrete, Option C". The mixes may be modified to maintain yield, slump, setting time and strength. Prior to unloading, a maximum of two (2) gallons of water per cubic yard, may be added, provided that the specification limits for slump and time are not exceeded. Reinforced masonry group proportions are selected from compression test results per ASTM C1019, "Standard Method of Sampling and Testing Grout".

Material	Course Agg.	Fine Agg.	Cement
Type	Basalt	Basalt	I / II
Source	Kapaa	Kapaa	Hawaiian
Spec	ASTM C-33	ASTM-C33	ASTM C-150

Weight in Lbs Per Cubic Yard (SSD)
Mix: 2500 psi Ductline

Pcode	Abs	Sp.G.	2567NOHS
Slump			5" - 7"
3 Fine	3.5	2.70	1517
Conc Sand	4.5	2.65	1693
Cement		3.15	423 (4.5sk)
Water		1.00	316 (38 gal)

(3) HECO's fluidized thermal backfill for ductbank as noted on drawings shall meet the following requirements.

(a) The proportions for the following mix designs shall be in accordance with the guidelines of ACI 211 and ASTM C94 "Standard Specification for Ready Mix Concrete, Option C". The mixes may be modified to maintain yield, slump, setting time and strength. Prior to unloading, a maximum of two (2) gallons of water per cubic yard, may be added, provided that the specification limits for slump and time are not exceeded. Reinforced masonry group proportions are selected from compression test results per ASTM C 1019, "Standard Method of Sampling and Testing Grout".

Material	Course Agg.	Fine Agg.	Fine Agg.	Cement
Type	Basalt	Coral	Basalt	I / II
Source	Kapaa	Maui	Kapaa	Hawaiian
Spec	ASTM C-33	ASTM-C33	ASTM-C33	ASTM C-150

Weight in Lbs Per Cubic Yard (SSD)
Mix: Fluidized Thermal Backfill

Pcode	Abs	Sp.G.	XX67NO15
Slump			N/A
3 Fine	3.5	2.70	1550
Dune Sand	2.0	2.65	500
Conc Sand	4.5	2.65	1300
Cement		3.15	150 (1.6sk)
Water		1.00	433 (52 gal)
Air			1.7%

GENERAL NOTES

1. This guide is intended as an aid in determining the sizes of UG Boxes (Manhole and Handholes) for 15 KV, 25 KV, 46 KV and 69 KV cables.

2. Minimum cable bending radius, minimum cable offset, cable racking, splice movement, and working space requirements are factors that must be considered i determining the sizes and locations or duct entrances into UG Boxes. Refer tc Std. 21-1043 for examples of cable racking.

3. New UG Boxes should normally be designed for a "Y" or "T" tap of the maximum size of cable that is anticipated. For cases where no "T" taps are anticipate in the future, such as for express 3Ø runs through subdivisions and other areas, UG Boxes of a minimum size, based on the ultimate cable size, may be specified. For any given UG Box size, the depth of the box should be specifie to provide adequate racking and splicing space to accommodate the worst or ultimate conditions anticipated. It may be necessary, in some cases, to specify a given size UG Box, due to space limitations dictated by field conditions, with more duct entrances or more ducts in a given run than is show in Tables I and II. For these cases, the depth should be increased to accommodate the additional cables and splices. This would apply only to UG Boxes without fixed depths in Tables I and II. A manhole wall height is fixed at 6'-6".

4. The handholes are to be placed in areas not subject to vehicular traffic. Consult the Technical Information Services Division of the Engineering Dept. i handholes are to be placed in areas that may be subject to incidental light traffic. For roadways and streets, manholes instead of handholes shall be applied.

5. All duct entrances to the long sides of the UG Boxes shall be made near the corners. All entrances to the short sides of the UG Boxes shall be made as specified in the Tables. Duct entrances may be made at an angle to the UG Boxes but these entrances shall be made at the corner of the UG Boxes. Refer to Std. 21-1043 for the types of duct entrances.

6. Whenever new ducts are extended into an existing UG Box, the box shall be examined to determine whether or not it should be rebuilt. Whenever medium or high voltage cables are to be installed in existing ducts and UG Boxes, the UG Boxes shall be examined to determine whether or not they are adequate for the cables that are to be installed.

7. Any special condition not covered in this guide should be referred to the Engineering Department.

8. The cable sizes indicated are the maximum size allowable for use with the particular UG Boxes. When selecting the UG Box sizes, consideration should be given to future cable installations. If it is justified, UG Boxes should be sized for future cable installations.

9. All duct entrances shall be sealed with duct sealing compound, Code 13155, after installing the cables. All spare ducts are to be capped. The sealing method shall be in accordance with Std. 30-1025 for the applicable field situations.

REVISION	DATE	INITIAL
	10/4/78	RM TN
	5/1/80	RM TN
	8/1/93	SK

DRAWN MM	DESIGNED TN/RM	APPD. TN VEC	REDRAWN 08-93
SUPERSEDES			ORIGINAL 03-70
ENGINEERING STANDARD HAWAIIAN ELECTRIC CO INC	UG BOXES APPLICATION GUIDE UG DUCTS & STRUCTURES		30-2000 R
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REVISION	DATE	5/3/78	5/1/80	8/11/93								
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SUPERSEDES

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ENGINEERING STANDARD
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UG BOXES
APPLICATION GUIDE
UG DUCTS & STRUCTURES

TABLE I

FOR NON-LEAD COVERED CABLES

ITEM	UG BOX (HANDHOLE MANHOLE) SIZE	STANDARD DRAWING NUMBER	APPLICATION	DUCTS IN MAIN RUN MAX. NUMBER	DUCTS IN MAIN RUN MAX. SIZE	DUCTS IN LATERAL RUN MAX. NUMBER	DUCTS IN LATERAL RUN MAX. SIZE	UG BOX ENTRANCE FOR MAIN RUN (REFER TO STD. 21-1043)	WALL HEIGHT OR DEPTH	CABLE RACKING DETAIL (REFER TO STD. 21-1043)	MAXIMUM CABLE SIZE	CABLE TAPS	COMMENTS
1	1'-6"X3'-6" 2'x3'	30-2005 30-2006	NON-VEHICULAR TRAFFIC	2	4"	-	-	TYPE A	2'-6" MAX.	FIG. 1	3-1/C #2 PEICN 15 KV	NONE	SERVICES
2	3'X5' PRECAST HH.	15501	NON-VEHICULAR TRAFFIC AND AREAS WHERE NORMAL WATER LEVEL IS MORE THAN 2'-6" BELOW SURFACE GRADE	4	4"	2	4"	TYPE A	2'-6" MAX.	FIG. 1	3-1/C #4/0 PEICN 15 KV	2 CKTS. MAX.	
				2	5"	-	-	TYPE C	2'-6" MAX.	FIG. 3	3-1/C 500 KCMIL PEICN 15 KV	NONE	FOR SHORT RUNS BETWEEN BOXES
				1	5"	-	-	TYPE C	2'-6" MAX.	FIG. 3	3-1/C 1000 KCMIL PEIJ 15 KV	NONE	FOR SHORT RUNS BETWEEN BOXES
				2	4"	-	-	TYPE A	2'-6" MAX.	FIG. 1	3-1/C #1/0 PEICN 25 KV	NONE	SERVICES
				2	4"	-	-	TYPE C	2'-6" MAX.	FIG. 3	3-1/C #1/0 PEICN 25 KV	NONE	SERVICES
				2	4"	-	-	TYPE C	2'-6" MAX.	FIG. 3	3-1/C #4/0 PEICN 25 KV	NONE	
	3'x5' HH.	18841 (SPECIAL)	NON-VEHICULAR TRAFFIC AND AREAS WHERE NORMAL WATER LEVEL IS LESS THAN 2'-6" FROM SURFACE GRADE	4	4"	2	4"	TYPE A	2'-6" MAX.	FIG. 1	3-1/C #4/0 PEICN 15 KV	2 CKTS. MAX.	
				2	5"	-	-	TYPE C	2'-6" MAX.	FIG. 3	3-1/C 500 KCMIL PEICN 15 KV	NONE	FOR SHORT RUNS BETWEEN BOXES
				1	5"	-	-	TYPE C	2'-6" MAX.	FIG. 3	3-1/C 1000 KCMIL PEIJ 15 KV	NONE	FOR SHORT RUNS BETWEEN BOXES
				2	4"	-	-	TYPE A	2'-6" MAX.	FIG. 1	3-1/C #1/0 PEICN 25 KV	NONE	SERVICES
				2	4"	-	-	TYPE C	2'-6" MAX.	FIG. 3	3-1/C #1/0 PEICN 25 KV	NONE	SERVICES
				2	4"	-	-	TYPE C	2'-6" MAX.	FIG. 3	3-1/C #4/0 PEICN 25 KV	NONE	

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(continued)

ITEM	UG BOX (HANDHOLE MANHOLE) SIZE	STANDARD DRAWING NUMBER	APPLICATION	DUCTS IN MAIN RUN MAX. NUMBER	DUCTS IN MAIN RUN MAX. SIZE	DUCTS IN LATERAL RUN MAX. NUMBER	DUCTS IN LATERAL RUN MAX. SIZE	UG BOX ENTRANCE FOR MAIN RUN (REFER TO STD. 21-1043)	WALL HEIGHT OR DEPTH	CABLE RACKING DETAIL (REFER TO STD. 21-1043)	MAXIMUM CABLE SIZE	CABLE TAPS	COMMENTS
	3'x5' HH.	HE SPEC. M-7901	NON-VEHICULAR TRAFFIC AND AREAS WHERE NORMAL WATER LEVEL IS LESS THAN 2'-6" FROM SURFACE GRADE	4	4"	2	4"	TYPE A	2'-6" MAX.	FIG. 1	3-1/C #4/0 PEICN 15 KV	2 CKTS. MAX.	
				2	5"	-	-	TYPE C	2'-6" MAX.	FIG. 3	3-1/C 500 KCMIL PEICN 15 KV	NONE	FOR SHORT RUNS BETWEEN BOXES
				1	5"	-	-	TYPE C	2'-6" MAX.	FIG. 3	3-1/C 1000 KCMIL PEIJ 15 KV	NONE	FOR SHORT RUNS BETWEEN BOXES
				2	4"	-	-	TYPE A	2'-6" MAX.	FIG. 1	3-1/C #1/0 PEICN 25 KV	NONE	SERVICES
				2	4"	-	-	TYPE C	2'-6" MAX.	FIG. 3	3-1/C #1/0 PEICN 25 KV	NONE	SERVICES
				2	4"	-	-	TYPE C	2'-6" MAX.	FIG. 3	3-1/C #4/0 PEICN 25 KV	NONE	
3	4'X6' HH.	18842	NON-VEHICULAR TRAFFIC	4	5"	2	5"	TYPE B	4'-6" MAX.	FIG. 2	3-1/C 500 KCMIL PEIJ 15 KV	2 CKTS. MAX.	
				2	5"	-	-	TYPE C	3'-0" MAX.	FIG. 3	3-1/C 1000 KCMIL PEICN 15 KV	NONE	FOR SHORT RUNS BETWEEN BOXES
4	5'X7' HH.	18843	NON-VEHICULAR TRAFFIC	6	5"	4	5"	TYPE B	5'-5" MIN.	FIG. 2	3-1/C 500 KCMIL PEICN 15 KV	2 CKTS. MAX.	
				8	4"	2	4"	TYPE A	4'-6" MIN.	FIG. 1	3-1/C #1/0 PEICN 25 KV	2 CKTS. MAX.	
				2	5"	-	-	TYPE C	4'-6" MIN.	FIG. 3	3-1/C 500 KCMIL PEICN 25 KV	2 CKTS. MAX.	FOR SHORT RUNS BETWEEN BOXES
				2	6"	-	-	TYPE C	4'-6" MIN.	FIG. 3	3-1/C 1000 KCMIL PEICN 25 KV	NONE	FOR SHORT RUNS BETWEEN BOXES

REVISION	DATE / INITIAL	5/3/78 RM TN	5/1/80 RM TN	8/11/93 JK

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(continued)

ITEM	UG BOX (HANDHOLE MANHOLE) SIZE	STANDARD DRAWING NUMBER	APPLICATION	DUCTS IN MAIN RUN MAX. NUMBER	DUCTS IN MAIN RUN MAX. SIZE	DUCTS IN LATERAL RUN MAX. NUMBER	DUCTS IN LATERAL RUN MAX. SIZE	UG BOX ENTRANCE FOR MAIN RUN (REFER TO STD. 21-1043)	WALL HEIGHT OR DEPTH	CABLE RACKING DETAIL (REFER TO STD. 21-1043)	MAXIMUM CABLE SIZE	CABLE TAPS	COMMENTS
5	6'X11' HH.	18844 (HANDHOLE)	NON-VEHICULAR TRAFFIC	6	5"	2	5"	TYPE B	6'-6"	FIG. 3	3-1/C 500 KCMIL PEICN 15 KV	2 CKTS. MAX.	
				6	5"	2	5"	TYPE B	6'-6"	FIG. 3	3-1/C 1000 KCMIL PEIJ 15 KV	2 CKTS. MAX.	
				6	4"	2	4"	TYPE B	6'-6"	FIG. 1	3-1/C #4/0 PEICN 25 KV	2 CKTS. MAX.	
				6	5"	2	5"	TYPE B	6'-6"	FIG. 3	3-1/C 500 KCMIL PEICN 25 KV	2 CKTS. MAX.	
				6	5"	2	5"	TYPE A	6'-6"	FIG. 1	3-1/C 500 KCMIL PEICN 25 KV	2 CKTS. MAX.	
				8	4"	-	-	TYPE B	6'-6"	FIG. 3	1-1/C 350 KCMIL PEIJ 46 KV	NONE	
	6'X11' HH.	18775 (MANHOLE)	ALL LOCATIONS	8	5"	4	5"	TYPE B	6'-6" MIN.	FIG. 3	3-1/C 500 KCMIL PEICN 15 KV	4 CKTS.	
				8	5"	4	5"	TYPE B	6'-6" MIN.	FIG. 3	3-1/C 1000 KCMIL PEIJ 15 KV	4 CKTS.	
				8	4"	4	4"	TYPE A	6'-6" MIN.	FIG. 1	3-1/C #4/0 PEICN 25 KV	4 CKTS.	
				8	5"	4	5"	TYPE B	6'-6" MIN.	FIG. 3	3-1/C 500 KCMIL PEICN 25 KV	4 CKTS.	
				8	5"	4	5"	TYPE A	6'-6" MIN.	FIG. 1	3-1/C 500 KCMIL PEICN 25 KV	4 CKTS.	
				6	4"	-	-	TYPE B	6'-6" MIN.	FIG. 3	1-1/C 350 KCMIL PEIJ 46 KV	NONE	

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FOR NON-LEAD COVERED CABLES

(continued)

ITEM	UG BOX (HANDHOLE MANHOLE) SIZE	STANDARD DRAWING NUMBER	APPLICATION	DUCTS IN MAIN RUN MAX. NUMBER	DUCTS IN MAIN RUN MAX. SIZE	DUCTS IN LATERAL RUN MAX. NUMBER	DUCTS IN LATERAL RUN MAX. SIZE	UG BOX ENTRANCE FOR MAIN RUN (REFER TO STD. 21-1043)	WALL HEIGHT OR DEPTH	CABLE RACKING DETAIL (REFER TO STD. 21-1043)	MAXIMUM CABLE SIZE	CABLE TAPS	COMMENTS
6	6'X14' HH.	71468 (HANDHOLE)	INCIDENTAL TRAFFIC	8	6"	4	6"	TYPE A	6'-6"	FIG. 1	3-1/C 1000 KCMIL PEICN 25 KV	4 CKTS.	
			(SEE ENGINEERING DEPT.)	8	6"	4	6"	TYPE B	6'-6"	FIG. 3	3-1/C 1000 KCMIL PEICN 25 KV	4 CKTS.	
				6	4"	-	-	TYPE B	6'-6"	FIG. 3	1-1/C 750 KCMIL PEIJ 46 KV	NONE	
				6	4"	-	-	TYPE B	6'-6"	FIG. 3	1-1/C 1500 KCMIL PEIJ 46 KV	NONE	
				6	4"	-	-	TYPE B	6'-6"	FIG. 3	1-1/C 750 KCMIL PEIJ 69 KV	NONE	
				6	5"	-	-	TYPE B	6'-6"	FIG. 3	1-1/C 1500 KCMIL PEIJ 69 KV	NONE	
	6'X14' HH.	71467 (MANHOLE)	ALL LOCATIONS	8	6"	4	6"	TYPE A	6'-6"	FIG. 1	3-1/C 1000 KCMIL PEICN 25 KV	4 CKTS.	
				8	6"	4	6"	TYPE B	6'-6"	FIG. 3	3-1/C 1000 KCMIL PEICN 25 KV	4 CKTS.	
				6	4"	-	-	TYPE B	6'-6"	FIG. 3	1-1/C 750 KCMIL PEIJ 46 KV	NONE	
				6	4"	-	-	TYPE B	6'-6"	FIG. 3	1-1/C 1500 KCMIL PEIJ 46 KV	NONE	
				6	4"	-	-	TYPE B	6'-6"	FIG. 3	1-1/C 750 KCMIL PEIJ 69 KV	NONE	
				6	5"	-	-	TYPE B	6'-6"	FIG. 3	1-1/C 1500 KCMIL PEIJ 69 KV	NONE	

NOTE: Asterisk denotes maximum number of taps if the mains are of maximum size indicated. More than 2 taps may be made if the wall height is increased.

GUIDE FOR UNDERGROUND DUCT LINE DESIGN FOR THE HAWAIIAN ELECTRIC COMPANY

Plans of the roads and monuments which are needed to lay out the duct line can generally be obtained from the City & County Engineering Division or the State Transportation Department. If no plans are available, field data must be taken by surveyors so that the road can be laid out. Duct line plans are generally drawn to a scale of 1"=20'.

All existing manhole covers, driveways, fire hydrants, poles, etc., along the route of the proposed duct line must be located with respect to the known road monuments. Existing grade along the proposed duct line should be taken every 50 feet.

Existing underground lines can generally be determined by checking the field locations of the manhole covers against the records of the various utilities such as gas, water, telephone, electricity, street lights, sewers and storm drains. Elevations may be checked wherever the utility passes through a manhole. However, this method is only approximate.

The City Planning Commission should be consulted for future plans, especially road changes and set-back lines which may affect the duct line. Future plans of the other utilities should also be considered. Should it be necessary to obtain a more accurate location of a water line, the Board of Water Supply can arrange to have metal pipes in the ground checked with their instruments.

The layout of an underground duct line depends on the location of the manholes involved. The problem of locating the manholes should, therefore, be considered first before the duct line is laid out.

The distance between manholes on a straight run is limited only by the length of cable that can be pulled into the duct line. The tension required to pull the cable into the duct must not exceed that recommended by the cable manufacturer. Cable handling equipment such as reels and reel supports also limit the length of cable that can be handled.

In working with the 3/c 46 Kv 600 MCM LPGF cable, the practice has been to limit the manhole spacing to 800 feet. When spacing manholes along a straight section of road, the distance between manholes should be made as nearly equal as possible.

Quite frequently, the manhole must be located at an intersection. The manhole opening should be so located that a winch truck or cable reel placed at the manhole opening does not cause excessive interference with vehicular traffic.

REVISION	DATE	INITIAL

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SUPERSEDES		DUCT LINE DESIGN GUIDE	ORIGINAL 9-14-70
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STANDARD CONSTRUCTION HAWAIIAN ELECTRIC CO. INC.		UG DUCTS & STRUCTURES	SHEET 1 of 3

When a manhole is to be built in the sidewalk area, consideration must be given to future road widening plans, so that the manhole cover will not fall in the space which will be occupied by the future curb or gutter. Difficulty will be experienced in construction as well as in future use if the manhole is build under an overhanging structure.

The manhole opening should be located outside of the parking lane, so that access to the manhole will not be blocked by parked cars. The manhole opening must be clear of the curb line and should be clear of the gutter.

Choose a location for the manhole free from underground obstructions. The site chosen should permit relocating of the manhole without major changes in case of the appearance of unrecorded underground structures such as old storm drains, sewers, or duct lines.

The duct line can now be laid out to connect the manholes. Layout of the duct line depends on different conditions. Some factors to consider in laying out the duct line are maintaining an adequate radius of curvature, avoiding underground obstructions, keeping the duct line square to the window face, and keeping out of the curb and gutter areas. Construction costs will be less if the curb and gutter need not be disturbed.

When planning the route of a duct line, it should be kept in mind that sewers, duct lines, and storm drains cannot be relocated except at prohibitive cost. Water and gas mains may be rerouted with the cost depending on the size of the pipe involved. Service lines may be moved at relatively little expense.

Duct line curvature, both horizontal and vertical, should be designed to have at least 300 feet radius, but field conditions frequently require that a lesser radius be used. The minimum permissible radius for any duct line curve should be determined by the number of curves as well as the length of that section of duct line.

Where possible, the duct line should be laid out parallel to the center line of the road. Complete ties should be made to locate the duct line with respect to road monuments.

The Planning Division will determine the number and size of ducts to be used in the duct line. With a 1-1/2" spacing between ducts and a 3" concrete envelope around the ducts, determine the height and width of the concrete duct line.

With the complete picture of underground obstructions plotted on a profile sheet, the profile of the duct line can be laid out. The profile drawing is most conveniently shown on a distorted scale such that 1"=2' vertically while horizontally 1"=20'.

Clearances between duct lines and other utilities shall meet all applicable requirements in the Public Utilities Commission's General Order #10.

The duct line should have the required cover and should not go any deeper than necessary to avoid obstructions. As a general rule, a minimum slope of 3" per 100 feet of duct line is maintained for drainage of the ducts if feasible. If the location of underground structures make it difficult to provide drain, it may be left out.

Where sharp vertical curves are indicated on the distorted scale, the profile scale should be expanded to obtain a true picture of the curve radii.

Not infrequently, a profile drawing of the tentative path of the duct line will indicate that there are too many underground obstructions to permit the full height of the duct line. This problem is generally solved by transposing the ducts into a flat configuration, thereby decreasing the required vertical space for the duct line. However, this solution requires a corresponding increase in the duct line width.

Sometimes, rerouting of the duct line plan will permit the duct line to cross the obstruction at a more convenient point, or sometimes even avoid the crossing altogether.

Where the duct line needs to be transposed into a special configuration, a 1/2"=1' scale drawing of the roll, showing the plan and elevation of the center lines of each duct in the roll, will provide information for trench width and grades as well as for determining the length of duct line needed for the roll. Duct curves in the roll, as elsewhere, should be limited to a minimum radius of 300 feet.

Wherever the duct arrangement changes in the duct line, a cross section view of the duct line should be drawn. The ducts should be so numbered that in the manhole, the duct numbers are read from left to right, then top to bottom, as in reading a printed page. Where an odd duct is encountered, it shall have the last number of the series.

Oftentimes, reinforcing steel in the duct line will provide additional structural strength for special conditions such as poor soil support or crossing under railroad tracks. The Initiating Division should be consulted before designing any reinforced duct line sections.

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SUPERSEDES		DUCT LINE DESIGN GUIDE	ORIGINAL 9-11-70
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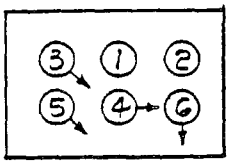

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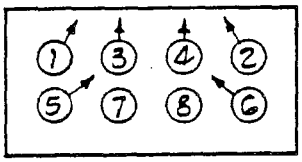

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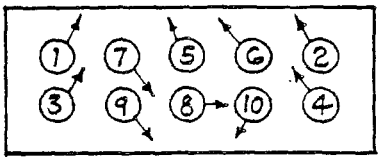

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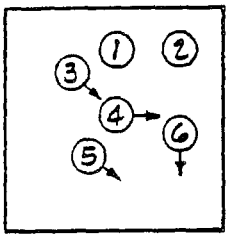

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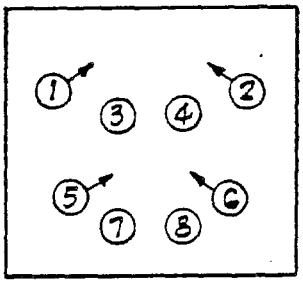

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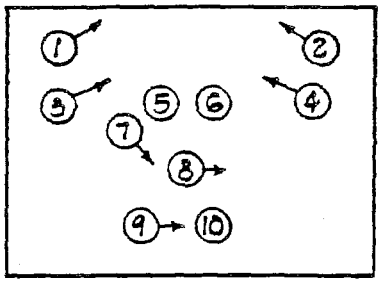

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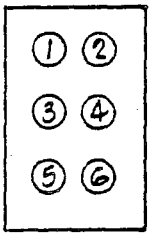
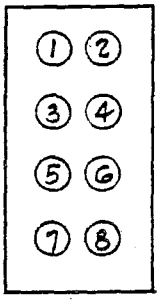


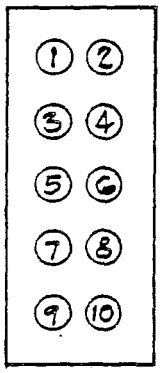
VERTICAL

SIX DUCTS
FIGURE 1



VERTICAL

EIGHT DUCTS
FIGURE 2



VERTICAL

TEN DUCTS
FIGURE 3

NOTE:

A MINIMUM OF FIFTY FEET BETWEEN A HORIZONTAL CONFIGURATION AND A VERTICAL CONFIGURATION SHALL BE REQUIRED FOR THE ROLLS.

REVISION	DATE	INITIAL

DRAWN JH	DESIGNED EM	APPD. JHC RDL VE	REDRAWN
SUPERSEDES		DUCT ROLL SECTIONS	ORIGINAL 9-14-70
STANDARD CONSTRUCTION HAWAIIAN ELECTRIC CO. INC.		U/G DUCTS & STRUCTURES	30-1020 0
			SHEET

Purpose:

This standard is intended to aid in installing duct seals. Duct seals and plugs are used to prevent the migration of water, gas, and debris through the conduit system.

Criteria:

1. If the ducts are installed below the water table or enter the manhole below the water table, both ends of the duct shall be sealed to prevent water from entering the manhole from split, cracked or leaking joints. (See figure 1)

2. Duct entrances to pad mount transformers and switchgears as well as submersible and walk in vaults shall be sealed. (See figure 2 and figure 3)

3. Both ends of all risers shall be sealed or plugged to prevent water ingress into the duct system. (See figure 4)

4. If the Manholes, Handholes, or Vaults are installed in low lying areas such as gutters or at the bottom of a valley or gulch, then all ducts in the manhole, handhole or vault shall be sealed as well as the upstream structures to prevent the migration of water and debris via the duct system. (See figure 5 and figure 6)

5. Lateral or service ducts that enter a building or structure are required to be sealed by General Order 6 Rule 31.6. The ducline shall be sealed both from last manhole or handhole before the ducts enter the building as well as inside the building to prevent gas and water from entering the building. If a Customer furnishes and installs the service conduit and CABLES, the customer shall be responsible for sealing both ends of the duct run including emtpy and spare ducts. This is described in the ELECTRIC SERVICE INSTALLATION MANUAL.

6. Other situations that Engineering or Construction and Maintenance deems necessary.

REVISION	DATE	INITIAL
	11-01-02	CT

DRAWN CT	DESIGNED RM	APPD TN VEC	REDRAWN
SUPERSEDES		CONDUIT AND DUCT SEALING DETAILS UG DUCTS & STRUCTURES	ORIGINAL Dec. 1970
			30-1025 REV 1
ENGINEERING STANDARD HAWAIIAN ELECTRIC CO. INC.			SHEET 1 of 9

Standard:

Conduit sealing systems:

1. Duct Seal Compound
   MIMS code 000124040, part number 13155
   - available in 1 or 5 pound blocks
   - prevents moisture and debris from entering system
   - Not intended for watertight or pressure seal.

2. Inflatable Sealing System
   - available for various duct sizes

Conduit Size	MIMS Code Number/Part Number	
	Seal	Clip
2"	000129585/29570	000129668/29578
3"	000129601/29572	000129668/29578
4"	000129627/29574	000129684/29580
5"	000129643/29576	000129700/29582
6"	000129652	000129714

   - Requires RDSS-IT inflation tool with CO2 cartriges MIMS code 000129726.
   - Should be installed before racking cables and splicing.
   - Insulated cable or solder sealed-bare copper neutrals should be used to make a water tight seal.
   - Intended for watertight seal or pressure seal.
   - Can be used to seal ducts with water flowing up to 16.4 feet of waterhead
   - Not typically used to seal empty ducts.

3. Conduit Plugs
   - available for various duct sizes

Conduit Size	MIMS Code Number	Jack Moon Number
2"	000167437	20D236U
3"	000154856	30D346U
4"	000155935	40D402U
5"	000154867	50D402U
6"	000175933	60D637U

   - Used to seal empty ducts
   - Withstand 30 PSI of water pressure

REVISION | DATE | INITIAL
11-01-02 CT

DRAWN CT | DESIGNED RM | APPD TN VEC | REDRAWN

SUPERSEDES

ENGINEERING STANDARD
HAWAIIAN ELECTRIC CO. INC.

CONDUIT AND DUCT
SEALING DETAILS
UG DUCTS & STRUCTURES

ORIGINAL Dec. 1970

30-1025 | REV 1

SHEET 2 of 9

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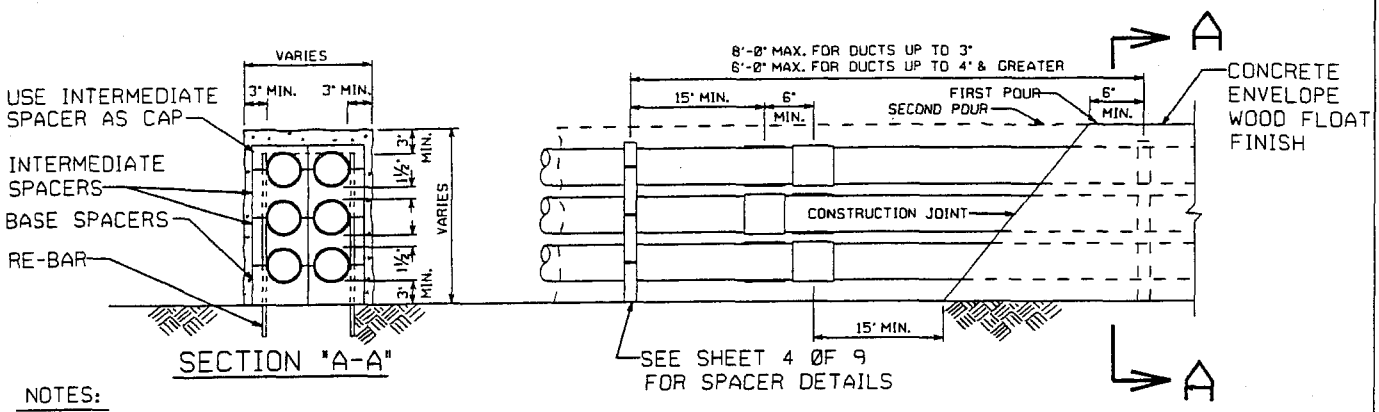
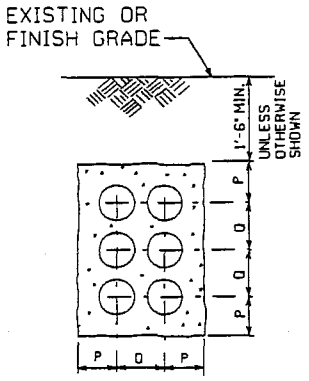


NOTES:

1. STAGGER COUPLINGS (OR BELLED ENDS).
2. ANCHOR CONDUIT WITH #14 STEEL TIE WIRE AND #4 REINFORCING BARS.
3. CEMENT ALL JOINTS.
4. AVOID STANDING ON CONDUIT.
5. REFER TO STD. 30-1005 FOR ADDITIONAL INFORMATION.

TYPICAL DUCT ELEVATION
6 WAY DUCT LINE SHOWN
NOT TO SCALE



REFER TO GO-10 OR SPECIFIC PROJECT DRAWINGS FOR DEPTH REQUIREMENTS

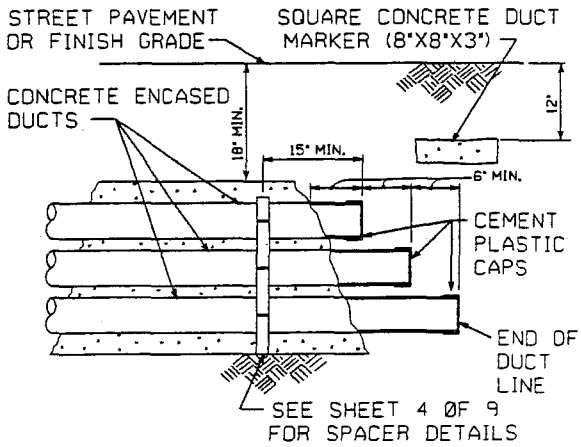
DUCT SIZE	DIMENSIONS P	Q
2	4 3/16	3 7/8
3	4 3/4	5
4	5 1/4	6
5	5 13/16	7 1/16
6	6 5/16	8 1/8

(DIMENSIONS IN INCHES)

NOTES:

1. MAINTAIN 1½" MINIMUM SPACING BETWEEN DUCTS; 3" MINIMUM CONCRETE ENVELOPE AROUND TOP, BOTTOM AND SIDES.
2. DIMENSIONS ARE MINIMUM DIMENSIONS.

CONCRETE ENCASED TYPICAL DUCT SECTION 6 WAY DUCT LINE SHOWN



TYPICAL STUB OUT DETAIL 6 WAY DUCT LINE SHOWN

CONCRETE ENCASEMENT DETAILS

REVISION / DATE / INITIAL	DRAWN CT	DESIGNED FK	APPD	REDRAWN
SUPERSEDES		PLASTIC DUCTS INSTALLATION DETAILS UNDERGROUND STRUCTURES	ORIGINAL 06-01	
ENGINEERING STANDARD HAWAIIAN ELECTRIC CO. INC.			30-1035	REV 0
			SHEET 5 OF 11	

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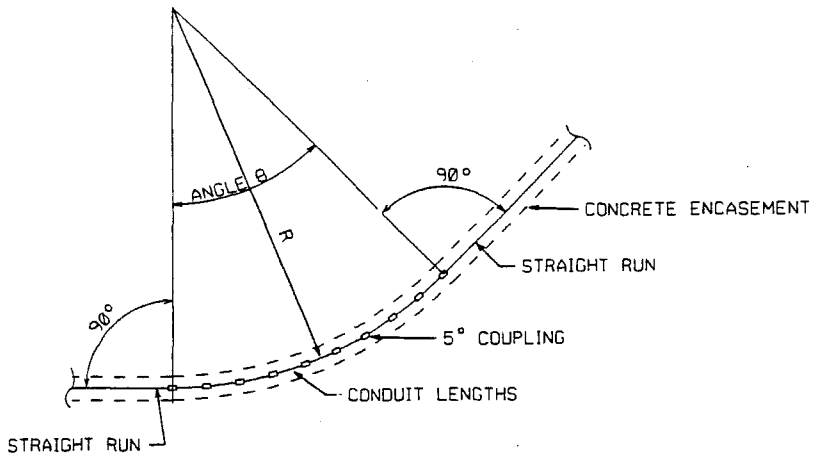


TABLE A

APPROX. RADIUS OF BEND R	LENGTH OF EACH CONDUIT FT. USING 5° BEND AT COUPLING
11'-6"	1
17'-3"	1.5
23'-0"	2
28'-9"	2.5
34'-6"	3
40'-3"	3.5
46'-0"	4
51'-9"	4.5
57'-6"	5
69'-0"	6
80'-6"	7
92'-0"	8

EXAMPLE OF NOTE 3:

RADIUS OF BEND (R) = 60'
ANGLE OF BEND (B) = 45°

FROM TABLE A, THE NEAREST VALUE TO 60' RADIUS IS 57'-6". LENGTH OF CONDUIT = 5'
FROM TABLE B, FOR 45° ANGLE
NUMBER OF COUPLINGS REQUIRED = 9
NUMBER OF CONDUIT LENGTHS REQUIRED = 8

TABLE B

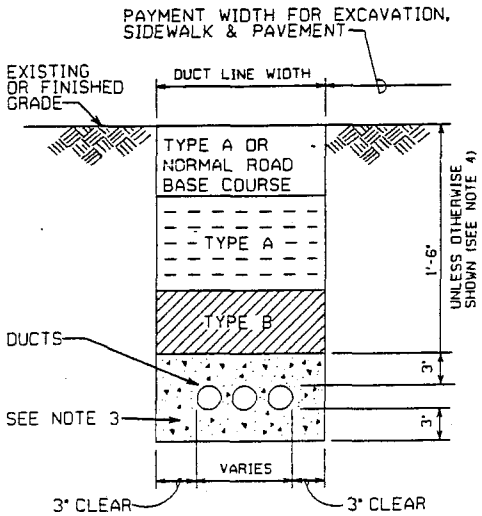
ANGLE OF BEND θ	NUMBER OF COUPLINGS & CONDUIT LENGTHS REQ'D	
	COUPLING	CONDUIT
15°	3	2
30°	6	5
45°	9	8
60°	12	11
75°	15	14
90°	18	17

NOTES:

THERE ARE 4 METHODS OF FORMING CURVES WITH PLASTIC CONDUIT.

1. "HEAT" BENDING: USE HOTBOX BENDING EQUIPMENT OR APPROVED MANUFACTURERS METHOD. DO NOT USE TORCH OR OPEN FLAME.
2. "COLD" BENDING: LIMIT TRENCH FORMED RADIUS SWEEPS TO 25' MINIMUM RADIUS.
3. 5° ANGLE COUPLINGS MAY BE USED AS SHOWN.
4. FACTORY MADE ELBOWS AND SWEEPS MAY BE USED.

METHOD OF FORMING CURVES



NOTES:

1. TYPE A: EARTH OR EARTH & GRAVEL. IF EARTH & GRAVEL, THE MAX. ROCK SIZE SHALL BE 1" & THE MIXTURE SHALL CONTAIN NOT MORE THAN 50%, BY VOLUME, OF ROCK PARTICLES.
2. TYPE B: EARTH OR EARTH & GRAVEL. IF EARTH & GRAVEL, THE MIXTURE MUST PASS A ½" MESH SCREEN & CONTAIN NOT MORE THAN 20%, BY VOLUME, OF ROCK PARTICLES.
3. CONCRETE ENCASED 3"
4. REFER TO SPECIFIC PROJECT DRAWINGS FOR DEPTH REQUIREMENTS. 1'-6" MINIMUM REQUIRED.

EXCAVATION & BACKFILL DETAILS (TYPICAL)

CONCRETE ENCASEMENT DETAILS

REVISION | DATE | INITIAL

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SUPERSEDES			ORIGINAL 06-01
ENGINEERING STANDARD HAWAIIAN ELECTRIC CO. INC.	PLASTIC DUCTS INSTALLATION DETAILS UNDERGROUND STRUCTURES		30-1035 REV Ø
			SHEET 6 OF 11

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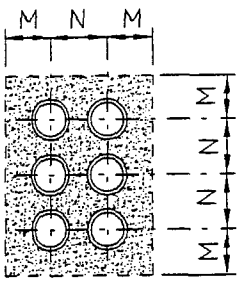
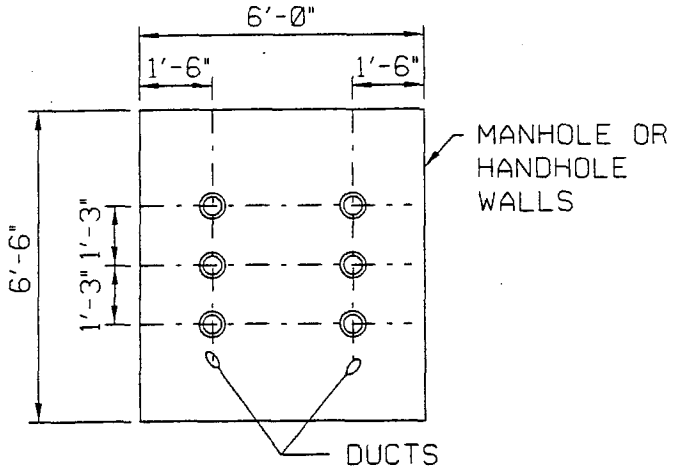
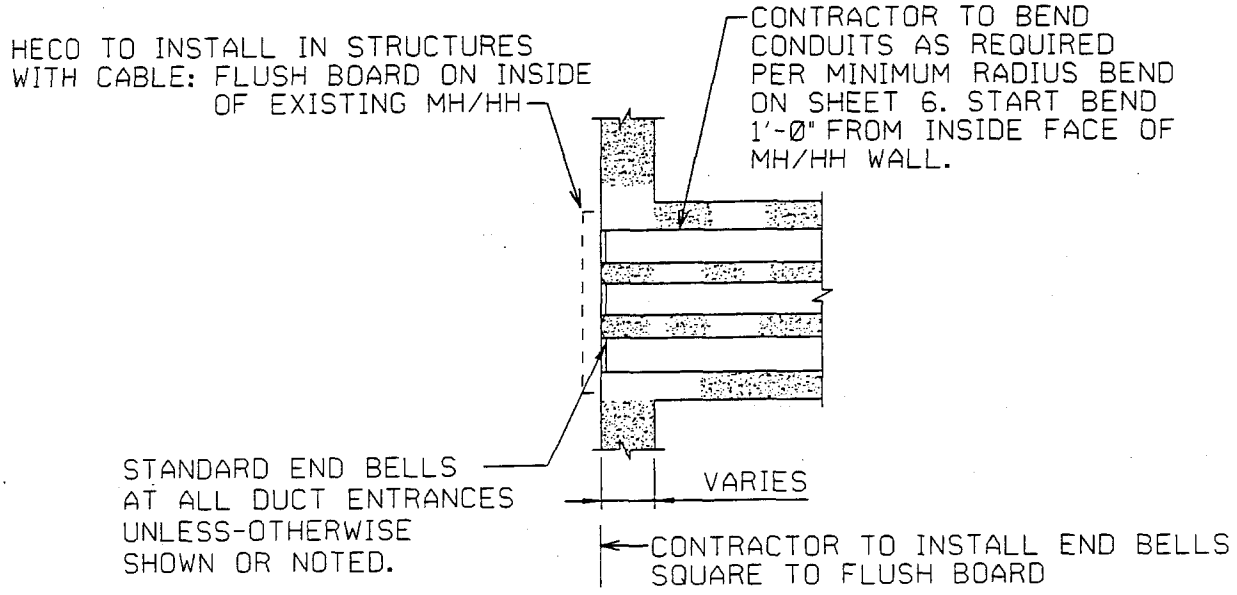


DUCT SIZE	DIMENSION M	N
2	4	5
3	5	6
4	5½	7
5	6	8
6	6 5/16	9

(DIMENSION IN INCHES)





TYPICAL CONDUIT ENTRANCE INTO MANHOLE OR VAULT WALLS (6 WAY DUCT LINE SHOWN)

REVISION	DATE	INITIAL

DRAWN TH II | DESIGNED | APPD | REDRAWN

SUPERSEDES | ORIGINAL 06-01

ENGINEERING STANDARD
HAWAIIAN ELECTRIC CO. INC.

PLASTIC DUCTS
INSTALLATION DETAILS
UNDERGROUND STRUCTURES

30-1035 | REV Ø

SHEET 10 OF 11

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REFERENCES:

Standards:

30-1005	Conduit Application Guide
30-1006	Ductline Applications
30-1010	Typical Backfill Details
30-1015	Typical Duct Encasement Details
30-1020	Duct Roll Sections
30-1030	Plastic Ducts, Special Installation Details
30-9000	References & Standard for UG Ducts & Structures

Specifications:

M7001	Plastic Conduits & Fittings Constructed With PVC Plastic
CS 7202	General Conditions
CS 7001	Construction of UG Facilities
CS 7003	Construction of Electrical Facilities

REVISION	DATE	INITIAL

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SUPERSEDES

ENGINEERING STANDARD
HAWAIIAN ELECTRIC CO. INC.

PLASTIC DUCTS
INSTALLATION DETAILS
UNDERGROUND STRUCTURES

REDRAWN

ORIGINAL 06-01

30-1035 | REV 0

SHEET 11 of 11

Mamala Substation
Design Considerations

Substation
1. CMU wall shall be designed for 100mph wind.

2. Construction of the CMU wall shall be completed before Hawaiian Electric starts work on the substation.

3. Heco inspector will need to be notified prior to start of construction of the CMU wall.

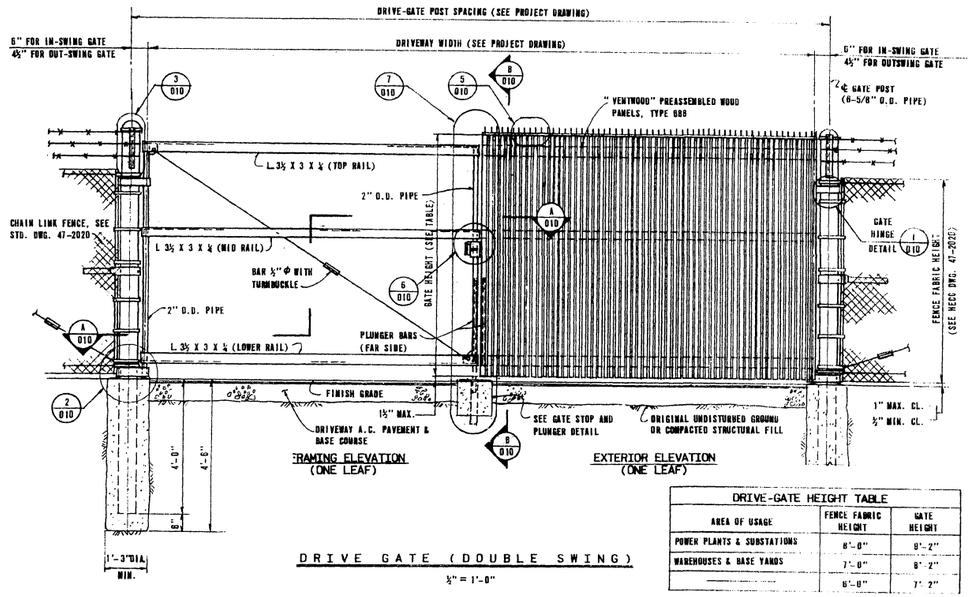
4. Heco checking with Safety/Security on the security measures on the top of the CMU wall, information to follow.

5. Heco checking with Safety/Security on the potential roof access into the substation via the adjacent control building, information to follow.

Ductline
1. If unsuitable soil material is encountered during the excavation for the ductline and manholes, the contractor shall provide 1ft of 3B fine directly
under the ductline or manhole and 2 ft of #2 Drain or Surge rock below that. The entire 3 ft thick shall be wrapped with geotextile fabric.

2. Provide profiles.

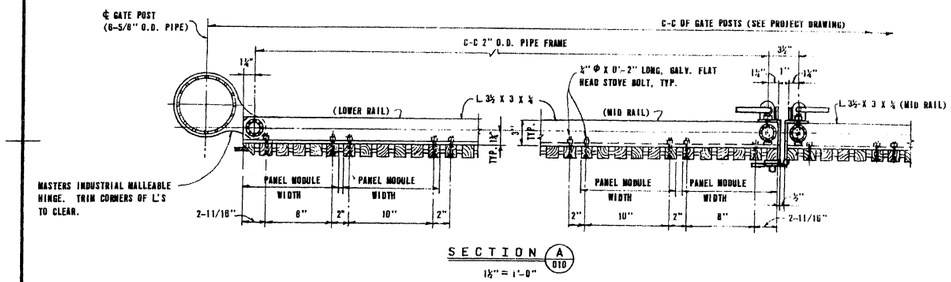
3. Provide manhole development drawings.



DRIVE GATE (DOUBLE SWING)

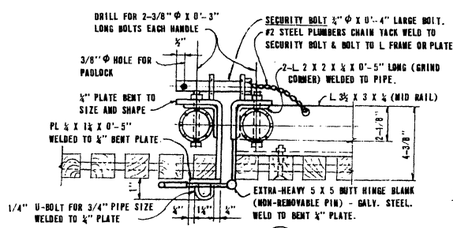
½" = 1'-0"

DRIVE-GATE HEIGHT TABLE		
AREA OF USAGE	FENCE FABRIC HEIGHT	GATE HEIGHT
POWER PLANTS & SUBSTATIONS	8'-0"	9'-2"
WAREHOUSES & BASE YARDS	7'-0"	8'-2"
———	6'-0"	7'-2"

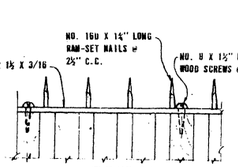


SECTION A 1/D10

1½" = 1'-0"

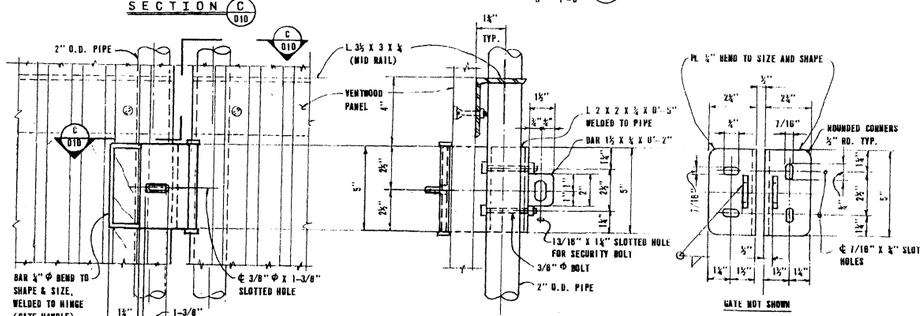


SECTION C 1/D10



SECURITY SPIKE ASSEMBLY DETAIL 5/D10

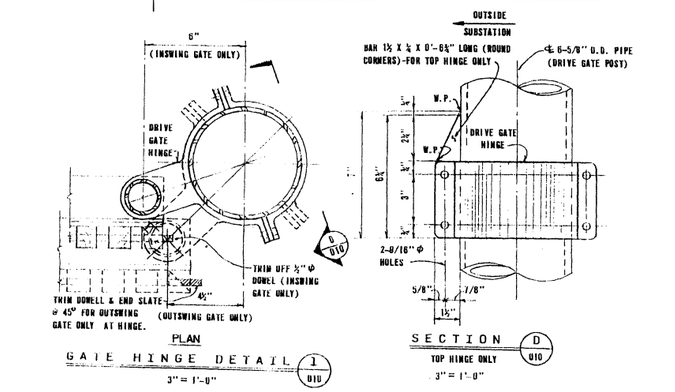
3" = 1'-0"

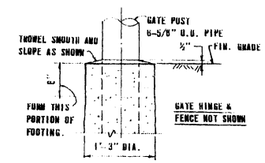


FRONT VIEW — SIDE VIEW — REAR VIEW

GATE HANDLE & PADLOCK DETAIL 6/D10

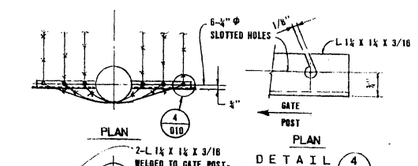
3" = 1'-0"

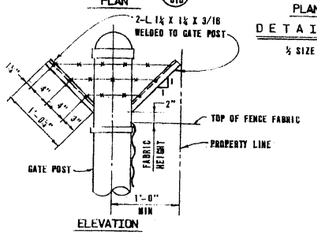


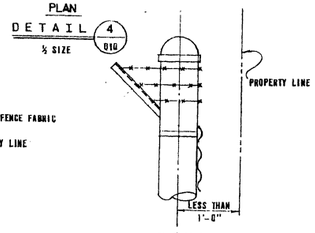


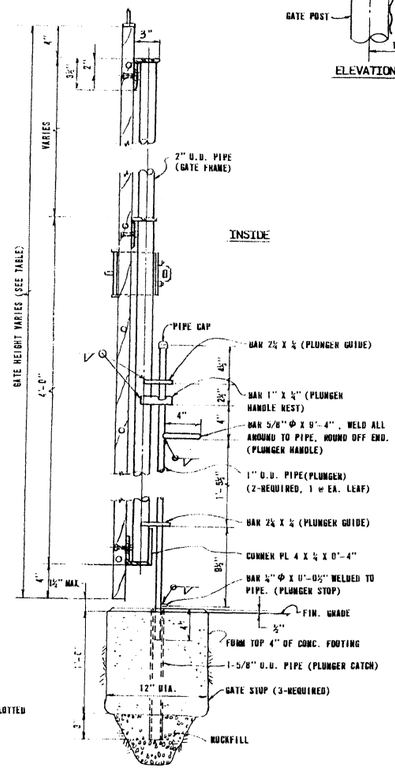
TOP OF GATE POST FOOTING DETAIL 2/D10

1" = 1'-0"





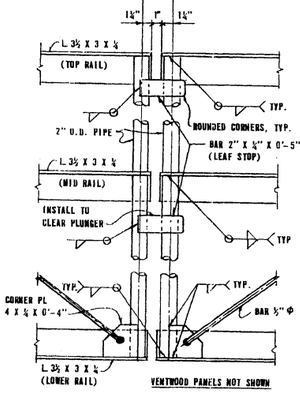




GATE STOP & PLUNGER DETAIL

SECTION B/D10

1½" = 1'-0"



INTERIOR ELEVATION

GATE LEAF STOP & CORNER PL DETAIL 7/D10

1½" = 1'-0"

SPECIFICATION

VENTWOOD - DRIVEGATE

1. CHAIN LINK - FENCE AND WALK GATE - REFER TO HECO DRAWING 47-2020 FOR DETAILS AND SPECIFICATIONS.
2. DRIVE-GATE POSTS SHALL BE HOT DIPPED GALVANIZED, INSIDE AND OUTSIDE, 6-5/8 INCH O.D. PIPE, 18.97 LBS. PER LINEAL FOOT, CONFORMING TO ASTM A120 STANDARD WEIGHT. REFER TO PROJECT DRAWING FOR DRIVE-GATE POSTS SPACING.
3. DRIVE GATE SHALL BE SWING TYPE COMPLETE WITH HANDLE, STOPS, AND HINGES.

   GATE FRAME SHALL BE CONSTRUCTED OF 2 INCH O.D. PIPE, 2.72 LBS. PER LINEAL FOOT, CONFORMING TO ASTM A120 STANDARD WEIGHT AND 3½ INCH X 3 INCH X ¼ INCH ANGLE IRON CONFORMING TO ASTM A36. THE MEMBERS SHALL BE WELDED AT ALL CONNECTIONS WITH 3/16 INCH FILLET WELD, EXCEPT WHERE OTHERWISE SHOWN. GATE FRAME SHALL BE GALVANIZED AFTER FABRICATION.

   GATE HINGE SHALL BE MASTER'S MALLEABLE INDUSTRIAL HINGE (90 DEGREES), GALVANIZED. THE HINGE SHALL BE OF ADEQUATE STRENGTH AND CAPABLE OF THE GATE BEING OPENED OR CLOSED EASILY BY ONE PERSON.

   GATE HANDLE AND STOPS SHALL BE PROVIDED FOR EACH DRIVE-GATE. THE HANDLE SHALL BE ARRANGED FOR LOCKING (PAD LOCKS SHALL BE FURNISHED BY THE HAWAIIAN ELECTRIC CO., INC.). THE DRIVE-GATE SHALL BE PROVIDED WITH THREE STOPS TO SECURE THE GATE LEAFS IN EITHER THE FULL CLOSED POSITION OR THE FULL OPEN POSITION. ALL MATERIALS SHALL BE GALVANIZED.

   WOOD PANELS SHALL BE "VENTWOOD" PREASSEMBLED WOOD PANELS, TYPE 888, AS MANUFACTURED BY HOWARD MANUFACTURING CO. (KENT, WASHINGTON OR HUNTINGTON PARK, CALIF.) OR EQUAL APPROVED BY THE ENGINEER IN WRITING. THE PANEL RAILS SHALL BE MADE OF WESTERN HEMLOCK AND DOWELS SHALL BE MADE OF ALASKA CYPRESS. ALL PANELS AND OTHER MISCELLANEOUS WOODWORK SHALL BE TREATED FOR TERMITES WITH "PENTA" OR APPROVED EQUAL. FINISH PAINT SHALL BE TWO COATS OF CABOTS "ALCAZAR BROWN" NO. HR-36, OR EQUAL APPROVED BY THE ENGINEER IN WRITING.

   SECURITY SPIKE ASSEMBLY SHALL BE NO. 16D RAM-SET NAILS, 1¾ INCH LONG, SPACED 2½ INCHES APART IN A 1½ INCH X 3/16 INCH BAR. THE ASSEMBLY SHALL BE ATTACHED TO THE TOP OF THE "VENTWOOD" PANELS WITH NO. 9 "ROUND HEAD" WOOD SCREWS, 1½ INCH LONG, SPACED 10 INCHES APART. PRIOR TO INSTALLATION, PAINT THE ASSEMBLY WITH KOPPERS "BITUMASTIC 50" & "BITUPLASTIC 30". ALL MATERIALS SHALL BE GALVANIZED.
4. SPECIAL INSTALLATION INSTRUCTION - AFTER INSTALLATION HAS BEEN COMPLETED, ALL EXPOSED THREADS OF BOLTED PARTS SHALL BE PEENED TO PREVENT REMOVAL OF THE NUT.

NO.	DATE	REVISIONS	BY	CHK'D	APP'D
0	7-20-81	REDRAWN	GEA	GP	

VENTWOOD DRIVE GATE
PLANS, SECTIONS & DETAILS
SUBSTATION STANDARDS

DESIGNED	GP	DRAWN	GEA	DATE 5-19-81	SCALE AS NOTED
CHECKED	ELEC. GP	MECH. BY HVAC			

APPROVAL
B. Perkins
M. Kaahanui

ENGINEERING DESIGN DEPARTMENT
HAWAIIAN ELECTRIC CO., INC.
HONOLULU, HAWAII

DRAWING NUMBER 47-2010

REV. 0

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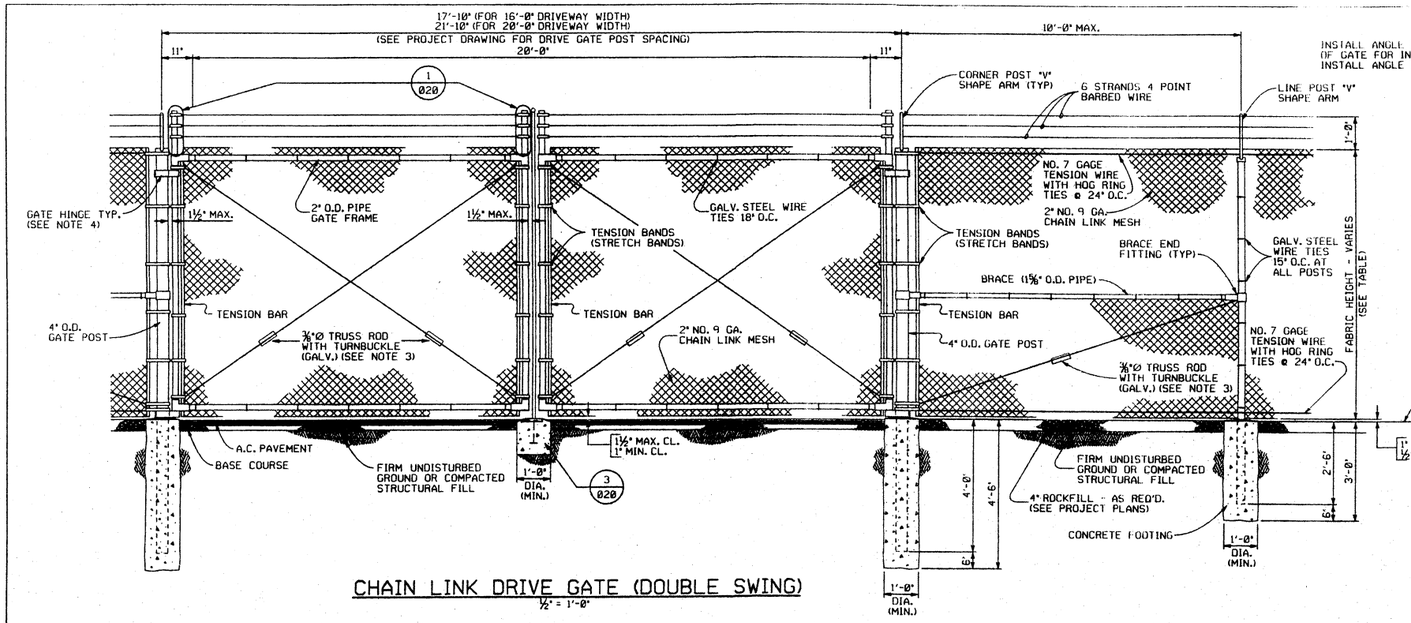
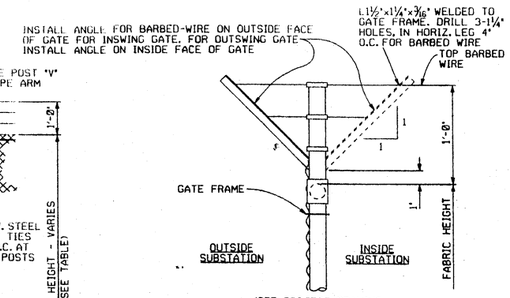


CHAIN LINK DRIVE GATE (DOUBLE SWING)

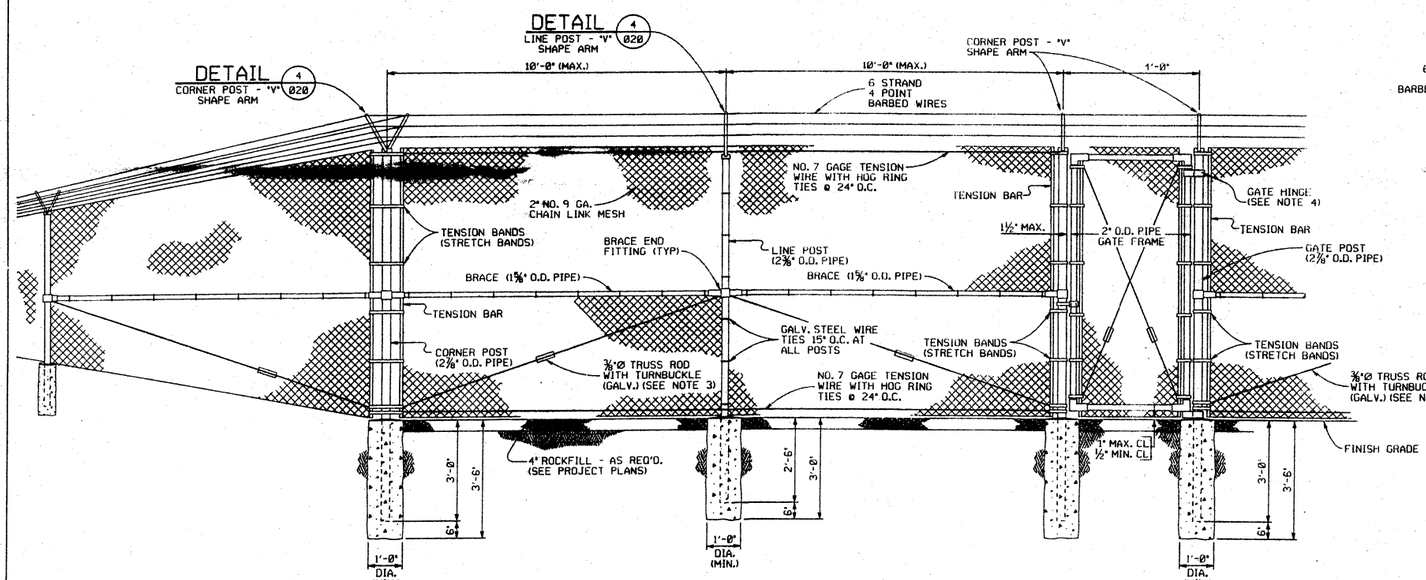
½" = 1'-0"



DETAIL 1 020

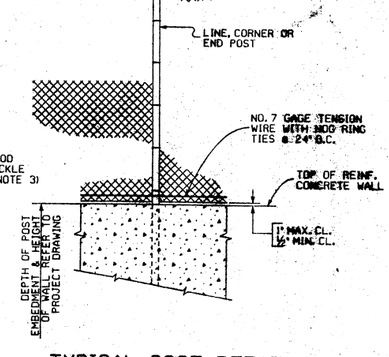
N.T.S.

SECURITY FENCE HEIGHT	
AREA OF USAGE	FENCE FABRIC HEIGHT
POWER PLANTS & SUBSTATIONS	8'-0"
WAREHOUSES & BASEYARDS	7'-0"
----------	6'-0"



CORNER & BRACE POST

½" = 1'-0"

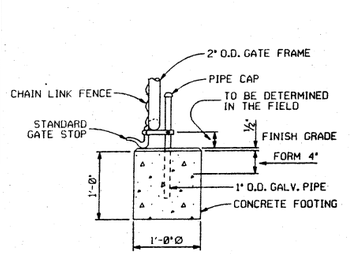


TYPICAL POST DETAIL AT CONCRETE WALL

½" = 1'-0"

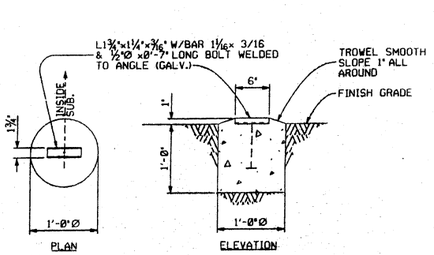
WALK GATE DETAIL - 7' & 8' FABRIC

½" = 1'-0"



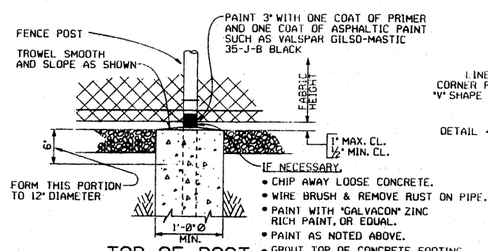
GATE KEEPER DETAIL 2 020

1" = 1'-0"



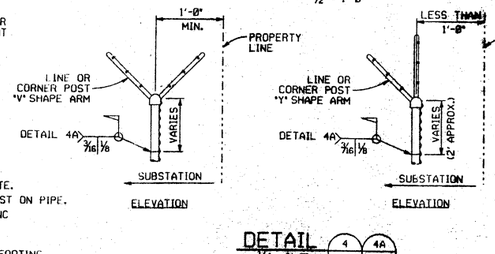
GATE STOP DETAIL 3 020

1" = 1'-0"



TOP OF POST FOOTING DETAIL - TYP

½" = 1'-0"



DETAIL 4 4A 020 020

½" = 1'-0"

PROPERTY LINE

NOTE:
DETAIL 4A FOR FENCE POST EXTENSION. AFTER POST HAS BEEN EXTENDED, PROVIDE FINISH AS FOLLOWS:

- WIRE BRUSH TO REMOVE RUST AND SURFACE DEPOSITS.
- WASH WITH CLEANING SOLUTION.
- PAINT WITH COLD GALVANIZED COATING, PRIMER AND FINISH COAT AS DETAILED IN PROJECT SPECIFICATION.

SPECIFICATIONS

pst472020.0104

CHAIN LINK - FENCE, WALK GATE & DRIVE GATE

1. FABRIC SHALL MEET THE GENERAL REQUIREMENTS FOR METALLIC-COATED STEEL CHAIN LINK FENCE FABRIC FOR INDUSTRIAL USAGE, AS COVERED BY ASTM A392. THE FABRIC SHALL BE OF A 2-INCH MESH WOVEN FROM A GOOD COMMERCIAL QUALITY STEEL WIRE OF NO. 9 GAUGE, 0.148 INCH NOMINAL DIA.. THE WIRE SHALL WITHSTAND A BREAKING LOAD OF 1,250 LBS. THE FABRIC SHALL BE HOT DIPPED GALVANIZED, NOT LESS THAN 1.2 OZ. OF ZINC PER SQ. FOOT OF ACTUAL SURFACE COVERED, AFTER WEAVING AND FURNISHED WITH TOP AND BOTTOM SELVAGE TWISTED AND BARBED. THE FABRIC SHALL BE AS SHOWN ON THE PROJECT DRAWING.
2. POSTS SHALL BE HOT DIPPED GALVANIZED, INSIDE AND OUTSIDE, ROUND PIPE CONFORMING TO ASTM A120 STANDARD WEIGHT. ALL POSTS SHALL BE SET TRUE TO LINE AND GRADE AND EMBEDDED IN CONCRETE FOOTINGS. ALL POST SHALL BE PROVIDED WITH "V" SHAPE BARBED-WIRE SUPPORT ARMS. ORNAMENTAL TOPS SHALL BE PROVIDED WHEN NECESSARY.

   LINE POSTS SHALL BE 2⅜" O.D. PIPE, 3.65 LBS PER LINEAL FOOT, SPACED NOT MORE THAN 10 FEET CENTER TO CENTER. FASTEN FABRIC TO LINE POSTS W/GALVANIZED STEEL WIRE AT INTERVALS NOT EXCEEDING 15 INCHES.

   CORNER OR END POSTS SHALL BE 2⅞" O.D. PIPE, 5.79 LBS. PER LINEAL FOOT.

   WALK GATE POSTS SHALL BE 2⅞" O.D. PIPE, 5.79 LBS. PER LINEAL FOOT, SPACED 4 FEET CENTER-TO-CENTER.

   DRIVE-GATE POSTS SHALL BE 4" O.D. PIPE, 9.10 LBS. PER LINEAL FOOT. SEE PROJECT DRAWING FOR DRIVE-GATE POSTS SPACING.
3. BRACING SHALL BE HOT DIPPED GALVANIZED, INSIDE AND OUTSIDE, 1⅝" O.D. PIPE, 2.27 LBS. PER LINEAL FOOT, CONFORMING TO ASTM A120 STANDARD WEIGHT. INSTALL THE HORIZONTAL BRACE AT EACH CORNER, END, WALK GATE, AND DRIVE-GATE POSTS AT MID-HEIGHT OF THE FABRIC. EACH BRACE SHALL BE DIAGONALLY TRUSSED WITH A ⅜" ROUND ROD, HOT DIPPED GALVANIZED, FROM THE LINE POST BACK TO THE CORNER, END, WALK GATE, OR DRIVE-GATE POST. EACH TRUSS ROD SHALL BE PROVIDED WITH A TURNBUCKLE, A HEAVY TRUSS TIGHTENER, AND BRACE END FITTING. FASTEN FABRIC TO BRACE RAIL WITH STEEL WIRE SPACED 24" O.C. ALL MATERIAL SHALL BE GALVANIZED.
4. GATES SHALL BE SWING TYPE COMPLETE WITH LATCHES, STOPS, KEEPERS, HINGES AND WITH PROVISIONS FOR SIX STRANDS OF BARBED-WIRE ABOVE THE FABRIC, UNLESS OTHERWISE SPECIFIED.

   GATE FRAMES SHALL BE CONSTRUCTED OF HOT DIPPED GALVANIZED, INSIDE AND OUTSIDE 2" O.D. PIPE, 2.72 LBS. PER LINEAL FOOT, CONFORMING TO ASTM A120 STANDARD WEIGHT. THE MEMBERS SHALL BE WELDED AT ALL CORNERS OR ASSEMBLED WITH FITTINGS AND RIGIDLY TRUSSED AND BRACED TO PREVENT SAG OR TWIST. WHERE WELDING IS DONE, CLEAN AND GRIND SMOOTH THE AREA BEFORE APPLYING AMERON "AMERCOAT 160" OR CARBOLINE "CARBOMASTIC 15" PER THE MANUFACTURERS DIRECTION.

   GATE HINGES SHALL BE MALLEABLE INDUSTRIAL HINGES (90°), GALVANIZED. THE HINGES SHALL BE OF ADEQUATE STRENGTH AND CAPABLE OF THE GATE BEING OPENED OR CLOSED EASILY BY ONE PERSON.

   GATE LATCHES, STOPS OR KEEPERS SHALL BE PROVIDED FOR ALL GATES. ALL DOUBLE SWING GATES SHALL HAVE A LATCH OF THE PLUNGER (DROP) ROD TYPE ARRANGED TO FULLY ENGAGE THE CENTER STOP. ALL SINGLE LEAF GATES SHALL BE EQUIPPED WITH A MALLEABLE FORK LATCH. ALL LATCHES SHALL BE ARRANGED FOR LOCKING (PAD LOCKS SHALL BE PROVIDED BY HAWAIIAN ELECTRIC COMPANY, INC.). KEEPERS SHALL CONSIST OF A MECHANICAL DEVICE FOR SECURING THE FREE END OF THE GATE WHEN IN THE FULL OPEN POSITION. ALL MATERIALS SHALL BE GALVANIZED.

   GATE FABRIC SHALL BE THE SAME TYPE AS USED IN THE FENCE CONSTRUCTION. THE FABRIC SHALL BE ATTACHED SECURELY TO THE GATE FRAME AT INTERVALS NOT EXCEEDING 15 INCHES.
5. BARBED-WIRE SUPPORTING ARMS, WHEN SPECIFIED ON THE PROJECT DRAWINGS, SHALL BE "V" SHAPED AT ANGLES OF APPROXIMATELY 45° AND SHALL BE FILLED WITH CLIPS FOR ATTACHING SIX STRANDS OF BARBED WIRE. AT 45° THE TOP BARBED WIRE SHALL BE APPROXIMATELY 12" HORIZONTALLY FROM THE FENCE LINE WITH THE OTHER WIRES SPACED UNIFORMLY FROM THE TOP OF FENCE AND THE OUTSIDE STRAND. THE ARMS SHALL BE OF SUFFICIENT STRENGTH TO WITHSTAND A WEIGHT OF 250 LBS. APPLIED AT THE OUTER STRAND BARBED-WIRE.
6. TENSION BARS AND BAND STEEL SHALL BE PROVIDED AT ALL CORNER, END, AND GATE POSTS. TENSION BARS SHALL NOT BE LESS THAN 2" SHORTER THAN THE HEIGHT OF THE FABRIC WITH WHICH IT IS TO BE USED. TENSION BANDS SHALL BE OF ADEQUATE STRENGTH AND OF SUFFICIENT NUMBER TO ADEQUATELY FASTEN THE FABRIC AND TENSION BAR TO THE CORNER, END, OR GATE POSTS AT INTERVALS NOT EXCEEDING 15 INCHES. ALL MATERIAL SHALL BE GALVANIZED.
7. TENSION WIRE SHALL BE MARCELLED NO. 7 GAUGE, 0.177 INCH NOMINAL DIAMETER, GALVANIZED WIRE. THE TENSION WIRE SHALL BE FASTENED TO THE FABRIC AT INTERVALS NOT EXCEEDING 24 INCHES.
8. BARBED WIRE SHALL CONSIST OF TWO STRANDS OF TWISTED NO. 12-½ GAUGE WIRE WITH 4 POINT THICK-SET NO. 14 GAUGE BARBS SPACED NO MORE THAN 4" APART. ALL MATERIAL SHALL BE GALVANIZED.
9. INSTALLATION OF FENCING, INCLUDING GATES, SHALL MEET THE REQUIREMENTS OF ASTM F567.
10. GALVANIZING OF ALL STEEL PARTS FOR FENCING AND GATES ABOVE AND BELOW GROUND SHALL BE BY THE HOT DIPPED PROCESS IN ACCORDANCE WITH THE ASTM DESIGNATION FOR THE PARTICULAR PART.
11. FENCE GROUND WIRE SHALL BE IN ACCORDANCE WITH THE PROJECT GROUNDING PLAN AND SPECIFICATIONS.
12. FOOTINGS SHALL BE CONSTRUCTED WITH REGULAR WEIGHT CONCRETE, DESIGNED IN ACCORDANCE WITH ACI 211.1, OF 2500 psi MINIMUM COMPRESSIVE STRENGTH AT 28 DAYS. THE CONCRETE SHALL BE EITHER JOB MIXED (IF APPROVED BY THE ENGINEER), IN ACCORDANCE WITH ACI 304, OR PLANT MIXED, CONFORMING TO THE PROVISIONS OF ASTM C-94, IN AN APPROVED TYPE OF POWER OPERATED MIXER THAT WILL INSURE UNIFORMITY AND HOMOGENITY OF THE CONCRETE PRODUCED. HAND MIXING WILL NOT BE PERMITTED. CONCRETE THAT HAS STARTED TO HARDEN WILL NOT BE PERMITTED. ADDITION OF WATER IN ORDER TO PRESERVE THE REQUIRED CONSISTENCY WILL NOT BE PERMITTED. THE TOP 6" OF ALL FOOTINGS SHALL BE FORMED. THE TOP OF ALL FOOTINGS SHALL BE TROWELLED SMOOTH AND CROWNED SLIGHTLY SO AS TO SHED WATER.
13. GENERAL - ALL MATERIALS SHALL BE NEW AND SHALL BE MANUFACTURED IN THE UNITED STATES OF AMERICA. THERE SHALL BE NO SPLICING OF PIPES AND RODS ALLOWED.

ALL APPLICABLE DETAILS AND SPECIFICATIONS ONLY SHALL BE USED FROM THIS DRAWING FOR THIS CONTRACT.

THIS DRAWING SUPERSEDES DRAWING S-11367 & DRAWING OF THE SAME NUMBER, DATED 9-11-62.

FOR CHAIN LINK FENCE AND VENTWOOD DRIVE GATE SEE DRAWING 47-2010.

FOR ELECTRICALLY ISOLATED FENCE SECTION SEE DRAWING 47-2040.

NO.	DATE	REVISIONS	BY	CHK'D	APP'D
4		REDRAWN ON CADD	SSR	[illegible]	[illegible]
3	8-15-96	ADDED FENCE POST EXTENSION DETAIL	CT	WJA	RN FK
2	8-15-96	REVISED TOP OF POST FOOTING DETAIL	CT	WJA	FK
1	7-30-81	ADDED DETAIL 4/020	SA	GJO	PP ST

CHAIN LINK FENCE-CHAIN LINK DRIVE & WALK GATE PLANS AND DETAILS SUBSTATION STANDARDS

DESIGNED GJO	DRAWN SSR	DATE 4/30/81	SCALE AS SHOWN
CHECKED ELEC. MECH. STRUC.			
APPROVAL P. Perkins, S. Tanno	ENGINEERING DEPARTMENT HAWAIIAN ELECTRIC CO., INC. HONOLULU, HAWAII		
	DRAWING NUMBER 47-2020		REV 4

PLANTING TREES NEAR HECO FACILITIES GUIDELINES

The primary job of the electric company is to provide safe and reliable electrical service. The utility also needs to assure the safety of the public, tree trimmers and its line workers. Because trees are effective conductors of electricity, the electric company must make sure they do not get close enough to energized lines and equipment to cause electrical outages or safety hazards.

The goal of these guidelines is to balance the health and appearance of trees with safety and electric service reliability. HECO is happy to help you plant the right tree in the right place, so that both communities and individuals can take advantage of their natural cooling, shade, reduction of unwanted noise and other environmental advantages. Prior to planting, contact Jason Sickmiller (543-7214) or Randy Amiscaray (543-7572), HECO's System Arborists with questions regarding the correct type of tree to plant.

Planting Trees Near Overhead Lines

Tall trees that can contact wires, poles or equipment should not be planted near overhead lines. Trees contacting overhead electric lines can cause electric service outages and expose the public, tree trimmers and electric company crews to electrical hazards. Trees and shrubs also block physical and visual access to poles and equipment for inspection, maintenance and repair. As a result, tall trees must occasionally be pruned increasing operating and maintenance costs.

Use the following guide to help select the right trees for planting near overhead lines:

- Trees that mature at heights below 20' may be planted under lines;
- Trees that mature at heights 20' to 30' should be planted at least 10' horizontally from overhead lines;
- Taller, columnar trees (e.g. palms, Formosa koa (*Acacia confusa*), vertical wiliwli (*Erythrina variegate 'fastigiata'*) can be planted as close as 15' horizontally from overhead lines;
- Taller trees with spreading crowns that mature at heights greater than 30' should be planted at least 30' horizontally from overhead lines.

Planting Trees Near Underground Lines

Large trees and/or trees with invasive roots must not be planted over or near underground lines. Invasive roots can infiltrate electrical conduits and create electrical service outages and hazards of electrical shock. The weight of large trees over underground lines can crush the electrical conduit resulting in electrical service outages and increase damage and costs associated with repairing the line. Future maintenance and/or excavation of the underground lines can result in severe tree damage or may require the removal of the trees planted too close to the lines. Irrigation water can transport salt from fertilizers and corrode underground line connections resulting in electric service outages.

Use the following planting guide to help select the right tree for planting near underground lines:

- Always locate all underground utilities prior to performing any digging by contacting your utility companies;
- Do not plant any trees or shrubs directly over underground electric lines;
- As a rule, plant the tree or shrub far away from the underground line so that the tree or shrub crown, at maturity, does not extend over the underground line.

The following trees may be planted not less than five (5) feet from an underground line:

Areca palm	*Chrysalidocarpus lutescens*
Dwarf Date palm	*Phoenix roebelenii*
Dragon tree	*Dracaena marginata*
MacArthur palm	*Ptychosperma macarthurii*
Ma'o	*Gossypium tomentosum*
Ho-awa	*Pittosporum hosmeri*
Kolea	*Myrsine lessertiana*
Awa	*Piper methysticum*
Tree Jasmine	*Posoqueria latifolia*
Kolomana	*Cassia suratensis*
Bottle palm	*Mascarena lagenicaulis*
Blue Latan palm	*Lantania loddigesii*
Manila palm	*Veitchia merrillii*
Thrinax palm	*Thrinax parviflora*
Crepe Myrtle	*Lagerstroemia indica*
Alahe`e	*Canthium odoratum*
Winim palm	*Veitchia winin*
Oleander	*Nerium oleander*
Yellow Jasmine	*Jasminum mesnyi*
Naupaka	*Scaevola sericea*
Panax	*Polyscias guilfoylei*

The following trees may be planted not less than seven (7) feet from an underground line:

Candle bush	*Senna alata*
Plumeria	*Plumeria rubra*
Tiare	*Gardenia taitensis*
Traveler's tree	*Ravenala madagascariensis*
Silver bush	*Sophora tomentosa*
Dwarf Poinciana	*Caesalpinia pulcherrima*
Yellow Bells	*Stenolobium stans*
Jathropha	*Jathropha integerrima*
Golden Dewdrop	*Duranta erecta*
Nanu	*Gardenia brighamii*
Noni	*Morinda citrifolia*
Mamane	*Sophora chrysophylla*

Papa Kepau	*Pisonia sandwicensis*
Aulu	*Pisonia umbellifera*
Keahi	*Nesoluma polynesicum*
Rhodesian Wisteria	*Bolusanthus speciosus*
Bottle Brush	*Callistemon citrinus*
Kou	*Cordia subcordata*
Allspice	*Pimenta dioica*
Palmer's Tecoma	*Tabebuia palmeri*
Lechoso	*Stemmadenia litoralis*
Olopua	*Nestegis sandwicensis*
Lama	*Diospyros sandwicensis*
Podocarpus	*Podocarpus gracilior*
Loulu palm	*Prichardia hillebrandii*
Joannis palm	*Veitchia joannis*
Montgomery palm	*Veitchia montgomeryana*
Mock Orange	*Murraya paniculata*

The following trees may be planted not less than ten (10) feet from an underground line:

Cotoneaster	*Cotoneaster pannosa*
Coconut	*Cocos nucifera*
Partridge Wood	*Andira inermis*
Carob	*Ceratonia siliqua*
Koki'o	*Hibiscus drynarioides*
Silver Buttonwood	*Conocarpus erectus*
Shower Tree	*Cassia spp.*
St. Thomas tree	*Bauhinia monandra*
Silver Trumpet	*Tabebuia aurea*
False olive	*Cassine orientalis*
Calabash Tree	*Crescentia cujete*
Ohia Lehua	*Metrosideros polymorpha*
Fern tree	*Filicium decipiens*

Large tree species like Monkeypod, Albizia, Eucalyptus, and Banyan will require an onsite investigation by a HECO System Arborist to determine a safe planting distance from any underground electrical facilities. In some instances, a mitigation measure such as a root barrier cloth may be used to reduce the planting distance from the underground facilities. As a guide, the recommended planting distance will be the estimated radius from the trunk of the tree at maturity to the farthest extent of the branches.

Prior to planting, contact Jason Sickmiller (543-7214) or Randy Amiscaray (543-7572), HECO's System Arborists with questions regarding the correct type of tree to plant.

SECTION 8

CONCRETE BLOCK MASONRY (HOLLOW BLOCK)

8.1 SCOPE

The Contractor shall furnish all materials, labor and supervision, tools and equipment to complete the execution of all concrete block masonry construction indicated on the Drawings and specified herein.

8.2 CODES AND STANDARDS

The design, construction, and details of concrete block masonry not otherwise specified, shall conform to the latest issue of the "Uniform Building Code."

8.3 MATERIALS

A. Concrete Block: All concrete block as indicated on the drawings shall be 6"x8"x16", 8"x8"x16", 8"x4"x16" or 12"x8"x16", conforming to the latest revision of ASTM Standard Specification Designation C90 or ASTM Designation C129.

Concrete blocks shall be "Buff" color unless otherwise specified. The color of all units shall be uniform. The Contractor shall state in his proposal the name and source of the block he proposes to use. Sample of the block shall be submitted to the Company for approval 10 days after award of the contract.

B. Sand: Conforming to the requirements of ASTM Designation C-144, except that not less than 3 percent (by weight), shall pass the No. 100 sieve.

C. Mortar: Mortar shall be Type S, meeting the requirements of the "Uniform Building Code." Mortar for split-faced concrete block shall match or approach color of concrete block.

D. Grout: Grout shall meet the requirements of the "Uniform Building Code" minimum compressive strength of 2500 psi at 28 days.

E. Reinforcing Steel: Reinforcing bars shall be deformed and shall conform to ASTM A 615, Grade 40, except that 1/4-inch ties may be plain bars. All reinforcement shall be lapped 30 bar diameters at splices and shall be continuous at all corners.

F. Water: All water to be clean and free from deleterious materials.

8.4 INSTALLATION

Masonry units shall be laid in running bond unless otherwise shown or specified on the Drawings. All masonry work shall be done in a neat and workmanlike manner by skilled block masons. Walls shall be true and plumb; joints shall be straight, clean and uniform in thickness. After erection, hollow cells with reinforcing steel shall be continuously filled with grout. All work shall be done in accordance with the current edition of "Uniform Building Codes" approved by the County Building Department, the Drawings, and as specified herein. No changes will be allowed in the masonry design unless approved by the Company.

A. Condition of Units

Masonry units shall be free of all dirt and dust before laying. Units shall be kept dry by stockpiling off the ground and by covering. To prevent excessive suction, concrete masonry units shall be lightly wetted with a fog mist spray as allowed by the Company. Soaking of the units before or during the work shall not be permitted.

B. Joints

Joints shall be 3/8 inches thick. All exterior joints shall be tooled and interior (building or house) joints flush unless otherwise shown or noted on Drawings.

C. Reinforcement

Before placement, all reinforcing steel shall be thoroughly cleaned of loose mill scale, excessive rust, oil and all coatings which would reduce bond. Reinforcing steel shall be fastened or supported in the required location and vertical bars shall be supported in such a manner as to prevent swaying.

D. Forms and Centering

Forms and centering shall be constructed true and rigid. Centering shall be kept in place not less than 10 days after completion of masonry construction.

E. Built-In Work

1. Sleeves, frames, bolts, anchors, inserts, reglets and rough hardware shall be placed as the work progresses.

2. Conduit in masonry shall be located in cores, and outlet boxes shall align with courses and joints so as to reduce the cutting of masonry to a minimum.

3. No piping, other than electrical conduit, shall be embedded in the masonry.

4. Anchors and fittings shall be provided in the masonry for attachment of door frames after masonry work is completed.

F. Grouting

All reinforced cells shall be filled with grout and pours shall be stopped one and one-half inches below the top of a course to form a key at pour joints. Maximum height of free drop shall be 4'-0".

Grouting of beams over openings shall be done in one continuous operation.

G. Caulking

Caulking shall be done at flashings and at such other locations as may be required to seal joints and openings between adjoining materials. Caulking material shall be gun grade and shall be approved by the Company.

H. Curing

Masonry units laid in cement mortar shall be dampened with a fog spray for one day after laying the block.

I. Cleaning

Upon completion of the work masonry surfaces shall be cleaned of excess mortar in joints and of mortar droppings. Masonry work shall be cleaned with a 10 percent maximum muriatic acid solution, if directed by the Company to do so. If an acid wash is used, the work shall be given a copious bath of fresh water preceding and following the acid cleaning.

HAWAIIAN ELECTRIC CO., INC.

SPECIFICATION NO. CS9301-0

FOR

CONCRETE WORK

Prepared by Engineering Department

PAC N. Kashiwabara, P.E.
Principal Engineer

R. B. Munger, Ph.D., P.E.
Manager
Engineering Department

Replaces Spec. No. 16164X
Replaces Spec. No. CS7401

Original Edition - 09/17/93

DOC ENG2\CS9301.292

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PART 1 GENERAL

1.1 RELATED DOCUMENTS

A. The Standard Specifications of General Conditions for Construction of Projects numbered CS7202, and Specific Conditions shall govern throughout the entire work, except for modifications described herein.

B. Cooperation with the various trades and accurate timing of the installations to the construction progress of adjoining work are essential to properly placing work specified under this section. Where items must fit spaces previously constructed, measurements shall be verified at the site. Coordinate with other work to insure that all required inserts and attachments are properly set and that adequate provision is made for embedding this work, where required.

1.2 SCOPE OF WORK

A. The Contractor shall furnish all labor, materials, tools, equipment and services necessary and reasonably incidental to complete construction of all concrete work including foundations, pads, anchors and duct encasement called for on the drawings and/or specified herein, unless specifically excepted.

1.3 SUBMITTALS

A. General Requirements: Before commencing the work, the Contractor shall submit three (3) each of product data, shop drawings, and mix design as described below. After review by the Engineer one set will be returned, marked accepted or with notations requiring change. If corrections are required, the Contractor shall make and clearly mark such corrections and resubmit for final review.

1. Product Data shall include manufacturer's specifications and product descriptions for proprietary materials and items, including reinforcement and forming accessories, admixtures, patching compounds, waterstops, joint systems, curing compounds, and other products or items as requested by the Engineer.

2. Shop Drawings for fabrication, bending, and placement of concrete reinforcement shall comply with ACI 315 "Manual of Standard Practice for Detailing Reinforced Concrete Structures" and shall show bar schedules, stirrup spacing, diagrams of bent bars, arrangement of concrete reinforcement, and any special reinforcement required for openings through concrete structures. Drawings shall bear the final review by the Engineer shall not relieve the Contractor of responsibility for completeness and accuracy of all dimensions and details.

3. Concrete Mix Design shall include a tabulation of the proposed aggregates, source location of aggregates, water-cement ratio and strength for each class of concrete.

4. Test Reports shall include the laboratory test results of items described in Section 3.16 Quality Control Testing During Construction.

1.4 QUALITY ASSURANCE

A. Specifications and Standards: Comply with the latest edition of the following codes, specifications, and standards, except where more stringent requirements are shown or specified:

1. ACI 301 "Specifications for Structural Concrete for Buildings."

2. ACI 318 "Building Code Requirements for Reinforced Concrete."

3. ACI 347 "Recommended Practice for Concrete Form Work."

4. ACI 304 "Recommended Practice Measuring, Mixing, and Placing Concrete."

5. ACI 309 "Consolidation of Concrete."

6. ACI 305 "Recommended Practice for Hot Weather Concreting."

7. Concrete Reinforcing Steel Institute (CRSI), "Manual of Standard Practice."

B. Codes and Ordinances: Wherever provisions of the current Uniform Building Code or the local current ordinances are more stringent than the above specifications and standards, the local codes and ordinances shall govern.

C. Concrete Testing Service: Testing of concrete cylinders, to determine compression strengths of concrete delivered to the jobsite, shall be performed by an independent testing laboratory approved by the Engineer. Tests shall be paid for by the Contractor. Testing requirements are specified in QUALITY CONTROL TESTING DURING CONSTRUCTION paragraph.

D. Materials and installed work may require testing and retesting at anytime during progress of work. Tests, including retesting of rejected materials for installed work, shall be done at Contractor's expense.

PART 2 PRODUCTS

2.1 FORM MATERIALS

A. Forms for Exposed Finish Concrete (Smooth Form Finish): Plywood, metal, metal-framed plywood faced, or other acceptable panel-type materials, to provide continuous, straight, smooth, exposed surfaces. Furnish in largest practicable sizes to minimize number of joints and to conform to joint system shown on drawings.

1. Use overlaid plywood complying with U.S. Product Standard PS-1 "A-C or B-B High Density Overlaid Concrete Form," Class I.

B. Forms for Unexposed Finish Concrete (Rough Form Finish): Plywood, lumber, metal, or other acceptable material. Provide lumber dressed on at least 2 edges and one side for tight fit.

C. Form Coatings: Provide commercial formulation form-coating compounds that will not bond with, stain, nor adversely affect concrete surfaces, and will not impair subsequent treatments of concrete surfaces, or finishes requiring bond or adhesion, nor impede wetting of concrete surfaces by water or curing compound.

D. Form Ties: Factory-fabricated, adjustable-length, removable or snap-off metal form ties, designed to prevent form deflection and to prevent spalling concrete upon removal. Provide units which will leave no metal closer than 1-1/2" to surface.

2.2 REINFORCING MATERIALS

A. Reinforcing Bars: ASTM A 615, Grade 60, deformed, free from loose rust, scale, and other coatings that may reduce bond.

B. Steel Wire: ASTM A 82, plain, cold-drawn metal.

C. Welded Wire Fabric: ASTM A 185, welded steel wire fabric, or sizes and types indicated in drawings. Provide galvanized mesh for all slabs on grade.

D. Supports for Reinforcement: Bolsters, chairs, spacers, and other devices for spacing, supporting, and fastening reinforcing bars and welded wire fabric in place. Use wire bar type supports complying with CRSI specifications.

1. For slabs-on-grade, use supports with sand plates or horizontal runners where base material will not support chair legs.

2. For exposed-to-view concrete surfaces, where legs of supports are in contact with forms, provide supports with legs which are plastic protected (CRSI, Class 1) or stainless steel protected (CRSI, Class 2).

E. Tie Wires: Soft, annealed iron wire not smaller than 18 gage.

2.3 CONCRETE MATERIALS

A. Portland Cement: ASTM C 150, Type I.

1. Use one brand of cement throughout project, unless otherwise acceptable to the Engineer.

B. Normal Weight Aggregates: Aggregates shall conform to ASTM C 33 for use in concrete and C144 for use in masonry mortar. Provide aggregates from a single source for exposed concrete.

1. The maximum aggregate size for use in concrete for duct encasement shall be 3/4 inch and in concrete for structures shall be 1-1/4 inches.

2. Fine aggregate shall be clean, hard, dense, free of foreign matter and shall consist of beach sand, manufactured fines, or a combination thereof.

3. Coarse aggregate shall consist of crushed stone or gravel manufactured from clean, hard, tough, dense, basalt, free from deleterious substances.

C. Water: Potable.

D. Air-Entraining Admixture: ASTM C 260, certified by manufacturer to be compatible with other required admixtures.

1. Available Products: Subject to compliance with requirements, products which may be incorporated in the work include, but are not limited to, the following:

"Air-Mix"; Euclid Chemical Co.
"Sika Aer"; Sika Corp.
"MB-VR or MB-AE"; Master Builders.
"Darex AEA" or "Daravair"; W.R. Grace.
"Edoco 2001 or 2002"; Edoco Technical Products.
"Air-Tite"; Gifford-Hill/American Admixutres.

E. Water-Reducing Admixture: ASTM C 494, Type A, and containing not more than 0.1 percent chloride ions.

1. Available Products: Subject to compliance with requirements, products which may be incorporated in the work include, but are not limited to, the following:

"WRDA Hycol"; W.R. Grace.
"PSI N"; Gifford-Hill/American Admixtures.
"Eucon WR-75"; Euclid Chemical Co.
"Pozzolith Normal"; Master Builders.
"Plastocrete 160"; Sika Chemical Corp.
"Chemtard"; Chem-Masters Corp.
"Pro-Kete-N"; Protex Industries, Inc.

F. High-Range Water-Reducing Admixture (Super Plasticizer): ASTM C 494, Type F or Type G and containing not more than 0.1 percent chloride ions.

1. Available Products: Subject to compliance with requirements, products which may be incorporated in the work include, but are not limited to, the following:

"WRDA 19" or "Daracem"; W.R. Grace.
"PSP"; Protex Industries Inc.
"Super P"; Anti-Hydro.
"Sikament"; Sika Chemical Corp.
"Mighty 150"; ICI Americas Corp.
"Eucon 37"; Euclid Chemical Co.
"PSI Super"; Gifford-Hill.
"Rheobuild"; Master Builders.

G. Water-Reducing, Non-Chloride Accelerator Admixture: ASTM C 494, Type E, and containing not more than 0.1 percent chloride ions.

1. Available Products: Subject to compliance with requirements, products which may be incorporated in the work include, but are not limited to, the following:

"Accelquard 80"; Euclid Chemical Co.
"Pozzolith High Early"; Master Builders.
"Gilco Accelerator"; Gifford-Hill/American Admixtures.

H. Water-Reducing, Retarding Admixture: ASTM C 494, Type D, and containing not more than 0.1 percent chloride ions.

1. Available Products: Subject to compliance with requirements, products which may be incorporated in the work include, but are not limited to, the following:

"Edoco 20006"; Edoco Technical Products.
"Pozzolith Retarder"; Master Builders
"Eucon Retarder 75"; Euclid Chemical Co.
"Daratard"; W.R. Grace
"PSI R"; Gifford-Hill/American Admixutres.
"Plastiment"; Sika Chemical Co.
"Protard"; Protex Industries, Inc.

I. Prohibited Admixtures: Calcium chloride thyocyanates or admixtures containing more than 0.1 percent chloride ions are not permitted.

2.4 RELATED MATERIALS

A. Granular Base: Evenly graded fine aggregate to provide, when compacted, a smooth and even surface below slabs on grade. Vapor barrier, polyethylene film 0.006" in thickness, shall be placed below granular base.

B. Non-Shrink Grout: CRD-C 621, factory pre-mixed grout.

1. Available Products: Subject to compliance with requirements, products which may be incorporated in the work include, but are not limited to, the following:

Non-metallic

"Sika Grout 212"; Sika Corporation.
"Set Grout"; Master Builders.
"Damp Pack Grout"; Burke Concrete.

C. Absorptive Cover: Burlap cloth made from jute or kenaf, weighing approximately 9 oz. per sq. yd., complying with AASHTO M 182, Class 2.

D. Moisture-Retaining Cover: One of the following, complying with ASTM C 171.

1. Waterproof paper.

2. Polyethylene film.

3. Polyethylene-coated burlap.

E. Liquid Membrane-Forming Curing Compound: Liquid type membrane-forming curing compound complying with ASTM C 309, Type I, Class A. Moisture loss not more than 0.055 gr./sq. cm. when applied at 200 sq. ft./gal.

1. Products: Subject to compliance with requirements, products that may be used in the work, are not limited to the following:

"Masterseal"; Master Builders.
"A-H 3 Way Sealer"; Anti-Hydro Waterproofing Co.
"Ecocure"; Euclid Chemical Co.
"Clear Seal"; A.C. Horn, Inc.
"Sealco 309"; Gifford-Hill/American Admixtures.
"J-20 Acrylic Cure"; Dayton Superior.
"Spartan-Cote"; The Burke Co.
"Sealkure"; Toch Div. - Carboline.
"Kure-N-Seal"; Sonneborn-Rexnord.
"Polyclear"; Upco Chemical/USM Corp.
"L&M Cure"; L & M Construction Chemicals.
"Klearseal"; Setcon Industries.
"LR-152"; Protex Industries.
"Hardtop"; Gifford-Hill.
"Sika MD7C"; Sika Corporation.

F. Expansion Joint Filler: ASTM D 1751-83, non-extruding premolded material of 1/2 inch thickness, unless otherwise noted, composed of fiberboard impregnated with asphalt.

G. Waterstops: PVC or rubber water stops, dumbbell or centerbulb type as indicated, of proper size to suit joints.

H. Connectors: Provide metal connectors required for placement in cast-in-place concrete, for the attachment of precast concrete members.

I. Slots for Masonry Anchors: 24 gage galvanized steel dovetail slots for masonry anchors, complete with felt or fiber fillers.

2.5 PROPORTIONING AND DESIGN OF MIXES

A. Prepare design mixes for each type and strength of concrete by either laboratory trial batch or field experience methods as specified in ACI 301 and ACI 318. If trial batch method used, use an independent testing facility acceptable to the Engineer for preparing and reporting proposed mix designs. The testing facility shall not be the same as used for field quality control testing. Proportion design mixes by weight for each class of concrete required, complying with ACI 211. 1-81 (85).

B. Submit written reports to the Engineer for each design mix at least 15 calendar days prior to the start of the work. Include in each report the project name, date of report, contractor, concrete supplier, concrete class, source of aggregates, manufacturer and brand name of manufactured materials, the precise proportions of the mix, the properties specified herein for the type and class of concrete, and the test results for each property specified.

C. Design mixes to provide normal weight concrete with minimum ultima‹e compressive strengths at 28 days as indicated on structural drawings.

D. Provide test results from the concrete supplier for each of his proposed design mixes, to establish the following:

1. Gross weight and yield per cu. yd. of trial mixtures.

2. Measured slump.

3. Measured air content.

4. Compressive strength developed at 7 days and 28 days, from not less than 3 test cylinders cast for each compressive strength.

E. Adjustment to Concrete Mixes: Mix design adjustments may be requested by Contractor when characteristics of materials, job conditions, weather, test results, or other circumstances warrant; at no additional cost to HECO and as accepted by the Engineer. Laboratory test data for revised mix design and strength results must be submitted to and accepted by the Engineer before using in work.

F. Admixtures:

1. Use water-reducing admixture or high range water-reducing (HRWR) admixture (super plasticizer) in concrete as required for placement and workability.

2. Use admixtures for water-reducing and set-control in strict compliance with manufacturer's directions.

G. Slump Limits: Design mixes to provide normal weight concrete with the following minimum ultimate compressive strengths at 28 days (Strength Class), maximum size aggregates (MSA), and slumps, unless shown otherwise in the drawings or special conditions:

Description	Strength Class (psi)	MSA (in.)	Slump* (in.)
Duct Encasement	2500	3/4	6 - 7
Slabs on Grade	3000	1-1/4	4
Foundations	4000	1-1/4	2 - 4
Columns, Beams, Suspended Slabs	4000	1-1/4	4
Precast Products	5000	3/4	4

*Where concrete is placed on ramps or sloped surfaces, slump shall be not more than 3 inches. When using HRWR admixture (superplasticizer), slump shall be 2 to 3 inches before addition of HRWR and not more than 8 inches after addition of HRWR.

2.6 CONCRETE MIXING

A. Ready-Mix Concrete: Comply with requirements of ASTM C 94, and as herein specified.

1. All concrete shall be ready-mixed, made and sold by a central batching plant, and delivered in a revolving mixer.

2. Gap graded concrete shall not be used. Concrete mixes shall contain all aggregate size groups up to and including the maximum size to be used in the concrete.

3. The total air content of the concrete, as measured at the point of discharge, shall be not less than three percent nor more than six percent of the concrete by volume.

4. Tolerances for slump shall be in accordance with ASTM C94. When the specified nominal slump is 2 inches or less, the tolerance shall be + 1/2 inch. When the specified nominal slump is greater than 2 inches but not more than 4 inches, the tolerance shall be + 1 inch. When the specified slump is more than 4 inches, the tolerance shall be + 1-1/2 inches.

PART 3 EXECUTION

3.1 GENERAL

A. Coordinate the installation of joint materials and vapor retarders with placement of forms and reinforcing steel.

B. Before commencing work, check indicated lines and levels. Report any discrepancies to the Engineer for adjustment. Erect substantial bench marks and preserve throughout the work.

C. Deliver materials other than read-mix concrete to site in their original packaging bearing manufacturer's brand name and store in a weather protected, well ventilated place, having a floor clear of the ground. Hardened cement shall not be used. Store reinforcing steel off the ground and maintain free from mud or other foreign materials. Protect aggregate materials against mixing with the ground or with other types of aggregate.

3.2 FORMS

A. Design, erect, support, brace, and maintain formwork to support vertical and lateral, static, and dynamic loads that might be applied until such loads can be supported by concrete structure. Construct formwork so concrete members and structures are of correct size, shape, alignment, elevation, and position. Maintain formwork construction tolerances complying with ACI 347. Crown all floors and ceiling soffits 1/4" in all directions for every 16 feet of span, unless otherwise noted.

B. Design formwork to be readily removable without impact, shock, or damage to cast-in-place concrete surfaces and adjacent materials.

C. Construct forms to sizes, shapes, lines, and dimensions shown, and to obtain accurate alignment, location, grades, level and plumb work in finished structures. Provide for openings, offsets, sinkages, keyways, recesses, moldings, rustications, reglets, chamfers, blocking, screeds, bulkheads, anchorages and inserts, and other features required in work. Use selected materials to obtain required finishes. Solidly butt joints and provide back-up at joints to prevent leakage of cement paste.

D. Fabricate forms for easy removal without hammering or prying against concrete surfaces. Provide crush plates or wrecking plates where stripping may damage cast concrete surfaces. Provide top forms for inclined surfaces where slope is too steep to place concrete with bottom forms only. Kerf wood inserts for forming keyways, reglets, recesses, and the like, to prevent swelling and for easy removal.

E. Provide temporary openings where interior area of formwork is inaccessible for cleanout, for inspection before concrete placement, and for placement of concrete. Securely brace temporary openings and set tightly to forms to prevent loss of concrete mortar. Locate temporary openings on forms at inconspicuous locations.

F. Chamfer exposed corners and edges using 1/2" chamfers or as indicated, using wood, metal, PVC, or rubber chamfer strips fabricated to produce uniform smooth lines and tight edge joints.

G. Provisions for Other Trades: Provide openings in concrete formwork to accommodate work of other trades. Determine size and location of openings, recesses, and chases from trades providing such items. Accurately place and securely support items built into forms.

H. Cleaning and Tightening: Thoroughly clean forms and adjacent surfaces to receive concrete. Remove chips, wood, sawdust, dirt, or other debris just before concrete is placed. Retightening forms and bracing after concrete placement is required to eliminate mortar leaks and maintain proper alignment.

3.3 PLACING REINFORCEMENT

A. Comply with concrete Reinforcing Steel Institute's recommended practice for "Placing Reinforcing Bars," for details and methods of reinforcement placement and supports, and as herein specified. Reinforcing steel bars, wire and wire fabric shall be provided in sizes, lengths and configurations as indicated on drawings; shall be thoroughly cleaned of loose mill scale, rust, oil, and all coatings that will destroy or reduce the bond before placing and again before pouring of concrete. All items shall be accurately positioned and secured in place as indicated in the drawings and as herein specified. Annealed steel wire of not less than 16 gage shall be used to secure reinforcement. Reinforcement shall be placed in specified positions.

B. Metal supports and spacers shall be used to secure the proper spacing. Stirrups shall be accurately and securely wired to the bars at both top and bottom. At slabs, footings and beams in contact with earth, pre-cast concrete solid blocks (not hollow tile) shall be used to hold reinforcement at a proper distance above earth.

C. Bars shall be tied at all intersections, and distances from forms shall be maintained by means of blocks, ties, metal chains, runners, bolsters, spacers, hangers or other approved supports.

D. Place reinforcement to obtain at least minimum coverages for concrete protection. Arrange, space, and securely tie bars and bar supports to hold reinforcement in position during concrete placement operations. Set wire ties so ends are directed into concrete, not toward exposed concrete surfaces. Minimum concrete protection over bar reinforcement shall conform to ACI 318 with the following minimum clear cover:

Concrete directly against earth (above water table)	3"
Concrete directly against earth (below water table)	6"
Concrete poured against forms but exposed to earth	2"
Column spirals or ties	2"
Formed surfaces exposed to weather . .	2"
Beams and girders not exposed to weather or earth	1-1/2"
Slabs and walls not exposed to weather or earth	3/4"

In all cases, provide minimum concrete protection at least equal to the bar diameter.

E. Install welded wire fabric in as long lengths as practicable. Lap adjoining pieces at least one full mesh plus 2 inches and lace splices with wire. Offset end laps in adjacent widths to prevent continuous laps in either direction. Support mesh on chairs to assure position in the middle third of slab. Install in accordance with the Wire Reinforcing Institute "Manual of Standard Practice for Welded Wire Fabric."

F. All reinforcement shall be inspected and reviewed by the Engineer before placing of any concrete. This review, however, shall not be construed to relieve the Contractor of his responsibility to place all reinforcement in accordance with the contract drawings.

3.4 JOINTS

A. Construction Joints: Locate and install construction joints as indicated or, if not indicated, locate so as not to impair strength and appearance of the structure, as acceptable to the Engineer.

1. Provide keyways at least 1-1/2" deep in construction joints in walls, slabs, and between walls and footings; accepted bulkheads designed for this purpose may be used for slabs.

2. Place construction joints perpendicular to main reinforcement. Continue reinforcement across construction joints, except as otherwise indicated.

3. Waterstops: Install waterstops in construction joints where indicated on the drawings, to form a continuous diaphragm in each joint. Make provisions to support and protect waterstops during the progress of the work. Fabricate waterstop field joints in accordance with manufacturer's printed instructions. Protect waterstop material from damage where it protrudes from any point.

B. Control Joints in Slabs-on-Grade: Construct control joints in slabs-on-grade to form panels or patterns as indicated, 1/4" wide x 1/5 to 1/4 of the slab depth, unless otherwise indicated. Saw cut joints or insert a premolded hardboard or fiberboard strip into the fresh concrete until the top surface of the strip is flush with the slab surface. Saw cut joints may be 1/8" wide. After the concrete has cured, remove inserts and clean groove of loose debris. When saw-cutting joints, time properly with the concrete set, but not later than 24 hours after concrete is poured.

C. Expansion Joints: Provide expansion joints at locations indicated. Do not permit reinforce-ment to extend continuously though any expansion joint.

3.5 INSTALLATION OF EMBEDDED ITEMS

A. General: Set and build into work anchorage devices and other embedded items required for other work that is attached to, or supported by, cast-in-place concrete. Use setting drawings, diagrams, instructions, and directions provided by suppliers of items to be attached thereto. Properly locate embedded items in cooperation with other trades and secure in position before concrete is poured.

B. Install inserts, dowels, reglets, hangers, metal ties, anchors, bolts, nailing strips, blocking, ground, and other fastening devices as required for attachment of other work.

C. Provide non-rusting sleeves for electrical conduits, pipes, and fittings that penetrate slabs, walls, or beams.

D. Edge Forms and Screed Strips for Slabs: Set edge forms or bulkheads and intermediate screed strips for slabs to obtain the required elevations and contours in the finished slab surface. Provide and secure units sufficiently strong to support the types of screed strips by the use of strike-off templates or accepted compacting type screeds.

3.6 PREPARATION OF FORM SURFACES

A. Clean re-used forms of concrete matrix residue, repair and patch as required to return forms to acceptable surface condition.

B. Coat contact surfaces of forms with a form-coating compound before reinforcement is placed.

C. Thin form-coating compounds only with thinning agent of type, amount, and under conditions of form-coating compound manufacturer's directions. Do not allow excess form-coating material to accumulate in forms or to come into contact with in-place concrete surfaces against which fresh concrete will be placed. Apply in compliance with manufacturer's instructions.

D. Coat steel forms with a non-staining, rust-preventative form oil or otherwise protect against rusting. Rust-stained steel formwork is not acceptable.

3.7 CONCRETE PLACEMENT

A. Notify the Engineer 24 hours before placing any concrete.

B. Vapor Barrier: Cover entire area of compacted fill or firm undisturbed earth under slabs-on-grade with vapor barrier material, laid dry with 6" wide dry side laps and end laps. Lay film just before reinforcement is placed and concrete is poured, and protect against punctures. Adhesive-apply extra sheet over punctures before proceeding.

C. Preplacement Inspection: Before placing concrete, inspect and complete formwork installation, reinforcing steel, and items to be embedded or cast-in. Notify other crafts to permit installation of their work; cooperate with other trades in setting such work. Moisten wood forms immediately before placing concrete where form coatings are not used. Make sure soil treatment for termite control has been applied to cushion fill before vapor barrier and concrete are installed. Coordinate the installation of joint materials and vapor barriers with placement of forms and reinforcing steel.

1. Apply temporary protection covering to lower 2' of finished walls adjacent to poured floor slabs and similar conditions, and guard against spattering during placement.

D. General: Comply with ACI 304 "Recommended Practice for Measuring, Mixing, Transporting, and Placing Concrete," and as herein specified.

1. Deposit concrete continuously or in layers of such thickness that no concrete will be placed on concrete which has hardened sufficiently to cause the formation of seams or planes of weakness. If a section cannot be placed continuously, provide construction joints as herein specified. Deposit concrete as nearly as practicable to its final location to avoid segregation.

E. Conveying: Convey concrete from the mixer to the place of final deposit by methods which will prevent the separation or loss of the materials. Provide equipment for chuting, pumping, and pneumatically conveying concrete of proper size and design as to insure a practically continuous flow of concrete at the point of delivery and without segregation of the materials. Keep open troughs and chutes clean and free from coating of hardened concrete. Do not allow concrete to drop freely more than 8 feet. All equipment and methods used for conveying are subject to the approval of the Engineer.

F. Placing Concrete in Forms:

1. Do not place concrete during rain. Protect fresh concrete from rain until it reaches its initial set.

2. The plant shall have sufficient capacity and transportation equipment to deliver concrete at the rate desired. The interval between batches for a pour shall not exceed thirty minutes.

3. The time elapsed between the introduction of the mixing water to the cement and aggregates or the cement to the aggregates, and the placing of concrete in its final position shall not exceed ninety minutes.

4. Concrete shall be mixed only in such quantity as is required for immediate use. No retempering will be permitted and concrete that has started to harden shall be discarded and promptly removed from the job. Excessive over-mixing requiring additions of water in order to preserve the required consistency will not be permitted.

5. Hand mixing will not be permitted.

6. Concrete shall be deposited in horizontal layers not deeper than 2 feet for structures and not deeper than 8 inches for duct encasement avoiding inclined layers and inclined construction joints. The depth of layers shall be shallow enough so that the succeeding layer will be placed before the previous layer has attained its initial set. Concrete shall not be allowed nor shall it be caused to flow horizontally or on slopes. Concrete placing on a slope shall begin at the lower end of the slope and progress upward to increase compaction of the concrete. Special care shall be used in placing duct line concrete to avoid "floating" of ducts and damage to ducts.

7. Deposit concrete for slabs in a continuous operation, within the limits of construction joints, until placing of a panel or section is completed. When less than a complete layer of concrete is placed in one operation, terminate in a vertical bulkhead in areas of minimum shear as acceptable by the Engineer.

8. Maintain reinforcing in proper location during concrete placement operations.

9. Bring slab surfaces to correct level with straightedge and strikeoff. Use bull floats or darbies to smooth surface, free of humps or hollows. Do not disturb slab surfaces prior to beginning finishing operations.

10. Protect adjacent finish materials from damage or spatter during concrete placement.

G. Consolidating Placed Concrete: Consolidate concrete during placing operations so that concrete is thoroughly worked around reinforcement and other embedded items and into corners.

1. Consolidate placed concrete by high frequency (7000 impulses per minute) mechanical vibrating equipment, supplemented by hand-spading, rodding, or tamping. Use equipment and procedures for consolidation of concrete in accordance with the recommended practices of ACI 309 to suit the type of

concrete and project conditions. Provide a sufficient number of vibrators to properly consolidate all concrete immediately after placing. Have at least one standby vibrator on hand at all times during placement of the concrete.

2. Do not use vibrators to transport concrete inside forms. Insert and withdraw vibrators vertically at uniformly spaced locations not farther than visible effectiveness of machine. Place vibrators to rapidly penetrate placed layer and at least 6" into preceding layer. Do not insert vibrators into lower layers of concrete that have begun to set. At each insertion limit duration of vibration to time necessary to consolidate concrete and complete embedment of reinforcement and other embedded items without causing segregation mix. Do not vibrate forms or reinforcement.

3. Maintain reinforcing in the proper position during concrete placement operations.

4. Bring slab surfaces to the correct level with a straightedge and strikeoff. Use bull floats or darbies to smooth the surface, leaving it free of humps or hollows. Do not sprinkle water on the plastic surface. Do not disturb the slab surfaces prior to beginning finishing operations.

5. Unless otherwise authorized, all duct line concrete shall be compacted by use of hand spades. The spade shall be inserted into the fresh concrete to the level of the bottom ducts, on both sides of each row of ducts and at intervals not greater than 9 inches along the ducts. Spading shall be done in a manner to prevent damage to or displacement of ducts.

H. Miscellaneous

1. Hot Weather Placing: When hot weather conditions exist that would seriously impair quality and strength of concrete, place concrete in compliance with ACI 305 and as herein specified.

2. Cool ingredients before mixing to maintain concrete temperature at time of placement below 90(F (32(C). Mixing water may be chilled, or chopped ice may be used to control temperature provided water equivalent of ice is calculated to total amount of mixing water.

3. Cover reinforcing steel with water-soaked burlap if it becomes too hot, so that steel temperature will not exceed the ambient air temperature immediately before embedment in concrete.

   a. Fog spray forms, reinforcing steel, and subgrade just before concrete is placed.

4. Use water-reducing retarding admixture (Type D) when required by high temperatures, low humidity, or other adverse placing conditions.

3.8 FINISHING OF TOP SURFACES

After concrete has been placed and compacted, the surface shall be struck off with a strike board. After striking off, the surface shall be floated, not less than two times with wood floats, until all excess water is removed. After the concrete has hardened sufficiently a final finish shall be applied to the various surfaces as follows:

A. Tops of encased duct lines, manholes and handholes over which backfill is to be placed - wood floated.

B. Tops of vaults, manholes and handholes at sidewalk grade - edged and broom finished.

C. Tops of equipment pads - edged and steel troweled.

D. Tops of foundation pedestals supporting column bases - roughened with a stiff brush or rake for grouted bases or edged and steel troweled for ungrouted bases.

E. Floors of buildings, vaults, manholes and handholes - steel troweled unless otherwise noted.

3.9 MONOLITHIC SLAB FINISHES

A. Float Finish: Apply float finish to monolithic slab surface to receive trowel finish and other finishes as hereinafter specified, and slab surfaces which are to be covered with waterproofing membrane or elastic roofing and as otherwise indicated.

1. After screeding, consolidating, and leveling concrete slabs, do not work surface until ready for floating. Begin floating when surface water has disappeared or when concrete has stiffened sufficiently to permit operation of power-driven floats, or both. Consolidate surface with power-driven floats, or by hand-floating if area is small or inaccessible to power units. Check and finish surface plane to tolerances of ACI 301 11.9. Cut down high spots and fill low spots. Uniformly slope surfaces to drains. Immediately after leveling, refloat surface to a uniform, smooth, granular texture.

B. Trowel Finish: Apply trowel finish to monolithic slab surfaces to be exposed-to-view, and slab surfaces to be covered with resilient flooring, carpet, ceramic or quarry tile, paint, or other thin film finish coating, system.

1. After floating, begin first trowel finish operation using a power- driven trowel. Begin final troweling when surface produces a ringing sound as trowel is moved over surface. Consolidate concrete surface by final hand-troweling operation, free of trowel marks, uniform in texture and appearance, and with surface finished to tolerances of ACI 301 11.9. Grind smooth surface defects which would telegraph through applied floor covering system.

3.10 CONCRETE CURING AND PROTECTION

A. General: Protect freshly placed concrete from premature drying and excessive hot temperatures, and from injurious action by the sun, rain, flowing water, and mechanical injury.

1. Start initial curing as soon as free water has disappeared from concrete surface after placing and finishing. Weather permitting, keep continuously moist for not less than 7 days.

2. Begin final curing procedures immediately following initial curing and before concrete has dried. Continue final curing for at least 7 days in accordance with ACI 301 procedures. Avoid rapid drying at end of final curing period.

B. Curing Methods: Perform curing of concrete by curing and sealing compound, by moist curing, by moisture-retaining cover curing, and by combinations thereof, as herein specified.

C. Provide moisture curing by following methods.

1. Keep concrete surface continuously wet by covering with water.

2. Continuous water-fog spray.

3. Covering concrete surface with specified absorptive cover, thoroughly saturating cover with water and keeping continuously wet. Place absorptive cover to provide coverage of concrete surfaces and edges, with 4" lap over adjacent absorptive covers.

D. Provide moisture-cover curing as follows:

1. Cover concrete surfaces with moisture-retaining cover for curing concrete, placed in widest practicable width with sides and ends lapped at least 3" and sealed by waterproof tape of adhesive. Immediately repair any holes or tears during curing period using cover material and waterproof tape.

E. Provide curing and sealing compound to exposed interior slabs and to exterior slabs, walks, and curbs, as follows:

1. Apply specified curing and sealing compound to concrete slabs as soon as final finishing operations are complete (within 2 hours). Apply uniformly in continuous operation by power-spray or roller in accordance with manufacturer's directions. Recoat areas subjected to heavy rainfall within 3 hours after initial application. Maintain continuity of coating and repair damage during curing period.

2. Do not use membrane curing compounds on surfaces which are to be covered with coating material applied directly to concrete, liquid floor hardener, waterproofing, dampproofing, membrane roofing, flooring (such as ceramic or quarry tile, glue-down carpet), painting, and other coatings and finish materials, unless otherwise acceptable to the Engineer.

F. Curing Formed Surfaces: Cure formed concrete surfaces, including undersides of beams, supported slabs, and other similar surfaces by moist curing with forms in place for full curing period or until forms are removed. If forms are removed, continue curing by methods specified above, as applicable.

G. Curing Unformed Surfaces: Cure unformed surfaces, such as slabs, floor topping, and other flat surfaces by application of appropriate curing method.

1. Final cure concrete surfaces to receive liquid floor hardener or finish flooring by use of moisture-retaining cover, unless otherwise directed.

H. Sealer and Dustproofer: Apply a second coat of specified curing and sealing compound only to surfaces given a first coat.

I. No wheeling, working, or walking on finished surfaces will be allowed for 16 hours after the concrete is placed.

J. After 21 days curing, treat treads, risers, and nosings of interior stairs, driving and&parking areas (including ramps) with concrete hardener.

3.11 SHORES AND SUPPORTS

A. Comply with ACI 347 for shoring and reshoring in multistory construction, and as herein specified.

B. Extend shoring from ground to roof for structures 4 stories or less, unless otherwise permitted.

3.12 REMOVAL OF FORMS

A. Formwork not supporting weight of concrete, such as sides of beams, walls, columns, and similar parts of the work, may not be removed after cumulatively curing at not less than 50(F (10(C) for 24 hours after placing concrete provided concrete is sufficiently hard to not be damaged by form removal operations, and providing curing and protection operations are maintained.

B. Formwork supporting weight of concrete, forms for beam soffits, joists, slabs, and other structural elements, may not be removed until concrete has attained a minimum 28-day compressive strength. Forms may be incrementally stripped in 7 days but concrete must be continuously shored or reshored for at least 21 days. Earlier stripping and reshoring procedures may be used where design calculations indicate acceptable performance and where approved by the Engineer.

3.13 REUSE OF FORMS

A. Clean and repair surfaces of forms to be re-used in work. Split, frayed, delaminated, or otherwise damaged form facing material will not be acceptable for exposed surfaces. Apply new form coating compound as specified for new formwork.

B. When forms are extended for successive concrete placement, thoroughly clean surfaces, remove fins and laitance, and tighten forms to close joints. Align and secure joint to avoid offsets. Do not use "patched" forms for exposed concrete surfaces, except as acceptable to the Engineer.

3.14 MISCELLANEOUS CONCRETE ITEMS

A. Filling-In: Fill-in holes and openings left in concrete structures for passage of work by other trades, unless otherwise shown or directed, after work of other trades is in place. Mix, place, and cure concrete as herein specified, to blend with in-place construction. Provide other miscellaneous concrete filling shown or required to complete work.

B. Curbs: Provide monolithic finish to interior curbs by stripping forms while concrete is still green and steel-troweling surfaces to a hard, dense finish with corners, intersections, and terminations slightly rounded.

C. Equipment Bases and Foundations: Provide machine and equipment bases and foundations, as shown on drawings. Set anchor bolts for machines and equipment to template at correct elevations, complying with certified diagrams or templates of manufacturer furnishing machines and equipment.

D. Grout base plates and foundations as indicated, using specified non-shrink grout. Use non-metallic grout for exposed conditions, unless otherwise indicated.

E. Reinforced Masonry: Provide concrete grout for reinforced masonry lintels and bond beams where indicated on drawings and as scheduled. Maintain accurate location of reinforcing steel during concrete placement.

3.15 CONCRETE SURFACE REPAIRS

A. Patching Defective Areas: R_pair and patch defective areas with cement mortar immediately after removal of forms, when acceptable to the Engineer.

1. Cut out honeycomb, rock pockets, voids over 1/2" in any dimension, and holes left by tie rods and bolts, down to solid concrete but, in no case to a depth of less than 1". Make edges of cuts perpendicular to the concrete surface. Thoroughly clean, dampen with water, and brush-coat the area to be patched with specified bonding agent. Place patching mortar after bonding compound has dried.

B. For exposed-to-view surfaces, blend white portland cement and standard portland cement so that, when dry, patching mortar will match color surrounding. Provide test areas at inconspicuous location to verify mixture and color match before proceeding with patching. Compact mortar in place and strike-off slightly higher than surrounding surface.

C. Repair of Formed Surfaces: Remove and replace concrete having defective surfaces if defects cannot be repaired to satisfaction of the Engineer. Surface defects, as such, include color and texture irregularities, cracks, spalls, air bubbles, honeycomb, rock pockets; fins and other projections on surface; and stains and other discolorations that cannot be removed by cleaning. Flush out form tie holes, fill with dry pack mortar, or precast cement cone plugs secured in place with bonding agent.

D. Repair concealed formed surfaces, where possible, that contain defects that affect the durability of concrete. If defects cannot be repaired, remove and replace concrete.

E. Repair of Unformed Surfaces: Test unformed surfaces, such as monolithic slabs, for smoothness and verify surface plane to tolerances specified for each surface and finish. Correct low and high areas as herein specified. Test unformed surfaces sloped to drain for trueness of slope, in addition to smoothness using a template having required slope.

F. Repair finished unformed surfaces that contain defects which affect durability of concrete. Surface defects, as such, include crazing, cracks in excess of 0.01" wide or which penetrate to reinforcement or completely through non-reinforced sections regardless of width, spalling, pop-outs, honeycomb, rock pockets, and other objectionable conditions.

G. Correct high areas in unformed surfaces by grinding, after concrete has cured at least 14 days.

H. Correct low areas in unformed surfaces during or immediately after completion of surface finishing operations by cutting out low areas and replacing with fresh concrete. Finish repaired areas to blend into adjacent concrete. Proprietary patching compounds may be used when acceptable to the Engineer.

I. Repair defective areas, except random cracks and single holes not exceeding 1" diameter, by cutting out and replacing with fresh concrete. Remove defective areas to sound concrete with clean, square cuts and expose reinforcing steel with at least 3/4" clearance all around. Dampen concrete surfaces in contact with patching concrete and apply bonding compound. Mix patching concrete of same materials to provide concrete of same type or class as original concrete. Place, compact, and finish to blend with adjacent finished concrete. Cure in same manner as adjacent concrete.

J. Repair isolated random cracks and single holes not over 1" in diameter by dry-pack method. Groove top of cracks and cut-out holes to sound concrete and clean of dust, dirt, and loose particles. Dampen cleaned concrete surfaces and apply bonding compound. Mix dry-pack, consisting of one part portland cement to 2-1/2 parts fine aggregate passing a No. 16 mesh sieve, using only enough water as required for handling and placing. Place dry pack after bonding compound has dried. Compact dry-pack mixture in place and finish to match adjacent concrete. Keep patched area continuously moist for not less than 72 hours.

K. Perform structural repairs with prior approval of the Engineer for method and procedure, using specified epoxy adhesive and mortar.

L. Repair methods not specified above may be used, subject to acceptance of the Engineer.

3.16 QUALITY CONTROL TESTING DURING CONSTRUCTION

The Contractor will employ a testing laboratory to perform tests and to submit test reports three (3) each.

Sampling and testing for quality control during placement of concrete may include the following, as directed by the Engineer.

A. Sampling Fresh Concrete: ASTM C 172, except modified for slump to comply with ASM C 94.

1. Slump: ASTM C 143; one test at point of discharge for each day's pour of each type of concrete; additional tests when concrete consistency seems to have changed.

2. Air Content: ASTM C 173, volumetric method for lightweight or normal weight concrete; ASTM C 231 pressure method for normal weight concrete; one for each day's pour of each type of air- entrained concrete.

3. Concrete Temperature: Test hourly when air temperature is 80(F (27(C) and above; and each time a set of compression test specimens made.

4. Compression Test Specimen: ASTM C 31; one set of 3, 6" x 12", standard cylinders for each compressive strength test, unless otherwise directed. Mold and store cylinders for laboratory cured test specimens except when field-cure test specimens are required.

5. Compressive Strength Tests: ASTM C 39; one set for each class of concrete poured each day plus additional sets for each 100 cu. yds. over and above the first 25 cu. yds. of each concrete class placed in any one day; one specimen tested at 7 days, two specimens tested at 28 days, and one specimen retained reserve for later testing if required.

B. Test results will be reported in writing to the Engineer within 24 hours after tests. Reports of compressive strength tests shall contain the project identification name and number, date of concrete placement, name of concrete testing service, concrete type and class, location of concrete batch in structure, design compressive strength at 28 days, concrete mix proportions and materials; compressive breaking strength and type of break for both 7-day tests and 28-day tests.

C. Nondestructive Testing: Impact hammer, sonoscope, or other nondestructive device may be permitted but shall not be used as the sole basis for acceptance or rejection.

D. In all cases where the strength of any group of 3 cylinders or of any individual cylinder falls below the minimum compressive strength specified, the Engineer shall have the right to require that test specimens be cut from the structure. Specimens shall be selected by the Engineer from the location in the structure represented by the test specimen or specimens which failed. Specimens shall be secured, prepared, and tested in accordance with ASTM C 42-87 within a period of 60 days after placing the concrete. Concrete shall be considered to meet the strength requirement of this specification if it meets the strength requirements of paragraph 4.8.4.4, part 3, of ACI 318. Should laboratory analysis indicated, however, that the proper concrete mix has not been used by the Contractor, all such concrete poured using the improper mix shall be subject to rejection. The cost of cutting specimens from the structure, patching the resulting holes, and making the laboratory analysis shall be borne by the Contractor. The holes from which the cored samples are taken shall be packed solid with no slump concrete proportioned in accordance with ACI 211.3-75 (80) "Recommended Practice for Selecting Proportions of No-Slump Concrete." The patching concrete shall have the same design strength as the specified concrete. If any of the specimens cut from the structure fail to meet the requirements outlined in paragraph 4.8.4.4 of ACI 318, the Engineer shall have the right to require any and all defective concrete be placed and all costs resulting therefrom shall be borne by the Contractor.

E. Contractor Sampling: In addition to the slump tests specified above, keep a cone (mold) and rod apparatus on the jobsite for random testing of batches. If, when concrete is being discharged from the mixer, the Engineer believes the concrete does not meet the specified maximum slump requirements, the Contractor shall immediately perform a slump test in accordance with ASTM C 143-78. Remove from the jobsite concrete not meeting the slump requirements.

3.17 CLEAN-UP

Contractor shall clean up all concrete and cement materials, equipment and debris upon completion of any portion of the concrete work when so directed by the Engineer and upon completion of the entire concrete and related work.

3.18 MEASUREMENT AND PAYMENT

A. All concrete placed, finished, and cured shall be measured for payment based on unit prices or lump sum as set forth in the proposal. Where 7payment is provided for on unit prices, measurement shall be by the cubic yard of concrete based on the dimensions shown on the plans or ordered by the Engineer.

B. Payment will be made at the unit bid prices or lump sum price and shall be full compensation for furnishing the materials, tools, equipment and labor necessary to complete the structure in place.

C. Unless otherwise specified, no direct payment will be made for reinforcing steel, but full compensation shall be considered as included in the price bid for concrete.

D. Concrete for duct encasement shall not be measured and paid for separately, but shall be included in the bid prices for underground ducts.

HAWAIIAN ELECTRIC CO., INC.

SPECIFICATION NO. CS9401-2

FOR

DESIGN AND CONSTRUCTION OF

PRECAST MANHOLES AND HANDHOLES

Prepared by **Planning & Analysis Department**

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PART 1 GENERAL

1.01 For certain project site conditions the use of precast concrete structures may not **be** suitable. For some project locations the Hawaiian Electric Company (the Company, or HECO) will make this decision in advance of bidding. If the Company does not make this decision and the project site conditions make the use of precast structures impracticable, the project general contractor shall be responsible for the additional costs of using cast-in-place concrete structures.

1.02 Unless approved otherwise by HECO, all precast concrete manholes, handholes or vaults, or sections thereof, shall be manufactured in a plant specifically designed for precasting reinforced concrete products performed in accordance with American Society for Testing and Materials (ASTM) C-858, Standard Specification for Underground Precast Concrete Utility Structures and shall be subject to inspection by the Company or its agent in accordance with ASTM C-1037, Inspection of Underground Precast Concrete Utility Structures.

1.03 Prior to submitting proposals to furnish precast items that will accommodate HECO facilities, the manufacturer shall be prequalified as follows:

a. **Support Services** and/or **Engineering** & Project Management **Departments** will determine if the manufacturer has the financial capacity to do the work and cover his warranties. The manufacturer shall be able to qualify for surety bonds.

b. The Company Engineering **& Project Management** Department or a Company-approved independent firm will check the manufacturer's facilities and methods to verify that they conform with the Company's technical requirements and industry standards and that the facilities are capable of producing the specified products.

1.04 All precast products shall conform to standard (or project) drawings prepared by the Company or to Company-approved manufacturer designs. The manufacturer shall have his product design drawings approved, stamped and signed in advance by an engineer with a current structural engineer's license from the State of Hawaii. The designs shall be in accordance with the latest revision of American Concrete Institute (ACI) 318, Building Code Requirements for Reinforced Concrete, and ASTM C-857, Minimum Structural Design Loading for Underground Precast

Concrete Utility Structures. In addition, the designs shall meet the requirements of the latest edition of the National Electrical Safety Code, Section 323 - Manholes, Handholes, and Vaults, and shall conform to the State of Hawaii Public Utilities Commission General Order No. 10, Rules for Construction of Underground Electric and Communications Systems, Section 42 - Manholes and Handholes. See also PART 2 DESIGN REQUIREMENTS.

1.05 **The design drawings shall have all the information necessary to make a complete structural analysis of the precast items and accessories. Design drawings may be detailed enough, such that they can also serve as shop drawings.** The manufacturer shall submit three (3) sets of detailed design drawings to the Contractor for approval by the Company prior to submission of shop drawings. A design drawing may cover many projects that use the same basic design. These drawings shall conform **to** the requirements of Section 1.04 above and PART 2 below. Design drawings shall include details and location of structural and incidental features as specified herein. The design drawings shall show the exact locations of the reinforcing steel with respect to the interior surfaces, so, if holes have to be drilled into the wall of a structure in the future for unanticipated duct entrances, the coring can be done without touching the reinforcing bars. **Approvals of project design drawings shall allow the manufacturer to proceed with fabrication of precast manholes, handholes and covers. See Part 14 of this specification for shop drawing requirements.**

1.06 The manufacturer shall provide permanently embedded brass identification tags on the interior of all precast units. The name of the manufacturer, product and/or model number, location of the precasting facilities, the date of precasting and the capacity of the pulling eyes shall be clearly and permanently marked on the tag. The tag shall be located on the side of the manhole opening.

1.07 Inspections shall be required of all products as detailed in PART 13 - INSPECTIONS.

PART 2 DESIGN REQUIREMENTS

2.01 All design criteria shall meet the minimum standards of the latest edition of the National Electric Safety Code (NESC) and the State of Hawaii Public Utilities Commission General Order No. 10, Rules for Construction of Underground Electric and

Communications Systems. In accordance with the NESC, Section 323 - Manholes, Handholes and Vaults, all structures shall be designed to sustain all expected loads that may be imposed upon the structures. In the case of conflicts among design requirements, the more stringent requirements shall apply.

2.02 Design loads shall consist of dead load, live load, 30% impact loading, loads due to the ground water and lateral soil pressure, and any other loads which may be imposed upon the structure. **Unless the project drawings call for a different amount, the ground water table shall be assumed to be 3 feet from finished grade.** Live loads for roadways or highways shall be for HS-20-44 truck loads per the latest revision of American Association of State Highway Transportation Officials (AASHTO) Standard Specifications for Highway Bridges. The governing live load shall be the combination of loadings which produces the maximum shears and bending moments in the structure. However, the manhole should be designed to withstand any combination of loadings at all points.

2.03 Live loads for structures *not* subject to roadway vehicular loading shall not be less than 300 lb. per square foot. The Company may choose to specify other live loads shown in the Table 1 below (From ASTM C857-87 Standard Practice for Minimum Structural Design Loading for Underground Precast Concrete Utility Structures) or loads not listed.

TABLE 1 - Vehicle and Pedestrian Load Designations

ASTM (A-) & Highway (HS-& H) Designations	Gross Vehicle Weight (GVW) In Pounds	Maximum Wheel Loads In Pounds (0.40 of GVW on one rear wheel), or as noted	Uses
A-16 (HS20-44) (a)	40,000	16,000	heavy traffic
A-12 (HS15-44) (a)	30,000	12,000	medium traffic
A-8 (H10144) (a)	20,000	8,000	light traffic
A-5 (H6.25) (a). HECO TR Load	12,500	5,000	very light traffic
A-4 Very Light Truck Loading	10,000	4,000	light pickups
A-1.2 Passenger Car Loading	3,000	1,200	passenger cars
A-0.3 Pedestrian Loading		300 pounds/sq. ft.	walkways

(a) **In the ASTM designation (A -) the number after A is the maximum wheel load in thousands of pounds. In the American Association of State Highway Transportation Officials (AASHTO) designation the number after the HS is the total loaded vehicle weight (comparable to GVW) in tons. The H stands for highway, and the S stands for semi-trailer.**

(b) Design loads other than those listed may be specified.

Live loads shall be increased by 30% for impact.

2.04 All pulling eyes or irons shall be capable of holding a working load of 10,000 lbs. pure tension with a factor of safety of 2.0, **except the pulling eyes for the 3'x5' handholes, which shall be capable of holding a working load of 2,000 lbs. pure tension with a factor of safety of 2. All pulling eyes and components, including the internal and external nuts, the u-bolts and plates of the u-bolt type of pulling eyes, shall be made of non-magnetic stainless steel, or of other non-corrosive material approved by Hawaiian Electric Co., Inc. All welding of stainless steel items shall be performed using an E316 Rod. When installed the u-bolt assemblies shall be water tight.** The manufacturer's drawings shall show the dimensional details of the pulling eyes, so the Company can verify that its cable pulling equipment will fit. The locations and capacities of these pulling eyes shall be as specified by the appropriate drawing in APPENDIX A of this specification and shall be shown on the manufacturer's drawings. Pulling eyes shall be aligned as close as possible to the duct banks they serve on the opposite walls. Each duct cluster shall have one pulling eye in line with the top of the cluster and another in line with the bottom of the cluster. Locations are subject to Company approval. **Pulling eyes shall be located a minimum of 18" from the floors and the ceilings and on the vertical centerlines of the duct banks, unless the proximity of the ducts to the ceilings and walls makes this 18" minimum impractical. In this situation, the distance shall be made as close to 18" as possible.**

2.05 Structure lifting eyes shall be galvanized or stainless steel and placed to maximize the ease of precast manhole, handhole or vault placement and shall have a minimum factor of safety of 4.0 times the section weight.

2.06 The buoyancy effect of any structure subjected to a high or fluctuating water table shall be considered in the design of said

structure. Appropriate installation recommendations shall be provided to the contractor by the precast manufacturer.

2.07 All sumps shall be centrally located under the manhole openings. All sumps shall be provided with removable, non-slip, non-corroding covers that will safely cover the sump.

2.08 Sufficient information and detail on the water sealing gaskets shall be shown on the precast drawings to facilitate the installation of waterproof joints. Water sealing gaskets shall be adequate to withstand environmental conditions (i.e., saltwater, petroleum, acidic and alkaline liquids, etc.).

2.09 Precast handholes shall be designed so that when the bottoms are set level, the tops match the grade of the ground or sidewalk surfaces at each location. Approved devices shall be provided with the handholes, so adjustments can easily be made in the field to make the tops of the handholes match the finish grades. The details of these devices and how to use them shall be illustrated on the manufacturer's design drawings.

2.10

a. The manufacturer's drawings shall make reference to the HECO 31" (nominal) diameter Manhole Frame shown in Standard Material Drawing 011327 and to HECO 31" Manhole Frame Standard Material Drawing 011328, and/or to HECO Drawing No. 16688 (Miscellaneous Details, Handholes and Manholes) Sheet 2 of 2 for Standard Handhole Covers, as appropriate.

b. **In case of handholes not subject to vehicular traffic, the manufacturer's drawings shall make reference to the HECO Handhole Concrete Cover SW (Sidewalk) 1'- 6 3/4" x 3' - 3 3/4" x 2 1/2", detailed on HECO Drawing 16688 (Miscellaneous Details, Handholes & Manholes), Sheet 2. This cover shall be designed for the 300 lbf/sq. ft. shown in TABLE 1.**

c. **In the case of handholes subject to very light vehicular traffic, the manufacturer's drawings shall make reference to the HECO Handhole Concrete Cover TR (Traffic) 1' - 3" x 3' - 4 3/4" x 3 3/8", detailed on HECO Drawing 16688**

(Miscellaneous Details, Handholes & Manholes), Sheet 2. This cover shall be designed for the A-5 loading (5000-pound wheel load) in TABLE 1.

d. At the discretion of the project designer or engineer, light-weight, galvanized steel, non-slip covers can be substituted for one or more of the SW-type concrete covers in a handhole. These steel covers, the handhole structure and shelves that support the covers shall be designed for the A-0.3 loading in TABLE 1. The steel covers shall be like light-weight, non-slip, galvanized steel covers, manufactured for HECO by INWESCO, or approved equals. The lifting nuts welded to the bottom of the cover shall be made of non-magnetic stainless steel. These light weight covers shall be designed to minimize the pressure build-up in the handhole in the event of a cable or gas explosion in the duct system served by the handhole or in the handhole. This objective can be accomplished by making sure the lifting holes are open at all times and by having holes made in the edge supporting angles or by providing spaces between angles through the proper cutting and positioning of the supporting angle segments. When necessary to prevent the entry of a spears or similar sharp device into the handhole, a strong metal clip shall be welded next to the lifting holes and nuts and bent over the nut to form a barrier to entry. To prevent unauthorized entry, this SW-type steel cover shall weigh at least 100 pounds but shall not weigh more than 110 pounds. To prevent injury to the general public and to workers, sharp corners and edges shall be eliminated prior to galvanizing.

e. Similarly, at the discretion of the project designer or engineer, light-weight, galvanized steel, non-slip covers can be substituted for one or more of the TR-type concrete covers in a handhole. These steel covers, the handhole structure and shelves that support the covers shall be designed for the A-5 loading in TABLE 1. The steel covers shall be like light weight, non-slip, galvanized steel covers, manufactured for HECO by INWESCO, or approved equals. The lifting nuts welded to the

bottom of the cover shall be made of non-magnetic stainless steel. These light weight covers shall be designed to minimize the pressure build-up in the handhole in the event of a cable or gas explosion in the duct system served by the handhole or in the handhole. This objective can be accomplished by making sure the lifting holes are open at all times and by having holes made in the edge supporting angles or by providing spaces between angles through the proper cutting and positioning of the supporting angle segments. When necessary to prevent the entry of a spears or similar sharp device into the handhole, a strong metal clip shall be welded next to the lifting holes and nuts and bent over the nut to form a barrier to entry. To minimize the possibility of back injuries, these covers shall weigh no more than 150 pounds. To prevent injury to the general public and to workers, sharp corners and edges shall be eliminated prior to galvanizing.

f. **To make them non-slip, the tops of the galvanized metal covers described above shall be made of Algrip galvanized steel plate produced by Safe-Walk Inc. Algrip plate consists of super-hard granules of aluminum oxide embedded into the top surface of the plate. An acceptable alternate for the tops of the covers is a Slip-Not steel plate made by W. S. Molnar Co. This product is made by the plasma deposition of file-hard steel on the top surface of the plate.**

2.11 The weights of each section shall be shown on the manufacturer's drawings and shall be stenciled on the products prior to shipment.

2.12 The design capacity of each pulling eye and lifting anchor shall be indicated on the drawings.

2.13 The design and project shop drawings shall show joint details and joint caulking material and method of application.

2.14 The design and project shop drawings shall clearly indicate the loadings for which the products are designed.

2.15 For special designs, the manufacturer may be asked to furnish, at no cost to the Company, certified evidence of physical proof tests which verify that specific components, such as the pulling eyes, meet the specified design loads with the required factors of safety.

2.16 The "elastic" method of structural design or the "ultimate strength" method of reinforced concrete design, as outlined in ACI (American Concrete institute) 318, shall be used to design the concrete sections, including the reinforcement required, when the structure is subject to the loading conditions covered in ASTM C857, Standard Practice for Minimum Structural Loading for Underground Precast Utility Structures. Unless otherwise indicated in this Specification CS9401, the requirements of ASTM C858, Standard Specification for Underground Precast Concrete Utility Structures, shall be followed. The minimum cover for reinforcing shall be 1 1/2" **for the exterior and 3/4" for the interior of the structure** under this CS9401 specification**, except that for concrete handhole covers the minimum reinforcing bar cover in the interiors and on the sides shall be 3/4" per ASTM 858, Section 7.5, and for the tops the cover shall be 1".**

2.17 **The manufacturer shall cast into the manhole or handhole a strong, plastic adapter that will provide for a smooth, tight connection with the incoming ducts. If the duct connections are to be made at some future time, these plastic adapters shall prevent any moisture or dirt from entering the manhole or handhole. The external portion of the adapters shall be covered with a removable cover that will keep the dirt out of the adapter until the connections are made in the future.** These sleeves shall snugly fit over and connect to Schedule 40 PVC ducts. The concrete around these sleeves shall be reinforced. The number, size, and location of these sleeves and sleeve-banks shall be shown on the manufacturer's shop drawings submitted for final approval prior to fabrication. The sleeve configuration shall conform to the maximum size and number shown on the previously approved design drawing. **The manufacturers have various trade names for these adapters or sleeves (termi-ducts, terminators, etc.). The Company gives these duct connector devices the generic name "duct connectors."**

2.18 The duct entrance locations and sizes shall be incorporated into the structural design calculations. The initial and future locations and sizes of ducts and pulling eyes will be shown for each project structure. The Company drawing(s) in Appendix A show the typical duct entrance and pulling eye arrangements.

2.19 The drawings for projects that require corner entrances shall show these special corner entrance details. Approximately 20% of the Company's projects require that some duct enter at corners.

PART 3 FORMS

3.01 Forms shall be sufficiently designed and braced to maintain their alignment during placement of wet concrete and shall not preclude the location of knockouts, blockouts or terminators at the vertical center of the precast manhole, handhole or vault walls. The form shall allow the placement of pulling eyes or irons directly opposite of duct entrances. The forms shall permit the use of a centrally located 31" diameter round opening frame and cover in the top section for access by personnel (See Section 2.10 above) and an adequately sized sump centered in the bottom section of the precast manhole, handhole or vault. Forms shall provide a surface finish that is smooth and free from honeycomb pockets.

PART 4 REINFORCING STEEL

4.01 All reinforcing steel shall be ASTM A615 Grade 60, as shown in Table 2a of ASTM A615, or shall be ASTM A706. Bars produced under the ASTM A615 specification are not to be welded. Bars produced under ASTM A706 may be welded, if the recommendations in the latest edition of ANSI/AWS D1.4 are used. All welded wire mesh shall be ASTM A185 Grade 65. All reinforcing steel shall be of the size and in the location as shown on the stamped structural plans and shall be sufficiently tied or welded to withstand any displacement during the concrete pouring operation. All steel shall be free of loose rust, dirt, oil or other deleterious material and shall maintain a minimum concrete cover in strict accordance with ACI 318-89 Section 7.7.2.

4.02 Minimum concrete cover over reinforcing bars shall be 1 1/2 inches **for the exterior and 3/4" the for the interior of the structures. For waterproofing requirements, Section 8.03**

shall apply. The 3/4" cover for the interior bars is based on appropriate waterproofing.

PART 5 INSERTS

5.01 **Threaded concrete inserts 1/2" diameter x 2-1/2" shall be provided at a minimum for 24" center to center horizontal and vertical spacing on each wall of the precast manhole, handhole, or vault, for cable racking purposes. The project designer shall specify in advance whether these inserts shall be made of plastic, galvanized steel or stainless steel. All these inserts shall meet the Bell Laboratories' Specification AT-8730. The principal provision of this Bell Laboratories Specification for the 1/2" diameter inserts are: Minimum Tension = 4000 pounds. Minimum Shear = 4000 pounds. Minimum Torque = 75 foot-pounds.**

5.02 Two opposite corners of the precast manhole, handhole or vault floor shall be provided with sealed holes through which 5/8" diameter ground rods can be driven as needed and made water tight after the driving is completed.

PART 6 CONCRETE

6.01 The concrete mix shall be designed in accordance with Chapter 3 of ACI 301 by a structural engineer licensed in the State of Hawaii or by a recognized commercial testing agency to reach the minimum design strength of at least 4,000 psi in 28 days with normal weight aggregates.

6.02 The concrete shall be proportioned in accordance with the ACI 211.1 "Standard Practice for Selecting Proportions for Normal, Heavy-weight, and Mass Concretes." Concrete proportions shall be verified by laboratory trials to establish water demand for materials selected to produce the specified concrete characteristics. Laboratory trials shall be performed on the proposed materials in accordance with ASTM C 192. A compressive strength ten (10) percent higher than the design minimum shall be obtained in the laboratory.

6.03 The water to cement material ratio shall not exceed 0.40. Concrete mixing water shall be taken from a potable supply used for domestic purposes and shall be free from rust and silt.

6.04 Maximum water soluble chloride ion (CL-) in concrete shall not exceed 0.15% by weight of cement.

6.05 Coarse and fine aggregates shall consist of gravel, crushed gravel, or crushed stone and shall meet the requirements of ASTM C 33, with grading in accordance with the requirements of size number 57 (1" to No. 4 Sieve (4.75 mm)). Aggregates shall be tested for reactivity in accordance with ASTM P 214-91, ASTM C 289 and ASTM C 295, or ASTM C 227 and shall be classified as non-reactive as verified by the test results. If a change of aggregate source or admixture is proposed, the engineer shall be notified and separate laboratory trials shall be required.

6.06 With prior approval of HECO, admixtures may be used if the strength and durability of the concrete is not impaired. Calcium chloride *shall not* be used as an admixture. The use of a high range water reducer (HRWR) shall be in accordance with the manufacturer's recommendations. If a HRWR is to be used in combination with any other liquid admixture, the time of initial set shall be established in the laboratory trial. The laboratory trial shall be performed in accordance with ASTM C 403.

PART 7 PLACEMENT OF CONCRETE

7.01 All concrete shall be handled from the batch plant to the form work in a continuous manner without segregation or loss of ingredients. Concrete shall be placed in layers not over two (2) feet deep. Each layer shall be thoroughly compacted by mechanical internal or external-vibrating equipment. The duration of the vibration cycle shall be limited to the time necessary to produce satisfactory consolidation, as measured by the appearance of the free surfaces before initial set of the concrete. Refer to Section 8.03.

PART 8 CURING AND FINISHING

8.01 The concrete may be steam cured after an initial set has taken place. The steam temperature shall not exceed 160 degrees F, and the temperature shall be raised from normal ambient temperatures at a rate not to exceed 40 degrees F per hour.

8.02 The steam cured unit shall not be removed from the forms until sufficient strength is obtained for the unit to withstand any structural loads that it may be subjected to during the form stripping operation. After the stripping of forms, further curing shall be continued by means of water spraying or by means of a continuous coating of an approved membrane curing compound. The curing compound shall be clear or white in color, conforming to ASTM C309.

8.03 Interior walls and ceilings shall be smooth and free of irregularities and all surfaces shall be sound. Sections having cracks and other defects that may impair structural strength or that may allow water migration are not acceptable. At HECO's option, interior walls shall be coated with a white cement based, heavy duty, waterproof coating, unless noted otherwise in the project documents. Also at the option of HECO the exterior surfaces subject to ground water exposure shall be treated with a cement based heavy duty waterproof coating so as to form a liquid tight seal, unless noted otherwise in the project documents.

When the structure is assembled, joints should be evenly aligned and completely filled with the sealant per Section 10.02. Manhole necks in ceilings shall have beveled edges (no sharp corners).

PART 9 DELIVERY

9.01 The concrete strength of the precast unit leaving the plant shall be sufficient to withstand all handling, pickup and impact stresses during its delivery. As a minimum, the concrete strength at the time of shipment shall be at least 75% of its 28-day strength.

9.02 Unless specifically instructed otherwise, the completed products must be held by the manufacturer for a minimum of 7 days after the pouring operation before shipment of the products, or unless the manufacturer proves that the precast unit meets the requirement of Section 9.01 above prior to shipment.

9.03 All spalls and cracks shall be repaired prior to shipment and/or installation. No product shall be delivered with cracks that affect the structural integrity of the product. Refer to Section 8.03 and Section 13.04.

PART 10 FIELD PREPARATION

10.01 The Contractor shall prepare and adequately shore an excavation large enough to accommodate the outside dimensions of the precast manhole, handhole or vault as shown on the approved drawings. Prior to setting, the Contractor shall provide a sub-base material approved by the appropriate permitting agency and suitable to receive the precast manhole, handhole or vault. The sub-base material shall be compacted and graded level to a proper elevation to receive the precast manhole, handhole or vault relative to the conduit grade and ground cover requirements as designated in the plans.

10.02 A mastic joint compound shall be used between precast manhole, handhole or vault sections as a sealant to insure a leak free structure.

10.03 The precast structures shall be installed in accordance with the provisions of the ASTM C891, Standard Practice for Installation of Underground Precast Concrete Structures and the latest revision of HECO CS7001.

PART 11 BEDDING

11.01 The latest revision of Hawaiian Electric Company, Inc. Specification No. CS7001, Standard Specifications for Construction of Underground Facilities, shall govern the bedding and backfill of precast manholes, handholes and vaults unless otherwise specified herein or by the Project Engineer.

11.02 Bedding beneath a precast manhole, handhole or vault shall be placed in relatively uniform lifts no greater than six (6) inches in loose thickness, moisture conditioned to within three (3) percent of their optimum moisture content, and uniformly compacted to at least ninety (90) percent relative compaction.

11.03 Near-surface sands, gravels or sandy clays may be reused as precast manhole, handhole or vault bedding provided all organic materials, rocks, concrete fragments and soil clods greater than three (3) inches in diameter are removed, and the approved purged materials are placed and compacted in accordance with these requirements. The excavated asphalt pavement may also be used as bedding, provided it is crushed sufficiently such that the maximum particle size is no larger than three (3) inches in diameter.

11.04 Organic silts are unsuitable for re-use as bedding material and should be disposed of offsite. Silty coral sands and gravels encountered beneath organic silts may be reused as fill, but will require extensive drying before they can be adequately compacted as backfill. Drying may not be practical within a limited construction area and construction period.

11.05 Imported bedding material should consist of low expansion granular soil, free of rocks and soil clods greater than three (3) inches in diameter, with a plasticity index of less than ten (10). Select Borrow conforming to Section 30 of the Standard Specifications for Public Works Construction for the City and County of Honolulu should meet this requirement.

11.06 Where the overexcavation of soil beneath the precast manhole, handhole or vault invert does not encroach within six (6) inches of the highest water table, the bedding material should consist of granular material meeting the above specified requirements.

11.07 Where overexcavations of soil from beneath the precast manhole, handhole or vault inverts extend to or beneath the highest groundwater level, bedding placed below depths of six (6) inches above the water table, should consist of a clean, well-graded granular material with a maximum particle size of three (3) inches, and less than three (3) percent passing the No. 200 sieve.

PART 12 BACKFILL

12.01 Precast manhole, handhole or vault excavations may be backfilled using a controlled low strength material (CLSM) mixture as the backfill material, if permitting agencies having jurisdiction (City, State, etc.) approve. The project general contractor shall have the responsibility for obtaining these approvals. CLSM shall be placed to fill the excavation as indicated on the plans or as directed by the Engineer. CLSM will be accepted in lieu of standard backfill specifications and shall conform to ACI 229R.

The CLSM shall be a mixture of aggregate, Portland cement, Flyash (optional), water, and approved admixtures that provides a backfill material that is self-compacting and can be readily re-excavated by conventional mechanical equipment to access

underground utilities. The water shall be taken from a supply used for domestic purposes and shall be free from rust and silt. Cement shall meet the standards as set forth in ASTM C-150, Type I or II cement. Flyash shall meet the standards as set forth in ASTM C-618. Aggregates *need not* meet the standards set forth in ASTM C-33. Any aggregate producing performance characteristics of flowable fill will be accepted, but shall be limited to a maximum size of one and one-half inches (1-1/2").

The CLSM manufacturer or contractor shall obtain permission from the appropriated permitting agencies (City, State, etc.) to use the CLSM before backfilling. If such permission is not obtained in time to meet the project schedule, the contractor shall backfill with appropriate materials as called for on the permitting agency approved construction drawings or in their specifications. Exploring these alternatives and obtaining approval shall be done at no cost to HECO.

12.02 The actual design mix for the CLSM shall be determined by the producer of the CLSM and the engineer to meet job site conditions. CLSM shall be proportioned to produce a 28-day compressive strength of approximately 50 to 250 psi. CLSM shall be batched by a ready mixed concrete plant and delivered to the job site by means of transit mixing trucks. Water content shall be such that a uniform, flowable mixture is developed that is essentially self-leveling when placed.

12.03 The CLSM shall be placed to the designated fill line without vibration or other means of compaction. Placing CLSM shall be by chute, pumping, or other approved methods. During placement operations around precast manholes, handholes or vaults, care shall be used to avoid dislocating any part of the structure, conduit, or adjacent utilities due to fluid pressure from the CLSM. All structures or pipes within the backfill area shall be secured to avoid the buoyant effect of CLSM if necessary. Care shall be taken to assure tight seals to avoid infiltration into pipelines, structures, and other areas not intended to receive flowable fill.

12.04 All CLSM fill areas subjected to traffic loads shall have durable riding surfaces before pavement is placed. No curing protection is required. The CLSM material for this traffic loading application shall have a 3 sack mix with a minimum compressive strength of 300 psi before allowing a pavement surface to be placed on it.

PART 13 INSPECTIONS

13.01 The inspection of the fabrication of all precast products at locations not on Oahu shall be performed by Company or subsidiary personnel, or by independent persons or firms approved in advance by the Company. The Company shall pay for this independent inspection. The manufacturer shall give ample notice to independent inspection agencies so the inspections will spot deficiencies in time for corrective action. In no case shall the advance notice be less than three working days. The inspection shall conform to the requirements of ASTM 1037, Standard Practice for Inspection of Underground Precast Utility Structures.

13.02 For precast products fabricated on Oahu, the precaster shall provide an advance listing of units to be built to the Company Supervisor Construction & Inspection (Phone 543-4405), on a monthly basis. The listing shall include the scheduled concrete pour dates and the projects on which the units are to be used.

13.03 The contractor responsible for the installation of the precast item shall notify the appropriate Company Inspector three working days in advance of the installation of the precast product.

13.04 The Company or its agent shall have the sole right to determine if an item is damaged or defective and is to be repaired or replaced. All repairs and replacements are to be at the manufacturer's or contractor's expense.

PART 14 PROJECT SHOP DRAWINGS

14.01 In addition to the product design drawings mentioned in Section 1.05, the manufacturer shall submit three (3) sets of Project Shop Drawings to Company's contractor or the developer for approval. These drawings shall show the location of the pulling eyes, duct entrances, sumps, and shall show other pertinent information, such as the dimensional layouts and reinforcing plans for the duct entrance sleeve clusters. The Company's contractor or the developer shall, in turn, submit two (2) sets of these drawings to the Company Project Engineer for approval. The Company will return one (1) set marked appropriately to the contractor or the developer.

14.02 These Project Shop Drawings shall identify the project on which the precast manhole(s) will be used. These drawings shall also reference the manufacturer's model number and the design drawing on which it is based, and the manufacturer shall certify that the basic design is the same as design drawings approved by the licensed structural engineer mentioned above in Section 1.04. The manufacturer shall have a licensed structural engineer make this certification.

14.03 The intent of calling for these Project Shop Drawings is to have design documentation for the inspection of the precast operations and inspection of the installation operations. For projects with identical models and minor variations of them, the drawings will be the same except for the project titles. In addition, Project Shop Drawings will help to ensure that the structures are installed in the correct locations. **The approval of the shop drawings by the Company is for general intent only and the Contractor is still responsible for the correctness of the product.**

PART 15 IDENTIFICATION

15.01 The manhole covers, the tops of visible end walls of handholes, or the handhole covers, if the end walls are too narrow or are not visible, shall be imprinted with the letters below to identify the ownership of the structures:

Owning Company	Identifying Letters
Hawaiian Electric Co., Inc.	HECO
Hawaii Electric Light Co., Ltd.	HELCO
Maui Electric Co., Ltd.	MECO

APPENDIX A

TYPICAL DUCT ENTRANCE AND PULLING EYE LOCATIONS AND SIZES

Figure A	**3'x5' Non-vehicular Traffic Handhole**
Figure 1	**6'x11' and 6'x14' Side Entrance Manhole**
Figure 2	**6'x11' and 6'x14' Corner and Side Entrance Manhole**
Figure 3	**6'x11' and 6'x14' Center Entrance Manhole**
Figure 4	**6'x11' and 6'x14' Corner and Center Entrance Manhole**
Figure 5	**6'x11' and 6'x14' Flat Entrance Manhole**
Figure 6	**6'x11' and 6'x14' Corner and Flat Entrance Manhole**
Figure 7	**6'x11' and 6'x14' Single Row Side Entrance Manhole**
Figure 8	**3'x5', 4'x6', 5'x7' and 6'x11' Center Entrance Handholes**

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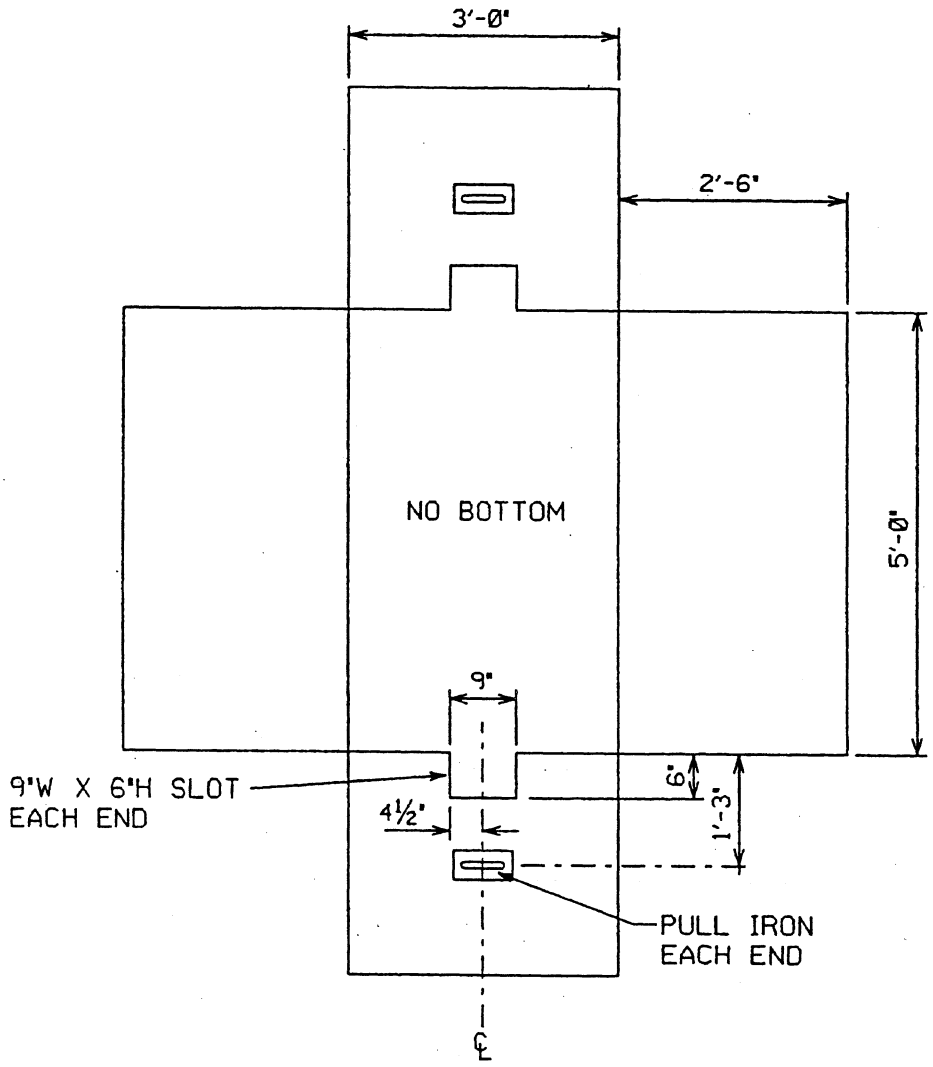

GRAPHICAL SCALE

½" = 1'-0"

FT. 0 1 2 3 4

IN. 3 9

APPROVER	HAWAIIAN ELECTRIC CO., INC. HONOLULU, HAWAII	3' X 5' NON-VEHICULAR TRAFFIC HANDHOLE FIG. A	ORIGINAL SPEC. NO. CS9401-2

DRAWN CT | REVISION | DATE INITIAL

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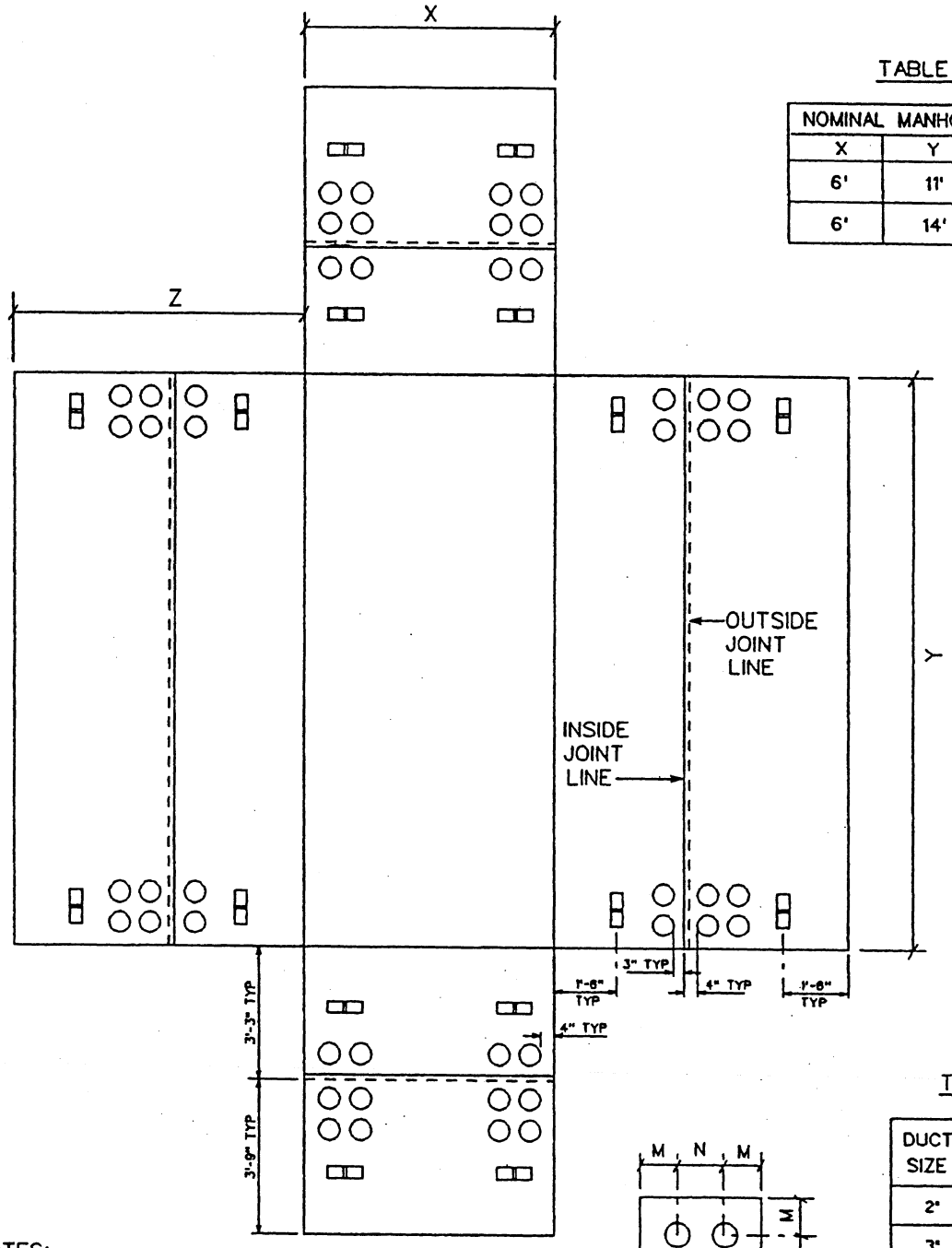


TABLE A

NOMINAL MANHOLE SIZES		
X	Y	Z
6'	11'	7'-0"
6'	14'	7'-0"

TABLE B

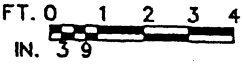
DUCT SIZE	DIMENSION	
	M	N
2"	4"	5"
3"	5"	6"
4"	5½"	7"
5"	6"	8"
6"	6⅝"	9"

NOTES:

1. ACTUAL DUCT SIZES, NUMBER & LOCATIONS WILL BE SPECIFIED IN PROJECT DRAWINGS. PULLING EYE LOCATIONS WILL BE SPECIFIED ACCORDINGLY.
2. REFERENCE HECO DWG. 16688 SHTS 1 & 2 FOR MISCELLANEOUS HANDHOLE DETAILS, AS APPLICABLE.
3. BOXES SHALL BE ABLE TO ACCEPT FUTURE DUCTS IN ANY LOCATION ON THE WALLS AND IN THE CORNERS.
4. TYPICAL CONDUIT SPACING GIVEN IN TABLE B.

GRAPHICAL SCALE

1/4" = 1'-0"



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HAWAIIAN ELECTRIC CO., INC.
HONOLULU, HAWAII

APPENDIX A: TYPICAL DUCT ENTRANCE LOCATIONS
FIG. 1 - SIDE ENTRANCE MANHOLE

ORIGINAL 9/14/94
SPEC. NO. CS9401-2

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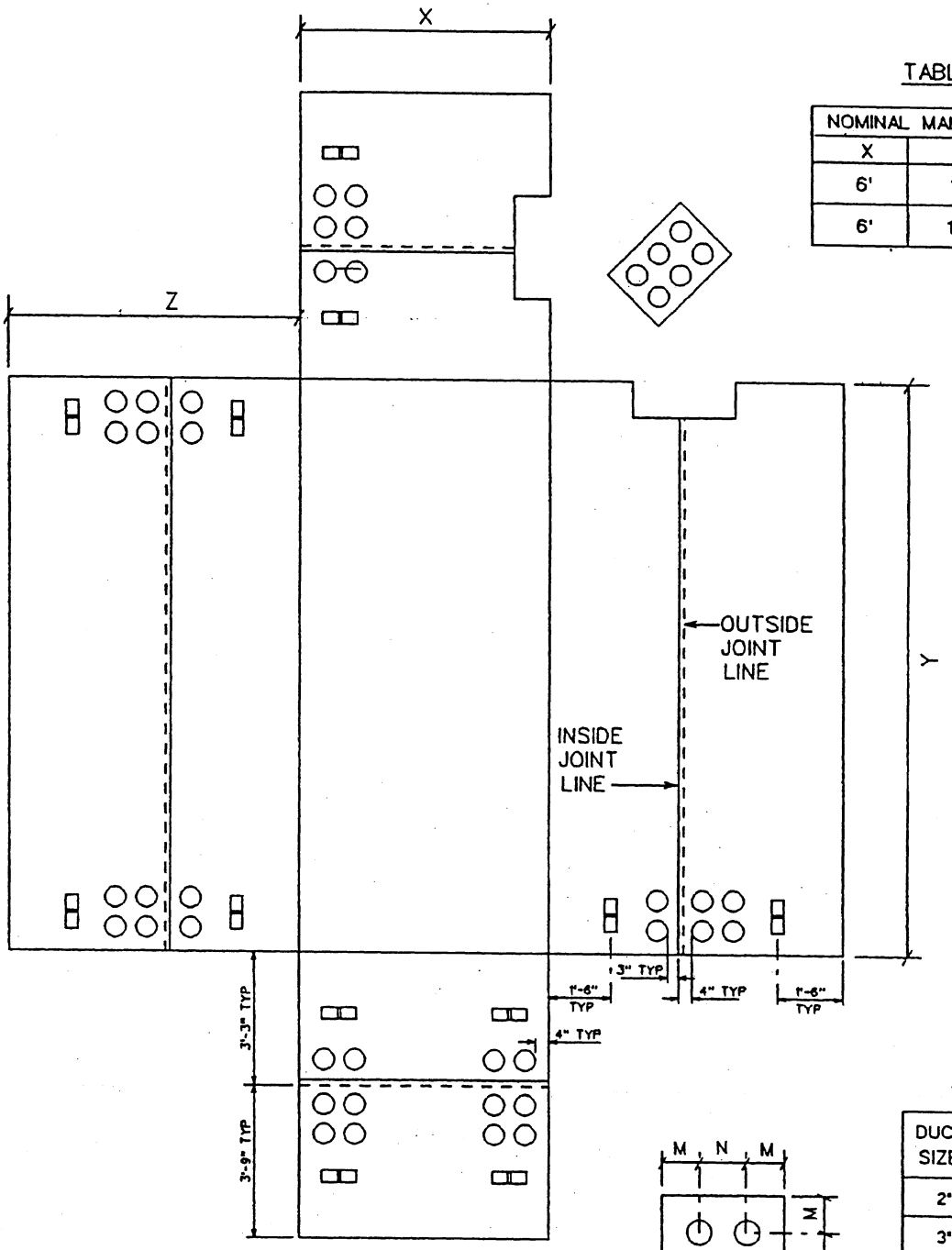

TABLE A

NOMINAL MANHOLE SIZES		
X	Y	Z
6'	11'	7'-0"
6'	14'	7'-0"

TABLE B

DUCT SIZE	DIMENSION	
	M	N
2"	4"	5"
3"	5"	6"
4"	5½"	7"
5"	6"	8"
6"	6⅝"	9"

NOTES:

1. ACTUAL DUCT SIZES, NUMBER & LOCATIONS WILL BE SPECIFIED IN PROJECT DRAWINGS. PULLING EYE LOCATIONS WILL BE SPECIFIED ACCORDINGLY.
2. REFERENCE HECO DWG. 16688 SHTS 1 & 2 FOR MISCELLANEOUS HANDHOLE DETAILS, AS APPLICABLE.
3. BOXES SHALL BE ABLE TO ACCEPT FUTURE DUCTS IN ANY LOCATION ON THE WALLS AND IN THE CORNERS.
4. TYPICAL CONDUIT SPACING GIVEN IN TABLE B.

GRAPHICAL SCALE

¼" = 1'-0"

FT. 0 1 2 3 4

IN. 3 9

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HAWAIIAN ELECTRIC CO., INC.
HONOLULU, HAWAII

APPENDIX A: TYPICAL DUCT ENTRANCE LOCATIONS
FIG. 2 - CORNER AND SIDE ENTRANCE MANHOLE

ORIGINAL 9/14/94

SPEC. NO. CS9401-2

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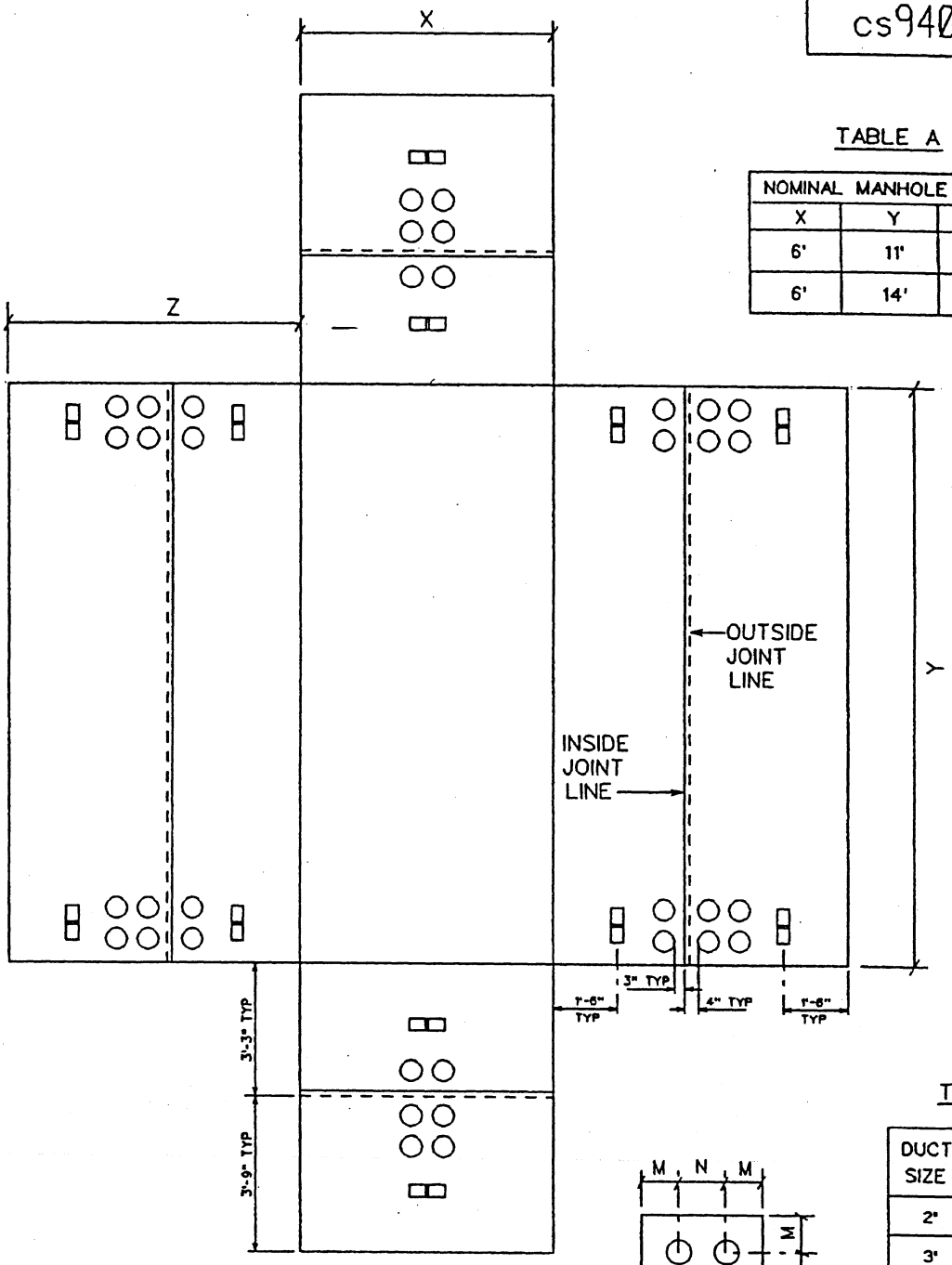

TABLE A

NOMINAL MANHOLE SIZES		
X	Y	Z
6'	11'	7'-0"
6'	14'	7'-0"

TABLE B

DUCT SIZE	DIMENSION	
	M	N
2"	4"	5"
3"	5"	6"
4"	5½"	7"
5"	6"	8"
6"	6⅝"	9"

NOTES:

1. ACTUAL DUCT SIZES, NUMBER & LOCATIONS WILL BE SPECIFIED IN PROJECT DRAWINGS. PULLING EYE LOCATIONS WILL BE SPECIFIED ACCORDINGLY.
2. REFERENCE HECO DWG. 16688 SHTS 1 & 2 FOR MISCELLANEOUS HANDHOLE DETAILS, AS APPLICABLE.
3. BOXES SHALL BE ABLE TO ACCEPT FUTURE DUCTS IN ANY LOCATION ON THE WALLS AND IN THE CORNERS.
4. TYPICAL CONDUIT SPACING GIVEN IN TABLE B.

GRAPHICAL SCALE

¼" = 1'-0"

FT. 0 1 2 3 4

IN. 3 9

APPROVED RI SE FK | DRAWN NS/CT | REVISION | DATE 3-7-96 | INITIAL

HAWAIIAN ELECTRIC CO., INC.
HONOLULU, HAWAII

APPENDIX A: TYPICAL DUCT ENTRANCE LOCATIONS
FIG. 3 - CENTER ENTRANCE MANHOLE

ORIGINAL 9/14/94

SPEC. NO. CS9401-2

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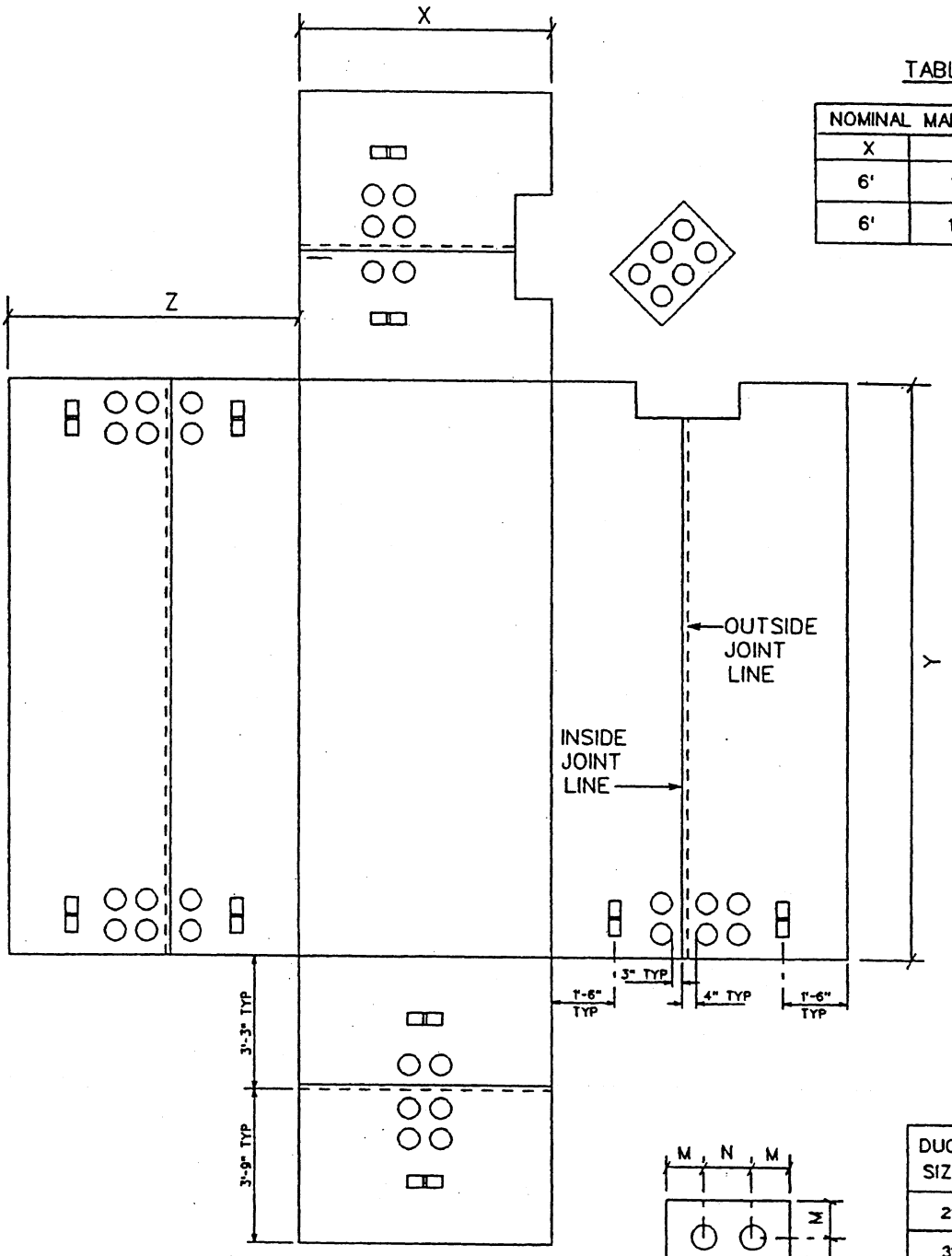

TABLE A

NOMINAL MANHOLE SIZES		
X	Y	Z
6'	11'	7'-0"
6'	14'	7'-0"

TABLE B

DUCT SIZE	DIMENSION	
	M	N
2"	4"	5"
3"	5"	6"
4"	5½"	7"
5"	6"	8"
6"	6 5/16"	9"

NOTES:

1. ACTUAL DUCT SIZES, NUMBER & LOCATIONS WILL BE SPECIFIED IN PROJECT DRAWINGS. PULLING EYE LOCATIONS WILL BE SPECIFIED ACCORDINGLY.
2. REFERENCE HECO DWG. 16688 SHTS 1 & 2 FOR MISCELLANEOUS HANDHOLE DETAILS, AS APPLICABLE.
3. BOXES SHALL BE ABLE TO ACCEPT FUTURE DUCTS IN ANY LOCATION ON THE WALLS AND IN THE CORNERS.
4. TYPICAL CONDUIT SPACING GIVEN IN TABLE B.

GRAPHICAL SCALE

1/4" = 1'-0"

FT. 0 1 2 3 4

IN. 3 9

APPROVED RI SE FK | DRAWN NS/CT | REVISION | DATE 3-7-96 INITIAL

HAWAIIAN ELECTRIC CO., INC.
HONOLULU, HAWAII

APPENDIX A: TYPICAL DUCT ENTRANCE LOCATIONS
FIG. 4 - CORNER AND CENTER ENTRANCE MANHOLE

ORIGINAL 9/14/94

SPEC. NO. CS9401-2

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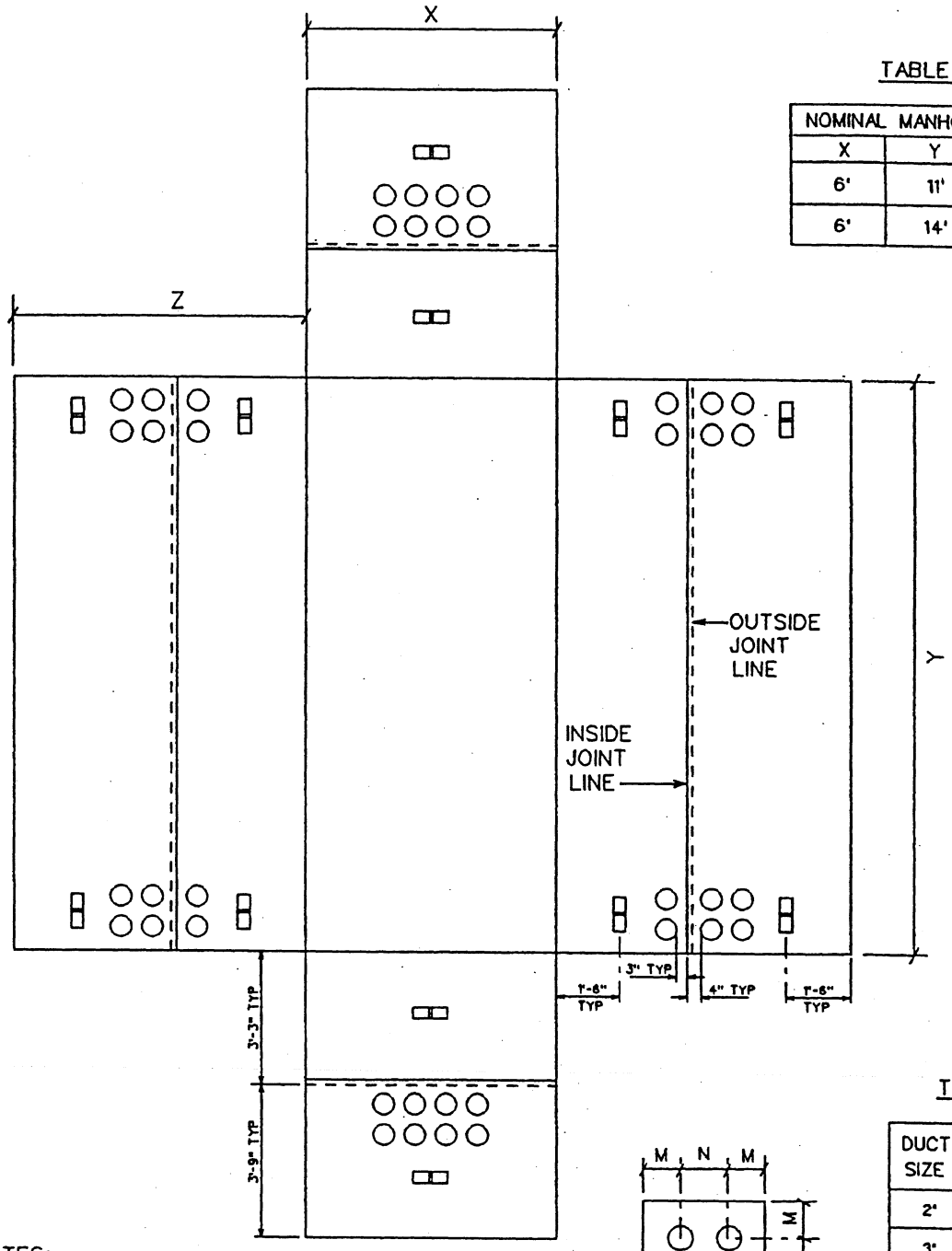

TABLE A

NOMINAL MANHOLE SIZES		
X	Y	Z
6'	11'	7'-0"
6'	14'	7'-0"

TABLE B

DUCT SIZE	DIMENSION	
	M	N
2"	4"	5"
3"	5"	6"
4"	5½"	7"
5"	6"	8"
6"	6⅝"	9"

NOTES:

1. ACTUAL DUCT SIZES, NUMBER & LOCATIONS WILL BE SPECIFIED IN PROJECT DRAWINGS. PULLING EYE LOCATIONS WILL BE SPECIFIED ACCORDINGLY.
2. REFERENCE HECO DWG. 16688 SHTS 1 & 2 FOR MISCELLANEOUS HANDHOLE DETAILS, AS APPLICABLE.
3. BOXES SHALL BE ABLE TO ACCEPT FUTURE DUCTS IN ANY LOCATION ON THE WALLS AND IN THE CORNERS.
4. TYPICAL CONDUIT SPACING GIVEN IN TABLE B.

GRAPHICAL SCALE

¼" = 1'-0"

FT. 0 1 2 3 4

IN. 3 9

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HAWAIIAN ELECTRIC CO., INC.
HONOLULU, HAWAII

APPENDIX A: TYPICAL DUCT ENTRANCE LOCATIONS
FIG. 5 - FLAT ENTRANCE MANHOLE

ORIGINAL 9/14/94

SPEC. NO. CS9401-2

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TABLE A

NOMINAL MANHOLE SIZES		
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6'	14'	6'-6"

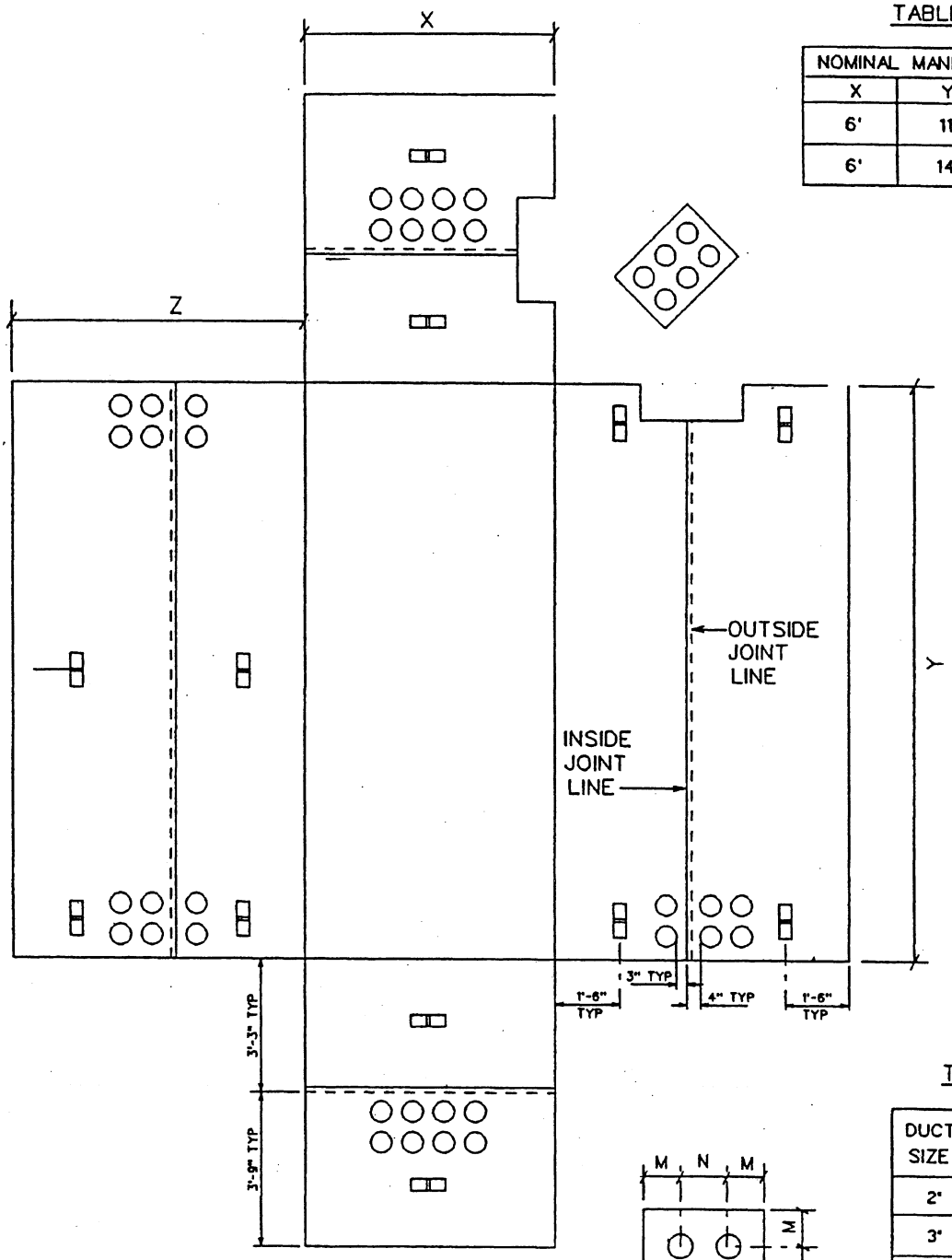

TABLE B

DUCT SIZE	DIMENSION	
	M	N
2"	4"	5"
3"	5"	6"
4"	5½"	7"
5"	6"	8"
6"	6⅝"	9"

NOTES:

1. ACTUAL DUCT SIZES, NUMBER & LOCATIONS WILL BE SPECIFIED IN PROJECT DRAWINGS. PULLING EYE LOCATIONS WILL BE SPECIFIED ACCORDINGLY.
2. REFERENCE HECO DWG. 16688 SHTS 1 & 2 FOR MISCELLANEOUS HANDHOLE DETAILS, AS APPLICABLE.
3. BOXES SHALL BE ABLE TO ACCEPT FUTURE DUCTS IN ANY LOCATION ON THE WALLS AND IN THE CORNERS.
4. TYPICAL CONDUIT SPACING GIVEN IN TABLE B.

GRAPHICAL SCALE

1/4" = 1'-0"

FT. 0 1 2 3 4

IN. 3 9

APPROVED RI SE FK | DRAWN NS/CT | REVISION | DATE 3-7-96 | INITIAL

HAWAIIAN ELECTRIC CO., INC.
HONOLULU, HAWAII

APPENDIX A: TYPICAL DUCT ENTRANCE LOCATIONS
FIG. 6 - CORNER AND FLAT ENTRANCE MANHOLE

ORIGINAL 9/14/94

SPEC. NO. CS9401-2

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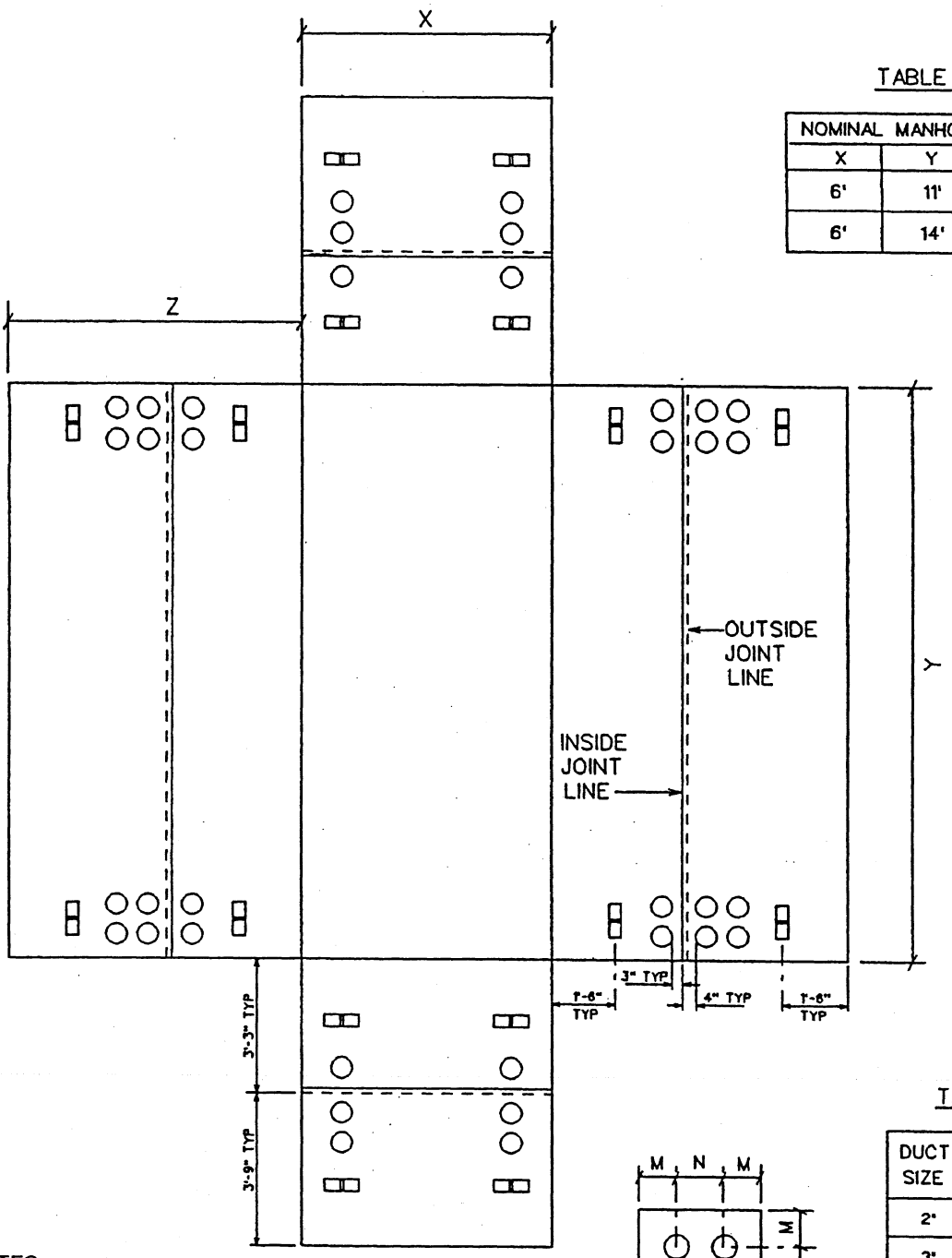


TABLE A

NOMINAL MANHOLE SIZES		
X	Y	Z
6'	11'	7'-0"
6'	14'	7'-0"

TABLE B

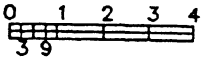
DUCT SIZE	DIMENSION	
	M	N
2"	4"	5"
3"	5"	6"
4"	5½"	7"
5"	6"	8"
6"	6 5/16"	9"

NOTES:

1. ACTUAL DUCT SIZES, NUMBER & LOCATIONS WILL BE SPECIFIED IN PROJECT DRAWINGS. PULLING EYE LOCATIONS WILL BE SPECIFIED ACCORDINGLY.
2. REFERENCE HECO DWG. 16688 SHTS 1 & 2 FOR MISCELLANEOUS HANDHOLE DETAILS, AS APPLICABLE.
3. BOXES SHALL BE ABLE TO ACCEPT FUTURE DUCTS IN ANY LOCATION ON THE WALLS AND IN THE CORNERS.
4. TYPICAL CONDUIT SPACING GIVEN IN TABLE B.

GRAPHICAL SCALE

1/4" = 1'-0"



APPROVED RI SE FK | DRAWN NS/CT | REVISION | DATE 3-7-96 | INITIAL RJA JK

HAWAIIAN ELECTRIC CO., INC.
HONOLULU, HAWAII

APPENDIX A: TYPICAL DUCT ENTRANCE LOCATIONS
FIG. 7 - SINGLE COLUMN SIDE ENTRANCE MANHOLE

ORIGINAL 9/14/94
SPEC. NO. CS9401-2

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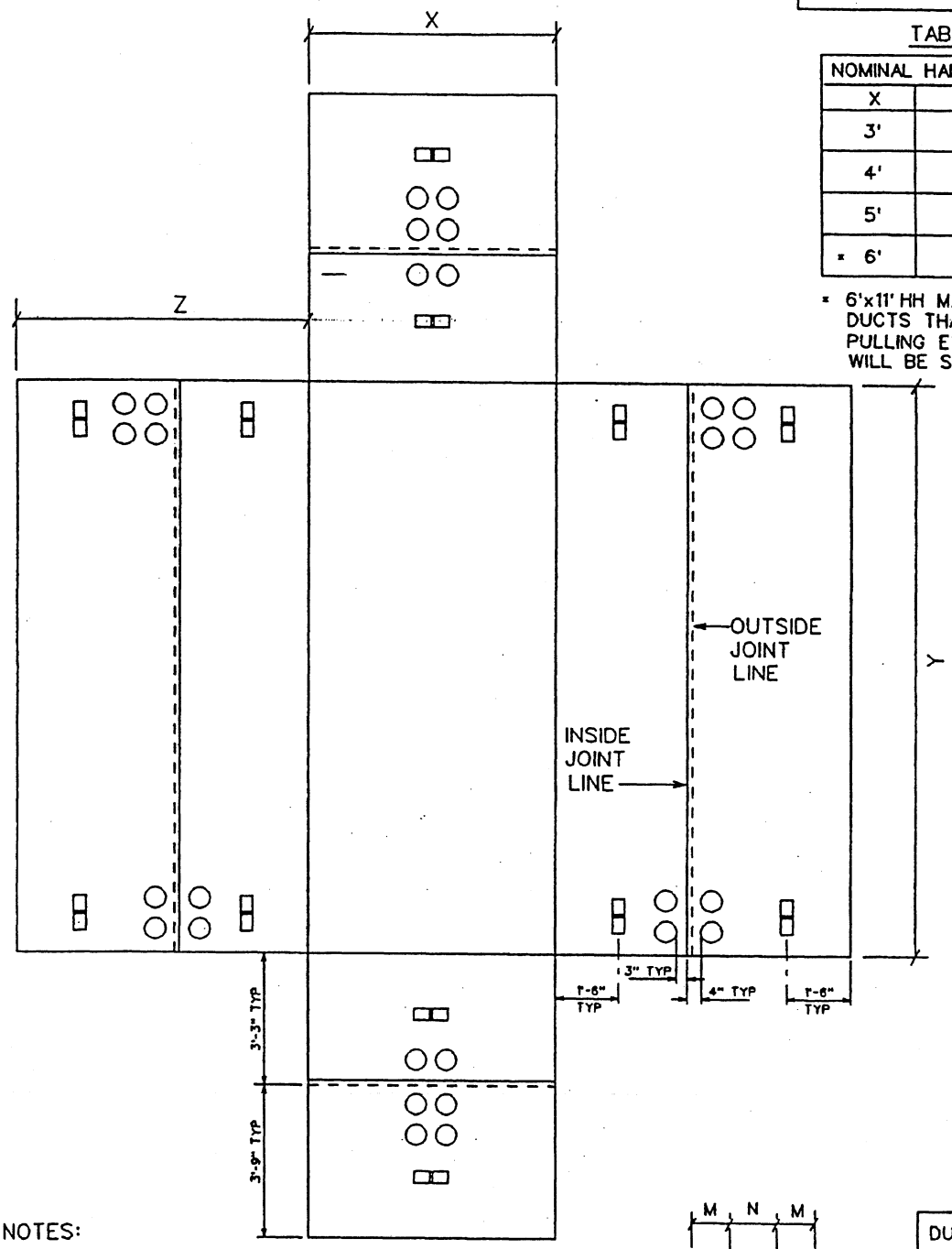

TABLE A

NOMINAL HANDHOLE SIZES		
X	Y	Z
3'	5'	2'-6"
4'	6'	4'-6"
5'	7'	5'-5"
* 6'	11'	7'-0"

* 6'x11' HH MAY HAVE MORE DUCTS THAN SHOWN & PULLING EYE LOCATIONS WILL BE SPECIFIED.

NOTES:

1. ACTUAL DUCT SIZES, NUMBER & LOCATIONS WILL BE SPECIFIED IN PROJECT DRAWINGS.
2. HANDHOLES ARE FOR USE IN AREAS NOT SUBJECT TO VEHICULAR TRAFFIC.
3. REFERENCE HECO DWG. 16688 SHTS 1 & 2 FOR MISCELLANEOUS HANDHOLE DETAILS, AS APPLICABLE.
4. BOXES SHALL BE ABLE TO ACCEPT FUTURE DUCTS IN ANY LOCATION ON THE WALLS AND IN THE CORNERS.
5. TYPICAL CONDUIT SPACING GIVEN IN TABLE B.
5. CONSTRUCTION JOINTS ARE SHOWN FOR HANDHOLES NOT CAST IN ONE PIECE.

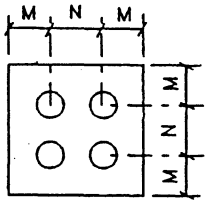

TABLE B

DUCT SIZE	DIMENSION	
	M	N
2"	4"	5"
3"	5"	6"
4"	5½"	7"
5"	6"	8"

GRAPHICAL SCALE

¼" = 1'-0"

FT. 0 1 2 3 4

IN. 3 9

APPROVED RI SE FK | DRAWN NS/CT | REVISION | DATE 3-7-96 | INITIAL JK

HAWAIIAN ELECTRIC CO., INC.
HONOLULU, HAWAII

APPENDIX A: TYPICAL HANDHOLE CONFIGURATION
FIG. 8 - CENTER ENTRANCE HANDHOLES

ORIGINAL 9/14/94

SPEC. NO. CS9401-2

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HAWAIIAN ELECTRIC CO., INC.

SPECIFICATION NO. CS7001-16

FOR

CONSTRUCTION OF UNDERGROUND FACILITIES

Prepared by Engineering Department

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Rev. 4 - 06/13/74
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Rev. 2 - 01/18/73
Rev. 1 - 06/02/72
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SECTION 1 - GENERAL SPECIFICATIONS

The Standard Specifications of General Conditions for Construction of Projects numbered CS-7202 and Standard Specifications for Construction of Electrical Facilities numbered CS7003 shall govern throughout the entire work, except for modifications described herein.

SECTION 2 - SCOPE OF WORK

The Contractor shall furnish all labor, materials, equipment and services necessary and reasonably incidental to complete construction of all underground facilities in accordance with the drawings and as specified herein.

SECTION 3 - TRENCH AND STRUCTURE EXCAVATION AND BACKFILL

3.1 Scope of Work

This work shall consist of excavating and backfilling for duct line trenches, vaults, manholes, handholes, service boxes, foundations and equipment pads to accurate alignment, grades and dimensions as shown on the drawings, as directed by the Engineer, and as specified herein. The work includes sheeting and bracing, dewatering, hauling, disposing of excavated materials and temporary trench patching.

3.2 Regulations

A. All excavation work on City and County streets and highways shall comply with the Revised Ordinances of Honolulu 1969, as amended, and sections of Standard Specifications for Public Works Construction dated May, 1975 relating to streets and sidewalks excavation; the special provisions; and with the requirements herein.

B. Work on Federal-Aid Highways and State Roads shall comply with the Revised Laws of Hawaii, with the standard specifications of the Department of Transportation, State of Hawaii, and all subsequent amendments thereto.

C. The Contractor shall obtain the necessary permits from the Department of Public Works and the Department of Transportation Services, City and County of Honolulu, before he begins work on City and County streets. He shall obtain the necessary permits from the State Department of Transportation for work on State and Federal-Aid Highways.

3.3 Backfill Materials

After the duct line, underground structure, foundation or pad is installed, inspected, and approved by the Engineer, the trench shall be backfilled with native material and/or imported materials as described herein below.

A. Trench for direct buried ducts and conduits.

(1) For the first lift from the bottom of the duct or conduit to 8 inches above the duct or conduit barrel, or for the cushion under the duct or conduit, either beach sand, earth, or a mixture of earth and gravel, passing a one-half inch sieve and containing not more than 20% by volume of rock particles.

(2) For the intermediate lift from 8 inches above the duct or conduit barrel to 2 feet below the existing or proposed finished grade, either borrow material conforming to requirements of the City and County or the State of Hawaii for "Borrow" or native material which does not contain more than 50% rock, hard lumps of earth of 6 inches in greatest dimension, rocks larger than 8 inches in their largest diameter, deleterious materials, adobe or other unsuitable materials.

(3) For the surface or top 2-foot lift, see Section 3.3-C below for material requirements.

B. Trench for encased buried ducts and conduits and excavation for underground structures, foundations and pads. Borrow or native material may be used in backfilling. The material shall meet the requirements as specified above under Section 3.3-A-(2).

C. For the surface or top 2-foot lift of all trenches and excavation for underground structures and foundations in streets and highways.

(1) Select material conforming to City and County or State of Hawaii requirements for Subbase Course.

(2) Aggregate material conforming to City and County or State of Hawaii requirements for "Aggregate Base Course", for the base course layer.

(3) Top soil for the top 6-inch layer in trenches across lawn or planting area.

(4) The finished surface shall match the original ground surface prior to trenching in material composition and in thickness. The finished product shall be equal to or better than the original.

D. Cold-mix asphalt concrete. Cold-mix asphalt concrete for temporary trench and underground structure excavation patches shall conform with the resurfacing mix requirements of the City and County or the State of Hawaii.

3.4 Construction Details

A. Excavation

(1) Trenches over existing improved streets, sidewalks, driveways and paved areas shall not be opened for more than 150 feet in advance of the duct or conduit laying unless specifically authorized by the Engineer. In other areas, the trenches shall not be opened for more than 200 feet. No jumping of excavation will be permitted.

(2) Trenches shall be excavated for a minimum distance of 30 feet ahead of duct concreting operations except at duct line terminations.

(3) Excavation for each manhole, vault, handhole or service box plus 30 feet of trenching for all ducts connected to these structures shall be completed before construction is started on these structures.

(4) All excavation shall be approved by the Engineer before any ducts or conduits are placed or any structures and foundations are constructed.

(5) All material excavated shall be piled adjacent to the trench or excavation for underground structure or foundation wherever possible and in such manner as will not obstruct movement of vehicular traffic and pedestrian walkways. Where it is not possible to do so, the Contractor shall haul and store the material at a convenient site approved by the Engineer. Access to existing driveways, fire hydrants and meters shall be provided at all times.

(6) When unsuitable material is encountered at the excavation, the Contractor shall be responsible for hauling and disposing of the material. The hauling shall be considered as incidental to the excavation work and no direct payment will be made. The Engineer shall determine if the excavated material is unsuitable.

B. Additional Excavation

(1) When the subgrade material below the established trench structure or foundation grade is unsuitable; such as muck, buried debris, or adobe, the Contractor shall excavate below grade to such depth and width as directed. The excavated area below grade shall be filled with approved aggregate in 6-inch compacted layers and brought up to within 3 inches of the grade of the bottom of direct buried ducts or conduits or up to the grade of the bottom of concrete encased ducts or conduits, structures or foundations.

(2) When water is encountered at the established grade for excavation for trenches or structures, the Contractor shall excavate to a depth 6 inches below required grade. This excavated area shall be filled with drainage fill consisting of a 4-inch bottom layer of No. 2B coarse rock (2-1/2" - 1-1/2") and a 2-inch top layer of No. 3B fine rock (3/4" - 3/8"). A drain pipe of 3-inch duct shall be installed in the bottom layer if directed by the Engineer.

C. Overexcavation

Any part of the trench of excavation for structures or foundations excavated below the established grade or beyond the maximum permitted width, other than work under "Additional Excavation," shall be refilled and compacted with select material by the Contractor at his own expense.

D. Sheeting

(1) Wherever necessary, the Contractor shall properly sheet and brace the open trench or structure excavation to render it safe and secure from possible slides, to protect existing improvements and properties, and shall remove same before completing the backfill. Sheeting of the trench shall be considered incidental to the construction and all costs thereof shall be included in the unit contract prices for the various bid items.

E. Dewatering

Trenches shall be kept free from water during the installation and backfilling of all ducts, conduits and structures. The Contractor may elect whatever method in dewatering the trench and shall be responsible for any damages to adjacent properties resulting from his dewatering operation. He shall be responsible to make his own arrangement for disposing of the water on or across public or private property. Dewatering procedures shall comply with all applicable Federal, State, and City and County ordinances and regulations concerning water pollution prior to its release into waterways or drainage systems.

F. Placing and Compacting of Backfill

(1) For direct buried ducts and conduits the first lift shall be backfilled by hand shoveling and tamping so that the backfill material is in contact with the entire periphery of the duct or conduit. Water saturation is not permitted.

(2) For the intermediate lift, the backfill material shall be placed in horizontal uniform layers and thoroughly compacted by mechanical tamping in conformance with requirements of the City and County or the State of Hawaii.

(3) The backfill around manholes and other structures or foundations shall be placed in horizontal layers not more than 6 inches in compacted thickness. Each layer shall be compacted to 95% of the material's maximum density.

(4) The surface 2-foot lift shall be placed and compacted in accordance with "Subbase Course," and "Aggregate Base Course" requirements of the City and County or the State of Hawaii.

(5) All compaction tests required by the Federal, State of Hawaii and City and County shall be arranged and paid for by the Contractor.

G. Temporary Trench Patching

(1) To accommodate traffic immediately after backfilling the trench and prior to constructing the permanent restoration, a temporary patch of cold-mix asphalt concrete shall be constructed over the compacted backfill. The cold-mix asphalt shall be compacted to a minimum thickness of 1-1/2 inches and shall be slightly humped not to exceed 3/8 inch for trench width less than 2 feet, and 3/4 inch for trench width greater than 2 feet.

(2) The Contractor shall maintain the temporary trench patches in good condition at all times until the permanent restoration is completed. Check holes and any depression greater than 1/2 inch shall be repaired immediately.

(3) Permanent restoration work shall be done in conformance with requirements of the City and County or the State of Hawaii.

3.5 Measurement

A. Trench excavation shall be considered as unclassified and shall be measured for payment by the cubic yard unless specified otherwise in the special provisions. The quantity shall be computed based on a trench width equal to the specified duct line width for the ducts or conduits installed and the actual depth measured from the established trench grade to the original ground, or to the finished grade, or to the subgrade of the proposed roadway whichever is less.

B. Trench backfill will not be measured and paid for directly, but shall be considered as incidental and included in the unit price bid for excavation.

C. The number of cubic yards of material to be paid for excavation and backfill for vaults, manholes, handholes, service boxes, foundations and equipment pads shall be considered as incidental and included in the unit price bid for the specific item.

D. The number of cubic yards of material to be paid for additional excavation and backfill shall be based on a trench width equal to the specified duct line width and depth and extent below the established trench grade as directed by the Engineer. Imported aggregate for backfilling below the established trench grade shall be measured for payment by the cubic yard.

E. Sheeting and bracing, dewatering, and disposing of excess excavated materials, temporary trench patching and other miscellaneous work shall not be measured and paid for directly but full compensation shall be considered as included in the unit bid price for trench excavation.

F. Computations for additional excavation and backfill for structures and foundations shall be based on horizontal limits one foot outside of the structures and the depth below established grade.

3.6 Payment

A. Payment for trench excavation and backfill as measured above will be made at the unit price bid per cubic yard and shall be full compensation for completing the excavation to the specified depth and backfilling the trench.

B. Payment for additional excavation below the established grade for trenches, structures and foundations will be made at the same unit bid price for trench excavation above the trench grade and shall be full compensation for hauling and disposing of the unsuitable material. Payment for imported aggregate will be made at the unit bid price per cubic yard. For projects which do not include a unit price for trench excavation, payment for additional excavation for structures and foundations will be made at a negotiated price.

C. Payment for drainage fill will be made at the unit price bid per cubic yard. Payment for 3" duct drain pipe will be made at a price agreed on by the Contractor and the Engineer.

SECTION 4 - CONDUIT-GENERAL

4.1 The Contractor shall furnish and install all conduit, fittings (i.e., couplings, adapters, end bells, etc.), spacers, tie wire, reinforcing steel and plastic cement (if plastic conduit is used). All material shall be new and manufactured in the United States of America.

4.2 The approved conduit materials for use in Company duct system are listed in Section 4.4.

A. The Contractor shall inform the Engineer in his bid which type of conduit is to be used.

4.3 Specifications

The selected material shall meet the requirements of the Company Purchase Specification indicated. (Copies of Company Purchase Specifications may be obtained from Purchasing Division; Hawaiian Electric Co., Inc., P. O. Box 2750, Honolulu, Hawaii 96840.) Installation of the selected conduit shall be in accordance with the Construction Specifications referred to in the tables.

4.4 Approved Conduit Materials

Approved Conduit Materials	Purchase Specification No.	Section No, This Specification & Drawings
EB (Encased Burial) 1. PVC Plastic Schedule 40	M7001	Section 5 Dwg. No. 30-1035
DB (Direct Burial) 1. PVC Plastic Schedule 40		Section 5 Dwg. No. 30-1035

SECTION 5 - PLASTIC CONDUIT (PVC)

5.1 This section of the Construction Specification applies only to plastic conduit, PVC (Polyvinyl Chloride). Refer to Company Drawing No. 30-1030 & 30-1035 for installation details and to Company Drawing No. 30-1035 for dimensions of plastic conduit accessories.

5.2 The accessories shall be of the same type and material as the conduit selected.

5.3 A twenty (20) foot length of conduit, with coupling attached on one end is recommended.

5.4 Plastic Conduit Storage and Transportation

A. Cover conduit that is to be stored for more than 2 weeks.

B. Provide support for the full length of the conduit when transporting or storing long lengths. Do not permit unsupported overhang.

5.5 Plastic Conduit Installation

A. A fine tooth wood saw may be used to cut the conduit. Make a square cut and remove all burrs.

B. Wipe all foreign matter off the sockets of the fittings and the edges of the conduit with a clean cloth.

5.6 Plastic Conduit Solvent-Cemented Joints

A. The PVC cement should be obtained from the conduit manufacturer. A clean paper paint pot is convenient for containing the cement during use. Thinners are not recommended.

B. Apply a liberal and uniform coat of cement to the conduit for a length equal to the depth of the socket. Also apply sufficient cement to wet the socket of the fitting. Avoid excess cement on the fitting as it is wiped into the joint and tends to weaken the pipe. Do not use plastic bristle brushes. The brush size should be about equal to joint depth, for example, a 2-inch brush for a 4-inch conduit.

C. Slip conduit into the socket of the fitting with a slight twist until it bottoms. Hold the joint for 15 seconds so the conduit does not push out of the fitting. Do not twist or drive the pipe after the insertion is complete.

D. Cure the joined members for at least 5 minutes before disturbing or applying stress to the joint. After this initial cure, care must be exercised in handling to prevent twisting or pulling the joint. In damp weather, increase this interval to allow for slower evaporation of the solvent. Where possible, assemble all conduit above ground and allow it to lay undisturbed while curing before lowering it into the ditch.

E. Wipe off the excess cement left on the outer shoulder of the fitting.

F. Another fitting or section of conduit may be added to the opposite end within 2 or 3 minutes if care is exercised in handling so that strain is not placed on the previous assembly.

G. After covering the joint surfaces, return the brush to the cement pot. When stopping work, place the brush in a solvent; pour unused cement back in the can and cover tightly. When reusing the brush, shake the excess solvent out before dipping it into the cement. The cement brush can be cleaned with a wire brush.

H. Assemble above ground any joint included in a section of conduit to be bent in the ditch, and allow it to lay undisturbed for at least 2 hours before installation. In cases where a plastic connection is made with the union under stress, due to misalignment or other factors, stake it out to relieve stress on the joint until the conduit is backfilled or encased.

I. Do not expose the conduit in an open trench longer than is absolutely necessary to minimize accidental mechanical damage.

5.7 Plastic Conduit Temperature

A. Expose all plastic conduit and fittings to the same temperature conditions for a reasonable length of time before assembly.

B. Precautions - Due to expansion and contraction of the plastic conduit of 1-1/2 inches per 100 feet for every 20°F change in the temperature, allow extra conduit footage at each tie-in for contraction when the conduit temperature is higher than that of the earth; or extra room for expansion if the converse condition exists.

5.8 Plastic Conduit Spacers - Refer to Drawing No. 30-1035

A. Spacers used for plastic conduit shall have the dimension shown on Company Drawing No. 30-1035, or be an equivalent approved by the Engineer.

B. Spacers for plastic conduit shall be placed along the length of the conduit as follows:

Conduit Size	Maximum Spacing
Up to 3 inches	8 feet
4 inches and greater	6 feet

C. Spacers must be 15 inches or more away from any coupling or joint. When conduit is assembled above the ground, the spacer may be supported in a vertical position by use of a #4 rebar and smooth black steel wire No. 14 gauge.

D. Spacers should not be located at the centers of a long radius bend: (1) On prefabricated bends, locate the spacer in the tangent, free of the coupling, (2) On trench formed bend, locate the spacer midway between the tangent and center of the bend.

5.9 Plastic Conduit Termination

A. Use ANSI/ASTM F512 as the specification for the terminations below. End bells shall be used to terminate all conduits ending in an underground structure (i.e., manhole, vault, handhole, or service box).

B. The terminated ends of the conduit in an underground structure must be free of support for a distance of at least 10 feet from the structure. The conduit will be aligned and supported inside the structure with proper spacing and will be cut to length after the concrete envelope has cured.

C. The ends of the conduit shall be sealed with a plastic cap, plug, or approved substitute at the end of each day's work, when work on duct installation has to be interrupted, where ducts may be submerged in water, and in stub outs.

SECTION 6 – BLANK

SECTION 7 - DRAINAGE

7.1 Whenever possible all conduits shall be installed with no "pockets" in the conduit run by maintaining a uniform grade of at least 0.25% for drainage towards manhole, vault, handhole, or service box.

7.2 All work must be done in the dry. If water is encountered during construction, provide drainage as shown on drawings.

SECTION 8 - STEEL CONDUITS

The Contractor shall furnish and install conduit runs and bends for risers. Conduits shall conform to Fed. Specs. No. WWC-581-d galvanized rigid steel conduit or approved equal. Place concrete envelope around all conduit runs and riser bends. Steel conduit shall either be included in the bid price of the appropriate duct line or shall be paid for under a separate bid price.

SECTION 9 - CONCRETE AND REINFORCING STEEL

9.1 Description

This section shall apply to concrete and reinforcing steel for use in duct lines and the various types of concrete structures and concrete pavements, and to cement mortar. The furnishing, transporting and placing the reinforcing steel and concrete; and curing and finishing the concrete duct lines and structures shall conform to the requirements specified herein.

9.2 Materials

A. Portland Cement. Cement for all classes of concrete shall conform to the requirements under ASTM Designation C150.

B. Aggregates

(1) Aggregates shall conform to the specifications of ASTM Designations C33 for use in concrete and C144 for use in masonry mortar.

(2) The maximum aggregate size for use in concrete for duct lines shall be 3/4 inch and in concrete for structures shall be 1-1/4 inches.

(3) Fine Aggregate. Fine aggregate shall be clean, hard, dense, free of foreign matter and shall consist of beach sand, manufactured fines, or a combination thereof.

(4) Coarse Aggregate. Coarse aggregate shall consist of crushed stone or gravel manufactured from clean, hard, tough, dense, durable lava rock, free from adherent coatings.

C. Water. Water shall be clear and free from injurious amount of oil, acid, salt, alkali, organic matter, or other deleterious substances.

D. Admixture. Except for encased buried duct lines, no admixture of any kind shall be used without the written consent of the Engineer.

E. Reinforcing Steel. All reinforcing steel shall be round deformed bars and shall meet the requirements for ASTM Designation A615, Grade 40.

F. Wire Mesh Reinforcing. Wire mesh shall meet the requirements for ASTM Designation A185.

9.3 Concrete Strength and Quality

A. Unless specified otherwise on the plans, all concrete shall meet the following requirements:

(1) For all **poured in place** structures: Minimum strength of 3,000 pounds per square inch at 28 days; maximum slump 4 inches; maximum aggregate size 1-1/4 inches.

(2) For all encased duct lines: Minimum strength of 2,500 pounds per square inch at 28 days; slump, min. 6", max. 7"; maximum aggregate size 3/4 inch; approved admixture shall be added to maintain minimum strength required.

9.4 Cement Mortar

Cement mortar shall be composed of Portland cement, fine aggregate, and water proportioned and mixed for the particular use intended. The proportion varies from equal volume of cement to fine aggregate to one part cement to three parts fine aggregate.

9.5 Mixing and Placing

A. Ready-Mixed Concrete. Ready-mixed concrete shall be used and the mixing, transporting, placing, and the quality shall meet the requirements as specified under ASTM Designation C94.

B. Placing Concrete

(1) The Engineer or Inspector shall be notified 24 hours before placing any concrete. Concrete shall be placed only in the presence of the Engineer or Inspector.

(2) Concrete shall be batched only in such quantities as are required for immediate use and placement. Any concrete having initial set before placing and finishing shall be discarded and shall not be used for the work. No remixing with water or with other materials will be permitted once the initial set has taken place.

(3) Concrete shall be placed as nearly as possible in its final position so as to avoid segregation of the materials and displacement of ducts, spreaders, inserts and reinforcement. The placement shall be completed within 30 minutes after water is first added to the mix. However, when the concrete is continually agitated, the time may be extended to 1 1/2 hours. Retempering will not be permitted after the concrete has stiffened.

(4) Concrete shall be placed on clean, damp surfaces, free from water, and in horizontal layers not exceeding 18 inches in thickness.

(5) Concrete shall not be dropped a distance of more than 5 feet unless approved in writing by the Engineer.

C. Compaction

(1) All concrete shall be thoroughly compacted during and immediately after placing to secure dense, water tight concrete.

(2) High frequency internal vibrators, sufficient in number, shall be used for all concrete used for structures. Approved spading tools shall be used wherever the use of a vibrator is not practicable or suitable.

(3) Unless otherwise authorized, all duct line concrete shall be compacted by use of hand spades. The spade shall be inserted into the fresh concrete to the level of the bottom ducts, on both sides of each row of ducts and at intervals not greater than 9 inches along the ducts.

D. Surface Finishes

(1) All concrete surfaces shall be smooth and free from defects. Metal ties, where used, shall be removed and the resulting holes filled with mortar. Surface finish requirements shall be as follows:

(a) Tops of encased duct lines and manholes and handholes over which backfill is to be placed - wood floated.

(b) Tops of vaults, manholes and handholes at sidewalk grade - edged and finished to match sidewalk.

(c) Tops of foundations and equipment pads - edged and steel troweled.

(d) Floors of vaults, manholes and handholes - steel troweled.

(e) Interior wall surfaces and ceilings of vaults, manholes and handholes - cement washed.

E. Curing

(1) Curing operations shall be started as soon as the concrete has attained initial set. The method and length of curing shall be approved by the Engineer.

(2) Concrete for encased duct lines shall be cured for 72 hours before motor traffic is allowed to pass over it.

9.6 Reinforcing

Steel reinforcing shall be thoroughly cleaned of any loose mill scale, mortar, oil dirt or coatings of any character. All details for bending, placing, fastening and splicing of steel reinforcing shall be in accordance with the American Concrete Institute Building Code (ACI 318, latest edition).

9.7 Forms

The finished forms shall be true to the required dimensions and grades, with smooth surfaces, mortar tight joints, and of sufficient strength to resist springing out of shape during the placing of concrete. The inside surfaces shall be thoroughly coated with commercial quality form oil. Forms may be of wood, metal, or any other material and shall be free of defects. All exposed surfaces shall be formed with new plywood or with metal.

9.8 Measurement

A. All concrete placed, finished, and cured shall be measured for payment as specified in the various items of work requiring concrete or as provided for in the proposal.

B. When unit volume is specified, it shall be measured in cubic yards and shall be computed based on the dimensions of the concrete structures as shown on the plans.

C. Reinforcing steel, forms and cement mortar shall not be measured and paid for separately, but shall be included in the bid prices of the various appropriate items of work.

9.9 Payment

Payment for Portland cement concrete as measured above or as provided for in the proposal, shall be full compensation for furnishing the necessary equipment, labor, and materials to complete the concrete structure in place and cured.

SECTION 10 - MISCELLANEOUS METALS

10.1 The Contractor shall furnish, fabricate and install all miscellaneous metals such as pulling irons, pulling eye inserts, handhole cover frames, flat bars, curbs, etc., unless otherwise noted on the drawings. All miscellaneous steel work shall be galvanized after fabrication. Galvanized work shall conform to ASTM Specifications A123 and A153.

10.2 Miscellaneous metal shall not be measured and paid for separately, but shall be included in the bid prices of the various appropriate items of work.

SECTION 11 - DUCT LINE INSPECTION

11.1 All duct line installation work shall be subject to the supervision and approval of the Engineer.

11.2 Duct installation shall commence only after trench is inspected and approved by the Engineer.

11.3 The completed duct lines shall be cleaned and field tested and pulling lines and plugs installed before final acceptance. The Contractor shall notify the Company Supervising Contract Engineer of the Inspection Division, Distribution Department a minimum of 48 hours before starting this work. An inspector of the Company shall be present at all times until the cleaning, and testing are completed and pulling lines and plugs are installed to his satisfaction.

11.4 The Contractor shall use a rodding machine consisting of a compressor or vacuum unit with a parachute or ball 1/2" less in size than the inside diameter of the duct and attached to a pulling line. The parachute or ball is then forced through the duct with air. By use of the pulling line a heavier cord then will be pulled through the duct to be used for cleaning and testing. Instead of using the rodding machine, fishing wire may be fed through the duct.

11.5 The wire brush for cleaning the duct shall be a standard duct wire brush and the diameter shall be the same as the inside diameter of ducts to be cleaned.

11.6 The Contractor shall pass a bullet-shaped wooden test mandrel through the entire length of each duct run of the duct line to test for freedom of burrs and obstructions. (Drawing 30-1030 Sheet 2 of 2)

The test mandrel shall be made of hardwood, 14 inches long with a diameter 1/2 inch less than the inside diameter of the duct.

11.7 The wire brush and wooden mandrel may be used together to clean and test the duct lines. A backup cord attached to the wooden mandrel shall be used for withdrawal in case it cannot pass through the duct line.

11.8 Scarring found on mandrel deeper than 1/32 inch, other than that caused by normal abrasion between the duct line and bottom of the mandrel shall be taken to indicate that burrs and/or obstructions are present in the duct run. The Contractor shall remove such burrs and/or obstructions after which the test mandrel is passed through again. The process will be repeated until a satisfactory result is obtained.

11.9 After completion of cleaning and testing of the duct line, the Contractor shall install in each duct run **"mule" tape rated at #1800 tensile strength with 1 foot interval markings (LH Dottie DWP 3001)** or equal and plug both ends of each duct with plastic plugs.

SECTION 12 - BLANK

SECTION 13 - DUCT LINES

13.1 Measurement

The lengths of duct lines measured for payment shall be the actual number of lineal feet of duct lines for a single duct and/or combination of ducts, including the concrete for encased buried ducts or without the concrete encasement for direct buried ducts, installed in place, as determined by field measurement.

13.2 Payment

Payment for duct lines as measured above will be made at the respective unit prices per lineal foot for a single duct or combination of ducts and shall be full compensation for all duct lines in place complete.

SECTION 14 - RESTORING SIDEWALKS, DRIVEWAYS AND PAVEMENT

14.1 Measurement

Restoration shall be measured on the basis of the width of trenches for ductline excavation as specified in the "Construction Standards".

It is understood that such additional replacement of pavements, driveways, and sidewalks as may be required because of shoring or bracing, undermining, settlements, and overexcavating will not be included in the measurement for replacing of the above mentioned items and such replacements shall be the Contractor's responsibility. Also any additional replacement as required by City/State Ordinances or as directed by City/State inspectors shall not be included in the measurement for restoration. Contractor shall provide for such allowances in his unit prices.

The measurement for driveway restoration shall be included in the measurement for sidewalk restoration and shall not be measured separately.

14.2 Payment

Payment for restoration work will be made at the unit price bid per square foot as measured above for each item except for driveways. Payment for driveways shall be made on the same basis as restoration for sidewalks.

SECTION 15 - RESTORING CURBS AND GUTTERS

15.1 Restoration of curbs and gutters removed for trench excavation shall be considered incidental to ductline excavation and will paid for by the Company.

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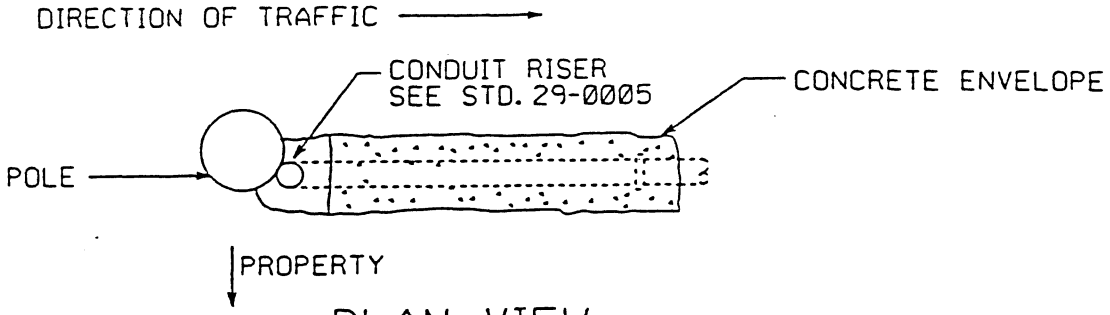
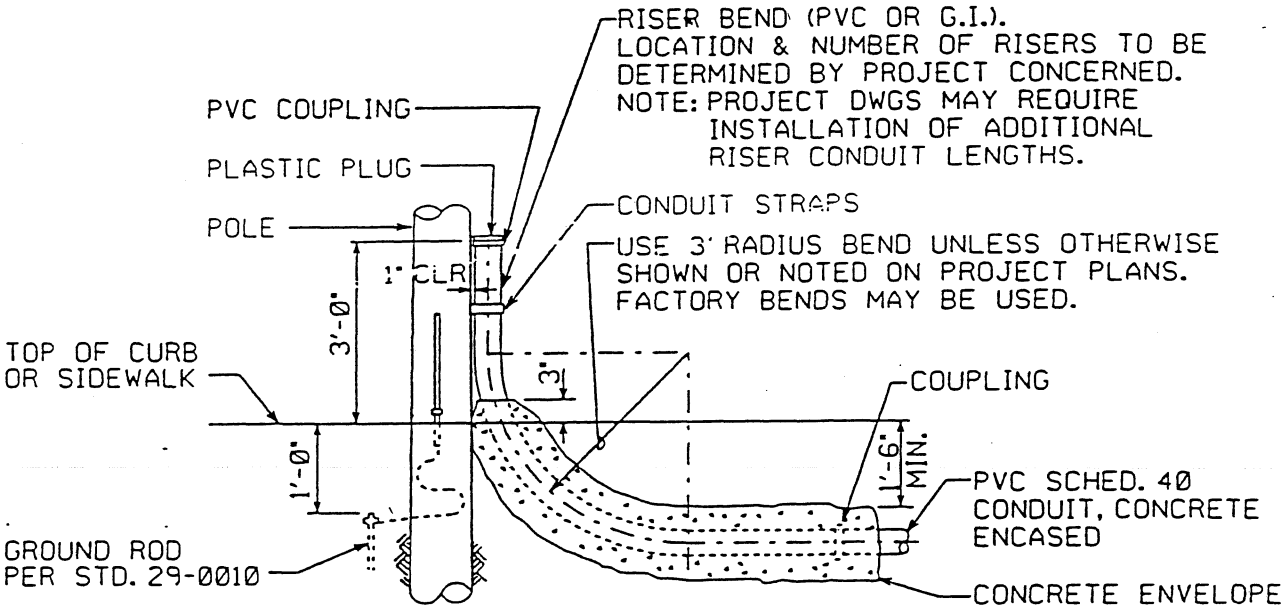
SCOPE:

THIS STANDARD PROVIDES DETAILS FOR CONSTRUCTION OF UNDERGROUND DUCTLINES UNDER SPECIAL CONDITIONS/CIRCUMSTANCES. REFER TO STD. 30-1035 FOR DETAILS FOR CONSTRUCTION OF UNDERGROUND DUCTLINES UNDER ROUTINE/TYPICAL CONDITIONS. REFER TO HECO ENGINEERING FOR CONDITIONS NOT COVERED ON THIS OR STD. 30-1035.



PLAN VIEW



ELEVATION

REFER TO STDS. 29-0005 AND 29-0010 FOR ADDITIONAL DETAILS

TYPICAL RISER DETAIL (POLE RISER SHOWN)

NOT TO SCALE

REVISION	DATE	INITIAL
	6-5-74	RM TN
	10-24-86	RM
	9/94	RM FK
	10/31/99	CT DII FK
	06-21	CT

DRAWN CT	DESIGNED	APPD ST JAR TN VEC	REDRAWN 10/31/99
SUPERSEDES 18585 & 20191		PLASTIC DUCTS SPECIAL INSTALLATION DETAILS UNDERGROUND DETAILS	ORIGINAL 6/13/72
ENGINEERING STANDARD HAWAIIAN ELECTRIC CO. INC.			30-1030 REV 5
			SHEET 1 OF 5

Spec CS7001.16

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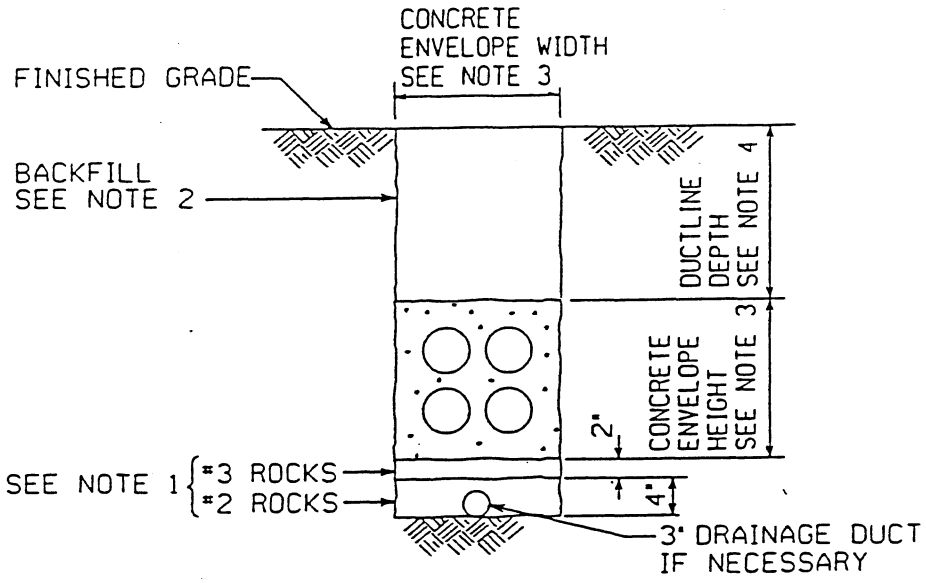

CONCRETE ENCASED DUCTS
EXCAVATION & BACKFILL DETAILS
AREAS REQUIRING DRAINAGE

NOT TO SCALE

NOTES:

1. IF DRAINAGE IS NECESSARY, INSTALL 6" ROCKFILL AS SHOWN. IN EXTREMELY WATERY AREAS, INSTALL 3" DRAINAGE DUCT.
2. REFER TO HECO SPECIFICATION CS7001, LATEST REVISION (OR EQUIVALENT) FOR BACKFILL MATERIAL REQUIREMENTS.
3. SIZE OF CONCRETE ENVELOPE (HEIGHT AND WIDTH) TO BE DETERMINED BY SPECIFIC PROJECT REQUIREMENTS. SEE PROJECT DRAWINGS AND SPECIFICATIONS.
4. DEPTH FROM FINISHED GRADE TO TOP OF CONCRETE ENVELOPE TO BE 1'-6" MINIMUM UNLESS OTHERWISE NOTED ON PROJECT DRAWINGS.
5. REFER TO STDS. 30-1005 AND 30-1035 FOR ADDITIONAL INFORMATION.

DATE	9/94	8/96	10/31/99	06-01
INITIAL	RM FK	KJA PAC FK	CT DH FK	CT

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DRAWN TH II	DESIGNED	APPD TN VEC	REDRAWN MARCH 1998
SUPERSEDES 18585 & 20191	PLASTIC DUCTS SPECIAL INSTALLATION DETAILS UNDERGROUND DETAILS		ORIGINAL 6/13/72
ENGINEERING STANDARD HAWAIIAN ELECTRIC CO. INC.		30-1030	REV 3
		SHEET 2 OF 5	

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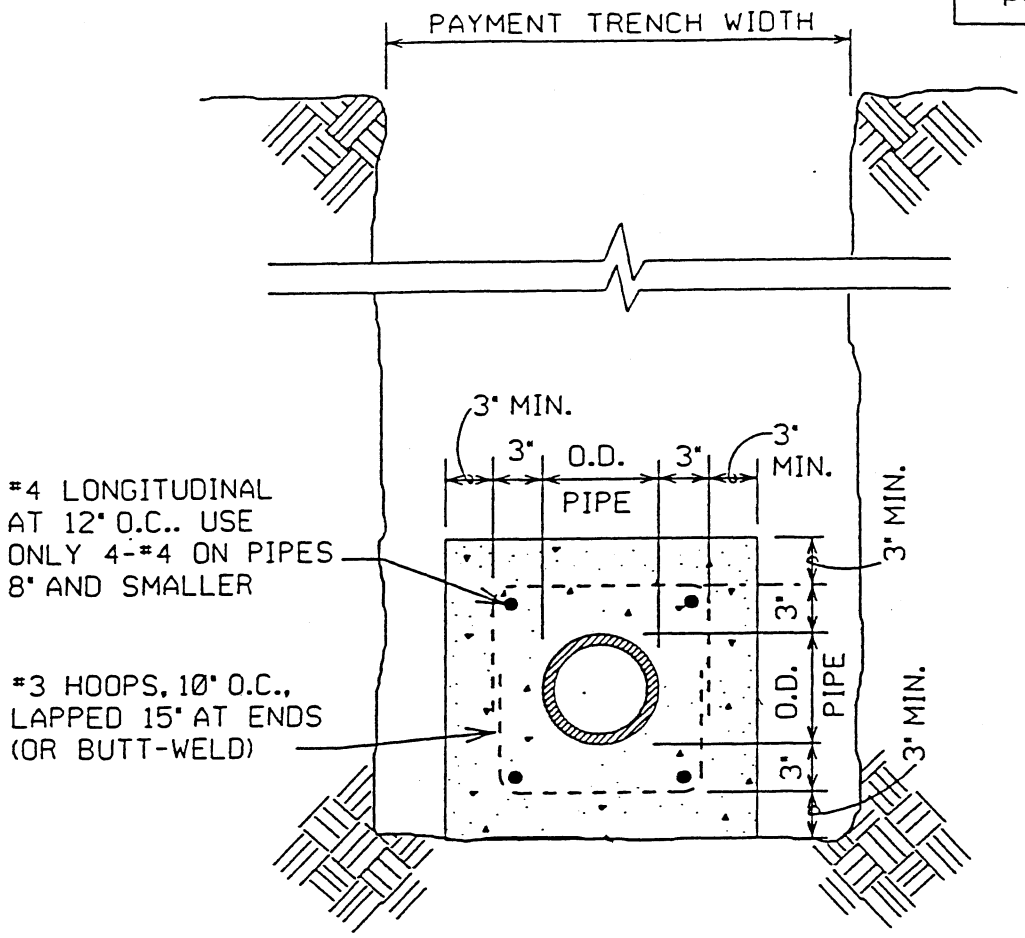


DETAIL OF CONCRETE JACKET FOR PIPES 12" & SMALLER

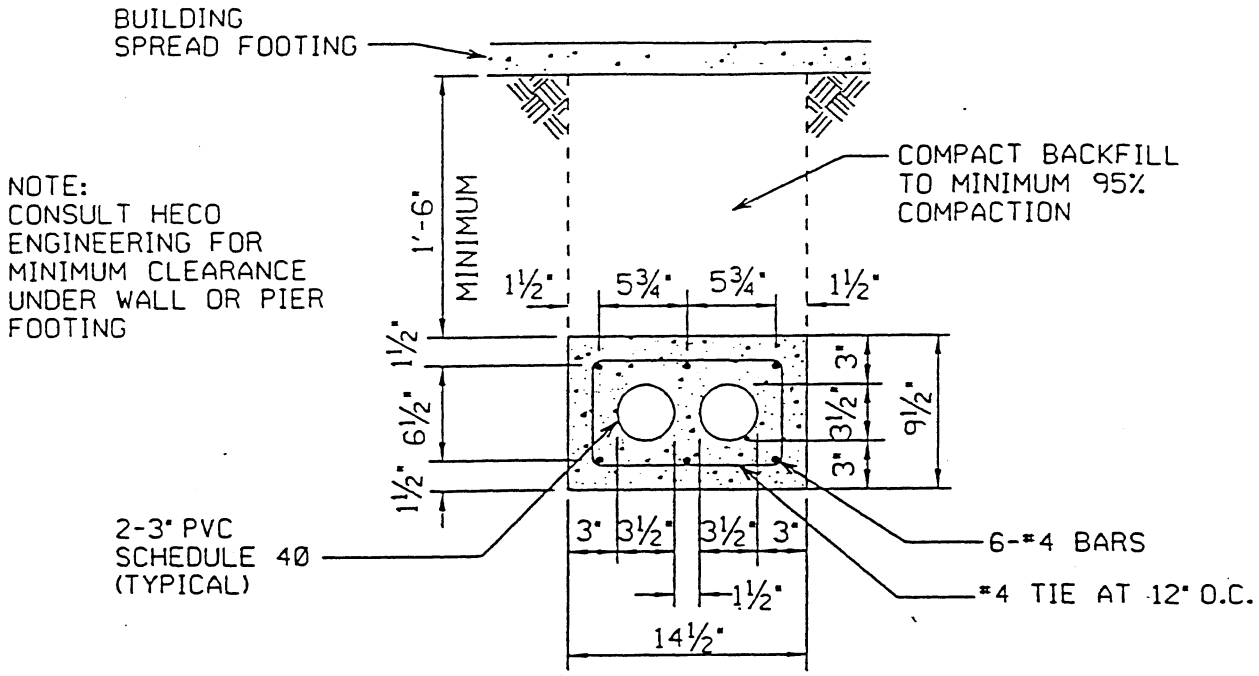
NOT TO SCALE

NOTES:

1. SEWER LINES WHICH CROSS OVER OR UNDER OTHER CONDUITS AND UTILITIES MAY REQUIRE PROTECTION FROM EXTRA LOADING.
2. WHEN THE SEWER CROSSES A CONDUIT AND THE CLEARANCE IS LESS THAN 12 INCHES, THE SEWER LINE SHOULD BE JACKETED WITH REINFORCED CONCRETE FOR A DISTANCE OF 5 FEET (INSIDE DIAMETER PLUS 5 FEET IF THE CONDUIT IS OVER 24 INCHES INSIDE DIAMETER).
3. WHERE THE CLEARANCE IS GREATER THAN 12 INCHES BUT LESS THAN 24 INCHES, A PLAIN CONCRETE JACKET MAY BE USED.
4. REFERENCE THE ABOVE DETAIL FOR PIPES LESS THAN OR EQUAL TO 12 INCHES INSIDE DIAMETER. SEE HECO STRUCTURAL DIVISION FOR PIPE DIAMETERS LARGER THAN 12 INCHES.
5. FINAL DETERMINATION OF THE STRUCTURAL REQUIREMENTS WILL BE MADE BY THE CITY

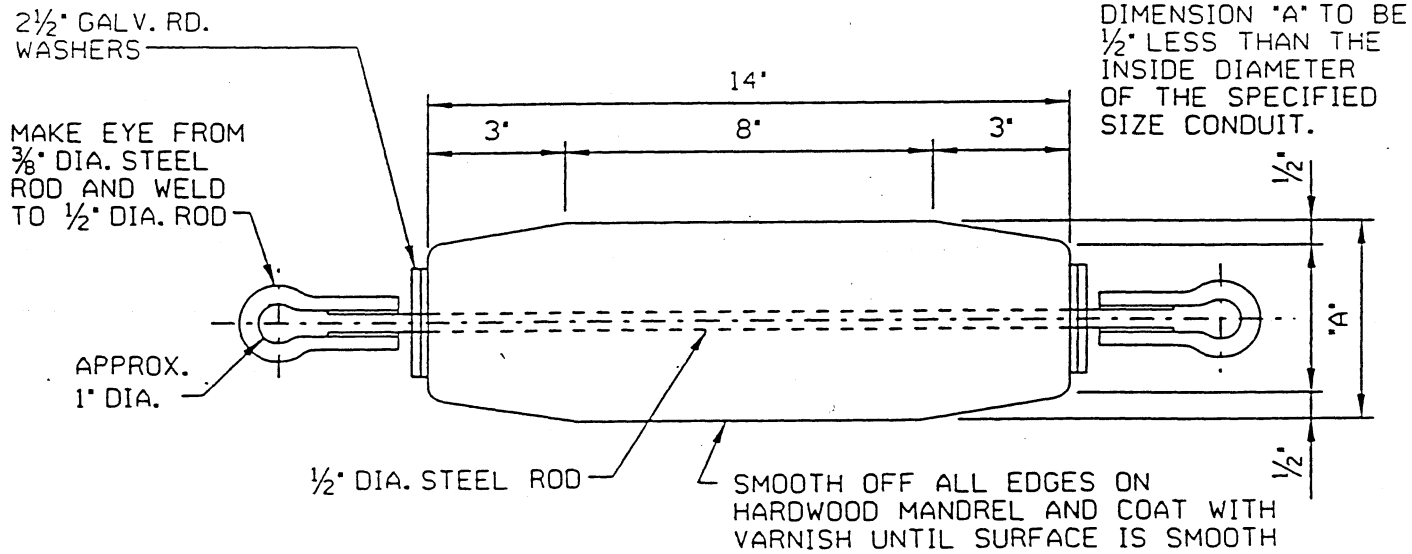
REVISION	DATE	INITIAL

DRAWN TH II DESIGNED FK	APPD	REDRAWN
SUPERSEDES	PLASTIC DUCTS SPECIAL INSTALLATION DETAILS UNDERGROUND DETAILS	ORIGINAL 06-01 30-1030 REV 0 SHEET 3 OF 5
ENGINEERING STANDARD HAWAIIAN ELECTRIC CO. INC.		



CONCRETE ENCASED DUCTS UNDER BUILDINGS

NOT TO SCALE



NOTE: OTHER MODELS OF MANDRELS MAY BE USED IF APPROVED BY ENGINEERING.

MANDREL DETAIL

NOT TO SCALE

DRAWN TH II DESIGNED FK	APPD		REDRAWN
SUPERSEDES	PLASTIC DUCTS SPECIAL INSTALLATION DETAILS UNDERGROUND DETAILS		ORIGINAL 06-01
			30-1030 REV 0
ENGINEERING STANDARD HAWAIIAN ELECTRIC CO. INC.			SHEET 4 OF 5

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References:

Standard:

29-0005	Riser Conduit Location at Base of Pole
29-0010	Grounding Requirements Wood Pole Construction
30-1005	Conduit Application Guide
30-1006	Duct Line Applications
30-1010	Typical Backfill Details
30-1015	Typical Duct Encasement Details
30-1020	Duct Roll Sections
30-1035	Plastic Ducts, Installation Details

Specifications:

M7001	Plastic Conduits & Fittings Constructed With PVC Plastic
CS 7202	General Conditions
CS 7001	Construction of UG Facilities
CS 7003	Construction of Electrical Facilities

SCOPE:

This standard provides the details for the construction of HECO's ductlines under typical conditions. Detailed information on many of the approved materials as well as detailed information for both concrete-encased and direct buried conduit installations are shown. See Std. 30-1030 for details on construction of ductlines under special conditions.

GENERAL:

1. PVC Schedule 40 and Schedule 80 conduits shall be used for HECO ductlines. The conduits are to conform to NEMA TC-2, latest revision, and HECO Specification M7001, latest revision. Accessories are to conform to NEMA TC-3, latest revision, and HECO Specification M7001.

2. Refer to Std. 30-1005 Conduit Application Guide for information on the type of conduit to use for various types of installations.

3. Refer to Std. 30-1030 Plastic Ducts, Special Installation Details for conditions not covered by this standard. In addition, for other conditions not covered by either this standard or Std. 30-1030, consult with HECO Engineering.

4. All ductline construction must conform to HECO Specification CS7001, latest revision.

5. All conduit installation must be inspected and approved by a qualified Company inspector before any concrete placement and/or trench backfilling. The contractor shall be responsible for arranging the inspection sufficiently ahead of schedule to enable the Company inspector to be present.

6. Each conduit is to be wire brush cleaned per Specification CS7001. In addition, each conduit must pass a mandrel per Specification CS7001 and as detailed in Std. 30-1030.

7. After cleaning and testing, the contractor is to place a MuleTape Pull Line in each conduit, as directed by the Company inspector. Both ends of each conduit shall be plugged with plastic plugs.

REVISION	DATE	INITIAL
	1-17-73	RM TN ST
	6-5-74	RM TN
	10-29-74	RM TN
	10-5-79	RM TN
	10-24-86	RM TN
	9-94	RM
	10-31-99	CT DH FK
	06-21	CT JKR

DRAWN CT DESIGNED	APPD ST JAR TN VEC	REDRAWN 10-31-99
SUPERSEDES	PLASTIC DUCTS INSTALLATION DETAILS UNDERGROUND STRUCTURES	ORIGINAL 6-13-72
ENGINEERING STANDARD HAWAIIAN ELECTRIC CO. INC.		30-1035 REV 8
		SHEET 1 of 11

ISION	DATE	1-17-73	9-11-74	6-5-74	2-24-76	2-12-79	10-31-99	06-01				
	INITIAL	RM TN ST	RM TN	RM TN	RM TN	RY ST	CT DH FK	CT SK				

SUPERSEDES

DRAWN CT | DESIGNED FK | APPD ST | JAR TN | VEC

ENGINEERING STANDARD
HAWAIIAN ELECTRIC CO. INC.

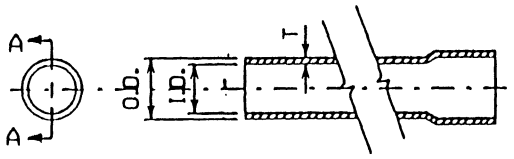
PLASTIC DUCTS
INSTALLATION DETAILS
UNDERGROUND STRUCTURES

Spec CS7001.16

PLASTIC CONDUIT (NEMA TC-2)

USE: SCHEDULE 40 = CONCRETE ENCASED INSTALLATIONS
SCHEDULE 80 = CONCRETE ENCASED AND SELECTED DIRECT BURIED INSTALLATIONS

NOTE: CONDUIT MUST CONFORM TO NEMA TC-2 AND ASTM D-1785



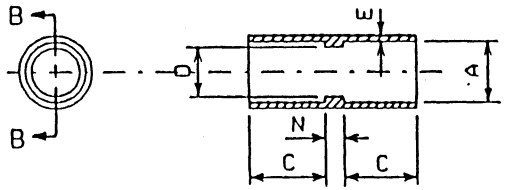
SECTION A-A

NOMINAL CONDUIT SIZE (IN.)	SCHEDULE 40				SCHEDULE 80			
	HECO STOCK NO./PART NO.	OUTER DIAMETER AVERAGE (IN.)	INNER DIAMETER MINIMUM (IN.)	WALL THICKNESS MINIMUM (IN.)	HECO STOCK NO.	OUTER DIAMETER AVERAGE (IN.)	INNER DIAMETER MINIMUM (IN.)	WALL THICKNESS MINIMUM (IN.)
2	000198574	2.375	2.021	0.154	000140570	2.375	1.881	0.218
3	000129262/29532	3.500	3.008	0.216	000157854	3.500	2.820	0.300
4	000129288/29534	4.500	3.961	0.237	000145744	4.500	3.737	0.377
5	000129304/29536	5.563	4.975	0.258	000145433	5.563	4.713	0.375
6	000129320/29538	6.625	5.986	0.280	000143087	6.625	5.646	0.432

CONDUIT COUPLING (NEMA TC-3)

USE: A FITTING FOR JOINING TWO LENGTHS OF RIGID PVC CONDUIT, OR A LENGTH OF RIGID PVC CONDUIT TO A RIGID PVC ELBOW OR OTHER BEND

NOTE: COUPLING MUST CONFORM TO NEMA TC-3



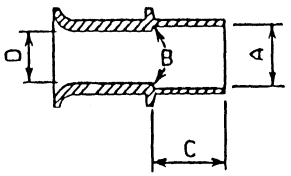
SECTION B-B

NOMINAL CONDUIT SIZE (IN.)	HECO STOCK NO.	A SOCKET ENTRANCE DIAMETER AVERAGE (IN.)	C SOCKET LENGTH MINIMUM (IN.)	D COUPLING INSIDE DIAMETER MINIMUM (IN.)	E WALL THICKNESS MINIMUM (IN.)	N BARRIER THICKNESS MINIMUM (IN.)
2	000140570	2.393	1.125	2.079	0.130	0.094
3	000100451	3.515	1.594	3.083	0.216	0.188
4	000140075	4.515	1.750	4.076	0.237	0.188
5	000140490	5.593	1.937	5.097	0.258	0.188
6	000148755	6.658	2.125	6.115	0.280	0.250

BELL END (NEMA TC-3)

USE: A FITTING INTENDED TO PROVIDE A BUSHED OPENING AT THE OPEN END OF A LENGTH OF RIGID PVC CONDUIT

NOTE: BELL END MUST CONFORM TO NEMA TC-3



NOMINAL CONDUIT SIZE (IN.)	HECO STOCK NO.	A SOCKET ENTRANCE DIAMETER AVERAGE (IN.)	B SOCKET BOTTOM INNER DIAMETER AVERAGE (IN.)	C SOCKET LENGTH MINIMUM (IN.)	D END BELL INNER DIAMETER MINIMUM (IN.)
2	000140590	2.393	2.369	1.125	2.079
3	000140704	3.515	3.492	1.594	3.083
4	000143593	4.515	4.491	1.750	4.076
5	000143057	5.593	5.553	1.937	5.097
6	000148075	6.658	6.614	2.125	6.115

GENERAL NOTES:

1. ALL DIMENSIONS IN INCHES.
2. THESE ACCESSORIES ARE TO BE USED WITH PVC (POLY-VINYL CHLORIDE) PLASTIC CONDUIT, PER HECO SPEC. M7001.
3. PLASTIC DUCT SPACERS SHALL BE OF UNDERGROUND PRODUCTS 'VERTICAL LOC PLASTIC SPACER CLAMPS' OR APPROVED EQUAL.

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SHEET 2 OF 11 | 30-1035 | REV 7

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INITIAL	RM TN ST	RY ST	RM TN	CT DH FK	CT JK							

SUPERSEDES

DRAWN CT | DESIGNED FK | APPD ST JAR TN VEC

REDRAWN 10-31-99

ORIGINAL 6-13-72

ENGINEERING STANDARD
HAWAIIAN ELECTRIC CO. INC.

PLASTIC DUCTS
INSTALLATION DETAILS
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30-1035

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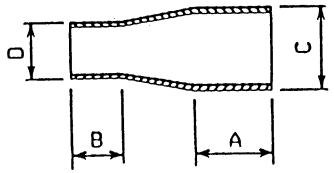
SHEET 3 OF 11

Spec CS7001.16

REDUCER COUPLING (NEMA TC-3)

USE: A FITTING INTENDED FOR JOINING LENGTHS OF TWO DIFFERENT SIZES OF RIGID PVC CONDUIT, RIGID PVC ELBOW, OR OTHER BEND.

NOTE: REDUCER COUPLING MUST CONFORM TO NEMA TC-3

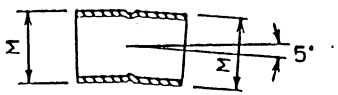


NOMINAL CONDUIT SIZES		HECO STOCK NO.	A	B	C	D
LARGE END (IN.)	SMALL END (IN.)		MINIMUM (IN.)	MINIMUM (IN.)	AVERAGE (IN.)	AVERAGE (IN.)
3	2	000143957	3.250	2.125	3.500	2.375
4	3	000134584	3.375	3.250	4.500	3.500
5	4	000109568	4.375	3.375	5.563	4.500
6	5	000134085	5.375	4.375	6.625	5.563

5° ANGLE COUPLING (NEMA TC-3)

USE: A FITTING INTENDED FOR JOINING TWO LENGTHS OF RIGID PVC CONDUIT TO CHANGE THE DIRECTION OF THE CONDUIT OR TO FORM A CURVE IN THE CONDUIT RUN.

NOTE: COUPLING MUST CONFORM TO NEMA TC-3.



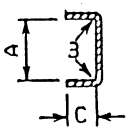
TYPICAL DIMENSIONS

NOMINAL CONDUIT SIZE (IN.)	HECO STOCK NO.	M MAXIMUM (IN.)
2	000143857	2.563
3	000140584	3.719
4	000104531	4.797
5	000145734	5.922
6	000104579	6.016

CAP (NEMA TC-3)

USE: A FITTING INTENDED FOR CLOSING THE ENDS OF UNUSED LENGTHS OF RIGID PVC CONDUIT.

NOTE: CAP MUST CONFORM TO NEMA TC-3



NOMINAL CONDUIT DIAMETER (IN.)	HECO STOCK NO.	A CAP ENTRANCE DIAMETER AVERAGE (IN.)	B CAP BOTTOM DIAMETER AVERAGE (IN.)	C CAP LENGTH MINIMUM (IN.)
2	000104388	2.393	2.369	1.125
3	000147844	3.515	3.492	1.594
4	000104585	4.515	4.491	1.750
5	000150734	5.593	5.553	1.937
6	000145807	6.658	6.614	2.125

GENERAL NOTES:

1. ALL DIMENSIONS IN INCHES.
2. THESE ACCESSORIES ARE TO BE USED WITH PVC (POLY-VINYL CHLORIDE) PLASTIC CONDUIT, PER HECO SPEC. M7001.
3. PLASTIC DUCT SPACERS SHALL BE CARLON SNAP-LOC SPACERS OR APPROVED EQUAL.

REVISION	DATE											
	INITIAL											

ENGINEERING STANDARD
HAWAIIAN ELECTRIC CO. INC.

SUPERSEDES

DRAWN CT | DESIGNED FK | APPD

PLASTIC DUCTS
INSTALLATION DETAILS
UNDERGROUND STRUCTURES

REDRAWN

ORIGINAL 06-01

30-1035

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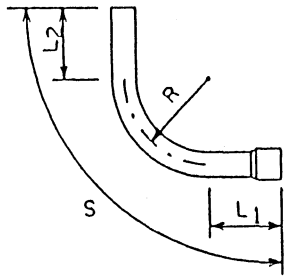
SHEET 4 OF 11

BENDS (NEMA TC-3)

USE: A CONDUIT SECTION INTENDED TO PROVIDE A SMOOTH CHANGE IN DIRECTION IN THE CONDUIT RUN.

NOTE: COUPLING MUST CONFORM TO NEMA TC-3.



90° BENDS

NOMINAL CONDUIT SIZE (IN.)	HECO STOCK NO.	R RADIUS (IN.)	S SWEEP (FT.)	L1 STRAIGHT MINIMUM (IN.)	L2 STRAIGHT MINIMUM (IN.)
2	000148754	24	12.5	2.000	2.000
2	000149857	36	12.5	2.000	2.000
3	000148574	30	12.5	3.125	3.125
3	000145794	36	12.5	3.125	3.125
4	000143054	36	12.5	3.625	3.625
4	000145790	60	12.5	3.625	3.625
5	000140579	36	12.5	4.250	4.250
5	000104759	60	12.5	4.250	4.250
6	000140750	48	12.5	5.250	5.250
6	000140459	60	12.5	5.250	5.250

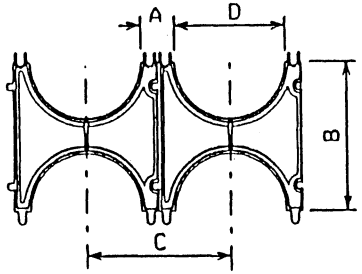
45° BENDS

NOMINAL CONDUIT SIZE (IN.)	HECO STOCK NO.	R RADIUS (IN.)	S SWEEP (FT.)	L1 STRAIGHT MINIMUM (IN.)	L2 STRAIGHT MINIMUM (IN.)
2	---	24	12.5	2.000	2.000
2	---	36	12.5	2.000	2.000
3	---	30	12.5	3.125	3.125
3	---	36	12.5	3.125	3.125
4	---	36	12.5	3.625	3.625
4	---	60	12.5	3.625	3.625
5	---	36	12.5	4.250	4.250
5	---	60	12.5	4.250	4.250
6	---	48	12.5	5.250	5.250
6	---	60	12.5	5.250	5.250

INTERMEDIATE SPACER

NOTE: DIMENSIONS SHOWN ARE FOR CARLON SNAP-LOC SPACERS.

TYPICAL DIMENSIONS

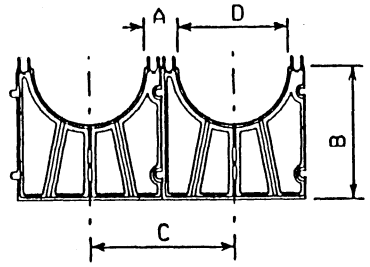


CONDUIT SIZE (IN.)	HECO STOCK NO.	A (IN.)	B (IN.)	C (IN.)	D (IN.)
2	000105834	1.50	3.88	4.12	2.50
3	000150875	1.50	5.01	5.25	3.63
4	000134057	1.50	6.01	6.25	4.63
5	000140574	1.50	7.07	7.31	5.69
6	000158744	1.50	8.14	8.38	6.75

BASE SPACER

NOTE: DIMENSIONS SHOWN ARE FOR CARLON SNAP-LOC SPACERS.

TYPICAL DIMENSIONS



CONDUIT SIZE (IN.)	HECO STOCK NO.	A (IN.)	B (IN.)	C (IN.)	D (IN.)
2	000108457	1.50	4.25	4.12	2.50
3	000140578	1.50	4.81	5.25	3.63
4	000140745	1.50	5.31	6.25	4.63
5	000140573	1.50	5.84	7.31	5.69
6	000134058	1.50	6.38	8.38	6.75

GENERAL NOTES:

1. ALL DIMENSIONS IN INCHES.
2. THESE ACCESSORIES ARE TO BE USED WITH PVC (POLY-VINYL CHLORIDE) PLASTIC CONDUIT, PER HECO SPEC. M7001.
3. PLASTIC DUCT SPACERS SHALL BE CARLON SNAP-LOC SPACERS OR APPROVED EQUAL.

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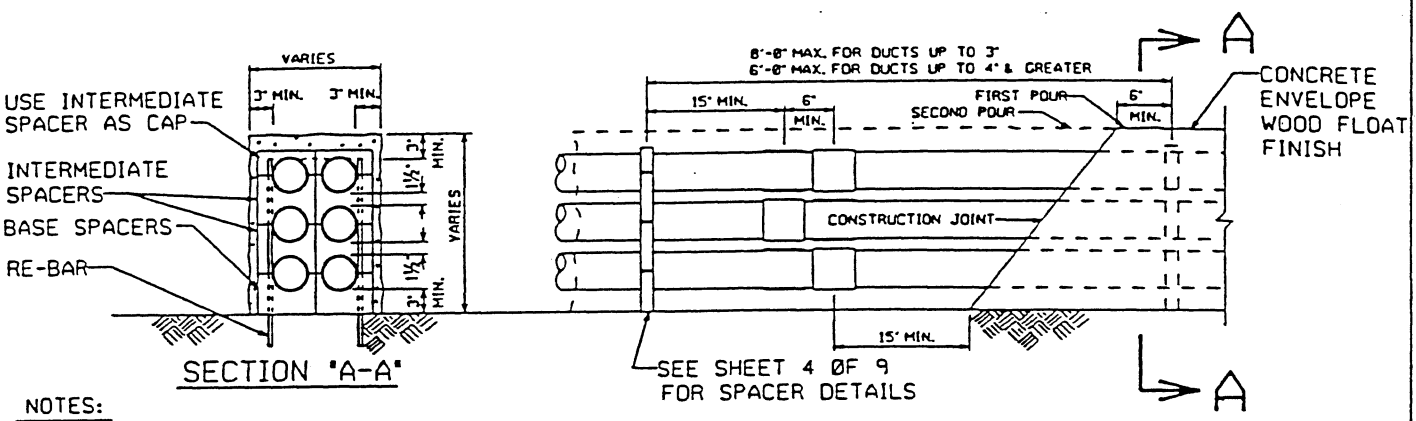
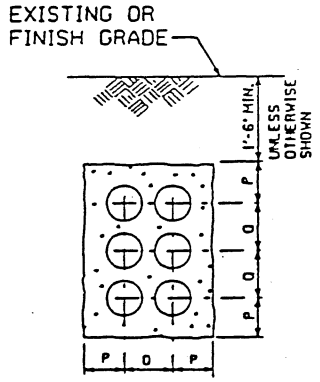


NOTES:

1. STAGGER COUPLINGS (OR BELLED ENDS).
2. ANCHOR CONDUIT WITH #14 STEEL TIE WIRE AND #4 REINFORCING BARS.
3. CEMENT ALL JOINTS.
4. AVOID STANDING ON CONDUIT.
5. REFER TO STD. 30-1005 FOR ADDITIONAL INFORMATION.

TYPICAL DUCT ELEVATION
6 WAY DUCT LINE SHOWN

NOT TO SCALE



REFER TO GO-10 OR SPECIFIC PROJECT DRAWINGS FOR DEPTH REQUIREMENTS

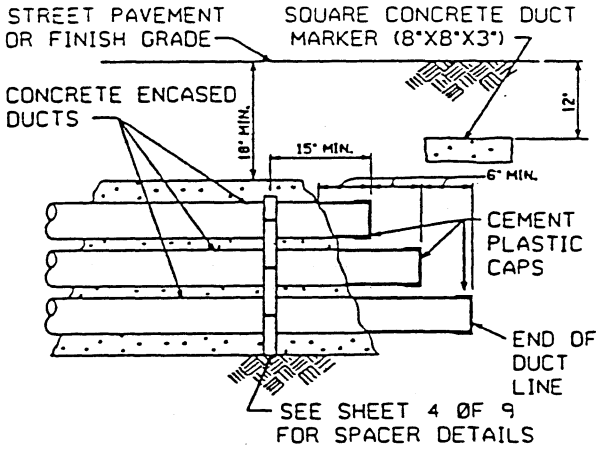
DUCT SIZE	DIMENSIONS P	O
2	4 3/16	3 7/8
3	4 3/4	5
4	5 1/4	6
5	5 13/16	7 1/16
6	6 5/16	8 1/8

(DIMENSIONS IN INCHES)

NOTES:

1. MAINTAIN 1½" MINIMUM SPACING BETWEEN DUCTS; 3" MINIMUM CONCRETE ENVELOPE AROUND TOP, BOTTOM AND SIDES.
2. DIMENSIONS ARE MINIMUM DIMENSIONS.

CONCRETE ENCASED TYPICAL DUCT SECTION 6 WAY DUCT LINE SHOWN



TYPICAL STUB OUT DETAIL 6 WAY DUCT LINE SHOWN

CONCRETE ENCASEMENT DETAILS

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SUPERSEDES	PLASTIC DUCTS INSTALLATION DETAILS UNDERGROUND STRUCTURES	ORIGINAL 06-01	
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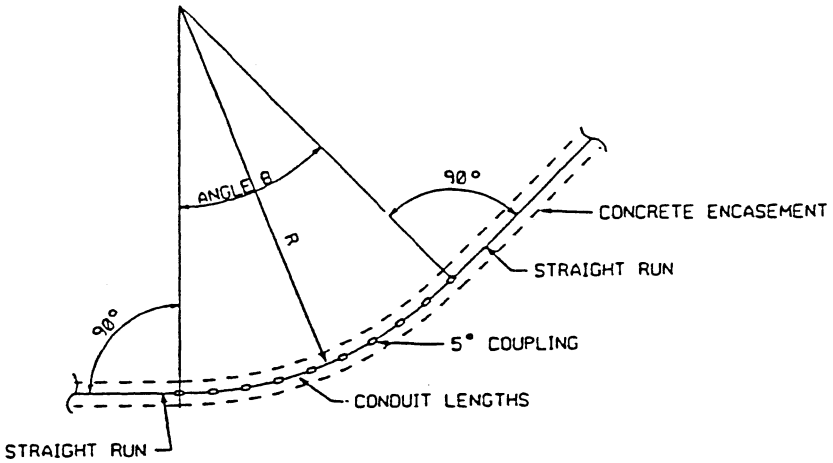


TABLE A

APPROX. RADIUS OF BEND R	LENGTH OF EACH CONDUIT FT. USING 5° BEND AT COUPLING
11'-6"	1
17'-3"	1.5
23'-0"	2
28'-9"	2.5
34'-6"	3
40'-3"	3.5
46'-0"	4
51'-9"	4.5
57'-6"	5
69'-0"	6
80'-6"	7
92'-0"	8

EXAMPLE OF NOTE 3:

RADIUS OF BEND (R) = 60'
ANGLE OF BEND (θ) = 45°

FROM TABLE A, THE NEAREST VALUE TO 60' RADIUS IS 57'-6". LENGTH OF CONDUIT = 5'
FROM TABLE B, FOR 45° ANGLE
NUMBER OF COUPLINGS REQUIRED = 9
NUMBER OF CONDUIT LENGTHS REQUIRED = 8

TABLE B

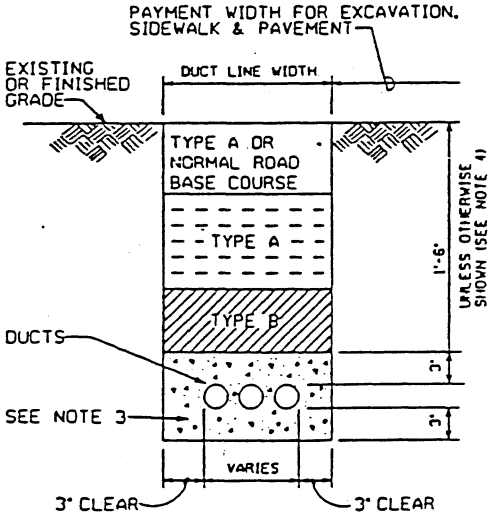
ANGLE OF BEND θ	NUMBER OF COUPLINGS & CONDUIT LENGTHS REQ'D	
	COUPLING	CONDUIT
15°	3	2
30°	6	5
45°	9	8
60°	12	11
75°	15	14
90°	18	17

NOTES:

THERE ARE 4 METHODS OF FORMING CURVES WITH PLASTIC CONDUIT.

1. "HEAT" BENDING: USE HOTBOX BENDING EQUIPMENT OR APPROVED MANUFACTURERS METHOD. DO NOT USE TORCH OR OPEN FLAME.
2. "COLD" BENDING: LIMIT TRENCH FORMED RADIUS SWEEPS TO 25' MINIMUM RADIUS.
3. 5° ANGLE COUPLINGS MAY BE USED AS SHOWN.
4. FACTORY MADE ELBOWS AND SWEEPS MAY BE USED.

METHOD OF FORMING CURVES



NOTES:

1. TYPE A: EARTH OR EARTH & GRAVEL. IF EARTH & GRAVEL, THE MAX. ROCK SIZE SHALL BE 1" & THE MIXTURE SHALL CONTAIN NOT MORE THAN 50% BY VOLUME. OF ROCK PARTICLES.
2. TYPE B: EARTH OR EARTH & GRAVEL. IF EARTH & GRAVEL, THE MIXTURE MUST PASS A ½" MESH SCREEN & CONTAIN NOT MORE THAN 20% BY VOLUME. OF ROCK PARTICLES.
3. CONCRETE ENCASED 3"
4. REFER TO SPECIFIC PROJECT DRAWINGS FOR DEPTH REQUIREMENTS. 1'-6" MINIMUM REQUIRED.

EXCAVATION & BACKFILL DETAILS (TYPICAL)

CONCRETE ENCASEMENT DETAILS

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DRAWN CT	DESIGNED FK	APPD	REDRAWN
SUPERSEDES	PLASTIC DUCTS INSTALLATION DETAILS UNDERGROUND STRUCTURES		ORIGINAL 06-01
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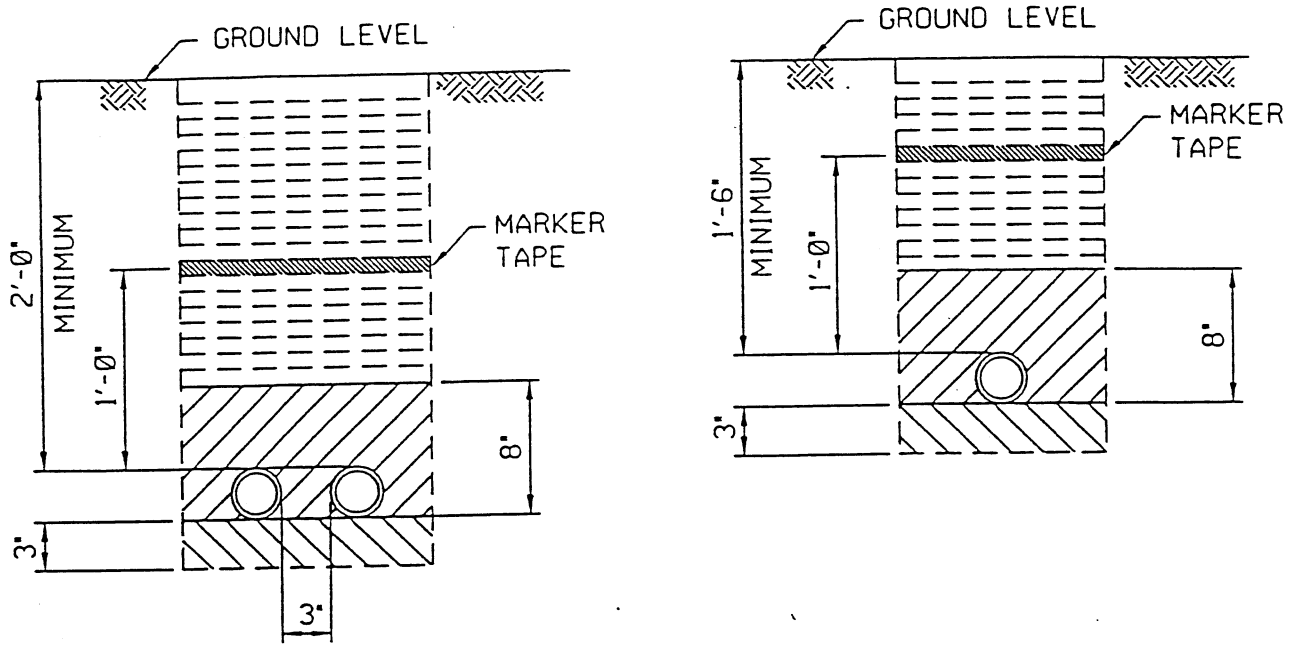

DIRECT BURIED CONDUITS

NOTES:

1. IF THE NORMAL MATERIAL IN THE BOTTOM OF THE TRENCH IS NOT TYPE "B", AN ADDITIONAL 3" SHALL BE EXCAVATED AND THE TYPE "B" BACKFILL SHALL BE PROVIDED.

2. BACKFILL
   a. PREFERRED BACKFILL

   TYPE "A" - EARTH OR EARTH AND GRAVEL. IF EARTH AND GRAVEL, THE MAXIMUM ROCK SIZE SHALL BE 1" AND THE MIXTURE SHALL CONTAIN NOT MORE THAN 50% BY VOLUME OF ROCK PARTICLES.

   TYPE "B" - EARTH OR EARTH AND GRAVEL. IF EARTH AND GRAVEL, THE MIXTURE MUST PASS A ½" MESH SCREEN AND CONTAIN NOT MORE THAN 20% BY VOLUME OF ROCK PARTICLES. CORAL OR CORAL WASTE MATERIAL WILL NOT BE ACCEPTABLE.

DIRECT BURIED CONDUIT DETAILS

REVISION	DATE	INITIAL

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b. Alternative Backfill

(1) A controlled Fluidized Thermal Backfill (FTB) may be placed around the the conduits in lieu of the Type A and Type B Backfill material. FTB is to be placed as a slurry around and above the conduits and, when properly formulated and mixed, will solidify into a uniform, efficient heat conducting medium that will provide structural support and mechanical protection for the buried conduits.

(2) The FTB shall be composed of fine to coarse natural aggregate, cement and water as specified.
The mix proportions to yield approximately 1 cu. Yd. of FTB are given below:

Course Aggregate (Crushed Basalt #67) - 1550 pounds/cu. Yd.
Medium Aggregate (Manufactured Concrete Sand) - 1330 pounds/cu. Yd.
Fine Aggregate (Maui Dunes Sand) - 1330 pounds/cu. Yd.
Cement (Normal Portland Cement Type 1) - 150 pounds/cu.Yd.
Water - 52 gallons

No substitutions of materials is permitted without HECO engineer's approval.

(3) The FTB is to be installed by pouring into the trench and completely filling all voids without causing excessive segregation. No. vibration ore compaction shall be used. The FTB may be pumped into place using conventional concrete pumps; however, this method shall be approved by the HECO engineer first as the flow requirements may have to be adjusted accordingly.

3. Place Electrical Warning Marker Tape 1'-0" above the direct buried conduits.

DIRECT BURIED CONDUIT DETAILS

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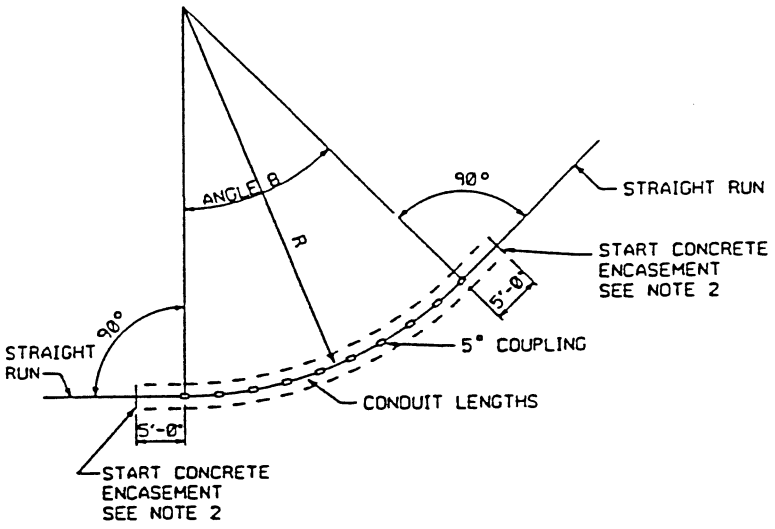

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NUMBER OF COUPLINGS REQUIRED = 9
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TABLE B

ANGLE OF BEND θ	NUMBER OF COUPLINGS & CONDUIT LENGTHS REQ'D	
	COUPLING	CONDUIT
15°	3	2
30°	6	5
45°	9	8
60°	12	11
75°	15	14
90°	18	17

NOTES:

1. THERE ARE 4 METHODS OF FORMING CURVES WITH PLASTIC CONDUIT.
   a. "HEAT" BENDING: USE HOTBOX BENDING EQUIPMENT OR APPROVED MANUFACTURERS METHOD. DO NOT USE TORCH OR OPEN FLAME.
   b. "COLD" BENDING: LIMIT TRENCH FORMED RADIUS SWEEPS TO 25' MINIMUM RADIUS.
   c. 5° ANGLE COUPLINGS MAY BE USED AS SHOWN.
   d. FACTORY MADE ELBOWS AND SWEEPS MAY BE USED.
2. PROVIDE 3" MINIMUM CONCRETE ENCASEMENT OVER THE ENTIRE LENGTH OF ALL BENDS EXCEEDING 45°. START CONCRETE 5' BEFORE START OF THE BEND AND CONTINUE TO 5' BEYOND THE END OF THE BEND.

METHOD OF FORMING CURVES

DIRECT BURIED CONDUIT DETAILS

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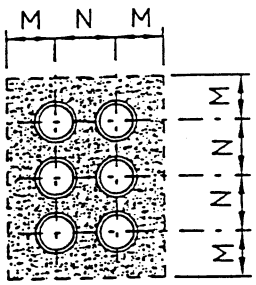
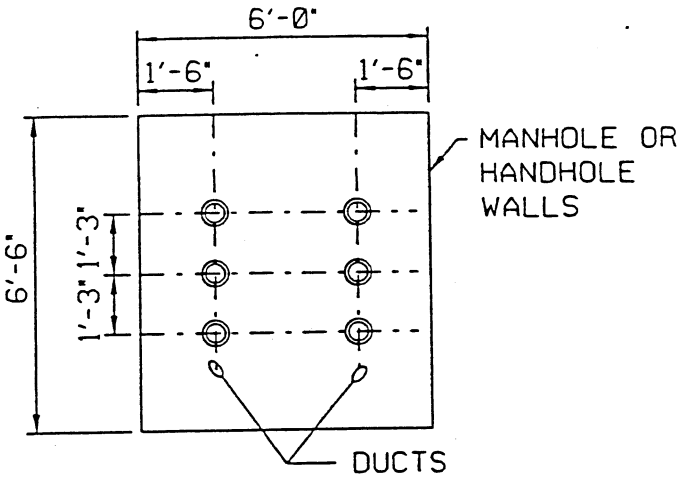
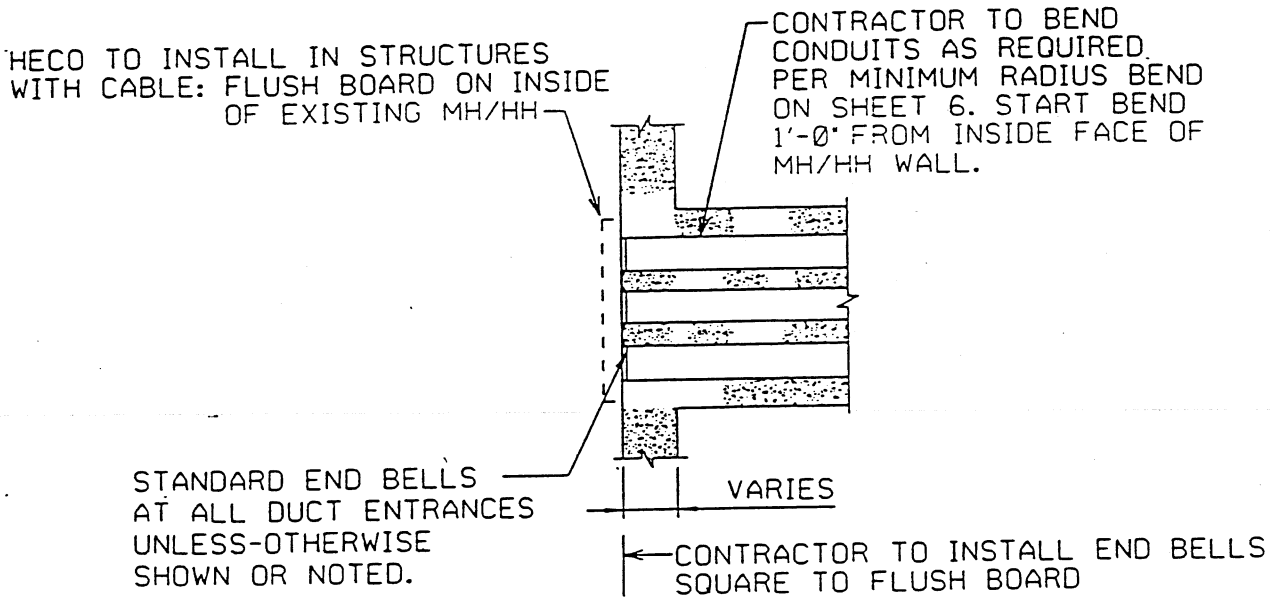


DUCT SIZE	DIMENSION M	N
2	4	5
3	5	6
4	5 1/2	7
5	6	8
6	6 7/16	9

(DIMENSION IN INCHES)





TYPICAL CONDUIT ENTRANCE INTO MANHOLE OR VAULT WALLS (6 WAY DUCT LINE SHOWN)

DATE | INITIAL | ION

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SUPERSEDES

ENGINEERING STANDARD
HAWAIIAN ELECTRIC CO. INC.

PLASTIC DUCTS
INSTALLATION DETAILS
UNDERGROUND STRUCTURES

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REFERENCES:

Standards:

30-1005	Conduit Application Guide
30-1006	Ductline Applications
30-1010	Typical Backfill Details
30-1015	Typical Duct Encasement Details
30-1020	Duct Roll Sections
30-1030	Plastic Ducts, Special Installation Details
30-9000	References & Standard for UG Ducts & Structures

Specifications:

M7001	Plastic Conduits & Fittings Constructed With PVC Plastic
CS 7202	General Conditions
CS 7001	Construction of UG Facilities
CS 7003	Construction of Electrical Facilities

REVISION	DATE	INITIAL

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HAWAIIAN ELECTRIC CO., INC.

SPECIFICATION NO. CS7003-36

FOR

CONSTRUCTION OF ELECTRICAL FACILITIES

Prepared by Engineering Department

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Rev. 35:	08/01/94
Rev. 34:	05/10/93
Rev. 33:	03/31/93
Rev. 32:	10/20/92
Rev. 31:	01/03/92
Rev. 30:	12/03/90
Rev. 29:	11/15/90
Rev. 28:	05/09/90
Rev. 27:	04/16/90
Rev. 26:	02/12/90
Rev. 25:	01/15/90
Rev. 24:	08/14/79
Rev. 23:	09/22/89
Rev. 22:	01/09/89
Rev. 21:	06/14/88
Rev. 20:	03/18/88
Rev. 19:	02/16/88
Rev. 18:	03/31/87
Rev. 17:	05/30/86
Rev. 16:	03/06/86
Rev. 15:	02/24/86
Rev. 14:	02/15/85
Rev. 13:	10/31/84
Rev. 12:	03/27/84
Rev. 11:	11/03/81
Rev. 10:	05/26/80
Rev. 9:	07/10/79
Rev. 8:	03/14/78
Rev. 7:	03/10/77
Rev. 6:	03/08/76
Rev. 5:	01/14/76
Rev. 4:	04/17/74
Rev. 3:	07/25/73
Rev. 2:	01/18/73
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Original Edition:	May 1970

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PART 1 GENERAL SPECIFICATIONS

The Standard Specifications of General Conditions for Construction of Projects numbered CS7202 shall govern throughout the entire work, except for modifications described herein.

PART 2 SCOPE OF WORK

The Contractor shall furnish all labor, materials, equipment and services necessary and reasonably incidental to complete construction of all electrical facilities in accordance with the drawings and as specified herein.

PART 3 LAWS TO BE OBSERVED

The Contractor is presumed to be familiar with all laws, ordinances and regulations which may in any way affect the equipment or materials used in the proposed construction, those engaged on the work, or the conduct of the work, and shall save the Company harmless against any and all claims arising from violation thereof.

PART 4 EXISTING UTILITIES

4.1 Existing utilities are shown on the drawings in approximate locations for the convenience of the Contractor. The fact that any utility is not shown on the drawings shall not relieve the Contractor of his responsibility under this section. It shall be the Contractor's responsibility to ascertain the location of all existing utilities which may be subject to damage by reason of his operations.

4.2 The Contractor shall (1) support and protect all utilities during construction, (2) notify immediately any utility of any damage to its system caused by construction under this Contract, and (3) reconstruct, at his expense, damaged portions of the utility system in accordance with the requirements and specifications of the utility concerned.

4.3 The drawings will indicate certain utility items to be relocated permanently by the utility owner because of interference with permanent Company facilities to be constructed. The Company shall provide direct payment to the utility owner for this relocation. All other work required for the relocation shall be performed by the Contractor at his expense.

PART 5 COMPANY FACILITIES

5.1 The Contractor shall provide the Company with 24 hour access to all existing Company facilities that are to remain, or, for facilities that are to be removed, until they are removed and to all new Company facilities after they are installed. The Contractor shall be held responsible for any delays in Company work due to his failure to provide access to Company facilities.

5.2 Electrical equipment or conductors whether electrically energized or not shall remain in place at all times during construction. Handling and moving of electrical equipment or conductors, when required by the Engineer, shall be done by the Company. Work by the Contractor in areas with energized electrical equipment or conductors shall be performed with extreme caution to prevent accidents and to avoid disturbing or damaging this equipment or conductors or any temporary supports or protective guards that are constructed. Unless otherwise permitted by the Company, all work by the Contractor in areas with energized equipment or conductors shall be performed in the presence of a Company inspector and/or standby man. The Contractor shall have the sole responsibility for maintaining safe and efficient working conditions and procedures in these areas.

5.3 Any existing or new Company facilities including equipment or conductors damaged by the Contractor during construction shall be replaced by the Company at the Contractor's expense.

5.4 Work by the Company

A. The Contractor shall give the Company two weeks advance notice for any work to be done by the Company on its facilities.

B. All temporary relocations of Company facilities at the Contractor's request shall be done at his expense.

C. All overtime work done by the Company at the Contractor's request shall be done at his expense.

D. Unless otherwise indicated on the drawings or otherwise directed by the Engineer, the Company shall:

(1) Remove the concrete envelope from existing underground ducts containing electrical cables.

(2) Construct temporary supports and protective barriers for bare ducts and electrical cables immediately after

removal of the concrete envelope is completed. Material for such supports and barriers shall be furnished by the Contractor at no expense to the Company.

(3) Remove temporary supports and protective barriers constructed under (2) above.

(4) Remove existing overhead facilities after construction of new underground facilities are completed, new equipment and conductors are installed and energized, and all overhead individual customer services are converted to underground.

5.5 Work by the Contractor

A. In addition to work indicated on the drawings, or unless otherwise indicated on the drawings or otherwise directed by the Engineer, the Contractor shall:

(1) Cut holes in or demolish and remove sections of entire existing structures other than ducts.

(2) Perform all work required to enable the Company to safely remove the concrete envelope from existing ducts containing electrical cables. Such work shall include excavation, backfilling, adequate dewatering, sheeting and bracing, demolition, and removal of debris resulting from work by the Company.

(3) Remove duct concrete envelope in cases where all cables have been removed by the Company.

(4) Provide adequate support and bracing for all existing poles and guys when such facilities are adjacent to areas being excavated.

(5) Provide safety precautions for the existing overhead facilities when they become a hazard to pedestrian and vehicular traffic, prior to their removal.

PART 6 MATERIALS TO BE FURNISHED BY THE COMPANY AND INSTALLED BY THE CONTRACTOR

6.1 The Company shall furnish to the Contractor at its Ward Avenue Warehouse the following material if required by the project plans:

A. All 5/8 ϕ x 8' - 0" copper-clad ground rods.

B. All Company standard 31-inch manhole frames and covers.

Requisitions for this material shall be furnished to the Contractor by the Engineer.

6.2 Arrangements shall be made in advance with the Stores Division, Ward Avenue Warehouse. The warehouse is open for business from 7:00 a.m. to 3:30 p.m., Monday through Friday, except on Company holidays. The Contractor shall furnish all labor, materials and equipment required to deliver the materials to the job site and to install the materials where required. Company materials lost or damaged by the Contractor shall be replaced in kind by him at his own expense.

PART 7 BOARD OF WATER SUPPLY FACILITIES

7.1 Unless otherwise specified, all materials and construction of water system facilities and appurtenances shall be in accordance with the City and County of Honolulu Board of Water Supply's "Water System Standards," Volume 1, dated 1985, and the "Approved Material List and Standard Details for Water System Construction," Volume 2, dated 1985, and all subsequent amendments and additions.

7.2 Deleted.

7.3 Deleted.

7.4 The Contractor shall notify BWS Planning and Engineering Division, Construction Section, one week prior to commencing on the water system.

7.5 Deleted.

7.6 The existence and locations of underground utilities and structures as shown on the plans are from the latest available data but is not guaranteed as to the accuracy or the encountering of other obstacles during the course of work. The Contractor shall be responsible and shall pay for all damages to existing utilities.

7.7 All plans by the Board of Water Supply are based solely on the adequacy of the water supply. All other features of the water system, such as lines, grades, fittings, etc., and drainage and other features of improvements shall not be the responsibility of the Board of Water Supply.

7.8 The Contractor shall be responsible for the protection of all water lines during construction. The Contractor shall be especially careful when excavating behind water line tees and bends wherever there is a possibility of water line movement due to removal of the supporting earth beyond the existing reaction blocks. The Contractor shall take whatever measure necessary to protect the water lines, such as constructing special reaction blocks (with BWS approval) and/or modifying his construction methods.

7.9 Polygon shape for mechanical joint glands as described in AWWA Standard C111 shall be "straight-sided" or an approved equal on a job-to-job basis.

7.10 Prior to installation, the Contractor shall submit for approval by the Board of Water Supply, the manufacturer's certification that all cast iron (gray or ductile) fittings for the project conform in all respects to the Water System Standards, dated 1985.

PART 8 SEWER AND STORM DRAIN FACILITIES

8.1 All materials and work pertaining to sewer and storm drain system facilities and appurtenances shall be performed in accordance with City Standard Specifications, September 1986, and the Department of Public Works Standard Details, September 1984, current City practices, and the Revised Ordinances of Honolulu, 1978, or the latest revisions of each.

8.2 The Contractor shall notify the Division of Wastewater Management and/or Division of Engineering, City and County of Honolulu, seven days prior to commencement of work.

8.3 Minimum clearance required between ductlines and storm drains shall be 1 foot when parallel and 6 inches when crossing. For sewers this clearance shall be 2 feet when parallel or when crossing. When sewer clearance is less than 2 feet in crossing ductlines, a concrete jacket shall be poured around the sewer in accordance with City Standards. City Standards shall govern details on Company Drawing No. 30-1030, Specification CS7001, page 21. The Contractor shall notify the Division of Waste Water Management prior to performing this work and submit four (4) sets of approved construction plans.

PART 9 PROTECTION OF PROPERTY

9.1 During the construction, the Contractor shall use extreme care to protect all adjacent buildings, driveways, trees, shrubbery, walls, utility lines, etc., and any damage caused by the Contractor shall be immediately remedied and paid for by him.

9.2 After the construction, the Contractor shall restore the premises used for his operations to their original condition.

9.3 The cost of the work under this section shall not be paid for directly but shall be considered incidental and included in the prices bid for the various items of work.

PART 10 PROTECTION OF PEDESTRIANS AND VEHICULAR TRAFFIC

10.1 The Contractor shall, during the progress of work, use proper precautions and methods of procedure and construction for the prevention of accidents and for the protection of persons and property by means of good and sufficient barriers, guards, temporary bridges, detours, notices, lights, warnings, and safeguards; and from sunset until sunrise he shall keep suitable lights burning wherever the public has access near or at any work in progress to define the line of safe passage. He shall indemnify and save harmless the Company against and from all suits, actions, and claims for cost, compensation, damages, or otherwise to which the said Company may be put, on account of the injury or alleged injury to the person or persons or property of another, resulting in any manner whatsoever from the negligence of the Contractor in the performance of the work or in guarding of the same.

A. Access. During the progress of the work, the Contractor shall provide free access to water meters, water valves, and abutting private property. No material or obstruction of any

sort shall be placed within 25 feet of any fire hydrant. Fire hydrants must be readily accessible to the Fire Department at all times.

B. Attention is called to private rights-of-way. Driveways shall be kept open and free from obstruction until temporary access driveways satisfactory to the owners are provided for and maintained during construction.

C. Material excavated during construction shall be placed in such a manner as to economize space and minimum interference with traffic.

D. The Contractor shall provide, install, and maintain all necessary signs and other protective facilities, which shall conform with the "Hawaii Administration Rules Governing the Use of Traffic Control Devices at Work Sites on or Adjacent to Public Streets and Highways" adopted by the Director of Transportation, and the Current U. S. Federal Highway Administration's "Manual on Uniform Traffic Control Devices for Streets and Highways, Part VI - Traffic Controls for Street and Highway Construction and Maintenance Operations."

E. Where pedestrian walkways exist, they shall be maintained in passable condition or other facilities for pedestrian shall be provided. Passage between walkways at intersections shall likewise be provided.

PART 11 RESTRICTIONS

11.1 During non-working hours, **the contractor shall install sufficient and safe non-skid steel plates over open trenches and excavations that are subjected to vehicular traffic. The steel plates shall be capable of supporting all types of vehicular traffic and shall be securely anchored with all edges ramped. The contractor shall also install adequate shoring and supports. Open trenches and excavations through pedestrian walkways and sidewalks shall be adequately and securely covered with all weather surfaced plywood and support installed by the contractor. Proper signs, cones, barricades and other devices shall be used to warn traffic and pedestrians of the temporary trench covering.**

11.2 No roadway may be closed except with the expressed permission of the Department of Transportation Service. The Contractor shall notify the Honolulu Police Department and the Honolulu Fire Department of the construction work in progress and the blocking or closing of any street or portion thereof.

11.3 Work on any City street area may be performed only between the hours of 8:30 a.m. to 3:30 p.m., Monday through Friday, unless otherwise permitted by the Department of Transportation Services.

PART 12 RESTORING OF EXISTING FACILITIES AND IMPROVEMENTS

12.1 The Contractor shall restore to a condition as good as it was when he entered upon the work all existing government and private facilities and improvements including pavement, embankment, drainage facilities, sidewalks, curbs, gutters, guard rails, signs, landscaping, grass, etc., disturbed, damaged or removed by him or as a result of his operations.

12.2 For work within City right-of-way, the Contractor shall reference, to the approval of the Department of Transportation Services, all existing traffic signs, posts and pavement markings prior to the commencement of construction. The Contractor shall replace or repair all traffic signs, posts, and pavement markings disturbed by his activities. The Contractor shall notify the Department of Transportation Services at 523-4029 one (1) week prior to any work to be done on signs, posts and pavement markings.

12.3 All materials and workmanship shall:

A. Conform to all applicable laws, ordinances, codes and specifications of any Federal, State and City and County agencies having authority over the work. Contractor shall furnish one-year bond in favor of City and County of Honolulu for restoration work done in City and County streets and highways.

B. Conform to the requirements and standards of any private individual, company and corporation having ownership of the work.

C. Be subject to inspection and approval by the government agency and private individual, company and corporation concerned.

PART 13 CLEANING AND REMOVAL OF ALL SLIT AND DEBRIS

13.1 The Contractor shall be responsible for the cleaning and removal of all slit and debris generated, deposited and accumulated within down stream waterways, ditches, drain pipes and on public roadways.

13.2 The Contractor agrees to reimburse the City and County of Honolulu for all costs expended in the performance of the above work if required for public health and safety or made necessary by non-performance by the Contractor.

PART 14 NOISE AND DUST CONTROL

14.1 The Contractor shall abate the noise nuisance by special scheduling of noise-producing operations, the use of noiseless equipment, or other means as necessary.

14.2 The Contractor shall keep dust in the immediate vicinity of the work to a minimum by sprinkling the area with water as required or by other dust control methods approved by the Engineer. The City shall require supplementary measures as necessary.

PART 15 PERSONAL SUPERVISION

15.1 The Contractor shall be present in person, or by a foreman capable of reading and understanding the drawings and specifications. Such person shall have the authority to act for the Contractor in connection with the contract and shall properly supervise and coordinate all work during the performance of the contract.

15.2 The Contractor shall file with the Engineer a written statement signed by the Contractor giving the name or names of any and all foremen and employees who are authorized to act in place of the Contractor, and any communication signed in behalf of the Contractor by such agents shall bind the Contractor. The Contractor shall be responsible for notifying the Engineer immediately and in writing of any change in the name or names so submitted.

PART 16 CHARACTER OF WORKMEN, METHODS AND EQUIPMENT

16.1 The Contractor shall employ persons who possess the skill required to perform the work under the contract.

16.2 When required by the Engineer, the Contractor shall replace any employee who lacks the skill to perform the work assigned to him or is discourteous or disorderly while performing such work. A person who has been replaced may be assigned other work with the approval of the Engineer.

16.3 The Contractor shall use proper and efficient methods and equipment for the performance of the contract.

PART 17 PAYMENT

17.1 The Contractor shall be paid the contract price as full compensation for the performance of the contract.

17.2 For lump sum contracts, the contract price shall be the result obtained by first reducing the amount designated as the total sum bid in the award by the amount included therein for allowances and contingencies, and adding thereto or deducting therefrom any extra cost or any reduction in cost, respectively, to the Company as a result of supplemental agreements in writing and written orders of the Engineer.

17.3 For unit price contracts, the contract price shall be the sum of results obtained by multiplying the number of the units of such items incorporated in the work under the contract by the unit price bid therefor. The unit price of an item shall be the amount therefor specified in the Contractor's Bid and shall include its pro rata share of overhead so that the sum of the products obtained by multiplying the quantity shown for each item by the unit price Bid represents the total Bid. Special attention of all Bidders is called to this provision, for should conditions make it necessary to revise the quantities, no limit will be fixed for such increased or decreased quantities nor extra compensation allowed, provided the net monetary value of all such additive and subtractive changes in quantities of such items of work (i.e., difference in cost) shall not increase or decrease the original contract price by more than twenty-five percent (25%).

17.4 The contract lump sum price or prices bid for the electrical facilities or the contract unit prices bid per unit for the various electrical facility items shall include full compensation for furnishing all labor, materials, tools and equipment and performing all the work involved in furnishing, installing and constructing all electrical facilities complete in place as shown on drawings and as herein specified.

17.5 Full compensation for all additional materials and labor not specifically shown or called for which are necessary to complete all required electrical facilities shall be considered as included in the lump sum or unit prices bid for the various items and no additional allowance will be made therefor.

PART 18 QUANTITIES AND MEASUREMENTS

18.1 All quantities of work actually completed in place under the contract shall be measured by the Engineer. These measurements shall be considered correct and final unless the Contractor files a written protest demonstrating the existence of an error within ten (10) calendar days after receipt of such measurement data.

18.2 Quantities or measurements indicated in the bid, if any, are given for the convenience of the Contractor. It will be assumed that the lump sum bid and unit prices made by the Contractor and the price agreed upon by him are based on a thorough knowledge of the existing conditions and the amount and kind of work to be performed. It is expressly understood and agreed by the Contractor that quantities and measurements of the work to be done and the materials to be furnished under this contract which have been estimated, as given, are approximate. The Contractor further agrees and hereby understands that neither the Engineer nor the Company is to be held responsible if such estimated quantities and measurements shall not be found to be the same or even close to the actual quantities and measurements required for the work under the contract. The Contractor will make no claim for anticipated profits, or for loss of profits because of a difference between the quantities or measurements stated in the bid. If an error, omission or misstatement shall be discovered in the quantities or measurements stated in the bid, the same shall not vitiate the contract, or release the Contractor or his surety or sureties from performing the contract, or affect the price agreed to under the contract, or excuse the Contractor from any of the obligations or liabilities under the contract, or entitle him to damages or compensation, except as provided herein.

PART 19 CHANGES IN THE WORK

19.1 The Company may make changes in the scope of the work required to be performed by the Contractor under the contract or make additions thereto or omit work therefrom, without invalidating the contract, and without relieving or releasing the Contractor from any of his obligations under the contract or any guarantee given by him pursuant to the contract provisions, and without affecting the validity of the guaranty bonds, and without relieving or releasing the surety or sureties of said bonds. All such work shall be executed under the terms of the original contract unless it is expressly provided otherwise.

19.2 If applicable unit prices are contained in the Bid, the Company may order the Contractor to proceed with desired changes in the work, the value of such changes to be determined by the measured quantities involved and the applicable unit prices specified in the contract; provided that the net value of all changes does not increase or decrease the original Bid total by more than twenty-five percent (25%).

19.3 If applicable unit prices are not contained in the Agreement or if the total net change increases or decreases the total contract price more than twenty-five percent (25%), the Company shall, before ordering the Contractor to proceed with the desired changes, request an itemized proposal from him covering the work involved in the change after which the procedure shall be as follows:

A. If the proposal is acceptable the Company will prepare the change order in accordance therewith for acceptance by the Contractor, and

B. If the proposal is not acceptable and prompt agreement between the two parties cannot be reached, the Company may order the Contractor to proceed with the work on a cost-plus basis as outlined below.

(1) Direct labor and supervision per approved time cards based on wage rates previously approved by the Company. Exclude salaries of engineers, project managers, or general supervisory personnel.

(2) Direct material and supplies, including freight and handling costs, per approved invoices.

(3) Rental costs of equipment, other than small tools, owned by others, per approved invoices based on rental rates previously approved by the Company.

Equipment fully operated and maintained without operator.

(4) Total of Items (1) through (3).

(5) Item (4) plus 10% for overhead.

(6) Payroll insurance, taxes, and fringe benefits for Item (1).

(7) Premiums on bonds and pro-rata costs of premiums on public liability, property damaged, or other insurance required by the Company.

(8) Subcontracts approved by the Company.

(9) Total of Items (5) through (8).

(10) Item (9) plus 10% for profit.

(11) Rental costs of equipment, other than small tools, owned by the Contractor, based on rental rates previously approved by the Company. Equipment fully operated and maintained without operator.

(12) Total of Items (10) and (11).

(13) State gross income tax on Item (12) less Item (8).

(14) Total of Items (12) and (13) = Total Cost-Plus Price.

C. For all cost-plus work, the Contractor shall support invoices for payment with itemized receipted bills for material and subcontract work. The Contractor shall submit a certified copy of payroll covering all labor employed by Contractor and by Subcontractors performing work on a cost-plus basis. Satisfactory evidence shall also e submitted to verify materials drawn from the Contractor's stock, the rental of Contractor's equipment, and other miscellaneous items of cost not otherwise verified.

PART 20 PAYMENTS DURING PERFORMANCE OF WORK

20.1 The Engineer shall, not later than the fifteenth (15th) day of each month during the performance of the contract, make an estimate of the amount of work done in accordance with the contract during the immediately preceding month, deducting sufficient allowance for incomplete or unprotected work or to provide for any contingency for defects or damage to said work or for the necessity of performing any part of the work over again to cure defects or damage.

20.2 Progress payments to the Contractor shall be for a sum equal to ninety (90) percent of the above estimate, less previous payments and sums withheld by the Company pursuant to the contract.

PART 21 FINAL INSPECTION - FINAL PAYMENT

21.1 After completion of the work required under the contract and final acceptance thereof by the Company, the Contractor will be paid the balance due in accordance with the Engineer's final estimate of the construction actually performed, provided that final payment will be made subject to Articles 14 and 16 of the General Conditions.

APPENDIX A

GAS LINE FACILITIES

1. The GASCO, Inc. gas pipe lines in the project area are coated and cathodically protected. The Contractor shall be extremely careful when working near these gas pipe lines.

2. The Contractor shall obtain from GASCO prior written clearance, at least five (5) working days prior to any excavation, and call GASCO, Inc. a minimum of 72 hours before starting excavation to arrange for field location of all existing gas lines.

   The Contractor shall excavate and backfill around gas pipe lines in the presence of a GASCO, Inc. representative. All backfill within six inches of gas pipe line shall be of Type B material per HECO, Inc. Specification CS7001, Page 24, D.B. Excavation and Backfill Details.

   All excavation within two feet of gas pipe lines shall be done by hand.

3. For relocation of any gas pipe line, the Contractor shall notify GASCO, Inc. five working days before starting work. The Contractor shall provide the necessary excavation and backfill, arrange for traffic permits and restore sidewalk, pavement or other facilities. Any relocation of gas facilities shall be done by GASCO. Hawaiian Electric Company, Inc. shall provide payments to GASCO for relocating the lines which interferes with the Company's permanent facilities.

4. The Contractor shall notify GASCO, Inc. immediately after any damage has been caused to existing gas pipe lines, their coatings or their cathodic protection devices. Repair work on this damage shall be done by GASCO, Inc. with payment for this work to be borne by the Contractor.

5. Minimum clearance required between duct lines and gas pipe lines shall be 12 inches when parallel and/or crossing. Provide adequate support and protection for gas pipe lines exposed in the trench. Such support and protection shall be approved by GASCO, Inc.

6. The Contractor shall work in an expeditious manner in order to keep uncovered gas pipe lines exposed for as short a period of time as possible.

APPENDIX B

TELEPHONE FACILITIES

1. The Contractor shall call Hawaiian Telephone Company 72 hours before starting excavation to arrange for field location of all existing telephone cables and/or duct lines.

   The Contractor shall excavate and backfill around telephone cables in the presence of Hawaiian Telephone Company Engineer or his representative. All backfill materials shall be the same as HECO, Inc. Specification CS7001, page 24, D.B. Excavation and Backfill Details.

   All excavation within two feet of telephone cables shall be done by hand.

2. For relocation of any telephone cables and/or duct lines, the Contractor shall notify Hawaiian Telephone Company five working days before starting work. The Contractor shall provide the necessary excavation and backfill, arrange for traffic permits and restore sidewalk, pavement or other facilities. The Contractor shall also provide all ducts, pullboxes, handholes, etc., as indicated by Hawaiian Telephone Company. Telephone cables will be relocated by Hawaiian Telephone Company and paid for by the Contractor.

3. The Contractor shall notify Hawaiian Telephone Company immediately after any damage has been caused to existing cables, duct lines, pull boxes, manholes, handholes, poles and guys. Repair work on damaged cables shall be done by Hawaiian Telephone Company and paid for by the Contractor and any other work involving existing underground facilities shall be done by the Contractor in the presence of Hawaiian Telephone Company Engineer or his representative with payment for this work to be borne by the Contractor.

4. Provide adequate support and protection for telephone cables and/or duct lines exposed in the trench. Such support and protection shall be approved by Hawaiian Telephone Company.

APPENDIX C

AT&T FACILITIES

1. The location of AT&T's underground facilities as shown on the plans are from records of varying degrees of accuracy and are not guaranteed as shown. The Contractor shall exercise extreme caution when the excavation and construction crosses or is in close proximity of underground fiber optic cable facilities. Any damage to the existing underground facilities shall be repaired and paid for by the Contractor.

2. When trench excavation is adjacent to or under existing structures or facilities, the Contractor is responsible for properly sheeting and bracing the excavation and stabilizing the existing ground to render it safe and secure from possible slides, cave-ins and settlement, and for properly supporting existing structures and facilities with beams, struts or underpinnings to fully protect it from damage.

3. Any work required to relocate underground facilities shall be done by AT&T Co. and paid for by the Contractor. The Contractor shall be responsible for all coordination.

4. For verifying the location of AT&T's underground facilities call 455-1010.

APPENDIX D

WATER NOTES

1. Unless otherwise specified, all materials and construction of water system facilities and appurtenances shall be in accordance with the City and County of Honolulu Board of Water Supply's "Water System Standards," Volume 1, dated 1985, and the "Approved Material List and Standard Details for Water System Construction," Volume 2, dated 1985, the "Water System External Corrosion Control Standards," Volume 3, dated 1991, and all subsequent amendments and additions.

2. The Contractor shall notify BWS Planning and Engineering Division, Construction Section, one week prior to commencing work on the water system.

3. All plans approved by the Board of Water Supply are based solely on the adequacy of the water supply. All other features of the water system, such as lines, grades, fittings, drainage, etc., and other features of improvements shall not be the responsibility of the Board of Water Supply.

4. The Contractor shall be responsible for the protection of all water lines during construction. The Contractor shall be especially careful when excavating behind water lines tees and bends wherever there is a possibility of water line movement due to removal of the supporting earth beyond the existing reaction blocks. The Contractor shall take whatever measure necessary to protect the water lines, such as constructing special reaction blocks (with BWS approval) and/or modifying his construction methods.

5. The existence and location of underground utilities and structures as shown on the plans are from the latest available data but is not guaranteed as to the accuracy of the encountering of other obstacles during the course of the work. The Contractor shall be responsible and shall pay for all damages to existing utilities. The Contractor shall not assume that where no utilities are shown, that none exist.

6. At the electrical/signal ductline water crossings, adjust all electrical/signal ductline elevation to maintain 6" vertical clear separation from all water lines (12" clear for all electrical/signal ductline structures larger than 16") at no cost to the BWS.

7. Maintain 3'-0" min. horizontal clear separation between all water line systems and nearest electrical/signal ductlines paralleling the water system at no cost to the BWS.

8. Reapproval shall be required if this project is not under construction within a period of two years.

9. The Contractor shall verify all existing service lateral locations whether shown or not shown on plans prior to commencing with any of the work and shall not assume that where no services are shown none exist.

APPENDIX E

ELECTRICAL & MAINTENANCE SERVICES DIVISION NOTES:

1. The Contractor shall notify the Joint Pole Committee two (2) weeks in advance of any relocation of utility pole that may be necessary.

2. The Contractor shall notify the Electrical & Maintenance Services Division, Department of Transportation Services, three (3) working days prior to commencing work on the street lighting system (Telephone: 527-5002).

3. The Contractor shall notify the Electrical & Maintenance Services Division, Department of Transportation Services, three (3) working days prior to commencing work on the traffic signal system (Telephone: 527-5007).

4. The Contractor shall notify the Electrical & Maintenance Services Division, Department of Transportation Services, three (3) working days prior to commencing work on the fiber optic system (Telephone: 527-5007).

5. Street lighting, traffic signal, and fiber optic systems shall be kept operational during construction. Any relocation or changeover required shall be approved by the Electrical & Maintenance Services Division, Department of Transportation Services, and performed and paid for by the Contractor.

6. The Contractor shall be responsible for any damages to existing street lighting, traffic signal, and fiber optic facilities, including the traffic signal interconnect system, and any and all damages to these facilities shall be repaired by the Contractor at his cost in accordance with the requirements of the City and County of Honolulu.

APPENDIX F

TRAFFIC NOTES FOR WORK ON CITY & COUNTY STREETS

1. A permit shall be obtained from the Department of Transportation Services before work on any portion of a public street or highway may begin. Submit a set of approved construction plans when applying for the permit.

2. The Contractor shall provide, install and maintain all necessary signs and other protective facilities, which shall conform with the "Hawaii Administration Rules Governing the Use of Traffic Control Devices at Work Sites on or Adjacent to Public Streets and Highways" adopted by the Director of Transportation, and the current U.S. Federal Highway Administration's "Manual on Uniform Traffic Control Devices for Streets and Highways, Part VI - Traffic Controls for Street and Highway Construction and Maintenance Operations."

3. Work on any city street area may be performed only between the hours of 8:30 a.m. to 3:30 p.m., unless otherwise permitted by the Department of Transportation Services.

4. During non-working hours, all trenches shall be covered with a safe non-skid bridging material, and all lanes shall be opened to traffic.

5. The Contractor shall contact the Department of Transportation Services parking section at 523-4314 at least two (2) working days prior to any parking meter work.

6. As required by the Department of Transportation Services, the Contractor shall provide off-duty police officers to control the flow of traffic.

7. Where pedestrian walkway exist, they shall be maintained in passable condition or other facilities for pedestrians shall be provided. Passage between walkways at intersections shall likewise be provided.

8. Driveways shall be kept open unless the owners of the property using these rights-of-way are otherwise provided for satisfactorily.

9. The Contractor shall reference, to the approval of the Department of Transportation Services, all existing traffic signs, posts and pavement markings prior to the commencement of construction. The Contractor shall replace or repair all traffic signs, posts, and pavement markings disturbed by his activities. The Contractor shall notify the Department of Transportation Services at 523-4029 one (1) week prior to any work to be done on signs, posts and pavement markings.

10. The Contractor shall notify Oahu Transit Services, Lowell Tom (848-4578) or Ed Sniffen (848-4571), two weeks prior to construction, informing them of the location, scope of work, proposed closure of any street or traffic lanes, and the need to relocate any bus stop(s).

11. No material and/or equipment shall be stockpiled or otherwise stored within street rights-of-ways except at locations designated in writing and approved by the Department of Transportation Services.

ATTACHMENT #6

SOIL THERMAL RESISTIVITY REPORT

GEOTHERM INC.

SERVING THE ELECTRIC POWER INDUSTRY SINCE 1978

1001 St. John's Sideroad E.
Aurora, Ontario
CANADA
L4G 3G8
Tel: 905-727-6448
Fax: 905-727-4325

November 19, 2003

MK Engineers, Ltd.
286 Kalihi Street
Honolulu, Hawaii
96819
Attn: Paul Yueda, P.E.

Dear Paul,

Re: Thermal Analysis of Native Soil Samples
Hickman Air Force Base, Hawaii, Your Project No. 03302

We are pleased to submit this test report of thermal dryout characterization conducted on the nine (9) native soil and one rock core sample from the referenced project. These bulk samples are believed to be at their natural moisture content (at the time of sampling). The rock core sample was fully saturated prior to thermal testing.

Test Procedure and Equipment:

The tests included the measurement of moisture content, density and thermal dryout characterization (thermal resistivity as a function of moisture content).

For thermal dryout characterization the bulk samples were re-compacted at their as received moisture content and at about 95% of standard Proctor density. In order to minimize the contact resistance at the soil/probe interface and to ensure a uniform density, the soil was compacted in multiple layers in test moulds (75 mm diameter by 150 mm high) with a laboratory type thermal probe held central and vertical in the base plate. Particles larger than ¾" (20 mm) were excluded when preparing test samples.

For the rock-core sample, a thermal probe was installed central and vertical in pre-drilled pilot hole.

A series of measurements were made in stages, with moisture content ranging from the as received to totally dry condition. At the end of each drying stage, samples were sealed and brought to thermal equilibrium with the ambient and to ensure uniform moisture re-distribution through the sample. The thermal dryout curves are presented in ***Figures 2, 3 and 4.***

MEASUREMENT OF THERMAL RESISTIVITY

In order not to exceed safe operating temperatures at the design ampacity, the heat generated by the cable(s) must be dissipated through the soil. The thermal resistivity or rho [ºC-m/W] is a measure of the resistance to heat flow through a unit area of soil, and is measured by the 'transient thermal probe' technique. Basically, a slender cylindrical probe, containing a heater and temperature sensor, is inserted into the soil to be tested. Constant power is applied to the heater and the probe temperature/time data is monitored. The thermal resistivity can be calculated from this curve. As long as certain theoretical assumptions and test procedures are met, the technique is equally applicable to small probes (100mm long by 3mm diameter) in laboratory soil samples and large probes (2m long by 25mm diameter) installed in-situ.

The TPA-7000 (EPRI EL-2128), manufactured by *Geotherm Inc.*, is a system that fully automates the thermal probe test. It is computer controlled and provides programmable power to the thermal probes, reads temperature sensors and heater current and voltage, and computes in real time the thermal resistivity. The unit consists of a programmable 10 amp, 60-volt power supply, a 10-channel data acquisition system, a notebook computer, and a printer. A nominal 110-volt power source is required. The entire test procedure is software controlled in a totally interactive manner, and various built-in error-reducing features ensure that the test complies with the theoretical assumptions. A statistical analysis of data indicates whether an acceptable test has been accomplished. Test data (time, temperature, power, etc.) is printed, plotted and stored on diskette for future analysis and reference to the results.

FACTORS AFFECTING THERMAL RESISTIVITY

Heat flows through a soil mainly by conduction along mineral particles, and secondarily by conduction and convection through the moisture or air that occupies the pore space between solid particles (***Figure 1***). Thermal resistivity depends on soil composition and texture, water content, density, and various other factors to a lesser degree. This complex interrelationship does not lend itself to a simple formula; rather a thermal probe test must be carried out on any given soil in an undisturbed condition. Laboratory tests on undisturbed soil samples should only be performed when correlated to field test results. Note that once a cable is installed, the soil moisture is the only parameter that changes significantly with time.

SOIL COMPOSITION: Soil is a composite material consisting of solid mineral grains, typically only making point-to-point contact, and pore space filled with water and air. The thermal resistivity of a given soil mass is a function of the intrinsic resistivities of its components. These may range from 0.12 °C-m/W for quartz mineral, to 0.40 °C-m/W for limestone, to 1.65 °C-m/W for water, to about 5.0 °C-m/W for organics (Figure 1). Even certain highly compacted soils can have up to 30% voids between solid particles, that in a dry state are filled with very high resistivity air (~45 °C-m/W).

TEXTURE: This refers to soil grain size, shape, and particle size gradation. Since most of the heat is conducted through the solid particles and their contacts, the resistivity is minimized for soils that maximize these contacts. In engineering applications, a soil is often qualitatively categorized by a visual description using accepted adjectives to indicate the fractional amount of each component (i.e. gravel, sand, silt, clay, etc.).

WATER CONTENT: For any given soil the major influence on the thermal resistivity is the moisture content. In a dry state the pore spaces are filled with air (~45 °C-m/W). As water (~1.65 °C-m/W) replaces air, the soil resistivity is substantially lowered (as much as 3 to 7 times) as the good heat conduction paths are expanded ('thermal bridges'). This is illustrated by the 'thermal dryout curve' (thermal resistivity vs. soil moisture content) (Figure 1). A soil that is better able to retain its moisture, as well as being able to efficiently re-wet when dried, will have better thermal performance characteristics. The soil water content is expressed as a percentage of the weight of water to the dry weight of soil solids, as determined by oven drying at 105 °C.

DRY DENSITY: Soil densification (or compaction) increases mineral grain contacts and displaces air (i.e. lowers porosity), therefore reducing the soil resistivity, most notably at low moisture contents. Well-graded soils are potentially more dense because smaller grains can efficiently fill the spaces between the larger particles. Dry density is expressed as the ratio of the dry weight of the soil solids to the total volume. The total volume is taken as the initial volume of the undisturbed moist soil in a sample tube.

OTHER FACTORS: Soil particle soundness (porosity), mineral type (limestone, granite, basalt, etc.) and organic content also affect the thermal resistivity to some degree. Porosity and organic content of higher than 4% increases the dry thermal resistivity by as much as 15-20%.

Sample ID, Description, Moisture Content, Dry Density and Thermal Resistivity:

B1 @ 3' – 4'
Reddish brown clayey SILT with coralline sand and gravel.
The as received moisture content was 20% and the dry density was 107 pcf.
Thermal resistivity at as received moisture content = **88 *°C-cm/W***
Thermal resistivity at 0% moisture content (totally dry) = **245 *°C-cm/W***

B2 @ 3' – 4'
Reddish brown, clayey SILT with coralline sand and gravel.
The as received moisture content was 20% and the dry density was 108 pcf.
Thermal resistivity at as received moisture content = **74 *°C-cm/W***
Thermal resistivity at 0% moisture content (totally dry) = **185 *°C-cm/W***

B3 @ 3' – 4'
Reddish brown, clayey SILT with coralline sand and gravel.
The as received moisture content was 19% and the dry density was 109 pcf.
Thermal resistivity at as received moisture content = **69 *°C-cm/W***
Thermal resistivity at 0% moisture content (totally dry) = **155 *°C-cm/W***

B4 @ 3' – 4'
Tan silty SAND with coralline gravel.
The as received moisture content was 20% and the dry density was 100 pcf.
Thermal resistivity at as received moisture content = **73 *°C-cm/W***
Thermal resistivity at 0% moisture content (totally dry) = **180 *°C-cm/W***

B5 @ 3' – 4'
Brown, clayey SILT with coralline sand and gravel.
The as received moisture content was 15% and the dry density was 117 pcf.
Thermal resistivity at as received moisture content = **68 *°C-cm/W***
Thermal resistivity at 0% moisture content (totally dry) = **155 *°C-cm/W***

B6 @ 3' – 4'
Tan, silty SAND with coralline gravel.
The as received moisture content was 15% and the dry density was 113 pcf.
Thermal resistivity at as received moisture content = **78 *°C-cm/W***
Thermal resistivity at 0% moisture content (totally dry) = **176 *°C-cm/W***

B7 @ 3' – 4'
Grayish brown VOLCANIC TUFF.
The as received moisture content was 35% and the dry density was 79 pcf.
Thermal resistivity at as received moisture content = **111 *°C-cm/W***
Thermal resistivity at 0% moisture content (totally dry) = **305 *°C-cm/W***

B8 @ 3.5' – 4.5'
Grayish brown, silty CLAY with sand.
The as received moisture content was 31% and the dry density was 85 pcf.
Thermal resistivity at as received moisture content = **123 *°C-cm/W***
Thermal resistivity at 0% moisture content (totally dry) = **365 *°C-cm/W***

B9 @ 3.5' (Rock-Core Sample)
Grayish brown, VOLCANIC TUFF.
The as received moisture content was 13% and the dry density was 121 pcf.
Thermal resistivity at as received moisture content = **75 *°C-cm/W***
Thermal resistivity at 0% moisture content (totally dry) = **150 *°C-cm/W***

B10 @ 3' – 4'
Grayish brown, VOLCANIC TUFF.
The as received moisture content was 21% and the dry density was 81 pcf.
Thermal resistivity at as received moisture content = **185 *°C-cm/W***
Thermal resistivity at 0% moisture content (totally dry) = **370 *°C-cm/W***

Comments:

Based on the description of the samples tested, the soils along the route are silty CLAY to silty SAND, and at a few locations, volcanic TUFF is encountered at shallow depths. The field moisture content varies significantly (13% to 35%). At most locations the in-situ thermal resistivity can be assumed to be about ***80 °C-cm/W, except at locations 7, 8 and 10 where this value is much higher (110-185 °C-cm/W).***

Increase in thermal resistivity as soil dries:
The heat front of the energized cables will dry the soil and the thermal resistivity will increase as shown in the thermal dryout curves. Although the thermal resistivity of some of most of the samples tested is less than 200 °C-cm/W in totally dry condition, for the cable rating it may be safer to use a thermal resistivity value of ***not less than 200 °C-cm/W.*** This is based on the findings that the thermal resistivity of soils at locations B7, B8 and B10 in particular, is fairly high even at natural moisture contents. The thermal resistivity of these soils in totally dry condition is higher than 300 °C-cm/W.

The extent of the dry zone around the cable(s) will be a function of the load and its duration. In order to maintain a uniform effective thermal resistivity for the entire route, a corrective thermal backfill envelope of varying thickness may be installed.

Corrective Thermal Backfill:
A granular type backfill such as a well-graded sand or stone dust can be sourced locally from quarries or from sand-aggregate suppliers. The other option is to use a Fluidized Thermal Backfill (FTB™) that has numerous advantages over granular type backfills. We will be pleased to discuss these options and their applications if you wish.

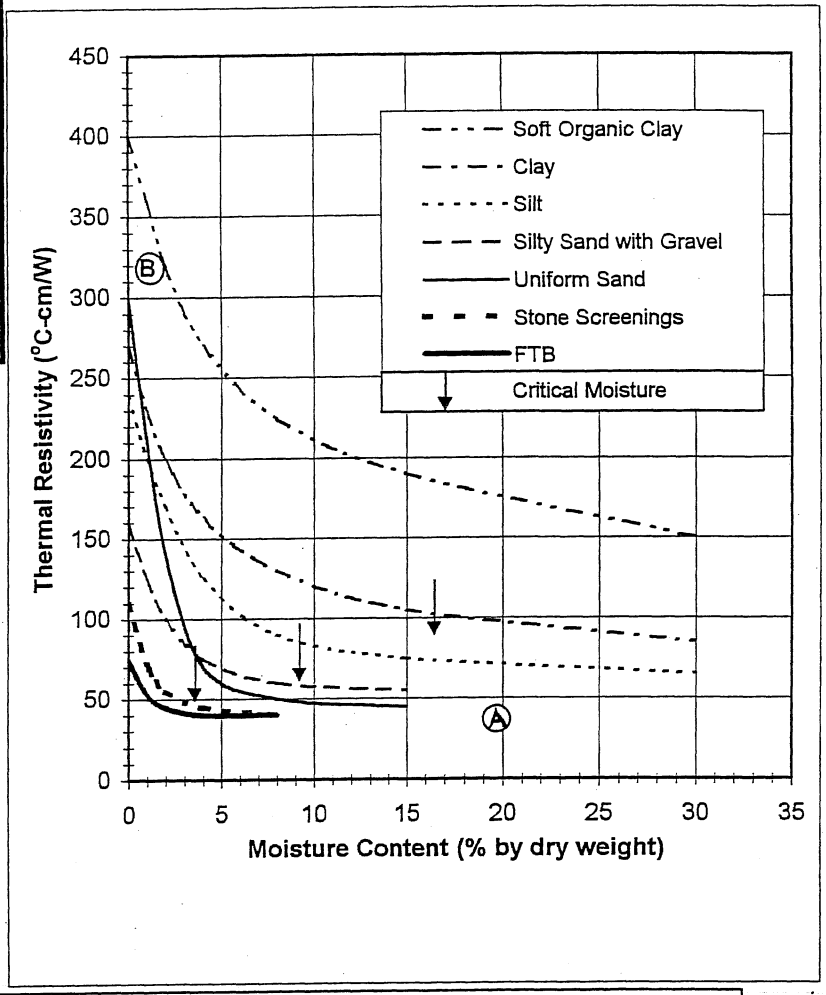
We trust you find this report to be satisfactory and to contain the required information. Please contact us if you or your client(s) have any questions, wish to discuss any part of this report or if we can be of further assistance.

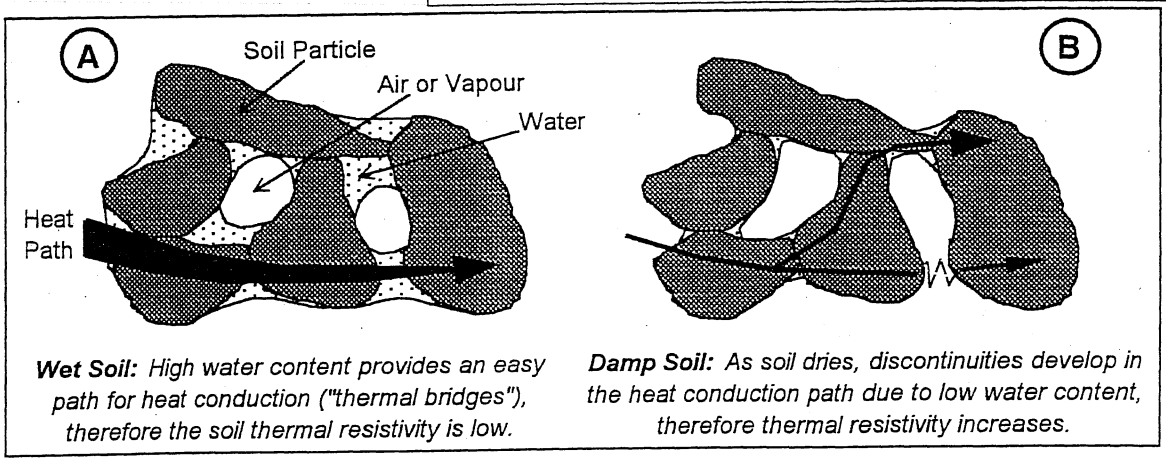
Yours truly
Geotherm Inc.

Deepak Parmar
President

SOIL COMPONENTS	
Description	**Thermal Resistivity Dry (°C-cm/W)**
Soil Grains	
Quartz	12
Granite	30
Limestone	40
Sandstone	50
Shale (sound)	60
Shale (highly friable)	200
Mica	170
Others	
Ice	45
Water	165
Organics	~500
Oil (petroleum)	~800
Air	~4500

THERMAL DRYOUT CURVES





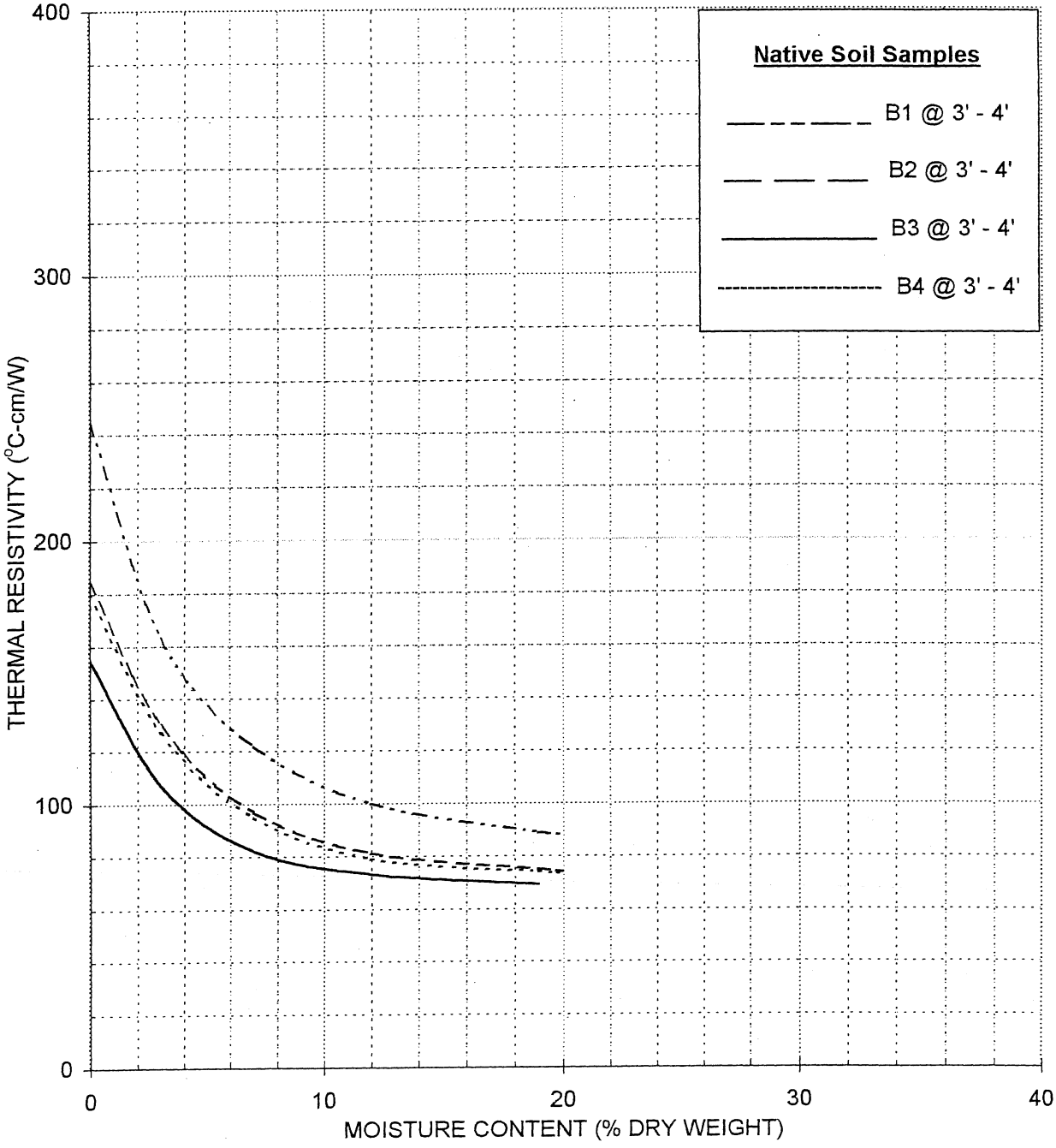
Wet Soil: *High water content provides an easy path for heat conduction ("thermal bridges"), therefore the soil thermal resistivity is low.*

Damp Soil: *As soil dries, discontinuities develop in the heat conduction path due to low water content, therefore thermal resistivity increases.*

FIGURE 1

GEOTHERM INC.

THERMAL DRYOUT CURVES



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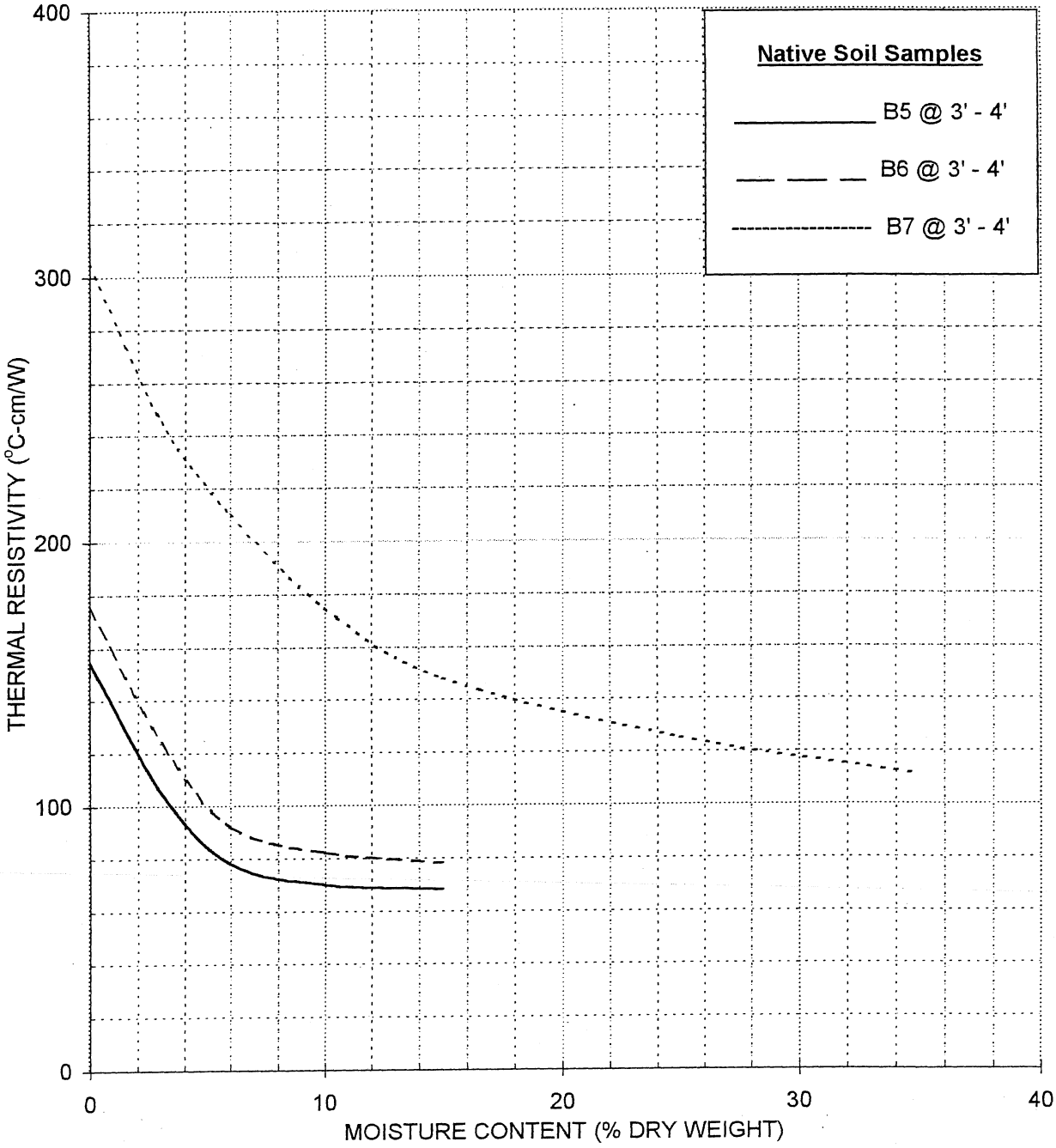
KNMD 01-3001 Upgraded Phase 1, HAFB

Hickman Air Force Base - Hawaii

November 2003

Figure 2

THERMAL DRYOUT CURVES



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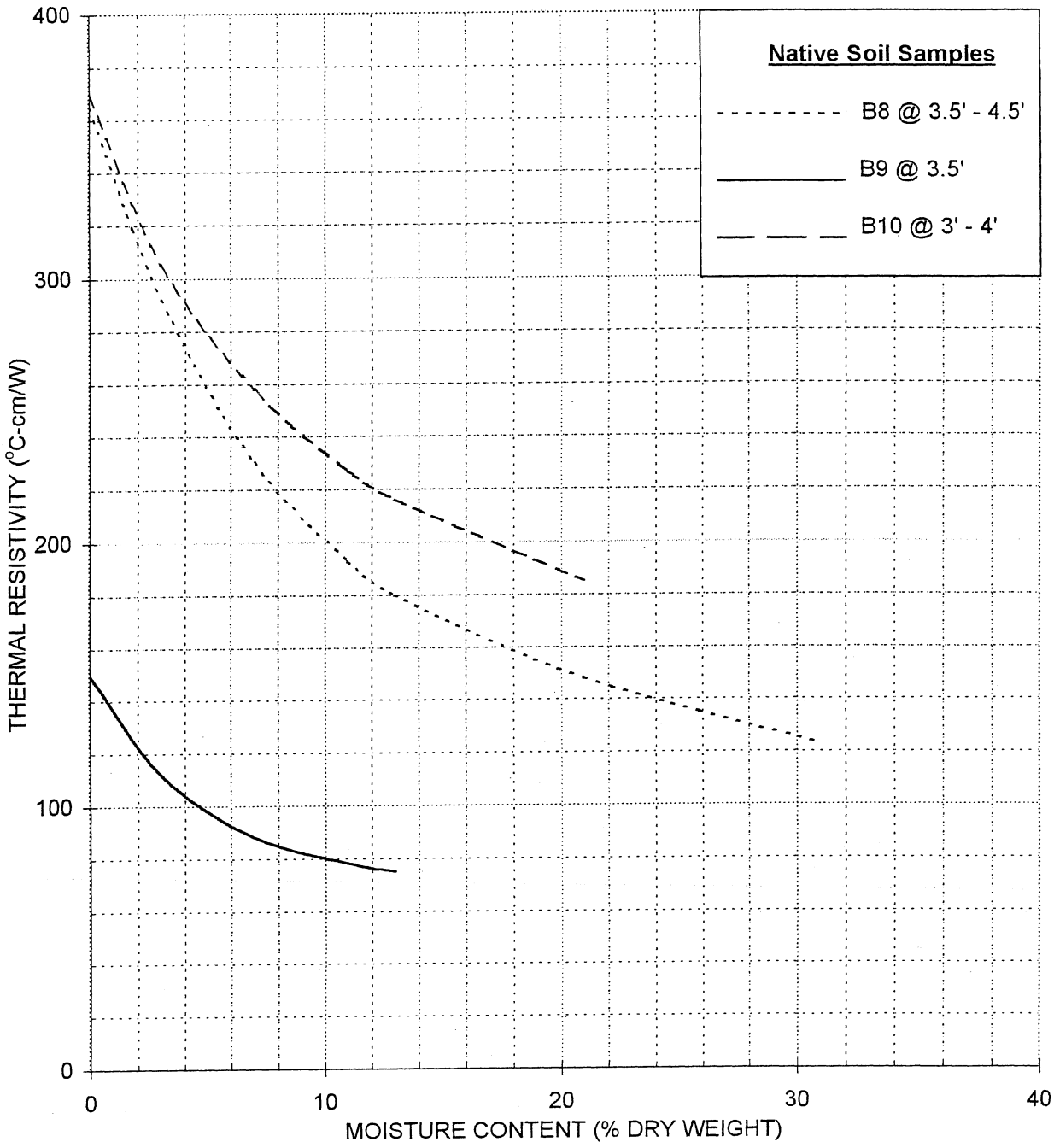
KNMD 01-3001 Upgraded Phase 1, HAFB

Hickman Air Force Base - Hawaii

November 2003

Figure 3

THERMAL DRYOUT CURVES



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Hickman Air Force Base - Hawaii

November 2003

Figure 4

ATTACHMENT #7

SOIL REPORTS

PRELIMINARY SOILS INVESTIGATION
FY05 KNMD 01-3002A1
UPGRADE ELECTRICAL DISTRIBUTION SYSTEM, PHASE I
HICKAM AFB, OAHU, HAWAII

for

MK Engineers, Ltd.

ERNEST K. HIRATA & ASSOCIATES, INC.
W.O. 03-3831
March 11, 2004

ERNEST K.
HIRATA & ASSOCIATES, INC.

99-1433 Koaha Place
Aiea, Hawaii 96701
Ph: 808-486-0787 Fax: 808-486-0870
Email: eha@hawaii.rr.com

March 11, 2004
W.O. 03-3831

Mr. Paul Uyeda
MK Engineers, Ltd.
286 Kalihi Street
Honolulu, HI 96819

Dear Mr. Uyeda:

Our report, "Preliminary Soils Investigation, FY05 KNMD 01-3002A1, Upgrade Electrical Distribution System, Phase I, Hickam AFB, Oahu, Hawaii," dated March 11, 2004, our Work Order 03-3831 is enclosed. This investigation was conducted in general conformance with the scope of work presented in our proposal dated September 10, 2003.

Our exploratory borings encountered silty sand and silty gravel in the area of the Mamala substation, and silty sand, silty gravel, silty clay, and volcanic tuff along the alignment of the proposed 46 kV duct line. Groundwater was encountered in borings B1 through B5 and B7, at depths ranging from about 1.5 to 2.7 meters below grade. Neither groundwater nor seepage water was encountered in the remainder of our borings to the maximum depths drilled.

The proposed substation may be founded on conventional shallow foundations bearing directly on the onsite silty sand. Only the conventional 100 mm gravel cushion and vapor barrier are recommended under concrete slabs-on-grade. However, as a precautionary measure, the building site should be proofrolled to compact the near surface soils. All soft/loose soils should be removed down to competent material and replaced with structural fill.

The following is a summary of our geotechnical recommendations. This summary is not intended to be a substitute for our report which includes more detailed explanations of our recommendations, as well as additional requirements.

- Allowable bearing value = 100 KPa
- Coefficient of friction = 0.4
- Passive earth pressure = 45 KN/m^3

We appreciate this opportunity to be of service. If you have any questions, feel free to call on us.

Very truly yours,

ERNEST K. HIRATA & ASSOCIATES, INC.

Paul S. Morimoto

Paul S. Morimoto Vice President

PSM:EHS

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PRELIMINARY SOILS INVESTIGATION
FY05 KNMD 01-3002A1
UPGRADE ELECTRICAL DISTRIBUTION SYSTEM, PHASE I
HICKAM AFB, OAHU, HAWAII

INTRODUCTION

This report presents the results of our preliminary soils investigation performed in support of Design-Build RFP solicitation documents for Phase I of the proposed electrical distribution system upgrade at Hickam AFB, Oahu, Hawaii. Our work scope for this study included the following:

- A visual reconnaissance of the site and its vicinity to observe existing conditions which may affect the project. The general location of the project site is shown on the enclosed Location Map, Plate A2.1.

- A review of available in-house soils information pertinent to the site and the proposed project.

- Obtaining the necessary permits for our drilling work and coordinating the toning of each boring site for underground utility lines.

- Drilling and sampling 10 exploratory borings to depths ranging from approximately 2.7 to 4.7 meters. A description of our field investigation is summarized in Plates A1.1 and A1.2. The approximate exploratory boring locations are shown on the enclosed Boring Location Plans, Plates A2.2 through A2.5, and the soils encountered in the borings are described on the Boring Logs, Plates A4.1 through A4.10.

- Drilling 10 borings for the environmental sampling performed by Edward K. Noda & Associates, Inc.

- Laboratory testing of selected soil samples. Testing procedures are presented in the Description of Laboratory Testing, Plates B1.1 and B1.2. Test results are presented on the Boring Logs (Plates A4.1 through A4.10), Consolidation Test reports (Plates B2.1 through B2.3), Direct Shear Test reports (Plates B3.1 through B3.3), and Gradation Curves report (Plate B4.1).

- Engineering analyses of the field and laboratory data.
- Preparation of this report presenting the results of our exploratory fieldwork and laboratory testing, as well as preliminary geotechnical recommendations in support of the design-build RFP solicitation documents.

PROJECT CONSIDERATIONS

The proposed improvements to the electrical distribution system will include a new substation (Mamala) planned west of Hangar 35 and a new 46 kV duct line extending from the new Mamala substation to near the existing Front Station, located near the intersection of Vandenberg Boulevard and Freedom Avenue. The Mamala substation structure will be one-story in height, with plan dimensions of about 9.1 by 21.3 meters. The structure will utilize CMU wall construction with concrete floor slabs. Structural loads were not available at the time of this report, but building loads are expected to be relatively light. Finish floor elevations were also unavailable, but based on the existing site topography, site grading will probably consist of only minor cutting and filling.

The 46 kV duct line will extend approximately 2,700 lineal meters from Eighteenth Street (northwest of the Front Station) to the Front Station, down Freedom Avenue, across O'Malley Boulevard, and down Hangar Avenue to the Mamala substation. The invert of the 46 kV duct line will be about 1.2 meters below existing grade. Manhole structures are expected to extend to depths of about 3 meters. Structural loads were not available at the time of this report, but loads for the electrical duct line and manholes are expected to be relatively light. We understand that due to buoyancy considerations, tie-downs may be required for manhole structures.

SITE CONDITIONS

The project area is located between "A" Street and Eighteenth Street in the northwestern portion of Hickam AFB, Oahu, Hawaii. The proposed substation is

planned on the southern side of the intersection of "A" Street and Hangar Avenue. The proposed building location is bordered by AC paved parking and driveway areas on all sides. Hangar Avenue is located to the north, aircraft washracks are located to the east and southeast, and Hangar 35 is located further east. The proposed building site is vacant of structures, but is generally covered by concrete pavement used for equipment storage. Total relief over the building site is less than 300 mm.

The proposed 46 kV duct line is generally proposed within existing roadway and parking areas. Therefore, AC pavement generally overlay the alignment. Most of the duct line alignment between the proposed and existing substations will be planned along Hangar and Freedom Avenues. However, the initial 270 meters of the alignment from the Mamala substation parallels Hangar Avenue through the aircraft parking area prior to connecting to Hangar Avenue. In its transition from Hangar to Freedom Avenue, approximately 220 meters of the alignment is located along O'Malley Boulevard. Also, from the Front Station, the 46 kV line will extend approximately 290 meters to Eighteenth Street where connection to the existing 46 kV circuits is planned.

SOIL CONDITIONS

Existing Pavement Section - All borings were drilled through surface pavement sections consisting of either asphaltic concrete or portland cement concrete. 150 mm of PCC was encountered at surface in boring B1, while AC sections ranging from 75 to 125 mm was encountered in borings B2 through B10. In boring B7, 150 mm of PCC was encountered below the surface 100 mm of AC.

Mamala Substation - Two distinct soil types, silty sand and silty gravel, were encountered in borings B1 and B2, drilled in the area of the proposed substation.

Silty Sand - Below the surface pavement sections, tan silty coralline sand was observed in a medium dense to dense condition. The near surface silty sand contained coralline gravel and lenses of brown and reddish brown clayey silt to depths of about 1 and 1.5 meters below ground surface. Sampling in the silty sand layer resulted in blow counts ranging from 24 to 32 blows per 300 mm of penetration.

Silty Gravel - Tan silty coralline gravel was encountered below the near surface sand and down to the maximum depths drilled. The silty gravel layer was in a loose to medium dense condition in boring B1, but medium dense to dense in boring B2. Sampling in the silty gravel layer resulted in blow counts ranging from 5 to 32 blows per 300 mm of penetration.

Groundwater - Groundwater was measured at depths of approximately 1.6 and 1.5 meters in borings B1 and B2, respectively, at the time of our fieldwork. Groundwater elevations are expected to vary with tidal fluctuations.

46 kV Duct Line - Four distinct soil types were encountered in borings B3 through B10 drilled along the alignment of the proposed 46 kV duct line: silty sand, silty gravel, volcanic tuff, and silty clay.

Silty Sand - Below the surface pavement sections, tan silty coralline sand was generally encountered in a medium dense to dense condition in borings B3 through B6, B8 and B9. The near surface silty sand contained coralline gravel down to depths ranging from about 900 mm to 3.4 meters below ground surface. Sampling in the silty sand layer resulted in blow counts ranging from 6 to 88 blows per 300 mm of penetration.

Silty Gravel - Tan silty coralline gravel was encountered below the near surface sand in boring B3. The silty gravel layer was in a medium dense to dense

condition down to a depth of about 3.7 meters. Sampling in the silty gravel layer resulted in blow counts ranging from 17 to 19 blows per 300 mm of penetration.

Volcanic Tuff - Grayish brown volcanic tuff was encountered in borings B3 through B5 and B7 through B10. In borings B3 through B5, drilled along the southern portion of the duct line alignment, the volcanic tuff was encountered at depths ranging from about 1.6 to 3.7 meters below grade. In borings B7 through B10, the volcanic tuff was encountered at depths ranging from 900 mm to 1.7 meters below grade. The volcanic tuff was in a medium hard to hard condition down to the maximum depths drilled in all borings in which it was encountered. Sampling in the volcanic tuff stratum generally resulted in refusal prior to 300 mm of penetration.

Silty Clay - Brown to grayish brown silty clay was encountered in boring B6 below about 1.5 meters and down to the maximum depth drilled, in boring B7 below the pavement section and down to about 900 mm, and in boring B8 between depths of 1.1 and 1.7 meters. The silty clay was generally in a medium stiff to stiff condition with sampling resulting in blow counts ranging from 15 to 34 blows per 300 mm of penetration. Our past experience in the project area indicates that the silty clay is moderately to highly expansive.

Groundwater - Groundwater was measured at depths ranging from about 1.8 to 2.7 meters in borings B3 through B5 and B7, at the time of our fieldwork. Groundwater elevations are expected to vary with tidal fluctuations. Groundwater was not encountered in borings B6 and B8 through B10.

Petroleum Odor - Petroleum odor was noted on the boring logs in boring B4 at a depth of about 2.4 meters, and boring B8 at a depth of about 3.8 meters.

CONCLUSIONS AND RECOMMENDATIONS

Based on the results of our exploratory fieldwork and laboratory testing, it is our opinion that from a geotechnical viewpoint, the site can generally be developed as planned. Preliminary recommendations for preparation of design-build RFP documents are presented in the following sections of this report. We understand that these recommendations will be confirmed by the Contractor's geotechnical engineer during the design phase.

We believe that design-build proposals may be based on the use of conventional spread footings or thickened slab type foundations founded directly on the onsite silty sand.

Building slabs-on-grade will only require the conventional 100 mm cushion of clean gravel. However, as a precautionary measure, we recommend that the building site be proofrolled prior to placement of slab cushion material. During proofrolling, the exposed subgrade soils should be scarified to a minimum depth of 150 mm, moisture conditioned as necessary, and compacted to a minimum 95 percent compaction as determined by ASTM D 1557 using a vibratory roller. Underlying soft/loose soils indicated by pumping conditions should be removed down to competent material and replaced with structural fill.

The bottom of duct line and manhole excavations should be thoroughly tamped prior to placement of granular material, concrete, or backfill.

Mamala Substation Foundations

Design-build proposals may be based on the use of conventional spread footings or thickened slab foundations founded on the in-place silty coralline sand. Foundations may be designed for an allowable bearing value of 100 kPa, and should be embedded

a minimum 300 mm below finish adjacent grade. Spread footings should be a minimum 400 mm in width, while thickened slab foundations should be a minimum 300 mm wide.

The allowable bearing value is for the total of dead and frequently applied live loads and may be increased by one-third for short duration loading which includes the effects of wind, and seismic forces.

The bottom of footing excavations should be thoroughly tamped and cleaned of loose material prior to placement of reinforcing steel and concrete.

Seismic Design

Based on the 1997 Uniform Building Code, the site is located within Seismic Zone 2A. Within this zone, a seismic zone factor (Z) equal to 0.15 is recommended (97 UBC Table 16-I) for calculation of shear and lateral load imparted on structures during an earthquake. A soil profile type S_D is recommended for preparation of the design-build proposal.

Lateral Design

Resistance to lateral loading may be provided by friction acting at the base of foundations, and by passive earth pressure acting on the buried portions of foundations.

An allowable coefficient of friction of 0.4 may be used with the dead load forces. Passive earth pressure for the silty sand and clayey silt above groundwater may be computed as an equivalent fluid having a density of 45 kN/m^3 with a maximum earth pressure of 140 kPa. Unless covered by pavement or concrete slabs, the upper 300 mm of soil should not be considered in computing lateral resistance.

For active earth pressure considerations above groundwater, equivalent fluid pressures of 6.3 and 7.9 kN/m^3 may be used for level and sloping backfill conditions, respectively.

Slabs-on-Grade

All building slabs-on-grade should be underlain by a 100 mm cushion of clean gravel, such as #3 Fine (ASTM C33 Size No. 67). Prior to placement of the gravel cushion, the subgrade soils should be proofrolled by scarifying to a minimum depth of 6 inches, moisture conditioning to slightly above the optimum moisture content, and compacting to a minimum 95 percent compaction as determined by ASTM D 1557 using a vibratory roller. The 100 mm gravel cushion should be compacted to a level surface.

All building slabs should also be protected by a plastic vapor barrier.

Manhole Structures

Manhole foundations may be supported on the exposed subgrade soils and designed based on recommendations presented in the *Mamala Substation Foundations* and *Lateral Design* sections of this report. Exposed subgrade soils should be thoroughly tamped prior to placement of reinforcing steel and concrete. Soft/loose soils indicated by pumping conditions should be removed down to competent material and replaced with structural fill.

Due to buoyancy conditions, tie-downs may be required. Uplift capacities for tie-downs may be designed for an allowable concrete/soil adhesion value of 38 kPa. The upper 600 mm of soil should not be considered in uplift capacity calculations.

Excavations for 46 kV Duct Line and Manholes

Trench excavations into the near surface silty sand, silty gravel, and silty clay can generally be accomplished using conventional excavating equipment. However,

excavations into the underlying volcanic tuff, especially in confined excavations, may require pneumatic equipment.

Based on the anticipated invert elevations, trench excavations are expected to expose silty sand, silty clay, and volcanic tuff in the sidewalls and bottom of trench. Trench excavations will generally be above groundwater level, but manhole excavations will extend below groundwater. Trench sidewalls are expected to stand temporarily at slopes of 1H:1V above groundwater. However, due to the granular nature of the majority of soils in the alignment, localized sloughing should be expected.

Considerable sloughing is expected where granular material is exposed in the sidewalls of excavations below groundwater, and we anticipate that shoring will probably be required to maintain excavation stability. It should be the Contractor's responsibility to conform to OSHA safety standards during construction which may require sheeting and bracing for onsite excavations. The Contractor's shoring plan should address the potential for adjacent ground settlement during installation and removal of temporary trench shoring, and the monitoring effort that will be implemented to detect ground movement or settlement near the trench.

In addition, based on the anticipated duct line invert elevations, dewatering will be necessary for placement of manhole structures and backfill. The Contractor's dewatering plan should address the potential effects of dewatering on adjacent structures, and the monitoring effort that will be implemented to detect ground movement or settlement of existing structures and infrastructure.

Backfill for 46 kV Duct Line and Manholes

The excavated onsite silty sand, silty gravel, silty clay, and volcanic tuff may be reused as backfill provided all rock and coral fragments larger than 75 mm in

maximum dimension are removed prior to reuse. However, due to its moderate to high expansion potential, the onsite silty clay should not be used as backfill within 600 mm of finish grade.

In areas where excavations extend below groundwater, clean, free-draining gravel, such as #3 Fine, should be utilized from the bottom of excavation to a minimum 300 mm above anticipated groundwater level. To reduce the potential for loss of granular material during removal of trench shoring and the migration of fines into the clean gravel, we recommend that non-woven geotextile fabric be used to envelope the free-draining gravel. Fabric such as Mirafi 140N or Supac 4N should be suitable.

Site Grading

Site Preparation - The project site should be cleared of all AC pavement, concrete pavement, vegetation, and other deleterious material. At the Mamala substation site, the building area should be proofrolled to compact the near surface soils. During proofrolling, the exposed subgrade should be scarified to a minimum depth of 150 mm, moisture conditioned as necessary, and compacted to a minimum 95 percent compaction as determined by ASTM D 1557 using a vibratory roller. Underlying soft/loose soil indicated by pumping conditions should be removed down to competent material and replaced with compacted structural fill.

Onsite Fill Material - The onsite silty sand, clayey silt, silty coralline gravel, silty clay, and volcanic tuff, may be reused in compacted fills or backfills, provided all rock fragments larger than 75 mm in maximum dimension are removed prior to reuse. Due to its moderate to high expansion potential, the onsite silty clay should not be used within the Mamala substation building area or within 600 mm of finish grade throughout the duct line alignment.

Imported Fill Material - Imported structural fill should be well-graded, non-expansive granular material. Soils with USCS classifications of GW, GW-GM, GM, SW, and SM will be acceptable. Specifications for imported granular structural fill should indicate a maximum particle size of 75 millimeters, and state that between 8 and 20 percent of soil by weight shall pass the #200 sieve. In addition, the plasticity index (P.I.) of that portion of the soil passing the #40 sieve shall not be greater than 10. Granular structural fill should have a CBR expansion value no greater than 1.0 percent.

Compaction - All structural fill shall be placed in horizontal lifts restricted to 200 millimeters in loose thickness and compacted to a minimum 95 percent compaction as determined by ASTM D 1557.

ADDITIONAL SERVICES

We recommend that we perform a general review of the final design-build RFP solicitation documents. This will allow us to verify that the preliminary foundation design and earthwork recommendations have been properly interpreted and implemented.

LIMITATIONS

The boring logs indicate the approximate subsurface soil conditions encountered only at those times and locations where our borings were made, and may not represent conditions at other times and locations.

This report was prepared specifically for MK Engineers, Ltd. and their sub-consultants for preparation of design-build RFP solicitation documents for Phase I of the proposed electrical system upgrade at Hickam AFB. The boring logs, laboratory test results, and recommendations presented in this report are not intended

for design purposes. We understand that a final geotechnical report will be required as part of the design-build contract.

Our preliminary recommendations and conclusions are based upon the site materials observed, the preliminary design information made available, the data obtained from our site exploration, our engineering analyses, and our experience and engineering judgement. The preliminary conclusions and recommendations are professional opinions which we have strived to develop in a manner consistent with that level of care, skill, and competence ordinarily exercised by members of the profession in good standing, currently practicing under similar conditions. No other warranty is expressed or implied.

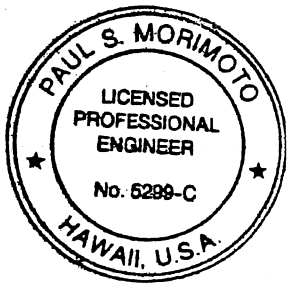
Respectfully submitted,

ERNEST K. HIRATA & ASSOCIATES, INC.

Ed Sniffen, Project Engineer

Paul S. Morimoto, Project Manager

PSM:EHS



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me or under my supervision

APPENDIX A

FIELD INVESTIGATION

DESCRIPTION OF FIELD INVESTIGATION

GENERAL

Our geotechnical fieldwork was performed on October 27 and 28, 2003, by performing a visual site reconnaissance and drilling ten exploratory test borings, ranging in depth from about 2.7 to 4.7 meters, with a Mobile B40-L12 truck-mounted drill rig.

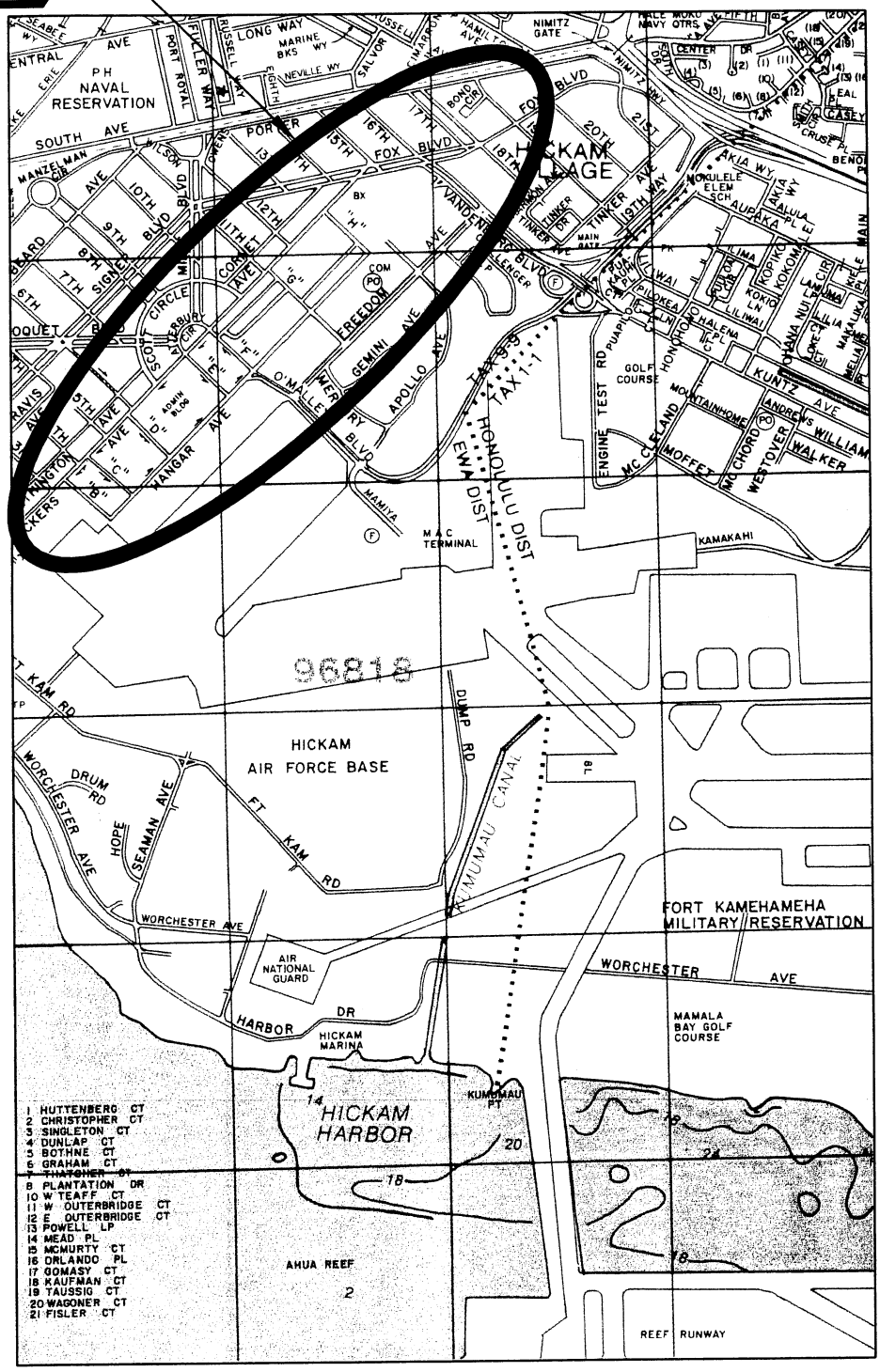
During drilling operations, the soils were continuously logged by our field engineer and classified by visual examination in accordance with the Unified Soil Classification System. The boring logs indicate the depths at which the soils or their characteristics change, although the change could actually be gradual. If the change occurred between sample locations, the depth was interpreted based on field observations. Classifications and sampling intervals are shown on the boring logs. A Boring Log Legend is presented on Plate A3.1, while the Unified Soil Classification System is shown on Plate A3.2. The soils encountered are logged on Plates A4.1 through A4.10.

Boring locations were located in the field by measuring/taping offsets from existing site features shown on the plans. A topographic survey map, provided by MK Engineers, Ltd. on January 22, 2004, was used to estimate the ground surface elevations at boring locations. As the method used for locating points in the field determines the accuracy of the provided location, boring locations shown on Plates A2.2 through A2.5, and surface elevations shown on the boring logs should be considered approximate.

Borings were drilled adjacent to our geotechnical test borings for environmental sampling by Edward K. Noda & Associates, Inc. on October 11 and 12, 2003. The 10 environmental test borings extended to a maximum depth of about 3 meters.

SOIL SAMPLING

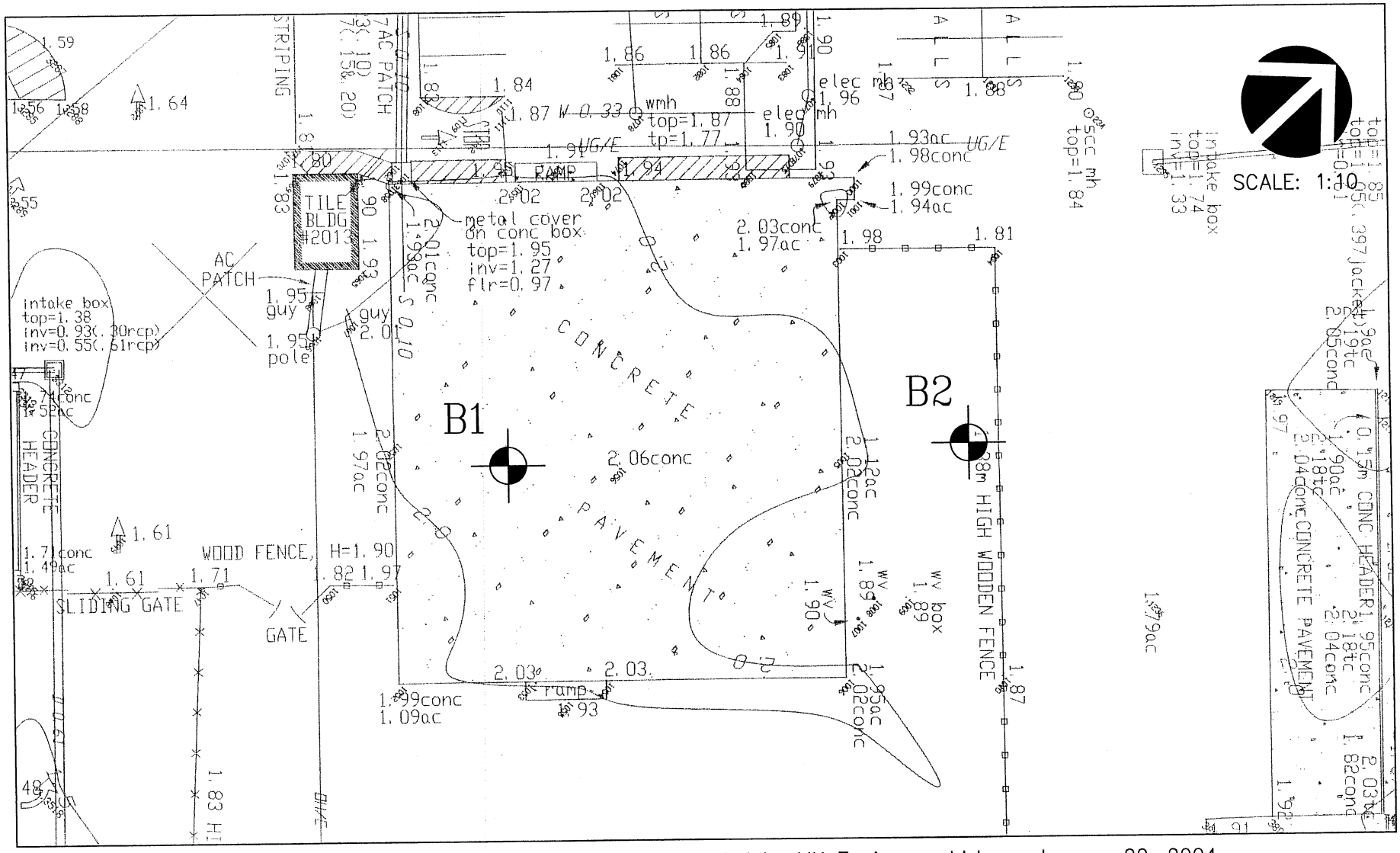
Representative and bulk soil samples were recovered from the borings for selected laboratory testing and analyses. Representative samples were recovered by driving a 3-inch O.D. split tube sampler a total of 450 mm with a 63.5 kg hammer dropped from a height of 760 inches. The number of blows required to drive the sampler the final 300 mm are recorded at the appropriate depths on the boring logs, unless noted otherwise. Bulk soil samples were recovered from near borings B2 and B5, between depths of 300 to 600 mm, for selected laboratory testing that would aid in soil classification and pavement design. In addition, bulk samples of soil and core samples of volcanic tuff were collected and shipped to Geotherm Inc. for thermal resistivity testing.



Reference: Bryan's Sectional Maps, 2003 Edition
(Copyright J.R. Clere, used with permission)

Not to Scale

W.O. 03-3831	**Upgrade Hickam Electrical Distribution System, Phase I**
Ernest K. Hirata & Associates, Inc.	# LOCATION MAP Plate A2.1

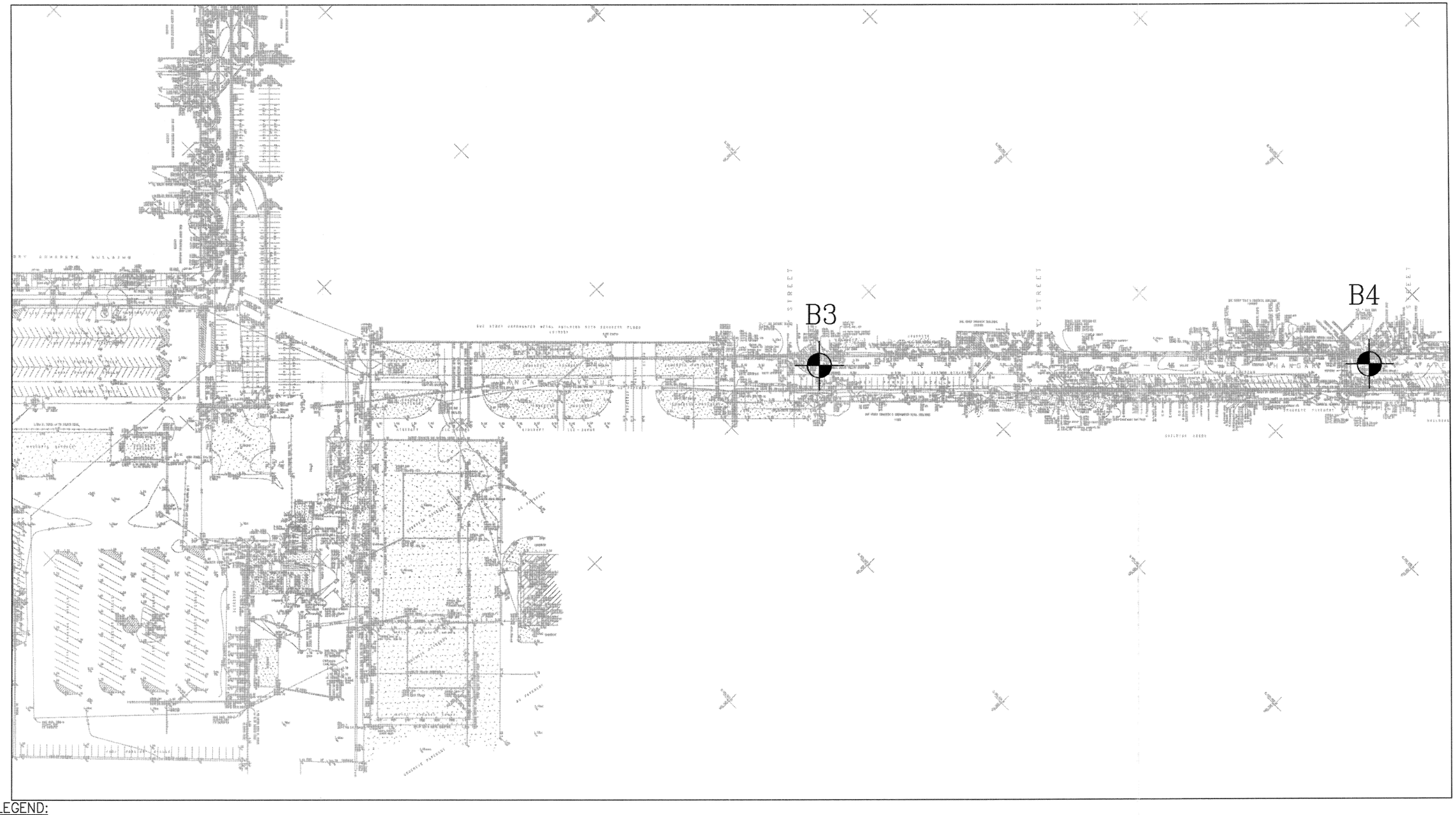


LEGEND:

Approximate location of borings

Reference: Topographic Map provided by MK Engineers, Ltd. on January 22, 2004.

W.O. 03-3831	Upgrade Hickam Electrical Distribution System, Phase I
Ernest K. Hirata & Associates, Inc.	BORING LOCATION PLAN Plate A2.2



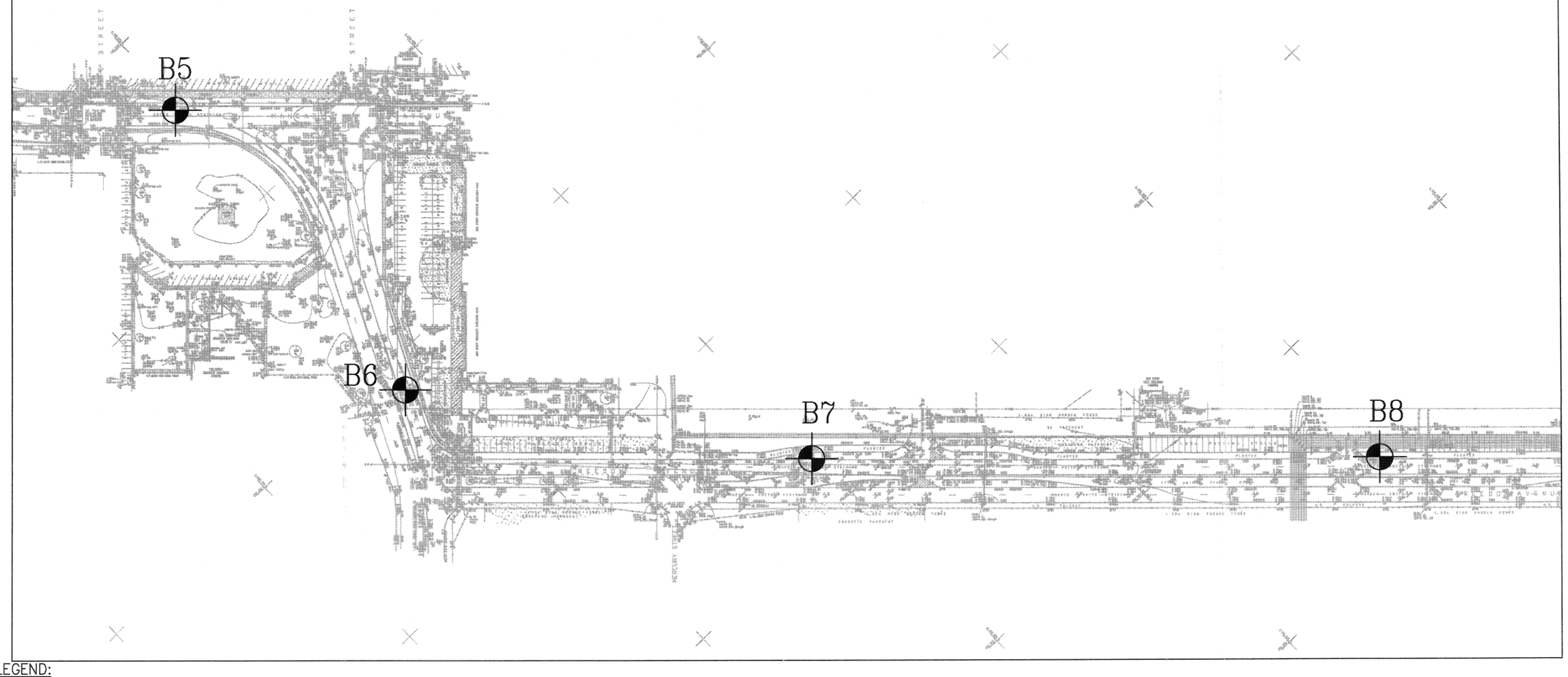
LEGEND:

Approximate location of borings

Reference: Topographic Map provided by MK Engineers, Ltd. on January 22, 2004.

SCALE: 1:50

W.O. 03-3831	Upgrade Hickam Electrical Distribution System, Phase I
Ernest K. Hirata & Associates, Inc.	BORING LOCATION PLAN Plate A2.3



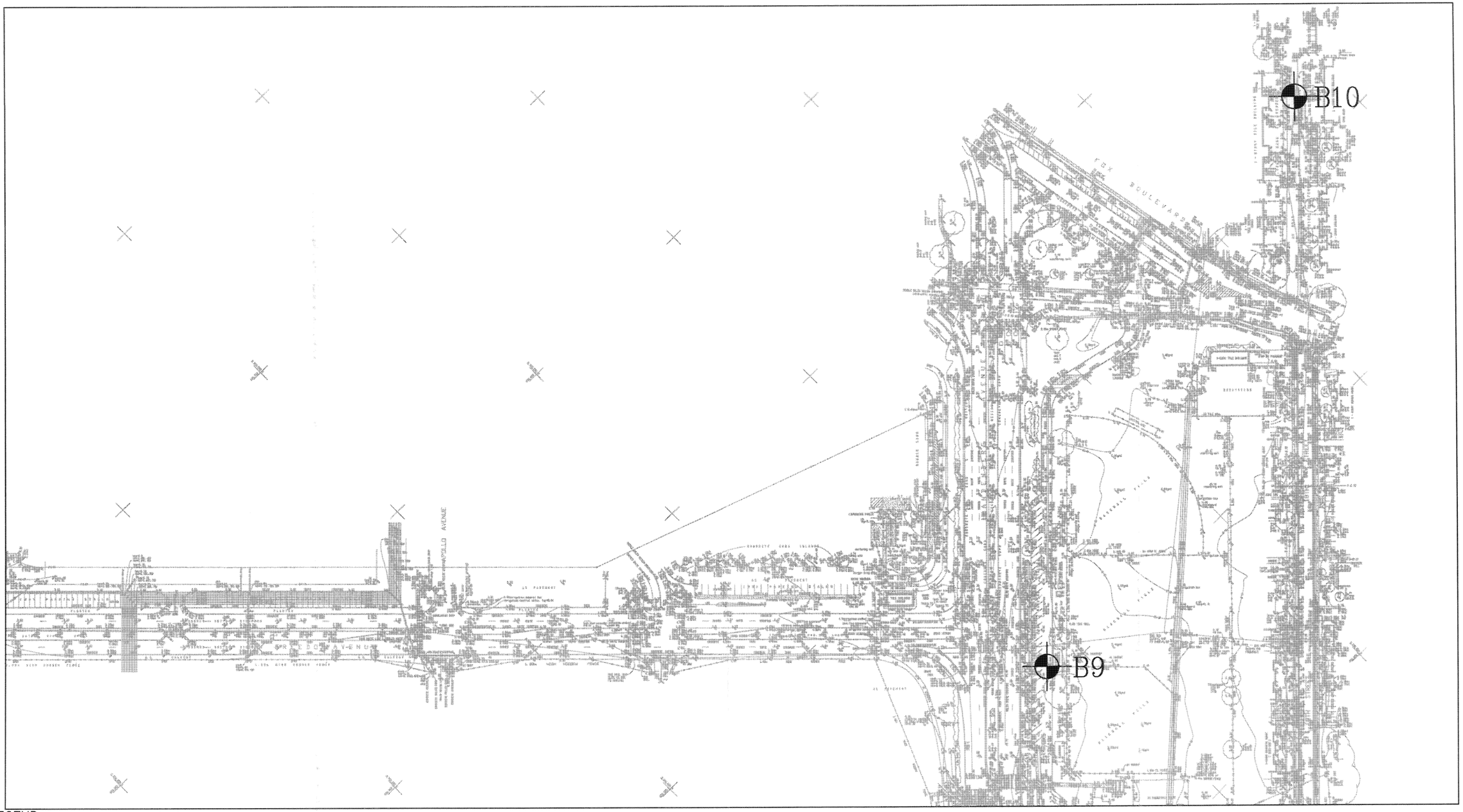
LEGEND:

Approximate location of borings

Reference: Topographic Map provided by MK Engineers, Ltd. on January 22, 2004.

SCALE: 1:50

W.O. 03-3831	Upgrade Hickam Electrical Distribution System, Phase I
Ernest K. Hirata & Associates, Inc.	BORING LOCATION PLAN Plate A2.4



LEGEND:

Approximate location of borings

Reference: Topographic Map provided by MK Engineers, Ltd. on January 22, 2004.

SCALE: 1:50

W.O. 03-3831	Upgrade Hickam Electrical Distribution System, Phase I
Ernest K. Hirata & Associates, Inc.	BORING LOCATION PLAN Plate A2.5

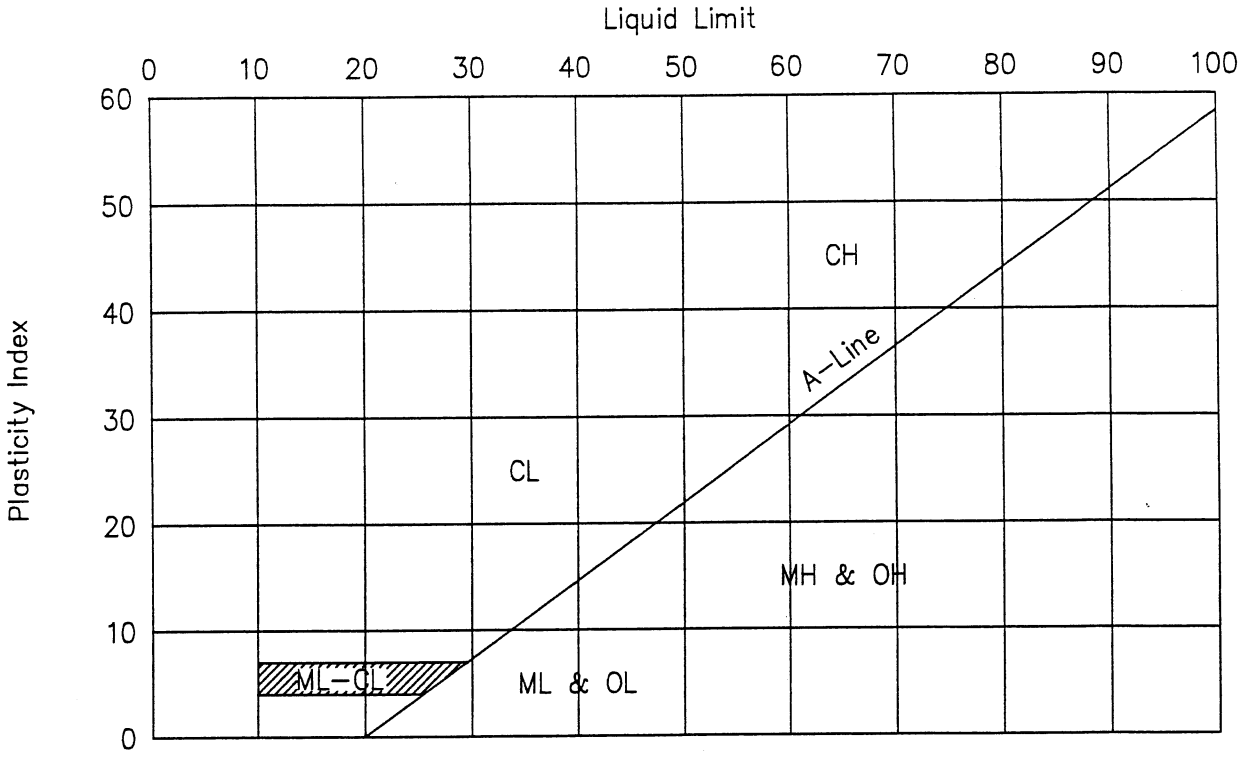
MAJOR DIVISIONS			GROUP SYMBOLS		TYPICAL NAMES
COARSE GRAINED SOILS (More than 50% of the material is LARGER than No. 200 sieve size.)	GRAVELS (More than 50% of coarse fraction is LARGER than the No. 4 sieve size.)	CLEAN GRAVELS (Little or no fines.)		GW	Well graded gravels, gravel–sand mixtures, little or no fines.
				GP	Poorly graded gravels or gravel–sand mixtures, little or no fines.
		GRAVELS WITH FINES (Appreciable amt. of fines.)		GM	Silty gravels, gravel–sand–silt mixtures.
				GC	Clayey gravels, gravel–sand–clay mixtures.
	SANDS (More than 50% of coarse fraction is SMALLER than the No. 4 sieve size.)	CLEAN SANDS (Little or no fines.)		SW	Well graded sands, gravelly sands, little or no fines.
				SP	Poorly graded sands or gravelly sands, little or no fines.
		SANDS WITH FINES (Appreciable amt. of fines.)		SM	Silty sands, sand–silt mixtures.
				SC	Clayey sands, sand–clay mixtures.
FINE GRAINED SOILS (More than 50% of the material is SMALLER than No. 200 sieve size.)	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 silts and organic silty clays of low plasticity.
	SILTS AND CLAYS (Liquid limit GREATER than 50.)			MH	Inorganic silts, micaceous or diatomaceous 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.
					FRESH TO MODERATELY WEATHERED BASALT
					VOLCANIC TUFF / HIGHLY TO COMPLETELY WEATHERED BASALT
					CORAL

LAB/FIELD TEST ABBREVIATIONS	
TV = Torvane	LL = Liquid Limit
DS = Direct Shear	PI = Plasticity Index
CT = Consolidation Test	UC = Unconfined Compression Test

SAMPLE DEFINITION		
50 mm O.D. Standard Split Spoon Sampler	Shelby Tube	RQD Rock Quality Designation
75 mm O.D. Split Tube Sampler	NX / 100 mm Coring	Water Level

W.O. 03–3831	Upgrade Hickam Electrical Distribution System, Phase I
Ernest K. Hirata & Associates, Inc.	BORING LOG LEGEND Plate A3.1

PLASTICITY CHART



GRADATION CHART

COMPONENT DEFINITIONS BY GRADATION	
COMPONENT	SIZE RANGE
Boulders	Above 305 mm
Cobbles	75 mm to 305 mm
Gravel Coarse gravel Fine gravel	75 mm to 4.75 mm 75 mm to 19 mm 19 mm to 4.75 mm
Sand Coarse sand Medium sand Fine sand	4.75 mm to 0.075 mm 4.75 mm to 2.0 mm 2.0 mm to 0.42 mm 0.42 mm to 0.075 mm
Silt and clay	Smaller than 0.075 mm

W.O. 03-3831	Upgrade Hickam Electrical Distribution System, Phase I
Ernest K. Hirata & Associates, Inc.	UNIFIED SOIL CLASSIFICATION SYSTEM Plate A3.2

ERNEST K. HIRATA & ASSOCIATES, INC.

Geotechnical Engineering

BORING LOG

W.O. 03-3831

BORING NO. B1 DRIVING WT. 63.5 kg START DATE 10/28/03

SURFACE ELEV. 2.0 m±* DROP 760 mm END DATE 10/28/03

DEPTH	GRAPH	SAMPLE	BLOWS PER 0.3 m	DRY DENSITY (kN/m³)	MOIST. CONT. (%)	DESCRIPTION
0						Silty Coralline SAND (SM) – Tan, moist, medium dense to dense, with coralline gravel. Covered by 150 mm of concrete.
			26	14.9	10	
1			8/150mm	11.3	41	With reddish brown clayey silt from 700 mm.
			35/50mm			Silty Coralline GRAVEL (GM) – Tan, moist, loose to medium dense, with coralline sand.
2			8	14.9	20	
3			8	16.3	23	
4			5	16.6	23	
5						End boring at 4.7 meters.
						Groundwater measured at 1.6 meters below existing grade at 9:52 am on 10/28/03.
6						
7						
8						* Topographic Survey provided by MK Engineers, Ltd. on January 22, 2004.
9						
10						

Plate A4.1

ERNEST K. HIRATA & ASSOCIATES, INC.

Geotechnical Engineering

BORING LOG

W.O. 03-3831

BORING NO. B2 DRIVING WT. 63.5 kg START DATE 10/28/03

SURFACE ELEV. 1.9 m± DROP 760 mm END DATE 10/28/03

DEPTH	GRAPH	SAMPLE	BLOWS PER 0.3 m	DRY DENSITY (kN/m³)	MOIST. CONT. (%)	DESCRIPTION
0						Silty Coralline SAND (SM) – Tan, moist, medium dense to dense, with coralline gravel. Covered by 50 mm of asphaltic concrete.
1			24	16.0	10	
			32	14.8	26	With brown clayey silt from 1 meter.
2			32	13.7	33	Silty Coralline GRAVEL (GM) – Tan, moist, dense, with coralline sand.
3			14	17.1	18	Medium dense from 2.7 meters.
4			18	15.1	28	
5						End boring at 4.7 meters.
						Groundwater measured at 1.5 meters below existing grade at 10:40 am on 10/28/03.
6						
7						
8						
9						
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Plate A4.2

ERNEST K. HIRATA & ASSOCIATES, INC.

Geotechnical Engineering

BORING LOG

W.O. 03-3831

BORING NO. B3 DRIVING WT. 63.5 kg START DATE 10/28/03

SURFACE ELEV. 2.2± DROP 760 mm END DATE 10/28/03

DEPTH	GRAPH	SAMPLE	BLOWS PER 0.3 m	DRY DENSITY (kN/m³)	MOIST. CONT. (%)	DESCRIPTION
0						Silty Coralline SAND (SM) – Tan, moist, medium dense to dense, with coralline gravel. Covered by 125 mm of asphaltic concrete.
			36	14.1	29	Gravelly from 600 mm.
1			26	13.4	18	Increased silt content from 1 meter.
			17	13.9	30	Silty Coralline GRAVEL (GM) – Tan, moist, medium dense to dense, with coralline sand.
2						
3			19	17.4	23	Grade sandy from 2.6 meters.
4			25/No Penetration			VOLCANIC TUFF – Grayish brown, medium hard to hard.
						End boring at 4.3 meters.
5						Groundwater measured at 1.8 meters below existing grade at 8:31 am on 10/28/03.
6						
7						
8						
9						
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Plate A4.3

ERNEST K. HIRATA & ASSOCIATES, INC.

Geotechnical Engineering

BORING LOG

W.O. 03-3831

BORING NO. B4 DRIVING WT. 63.5 kg START DATE 10/27/03

SURFACE ELEV. 2.5 m± DROP 760 mm END DATE 10/27/03

DEPTH	GRAPH	SAMPLE	BLOWS PER 0.3 m	DRY DENSITY (kN/m3)	MOIST. CONT. (%)	DESCRIPTION
0						Silty Coralline SAND (SM) – Tan, moist, dense, with coralline gravel. Covered by 125 mm of asphaltic concrete.
1			80	14.8	14	
			16	14.3	20	Grade medium dense from 1 meter.
2 ▽			50/50mm	12.6	35	VOLCANIC TUFF – Grayish brown, medium hard to hard. Fuel odor from 2.4 meters.
3						End boring at 2.7 meters.
4						Groundwater measured at 2.3 meters below existing grade at 3:16 pm on 10/27/03.
5						
6						
7						
8						
9						
10						

Plate A4.4

ERNEST K. HIRATA & ASSOCIATES, INC.

Geotechnical Engineering

BORING LOG

W.O. 03-3831

BORING NO. B5 DRIVING WT. 63.5 kg START DATE 10/28/03

SURFACE ELEV. 2.8 m± DROP 760 mm END DATE 10/28/03

DEPTH	GRAPH	SAMPLE	BLOWS PER 0.3 m	DRY DENSITY (kN/m³)	MOIST. CONT. (%)	DESCRIPTION
0						Silty Coralline SAND (SM) – Tan, moist, medium dense, with coralline gravel. Covered by 125 mm of asphaltic concrete.
			13/150mm 15/150mm	17.3	13	
1			24	15.8	19	With brown clayey silt from 700 mm.
						Grade loose from 1.5 meters.
2			6	15.6	21	
3			44/225mm	15.8	22	Grade gravelly and dense from 2.6 meters.
4			25/No Penetration			VOLCANIC TUFF – Grayish brown, medium hard to hard.
5						End boring at 4.5 meters.
						Groundwater measured at 1.9 meters below existing grade at 11:40 am on 10/28/03.
6						
7						
8						
9						
10						

Plate A4.5

ERNEST K. HIRATA & ASSOCIATES, INC.

Geotechnical Engineering

BORING LOG

W.O. 03-3831

BORING NO. B6 DRIVING WT. 63.5 kg START DATE 10/27/03

SURFACE ELEV. 3.1 m± DROP 760 mm END DATE 10/27/03

DEPTH	GRAPH	SAMPLE	BLOWS PER 0.3 m	DRY DENSITY (kN/m³)	MOIST. CONT. (%)	DESCRIPTION
0						Silty Coralline SAND (SM) – Tan, moist, dense, with coralline gravel. Covered by 100 mm of asphaltic concrete.
1		□	88	15.0	12	
		□	65	15.1	19	
2		□	15	12.0	46	Silty CLAY (CL–CH) – Grayish brown, moist, medium stiff to stiff.
3		□	15	11.1	50	
4		□	18	10.6	47	Grade dark grayish brown from 4.4 meters.
5						End boring at 4.7 meters.
6						Neither groundwater nor seepage water observed.
7						
8						
9						
10						

Plate A4.6

ERNEST K. HIRATA & ASSOCIATES, INC.

Geotechnical Engineering

BORING LOG

W.O. 03-3831

BORING NO. B7 DRIVING WT. 63.5 kg START DATE 10/27/03

SURFACE ELEV. 3.3 m± DROP 760 mm END DATE 10/27/03

DEPTH	GRAPH	SAMPLE	BLOWS PER 0.3 m	DRY DENSITY (kN/m³)	MOIST. CONT. (%)	DESCRIPTION
0			34	12.8	38	Silty CLAY (CL–CH) – Brown, moist, stiff, with sand and coralline gravel. Covered by 100 mm of asphaltic concrete over 150 mm of concrete.
1			49	11.6	40	VOLCANIC TUFF – Grayish brown, medium hard, to hard.
			25/No Penetration			
2						
			25/No Penetration			
3						
4			46/150mm 15/No Penetration	12.1	45	
5						End boring at 4.6 meters. Groundwater measured at 2.7 meters below existing grade at 12:19 pm on 10/27/03.
6						
7						
8						
9						
10						

Plate A4.7

ERNEST K. HIRATA & ASSOCIATES, INC.

Geotechnical Engineering

BORING LOG

W.O. 03-3831

BORING NO. B8 DRIVING WT. 63.5 kg START DATE 10/27/03

SURFACE ELEV. 3.8 m± DROP 760 mm END DATE 10/27/03

DEPTH	GRAPH	SAMPLE	BLOWS PER 0.3 m	DRY DENSITY (kN/m³)	MOIST. CONT. (%)	DESCRIPTION
0			46	14.5	23	Silty Coralline SAND (SM) – Tan, moist, dense, with coralline gravel. Covered by 75 mm of asphaltic concrete over 100 mm of base.
1			26	12.4	38	Silty CLAY (CL–CH) – Grayish brown, moist, stiff, with sand.
			42/150mm	13.1	30	
2			50/75mm			VOLCANIC TUFF – Grayish brown, medium hard to hard.
3			15/No Penetration			
4			15/No Penetration			Fuel odor from 3.8 meters.
5						End boring at 4.3 meters. Neither groundwater nor seepage water observed.
6						
7						
8						
9						
10						

Plate A4.8

ERNEST K. HIRATA & ASSOCIATES, INC.

Geotechnical Engineering

BORING LOG

W.O. 03-3831

BORING NO. B9 DRIVING WT. 63.5 kg START DATE 10/27/03

SURFACE ELEV. N/A DROP 760 mm END DATE 10/27/03

DEPTH	GRAPH	SAMPLE	BLOWS PER 0.3 m	DRY DENSITY (kN/m^3)	MOIST. CONT. (%)	DESCRIPTION
0			50/125mm	15.4	6	Silty Coralline SAND (SM) – Tan, moist, dense, with coralline gravel. Covered by 75 mm of asphaltic concrete over 100 mm of base.
1			65/100mm	11.0	19	VOLCANIC TUFF – Grayish brown, medium hard. to hard. NX core from 1.1 to 1.5 meters. 90% Recovery from 1.1 to 1.5 meters.
2			15/No Penetration			
3			15/No Penetration			
4			15/No Penetration			
5						End boring at 4.3 meters. Neither groundwater nor seepage water observed.
6						
7						
8						
9						
10						

Plate A4.9

ERNEST K. HIRATA & ASSOCIATES, INC.

Geotechnical Engineering

BORING LOG

W.O. 03-3831

BORING NO. B10 DRIVING WT. 63.5 kg START DATE 10/28/03

SURFACE ELEV. N/A DROP 760 mm END DATE 10/28/03

DEPTH	GRAPH	SAMPLE	BLOWS PER 0.3 m	DRY DENSITY (kN/m³)	MOIST. CONT. (%)	DESCRIPTION
0			25	13.7	33	Silty CLAY (CH) – Grayish brown, moist, medium stiff, with sand. Covered by 75 mm of asphaltic concrete over 225 mm of base.
1			62/150mm	15.1	20	VOLCANIC TUFF – Grayish brown, medium hard.
2			15/No Penetration			
3			50/100mm	15.6	25	
4			45/75mm			
5						End boring at 4.4 meters. Neither groundwater nor seepage water observed.
6						
7						
8						
9						
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Plate A4.10

APPENDIX B

LABORATORY TESTING

DESCRIPTION OF LABORATORY TESTING

CLASSIFICATION

Field classification was verified in the laboratory in accordance with the Unified Soil Classification System. Laboratory classification was determined by both visual examination and sieve analysis testing performed in general accordance with ASTM D 422. The final classifications are shown at the appropriate locations on the Boring Logs, Plates A4.1 through A4.10.

MOISTURE-DENSITY

Representative samples were tested for field moisture content and dry unit weight. The dry unit weight was determined in pounds per cubic foot while the moisture content was determined as a percentage of dry weight. Samples were obtained using a 75 mm O.D. split tube sampler. Test results are shown at the appropriate depths on the Boring Logs, Plates A4.1 through A4.10.

CONSOLIDATION

Representative samples were tested for their consolidation characteristics. Test samples were 61.5 mm (2.42 inches) in diameter and 25 mm (1 inch) high. Porous stones were placed in contact with the top and bottom of test samples to permit addition and release of pore fluid. Loads were then applied in several increments in a geometric progression, and the resulting deformations recorded at selected time intervals. Test results are plotted on the Consolidation Test Reports, Plates B2.1 through B2.3.

SHEAR TESTS

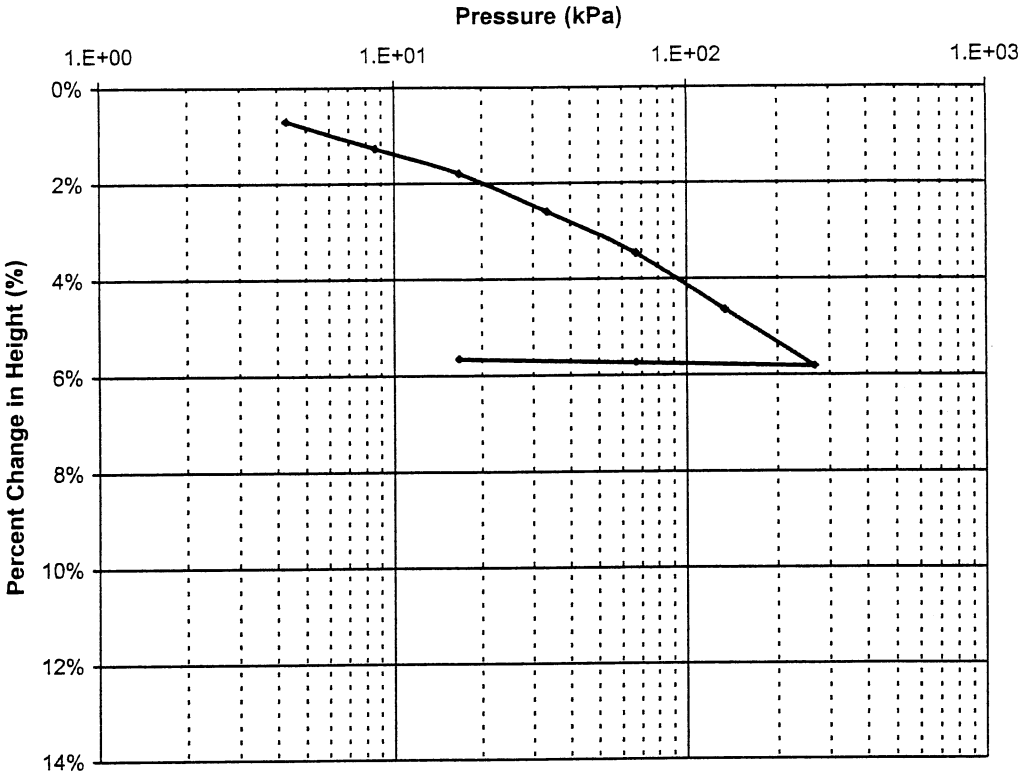
Shear tests were performed in the Direct Shear Machine which is of the strain control type. The rate of deformation was approximately 0.5 mm (0.02 inches) per minute. Each sample was sheared under varying confining loads in order to determine the

Coulomb shear strength parameters, cohesion and angle of internal friction. Eighty percent of the maximum value was taken to determine the shear strength parameters. Test results are presented on Plates B3.1 through B3.3.

SIEVE ANALYSIS

Sieve analysis tests were conducted on bulk samples from borings B2 and B5 between depths of 300 to 600 mm. Tests were performed in general accordance with ASTM D 422. The test is used to classify granular soils. Test results are presented on Plate B4.1.

Consolidation Test Results



Sample Description

Boring No.: B1 **Depth (m):** 1.50

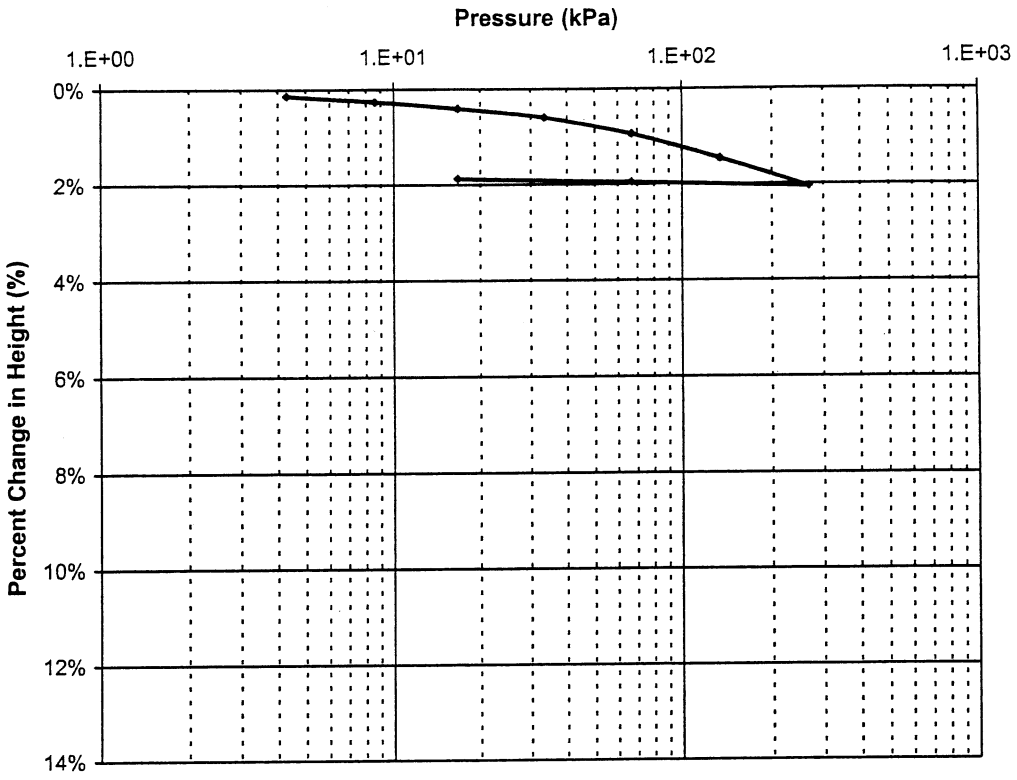
Soil Description: Tan silty coralline gravel with sand

	Moisture Content (%)	Dry Density (kN/m^3)
Initial	19.7	14.9
Final	15.7	15.8

Remark: Date: 12/4/03

W.O. 03-3831	Upgrade Hickam Electrical Distribution System, Phase I
Ernest K. Hirata & Associates, Inc.	**CONSOLIDATION TEST** Plate B2.1

Consolidation Test Results



Sample Description

Boring No.: B5 **Depth (m):** 1.50

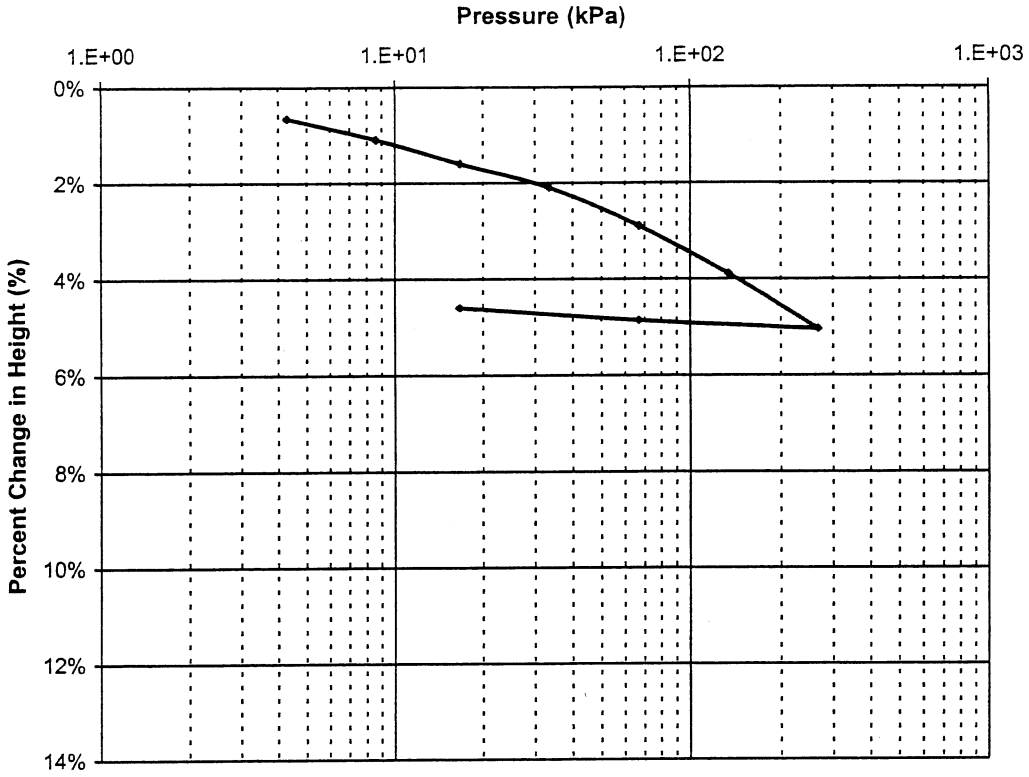
Soil Description: Tan silty coralline sand with gravel

	Moisture Content (%)	Dry Density (kN/m^3)
Initial	21.4	15.6
Final	17.2	15.9

Remark: Date: 12/4/03

W.O. 03-3831	Upgrade Hickam Electrical Distribution System, Phase I
Ernest K. Hirata & Associates, Inc.	**CONSOLIDATION TEST** Plate B2.2

Consolidation Test Results



Sample Description

Boring No.: B6 **Depth (m):** 1.50

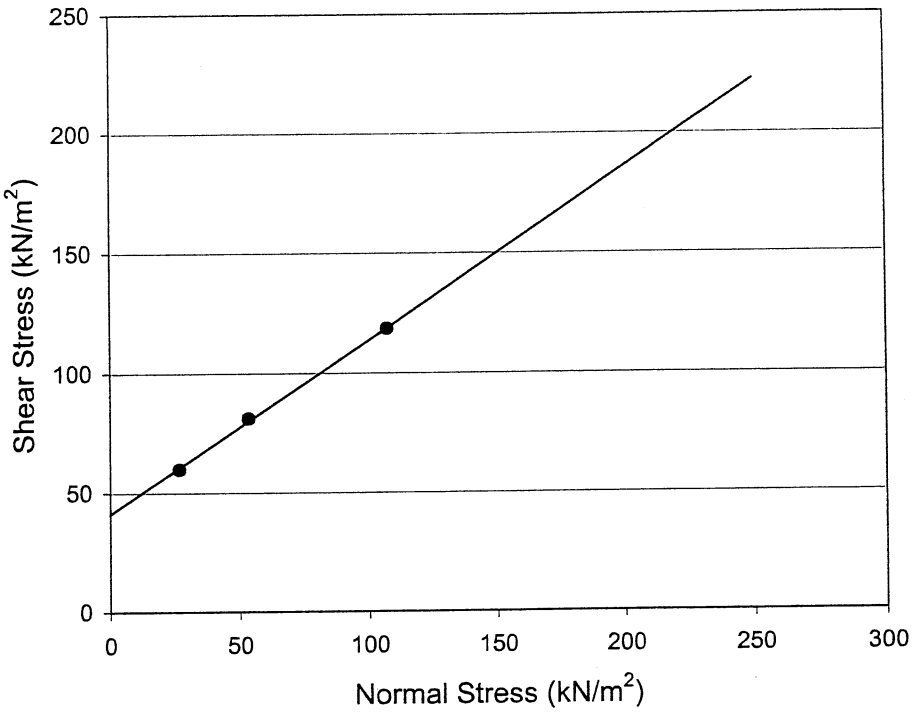
Soil Description: Grayish brown silty clay

	Moisture Content (%)	Dry Density (kN/m^3)
Initial	46.4	12.0
Final	43.6	12.6

Remark: Date: 12/4/03

W.O. 03-3831	Upgrade Hickam Electrical Distribution System, Phase I
Ernest K. Hirata & Associates, Inc.	**CONSOLIDATION TEST** Plate B2.3

Direct Shear Test Results



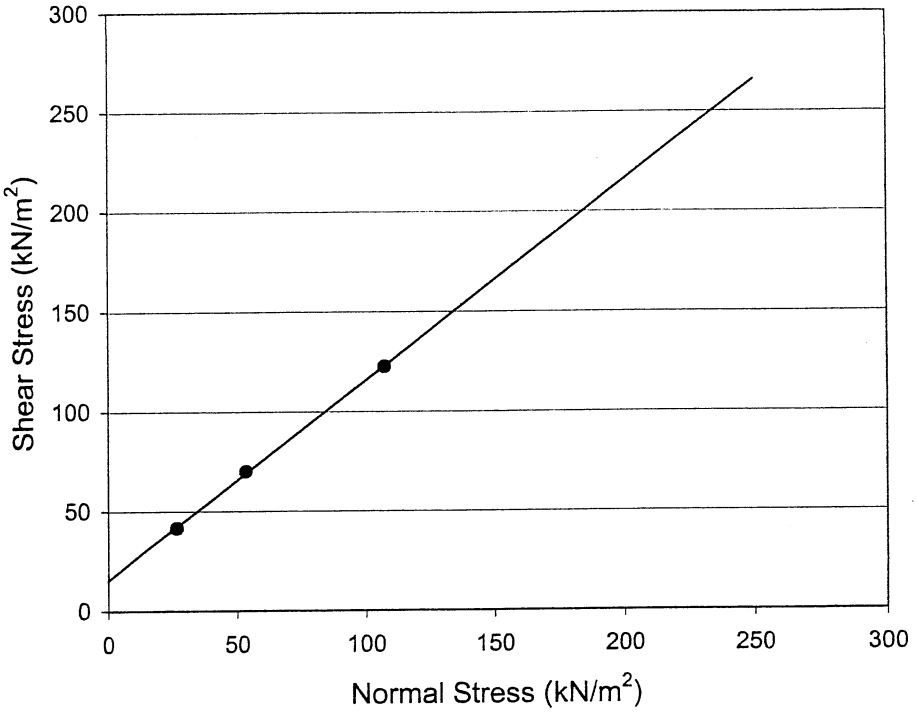
Sample Description

Boring No.: B2 **Depth (m):** 1.00
Soil Description: Tan silty coralline sand with gravel
Strength Intercept (C): 40.9 kN/m^2 (Peak Strength)
Friction Angle (ϕ): 36.0 DEG (Peak Strength)

Remark: Date: 11/20/03

W.O. 03-3831	Upgrade Hickam Electrical Distribution System, Phase I
Ernest K. Hirata & Associates, Inc.	**DIRECT SHEAR TEST** Plate B3.1

Direct Shear Test Results



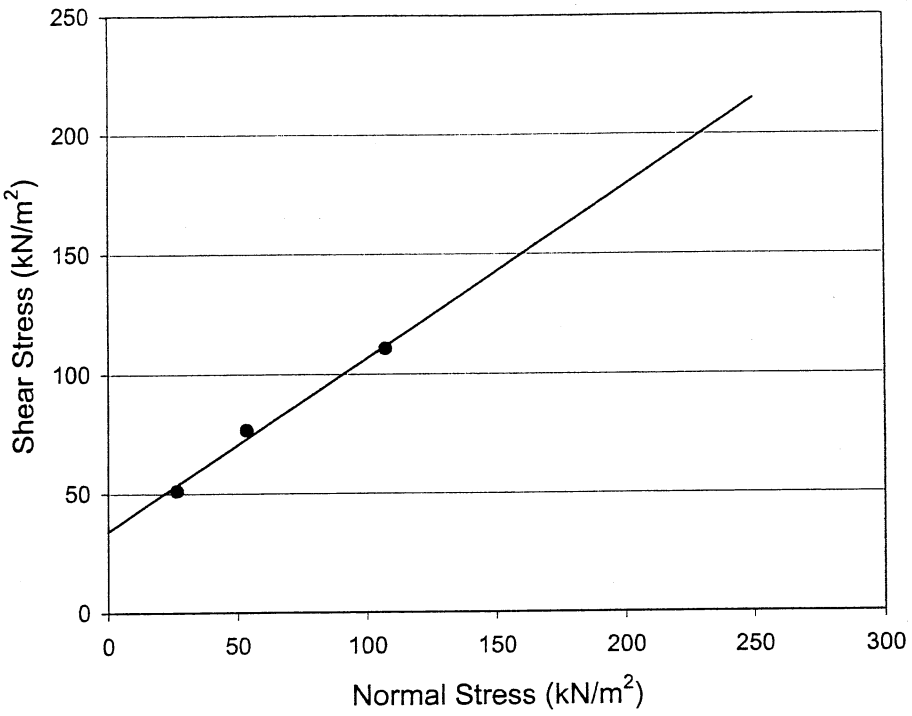
Sample Description

Boring No.: B4 **Depth (m):** 1.00
Soil Description: Tan silty sand with coralline gravel
Strength Intercept (C): 15.2 kN/m^2 (Peak Strength)
Friction Angle (ϕ): 45.1 DEG (Peak Strength)

Remark: Date: 11/20/03

W.O. 03-3831	Upgrade Hickam Electrical Distribution System, Phase I
Ernest K. Hirata & Associates, Inc.	**DIRECT SHEAR TEST** Plate B3.2

Direct Shear Test Results

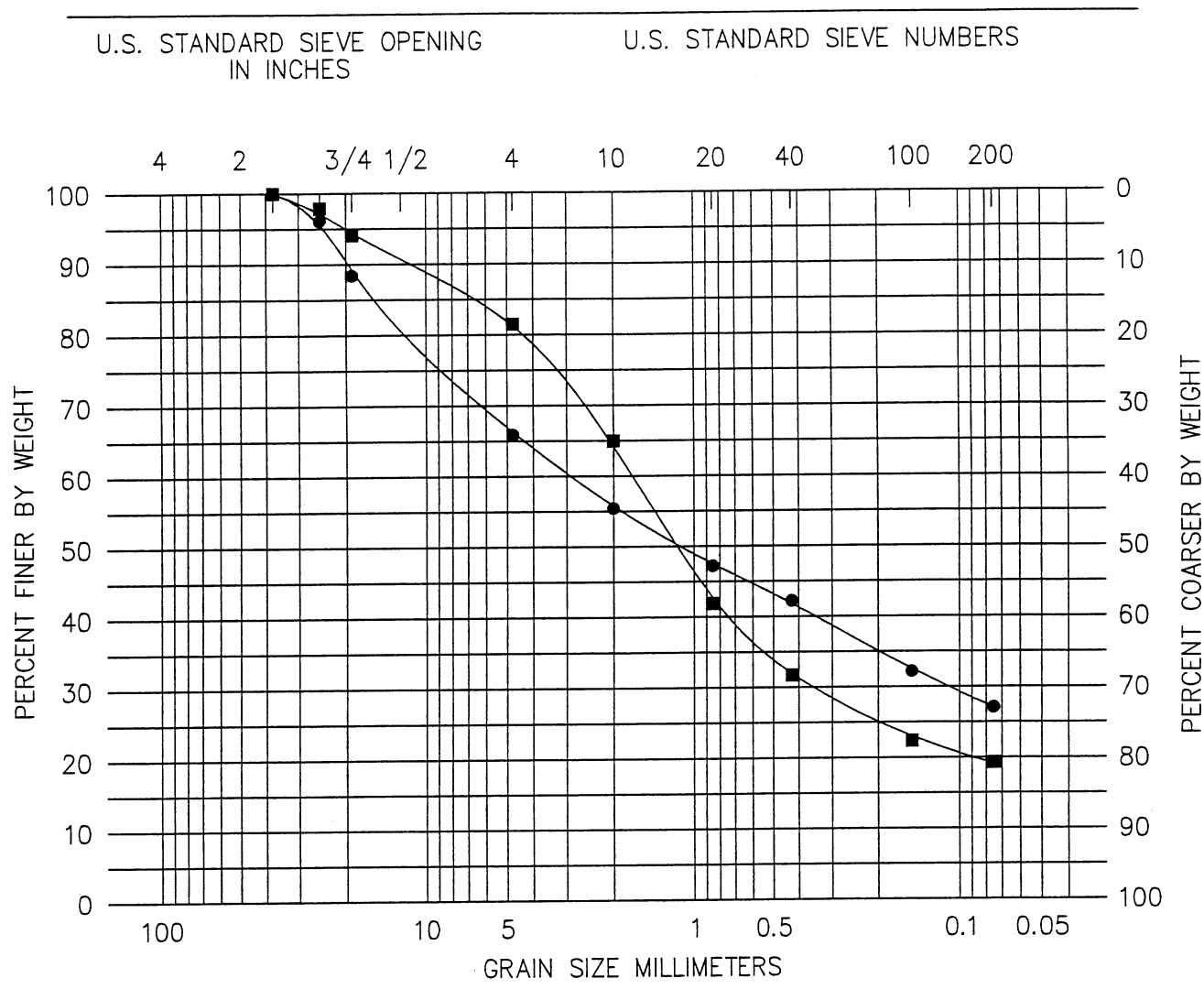


Sample Description

Boring No.: B8 **Depth (m):** 0.30
Soil Description: Tan silty coralline sand with gravel
Strength Intercept (C): 33.9 kN/m^2 (Peak Strength)
Friction Angle (ϕ): 35.9 DEG (Peak Strength)

Remark: Date: 11/20/03

W.O. 03-3831	Upgrade Hickam Electrical Distribution System, Phase I
Ernest K. Hirata & Associates, Inc.	**DIRECT SHEAR TEST** Plate B3.3



COBBLES	GRAVEL		SAND			SILT or CLAY
	Coarse	Fine	Coarse	Medium	Fine	

● Sample #1	Location:	Boring B2 at 300 to 600 mm
	Description:	Tan silty coralline sand with coralline gravel
■ Sample #2	Location:	Boring B5 at 300 to 600 mm
	Description:	Tan silty coralline sand with coralline gravel

W.O. 03-3831	Upgrade Hickam Electrical Distribution System, Phase I
Ernest K. Hirata & Associates, Inc.	GRADATION CURVES Plate B4.1

ATTACHMENT #8

LIST OF GRAPHICS

(DRAWINGS ARE BOUND
SEPARATELY FROM THIS SET)

LIST OF DRAWINGS
DRAWINGS DATED: FEBRUARY 2004

RING NO.	DRAWING NO.	SHT NO.	TITLE
FY04 MCP PN KNMD 01-03002A1			
UPGRADE ELECTRICAL DISTRIBUTION SYSTEM, PH. 1			
HICKAM AIR FORCE BASE, OAHU, HAWAII			
001	812-42-05	G-101	PROJECT TITLE, VICINITY MAP, LOCATION MAP
002	812-42-05	G-102	SCHEDULE OF DRAWINGS AND PROJECT SCHEDULE
003	812-42-05	C-101	NEW MAMALA SUBSTATION PLAN
004	812-42-05	S-101	STRUCTURAL PLANS AND SECTIONS
005	812-42-05	A-101	FLOOR PLAN, REFELCTED CEILING PLAN AND ROOF PLAN
006	812-42-05	A-102	BUILDING SECTION AND INTERIOR ELEVATIONS
007	812-42-05	A-103	EXTERIOR ELEVATION
008	812-42-05	A-104	DOOR, LOUVER, & FINISH SCHEDULE AND DETAIL
009	812-42-05	E-001	ELECTRICAL SYMBOLS AND NOTES
010	812-42-05	E-002	ABBREVIATIONS
011	812-42-05	E-003	HECO NOTES
012	812-42-05	E-101	OVERALL SITE ELECTRICAL PLAN
013	812-42-05	E-102	PARTIAL SITE ELECTRICAL PLAN "A"
014	812-42-05	E-103	PARTIAL SITE ELECTRICAL PLAN "B"
015	812-42-05	E-104	PARTIAL SITE ELECTRICAL PLAN "C"
016	812-42-05	E-105	PARTIAL SITE ELECTRICAL PLAN "D"
017	812-42-05	E-106	PARTIAL SITE ELECTRICAL PLAN "E"
018	812-42-05	E-107	PARTIAL SITE ELECTRICAL PLAN "F"
019	812-42-05	E-108	PARTIAL SITE ELECTRICAL PLAN "G"
020	812-42-05	E-109	PARTIAL SITE ELECTRICAL PLAN "H"
021	812-42-05	E-110	PARTIAL SITE ELECTRICAL PLAN "I"
022	812-42-05	E-111	PARTIAL SITE ELECTRICAL PLAN "J"
023	812-42-05	E-112	PARTIAL SITE ELECTRICAL PLAN "K"
024	812-42-05	E-113	PARTIAL SITE ELECTRICAL PLAN "L"
025	812-42-05	E-114	PARTIAL SITE ELECTRICAL PLAN "M"
026	812-42-05	E-115	PARTIAL SITE ELECTRICAL PLAN "N"
027	812-42-05	E-116	BASE PLAN PART A
028	812-42-05	E-117	BASE PLAN PART B
029	812-42-05	E-401	OVERALL SUBSTATION PLAN
030	812-42-05	E-402	SUBSTATION ELECTRIC AND LIGHTING PLANS
031	812-42-05	E-403	SUBSTATION GROUNDING PLAN AND DETAIL
032	812-42-05	E-501	SWICHGEAR DETAILS
033	812-42-05	E-502	DUCT SECTION DETAILS
034	812-42-05	E-503	ELECTRICAL DETAILS
035	812-42-05	E-504	1230 X 1830 (4' X 6') MANHOLE DETAIL
036	812-42-05	E-505	1830 X 3350 (6' X 11') MANHOLE DETAIL
037	812-42-05	E-506	1830 X 4720 (6' X 14') MANHOLE DETAIL
038	812-42-05	E-601	ONE LINE DIAGRAM PART "A"
039	812-42-05	E-602	ONE LINE DIAGRAM PART "B"
040	812-42-05	E-603	SWITCHGEAR "MA" ONE LINE DIAGRAM
041	812-42-05	E-604	SWITCHGEAR "MB" ONE LINE DIAGRAM
042	812-42-05	E-605	11.5 KV MANHOLE DIAGRAM PART "A"
043	812-42-05	E-606	11.5 KV MANHOLE DIAGRAM PART "B"

044	812-42-05	E-607 MANHOLE DEVELOPMENT DIAGRAMS
045	812-42-05	E-608 MANHOLE DEVELOPMENT DIAGRAMS
046	812-42-05	E-609 MANHOLE DEVELOPMENT DIAGRAMS
047	812-42-05	E-610 MANHOLE DEVELOPMENT DIAGRAMS
048	812-42-05	E-611 MANHOLE DEVELOPMENT DIAGRAMS