Draft

August , 1987

Southern California Rail Consultants
403 West Eighth Street, Suite 800
Los Angeles, California 90014

Contract No. TW 1005
(Our Job No. A-85005-16)

Attention: Mr. Steve Tayanipour

Gentlemen:

Geotechnical Investigation for
Slauson Avenue and Imperial Highway Facilities
Proposed Traction Power Supply System
Long Beach-Los Angeles Rail Transit Project

SCOPE

This letter presents the results of a geotechnical investigation for the Slauson Avenue and Imperial Highway Facilities of the Traction Power Supply System (TPSS) of the proposed Long Beach-Los Angeles Rail Transit Project. We previously performed a geotechnical investigation for the TPSS sites of the transit project and submitted the results in a report dated July 29, 1987; however, access to the Slauson Avenue and Imperial Highway sites were not available at that time. This letter supplements the report dated July 29, 1987 and should be considered as part of that report.

The professional opinions presented in this letter have been developed using that degree of care and skill ordinarily exercised, under similar circumstances, by reputable geotechnical engineers practicing in this or similar localities. No other warranty, expressed or implied, is made as to the professional advice included in this letter.

PROJECT DESCRIPTION

Traction Power Supply System (TPSS) facilities are planned near the alignment of the rail transit project at Slauson Avenue and Imperial Highway. The locations of the proposed TPSS facilities are presented on Figures 1-1 and 1-2, Site and Boring Location Plan.

Each of the TPSS facilities will consist of a prefabricated substation structure and a communications and signal building.

FIELD EXPLORATION

At the time of the initial investigation, permission to enter the Slauson Avenue and Imperial Highway sites had not been granted. The borings had to be deferred until the necessary permits were granted by the Southern Pacific Transportation Company and Caltrans, respectively.

Four borings (Boring T-09, T-10, T-18 and T-19) were drilled at the two sites. The boring locations are shown on Figures 1-1 and 1-2. The borings were drilled to depths of 25 feet below the existing grade using 24-inch-diameter bucket and 5-inch-diameter rotary wash-type drilling equipment. Raveling occurred in one of the borings as indicated on the boring logs.

The soils encountered were logged by our field technician and both undisturbed and loose samples were obtained for laboratory inspection and testing. The logs of the borings are presented on Figures 2-1 through 2-4; the depths at which undisturbed samples were obtained are indicated to the left of the boring logs. The energy required to drive the sampler 12 inches is indicated on the logs. The soils are classified in accordance with the Unified Soil Classification System described on Figure 3. An explanation of the information presented on the boring logs is presented on Figure 4.

LABORATORY TESTING

The field moisture content and dry density of the soils encountered were determined by performing tests on the undisturbed samples. The results of these index property tests are shown to the left of the boring logs.

Direct shear tests were performed on selected undisturbed samples. The tests were performed at field and increased moisture contents and at surcharge pressures equal to the existing overburden pressures. Selected samples were tested at an increased surcharge pressure to provide more complete data. All of the samples were tested at a constant strain of 0.05 inches per minute. The yield-point values determined from the direct shear tests are presented on Figures 5-1 and 5-2.

Undisturbed samples and remolded samples, compacted to 90% at optimum moisture content, were tested in consolidometers to determine the consolidation characteristics of the soils. Vertical loads were instantaneously applied in increments and the rate of vertical consolidation was measured for each increment. Water was added to selected samples during the tests to illustrate the effect of moisture on the compressibility; the other samples were tested at field moisture content. The results of the consolidation tests are presented on Figures 6-1 through 6-4.

The optimum moisture content and maximum dry density of the soils were determined by performing compaction tests on two samples. The tests were performed in accordance with the ASTM Designation D1557-78 method of compaction. This method of compaction utilizes a 1/30 cubic-foot mold, in which each of five layers of soil is compacted by 25 blows of a 10-pound hammer falling 18 inches.

After completion of the compaction tests, California Bearing Ratio tests were performed on two of the samples in accordance with the ASTM Designation D1883-73 method. The results of the compaction and California Bearing Ratio tests are presented on Figure 7, Compaction and CBR Tests Data.

SOIL CONDITIONS

SLAUSON AVENUE

Existing fill soils, one to four feet in thickness, were encountered in the two borings. The fill soils consisted of silt and are moderately soft to moderately firm. Some debris and gravel was encountered in the fill. Thicker and/or poorer quality fill could occur between borings.

The natural soils consisted of silt and silty sand. The upper natural soils are only moderately firm at present moisture content and will become weaker when wet. The natural soils become firmer with depth. Water was not encountered.

IMPERIAL HIGHWAY

Existing fill soils, 2½ feet in thickness, were encountered in one of two borings. The fill consisted of silty sand with some debris. The fill soils are moderately firm.

The natural soils consisted of silty sand, sand and silt. The natural soils are only moderately firm at present moisture content and will become weaker and more compressible when wet. Water was not encountered.

RECOMMENDATIONS

SOIL PROPERTIES FOR STATIC DESIGN

The soil properties presented in Table 1 are based on the moisture content and the dry unit weight of the soils presented in the boring logs, and the shear test results presented in Figures 5-1 and 5-2.

Table 1

Summary of Soil Properties for Static Design

TPSS Facility	Ø (deg)	C (psf)	Moist Unit Weight (pcf)
Slauson Avenue	28	50	105
Imperial Highway	27	100	105

FOUNDATION SUPPORT

Foundation design recommendations are presented herein for the proposed Traction Power Supply System facilities at Slauson Avenue and Imperial Highway. Structural loads are not available for the various facilities at this time, however, the loads are anticipated to be relatively light. Accordingly, the recommendations presented herein should be reviewed at such time that the structural information becomes available.

The proposed TPSS structures at these locations may be supported on spread footings established in properly compacted fill soils. Footing excavations should be carefully inspected to verify the competency of the compacted fill soils. If the grading recommendations discussed in the following section on grading are followed and if inspection of the footing excavations is performed as recommended, the spread footings may be designed to impose an allowable bearing pressure of 2,000 pounds per square foot. The footings should be established at a depth of at least two feet below the lowest adjacent grade. Also, the footings should be underlain by at least three feet of compacted fill.

The settlement of the facilities at the planned TPSS facilities, supported on spread footings in the manner recommended, will depend on the loads imposed, but should be within acceptable limits.

Lateral loads may be resisted by soil friction and by the passive resistance of the soils. A coefficient of friction of 0.4 may be used between footings or the floor slab and the supporting soils.

The passive resistance of the natural soils or properly compacted fill against spread footings may be assumed to be equal to the pressure developed by a fluid with a density of 250 pounds per cubic foot. A one-third increase in the passive value may be used for wind or seismic loads. The frictional resistance and the passive resistance of the soils may be combined, without reduction, in determining the total lateral resistance.

GRADING

To provide improved support for spread footings and the building floor slabs, any uncompacted fill should be excavated, the underlying natural soils should be reworked, and all required fill should be properly compacted. To provide support for shallow spread footings, the upper natural soils beneath the footings should be excavated and replaced as compacted fill; footings should be underlain by at least three feet of compacted fill.

After clearing the sites and removing any existing paving and vegetation, all uncompacted fill soils and disturbed natural soils should be excavated. Within footing areas and at least three feet beyond in plan, the soils should be excavated to a depth of at least three feet below the footing bottoms.

After excavating as recommended, the exposed soils should be inspected by a qualified and competent geotechnical engineer to verify the removal of all unsuitable deposits. Next, the exposed natural soils should be scarified to a depth of at least six inches and rolled with heavy compaction equipment. The upper six inches of exposed natural soils should be compacted to at least 90% of the maximum density obtainable by the ASTM Designation D1557-78 method of compaction.

After compacting the exposed soils, any required fill should be placed in horizontal lifts not more than eight inches in thickness and compacted to at least 90%. Granular soils should be compacted at a moisture content varying no more than 2% below or above optimum moisture content.

The on-site soils, less any debris or organic matter within existing fill, may be used in the required fills. Any required imported fill should consist of relatively non-expansive soils. The Expansion Index of the material should be less than 35. The material should contain sufficient fines (binder material) so as to be relatively impermeable when compacted and result in a stable subgrade.

The excavation of the fill, the reworking of the underlying soils and the compaction of all required fill should be observed and tested by a qualified and competent geotechnical engineer. All required fill material should be approved for use prior to placement and compaction. The bearing value of the compacted soils should be verified after placement by appropriate testing.

PAVING

General

To provide data for the design of asphaltic paving, California Bearing Ration tests were performed on selected samples. The results are summarized in Figure 7, Compaction and CBR Test Data.

To provide support for paving, the subgrade soils should be properly prepared. Compaction of the subgrade to at least 90%, including trench backfills, will be important for paving support. The preparation of the subgrade should be done immediately prior to the placement of the base course. Proper drainage of the paved areas should be provided to reduce moisture infiltration into the subgrade and increase the life of the paving.

Subgrade Preparation

Existing fill soils should be excavated to a depth of at least one foot below the planned subgrade level. After excavating as recommended, the exposed soils should be proof-rolled to determine the presence of any unsuitable deposits which should be removed by further excavation. Next, the exposed soils should be scarified to a depth of six inches and rolled with heavy compaction equipment. The upper six inches of exposed soils should be compacted to at least 90% of the maximum density obtainable by the ASTM Designation D1557-78 method of compaction.

All required fill should be placed in loose lifts, not more than eight inches in thickness, and compacted to at least 90%. The moisture content of predominantly granular soils at the time of compaction should vary no more than 2% above or below optimum moisture content.

The on-site soils, less any debris or organic matter within the existing fill deposits, may be used in required fills. Any required imported fill material should consist of relatively non-expansive soils with an Expansion Index of 35. The material should contain sufficient fines (binder material) so as to result in a stable subgrade. Imported fill material to be used beneath asphaltic paving should have a CBR value of at least 15 when compacted to 90%.

The excavation and reworking of the upper soils and the compaction of all required fill should be observed and tested by a qualified and competent geotechnical engineer. Any required imported fill material should be approved for use prior to importing.

Asphaltic Paving

The required paving thickness and base thickness will depend on the anticipated wheel loads and volume of traffic (Traffic Index). Assumed Traffic Indexes and the corresponding paving sections are presented in Table 2, Recommended Paving Sections.

Table 2

Recommended Paving Sections

		Thickness (Inches)	
TPSS Facility	Traffic Index	Asphaltic Concrete	Base Course
Slauson Avenue	5	3	3
	6	3	3
	7	3	4
Imperial Highway	5	3	3
	6	3	4
	7	3	5

Careful inspection is recommended to verify that the recommended thickness, or greater, are achieved and that proper construction procedures are used.

Base Course

The base course should meet the specifications for Class II Aggregate Base as defined in Section 26 of the State of California, Department of Transportation, Standard Specifications, dated July 1984. The base course should be compacted to at least 95%.

Respectfully submitted,

LeROY CRANDALL AND ASSOCIATES

by

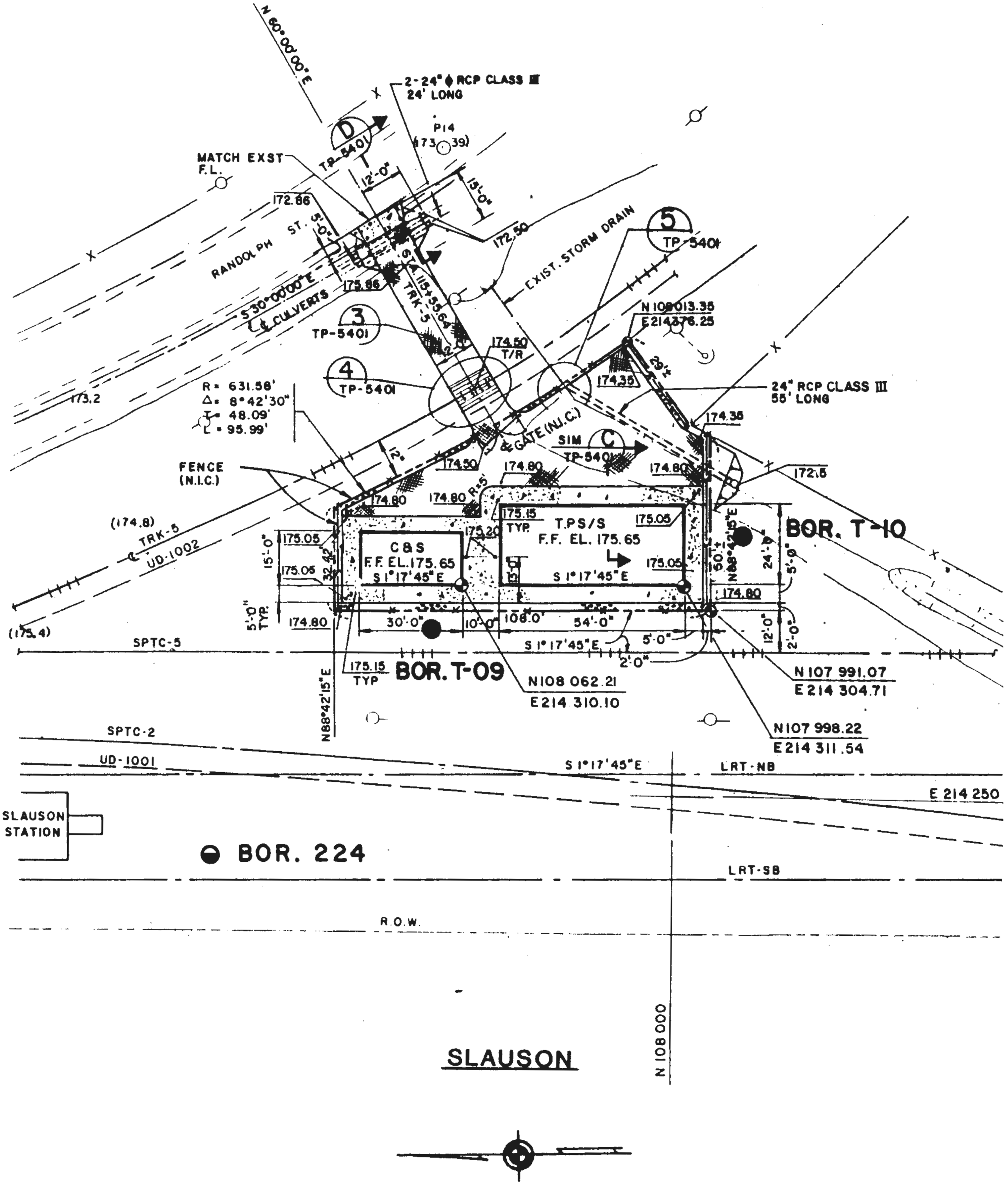
Do Mar
Project Engineer

by

Marshall Lew, Ph.D.
Senior Engineer/Vice President

S3/ge
(25 copies submitted)

FORM 120 JOB AVE-88005-16 DATE 5/21/91 DR. ou O.E. pm W.P. CHKD



SITE AND BORING LOCATION PLAN

SCALE 1"= 40'

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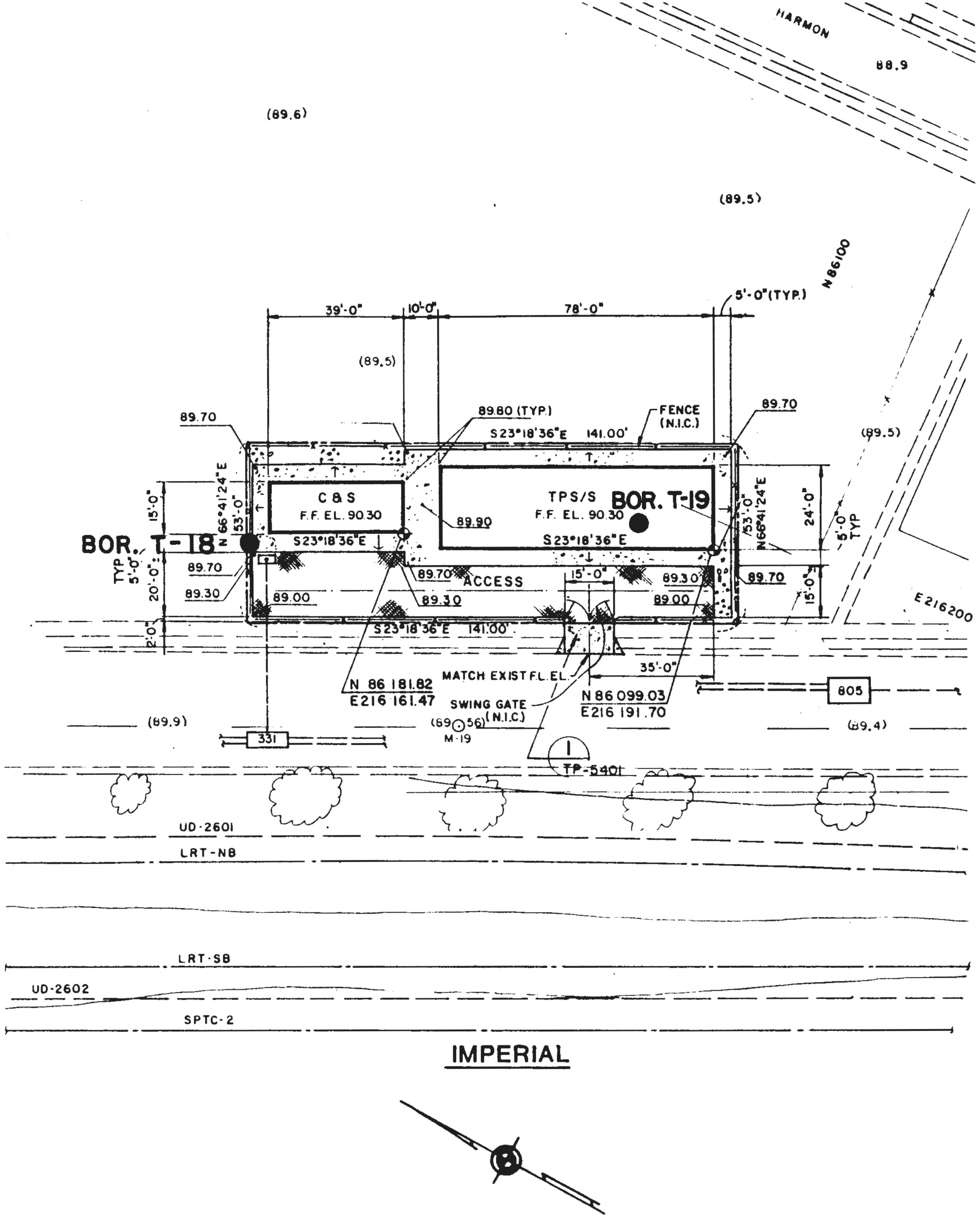
FIGURE 1-1

JOB ADE-85005-16 DATE 5/21/87 DR. or O.E. DM W.P. CHKD



SITE AND BORING LOCATION PLAN

SCALE 1"= 40'

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FORM 120

FIGURE 1-2

JOB A-85005-16 DATE 8/3/87 F.T. LS DR. dmh O.E. DM DM W.P. dmh CHKD /

Note : The log of subsurface conditions shown hereon applies only at the specific boring location and at the date indicated. It is not warranted to be representative of subsurface conditions at other locations and times.

BORING T-09

DATE DRILLED: July 29, 1987
EQUIPMENT USED: 24" - Diameter Bucket

ELEVATION 174

ELEVATION (ft.)	DEPTH (ft.)		MOISTURE (% of dry wt.)	DRY DENSITY (lbs./cu. ft.)	DRIVE ENERGY (ft.-kips/ft.)	SAMPLE LOC.		
							ML	FILL - SANDY SILT - about 30% Gravel, brown
								About 5% Gravel
			11.8	106	1			
170							SM	SILTY SAND - fine, brown
			7.5	98	2	S		
	5							
								Layers of Sandy Silt
			27.4	90	1	C		
			6.8	99	2			
165								
	10							
			19.4	107	3			
			15.0	111	3			
160								
	15							
			10.9	107	3			
155								
	20						ML	SANDY SILT - brown
150								
			16.1	110	3			
	25							

NOTE: Water not encountered. Raveling from 0' to 3' (to 2-1/2' in diameter).

LOG OF BORING

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FIGURE 2-1

JOB A-85005-16 DATE 8/3/87 F.T. LS DR. dmh O.E. DM [illegible] W.P. dmh CHKD BW

Note : The log of subsurface conditions shown hereon applies only at the specific boring location and at the date indicated.
It is not warranted to be representative of subsurface conditions at other locations and times.

BORING T-10

DATE DRILLED: July 29, 1987
EQUIPMENT USED: 24" - Diameter Bucket

ELEVATION 173

ELEVATION (ft.)	DEPTH (ft.)		MOISTURE (% of dry wt.)	DRY DENSITY (lbs./cu. ft.)	DRIVE ENERGY (ft.-kips/ft.)	SAMPLE LOC.		
							ML	FILL - SANDY SILT - pieces of asphalt and glass, brown
							ML	SANDY SILT - brown
			14.7	99	2	S		
170								
			9.3	92	< 1	C S		
	5							
			28.5	84	1			
165			8.9	97	1			Thin layers of Silty Sand
	10							
			16.2	99	2	C		
160								
	15		16.7	100	3			
155								Layer of Silty Sand
	20		16.2	106	3			
150								
	25		16.1	114	2			

NOTE: Water not encountered. No caving.

LOG OF BORING

LeROY CRANDALL AND ASSOCIATES

JOB A-85005-16 DATE 8/14/87 F.T. GMC DR. dmh O.E. DM W.P. dmh CHKD BW

Note : The log of subsurface conditions shown hereon applies only at the specific boring location and at the date indicated. It is not warranted to be representative of subsurface conditions at other locations and times.

BORING T-18

DATE DRILLED: August 12, 1987
EQUIPMENT USED: 5" - Diameter Rotary Wash

ELEVATION 90

ELEVATION (ft.)	DEPTH (ft.)		MOISTURE (% of dry wt.)	DRY DENSITY (lbs./cu. ft.)	DRIVE ENERGY (ft.-kips/ft.)	SAMPLE LOC.		
							SM	FILL - SILTY SAND - fine, pieces of wood and glass, light grey and brown
			9.4	104	6			
							SM	SILTY SAND - fine, greyish brown
			13.0	95	3	C S		
85	5							Sandier Lenses of Silt
			7.1	99	5	S		
			6.3	97	5			
80	10							
			7.5	101	8	S		
							ML	SANDY SILT - brown
75	15		26.7	95	2	S		
70	20		22.6	103	3	S		
65	25		21.3	104	4	C S		

NOTE: Drilling mud used in drilling process. Water level not established.

LOG OF BORING

LeROY CRANDALL AND ASSOCIATES

JOB A-85005-16 DATE 8/14/87 F.T. GMC DR. dmh O.E. DM DW W.P. dmh CHKD

Note : The log of subsurface conditions shown hereon applies only at the specific boring location and at the date indicated. It is not warranted to be representative of subsurface conditions at other locations and times.

BORING T-19

DATE DRILLED: August 12, 1987
EQUIPMENT USED: 5" - Diameter Rotary Wash

ELEVATION 88

ELEVATION (ft.)	DEPTH (ft.)		MOISTURE (% of dry wt.)	DRY DENSITY (lbs./cu. ft.)	DRIVE ENERGY (ft.-kips/ft.)	SAMPLE LOC.		
							SM	SILTY SAND - fine, greyish brown
			9.7	100	7	C S		
								Layers of Sand
85								
			10.0	93	5	S		
							SP	SAND - fine, lenses of Silt, light brown
	5							
			7.9	96	6			
80								
			6.3	94	6	S		
							ML	SANDY SILT - brown
	10							
			24.1	91	2	C		
75							ML	CLAYEY SILT - brown
	15		29.1	95	2	S		
70								
	20		28.4	94	2	S		
							SP	SAND - fine, light grey
65								
	25		8.9	98	11	C S		

NOTE: Drilling mud used in drilling process. Mud removed. Water not encountered.

LOG OF BORING

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FIGURE 2-4

MAJOR DIVISIONS			GROUP SYMBOLS	TYPICAL NAMES
COARSE GRAINED SOILS (More than 50% of 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 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.

BOUNDARY CLASSIFICATIONS: Soils possessing characteristics of two groups are designated by combinations of group symbols.

PARTICLE SIZE LIMITS

SILT OR CLAY	SAND			GRAVEL		COBBLES	BOULDERS
	FINE	MEDIUM	COARSE	FINE	COARSE		

NO. 200 NO. 40 NO. 10 NO. 4 3/4 in. 3 in. (12 in.)

U. S. STANDARD SIEVE SIZE

UNIFIED SOIL CLASSIFICATION SYSTEM

Reference:
The Unified Soil Classification System, Corps of Engineers, U. S. Army Technical Memorandum No 3-357, Vol. I, March, 1953. (Revised April, 1960)

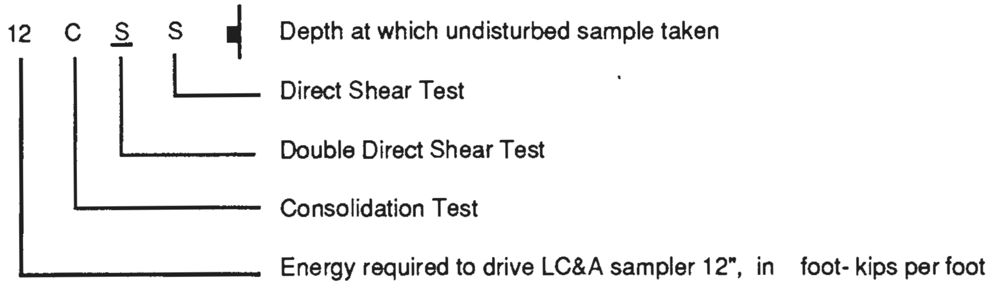
LEROY CRANDALL & ASSOCIATES

FIGURE 3

JOB ADE-85005-16 DATE 8/26/87 W.P. dmh O.E. DM CHKD

LC&A SAMPLING:

(Sampler Diameter - I.D. = 2.625"; O.D. = 3.188")



BUCKET BORINGS:

Depth Increment	Driving Weight	Stroke
0' to 25'	1,600 lbs.	1'
below 25'	800 lbs.	1'

ROTARY WASH BORINGS:

Driving Weight = 450 lbs.

Stroke = 1-1/2'

CLASSIFICATION SYSTEM:

Unified Soil Classification System

KEY TO LOG OF BORINGS

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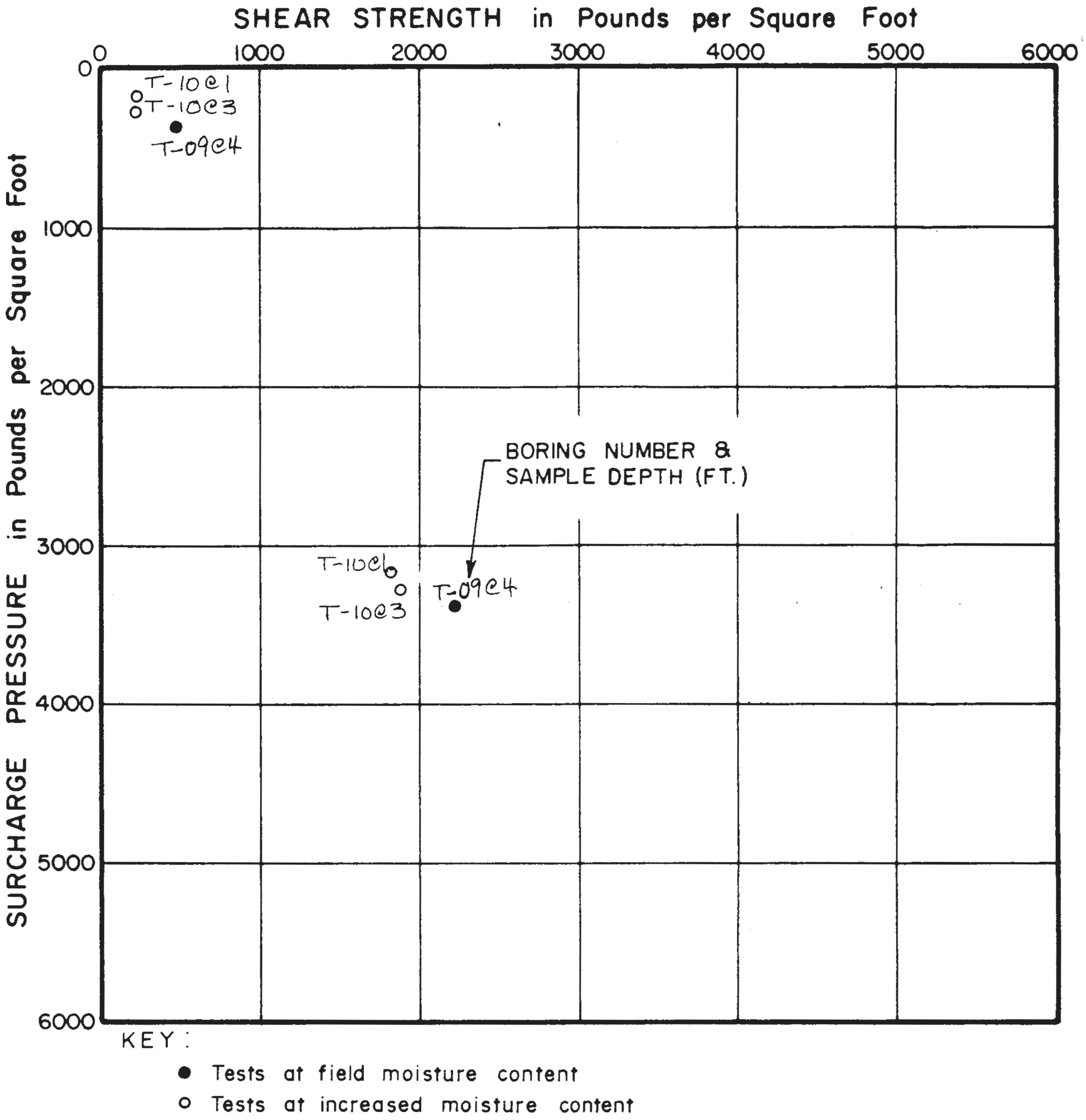
FIGURE 4

JOB DATE DR ; OF CHKD



DIRECT SHEAR TEST DATA

SLAUSON AVENUE

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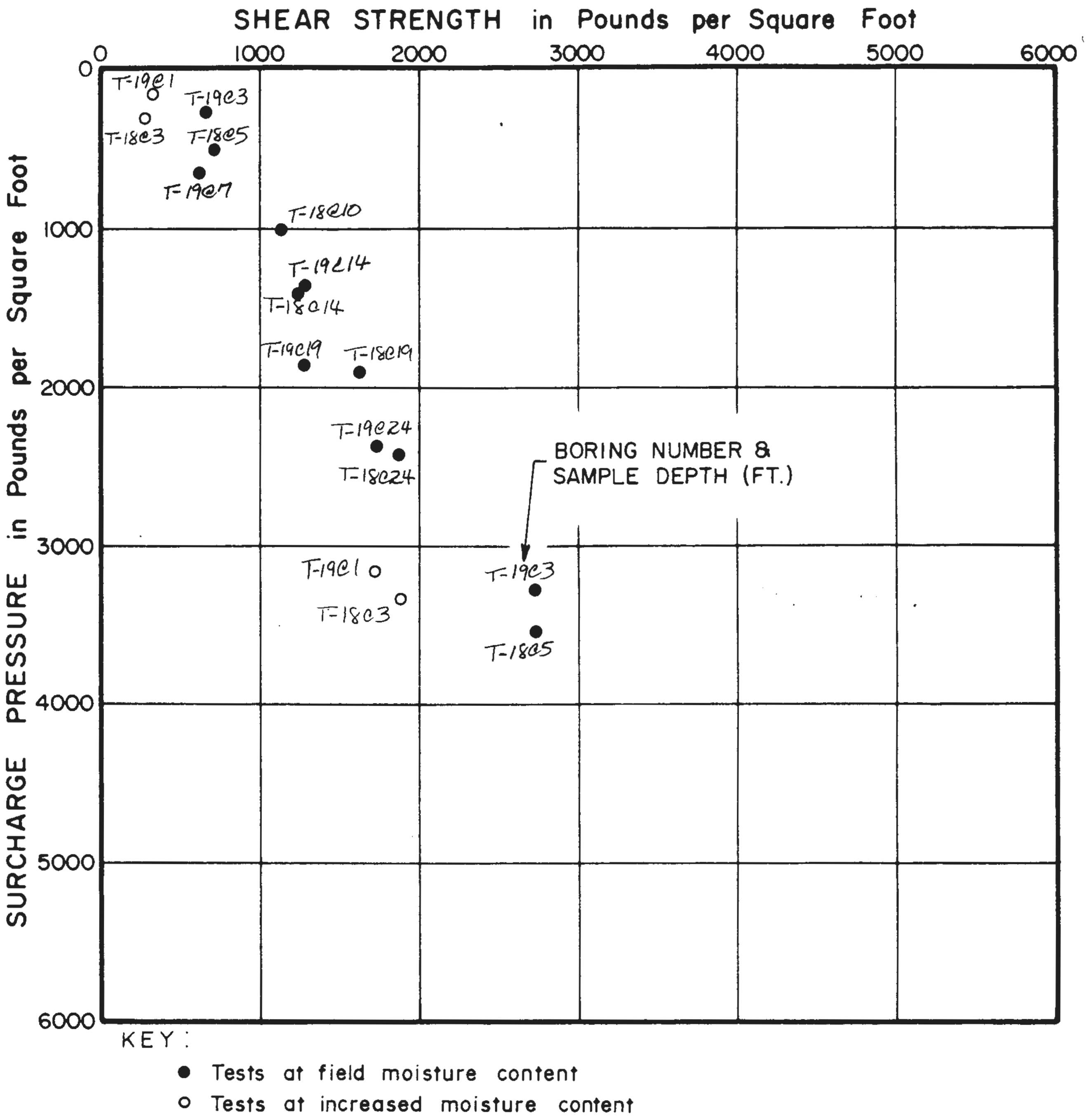
FIGURE 5-1



DIRECT SHEAR TEST DATA

IMPERIAL HIGHWAY

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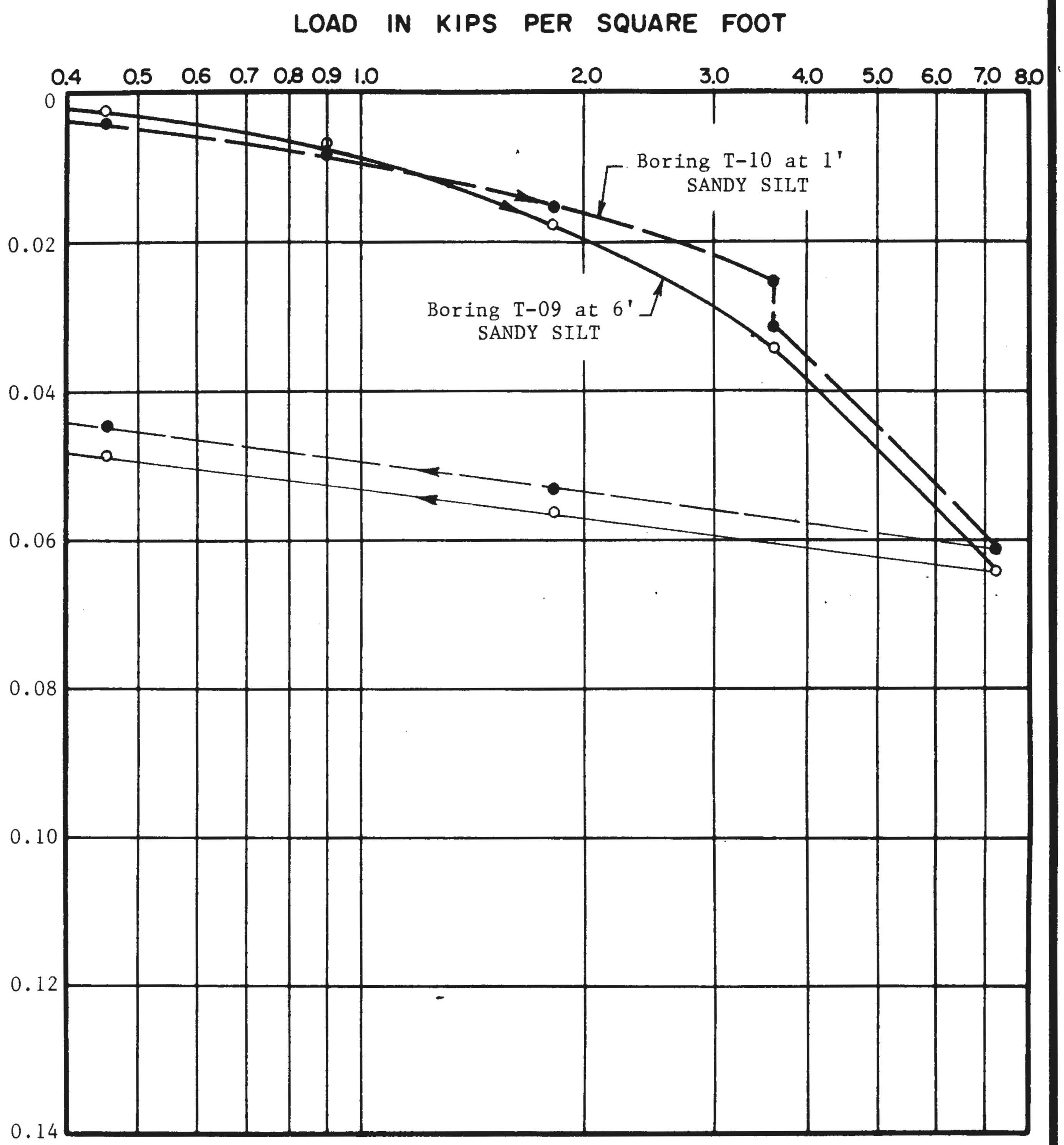
FIGURE 5-2



NOTE: Water added to sample from Boring T-10 after consolidation under a load of 3.6 kips per square foot. The other sample tested at field moisture content.

CONSOLIDATION TEST DATA

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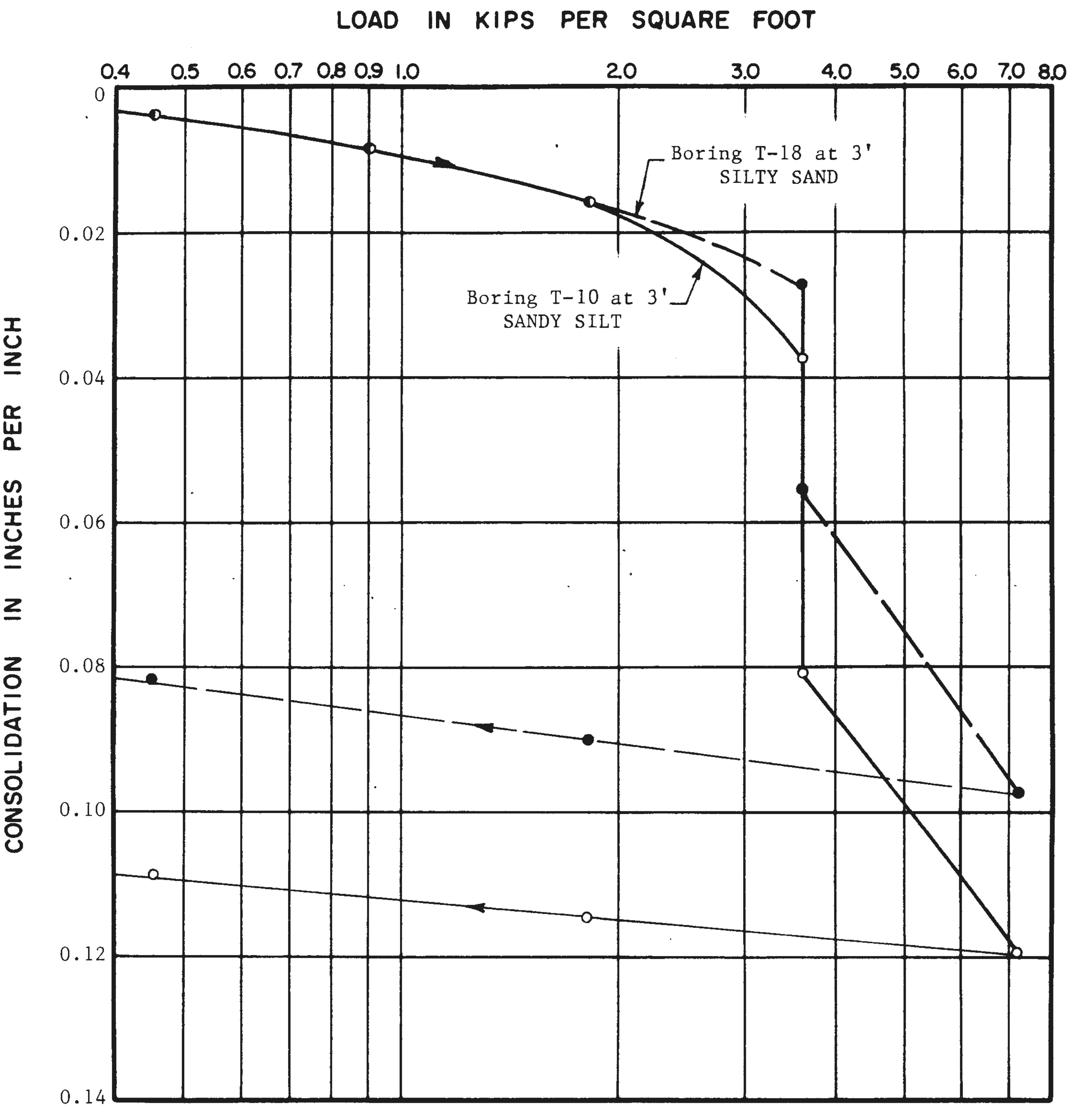
FIGURE 6-1

JOB 41-85005-16 DATE 8/25/87 DR SANDY/ OF. L/TM W.P 1D CHKD RH



NOTE: Water added to samples after consolidation under a load of 3.6 kips per square foot.

CONSOLIDATION TEST DATA

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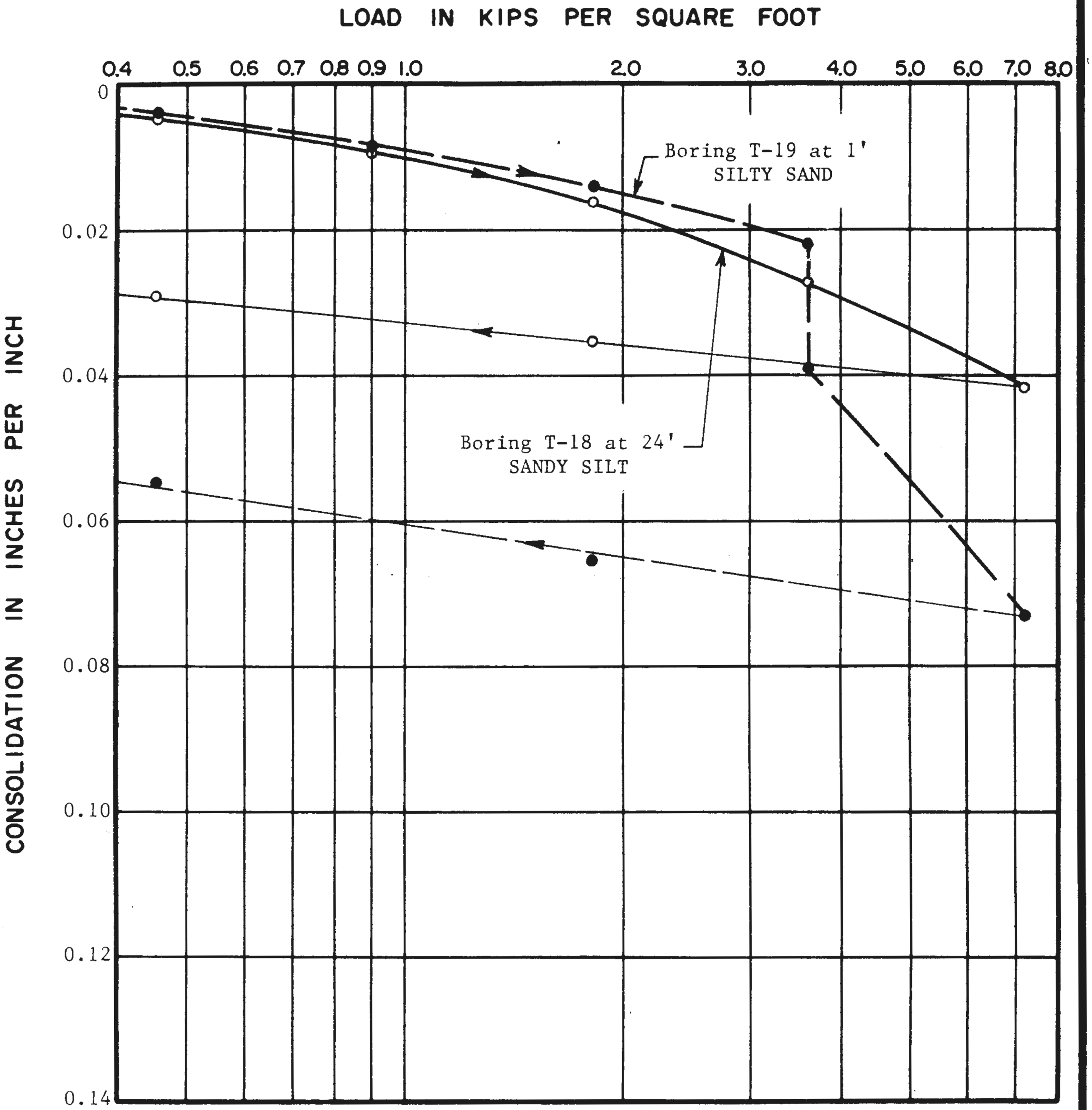
FIGURE 6-2

FORM 116 JOB A-85005-AL DATE 8-25-87 DR SANDY O.F. DM W.P lp CHKD BW



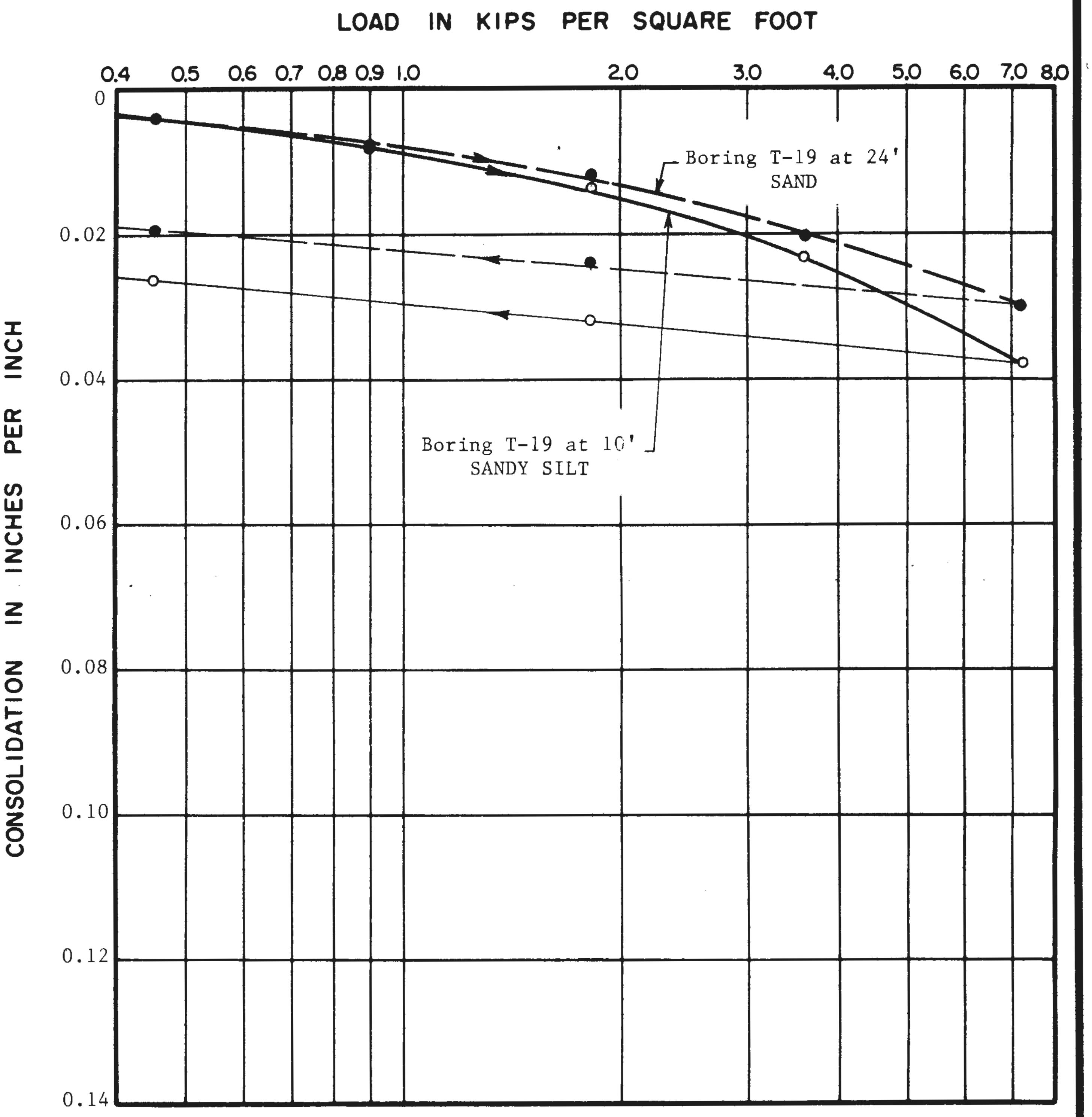
NOTE: Water added to sample from Boring T-19 after consolidation under a load of 3.6 kips per square foot. The other sample tested at field moisture content.

CONSOLIDATION TEST DATA

LeROY CRANDALL AND ASSOCIATES

JOB A-85005-16 DATE 8/25/87 BY [illegible] OF. DMM W.P 10 CHKD RN

FORM 116



NOTE: Samples tested at field moisture content.

CONSOLIDATION TEST DATA

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FIGURE 6-4

JOB A-X5005-16 DATE 8/25/87 DR. SANDY O.F. __ DMDM W.P. 1p CHKD RN

JOB A-85005-16 DATE
W.P. lp O.E. DM CHKD BW

BORING NUMBER AND SAMPLE DEPTH :	T-10 at 1' to 5'	T-19 at 0 to 2'
SOIL TYPE :	SANDY SILT	SILTY SAND
MAXIMUM DRY DENSITY * : (lbs./cu. ft.)	127	126
OPTIMUM MOISTURE CONTENT * : (% of dry wt.)	11	11
EXPANSION (%) : (From optimum to saturated moisture content)	0.5	1.6
C. B. R. ** (% of standard)		
AT 90% COMPACTION :	39	19
AT 95% COMPACTION :	71	33

* TEST METHOD : ASTM Designation D 1557 - 70.

** TEST METHOD : ASTM Designation D 1883 - 73.

COMPACTION AND C. B. R. TEST DATA

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FIGURE 7