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16. ABSTRACT

Introduction

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STATE OF CALIFORNIA
DEPARTMENT OF PUBLIC WORKS
DIVISION OF HIGHWAYS

RESULTS of SAND DRAIN STUDIES on STATE HIGHWAY at EUREKA SLOUGH APPROACH

ROAD I-Hum-1-Eur

PROGRESS REPORT NO. 1

November 1956

M E M O R A N D U M

November 1, 1956

I-Hum-1-Eur

TO: A. W. Root

FROM: W. G. Weber

SUBJECT: Progress Report No. 1. Effects of driving sand drains at Eureka Slough

Introduction

A test section has been established at the approaches to Eureka Slough Bridge to study the action of sand drains. The North Approach is constructed over a clayey sand to fine sand that is semi-pervious. The South Approach is constructed over a silty clay to clayey silt that is semi-impervious. Fills up to 25 feet in height are to be constructed across the above soils. The native soils are being stabilized by means of vertical sand drains. This report covers the effects of placing the sand drains.

Installation of the Sand Drains

The sand drains under the South Approach were installed by means of a nineteen inch closed mandrel to a depth of about 20 feet in the south approach. The mandrel drove very easily for the first 16 to 18 feet, two to three blows per foot with a 1-1/2-ton drop hammer. The remaining depth was considerably harder driving with 5 to 15 blows per foot being required. The mandrel was then filled with sand and a cap placed upon the mandrel. An air pressure of 70 to 90 lbs. per sq. in. was then applied to the mandrel and the mandrel withdrawn leaving the sand in its place. When the mandrel was completely withdrawn the sand would be 4 to 5 feet below its original level in the mandrel. The sand column was then completely filled to the ground surface. A one to two-foot working table was used to support the pile driving rig. No stripping of the area was done.

On the north approach a 22 inch diameter rotary drill rig was used to drill a hole to a depth of 8 to 15 feet. The boring was then backfilled with sand, and a water jet used to insure that no arching of the sand occurred. No working platform was required and stripping was done with a motor grader after the sand drains were installed.

On both approaches all sand drains were exposed prior to the placing of a two-foot sand blanket. The sand drains on the north approach all were weeping within two days of installation. On the south approach the sand drains required about five days, after installation, before weeping occurred.

See attached photos for details of operations.

Sand Material

The same sand was used in the sand drains and in the sand blanket. It is a fine sand obtained from a nearby sand spit. The grading is shown in the following table.

TABLE NO. 1

Grading of Sand Used in Sand Drains and in the Sand Blanket

Sieve Size	Percent Passing
30	100
50	94
100	3
200	1

Permeability tests show a permeability of 84 feet per day in the loose state.

Settlements

Settlement platforms were installed prior to the driving of the sand drains. For location of installations see Fig. No. 1. The readings of the settlement platforms before and after driving the sand drains in the south approach are shown in Table No. 2. The settlement platforms show an appreciable rise after the sand drains were driven in the south approach.

The settlement platforms were placed in the center of a square formed by four sand drains. Readings were taken before driving each sand drain, after the mandrel was in place and before the air pressure was applied, and after the mandrel was withdrawn. The results of these readings were very erratic. The rise in the platform would start when the sand drains were driven 15 to 25 feet from the platform and continue to rise in an erratic manner until the platform had been passed. For this reason the readings shown in Table No. 2 are in the morning before the contractor's operations started and in the evening after the contractor completed his operations. Measurements were taken in an attempt to determine the effects of driving the closed mandrel and applying the air pressure in withdrawing the mandrel. Due to the uncertainty and erraticness of the readings they are not being included.

No change in elevation was noted in the settlement platform on the north approach. As the sand drains under the north approach were installed by means of a drilled hole, it is reasonable to expect no change in elevation.

Hubs were driven in the soil before the start of sand drain operations to check the settlement platforms. All of the hubs were destroyed by the contractor's operations.

Pore Pressures

Piezometers were installed before the driving of sand drains. The piezometers are of two types: the control piezometers placed equal distance from four sand drains at a depth of 10 and 20 feet, and special test group placed at various distances from a sand drain and at various depths. The special test group are piezometers Z-33 to Z-39 inclusive.

The control piezometers under the south approach showed a varying increase in pore pressure due to the placing of the sand drains; see Table No. 3. This increase in pore pressure varied from 0.05 to 0.38 tons per sq. ft., with an average increase of 0.20 tons per sq. ft. Three piezometers were placed in the stiff silty clay underlying the depth to which the sand drains were driven. These piezometers showed an increase in pore pressure of 0.30 tons per sq. ft.

The piezometers in the special test area, at various distances from a sand drain showed that a uniform increase in pore pressure occurred in a horizontal direction (0.12 tons per sq. ft.). In the vertical direction the increase in pore pressure increased with depth from 0.11 to 0.16 tons per sq. ft.

Attempts were made to take pore pressure readings during the driving of the sand drains, but due to the time lag of the piezometers this proved impossible. The pore pressures shown in Table No. 3 are the morning readings only.

The pore pressures under the north approach did not change during the placing of the sand drains.

Pressure Cells

One 8-inch diameter pressure cell was placed near the toe of slope so as to record the horizontal stress. (C-41). This cell showed an increase of 0.20 tons per sq. ft. in stress after driving the closed mandrel and 0.35 tons per sq. ft. after withdrawing the mandrel. Within a week's time the horizontal stress had been relieved and the pressure cell read slightly above its original reading.

Heave Stakes

A series of heave stakes were installed to the side of the sand drain area. Due to the soft condition of the native soil walking would move these stakes, so this attempt was discontinued. A series of lath were placed in the channel change to record movement at the sides and bottom. At high tide they floated away, and attempts were again discontinued. The only reliable measurements of movement obtained were 4 x 4 inch posts set two feet into the mud. These posts were set at Stations 215± and 217±, near the bank of the channel change. At Station 215± an upward movement of 0.03 feet and an outward movement of 0.10 feet were recorded. At Station 217± an upward movement of 0.02 feet and an outward movement of 0.15 feet were recorded. The accuracy of the above movements is ±0.02 feet. The major movement appears to be in the horizontal direction away from the fill. The 4 x 4 inch posts are about 20 feet from the sand drain area, and it is reasonable to assume that greater movement occurred close to the sand drain area.

Discussion of Settlement and Pressure Data

The driving of the closed mandrel produces a downward force below the bottom of the sand drains and a horizontal force along the depth of the sand drains. These stresses are caused by the soil being displaced in the driving of the sand drain. For the 20-foot sand drains under the south approach the mandrel occupied a volume of 43 cu. ft. If all of this volume caused a vertical displacement a surface movement of 0.43 feet would have occurred. However, a portion of this movement is in the horizontal direction. At the south approach the movement in the horizontal and vertical directions appeared to be about equal. The volume displaced resulted in an increase in pore pressure that increased with depth. This pore pressure could be important where low fills of questionable stability are involved. This may be a factor where fills have failed when loaded before the sand drains have had an opportunity to relieve the pore pressure induced by driving the sand drains. The pore pressure readings will be observed to see if loading increases the pore pressure or if the pore pressure remains constant until its loading has been reached. The downward force is evident from the pore pressure below the bottom of the sand drains.

The use of compressed air in withdrawing the closed mandrel could increase the horizontal pressure. The piezometers gave indications that the air pressure caused a sudden increase in pore pressure; however, the time lag was such that no accurate measurements could be obtained. The horizontal pressure cell (C-41) had sufficiently high response to record this effect. This installation showed that the horizontal pressure was increased from 0.20 to 0.35 tons per sq. ft. when the air pressure was applied. It would be advisable to try using a lower air pressure, 40 to 50 lbs. per sq. inch, to reduce this increased pressure and still result in a continuous sand column.

With the use of a one size sand, 30 to 50 mesh, it is possible that the horizontal force may result in the native soil working into the sand drains. Auger borings in two sand drains to a depth of ten feet did not show any intrusion of the sand. Intrusion of the native soil into the sand drain could greatly decrease the sand drains effectiveness.

Piezometers were placed in two sand drains to check if plugging action occures.

At the north approach the soil was removed from the sand drain. This resulted in the placing of the sand drains without causing a pore pressure or a soil movement.

Strength of the Native Soil

Two special test areas were established, one outside the sand drain area, and one inside the sand drain area. Two-inch sample borings were made in both areas before and after driving the sand drains. The strengths are shown on Fig. No. 2. In the sand drain area a boring was made two feet from the center of a sand drain and five feet from the center of a sand drain. The borings were made one and two days after driving the sand drains in this area. A slight increase in strength appears to have occurred from elevation -5 to -15. This increase in shearing strength is of doubtfull significance being about 0.05 ton per sq. ft. Outside the sand drain area about two feet of fill was in place. No change in strength was noted.

Moisture Contents

In the borings inside and outside the sand drain areas moisture contents were taken. The moisture contents are shown in Fig. No. 3. Outside the sand drain area there was no moisture change noted. The test area inside the sand drain area showed a decrease of 15 percent moisture content between elevation -4 and -11. It is not known if this moisture content existed before the driving of the sand drains or if for some reason the sand drains rapidly decreased the moisture content.

Three moisture contents by nuclear methods tubes were placed in the sand drain area. These tests are being run in cooperation with the University of California. Our preliminary analysis of the data indicates that considerable change in moisture content occurred. The data is being worked up by the University of California and will be included in later reports when it is received.

The large decrease in moisture content indicated by the borings, 15 percent, should have resulted in an appreciable increase in strength. The triaxial tests have not been completed so that a definite relation between moisture content and strength has not been established. The preliminary data indicate that the increase in strength should have been about 0.15 tons per sq. ft. This discrepancy in the increase in strength could be due to a remolding affect during the driving of the sand drains. There is also the possibility that, although four borings were placed in the test area before construction, the sampling after the placing of the sand drains was in a lower initial moisture content area.

Conclusions

Only limited conclusions may be drawn at the present time. The following conclusions will only apply to the conditions at Eureka Slough and may or may not apply in general to sand drain installations.

1. The placing of sand drains by means of a closed mandrel results in an increase in the pore pressure.

2. The placing of sand drains by means of a drilled hole did not disturb the soil.

3. The placing of the sand drains in the south approach by means of a closed mandrel did not change the strength of the native soil.

William G. Weber Jr.

W. G. Weber, Jr.
Asst. Phys. Test. Engr.

WGW:ml
Attach.

TABLE NO. 2

COMPARISON OF SETTLEMENTS BEFORE AND AFTER DRIVING SAND DRAINS

Settlement Platform No.	Sand Drain Lines	Settlements Feet		Rise in Feet	Distance from Sand Drain to Settlement Platform	Remarks
		Before	After			
SP44	B,C,D	0.03	-0.07	0.10	5	
SP44	F,G	-0.07	-0.15	0.08	5	
SP45	B,C,D	0.03	-0.02	0.05	5	In firm clay
SP45	F,G	-0.02	-0.08	0.06	5	Ditto
SP47	B,C,D	0.07	0.11	-0.04	5	
SP47	F,G	0.11	0.10	0.01	23	
SP51	C,D	0.01	-0.02	0.03	5	Existing sand drain area
SP52	C,D	0.10	0.05	0.05	15	
SP52	F,G	0.05	-0.20	0.25	5	
SP53	C,D	0.06	0.03	0.03	15	In firm clay
SP53	F,G	0.03	-0.04	0.07	5	Ditto

TABLE NO. 3

COMPARISON OF PORE PRESSURES
BEFORE AND AFTER DRIVING SAND DRAINS

Piezometer No.	Sand Drain Lines	Pore Pressure Ton/sq. ft. Before	After	Rise in Pore Pressure	Distance of Sand Drains from Piezometer	Remarks
Z-9	C,D	.01	0.13	0.12	10	In existing S.D. area
Z-13	B,C,D	.01	0.39	0.38	5	
Z-13	H,J	.25	0.28	0.03	15	
Z-14	H,J	.02	0.20	0.18	5	At toe of slope
Z-16	H,J	.04	0.26	0.22	7	Ditto
Z-33	B,C,D	.16	0.46	0.30	5	In firm clay
Z-33	F,G	.45	0.46	0.01	20	
Z-34	B,C,D	.10	0.22	0.12	5	
Z-34	F,G	.24	0.34	0.10	20	
Z-35	B,C,D	.11	0.27	0.16	5	15 ft. depth
Z-35	F,G	.27	0.30	0.03	20	
Z-36	B,C,D	.05	0.16	0.11	4	5 ft. depth
Z-36	F,G	.15	0.20	0.05	20	
Z-37	B,C,D	.10	0.23	0.13	3	
Z-37	F,G	.23	0.29	0.06	20	
Z-38	B,C,D	.09	0.21	0.12	2	
Z-38	F,G	.22	0.21	-0.01	20	
Z-39	B,C,D	.10	0.22	0.12	1/2	
Z-39	F,G	.20	0.15	-0.05	20	
Z-62	C,D	.18	0.18	0.00	17	
Z-62	H,J	.18	0.18	0.00	13	In firm Clay
Z-62	F,G	.18	0.52	0.34	5	
Z-63	C,D	.18	0.24	0.06	23	
Z-63	F,G	.23	0.28	0.05	5	

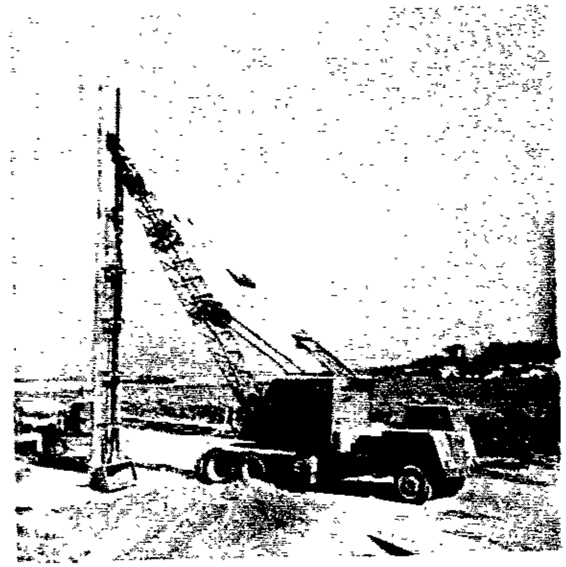


Fig. No. 1. General view of the pile driving rig used in placing the sand drains by means of a closed mandrel. North approach.

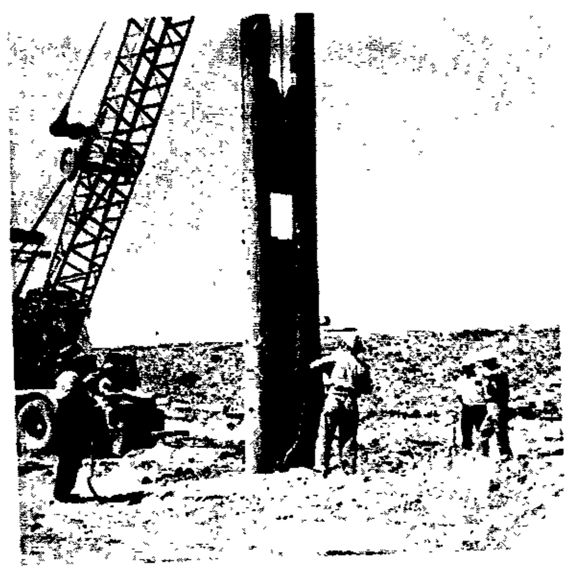


Fig. No. 2. Driving the closed mandrel.

Fig. No. 3. Mandrel driven to required depth and ready to be filled with sand.

Fig. No. 4. Filling the mandrel with sand.

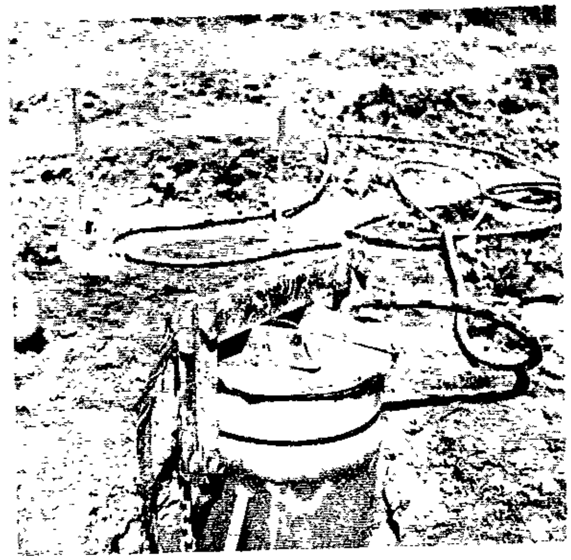


Fig. No. 5. The mandrel filled with sand and the cap in place ready to withdraw the mandrel from the soil.

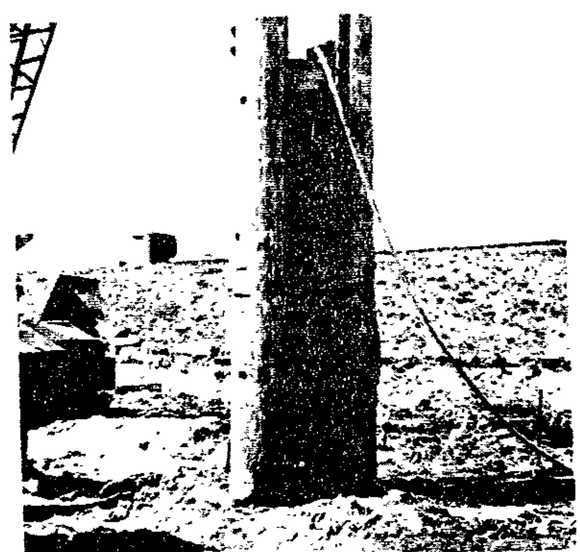


Fig. No. 6. Withdrawing the mandrel from the soil. Note air hose supplying air to aid in withdrawing the mandrel.

Fig. No. 7. General view of the rotary drill rig placing sand drains on the south approach.

Fig. No. 8. Rotary drill rig bringing up an auger full of soil.

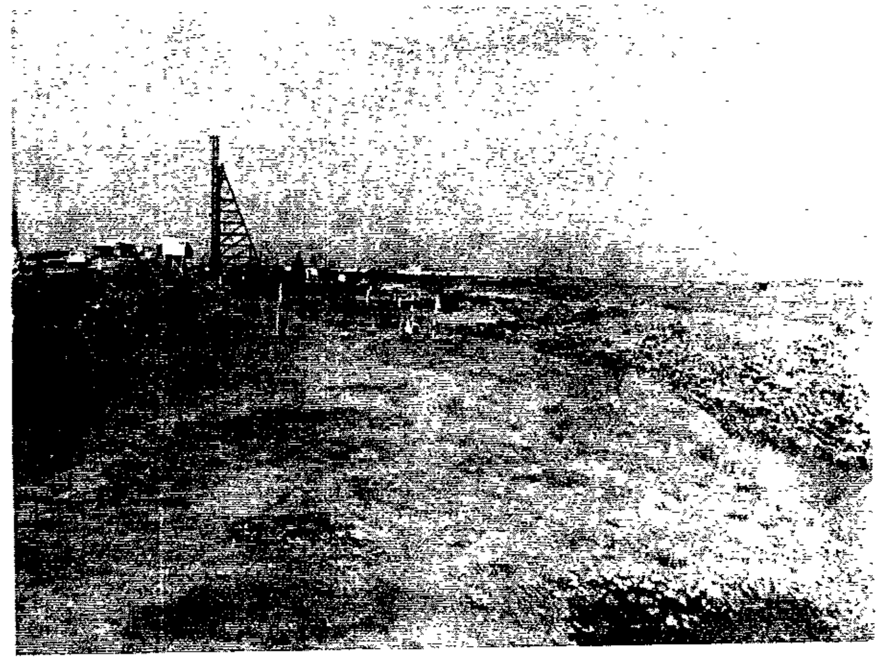


Fig. No. 9. General view of the south approach before placing the sand drains, from bridge to motel.

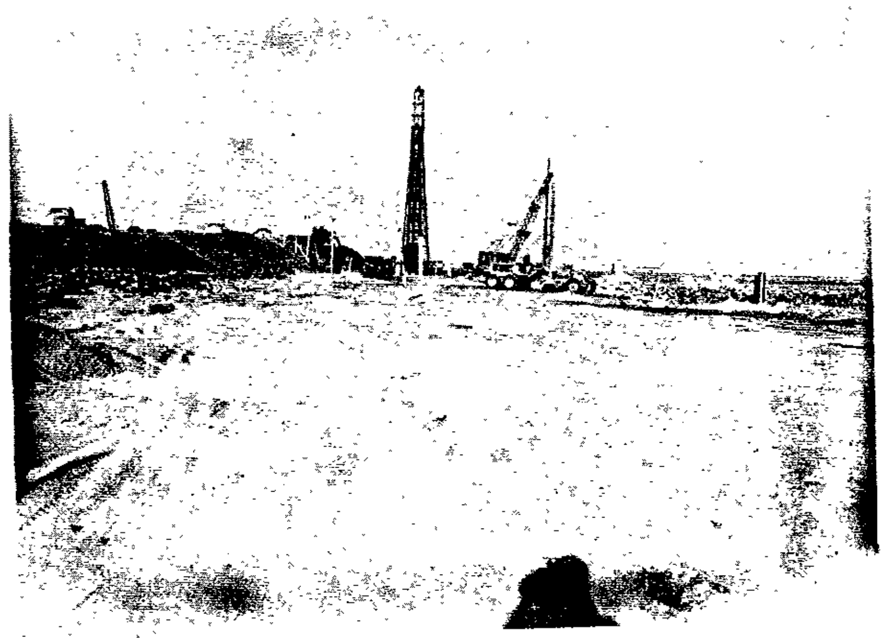


Fig. No. 10. General view of the south approach after completing the sand drains from the bridge to the motel.

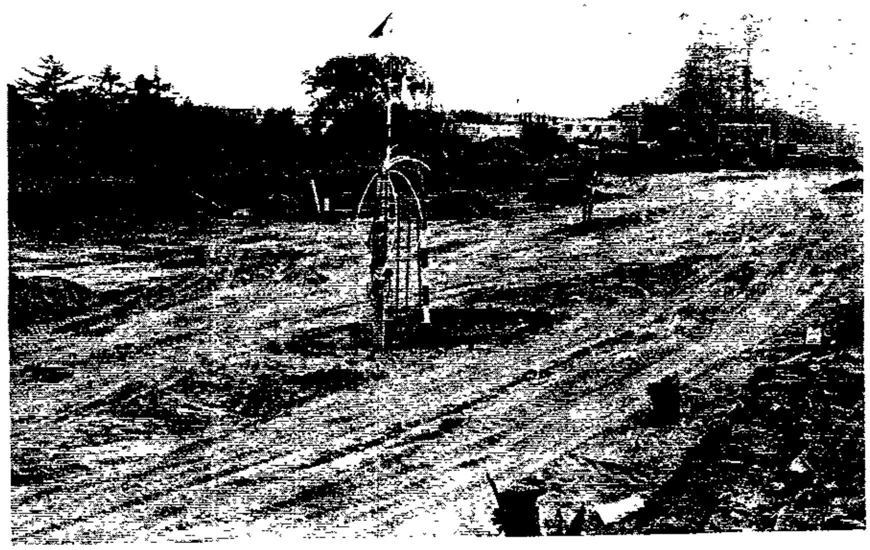


Fig. No. 11. Special test section in the sand drain area, Station 215+75, after completion of the sand drains. Note sand drains weeping in right of picture. Settlement platforms at Station 215+00, on centerline, just to right of center of picture.

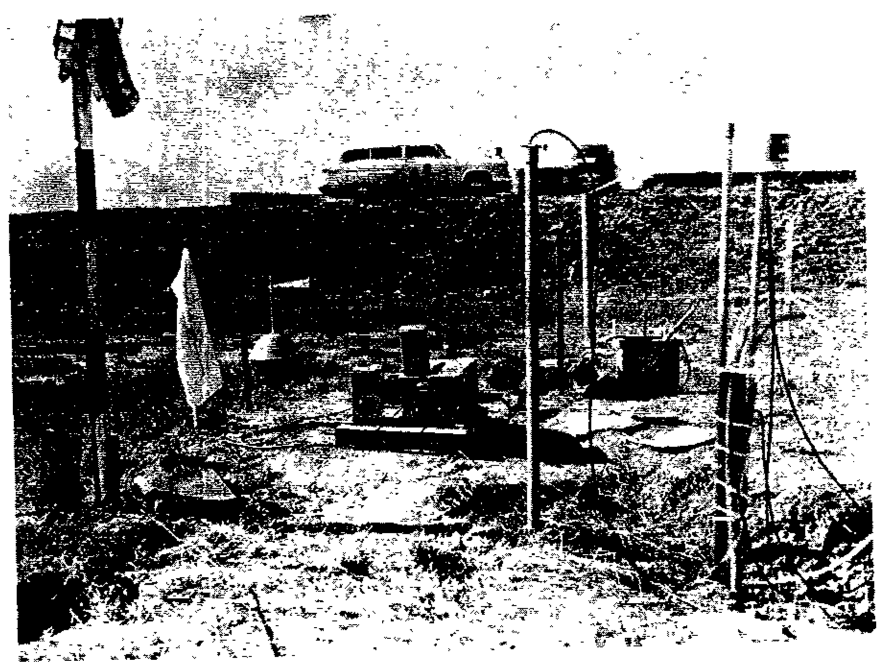


Fig. No. 12. Special test section outside sand drain area, Station 213+50, before placing fill. Running moisture density by nuclear methods.

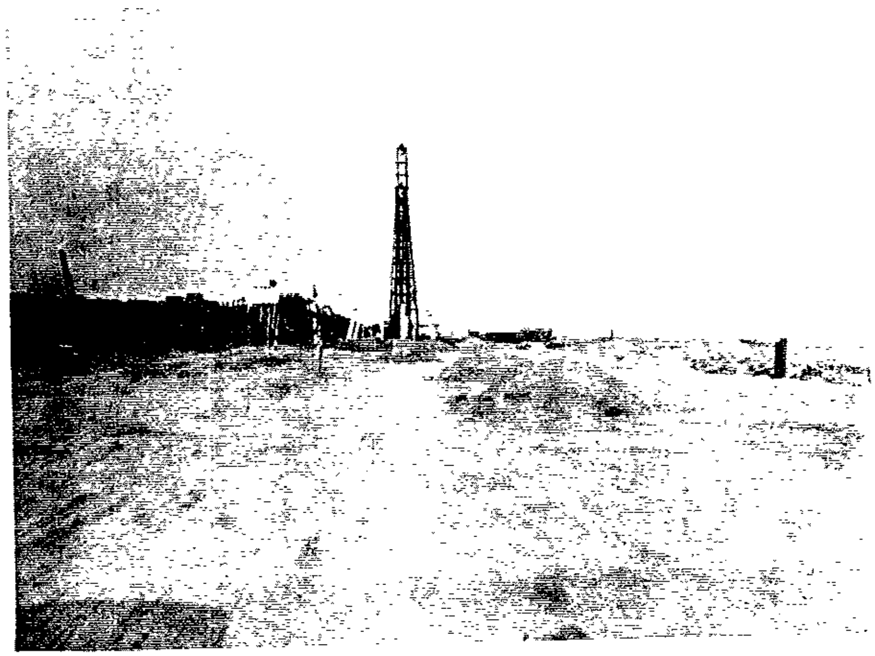
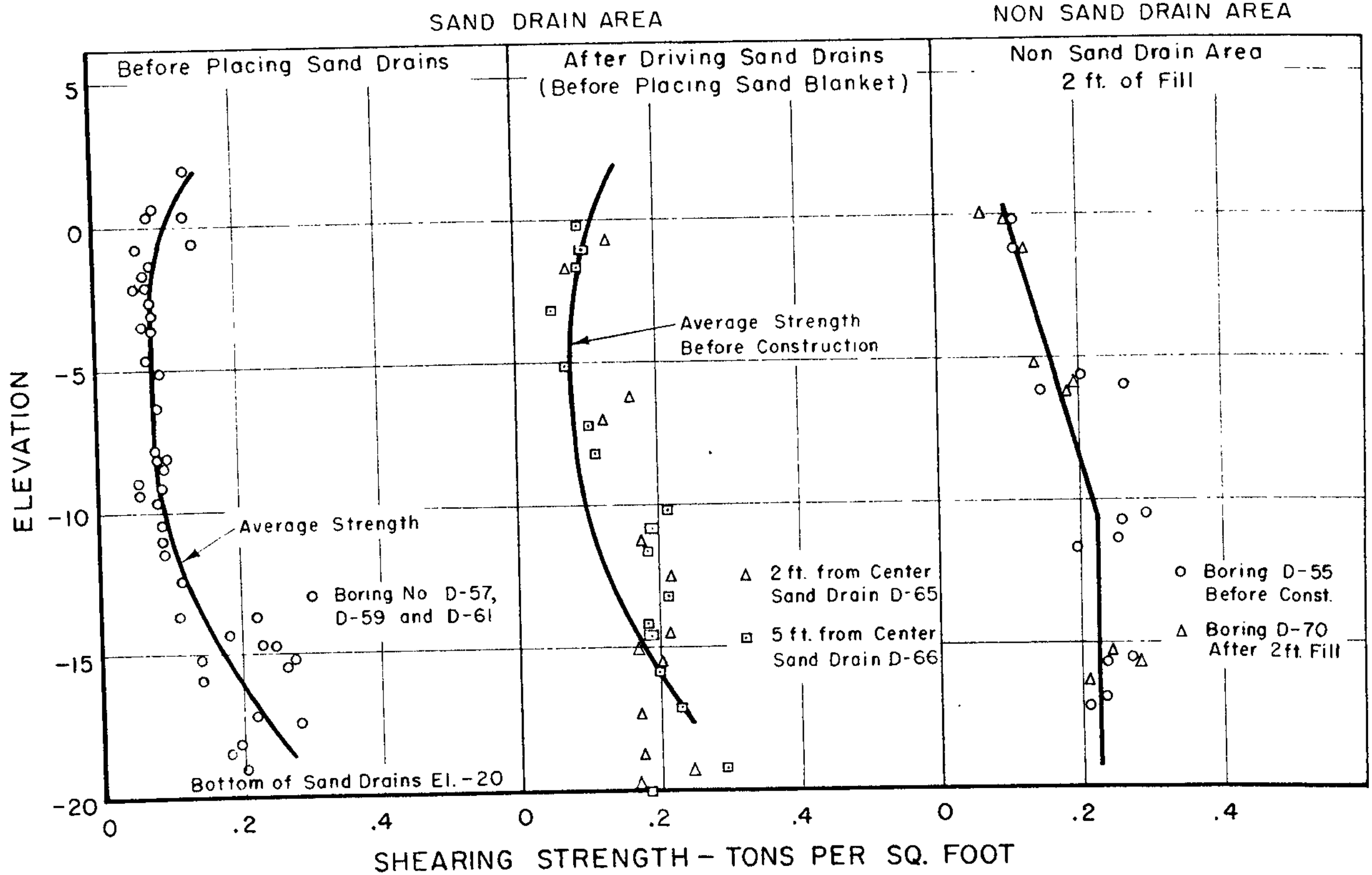


Fig. No. 13. Horizontal and vertical pressure cells in place after driving sand drain.

Fig. No. 14. Placing of the sand blanket in the south approach sand drain area.

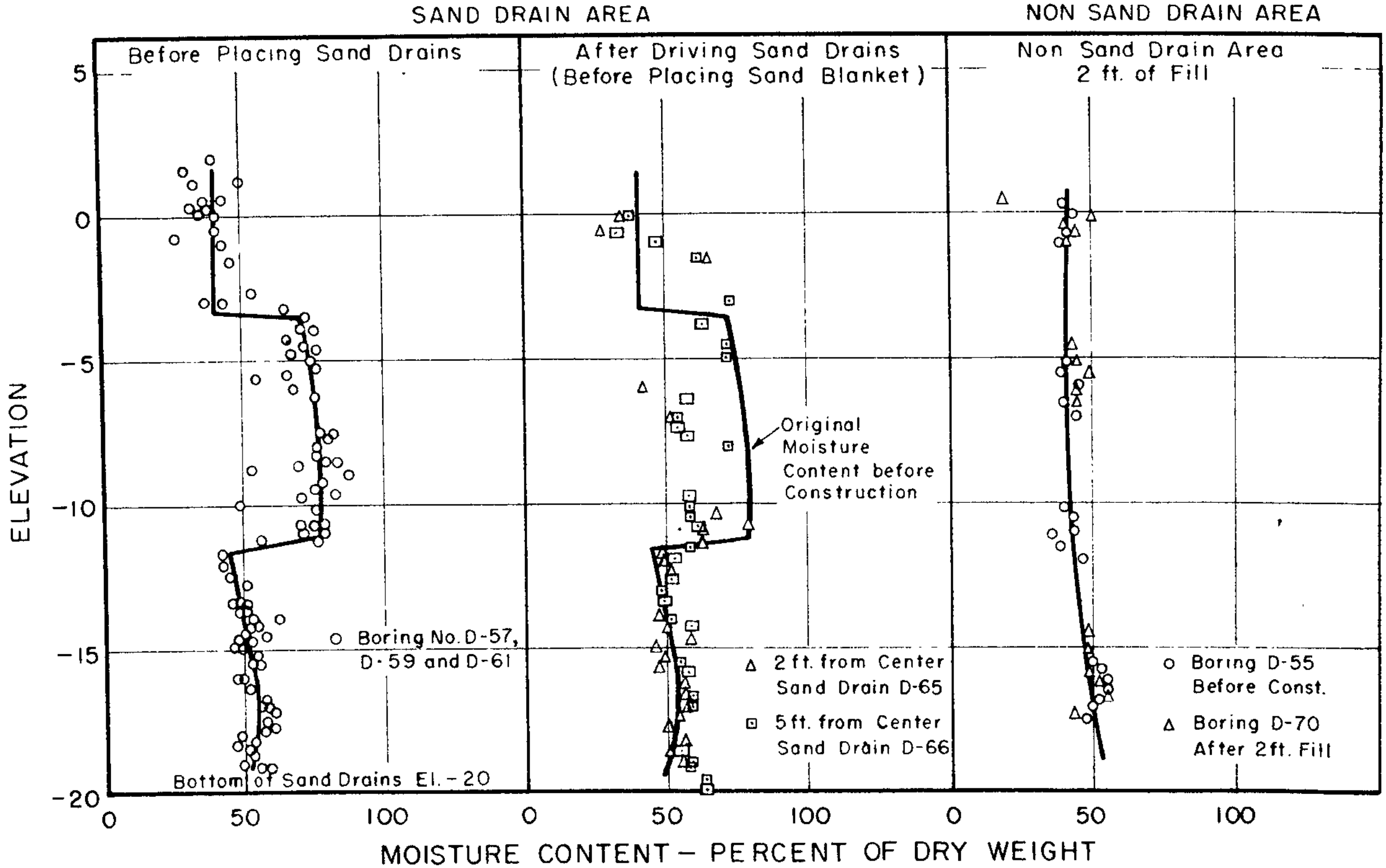
COMPARISON OF UNCONFINED COMPRESSIVE SHEARING STRENGTH BEFORE & AFTER DRIVING SAND DRAINS



MATERIALS & RESEARCH DEPT.
JOB 21-R-2094

FIG. 2

COMPARISON OF MOISTURE AS DETERMINED FROM BORINGS
BEFORE & AFTER DRIVING SAND DRAINS



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JOB 21-R-2094

FIG. 3

STATE OF CALIFORNIA
DIVISION OF HIGHWAYS
MATERIALS AND RESEARCH DEPARTMENT

SUMMARY OF TESTS—FOUNDATION INVESTIGATION

Job No. 2094-R-21
Boring No. D55

LOCATION Eureka Slough DIST 1 CO Hum RTE 1 SEC Eur WO

DATE REPORTED 3-4-56

FIELD DATA			TEST RESULTS																						
SAMPLE NO	TUBE NO	~~ELEV~~ DEPTH	UNIT WEIGHT LBS PER CU FT		MOIST CONT	SPEC GRAV	VOIDS RATIO	GRAIN SIZE ANALYSIS					ATTERBERG LIMITS		CONSOLIDATION % OF ORIGINAL HEIGHT (LOAD—TONS PER SQ FT)							DIRECT SHEAR		UNCONF COMP	REMARKS
			WET	DRY	% DRY WEIGHT			GRAVEL	SAND	SILT	CLAY	COLL'D	LL	PI	1/8	1/4	1/2	1	2	4	8	COHESION psf	ANGLE OF INTERNAL FRICTION	COMP STRENGTH T/FT²	
1	IV	3'			40			0	4	63	33	18												0.21	
	III		111		44																				
	II		111		41																				
	I		114		40								30	10										0.22	gre. 0.08
2	VI	8'			40																				
	V				39								31	7										0.40	
	IV		109		45																				
	III		108		41																			0.53	
	II		111		40			0	10	68	22	12												0.28	gre. 0.16
	I				45																				
3	VII	11'	110		39																			0.59	
	VI				43			0	17	58	25	12												0.51	
	V				44	2.76									0.7	1.1	2.2	4.3	8.5	13.7	18.6				
	IV		110		41																				
	III		112		37																			0.51	
	II		112		38								34	10										0.38	gre. 0.18
	I				47																				
4	VIII	18'	104		49																			0.54	
	VII				50			0	0	54	56	28												0.46	
	VI		103		53																				
	V		104		56																				
	IV		103		57																				
	III		107		52																			0.54	
	II		114		50								46	19										0.41	gre. 0.16
	I				49																				

Ground Elev. 3.4 Prior to construction, outside sand Drain test Area.

SHEET NO 1 OF 11 SHEETS

FORM T-39-50
5-14R-1

STATE OF CALIFORNIA
MATERIALS AND RESEARCH DEPARTMENT
DIVISION OF HIGHWAYS

SUMMARY OF TESTS—FOUNDATION INVESTIGATION

Job No. 2094-R-21
Boring No. D57
LOCATION Eureka Slough DIST 1 CO Hum RTE 1 SEC Eur WO
DATE REPORTED 3-4-56

FIELD DATA			TEST RESULTS																						
SAMPLE NO	TUBE NO	DEPTH	UNIT WEIGHT LBS PER CU FT		MOIST CONT	SPEC GRAV	VOIDS RATIO	GRAIN SIZE ANALYSIS					ATTERBERG LIMITS		CONSOLIDATION % OF ORIGINAL HEIGHT — LOAD-TONS PER SQ FT							DIRECT SHEAR		UNCONF COMP	REMARKS
			WET	DRY	% DRY WEIGHT			GRAVEL	SAND	SILT	CLAY	COLL'D	LL	PI	1/8	1/4	1/2	1	2	4	8	COHESION psf	ANGLE OF INTERNAL FRICTION	COMP STRENGTH T/FT²	
1	III	1	112		32																				
	II				44			0	15	71	14	7												0.15	
	I		111		38								43	20										0.17	
2	III	4	99		55			0	10	51	39	19													
	II		106		37																			0.16	gre. 0.06
	I		93		60								68	34										0.16	
3	VI	7	94		68								65	30											
	V				75			0	0	51	49	25													
	IV				66	2.71									1.7	3.6	8.5	16.2	21.6	27.6	33.4				
	III		102		55																				
	II		98		68								44	14										0.17	gre. 0.04
	I		92		76			0	5	54	41	25													
4	VI	10	92		82								72	35											
	V				77			0	4	67	29	18												0.16	
	IV		99		84																				
	III		93		79			0	3	73	24	16												0.19	
	II				88								50	19										0.12	
	I		91		82								71	36										0.12	
5	VII	13	85		79								78	42											
	VI				79			0	3	63	34	21												0.18	
	V		102		57																				
	IV		110		42																				
	III		110		42																				
	II		108		45								36	9										0.22	gre 0.08
	I		105		57			0	0	35	65	33													

Ground Elevation +2.7 prior to construction, sand drain test area.

SHEET NO 2 OF 11 SHEETS

FORM T-39-50 5-148-1

STATE OF CALIFORNIA
DIVISION OF HIGHWAYS
MATERIALS AND RESEARCH DEPARTMENT

SUMMARY OF TESTS—FOUNDATION INVESTIGATION

Job No 2094-R-21
Boring No. D 57

LOCATION Eureka Slough DIST 1 CO Hum RTE 1 SEC Eur. WO .... DATE REPORTED 3-9-56

FIELD DATA			TEST RESULTS																						
SAMPLE NO	TUBE NO	~~ELEV~~ DEPTH	UNIT WEIGHT LBS PER CU FT		MOIST CONT	SPEC GRAV	VOIDS RATIO	GRAIN SIZE ANALYSIS					ATTERBERG LIMITS		CONSOLIDATION % OF ORIGINAL HEIGHT, LOAD-TONS PER SQ FT							DIRECT SHEAR		UNCONF COMP	REMARKS
			WET	DRY	% DRY WEIGHT			GRAVEL	SAND	SILT	CLAY	COLL'D	LL	PI	1/8	1/4	1/2	1	2	4	8	COHESION psf	ANGLE OF INTERNAL FRICTION	COMP STRENGTH T/FT²	
6	VIII	16	104		49																				
	VII		105		50								57	28											
	VI				52			0	0	45	55	31												0.36	
	V		101		49																				
	IV				53	2.79									2.6	3.8	6.1	10.9	14.7	20.8	26.6				
	III		97		63			0	0	29	71	38												0.59	
	II				50								50	20										0.55	
	I		105		54																				
7	VII	19	102		56								73	41											
	VI				58			0	0	40	60	31												0.56	
	V		109		61																				
	IV		104		48																				
	III		106		57																				
	II		106		50								44	18										0.40	9re. 0.10
	I		101		59																				

SHEET NO 3
OF 11 SHEETS

FORM T-39-50
5-148-1

STATE OF CALIFORNIA DIVISION OF HIGHWAYS
MATERIALS AND RESEARCH DEPARTMENT

SUMMARY OF TESTS—FOUNDATION INVESTIGATION

Job No. 2099-R-21
Boring No. D 59

LOCATION Eureka Slough DIST 1 CO Hum RTE 1 SEC Eur WO ______ DATE REPORTED 3-4-56

FIELD DATA			TEST RESULTS																						
SAMPLE NO	TUBE NO	~~ELEV~~ DEPTH	UNIT WEIGHT LBS PER CU FT		MOIST CONT % DRY WEIGHT	SPEC GRAV	VOIDS RATIO	GRAIN SIZE ANALYSIS					ATTERBERG LIMITS		CONSOLIDATION % OF ORIGINAL HEIGHT, LOAD—TONS PER SQ FT							DIRECT SHEAR		UNCONF COMP	REMARKS
			WET	DRY				GRAVEL	SAND	SILT	CLAY	COLL'D	LL	PI	1/8	1/4	1/2	1	2	4	8	COHESION psf	ANGLE OF INTERNAL FRICTION	COMP STRENGTH T/FT²	
1	II	0	110		41			0	27	46	27	14												0.26	
	I		111		30								56	29											
2	II	3	108		44			0	22	54	24	12												0.13	
	I		107		46								45	20										0.17	
3	IV	6																							
	III		93		72																				
	II				68			0	0	56	44	23												0.18	grc 0.02
	I		95		76								46	16											
4	V	9	91		78								66	32											
	IV		93		81			0	3	59	38	31												0.16	
	III		93		76																				
	II				80	2.71									2.4	5.4	12.0	18.9	27.4	34.2	39.9				
	I		101		53								36	11										0.18	
5	I	12	104		49			0	6	61	33	17													
6	V	15	104		49								53	28											
	IV		107		48			0	0	29	71	40												0.44	grc 0.14
	III		103		48																				
	II		106		52								46	19										0.46	
	I		105		49																				

Ground Elev. +2.0 Prior to construction, Sand Drain test Area.

SHEET NO 4 OF 11 SHEETS

FORM T-39-50
5-148-1

STATE OF CALIFORNIA — DIVISION OF HIGHWAYS
MATERIALS AND RESEARCH DEPARTMENT

SUMMARY OF TESTS—FOUNDATION INVESTIGATION

Job No. 2094-R-21
Boring No. D59

LOCATION Eureka slough DIST 1 CO Hum RTE 1 SEC Eur. WO ....

DATE REPORTED 3-4-56

FIELD DATA			TEST RESULTS																						
SAMPLE NO	TUBE NO	~~ELEV~~ DEPTH	UNIT WEIGHT LBS PER CU FT		MOIST CONT	SPEC GRAV	VOIDS RATIO	GRAIN SIZE ANALYSIS					ATTERBERG LIMITS		CONSOLIDATION % OF ORIGINAL HEIGHT — LOAD-TONS PER SQ FT							DIRECT SHEAR		UNCONF COMP	REMARKS
			WET	DRY	% DRY WEIGHT			GRAVEL	SAND	SILT	CLAY	COLL'D	LL	PI	1/8	1/4	1/2	1	2	4	8	COHESION psf	ANGLE OF INTERNAL FRICTION	COMP STRENGTH T/FT²	
7	IX	18	102		47								70	39											
	VIII		102		52																				
	VII		102		58			0	3	39	58	31												0.43	
	VI		100		58																				
	V		100		61								72	39											
	IV		89		58																				
	III				54	2.71									0.8	1.6	3.0	5.6	11.8	18.6	24.8				
	II		103		54			0	3	46	51	27												0.37	
	I		102		56								58	32											

SHEET NO 5 OF 11 SHEETS

FORM T-39-50

STATE OF CALIFORNIA DIVISION OF HIGHWAYS
MATERIALS AND RESEARCH DEPARTMENT

SUMMARY OF TESTS—FOUNDATION INVESTIGATION

Job No. 2099-R-21
Boring No. D61

LOCATION Eureka slough DIST. 1 CO. Hum RTE 1 SEC. Eur. WO

DATE REPORTED 3-9-56

SAMPLE NO	TUBE NO	~~ELEV~~ DEPTH	UNIT WEIGHT LBS PER CU FT WET	UNIT WEIGHT LBS PER CU FT DRY	MOIST CONT % DRY WEIGHT	SPEC GRAV	VOIDS RATIO	GRAVEL	SAND	SILT	CLAY	COLL'D	LL	PI	1/8	1/4	1/2	1	2	4	8	COHESION psf	ANGLE OF INTERNAL FRICTION	COMP STRENGTH T/FT²	REMARKS
1	VI	2	103		50																				
	V		114		36			0	42	35	23	13												0.26	
	IV				37																				
	III		114		35																				
	II		109		41								32	9										0.28	
	I		109		27																				
2	IV	7	92		74			0	40	16	54	30												0.15	qrc 0.04
	III		93		71																				
	II		93		68			0	2	59	39	23												0.16	
	I		98		66								43	13										0.14	
3	VIII	12	93		70								69	32											
	VII		93		76			0	4	56	40	14												0.17	qrc 0.02
	VI		104		71			0	4	65	31	24			1.4	2.9	6.7	13.2	20.9	27.4	33.6				
	V		88		76																				
	IV		93		75								70	35											
	III		94		72																				
	II		92		79			0	0	67	33	21												0.18	
	I		93		76								82	46											
4	VIII	17	100		50																			0.22	
	VII		104		47								53	25											
	VI		105		51			0	0	44	56	33												0.49	
	V		103		53																				
	IV		100		58																				
	III		104		48			0	0	31	69	39												0.62	
	II		104		55								64	31										0.28	qrc 0.12
	I		102		57																				

Ground Elev. +3.5 Prior to construction, sand drain test Area.

SHEET NO 6 OF 11 SHEETS

FORM T-39-50
5-148-1

STATE OF CALIFORNIA — DIVISION OF HIGHWAYS
MATERIALS AND RESEARCH DEPARTMENT

SUMMARY OF TESTS—FOUNDATION INVESTIGATION

Job No 2099-R-21
Boring No. D65

LOCATION Eureka Slough DIST 1 CO Hum RTE 1 SEC Eur. WO

DATE REPORTED 3-9-56

FIELD DATA			TEST RESULTS																						
SAMPLE NO	TUBE NO	ELEV DEPTH	UNIT WEIGHT LBS PER CU FT		MOIST CONT	SPEC GRAV	VOIDS RATIO	GRAIN SIZE ANALYSIS					ATTERBERG LIMITS		CONSOLIDATION % OF ORIGINAL HEIGHT — LOAD-TONS PER SQ FT							DIRECT SHEAR		UNCONF COMP	REMARKS
			WET	DRY	% DRY WEIGHT			GRAVEL	SAND	SILT	CLAY	COLL'D	LL	PI	1/8	1/4	1/2	1	2	4	8	COHESION psf	ANGLE OF INTERNAL FRICTION	COMP STRENGTH T/FT²	
1	IV		112		35			0	23	52	25	15												0.26	
	III		109		28										1.5	2.5	4.8	7.6	10.9	14.4	18.2				
	II																								
	I		97		66			(Peaty)			27	17												0.13	
2	IV		111		42			0	11	60	29	14												0.32	
	III																								
	II																								
	I		103		51								53	21										0.24	qre = 0.08
3	VII	15	94		68								81	45											
	VI		94		79			0	0	26	74	37												0.35	
	V		99		63																				
	IV				69										1.6	3.5	7.1	12.1	18.4	24.9	31.7				
	III																								
	II		106		49								56	25										0.43	qre 0.14
	I		112		50			0	0	31	39														
4	VII	18	105		49																				
	VI		107		50			0	0	38	62	35												0.43	
	V		104		49								61	32											
	IV		100		59																			0.34	
	III		105		47																				
	II		106		49			0	3	32	65	35												0.40	
	I		108		48								69	38											

Ground Elev. +4.9 After Driving Sand Drains, Sand Drain test Area, 2 ft. from center of Sand Drain.

SHEET NO 7 OF 11 SHEETS

FORM T-39-50 5-148-1

STATE OF CALIFORNIA — DIVISION OF HIGHWAYS
MATERIALS AND RESEARCH DEPARTMENT

Job No. 2094-R-21

Boring No. D65

SUMMARY OF TESTS—FOUNDATION INVESTIGATION

LOCATION Eureka Slough DIST 1 CO Hum RTE 1 SEC Eur W.O. ______ DATE REPORTED 3-9-56

FIELD DATA			TEST RESULTS																						
SAMPLE NO	TUBE NO	~~ELEV~~ DEPTH	UNIT WEIGHT LBS PER CU FT		MOIST CONT	SPEC GRAV	VOIDS RATIO	GRAIN SIZE ANALYSIS					ATTERBERG LIMITS		CONSOLIDATION % OF ORIGINAL HEIGHT — LOAD-TONS PER SQ FT							DIRECT SHEAR		UNCONF COMP	REMARKS
			WET	DRY	% DRY WEIGHT			GRAVEL	SAND	SILT	CLAY	COLL'D	LL	PI	1/8	1/4	1/2	1	2	4	8	COHESION psf	ANGLE OF INTERNAL FRICTION	COMP STRENGTH T/FT²	
5	VIII	21	100			55																		0.33	
	VII		101			54							73	40											
	VI		101			57		0	0	45	55	33												0.34	
	V		105			55									1.1	3.1	6.1	10.8	16.3	21.9	27.5				
	IV		103			51																		0.49	
	III		102			57																			
	II		105			51							56	25										0.35	qu 0.10
	I		102			55		0	0	44	56	31													

SHEET NO 8 OF 11 SHEETS

FORM T-39-50
S-148-1

STATE OF CALIFORNIA DIVISION OF HIGHWAYS
MATERIALS AND RESEARCH DEPARTMENT

SUMMARY OF TESTS—FOUNDATION INVESTIGATION

Job No. 2099-R-21
Boring No. 0 66

LOCATION Eureka Slough DIST 1 CO Hum RTE 1 SEC Eur WO ....

DATE REPORTED 3-9-56

FIELD DATA			TEST RESULTS																						
SAMPLE NO	TUBE NO	~~ELEV~~ DEPTH	UNIT WEIGHT LBS PER CU FT		MOIST CONT	SPEC GRAV	VOIDS RATIO	GRAIN SIZE ANALYSIS					ATTERBERG LIMITS		CONSOLIDATION % OF ORIGINAL HEIGHT, LOAD—TONS PER SQ FT							DIRECT SHEAR		UNCONF COMP	REMARKS
			WET	DRY	% DRY WEIGHT			GRAVEL	SAND	SILT	CLAY	COLL'D	LL	PI	1/8	1/4	1/2	1	2	4	8	COHESION psf	ANGLE OF INTERNAL FRICTION	COMP STRENGTH T/FT²	
1	IV	5	110		37			0	23	49	28	13												0.17	
	III		109		32								39	16											
	II		105		48																			0.18	
	I		97		61			0	3	69	28	19												0.17	
2	IV	8	91		73			0	0	22	78	37												0.09	
	III		98		63																				
	II		95		72										2.7	6.5	12.2	18.9	26.1	32.4	37.9				
	I		95		72								69	35										0.11	gre 0.04
3	V	11	96		57								59	28											
	IV		104		54			0	3	64	33	15												0.20	
	III		100		54																				
	II		102		56																				
	I		97		72								76	36										0.21	
4	VII	14	102		58								69	38											
	VI		102		59			0	0	35	65	33												0.42	
	V		101		58										1.0	2.7	5.6	9.7	16.5	23.4	29.9				
	IV		101		62																			0.38	
	III		99		63																				
	II		100		59								66	33										0.36	gre 0.12
	I		103		53			0	4	28	68	35													

Ground Elev. + 4.8 After Driving Sand Drains, Sand Drain test Area, 5ft. from sand Drain center.

SHEET NO 9 OF 11 SHEETS

FORM T-39-50
5-14R-1

STATE OF CALIFORNIA
MATERIALS AND RESEARCH DEPARTMENT
DIVISION OF HIGHWAYS

SUMMARY OF TESTS—FOUNDATION INVESTIGATION

Job No. 2094-R-21
Boring No. D66

LOCATION Eureka slough DIST 1 CO Hum RTE 1 SEC Eur WO ....

DATE REPORTED 3-1-56

FIELD DATA			TEST RESULTS																						
SAMPLE NO	TUBE NO	ELEV DEPTH	UNIT WEIGHT LBS PER CU FT		MOIST CONT	SPEC GRAV	VOIDS RATIO	GRAIN SIZE ANALYSIS					ATTERBERG LIMITS		CONSOLIDATION % OF ORIGINAL HEIGHT LOAD—TONS PER SQ FT							DIRECT SHEAR		UNCONF COMP	REMARKS
			WET	DRY	% DRY WEIGHT			GRAVEL	SAND	SILT	CLAY	COLL'D	LL	PI	1/8	1/4	1/2	1	2	4	8	COHESION psf	ANGLE OF INTERNAL FRICTION	COMP STRENGTH T/FT²	
5	VI	17	104		51								61	31											
	V		108		48			0	0	73	27	15												0.43	
	IV		109		49																				
	III		105		48																				
	II		107		51								54	23										0.36	
	I		100		59			0	2	31	67	35												0.35	
6	IV	20	104		55			0	0	33	67	38												0.40	
	III		102		57								71	37											
	II		102		58										0.8	2.0	4.0	7.7	13.9	20.9	27.2				
	I		101		57								62	30										0.45	9rc 0.10
7	VII	23	103		53								66	34											
	VI		101		59			0	0	47	53	28												0.58	
	V		95		65																				
	IV		99		63																				
	III		97		64																				
	II		100		55								60	27										0.37	9rc 0.10
	I		91		78			0	2	26	72	28													

SHEET NO 10
OF 11 SHEETS

FORM T-39-50
5-148-1

STATE OF CALIFORNIA DIVISION OF HIGHWAYS
MATERIALS AND RESEARCH DEPARTMENT

SUMMARY OF TESTS—FOUNDATION INVESTIGATION

Job No. 2099-R-21

Boring No. D 70

LOCATION Eureka Slough DIST. 1 CO. Hum. RTE. 1 SEC. Eur. W.O. ....

DATE REPORTED 3-4-56

FIELD DATA			TEST RESULTS																						
SAMPLE NO	TUBE NO	ELEV DEPTH	UNIT WEIGHT LBS PER CU FT		MOIST CONT	SPEC GRAV	VOIDS RATIO	GRAIN SIZE ANALYSIS					ATTERBERG LIMITS		CONSOLIDATION % OF ORIGINAL HEIGHT LOAD—TONS PER SQ FT							DIRECT SHEAR		UNCONF COMP	REMARKS
			WET	DRY	% DRY WEIGHT			GRAVEL	SAND	SILT	CLAY	COLL'D	LL	PI	⅛	¼	½	1	2	4	8	COHESION psf	ANGLE OF INTERNAL FRICTION	COMP STRENGTH T/FT²	
1	V	2'	121		18								N.P.											0.12	
	IV		105		50			0	3	55	42	21												0.18	
	III		112		40										1.5	3.5	6.5	11.0	15.8	20.0	26.1				
	II																								
	I		113		40								42	17										0.24	
2	V	7	109		42								42	13											
	IV		110		45			0	0	47	53	25												0.27	
	III																								
	II		108		46			0	9	61	30	16												0.38	
	I		108		45								44	13										0.36	gra 0.10
3	VIII	17	107		47								57	27											
	VII		107		48			0	5	71	24	11												0.49	
	VI																								
	V				50																			0.56	
	IV		107		48										0.6	1.9	4.2	7.2	11.4	17.5	23.2				
	III																								
	II		105		53								57	26										0.41	
	I				47																				

Ground Elev + 3.0 After 2 ft. fill in place, Non Sand Drain Test Area.

SHEET NO 11 OF 11 SHEETS

FORM T-39-50
5-148-1