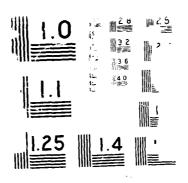
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RECVALUATION OF THE ESCER SAN FERNANDO DAM

Report 1

AN INVESTIGATION OF THE FEBRUARY 9 1901 SLIDE VOLUME II: APPENDIXES AF

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Gonzalo Castro, Thomas O. Keller, Stephen S. House F.

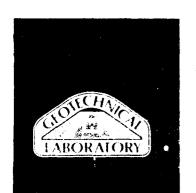
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September 1989 Report 1 of a Series

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NOTATIONS

The following symbols are used in this report:

Symbols and Abbreviations

Ac = area of triaxial test specimen after consolidation

amax = maximum base rock acceleration

B_c = Skempton's pore pressure coefficient after consolidation

C = cone penetration test sounding prefix

c = cohesion intercept of a strength envelope

CR = clearance ratio of sampling tube = $\frac{ID - CE}{CE}$

where ID = inside diameter of tube and CE = inside diameter of cutting edge

 $C\overline{R}$ = consolidated undrained cyclic load triaxial test

 $C\overline{R}R = C\overline{R}$ test followed by an \overline{R} phase

 D_{10} = diameter at which 10% of the soil is finer by weight

E = east

 e_t = void ratio in sampling tube

e = void ratio

 e_c = void ratio after consolidation

ES = exploration shaft

 e_{1985} = in situ void ratio at time of sampling in 1985

e₁₉₇₁ = in situ void ratio immediately prior to 1971 San Fernando earthquake

F = force

 F_a = maximum cyclic load applied in $C\overline{R}$ test

NOTATIONS (continued)

- FD = field density test
- F_L = factor of safety against liquefaction susceptibility (equal to ratio of S_{us}/τ_d)
- F_r = maximum load above anisotropic load felt by sample during cyclic loading in CR test
- ft = feet
 - G = specific gravity of solids
- G = shear modulus
- g = acceleration due to gravity (32.2 feet per second)
- G_{max} = shear modulus at very low strains
 - K_c = consolidation stress ratio = $\bar{\sigma}_{1c}/\bar{\sigma}_{3c}$
 - $K_0 = \text{coefficient of lateral earth pressure, equal to } \frac{\overline{\sigma}_h}{\overline{\sigma}_v}$
- k(t) = time history of average acceleration of sliding mass
- kmax = maximum value of k(t)
 - ky = yield acceleration
 - LV = laboratory vane shear test; undrained
 - N = north
 - N = standard penetration test blowcount, blows/foot
- NGVD = National Geodetic Vertices atum; elevation
 - p = mean of minor and major effective principal stresses or vertical effective stress when used in the form c/p
 - q = one half of difference between major and minor principal stress; shear stress on plane inclined at 45° to major principal plane;
 - q_a = maximum applied q during $C\overline{R}$ test; summation of q_c and F_a/Ac

NOTATIONS (continued)

- $q_c = q$ at completion of consolidation
- q_p = q when peak shear stress is reached during triaxial
 test
- q_r = maximum soil stress felt by sample during $C\overline{R}$ test; summation of q_c and F_r/Ac
- $q_s = q$ during steady state deformation
- - \overline{R} = consolidated undrained, monotonically loaded triaxial test
 - S = south
 - S = degree of saturation
 - S = split-spoon sample boring number prefix
 - S = consolidated drained, monotonically loaded triaxial test
- sec = seconds
- S_{ds} = drained steady state shear strength
- SSL = steady state line
- S_{up} = peak undrained shear strength
- S_{us} = undrained steady state shear strength
 - S_y = yield strength
 - t = time
 - t = tons
- tsf = tons per square foot
- TS = tripod tube sample number prefix
 - U = undisturbed sample boring number prefix

NOTATIONS (continued)

U = undisturbed sample number prefix for fixed piston samples from borings

 u_c = backpressure in triaxial test

V = volume

W = west

W = weight of sliding mass

 α_S = slope of line through points representing steady state of deformation on stress path plot (q versus \overline{p})

 ΔV = change in volume

 Δe = change in void ratio

 δ = shear deformation

 z_a = axial strain

 ϵ_S = axial strain when steady state deformation is reached during triaxial test

 ϵ_p = axial strain when peak shear stress is reached during triaxial test

 ϵ_{ec} = axial strain at end of cyclic loading in \overline{CR} test (see Fig. F105)

 ε_{rf} = axial strain at start of rapid failure in $C\overline{R}$ test (see Fig. 105)

εtr = triggering axial strain; axial strain required to trigger liquefaction failure

 γ = shear strain

 γ_t = total unit weight

 γ_d = dry unit weight

 γ_{dc} = dry unit weight at end of consolidation

Ytr = triggering shear strain; shear strain required to trigger liquefaction failure

NOTATIONS (concluded)

- $\mu = Poisson's ratio$
- ϕ_s = friction angle at steady state of deformation in terms of effective stress
- ϕ_p = maximum effective stress friction angle computed from a Mohr diagram
- $\bar{\sigma}_h$ = horizontal effective stress
- $\bar{\sigma}_1$ = major principal effective stress
- $\bar{\sigma}_{1c}$ = major principal effective stress after consolidation
- $\bar{\sigma}_{3ec}$ = minor principal effective stress at end of cyclic loading in CR test (see Fig. F105)
- $\bar{\sigma}_{3s}$ = minor principal effective stress during steady state of deformation
- $\bar{\sigma}_{3rf}$ = minor principal effective stress at start of rapid failure in CR test (see Fig. F105)
 - $\bar{\sigma}_3$ = minor principal effective stress
 - $\bar{\sigma}_{3c}$ = minor principal effective stress after consolidation
 - $\bar{\sigma}_f$ = effective normal stress on failure plane
 - $\bar{\sigma}_{fs}$ = effective normal stress on failure plane during steady state of deformation
 - $\bar{\sigma}_{V}$ = vertical effective stress
 - $\bar{\sigma}_{0}$ = octahedral effective stress; also contact stress between soil particles
 - τ = shear stress on failure plane
 - τ_{d} = driving shear stress on failure plane

APPENDIX A: SUBSURFACE EXPLORATION PROGRAM

APPENDIX A

SUBSURFACE EXPLORATION PROGRAM

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A.5	Groundwater Observation Wells	A7

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- A1 Summary of Boring and Exploration Shaft Locations and Elevations
- A2 Undisturbed Fixed-Piston Sample Data

LIST OF BORING LOGS

General Notes and Abbreviations for Boring Logs

Romina	9101
	S102
	S103
	S104
	S105
	S111
	U102
	U103
	U104
	U105
	U111
	U111A

LIST OF OBSERVATION WELL REPORTS

OW104 OW111

APPENDIX A

SUBSURFACE EXPLORATION PROGRAM

A.1 Purpose and Scope

The purpose of the exploration program was to characterize and obtain undisturbed samples of the sections of the dam which did not fail in 1971. Sampling was concentrated in the intact hydraulic fill shell on the downstream side of the dam.

The exploration program consisted of the following:

- a. Six standard penetration test (SPT) borings performed by the Corps of Engineers waterways Experiment Station (WES) between September 9 and 24, 1985.
- b. Twelve cone penetration test soundings (CPT) performed by the Earth Technology Corporation (ERTEC) on September 18 and 19, 1985.
- c. Six undisturbed sample borings performed by WES between September 25 and October 12, 1985.
- d. Two groundwater observation wells installed by WES on September 25 and October 4, 1985.
- e. One deep exploration shaft advanced by Zamborelli Drilling to obtain undisturbed samples, perform in situ density tests, and map sidewalls of the excavation.

An engineer from GEI was at the site during the investigation to coordinate and observe borings and soundings. Two engineers from GEI performed all geotechnical work in the exploration shaft.

The locations of all borings, soundings observation wells, and exploration shaft are shown in Fig. 5 of the main text. Their stations and elevations are presented in Table Al. Explorations were performed at 12 locations, Nos. 101 to 112, shown in Fig. 5. Earings and soundings are referenced to their location number. A description of the exploration shaft is presented in Appendix B.

The main purpose of the SPT borings and CPT soundings was to identify the various layers comprising the dam. The SPT and CPT data was used to identify locations and depths for undisturbed sampling from borings and exploration shaft.

A.2 Split-Spoon Sample (SPT) Borings

The SPT borings were performed to: 1) recover split-spoon samples to classify soils comprising the dam and foundar on and 2) obtain standard penetration resistance values (N-values) of the various layers encountered. Six SPT borings (S101 through S105 and S111) were performed at the dam site. Detailed logs of these borings prepared by GEI are included at the end of this appendix.

Split-spoon samples were obtained every 5 feet in Boring S104. Intense stratification was observed in the split-spoon samples of the hydraulic fill in Boring S104, and it became evident that continuous sampling of the hydraulic fill in future borings would be necessary to define zonation within the hydraulic fill. Therefore, split-spoon samples in the remaining five SPT borings were obtained every 5 feet in the upper compacted fill, continuously in the hydraulic fill, and either continuously or at 5-foot intervals in the foundation soils. Each boring was advanced at least 5 feet into foundation material.

The SPT borings were drilled with a Failing 1500 truckmounted drill rig using standard rotary wash boring techniques. Each borehole was advanced without casing, using N-rods and a 4-inch fishtail bit with deflectors which discharged the drilling mud upward. A bentonite drilling mud, maintained at the top of the borehole during the sampling and drilling operation, was used to stabilize the borehole. Split-spoon samples were taken using a 1-3/8-inch-I.D. sampling shoe attached to a 1½-inch-I.D. by 2.0-inch-O.D. split-barrel sampler. The split barrel had room for liners, but liners were not used. A 140-lb automatic trip hammer designed for a 30-inch free fall was used to drive the splitspoon sampler. The standard penetration test N-value used was taken from the second and third 6-inch interval of a 24-inch drive. The rate at which the blowcounts were delivered was approximately 30 to 40 blows per minute.

Stress wave energy measurements of the 140-lb trip hammer system were made by the U.S. Bureau of Reclamation (Farrar, 1986)¹. The energy ratio of the hammer was found to be 72%.

¹List of References is presented at the end of the main text.

A.3 Cone Penetration Test (CPT) Soundings

Twelve CPT soundings (C101 to C112) were performed at the locations shown in Fig. 5. CPT sounding procedures and results are presented by the Earth Technology Corporation (1985).

The CPT soundings were conducted in general accordance with ASTM Specification D3441-79 using an electronic cone penetrometer. The cone tip and friction sleeve had outside diameters of 4.37 cm and a cross-sectional area of 15 sq cm.

A.4 Undisturbed Cample Borings

Undisturbed sample borings were performed to obtain undisturbed samples suitable for laboratory triaxial testing and void ratio measurements. Six undisturbed sample borings were performed at the site. Five undisturbed sample borings (U102 through U105 and U111) were located 5 feet east of the SPT borings with the same location numbers. One boring, U111A, was located 5 feet south of Boring S111. Logs of each of the undisturbed borings are presented at the end of this appendix.

Eighty fixed-piston tube samples were obtained in the six undisturbed sample borings. Data for each undisturbed fixed-piston sample is presented in Table A2.

The tube sample borings were advanced using the same equipment and drilling techniques as described in Section A.2. Each tube sample was obtained using a Hvorslev-type stationary fixed-piston sampler. Sampling tubes were 3.0-inch-0.D., 36-inch-long thin-walled galvanized coated steel tubes with a wall thickness of 1/16 inch. The cutting edge of each tube was machined and the clearance ratio, CR, of each tube was measured. Clearance ratio is defined and the values for each tube are presented in Table A.2. Clearance ratios of tubes ranged from 0.08 to 1.28% and averaged 0.6%.

The tube sampling procedure consisted of lowering the sampler to the bottom of the borehole with the actuating rods (attached to the fixed piston) inside the drill rods. The actuating rods were fixed to an independent frame that was set up over the borehole. The frame was supported on steel rods driven 2 feet into the ground. The sampler was pushed hydraulically in a smooth continuous motion until a pressure of 550 psi or 24 inches of penetration was reached. The penetration and any movements of the actuating rods and frame were carefully measured before and after each push. The tube was withdrawn from the bottom of the borehole in a smooth constant motion using hydraulic pressure to pull the tube at a

rate of 1 inch per second or less for the first 2 feet. After the sampler was pulled free from the bottom of the borehole, withdrawal continued to the ground surface at a slow uniform rate no greater than 1 foot per second.

Special care was taken to avoid jarring or disturbing the tube samples during sampling, storage, and transportation. Each tube was held in a vertical position at all times from sampling in the field to arrival at GEI's laboratory in Winchester, Massachusetts. Precise measurements were made of sample penetration, sample recovery length, and any change in sample length during storage and transportation. Soil volume changes which occurred during the sampling operation, expressed as $\Delta V/V$, are summarized in Table A2. A large number of samples had very little volume change during sampling. No changes in sample length were recorded after storage and transportation to GEI's laboratory.

All undisturbed tube samples were brought to Futura Engineering Laboratories Inc., Santa Fee Springs, California for x-raying. A GEI engineer was present during x-raying to assist in handling the tubes.

A.5 Groundwater Observation Wells

Groundwater observation wells were installed at Locations 104 and 111 shown in Fig. 5. Groundwater observation well reports are presented at the end of this appendix. The following stabilized groundwater levels were recorded in each well:

Well No.	Date	Groundwater Elevation, NGVD, ft
CW104	10/17/85	1016.4
OW111	10/17/85	1011.3

Groundwater elevation in the exploration shaft, located 14 feet from OW111, was 1012.4 in December 1985.

TABLE A1 - SUMMARY OF BORING AND EXPLORATION SHAFT LOCATIONS AND ELEVATIONS Lower San Fernando Dam - California

Number(1)	Station	Offset from Dam Centerline, ft	Ground Elevation (NGVD)
C101 C102 C103 C104 C105 C106 C107 C108 C109 C110 C111	16+45 16+50 9+40 9+40 9+40 5+90 16+45 12+85 12+85 12+85 5+90 5+90	68.8 S 54.0 N 132.0 S 73.1 S 23.4 S 73.1 S 23.4 S 132.0 S 73.1 S 23.4 S 132.0 S 73.1 S 23.4 S	1115.5 1114.6 1093.9 1114.5 1114.1 1114.8 1115.2 1094.4 1114.9 1114.3 1095.1 1114.4
S101	16+40	68.8 S	1115.5
S102	16+40	54.0 N	1114.6
S103	9+35	132.0 S	1093.9
S104	9+35	73.1 S	1114.5
S105	9+35	23.4 S	1114.1
S111	5+85	132.0 S	1095.1
OW104	9+55	73.1 S	1114.5
OW111	5+95	132.0 S	1095.1
U102	16+35	54.0 N	1114.6
U103	9+30	132.0 S	1093.9
U104	9+30	73.1 S	1114.5
U105	9+30	23.4 S	1114.1
U111	5+80	132.0 S	1095.1
U111A	5+85	137.0 S	1095.1
ES111	5+85	120.0 S	1097.5

Note:

⁽¹⁾ C - Cone penetration test sounding

S - Split-spoon sample boring

OW - Observation well

U - Undisturbed sample boring

ES - Exploration shaft

TABLE A2 - UNDISTURBED FIXED-PISTON SAMPLE DATA Lower San Fernando Dam - California

Page 1 of 3

Boring No.	Sample No.	Elevation ⁽¹⁾ Top of Sample ft	Clearance ⁽²⁾ Ratio CR %	Penetration of Sampler P cm	Gross Recovery R	△V/V(3) During Sampling 7
U102	UF-1	1054.6	0.549	61.5	61.2	0.60
0102	UF-2	1052.6	0.509	61.0	60.6	0.36
	UF-3	1050.6	0.169	60.3	59.5	-1.00
	UF-4	1048.6	0.568	61.1	60.6	0.31
	UF-5	1046.6	0.494	60.3	59.9	0.32
U103	UF-1	1017.9	0.568	44.7	35.2	-20.36
	UF-2	1015.9	1.219	36.9	36.1	0.23
	UF-3	1013.9	0.925	59.6	58.4	-0.11
	UF-4	1011.9	0.941	60.1	59.5	0.87
	UF-5	1009.9	1.004	60.8	60.2	1.01
U104	UF-1	1046.8	0.596	61.3	60.7	0.20
	UF-2	1044.4	0.930	60.7	60.1	0.36
	UF-3	1042.5	0.642	60.7	59.6	- 0.55
	UF-4	1040.5	0.665	61.0	60.0	-0.33
	UF-5	1033.5	0.766	60.2	57.4	-3.18
	UF-6	1031.5	0.797	60.2	58.7	- 0.93
	UF-7	1024.5	0.660	55.8	53.4	-3.13
	UF-8	1022.5	0.582	59.8	58.8	- 0.53
	UF-9	1020.5	0.741	55.8	55.7	1.31
	UF-10	1009.5	0.527	59.8	59.6	0.71
	UF-11	1007.5	0.288	43.4	41.2	- 4.74
	UF-12	1005.5	0.247	24.6	23.9	-2.42
	UF-13	1003.5	0.743	57.6	56.0	-1.33
	UF-14	1001.5	0.623	60.5	60.1	0.58
U105	UF-1	1064.4	0.187	61.7	60.8	-1.09
	UF-2	1062.1	0.270	60.6	59.9	- 0.62
	UF-3	1051.1	0.700	60.5	59.7	0.06
	UF-4	1049.1	0.656	61.2	60.5	0.16
	UF-5	1047.1	0.522	60.6	59.9	-0.12
	UF-6	1045.1	0.288	61.3	60.4	-0.90
	UF-7	1038.1	0.224	62.4	62.1	-0.03
	UF-8	1036.1	0.564	60.8	59.9	-0.37
	UF-9	1027.1	0.594	59.6	58.4	- 0.85

Notes: See page 3

Geotechnical Engineers Inc.

Project 85669 September 2, 1987

TABLE A2 - UNDISTURBED FIXED-PISTON SAMPLE DATA Lower San Fernando Dam - California

Page 2 of 3

Boring No.	Sample No.	Elevation(1) Top of Sample ft	Clearance ⁽²⁾ Ratio CR %	Penetration of Sampler P cm	Gross Recovery R cm	△V/V(3) During Sampling Ž
U105	UF-10	1025.1	1.054	62.1	60.8	-0.02
	UF-11	1022.1	0.196	59.6	59.0	-0.62
	UF-12	1020.1	0.439	61.0	59.8	-1.10
	UF-13	1018.1	0.564	60.9	59.8	-0.70
	UF-14	1016.1	0.169	60.4	59.7	-0.82
U111	UF-1	1071.1	0.425	60.8	53.3	-11.59
	UF-2	1069.1	0.330	61.4	52.0	-14.75
	UF-3	1047.1	0.320	63.1	63.3	0.96
	UF-4	1045.1	0.459	61.6	60.1	-1.54
	UF-5	1043.1	0.215	60.6	59.8	-0.90
	UF-6	1041.1	0.215	53.4	50.3	-5.40
	UF-7	1039.1	0.219	34.4	32.5	-5.11
	UF-8	1037.1	0.329	35.5	35.2	-0.19
	UF-9	1035.1	0.229	60.6	59.2	-1.86
	UF-10	1033.1	0.293	53.3	51.2	-3.38
	UF-11	1031.1	0.311	50.2	48.9	-1.98
	UF-12	1029.1	0.215	56.4	54.2	-3.49
	UF-13	1027.1	0.499	42.3	41.3	-1.39
	UF-14	1025.1	0.518	14.0	13.6	-1.85
	UF-15	1024.1	0.462	52.4	51.8	-0.13
	UF-16	1022.1	1.286	60.5	59.8	1.40
	UF-17	1020.1	0.082	51.0	50.0	-1.80
	UF-18	1018.1	0.408	60.6	60.1	-0.01
	UF-19	1016.1	1.183	61.3	60.3	0.71
	UF-20	1014.1	0.160	61.4	60.6	-0.99
	UF-21	1012.1	0.717	60.5	59.2	-0.74
	UF-22	1010.1	0.504	61.7	61.0	-0.14
	UF-23	1008.1	0.462	53.5	53.0	- 0.02
Ullla	UF-1	1047.1	0.490	60.8	61.1	1.48
	UF-2	1045.1	0.444	59.8	55 .9	- 5.69
	UF-3	1043.1	0.431	59.7	59.0	- 0.32
	UF-4	1041.1	0.541	60.2	57.3	-3.78
	UF-5	1039.1	0.536	54.5	53.7	- 0.41

Notes: See page 3

Geotechnical Engineers Inc.

Project 85669 September 2, 1987

TABLE A2 - UNDISTURBED FIXED-PISTON SAMPLE DATA Lower San Fernando Dam - California

Page 3 of 3

Boring No.	Sample No.	Elevation(1) Top of Sample	Clearance ⁽²⁾ Ratio CR 7	Penetration of Sampler P cm	Gross Recovery R cm	△V/V(3) During Sampling X
UlllA	UF-6	1037.1	0.508	58.9	57.9	- 0.70
	UF-7	1035.1	0.568	59.1	57.7	-1.26
	UF-8	1033.1	0.559	40.0	38.5	- 2 67
	UF-9	1031.1	0.828	48.1	47.2	-0.24
	UF-10	1029.1	0.855	59.6	58.5	-0.16
	UF-11	1027.1	1.145	27.2	27.2	2.30
	UF-12	1025.1	1.116	24.7	24.1	-0.24
	UF-13	1024.1	0.800	49.2	48.6	0.37
	UF-14	1022.1	0.91	60.0	59.2	0.47
	UF-15	1020.1	0.550	56.1	53.5	-2.86
	UF-16	1018.1	1.186	60.2	59.7	1.54
	UF-17	1016.1	0.916	60.1	58.9	-0.19
	UF-18	1014.1	1.005	60.4	59.5	0.50
	UF-19	1012.1	0.824	60.6	59.5	-0.19
	UF-20	1010.1	0.620	59.3	58.4	-0.29
	UF-21	1008.1	0.710	61.1	60.6	0.60

Notes:

- (1) Elevation Datum is NGVD.
- (2) Clearance Ratio (CR) is defined as:

$$CR = \frac{ID - CE}{CE} \times 100\%$$

Where: ID = inside diameter of sampling tube

CE = diameter of cutting edge of sampling tube

(3) Change in volume during sampling $(\Delta V/V)$ is computed as:

$$\Delta V/V = \left[\left(1 + \frac{CR}{100} \right)^2 \times \frac{R}{P} - 1 \right] \times 100 \text{ (in percent)}$$

Where: CR = clearance ratio of sample tube, defined above.

R = gross recovery

P = penetration length

Positive values indicate sample expansion; negative values indicate sample compression.

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	- 11 -	"	14 24	[*]	1		, ,	fines,	10% grave	up c	led coarse to fine sand, ~25% nonpi o 1/2", brown and gray (SM)	48616	7
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8L0WS PE		HAMMER	FALLING	10 TO	DANAS A	2 On an NOT	ES .						
REC: REC	ETRATION LE DVERT LENG	NGTH OF TH OF SA	MATE STRATE	OR COP	-	MEL 13	Cicondwa		11 5 Not the				
ROO LEN	STH OF SOUR SPOON SAME	IO CORES		£4614	CORED	.7	because o used in l inaccuru	bareholi	te diitting t would pro	mud duce	-E-EVALUATION OF THE STIFE	in The M	- {
	TURBED BAN US - SHELBY UF - FIXED UG- OSTERN			UD DE	II SON	1		ce read	10K2.				l
Ø ekonir		EA4		V6 - 6()	_							ATE 3/3	
L <u>`</u>											A) montries multipopulation bi	MARCE 8	0669

							ELEVATION (NGVD) :115.5 ft D	ATE START/FINISH 19/85/ 2/20/8 S 101
CASI	NG 10_	Not us	ed CORI	SIZ	E NA	GROUNDY	VATER EL. NR ¹⁾ DATE L	OGGED BY F.R. Perkins DATE 9/19-20/85 PG 2 OF 7
ξL	DEPTH		AMPL	ξ		REMARKS		
ļ	ļ	TYPE	BLOWS	PEN	REC		SOIL	AND ROCK DESCRIPTIONS
FT	FT	NQ	6 IN	IN	IN			
	14	54	8 9 8 8	24	3		S4 - SANDY CLAY, si. plastic Sample contained a 1"	c fines, ∿20% fine sand, brown (CL) piece of gravei jammed in shoe.
	18							- - - - - - - - - - - - - - - - - - -
	21	\$5	5579	24	14		S5 - SANDY CLAY, 81. to mod. Occ. pockets of very di	. plastic fines, ~15% fine sand, brown (CL) ry gray clayey sand.
B.O.S.	25	56	:4 :9 :50	24		20m oct NOT	ight brown (5P),	ed, to time sand. I nonplayedd Cloes. Le contained a - 5' prece of grave, domed -
PEN-PEI PEC-REC ROO-LES S-SPLIT U-UMOIS	ME TRATION COVERY LER WETH OF SO SPOON SA ETURBED SE US : SHEL UF : FIXE UG : OSTE NO WAFER	ENGTH OF S GTH OF S MO COMES APLE IMPLES	SAMPLER AMPLE S >4+H/I	on co	CORED	1	See page 1.	GELEVATUATION OF THE OLICE IN THE COHER SAN FERNANDO DAM DESTRUCTION AL ENGUREERS DIC SATE 37/10/86
L								

INCL	NATION_	Vertice	1_8E	L RING	NA	6'5 GROUND	EPTH (FT	:)8	5.5			DRI	LLED BY	Y	F. 50	levart.	_ SES/COE	!		SIC	!
CASI	NG ID N	ot veed	_ CORI	SIZ	E NA	GROUND	VATER E	L <u>48</u>	1)	DATE	E <u> </u>	_ LOG	GGED BY	¥ـــــــــ¥	Pers	<u> </u>	ATE9/19-2	2/45	PG.	3 of	7
EL	DEPTH		5 A M P L			REMARKS															
ŀ		and	BLOWS	PEN	REC						\$	OIL A	ND ROC	K DE	SCRIP	TIONS					Į
FT		NO	6 IN.	IN.	IN.		L														
	76 F	S 6	14 19 16 20	24	5		S 6 -	See p	rev	ious	page.										
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i	- 31 -	\$7	10 12 14 20	24	15		S7 -	SAND,	nar 8%	rrowl; nonp	y gra lasti	ded me c fine	ea, to	fine the br	sand.	mosc SP)	ly med	31	COATS	•	4141
	32																				1
	- - 33 -		,			,															1414
	- 34 - 34 -																				
	35																				1
	36 -	88	9 15 16 17	24	17		S 8 -	SAND, plast: silt		. rues .	/ grac	ded me	o. to t	fine -SM)	eand, Samp	most i	y fine. cained	101 two t	non-	randy	1
	37 - 37																				4111
	38																				
	- ₂₁ ,			ĺ	- 1																7
FEN PEN FIN BECO FOO LENG 3:SPLIT	R 6 1140 LB SPELT TRATION CE TYERY LENGT ITH OF SOUN SPOON SAMP URBED SAM	NGTH OF: TH OF SAI D COMES LE	SAWPLER WPLE	OR COR	E 84P#	I	S ∷ee	Page 1		-				-5-FV			7 (7 (8)) 1 (8) (8) (8)			<u> </u>	
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CASI	ING ID	Sot use	d CORE	SIZE	- NA	GROUNDWA	TH (FT.) <u>85.5</u> (TER EL. 38 ¹³	DATE -	LOGGED BY J.R. PORKING DATE 3/19-20/85 PG 4 OF 7
EL.	DEPTH		AMPL			REMARKS			200020 81
	}	TYPE	BLOWS	_	REC			\$01	IL AND ROCK DESCRIPTIONS
_FT	FT	DNG ON	PER	IN	IN.				
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l	40	∐ —			Н	, }			•
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	Ł		12 17	.			S 9	CAND	owly graded fine sand, ~10% nonplastic fines.
	F 41	\$ 9	19 22	24	19		37	~15% med. sai	ind, brown (SP-SM) Sample contained three thin
	ţ	ı	''					lenses of s	sendy sitt.
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1	- 45	Ш.	<u> </u>	_	_		 .	Approxi	imate Interface - Rolled Fill
1	+ "	1							Hydraulic Fill
1	F	ł		ł	1	1			
	-46	\$10	15	24	20	l i	\$10	SAND, narro	owly graded med. to fine sand. ~10% nonplastic on (SP-5M) Sample contained three 1- to
	-	•	13	1		1		2"-thick la	ayers of stratified sandy clay to sandy silt.
	Ļ		ļ	1		}			
ļ	L47	1							
l .	F"'					1 1			
	t				1				
[-	S11	8 5	24	19	ł .	\$11-Top 3"	SAND, w del	ly graded coarse to fine sand, <5% fine gravel, stic fines, brown (SW)
1	-48		20	"	''		Next 5"	SANDY SILT,	, non to sl. plastic fines, ~45% fine sand,
	†	ı		ļ			Next 3"	: SILTY CLNY.	, dark olive brown (ML) , mod. plastic fines, C5% fine sand, stratified,
1	F	1		1	1		80t 8"	dark oli e : SAND, nairo	owly graded med. to fine sand, ~10% coarse sand,
}	-49		1	†	 	1 !		>% nonplas	ectc fines, light brown (SP)
	-	1				[[
1	ļ		11			1 1	S12-Top 8"	fines, stra	, narrowly graded fine sand, ~15% nonplastic stified (SM). Top 1/2 of section was prown and
	-50	\$12	15	24	19			bottom 1/2 w	was gray. The above sections were separated by a layer of stratified sandy siit.
	F		"	1			Next 5"	: SAND, narro	owly graded med, to fine sand, (5% nonplastic ht brown (SP)
1	ţ	1	1		1			: SANDY SILT,	, sl. plastic, stratified (ML)
1	51	-	 	+-	+	-		~10% med. sa	owly graded fine mand, NO% nonplastic fines, and, olive grav (SP-SM)
1	F	S 1 3	13	124	14		"ext 2" "ext 4"	- STLIY CLAY	onn SANDY SILT, stratified (CL-ML) readed coarse to fine sand, CST homplastic
1	<u> </u>		13					fines. oits	ve gray (SW) continued on next page
	52	<u>_</u> _		1_	_				
BLOWS PF II -	PER &40 SP. PENETRATION	SPOON SPOON SPOON	ER FALL Y SAMPLES F SAMPLES	G SO ↑ Bookin	0 0 €1VI A	AREL NOTE	E S 1. See Page i	i.	
BEC - R	LECOVERY LE LINGTH OF SC	NSTH OF NAME OF	SAMP.				• •		PE-EVALUATION OF THE SLIDE IN THE LOWER SAN FERNANDO DAM
3:35	JT SPOOM SA DISTURBED S	MALE AMPLES							
1	J\$ - \$HE	D PSTON		13.0	ENISON TEHER	}			1
72 and	NET DU OSI			~ •					GEOTECHNICAL ENGINEERS INC. DATE 3/10/86
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ŀ											TE START/FINISH 9/19/85 /9/20/85	SIOI
CASI	JON ING ID_						TOTAL DEPT GROUNDWAT				GGED BY J. A Perking DATE9/19-20/85	PG. 5 OF 7
EL	DEPT			AMPL		1	REMARKS					10.0
			YPE	BLOWS	PEN	REC				SOIL A	ND ROCK DESCRIPTIONS	
FT	FT		NQ.	6 IN	IN	IN.						
	52 - - - - 53		\$13	13 10 13 14	24	14		S13-Bot	c 3":		arrowly graded fine sand, ~20% non fied, olive gray (SM)	plastic -
	- - - - - -		S 14	8 13 12 10	24	16		\$14		∿10% med. sand	y graded fine sand, ~10% nonplasti , olive brown (SP-SM). Sample cont f stracified silty clay,	
	55		\$15	2 5 12 12	24	16				gray (ML) SAND, widely	l. plastic fines, ~35% fine sand, graded coarse to fine sand, ~10% n ravel up to ½", brown (SW-SM)	_
	57		\$16	6 11 16 13	24	14		Sex	KE 4":	nonplastic fit SILTY CLAY to stratified at depth to a st fines, dark of SAND, narrowl	graded coarse to fine sand, moscly nes, brown (SW) SILTY SAND. Top of section consi lty clay with fines content decres lty fine sand containing ~ 25% nonp live gray (CL-SM) y graded med. to fine sand, mostly nes, ~10% coarse sand, light gray	sted or sing with lastic med., <5%
	60		\$17	10 10 14	24	20		Nex	KC 4":	fines, :0% m SANDY CLAY, s scracifies, d SILTY SAND, n	arrowly graded fine sand. ~15% noned. sand, olive gray (SM) 1. to mod. plastic fines. ~15% finerk olive gray (Cl) arrowly graded fine sand, 48% non, dat olive (SM)	e sand,
	61		S18	3 3 7 10	24	19		Nex Nex	et 5":	fines, dark o SILTY CLAY, m tified, dark Op = 1.6, SANDY SILT, s gray (ML) SILTY SAND, no	od. plastic fines, ~10% fine sand,	etra dark olive -
	64		\$19	9 8 11 12	24	18		Nex		fines, orive tified silty SAND, narrowl nonplastic fit SILTY CLAY, m	arrowly graded fine sand, \20% nongray (SM) Sample contained lavers clay up to \20% thick, y grauge med. to fine sand, mostly nes, light brown (SP) on plastic times, \10% fine sand, olive brown (CD)	med., CS%
PEN-PE REC-RE ROO-LE S-SPUT	SPI NE TRATION COVERY LE NGTH OF S F SPOON S STURBER	, IT SP I LENG (NOTH OXHO) AMPLE NAMPLE	OON S TH OF OF SA COPIES FR	SAMPLER SAMPLE IMPLE I >4:N/I	ю со Н1 риз.	748 37 33703	1	er# Pa	2 P		TETEVAL N. I. Y T. F. MIDTE TOWER SALEEFNANDO DA	IN THE M
⊋ enou	HE - 2 F - FIXI TEO - DU RETAWDIN	E NOLA	TON		90 - 9€ 94 - 9 -1 9 6 - 4€	CHER I					OBJECHNICAL ENGINEERS INC	ATE 3 1 5 MM POJECT HISHOW

									TE START/FINISH 9/19/45 4/20/85 SIOI
CASI	NG ID _No	ertica C used	_ CORE	SIZE	 	GROUNDW	ATER EL. SR1)	_ DATE LO	GGED BY IR PERLIS DATE 9/12/85 PG 6 OF 7
ΕL	DEPTH		AMPL		_	REMARKS		·	
		TYPE	BLOWS PER	PEN	REC			SOIL	AND ROCK DESCRIPTIONS
FT	FT.	NQ.	6 IN	IN.	IN.				
	66	s2 0	2 5 7 10	24	19		SZU	tified, very of pockets and le	od. plastic fines, ~10% fine sand, stra- dark olive brown (CL) Occ. irregular enses of silty fine sand, .3, 1.5 tsf, bottom to top
	68	52 1	5 9 11	24	22		•	(SM-ML) SANDY CLAY, sl scractifed, da	plastic fines, ~45% fine sand, olive brown to mod, plastic fines, ~20% fine sand, irk office brown (CL) Occ. irregular enses of silty fine sand.
	70	\$ 22	10 13	24	24		522		i. plastic fines. ~30% fine sand, stratified, .) Occ. irregular pockets and lenses of id.
	71 72 72	\$23	HOR 5" 1 I'' 12 18 19	24	18		S23-T op 7":	SANDY CLAY, no very dark brownsy = 0.5, 0 Qp = 1.0, 1	1.69 ref
	- - - - - - - - - - - - - - - - - - -	824	10	24	14		524	dark olive (Ci	oo. plastic fines, <5% fine sand, scratified, _) 1.2, 2.2 tef
	75	\$25	6 6 8 12	24	24		S25	Similar to \$24 Qp = 1.8, 2	(CL) 2.2, 2.2 csf, botcom to cop
	77-	524	9 10 13 20	24	24		· · · · · · · · · · · · · · · · · · ·	fines, olive b SILTY CLAY, mo dark olive bro	od, plastic fines, CS% fine sand, stratified,
PENTP RECTA ROOTE 1:5PL	PER \$ '-401 ENETRATION I ECOVERY LEN ENGTH OF SOI O'S TOOM SAI US T SHELL UF - FREE	T SPOOR LENGTH OF ISTH OF UMO COM MPLE AMPLES	SAMPLE P SAMPLE SAMPLE SB >4181/	POPICE	OPE BA	70.%	ES :. See Page 1.		FE-EVALUATION OF THE SUITE IN THE LOWER SAN FERNANDO CAM
₽ sec	UF - FIREE UO - OSTE RUNDWATER	, 11310M Park (146)		uar e	(i				OROTECHHICAL EMOLIFERAR DIO DATE 2,10/86

									E START/FINISH 9/19/85 /9/20/85 S 101
									GED BY I PERSON DATE 9/19-20/85 PG 7 OF 7
EL	DEPTH		AMPL			REMARKS			
•		TYPE	BLOWS		AEC		il	SOIL AN	D ROCK DESCRIPTIONS
FT	FT	NQ.	S IN	IN	IN.				
	78			П					
	<u>t</u>	526	10	24	24			Approximate	Incerface - Hydraulic Fili Allivina
	79	1	13 20	1		'	\$26-Bot 6":	SILTY SAND, nar	rowly graded fine sand, ~ 30% nonplastic
	F "		,					fines. with med	. sand, blackish olive (SM)
	ţ	527	50	13	13		\$27-Top 12":	SILTY SAND, nar	rowly graded fine sand, >25% nonplastic
	- 80	•	1	}			Βος 1":	fines, ~10% med	. sand, black (SM)
	F	-	 -		├—				
	-								
	81	Ц_	ļ	L					-
	-	528	<u> </u>)	3	ļ	S 2 8	SAND, narrowly yellow-brown an	graded fine sand, 25% nonplastic fines, id gray (SP)
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सर्द ः श	GDAEMA LEH GDAEMA LEH	. (4574.0 574.08.5	MAMT LOTHER	ne co	797 BA	•	Tee Page 1		-E-EVAL AT NO E T E TILLE IN THE LIMER SAN FERNANDO DAM
1 · 3PU	NGTH OF SOL 7 SPOON SAN STURBED SA	IR E	s >418/	LE MGT	M COPE	·			SOMEN SAN CETANORY PAG
	3 - 3HEL	BT TUBE			ENISON TURES				
7 500	JO OSTEI INOWATER			JQ 0	.,				OBJECHNICAL ENGINEERS DEC CATE 2 85
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BOR	ING LOC	ATION	غــدند BE_نــ	ARING	بانت ت بمنت ا	GROUND	ELEVATION	N (NGVD)	0 0	ATE START/FINISH	SEWERT STATE	S102
CASI	NG 10	Vot use	u COR	E SIZ	εي	GROUND	NATER EL	(DATE L	OGGED BY	ACRES DATE	PG OF 8
EL	DEPTH	<u> </u>	SAMP		,	REMARKS						· *
FT	FT	and	BLOWS PER	1	l				SOIL	AND ROCK DESCR	IIPTIONS	
1114.6		NO.	6 IN	J <u>IN</u>	IN							
	- - - - - - - - - - - - - - - - - - -	S1	15 25 21 24	24	16	Borehola advanced using etenderd rotarv wash horing techniques with a hentonite drilling mud. Torehole	S1 - :	SILTY SAND, nonplastic	Hoselv grad tines, NIU%	ied coarse to tir	ne sand, mostry to ', brown (SM)	ne. 525 t
						fightesis fightesis fowich upward jetting.						4174
		52		24			52 · 3	CLTY SANS.	Hitely grad Cine∎, Sin∜i	ed charse to fin graves up to 3 w	e wand, dietzwolle ", brown od	e. 5.5%
		s 3		. 4			41 - 1	(3 1 5 5 2). 20 10 •,	willer z grein Lawt in disper	id dige (d.). ., (t. grøvev).	e Ala is i E Alige e Colo an i Silo i Sala a i i i i i	**************************************
PT V PT VS PS RECO POO LENG 3 9P 1 4	D. A. B. B. S. B. S. S. S. S. S. S. S. S. S. S. S. S. S.	PERMENTAL PROPERTY OF THE PERMENT OF	W. AMP E: Pul > E: N/ (J	- 4	BAHP)		rdear e allie	er e			, and the second	en en en en en en en en en en en en en e

INCL	NATION	Yerri	ع8 نین	RING	مد	TOTAL DE	PTH (FT) ORI	TE START/FINISH 9/15/85 / 3.17.55	SIO2
CAS	ING ID_	Not use	• CORE	SIZ	E	A_GROUNDY	VATER EL NRED DATE . LO	GGED BY T. R. Persons CATE 9/16-12 P	PG 2 OF 8
€L	DEPTH	<u> </u>	BLOWS		1000	REMARKS	SOIL A	IND ROCK DESCRIPTIONS	
,,	l n	and DN	PER 6 IN	IN					
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	-		10				S4 - GRAVELLY SAND, WIDELY R	raued coarse to fine sand, 5-20% g	ravel up ro
	16	54	14	24	8		sample contained 2" of	inem, gray and brown (SW+SM). But freshly broken gravel.	com of
	<u> </u>		'"						,
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	21	5.5	8 27 33	24	5		S5 - GRAVELLY SAND, widely go 3 3/8", w10% nonplantic	raded coarse to tine sand, $\sim 10\%$ gr fines, brown and gray (SW-SM)	rever up to -
	-	I	42						
	22]	<u> </u>	_		,			
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	25		-	-	ļ				_
	F	\$6	9	24	q		Sb - MAYELLY SAND, wideyv p	raded mo <mark>ark</mark> e to line kans, N.C.% gr	Tavel up to
	<u> </u>				1	•	2", 515% nonplastic i.	лея, дряу кто оромпі (М.	-
8,0 91	F 6 1 401	B -44447	FALL NG	5 0 TO	DATE:	10m ∞ NOT	ES		
01 01	CONTRACTOR OF A	ENSTHOR STHOP SI	SAWR ER NAME	DIR CO	PT BAR	er.	, The rage 1	A CONTRACT AND A CONTRACT OF THE CONTRACT OF T	DN T⊬E
3:3607	NG THE DIF SIX TSPINON SAL BEWRBED SA	ነሚ (ዓጥ (5	>4:4/(<u>i</u> NGTH	COREC	1.7%		JWER SAN FRENANCE L	A M.
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7 **∞	*11440#							28 TECHNICAL ENGINEERS INC	ATE 3 TO RM PHOMETT MEMNY

CASHED Continue Code SIZE Company Code Co	INCL	_NATION_	Verti	41 BE	ARING	NA.	GROUND I	PTH (FT	r)	36.0			DRI	LLED BY	r.	Stewart	, wES/CO	Œ	<u> </u>	102	
10			_		_	-		VATER E		VR -	DA1	TE	_ LO	GGED BY		critina.	DATE 9		Y PG	3 OF	8
17			TYPE	BLOWS		REC						s	OIL A	NO ROCK	DESCR	IPT101	4 \$				
28	FT	FT.		6 IN	IN	IN															
56 32 24 9 57 - SILTY SAND, narrowly attacks fine aand, N201 nonpleatic fines, N01 and, to course sand, brown (SM) Sample contained one in place of arrayal. 33 57 30 24 9 57 - SILTY SAND, narrowly attacks fine aand, N201 nonpleatic fines, N01 and, to course sand, brown (SM) Sample contained one in place of arrayal. 34 35 35 37 38 39 39 37 - SILTY SAND, narrowly attacks fine aand, N201 nonpleatic fines, N01 and arrayal. 35 58 58 58 59 24 15 58 58 - SMAYELY SAND, whosis graded coarse to fine aand, N131 grave, up to 72 N101 nonpleatic fines, gray and brown (3-5M) 36 37 38 39 39 39 39 39 39 39		26	1	Я							-										
27 28 29 37 - SILTY SAND, narrowly ataken fine sand, NJOR monojectic fines, NIOR sed, SO coarse sand, brown (SM) Sample contained one in piece of Atavel. 22 33 - 35 - 36 - 36 - 37 - 38 - 38 - 38 - 38 - 38 - 38 - 38		}	\$6	15	24	9		S6 -	- Sec	e prev	/10us	page.									4
S7 - SILTY SAND, narrowly graded fine sand, N20% nonpleatic fines, N10% red, to coarse sand, brown (SM). Sample contained one 1° piece of atavel. 32 33 34 35 35 35 35 35 35		27		22																	
S7 - SILTY SAND, narrowly graded fine sand, N20% nonpleatic fines, N10% red, to coarse sand, brown (SM). Sample contained one 1° piece of atavel. 32 33 34 35 35 35 35 35 35		<u> </u>]]																		1
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S7 - SILTY SAND, harrowly graded fine sand, N20% nonpiastic fines, N10% med, co coarse sand, brown (SN) Sample contained one 1º piece of gravel. 32 32 33 34 35 34 35 36 37 37 37 37 37 37 37		F 30	<u> </u>																		-
S7 - SILTY SAND, necrowity graded fine sand, N201 nonplastic fines, N101 med. to coarse sand, brown (SH) Sample contained one in place of gravel. 32 - 33 - 35 - 35 - 35 - 35 - 35 - 35 -		-	}																		1
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CAS	ING ID_	Not use	ed CORI	E SIZ	E !	A GROUNDY	VATER EL	NR ¹⁾	DATE - IO	GGED BY J.R. Perkins DATE 9/16-17/85 PG 4 OF 8	
	DEPTH		AMPL			REMARKS				OGEN BY THE PERSON DATE TO THE TOP OF O	4
		TYPE	BLOWS		REC				SOIL A	IND ROCK DESCRIPTIONS	
FT	FT	NQ.	PER 6 IN.	IN.	IN.						- 1
<u> </u>	_ 39			Π	ī						7
	 		l		ł						1
	F	H	Ì	ł	l	}			Approximat	e Interface - Rolled Fill	1
ł	- 40	.	 	\vdash	 					Hydraulic Fill	┥
	_				l		S9-Top	5":	SILTY SAND, n	arrowly graded fine sand, ~20% nonpiastic	7
			2				Nave	a	laver.	brown (SM) Gradual transition to next 1. plastic fines, ~45% fine sand, clive	1
Į	F 41	59	5 5	24	19		Bot		brown (ML)		\dashv
l	<u> </u>							• .	Cified, dark		7
1	-			}	İ				ψ _p = 1.2 t	af	4
	- 42				_						\dashv
	-										7
1	- 1		5 11	. '			510-Top		tified, olive	od. plaetic fines, ~10% fine sand, stra~ brown (CL)	1
	- 43 -	\$10	12	24	19				tines brown	graded coarse to fine sand, (5% nonplastic (SW)	1
[<u> </u>						500	14";	black, brown	L. plastic fines, 745% fine sand, mottled and olive (CL). Portions of sample were dry	\forall
	Ł., I								and randomly	mixed by color and clay content.	7
	- 44										7
ļ							SII-Top	6":	SANDY CLAY	l. plantic fines, w35% fine wand, mottled	1
	- 45	S11	8	24	19		·		black, olive	and brown (CL) Portions of sample were dry mixed by color and clay content.	7
}	F "		10 11	'	'		Next	5":	SILTY CLAY, m	od. plastic fines, ~10% very time sand, live brown (CL)	7
					1	}			Su = 0.46	t s f	4
	١						Bot	7" -	Q ₀ = 0.8 t Similar to to	p 6" (CL)	7
	- 46										コ
	-										1
	47	512	5	24	22	}	S12		SANDY CLAY, .	l. plastic fines, ~ 20% fine sand, mottled	+
	- "	31.	14	4	"				black brown as	nd olive (CL) Sample was randomly mixed by y content. Sample contained pockets of dry	7
	F								clay.		1
	- 48				_	1					Ė
	<u> </u>	, ,									7
	- 1		6		İ	ĺ					1
	- 49	s13	٥	24	19	Ì	S13		SANDY CLAY, .	l. plastic fine., ~40% fine sand, mottled	\exists
			13			1			color and clay	and olive (CL) Sample was randomiv mixed by content. Sample contained pockets of dry	7
	-	1	1			ŀ			C1471		4
	50	\longrightarrow									
					ļ	1					+
	-			}		}	514-Top	*** .		errowly graded fine sand. 925% nonplastic	7
	- 51	S14	9	24	21		Next	1.1.7	ip to 1/8" thi	olive brown (SM) Doc. Lavers of stity clay CK.	1
			']	1	J	1	HEAL		tified, orive	od. plantic fines, NOT fine sand, stra- brown (dL) Occ. irregular lensem of silty	1
							Bot) ·		irrowiv graded tine kand, 5:5% hompiastic	-
										AVE COOK TO	1
D4 # - 84 /6	TRATION IN	GD+ OF S	AMPLER	xorrox on com	001VE A	20m ∞ NOTE					
POD LENS	OVERY LENGT OT SOUNC	H OF SAM COMES	PLE .			1	गह होन्द्रह			State Accase Soft To The IN Set	
U MINORET	SPOON SAMPL URBED SAMP	1.63		o . • • •						, WER DAN 7+4N/NGC CAM	,
	.5 SHELBY FORED P GOOSTEREE	15 T ON	ú	0 - 0 (M P - P - TC 4 - 0 (L	HER						
7 4 POURT										OBSTRUMENT ENGINEERS OND CASE 2. 180	!

										TE START/FINISH #1.50.85 /4.13.55 S102	
										GEED BY CREEKIN DATE POPULE PG 5 OF	8
٤L	DEPTH	s	AMPL	E		REMARKS					
FT	FT	and	BLOWS PER 6 IN	PEN	REC IN				SOIL	ND ROCK DESCRIPTIONS]
	53	\$15	4	24			S15-Top Next Next Bot	6": 11":	cified, oliv sand. SiLTY SAND, fines, strac SILTY CLAY, t tified, oliv layer of sil SILTY SAND,	mod. plastic fines ~20% fine sand, scra- e brown (UL) Ucc. lenses of slity fine narrowly graded fine sand, ~30% nonplastic lified, dark olive brown (SM) mod. plastic fines, ~10% fine sand, stra- re brown (CL) Section contained a 1"-thick ty fine sand at middle. narrowly graded fine sand, ~30% nonplastic olive brown (SM)	11
	55 - - - - - -	S 16	25.59	24	24		S16-Tap Nexc Bot	5":	recalified. pocket of si SILIY SAND. fines. sera	mod. plastic fines, NISS very time sand, office brown (CL). Section contained one lity line sand, narrowly graded fine sand, NJOS nonplastic littled, office brown (SM) nonplastic fines, NZOS very fine sand, strange brown (CL).	
	56	S17	3 50 14	24	24			11":	sand, strati fine sand up SILTY SAND, fines, black SILTY CLAY,	si, to mod. Plastic rines, \$20% seev fine ified, olive brown (UL) - One, lavers of siley to 10. thick, narrowity graded fine sand, \$25% nonplastic tish gray (SM) mod. plastic fines, \$10% very fine sand, blackish gray (UL)	لماعملمهما
	59	S 18	5 10 13	24	20		S18 Top Next Bot	10":	fines, dark SILTY GLAY, stratified.	narrowly graded fine sand, ~20% nonplastic office prown (LM) mod. plastic fines, ~10% very fine sand, dark citive brown (CL) yly graded fine sand, ~10% nonplastic fines, (SP-SM)	
	62	\$19	12	24	21		S19-Top Next Bot	⊣ ":	SILTY CLAY, sified, dark	mod. plastic fines, NIOX fine sand, stra- k olive brown (CL) wiv graded med. to time sand, NIX nonplastic	
	63	s20	9.00.00	24	15		S20-Top hext Bot	1.8":	SILTY SAND,	DOCTOR JT of SIV .SP SILTY CLAY (CL) narrowix graded fine sand, ≈ S% nonplastic med, sand, olive gray (SM)	1 1111
	64	52:		2.4	24		\$2:		fines, dark 	narrowly graded fine kand, NIST nonclastic olive gray in lamble incalned three were instrationed killy have livers were the top, middle, and bott mishilling of	1
97 F	COVERY LEN NOTH OF SIX T SPOON SAN STURBED SA LS CEMELE LF FORFO	OTH OF S MO COME IME IMPLES IT TUBE PISTON	AHP.E	u(1495)	H 60AE FN 10A	A 2 0 IN 00 N 0 T E !	S Tee Page			HERE DAN BERNAND LAM	
¥ 1#00	JO-OSTER JADWATER	ncm"		A .	C)					OBSTRUMENT AL ENGINEERS DIC LATE 1 1 9 WHENCH WAS ARRESTED TO SERVICE STATES AND SERVICE	

INCL	NOTTANI	Yerri	BE_	ARING	<u>مئا۔</u> ا	TOTAL D	EPTH (FT.)	3	s.0	DATE START/FINISH A SHARE AFS/COE STORE
CASI	NG 10 _ N	t user	_ COR	E SIZ	E_84	GROUND	NATER EL		\p ¹¹	_ DATE	LOGGED BY I.R. Perkins DATE 9/15-1-AS PG 6 OF 8
EL	DEPTH		SAMPL			REMARKS	ſ <u>.</u>				
FT	FT	TYPE and NO	BLOWS PER 6 IN	PEN	REC IN.					SOIL	AND ROCK DESCRIPTIONS
	65	r	T .	T	_						
	<u> </u>	S21	3 6 8	24	24		521			See previous	page.
ĺ	- 66	 -	ļ	\vdash	-						<u>-</u>
	[_
	- 67 -	S22	5 5 7	24	21					fines, dark o	narrowly graded fine sand, \\00% nonplastic oblive gray (SM-ML) sl. plastic fines, \\00% fine sand, stratified, ray (CL)
ł	-										•
]	- 68 -		1	1-							_
	- - - 69 -	\$23	3 6 7 11	24	24					dark olive grant of the state o	nod, plastic fines, NIUX fine sand, strs- olive gray (CL) Ucc. irregular pockets and lty fine sand.
	F 70		<u> </u>	I—							
	<u> </u>		5				524-1	·on	4.**	SANDY CLAY	si. plastic fines, ~40% fine sand, dark olive
	- 71	\$24	6 9 9	24	24					gray (CL) SILTY SAND, r	narrowly graded fine sand, ~20% nonplastic ————————————————————————————————————
	72										• •
	-										7
	73	\$25	2017	24	24		\$25-T 3	ap ot	20"	SILTY CLAY, m tified, verv lenses of sil Su = >1.0	op 4" of S24 (CL) od. plastic fines, NOX fine sand, stra- dark olive (CL) Occ. irregular pockets and ctv fine sand. tsf 1.7, 1.5 caf
	74				\dashv	Ì					
	-	034	2	24			\$26			SILTY CLAY, m	od. plastic fines, viox very fine sand, stra-
	75 	320	; 8	24	24	j				tified, very $S_0 = 0.76$,	dark olive (CC) 0.86, 0.90 tet
					1					ν _p = 1.2.	1.2. 1.3 cef
	- 76										7
	-	527	HOR	24	رند		S 2 7			stratified, d	i, to mad, plastic fines, NPS% fine sand, ark olive brown tob.
	- 77 -	i				ļ				54. ip - 0.9.	0.60, 0.70 ter 1.1. 1.1 ter
	L ,		::								i. to mod. plastic fines, NIS% fine sand, ark citive brown (CL) 0.hu, 0.70 tst 1.1. 1.1 tst
Buiws PE	e 6 Han ca Seult s	~A M M7 F	FA. L NG	30 10 /	RIVE A	≥ Dim oc NOTE	5				
	SPLIT S PANON LEN SYEM LENGT	CON OF S	77007	on com	E BARR	£1.		, 40			
PGO LENS SISPLITIS	TH OF SOUNC SPOON SAMPL	COMES.	>4m/u	Lhu!H	CORED.	٧.			-		A PART OF THE PART
	URBED SAMP SISHELBY FIFTH	TUBE	-	0 0 W	SON						
₹ smound	JO OSTERBE	~0	•	%·9€i							DISPATECHNICAL SHUINSERS DEC _A E Ph

										FINISH 9/16/85 / 9/17	si02
CAS	ING IO	ertice	il_BE	ARING E SIZ	 	TOTAL DE	PTH (FT.) VATER ELNR ¹³			F. StevartFS/COE	7 - 7
ΕL	DEPTH		SAMPL			REMARKS	MIER EL.	UATE LO	GGED BY_	J.R. Persons DATE 2/16-1	2.45 PG 7 OF 8
		TYPE	BLOWS		REC			SOIL	AND ROCK	DESCRIPTIONS	
FT	FT.	NO	PER 6 IN.	IN.	(N			·			
	78	\$28	WOR 5" 1 T" 6 7	24	24		S28	tified, dark o	live brown	t fines, ~10% fine ser (CL)) tsi, top to bottom tei, top to bottom	nd, stræ- -
	80	s29	WOR 5' 1 T'' 5 7	24	24		S29	SILTY CLAY, mo- tified, dark o Sv = 0.85, 1 Qp = 1.4, 1	live brown 0.93, 0.93	l tsf	e sand, stra-
	82	s3 0	⊌OR 7 6 9	24	24		\$30	dark olive browns, su = 0.92, (wn (CL) 0.98, 1.0	: fines, ~10% fine san tsf, top to bottom tsf, top to bottom	d, stratified
	85	S31	WOR 6 8 10	24	24		531	SANDY CLAY, mod tified, dark of		fines, ~15% very fin (CL)	e sand, scra-
	87	S32	5 7 9 11	24	24		532	tified, dark of	live brown y fine san	fines, ~20% verv fine (CL) Sample contain d. Sample contained d.	eo several —
	89	s3 3	5 6 9 9	24	24			plastic ines, neveral stratif	dark oliv fied siltv 1. plastic	ded fine sand, >35% not e prown (SM) Section clay layers up to 1%, fines, >10% fine sand (CL)	contained
	90	534	5. 15 h	24	20			Similar to bott Approximate		533 .CU) - <u>mydraulic Fill</u> Alluvium <u>rootio</u> ne	1 Coext pice
PEC : MEC POO LEN S : SPLIT	FR 6 - 40 LB STORY LENG OVERY LENG SPOON SAME SPOON SAME US 5 PHELBY OF FIXED UG OSTERB OWATER	NOTH OF TH OF SAI D CORES LE PLES	SAMPLER MPLE >4IH/U	OF COR	E BARR CORED.	ec :	S . See Page 1.		000	-EVALUATION OF THE ST COMER SAN FERNANDO	DATE 3/10/86
						1) \ \ \ ·	Papagaga - Vilabella (III) 176	PROJECT 85669

									E START/FINISH 9/36/AS /4/34AS	S!02
CASI	NG ID	Yerrica You was	A CORE	E SIZ	<u>— М</u> Е s	GROUNDY	VATER EL. 48 ²³	DATE - LOG	GED BY 18 PERLING DATES 114-17/85	PG 8 OF 8
EL DEPTH SAMPLE , REMA										
	TYPE BLOWS PEN REC							SOIL A	ND ROCK DESCRIPTIONS	
FT	FT.	NO	6 ÎN	IN	IN					
	92	934	5 14 15 16	24	20			plastic fines. GRAVELLY SILTY	ely graded coarse to fine sand, NIUX gravel up to '2", olive blu SANU, widely graded coarse to fi to 1", NISX nonplastic fines, br	e (SM) ne sand,
	- 93 94 94									
	95 - - -	\$35	36 90 50	24	20		\$35	GRAVELLY SAND, gravel up to 1	widely graded coarse to fine san 1/8", ~10% nonplastic fines, bro	d, ~40% un (SW-SM)
	96	j	-	-	-			R	of Borehole - 96.0 ft	
	- - - 97 - - - -							50000		
	98									- - - -
	- '00 -									: :
	102									
	:03									
								- · · · · · · · · · · · · · · · · · · ·		-
920 LLN 5:5PUT	SUMS PER 6 140 LIN NAMER FALLING 30 TO DRIVE A ZOIN OD SPIT STOOM SAMPLE FOR THE PER T						ES : See Page 1.		REHEVALUATION OF THE SUITE TOWER SAN FERNANDO) IN THE NAM
Z chan	.310518.4	#370N BERG		JB+911 JG+ 0€	TCHE#			_	O BOTTECHNICAL ENGINEERS DIC	DATE 3 10/85

							ROUND ELEVATION (NGV D) 1093.9 DAT					Š	SIC)3
CASING ID Not used CORE SIZE NA GR				GROUNDY	VATER EL	væ ¹⁾	_ CATE	LOG	GED BY 1.R. Perkine DATE 9/17-18/85	PG	1 01	8		
			REMARKS											
	1	TYPE	BLOWS PER	PEN	REC				\$0	IL AN	ID ROCK DESCRIPTIONS			
FT	FT	NO	6 IN	IN	IN		L	-						
U~J. -	1	S1	6 9 11 12	24	17	Borenoie advanced using standard rotary wash boring cechniques with a benionite filling mud. Cleaned out torehois		1":	Bituminous SANDY CLAY,	Paven si.	ment. plactic fines, ~20% fine mand, b	rown	(CL)	
	1 3 1 4 5 1 5 1 5 1 5 1 5 1 5 1 5 1 5 1 5 1					with a 0" flushtati bit with speerd etting."								
		S2	26 100 15	24	21		S2		Similar to	\$1 (CL)			
	10 11 12 12 12	53	5 11	24	15		S 3-Top Hoc	4": 11"	Similar to SAND, narr and tine g	S! (owly ravel	CL) graded med. To fine sand, will co , KSI nonplastic tines, brown KSP	arse	sand	
A) PICE A PHANMER AND TO BEEL NOT SELL NOT SELL NOT SEMESTED TO COME BARREL AND THE OR COME BARREL AND THE OR COME BARREL AND THE OR COME BARREL AND THE OR COME BARREL AND THE OR COME SELL NOT SERVICE OF SERVICE AND THE OR SOUND COMES SELL NOT SERVICE AND THE OR SELL SELL SELL SELL SELL SELL SELL SEL							# 3450 Sc	01001 1850	eis not reic te tri link e whold prod ings,	* 10 B	RE-EMALLATION OF THE SLICE WERE AN RESMANL) I	, u	18 17 10 71	86
7 0*00	MO#ATE#										ORDITECHNICAL ENGINEERING DIC	OJECT	8566	9

									E START/FINISH 9/17/85 0/18/85	\$103			
CASI	NG ID.	Not use	L CORE	SIZE	NA.	TOTAL DE	PTH (FT)NR1)	DATE LOG	LED BY Stevert _ HES/COF	PG. 2 OF 8			
EL	DEPT	·	AMPL		1	REMARKS				<u></u>			
FT	FT	and	BLOWS PER 5 IN.	PEN	1			SOIL AN	ID ROCK DESCRIPTIONS				
	14												
	- - - - - - - - - - - - - 	\$ 4	6 11 15 18	24	16		54	SAND, narrowly g brown (SP)	raded fine sand, ~5% nonplastic	fines.			
	18 18 19									-			
	Ė							Approximat	e Interface - Rolled Fill	- -			
	20						Hydraulic Fill						
	21		14 17 10 12	24	18		Next 8":	olive brown (SM- SANDY SILT, non brown (ML)	to al. plastic fines, ~45% fine raded med. to fine sand, mostly	sand, olive _			
	23 23 24 24 24 24] 			
	24		10 6 12 14	24	20		1	coarse sand and (SP)	raded med. to fine sand, mostly fine gravel, CST nonplastic fine LTY CLAY, fines content increase	s, brown —			
RENTRE RECTRE ROOTLE STSPU	BLOWS PER 4 - 140-08 PLANMER PAILLING SO TO ORIVE A 2 DIN OD SPET S PROPIN SAMELE PROPINS AND SERVING PROPINS AND SERVING PROPINS PROP						TES . See Page 1.		SE-EVALUATION OF THE SLIDE LOWER SAN FERNANDO D				
₽ enoi	O OS	EPBERG		JS-01	्र महत्र १				O BOTECHOYCAL ENGOYEERS DIC.	DATE 3/10/86 PROJECT 85669			

										THE START/FINISH 9/17/85 / 9/18/85	SIC	3
CASI	NG ID N	ot used	COR	E SIZ	E_NA	GROUND	WATER EL. NE	D	DATE LO	GGED BY J.R. Perkins DATE 9/17-18/	PG. 3 OF	8
EL	DEPTH		BLOWS		Tess	REMARKS	1		\$011.4	AND ROCK DESCRIPTIONS		
FT	FT.	and NO	PER 6 IN	IN.	IN.							
	27	\$6	10 6 12 14	24	20		S6-8oc	8":	Similar to t	op 6" (SP)		المسما
	28 - - - - -	S 7	6 11 5 13	24	15		S7			ly graded med. to fine sand, most and and fine gravel, <5% nonplast		
Andrews and the same of the sa	- 30 - 31	82	7 11 11 13	24	18			7": 2":	brown (SP) SAND, narrow coarse sand,	ly graded fine sand, ~5% nonplast ly graded med. to fine, mostly me <5% nonplastic fines, brown (SP) al. plastic fines, ~40% fine sand op 5" (SP)	d., ~10%	, , , , , , , , , , , , , , , , , , , ,
	- - - - - - - - - - - - - - - - - - -	S 9	7 11 14 5	24	18		S9-Top Next Bot	4":	SAND, narrow.	ly graded med. to fine mand, most (SY nonplastic fines, brown (SP) ly graded fine sand, ~10% med. smines, brown (SP) op 7" (SP)		• 111111111
	- - - - - - - - - - - - - - - - - - -	510	4 8 9 12	24	20		S10-Tup Next Bot	: 10":	SAND, widely (5% nonplant)	grader coarse to fine send, \$10% ic fines, brown (SW) iv graded med. to fine sand, \$5%	fine gravel	
	- - - 36 - - -	\$11	10R+H	24	8			3": 2".	nonplastic fi SILTY SAND, r fines, strati SAND, narrowi	graded coarse to fine sand, most ines, brown (SW) narrowly graded fine sand, ~20% n itled, olive brown (SM) ly graded med, to fine sand, most ines, tan (SP)	onplastic	7
	38	\$12	7.7.0	24	• 3		S12-Tap Bot	3": 10":	sand, (5% non	ly graded med. to fine sand, ~10% splastic fines, light brown (SP) (v graded fine sand, ~20% nonplast)		Linithini
ROD-LENG 5 SPLIT	FR 6 - 40 (B SPLIT 1 - 1 - 1 - 1 - 1 - 1 - 1 - 1 - 1 - 1	H OF SAI O COMES LE M.ES TUBE	>4-4\F >4-4\F	OR COR	E BARR COREO 190N CHER	e (,	5 See Page '.			PR-EVALUATION OF THE SLIDE COMER SAN FERNANDO D	IN THE AM	69

									TE START/FINISH 9/17/85 9/17/85	S103
									GGED BY J.R. Perkine DATE 9/11-14/85	PG 4 OF 8
L	DEPTH	\vdash	AMPL	<u> </u>	1	REMARKS		SOU A	NO ROCK DESCRIPTIONS	
**	FT	and NO	BLOWS PER 6 IN	PEN	-			30.6	NO NOCK DESCRIPTIONS	
_	- 37	1	Τ=	Τ	$\overline{}$					
	40	S 13	\$ 8 7 8	24	18		Next 5": Next 3": Next 4":	¹ 2"、〜5% nonpl SILTY SAND, na fines, dark ol tained a layer Similar to top	TY SAND above (SM)	
	- 4! -						S14	SILTY CLAY. T	lavers of SILTY SAND gradually chines four 3"-thick lavers above and here 2"-thick lavers of SAND, Desi	re
	F 43	\$14	10 8 7	24	20			of each layer SILTY SAND, na fines, dark ol SILTY CLAY, sl stratified, da SAND, widely g	are as follows: rrowly graued fine sand, ~25% non- ive brown (SM) , to mod. plastic fines, ~10% fine rk olive brown (CL) raued coarse to fine sand, ~10% fines, olive brown (SW)	plastic e sand,
	-	1	1							
	- 44	S15	11 10 11	24	20		Next 3": Next 3": Next 8":	<pre><5% nonplastic SILTY SAND, na fines, dark of SANDY SILT, sl derk clive bia Similar to top</pre>	<pre>, plastic fines, ~40% fine sand, : ck (ML) i" (SW)</pre>	plastic
	t 45				_		Next 2": Bot 2":	SAND, narrowly	TY SAND and SANDY SILT. graded med. to fine sand, mostly es, light brown (SP)	med., <5%
	45	\$16	9 10 10 10	24	20		S16	graded fine sailayers up to 2 SANDY SILT, all dark olive book Sample contains	Y SAND and SANDY SILT: SILTY SANI nd, ~25% nonplastic fines, olive la "thick (SM) , plastic fines, ~40% fine sand, a wm, lavers up to ½" thick (ML) ed a 3"-thick layer of widely grad located in middle of sample.	cracified
	- 48	S17	6 8 1.	24	18		S17	nonplastic fin- i"-thick layer	graded fine mand, ~15% med. mand, em, light brown (SP) Sample conce m of stratified milty clay, locate	ined two
	-		[[sample. Sample also contained or sample silt, located at middle of sample	
	- 49		-	L 						
	50	S18	11 13 13 15	24	22		S18-Top ?": Next 7": Next 5":	fines, brown (of silty clay, SAND, widely g fine, <5% nonp		med. to
	51	1_		_	ļ		Bot 3":		graded med. to fine sand, <5% nor	plastic
	-	S19	10 11 19 19	24	17		\$19+Top 3": Next 6":	plastic tines.	rrowly graded fine sand, \30% non- dark olive (SM) raded coarse to fine sand, \5% non- SW)	
PEN PEN LEN	ER 6 THO LI SPLIT RETRATION L COVERY LENG HITH OF SOU SPOON SAM STURBED SAI JE FRED	ENGTH OF STH OF SA HO CORES PLE MPLES	SAMPLE MPLE >4:N/L	OF CO	COREO	MEL	ES 'See Page 1.		RE-EVALUATION OF THE SLIDE LUNER SAN FERNANDO DA	
ROUI	DE OSTER	P-STON BERG		P-PIT	CHER				OBOTTECHORICAL EVOCHERRIS DIC	ATE 3/10/86

						S GROUND ELEVATION (NGVD) 10	
	_					11	DATE LOGGED BY P. STEWARTS, MES/COE
EL	DEPTH	<u> </u>	AMPL			REMARIS	SOIL AND ROCK DESCRIPTIONS
FT	FT.	ond NO.	PER 6 IN	PEN IN.	REC		SOIL AND ROCK DESCRIPTIONS
	53	5 19	10 11 19 19	24	17	Bot 6": S	SANDY SILT, al. plastic fines, ~40% fine sand, stratified ark olive brown (ML) SAND, widely graded coarse to fine sand, <5% nonplastic ines, brown (SW)
	54 - 54 - 55	S2 0	3 20 14 9	24	20	Next 2": 5 Next 9": 5 Next 9": 5 Next 3": 5	ELTY SAND, narrowly graded fine sand, ~20% nonplastic ines, olive brown (SM) ANDY SILT, al. plastic fines, ~40% fine sand, stra iffled, olive brown (ML) AND, widely graded coarse to fine sand, ~10% fine gravel, 5% nonplastic fines, brown (SW) Similar to top 4" /SM) Similar to SANDY SILT above (ML)
	56	52 1	18 14 19 26	24	18	Next 7": 5 Next 4": 5	AND, widely graded coarse to fine sand, ~5% nonplastic ines, brown (SW) AND, narrowly graded med, to fine sand, <5% nonplastic ines, brown (SP) SILTY SAND, narrowly graded fine sand, ~25% nonplastic ines, stratified, dark olive brown (SM) Similar to top 3" (SW)
	58	S2 2	22 18 18 13	24	20	Next 4": 5	GAND, widely graded coarse to fine same, woatly med., ~5% ine gravel, (5% nonplastic fines, brown (SW) SILTY SAND, narrowly graded fine sand, ~40% non to sl. clastic fines, olive brown (SM) SILTY CLAY, mod. plastic fines, ~10% fine sand, stra-clfied, dark olive brown (CL)
	60	\$23	12 16 16 24	24	21	Next 7": 5	SAND, widely graded coarse to fine sand, mostly med. to fine, (S% nonplastic fines, brown (SW) SAND, narrowly graded fine sand, ~10% nonplastic fines, blive gray (SP-SM) SAND, widely graded coarse to fine sand, (5% nonplastic lines, olive gray (SW)
	62	524	8 13 24 *9	24	21	Next 7":	SILTY SAND to SANDY SILT: SILTY SAND, narrowly graded ine sand, ~20% nonplastic fines, olive brown (SM) radually changes to SANDY SILT, sl. plastic fines, ~40% ine sand, stratified, olive brown (ML) SAND, widely graded coarse to fine sand, <5% nonplastic ines, brown (SW) SAND, narrowly graded fine sand, ~5% nonplastic fines, prown (SP)
	64	s25	17 24 26 23	24	21	Yext 8":	SAND, narrowly graded fine sand, v10% nonplastic fines, prown (SP-SM) SAND, widely graded coarse to fine sand, v10% nonplastic fines, brown (SW-SM) Similar to top 3" (SP-SM)
PENIPER RECIREC RODILEN SISPLIT	IETHATION L TOVERY LENG IGTH OF SOUL SPOON SAM ITURSED SAI JET FISED UO OSTER	ENJTH OF SA NO COMES MLE HPLES Y TUBE MSTOR	>+i4\i	OP CU	COREO	. See Page 1.	OBSTRUCTION OF THE SLIDE IN THE COMER SAN FERNANDO DAM OBSTRUCTURE BROWNING DATE 3/10/86 PROJECT 85669

INCL	NATION_	Vertic	el_BE	ARING	NA.	TOTAL DE	PTH (FT.) 97.0	ORI	E START/FINISH 9/17/45 /9/18/45 S103
			_ CORI		EN		ATER EL NE	DATE LOC	GGED BY J.R. Perkins DATE 9/17-14-55 PG 6 OF 8
EL	DEPTH	$ldsymbol{eta}$	BLOWS	_	REC	REMARKS		SOIL A	ND ROCK DESCRIPTIONS
FT	FT	end NO	6 IN	IN	IN.				·····
	66	S26	11 11 10 28	24	22		\$26-Top 8": Next 6": Bot 8":	brown (SP-SM) SILTY SAND, na plastic fines container a la Qp= 1.05, SAND, widely	y graded fine eand, ~10% nonplastic fines, strowly graded fine eand, ~25% non to al., dark olive brown (SM). Bottom i" of section wher of stratified silty clay. 1.10 taf graded coarse to fine sand, ~15% gravel up to %% nonplastic fines, brown (SM).
	68	S27	20 28 26 22	24	20			up to 3/4", SAND, narrowly	idely graded coarse to fine sand, $\sim 10\%$ gravel 20% nonplastic fines, brown (5%) y graded fine sand, $\sim 10\%$ med. sand, $\sim 5\%$ nes, brown $(5P)$
	70	S28	13 •9 21 26	24	22		Next 6": Next 9":	cified, dark of SAND, widely so 15% g on 1 up SILTY a. 4D, no fines, ~10% me	od. plastic fines, NIOX fine sand, stra- blive brown (UL) graded coarse to fine sand, mostly sed., to 3/4", <5% nonplastic fines, brown (SW) strowly graded fine sand, N3O% nonplastic ed. sand, stratified, olive brown (SM) sand layer above (SW)
	72	52°	13 15 14 11	24	16		·	gravel, ~10% r tained a 2"-th	graded coarse to fine sand, <10% fine nonplastic fines, brown (SW-SM) Section con- nick layer of silty fine sand. acrowly graded fine sand, <15% nonplastic (SM)
	74	s30	8 18 20 15	24	18		·	fines, dark by a stratified SAND, widely s	graded coarse to fine sand, NIST gravel up Tamping to NIST own (SW) ranged fine sand, NIST nonplastic fines,
	76	S31	7 12 14 13	24	18		\$31-Top 3" Next 9" - Rot 6"	SAND, widely a fines, ST fir SANDY SILT, no	i. to mod. plastic fines, 500% fine sand, ark olive brown (CL) graded, coarse to fine sand, 500% nonplastic ne gravel, brown (SW-SM) mplastic to 51. plastic fines, 50% fine olive grav and brown (ML). Section appears to
	77	\$32	£ 40.	24	20		\$32-Top (2")	SANDY SILT, no olive brown, s	on to all plastic fines, two't fine sand, dark stratified PMD:
PEN-MEN REC REC RUD LEN S SPEIT	ETRATION	SPOON S INJTH OF TH OF SA ND COMES HUE IPLES F STON	awrier Sawrier Wrie Dairzi	o# co ∡ NaTh	RE BARI CORED NISON	■F.	e case		SELEVAL ATTING HIT FORESTS IN THE HER CAN KINNANT SAM
Z snow	. U OSTERI	BE RG		Jis • 6€					OBJECTORINGAL ENGINEERING DIC CATE 3, 10786

INCL	L NOTTAN	ertica	8E/	VRING	<u></u>	TOTAL DE	PRH (FT)	97.	U DRI	TE START/FINISH N 17:85 / 2:38.65 S103
CASI	NG 10	ot u∎e	d CORE	SIZ	E_N	GROUNOV	VATER EL _ NE	1)	DATE LO	GGED BY T.R. Perking DATE 9117- 8-85 PG 7 OF 8
EL	DEPTH		AMPL			REMARKS				
FT	PT.	and NO.	BLOWS PER 6 IN	PEN	REC IN.				SOIL A	NO ROCK DESCRIPTIONS
	78 - - - 79	\$32	6 4 10 11	24	20		532-Bot	8":	SAND, widely g fines, brown (raged coarse to fine sand, ~10% nonplastic SW-SM)
	80	\$3 3	8 13 16 19	24	٠7		s 33		fines, brown (S	graded med, to fine sand, NOT nonplantic (P-SH) Sample contained a 1-in, thick layer stity clay (CL)
	81	S34	10 15 17 15	24	17		534		3AND, narro⊌: brown (SP-SM)	y graded fine sand, who% nonplastic tines,
	- 83 - - - - 84 -	\$35	8 10 15 19	24	17		535		SILTY SAND, n fines, brown	arrowly graded fine sand, 215% nonplastic (SM)
	- 85 - - - - 86 - -	536	6 6 9 11	24	22		Next Next	5": 6":	fines, brown SILTY CLAY, mo (CL) Qp = 1.3. Sy = 0.80 (Similar to ro)	od, plastic fines, >10% fine sand, brown
	- 87 - - - - 88	\$3 7	6 6 8	24	24		S37-Top	5" · 3" :	SILTY SAND par fines, brown - S SILTY CLAY, mod etratified, dur Qp = 2.2, 1. Sy = 31.0 cs	Trowly graded fine sand, \$15% nonpeastic (ii) D. plastic fines, \$10% very time sand, K brown (UL) T, 2.1 tsf
	- 89 90 	\$38:	11 22 17 17	24	20		Next Bot S38		SANDY SILT, and HLD SILTY SAND, WE nonplastic fir	Alluvium plastic fines, v35% fine sand, black
PENTRENE PECTREGO PGOTLENG STSPLIT S UTUNDISTI	R 6	HOF SAA HOF SAA HORES COMPS LES TUBE	IAMPLER C HPLE > 4 H / LE	× co×	E BARR CORED	€L 1,	S Gee Page 1			GENTECHNICAL ENGINEERS DIC 14TE 2 10.86

						<u>s</u> ground i											-	310	3
						A_GROUND											PG	8 of	8
EL	DEPTH		AMPL			REMARKS				5011	LANG	ROCK	0651	RIPTIO	15	,			
FT	FT	and NO	BLOWS PER 6 IN		REC						-								
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	- 96	s 3 9		24	22		S39 -	SILTY	SAND, n	arrowl	у дгл	ided me	d. ro	fine =	and. mo	sclv f	ine.	~35 ±	-
	- 79	337	1.4	"				non to	si. pi	astic	tines	, oliv	e and	brown	7 SM1	, -			-
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	9.7		-	 						Boti	tom o	f Boret	hole	- 97.0	f t				
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9.75 CEN	ол'н ой 50на Сртин 52н Срниго 544	10 50 913 PLE IPLES	>4 4 /\	<u>į ng</u> th	CORED	*•								ILATI N WER CA	N FERNA	NÇ TÎ A	ů .	4	
, ,	SHEET SHEET	* 15 AE		. g. ge . u. se	4 50A THER	1													
7 show				•1								Ф "	В. ЛЪСН ~4348	OHEAL ENG	HEERN DIC		CATE 3	, 10 /8/ 05689	5

INCLI	NATION_	Yerric	a⊥_8E/	ARING	NA.	S GROUND (PTH (FT)	112	2.2		ORI	LLED BY	Y	F Stewe	art. 🗝	S/COE_		<u> </u>	SIC	
CASIN	4G ID_4				E _ 4^	GROUNDY	VATER EL	- 48		DAT	E	roc	GED BY	Y	P. Peri	10. DA	TE 9/10-	17 84	PG	1 0	r 9
£L	DEPTH		BLOWS	_	950	REMARKS					5	01L A	ND ROC	K D	ESCRIF	TIONS					
FT	FT	and NO	PER 6 IN	IN	IN																
114.2	1 2	\$1	25 27 18 18	24		Roreliule advanced using standard rotary wash boring techniques with a bentonice drilling mud. Cleaned out borehole with a 4"	51										d, most				
		\$2	9 15 22	24	19	fishteri bit with speard secting.	52		plast								d, mosc bangula				
PEN PEN	FTRATION .	(North Of	SAMPLER	SO TO	20 onve		ES and	plae brow	reic	finer M)	e, with	order.	ed coat vel up	•	·2". •	ubroun	, ∿30% a∉d to	subar	ngu i	·	
RECTRECT ROOTLEM S SPLIT JACKS	OVERVICEN GITH OF SOC SPOON SAN TURBED SAN JS SHELL JF FITED JO TOSTER	GTH OF SI WO CURES IPLE MPLES IT "URE PRETON	ωη(<u>ξ</u>) 4 η/ι		GOREO MISON TOHER		endw Terause Ned In Taccur	o pare	ionit No.e	e di Vilu	1.11.5	g = m = 1	Φ	o decyr	EVALLA " wi	ER SAN		Deci A	ATE	:4E 3710 1 850	/86 569

INCL	NATION_	Vertic	et BEA	ARING	- 54	TOTAL DE	ELEVATION (1124.5 DATE START/FINISH 4 10185 / 9/32/85 S104
		_			<u> </u>		VATER EL NE DATE LOGGED BY REPERSON DATE 2001 BY PG 2 OF 9
EL	DEPTH	TYPE	BLOWS			REMARKS	SOIL AND ROCK DESCRIPTIONS
FT	FT	and NQ	PER 6 IN	iN	1N	1	
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	- 16	54	14 17 19	24	19		54 - SILTY SAND, widely graded coarse to fine sand, mostly med, to fine,
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	È	s 5	::	,,	17		SS - SILTY SAND, widely graded coarse to fine sand, mostly med. to fine.
	21		. 6	1"			530% slightly plastic fines, 510% gravel up to 72%, subangular, top = 5% dark brown, bottom 11% brown (SM)
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	<u> </u>	s6]	24	6		
	F :6			"			56 - SAND, natrowly graded med, to fine sand, 5% nonplastic fines, subrounded to subangular, light brown (SP) A 'u' piece of gravel has wedged in sampler in top of sample.
BLOWS #	E# 6 1:401	B HAMME	FALL NG	30 10	CRIVE A	ZOIN OO NOT	
# (1 m)	FETRATION I TOVERY LEN 12TH OF SOL	ENSTH OF GTH OF SI	SAMPLER MPUE	ON CON		ti .	Tee Page 1. SEVENAUTATION OF THE SLIDE IN THE
5 500.17	SPOOM SAN TURBED SA	(주. E 보면, ES				•	LIWER SAN FERNANDO DAM
	S SHELL F F LED C OSTER	PISTON BERG		0 0E	4:50m Tu£# -		
7 4 400	N)TAWOR						abotechnical endoremental pag parts 3/10/86

BOR	ING LOCA	ATION .	Sta 9	.)\ \PING	73.	GROUND (ELEVATION (NG	VD) 1114.5 DA	TE START/FINISH 9/10/95 /9/12/85 ILLED BY F. STEWART, WES/COE	S104
CASI	NG ID N	c used	_ CORE	Siz	E NA	GROUNDY	VATER EL	NR ¹⁾ DATE LO	GGED BY Perkine DATE 9/10-12/A5	PG. 3 OF 9
ΕL	DEPTH		AMPL			REMARKS				'
			BLOWS	PEN	REC			SOIL	AND ROCK DESCRIPTIONS	İ
FT	FT	NO NO	PER 6 IN	1N	IN					
	- 10	56	3	24	6		\$6	See previous p	page.	
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	١١ -	S 7	8 11 14	24	12	!	S 7	coarse sand ar	r graded med, to fine sand, mostly id fine gravel up to ½", <3% nonpided to subangular, light tan (SP)	hed., Vist
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	34									4
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	F									4
	- 35									7
	E		10				S8-Top	8": SAND, widely g	raded coarse to fine sand, ~10% g	ravel up to
	36	SB	13	24	111		Bot	3" SAND, widely g	lastic fines, subrounded, brown () raded coarse to fine sand, 65% nor lar, reddish brown SW1 Sample (piastic -
	[two pieces of		1
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	F 10	<u>li.</u>	<u> </u>	_						
A 45	PE 6 40 ()	SP. TH	FALL NG	1 0 to	SRIVE					
#EC:#E	METRATION C COVERY LENG NGTH OF SOU	STH OF SI ND CORES	MPLE				See Page	! .	FE-EVALUATION OF THE SLIDE	IN THE
	SPOON SAM STURBED SA STURBED SAMELE STIFFED	⊌P. (3		.a · n#	No. al-Lan					μ
7 440	F FIED D OSTER	MISTON BERG		-0 -0E	TCHER				GROTTECHORICAL BHOMPERSM DHC	DATE 3/10/86
									ORDARCHOLICYT BHOMARING DAC	85669

CUNAT	TON_	Vertic.	1_8E/	RING	NA.	TOTAL DEF		117.0 DRI	TE START/FINISH 9/10/85 9/12/85 LLED BY 5. Stewart, WES/COE GGED BY 1.8. PETRINS DATE 9/10-12/85	S104
0	EPTH FT	9	BLOWS PER 6 IN	PEN		REMARKS			NO ROCK DESCRIPTIONS	<u> </u>
Ę	40						S9-Top 3":	dark gray (CL) to 14" thick.	d. plastic fines, ~10% fine sand, 0cc. irregular layers or silty: Interface - Rolled Fill Hydraulic Fill	
- - -	41	sy	3 6 5 6	24			Next 4": Next 4":	rines, laminate Similar to top Similar to SIL (Top 3") SANDY sand, dark gra-	TY SAND above (SM) SILT, slightly plastic fines, ~3! y (ML) LTY CLAY, mod. plastic fines, <5%	T fine
1	43									-
<u> -</u>	45	s10	11 10 10 76	24	20			fines, dark ol (Top 2") SANDY sand, dark oli 'Middle 6") SI nonplastic fine	SILT, bl. plastic fines, ~40% ver we gray(ML) LTY SAND, narrowly graded fine sar es, dark olive gray (SM)	y fine =
<u>+</u> + +	48						3ot 6 "∶	.Bottom 1") SI dark olive gra Similar to top	LTY CLAY, mod. plastic tines, <5% y (CL) 5" (SP)	fine sand,
<u> </u>	49 50									-
+	51	\$11	\$ 9 9 7	24	15		S11-Top 5". Next 7" Bot 3"	fines, dark ol SAND, widely gi fines, dark ol	raded coarse to fine sand, <5% nor	plastic -
MEMETRA PECOVER ENGTH PE SPOK PSTURB	M TEAC.	NGTH OF TH OF SA ID CORES ILE IPLES	SAMPLER MPLE >4IN/L	OP COP	CORED	1 .	Siee page 1.		PEHEVALLATION OF THE SLIDE LUWER SAN FERNANDO DA	

									ATE START/FINISH 4/10/85 / 9/12/85	SI04
CAS	ING ID_	lot uar-	COR	E SIZ	Ε	GROUNDY	VATER EL NE	DATE LC	OGGED BY 1.k. Perkins DATE 9/10-12/85	PG. 5 OF 9
EL	ОЕРТН		SAMPL			REMARKS				
		TYPE	BLOWS	PEN	REC	i l		\$01L /	AND ROCK DESCRIPTIONS	
FT	FT,	NO.	6 IN	IN	IN	<u></u>				
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	- 56	S12	9	24	17	1		linës, dark ol	errowly graded fine sand, ~20% nonp live brown (SM)	
	F "	1	14				300 11 :	fines, subangu	graded coarse to fine sand, <5% non- plar, light olive brown (SW)	plastic -
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	- - 61		10					brown, laminar	d. plastic fines, $\langle 5\% \rangle$ fine sand, b ed $\langle CL \rangle$	1
	<u></u>	\$13	10	24	24		Next 12":	rines, time co	rrowly graded fine sand, ~20% nonportent decreases with depth, blacki	lastic sh brown
	F					}	Bot 5":	(SM to SP) Similar to top	7" (CL)	ţ
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BLOWS P	ER 6 140 LB	MANUER 5004 5	FALLING	30 70	A SVIRO	310M 00 MCE	s			
REC REC	ETRATION LE COVERY LENG IGTH OF SOLA	HGTH OF SAI	SAMPLER : MPLE	OF COF	E 8488	e	. See Page 1.			
S SPLIT	SPOON SAME TURBED SAME	1.E	/-·-/U	L-TOIN	COMED	"			RE-EVALUATION OF THE SLIDE LOWER SAN FERNANDO DAM	
	UF - FIEED UG - OSTERN	TUBE		10 - 0EH	HEA					
₽ enoum		-	•						OBOTECHORICAL EMODIFERS DIC DA	mr 3/10/86
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						S GROUND E									SI	04
						GROUNDY								ATE 9-10-12/	PG 6	of 9
EL	DEPTH	S	AMPL	٤		REMARKS										
		and	PER	ł	1 6					201F W	AD MOCK	DESCR	IIPTIONS			
	22	NO.	6 IN	IN	IN											
	60	S14	2 5 8 8	24	22		S14		naced, layers sample	, very da ot silt	rk brown y fine	n (CL) sand lo tsf	Sample	% very fin contained t the midd	two 1"	-
	68															
	72	S15	7 7 10	24	24		Ne	ext 12":	nated, Qp Sy SILTY fines, SILTY nated, fine s	very da 1.50. 0.93, SAND, na very da CLAY, mo	ick olive 1.60 ts: 0.95 ts: icrowly ; ick olive d. plase ck olive	e brown t f graded e brown tic fir	fine sa (SM) nes, ~10	X very fin nd, ~15% n X very fin Occ. lense	onplastic	lami-
	76	\$16	7674	24	19		8 8 8	lext 4": lext 7": lext 4":	fines, SILTY very d SILTY plasti Simila	very da CLAY, mo- lark oliv	rk olived. plaste brown rrowly p very da TY CLAY	e brown ic fin (CL) graded ark oli above	(SM) ies, (S% fine sa ve brow	nd, ~20% nd fine sand nd, ~30% nd n (SM)	, laminac	ed,
PEN-PEN PEC PEC #20-LEY 5 SPL-1	ETBATION LE OVERT LENG GTH OF SOUN SPOON SAME TURBED SAM S SHELBY LT T F FED I LT OSTERB	NITH OF SA TH OF SA ID CORES TLE IPLES T TUBE PISTON	taupi£R MPi£ ⇒4·N/L	≫ (O	COREO		ne fage	· ;				10.11 И ончини	JATION O WER SAN		E IN THE AM OATE 3.1 PROJECT 8	

NCLIAND NO.	BOR	ING LOCA	TION _	Sta 9	+35	73.	115 GROUND I	ELEVATION (NGVDL.	1114.5	DATE	START	/FINISH 9/10/85 F. Stewart.	/9/12/85 WES/COE	S	10	4
THE ROOM FROM THE MACE SOIL AND ROOK DESCRIPTIONS THE ROOM FROM THE MACE SOIL AND ROOK DESCRIPTIONS THE ROOM FROM THE MACE SOIL AND ROOK DESCRIPTIONS THE ROOM FROM THE MACE SOIL AND ROOK DESCRIPTIONS THE ROOM FROM THE MACE SOIL AND ROOM SITE OF THE STATE SOIL AND ROOM SITE OF THE S	CASI	ING ID	Yot us	edCORE	SIZI	E	NA_GROUNDY	WATER EL	NR ¹⁾	DATE	LOG	SED BY_	J.R. Perkins p	ATE 9/10-12/85	PG 7	7 of	9
The set of the set of	EL	DEPTH	s	AMPL	E		REMARKS										
SIB-TOP 10": SILTY SAND, nerrowly graded fine sand, -DI nonplastic fines, cot very fine sand, lawings, -DBBBBBBBBBB					PEN	REC		<u>.</u>		5	OIL AN	D ROCK	DESCRIPTION	5			
SIP-Top 1": SILTY CLAY, mod. plactic fines, (St very fine sand, lams- nated, very dark olive brown (CL) Sp. 10.1; J. Off Sp.	FT.	<u> </u> FT.		6 IN	IN.	IN.		<u> </u>									
S17-Top J": SILTY CLAY, mod. plastic fines, (St very fine sand, leminated, very dark olive brown (CL) 82 83 84 85 86 87 88 88 88 88 88 88 88 88		78															-
S17-Top J": SILTY CLAY, mod. plastic fines, (St very fine sand, leminated, very dark olive brown (CL) 82 83 84 85 86 87 88 88 88 88 88 88 88 88		F															
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S20-Top II" SILTY SAND, narrowly graded fine sand, N201 momplescic fines (ask olive brown (SM)) 95			S19	- 5	24	24			Sy = 0.98, Qp = 1.8, 1 SANG, MARROWIN	olive brown (CL) >1.0 tsf 1.9, 2.2 tsf	4
Signer, dark olive brown (SM) Sex 6': SILTY CLAY, most plastic fines, m3x fine sand, stratified, oark olive brown (cl) Social 75 2.0, 2.0 tef Bot 3'': SAMU, narrowly graded med. to fine sand, mostly fine, CSX nonplastic fines, brown (SP) 101 Signer and service fines, brown (SP) Silty SAMU, narrowly graded fine sand, mostly fine, CSX nonplastic fines, olive brown (SP) Silty SAMU, narrowly graded fine sand, mostly fine, CSX nonplastic fines, olive brown (SM). Sample contained a 1"-thick layer of scratified allty clay. Silty SAMU, narrowly graded fine sand, mostly fine, CSX nonplastic fines, olive brown (SM). Sample contained a 1"-thick layer of scratified allty clay. Silty SAMU, narrowly graded fine sand, mostly fine, CSX nonplastic fines, olive brown (SM). Sample contained a 1"-thick layer of scratified allty clay. Silty SAMU, narrowly graded fine sand, mostly fine, CSX nonplastic fines, olive brown (SM). Sample contained a 1"-thick layer of scratified allty clay. Silty SAMU, narrowly graded fine sand, mostly fine, CSX nonplastic fines, mostly graded fine sand, mostly fine, CSX nonplastic fines, brown (SP) Silty SAMU, narrowly graded fine sand, mostly fine, CSX nonplastic fines, mostly graded fine sand, mostly fine, CSX nonplastic fines, mostly graded fine sand, mostly fine, CSX nonplastic fines, mostly graded fine sand, mostly fine, CSX nonplastic fines, mostly graded fine sand, mostly fine, CSX nonplastic fines, mostly graded fine sand, mostly fine, CSX nonplastic fines, mostly graded fine sand, mostly fine, CSX nonplastic fines, mostly graded fine sand, mostly fine, CSX nonplastic fines, mostly graded fine sand, mostly fine, CSX nonplastic fines, mostly graded fine sand, mostly fine, CSX nonplastic fines, mostly graded fine sand, mostly fine, CSX nonplastic fines, mostly graded fine sand, mostly fine, CSX nonplastic fines, mostly graded fine sand, mostly fine, CSX nonplastic fines, mostly graded fine sand, mostly fine, CSX nonplastic fines, mostly graded fine sand, mostly fine, mostly graded fine s		94									111111111111111111111111111111111111111
Thoms with a signal numerical state to come manner. Thoms with a signal numerical state to come manner. The		- - - - - - - - - - - - - - - - - - -	s20	6	24	20		Next 6":	fines, dark of SiLTY CLAY, modark olive broader Sy >1.0 ts: Qp = 1.75, SAND, narrowly	live brown (SM) od. plastic fines. ∿5% fine sand, own (CL) t 2.0, 2.0 tsf y graded med. to fine sand, mostly	stratified,
BLOWS PIPE THROUGH HAMMER PALLING SO TO DRIVE A ZON OO NOTES OF IN PRIVING THAT THE STAND OF SAMPLE OF COME BARREL OF IT SPOOLS SAMPLE OF COME BARREL OF IT SAMPLE OF SAMPLE OF COME SAMPLE OF COME BARREL OF IT SAMPLE OF SAMPLE STANT OF SOME COMES SAMPLE OF COMES SAMPLE OF IT SAMPLE OF SAMPLE LIMER SAMP FERNANDO DAM STANT OF SOME SAMPLE OF IT SAMPLE OF SAMP		101	S21	1.8	24	17		\$21	fines, olive t	brown (SM) Sample contained a 1"-	plastic thick
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	}		5				S22 -	SANDY S	ILT, non	to sl.	plastic fir e gray (ML	nes, 35% fin	ne - med sa	nd, ∿5	% grav	•1 -
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930 LE	COVERY CENS NGTH OF SOUN	D COMES	up. I			I		•			: E - E	VALUATION OF				
	SPOON SAME STURBED SAM	P. 23								J		LOWER SAN FE	EMNANDO DAM			
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7 0 1001	HOWATER			-							(h) 08077	BEHTHEAL BHOOKERS	19 (1940)	ATE 3	10/86	
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INCL	NATION,	Yez 11 cz	u_ SE	ARING	<u>`</u>	TOTAL DE	PTH (F1) OR	TE START/FINISH 9/12/85 2014/85 ILLEO BY 5 SCENARC PES/COE GGED BY 1.8 PERFORD DATE 2 2-14/85	S105
EL.	DEPTH		AMPL		=	REMARKS	VAIEH E	COATECO	GGED BY J.R. Pervins DATE 9-33-14/85	PG OF 9
FT	ก	TYPE and NO	BLOWS PER 6 IN	PEN	i i	i		SOIL A	AND ROCK DESCRIPTIONS	
1110		51	19 35 36 32		23	Boreliose advanced using standard		SILT: JAND, widely grad nonplastic fines, <5% g	ed coarse to fine sand, mostly fin ravel, brown (SM)	e, ~30x
	<u>, , , , , , , , , , , , , , , , , , , </u>	s2	9 14 25 24	24	21		S2 -	SILTY SAND, widely grad nonplastic fines, ~5% g	ed coarse to fine sand, mostly fin ravel up to ½", blackish brown (S	e, ~30% M)
	, , , , , , , , , , , , , , , , , , , ,	53	7 15 18 21	24	17				plastic fines, N40% coarse to fin brown and olive gray (CL)	e mand,
하는 내 기 하는 내는 이 이 기 등 내가 하는 내가 하는 기 등 다른 내가 있다. 기 등 다른 기 등 기 등 다른 기 등 기 등 다른 기 등 다른 기 등 다른 기 등 다른 기 등 다른 기 등 다른 기 등 다른 기 등 다른 기 등 다른 기 등 다른 기 등 다른 기 등 다른 기 등 다른 기 등 다른 기 등 다른 기 등 다른 기 등 다른 기 등 기 등 기	S FER 6 - 40 B HANNER FALLING SO TO DRIVE A ZOWN FOR T SPOON SAMPLER FOR T SPOON SAMPLER FOR THE STAND CONTROL OF CONTROL FOR THE STAND CONTROL FOR THE ST				CORED	.%.	round reause sed to	vater levels not recorded bentonite drilling mud toprenoie would produce rate readings.	RE-EVALUATION OF THE SLIDE LIVER SAN FERNANDO DA	

INCL	MATION	Verti	CAL BEA	ARING	<u>\`A</u>	GROUND ELEVATION (NGVD) 1114.1 DATE TOTAL DEPTH (FT.) 117.0 DRIL		_
CASI	DEPT		SAMPL		هندع ا	GROUNDWATER EL. NR DATE LOGG	GEO BY THE PERKINS DATE STITES PG Z OF	
			BLOWS	PEN	REC	I	D ROCK DESCRIPTIONS	
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	Ē	S4	10	34	21	S4 - SILTY SAND, widely grade	d coarse to fine sand, mostly fine, ~30%	
	- 16 -	"	25 27	"	`	non to sl. plastic fines	, 10% gravel up to 1/2", blackish gray (SM)	
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	F	56	21 22 25	24	19	56 - SILTY SAND, widely grade tines, Not gravel up to	d coarse to fine sand, x30% nonplastic 1.3", blackish brown (5%)	
245 •	E# 6 - 140	HAMME	FALLING SAMPLER	30 TO	ORIVE A			=
2 - 8 £3	HETRATION COVERY LI	I LENGTH OF INGTH OF SI OUND COPES	SAMPLER AMPLE	OF CO	** 8488	'. See Page '.	PE-EVALUATION OF THE SUIDE IN THE	
5 P	50004 \$	AUPLES SAUPLES				ĺ	SOWER SAN PERNANDO CAM	
	.5 : 3ME	LBY TUBE ED PISTON ERBERG		00.0E	NISON CHER I			
6 #Out	****						GROTECHNICAL ENGINEERS SIC. DATE 3/10/8	6

												FINISH 9/12/85	9/14/85 -ES/COE	SI	05
CASII	NG ID No	t used	CORE	SIZ	E_N/	GROUNDY	VATER EL.	HR ¹⁾	DATE _	LOG	GED BY	J.R. Perkins (DATE 9/12-14:85	PG. 3	of 9
EL	DEPTH	_	AMPL		_	REMARKS				\$011.44	HD BOCK (DESCRIPTION	•		
FT	FT.	and NQ	PER 6 IN	1	REC					3416 21	NO NOCK	or Jenir Hon	•		
	26						<u> </u>								
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	- 31	S 7	28 33 46	24	15		S7 -	GRAVEL	LY SILTY	SAND, w	idely gra	ded coarse	to fine sand,	~20%	-
	F							nonpla	stic fir	ies, ~20%	gravel u	ip to 11/4", (dark olive b	own (SM)	1
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	- 35 -				Н										4
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	}- 36 1	s 8	24 16 20	24	14		S8 -						to fine sand, fark olive to		4
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i	-														1
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	- ,,														
PEN - PEN	ETRATION LE	ngth of Th of sa	Samplea Mple	OF CO	W BAR	NEL	See Page	1			ΑE	-EVALUATION	OF THE SLIDE	IN THE	
3 · SPUT U' UNDIB	GTH OF SOUR SPOON BAM! TUPBED BAM	1.L										LOWER SA	(N FERNANDO D	AH.	
	US - SHELBY UF - FIXED UG - OSTERN			-0.0E	HSCH THER						Т • • • • • • • • • • • • • • • • • • •	THEORNICAL ENGD	ERRE DEC.	و (د sate ا	86
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											TE START/FINISH 9/12/85 /3/14/85	S	10	5
						TOTAL DEI					LLED BY F. Stewart, WES/COE GGED BY 1. R. Perkine DATE 9/17-14/85	PG 4	1 of	9
£L	DEPTH		AMPL			REMARKS					57.0			<u> </u>
			BLOWS		REC				•	SOIL A	NO ROCK DESCRIPTIONS			ĺ
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	١.								Appi	oximat	re Interface - Rolled Fill			4
	- 45 -										Hydraulic Fill			
	-	3		•										- 1
	46	S1 0	9	24	12		510-T	op 5":	SANDY CLAY	(, el.	to mod. plastic fines, $^35\%$ coars ne, $^35\%$ gravel up to $^3/2$, olive b graded med. to fine sand, mostly m	e to f	ine	ᅼ
	-	•	8				5	ot 7":	SAND, narr	owly a	traded med, to fine sand, mostly m I nonplastic fines, brown (SP)	ed., 1	10%	4
	F										cained a thin layer of silty clay.			- 1
	- 47	!		<u> </u>										4
	-					}								
	F	1	4			İ								7
	48	S11	4	24	15		S 1 1		tified, ve	ery dar	, plastic fines, ~10% very fine sa rk olive brown (CL)	nd, st	re-	7
			5	1					Qp - 1.	2. 1.1 66. 0.	1, 1.0 tef .60, 0.60 tef			1
! !	-	1				1								
	49	-	 	-	-									7
	-		1											7
	F	512	2	24	24		S12		SANDY CLAY	/. al.	plastic fines, ~20% very fine san	d. acr		#
	<u></u> 50 −	•	٥	• •	1				tified, b)	ackint	h olive		_	-
Ì	Ł	ı							Qp = 1. Sv = 0.	7 csf				4
,	F	•	ļ	ļ]								7
	<u>}−</u> 51 −	I —	2				S13		SANDY CLAY	, mod.	. plastic fines, ~20% very fine sa (CL) Occ. irregular pockets of si	nd, lev fi	ne.	コ
}	ļ	\$13	i. 5	24	14						ontained a 114" piece of gravel at			4
	52	I	5	<u> </u>										
8L0W5 #	ER 6 1140 U	HAUMER SPOON S	PALLING	30 ° TO	DAIVE	1 2 0 PH 00 NOTE	\$							
MEC. MEC	e tration li Overt leng	LHGTH OF TH OF SA	SAWPLER MPLE	OP CO	M BAR	MEL .	See Pa	ige 1.			RE-EVALUATION OF THE SLIDE	7 N - TO	r	
3:3PUT	eth of sole spoon same tupped same	N.	>4.876	e me th	COREC	. 76					LOWER SAN FERNANDO DA		L.	
	US - SHELD UF - FIXED UG - MSTERN	TUBE PSTOR		UD : 00	R SON									
\$ evore				U6-0E	•							ATE 3		
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									ATE START/FINISH 9/12/85 9/14/85	S105
CASI	NG ID No	t_used	COR	F. SIZ	E_NA	GROUNDY	VATER EL. SR ¹¹	DATE : LO		0.5 of 9
EL	DEPTH		AMPL	_		REMARKS			, oct of	0.00.0
		<u> </u>	BLOWS		REC			SOIL	AND ROCK DESCRIPTIONS	!
FT	FT	NO.	PER 6 IN	IN	IN					
	32	_		T						
	[s 13	2	24	14		S13	See previous	page	1
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	- 53	!		 _ 	_					4
			ļ	ŀ						4
	-		3	ŀ						7
	- 54	514	3 5	24	24		S14	SANDY CLAY,	1. plastic fines, ~25% fine sand, ir:	regular 🚽
			5	1				Qn = 1.3 ts	n, blackish olive (CL) sf	4
			1	1				Sy = 0.72	csf	1
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	- "									コ
	-									
	-	S 15	5	24	1,6					7
	- 56 -	3 ()	8,				515	SANDY CLAY, al	l. plastic fines, ~25% very fine sand ish olive (CL)	i, atra-
	_									4
	-						'			1
	 57			-	\vdash	ŀ				4
	-			İ						1
	-		•			ļ	\$16	SILTY CLAY me	od. plastic fines, ~10% very fine san	, 1
	- 58	S16	2 4	24	24	ļ	3.3	arrarified bl	lackish olive (CL)	···
	-	В.	6]			S _v = 0.53,	0.73, 0.75 tsf	4
	- 1				1					4
	- 59			_	\square					
	-									
}	-	}	2							1
	- 60	S17	j	24	24		\$17-Top 231/2":	stratified, bl	sod. plastic fines, ~10% very fine sa lackish olive (CL)	ind,
	-		,	1.7	-			$Q_p = 1.3.1$ $S_v = 07.8.$	0.73 tef	7
	-						Bot 1/2":	SAND, narrowly olive brown (/ graded fine sand,∿!O% nonplastic fi	nes,
Ì	- 61	i								Ⅎ
ŀ	-									7
ţ										+
}	- ,,		. 8 14			}	S18-Top 5":	CLUDY CLAY -1	-1]
Ī	- 62 -	S18	.5	24	15		·	olive (CL)	l. plastic fines, ~25% fine sand, bla	7
ł	-				1	İ	20 C 19 E	(SP)	graded fine sand, 55% nonplastic, b	rown
-	-									1
1	- 63 -				\dashv]	\$19-Top 5":	SILTY CLAY, no	d. plastic fines, ~15% fine sand, st ive brown (CL) Occ. pockets and	ra
}			ł			ļ	Neve an	lenses of silt	y fine sand.	1 1
	.		5	j			TEAL D :	olive brown (M	n to sl. plastic fines,~35% fine san (L) Occ. layers of silty clay to 1/8	" UEFK
ŀ	- 64	S19		24	18	İ	80 c 5":	SILTY SAND, na	rrowly graded fine sand, >20% nonpla	stic -
F	-					}		Tines. Whi med	to coarse sand, olive brown (SM)	
ļ	. 45					1				4
- 14 min	TRATICA LEA	es me our s	亚田斯 医单位	oot De Henne) B. D. P.	TOM OF NOTE				
MODILENG	VERN LENGT De OF BOURK	H OF SAN COPES	PLI			i i	're Page ".		RE-EVALUATION OF THE SLICE IN WER SAN FERNANDS DAM	THE
S SPLIT S UNDISTI	POON SAWR IRRED SAWE	. (C 15 (E)							The same restrance can	j
	1 THE LBY I FIZED P D OSTERNO	10 RE 1170H 186	-	0 0EN	HER					ļ
7 4 POUNO						1				3/10/86
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EL	DEPTH		AMPL	_		REMARKS	DATE LOGGED SY DATE 9/12-14/85 PG 6 OF
FT	FT.		BLOWS PER 6 IN		1		SOIL AND ROCK DESCRIPTIONS
	65						
	- - 66 -	\$20	7 5 5 7	24	20	\$20-Top 5" Bat 15"	SiLTY SAND, narrowly graded fine sand, ~15% non plactic fines, ~5% med. to coarse sand, olive brown (SN) SANDY SILT-SILTY SAND, non to al, plactic fines, ~bu% fine sand, blackish olive (ML-SM)
	67					621 7-2 129	
			1	!		52)-10p 1/":	SILTY CLAY, mod. plastic fines, ~10% fine sand, stratified blackish olive (CL) Sv = 0.90, 0.90 tef Qc = 1.50, 1.50 tef
	- 68 -	\$21	469	24	24	L .	SANDY SILT, non to si. plastic fines,~45% fine sand, blackish diive (ML) Similar to top)?"(cL)
	- 69 						
	70	522	3 6 •2 17	24	12	S22	SILTY SAND, narrowly graded fine eand. ~40% non to el. plastic fines, blackish olive (SM) Entire length of sample disturbed. Piece of grave, in head of sampler.
	- 71				-		
	72	\$23	6 6	24	19		SILTY SAND, narrowly graded fine sand $\sim 30\%$ nonplastic fines, very dark olive (SM)
	-	343	19	۷4	19	Next 2";	SILTY CLAY, mod. plastic fines, ~10% fine sand, stra- tified, very dark olive (CL) SILTY SAND, narrowly graced fine sand, ~20% nonplastic fines, very dark olive (SM) SANDY CLAY, si. plastic fines, ~35% fine sand, stratified,
	- 73 -		_			Bot 3h;	very dark olive (CL) SAND, narrowly graded fine sand, ~5% nonplastic fines, tan (SP)
	74	S24	8	24	24		SILTY CLAY, el. plestic fines, ~30% fine send, very dark olive (CL) SILTY CLAY, mod. plestic fines, ~10% fine send, stratified very dark olive (CL) Sy = 0.86, 0.91, 0.74 tef top to bottom
	- - 73 -				\dashv		Qp = 1.6, 1.6, 1.3 tef top to bottom
	76	325	2 5 8 9	24	24	525	SILTY CLAY, mod. plastic fines, $\sim 10\%$ fine sand, stractified, very dark olive (3L) Sy = 0.56, 0.75, taf top to bottom Qp = 0.80, 1.60, taf top to bottom
	77					526	SILTY CLAY, mod. plastic fines, ~10% very fine sand, stra- tified, dark olive (CL)
	- - - - 78	S 26	3	24	24		$S_{V} = 0.74$, 0.93, 0.93 taf top to bottom $Q_{p} = 0.99$, 1.6, 1.5 taf top to bottom
~ ~~		G TH OF 1	AMPLIAN	0 70 0	A SYSKE	Om ac NOTES See Page 1.	
O-LENG SPLIT S UNIONST	TH OF SOUND POON SAMPL UPSED SAMP 13 SHELBY	COMES E LES	>4:4/4	MSDA(0°DE# Pr#IT		×	SELEVALUATION OF THE STIDE IN THE CURRENT OF THE COMMER SAN FERNANDS COM
	O OSTERNE.	ALCON ALCON	7	6 : 6 () 6 : 6 ()	7+ CP		CALIFECTURINAL ENGERGENIA SHO. DATE 3/10/86

							LEVATION (NGVD)_						SI	05
							PTH (FT.)						oc 7 /	· 0
EL	DEPTH		AMPL			REMARKS	ATER EL	_ UATE		3ED B1_	7.81 7378111	OATE STREET,	7	"
		TYPE	BLOWS PER	PEN				3	OIL AN	D ROCK	DESCRIPTION	15		
	FT.	NO.	6 IN	IN.	IN									===
	78	526	3 4 7	24	24									4 4 4
	80	\$2 7	2 6 6 11	24	24		\$27	tified, \Su = (very da	rk oliv	(CL) Staf top	Of fine sand, to bottom	etra-	1
	81	_	2 5											1
	- 82 - - - - 53	S28	9	24	13		S28	SILTY CLA tified, v from piec	very da	rk olive	Lo fines, ∿1 m (CL) Host	OT very fine of sample di	sand, st sturbed	ra
	- 84	\$ 29	3 6 9	24	24		\$29	stratifie	ed, ver	y dark o	olive (CL)	O%, very fine Sample contai lty fine sand	ned seve	ral
	85							S (0.95, 0	.95, 0.1		to bottom		
	- 86 87	\$30	4 9 10 11	24	24		Next 6": Hext 3": Next 2":	SILTY SAM fines, ve SILTY CLA SILTY SAM fines, ve	very da ND, nar ery dar NY, siu ND, nar ery dar	rk olive rowly gr k olive ilar co rowly gr k olive	e (CL) raded fine a (SM) top 4" (CL) raded fine s	and, ∿20% non	plastic	ra
	- 88 - 89	\$31	14 14 12 15	24	22		Next 1": Next 2": Next 7": Next 3":	SILTY SAM fines, ve SILTY CLU SILTY SAM fines, ve SILTY CLU	very da ID, nar ery dar IY, sim ID, nar ery dar IY, sim ID, sim	rk olive rowly gr k olive ilar to rowly gr k olive ilar to	(CL) raded fine (SM) (SM) top 5" (CL) raded fine s (SM) top 5" (CL)	and, ~30% non	plastic	FA
	- - - - - - - - - - - - - 	5 32	6 12 14 15	24	19			brown (Mi	.) XY, mod	. plasti	c fines, wh	es, ~30% fine 0%, very fine		ive 1
PENTEN RECTREC RODILEM STSPLIT	ETHATION LING OVERY LENG GTH OF SOUR SPOON SAM TURBED SAM US - SMELE UF - FIXED	SPOON ! ENDTH OF SA HO COPES PLE PREPS Y TUBE PISTON	SAMPLER SAMPIR MPLE SAMPLE	OF COL	RE BAR COREC THEON	MEL .	S fee Page '.			₽E		OF THE SUICE IN FERNANDO DA		
Z sucre	UO: OSTERI FORMATER	E/NG		90-0€	•					Ф"	OTECHOROAL ENGI	Origina DPC.	NATE 3/10/	/86 69

1											,	9/14/85	SIC)5
							PTH (FT) VATER EL				F, Stevert, WE J.R. Perkins DATE		PG B OF	- 9
Εί	DEPTH		AMPL			REMARKS								
		TYPE	BLOWS	PEN	REC				\$01L	AND ROCK	DESCRIPTIONS			
FT	FT.	Na	6 ÎN.	1N	IN		<u></u>							
	91 92 92 93	533	6 9	24	23		533	t	ified dark b f silty fine S _v = 1.0,	rown (CL) sand. 1.0 tsf	: fines, ~5% ver Ccc. irregular; top to bottom top to bottom	y fine sar pockets ar	nd, etra- nd lenses	
	94	\$34	4 6 7 11	24	8		534	S E	ILTY CLAY, m 1fled, dark	od. plastic brown (CL)	: fines, ~10% ved	ry fine aa	and, ⊕træ-	
	96	\$3 5	7 6 8 12	24	24		Yext 4	t'': S' 7": S	ified, dark ILTY SAND, n lastic fines ILTY CLAY, m ified, dark es of silty Su = 1.3,	brown (CL) arrowly gra , dark oliv od. plastic brown (CL) fine sand. 0.86 tst	tines, NIOR verided fine sand, Ne brown (SM) tines, NIOR verions, NIOR verions to bottom top to bottom	40% non t	o sl.	4
	98	\$36	4 7 9 10	24	24		\$36		tified, dark see of silty Lower half o	brown (CL) fine mand. f sample co	c fines, NOT ve Occ. irregular incained a 47-chi plastic fines.(5)	ck layer	and len-	
	100	\$3 7	4 3 10	24	24		\$37	¢ :		brown (CL) ty fine sar	: fines, ~10% ver Several irregui id.			
	102	S 38	4 10 10 12	24	24		S38	t i Sa	ified, dark $S_V = 0.95$ $Q_p = 1.6$ supple contain	brown (CL) tsf tsf ned two 2"-	thick layers at bottom haif.	the top h	ølf mnd	
	103	\$39	<u> </u>		24		519	9 1 1 5 5 1	isted of SIL' onplastic iii	TY SAND, na nea, dark t od. plasete lark berwn	rrrowly graded forown (SM) fines, NOT very lines, NOT very lines, NOT very do.	ine sand, v fine sar gular poci	10, stra-	•
PEU PEU PEU PEU PUDIUEN S SPAT U INDES	FR 6 47 OB FIRST N 2 OVERY IF NO SPOON SAME FUMBED SAME F FRED SAME F FRED SAME F FRED SAME F FRED SAME F FRED SAME F FRED SAME F FRED SAME F FRED SAME F FRED SAME	NUTH A THEOREM OCCUPIES NE PLES THEOREM THEOREM	SAMPIA MMI MMI	# CO	PE BARI CGRED NISON CHER	i	ES AE NAVA			-	S-FVALLATION OF THE CAN 59	* # * * * * (*)		
7 **oun	DWATER									Ф °	CTRCIONICAL BROBRISHE MACHINE COMMINICAL PR		ATE 3/10/8	

						15 GROUND I				TE START/FINISH 9/12/85 9/14/85 S 105
						GROUNDY				GGED BY J.R. Perkine DATE 9/12-14/51 PG 9 OF 9
٤٤	DEPTH	<u> </u>	AMPL			REMARKS			\$00 4	NO ROCK DESCRIPTIONS
PT	77	TYPE end NO	BLOWS PER 6 IN.	PEN	i ł					
	104		5 9				539		Sy = >1.0 t Qp = 1.7 t	st
	-	539	10	24	24				Sample contai	ned two 2"-thick layers of SILTY SAND, uni-
	105			-						d, ~30% nonplastic fines, dark brown (SM) ocated at middle of sample.
l	E		4				\$40			
}	106	540	12	24	24		340		tifled, dark	od, plastic fines, <10% very fine sand, stra- brown (CL). Occ. lenses of silty fine sand. csf
	Ė								$Q_p = 2.1$,	2.3, 2.4 csf
	107	-		-	-					-
	Ė	l								
	_ :08 _	34,	12	24	24		S4!		tified, verw layer of silt Su = >1.0	od, plastic fines, ~10% very fine sand, stra- dark brown (CL) Sample contained a 3"-thick " y fine sand at middle of sample.
	109						S42-Top	5":	,	2.2, 2.4 tsf miler to S41 (CL)
	-									Interface - Hydraulic Fill
	- 110	542	12	24	24		Вс	t 18":	SILTY SAND. n	Alluvium arrowly graded fine sand, ~40% nonplastic
	F	•	. 7							d. to coerse sand, black (SM)
	<u>-</u>									
}	E	1								
	+									
	- 112									
	- - - ;:3									
	-			1						
	} 44 <u>5</u> }									•
	E									
	- 115			-	-					
		l	4							
		54.3		2.4	.3		4.3		MILTY SAND, n. Mines. Ulive	Arrowly graded fine wand, %30% nonplastic
	ļ	l								
9 +1 +	ATON I	7,74 1,107	1.12	N *5	:0.4	NOT NOT	ES		:ottom	of Borehole - 1110 ft
*20 : Z×	COVERN END FOR OF SKAR	AD CLAMAR AD CLAMAR	144.1			,	'ee fage			REPERATORS IN THE THE STORE IN THE STREET AND THE STREET AND PRENANCE LAM
	SPOOM SAM ITUPACO SAI BUSMC E. OFFEE	P. C.		្ត្	N 973N ™, H (A					
\$ ••×	-0:051ER	KAG "		A-91						OBJITECHOROLL SHIPPERNS DIG. 124TL 3.12786

INCLI	NATION_	Vertica	<u>1 8E</u>	ARING	NA_	TOTAL D	EPTH (FT.) 104.0 DF	RILLED BY Frank Stevare MESICOE OGGED BY 18 PERSON DATE 9/20/2/18	SIII
EL	DEPTH		AMPL			REMARKS	77.00	VIII VIII VIII VIII VIII VIII VIII VII	1.0.1
		TYPE	BLOWS		REC	ı	SOIL	AND ROCK DESCRIPTIONS	
FT.	FT.	NQ	PER 6 IN.	IN.	IN.	}			
1095.1	U			Ε		Borehole			
	1	S1	11 15 14 15	24	3	advanced using standard rotary wash boring techniques with a drilling mud. Cleaned out borehole		: fines, ∿30% med. to fine sand, br	own (CL)
		52	5 7 10 14	24	17	orrance with a 4" fishtati bit with upward jetting.	S2 - SANDY CLAY, sl. plastic Occ. irregular pockets	fines, ~15% fine sand, brown (CL) of stity fine sand.	
RECTRECO ROCTLENG 5 SPLIT 3 UT UNOST	10 11 12 12 13 14 14 14 14 14 14 14 14 14 14 14 14 14	TH OF SAI TH OF SAI NO CORES PLE IPLES	SAMPIA MPCE >4:4/L	OR COR ENGTH: O DEN O P P T	CORED.	.*	S3 - Similar to S2 (CL) E5	FE-EVALUATION OF THE SLIDE I LUMBER SAN FERNANDO DAM	N THE
₩ 4 ROUNG		eń "	·	A- 0E					лтк 3/10/86 пыккт 85669

										E START/FINISH 9/20/85 /9/24/85	SIII
1										GED BY J.R. Perkine DATE (20-24/85	PG. 2 OF 8
EL	DEPTH		AMPL			REMARKS					7.5.2
		TYPE	BLOWS		REC				SOIL A	ND ROCK DESCRIPTIONS	
**	- FT	HQ.	PER 6 IN	IN.	IN						
	- 13										-
	-		İ	ł			ł				1
}	- 14						İ				
	Į '`										
	F	11					1				7
	- 15	<u> </u>		<u> </u>			ł				4
]	-										1
	<u> </u>	SA	?			l	S4		SAND parrowl	y graded fine sand, ~10% nonplasc	ic fines.
	16	SA	5 2 8	24					dark brown (SP	-SM)	
	E	1	°				[4
1	F						į				1
	- 17						1				7
Ì	Ļ		1								4
}	- - 18	11	ļ	ĺ							_
	<u> </u>		ļ								7
	-	[[4
1	19	11	}	1			İ				4
]	ţ						}				1
	-		ĺ				[Approximat	e Interface - Rolled Fill	4
	20			-			-			Hydraulic Fill	
	E						1				Ė
	L - 21	S 5	7 9	24	19		85		SAND, narrowly	graded med. to fine sand, ~5% nor	plastic
İ	F ''	ľ	14 16	1			ł		tines, brown (SP) Sample contained a 1"-chick cy clay.	layer of]
Ì	F]	j							7
	22	 		_							4
ł	ţ	ł					ł				j
	-	36	6	24	10						4
	23		8	1	10		S6-	Top 5":	SILTY SAND, natifices, dark of	rrowly graded fine sand ~20% nonp.	lastic =
	F							Next !" Bot 4"	SILTY CLAY, st SAND, widely g	ratified ($\mathrm{GL})$ raded coarse to fine sand, \sim 10% no	onplastic T
	F	}]]	,	;			fines, brown (:	SW-SM)	7
	- 24										7
1	ļ.										4
}	<u> </u>	S 7	12	24	15		S.7			graded med. to fine sand, mostly	
	25	ł	8 7						sample contains	5% honplastic fines, brown (SP) to ed a 17-thick laver of grav, strat	ified -
	F								silty fine sand	u.	7
<u> </u>	<u> </u>	<u> </u>		<u></u>	Щ		<u></u>				
1 - 1 4 194	CTATON LE	* * * *	SAWRIA	SO TO	A SVINC	AZ GUN OC NOT					
*00:UE	PECOVERY LENGTH OF SAMPLE LENGTH OF SOUND CORES > 4 N / LENGTH CORED, %						` Se	e Page 1.		PE-EVALUATION OF THE SLIDE IAN FERNANDO DAM	IN THE
3 3PU	TURBED SAN	P. C3		,a - nei	er sc=]					
	S SHE. BY FIELD JO: OSTERN	m 510m MPG	,	00 BE	THEA						3110101
7 400	N STAPO									O BOTTECHOTICAL EMODVEENE DIG.	PATE 3/10/86

1									E START/FINISH 4/20/35 / 3/24/35	SIII
l .							EPTH (FT)04 WATER EL		CED BY 1.8. Peckine DATE a mile of	PG 3 OF 8
EL	DEPTH		AMPL			REMARKS	1	_ 54.0 000	34.0	10000
		TYPE	BLOWS		REC			SOIL A	NO ROCK DESCRIPTIONS	
FT	F7.	NO.	9 E R	IN	IN		<u> </u>			
	25									
	27	S8	11 15 5	24	15		Next 3" - Next 2":	12", NIOX nonpl SILTY SAND, mar finem, scratifi STRATIFIFO SILT	aded coarse to fine mand, 70% grastic fines, brown (SW - SM) rowly graded fine mand, 730% nonped, dark clive gray SM) Y CLAY (CL) y Sand above (SM)	
	28		 				<u> </u>			
	29	s 9	7 16 13 19	24	19		59	nonplastic fine	elv graded coarse to fine sand, "s, brown (SMI) Sample contained a fied silty fine sand. [ample con	I -thick
}	- 30				<u> </u>					-
	3:	s 10	10	24	16		Νέκε ο".	fines. 510% coa Section contain cley SAND, widely gr fines, brown 13	rowly graded fine sand, %25% hosp	i stity — plastic —
	33	S11	6 12 11	24	16		\$11-Top 4". Next 2" Next 6": 80t 4"	fines, gray and STRATIFIED SAND SAND, widely gr fines, brown (S	Y CLAY (CL) aded coarse to fine sand, <5% non-	
	35	S12	5 74	24	.8			fines, scratiff two %4"-thick] tained three La Lhick. SAND, widely go	rowly graded fine sand, N3C% nonped, dark office gray SMT medition avers of med, to fine sand, Festivers of fine sandvailt layers of aided coarse to fine sand, mostly 17, N1C% nonplastic fines, prown 17	contained ion con- up to 2" H red., N'OX L
	- - - - - - - -	\$13	9 13	24	15		\$1.	tines, prown S	aded coarse to fine sand, Niot nor W-SM) - Sample confainer two 4.77 ified sandy silt.	opiaetic Prok
	18	\$14	8	24						
HI AF HID TO HID TO J JHOH	DAS PER 6 - ROLE MANMER FALLING SO TO DRIVE A ZON- SELT SPOON SAMPLE VERY TREFOR LYNUTH OF SAMPLE OF COVERY LENGTH OF SAMPLE OF COVERY LENGTH OF SAMPLE OF SPOON SAMPLE JOURNALIS REDUNDMATER						ES : "ee fair			15 THE ATE 3/10/86

										FIMIRH 9/20-85 9/24/85	SIII
							PTH (FT.) 104 VATER EL NE ¹⁾			1. R. Perkins DATB/20-24/AS	PG 4 OF 8
EL	DEPTH		AMPL			REMARKS					
FT	еT	TYPE and NO	DLOWS PER 6 IN	PEN IN				501	L AND ROCK	DESCRIPTIONS	
	۵,	s14	8 10	24	17			fines, brow	m (SH)	aded rine sand, ~20% non fines, ~35% fine sand,	7
	40		112			İ	Bot 10":	SAND, widel	(ML) y graded coa	rse to fine sand, $\sim 10\%$ n ection contained two $^{-1}\!2''$	onplastic
	41	SID	10 8 3 11	24	13		Next 6":	3/8", ~10% SILTY SAND, fines, dark layer of co	nonplastic f narrowly gr olive (SM) arse to fine	rme to fine mand, ~10% gines, brown (SW-SM) added fine mand, ~20% non-Section contained one 1/ mand. (SW-SM)	plastic ',
	42										<u>-</u>
	- - 43 - -	S16	12	24	20			fines, dark layers of c bottom of s	olive (SM) coarse to fin ection. si. plastic	aded fine sand, ~25% non Section contained three e sand located at top, m fines, ~40% fine sand,	2"-thick iddle and
	44	\$17	4 10 9 11	24	17		Next 6":	dark olive clay. SAND, widel fines, brow of silty fi SAND, narro	(ML-SM) Oc y graded coa m (SW) Sect ne sand.	fines, ~50% fine sand, action layers of silty ree to fine sand, <5% notion contained one 1/2"-th time sand, ~10% nonplast:	nplastic - ick layer -
	46	\$18	5 10 6 8	24	16		S18	STRATIFIED bottom) Gr Description SANDY CLAY dark olive SILTY SAND, fines, dark SANDY SILT,	SANDY CLAY, adual transi s of each la sl. plastic (CL) narrowly gr olive (SM)	SILTY SAND and SANDY SILT tion from sandy clay to a yer are as follows: fines, ~20% fine sand, st sded fine sand, ~40% non; plastic fines, ~40% fine	racified,
	49	S19	10	24	15		\$19 Top 3": Bot 12".	dark oitve SAND, widel	(ML) y graded coa	fines, ~30% fine sand, a rse to fine sand, mostly brown (SW-SM)	7
	51	.2 0	5.53.	24	18		S20 Top S1: Next 31 Next 411 Next 411 Hext 411	cified, dar SAND, widel fines, brow Similar to SAND, marro brown SCA	k olive (ML) y graded coa n (SW-SM) top 5" (ML) wiv graded f	fines, ~35% fine sand, s rae to time sand, ~10% no lne sand, ~10% nonplastic r above -SW-SM)	onplastic -
PEN MENE MECHMESS MODILENS 1 SPC-11 UTUNCHST	CTRATION LE OVERY LENS STH OF SCHA SPOOM SAMI FURBED SAMI	HIGH OF THIOF SA 10 WARS PLE IPLES	SAUPLER MPLE ->4-4/L	Դ# СОН Ечатн	CORED	Hr. ∫ ¹.	ES The Page 1		- 8	-EVALUATION OF THE SCIDE COMER SAN FECHANDO D	
 ⊈ arouni	S SHELBI F FIXED 20: OSTERN DWATER	, RE PISTON MERG		. C : OE	THER THER					PTECHORICAL EMODRESHEDED. (ATE 3/10/86

									TE START/FINISH 9/20/85 / 9/2//85	SIII
CASI	NATION_ NG ID_No.	Vertic	CORE	aring E siz	ئــــــــ 8 × E	TOTAL DE	EPTH (FT)104.0 WATER EL = ** ^{1.3}	DATE - LOI	ILLED BY F. Stewart, MFS/COR. GGED BY J.R. PERKINS DATES/20-24/85	PG 5 OF 8
EL	DEPTH		AMPL			REMARKS			0.000	11.0.0
		TYPE	BLOWS	PEN	REC			SOIL A	NO ROCK DESCRIPTIONS	
FT	FT.		6 IN.	IN.	IN.	<u> </u>	<u> </u>			
	52 - - - - - 53 - - - - - - - - - - - - -	S2 1	3 12 7 8	24	18		Next 5": Next 3": Next 4":	dark olive and SAND, widely glot nonplastic SILTY SAND, natines, dark britished to top	i. plastic fines, ~40% fine sand, idatk brown (ML) graded coarse to fine sand, ~10% fi fines, brown (SW-SM) atrouby graded fine sand, ~20% non rown and dark gray (SM) p 4" (ML) ND above (SW-SM)	ine gravel,
	55	52 2	7 5 11 11	24	18	!	Next 5":	nonplastic fin SANDY SILT, sl section decrea stratified, br SILTY SAND, na	arrowly graded fine sand, ~19% non (SP-SM) Section contained two ½"-	t top of of section,
	57	s2 3	8 12 15 11	24	19		523	SAND, nerrowly 10% nonplastic	r graded med. to fine sand, ~10% c : fines, stratified, olive brown (oarse sand, SP-SM)
	58	S24	10 13 18 16	24	15		524	nonplastic fin	r graded med. to fine eand, mostly nes, brown (SP-SM) Sample contain nrs of coarse to fine sand.	
	61	S25 I	8 13 12 11	24	15		}	and fine grave	r graded med. to fine eand, ~20% or pl. <5% nonplastic fines, brown (S n-plastic, ~ 40% fine sand sand, s u.)	P) -
	63	S 2 6	11 12 20 25	24	18		\$26		graded med, to fine sand, mostly es, brown (SP-SM)	fine,~10%
	- 64 - - - - 65	s27	13 15 20 25	24	17		\$27	SILTY SAND, na nonplastic tin	rrowly graded med. to fine sand, 'es, brown (SM)	-20%
PEN-PENE REC: RECC ROOTLENC S SPUT J UNDIST	ETRATION CE OVERY LENG 3TH OF SOUN SPOON SAMP LURSED SAM LS 'SHELBY LF FEED LOO OSTERS	SPOON S NOTH OF TH OF SA O CORES LE PLES TUBE PISTON	AMPLER SAMPLER MPLE > 4:H/L	on cor	ME BARR COREO MERM TMER		ES See Page '.		RE-EVALUATION OF THE SLIDE LUMER SAN FERNANDO D	

,										FINISH 9/20/85 9/24/85 F. Stewart, VES/COR	SIII
										1.8. Perkins DATE9/20-24/85	PG. 6 OF 8
EL	DEPTH	5	AMPL	E		REMARKS	1				<u> </u>
		TYPE	BLOWS	PEN	REC			SOIL A	ND ROCK	DESCRIPTIONS	
FT.	177	NQ.		IN.	IN.		<u> </u>				
	- 65 - 66	s 2 7	13 15 20 25	24	17		527	See previous p	age.		
	- - - - - -	S28	14 12 10 16	24	18		S28	SILTY SAND, na:		aded fine sand ~30% nonp gray (SM)	lastic
	68	529	22 38 28 27	24	14			SAND, widely g '2", ~10% nonp Freshly broken	lastic fi	rse to fine sand, ~10% g nes, brown (SW-SM) d gravel	ravel up to
	71	s3 0	16 24 19 16	24	15		\$30			rse to fine eand, ~10% g nes, brown (SW-SM)	ravel up to
	73	s31	A 11 13 12	24	14			brown (ML-SP) : SILTY SAND, na	rrowly gr	fines, %50% fine sand, aded med. to fine sand, coarse sand, brown (SM)	- 1
	74	\$32	4 3 9 .	24	16		\$32-Top !!" Bot 5"	fines, brown (SM) graded f	aded fine sand, ~40% non ine sand, ~10% med. sand . (SP-SM)	
	77	\$32	10 13 15 12	24	14		2; 533	SAND, narrowly tines, brown (graded, SP-SM)	med. to fine #and, %30%	nonplastic
PEN PE PEC PE PODILEI SI SPLIT	PER 6 40.2 NETRATION LI COVERY LENG HIGH OF SOUR S POON SAM S TURBED SALE JE STREED	ENGTH OF SH OTH OF SH NO CUPES PLE WPLES IV TUBE PRSTON	SAMPLER IMPLE - >4 4/L	OF COL ENGTH	COREC	MEL .	See Page 1.	ed in Laboratory.	₽ g-	EVALUATION OF THE SLIDE UWER SAN FERNANDO DA	
\$ anon	ŬO÷ Q¶TEŘ INOWATEŘ	BE.PIG		Ŭ o ∵ a €	, -				ф "	OTRICKNICAL ENGINEERS DIG	DATE 3/10/86

									START/FINISH9/20/85 /4/24/85	SIII
									SED BY J.R. Perkins DATE 9/20-24/85	PG. 7 OF 8
£L	DEPTH	S	AMPL	ε		REMARKS				
	_	and	BLOWS PER	- 1		1		SOIL AN	D ROCK DESCRIPTIONS	
FT	FT. 78	NQ.	6 IN.	IN.	IN.					
	79	\$34	2 4 14 16	24	19	i		fines, dark oliv	traded med to fine sand, ~5% nonp	
	80	S3 5	6 8 73 12	24	18	535		fines, brown (SP	rowly graded med to fine sand, ~4 -SM) Sample contained one 3"-thi ayer of sl. plastic sandy silt.	0% nonplastic = ck layer and =
	82	\$36	4 6 9 12	24	19	536	ı		ely graded coarse to fine sand, m lastic fines, brown (SM)	ostly
	84 85 86	\$3 7	8 12 9 10	24	20	2 537)	SAND, widely grafines, dark brow	aded coarse to fine sand, ~40% no en (SM)	nplastic
	87	S38	5 7 8 10	24	19		Next 7": Bot 6":	fines, ~10% gias SILIY SAND, nari fines, ~15% med. SANDY SILT, si. brown (ML) SILTY CLAY, mod cified, dark go	ely graded coarse to fine sand, ~ vel up 4", brown (SM) rowly graded fine sand, ~30% nonp sand, brown (SM) plastic fines, ~40% fine sand, d d. plastic fines, ~10% very fine ray and dark brown (CL)	elastic
	89	s 3 9	6 17 33 16	24	19			Qp = 2.3, 2. Approximate SANDY CLAY, sl. blackish gray (.5, 2.8 tef Interface - Hydraulic Fill Alluvium . plastic fines, ~30% coarse to f	7
	90	540	18	24	15	1 1	Top 7": Bot 8"	gravel up to 3/	widely graded coarse to fine sand "", 5% nonpiastic fines, olive is plastic fines, ~35% fine sand, ~)	(W) _
의 (기 의 의 의 의 의 의 의 의 의 의 의 의 의 의 의 의 의 의	PER 8 (40) SPUI SPUI SPUI SENE TRATION LEN ENGTH OF SOU JT SPOON SAI JS 1 SHEL JO 1 OSTE! DUMOWATER	ENUTH OF GTH CF 3 IND CORE APLE IMPLES BY TUBE I PISTON	SAMPLE AMPLE	ENOTE	ME 9AA 4 COREI ENISON TOHER	0.% 2. Sam	Page pie desci oratory.	ribed in	-S-EVALUATION OF THE SLICE COMER SAN FERNANCE C	OATE 3/10/86

BORING LOCATION													
CASI	NG ID NO	t used	_ CORE	SIZ	نـــــــ <u>۱</u> ۸ <u>۸</u> ع	GROUNDWAT	TER EL. NR ¹⁷	_ DATE LOG	GED BYLE POLLIN DATE 9/20-2-8 PG 8 OF 8				
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ļ	E 93	541	15	24	24			fines. 5% med.	rowly graded fine sand, ~40% sl. plastic sand, black (SM) . plastic fines, ~25% very fine sand, black				
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ļ	Ē	544	11 23	24	20		544	SILTY SAND, man	rrowly graded fine sand, Table non-co-sl. prown and olive gray (SM) Fines content				
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ĺ	100	-	-	1-	\vdash								
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	101	S45	26 33 34	24	1:6			fines, olive ge SILTY SAND, man	ray (SM) rrowly graded fine sand, ~20% nonplastic				
	-		4 0	1				fines, olive b	cown (36)				
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	-	1	35				546-Top 8"	fines, grav 🤌	graded med, to fine sand, 198 nonplastic P) Rection contained a 12 piece of freshly				
	103	546	•0	24	17		30t 9":	broken gravel. SAND, widerv g	raded coarse to fine sand, 55% nonpiastic aver up to 52%, brown (58)				
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	TUPRED S	AWALES		.0 pr	N-90H	2.5	Porehole advanced using standard	
7	-0.0416	HBERG		.n .e.	**** # E.M	!	rotary wash boring procedures with a benconte drilling mud. Cleaned out perenole with a 4.7 permissionical amountains one care 1	1:4/85
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BORING LOCATION St. 9-30, 23.415 GROUND ELEVATION (NGVD)	
INCLINATION Vertical BEARING NA TOTAL DEPTH (FT.) 100.1 CASING ID Not used CORE SIZE NA GROUNDWATER EL NR 1.5	DATE - LOGGED BY J.A. Perkins DATE 10/6-8/85 PG 2 OF 2
EL DEPTH SAMPLE REMARKS	
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UF11 - Bottom Tr:	
95 UF12 PUSH 61.059.8 UF12 - Bottom Tr:	· ·
UF13 PUSH 60.959.8 UF13 - Bottom Tr	-
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GROUN	D'VATER OF	BSERVATION	WELL REPOR	T
Location San F	San Fernando Dam ernando Valley, Ca	lifornia	Page 1 Mell No. OW	.04
Client WES/C		 	Boring No.	
Contractor WES		ler <u>F. Stewart</u>	location Sta	9+55
		September 25, 1985		
Checked by T.	O. Keller Date	November 7, 1985	Proj. No. 85	
Survey	ır	- Elev. or length of below ground surfa	surface casing above/	0.1'
Datum NGVD		·	f riser pipe <u>above/</u>	0
Ground Elevation 1114	.5	•	ice seal below ground	
11211211211	27/25	surface, if any	ice sear below ground	78.01
Rolled Fil		Type of surface seditional seals) ID of surface casi Type of surface ca	,	4.0"
Hydraulic I	7111	Elev./depth bottom ID and OD of riser Type of riser pipe	r pipe	2.0' 1½" PVC
2		— Diameter of boreho	Die	4.0"
(tkot		— Type of backfill a	around riser pipe	cement grout
Se		Elev./depth top or	f seal, if any	0
ndi Crons		Type of seal Elev./depth bottom	m of seal	78.0'
ibua		- Elev./depth_top_o:		100.0'
Alluvium		Type of pervious :		PVC
10%	0 3	Describe openings		siotted
1 1		ID and OD of pervi	ious section	13"
ocheral	0,	— Type of backtill	tround corvinus section	Ottawa sand
	0 3	— There <u>imme</u> contr	n op ogrende bedroch	115.0
		<u> </u>	en i drug lugg.	
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GROU	NDWATER	OBSE	RVATION	WELL	REPOR	T
	ower San Fernan				Page 1	of <u>1</u>
Location Sa	an Fernando Val	ley, Califo	ornia		Well No. <u>OWl</u>	11
Client WE	ES/COE				Boring No	OW 111
Contractor Wi	ES/COE	Driller	F. Stewart		location Sta	5+95,
Inspected by	J. R. Perkins	Date0	tober 4, 1985		132.0' S	
Checked by T .	. O. Keller	DateNo	ovember 7, 1985		Proj. No. 85	669
Survey	1		ev. or length of low ground surfac		casing above/	
Datum NGVD Ground	I		ev. or <u>length</u> of low ground surfac		pe <u>above</u> /	1.5'
Elevation 109			ickness of surfac rface, if any	ce seal b	elow ground	78.0'
Rolled 1	Fill	di	pe of surface sea tional seals) of surface casin		ate any ad-	cement grout
		4	pe of surface cas	•		
	9	£10	ev./depth bottom	of casin	9	
			and OD of riser pe of riser pipe	bībe		PVC
to Scale)			ameter of borehol	ie		4.0"
(NO t		Ту:	pe of backfill as	round ris	er pipe	cement grout
Conditions Hydraul	ic Fill	Ty:	ev./depth top of pe of seal		any	cement grout
di l		1 1	ev./depth bottom			78.0
l io		Σ1	ev./depth top of	pervious	section	88.0'
1			pe of pervious 3	ection		PVC slotted
S Alluvium	m 0°	ID ID	scribe openings and OD of pervi	ous secti	on	15"
General	0	TY	pe of backfill a	rouna per	vious section	Ottawa sand
		a ('	ev./depth bottom	of pervi	ous section	93.0'
	,		ev., depth sortom			95.01
		↓ TV	ev./Henro frp. of pe of seal ev.,deptn bortom		100	
	\ 		pe of backfill b	elow perv	nous section,	Ottawa sand

APPENDIX B: EXPLORATION SHAFT

APPENDIX B

EXPLORATION SHAFT

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B • 2	Shaft Advancement Procedure	В5
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- B2 Summary of Field Density Tests Performed in Exploration Shaft

LIST OF FIGURES

- B1 Photograph of GEI Tripod Tube Sampler
- B2 Sample Location Plan Zone 2 in Exploration Shaft
- B3 Sample Location Plan Zone 3 in Exploration Shaft
- B4 Sample Location Plan Zone 5 in Exploration Shaft
- B5 Photograph of Exploration Shaft Wall Zone 2
- B6 Photograph of Exploration Shaft Wall Zone 3
- B7 Photograph of Exploration Shaft Wall Zone 5

APPENDIX B

EXPLORATION SHAFT

B.1 Purpose and Scope

An exploration shaft was made through the downstream hydraulic fill shell of the dam to perform the following tasks at three separate levels in the dam:

- a. Obtain undisturbed samples using GEI's tripod tube sampler.
- Perform field density tests.
- c. Obtain bag samples for laboratory testing.
- d. Map the sidewalls of the excavation.

The exploration shaft was made at Location 111 as shown in Fig. 5 of the main text. The shaft was made at this location because N-values at the base of the hydraulic fill shell were more consistently low at this location than at other locations. The centerline of the shaft was located 12 feet north (upstream) of SPT boring S111.

The excavation and backfilling of the shaft was performed by Zamborelli Drilling Company, Inc. of Los Angeles, California. All sampling, testing, and mapping was performed by GEI from November 26 through December 20, 1985.

Explorations were performed in the shaft within Zones 2, 3, and 5 of the hydraulic fill shell shown in Fig. 9. The elevation ranges for explorations in each zone were as follows:

Zone	Exploration Elevation Range, ft
2	1047-1040
3	1034-1030
5	1016-1010

The ground surface elevation at the shaft location was E1. 1097.5.

A total of 44 undisturbed cube samples were obtained from the shaft using GEI's tripod sampler. A total of 12 field

density tests were performed using sand cone techniques. Approximately 2,500 pounds of bag samples were obtained from the shaft. Bag samples were obtained from the same layers in which tripod tube samples were taken and field density tests were performed. Bag samples from a particular layer were later mixed at GEI's laboratory to form batch mixes for laboratory testing.

B.2 Shaft Advancement Procedure

The shaft was excavated using a caisson drilling rig with a 6-foot-diameter auger. The sidewalls of the shaft were supported with 6-foot-diameter steel casing.

The excavation was advanced using an auger to approximately 1.5 feet above each sampling level. The casing was then lowered to the bottom of the excavation and fixed at the ground surface with two steel I-beams to prevent further penetration. The contractor hand excavated to within 2 to 3 incles of the desired sampling depth. While hand excavating to the top of the sampling level, one-quarter circles of plywood were placed on the lottom of the test shaft so as not to disturb the underlying layers. The last few inches were hand excavated by GEI's field engineers. A pilot excavation, one quarter of the shaft bottom area, was hand excavated approximately 1.0 foot below the sampling depth. This pilot excavation was used to identify soil layers prior to the start of sampling so that sampling and field density tests would be performed within a defined layer. Once the remaining three quarters of the shaft bottom was leveled and smoothed. sampling and field density testing was performed until the area was depleted. Details of tripod tube sampling and field density testing are presented in Sections 8.3 and B.4, respectively. Hand excavating, sampling, and testing continued in approximately 1 foot vertical increments to the bottom of the pampling level.

When the bottor of the sampling level was reached, the stdewalls of the exposed layers below the casing were napped. After all ampling and testing was completed, the casing was removed and the shaft was advanced with angers to the text complete level.

ending which are was engountered in the sharp of E1. Is the both of the property of the sharp of E2 in the south of the first of approximate is 12 in the south of the first o

12-inch perforated steel casing that penetrated approximately 6 inches below the bottom of the drain. Inside the 12-inch perforated casing, a small submersible pump was used to remove the water.

After sampling, testing, and mapping were completed, the steel casing was removed and the test shaft backfilled with a 4,000 psi concrete mix to 1 foot below the ground surface. During the backfilling, the concrete mix was poured through a hopper connected to a 15-foot-long hose centered over the shaft.

B.3 Undisturbed Tripod Tube Sampling

Forty-four undisturbed tripod tube samples were obtained using GEI's tripod sampler. Tripod tube sample data is presented in Table B1. A photograph of the GEI tripod tube sampler is shown in Fig. B1. Sampling tubes were 3.0-inch 0.D., 14-inch-long thin-walled galvanized steel tubes. Each tube was machined to have approximately zero clearance ratio, as defined in Table B1. Precise measurements showed that actual clearance ratios ranged from -0.01% to 0.01%.

All hand excavating and sampling was performed while standing on one-quarter circles of plywood so as not to disturb the underlying soils. The remaining three quarters of the soil surface was leveled prior to sampling and testing. The locations of tripod tube samples at each sampling level are shown in Figs. B2 to B4. An effort was made to obtain samples consisting of predominantly one soil type. This was done by starting the sampling at the top of a soil layer.

The tripod sampler shown in Fig. B1 was used to maintain the sampling tube in vertical alignment during advancement. The tube was advanced in increments of about 1/2-inch by using no more than light hand pressure. About 1/2 to 1 inch of soil around the periphery of the tube, below the cutting edge, was excavated prior to advancement of the tube. This preexcavation allowed soil to easily peel away from the tube as it was advanced and minimized volume changes during sampling. Several hours of effort were required to obtain each sample.

Detailed measurements of tube penetration and soil recovery were made during advancement of the tube. These measurements are included in Table B1. Soil volume changes which occurred during sampling were computed based on these measurements.

B.4 Field Density Tests

Twelve field density tests were performed in the shaft using sand cone techniques. The test procedure was in accordance with ASTM D1556-82, "Density of Soil In Place by the Sand-Cone Method." A summary of field density test results is presented in Table B2.

At least one field density test was performed on each layer in which tripod tube samples were obtained (except one layer). An attempt was made to centrally locate each field density test with respect to the tube samples. The locations of field density tests are shown on the sampling location plans in Figs. B2 to B4. An effort was made to perform field density tests in one soil layer. However, virtually every layer encountered was intensely stratified. Representative samples of material were taken adjacent to the field density test locations for compaction testing in the laboratory.

B.5 Wall Mapping

Mapping of the exposed sidewalls below the casing was performed at each exploration level to document the stratification of the hydraulic fill.

Mapping was performed after tube sampling and field density testing because the largest amount of wall was exposed at that time. The upstream direction of the shaft was established and called north. Mapping started at the bottom of the casing and continued to the bottom of the sampled level.

Photographs of the excavation sidewalls were taken at each level of the shaft. Typical photographs at each level are shown in Figs. B5 to B7. These photos show the intense stratification present in the hydraulic fill shell.

TABLE B1 - UNDISTURBED TRIPOD TUBE SAMPLE DATA Lower San Fernando Dam - California

Page 1 of 5

<u>Z O N E 2</u>

Sample	Elevation, (1) Top of Sample	Clearance ⁽²⁾ Ratio CR	Cumulative Penetration P		Total(3)
	ft	<u> </u>	<u>Cm</u>	СШ	
TS101	1044.3	0.000	10.40 18.42	10.80 18.87	2.44
TS102	1044.3	-0.041	10.41 15.67	10.36 15.59	-0.59
TS103	1044.4	-0.032	6.90 15.97	7.08 16.14	1.00
TS104	1044.4	0.018	10.69 11.44	10.78 11.46	0.21
TS105	1044.5	-0.096	9.34 14.49	9.64 14.72	1.39
TS106	1044.4	0.036	8.98 16.53	8.99 16.69	1.04
TS107	1044.4	0.018	8.49 17.32	8.76 17.50	1.08
TS108	1043.0	-0.041	6.02 14.40	5.95 14.31	- 0.71
TS109	1042.9	0.036	7.83 15.03	7.82 14.98	-0.26
TS110	1043.0	-0.077	q (10.1.	9.43 18.05	-0.81
TS111	1042.9	-0.018	19.48 16.61	10.34 16.40	-1.30
TS112	1042.4	-0. 032	2.14 7.29 14.28	2.26 7.50 14.46	1.20

Notes: See page 5

Project 85669 September 2, 1987

TABLE B1 - UNDISTURBED TRIPOD TUBE SAMPLE DATA Lower San Fernando Dam - California

Page 2 of 5

<u>Z O N E 2</u>

Sample	Elevation, (1) Top of Sample	Clearance ⁽²⁾ Ratio CR	Cumulative Penetration P		Total (3) $\Delta V/V$
	ft	Z	cm	CIQ.	2
		2.242		- 0 -	
TS113	1042.3	-0.068	5.12	5.35	
			9.34 14.83	9.72 15.47	4.17
			14.03	15.47	4.1/
TS114	1042.4	-0.050	5.86	6.18	
			9.49	9.85	
			19.81	20.27	2.22
TS115	1041.2	-0.004	8.82	8.93	
1311)	1041.4	-0.004	16.05	16.06	0.05
			10.00	10.00	0.03
TS116	1041.1	-0.041	8.71	8.84	
			15.58	15.60	0.05
ma117	10/1	0.007	ć 0 2	(00	
TS117	1041.1	-0.027	6.03	6.08	1 27
			15.81	16.02	1.27
		ZONE	3		
TS201	1032.5	-0.082	5.18	5.20	
			11.16	11.16	
			24.18	24.17	-0.21
TS202	1032.5	-0.027	8.37	8.37	
15202	103213	0.027	13.56	13.56	
			23.51	23.40	-0.52
					2 2 2 2
TS203	1032.5	-0.004	10.08	10.08	
			15.63	15.56	
			24.31	24.23	-0.34
TS204	1032.5	0	10.24	10.21	
		•	14.64	14.64	
			26.34	26.21	→).49

Notes: See page 5

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TABLE B1 - UNDISTURBED TRIPOD TUBE SAMPLE DATA Lower San Fernando Dam - California

Page 3 of 5

<u>z o n e 2</u>

Sample	Elevation, (1) Top of Sample ft	Clearance ⁽²⁾ Ratio CR %	Cumulative Penetration P cm		Total(3)
TS205	1032.5	-0.050	12.11 20.10	12.05 19.95	
			28.91	28.79	-0.51
TS206	1032.5	-0.095	11.56	11.52	
			15.81 19.15	15.72 18.98	-1.08
TS207	1032.5	-0.055	9.27	9.28	
			19.72 28.79	19.76 28.79	-0.11
TS208	1031.1	0.027	6.64	6.67	
			14.57 17.01	14.58 17.00	0
TS209	1031.2	-0.046	8.67	8.67	
			15.36 17.11	15.28 17.10	-0.15
TS210	1031.2	-0.036	7.10	7.08	
			14.14 18.20	14.03 18.11	-0.57
TS211	1030.8	-0.055	7.30	7.41	
			11.55 13.41	11.57 13.48	0.41
		<u>z</u> <u>o</u> <u>n</u> <u>e</u>	<u>5</u>		
TS301	1015.2	0.009	6.18	6.18	
	191912	3,003	11.69	11.72 13.91	0.16
TS302	1014.0	-0.004	6.32	6.35	0.10
10002	101440	0.004	17.04 27.30	16.95	- 0.85
			27.50	27.07	- 0.00

Notes: See page 5

TABLE B1 - UNDISTURBED TRIPOD TUBE SAMPLE DATA Lower San Fernando Dam - California

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<u> Z O N E 2</u>

Sample	Elevation,(1) Top of Sample	Clearance ⁽²⁾ Ratio CR	Cumulative Penetration P		Total(3)
	ft	% %	CIII.	CID:	Z V / V
TS303	1013.9	-0.018	9.39	9.42	
			15.97	15.93	
			19.94	19.84	
			23.01	22.83	- 0.82
TS304	1014.0	-0.096	6.46	6.44	
			11.32	11.24	
			16.70	16.53	
			21.55	21.25	-1.58
TS305	1014.0	0.018	5.59	5.56	
			12.20	12.11	
			16.96	16.75	
			19.79	19.55	-1.18
TS306	1014.0	-0.018	5.73	5.76	
			13.82	13.78	
			21.91	21.82	
			27.20	27.12	-0.33
TS307	1014.0	0	6.18	6.16	
			12.57	12.58	
			19.28	19.21	
			23.43	23.32	-0.47
TS308	1014.1	0	8.10	8.09	
			14.62	14.55	
			20.40	20.27	
			21.55	21.41	- 0.65
TS309	1014.1	0	7.99	8.02	
			14.02	13.46	
			22.06	21.91	
			26.51	26.31	- 0.75
TS310	1013.1	0.009	7.61	7,49	
			12.55	12.37	
			21.30	21.00	_
			25.45	25.09	-1.40

Notes: See page 5

TABLE B1 - UNDISTURBED TRIPOD TUBE SAMPLE DATA Lower San Fernando Dam - California

Page 5 of 5

<u>Z O N E 2</u>

Sample	Elevation, (1) Top of Sample	Clearance ⁽²⁾ Ratio CR	Cumulative Penetration P		Total(3)
	ft	Z	СТ	сп	
тs311	1013.1	-0.014	3.78 12.48 19.22	3.74 12.28 18.87	-1.85
TS312	1013.2	-0.004	7.36 15.47 20.56	7.35 15.36 20.37	-0.93
TS313	1013.3	0.014	9.07 13.20 18.19 22.08	9.06 13.17 18.09 21.92	-0.70
TS314	1013.4	-0.018	9.96 15.76 17.68	9.78 15.53 17.42	-1.51
т\$315	1012.4	0.009	8.28 12.27 15.31	8.37 12.33 15.33	0.15
TS316	1012.4	0.009	7.58 12.25	7.55 12.23	-0.15

Notes:

- (1) Elevation datum is NGVD
- (2) Clearance Ratio (CR) as defined as: $CR = \frac{ID-CE}{CE} \times 100\%$

$$CR = \frac{1D - CE}{CE} \times 1002$$

Where: ID = inside diameter of sampling tube

CE = diameter of cutting edge of sampling tube

Negative values indicates diameter of cutting edge is larger than inside diameter of sampling tube

(3) Change in volume during sampling $(\Delta V/V)$ is defined as:

$$\Delta V/V = \left[\left(1 + \frac{CR}{100} \right)^2 \times \frac{R}{P} - 1 \right] \times 100 \text{ (in percent)}$$

Where: CR = clearance ratio of sample tube, defined above.

R = gross recovery

P = penetration length

Positive values indicate sample expansion; negative values indicate sample compression.

TABLE B2 - SUMMARY OF FIELD DENSITY TESTS
PERFORMED IN EXPLORATION SHAFT
Lower San Fernando Dam

Field	Depth,	Elevation,		d Measuremen	its1)	Estimated	Estimated
Density	Top of	Top of	Water	Dry Unit	Void	Δe Due	In situ
Test No.	Layer	Layer	Content	Weight, Yd	Ratio	to Swell	Void Ratio
	<u>ft</u>	ft, NGVD		pcf	(2)	(3)	in 1985 (4)
101	53.2	1044.3	10.0	97.3	0.719	-0.017	0.702
102	54.6	1042.9	33.3	91.1	0.856	0	0.856
103	55.1	1042.4	8.2	108.0	0.542	-0.017	0.525
104	56.4	1041.1	16.1	95.8	0.746	-0.017	0.729
201	65.0	1032.5	14.8	93.3	0.785	-0.016	0.769
202	66.3	1031.2	12.7	94.9	0.762	-0.018	0.744
203	66.3	1031.2	13.2	93.9	0.781	-0.018	0.763
301	83.5	1014.0	26.2	98.6	0.702	-0.026	0.676
302	84.4	1013.1	27.4	96.7	0.736	-0.032	0.704
303	84.4	1013.1	26.0	98.1	0.711	-0.032	0.679
304	84.4	1013.1	27.9	95.8	0.752	-0.032	0.720
305	85.2	1012.3	23.8	106.7	0.667	-0.028	0.639

Notes:

- 1) Field density tests were performed using sand cone techniques, ASTM D1556. Density and water content measurements are for the fraction passing the No. 4 sieve.
- 2) Void ratio based on specific gravity measurements of batch mix from the same elevation. Void ratio not corrected for swell at base of exploration shaft.
- 3) Void ratio changes due to swell of soils at the base of the exploration shaft were estimated using procedures described in Section 4.2.1 and Table 5 of the text.
- 4) Corrected for estimated swell at base of exploration shaft.



Tripod Tube Sample 303 Being Taken at a Depth of 83.6 feet in the Exploration Shaft

Army Corps of Engineers Vicksburg, Mississippi

GEOTECHNICAL ENGINEERS INC

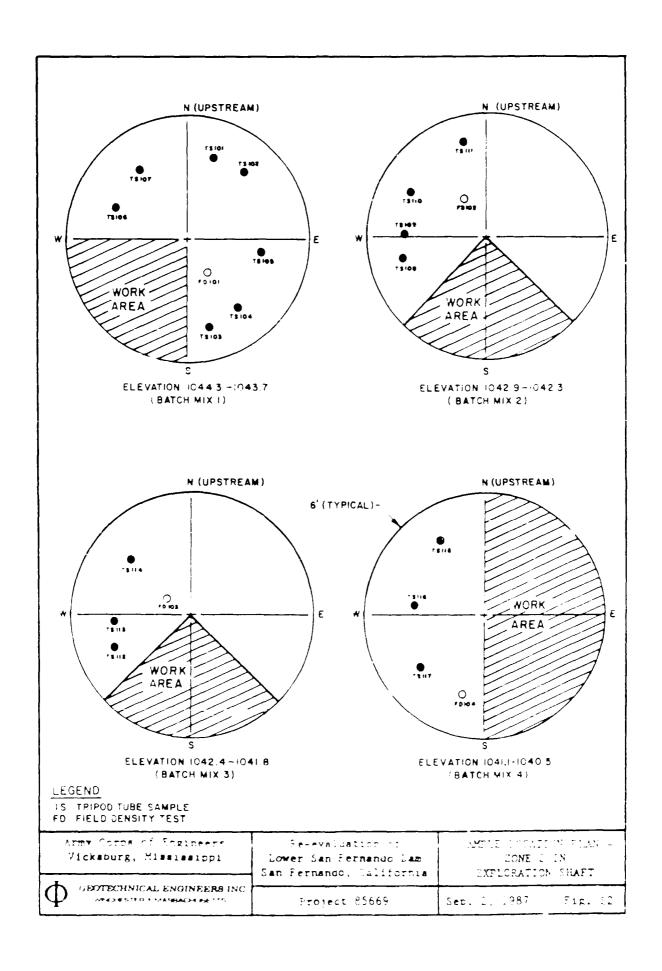
he-evaluation of Lower San Fernando Dam San Fernando, Valifornia

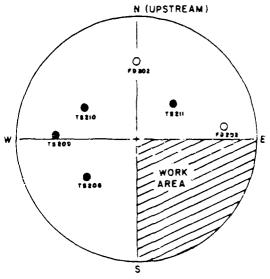
EHOTOGRAPH OF SELECTION OF SELECTION OF THE SAMPLER

Project Paneq

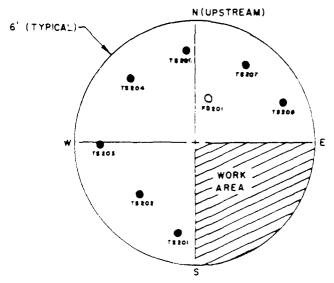
Ser. 2. 1047

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ELEVATION 1032,5-1031.6 (BATCH MIX 5)



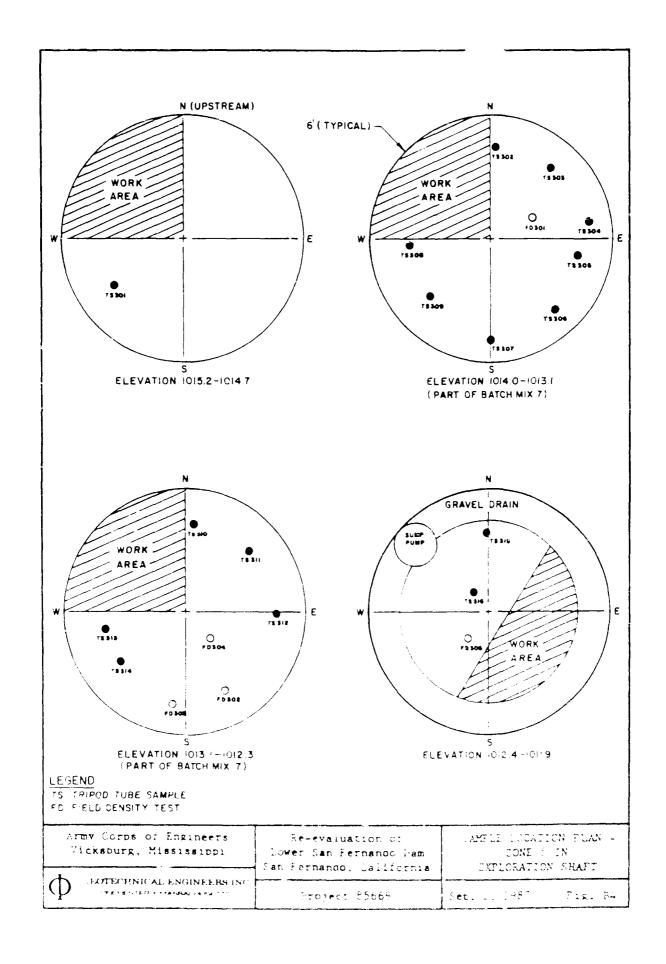
ELEVATION 1031.2 - 1030.5 (BATCH MIX 6)

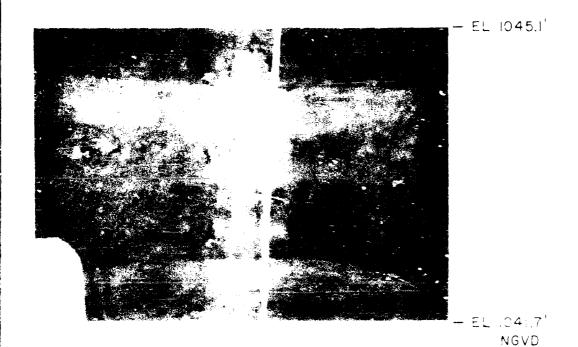
LEGEND

TS TRIPOD TUBE SAMPLE

FO FIELD DENSITY TEST

Army Corps of Engineers Vicksburg, Mississippi	Re-evaluation of Lower San Fernando Dam San Fernando, California	SAMPLE LUCATION THAN - ZONE 3 IN EXPLORATION SHAFT	
GEOTECHNICAL ENGINEERS INC	'	Sep. 2, 1987 Fig. B3	



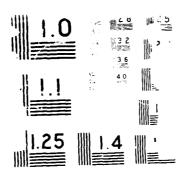


Downstream Wall of Exploration Shaft in Zone 2 of Hydrautic Fill Shell

Darker layers correspond to sandy silts and clays, and lighter colored soils are sands and silty sands.

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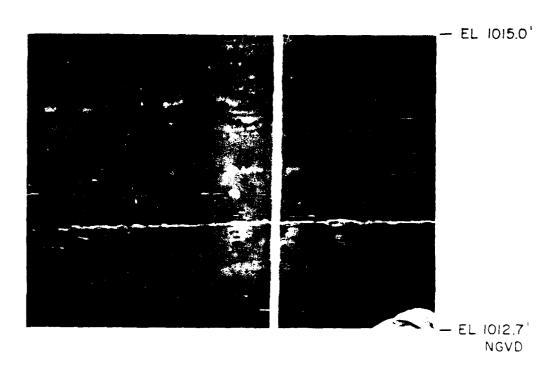


- EL 1032.3 NGVD

Downstream Wall of Exploration Shaft in Zone 3 of Hydraulic Fill Shell

Darker layers correspond to sandy silts and clays, and lighter colored soils are sands and silty sands.

Army Corps of Engineers Vicksburg, Mississippi		FHOTOGRAPH OF EXPLORATION SHAFT WALL -	
I	San Fernando, California	IONE 3	
GEOTECHNICAL ENGINEERS INC	Project 85669	Sep. 2, 1987 Fig. R6	



Downstream Wall of Exploration Shaft in Zone 5 of Hydraulic Fill Shell

Darker layers correspond to sandy silts and clays, and lighter colored soils are sands and silty sands.

Army Corps of Engineers Vicksburg, Mississippi	Jones Gan Larianon Dans	PHOTOGRAPH OF EXPLORATION SHAFT WALL -
GEOTECHNICAL ENGINEERS INC	San Fernando, California	ZONE 5
WHICHESTED + MASSACHERSETTE	Project 85669	Sep. 1, 1987 Fig. 87

APPENDIX C: IN SITU VOID RATIO CHANGES OF CRITICAL LAYER

APPENDIX C

IN SITU VOID RATIO CHANGES OF CRITICAL LAYER

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APPENDIX C

IN SITU VOID RATIO CHANGES OF CRITICAL LAYER

C.1 Introduction

Undisturbed samples of the critical layer of the hydraulic fill shell on the downstream side of the dam were obtained in 1985. The void ratio and strength of these samples represent 1985 conditions. Thus it became necessary to estimate the void ratio changes that took place in the critical layer between the time of the earthquake in 1971 and the time of sampling in 1985. These void ratio changes were then used to estimate steady state strengths of the critical layer soils on the downstream side immediately before the 1971 carthquake. The 1971 void ratios of critical layer soils on the upstream side of the dam would be expected to be higher than the 1971 void ratios of the critical layer soils on the This is because the critical layer on the downstream side. upstream side was under a lower sustained effective stress due to the presence of the reservoir and the fact that the downstream slope was under additional load from the 1930 and 1940 berms. The estimated difference in yold ratio between the upstream and downstream critical layers, in conjunction with strength data obtained for the downstream critical layer, were used to estimate the steady state strength of the upstream critical layer which actually participated in the 1971 flow slide.

The Los Angeles Department of Water and Power (LADWP) made detailed vertical and horizontal movement surveys of the embankment and groundwater observation well readings between 1929 and 1985. These excellent data were essential for estimating the void ratio changes which took place in the critical layer on the downstream side of the dam after the 1971 earthquake and for estimating differences between upstream and downstream void ratios.

The movement and observation well data were analyzed to develop a general understanding of the behavior of the downstream section of the dam prior to, during, and after the 1971 earthquake. Then the pertinent data were used to evaluate void ratio changes in the critical layer. The plots presented in the subsequent sections of this Appendix were prepared by GEI from the LADWP field survey sheets.

C.2 Movement and Settlement Data

C.2.1 General

The LADWP made detailed measurements of the vertical and horizontal movements of the dam starting in 1929. Five survey lines were established at the locations shown in Fig. C1. Vertical and horizontal movements of about 110 points were measured at least 6 times a year and sometimes 12 times a year up until the 1971 earthquake. Measurements were continued on a frequent basis for a period of about one year after the 1971 earthquake. The interval between measurements was reduced to one year starting in 1974.

Undisturbed samples of the critical layer on the downstream side of the dam were obtained at two locations: the exploration shaft and undisturbed sample borings at Location 111 and undisturbed sample boring at Location 103. Thus the movement data analyzed correspond to sections passing through these two locations.

C.2.2 Movements Measured Immediately After the 1971 Earthquake

Plots of vertical and horizontal movements at Stations 5+00 and 9 00 between December 30, 1970 (before the earthquake) and both February 13 and May 12, 1971 (after the earthquake) are shown in Figs. C2 and C3. These plots show that almost all of the movements measured in the three-month period following the earthquake occurred during the four-day period following the earthquake. The vertical and horizontal movements measured on February 13, 1971 were combined and are shown as vectors in Figs. C4 and C5 for Stations 5+00 and 9+00, respectively.

Examination of Figs. C2 through C5 indicates the following patterns of movement of the downstream slope as a result of the 1971 earthquake:

- a. The downstream toe of the dam did not move appreciably as a result of the earthquake.
- b. There was no bulging of the downstream slope.
- c. Downstream of point 3 at Sta 5+00 and Sta 9+00, the horizontal components of the movements were in the downstream direction. Upstream of this point,

and close to the scarp, horizontal movements were in the upstream direction, reflecting proximity to the scarp left by the upstream slide.

- d. Downstream of point 5 at Sta 5+00 and point 6 at Sta 9+00, the rate of change of horizontal movements indicated horizontal compression, while upstream of these points, there was horizontal extension.
- e. The settlements increased gradually in the upstream direction starting approximately from zero at the toe. However, they increased rapidly upstream of the point that separates horizontal compression from horizontal extension, i.e., point 5 at Sta 5+00 and point 6 at Sta 9+00, Figs. C2 and C3.

It can be concluded from the above observations that downstream of about points 5 and 6, the downstream section of the dam developed mainly a decrease in volume with relatively low shear strains. Upstream of these points, the dam developed increasingly large shear distortions near the scarp of the upstream slide.

A plot of vertical movements which occurred along the downstream berm road (122 feet south line) between December 30, 1970 and May 12, 1971 is shown in Fig. C6. Discussion of this plot is presented in Section C.4.

C.2.3 Long-Term Movements Prior to and After the 1971 Earthquake

Plots of vertical and horizontal movements vs. time for the measurement point located closest to the exploration shaft are shown in Figs. C7 and C8. This measurement point on the 122-foot south line, Sta 6+00, was only about 15 feet east of the shaft. The following are comments related to the vertical movement plot shown in Fig. C7:

- a. The August 30, 1930 earthquake caused a little over 0.1 foot of settlement.
- b. The relatively faster rate of settlement for the few years after the 1930 earthquake may be due to the effects of the 1930 earthquake, raising of the embankment to its final height and/or placement of the blanket on the downstream slope between 1929 and 1930.

- c. Placement of the 1940 berm on the downstream slope caused so lement of about 0.12 feet between the time of lement and 1943.
- d. The rate of settlement between about 1943 and the time of the 1971 earthquake was approximately constant at about 0.005 feet per year.
- e. The 1971 earthquake caused a relatively large settlement to occur.
- f. Settlements continued after the 1971 earthquake up to the time of soil sampling in 1985. Note that dam reconstruction was done in the upstream section of the dam, and thus had no effect on settlements on points along the downstream berm. These settlements are discussed in more detail later.

The horizontal movements of the same measurement points (Fig. C8) have the same pattern as the vertical movements, except after the 1971 earthquake. After the 1971 earthquake, with the reservoir empty, lateral movements essentially stopped whereas settlements continued. Note that the scatter is larger in the horizontal movement data than in the settlement data, reflecting more accuracy in the measurement of settlement.

Plots of vertical and horizontal movements vs. time for the measurement point located closest to Location 103 (Measurement Point at Sta 9+00 on the 122-foot South Line) are shown in Figs. C9 and C10. The vertical and horizontal movement data for this point follow the same pattern as that for the point located 300 feet east. This indicates that the behavior of the downstream slope was consistent over substantial horizontal distances.

Vertical movements vs. time for Points 16 and 24 on the 5+00 line are shown in Figs. C11 and C12. These points are located downstream of the exploration shaft. Point 16 is located on the berm over the toe of the criginal dam section. Point 24 is located at the toe of the dam. Point 16 indicates settlement after construction of the berm and significant settlement due to the 1971 earthquake. The vertical movement of Point 24 was essentially zero over the time it was monitored between 1949 and 1975, indicating negligible settlements of the foundation soils at the toe of the dam.

Expanded plots of settlement vs. time immediately after the 1971 earthquake for points near Locations 103 and 111 are shown in Fig. C13. These plots show that relatively large settlements occurred in the four days after the earthquake (February 9-13). The settlement rate decreased with time in the five months following the earthquake (up to about July 1, 1971). The settlement rate became approximately constant from July 1, 1971 to 1985 (Figs. C7 and C9).

C.3 Groundwater Data

The LADWP provided GEI with groundwater elevation measurements from numerous wells in the embankment. Two of these wells, 64I and 64J, are shown in Fig. C1. Well 64I was the closest to the exploration shaft location. The bottom of each well penetrated the 1971 phreatic surface by only a few feet as shown in Fig. C14. The tip of 64I was close to the boundary between Zones 1 and 2 of the hydraulic fill (see Figs. 9 and 10 in main text).

Groundwater elevations vs. time in Wells 64I and 64J are shown in Figs. C15 and C16. Data from each well is discussed below.

Well 64I - The bottom of this well was located at El. 1053, about 31 feet above the critical layer. Groundwater elevations in this well rose about 1 foot after the earthquake, but this rise occurred ove. a period of several weeks. The rise may be due to excess pore pressure generated as a result of earthquake shaking, but it is more likely due to the fact that after the failure, the reservoir was closer to the well for a short time after the failure.

The reservoir was essentially empty about 1.5 months after the earthquake. However, the groundwater level in Well 64I remained above its normal level for about 5 months after the earthquake (up to about June 1, 1971).

Groundwater levels in Well 64I decreased at a rate of about 1 foot/year until it became dry in November 1973. In 1985, the groundwater level in the exploration shaft, near Well 64I, was near the base of the embankment, as shown in Fig. C14.

Well 64J - The bottom of this well was located near the base of the hydraulic fill at about El. 1017. This elevation is close to the top of the critical layer. Water level in the well was about 3 feet higher than normal on the day after the earthquake. The water elevation decreased to its preearthquake level in a period of about one month. Water levels

in 64J decreased at a faster ate than water levels in Well 64I, probably because of its proximity to the downstream drain.

C.4 <u>Void Ratio Changes in Critical Layer Due to 1971</u> <u>Earthquake</u>

The 1971 earthquake caused generation of excess pore pressures in at least some of the soils in the downstream section of the dam located below groundwater level. The observations in Well 64I indicate that negligible pore pressures developed in Zone. I and 2 of the hydraulic fill. The observations in Well 64J indicate that excess pore pressure did develop in the lower part of the hydraulic fill followed by reconsolidation after the earthquake. The reconsolidation is assumed to have manifested itself as settlements at the surface of the downstream slope and horizontal compression of the downstream section of the dam, except for the zone near the slide scarp which developed horizontal stretching.

For the purpose of our investigation, it is necessary to estimate the void ratio changes which took place after 1971 in the critical loose layer where undisturbed samples were take. These changes would then be used to correct the 1985 void ratios of undisturbed samples to pre-1971 earthquake void ratios. Undisturbed samples were taken below the location of the berm road on the downstream slope. At this location, the downstream section of the dam was subjected to both vertical and horizontal compression. Virtually all of the horizontal movements occurred within about one month after the earthquake when there was still water in the reservoir. Subsequently, when the reservoir was empty, the horizontal movements stopped and only vertical movements were observed.

For analysis purposes, we considered separately two phases of the consolidation of the critical layer soils on the downstream side of the dam after the 1971 earthquake:

- Consolidation due to dissipation of excess pore pressures generated during earthquake shaking, discussed in this section.
- 2. Consolidation due to the increase in effective stress caused by the permanent lowering of the reservoir (Section C.5).

The groundwater level at the location of the Jownstream berm road started dropping below its pre-earthquake level about five months after the earthquake (Fig. C15). This corresponds to the time when the settlement rate became approximately constant (Fig. C13). Therefore, settlements

which occurred in the first five months after the earthquake probably are mainly due to dissipation of excess pore pressures generated by the earthquake, and those which occurred after that time can be assumed to be due to general groundwater lowering below pre-earthquake levels.

Void Ratio Changes at Location 111 - The sett'-ment of the ground surface at Location 111 in the first five months after the earthquake was 0.46 foot (Fig. C13). Analyses were performed to estimate what part of the 0.46 foot of settlement occurred in the 15-foot-thick critical layer at the base of the hydraulic fill, so that the void ratio change of this layer could be estimated.

The volume change of each layer below groundwater level due to dissipation of pore pressure generated by cyclic loading is related to the maximum cyclic strain which occurred in the layer during cyclic loading. Castro (1987) has summarized laboratory test lata relating the volumetric strain of saturated sand and silt samples to the maximum cyclic shear strain experienced by the samples (Fig. C17). The band labeled No. 3 in Fig. C17 represents data from tests performed on samples from Location 111 and reported in Appendix F, Section F.4.7. Castro (1987) has also summarized laboratory test data relating the volumetric strain of drained sands to the maximum cyclic shear strain experienced by the samples (Fig. C18).

The soil profile at Location 111 is shown in Fig. 9. Groundwater level prior to the earthquake was about El. 1060 at this location. For analysis of sands below groundwater level, the correlations between volumetric strain and cyclic shear strain shown in Fig. C19 were used. For sands above groundwater level, the hatched line in Fig. C18 was used.

The maximum cyclic shear strain in each layer of the soil profile which occurred during the 1971 earthquake was estimated using a SHAKE analysis. Details of the analysis are presented in Appendix E. A plot of maximum cyclic shear strain vs. depth is shown in Fig. E2. The maximum cyclic shear strain at the mid height of each zone of the soil profile based on the SHAKE analysis is presented in Table C1.

Each zone of the Location 111 soil profile (Fig. 9) was classified as loose, medium, or dense based on average N-values in the zones. The maximum cyclic shear strain and lensity classification of each zone was used to obtain a volumetric strain for the zone after reconsolidation using the correlations in Figs. C18 and C19. The thickness of each zone was multiplied by the computed volumetric strain in the zone to obtain settlements. The volumetric strain and computed settlement for each zone are presented in Table C1.

The summation of settlements of each zone for the above analyses was 0.51 foot which is very close to the measured value of 0.46 foot. The agreement in total settlement is somewhat fortuitous, since several interpretations of the correlations in Fig. C18 and C19 can be made. However, the more significant result is that about 49% of the 0.51 foot of computed settlement occurred in Zone 5, the critical layer. The above analyses was repeated using several positions for the loose, medium, and dense curves shown in Fig. C19. Computed settlements were different than 0.51 foot, but the percentage of the total settlement which occurred in Zone 5 was about 49% in all cases. Therefore, the actual height change of Zone 5 was about 49% of 0.46, or about 0.23 foot.

The void ratio change of Zone 5 soils due to dissipation of excess pore pressures after the earthquake was computed using the following equation (one-dimensional settlement):

$$\Delta e_1 = \frac{\Delta H_1}{H} (1 + e_0)$$

where Δe_1 = void ratio change in Zone 5 due to dissipation of excess pore pressures

ΔH₁ = settlement of Zone 5 due to dissipation of excess pore pressures, equal to about 0.23 foot at Location 111

H = thickness of Zone 5, equal to 15 feet at Location 111

 e_0 = initial void ratio of soil in Zone 5

Computed values of Δe_1 for undisturbed samples from Location 111 are shown in Table 3 in the main text. For a typical initial void ratio of 0.7, the void ratio change, Δe_1 , is equal to 0.026.

The above analysis neglects the horizontal compression developed in the hydraulic fill after the earthquake. An estimate of the horizontal compression in the critical layer was made, resulting in void ratio changes of 0.001 to 0.002. These void ratio changes result in changes in estimated in situ steady state strength of only a few percent and thus were neglected.

Void Ratio Changes at Location 103 - Void ratio changes, Δe_1 , of Zone 5 soils at Location 103 were estimated using the same approach for estimating Δe_1 at Location 111. The estimated values of Δe_1 at Location 103 are also shown in Table 3 of the main text.

Settlements Near Abutments - Settlements along the 122-foot-south survey line (downstream berm road) which occurred as a result of earthquake shaking are shown in the upper part of Fig. C6. There is a consistent pattern of settlements between Stations 3+00 and 17+00. The settlement pattern approximately reflects the pattern of the ground surface elevation changes below the survey line.

The relatively large settlements in the vicinity of Station 2+00 are probably related to an historical problem in a gypsum foundation layer on the left abutment. Based on these historical records, dissolving of the gypsum by the reservoir water gradually developed paths (voids) for percolating water and resulted in excessive seepage through the east abutment. Grouting of these voids had been performed periodically to alleviate the seepage problem.

The survey line along the berm road is actually located a few feet upstream of the road on the slope of the embankment, presumably to prevent damage to the measurement points from traffic along the road (Fig. C1). However, near Station 18+00 to 21+00 the berm road starts to climb towards the right abutment and crosses the survey line. A possible explanation for the shape of the settlement profile between these stations, shown in Fig. C6, is that the measurement points at Stations 19+00 and 20+00 may have been disturbed by traffic along the berm road in the months following the earthquake when the crest road was no longer available for traffic. Note, however, that even though the shape of the settlement profile appears unusual, the average settlement in the Station 18+00 to 21+00 area is consistent with the results of an analysis of the type performed for Locations 103 and 111.

C.5 <u>Void Ratio Changes in Critical Layer Due to Groundwater</u> Lowering

The groundwater level at the location of the downstream berm road started dropping below its pre-earthquake level about five months after the earthquake (Fig. C15).

Groundwater well data indicate that groundwater levels at the location of the downstream berm road decreased at a slow rate after the reservoir had been completely emptied. This is consistent with settlement data which indicate that settlements at Locations 103 and 111 (berm road) occurred gradually for many years after the earthquake (Figs. C7, C9, C13).

Void Ratio Changes at Location 111 - The total settlement of the ground surface at this location which occurred from the time of the 1971 earthquake to the time of sampling in 1985 was 0.63 feet. About 0.46 feet of this settlement was due to

consolidation as a result of the dissipation of excess pore pressures generated by the earthquake (Section C.4). The remaining 0.17 feet of settlement was due to consolidation which occurred as a result of groundwater lowering.

The soil profile at Location 111 is shown in Fig. 9. The settlement of each soil zone due to groundwater lowering is a function of the compressibility of the zone and the change in effective stress within the zone.

Consolidation curves from laboratory triaxial tests were used to determine the compression index of soil samples. These consolidation curves are presented in Appendix F, Figs. F70 and F71. Table C2 is a summary of compression index data for undisturbed samples from Zone 5, the critical layer, for different effective stress levels.

The increase in effective stress for each zone of the Location 111 soil profile was computed using the pre-earthquake and 1985 groundwater levels. Each soil zone was assigned a compression index on the basis of laboratory consolidation data and the average effective stress in the zone. Settlements of each zone were then computed using the change in effective stress and compression index for each zone. Table C3 presents a summary of settlement computations.

The total computed settlement of all soil zones at Location 111 for the above analysis was 0.20 feet. The computed settlement is close to the measured settlement of 0.17 feet. About 33% of the 0.20 feet of computed settlement occurred in Zone 5, the critical layer. Therefore, we estimate that the actual height change of Zone 5 was about 33% of 0.17 feet, or about 0.057 feet.

The void ratio change of Zone 5 soils due to groundwater lowering was computed using the following equation:

$$\Delta e_2 = \frac{\Delta H_2}{H} (1 + e_0)$$

where Δe_2 = void ratio change in Zone 5 due to ground-water lowering

ΔH₂ = settlement of Zone 5 due to groundwater lowering, equal to about 0.057 feet at Location 111

H = thickness of Zone 5, equal to 15 feet at Location 111

 e_0 = initial void ratio of soil in Zone 5

Computed values of Δe_2 for undisturbed samples from Location 111 are shown in Table 3 in the main text. For a typical initial void ratio of 0.7, the void ratio change, Δe_2 , is equal to 0.006.

Void Ratio Changes at Location 103 - Void ratio changes, Δe_2 , of undisturbed samples from Location 103 were estimated using the same approach for estimating Δe_2 at Location 111. The estimated values of Δe_2 at Location 103 are shown in Table 3.

C.6 <u>Void Ratio Difference Between Upstream and Downstream</u> Critical Layer

Up to this point, all estimates of void ratio changes have reflected those which occurred in the critical layer on the downstream side between 1971 and 1985. These void ratio changes allow an estimate to be made of critical layer void ratios and strengths on the downstream slide of the dam just prior to the 1971 earthquake. It is reasonable to expect that void ratios of the upstream critical layer in 1971 were greater than those on the downstream side because of two factors:

- 1. Upstream soils had been under a lower sustained effective stress due to prolonged submergence prior to 1971.
- Downstream soils had been subjected to higher effective stress due to the presence of the 1930 and 1940 berms.

Therefore, the 1971 steady state strengths of the critical layer soils on the upstream side of the dam would be less than the strengths on the downstream side.

Void Ratio Difference Due to Submergence

Historical records of the dam construction indicate that the crest of the dam was at El. 1088 NGVD in 1915 and that the reservoir was filled to within 5 feet of the crest at that time. The dam crest was raised gradually in 1916 and 1917 to about El. 1128. The records indicate that during these early years, while the dam was under construction, the reservoir was filled for summer irrigation use and was practically emptied during the winter season as a provision against unusual storms. Presumably, there was no longer a reason to empty the reservoir in the winter once the spillway was completed circa 1917.

No information was available on reservoir levels during most of the 1920s. However, there appears to be no reason why the reservoir should have been lowered during this period. Repairs to the upstream concrete facing were made in 1929. In order to repair the concrete racing, the reservoir had to be lowered to about El. 1050 in 1929.

Detailed records of reservoir elevation were available starting in 1930. These records indicate that the reservoir elevation was always above 1095 up until the 1971 earthquake with only one significant exception. This exception was a 4-to 5-month period in 1930 when the reservoir level dropped to El. 1076 and rose back to 1095.

The question arises as to whether the critical layer on the upstream side of the dam was ever subjected to an effective stress significantly greater than that corresponding to a fully submerged state. The most critical time for this would have been during lowering of the reservoir in the winter months circa 1915-1917 and during repairs in 1929. We believe that the upstream critical layer has not been subjected to effective stresses significantly greater than those corresponding to submerged conditions, as explained below.

The hydraulic fill process used to construct the dam no doubt caused the soil between the starter dikes to be saturated with a phreatic surface near the pond level at the crest of the dam. The reservoir filling in 1915 completely saturated the upstream slope. When the reservoir was lowered for a few months, drainage of water within the upstream slope started to occur. However, this drainage would occur very slowly as evidenced by the fact that the phreatic surface on the downstream side of the dam did not drop significantly in the 6 months after the upstream slope had failed in 1971 and the reservoir had been completely emptied.

The vertical effective stress in the upstream critical layer $(\bar{\sigma}_{V,us})$ at the location which mirrors the exploration shaft location (berm road) would be about 2.4 kg/cm² for submerged conditions. Below the downstream berm road, the vertical effective stress in the critical layer $(\bar{\sigma}_{V,ds})$ would be about 3.5 kg/cm² for a ground water depth of 35 feet. The following equation can be used to estimate the void ratio difference between the upstream and downstream critical layers due to the submergence effect:

$$\Delta e_{sub} = C_c \log_{10} \frac{\bar{\sigma}_{v,ds}}{\bar{\sigma}_{v,us}}$$

Using a value of C_c = 0.048 from Tables C2 and C3 results in a value of $\Delta \, e_{sub}$ = 0.008.

Void Ratio Dimerence Due to 1930 and 1940 Berms

Berms on the downstream slope have caused consolidation stresses to be higher in the critical layer on the downstream side compared to the upstream side. The majority of the additional effective stress was caused by the large 1940 berm.

Using stress distribution equations, we estimate that the 1940 berm caused an increase in effective stress in the critical layer of about $0.58~\rm kg/cm^2$ at the location of the exploration shaft. Using a $C_c = 0.048$ as before, this increase in effective stress would cause a decrease in critical layer void ratio of about 0.003.

This void ratio change of 0.003 is corroborated by settlement measurements along the berm road (122 feet south line), shown in Fig. C7. The data indicates that the survey point adjacent to the exploration shaft settled about 0.12 feet as a result of primary consolidation which occurred in the few years following placement of the 1940 berm. Based on analysis similar to that described in Section C.5, we estimate that about 20% of the measured settlement was caused by consolidation of critical layer (Zone 5) soils. For a critical layer thickness of 15 feet and initial void ratio of 0.7, the backcalculated change in void ratio of critical layer soils is:

$$\Delta e_{\text{berm}} = \frac{0.12' \times 0.20}{15} (1+0.7) = 0.003$$

This backcalculated value of 0.003 is the same as that estimated using the consolidation approach described previously.

Summary of Upstream/Downstream Void Ratio Difference

Void ratios are estimated to be higher in the upstream critical layer compared to the downstream layer by the following amounts:

		∆ e
1.	Submergence effect	0.008
2.	Berm effect	0.003
	Tota	0.011

Therefore, we added 0.011 to the estimated in situ void ratios of samples from the downstream critical layer to obtain void ratios for the upstream critical layer.

TABLE C1 - SUMMARY OF COMPUTED SETTLEMENTS IN SOIL ZONES AT LOCATION 111 DUE TO CYCLIC STRAINING AND DISSIPATION OF EXCESS PORE PRESSURES Lower San Fernando Dam

Sofl Zone	Above (A) or Below (B) Groundwater	Zone Thickness ft	Maximum Cyclic Shear Strain at Midheight of Zonel)	Average N-value in Zone2) blows/ft	Layer Classifi- cation	$\frac{\Delta V^3)}{V}$	Computed Settlement ft	Contribution to Computed Settlement
Rolled Fill4)	V	9	0.14	7	Medium	0.13	0.008	2
_	¥	15	0.22	20	Medium	0.18	0.027	5
	æ	9	0.35	22	Medium	0.18	0.011	2
~	æ	1.5	0.75	17	Loose	0.57	0.085	17
3	8	11	1.00	28	Medlum	0.53	0.058	=
ব	æ	9	0.80	42	Dense	0.36	0.022	7
>	83	51	3,50	18	Loose	1.65	0.247	67
Alluvíum ⁵⁾	æ	œ	2,00	>40	Dense	0.64	0.051	9
Notes:						Total	0.509	100

Maximum shear strain based on SHAKE analysis, see Appendix E.

N-values measured in 1985 borings.

Volumetric strain of layers above groundwater based on Fig. CI8 and below groundwater on Fig. CI9.

Thickness of rolled fill is for sand portion only. The upper 14 feet of clay in this zone was 2332

alluvium were assumed to have negligible volume change after cyclic loading. N-values for the alluassumed to have negligible volume change after cyclic loading. N-values are for sand portion only. Thickness of alluvium taken as approximate total thickness of sand layers only. Clay layers in the vium are for sand layers only. ?

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TABLE C2 - SUMMARY OF COMPRESSION INDICES
UNDISTURBED SAMPLES FROM ZONE 5
Lower San Fernando Dam

	С	OMPRI	ESSI	0 N	INDEX	, C c 2	2)
Triaxial ¹⁾ Test No.	At l	Isotropic 2	Consol	idation 6_	Stress, o	o kg/cm 8	n ² = 12
\overline{R} 1	0.021	0.033	0.046	-	-	-	_
R5	0.018	0.030	0.046	0.055		-	-
R6	0.026	0.041	0.051		_	0.063	
R 7	0.024	J.036	0.057	~	-	0.066	-
R8	0.030	0.047	0.068	-	-	0.085	
R12	0.018	0.033	0.045	-	-	0.061	0.065
R 13	0.026	0.045	0.061	-	-	0.084	0.113
R 14	0.025	0.039	0.054	-	·	0.083	0.106
R 15	0.036	0.058	-	-	-	0.100	0.128
R16	0.017	0.031	0.051	-	-	0.080	0.099
R17	0.028	0.043	0.055	~	~	0.086	0.091
R18	0.038	0.053	0.075	~	-	0.109	0.119
R 19	0.019	0.027	0.036	~	**	0.039	0.039
R 20	0.017	0.032	0.050	-	0.065	-	0.074

Notes:

- Consolidation curves for triaxial tests are presented in Appendix F.
- 2) Compression Index, C_c , = $\Delta e/\Delta \log \overline{\sigma}_0$.

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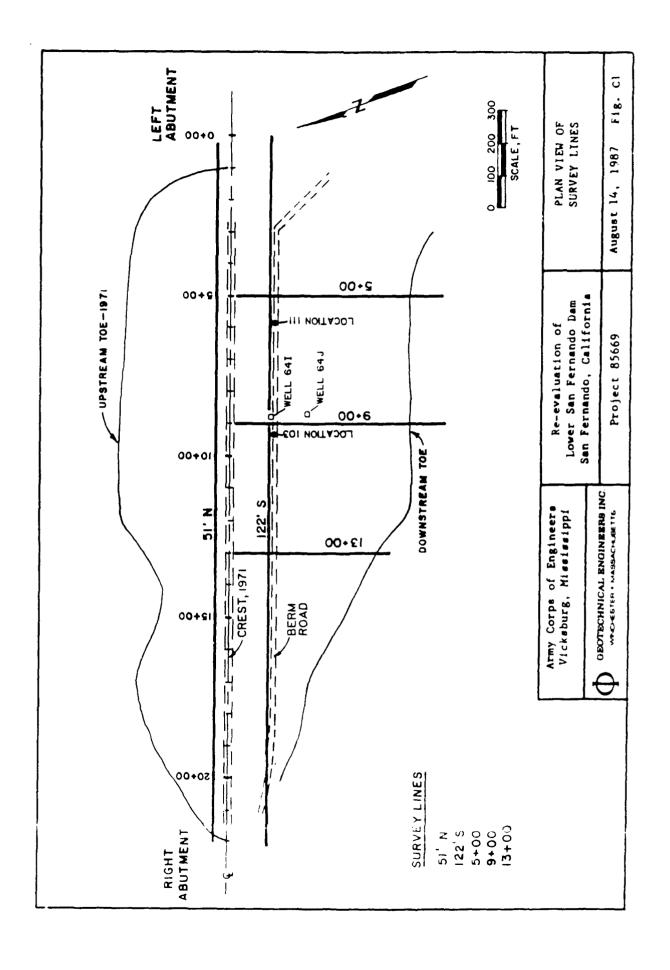
Contribution to Computed	Serriement %	87	33	19
Computed ³⁾ Settlement	ft	0.095	0.067	0.038
$\frac{Compression^2)}{Index, C_C}$		0.042	0.048	0.042 Total
r at ne 1)	$\Delta \tilde{\sigma}$ kg/cm^2	0.41	0.97	1.02
Effective Stress at Midheight of Zone ¹⁾	01985 kg/cm ²	2.07	3.16	3,43
Effect. Midhei	01971 kg/cm ²	1.66	2.19	2.41
Zone Thickness,	f f	07	15	10
Soil Zone Below		1 to 4	5	Alluvium

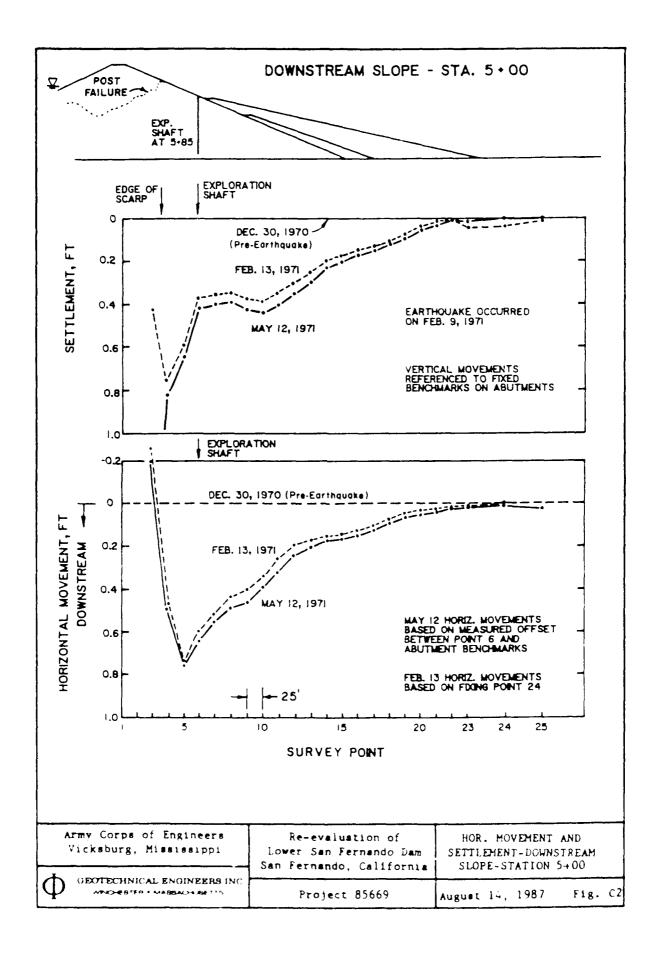
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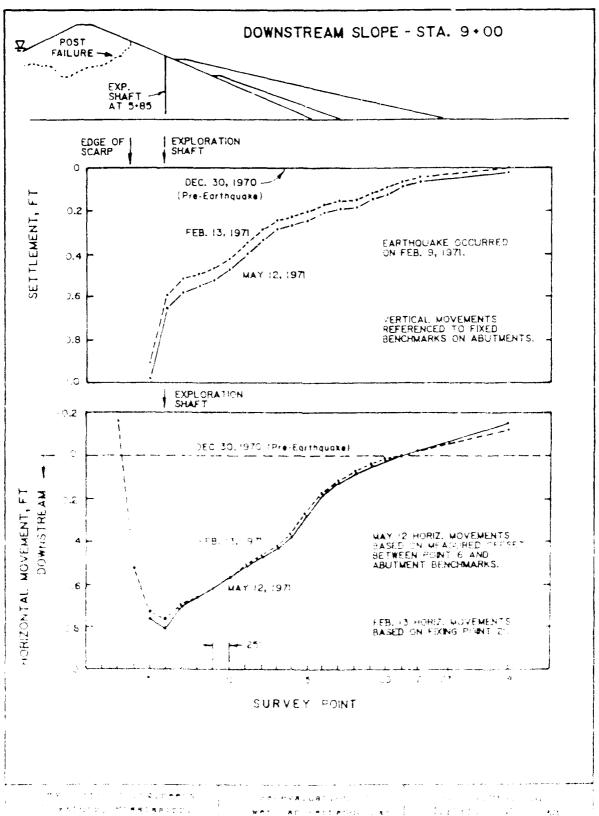
- l) Effective stress is equal to the octahedral stress, or two-thirds vertical effective stress for $K_{\rm O}$ = 0.5.
- 2) Compression Index, C_c , based on laboratory triaxial test data. C_c data for Zone 5 is shown in Table C2. C_c for alluvium zone was estimated.
- 3) Settlement equals = $\frac{C_c}{1+e_o}$ H log10 $\frac{\sigma_{1985}}{\sigma_{1971}}$

An initial void ratio, e_0 , equal to $0.7\ was$ used.

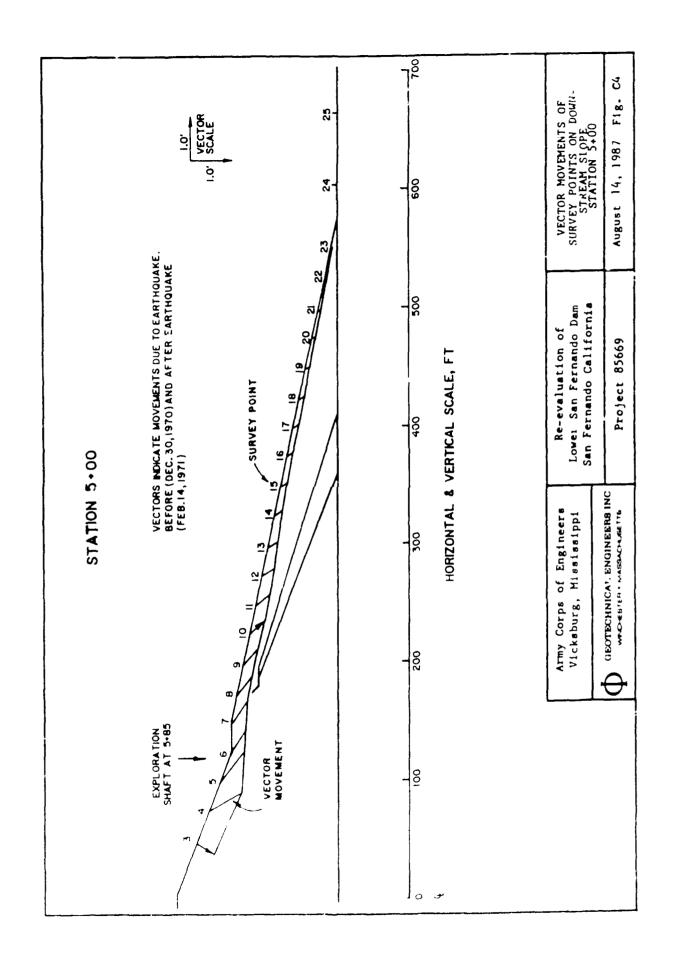
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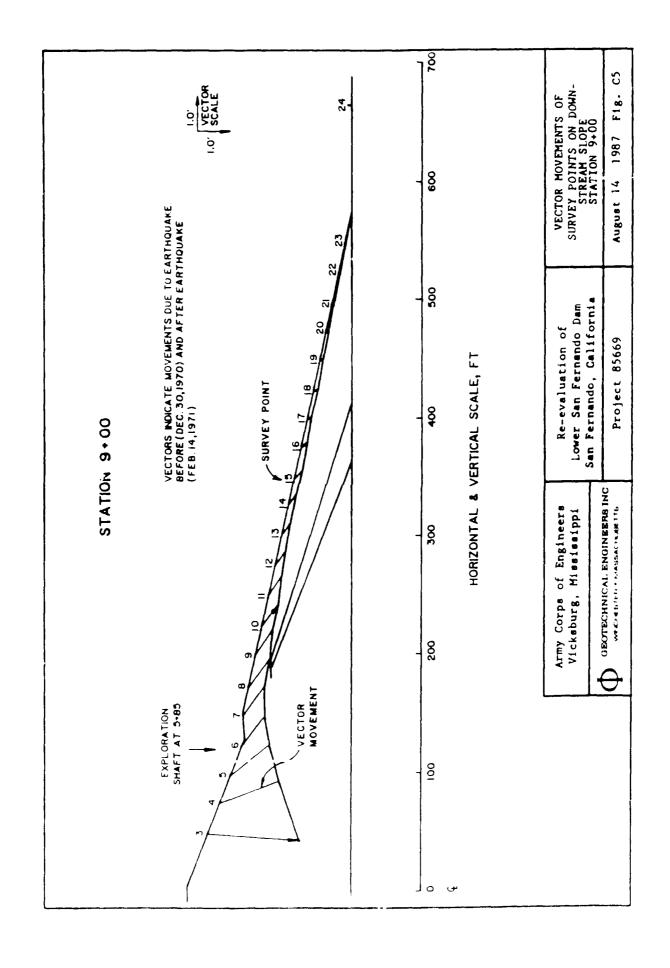


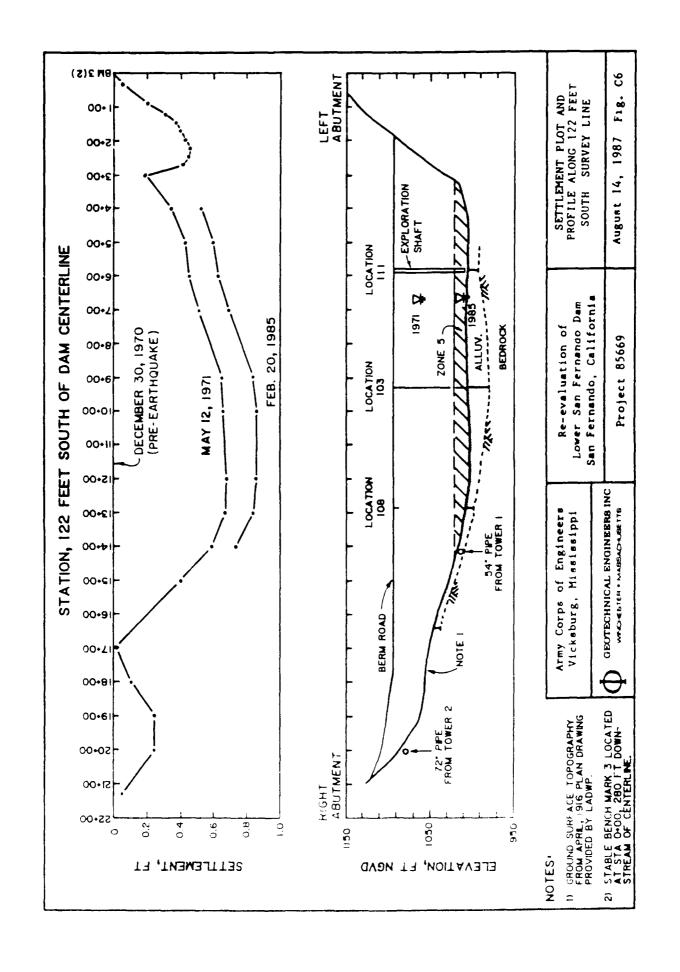


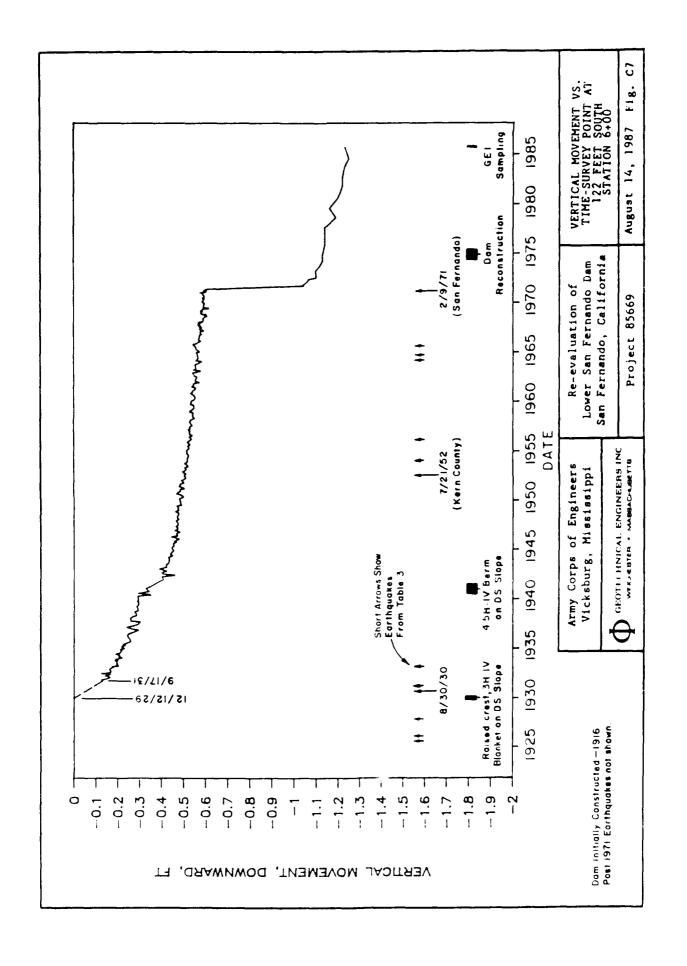


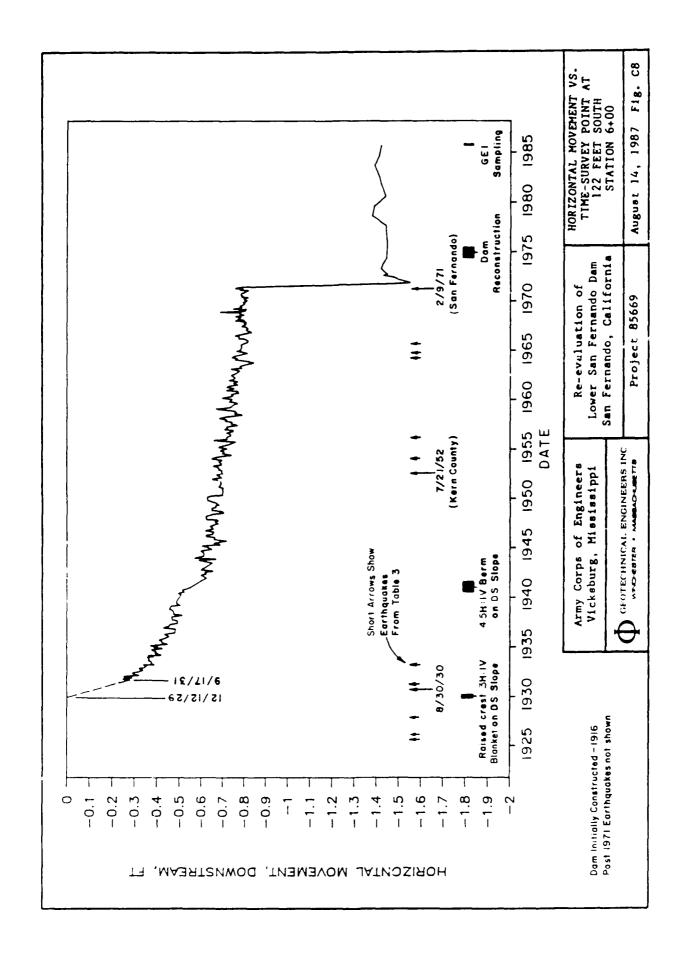
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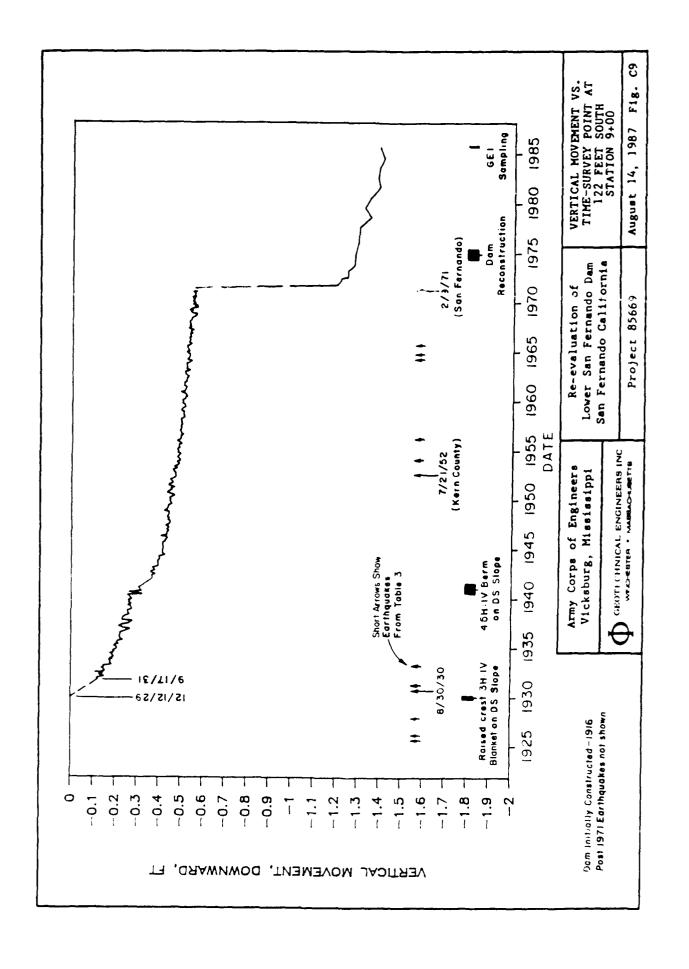


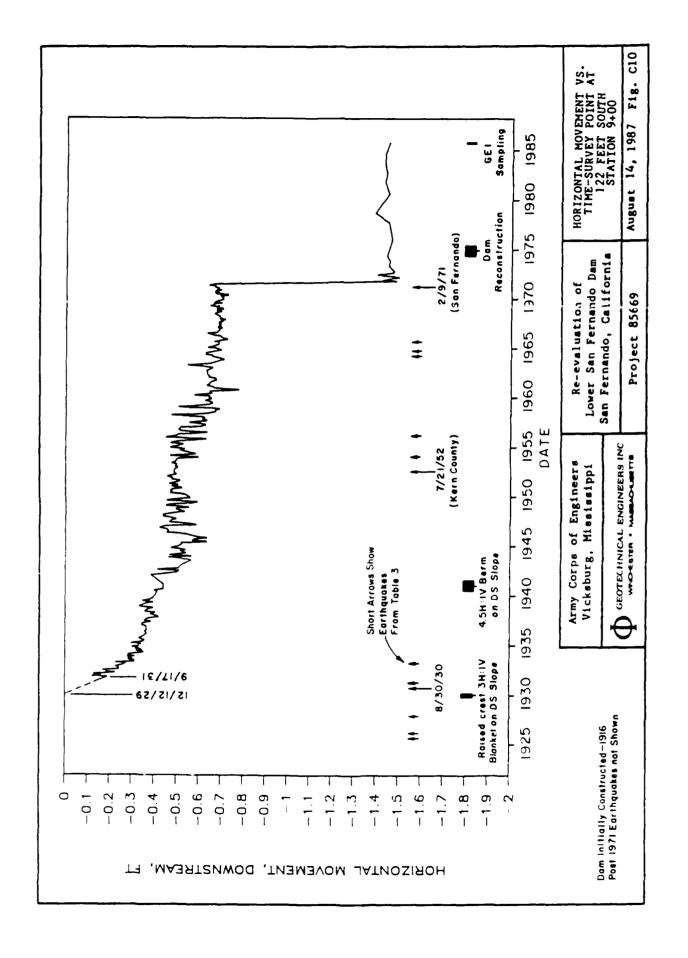


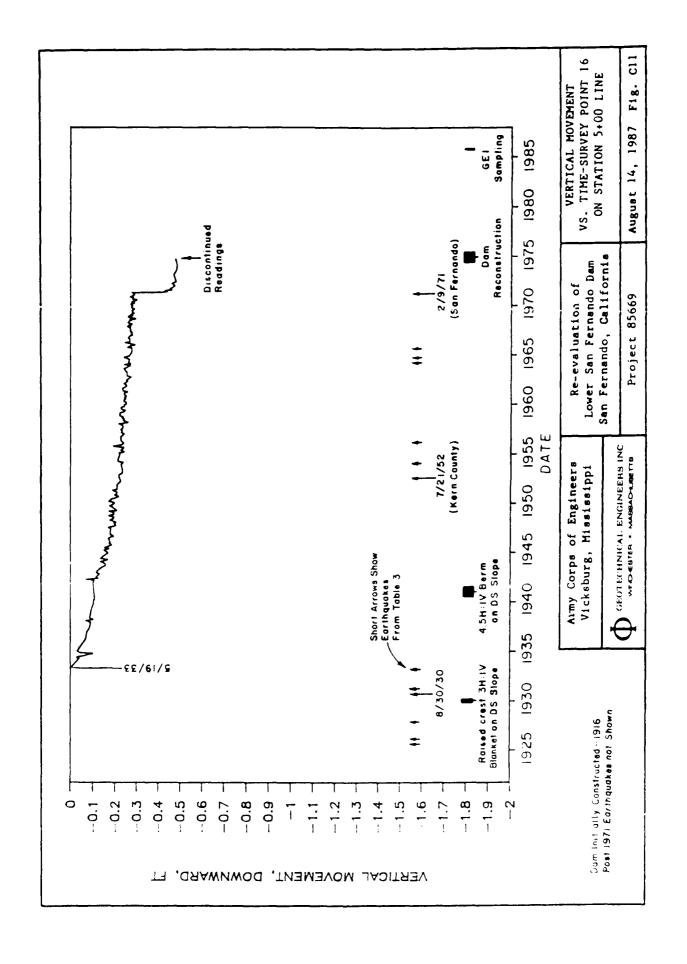


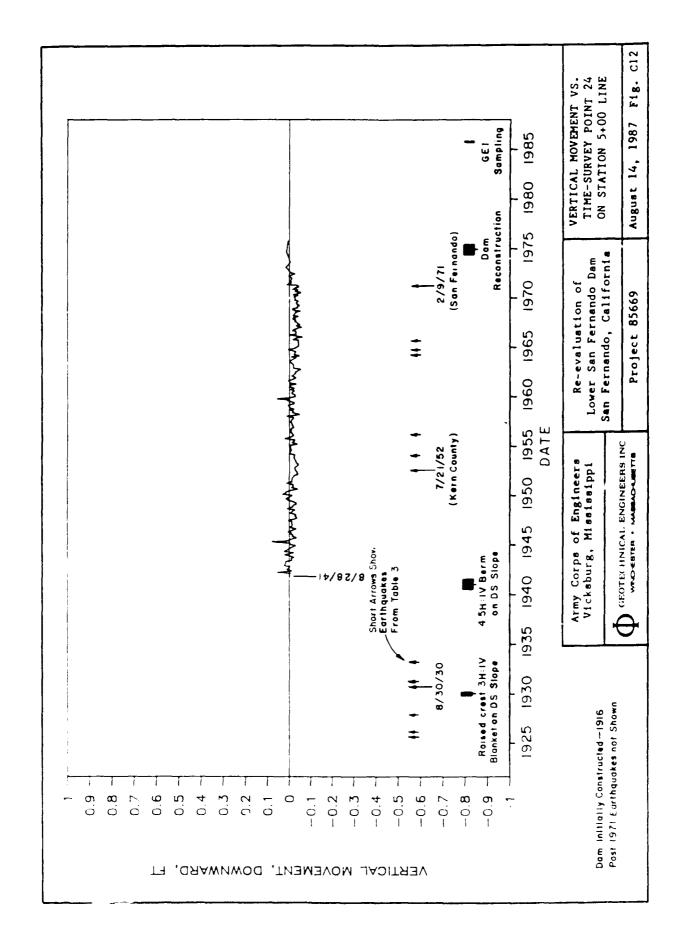


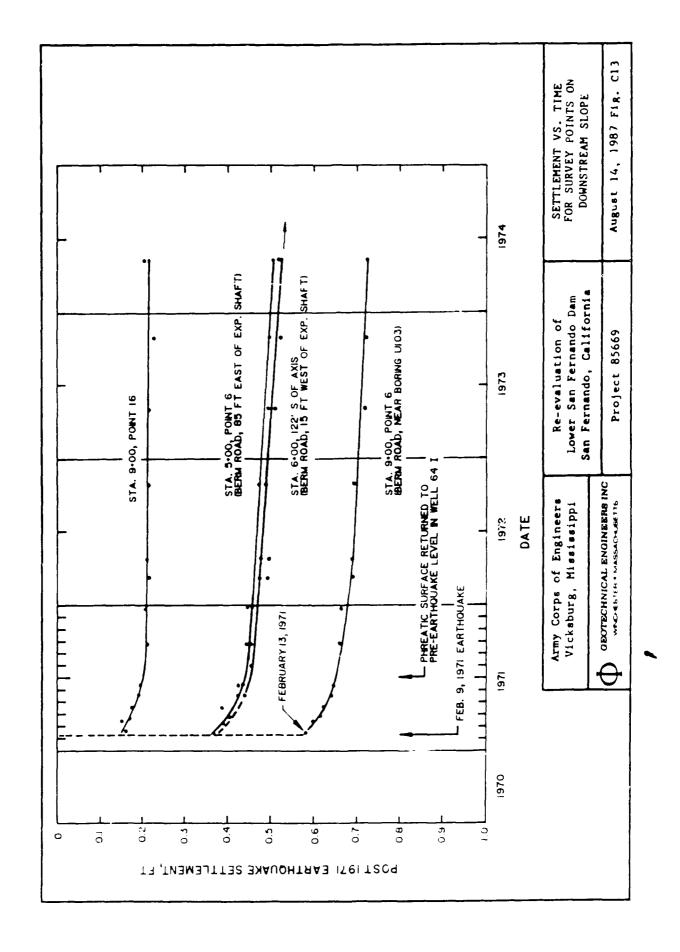


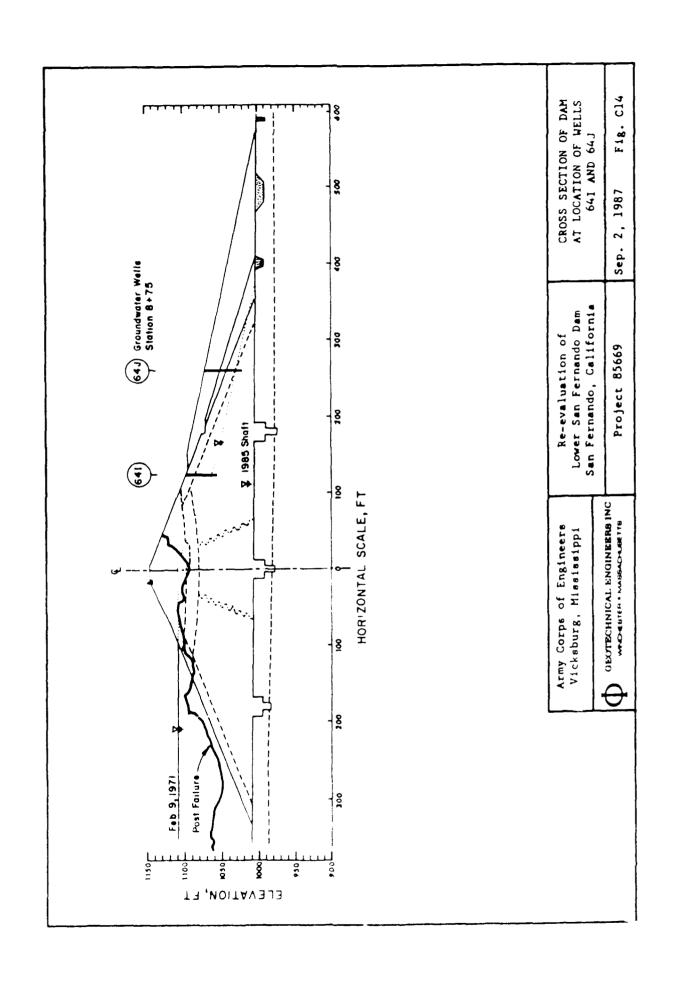


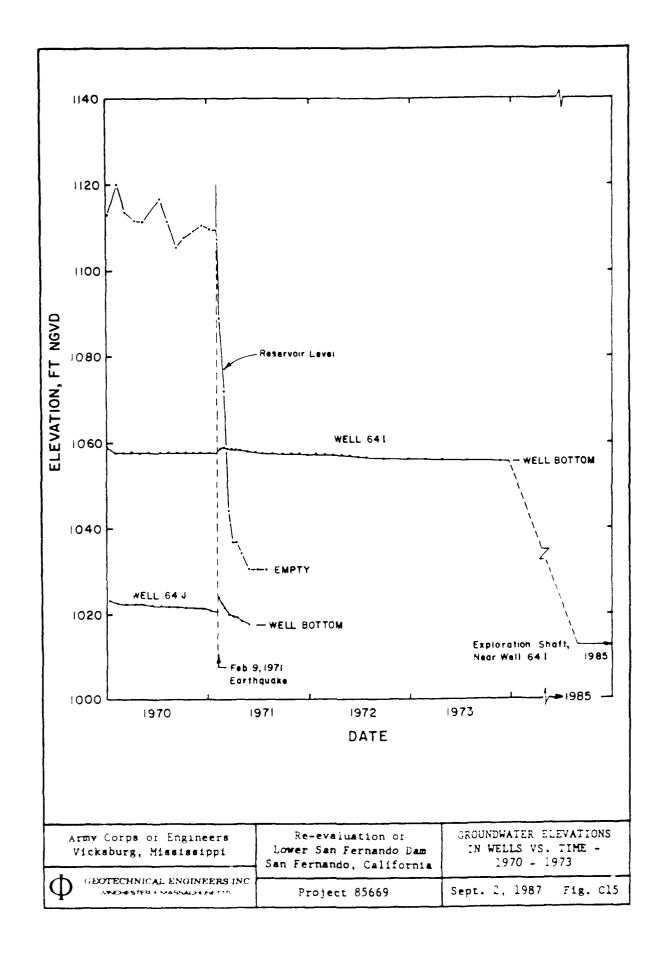


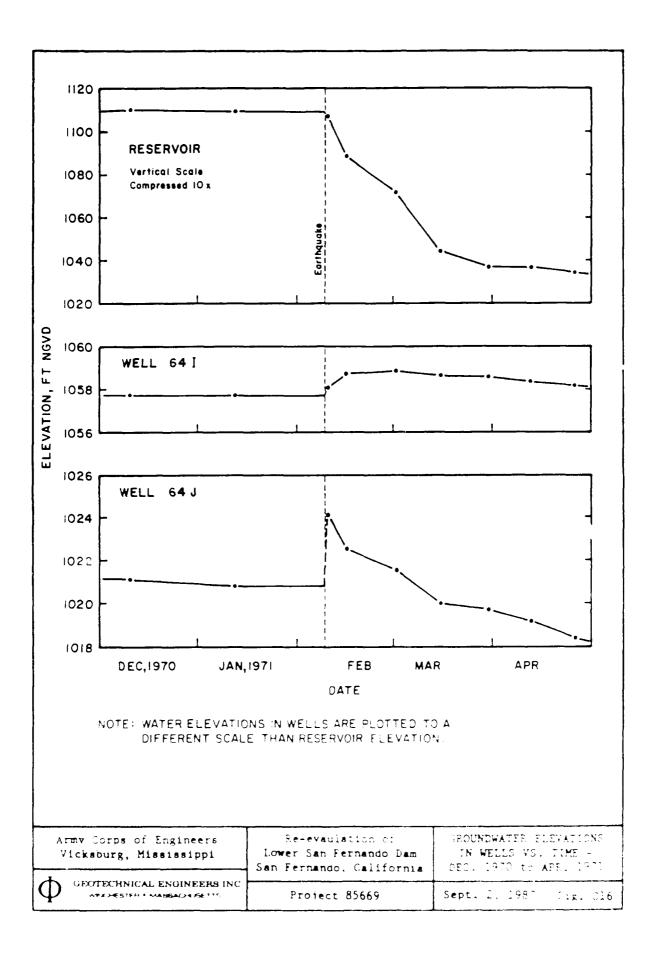


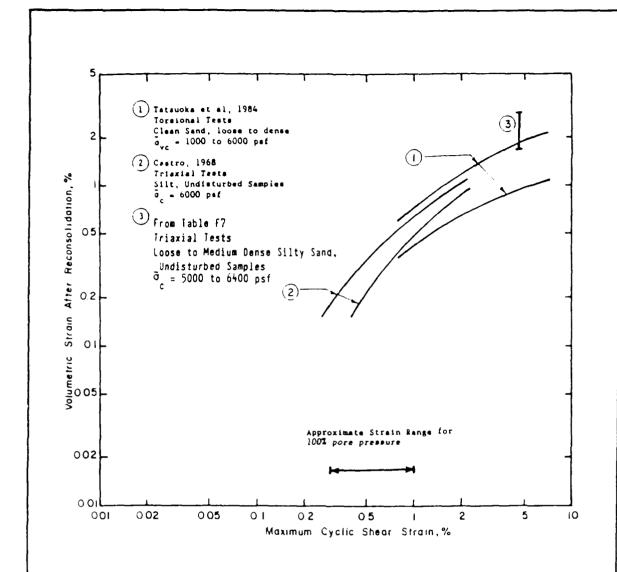






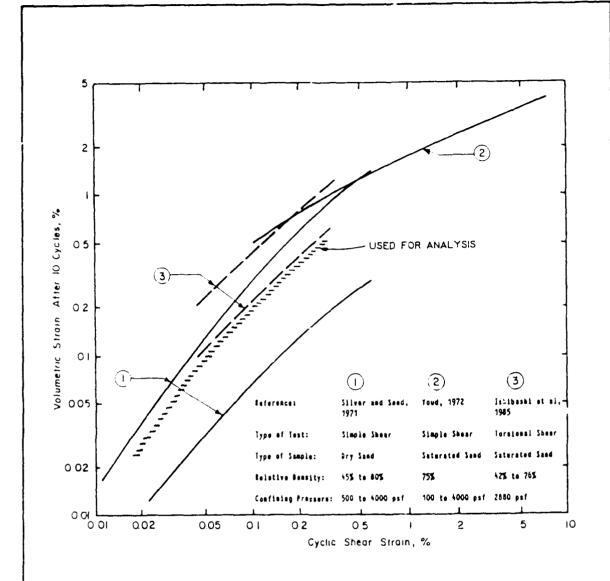






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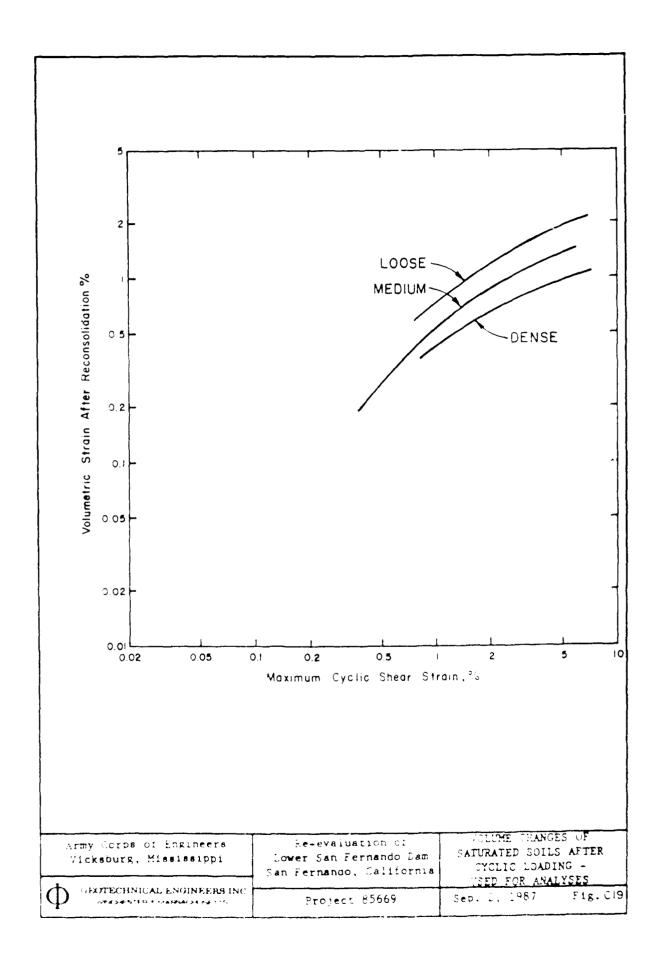
Army Corps of Engineers (toksburg, Mississippi	Re-evaluation of Lower San Fernando Dam	FOLUME CHANGES OF SATURATED SANDS & SILTS AFTER CYCLIC LOADING	
GEOTECHNICAL ENGINEERS INC	San Fernando, California Project 85669	Sep. 2, 1987 Fig. C17	



Note: Volumetric strain after 3 cycles was used in the analysis. The volumetric strain after 3 cycles is approximately 50% of the volumetric strain after 10 cycles.

After Castro, 1987

Army Corps of Engineers Vicksburg, Mississippi	Re-evaluation of Lower San Fernando Dam	VOLUME CHANGES OF SANDS UNDER CYCLIC LOADING - DRAINED		
GEOTECHNICAL ENGINEERS INC	San Fernando, California Project 85669	Sep. 2, 1987 Fig. C18		



APPENDIX D: STATIC AND PSEUDOSTATIC STABILITY ANALYSES

APPENDIX D

STATIC AND PSEUDOSTATIC STABILITY ANALYSES

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APPENDIX D

STATIC AND PSEUDOSTATIC STABILITY ANALYSES

D.1 Static Stability Analyses

D.1.1 Introduction

One of the steps in evaluating the liquefaction susceptibility of the dam is to determine the in situ driving shear stress in the critical soil layer (Section 4.6.1 of the main text). This section of the appendix describes stability analyses performed to determine the driving stress in the critical layer on the upstream side of the dam, as well as in the critical layer on the downstream side.

The computer program SSTAB2 (Wright, 1974) was used to analyze the slopes of the dam. The program uses a Spencer method of analysis in which the interslice forces are assumed to be inclined and parallel. The method satisfies all conditions of static equilibrium. Sliding wedges and circular arc failure surfaces were used in the analyses. Wedge failures were more critical than circular failures, so results of the wedge analyses were used. A manual search was performed to find the most critical wedge.

The driving shear stress in the critical layer is equal to the minimum shear resistance the layer must have to maintain stability of the slope, assuming fully mobilized strengths in other layers. The fully mobilized strengths are those that would act while deformations of the slope were occurring and would be available to resist a massive flow slide. The strength of the critical layer (c = strength, $\varphi = 0$) is varied in the analysis until the factor of safety of the slope is equal to 1.0.

A cross section through the dam prior to the 1971 failure is shown in Fig. 2 of the main text. The simplified geometry used for performing stability analyses is shown in Fig. D1. The mobilized strengths of layers used in the analysis are presented in Table D1. A discussion of strengths used in the analyses is presented below.

Rolled Fill Cap and Ground Shale Laver - The rolled fill cap and ground shale layer, Layer 1 in Fig. D1, were judged to be

slightly dilative based on soil descriptions and blowcounts in these layers. The mobilized strengths in these layers were varied using a friction angle of either 30° or 35°. These layers may have had slightly higher strengths below the groundwater due to dilation at the beginning of shear deformations, but dissipation of negative pore pressures would have reduced their strengths to drained values.

Clayey Core - The clayey core was assumed to act undrained during the failure. A laboratory vane shear test was performed on an undisturbed sample of the clayey core obtained from Boring U105 (Appendix F, Section F.5). The test was performed on a sample obtained below the 1985 groundwater level, and thus the sample is probably normally consolidated to the 1985 stresses

A plot of vane shear strength vs. vane displacement is shown in Fig. F116. plot shows that large vane displacements were required to reduce the strength of the clay sample to its steady state strength. the strength available in the field to resist the initial movements of a flow slide is the peak undrained strength, Sup. The strength used in stability analyses was varied from a high corresponding to $S_{up}/\bar{p} = 0.3$ to a low corresponding to $S_{up}/p = 0.2$. The peak strength of the labbratory vane specimen corresponded to a c/p ratio, $S_{\rm up}/p$, equal to about 0.3 for 1985 conditions. Note that the resistance mobilized at a vane displacement of about 1 cm corresponded to an S_{up}/p ratio of about 0.16 and that the steady state strength corresponded to an S_{us}/p ratio of about 0.09.

A limited number of torvane shear strength measurements of the upper part of the clayey core were made soon after the 1971 failure (Seed, 1973). These measurements indicated an $S_{\rm up}/\bar{p}$ ratio of about 0.3 which is consistent with the 1985 measurements of clay strength.

The clayey core was divided into three zones as shown in Fig. D1. The strength at the

mid-height of each zone was used in the analyses.

Starter Dikes - Starter dikes used in the hydraulic filling process can be seen in construction photographs. Some compaction of these dikes resulted from equipment traffic. Because of the low confining pressures in the starter dike zone, it is likely that the soils in the dikes were dilative. The starter dikes were assigned a mobilized strength corresponding to drained conditions. The friction angle for the starter dikes was varied between 30° and 35° . As discussed in Section 5.7 of the main text, the toe of the starter dike on the upstream side of the dam may have dilated significantly and resisted initial flow slide movements with an undrained strength higher the the drained strength. Subsequent drainage of negative pore pressures in the toe dike would have reduced its strength from its undrained value towards its drained value which then could have allowed the flow slide to continue. This scenario points out the need to use the drained strengths of dense, dilative layers when evaluating susceptibility to a liquefaction flow slide.

1929-1930 Blanket and 1940 Berm - The engineering properties of these layers are not well known. Records indicate that they were apparently compacted to some degree during placement. The mobilized strengths of these layers were assumed to correspond to a drained friction angle of 40°.

Hydraulic Fill Shells - The upstream and downstream hydraulic fill shells were assumed to act undrained during the failure.

D.1.2 Static Stability Analysis of Upstream Slope

The critical failure surface through the upstream slope based on our stability analyses is shown in Fig. D1. The majority of the failure surface through the upstream hydraulic fill shell passes through the base of the shell, the location of the critical layer. Analyses were performed for two cases. Case A was based on lower bound values of the mobilized strengths varied in the analyses and Case B was based on upper bound values (Table D1). The driving shear stress, τ_d , through the critical layer on the upstream side of the dam was computed to be the following:

	riving Shear Stress τ _d , kg/cm ²
Case A	0.53
Case B	0.44
Average	0.48

We believe that a driving shear stress of 0.48 kg/cm² is a reasonable value to use for evaluating the liquefaction susceptibility of the critical layer on the upstream side of the dam.

D.1.3 Static Stability Analysis of Downstream Slope

The critical failure surface through the downstream slope based on our stability analyses is shown in Fig. D2. Stability analyses were performed for the same two cases described in the previous section. The majority of the failure surface through the downstream hydraulic fill shell passes through the base of the shell, the location of the critical layer. The driving shear stress, τ_d , through the critical layer on the downstream side of the dam was computed to be the following:

	Driving Shear Stress td, kg/cm ²
Case A	0.41
Case B	0.24
Average	0.33

We believe that a driving shear stress of 0.33 kg/cm 2 is a reasonable value to use for evaluating the liquefaction susceptibility of the critical layer on the downstream side of the dam for the prefailure condition.

Stability analysis of the downstream slope were also performed using the geometry of the dam immediately after the 1971 failure. The geometry used in the analysis was based on that shown in the upper part of Fig. 3. For the post-failure condition, the driving shear stress through the critical layer on the downstream side of the dam was computed to be $0.22~{\rm kg/cm^2} + 0.06~{\rm kg/cm^2}$.

D.2 Pseudostatic Stability Analysis

The purpose of the pseudostatic stability analyses was to determine yield accelerations to be used for estimating strains with a Newmark-type analysis for various earthquake intensities. The strain estimates were then compared with the strains required to trigger liquefaction.

The shear stresses present along the base of the critical wedge for an upstream failure, prior to the earthquake, were related to the drained strengths for all soils. The earthquake stresses represented by a horizontal force acting on the critical wedge will cause additional shear stresses along the base of the wedge, and for a sufficiently large horizontal force, yielding of the soils will occur. The yielding that is relevant to the triggering of liquefaction is that of the Zone 5 hydraulic fill soils. These soils reach a peak strength at very small strains and liquefaction is triggered if yielding causes an accumulation of shear strain of 0.5% or The question arises as to how much additional resistance is mobilized in the other soils along the base of the wedge under the small strains needed to trigger liquefac-Two assumptions were made for the strengths used in the pseudostatic stability analyses to obtain upper and lower bounds for the yield acceleration, as shown in Table D2. two assumptions are as follows:

- a. the shear strengths in all soils are equal to the pre-earthquake mobilized shear strengths, except for the critical soil in which yielding is assumed to occur at the peak undrained strength (1,700 psf); and
- the applicable shear strengths are equal to the peak drained strength in the rolled fill cap and ground shale layer and equal to the peak undrained strength in the clayey core, starter dike, and Zone 5 of the hydraulic fill shell (critical soil).

For cases a. and b. the computed yield accelerations of the upstream slope were 0.05 and 0.07 g, respectively.

TABLE D1 - SOIL PROPERTIES USED IN STABILITY ANALYSES TO DETERMINE IN SITU DRIVING SHEAR STRESSES Lower San Fernando Dam

Soil	Layer ^{l)}	Total Unit Weight, pcf	Case A - Lower Bound		Case B - Upper Bound	
			c psf	φ degrees	c psf	φ degrees
Rolled Fill Cap and Ground Shale Layer	1	120	0	30	0	35
Clayey Core ²⁾	2 3 4	120 120 120	1300 1600 1900	0 0 0	1970 2400 2830	0 0 0
Starter Dikes	5	120	0	30	0	35
1929-1930 Blanket	6	120	0	40	0	40
1940 Berm	7	120	0	40	0	40
Upstream Hydraulic Fill Shell	8	120	Note 3	0	Note 3	0
Downstream Hydraulic Fill Shell	9	120	Note 4	0	Note 4	0

Notes:

- 1) See Fig. D1 for dam geometry and layer numbers used in stability analyses.
- 2) Case A corresponds to $c/\overline{p} = 0.2$ and Case B corresponds to $c/\overline{p} = 0.3$.
- 3) The strength in this zone was varied until the factor of safety of the potential upstream failure surface equaled 1.0.
- 4) The strength in this zone was varied until the factor of safety of the potential downstream failure surface equaled 1.0.

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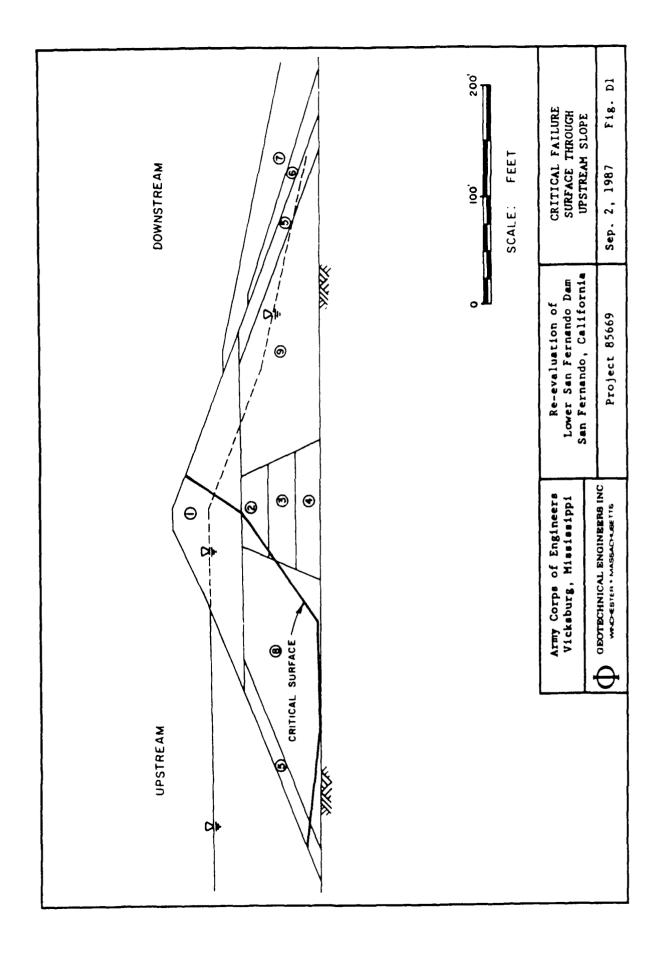
TABLE D2 - SOIL PROPERTIES USED IN PSEUDOSTATIC STABILITY ANALYSES TO DETERMINE YIELD ACCELERATIONS OF UPSTREAM SLOPE Lower San Fernando Dam

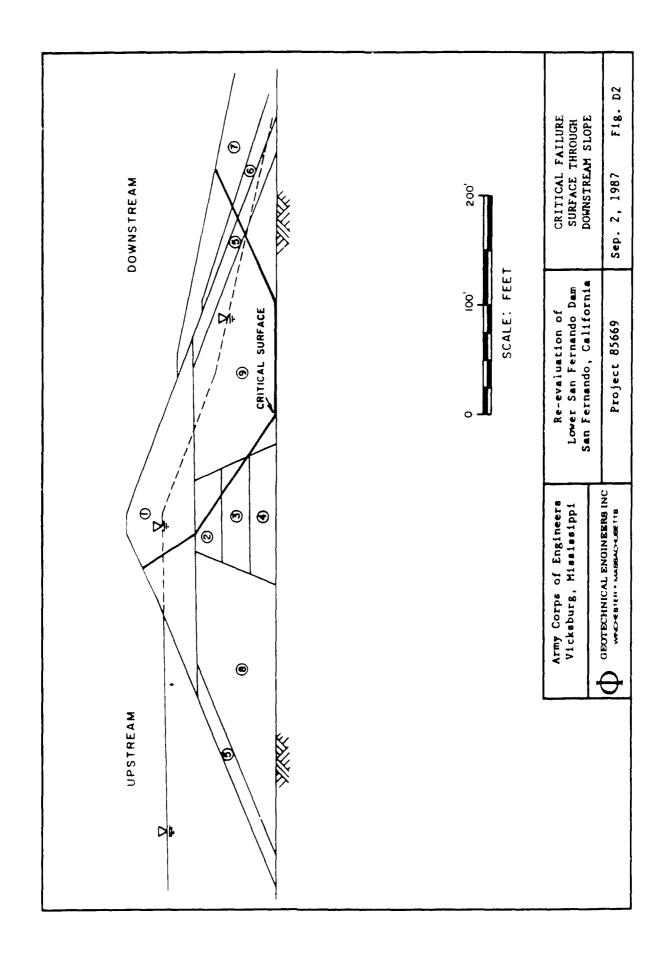
Soil	Layer ¹⁾	Total Unit Weight, pcf	Yield Strength, Sy psf	
			Case A	Case B
Rolled Fill Cap and Ground Shale Layer	1	120	400	700
Clayey Core	2	120	1,400	1,600
Starter Dike	5	120	100	3,400
Upstream Hydraulic Fill Shell	8	120	1,700	1,700

Note:

1) See Fig. D1 for dam geometry and layer numbers used in stability analyses.

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APPENDIX E: SHAKE ANALYSES

APPENDIX E

SHAKE ANALYSES

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APPENDIX E

SHAKE ANALYSES

E.1 General

The computer program SHAKE (Schnabel et al, 1972) involves a one-dimensional analysis in which the soil profile is modeled as a series of horizontal layers, and the vertical propagation of shear waves is considered.

SHAKE analyses were performed on soil profiles through the downstream and upstream hydraulic fill shells of the dam.

E.2 Soil Profile Through Downstream Shell

A SHAKE analysis was performed using the soil profile at Location 111 to determine the maximum cyclic shear strain in each layer of the soil profile which occurred during the 1971 earthquake (see Appendix C, Section C.4). The soil profile at Location 111 is shown in Fig. 9 of the main text. The ground-water level for the SHAKE analysis was assumed to be its 1971 elevation, or about 35 feet below ground surface at Location 111.

The input parameters for the SHAKE analysis of the Location 111 soil profile are shown in Table E1. Values of maximum soil modulus coefficient $(K_2)_{max}$, for each layer of the hydraulic fill shell were estimated on the basis of corrected 1985 N-values as explained in Table E1. The N-values prior to the 1971 earthquake would be somewhat less than the 1985 values. We did not try to predict 1971 N-values for the purpose of estimating maximum soil modulus coefficients because we felt this level of refinement in estimating the coefficients was unwarranted.

Earthquake time histories of acceleration were input at the surface of the bedrock layer. The earthquake time history was that obtained from a seismoscope located on the right abutment. The motion in the direction normal to the axis of the dam was used. The record, developed by R. F. Scott (Seed, et al 1973) is shown in Fig. E1.

A plot of maximum cyclic shear strain vs depth developed from the SHAKE analyses is shown in Fig. E2.

E.3 Soil Profile Through Upstream Shell

SHAKE analysis were performed on a soil profile through the upstream hydraulic fill shell to determine time histories of stresses applied to the potential sliding mass on the upstream slope. Stresses from the SHAKE analyses were used to define time histories of acceleration as discussed in Section 5.5 of the main text.

The soil profile used for SHAKE analyses of the upstream shell was taken to be the same as that observed at Location 111 through the downstream shell, except that the groundwater level was placed at the ground surface due to the presence of the reservoir.

The input parameters for SHAKE analyses of the upstream soil profile are shown in Table E2. Values of maximum soil modulus coefficient, $(K_2)_{max}$, for each layer were taken to be the same as those estimated for the downstream slope. The shear moduli of layers in the upstream profile are less than shear moduli in the downstream profile due to the lower effective overburden stresses.

Earthquake time histories of acceleration were input at the surface of the bedrock layer. The earthquake time history was that developed by R. F. Scott (Fig. E1). The accelerations in the record were scaled to obtain several earthquake time histories with various peak accelerations for use in SHAKE analyses as described in Section 5.5 of the main text.

TABLE E1 - SUMMARY OF INPUT PARAMETERS FOR SHAKE ANALYSIS OF LOCATION 111 SOIL PROFILE - DOWNSTREAM SLOPE Lower San Fernando Dam

Layer ^{l)}	Thick- ness	Total Unit Weight	2) (N ₁) ₆₀	3) 5 _m	$(K_2)_{\text{max}}^{4}$	Gmax ⁴⁾
	ft	pcf	blows/ft	psf		<u>psf x 10⁶</u>
Dense Fill	20	120	-	780	52	1.45
Zone l above groundwater	15	120	22	2140	56	2.59
Zone l below groundwater	6	120	22	2840	56	2.98
Zone 2	15	120	15	3230	49	2.79
Zone 3	11	120	20	3720	54	3.29
Zone 4	6	120	30	4040	62	3.94
Zone 5	15	120	11	4430	44	2.93
Alluvium	12	120	-	4940	₅₂ 5)	3.65

Notes:

- 1) Soil profile is that shown in Fig. 9 with groundwater level 35 feet below ground surface.
- 2) (N₁)₆₀ is 1985 measured N-value in layer corrected for overburden pressure, using 60% of the theoretical free-fall hammer energy transferred to drill rods instead of the measured 72%, and liner effects as described in Seed, 1985.
- 3) $\overline{\sigma}_m$ is the 1971 octahedral effective stress at the midheight of the layer, equal to 0.65 $\overline{\sigma}_v$.
- 4) Maximum soil modulus coefficient, $(K_2)_{max}$, and maximum shear modulus, G_{max} , based on relationships between these parameters and $(N_1)_{60}$ and σ_m suggested by Seed, et al (1986). Attenuation curves for Damping Ratio and Shear Modulus based on Seed and Idriss (1970) for cohesionless soils. Input earthquake record is that shown in Fig. El.
- 5) Value of (K_2) for alluvium same as that used in Seed, et al (1973) for upper alluvium.

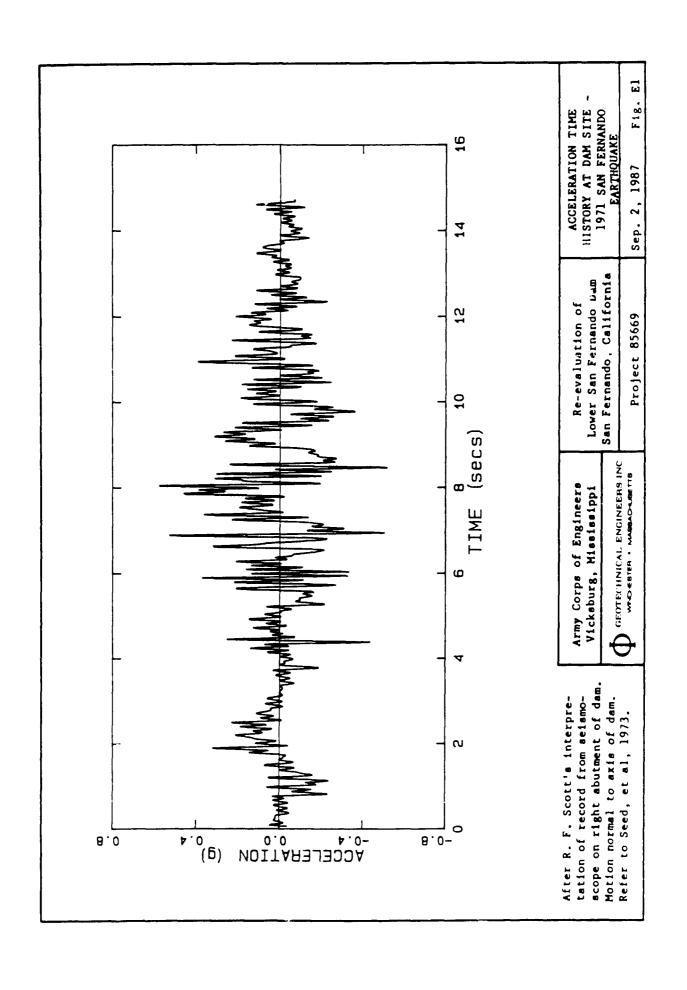
TABLE E2 - SUMMARY OF INPUT PARAMETERS FOR SHAKE ANALYSIS OF SOIL PROFILE THROUGH UPSTREAM SLOPE Lower San Fernando Dam

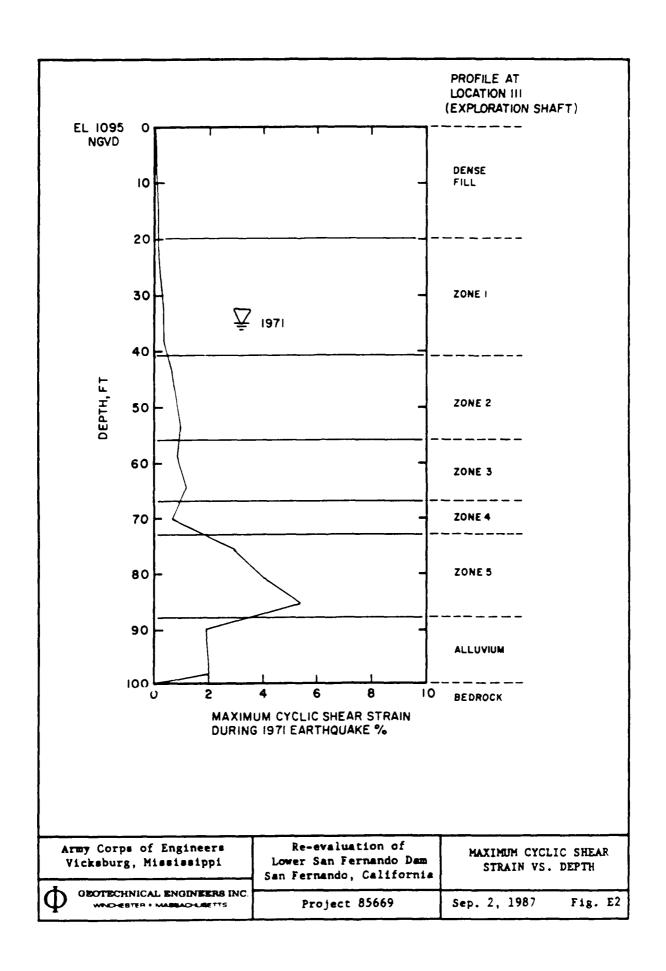
Layer ¹⁾	Thick- ness	Total Unit Weight	2) 5 _m	$(K_2)_{\text{max}}^3$	$G_{max}3)$
	ft	pcf	psf		psf x 106
Dense Fill	20	120	380	52	1.02
Zone 1	21	120	1170	56	1.91
Zone 2	15	120	1860	49	2.11
Zone 3	11	120	2360	54	2.62
Zone 4	6	120	2690	62	3.21
Zone 5	15	120	3090	44	2.45
Alluvium	12	120	3610	52	3.12

Notes:

- 1) Soil profile is that shown in Fig. 9 except that a groundwater level at the ground surface was used.
- 2) $\vec{\sigma}_m$ is the 1971 octahedral stress at the midheight of the layer, equal to 0.65 $\vec{\sigma}_v$.
- Maximum soil modulus coefficient, $(K_2)_{max}$, the same as those in Table E1. Maximum shear modulus, G_{max} , based on $\bar{\sigma}_m$ and $(K_2)_{max}$. Attenuation curves for Damping Ratio and Shear Modulus based on Seed and Idriss (1970) for cohesionless soil.

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APPENDIX F: LABORATORY TESTING PROGRAM

APPENDIX F

LABORATORY TESTING PROGRAM

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APPENDIX F

LABORATORY TESTING PROGRAM

F.1 Introduction

Laboratory tests were performed on the following types of soil samples from Lower San Fernando Dam:

Source	Sample Type
Borings	Split-spoon samples Undisturbed fixed piston samples
Exploration Shaft	Undisturbed tripod tube samples Batch mixes formed from bag samples

Laboratory tests included index tests, monotonically and cyclically loaded triaxial tests, and vane shear tests. A list of all laboratory tests performed on each sample is presented in Table F1.

F.2 Preparation of Batch Mixes

Seven batch mixes were prepared from bag samples obtained from the exploration shaft. The individual bag samples used to form each batch mix are presented in Table F2, as well as the elevation range from which the bag samples were taken. An attempt was made to form batch mixes which would represent a particular soil layer encountered in the shaft.

Individual bag samples used to form a particular batch mix were combined on a large mixing boa i in the laboratory. The mixture was worked with a shovel until the soil was homogeneous. All laboratory tests of batch mixes were performed on the fraction passing the No. 4 sieve.

F.3 Index Tests

The following types of index tests were performed: specific gravity, compaction, Atterberg limits, mineralogical analysis, and grain size analyses. Results of index tests are summarized in Table F2 and discussed separately below.

F.3.1 Specific Gravity Determinations

Specific gravity tests were performed on each of the seven batch mix samples. Results of specific gravity tests are presented in Table F2. The measured specific gravities were used to calculate void ratios of triaxial test specimens.

F.3.2 Compaction Tests

Laboratory compaction tests were performed on each of the seven batch mix samples. The tests were performed in accordance with ASTM Procedure D1557-78, Method A. Results of the compaction tests are shown in Figs. F1 through Fig. F7.

F.3.3 Atterberg Limits Determination

One Atterberg limit test was performed on the minus No. 40 fraction of Batch Mix 7. The results of this test are as follows:

Liquid Limit = 24 Plastic Limit = 20 Plasticity Index = 4

Based on these results, the minus No. 40 fraction of Batch Mix 7 has a Unified Soil Classification of ML.

F.3.4 <u>Mineralogical Analysis</u>

A mineralogical analysis of a sample of Batch Mix 7 was performed for GEI by Resource Engineering Incorporated of Waltham, Massachusetts using reflected light microscopy. The following results were reported:

<u>Mineral Type</u>	Volume %
Quartz	67
Feldspar	15
Clays	10
Opaques	5
Other	3

The shape of most of the mineral grains was described as angular or blocky, and equiaxis with very few exhibiting a platy structure. No organic materials were found in the sample.

F.3.5 Grain Size Analyses

Grain size analyses were performed on the following samples:

No. of Tests	Sample Type
10	Split-spoon samples
21	Undisturbed samples
7	Batch mix samples

Grain size curves of all samples tested are presented in Figs. F8 to F49. Grain size analyses of triaxial test specimens were performed on a representative portion of the failure zone of the specimens. In some cases, two grain size analyses were performed on a triaxial test specimen to classify two obviously different layers in the specimen.

Grain size curves of undisturbed samples from Zone 5 of the hydraulic fill shell (critical layer) are plotted together in Fig. 11. Batch Mix 7 from the same zone is also shown in Fig. 11.

F.4 Triaxial Tests

F.4.1 General

The following triaxial tests were performed as a part of this study:

- Isotropically consolidated, undrained triaxial, monotonic compression (\overline{R}) tests on undisturbed samples.
- 10 Isotropically consolidated, undrained triaxial, monotonic compression (\overline{R}) tests on remolded samples of Batch Mix 7.
- Isotropically consolidated, drained triaxial, monotonic compression (S) tests on remolded samples of Batch Mix 7.
- Anisotropically consolidated, undrained triaxial, monotonic compression (\overline{R}) tests on remolded samples of Batch Mix 7.
- 5 Anisotropically consolidated, undrained triaxial, cyclic load followed by monotonic compression (CRR) tests on undisturbed

specimens; the consolidation phase of these tests included an unloading cycle to measure swelling properties.

Anisotropically consolidated, undrained triaxial, cyclic load $(C\overline{R})$ tests on remolded samples of Batch Mix 7.

Specimen preparation techniques are discussed below in Section F.4.2, followed by discussions of the individual test results in Sections F.4.3 through F.4.7.

F.4.2 Specimen Preparation

F.4.2.1 Undisturbed Tube Samples

The general procedure followed for preparing undisturbed tube samples for triaxial testing was as follows:

- 1. The distance from the ends of the tube to the soil surfaces at both ends of the tube were measured. These distances were compared to measurements of the same distance recorded just after the tube was taken in the field. Differences between the two sets of measurements were used to determine void ratio changes during sample shipment. In this investigation, no changes in sample length were measured during shipment.
- 2. The X-ray of the undisturbed tube sample selected for testing was examined to identify soil layers within the tube. Triaxial tests were performed on samples which appeared from the X-ray to be one soil layer within the tube. The section of tube for testing was identified and marked for cutting, leaving about 2 cm on each end of the section for trimming.
- 3. The tube was secured vertically in a chain vise, and stiffening rings placed adjacent to the cut locations. The purpose of the rings was to prevent the tube from deforming during cutting and thus to reduce stresses on the soil during cutting.

- 4. The tube cutter was positioned at the desired cut location and then turned slowly while applying gentle pressure. The distance from the top of tube to the soil was measured before and after cutting to determine if soil length changes occurred during cutting. A typical cut required about 15 to 20 minutes. In this investigation, little to no volume changes took place during cutting.
- 5. To promote saturation and easier sample extrusion, the bottom section of the tube was placed in a water bath, allowing water to be drawn to the top by capillarity. The bottom was protected by a piece of filter paper and a porous stone during saturation, with only the porous stone coming in contact with the water.
- 6. After saturation, the sample was trimmed to the desired test length in the tube, and measurements of the sample length recorded for determining the void ratio of the sample in the tube.
- 7. A membrane was placed on a membrane stretcher and the sample extruded directly into the membrane. Extrusion was performed with the tube in a vertical position.
- 8. The sample was placed on the bottom platen of the triaxial cell, the top cap was placed on the sample, and a vacuum of about 15 inches of mercury applied to the sample. Lubricated end platens were used for virtually all triaxial tests so that the smallest sample height could be used. This increased the probability that the triaxial test specimen would be essentially of one soil type.
- 9. The diameter and height of the sample were measured, the triaxial cell assembled, and the cell filled with water.
- 10. The vacuum was locked into the sample by closing the drainage lines, and the cell

pressure was increased to 0.5 kg/cm². The drainage lines were opened, releasing the vacuum and bringing the pore water pressure to atmospheric.

The sample was then ready for backpressure saturation and consolidation as discussed in Section F.4.2.3 below.

F.4.2.2 Remolded Samples

Triaxial tests were performed on remolded samples of Batch Mix 7. Only the fraction passing the No. 4 sieve was used for testing. The soil was passed through either a No. 10 or No. 40 sieve prior to testing to break lumps of soil.

Three methods were used to form samples of Batch Mix 7 for triaxial testing. The first method consisted of compacting the samples at a water content of about 7%. After compaction, the samples were saturated by flowing water through the samples from the bottom to the top, and then using backpressure saturation to achieve full saturation. This method required high backpressures to achieve proper saturation.

The second method involved placing the sample as a slurry at a water content ranging from 30 to 38%. This method was used for tests $\overline{R}104$ and $\overline{R}105$. Samples formed in this manner were found to be very soft and difficult to handle, and required long consolidation times at low consolidation pressures.

The third method was the most practical and was used for the majority of the triaxial tests on remolded samples. Samples were compacted in a mold at water contents typically between 3 and 4%. The following is a detailed summary of this procedure:

1. A confining membrane was secured in a sample mold and stretched smooth by applying a vacuum between the mold and the membrane. The mold was placed around the bottom platen of the triaxial cell. The diameter and height of the mold with the membrane in place was measured.

- 2. Using a target void ratio, known mold dimensions, and the water content of the batch mix, the required weight of soil for the test was weighed and mixed with CO_2 .
- 3. Samples were compacted to target void ratios in layers between 1.35 and 1.5 cm thick by static pressure from a tamper. The top of each layer was scarified prior to the addition of the next layer.
- 4. When the desired sample height was reached, the top platen was placed on the sample and the membrane stretched over the platens. A small vacuum was applied to the sample, and the mold removed. Lubricated end platens were used for almost all tests.
- 5. After removing the mold, air within the sample was displaced by flowing CO₂ through the sample. The CO₂ entered the bottom of the sample under atmospheric pressure, and was pulled through the sample by a vacuum. The drainage line to the bottom of sample was then closed.
- 6. Sample dimensions were measured with the vacuum still applied. The cell was assembled and filled with water, and a small cell pressure of about 0.1 kg/cm² applied.
- 7. The vacuum was locked into the sample by closing the valve to the top drainage line. De-aired distilled water was then slowly introduced to the bottom of the sample. Water was drawn upward through the sample under the gradient imposed by the locked in vacuum. The rate of inflow was carefully controlled to prevent surges of water inflow.
- 8. When the distilled water reached the top of the sample and appeared in the top drainage line the sample was ready for backpressure saturation and consolidation. The drainage lines were opened, releasing the vacuum and bringing

the pore water pressure to atmospheric, while the cell pressure was increased from 0.1 to 0.5 kg/cm².

F.4.2.3 Backpressure Saturation and Consolidation

Backpressure saturation and isotropic consolidation was performed using a regulated air pressure system, with air over water interfaces. Graduated burettes having capacities of 60 ml vere used to measure volume change from either the cop or bottom drainage lines.

The air regulating system used allowed simultaneous increase of cell pressure and back-pressure. Starting from a confining pressure of 0.5 kg/cm² and a backpressure of 0.0 kg/cm², the pressures were increased in increments of 0.5 or 1.0 kg/cm², with drainage lines open. Measurements of the pore pressure coefficient, B, were performed during incremental increases in cell pressure and backpressure until the measured B-coefficient was approximately 0.95 or greater.

Upon completion of saturation, samples were isotropically consolidated to the desired effective stress. Volume and height changes were monitored during each increment of consolidation stresses.

When necessary, anisotropic consolidation loads were applied prior to shear. The required load was calculated based on the desired anisotropic stress and the estimated area after isotropic consolidation. Anisotropic loads were applied using either a dead load system, air pressure in a triaxial cell top with a built in air piston, or by loading the sample at a slow strain rate in a load frame. In all cases, the load was monitored by a load cell mounted beneath the soil sample.

At the completion of consolidation, the samples were loaded either monotonically or cyclically. After loading the samples were reconsolidated to their original isotropic stresses, (for undrained tests). The drainage lines were closed, and the triaxial cell dismantled. The final water content was then measured, using one half of the specimen for undisturbed tests and the whole sample for remolded samples. The final

water content, final weight of solids, and specific gravity were then used to calculate the void ratios during shear and consolidation.

F.4.3 R Tests - Undisturbed Samples

Twenty \overline{R} tests ($\overline{R}1$ through $\overline{R}20$) were performed on either undisturbed tripod tube samples from the exploration shaft, or on undisturbed fixed piston tube samples from borings. The purpose of the tests was to provide data for determining the in situ undrained steady state shear strength of the soils.

Results of \overline{R} tests on undisturbed samples are summarized in Table F3, and summary plots for the individual tests are presented on Figs. F50 through F69. Triaxial consolidation curves for samples from Zone 5 are presented in Fig. F70, and consolidation curves for all other undisturbed samples are shown in Fig. F71. Descriptions of undisturbed samples after triaxial testing are presented in Table F8.

Conventional end platens were used for the first five \overline{R} tests ($\overline{R}1$ through $\overline{R}5$). The remainder of the tests were performed using lubricated end platens. The reason for choosing lubricated ends was to minimize the number of layers within a given test specimen. The height-to-diameter ratio for the conventional end samples ranged from about 2.1 to 2.3, while the lubricated end platen tests were performed using a height-to-diameter ratio of about 1.5.

The drainage lines to the specimens were closed at the conclusion of consolidation and the samples sheared in monotonic compression. All of the tests were performed in a strain controlled loading device. Pore pressure changes, applied load, and axial deformation were monitored throughout the tests. Axial strain rates were chosen to allow pore pressure equalization during shear. Axial strain rates ranged from about 0.21 to 0.76 %/min.

The samples were typically sheared to an axial strain of about 25%. Test $\overline{R}11$ and $\overline{R}12$ were stopped at lower strains because the applied loads had reached or exceeded the capacity of the load cells.

The drainage lines were opened at the conclusion of shearing to allow excess pore pressures to dissipate. The volume change during reconsolidation was recorded,

and the drainage lines were again closed. The triaxial cell was dismantled and the sample was cut vertically. One half of the sample was used for water content determination, and the remaining half was photographed and visually classified. A representative portion of the sample in the failure zone of the specimen was selected for grain size analysis.

F.4.4 \overline{R} Tests - Remolded Samples, Isotropically Consolidated

Ten \overline{R} tests, $(\overline{R}101$ through $\overline{R}110)$, were performed on isotropically consolidated remolded samples of Batch Mix 7. The samples were prepared using three procedures, as discussed in Section F.4.2.2 above. The purpose of the tests was to develop the steady state line for Batch Mix 7.

Results of these tests are summarized in Table F4, and summary plots for the individual tests are presented in Figs. F72 through F81.

The shearing procedure for these tests was essentially identical to that used for undisturbed samples. Pore pressures, load, and axial deformation were measured continuously while the samples were sheared at slow strain rates to allow pore pressure equalization. The strain rates ranged from about 0.07 to 2 %/min.

The steady state condition was not reached in Test $\overline{R}104$, one of the samples prepared as a slurry. The value of $\overline{\sigma}_f$ at the end of this test was plotted in Fig. 15 and an arrow shown next to the data point to indicate that $\overline{\sigma}_{fs}$ was not reached.

The procedure for reconsolidating the sample and measuring the water content at the end of the test was similar to the procedure for the \overline{R} tests on undisturbed samples, except that the entire sample was used for the water content determination.

A plot of q vs \overline{p} for all isotropically consolidated \overline{R} tests on Batch Mix 7 samples is shown in Fig. F84. This plot shows that the steady state friction angle of Batch Mix 7 was consistently 34° for values of \overline{p} less than about 13 kg/cm². The friction angle decreased slightly at higher effective stresses.

The steady state lines for Batch Mix 7 (Figs. 15 and 17, in terms of $\bar{\sigma}_{fs}$ and S_{us} , respectively) were

determined on the basis of the measured values of $\bar{\sigma}_{3s}$ and a steady state friction angle of 34°. The corresponding relationships are:

$$\bar{\sigma}_{fs} = \left(\frac{\cos^2 \varphi}{1 - \sin \varphi}\right) \bar{\sigma}_{3s} = 1.56 \; \bar{\sigma}_{3s} \; \text{for } \varphi = 34^\circ$$

$$S_{us} = \left(\frac{\sin \varphi \cos \varphi}{1 - \sin \varphi}\right) \bar{\sigma}_{3s} = 1.05 \; \bar{\sigma}_{3s} \; \text{for } \varphi = 34^\circ$$

$$S_{us}/\bar{\sigma}_{fs} = \tan \varphi$$

F.4.5 S Tests - Remolded Samples

Two S tests (S1 and S2) were performed on isotropically consolidated remolded samples of Batch Mix 7. The purposes of the tests were to provide additional data for developing the steady state line, and to demonstrate the independence of test type on the steady state strength of a soil. Results of these tests are presented in Table F4 and individual test results are shown in Figs. F82 and F83.

Both S tests were performed using lubricated end platens, and were set up following the same general procedure discussed in Section F4.2.2. The samples were sheared under conditions of controlled strain at a rate slow enough to allow pore pressure dissipation. Measurements of applied load, axial strain, and volume change were measured during shear.

The minor principal stress was decreased during shear in an attempt to keep the effective stress on the failure plane constant throughout the test. The effective stress on the failure plane varied somewhat during shear as shown by the stress paths in Figs. F82 and F83. The samples were contractive throughout shear, and the void ratios were essentially constant at the end of the test.

F.4.6 R Tests - Remolded Samples, Anisotropically Consolidated

Nine \overline{R} tests ($\overline{R}201$ through $\overline{R}209$) were performed on anisotropically consolidated remolded samples of Batch Mix 7. The main purposes of these tests were to determine peak strengths and strains and to investigate their variation with strain rate. In addition, five of the tests reached a steady state condition and provided addi-

tional data for defining the steady state line of Batch Mix 7. Results of these tests are summarized in Table F5, and summary plots for the individual tests are shown in Figs. F85 through F93.

The samples were prepared as discussed in Section F.4.2.2 above. Both lubricated end platens and conventional end platens were used as shown in Table F5.

Anisotropic stresses were applied at the end of isotropic consolidation. This was done by applying an axial load with a dead load frame or an air piston.

The samples were tested at strain rates that can be considered either slow (<1%/min.), medium (about 30 to 50%/min.), or fast (from 3800 to 4900%/min.). The slow and medium strain rate tests were performed under conditions of controlled strain. Fast strain rates were achieved by instantaneously applying a large compression pulse to the load piston attached to the top of the sample. Test results were recorded on a strip chart recorder, and the strain rate reported in Table F5 was measured from the record. The strain rate at the beginning of the test tended to vary, until the sample had passed its peak strength. Thereafter the sample tended to deform at a relatively constant velocity. Strain rates reported on Table F5 are based on the constant velocity portion of the test.

F.4.7 CRR Tests - Undisturbed Samples

Five triaxial tests ($\overline{CRR1}$ through $\overline{CRR5}$) were performed on undisturbed samples primarily to obtain reconsolidation characteristics of the soil after being subjected to cyclic loading. The tests are designated \overline{CR} to indicate cyclic loading under undrained conditions and \overline{R} to indicate monotonic loading after cyclic loading. The following procedure was followed:

Phase	Procedure
a	Anisotropically consolidate specimen to the approximate in situ stresses at the sample location prior to the 1971 earthquake.
Ъ	Close drainage to specimen and cyclically load specimen to a maximum cyclic axial strain (single amplitude) of about 3%. Restrictors were placed on the load

piston so that cyclic strains would not exceed 3%.

- c Open drainage to specimen and measure the decrease in void ratio caused by dissipation of excess pore pressure in specimen.
- d Anisotropically consolidate specimen to the approximate in situ stresses at the sample location in 1985.
- e Decrease consolidation stress to $\sigma_{1c} = \sigma_{3c} = 0.1 \text{ kg/cm}^2$.
- f Isotropically consolidate specimen to $\bar{\sigma}_{3c} = 8.0 \text{ kg/cm}^2$.
- g Shear the specimen in undrained monotonic compression.

Undisturbed samples ranged from a slightly silty, widely graded sand to a clayey silt. Grain size curves of samples tested are presented in Figs. F45 to F49. Descriptions of individual samples after triaxial testing are presented in Table F8.

Plots of void ratio e vs $\bar{\sigma}_3$ for each test are presented in Figs. F94 to F98. These plots show void ratio changes which occurred during each of the phases described above.

A surmary of Phases a through c is presented in Table F7. During cyclic loading, σ_3 decreased from initial values ranging from 2.5 to 3.2 kg/cm² to final values ranging from about 0.1 to 0.3 kg/cm². Drainage after cyclic loading caused void ratios to decrease in the range of 0.027 to 0.048.

Phase "e" was performed to obtain data on the amount of swelling caused by a decrease in consolidation stress. A plot of swelling coefficient ($^{\Delta}e/^{\Lambda}\log^{\bar{\sigma}}0$) vs initial void ratio is shown in Fig. 13.

Samples were reconsolidated to $\bar{\sigma}_{3c}$ = 8 kg/cm² prior to the \bar{R} phase. Results of the \bar{R} phase are presented in Table F3 and data plots for individual \bar{R} tests are presented in Figs. F99 to F103.

F.4.8 $C\overline{R}$ Tests - Remolded Samples

Eleven cyclic triaxial tests ($C\overline{R}101$ through $C\overline{R}111$) were performed on anisotropically consolidated remolded samples of Batch Mix 7. The tests are referred to as $C\overline{R}$ tests to indicate that a cyclic axial load was applied, and that the samples were undrained during shear. Results of these tests are summarized in Table F6, and summary plots of the individual tests are shown in Figs. F106 through F115.

The purpose of these tests was to determine the minimum axial strain required to trigger specimen failure after undrained cyclic loading. The consolidation stresses were chosen such that the ratio of undrained steady state shear strength to driving shear stress on the failure plane would be as close as possible to 0.54, the same as the factor of safety against a liquefaction flow slide, $S_{\rm us}/\tau_{\rm d}$, through the critical layer (Zone 5) on the upstream side of the dam in 1971. Because of the sample preparation and consolidation procedures used, we typically achieved laboratory $S_{\rm us}/\tau_{\rm d}$ ratios of 0.60 to 0.70.

It was desired to apply cyclic transient loads that would not be available to drive the failure. Only the static (consolidation) anisotropic loads would drive the failure. A loading apparatus was developed that allowed application of triangular shaped axial compression pulses. A schematic diagram of the loading apparatus is shown in Fig. F104. The anisotropic load (Lc) was applied to the sample by adding dead load to the hanger system beneath the sample. At the conclusion of consolidation, the drainage lines to the specimen were closed. The cyclic load (F_a) was then applied by imparting blows to the spring/cushion system above the sample using a hand-held sledge hammer. The stiffness of the spring/cushion system resulted in triangular spikes lasting about 0.03 to 0.05 seconds.

The force applied to the loading yoke was monitored using a load cell mounted beneath the spring/cushion system. The load applied to the soil was measured using the load cell mounted below the soil sample. Axial strain was measured using DCDT's mounted on the load piston, and pore pressure was monitored using standard pore pressure transducers. All measurements were recorded on a strip chart recorder.

A typical strip chart record, from test CR111, is shown in Fig. F105. The record has been redrawn to show axial strain (ε_a) instead of deformation, and effective minor principal stress ($\overline{\sigma_3}$) instead of pore pressure. The applied cyclic force F_a is the force applied over and above the anisotropic consolidation load L_c . The total soil force F_r is the lead resisted by the soil at any point in time, and therefore includes the anisotropic load and any additional load imparted to the soil by the cyclic loading.

As shown in Fig. F105, the applied cyclic force for test $C\overline{R}111$ greatly exceeded the available soil resistance, (i.e. a force of approximately 36 kg was applied to the loading yoke, while the soil could resist only about 19 kg more than the consolidation load). Therefore the sample yielded and accumulated axial strain. Two load cycles of approximately equal magnitude were applied in the test.

The axial strain at the end of cyclic loading for test CRIII was about 0.47%. After cycling had stopped the sample continued to creep under constant load to a strain of 1.05%. At that point the creep rate accelerated and the sample underwent rapid failure.

The significance of the axial strain at the end of cycling, and at the start of rapid failure can be seen by observing the stress-strain curve for anisotropically consolidated specimens loaded monotonically at slow strain rates. The axial strain at peak for the strain controlled tests averaged about 0.1%. Therefore, the strain at the end of cycling during test $C\overline{R}111$ had exceeded the strain to peak. However, during the strain controlled tests the available soil resistance at strains of up to about 1% was greater than the consolidated shear stress. Therefore, during the cyclic test, when the accumulated strain had reached about 1%, the driving shear stress exceeded the soil resistance, and the sample failed rapidly.

F.5 Laboratory Vane Shear Test

One laboratory vane shear test was performed on an undisturbed sample of the clayey core (Sample UF14C from Boring U105). This sample was located below groundwater level at the time of sampling in 1985.

The laboratory vane was 1.27 cm in diameter and 1.27 cm in height. The vane rotation rate was 19 degrees/second.

Results of the vane shear test are presented in Fig. F116, which includes a plot of vane shear strength vs displacement of the periphery of the vane.

Page 1 of 2	Engineering Properties Tests ²⁾	Fig. No.		1	ı	! :	1) 1	1 1	ı	i 1	۱ ا		F68	F57	0	F116		198, 1103	101	F97 F103	5011 (77)	F6.	F04	753	F 74	F66
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$\frac{S1, S}{\mathbb{R}^{201-R2}}$	1+1		_	F24	F2	F6	R101-R110	F4	F72-F81
$\frac{R201-R2}{CR101-CR}$							S1, S2	F4	F82, F83
CR101-CR							R201-R209	F5	F85-F93
							CR101-CR11	1 F6	F104-F115

Elevation datum is NGVD. 1,000

See text of Appendix F for definitions of engineering property test prefixes: R, CR, CRR, S, LV.
See Table F2 for description of batch mixes.
See Section F3.3 of text for Atterberg Limit Determinations and Section F3.4 of text for Mineralogical Analyses.

TABLE F2 - SUMMARY OF BATCH MIX SAMPLES FORMED FROM BAG SAMPLES TAKEN FROM EXPLORATORY SHAFT Lower San Fernando Dam - California

Maximum Dry Unit Weight, ASTM D15572)	pcf 104.0	113.5	110.5	104.5	104.8	103.5	115.9
Specific Gravity	2.68	2.71	2.67	2.68	2.67	2.68	2.69
n _o	3.6	>30	6.4	3.8	6.1	4.2	31.5
Soil Description mbol % Passing 1) No. 200	Sieve 14.1	87.8	10.6	20.9	37.5	30.7	50.5
Soll I	SM	MI, MI-CL	SP-SM	SM	SM	WS	SM-ML
Bag Samples Forming Mix	BS 102, 103, 104	BS 105, 106, 107	BS 108, 109, 110	BS 112, 113, 114	BS 201, 202, 203 204, 205	BS 207, 208, 209 210	BS 301, 302, 304 305, 306, 308 309, 311
Elevation Range, NGVD	1044.3 to 1043.7	1942.9 to 1042.3	1042.4 to 1041.8	1041.1 to 1040.5	1032.5 to 1031.6	1031.2 to 1030.5	1014.6 to 1012.3
Batch Mix		≎ •	~	*	<i>s</i>	£	-

Notes:

- 1) The percent passing the No. 200 sleve is based on the ainus No. 4 sleve fraction.
- 2) ASTM D1557, Method A was used. Only the minus No. 4 sleve fraction is used for this method.

That is in the $\overline{R} > 5$ for the infinite forming SPECTMENS . Under the standardo DAm

	Pressore Strain Confficient Rate	H _C (5)		0,47 0,31	6.97 0.33	57.0 Ye.0	0,40	0,98 0,54	1,6 0,47	3,47	£ .	17.6	0,97	0,94		£ 7
	Pressure Pres		E 0 7	તું હ•્ય			ë •	6. 0	7.0	6.7 6.7	.* .*	7.0	ю	· · · · · · · · · · · · · · · · · · ·	-· 	
	Friction Pr Angle		i i	54.7	15. H		£.77	55.7	3.44	11.5	s. Ž	3	7.75	7.4.5	π 	<u>)</u> ;
	Strength	\$ (4)	5	2.45	4.50	6.20	,	3.96	5.20	2,52	5.54	5.22	4.47	r	(30.4)	5.47
- 1	Ax lat Strain	<u>د</u> د	•	5.5	24.6	о 1.	÷.	2	25.0	24.4	33.5	0.50	0.4.7	٠. 4.	<u>.</u>	4.4
٧.	Effective Minor Principal Stress		5	2.25	4.38	5.86	4.55	5.82	5.04	2.4°	5.29	5,34	4.4	ē: :	₹ .'	7
	Shear	£ 8 }	5	86.77	5.43	7.43	\$ \$	4.10	5.80	?*°°°	4.30	3,81	5.32	ž.	7.	4.1.
	Friction Angle	а 9- ;	P.	54.7	7. 4.	÷	£ *	35.	ž	 	۲. ک	35.1	2.33	54.8	5.5	H. 23.
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- 1	Shear	£ 2 }	E	#	, · · ·	<u>.</u> .		4.10	2.91	5	÷.	÷.	5.	, 4 4 4 4 4 4 4 4 4 4 4 4 4 4 4 4 4 4 4	÷.	
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Axial	Strain	1 /m/n	0.36	0.47	0,48	÷.	٠ ٠.	.4.0	a1.		3.15	3.75	π 		
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Back	Pressure	ار و کرد ۱۰۰۸ میر ۱۳۹۸	5.0	6. 0	٠٠٠ ن•،	°.	13.0	٠	- - -	ŗ.	·	: •	r,		
	Friction Angle	e e e e e e e e e e e e e e e e e e e	52,8	35.3	52.7	33.7	34.0	- 7	5.5.5	35.5	1	\$2.4	£. 47		
state	Shear Strength	S _{us} (4) (4) κg/σπ ²	3.90	3,42	4.55	4.09	6,99	4.90	5,02	5.40	17.84	5.16	4e.*		
At Steady State	Axfat Strain	م م	21.5	9.	25.0	23.9	0*42	70.1	41.4	24.4	\$ 6.73	25.0	24.3		
AT	Effective Minor Principal Stress	035 kg/ga ²	3,93	3, 56	4.68	4.34	6.64	4.65	5.80	4	\$ 6* 50	5, 30	;;		
	Shear	ور (3) الاعراج	4.04	4.09	5,49	4.81	8.43	26.5	1.22	0. V	5.	ī.	<u>:</u>		
	Friction Angle	g ge	52.9	3.3	35.2	32.0	ं.	54.4	34.2	 	, 53, 7	55.2	e • • • • • • • • • • • • • • • • • • •		767.00
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Fig. 1. The Control of Section of the Control of Section of Sec

(i) this thin below to correction due to wall at leve of exploration shaft. (i) validates on the 45° plane (4) share stress on the 45° plane (4) $s_{u,\zeta}$ and massical s_{ζ} and q_{ζ} . (4) $s_{u,\zeta}$ and massical s_{ζ} and q_{ζ} . (4) $s_{u,\zeta}$ and parentheses equal 1.051 $\tilde{\sigma}_{3\zeta}$ derived from the geometry of the Mohr's circle and standy state triction angle of 34° measured for Batch Mix 7 from 20ne 5 of the hydraulic fill shell.

(5) 8, is the B-value of the specimen after back pressure saturation.

September 2, 1987 Project 85669

TABLE F4 = \overline{R} AND S TESTS ON BATCH MIX 7 ISOTROPIC CONSOLIDATION Lower San Fernando Dam

Page 1 of 2	Axtal Strafa Fee		rje * !		<u>.</u> •	·:			· -	·	~ ~ —	<i>.</i>	.*
Радо	Pore Pressure Coeffictent	m .	(*)	ч ь " р	86°C	50°C	e 6.	37.			<u>-</u>	• • •	£ 7.
	Back Programo	j.	, b, L' (cm.)	Ţ. 2	•	. · ·	· · · · · · · · · · · · · · · · · · ·	<i>5</i>	į	2. 2	<u>.</u> .	٠ ټ	Ē.
	Frietjen Angle	√ ÷	dop	15.1	%5.4 (-1.4%)	15.2 (1.45.1)	5	34.11	÷. ž	o	~ : :	•	· · · ·
	Shear Strongth	y	(3) ************************************	8.5 8.8	(n. 48)	0.58	× 2,41 (×2,48)	\$ 0,5) (30,06)	\$6.7° (0.7° (0.7° (0.7°)	2.5 2.5	**************************************	A	
	Axial Straft	у -	61	*. *	į	r. g		or or		0.5	-		٠
ndo Dam	At Steady State Firective Axial Minor Prine Strafu	ofpol Stress	(2) Hg 'cm'		5.43 (24.17	0.57	7 2.82 (74.48)	> 11,63 (>11,94)		67.1 (36.1)	9.73 (15.2.8)	4.55	2.63 (3.10)
Lower San Fernando Dam	Shear	,	ky (cm.)	£ ;	1.24	. 68	8	× 0,89	<u>.</u>	G:	\$	÷,	÷.
Lower	Friction Angle	ŝ.	를 등 -	*** ***	5°* 5	5. 5.	٠. د.	35.7	<u>x</u>	π. ~	·		\$. 2.
	Short Axfal F	÷	e8]	€.	₹ ₹.	£		n: m: n:	**************************************	₹. 1	311, 1	**	x 2 7.
	Short	<u>-</u> 2-	(L)	£ ;	÷	5.0	8.7°		€ •	.	7		÷.
	Ellocifice Chacfidation Stross	15 15	्र हा अ अ		ē -:	e 2	· •	ă:		ż	<u>.</u> .	· · · · · · · · · · · · · · · · · · ·	ē
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TABLE F4 - R AND S FESTS ON BATCH MIX 7 ISOFROPIC CONSOLIDATION Lower San Fernando Dam

Ax1.41	Strain Rate		%/mtn	·:	5. t
Pote	Pressure Pressure Coefficient	ച് ജ	(*)	/6°C	76*0
. r 20	Pressule	<u>ु</u> इ			÷
	Friction	9	deg kg cm.	45.0	2.13
	Shear Strength	$^{ m S}_{ m ds}$	(4) kg/cm ²	28.4 1.27 (1.20)	6.37 (7.36)
ady State	Axial	ž	9.4	28.4	19.2
At Ste	Stress Minor Print Strain Street Axial Shares Aires Minor Print Strain Street	Sp Sb Sb Sb	ì	1.14(7)	7.0 (8) (10.91)
	Shear	z _A	(1) kg/cm ²	55:1	Ĩ:
	tog Sbear Axial Friedom Stress Strata Angle	a g	Kap	*. **	
At Peak	Axial	j.	: ::	X.	
	Stress	j.	(E)	<u> </u>	
etter ciye	Consolidatios Stress		1.61 1.61 1.61	i i	
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 $\tau_{\rm dec}$ in this steady state shour arrently $(q_{\rm s})$ and $q_{\rm s}$ is the remarks equal 1.951 $\gamma_{\rm LS}$ derived from the geometry at the Marris (i. le and $q_{\rm s}=3.2$

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is a first factor of the elements of prompts. Without in parentheses equal Libbing, for Leel from the geometry of the Mohils effecte and $\phi_{s} \approx 36\%$.

ر د به	20 € 08 40 €	(P)	\$ ***	5.83	69°0	÷.	0,73	•	**************************************	4 L • E	94.°	
Mo € I × cM	Axial Strain Rate	\$/m/n.	<u> </u>	4	46.0	Š.	<u>.</u>	-	3	3 3	Ť	
والمراجع والمعارف	Settle lent	έ,	%*°€	?	\$	÷		3	÷	•		
* .003	Pressure	k1/cm ²	£ 3.	4.50	.8.	G/ **	î.	7. 60°.	5. m	? *	5.50	
	fefetfon Angle		ı	55.6	ŧ	1	55.5	ı	37,1	34.5	1.53	
	Shear strengts	(5) hq/cm ²	9,72(4)	5.80	J. 28 [4]	9,75(4)	6,78 10,501	े <u>.</u> 44(4)	0.49	0.44	0,25	
ealy state	Axfalls Strals	- 1	ı	0.41	1	•	0. HI	ı	25.0	1.1	74.0	
¥1 14	Struck When from Strate (1981) (1981)	101 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1	6)	6,73	(4)	2	(8 4. 0)	Ę	0,62)	3,41 (3,64)	0,34	
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(7) upper ligm of specimum accidentally densitius delay cutius into returning presented is average for specimen and is tigher transitional to shear. given of specimen. (4) $q_{\rm c} \approx 3.00 \, \rm GeV$, a grain of $q_{\rm c} \approx 3.00 \, \rm M_{\odot}$

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Maximum Cyclic Strain (3)	3.447	3.113	ж т т	3.05	æ
Mo. of Load Cycles Applied	\$\frac{1}{2}	5.5	9.0	3.5	11.5
	×		3.00.5	10.30	7. .
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Project Bounds September 7, 1987

TABLE F8 - DESCRIPTION OF TRIAXIAL TEST SPECIMENS - UNDISTURBED SAMPLES LOWER San Peinando Dam

Page 1 of 5

Remarks		Specimen bulged at Clayey Silt. Grain size analyses performed on a) 1.5 cm silt portion and b) 2 cm fine sand portion.	Grain size analyses on Bot. 9.5 cm.	Grain size analyses on Top 9 cm.
Sample Descriptions	Stratified silty fine sand, fine sandy silt, and silt. Layers typically 0.5 to 2 mm thick, >50 layers.	Stratified silty fine sand. Clayey Silt. Predominantly fine sand. Stratified silty fine sand and fine sandy silt.	Sand, widely graded. Stratified fine sand, silty fine sand, and fine sandy silt. Some sandy layers contain occasional coarse- medium sand particles. Layers typically 0.5 to 2 mm thick, >50 layers.	Stratified very fine sand and silty fine sand. Layers typically <1 mm thick, >50 layers.
Ѕаш	Stratified sistif, and silt, and silt, to 2 mm thick	Top 5 cm: Next 1.5 cm: Next 2 cm: Bot. 4 cm:	Top 3 cm: Bot. 9.5 cm:	Top 9 cm: Bot. 2 cm:
Sample Length After Testing	13.0	12.5	12.5	C
Sample:	TS302	TS203	TS116	TS1C2
Boring No. or Exploration Shaft(ES)	ES	ES	S S	ਲ ਨ
Triaxial Test No.	ı~	2 Sa:	R1 3	α 3

Geotechnical Engineers Inc.

TABLE F8 - DESCRIPTION OF TRIAXIAL TEST SPECIMENS - UNDISTURBED SAMPLES LOWER San Fernando Dam

Page 2 of S

Remarks			Grain size analyses on Top 7 cm.		Grain size analyses on Top 8 cm.
Sample Descriptions	Stratified very fine sand, silty fine sand, and fine sandy silt. Top 7 cm is intensely stratified. Middle 2 cm contains silt lenses and occasional coarse-medium sand. Bottom 5 cm contains occasional fine gravel, coarse-medium sand, and is less stratified.	Stratified itne sund, silty fine sand, and fine silt. Occasional medium sand. Middle 3 cm is predominantly silty fine sand.	Top 7 cm: Stratified fine sand, silty fine sand, and fine sandy silt. Layers typically <0.5 mm thick, >50 layers. Bot. 1.5 cm: Silt.	Silty fine sand to sandy silt. Two 5 mm thick layers of fine sand at top. Numerous 0.5 to 1 mm laminae of very fine sand.	Clayey, sandy silt. Sand is fine grained. Several lenses of fine sand up to about 5 mm in diameter.
Sample Length After Testing	\$	8.3	8.5	8.9	80 •
Sample No.	UF19C	TS309A	TS306B	UF3C	0 61 0C
Boring No. or Exploration Shaft(ES)	(11 1 1 A	E.S	R S	£01n	5010
Triaxial Test No.	<u>د</u> ای	18 6	787	88	1 <u>5</u>

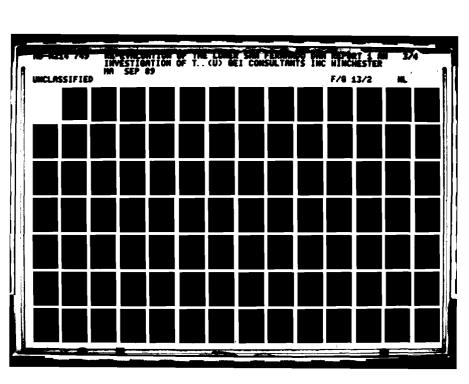
Geotechnical Engineers Inc.

Table f8 - Description of Triaxial Test Specimens - Undisturbed Samples Lower San Fernando Dam

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Remarks	Grain size acalyses on Top 8 cm.				Grain size analyges on bottom 6 cm.	
Sample Descriptions	Top 8 cm: Silty, rine sand with several laminae of siltier sand about 2 cm from top.	Silty fine to medium sand. Mostly fine sand. Occasional pieces of fine gravel and coarse sand. Sand is subangular.	Stratified silt, fine sandy silt, silty fine sand, and fine sand. Layers typically 0.5 to 2 nm thick, >50 layers.	Stratified Bilt and fine sandy siit. Numerous 0.5 to 2 mm thick laminae of very fine sand. Estimate >50 layers.	Stratified fine sand, silty line sand, sandy salt, and silt. Sandier layers predominate in top 2 cm. Swirl patterns evident in bottom 6 cm.	Stratified fine sand, silty fine sand, sandy silt, and silt. Occasional coarsemedium sand particle. Layers typically 0.5 to 2 mm thick, >50 layers.
Sample Length After Testing	٠. ٥.	9.5	6. 0	B. O	7.2	8.3
ample No.	TS207A	TS103	TS315	TS314	UF14D	UELOD
Bering No. or exploration Shaft(ES)	50 36	ж Ж	ES	ES	0111A	Ullia
Test No.	<u>2</u> 2,2	ж 	Z Z	- <u>ar</u> 	:7 	-

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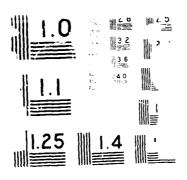


TABLE F8 - DESCRIPTION OF TRIAXIAL TEST SPECIMENS - UNDISTURBED SAMPLES
Lower San Fernando Dam

Page 4 of 5

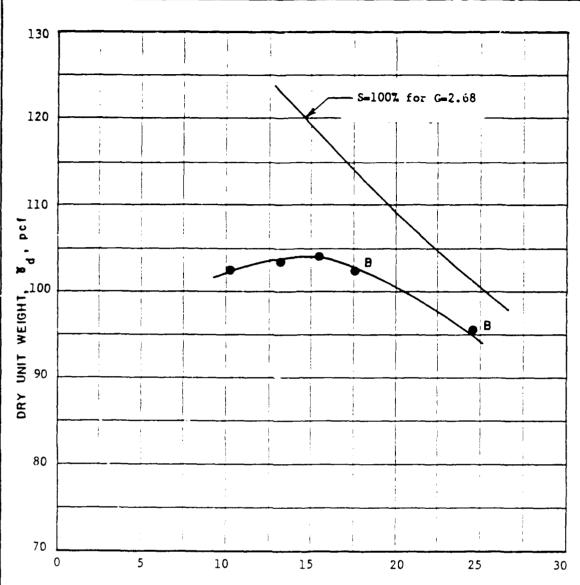
Remarks		Grain size analyses did not include silt inclu- sions.	Grain size analyses on Mid. 2.5 cm.			
Sample Descriptions	Silty fine sand. Occasional lenses of silt. Occasional medium sand particle. Relatively little stratification.	Fine sandy silt at top grading to silty fine sand at bottom. Top contains inclusions of silt about I to 1.5 cm in size. Faint stratification evident.	Top 2.5 cm: Stratified silty fine sand. Pid. 2.5 cm: Stratified clayey silt. Bot. 2.5 cm: Intensely stratified silty fine sand and sandy silt.	Silty fine sand. Top 2 cm contains medium sand and occasional coarse sand. Relatively little stratification.	Silty fine sand. Occasional coarsemedium sand. Faint stratification.	Top 2 cm: Stratified silty sand and sandy silt. Layers typically 0.5 mm thick. Mid. 2 cm: Predominantly silty sand. Bot. 2 cm: Predominantly sands
Sample Length After Testing	7.2	7.7	7.5	8.6	8.5	0.9
Sample No.	UF20D	UF21A	UF23B	UF3B	UF19A	TS3098
Boring No. or Exploration Shaft(ES)	UIIIA	U111A	1110	U103	UIIIA	ES.
Triaxial Test No.	R16	RIT	R18	<u>R</u> 19	<u>R</u> 20	CKR1

TABLE F8 - DESCRIPTION OF TRIAXIAL TEST SPECIMENS - UNDISTURBED SAMPLES
Lower San Fernando Dam

Page 5 of 5

Remarks			Specimen failed in top portion. Grain size analyses on Top 2 cm.	
Sample Descriptions	Stratified silty fine sand and fine sandy silt. Mostly silty sand, several very fine sand laminae. Layers typically 0.5 to 2 mm thick.	Sand, widely graded. Mostly fine sand. About 8% silt.	Top 2 cm: Silt to Clayey Silt. Occasional fine sand laminae. Two clay laminae <0.5 mm thick. Bot. 6 cm: Stratified silty fine sand and fine sandy silt.	Sand, widely graded. Mostly fine-medium sand. About 11% silt.
Sample Length After Testing	7.3	8.6	0.8	8.7
Sample No.	TS306A	TS112	UF98	UF8B
Boring No. or Exploration Shaft(ES)	ES	ES	U111A	11110
Triaxial Test No.	CRR2	CRR3	CRR4	CRRS

Project 85669 September 2, 1987



WATER CONTENT AFTER COMPACTION, w, %

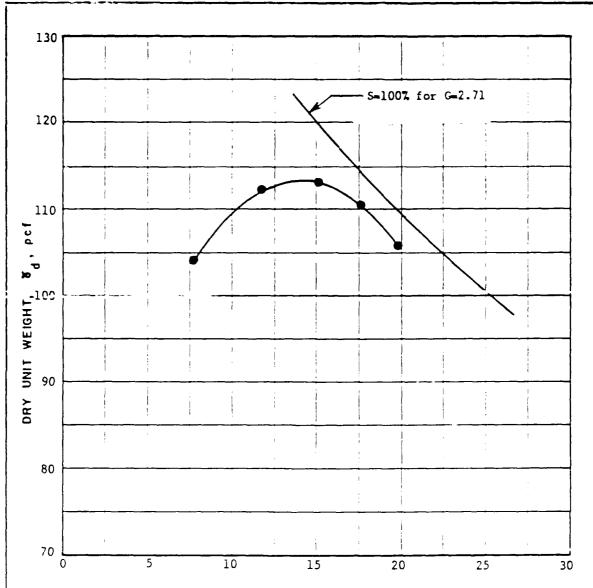
SOURCE OF SOIL: Exploratory Shaft

SOIL DESCRIPTION: Batch Mix 1; Bag Samples BS102, BS103, BS104; Silty Sand (SM)

COMPACTION PROCEDURE: ASTM D1557-78, Method A

NOTE: "B" indicates bleeding of water from base of compaction mold during compaction.

Army Corps of Engineers Vicksburg, Mississippi GEOTECHNICAL ENGINEERS INC.	Re-evaluation of Lower San Fernando Dam San Fernando, California	COMPACTION CURVE BATCH MIX 1	
WNO-ESTEP - MASSAC-LISETTS	Project 85669	Feb. 20, 1986 Fig. Fl	



WATER CONTENT AFTER COMPACTION, w, %

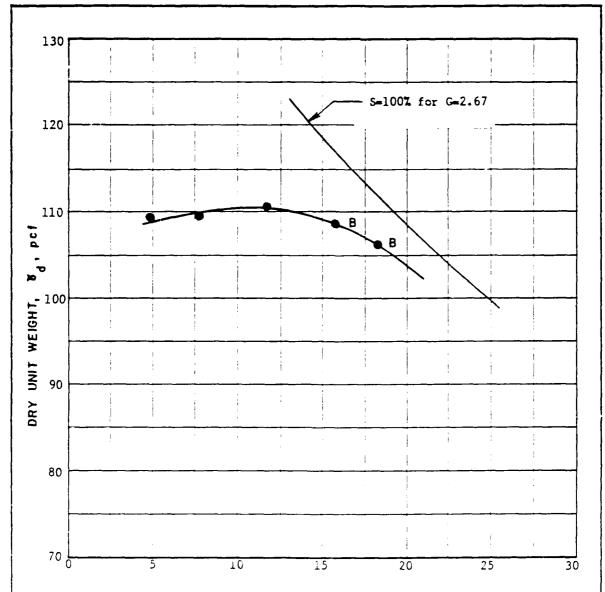
SOURCE OF SOIL : Exploratory Shaft

Batch Mi. Bag Samples BS105, BS106, BS107; SILT (ML-C... SOIL DESCRIPTION : Batch Mi.

COMPACTION PROCEDURE: ASTM D1557-78, Method A

NOTE: "B" indicates bleeding of water from base of

Army Corps of Engineers Vicksburg, Mississippi	Re-evaluation of Lower San Fernando Dam San Fernando, California	COMPACTION CURVE BATCH MIX 2
GEOTECHNICAL ENGINEERS INC	,	Feb. 20, 1986 Fig. F2



WATER CONTENT AFTER COMPACTION, w, %

SOURCE OF SOIL : Exploratory Shaft

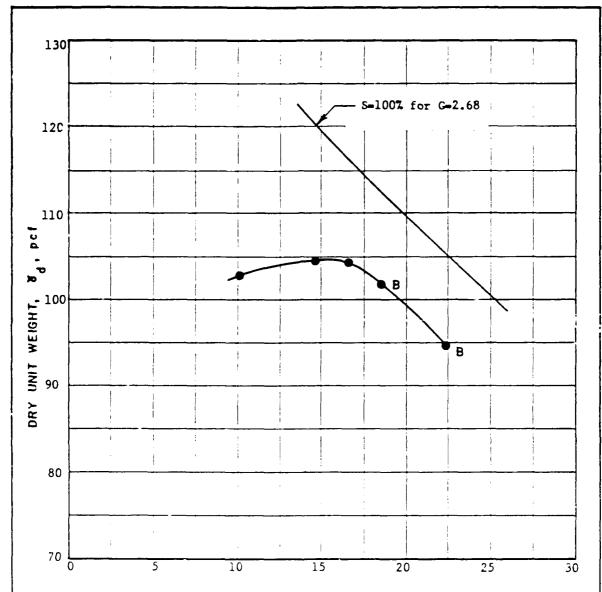
SOIL DESCRIPTION: Batch Mix 3; Bag Samples BS108, BS109, BS110;

Sand and Silty Sand (SP-SM)

COMPACTION PROCEDURE: ASTM D1557-78, Method A

NOTE: "B" indicates bleeding of water from base of

Army Corps of Engineers Vicksburg. Mississippi	Re-evaluation of Lower San Fernando Dam	COMPACTION CURVE BATCH MIX 3
GEOTECHNICAL ENGINEERS INC	San Fernando, California	
GEOTECHNICAL ENGINEERS INC.	Project 85669	Feb. 20, 1986 Fig. F3



WATER CONTENT AFTER COMPACTION, w, %

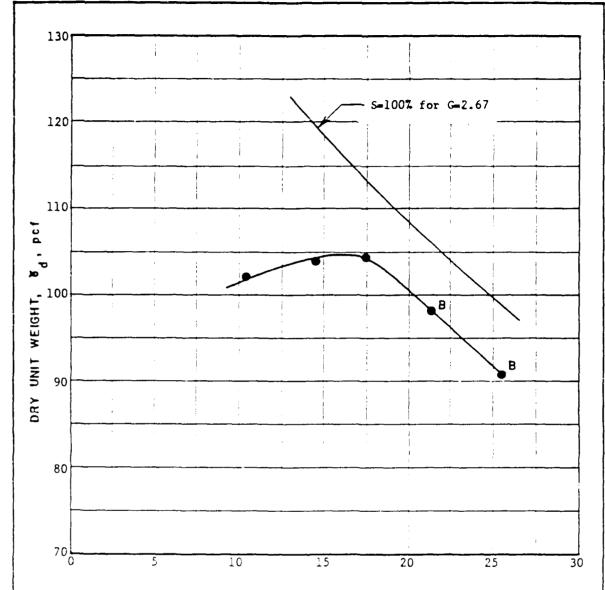
SOURCE OF SOIL: Exploratory Shaft

SOIL DESCRIPTION: Batch Mix 4; Bag Samples BS112, BS113, BS114; Silty Sand (SM)

COMPACTION PROCEDURE: ASTM D1557-78, Method A

NOTE: "B" indicates bleeding of water from base of

Army Corps of Engineers Vickshurg, Mississippi	Re-evaluation of Lower San Fernando Dam San Fernando, California	COMPACTION CURVE BATCH MIX 4
GEOTECHNICAL ENGINEERS INC.		
WNO-ESTER • MASSAD-LISETTS	Project 85669	Feb. 20, 1986 Fig. F4



WATER CONTENT AFTER COMPACTION, w, %

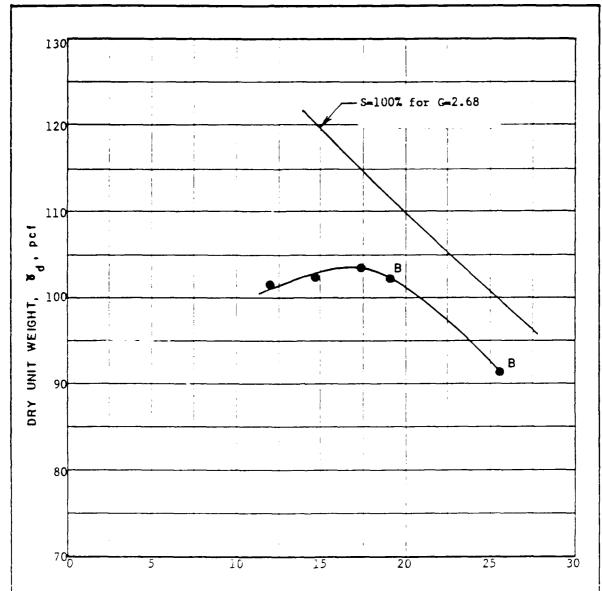
SOURCE OF SOIL : Exploratory Shaft

SOIL DESCRIPTION : Batch Mix 5; Bag Samples BS201 through BS205; Silty Sand (SM)

COMPACTION PROCEDURE: ASTM D1557-78, Method A

NOTE: "B" indicates bleeding of water from base of compaction mold during compaction.

Army Corps of Engineers Vicksburg, Mississippi	Re-evaluation of Lower San Fernando Dam	COMPACTION CURVE BATCH MIX 5
GEOTECHNICAL ENGINEERS INC	San Fernando, California	
WYCHESTED + MASSACHURETTS	Project 85669	Feb. 20, 1986 Fig. F5



WATER CONTENT AFTER COMPACTION, w, %

SOURCE OF SOIL: Exploratory Shaft

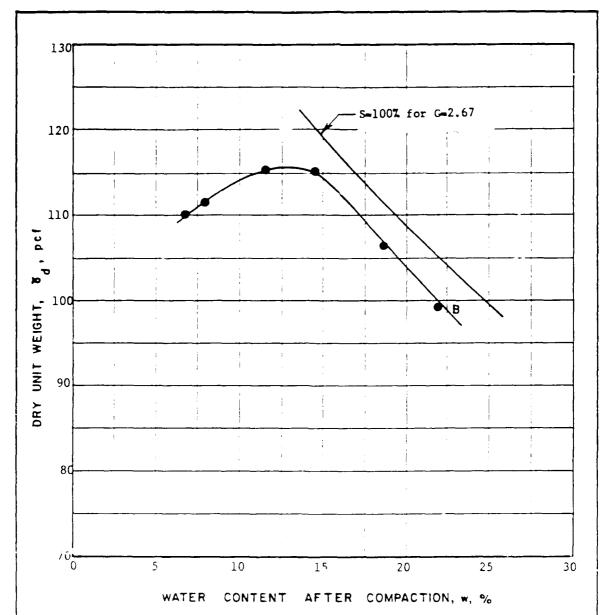
SOIL DESCRIPTION: Batch Mix 6; Bag Samples BS207 through BS210;

Silty Sand (SM)

COMPACTION PROCEDURE : ASTM D1557-78, Method A

NOTE: "B" indicates bleeding of water from base of

Army Corps of Engineers Vicksburg, Mississippi	Re-evaluation of Lower San Fernando Dam San Fernando, California	COMPACTION CURVE BATCH MIX 6
GEOTECHNICAL ENGINEERS INC	Project 85669	Feb. 20, 1986 Fig. F6



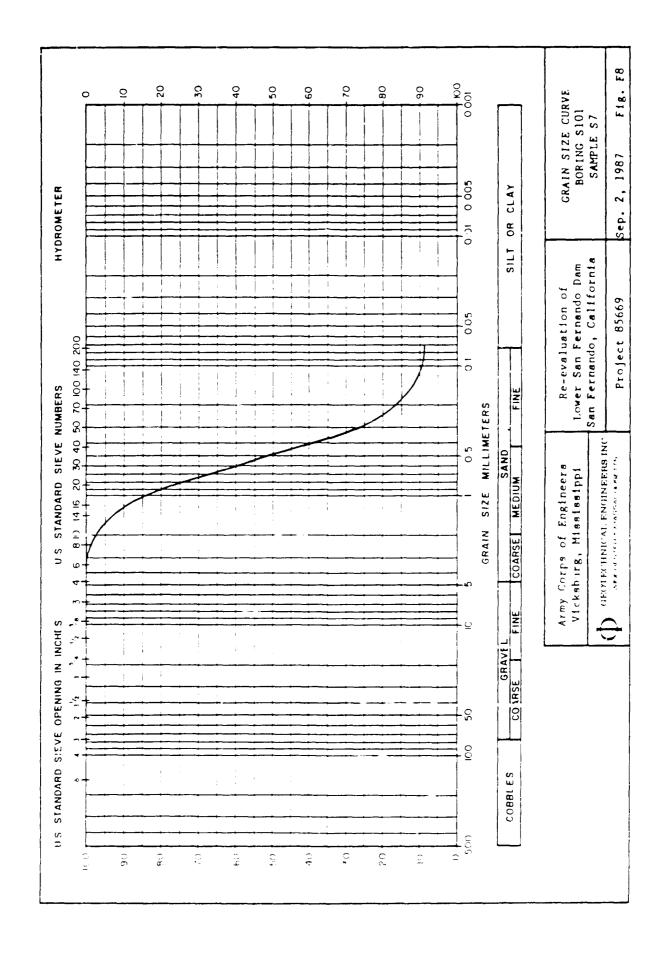
SOURCE OF SOIL: Exploratory Shaft

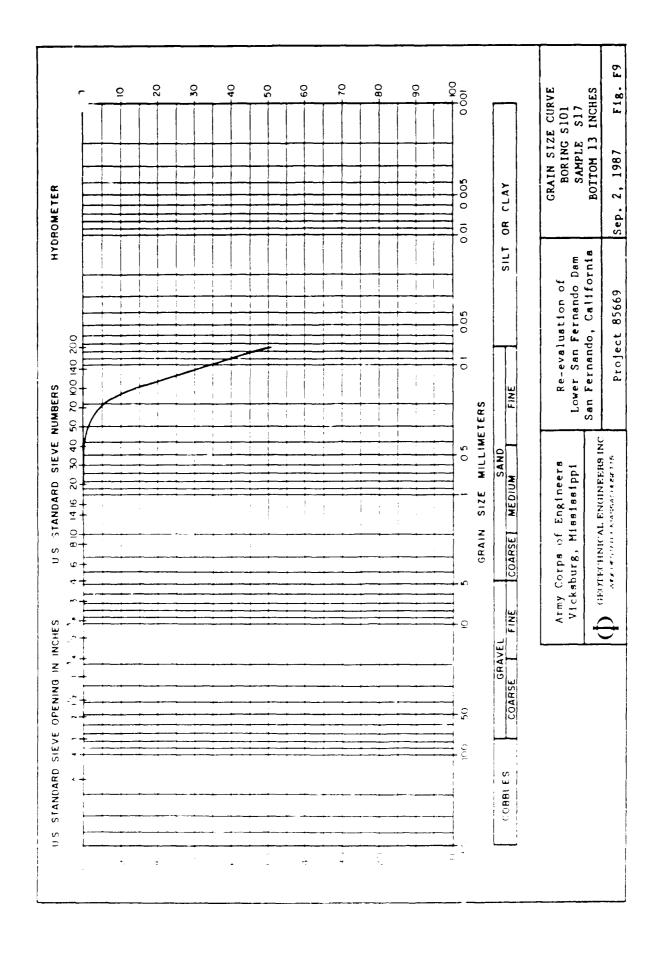
SOIL DESCRIPTION: Batch Mix 7; Bag Samples BS301, BS302, BS304, BS305, BS306, BS308, BS309, BS311; Sandy Silt (ML)

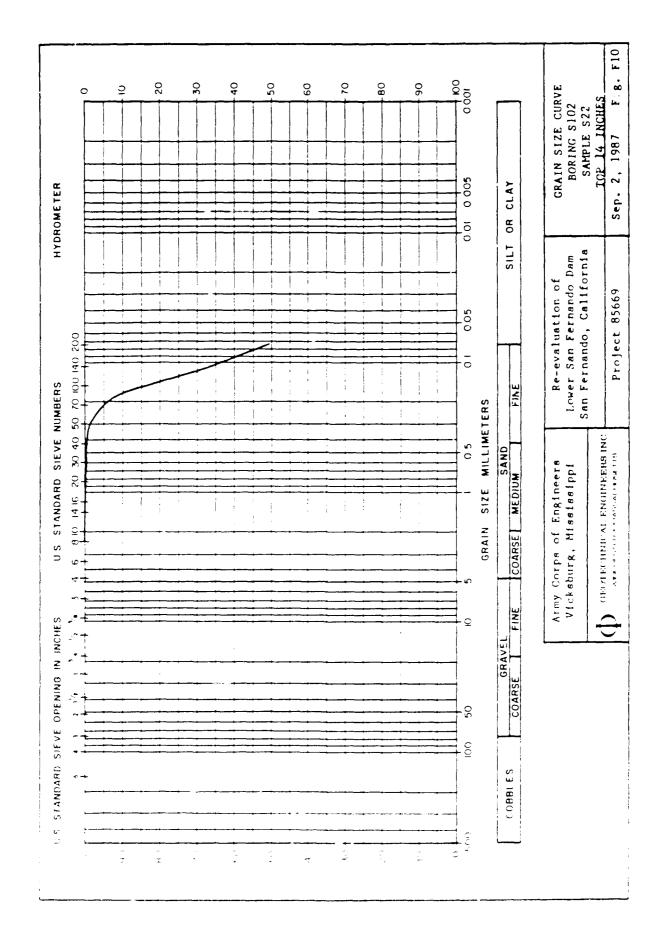
COMPACTION PROCEDURE: ASTM D1557-78, Method A

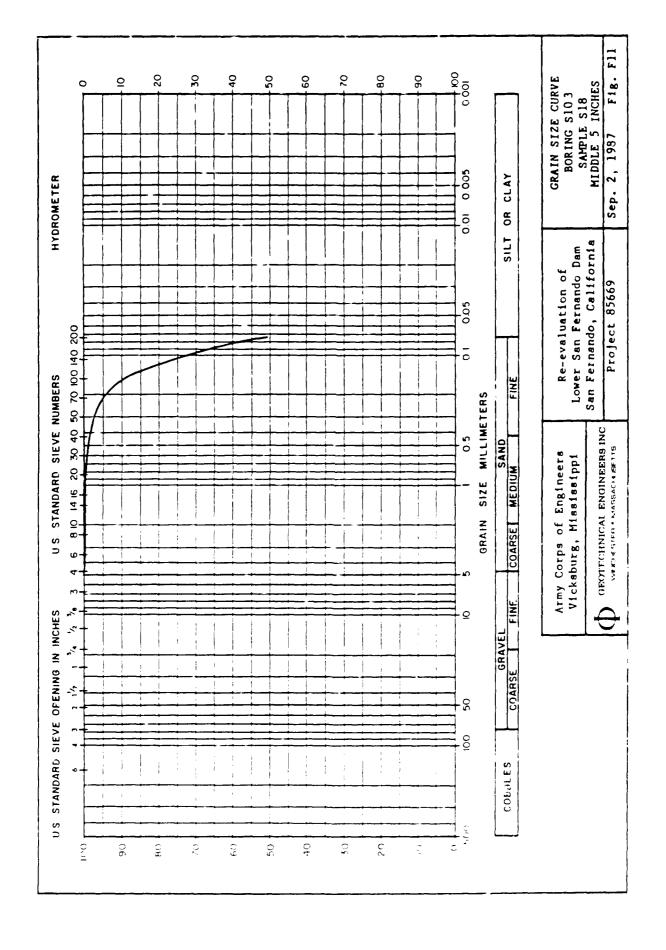
NOTE: "P" indicates bleeding of water from base of compaction mold during compaction.

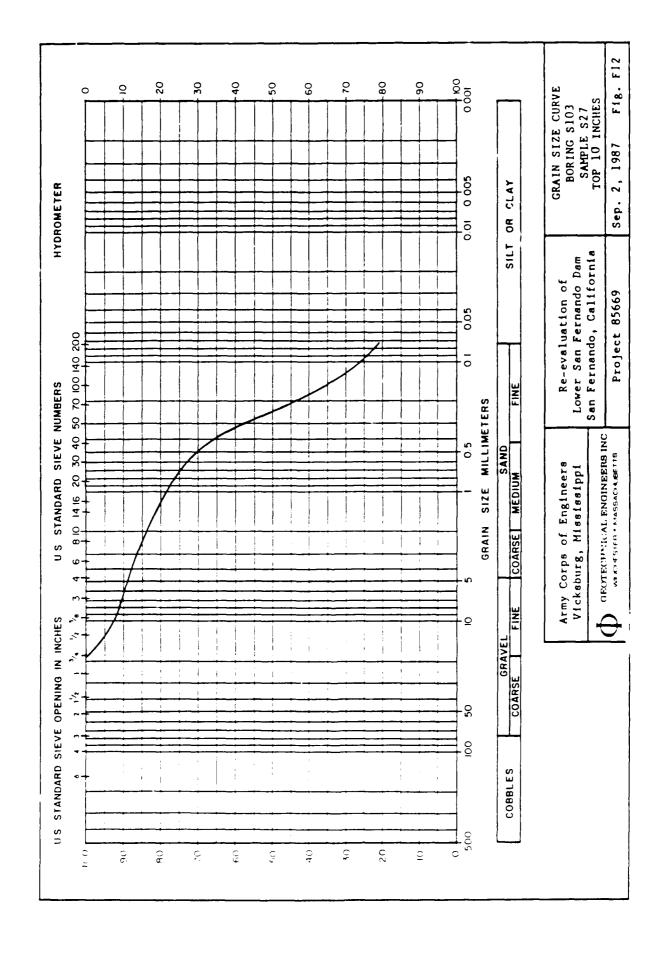
Army Corps of Engineers Vicksburg, Mississippi	Re-evaluation of Lower San Fernando Dam	COMPACTION CURVE BATCH MIX 7
GEOTECHNICAL ENGINEERS INC	San Fernando, California	
GEOTECHINICAL ENGINEERS INC	Project 85669	Feb. 20, 1986 Fig. F7

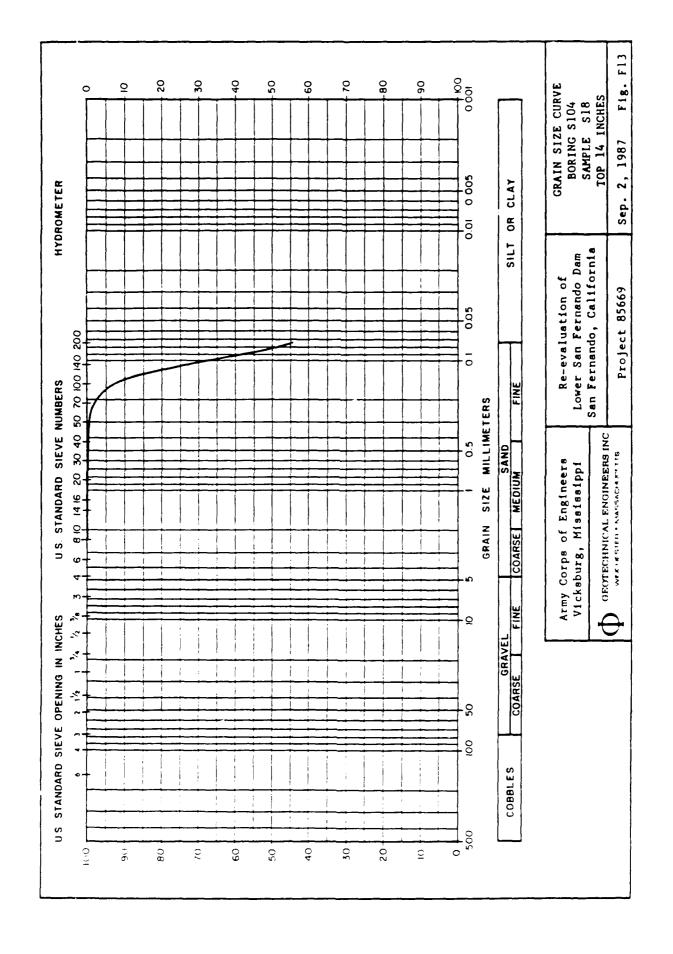


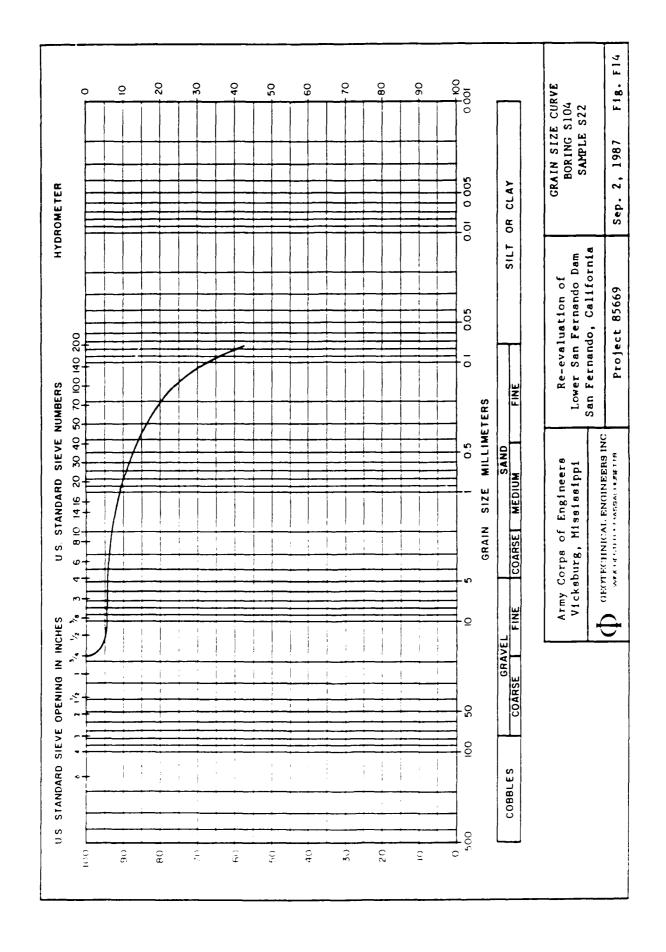


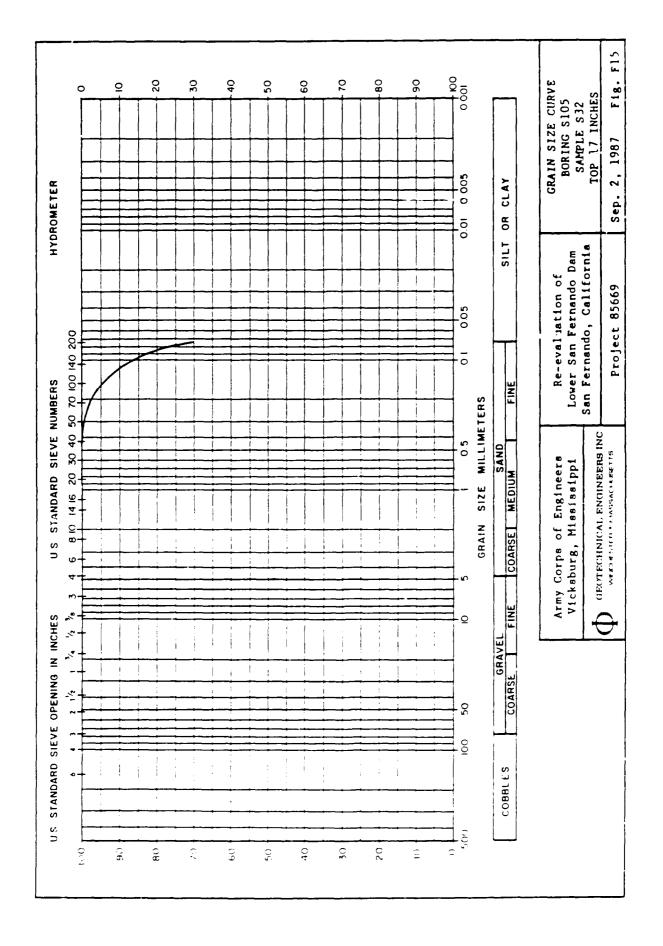


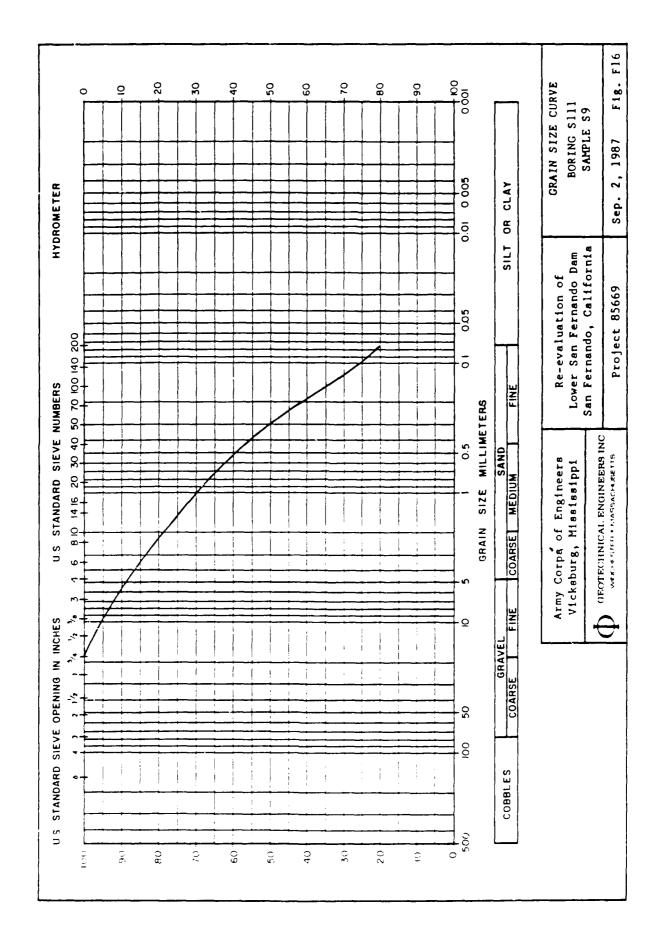


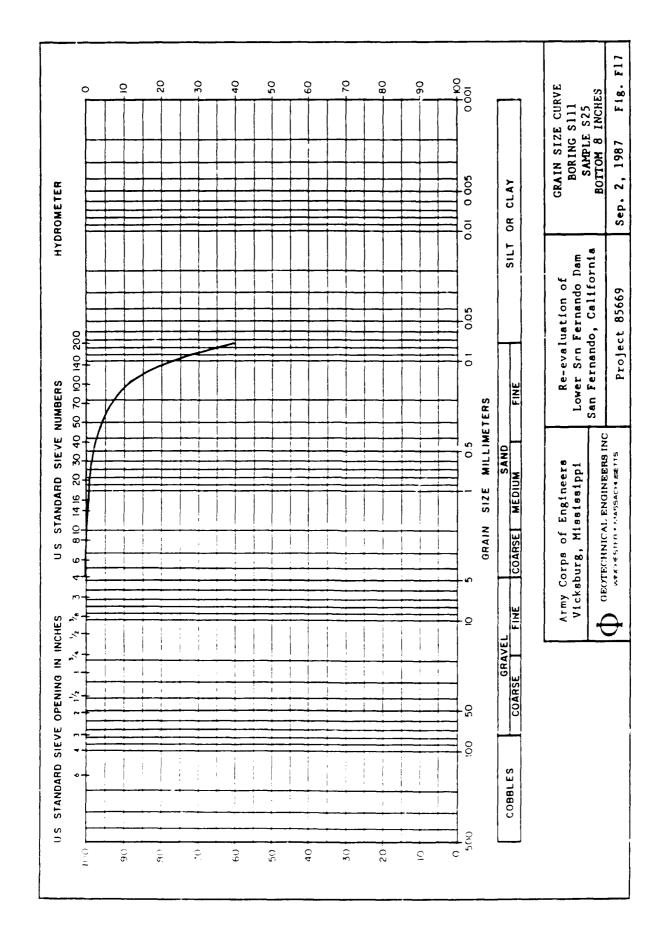


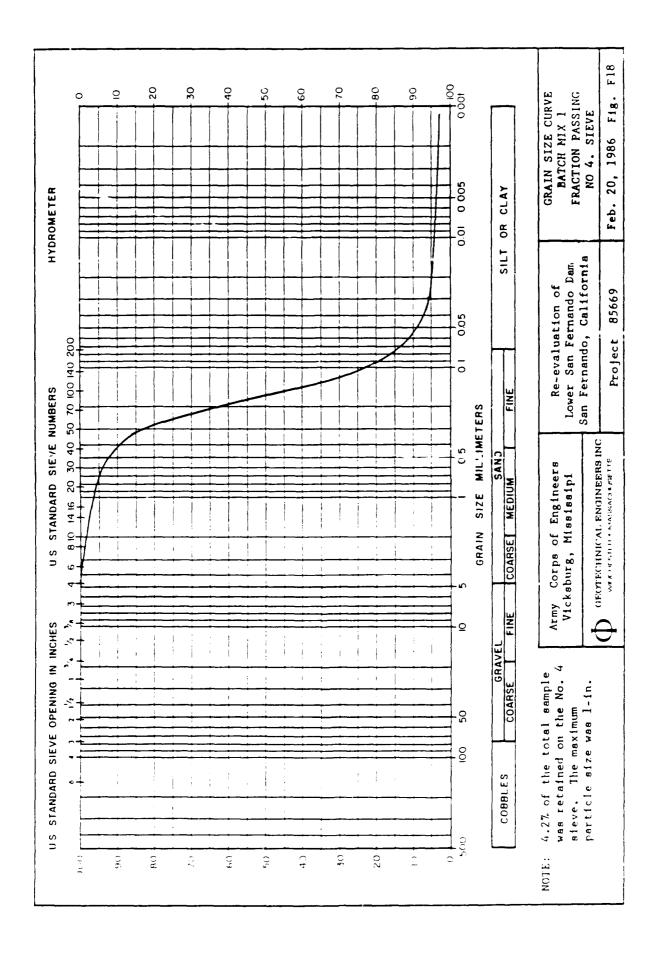


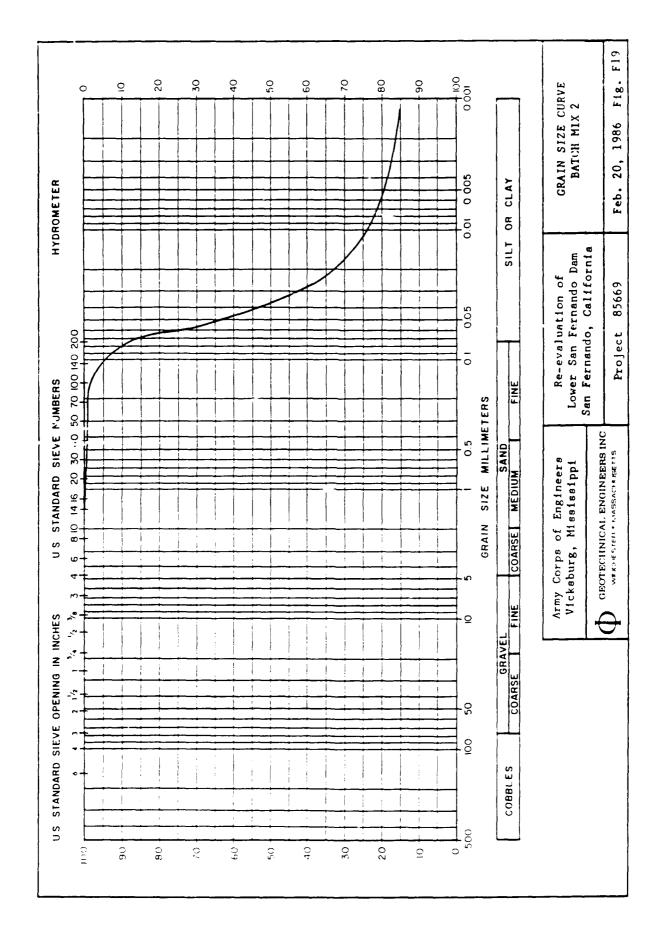


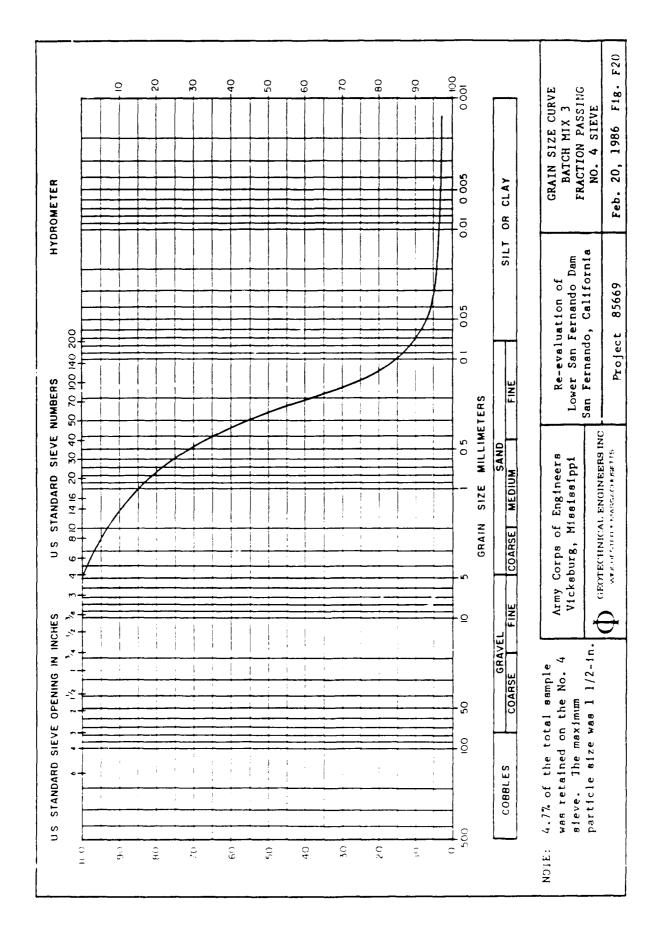


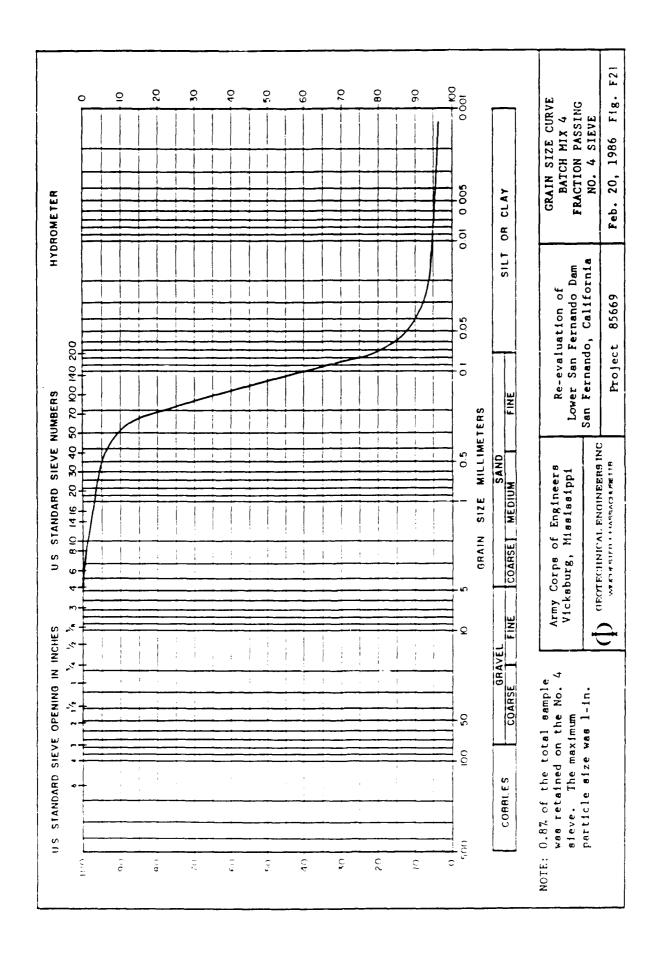


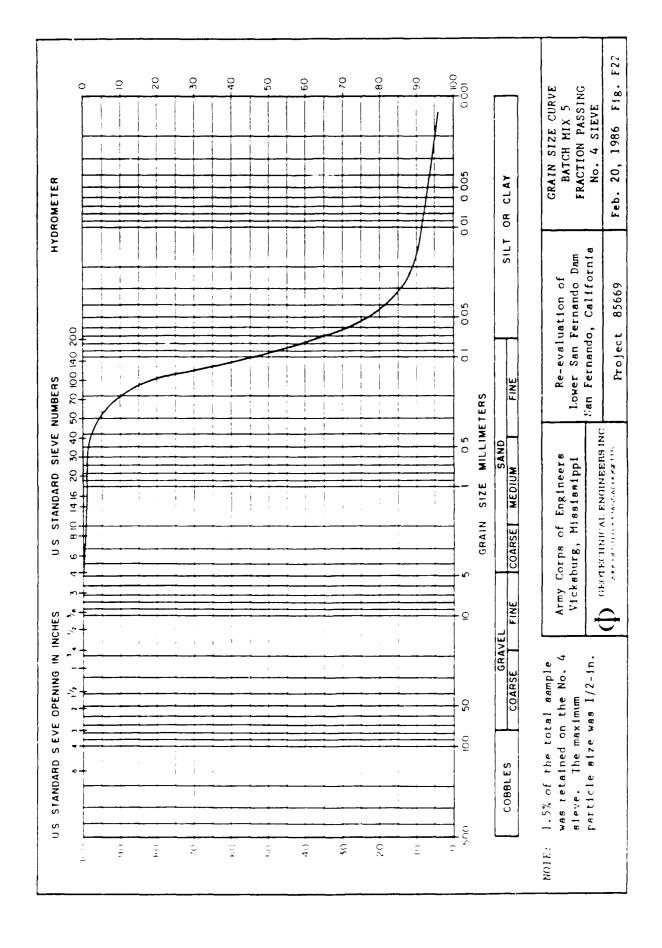


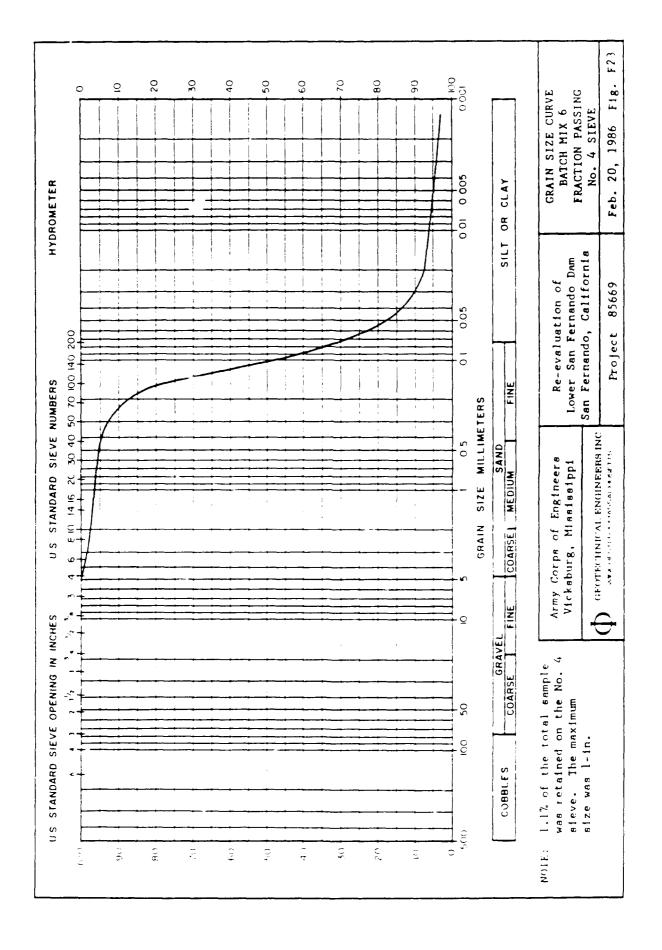


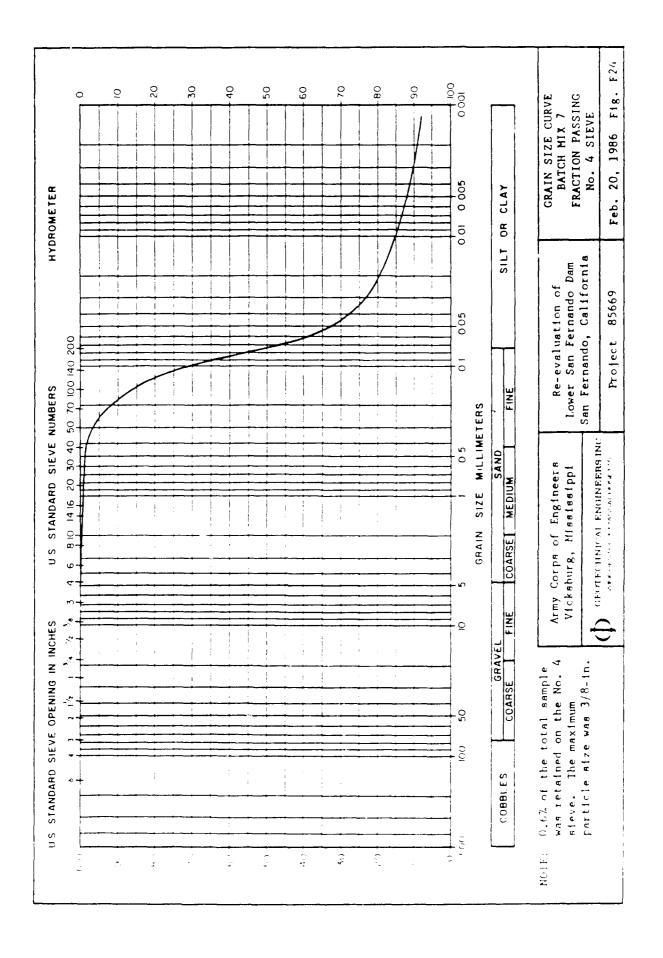


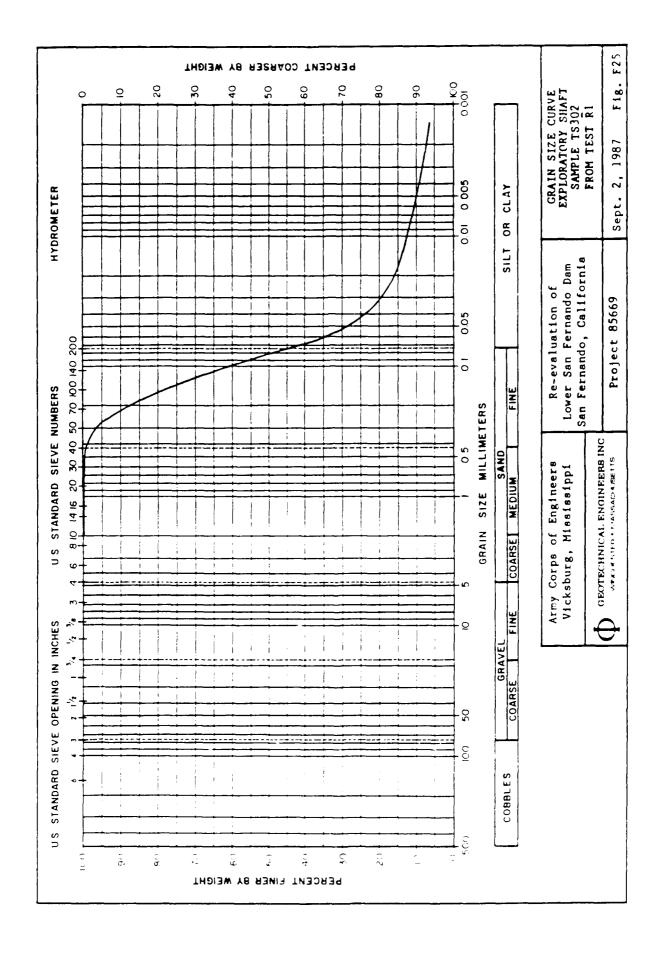


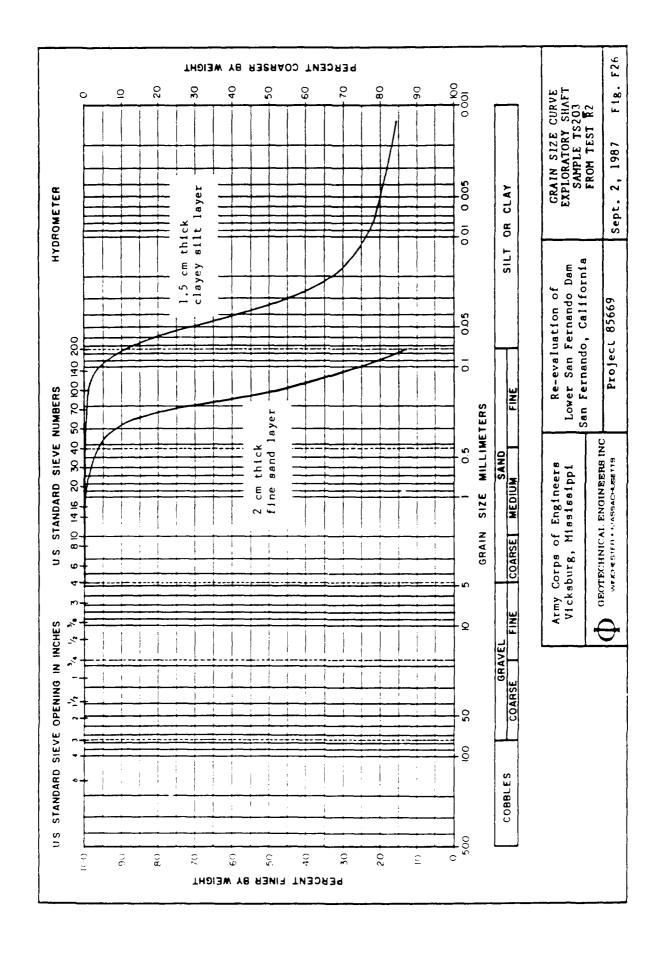


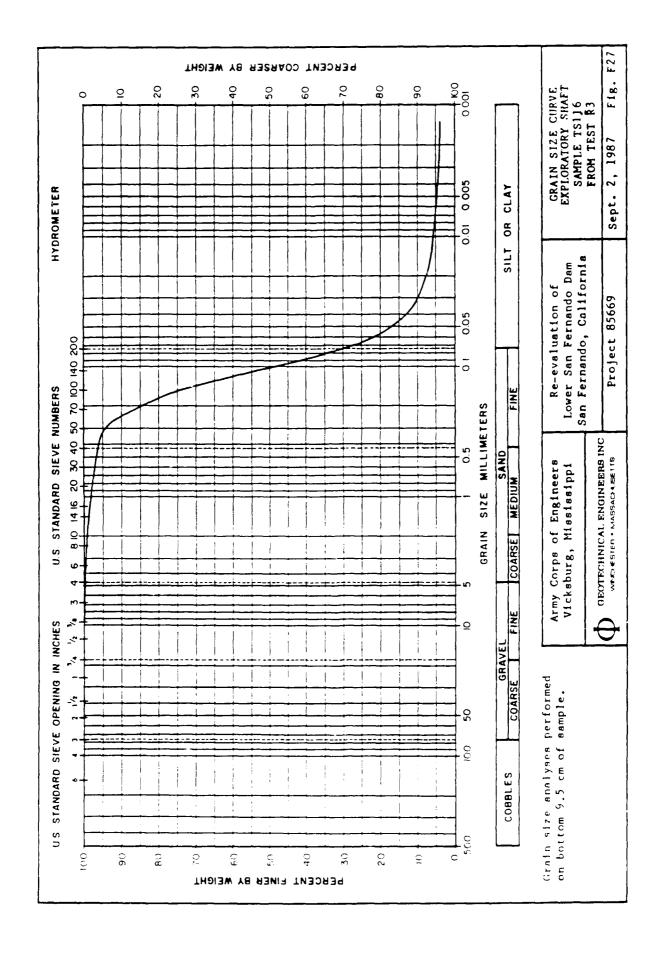


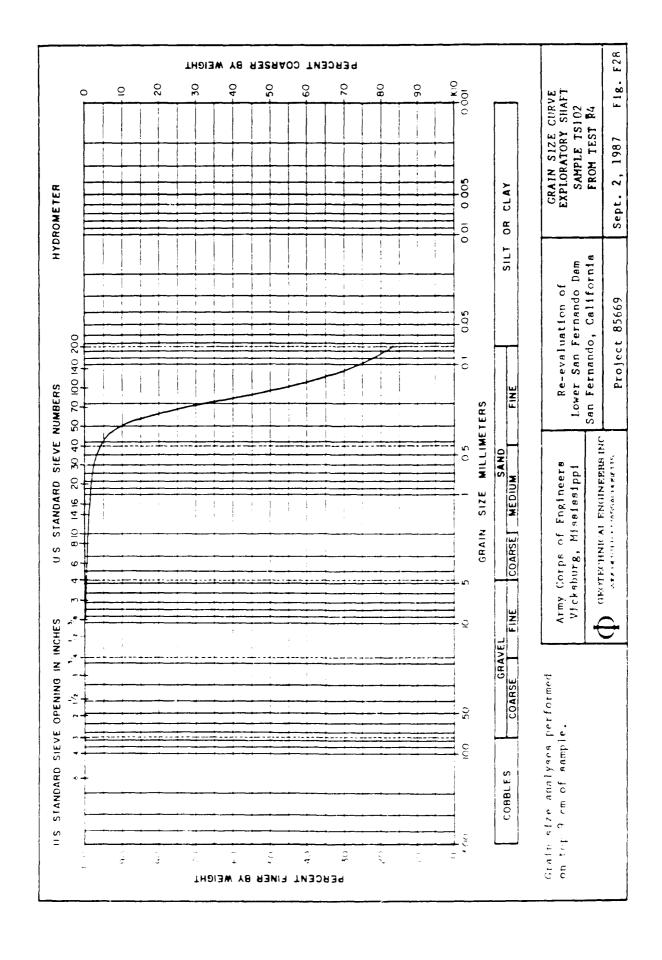


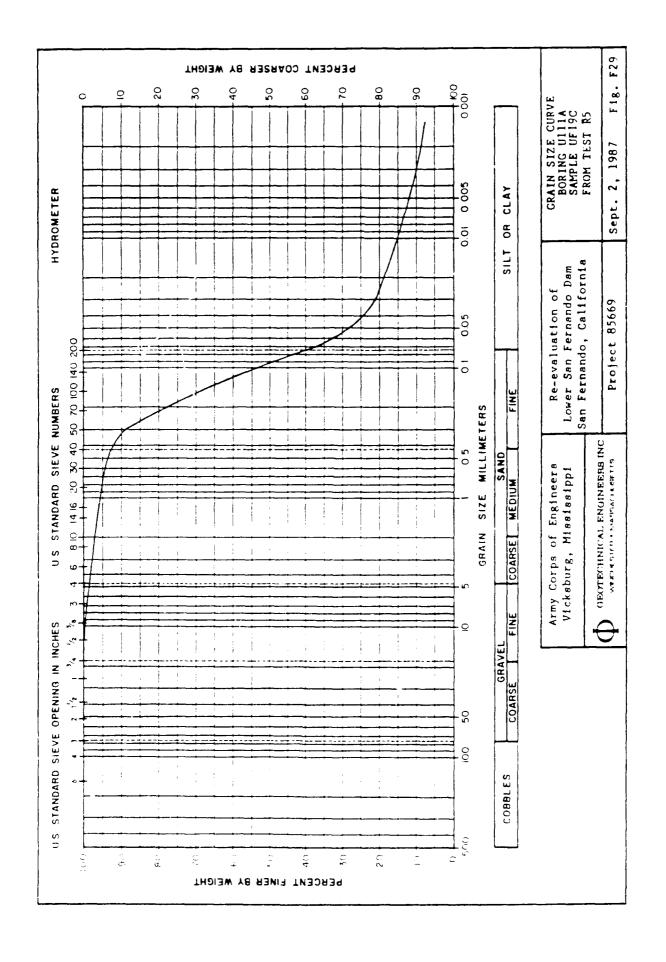


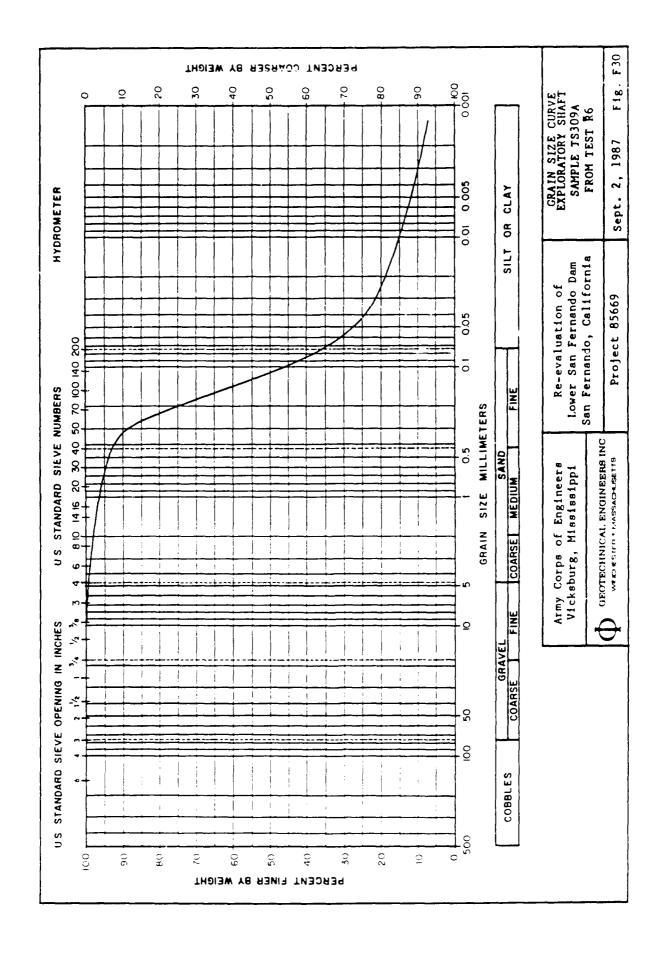


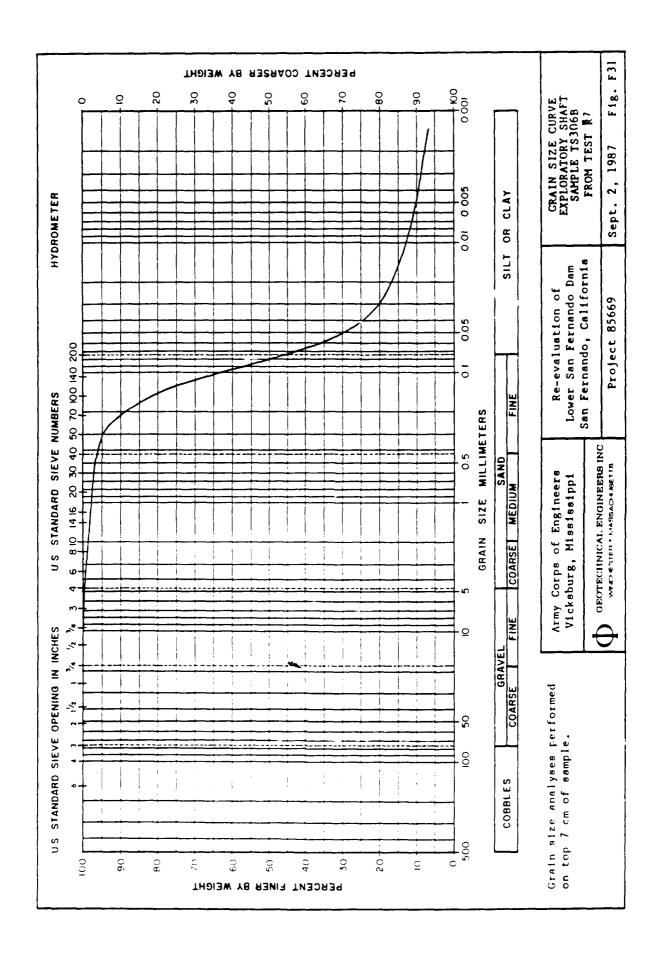


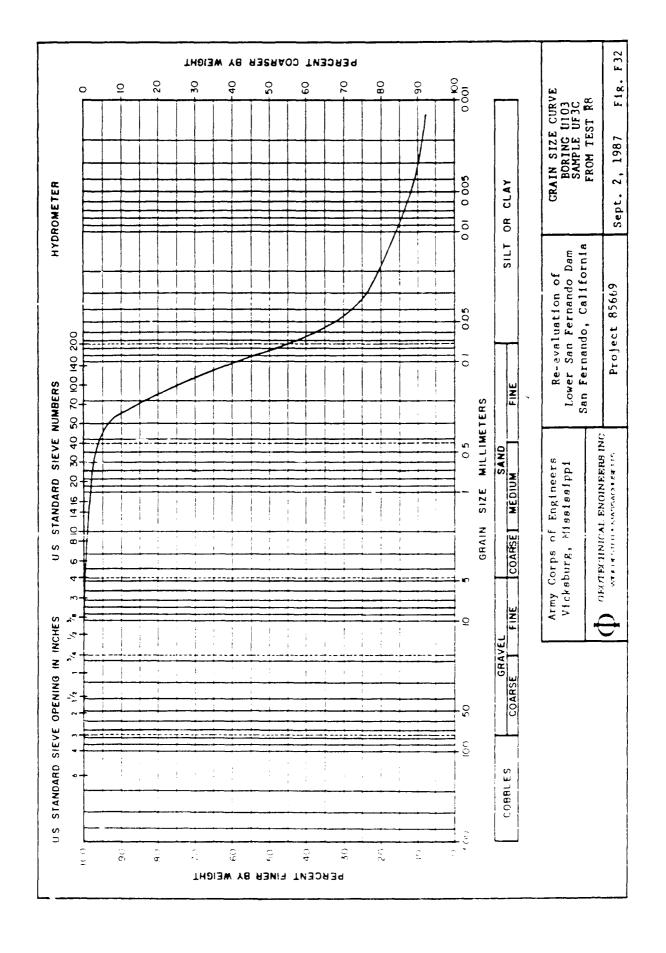


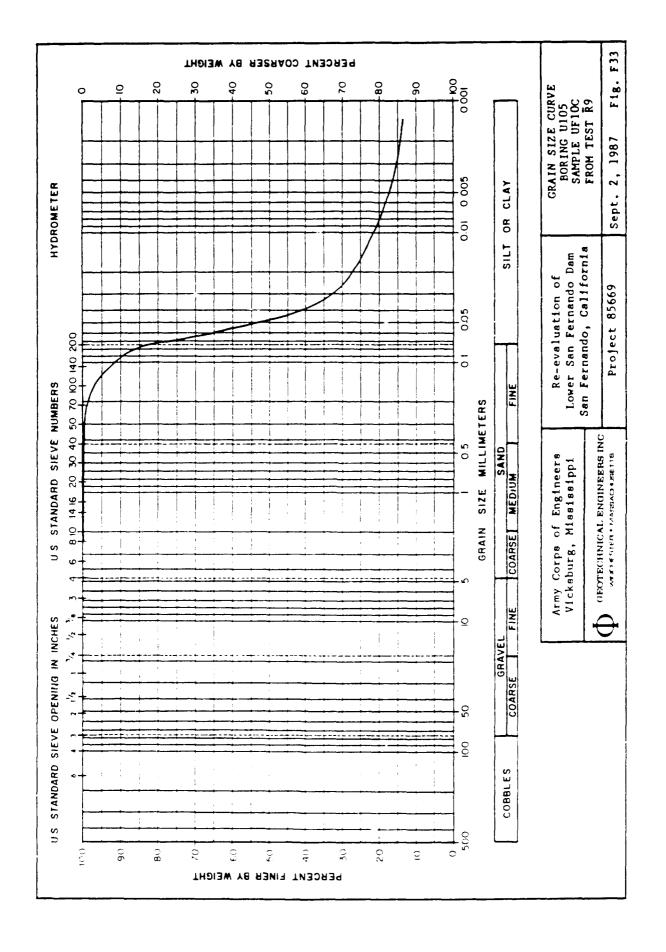


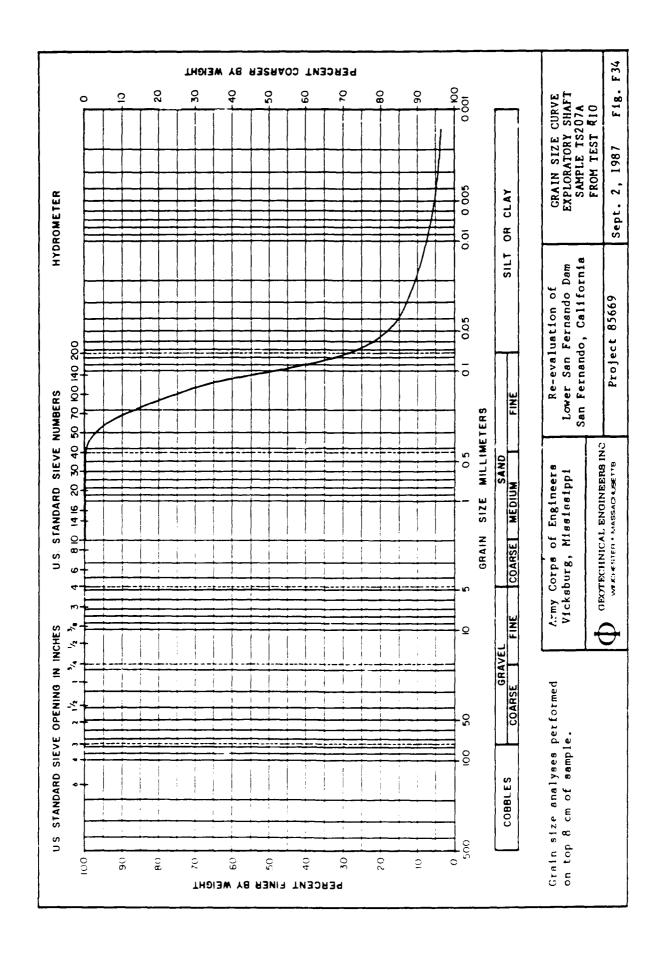


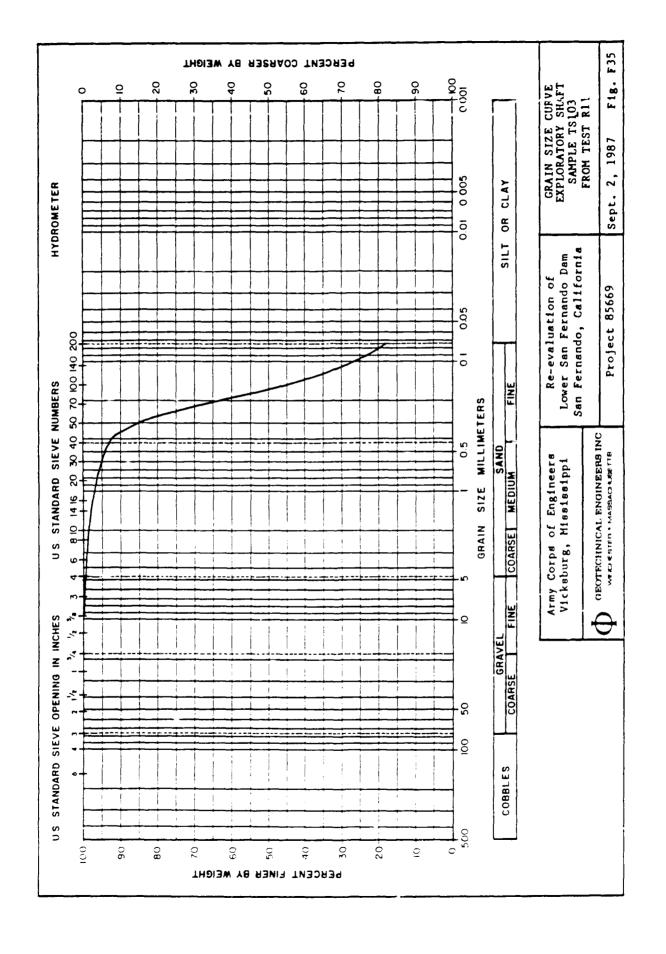


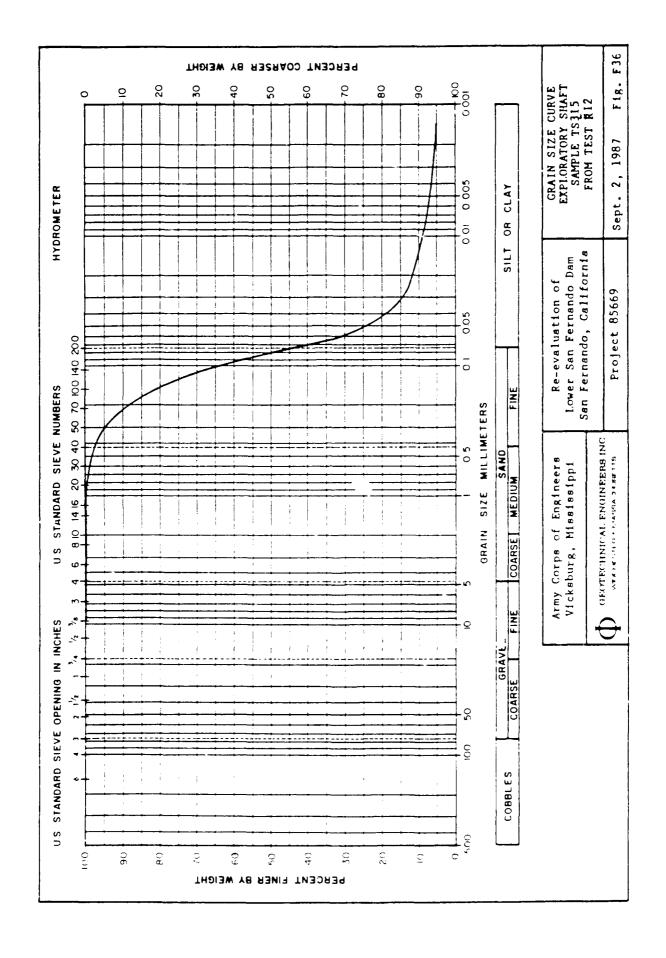


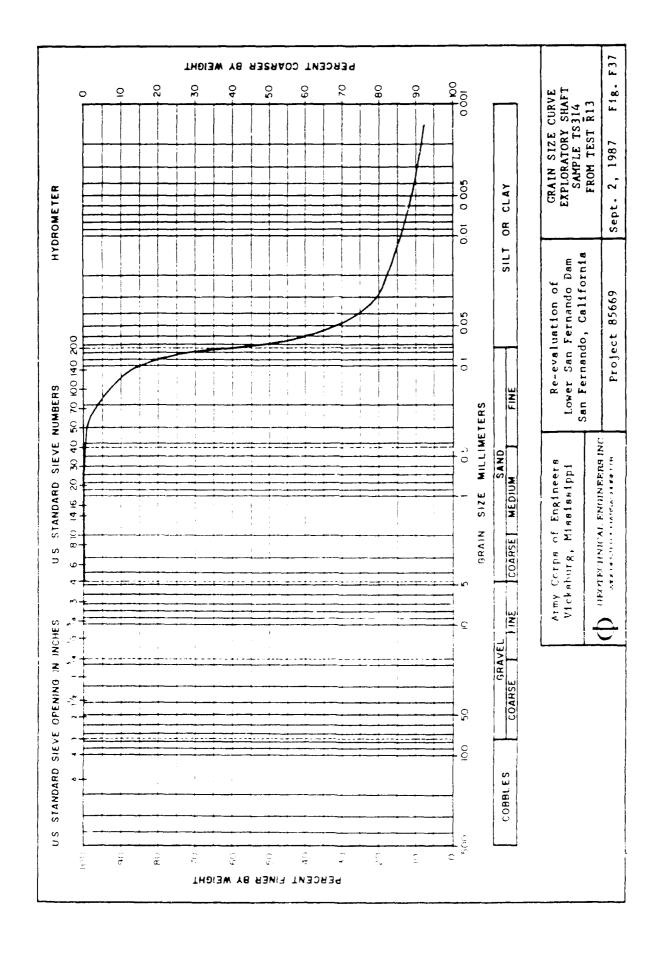


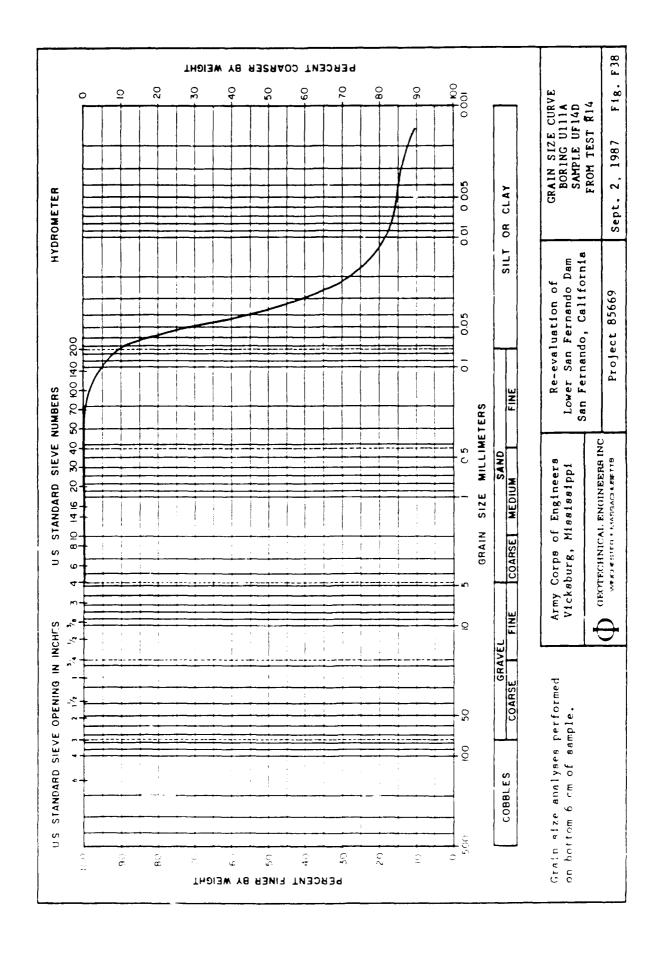


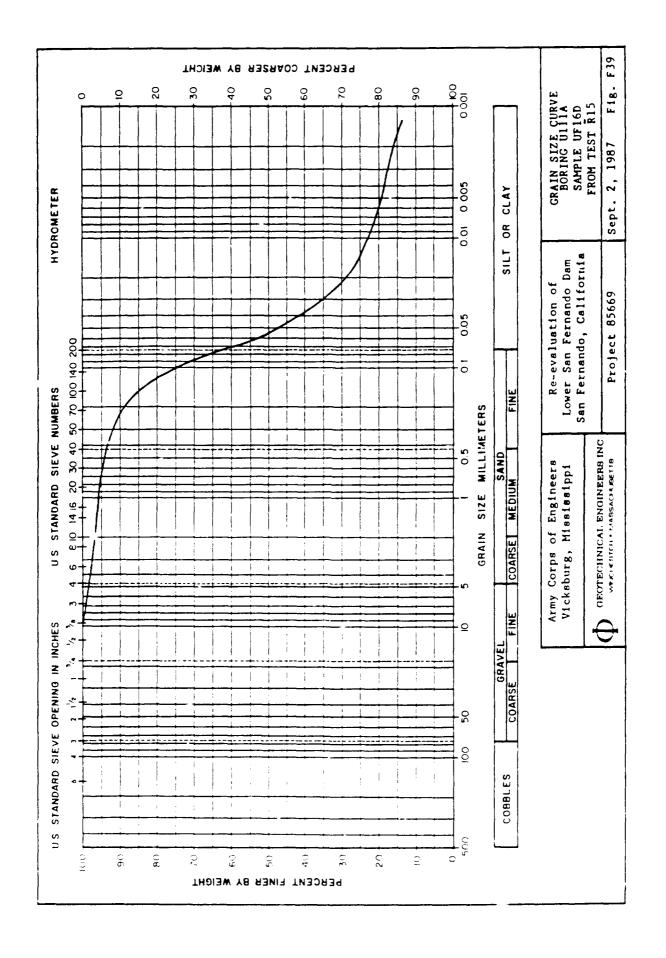


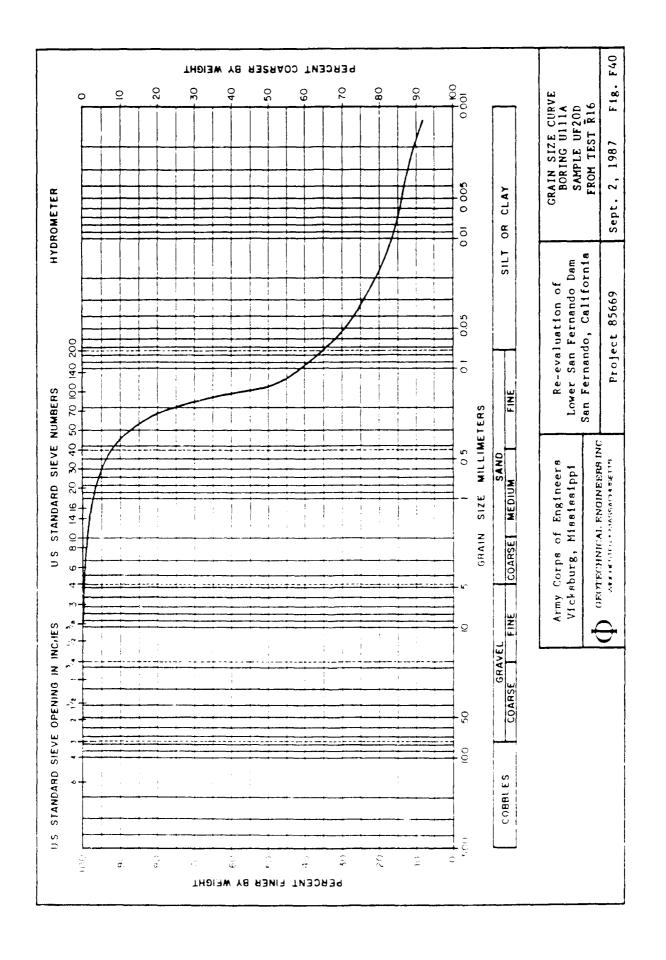


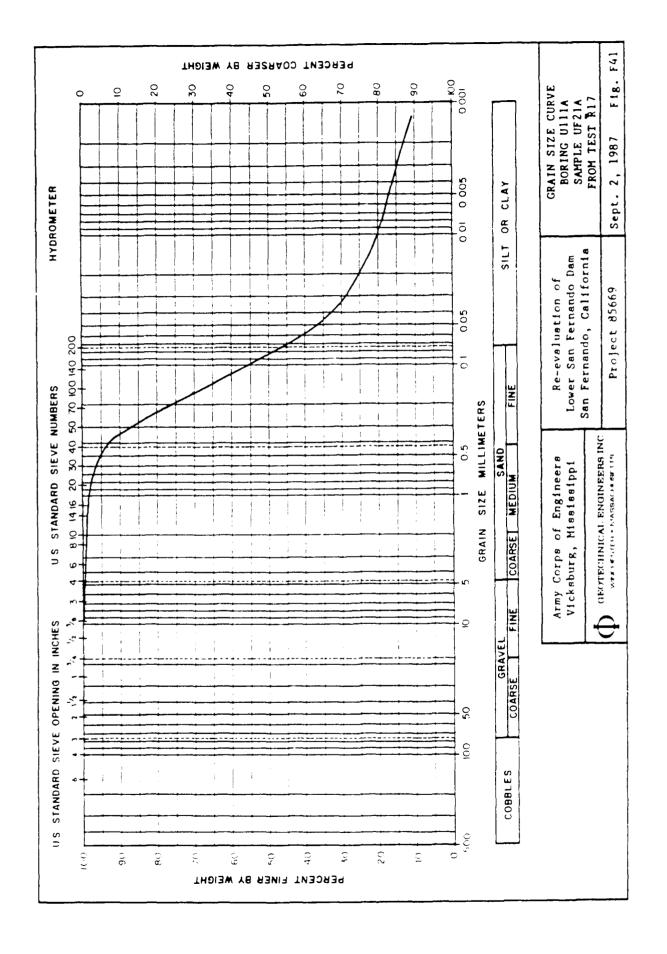


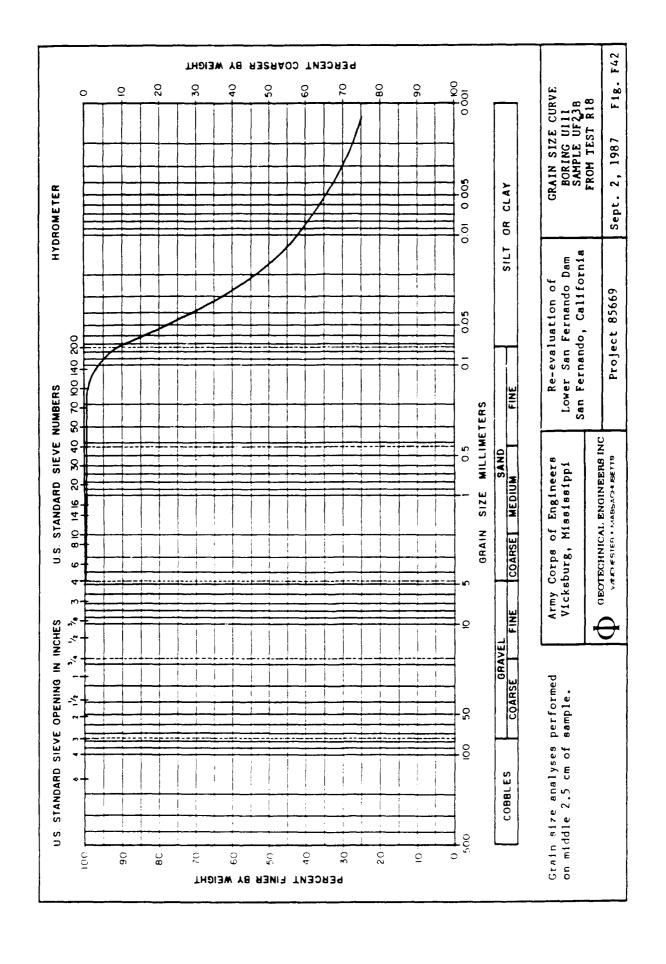


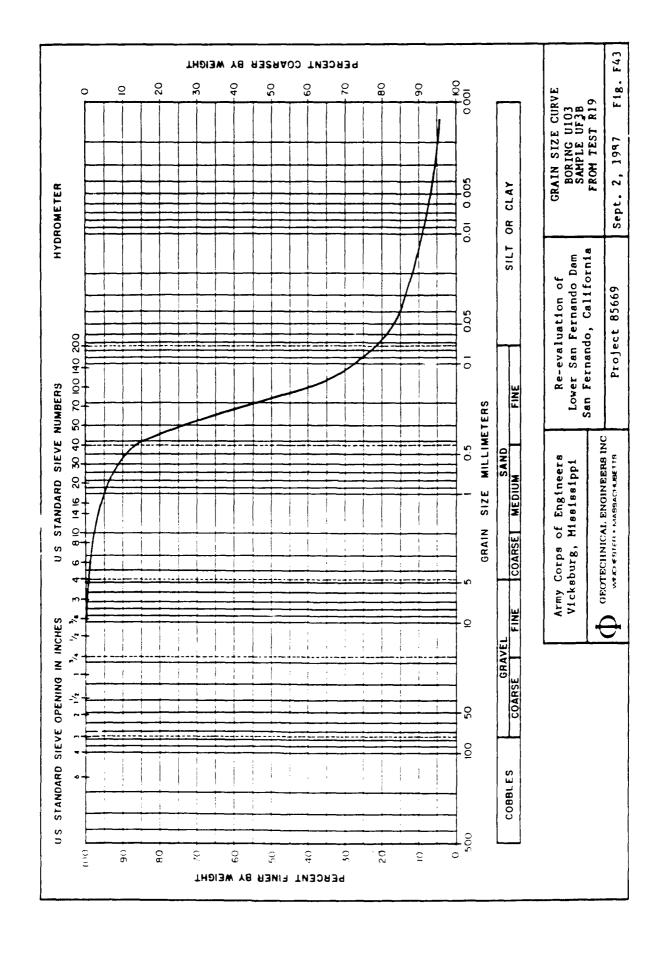


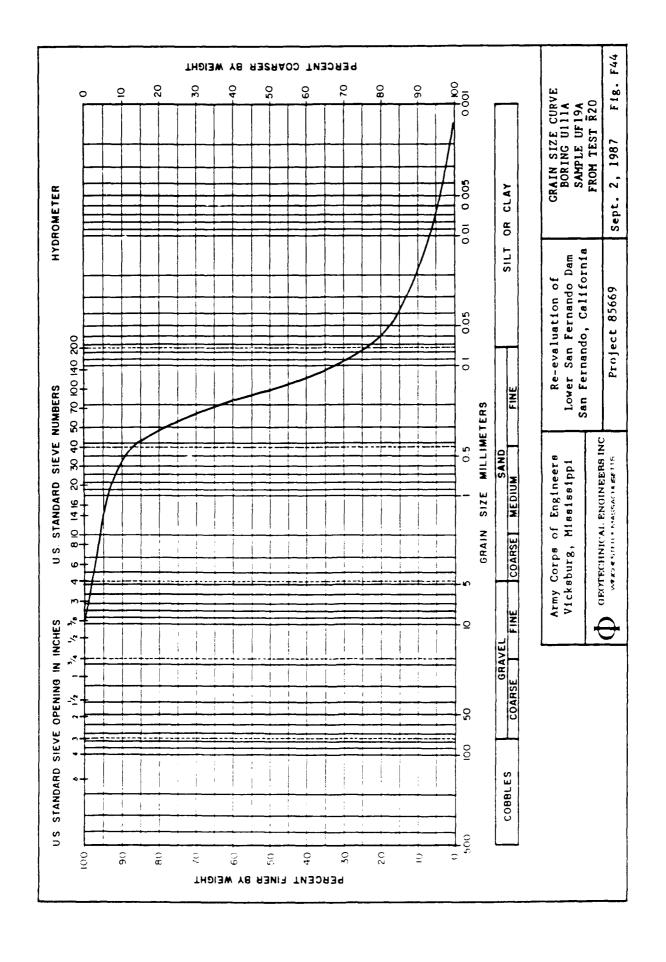


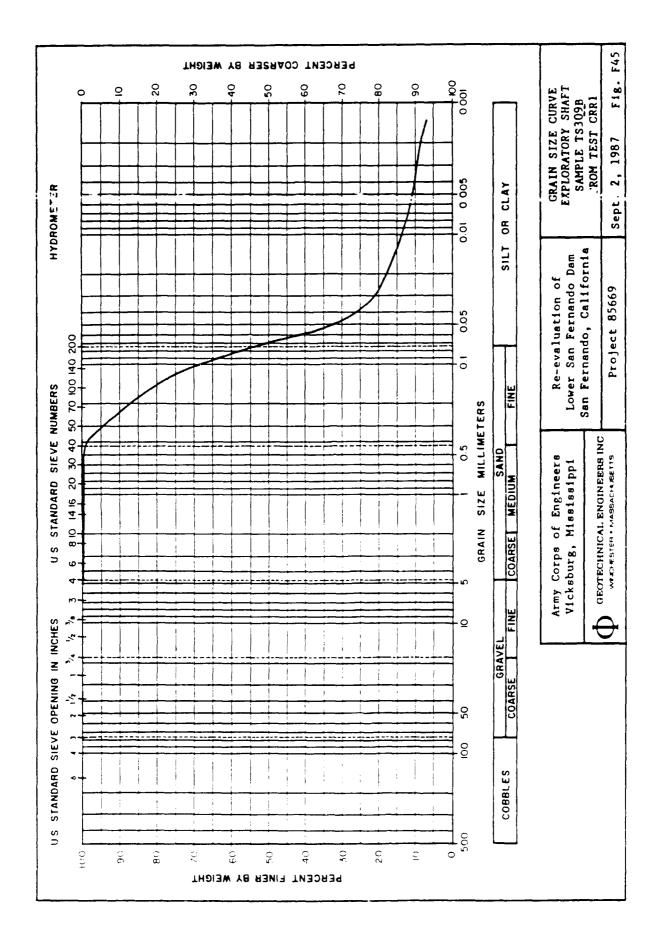


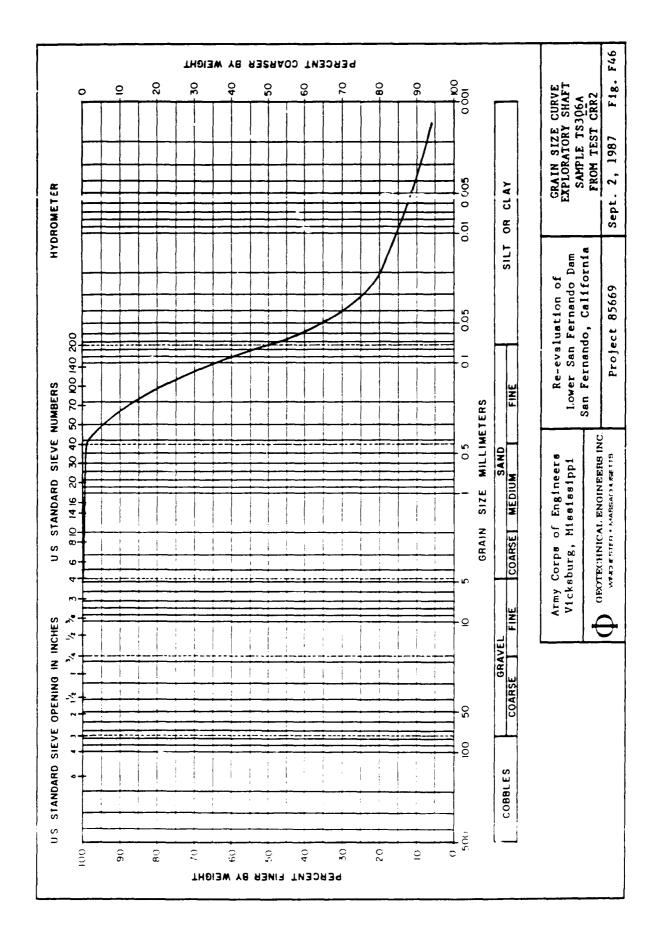


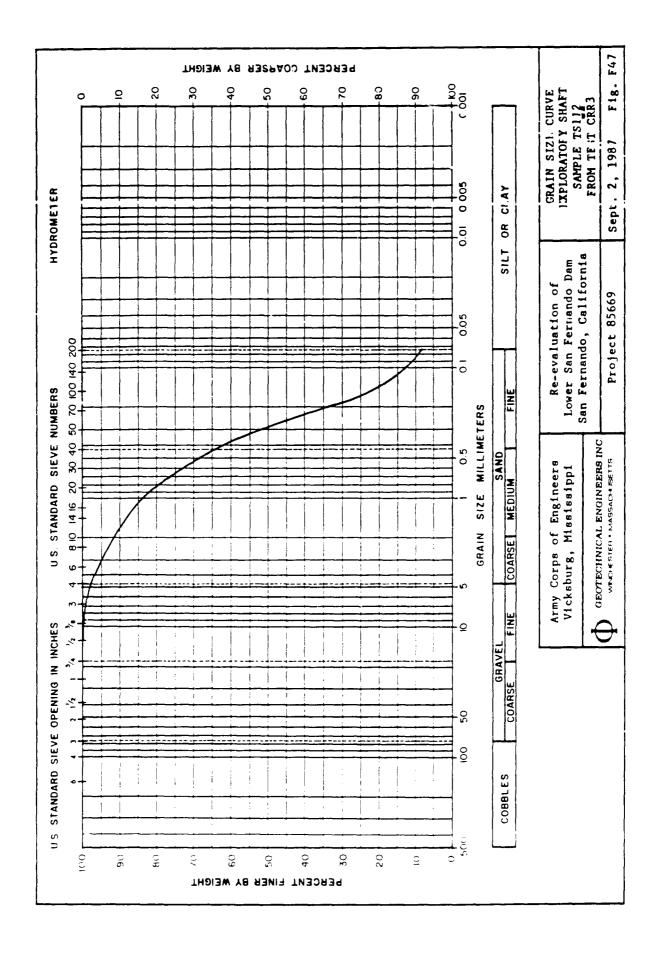


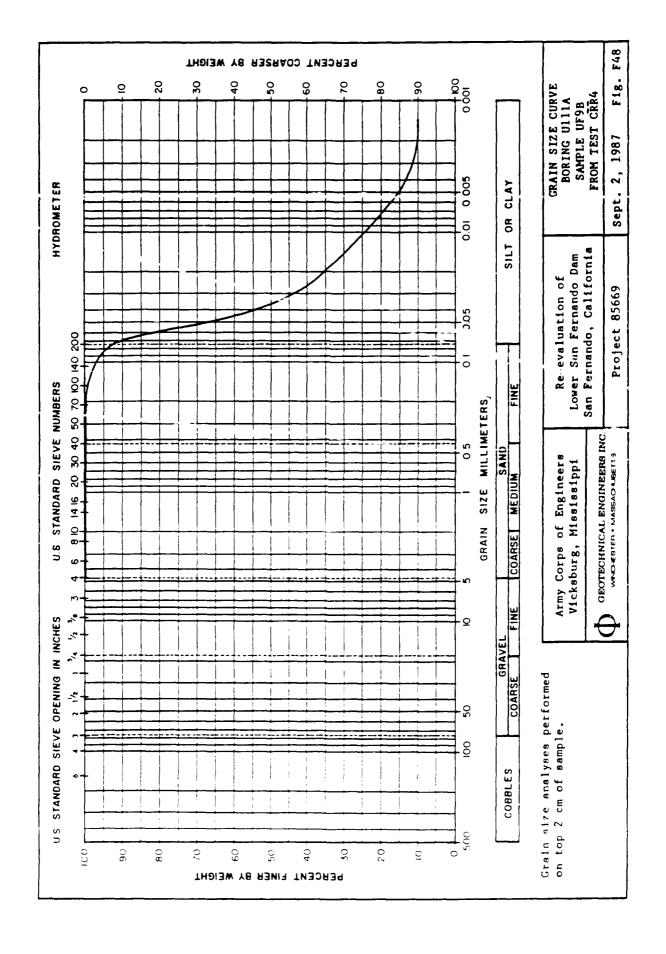


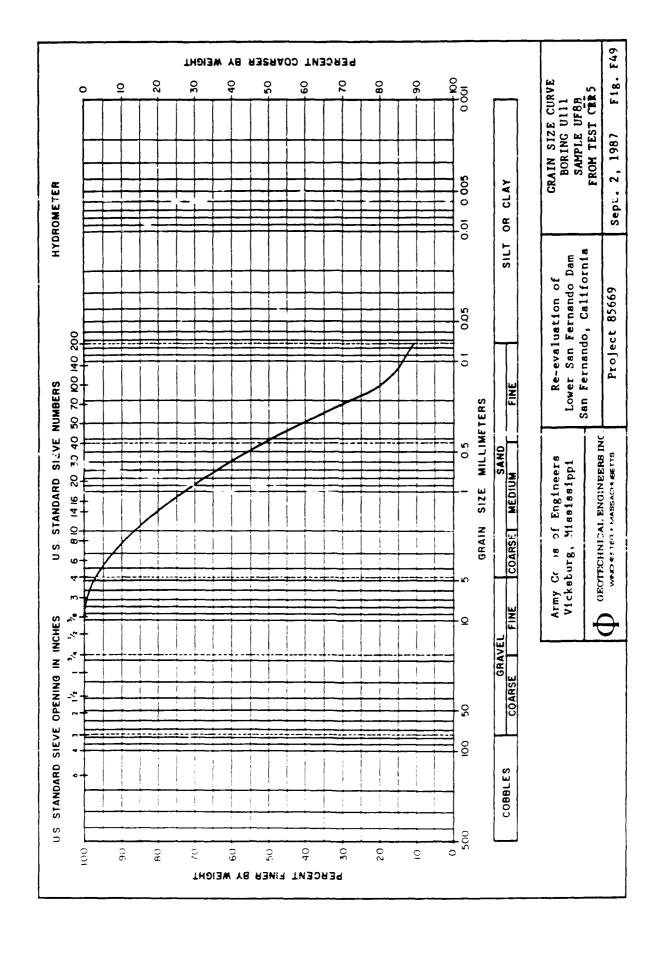


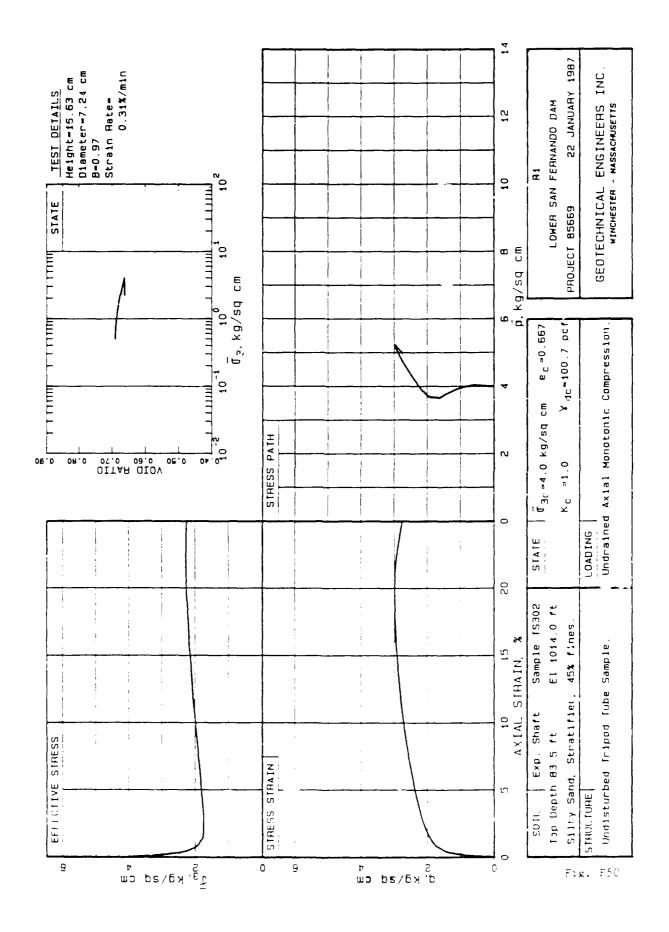


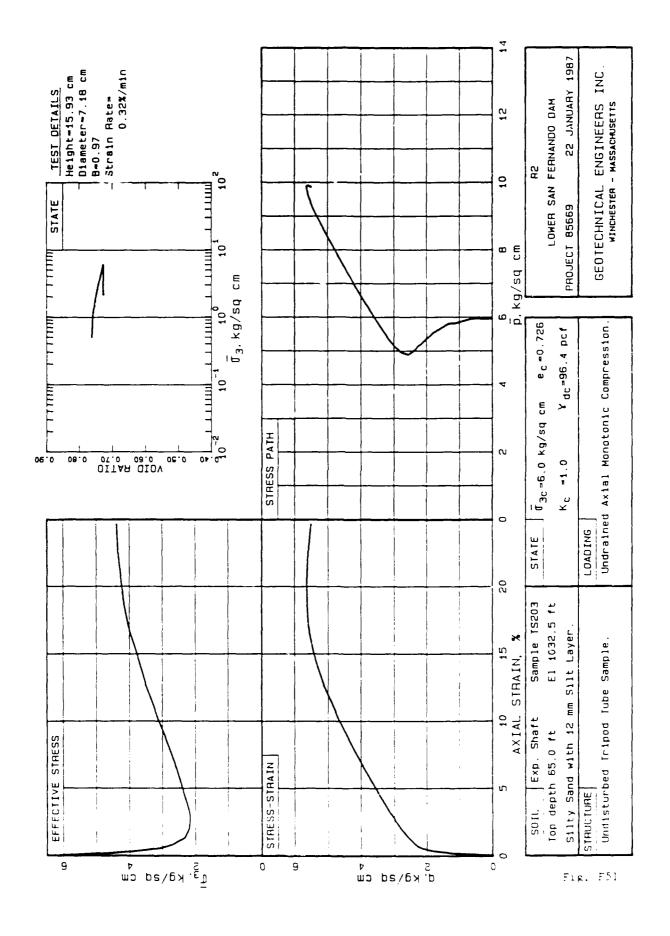


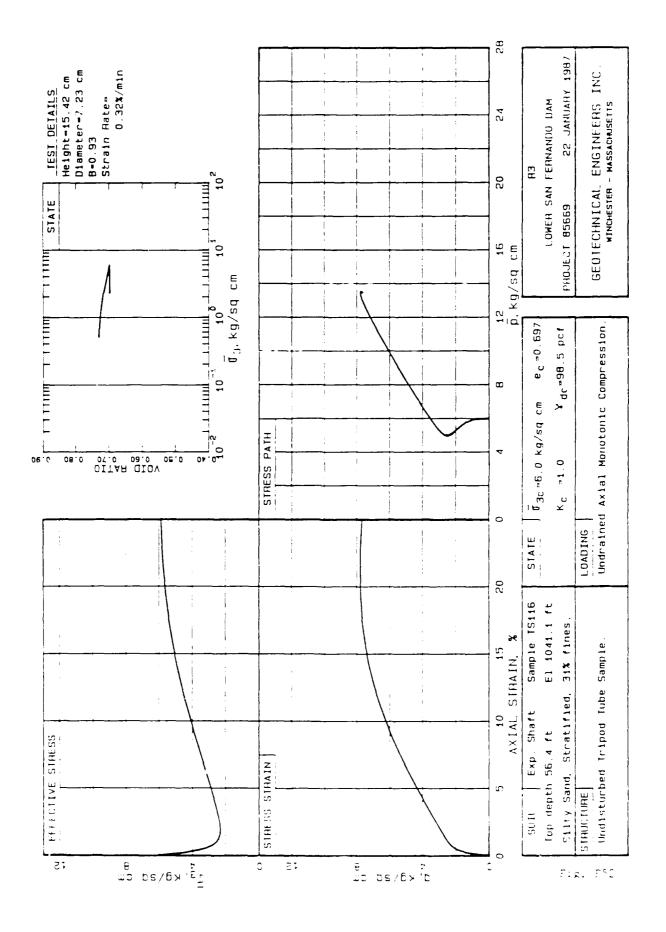


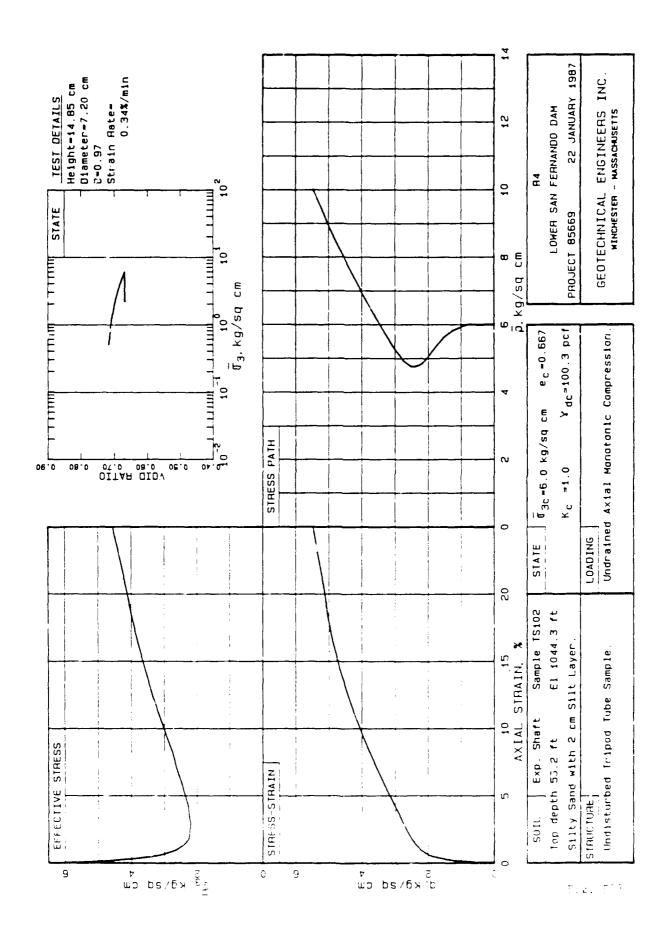


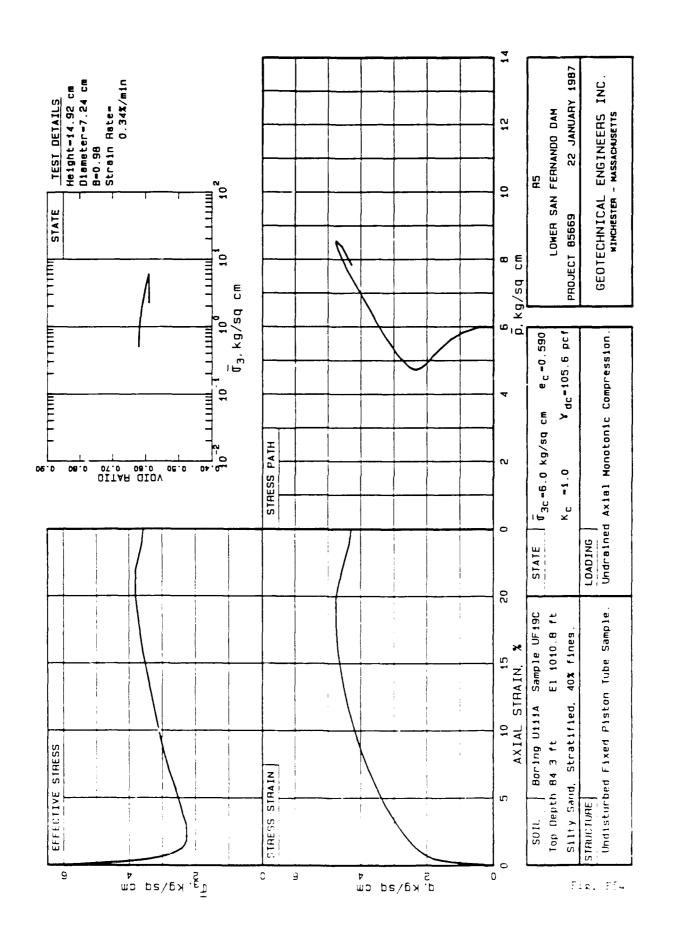


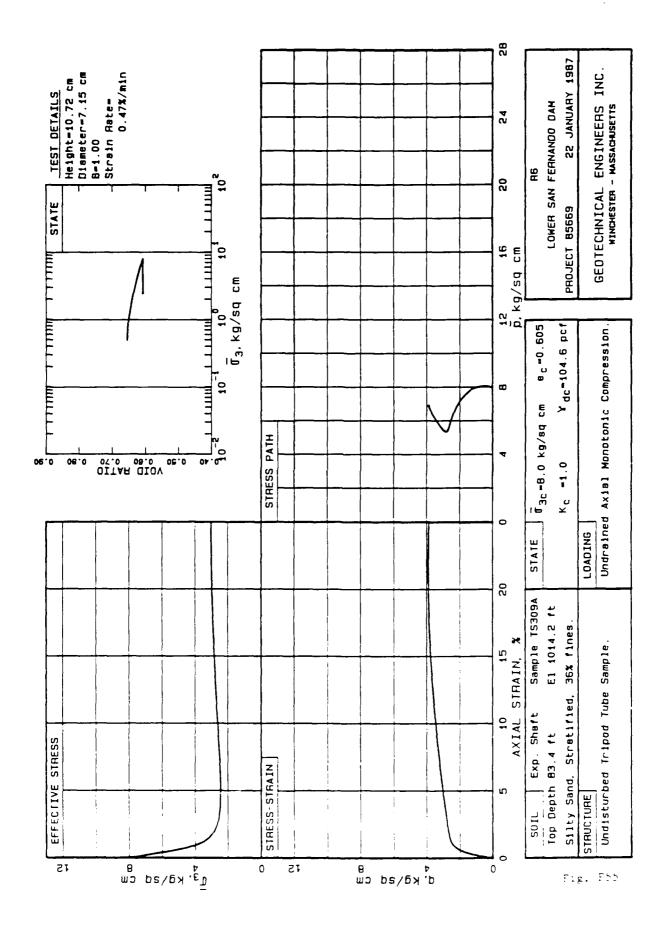


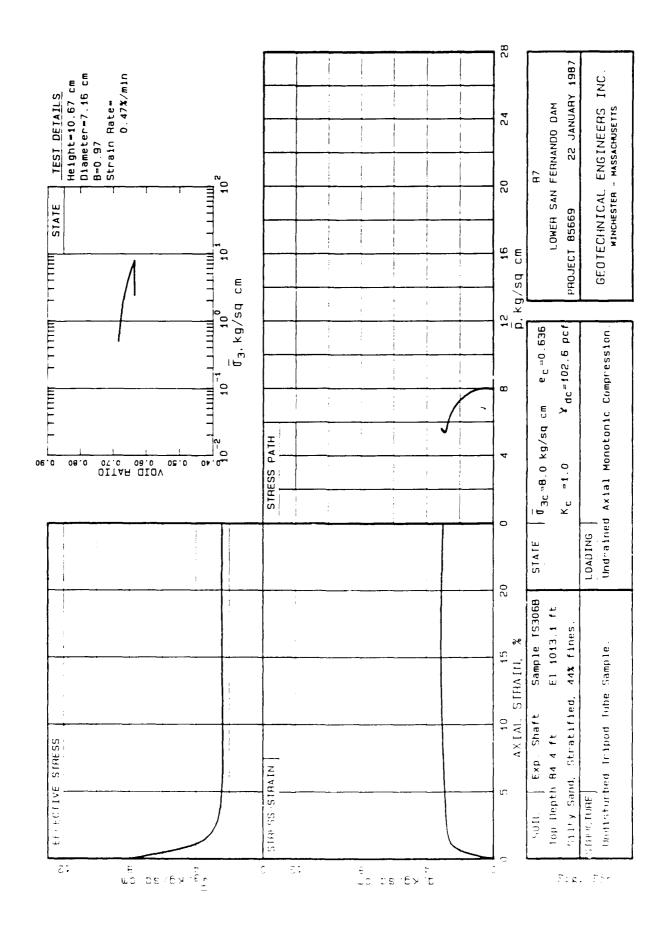


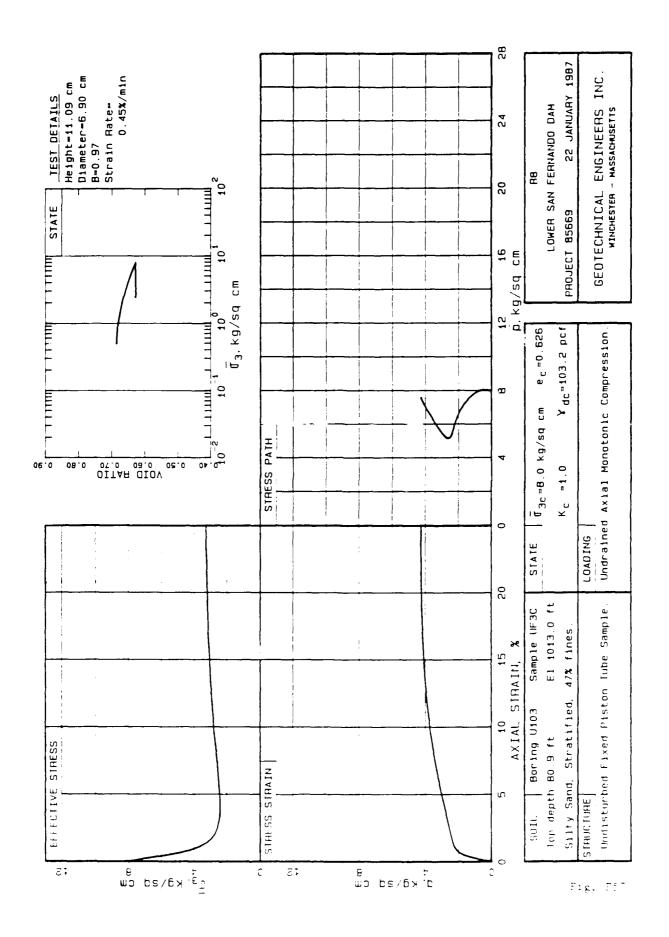


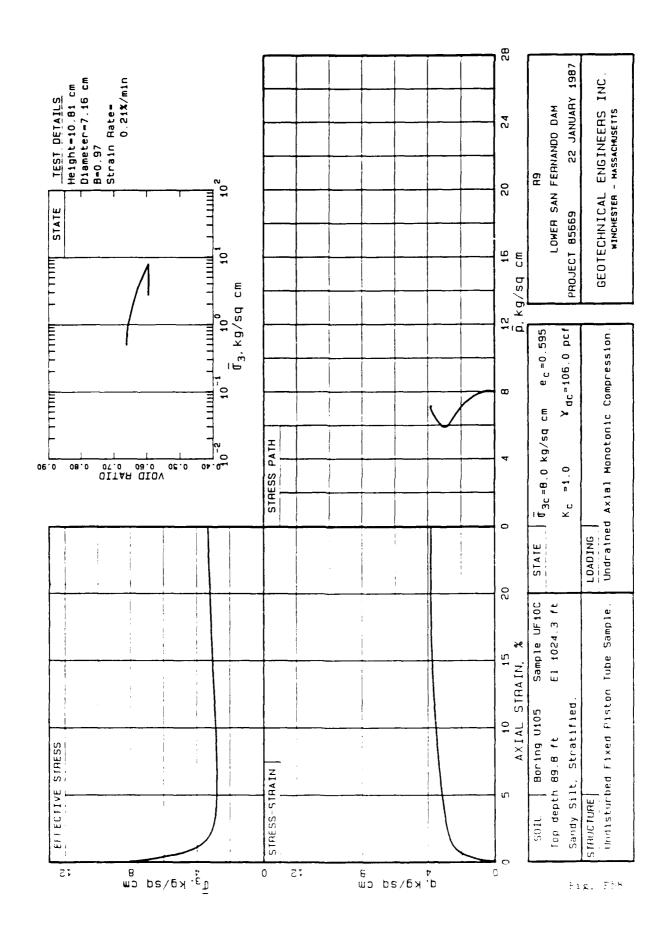


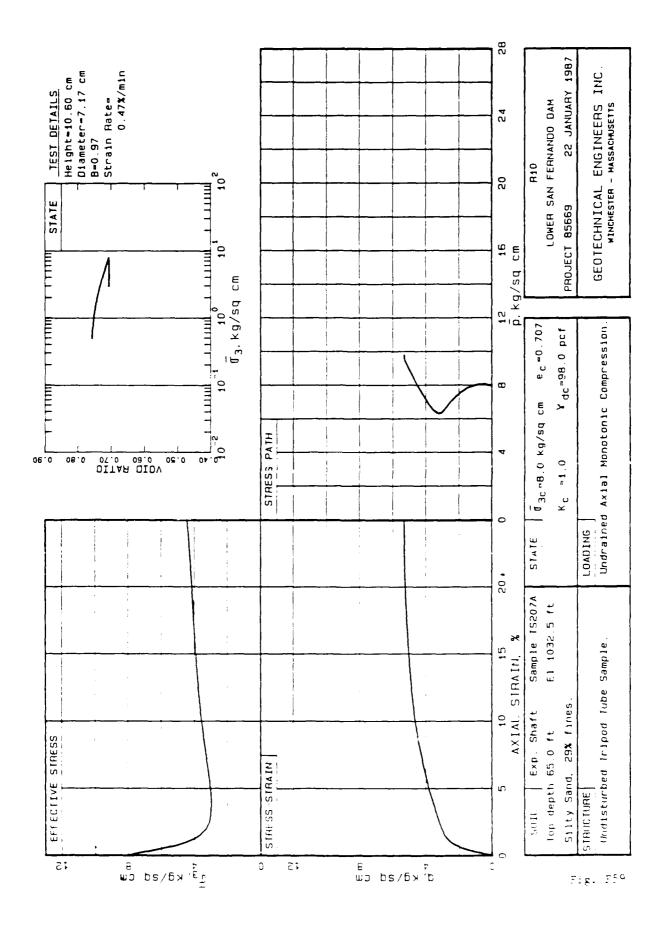


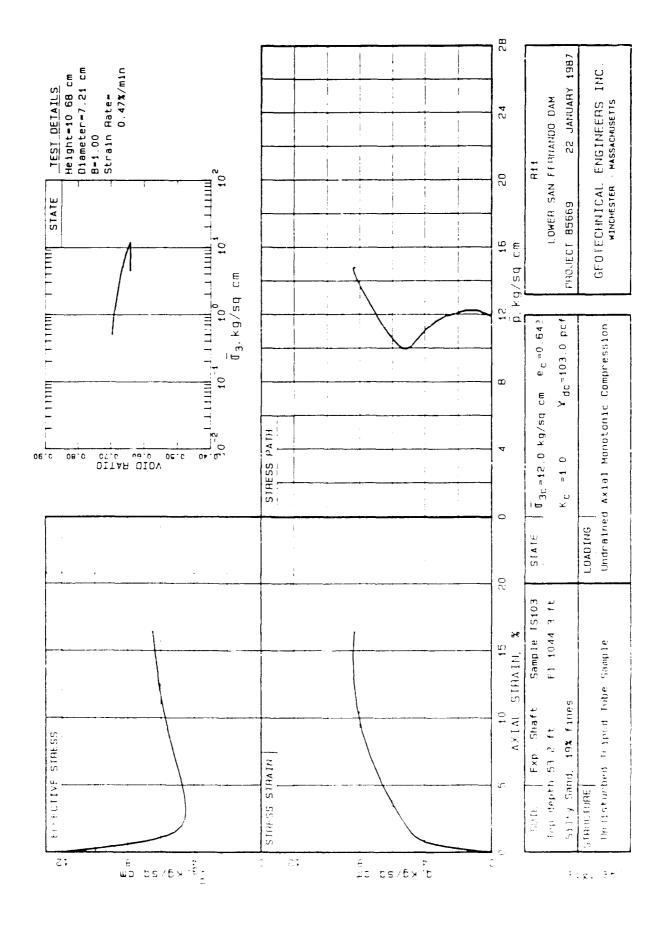


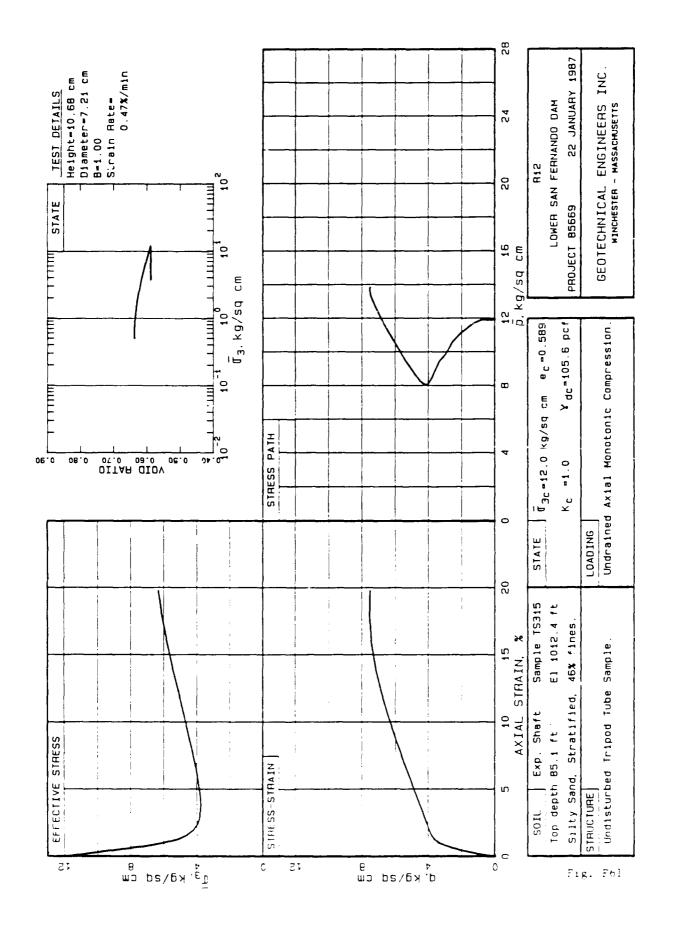


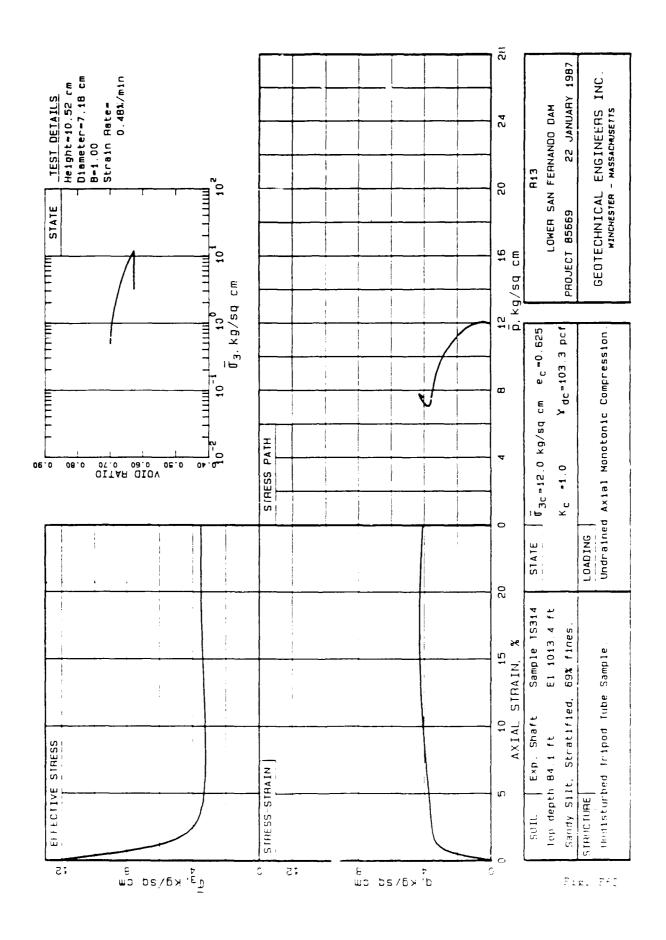


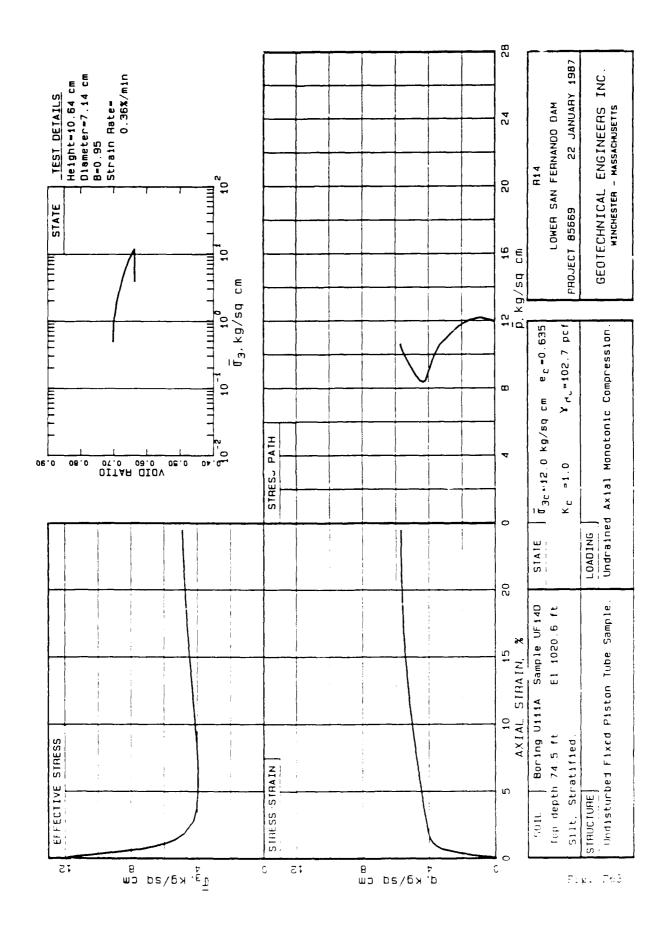


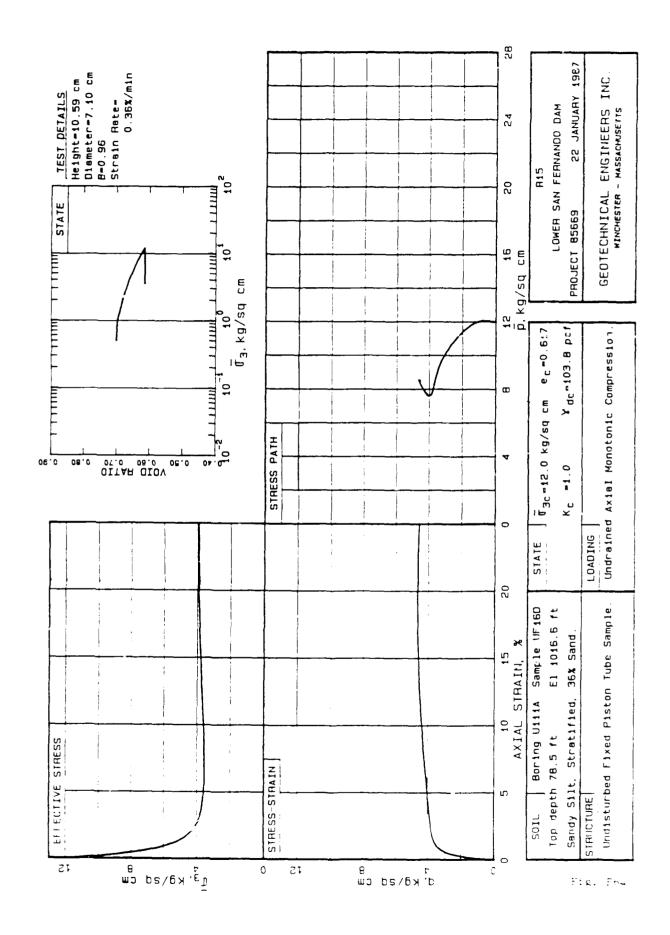


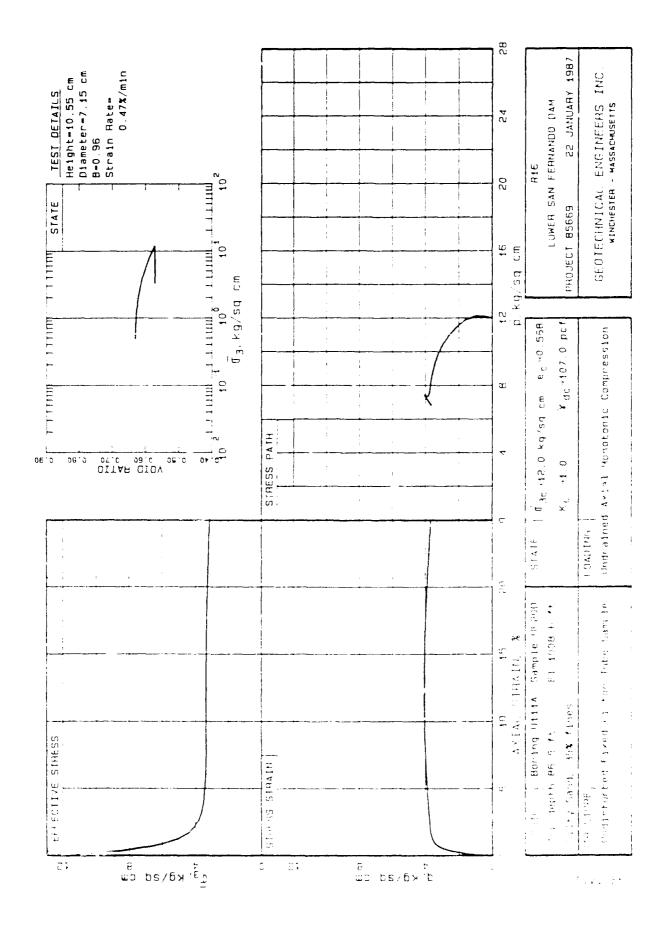


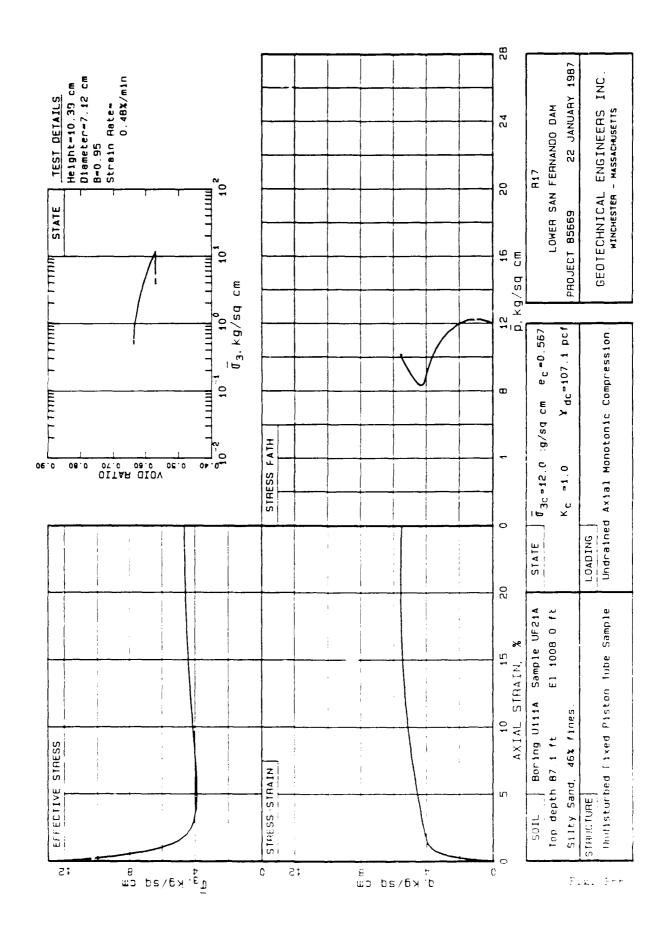


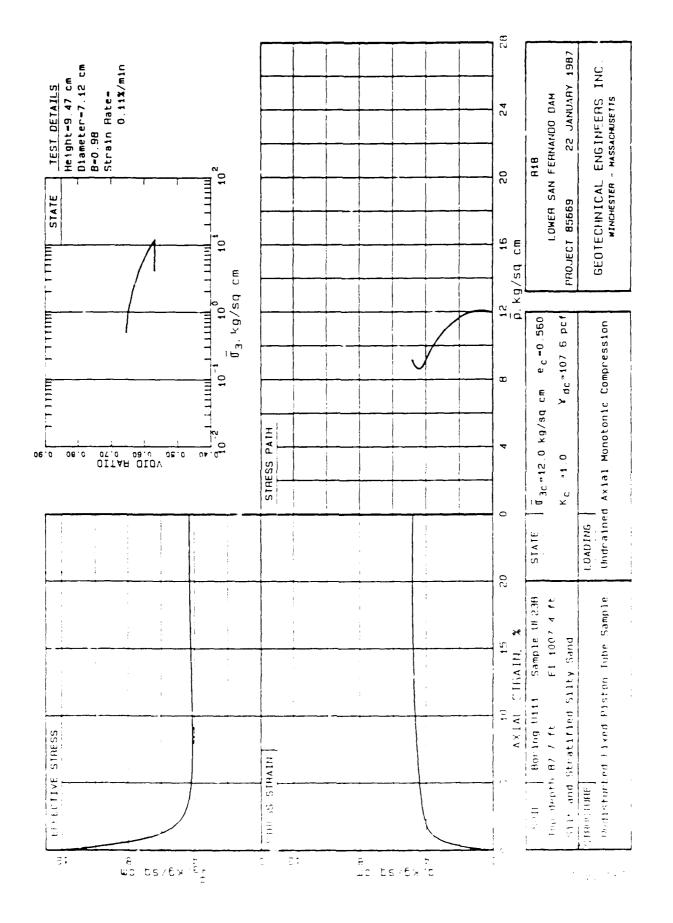


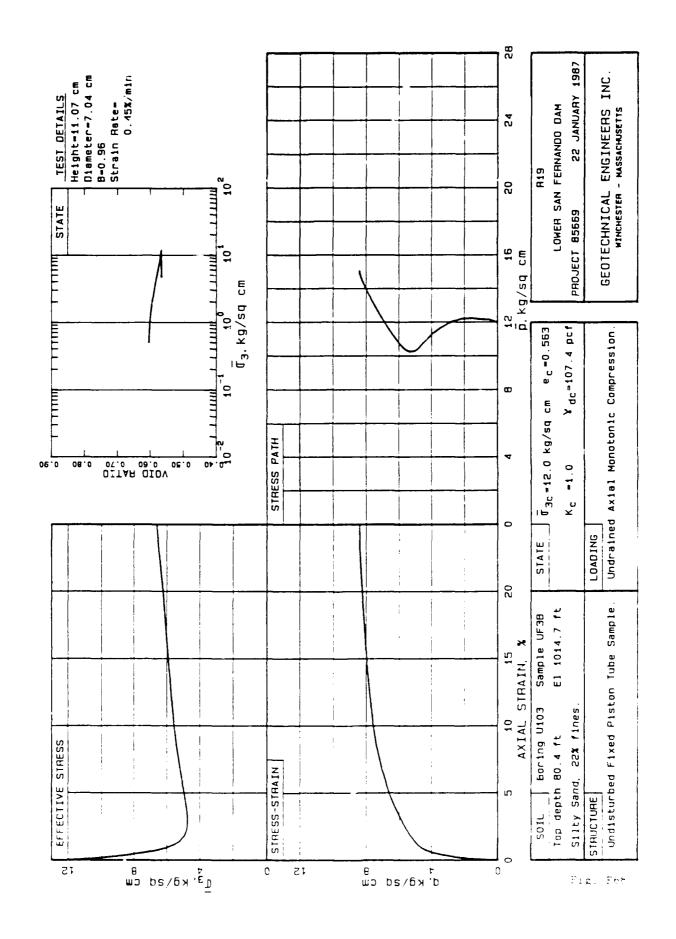


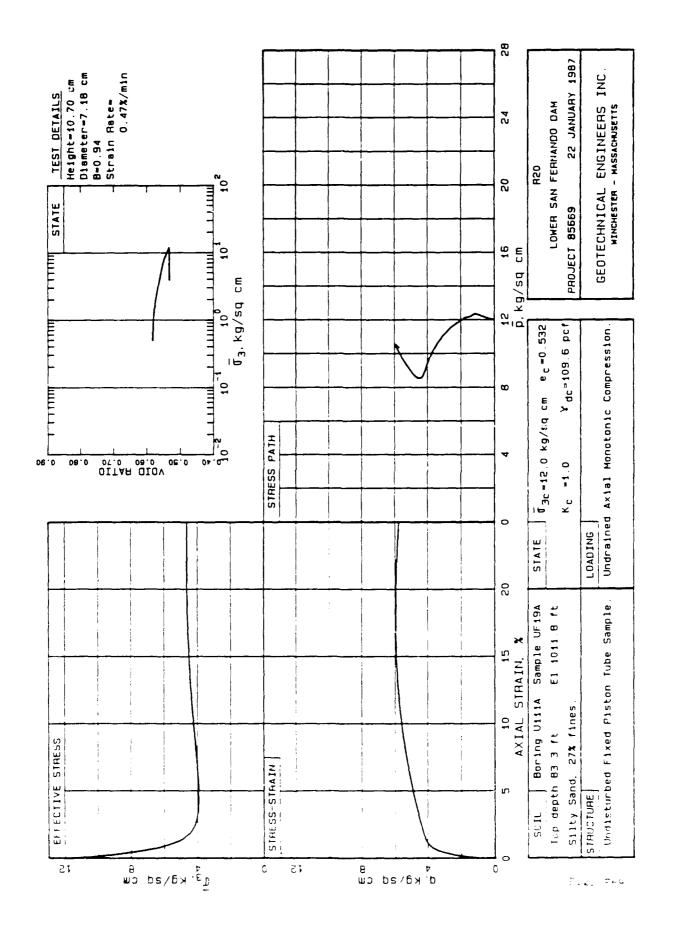


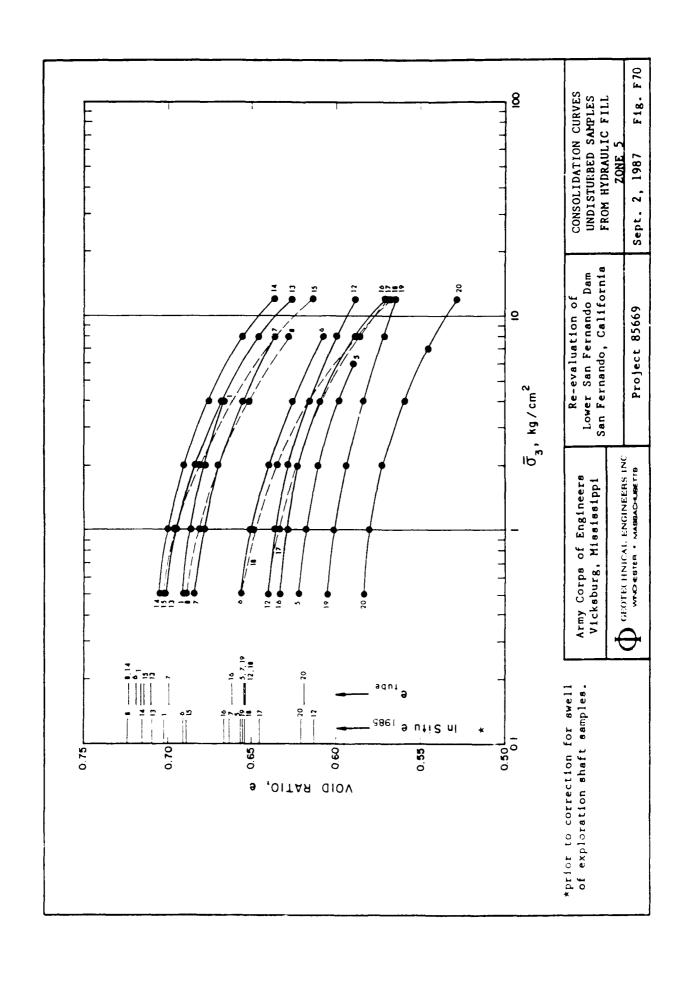


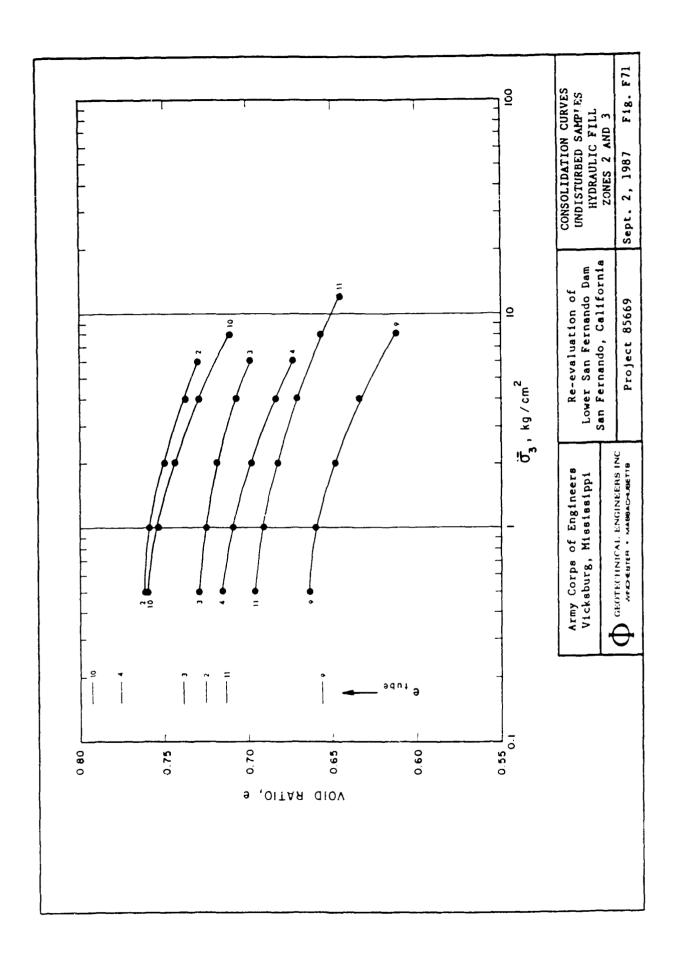


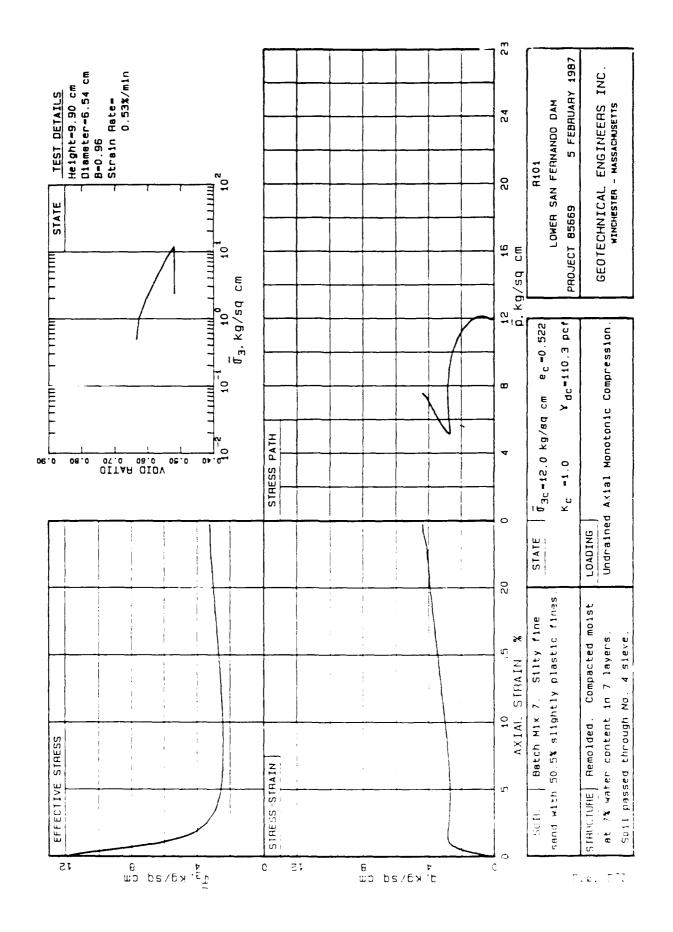


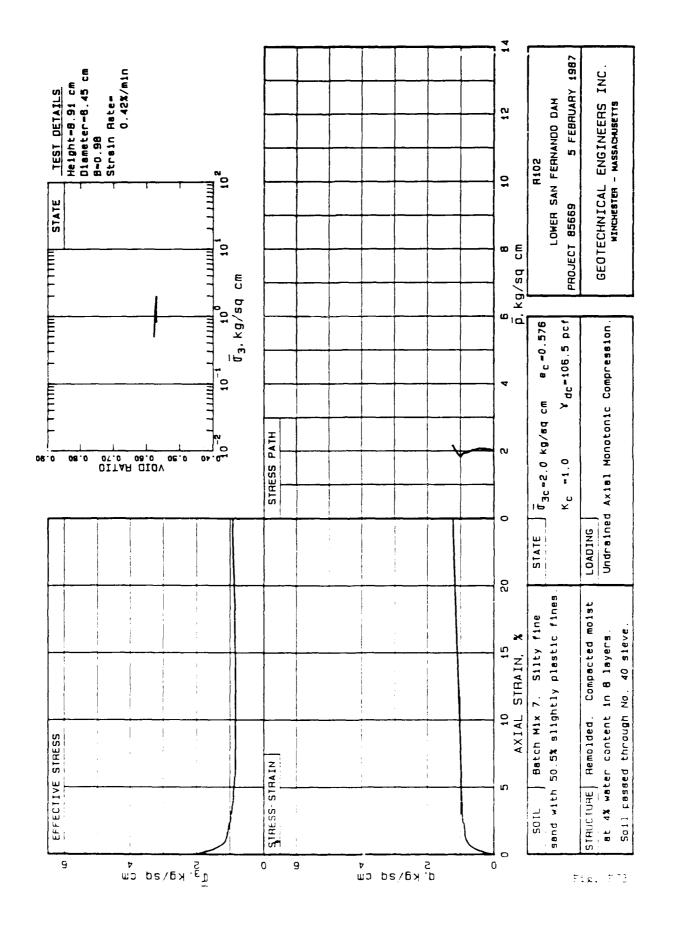


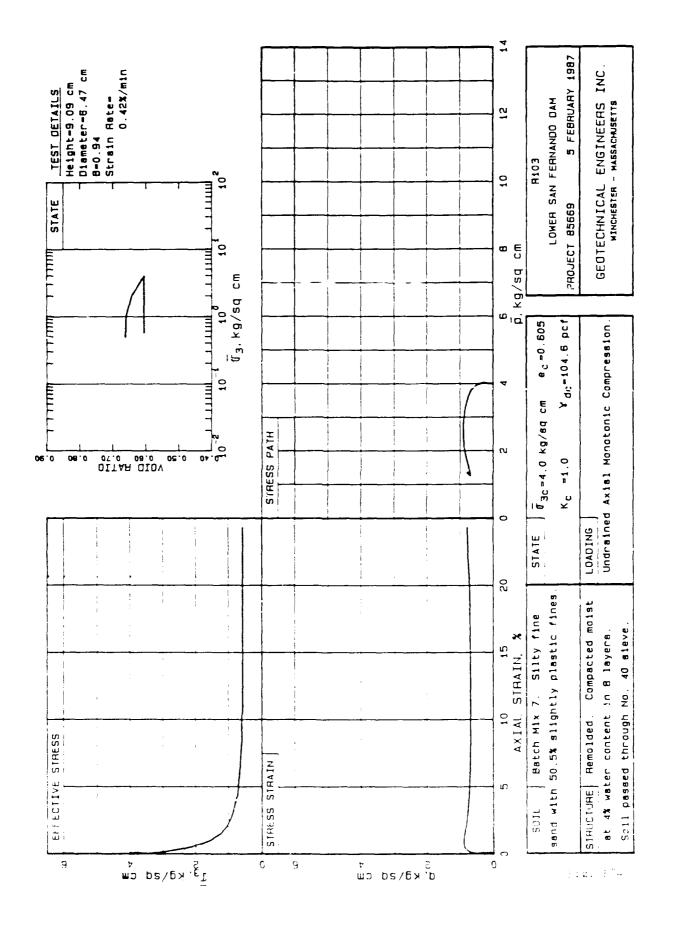


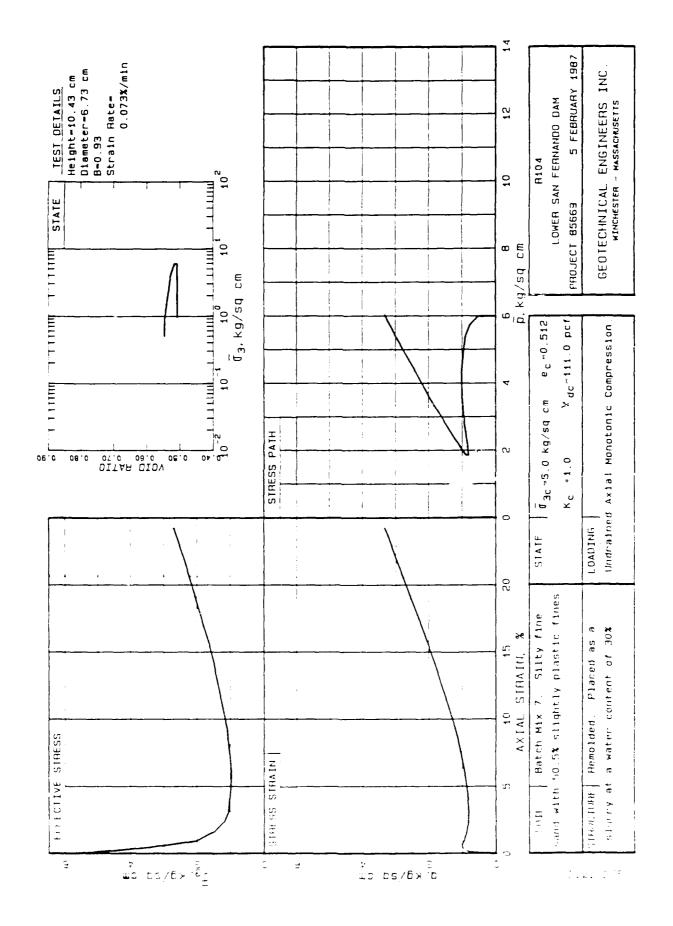


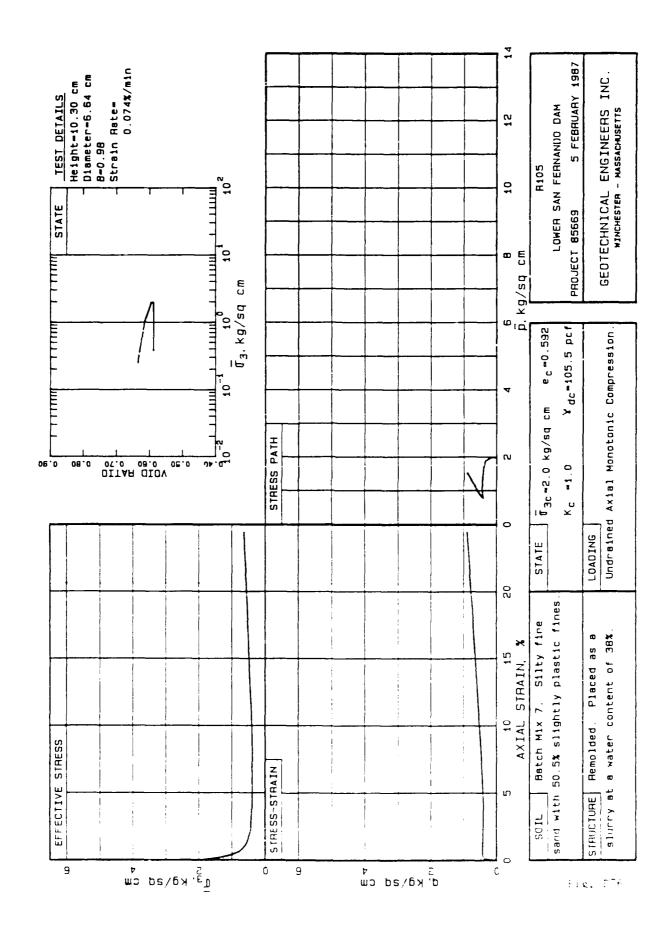


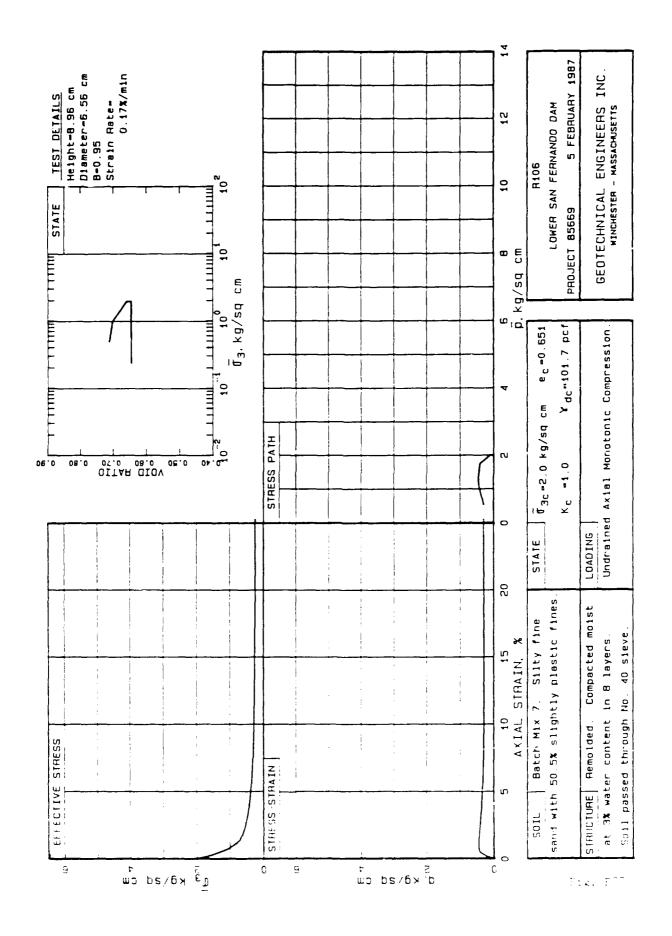


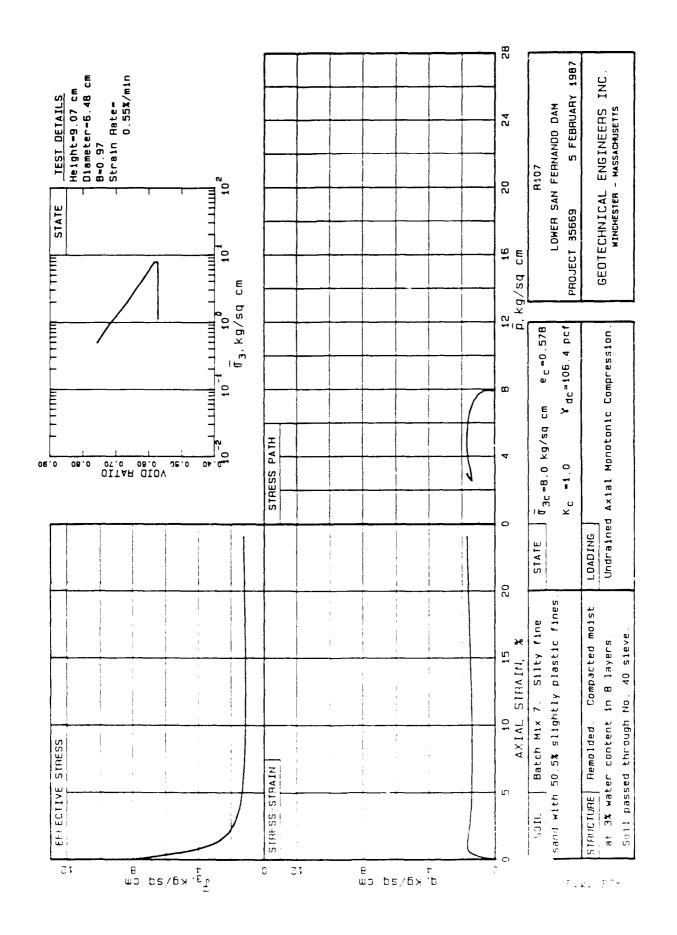


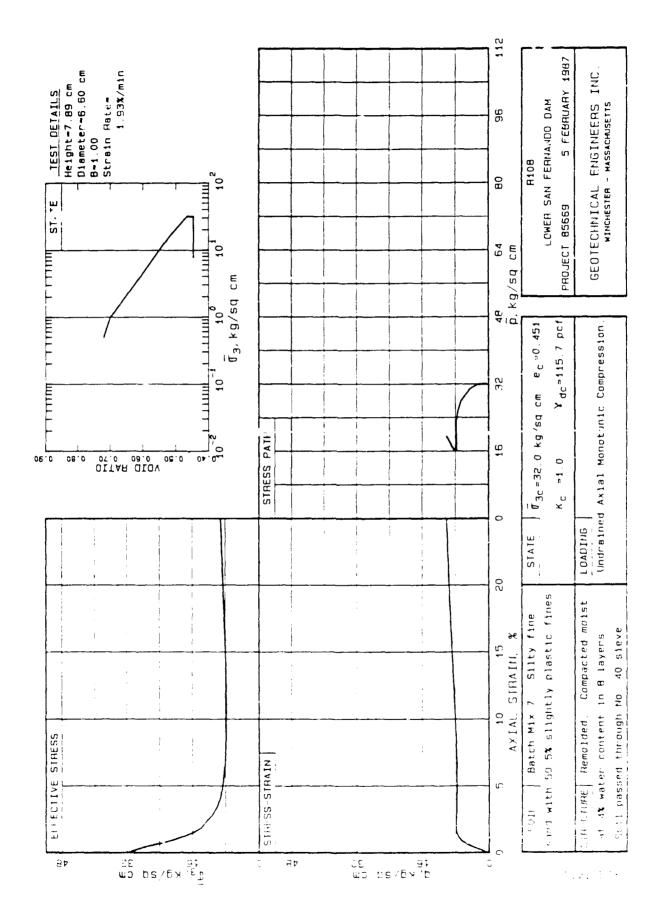


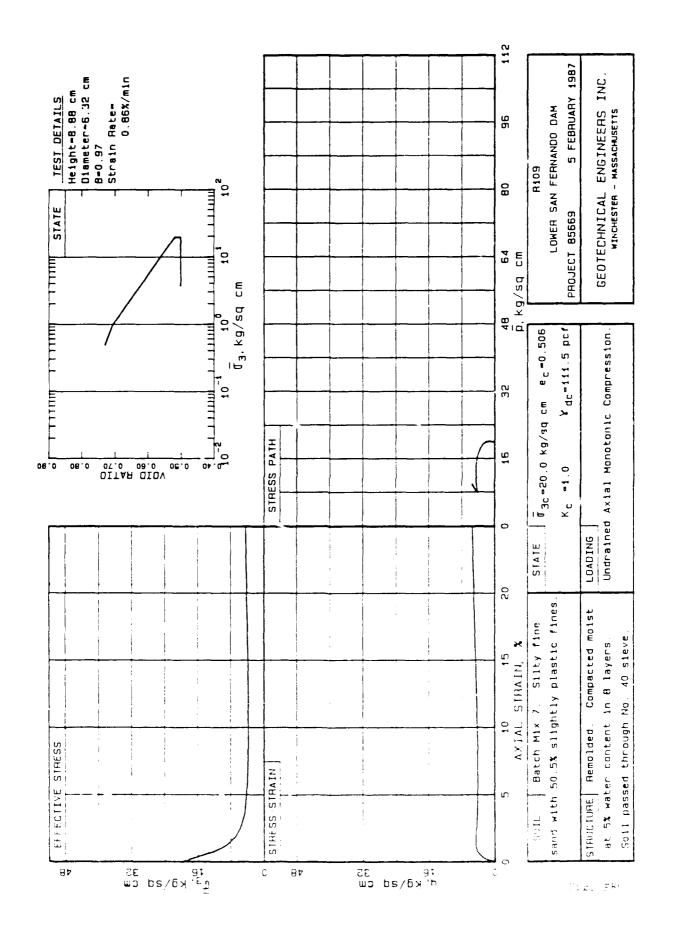


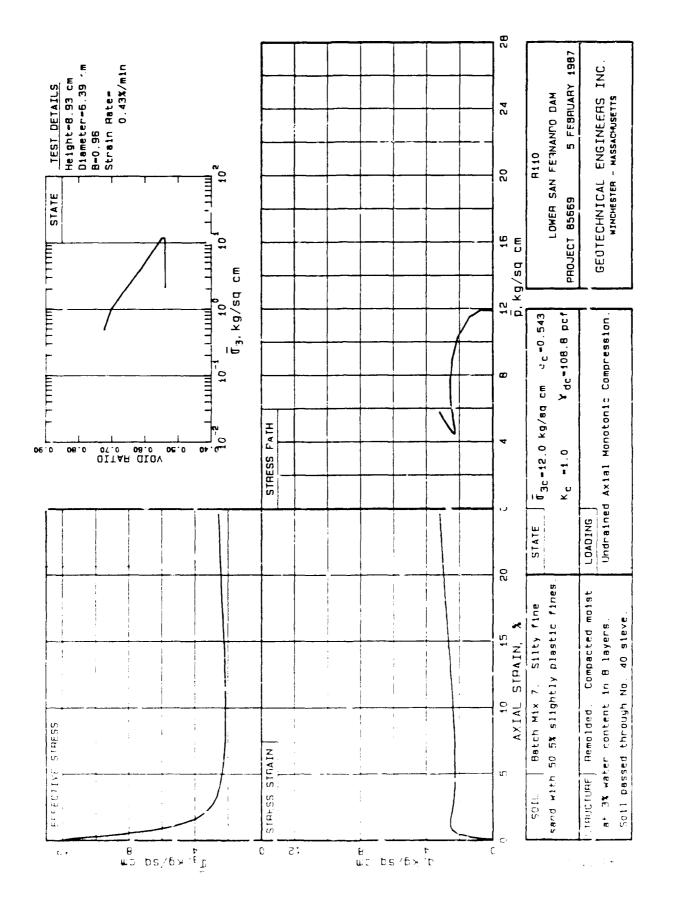


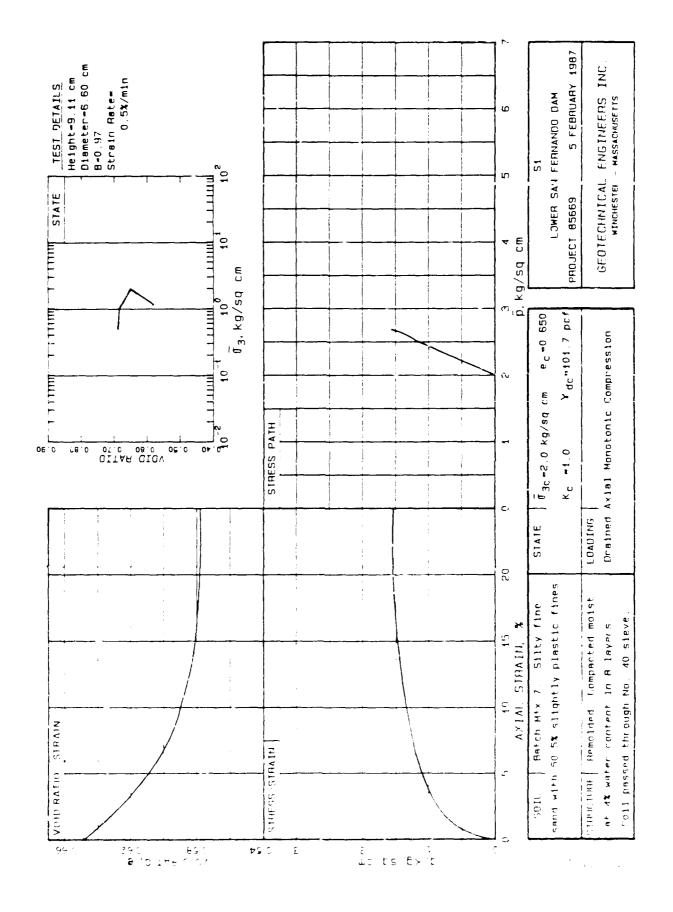


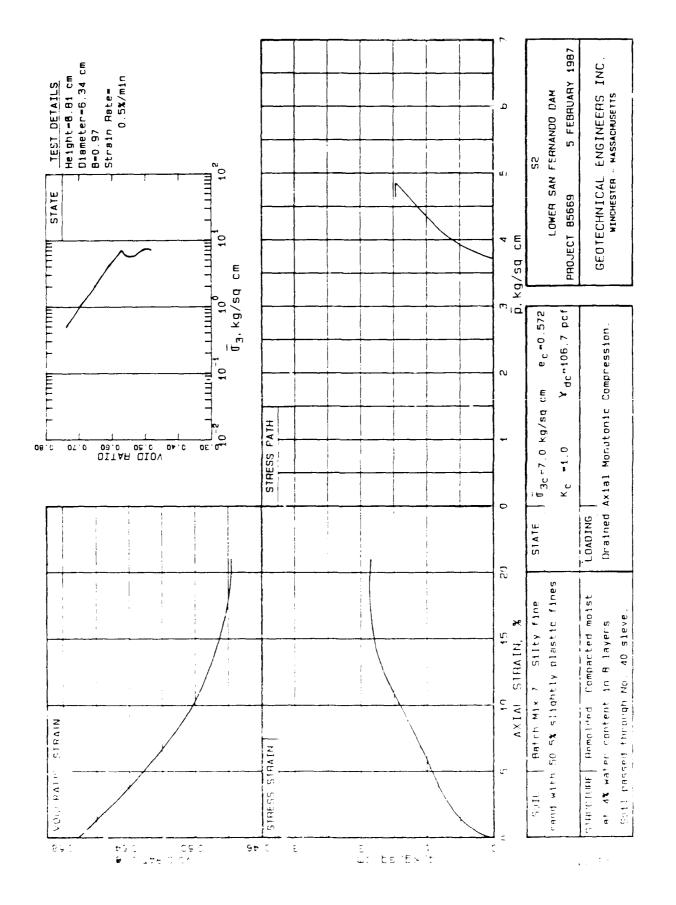


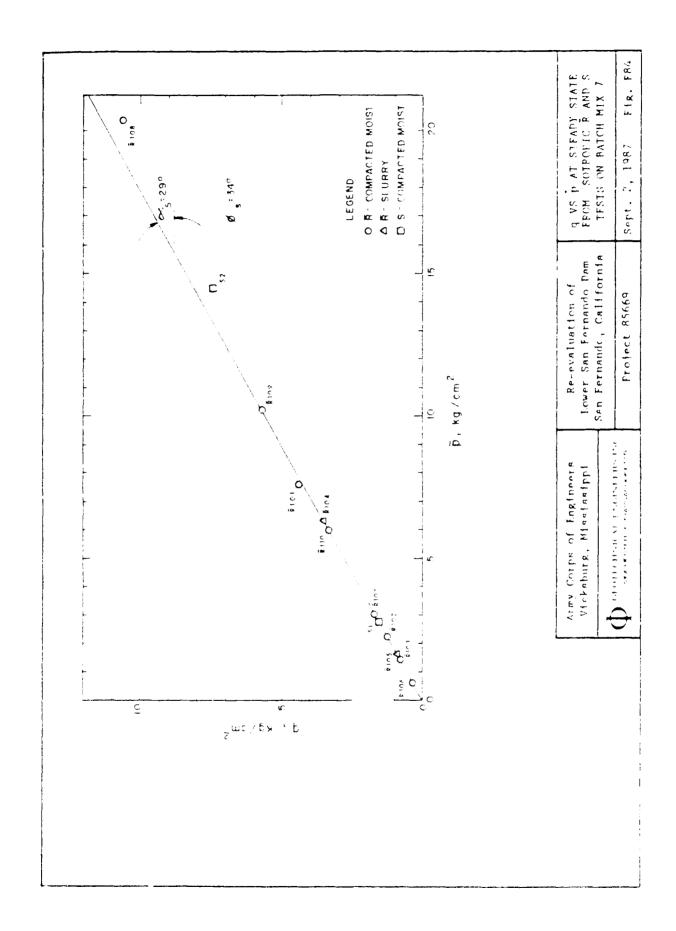


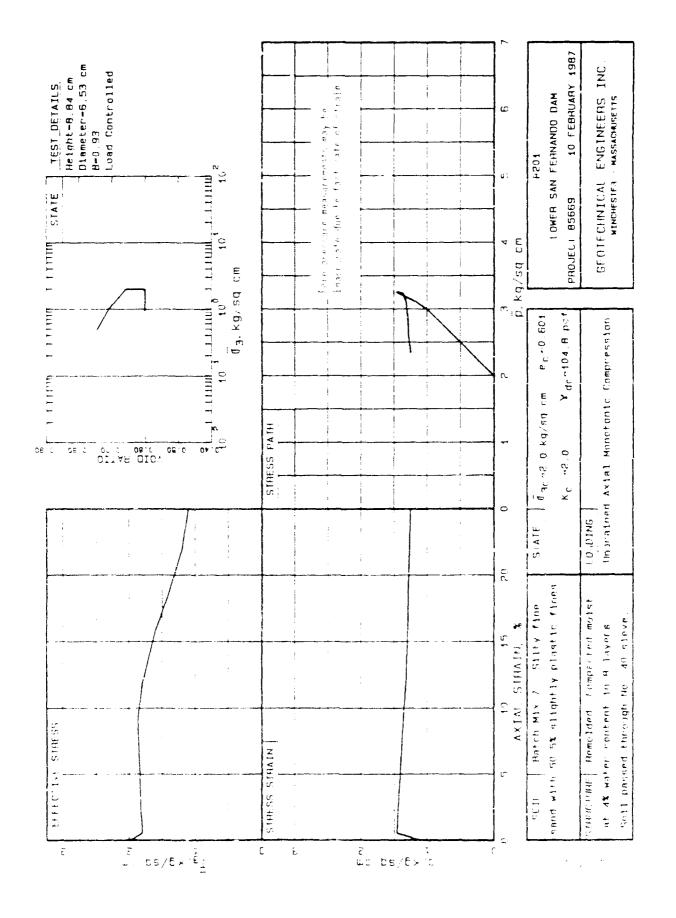


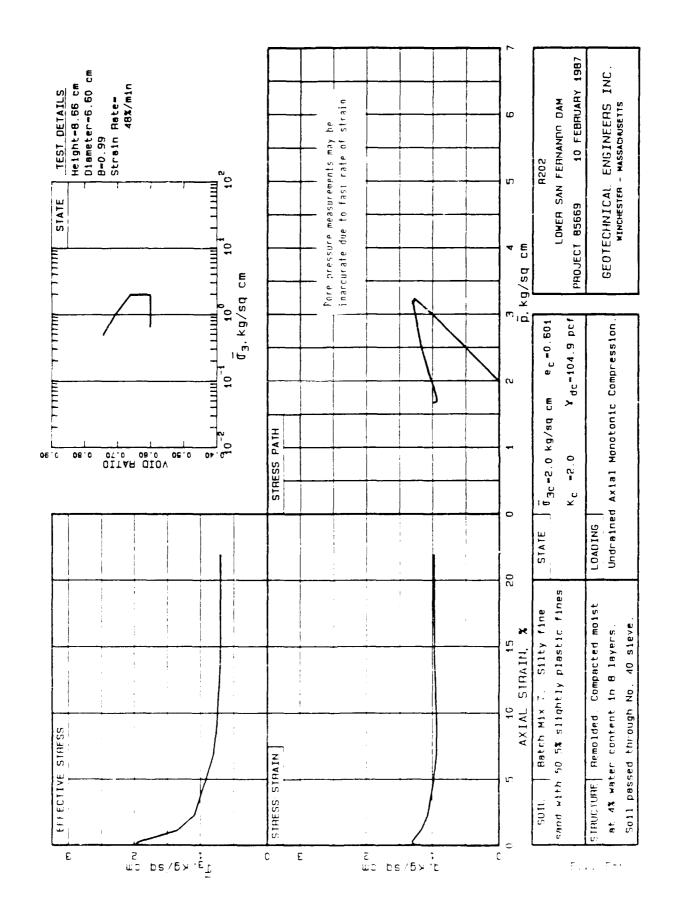


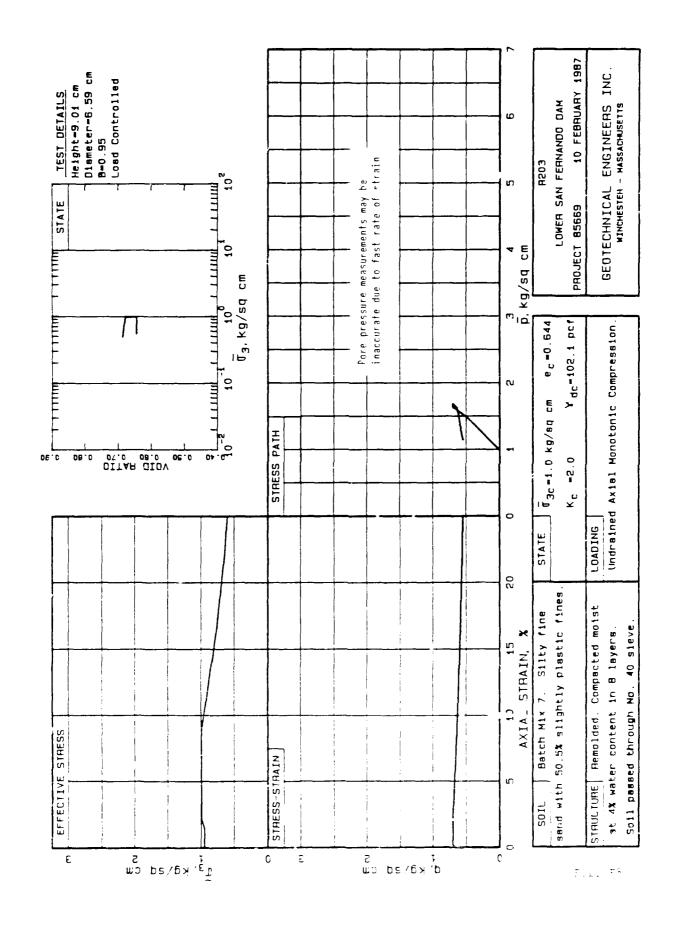


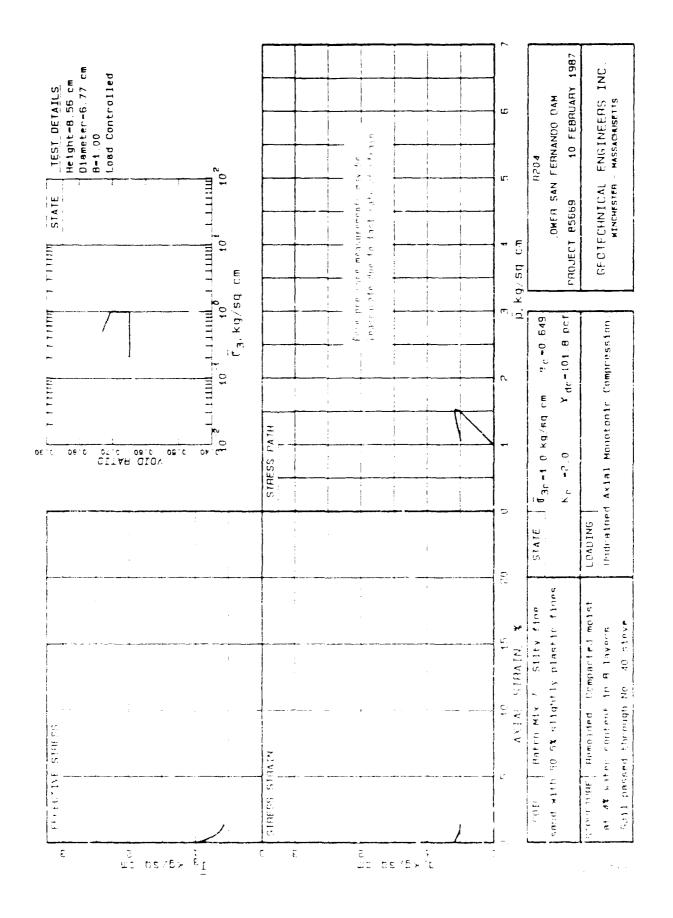


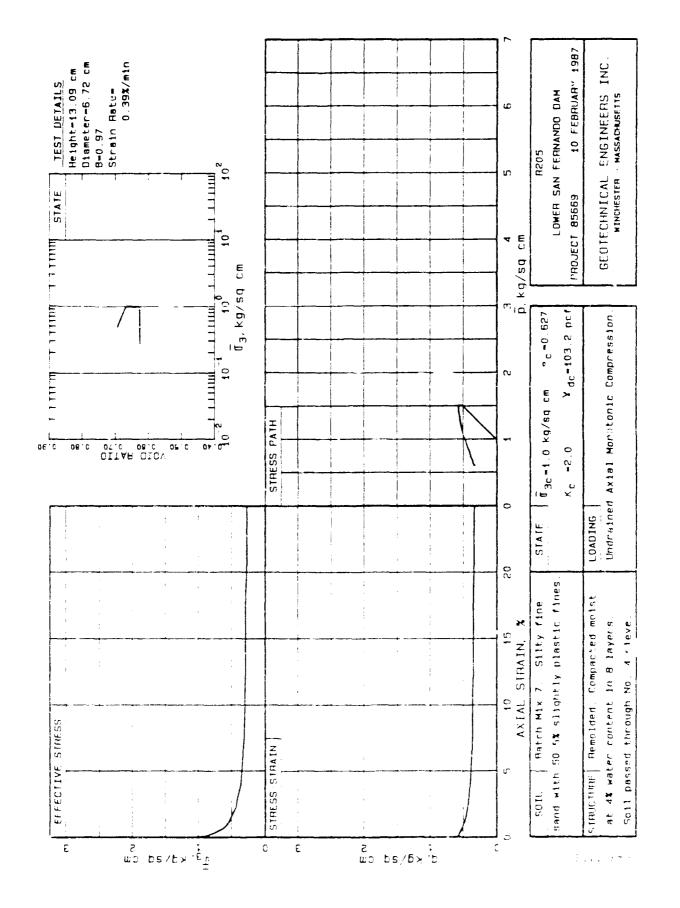


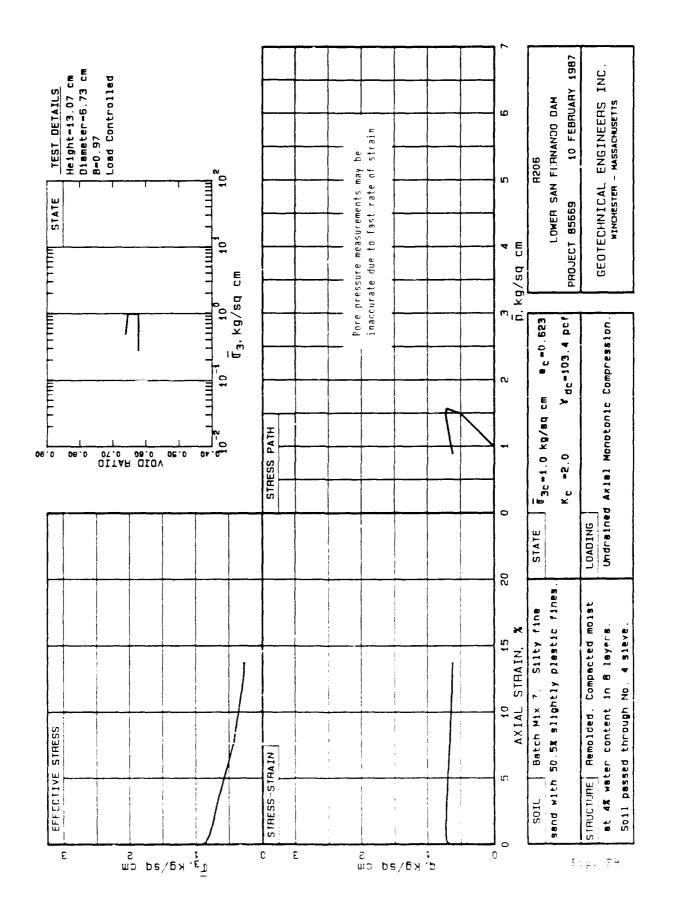


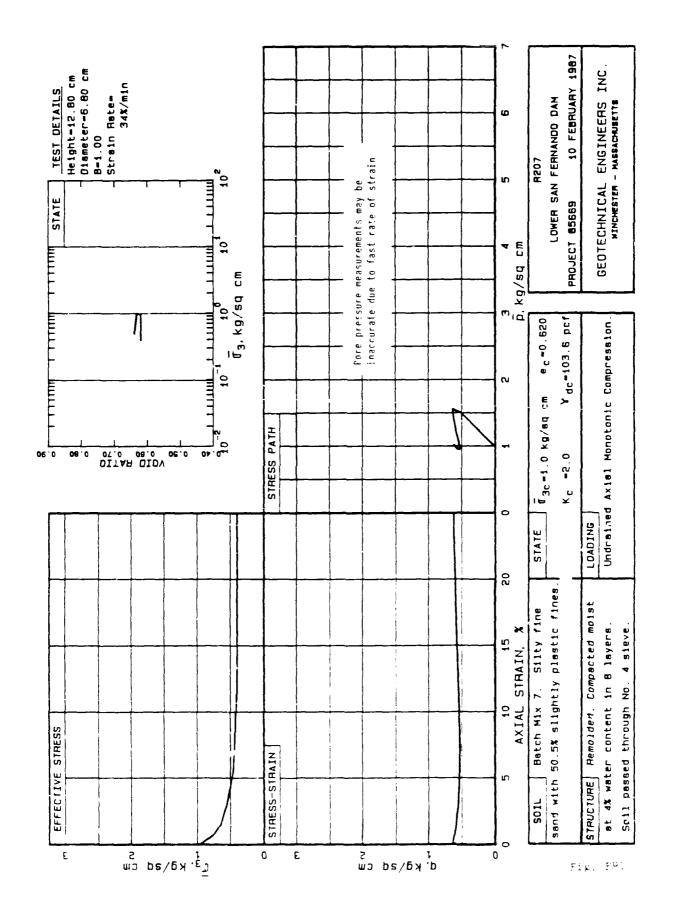


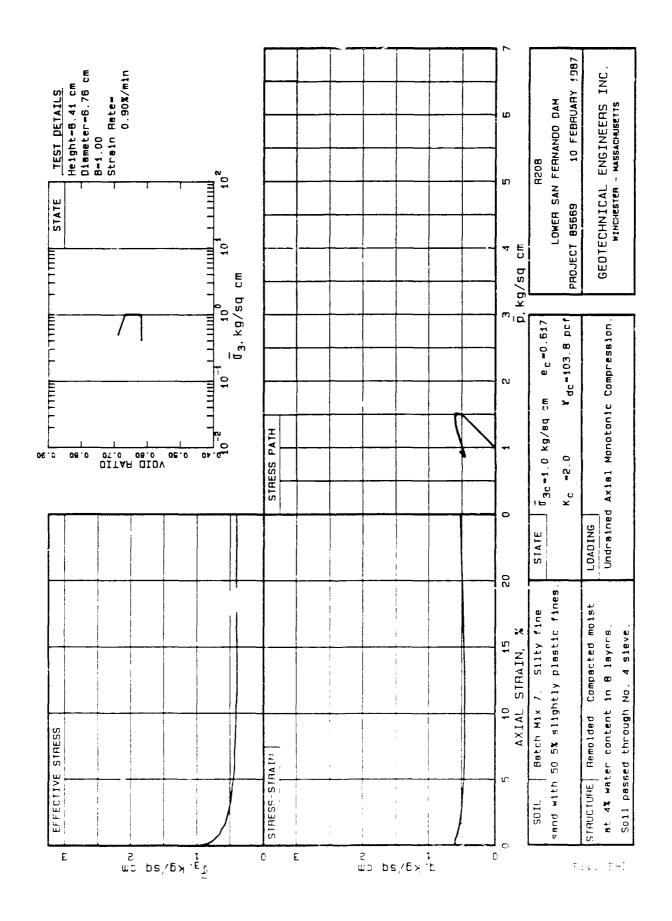


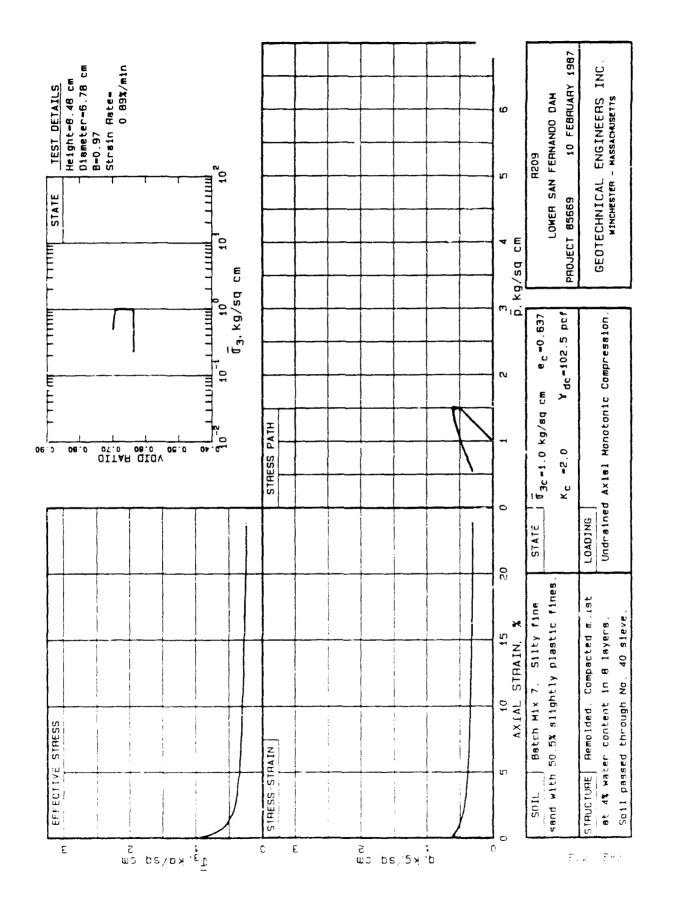


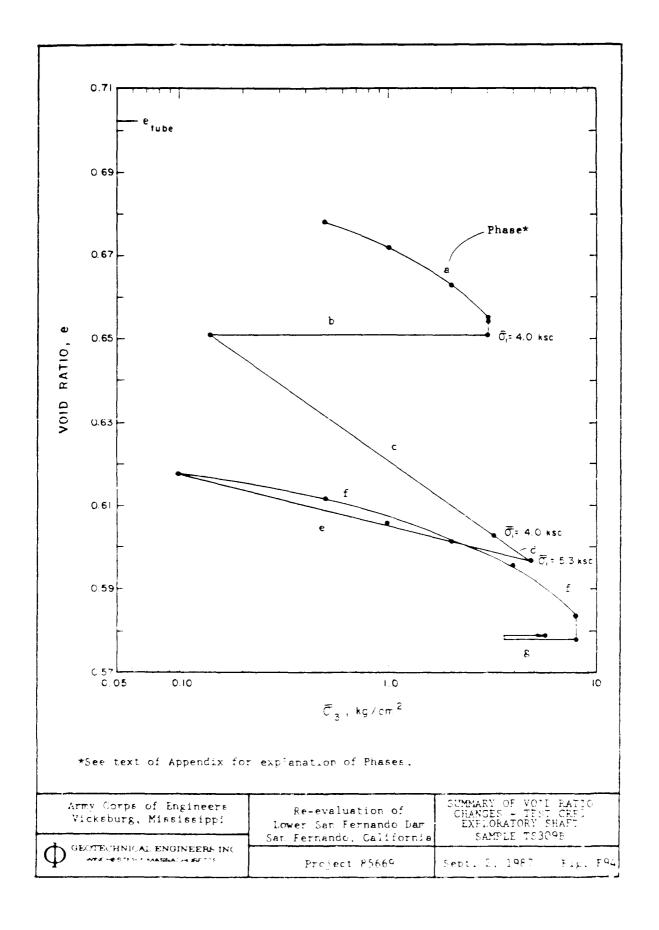


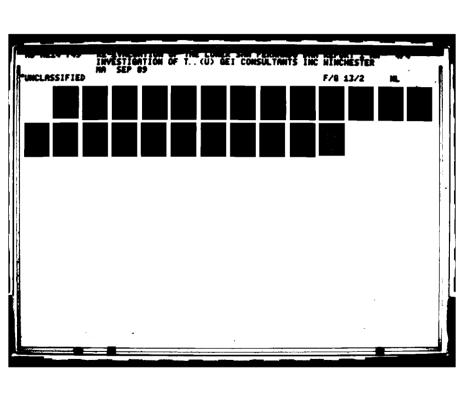


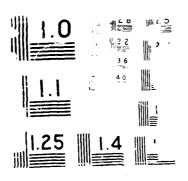


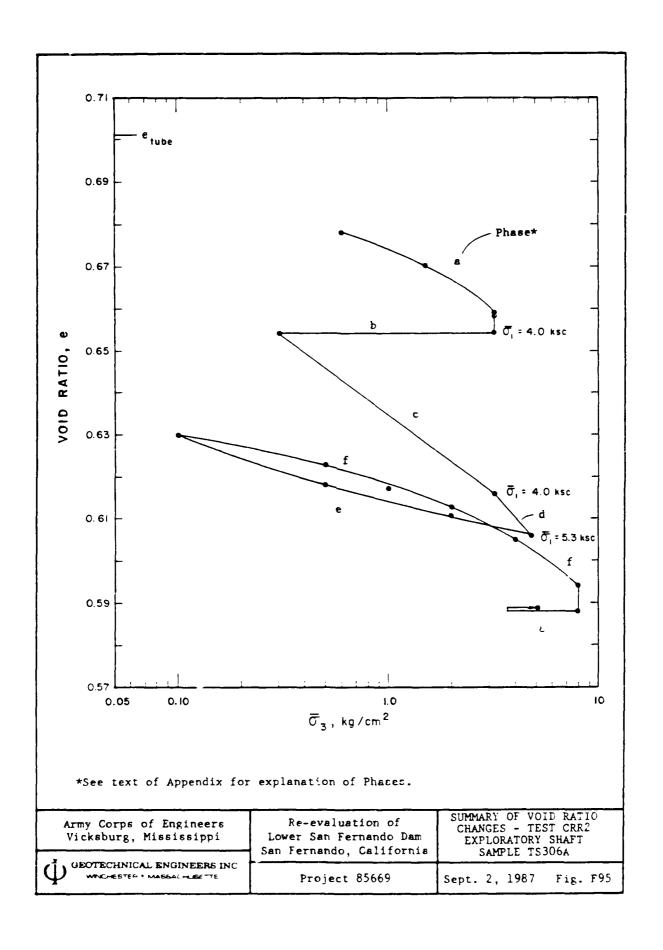


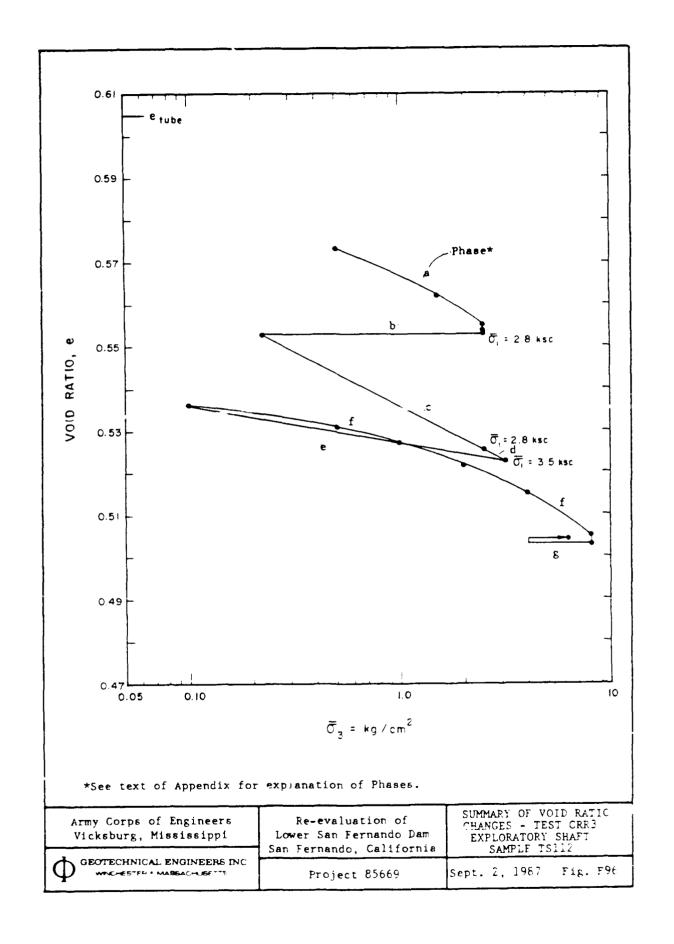


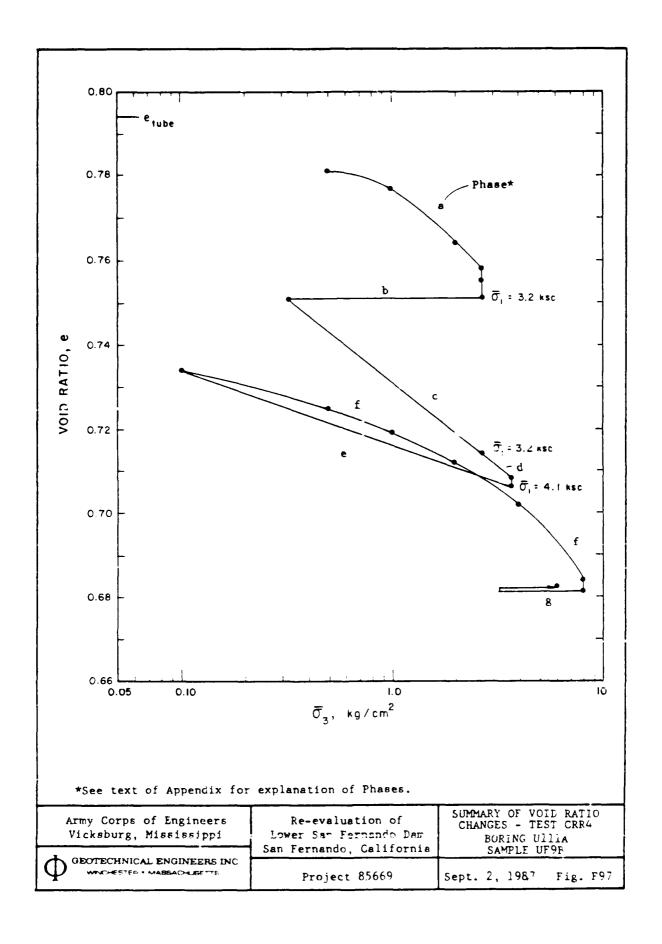


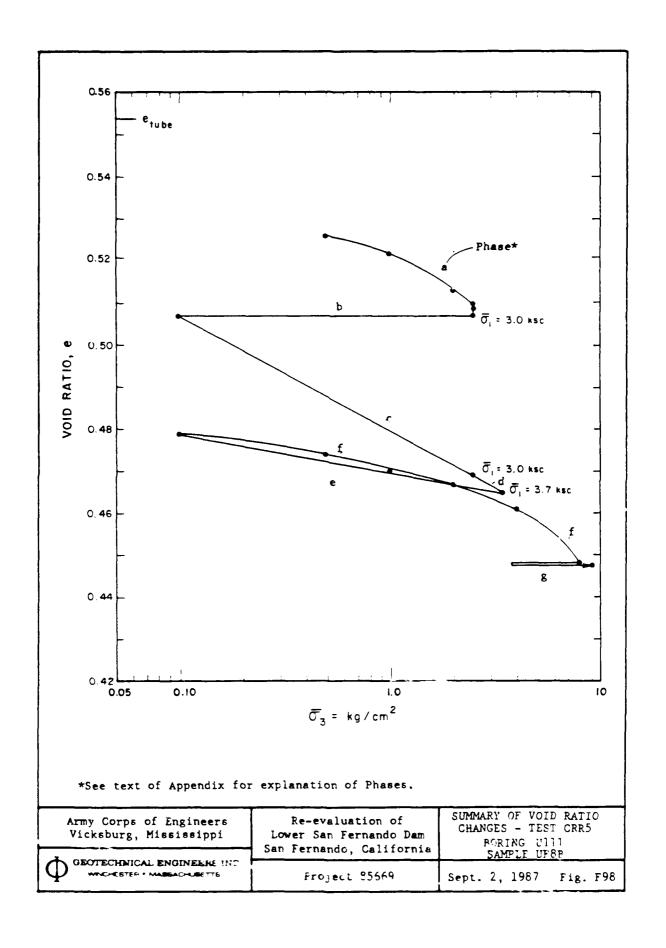


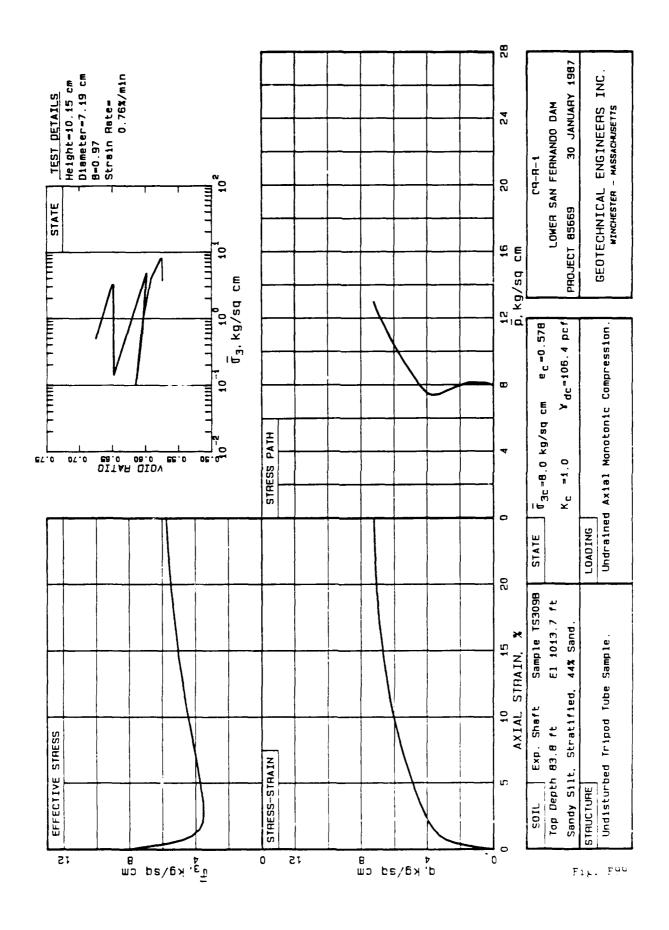


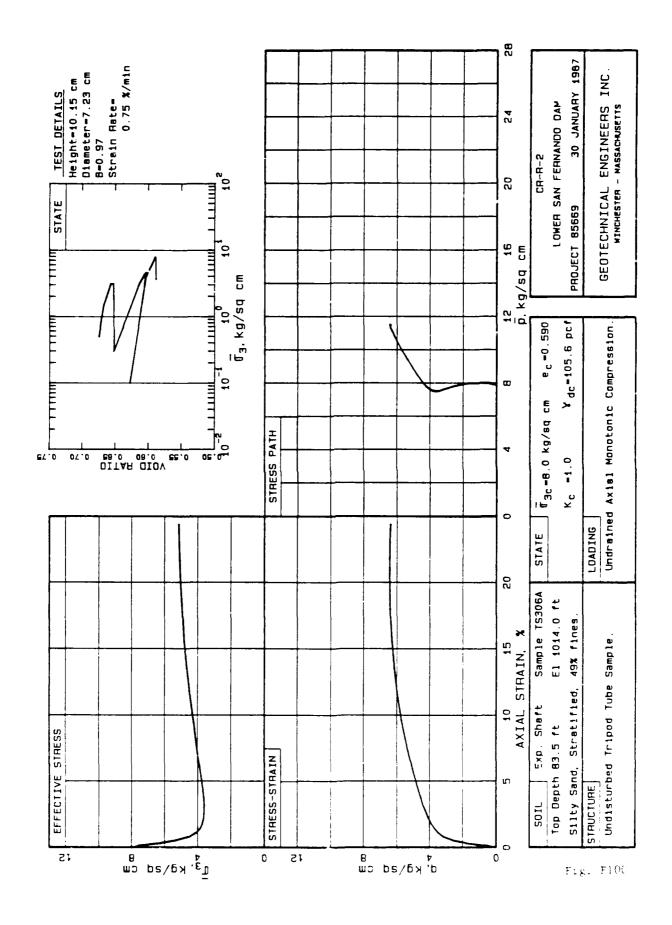


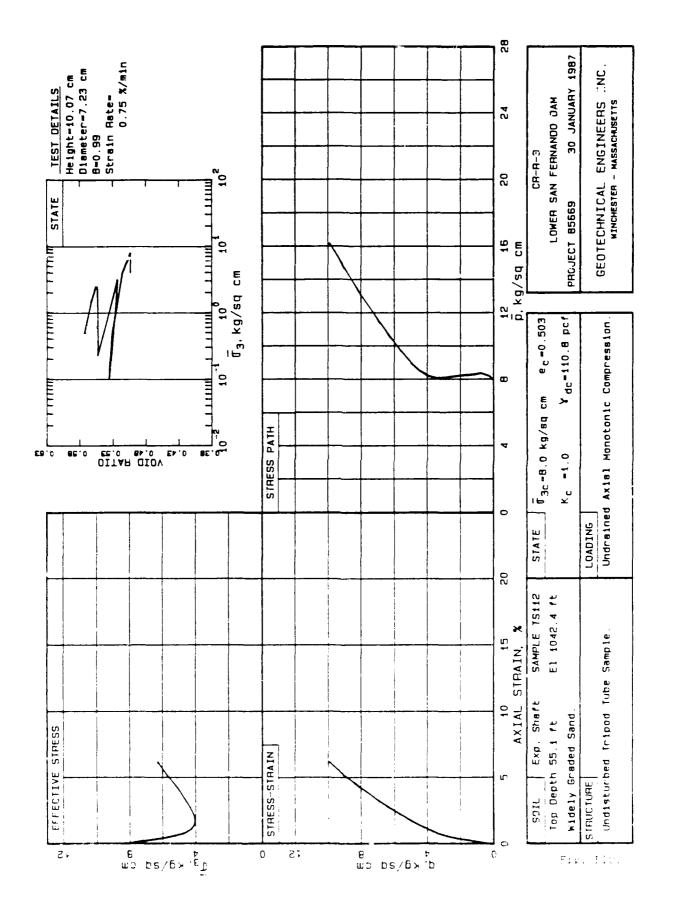


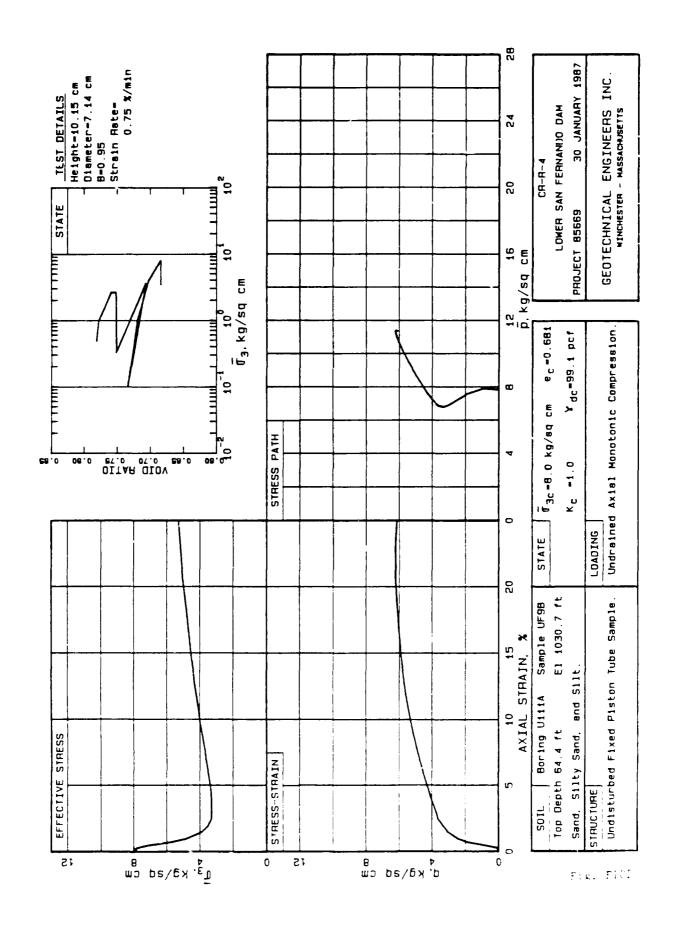


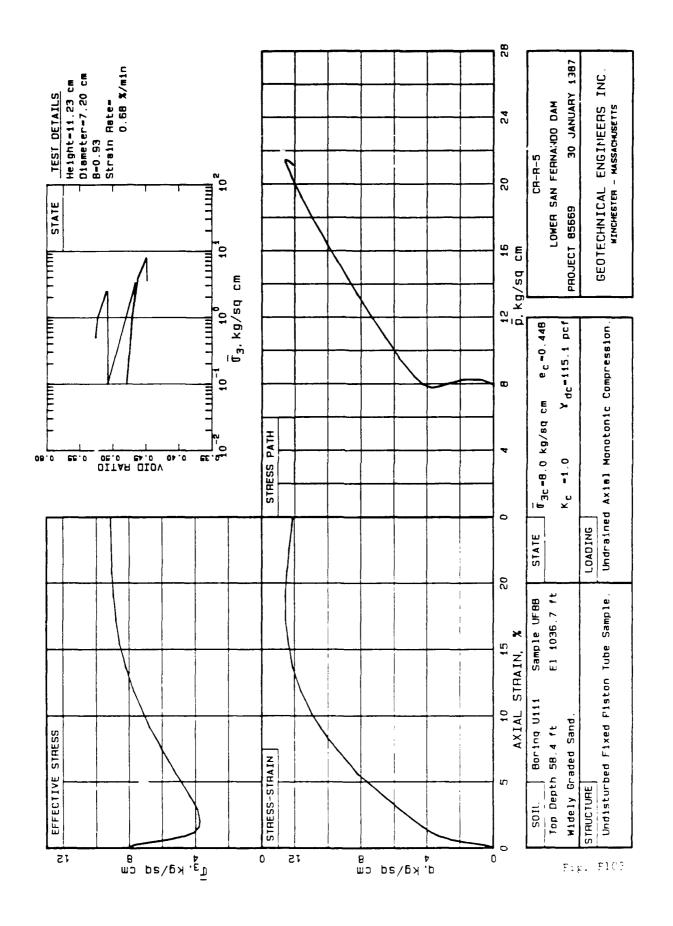


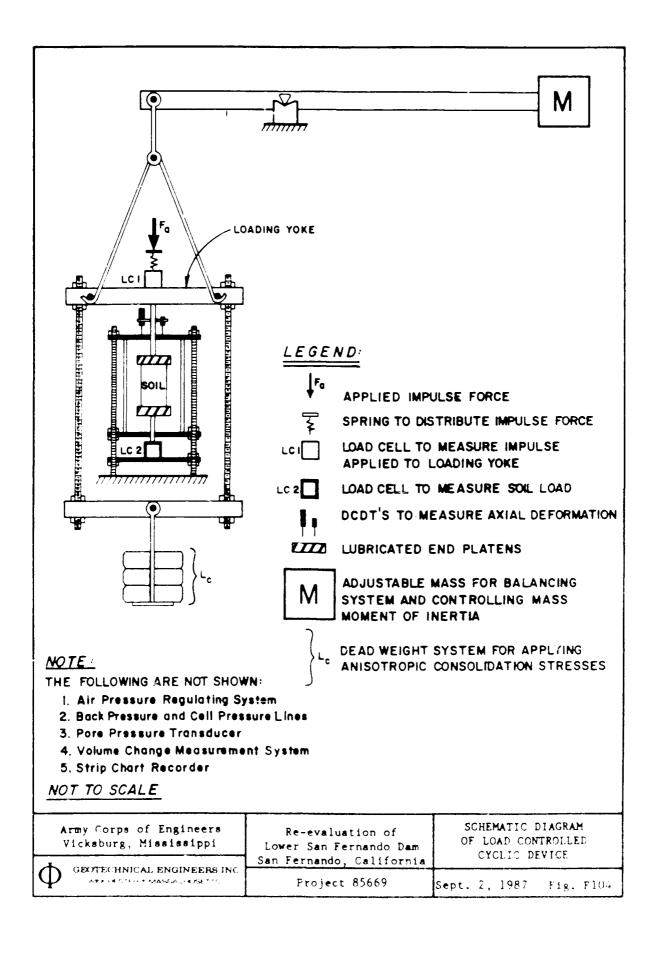


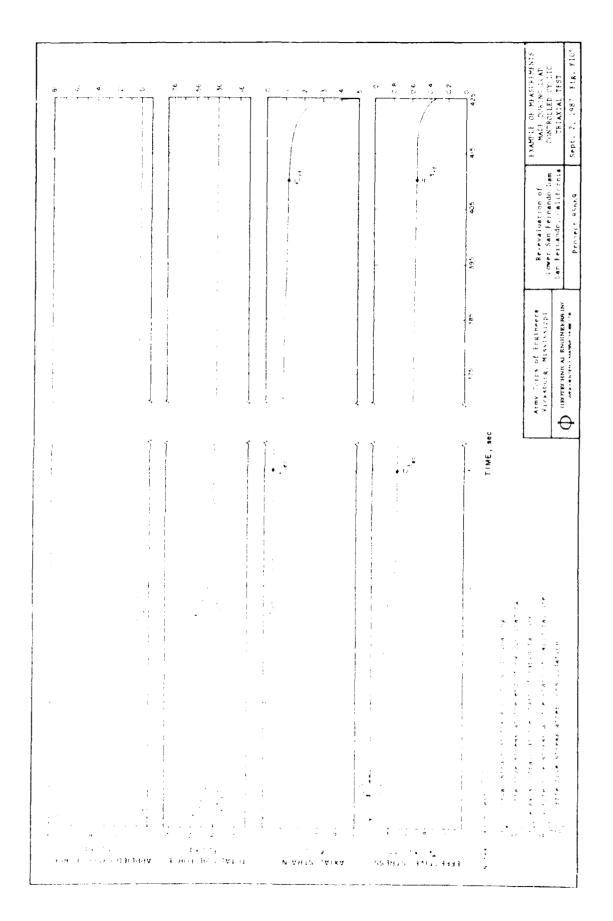


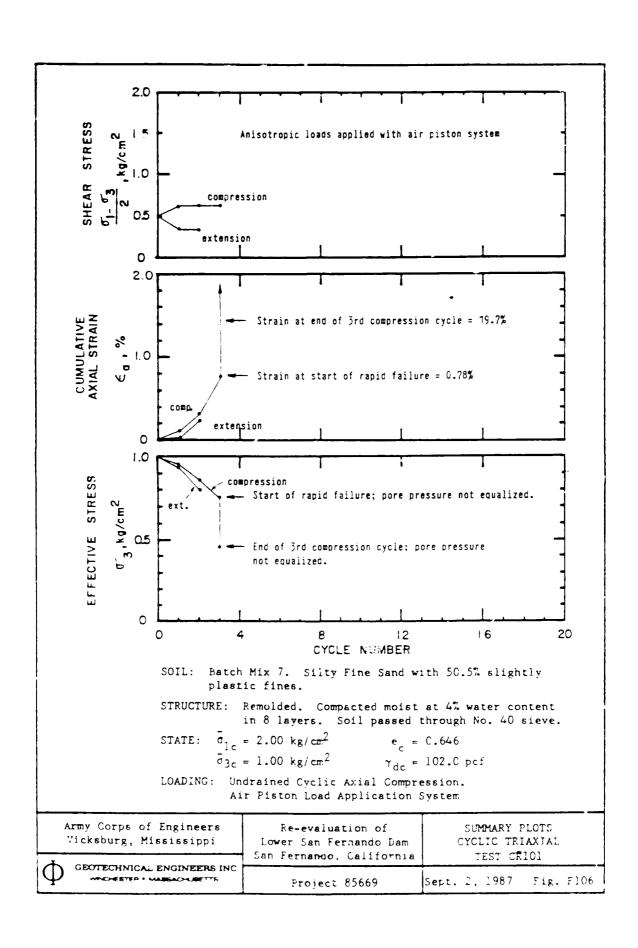


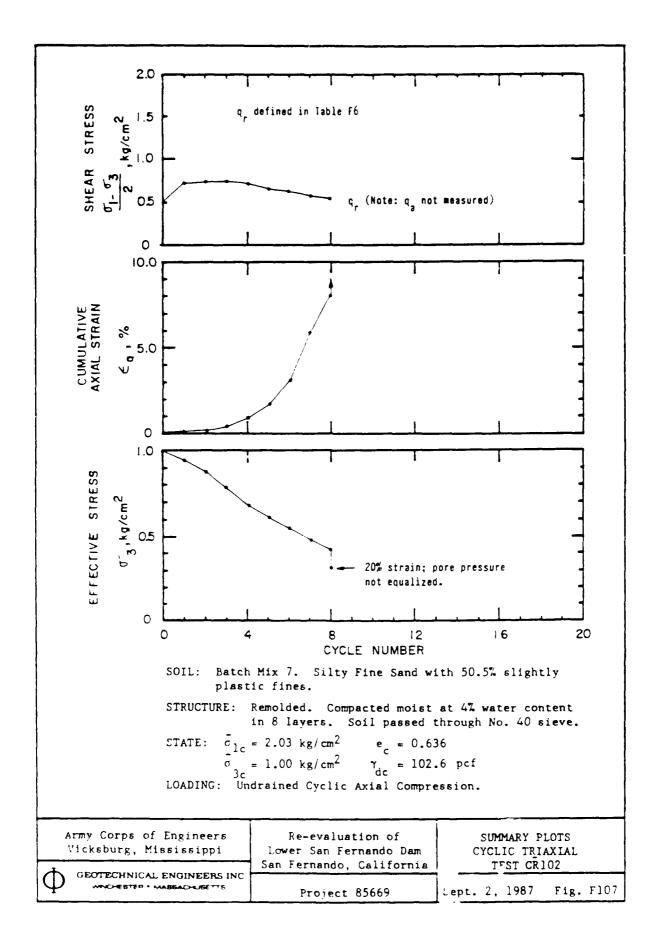


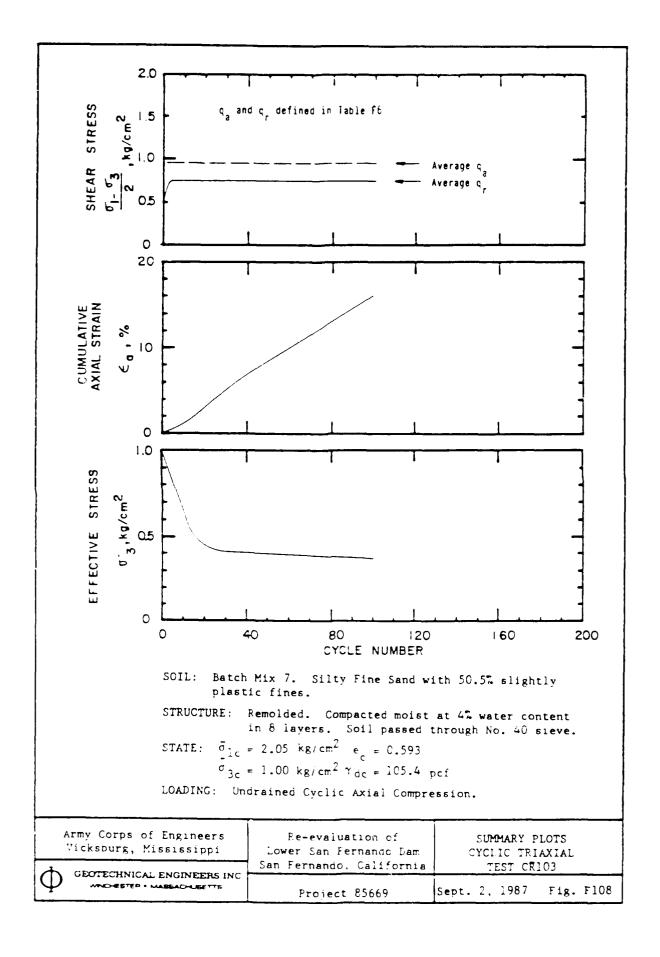


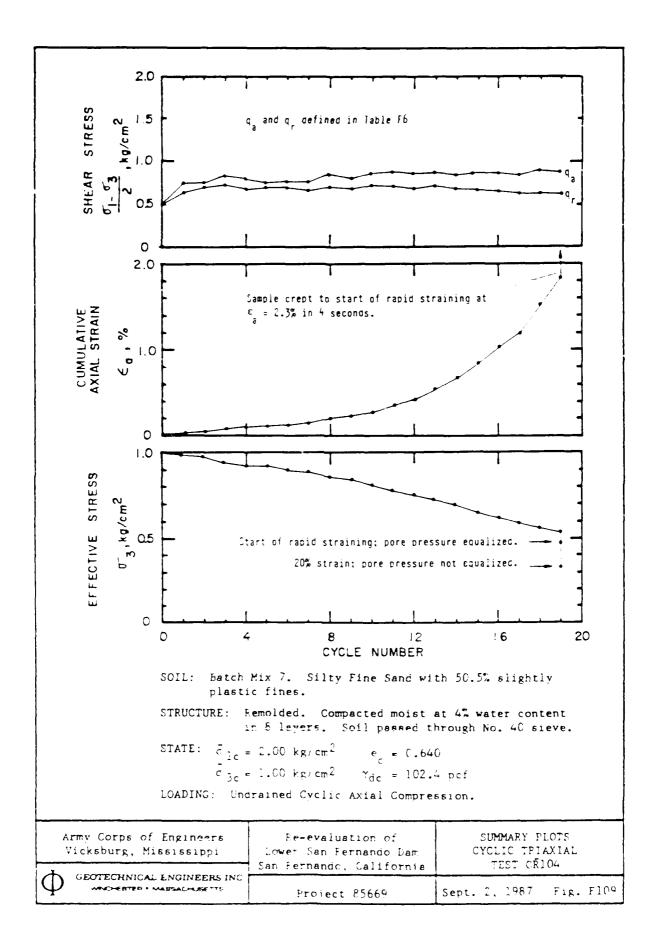


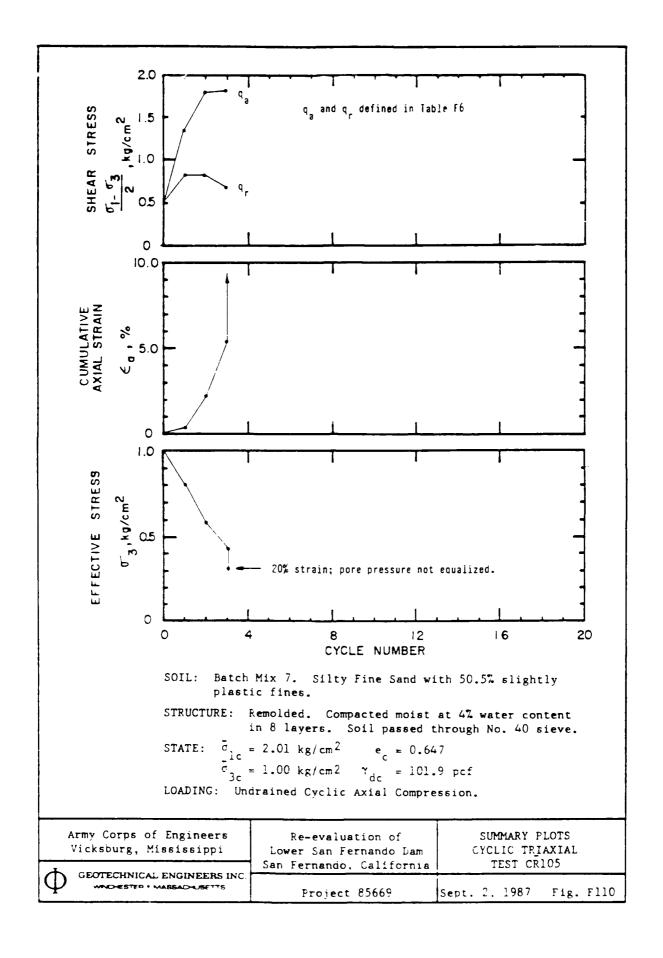


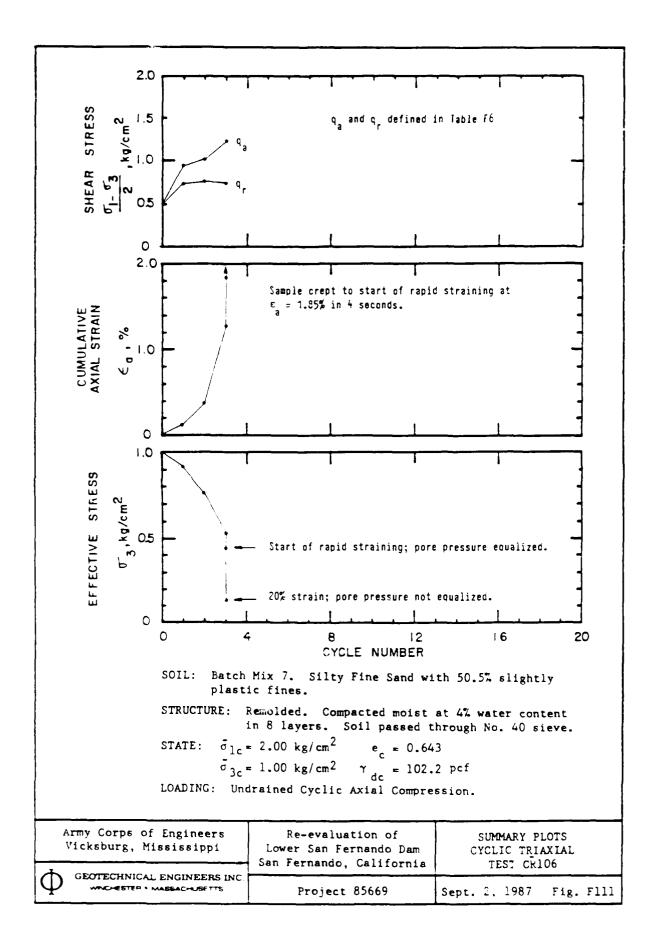


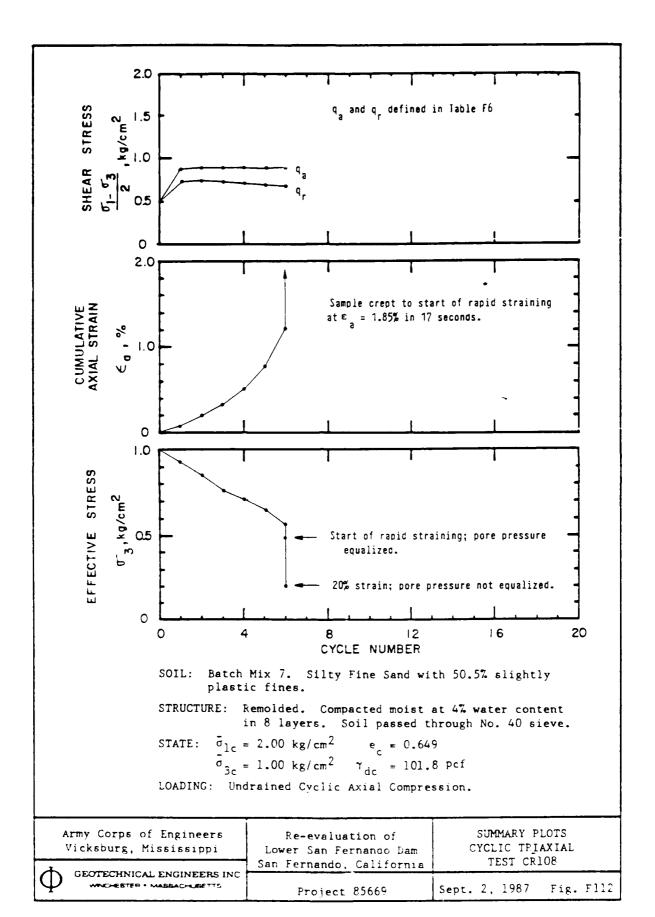


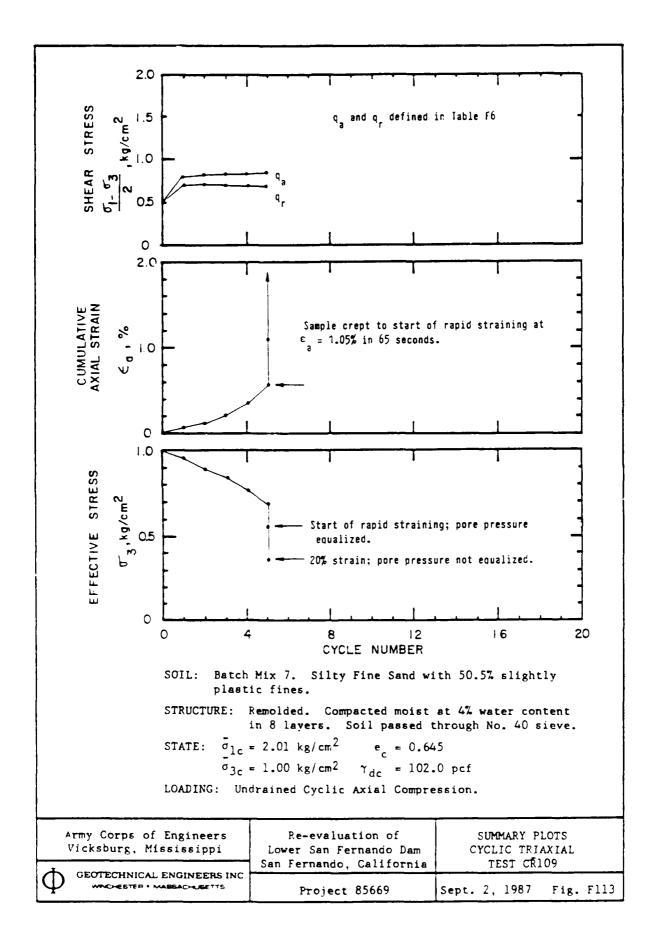


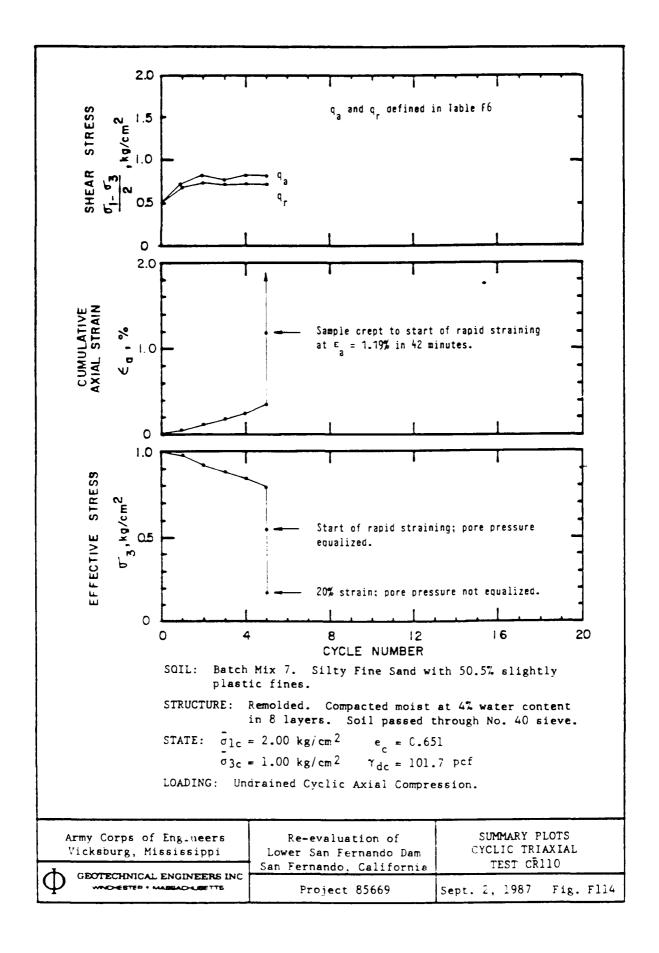


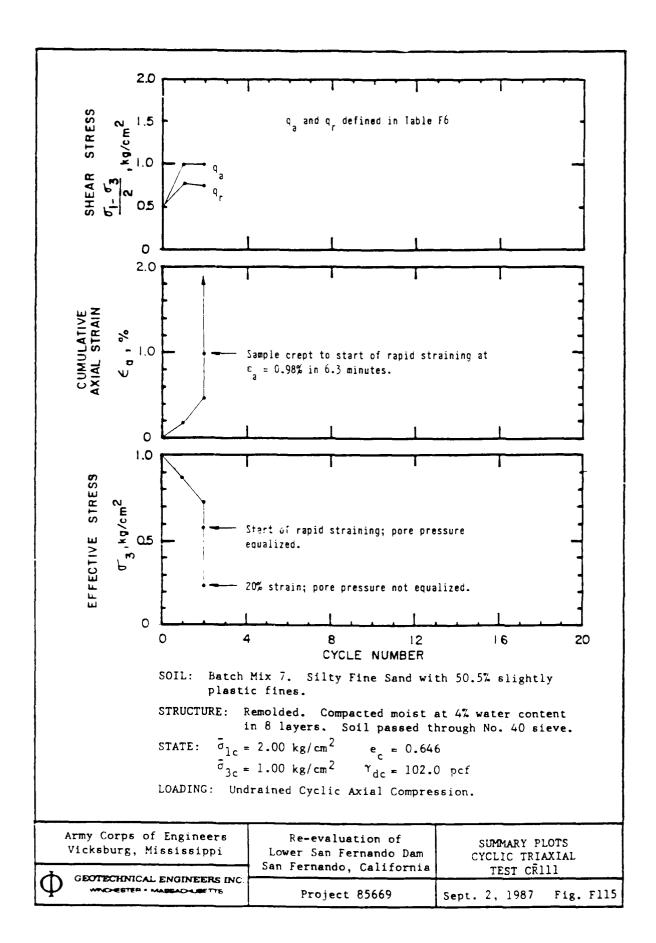


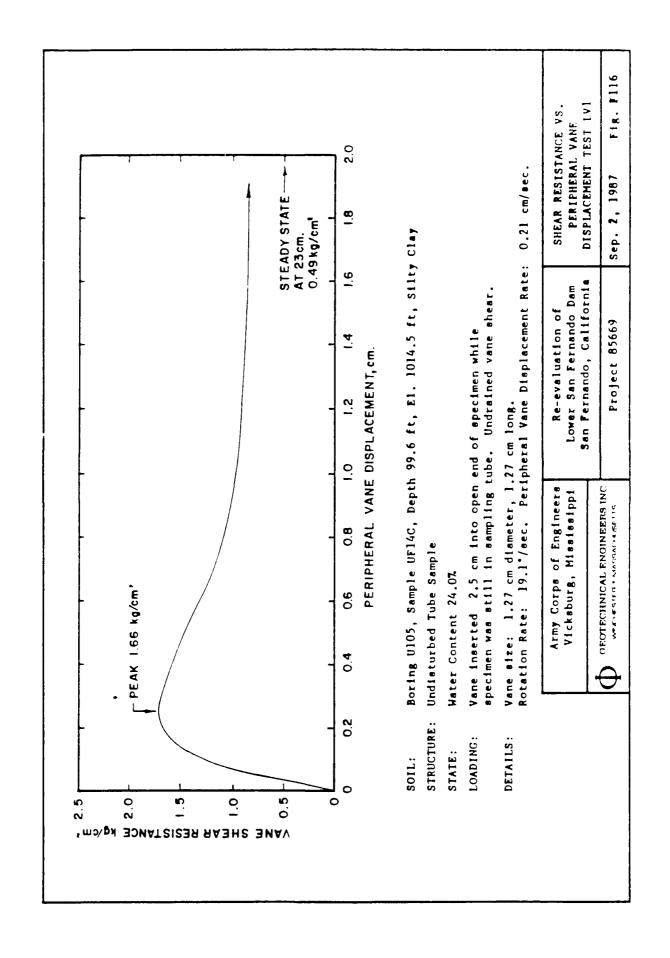












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