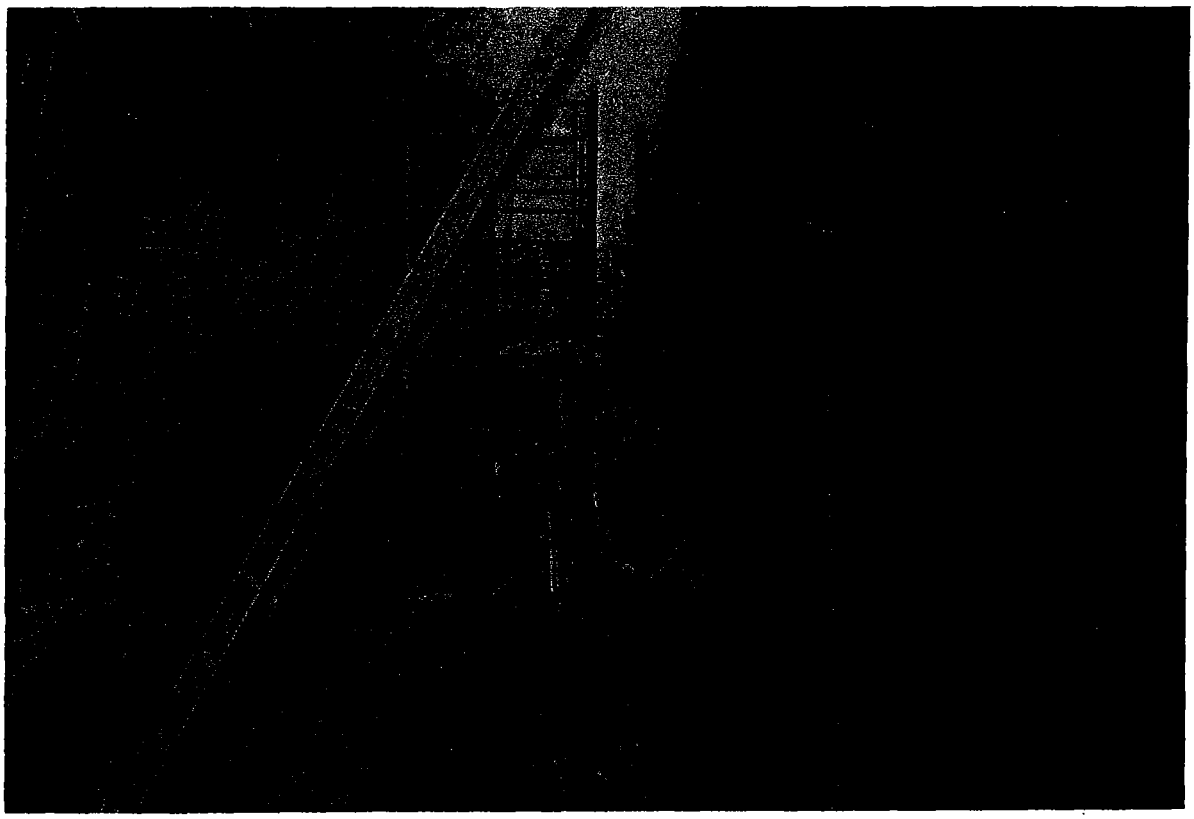
US Army Corps
of Engineers
Lower Mississippi Valley
Division

TECHNICAL REPORT NO. 1

E-99 SHEET PILE WALL FIELD LOAD TEST REPORT



U.S. ARMY ENGINEER DIVISION
LOWER MISSISSIPPI VALLEY
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This technical report presents the results of a field load test that was performed on a PZ-27 sheet pile wall located in the Atchafalaya Basin south of Morgan City, LA. Flood loading was simulated by ponding water against the wall, which was founded in soft clays, at levels up to 8 ft for a period of 60 days. Instrumentation consisted of inclinometers, strain gages, and piezometers. Instrumentation data are plotted and analyzed. Sheet pile performance is compared to that predicted by conventional limit equilibrium analyses and soil-structure interaction analyses. Conclusions are presented regarding the applicability of current sheet pile wall design criteria to the test wall.

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PREFACE

This report describes a field load test that was performed on a sheet pile wall and presents the data that were obtained in the test. This test was initiated by the US Army Engineer Division, Lower Mississippi Valley (LMVD), in a letter to US Army Engineer District, New Orleans (NOD), dated 29 Oct 84. The load test was performed during the period May through September 1985 as part of the E-99, East Atchafalaya Basin Protection Levee Sheet Pile Floodwall construction contract.

The test was coordinated in the field by Mr. William Caver of the NOD under the general supervision of Mr. Rodney Picciola, Chief, Foundation and Materials Branch, Engineering Division, and under the direct supervision of Mr. Gerard Satterlee, Chief, Dams, Levees, and Channels Section. This report was prepared at the LMVD office by Mr. Richard Jackson under the general supervision of Mr. Frank Weaver, Chief of the Geotechnical and Materials Branch, Engineering Division, and under the direct supervision of Mr. Lawrence Cave, Chief of the Soils Section. Mr. Frank Johnson of Technical Engineering Branch at LMVD provided assistance with the structural engineering aspects of the load test design and report preparation. Instrumentation support was provided by the US Army Engineer Waterways Experiment Station, Instrumentation Division, supervised by Mr. Leiland Duke, Chief of the Operations Branch.

Commander of the NOD during the test was COL Eugene Witherspoon, CE. Commander of the LMVD was BG Thomas Sands.

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CONVERSION FACTORS, NON-SI TO SI (METRIC) UNITS OF MEASUREMENT

Non-SI units of measurement used in this report can be converted to SI (metric) units as follows:

Multiply	By	To Obtain
feet	0.3048	metres
foot-pounds (force)	1.355818	metre-newtons or joules
inches	25.4	millimetres
pounds (force) per square inch	6,894.757	pascals
pounds (mass) per square foot	4.882428	kilograms per square metre

E-99 SHEET PILE WALL
FIELD LOAD TEST REPORT

I. Introduction

Background

Within the New Orleans District (NOD) cantilever sheet pile walls, often capped with concrete and called I-walls, are utilized to provide flood protection along the Mississippi and Atchafalaya Rivers, as well as hurricane protection. Over the next few years, construction of many miles of these I-type floodwalls is proposed at an estimated cost of over $100,000,000. The cost of these walls is obviously highly dependent on the sheet pile penetration required for stability.

Purpose of Test

The most appropriate method of analysis for determining the optimum depth of penetration for cantilever sheet pile walls has been the subject of considerable discussion among design engineers for many years. The method of analysis currently used within the Lower Mississippi Valley Division to determine sheet pile penetration is the conventional limit equilibrium fixed-end method with a minimum factor of safety of 1.5 using "S" shear strengths. This method, however, is somewhat conservative in order to account for uncertainties in sheet pile and soil behavior. There are also no known existing field load test data that could be used to verify analysis of I-type floodwalls and little performance data is available on existing floodwalls since these walls have seldom been loaded to any degree by floodwaters. Therefore, it was considered advisable to pond water against a test section of floodwall, collect performance data, and use this data to reevaluate current design procedures for sheet pile walls.

II. Test Site

Site Selection

A 200-ft-long* floodwall section was constructed on the landside berm of the Item E-99 East Atchafalaya Basin Protection Levee (EABPL) which is located on Avoca Island just south of Morgan City, LA. (See Plate 1 for an area map showing the test site.) Plates 2 through 5 show plan and section drawings for the test section, which was located between levee Stations 100+00 and 102+00. This site was selected for the following reasons:

1) The foundation soils are relatively poor, consisting of soft, highly plastic clays, and would be representative of a near worst case condition in the NOD.

2) The test section results could be used in the determination of floodwall sheet pile penetration for adjacent levee Items E-96 and E-105.

3) The cost of the test section could be minimized by constructing the test wall as part of the Item E-99 floodwall contract.

Foundation Conditions

Two undisturbed borings (C-U and F-U) and two general borings (C-A and F-A) were made along the test wall alignment (see Plate 2 for the boring locations and Plates 6, 7, and 8 for the boring logs). These borings indicated that the test wall would be founded in normally consolidated highly plastic clays with liquid limits of between 76 and 114, and natural water contents varying from 40 to 80. Unconsolidated-undrained triaxial (Q) tests were performed on selected soil samples to determine the undrained shear strength of the foundation clays.

Plate 9 shows the Q and unconfined compression test results and the selected design strengths and densities for the test wall foundation clays, which varied from 200 to 500 psf.

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* A table of factors for converting non-SI units of measurement to SI (metric) units is presented on page iii.

III. Test Section Design and Construction

Design

Water was ponded against the test wall in such a manner as to simulate project flood conditions. The top 8 ft of the project flood hydrograph was used to determine the actual ponding levels and sequence. The water would be retained within an enclosure formed by the sheet pile test wall, sheet pile side walls, and the levee (see Plates 2-5). To eliminate end effects, the ends of the test wall were not connected to the side wall. A rubber seal was used to prevent leakage between the test wall and the side walls, and vinyl sheeting was placed against the floodside of the wall to reduce leakage through the PZ-27 sheet pile interlocks.

It has long been debated whether or not the S-case (long-term) sheet pile penetration analysis, which usually governs sheet pile floodwall penetration, is applicable to floodwall design with relatively short loading periods. Therefore, in order to ascertain whether sheet pile penetrations determined using "Q" (undrained) shear strengths are adequate, a test wall penetration of 23 ft was selected for an 8-ft maximum head using the conventional limit equilibrium Q-case (undrained) analysis and a factor of safety of 1.25 (see Analysis 1, Appendix A for a CANWAL computer analysis printout). This penetration was much less than the 44-ft penetration that would be required by our normal design criteria using the S-case strengths and a 1.50 factor of safety (see Analysis 2). In fact, the computed S-case factor of safety for the 23-ft penetration test wall at an 8-ft head was less than 1.0 (see Analysis 3). In order to ensure that the test section did not adversely affect levee stability, a landside stability analysis was performed (see Plate 10). Plate 11 shows the ground surface profile, soil stratification, and design strengths used in the test wall penetration analyses.

Instrumentation

In order to measure wall deflections and strains, steel inclinometer tubes and bonded electrical strain gages were attached to four of the sheet piles. Plate 2 shows the location of the instrumented piles, designated A, B, C,

and D and spaced 50 ft apart along the wall. Inclinometer tube and strain gage details are shown in Plates 12, 13, 14, and 15. In addition to the wall inclinometer tubes, four soil inclinometer tubes with tip elevations at -100 ft, NGVD* were installed 4 ft landside of the instrumented piles. The purpose of these inclinometers was to measure soil deflections in front of the wall and also to determine if the test caused a landward soil movement below the tip of the sheet pile wall. Surveys were periodically made along the top of the wall during the test, and ground surface elevations were also recorded. Open piezometers were installed to measure landside and floodside piezometric levels. See Plate 2 for piezometer locations and tip elevations.

Construction

The area along the wall alignment was cleared and graded to approximate el +6.5 as shown in Plate 2 and the PZ-27 sheet pile wall was driven in May of 1985. Based on initial inclinometer measurements, the as-driven inclination of the instrumented piles from the vertical on 29 May 1985 is as shown in Plate 16. Between the driving of the sheet piling and filling of the test section with water, 2 ft of excess fill was inadvertently placed on the levee section behind the test wall on 27 June 1985. This excess fill, which lowered the theoretical factor of safety of the levee at the wall well below the 1.30 allowable, was removed after a few days.

Loading

Filling of the test section with water began on 15 July 1985. The inclinometer and strain gage readings made just prior to filling were used as "zero" readings for the test. The filling and emptying schedule that was followed during the test is presented in Plate 17. Although it was intended to empty the test section in such a manner as to more closely match the flood hydrograph, the test section was emptied within a few hours on 9 September 1985 as a result of a leak beneath one of the rubber end seals. No attempt was made to refill the test section, since the test schedule called for lowering of the

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* All elevations (el) cited herein are in feet referred to the National Geodetic Vertical Datum (NGVD).

head to 6 ft on 9 September, and only rebound wall measurements would have been affected.

IV. Test Wall Performance

Lateral Deflection

Small deflections (0.3 in. maximum) were recorded at the top of test piles A and B when the 2 ft of excess fill was placed on the levee prior to filling the test section. See Plate 18 for a comparison of deflections measured by inclinometer at pile A after placement of the excess fill to initial as-driven inclination. Little or no movement was recorded at test piles C and D. Test piles A and B rebounded somewhat after the excess fill was removed and it is doubtful that this excess fill had any significant effect on the test results.

Plates 19-22 show the final test pile deflections for each test pile at each head as related to their pre-load inclinations measured on 15 July 1985. These heads were computed using the actual ground surface elevation at each test pile. Although the heads shown in Plate 18 were based on an assumed ground surface elevation of 6.5, the ground surface varied from el 6.2 at test pile A, to el 6.7 at test pile D. The inclinometer data in Plates 19-22 suggest that the test wall sheet piling behaved as assumed in the "free earth" method of analysis, and did not rotate as a rigid body about a point somewhere in its embedded depth as assumed in the "fixed earth" method of analysis. For an example of "fixed earth" sheet pile behavior, see Plate 18. Plate 23 was developed utilizing the data in Plates 19-22 to show lateral deflections at the top (el 14.5) of the wall (with respect to the tip) for various heads. Final (4 September 1985) inclinations from the vertical for each test pile at the maximum head (±8 ft) are shown in Plate 24. A review of Plates 16, 23, and 24 indicates that pile A at the upstream end of the test wall may have deflected more at a given head in order to achieve a similar inclination from the vertical as the piles at the downstream end.

The deflections of the soil inclinometers (designated AP, BP, CP, and DP) installed 4 ft landside of each test pile are compared to adjacent wall deflections in Plates 25-28. These plates indicate that soil movements at the

ground surface 4 ft landside of the wall varied from 60 to 100 percent of the wall movement recorded at the ground surface on 29 August 1985 (7-ft head). The soil inclinometers showed no significant deflection below the tip of the sheet pile wall which infers that the tip of the test wall was relatively stable. The wall alignment surveys through 9 September 1985, which are shown in Plate 29, generally indicate lateral deflections at the top of the wall of the same magnitude as those indicated by the wall inclinometers. These surveys provide further evidence of minimal wall tip movement. The 16, 23, and 30 September 1985 readings shown in Plate 29 are assumed to be in error since the inclinometer data indicate that the wall rebounded toward the floodside after the water was drained from the test section.

A plot of the measured lateral deflection at the top (el +14.5) of each test pile versus elapsed time is presented in Plates 30-33. It is apparent that at each constant head the amount of deflection increases with time. However, the rate of increase in deflection decreases with time and is near zero after about a 2-week period.

Strain Gage Measurements

Strain gage readings were made at the heads on the dates shown in Plate 17. Generally, readings were made just after a raise in head and just before raising to the next head. Based on the strain gage data, stresses and moments were computed in the steel sheet piling. Alignment surveys made along the top of the test wall (see Plate 29 for survey results) indicate that the deflection of the test piles and the adjacent sheet piling are approximately equal. Therefore, it can be assumed that the strains and stresses measured in the test sheet piling are representative of the entire wall. Moment-versus-elevation diagrams for the test piles for various heads are shown in Plates 34-37. The maximum moment along the sheet piles generally occurred near el -5 (11 to 12 ft below the ground surface) and the maximum stresses measured did not exceed 10,000 psi or about half the allowable. The strain gages installed on the floodside flange of the instrumented piles (see Plate 14) indicated strain approximately equal to the strain measured at the same elevation on the landside flange. The neutral axis of each loaded test pile was therefore near the geometric axis of the sheet pile section. Some

horizontal strain (and therefore bending) was also recorded by the F6H strain gages (see Plate 14 for locations of the F6H gages).

Piezometer Readings

All of the floodside and some of the landside piezometric data obtained by contract surveyor during the test are considered unreliable. However, utilizing some reliable landside readings and independent Government piezometer readings made at Sta 100+75 on 3 September 1985, the landside piezometric level likely varied from el 4.0 to 5.0 during the test. The floodside piezometer readings made at Sta 100+75 on 3 September 1985 indicated that the floodside piezometric level in the foundation above the tip of the sheet pile was near the ponded water level (el 14.5). Therefore, for test wall analysis purposes, it was assumed that the floodside piezometric level was equal to the ponded water level (head) and that the landside piezometric level was between el 4.0 and 5.0.

V. Analysis of Test Data

Although the test wall was not loaded to "failure," i.e., structural failure of the steel sheet piling or overturning of the wall, the plot in Plate 23 indicates failure may have been imminent as the head on the wall approached and exceeded 8 ft. The deflection and rebound data in Plate 23, which are similar to a bearing pile load settlement curve, indicate that beyond 6 ft of head, the wall deflections are "plastic" and nonrecoverable. Table 1 below summarizes the maximum lateral deflections at the top of the pile and moments experienced in the test piles before the test section was drained.

Table 1

Test Pile	Head (ft)	Lateral Deflection (in.)	Maximum Stress (psi)	Maximum Moment (ft-lb)	El of Maximum Moment (ft, NGVD)
A	8.3	8	9,800	25,100	-5.5
B	8.1	6	7,200	18,400	-5.5
C	7.8	4	6,500	16,500	-5.5
D	7.8	4	7,500	19,200	-3.5

Even though variations in foundation soil stress-strain properties and as-driven plumbness of the test piles may have contributed to some variations in lateral deflections along the wall alignment, the test wall appeared most sensitive to changes in head. The fact that little additional wall deflection occurs after about 2 weeks at a constant head (see Plates 30-33) indicates that undrained creep was essentially complete.

Prior to testing, both conventional limit-equilibrium sheet pile penetration analyses and soil-structure interaction analyses were performed to establish the test wall penetration. As shown in Plate 38, the test data indicate that at 7 ft of head the lateral wall deflection of test pile B actually experienced was about twice that predicted by conventional analyses (see Analyses 4 and 5, Appendix A) and about half of that predicted using the Waterways Experiment Station (WES) "Computer Program for Soil-Structure Interaction Analyses of Sheet Pile Retaining Walls (CSHTSSI)" and the soil modulus guidelines therein (see Analysis 6, Appendix A). The maximum stresses measured in the instrumented piles were roughly half the allowable, and either method of analysis predicted these stresses as accurately as necessary. This indicates that moments and stresses are not too sensitive to values of subgrade modulus ($E_{s/d}$). See Plate 39 for a comparison of predicted and actual moments for an 8-ft head.

Additional CSHTSSI analyses were performed after testing, and the soil moduli E_s and interaction distances d were revised from the pretest values so that the deflections predicted by CSHTSSI matched test pile B deflections at 4-, 6-, and 7-ft heads and test pile A deflections at an 8.3-ft head as closely as possible (see Analyses 7, 8, 9, and 10, Appendix A). It is interesting to note from Analyses 7-10 that as the head on the wall increased, larger interaction distances and thus smaller values of subgrade modulus $E_{s/d}$ were necessary in order for the CSHTSSI predictions to match the measured values. CSHTSSI analyses were then performed for various heads and tip elevations, using the values of subgrade modulus calculated after testing to determine the predicted effect of penetration on wall deflection. Plates 40-43 show plots of predicted lateral wall deflection versus sheet pile penetration for 4-, 6-, 7-, and 8.3-ft heads. Using Plate 42 as an example, it can be seen that by increasing the sheet pile penetration beyond that of the test wall (23 ft)

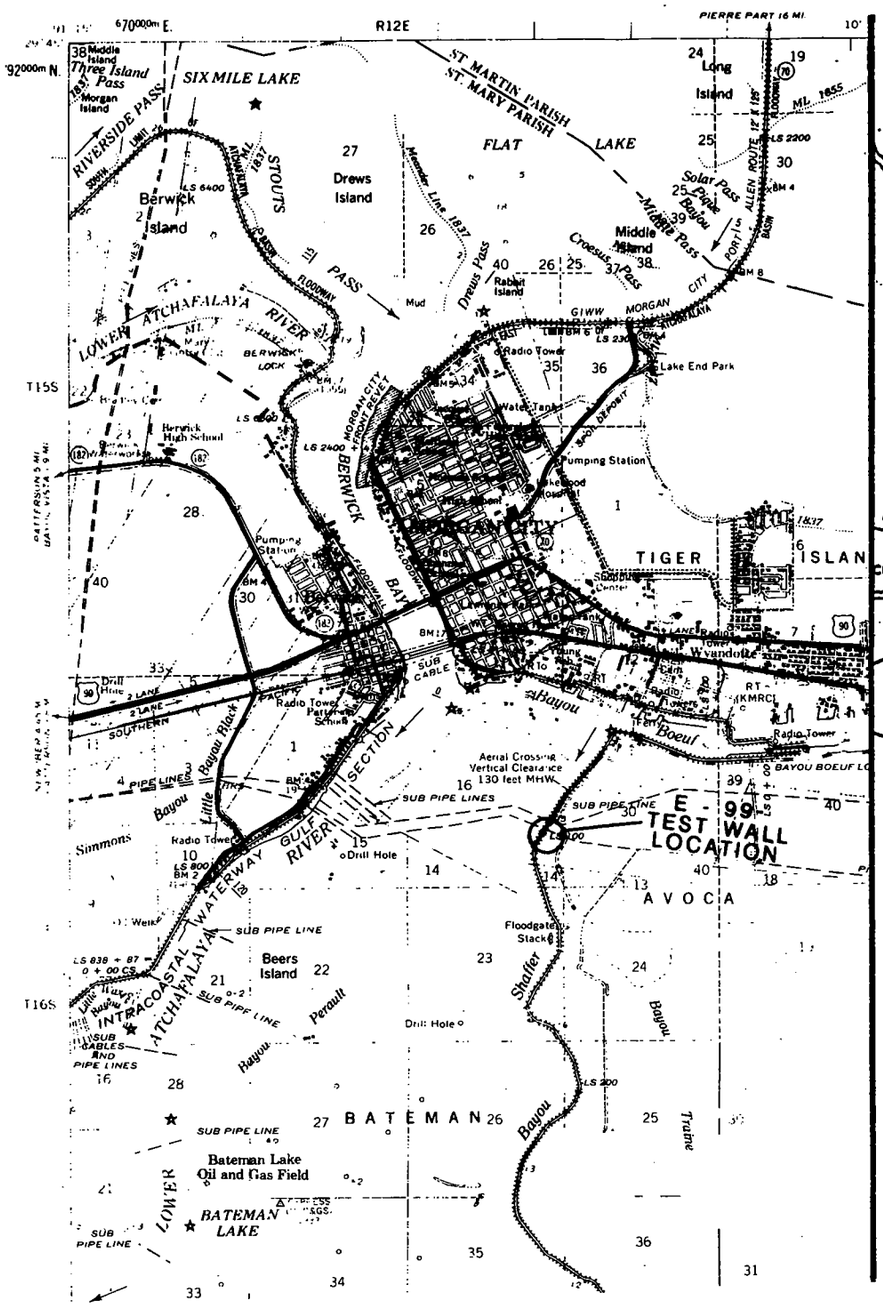
only a slight decrease in wall deflection would theoretically result for the test conditions. The minimum required sheet pile penetrations necessary to avoid excessive wall deflections and possible failure were selected from Plates 40-43 and plotted in Plate 44 for various heads. In addition, the required sheet pile penetrations based on CANWAL (S-case, FS = 1.0 and Q-case, FS = 1.5) have been plotted in Plate 44. From Plate 44 it can be seen that there is surprisingly good agreement between the minimum penetrations required to avoid excessive wall deflections and possible wall failure based on CSHTSSI and CANWAL (S-case, FS = 1.0).

VI. Conclusions

The test data indicate that the current sheet pile penetration design procedure, which is based on the S-case analysis and a factor of safety of 1.50, would be too conservative for design of the test section wall. The computed S-case factor of safety of the test wall at a 7-ft head was 1.0 and the wall performed satisfactorily at that level. Based on the data shown in Plate 44, sheet pile penetrations determined using the S-case analysis (FS = 1.2) should be adequate to provide satisfactory limit equilibrium stability and to avoid excessive deflections. From Plates 40-43, it is evident that no significant decrease in wall deflection would result from increasing sheet pile penetration beyond that required to achieve an S-case of FS = 1.2. For example, from Plates 42 and 44, it can be seen that no significant decrease in deflection would result from increasing the sheet pile penetration beyond 28 ft, which is required to achieve FS = 1.2 for a 7-ft head.

It should be noted, however, that most floodwalls in the NOD are founded in the levee crown, while the E-99 test section was founded at the levee toe due to cost constraints (see Plate 45). In order to better utilize the E-99 test data to study the design of sheet pile walls driven in the levee crown, WES has been contracted to perform a finite element model study. WES will first model the E-99 test wall, adjusting the soil strength parameters so that the model performs similarly to the test wall. Then, using the soil strength/modulus relationships derived from the E-99 model, a model of a typical sheet pile wall driven into a levee crown with very soft foundation soils will be developed. This levee/sheet pile wall model will be utilized to predict the

effect of sheet pile penetration on deflections and overall levee/sheet pile stability.



VICINITY MAP

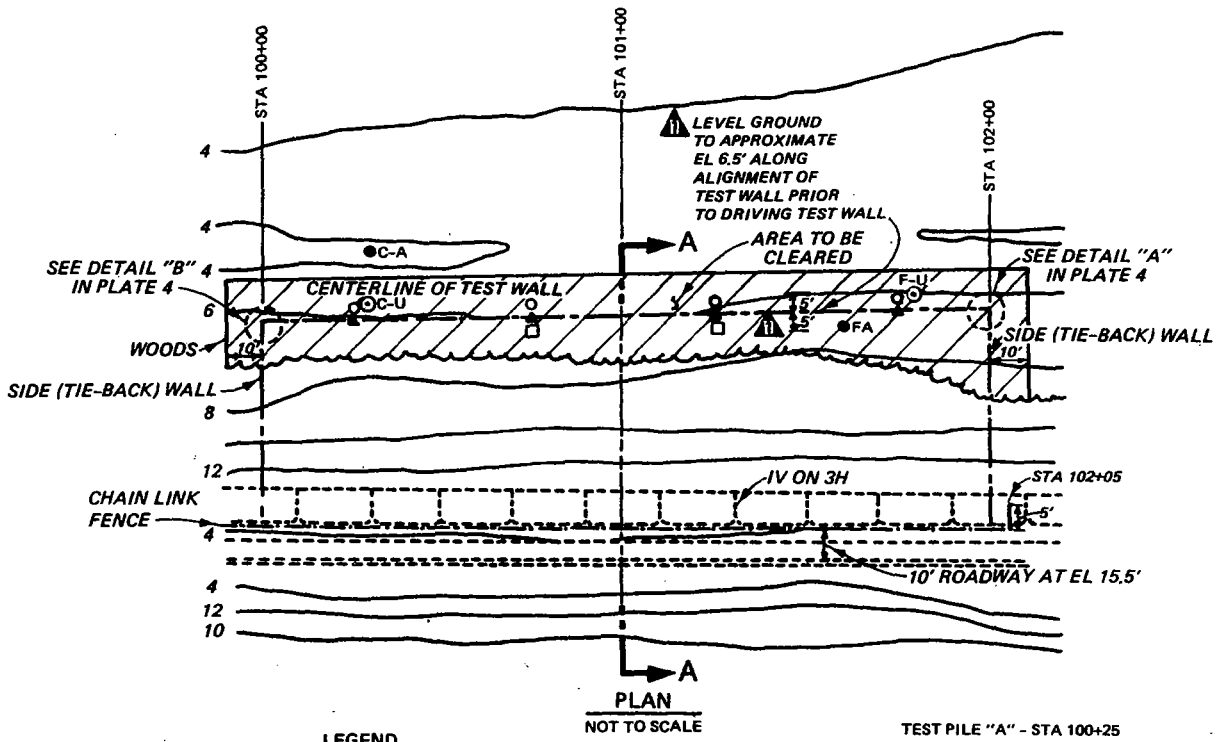
SCALE OF MILES

20 0 20 40 60

SHEET PILE WALL LOAD TEST

LOCATION MAP

PLATE 1



PLAN

NOT TO SCALE

LEGEND

- ▲ STRAIN GAGES AND SLOPE INCLINOMETERS ATTACHED TO SHEET PILE WALL AT STATIONS 100+25, 100+75, 101+25, AND 101+75.
- □ PIEZOMETERS, INSIDE OF TEST WALL AT STATIONS 100+75 AND 101+25.
- ○ SLOPE INDICATORS AND PIEZOMETERS OUTSIDE TEST WALL AT STATIONS 100+25, 101+25, AND 101+75.
- ⊙ UNDISTURBED BORING
- ● GENERAL BORING

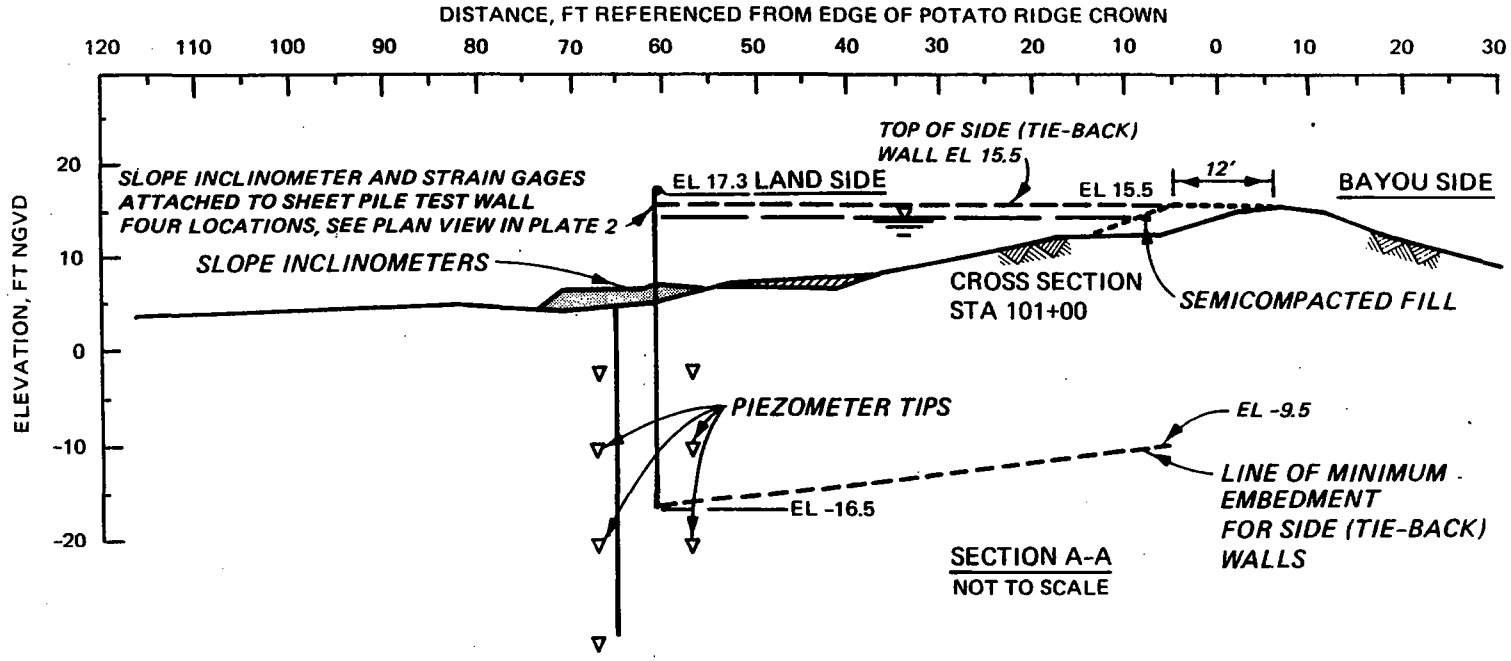
TEST PILE "A" - STA 100+25
TEST PILE "B" - STA 100+75
TEST PILE "C" - STA 101+25
TEST PILE "D" - STA 101+75

SHEET PILE WALL LOAD TEST

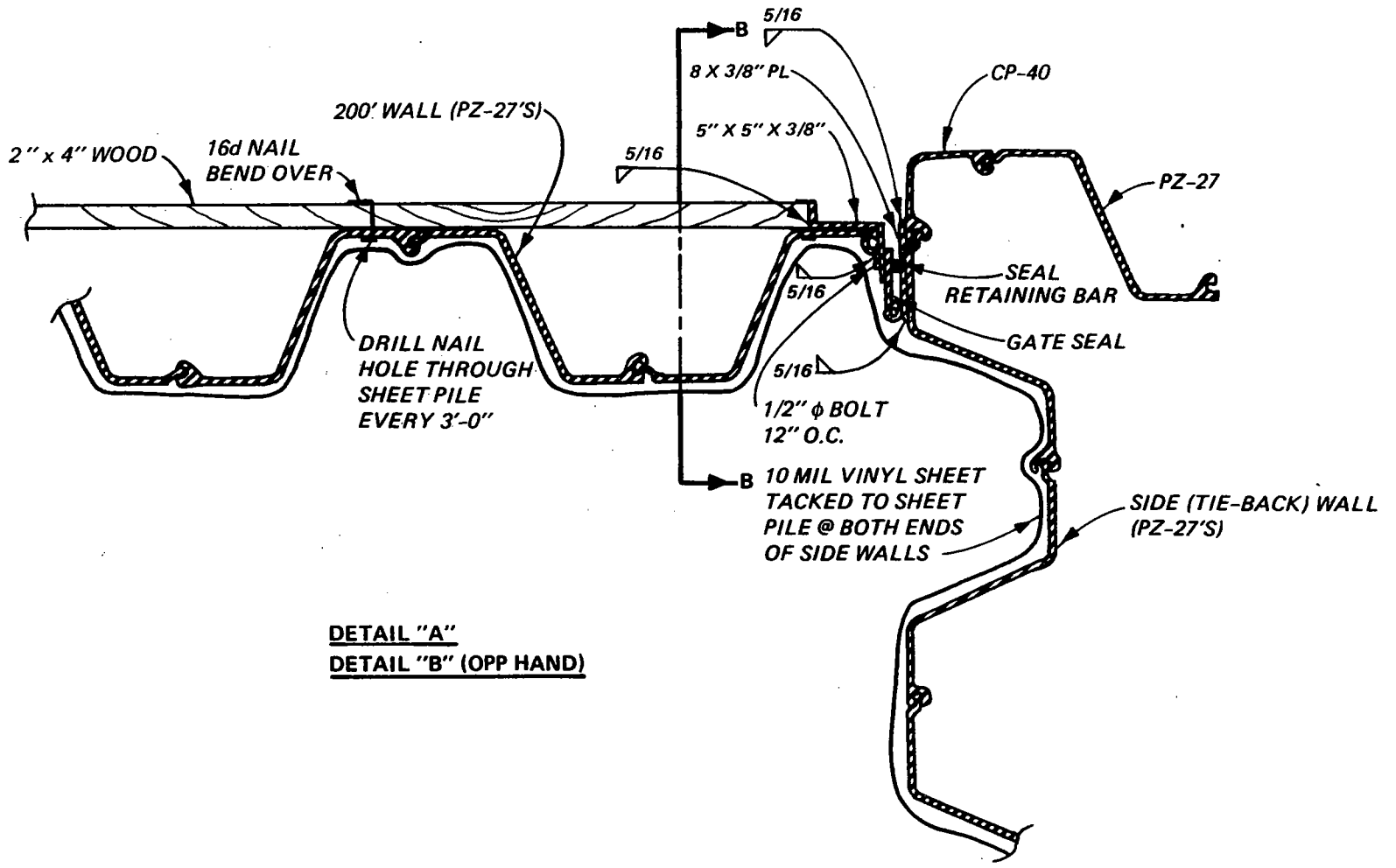
PLAN

PLATE 2

PLATE 3



SHEET PILE WALL
LOAD TEST
SECTION



SHEET PILE WALL
LOAD TEST
DETAILS A & B

PLATE 4

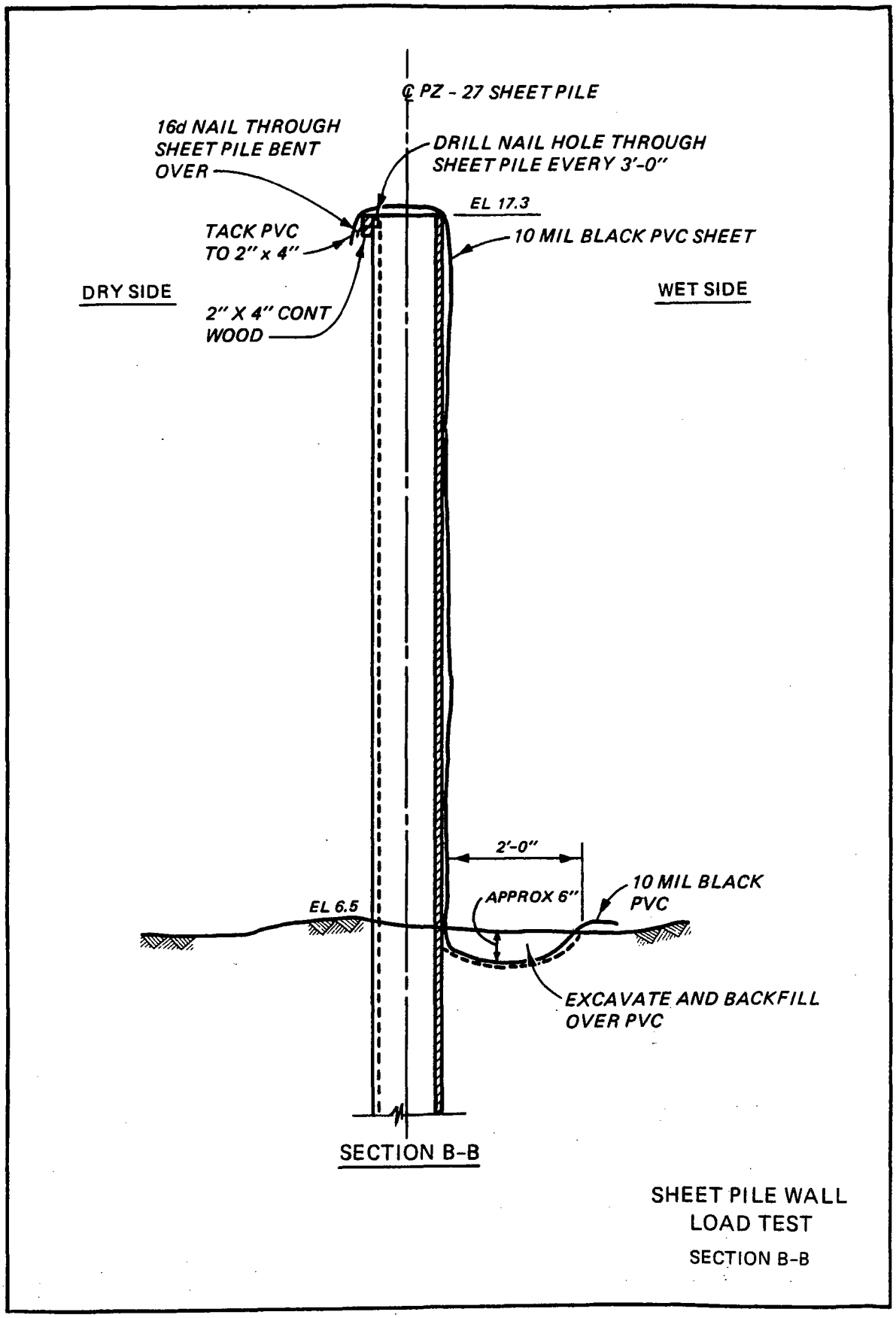

℄ PZ - 27 SHEET PILE
16d NAIL THROUGH SHEET PILE BENT OVER
DRILL NAIL HOLE THROUGH SHEET PILE EVERY 3'-0"
EL 17.3
TACK PVC TO 2" x 4"
10 MIL BLACK PVC SHEET
DRY SIDE
WET SIDE
2" X 4" CONT WOOD
2'-0"
10 MIL BLACK PVC
APPROX 6"
EL 6.5
EXCAVATE AND BACKFILL OVER PVC
SECTION B-B
SHEET PILE WALL LOAD TEST
SECTION B-B

PLATE 5

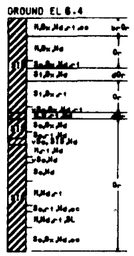
BOR. C-U LOCATION

STA 100+25

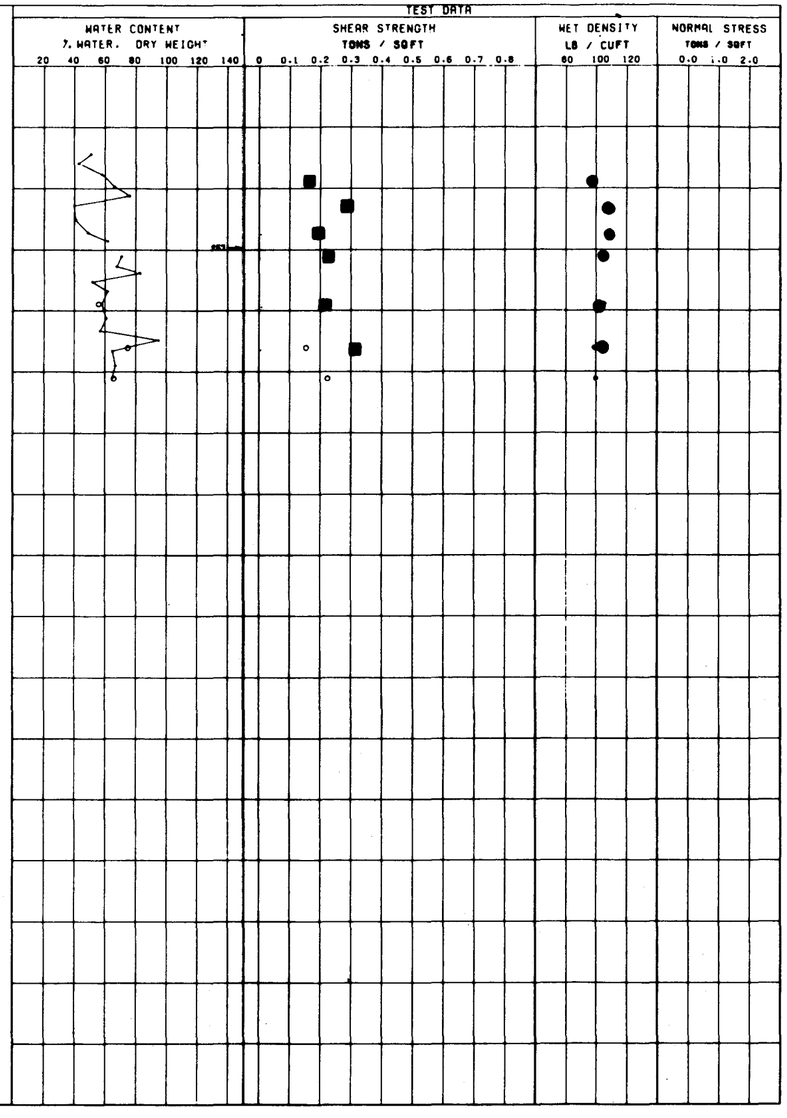
PIEZ 3-56 FT L.S. OF C/L

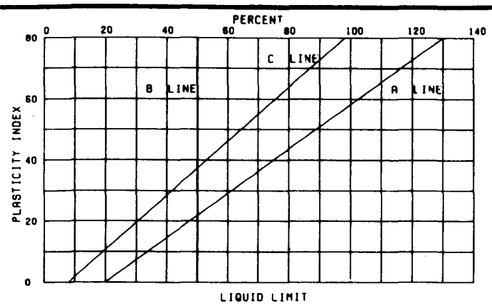
14 DEC 84

GROUND EL 8.4

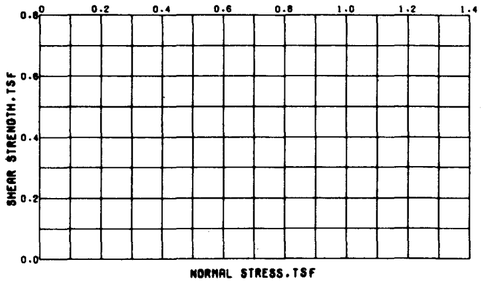


TEST DATA



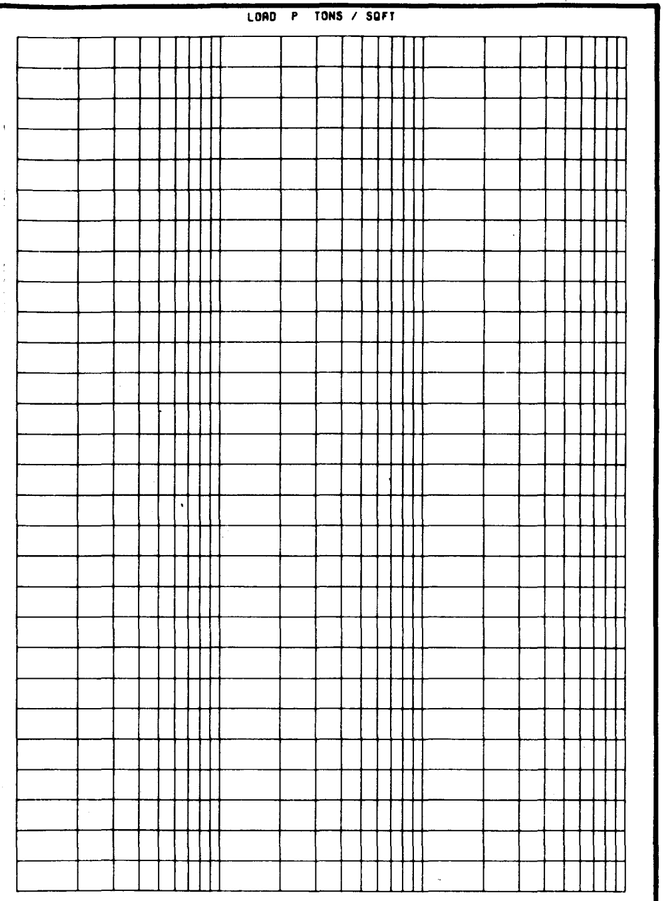


PLASTICITY CHART



SHEAR STRENGTH DATA

ENVELOPE NO.	ENVELOPE EL	TYPE	STRENGTH Φ	STRENGTH C - TSF	CLASS



CONSOLIDATION DATA

○ - (UC) UNCONFINED COMPRESSION TEST

■ - (U) UNCONSOLIDATED - UNDRAINED SHEAR TEST

- (R) CONSOLIDATED - UNDRAINED SHEAR TEST

- (S) CONSOLIDATED - DRAINED SHEAR TEST

BORINGS WERE TAKEN WITH A 5 - IN - DIAM STEEL TUBE PISTON - TYPE SAMPLER

INSTRUMENTATION INSTALLATION

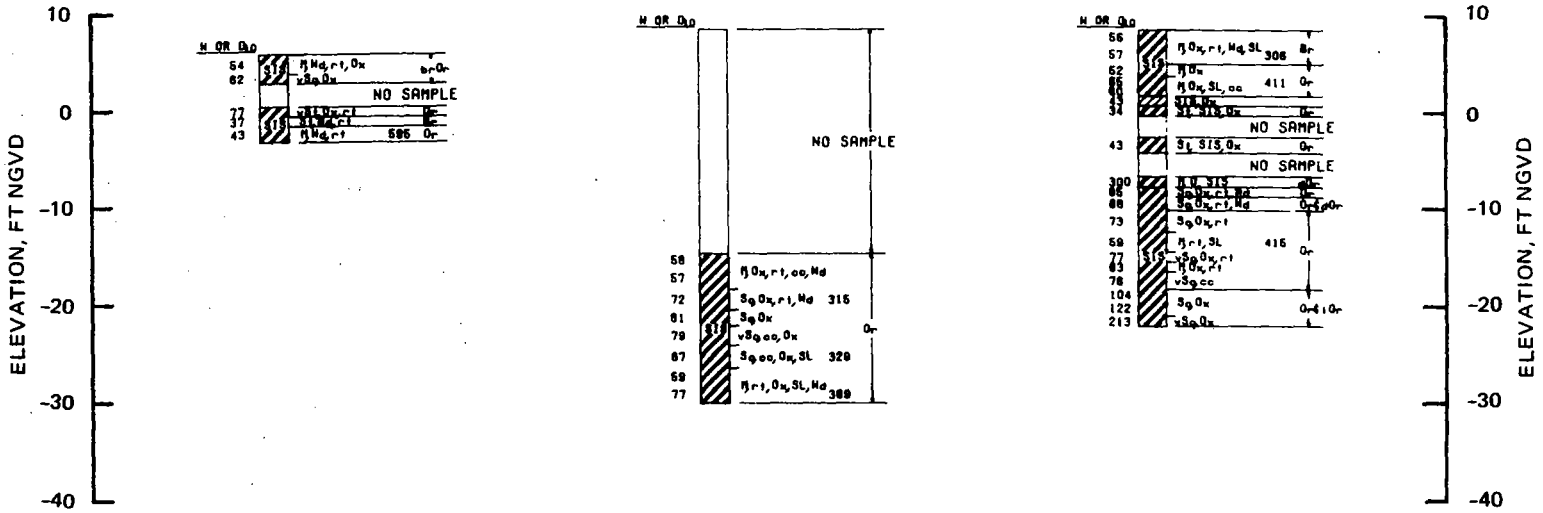
BORING: C-U LOCATION

PLATE 6

BOR CA
STA 100+25
72 FT LS OF C/L POTATO RIDGE
18 JAN 1985
GROUND EL 5.8

BOR FA
STA 101+65
64 FT LS OF LEV.
15 JAN 85
GROUND EL 8.3

BOR F
STA 101+75
64 FT LS OF C/L
JAN 8 1985
GROUND EL 8.3



INSTRUMENTATION INSTALLATION
GENERAL BORINGS

PLATE 7

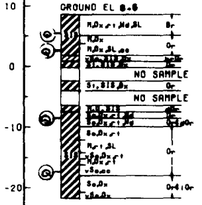
BOR. F-U

STA 101+75

64 FT L.S. OF C/L

8 JAN 1985

GROUND EL 8.3



ELEVATION IN FT, NGVD

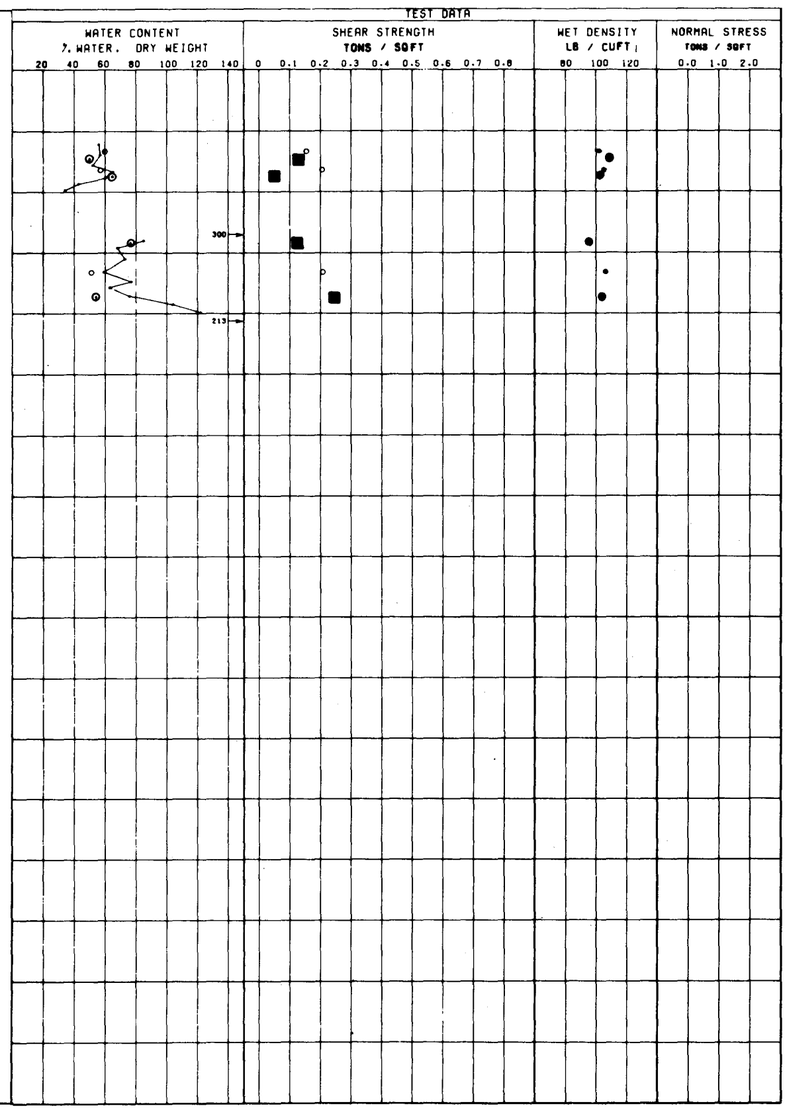
TEST DATA

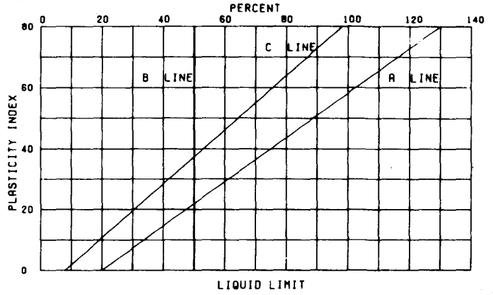
WATER CONTENT
% WATER. DRY WEIGHT

SHEAR STRENGTH
TONS / SQFT

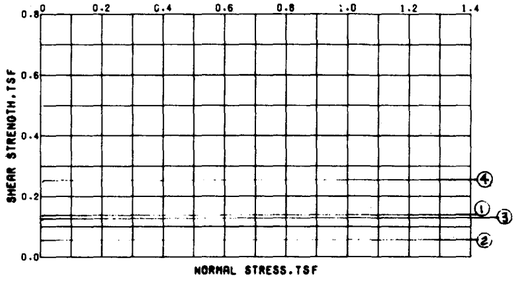
WET DENSITY
LB / CUFT

NORMAL STRESS
TONS / SQFT



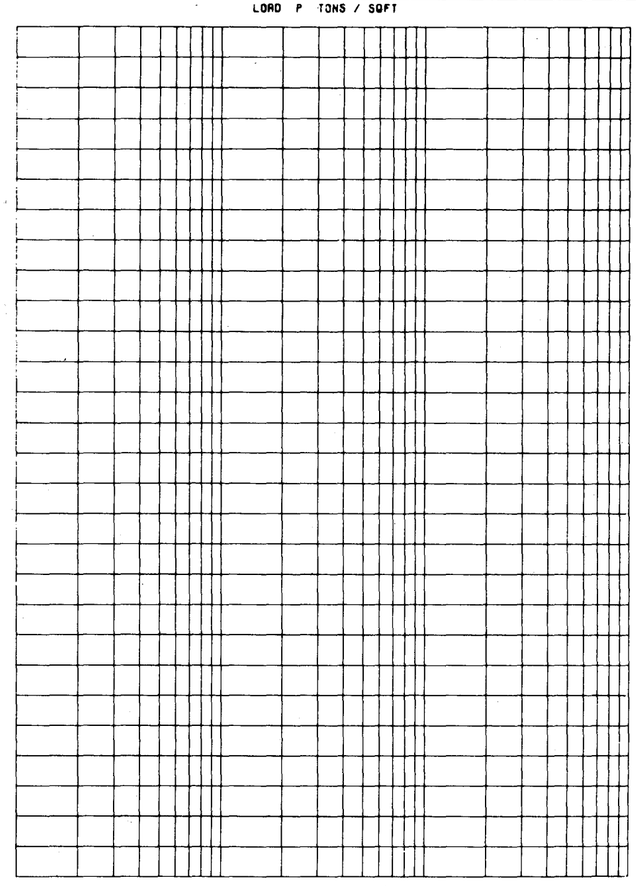


PLASTICITY CHART



SHEAR STRENGTH DATA

ENVELOPE NO.	ENVELOPE EL	TYPE	STRENGTH Φ	STRENGTH C - TSF	CLASS
1	5.7	Q	0	0.14	CH
2	2.9	Q	0	0.06	CH
3	-8.4	Q	0	0.13	CH
4	-17.0	Q	0	0.25	CH



CONSOLIDATION DATA

○ - (UC) UNCONFINED COMPRESSION TEST
■ - (Q) UNCONSOLIDATED - UNDRAINED SHEAR TEST
- (R) CONSOLIDATED - UNDRAINED SHEAR TEST
- (S) CONSOLIDATED - DRAINED SHEAR TEST

BORINGS WERE TAKEN WITH A 5 - IN - DIAM STEEL TUBE PISTON - TYPE SAMPLER

INSTRUMENTATION INSTALLATION

BORING: F-U

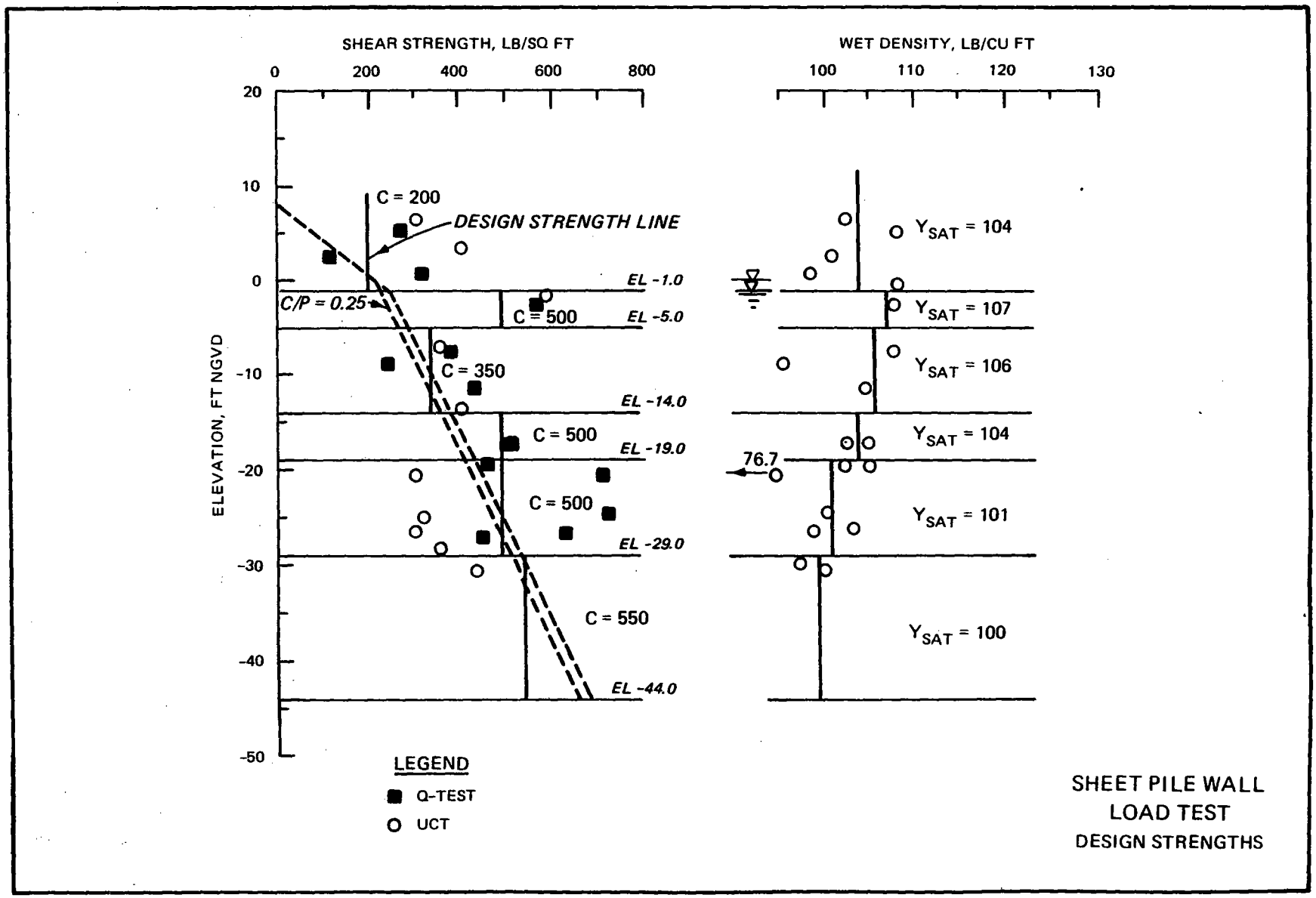
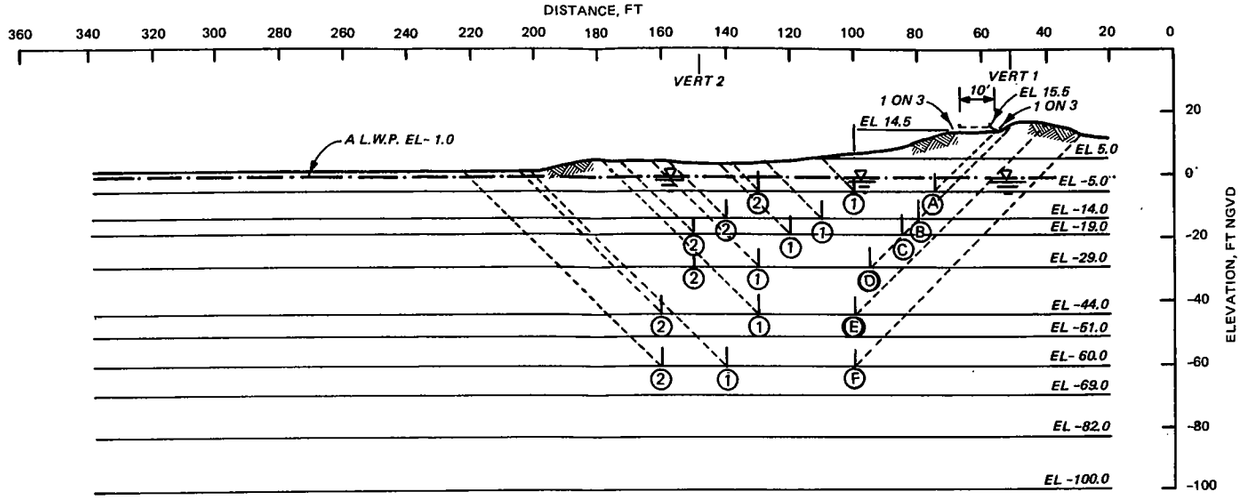

SHEAR STRENGTH, LB/SQ FT
0
200
400
600
800
WET DENSITY, LB/CU FT
100
110
120
130
ELEVATION, FT NGVD
20
10
0
-10
-20
-30
-40
-50
C = 200
DESIGN STRENGTH LINE
EL -1.0
C/P = 0.25
C = 500
EL -5.0
C = 350
EL -14.0
C = 500
EL -19.0
C = 500
EL -29.0
C = 550
EL -44.0
Y_{SAT} = 104
Y_{SAT} = 107
Y_{SAT} = 106
Y_{SAT} = 104
76.7
Y_{SAT} = 101
Y_{SAT} = 100
LEGEND
Q-TEST
UCT
SHEET PILE WALL
LOAD TEST
DESIGN STRENGTHS

PLATE 9



GENERAL NOTES

CLASSIFICATION STRATIFICATION SHEAR STRENGTHS AND UNIT WEIGHTS OF THE SOIL WERE BASED ON THE RESULTS OF THE UNDISTURBED BORINGS. SEE BORING DATA PLATES.

SHEAR STRENGTHS BETWEEN VERTICALS 1 AND 2 WERE ASSUMED TO VARY LINEARLY BETWEEN THE VALUES INDICATED FOR THESE LOCATIONS.

VERT. 1 = BOR. 2-A'U
VERT. 2 = BOR. 2-BIUT

STRATUM NO.	SOIL TYPE	EFFECTIVE UNIT WT. PCF		C - UNIT COHESION - PSF				FRICTION ANGLE DEG
				CENTER OF STRATUM		BOTTOM OF STRATUM		
		VERT. 1	VERT. 2	VERT. 1	VERT. 2	VERT. 1	VERT. 2	
1	WA	62.0	62.0	0.0	0.0	0.0	0.0	0.0
2	CH	110.0	110.0	400.0	400.0	400.0	400.0	0.0
3	CH	110.0	110.0	400.0	400.0	400.0	400.0	0.0
4	CH	100.0	100.0	350.0	350.0	350.0	350.0	0.0
5	CH	38.0	38.0	350.0	350.0	350.0	350.0	0.0
6	CH	40.0	38.0	450.0	450.0	450.0	450.0	0.0
7	CH	28.0	28.0	300.0	200.0	300.0	200.0	0.0
8	CH	34.0	34.0	550.0	350.0	550.0	350.0	0.0
9	CH	38.0	38.0	550.0	500.0	550.0	500.0	0.0
10	ML	55.0	55.0	200.0	200.0	200.0	200.0	15.0
11	CH	43.0	43.0	600.0	600.0	600.0	600.0	0.0
12	CH	40.0	40.0	950.0	800.0	950.0	800.0	0.0
13	CH	38.0	38.0	1050.0	900.0	1050.0	900.0	0.0
14	CH	43.0	43.0	1000.0	1000.0	1000.0	1000.0	0.0

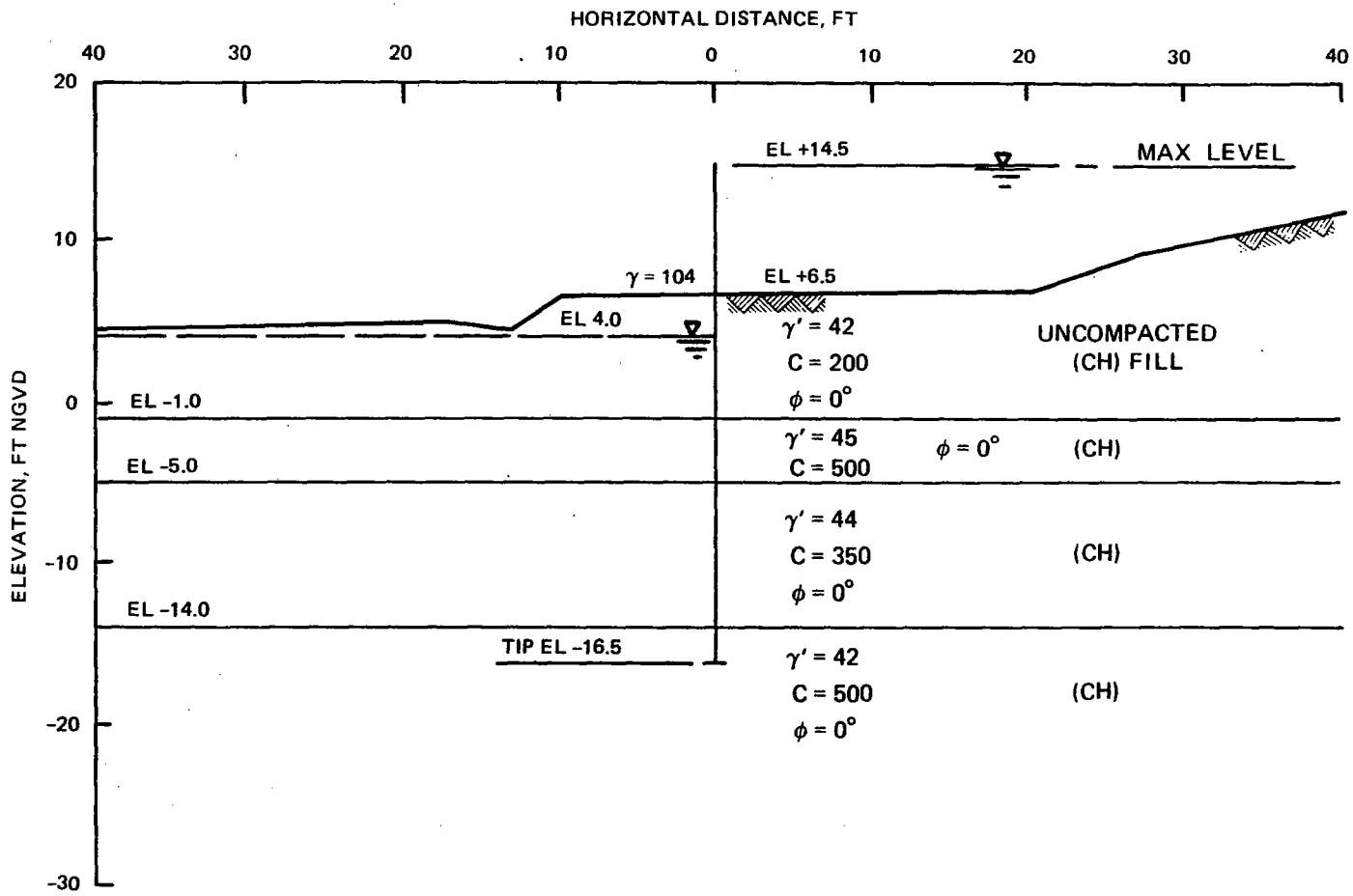
ASSUMED FAILURE SURFACE			RESISTING FORCES			DRIVING FORCES		SUMMATION OF FORCES		FACTOR OF SAFETY
NO.		EL	R_A	R_B	R_P	D_A	$-D_P$	RESISTING	DRIVING	
A	1	-5.00	14733	8750	7316	21109	5665	30799	15443	1.994
A	2	-5.00	14733	19250	5600	21109	2724	39583	18385	2.153
B	1	-14.00	22009	13500	14050	38152	11777	49559	26374	1.879
B	2	-14.00	22009	27000	14283	38152	9624	63293	28528	2.219
C	1	-19.00	24654	8558	15945	48224	14826	49157	33398	1.472
C	2	-19.00	24654	14922	16612	48224	16088	56188	32136	1.748
D	1	-29.00	33934	14665	23974	69586	26998	72573	42588	1.704
D	2	-29.00	33934	21954	23579	69586	29525	79467	40061	1.984
E	1	-44.00	49743	15480	38836	110042	53747	104058	56295	1.848
E	2	-44.00	49743	30552	36300	110042	52047	116595	57994	2.010
F	1	-60.00	72298	24000	61440	164997	90622	157738	74375	2.121
F	2	-60.00	72298	36000	61829	164997	85796	170127	79201	2.148

NOTES

- ○ -- STRATUM NUMBER
- ○ -- WEDGE NUMBER
- ⌐○ -- CROSSOVER POINT
- ϕ -- ANGLE OF INTERNAL FRICTION, DEGREES
- C -- UNIT COHESION, P.S.F.
- ▽ -- STATIC WATER SURFACE
- D -- HORIZONTAL DRIVING FORCE IN POUNDS
- R -- HORIZONTAL RESISTING FORCE IN POUNDS
- A -- AS A SUBSCRIPT, REFERS TO ACTIVE WEDGE
- B -- AS A SUBSCRIPT REFERS TO CENTRAL BLOCK
- P -- AS A SUBSCRIPT REFERS TO PASSIVE WEDGE

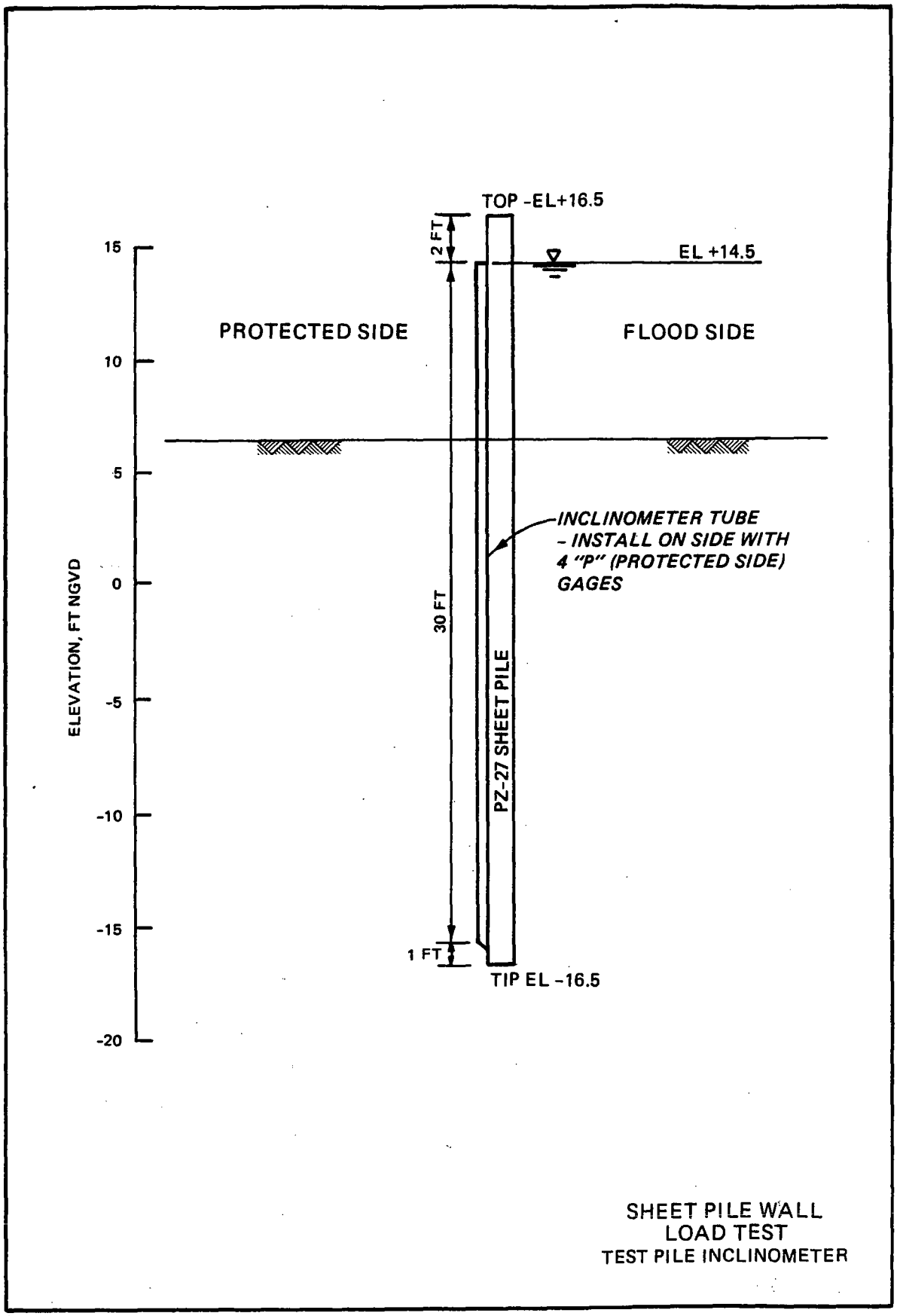
$$\text{FACTOR OF SAFETY} = \frac{R_A + R_B + R_P}{D_A - D_P}$$

SHEET PILE WALL LOAD TEST STABILITY ANALYSIS



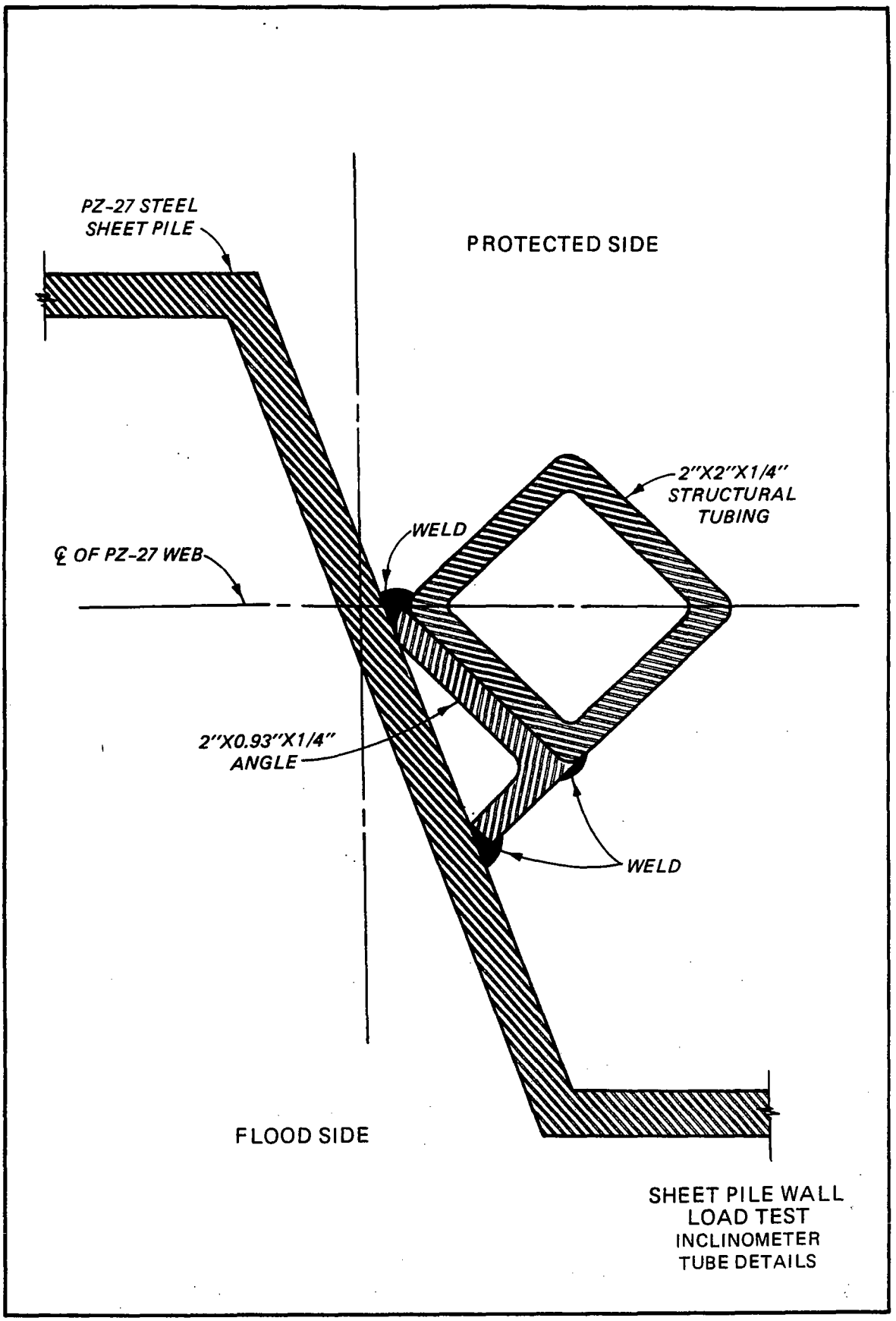
SHEET PILE WALL
LOAD TEST
GROUND PROFILE AND
SOIL STRATIFICATION

PLATE 11



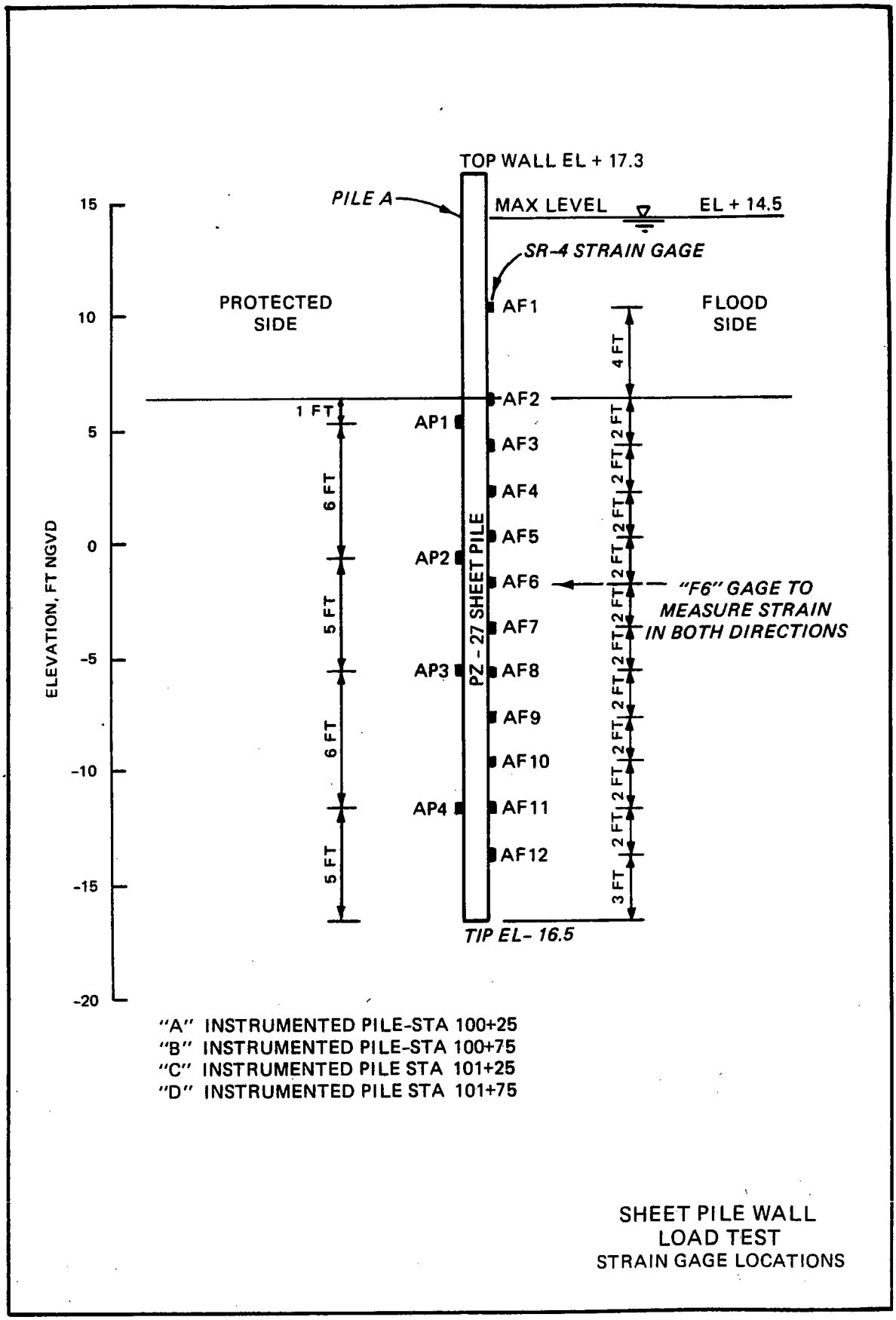
SHEET PILE WALL
LOAD TEST
TEST PILE INCLINOMETER

PLATE 12



SHEET PILE WALL
LOAD TEST
INCLINOMETER
TUBE DETAILS

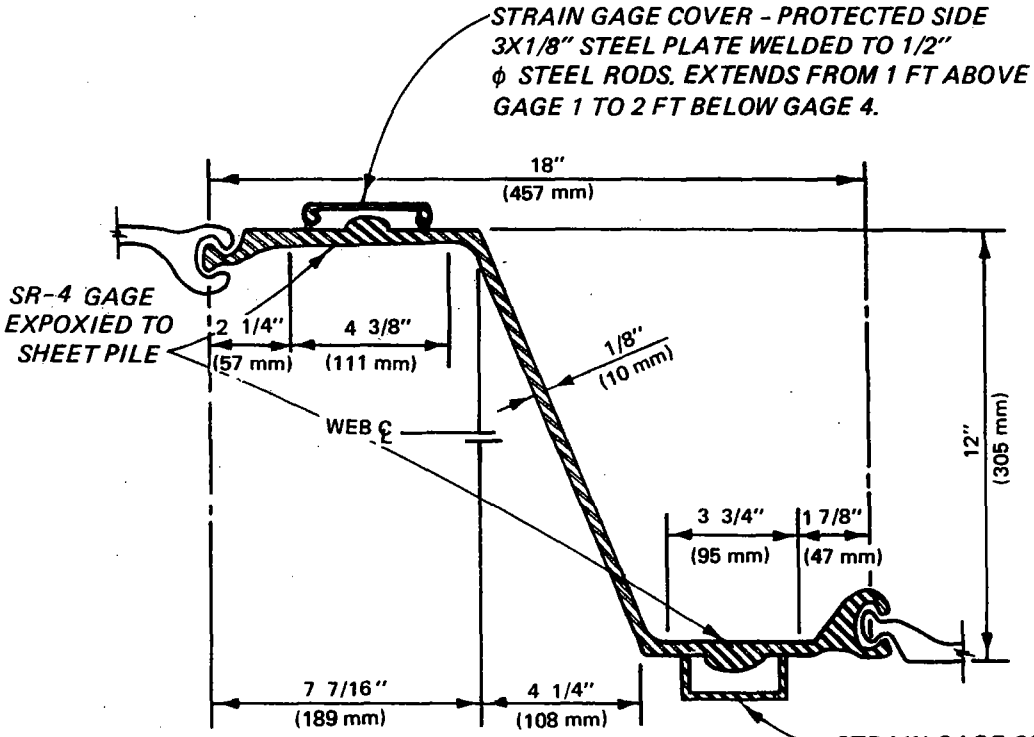
PLATE 13



"A" INSTRUMENTED PILE-STA 100+25
"B" INSTRUMENTED PILE-STA 100+75
"C" INSTRUMENTED PILE STA 101+25
"D" INSTRUMENTED PILE STA 101+75

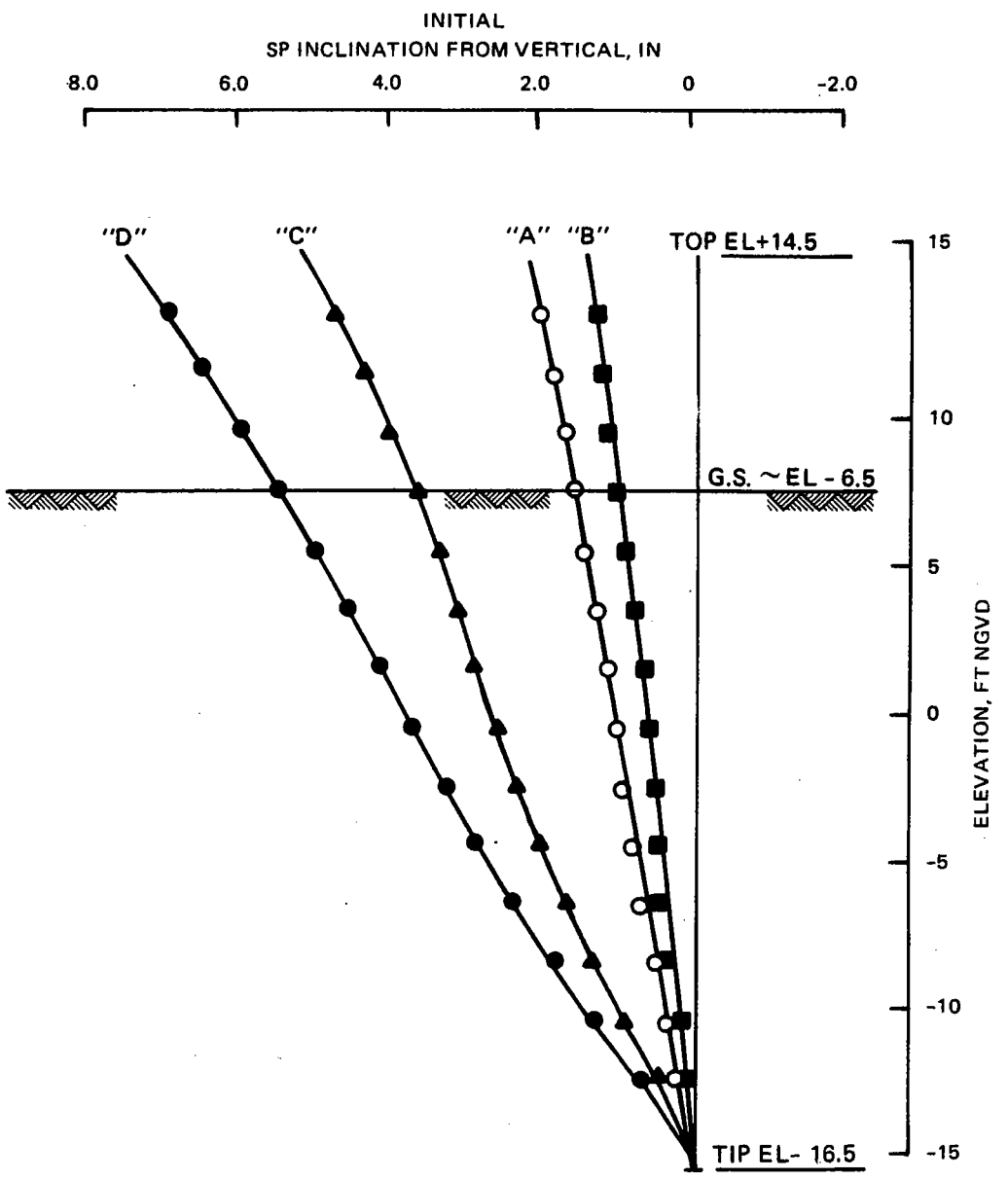
SHEET PILE WALL
LOAD TEST
STRAIN GAGE LOCATIONS

PLATE 14



SHEET PILE WALL
LOAD TEST
STRAIN GAGE DETAILS

PLATE 15



SHEET PILE WALL
LOAD TEST
AS-DRIVEN SHEET
PILE INCLINATION

PLATE 16

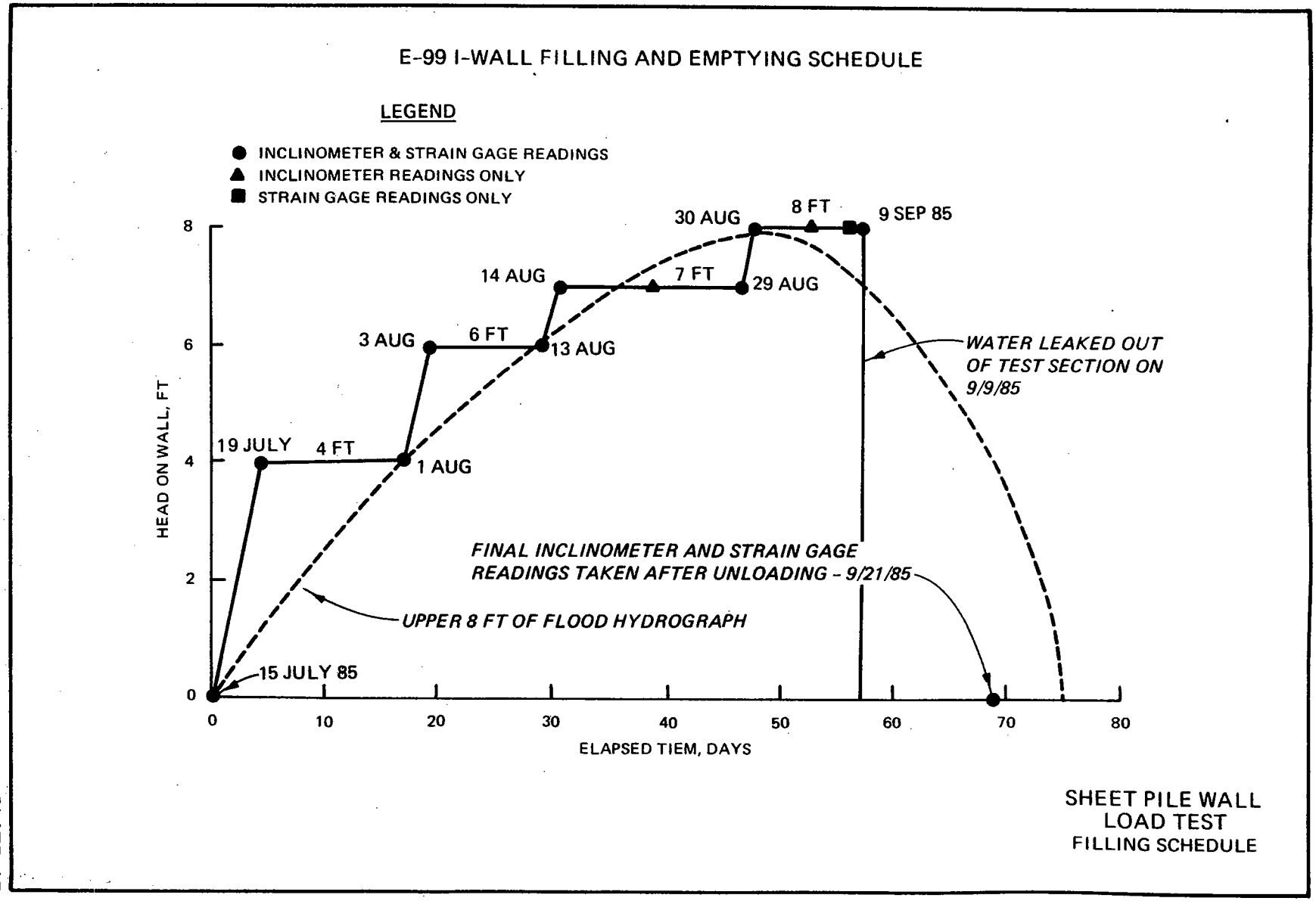
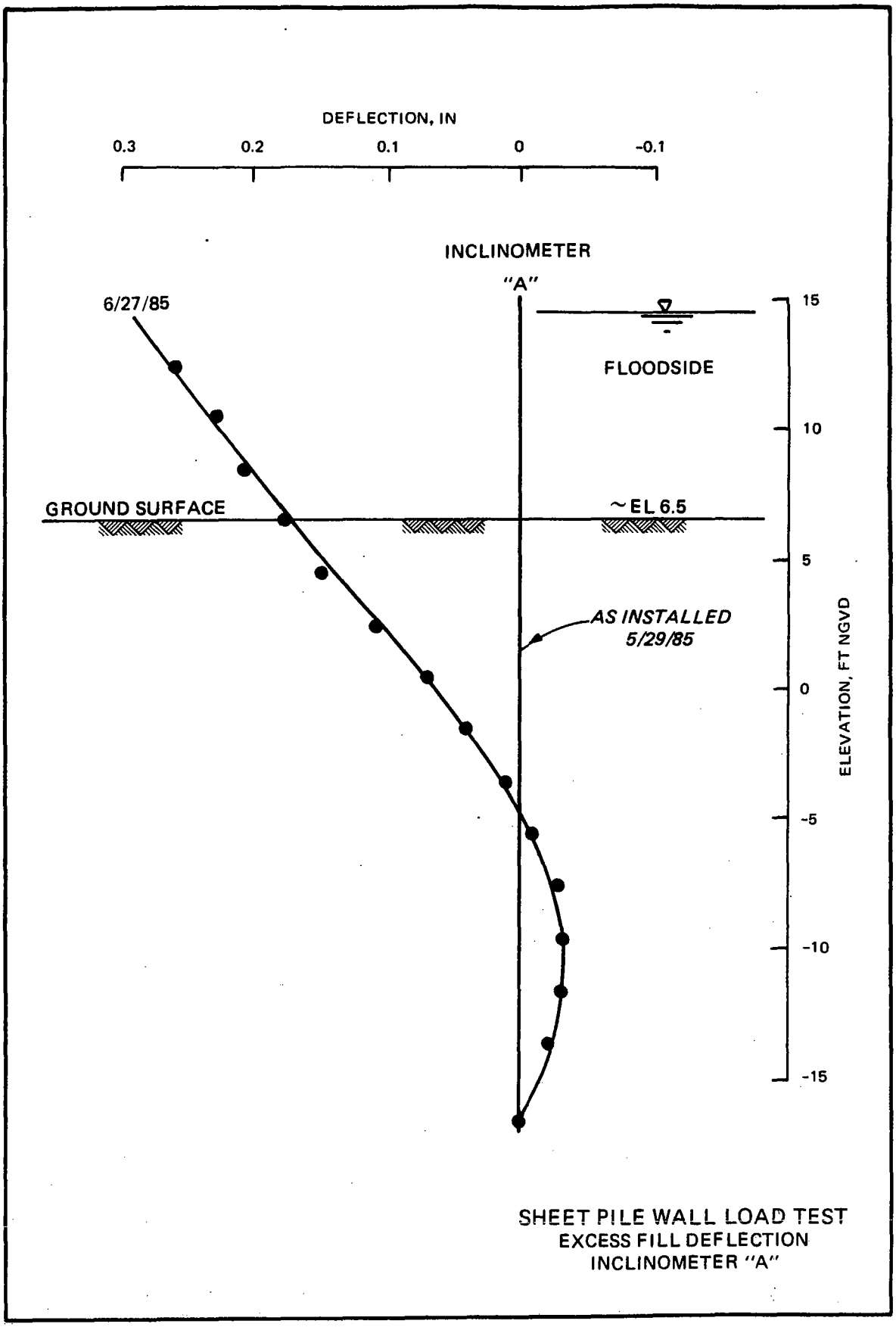
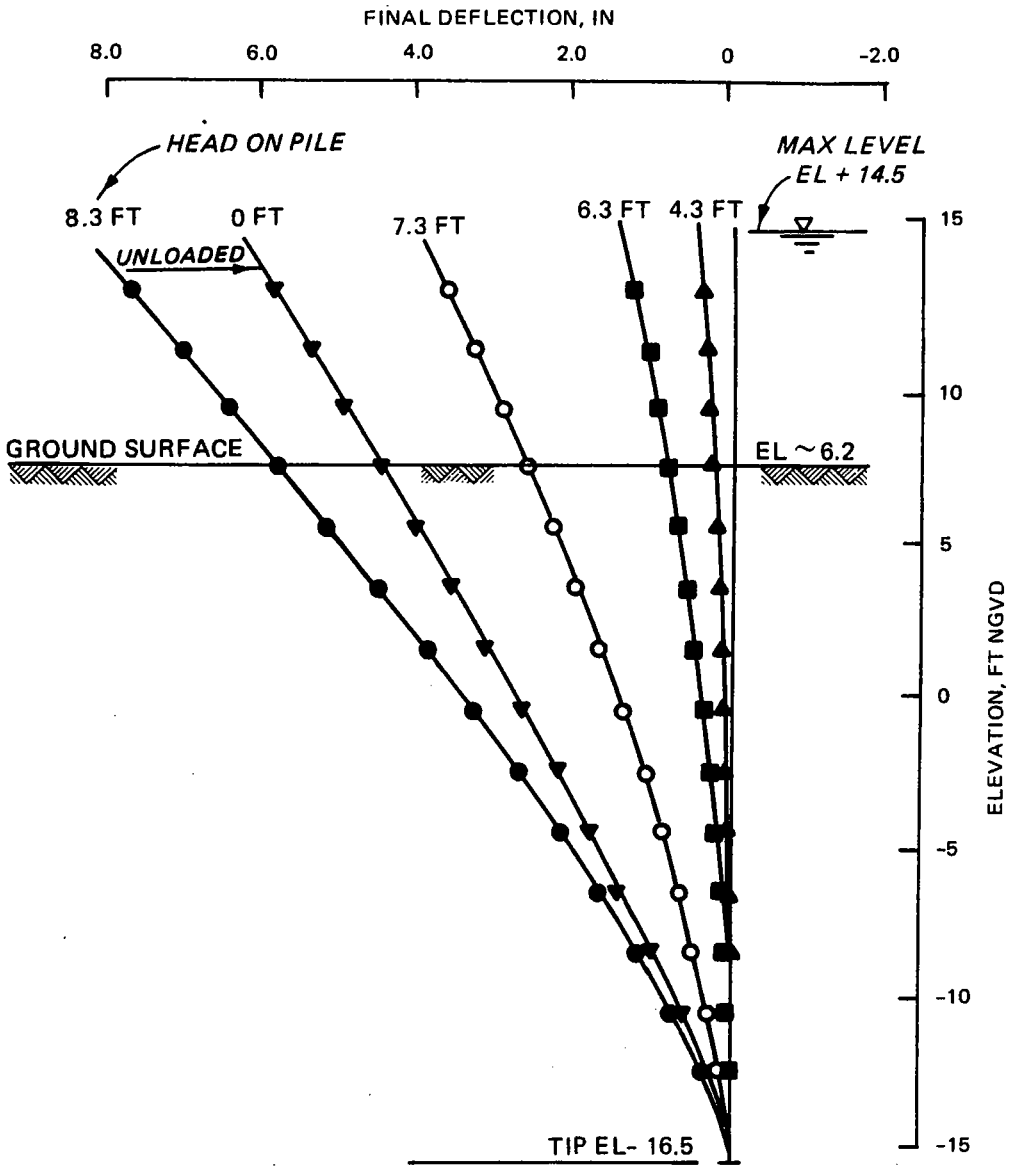

E-99 I-WALL FILLING AND EMPTYING SCHEDULE
LEGEND
INCLINOMETER & STRAIN GAGE READINGS
INCLINOMETER READINGS ONLY
STRAIN GAGE READINGS ONLY
HEAD ON WALL, FT
ELAPSED TIEM, DAYS
0
2
4
6
8
0
10
20
30
40
50
60
70
80
15 JULY 85
19 JULY
4 FT
1 AUG
3 AUG
6 FT
13 AUG
14 AUG
7 FT
29 AUG
30 AUG
8 FT
9 SEP 85
WATER LEAKED OUT OF TEST SECTION ON 9/9/85
FINAL INCLINOMETER AND STRAIN GAGE READINGS TAKEN AFTER UNLOADING - 9/21/85
UPPER 8 FT OF FLOOD HYDROGRAPH
SHEET PILE WALL
LOAD TEST
FILLING SCHEDULE

PLATE 17



SHEET PILE WALL LOAD TEST
EXCESS FILL DEFLECTION
INCLINOMETER "A"

PLATE 1.8



SHEET PILE WALL
LOAD TEST
INCLINOMETER
DATA - PILE A

PLATE 19

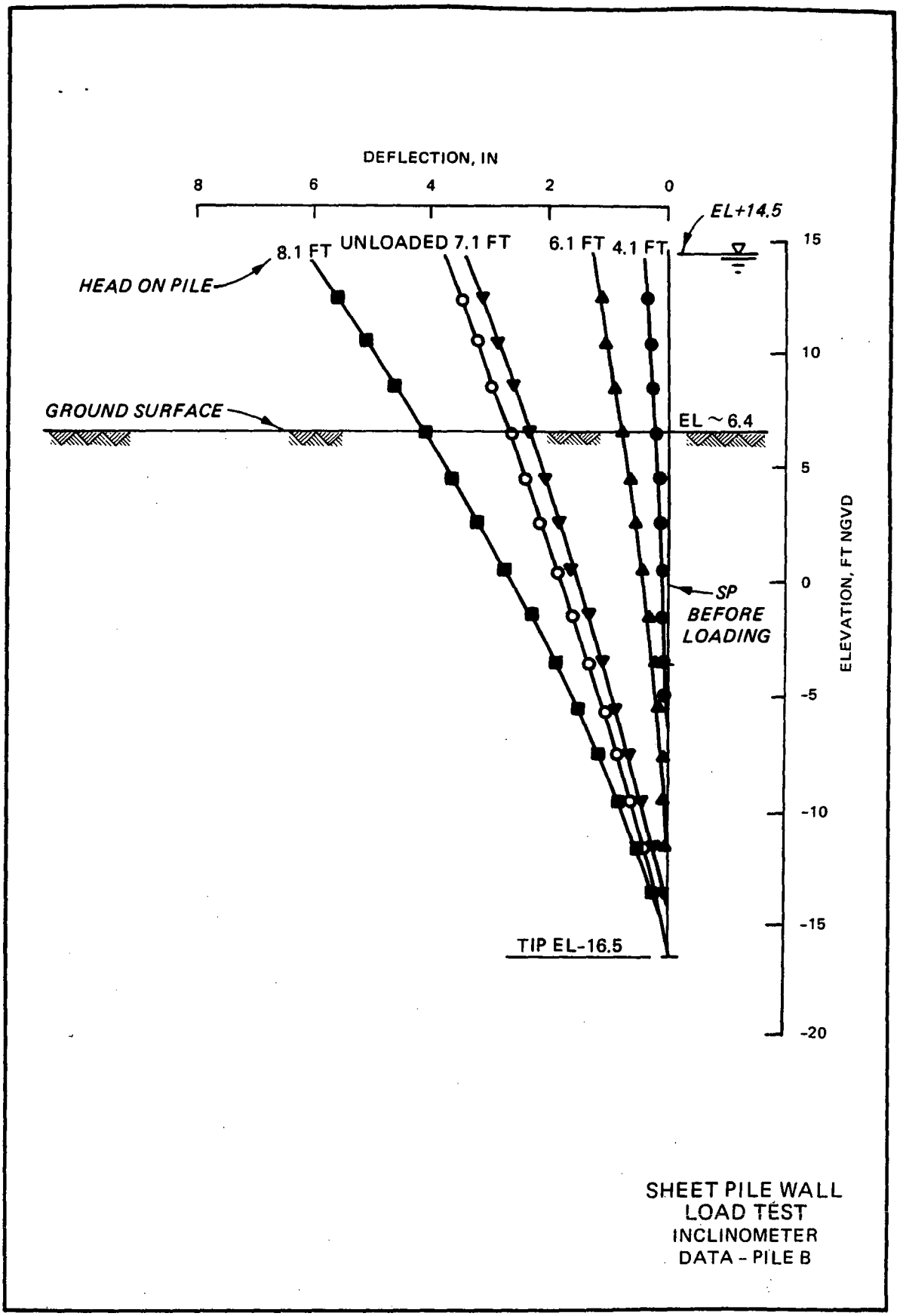
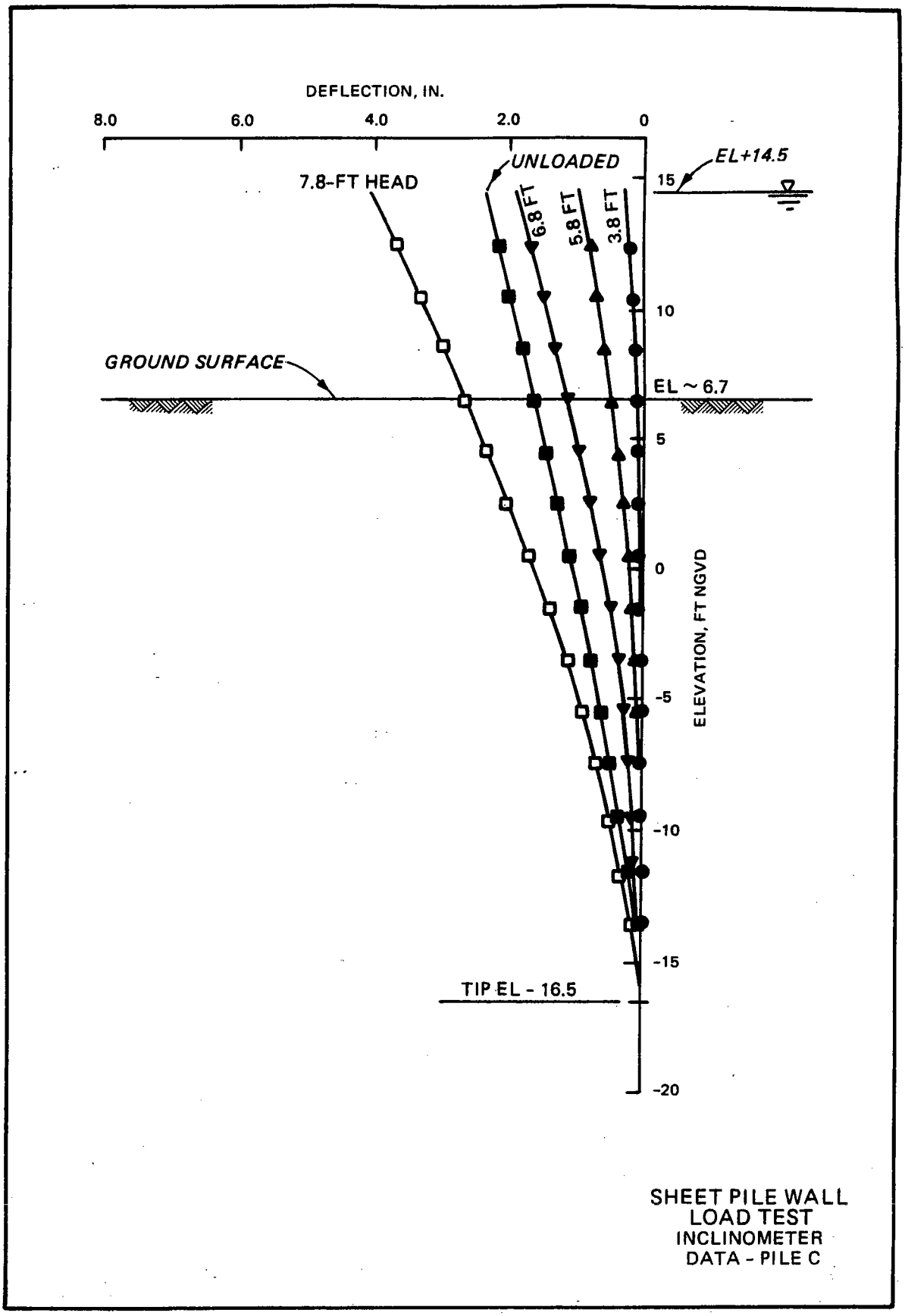

DEFLECTION, IN
8
6
4
2
0
EL+14.5
8.1 FT
UNLOADED 7.1 FT
6.1 FT
4.1 FT
HEAD ON PILE
GROUND SURFACE
EL ~ 6.4
SP
BEFORE
LOADING
TIP EL-16.5
15
10
5
0
-5
-10
-15
-20
ELEVATION, FT NGVD
SHEET PILE WALL
LOAD TEST
INCLINOMETER
DATA - PILE B

PLATE 20



SHEET PILE WALL
LOAD TEST
INCLINOMETER
DATA - PILE C

PLATE 21

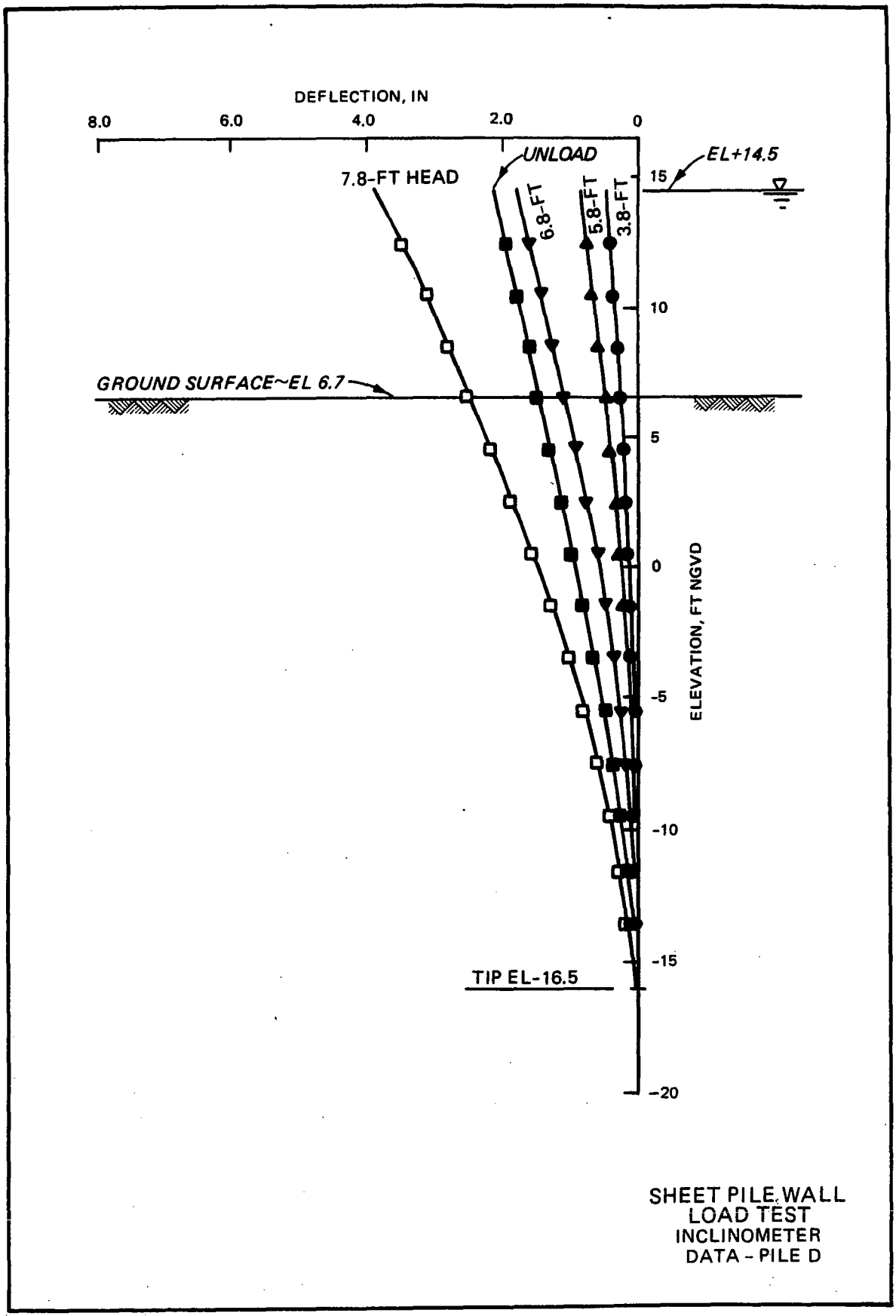
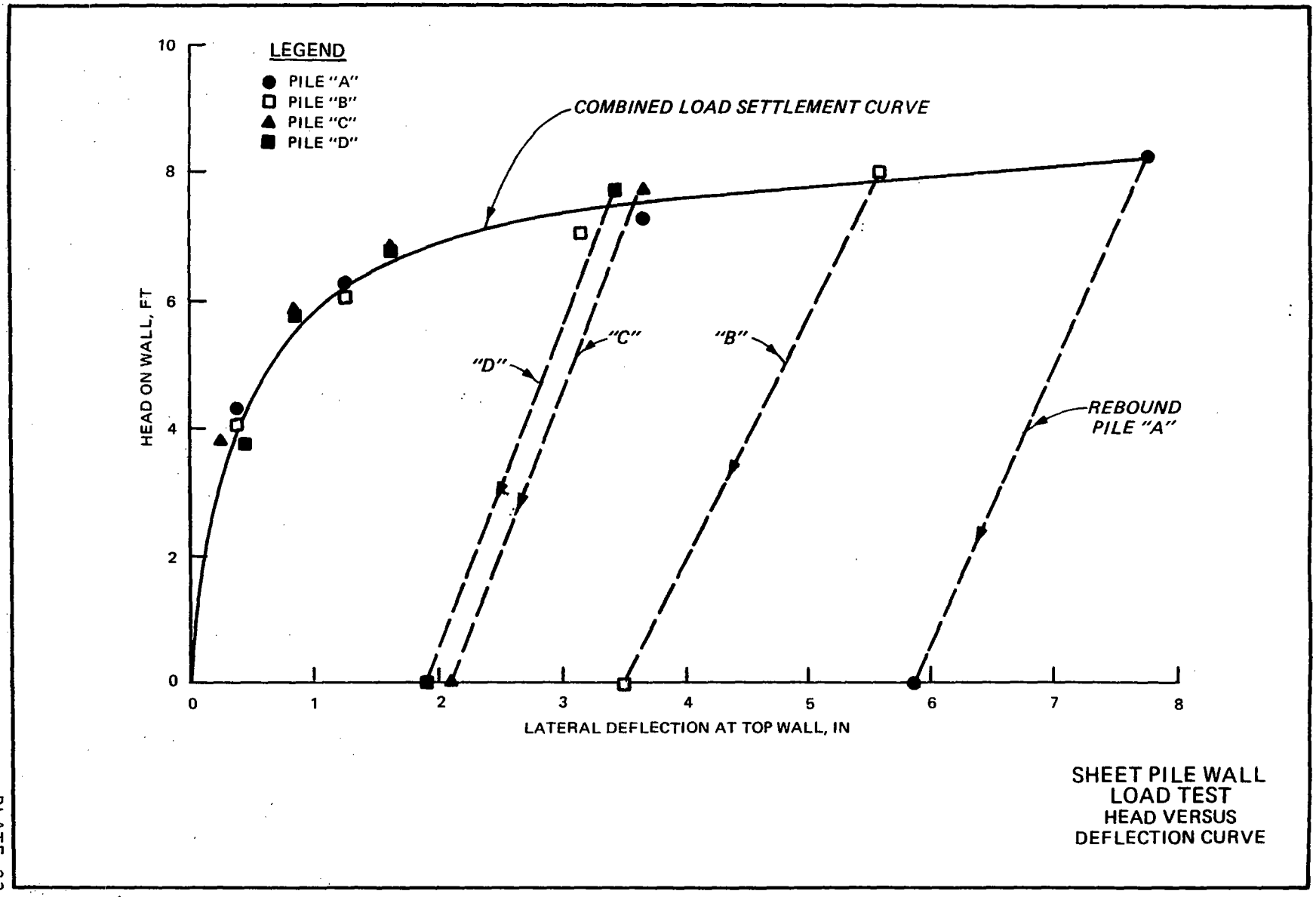

DEFLECTION, IN
8.0
6.0
4.0
2.0
0
UNLOAD
EL+14.5
7.8-FT HEAD
6.8-FT
5.8-FT
3.8-FT
15
10
GROUND SURFACE~EL 6.7
5
0
-5
-10
-15
-20
ELEVATION, FT NGVD
TIP EL-16.5
SHEET PILE WALL
LOAD TEST
INCLINOMETER
DATA - PILE D

PLATE 22



SHEET PILE WALL
LOAD TEST
HEAD VERSUS
DEFLECTION CURVE

PLATE 23

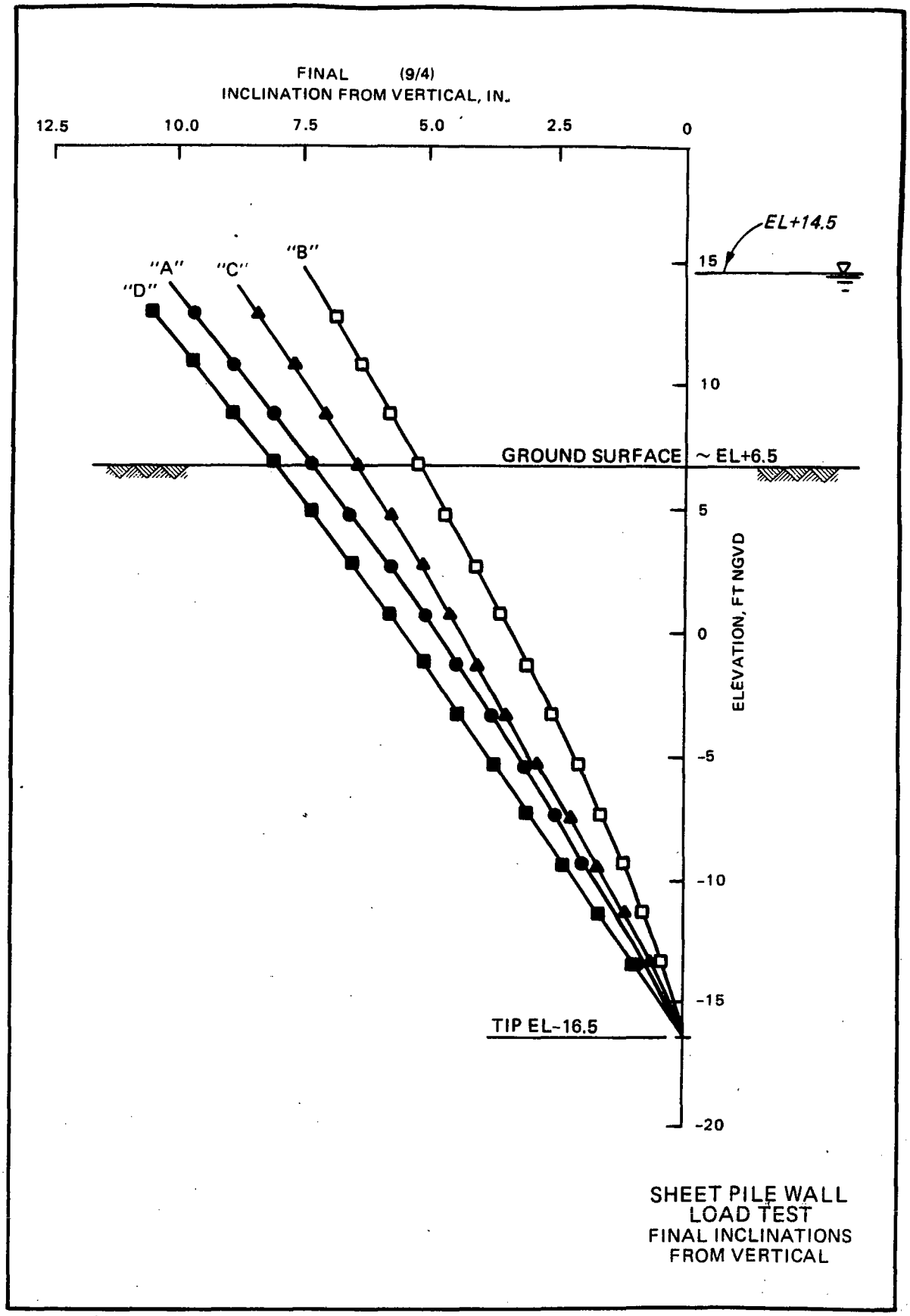

FINAL (9/4)
INCLINATION FROM VERTICAL, IN.
12.5
10.0
7.5
5.0
2.5
0
EL+14.5
15
"A"
"B"
"C"
"D"
10
GROUND SURFACE ~ EL+6.5
5
0
-5
-10
-15
TIP EL-16.5
-20
ELEVATION, FT NGVD
SHEET PILE WALL
LOAD TEST
FINAL INCLINATIONS
FROM VERTICAL

PLATE 24

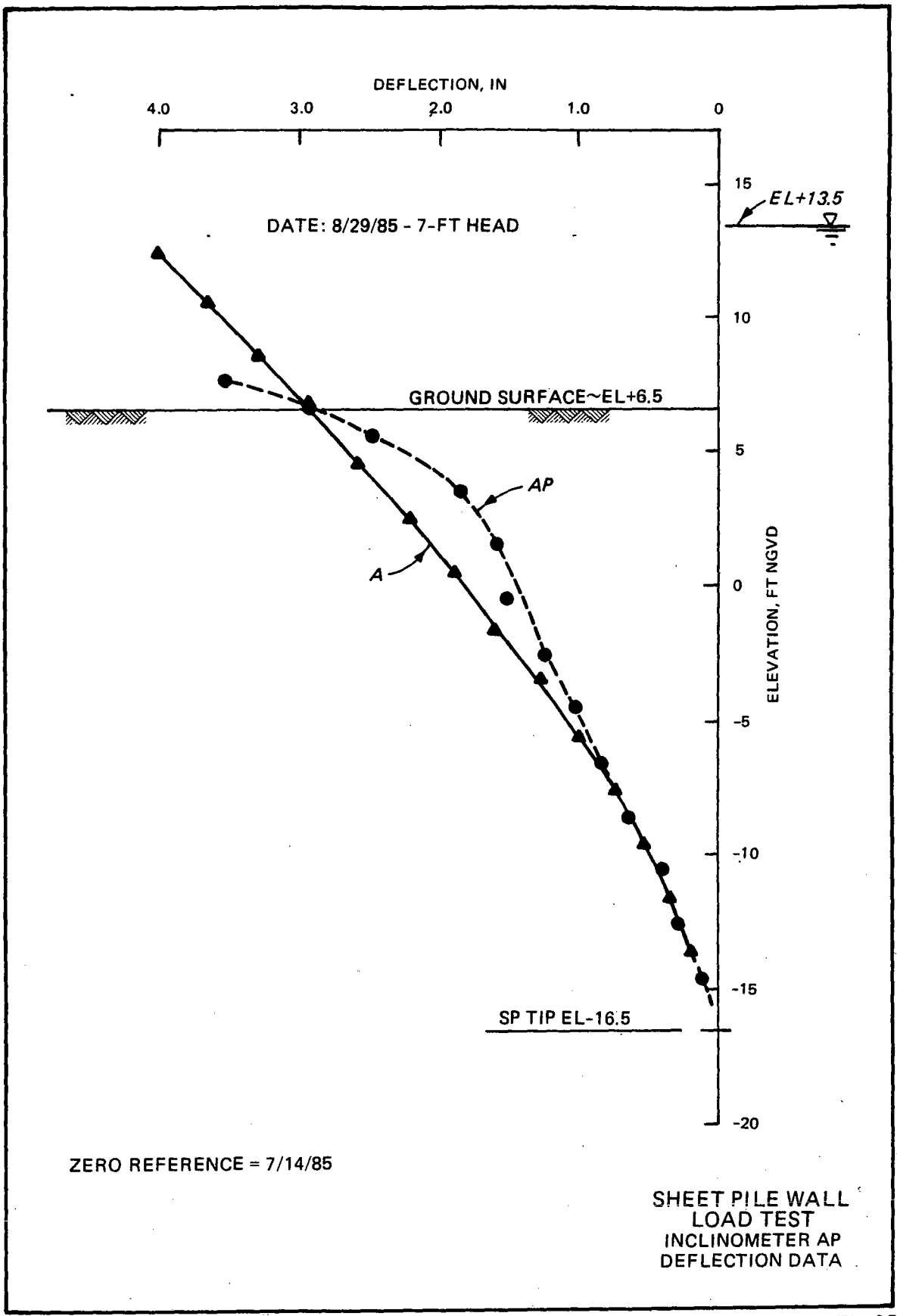

DEFLECTION, IN
4.0
3.0
2.0
1.0
0
DATE: 8/29/85 - 7-FT HEAD
EL+13.5
15
10
5
0
-5
-10
-15
-20
GROUND SURFACE~EL+6.5
AP
A
ELEVATION, FT NGVD
SP TIP EL-16.5
ZERO REFERENCE = 7/14/85
SHEET PILE WALL
LOAD TEST
INCLINOMETER AP
DEFLECTION DATA

PLATE 25

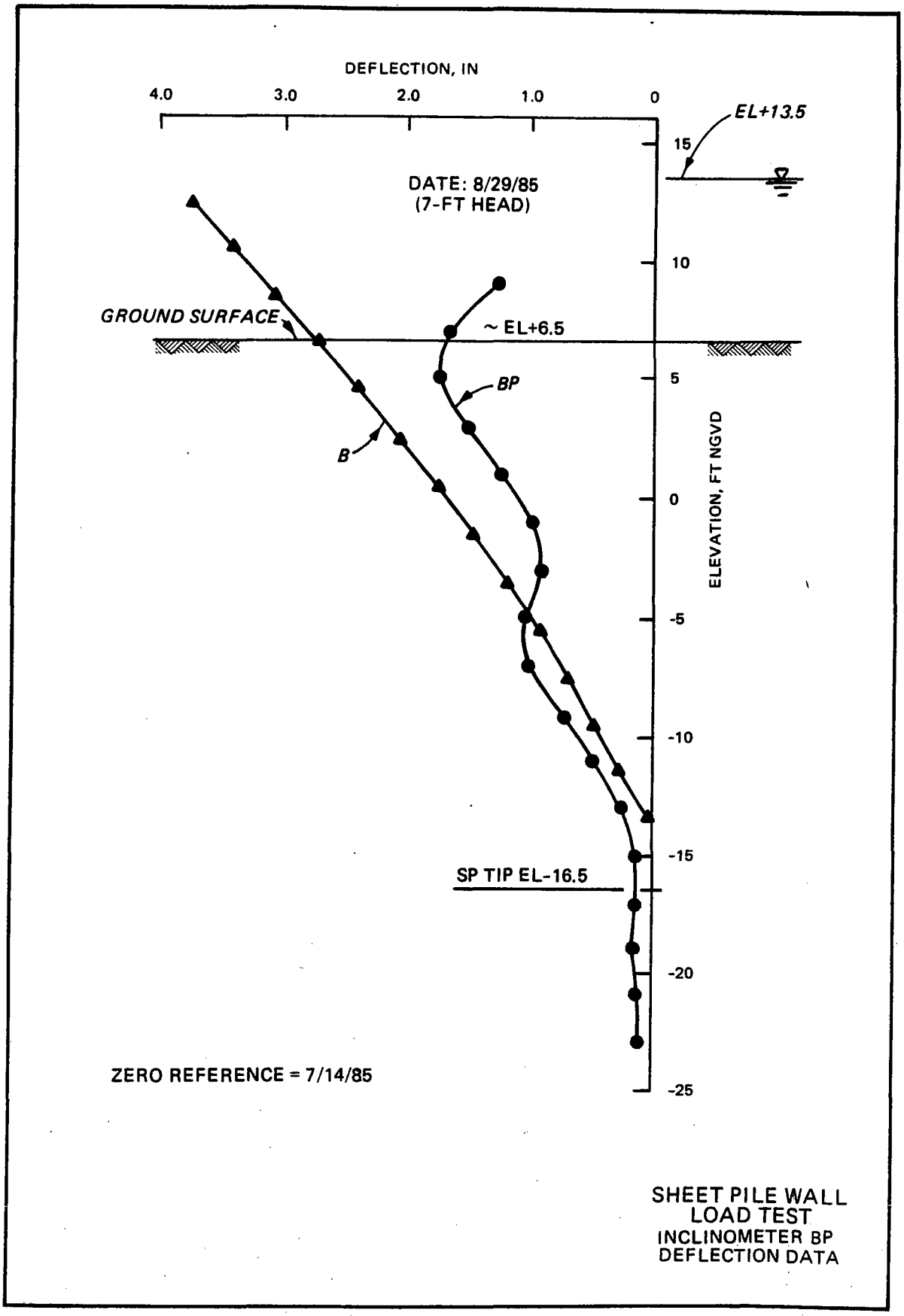
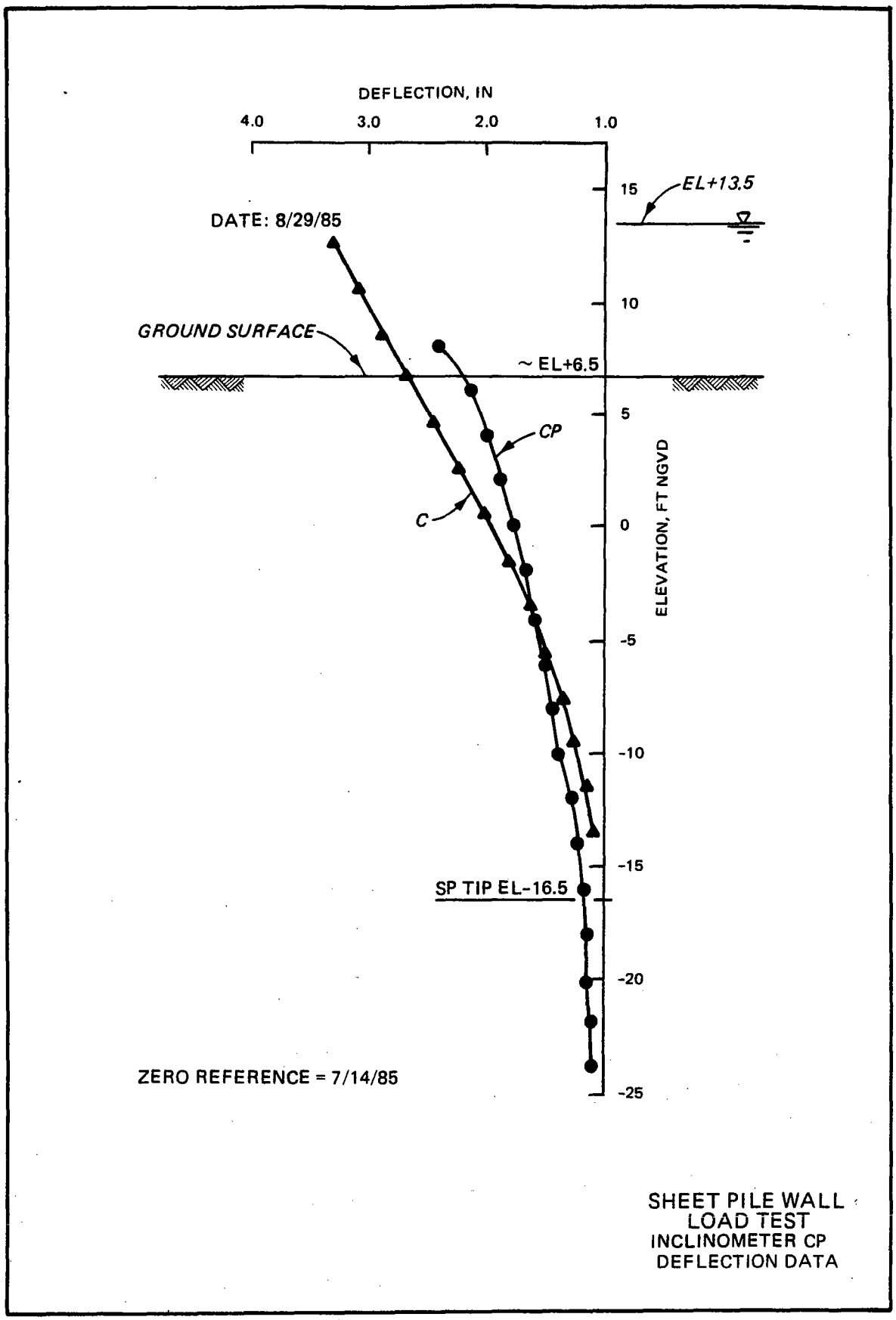
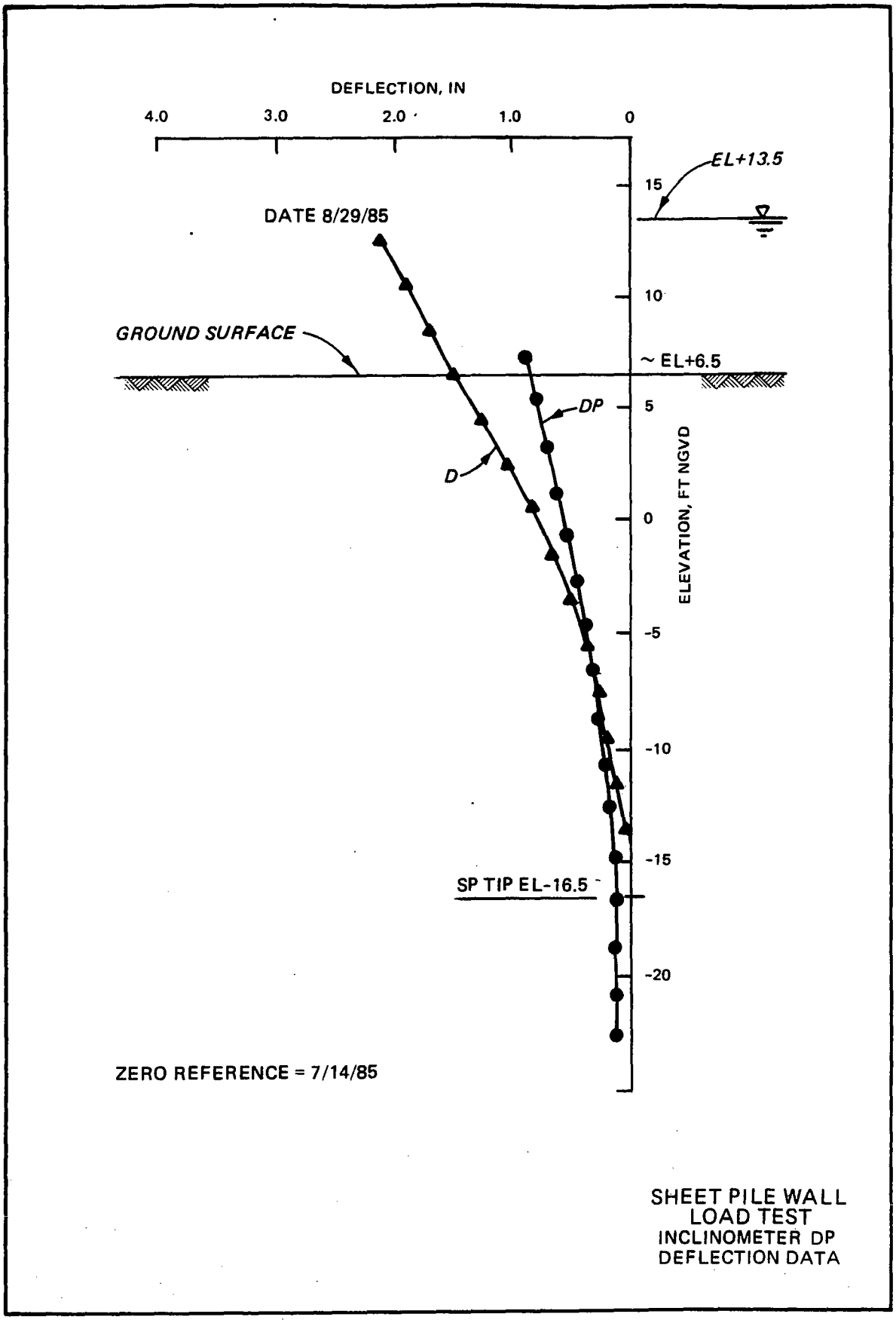

DEFLECTION, IN
4.0
3.0
2.0
1.0
0
EL+13.5
15
DATE: 8/29/85
(7-FT HEAD)
10
GROUND SURFACE
~ EL+6.5
BP
B
5
0
ELEVATION, FT NGVD
-5
-10
-15
SP TIP EL-16.5
-20
ZERO REFERENCE = 7/14/85
-25
SHEET PILE WALL
LOAD TEST
INCLINOMETER BP
DEFLECTION DATA

PLATE 26



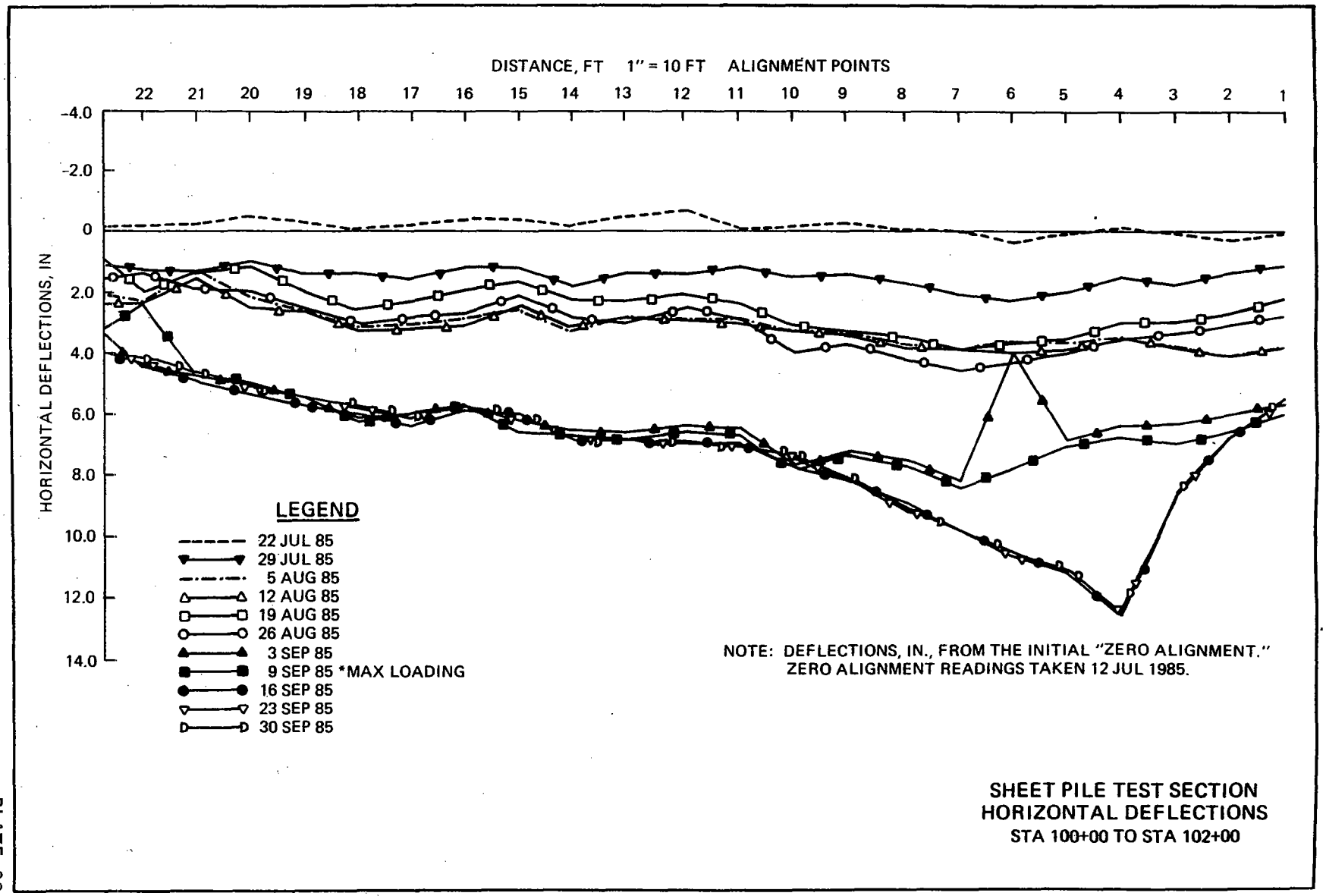
SHEET PILE WALL
LOAD TEST
INCLINOMETER CP
DEFLECTION DATA

PLATE 27



SHEET PILE WALL
LOAD TEST
INCLINOMETER DP
DEFLECTION DATA

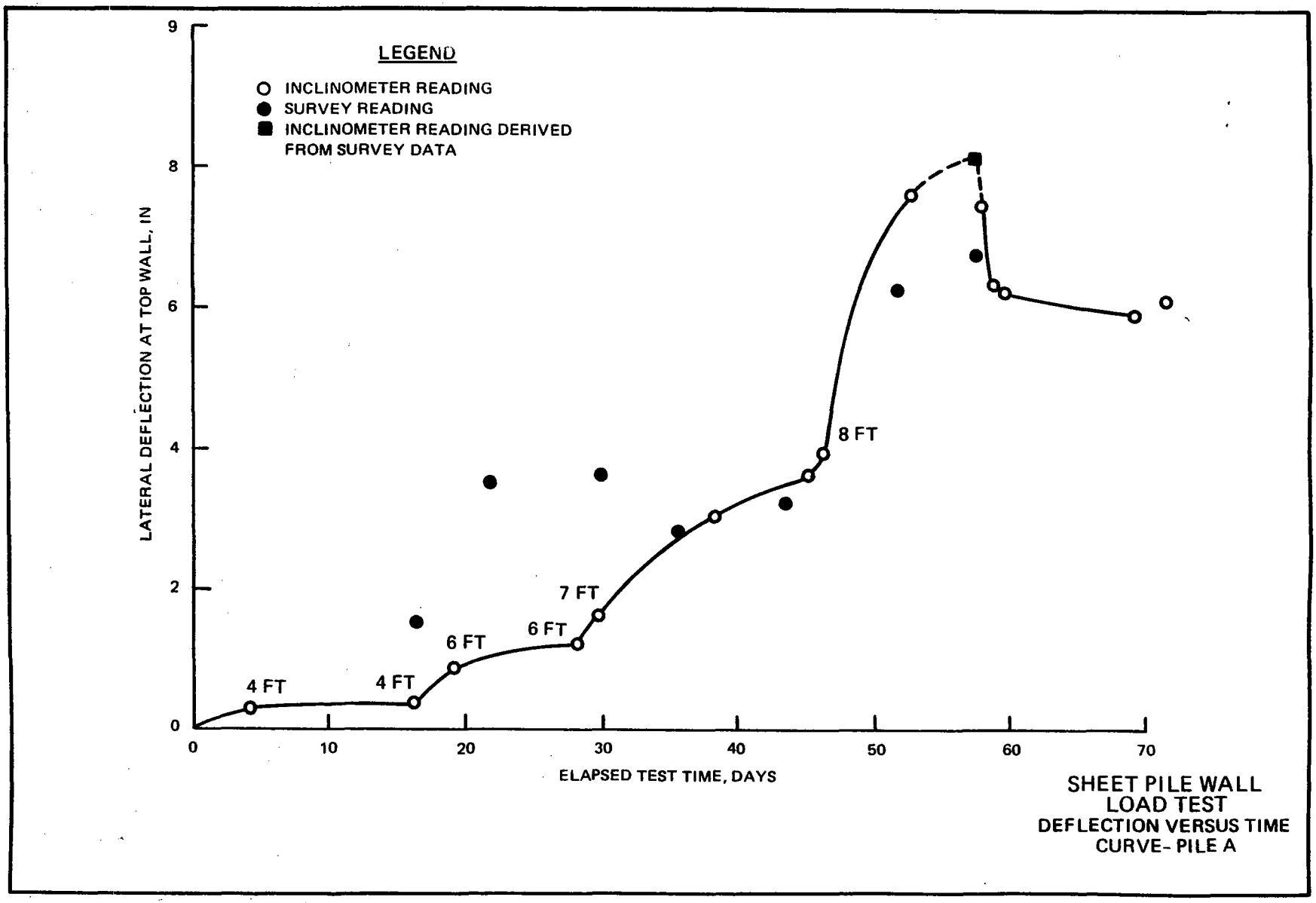
PLATE 28



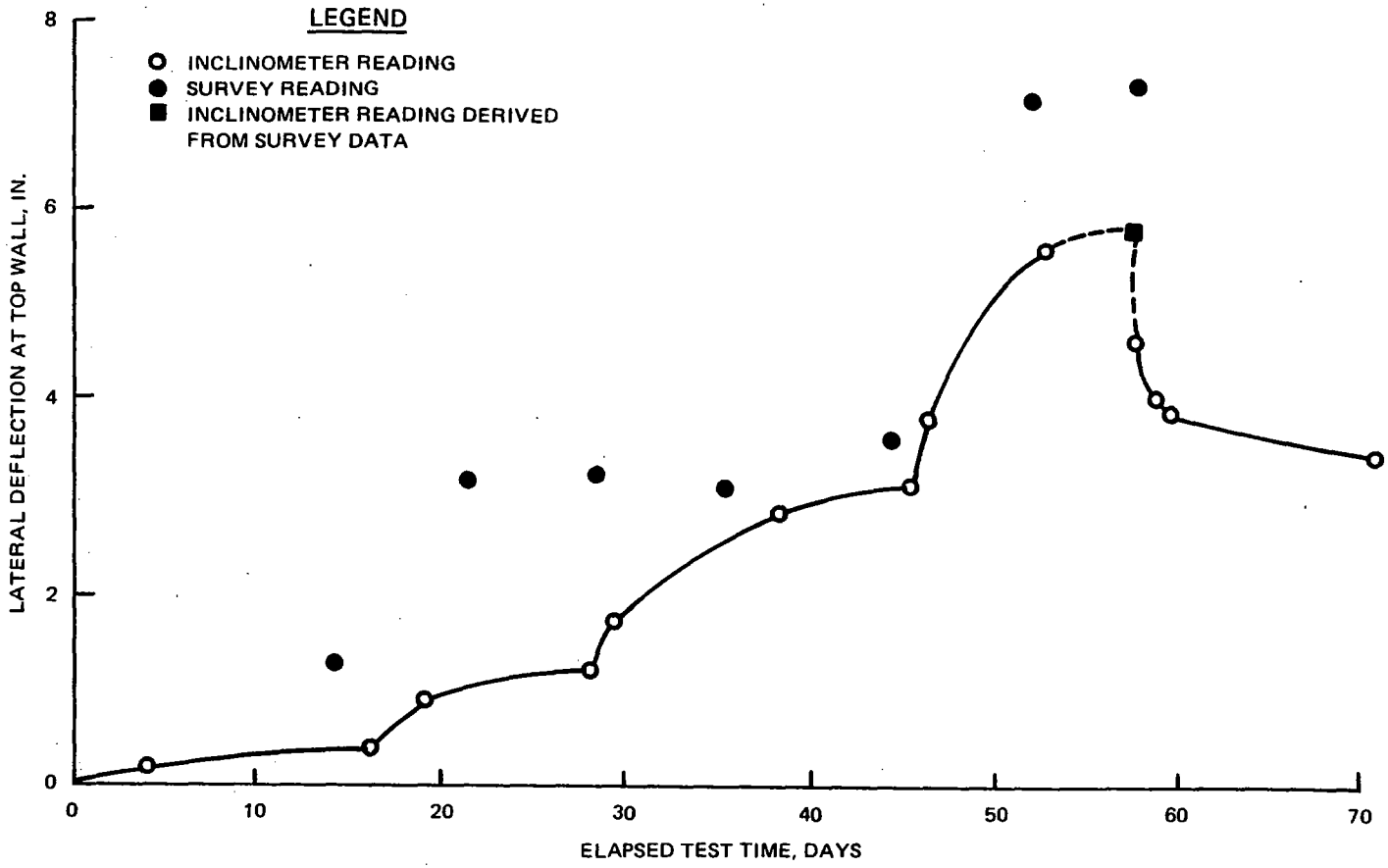
SHEET PILE TEST SECTION
HORIZONTAL DEFLECTIONS
STA 100+00 TO STA 102+00

PLATE 29

PLATE 30



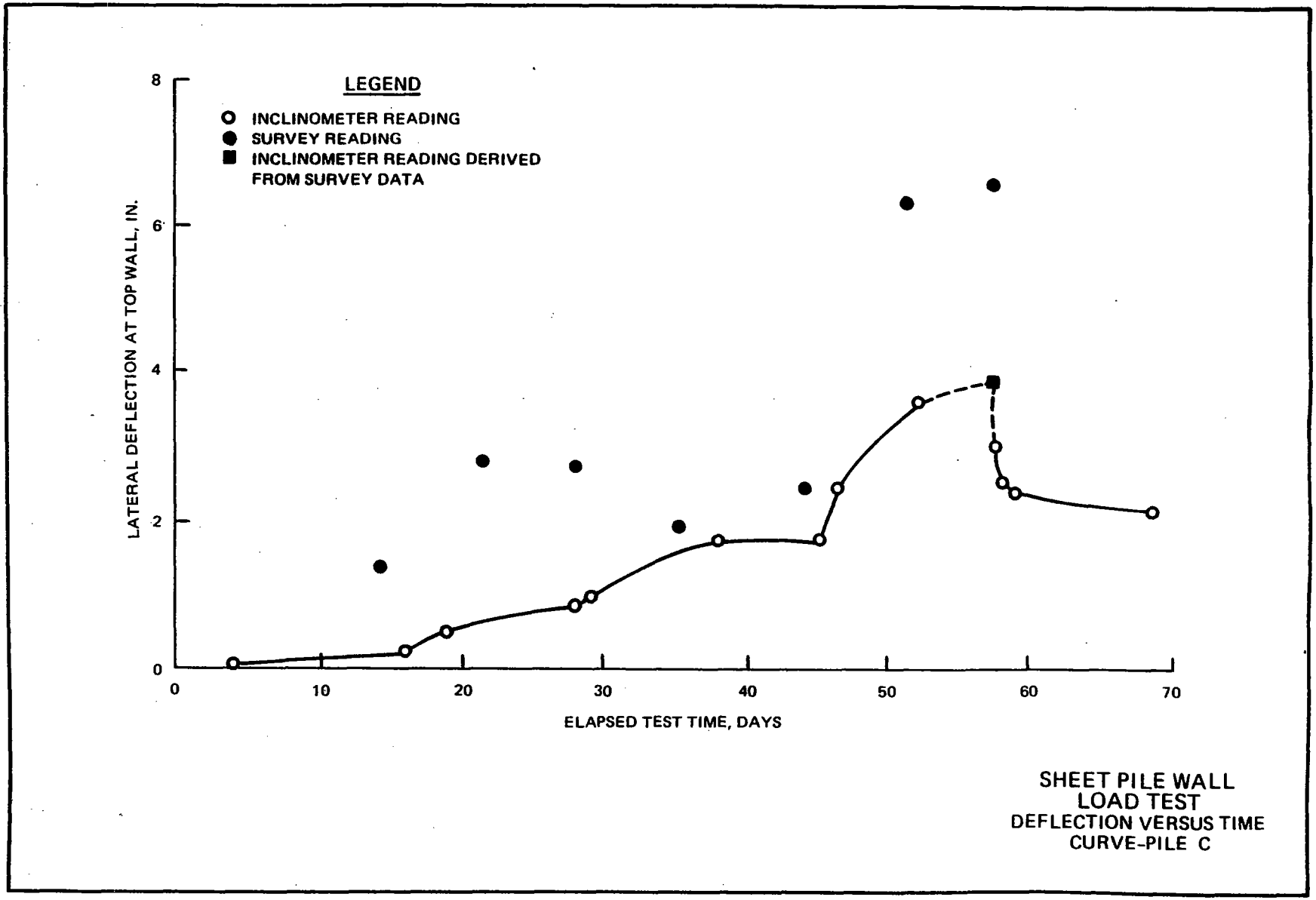
SHEET PILE WALL
LOAD TEST
DEFLECTION VERSUS TIME
CURVE- PILE A



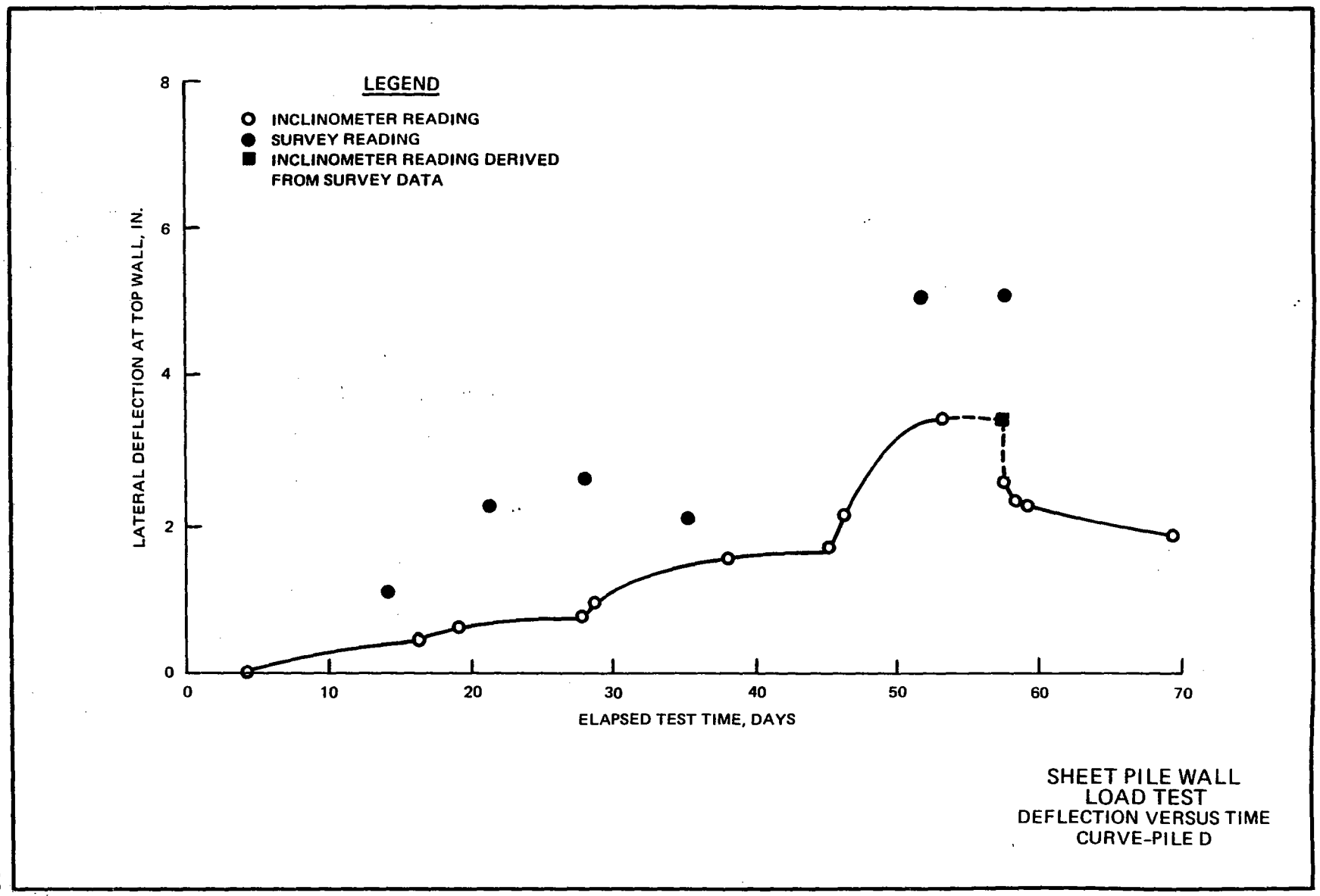
SHEET PILE WALL
LOAD TEST
DEFLECTION VERSUS TIME
CURVE -PILE B

PLATE 31

PLATE 32



SHEET PILE WALL
LOAD TEST
DEFLECTION VERSUS TIME
CURVE-PILE C



SHEET PILE WALL
LOAD TEST
DEFLECTION VERSUS TIME
CURVE-PILE D

PLATE 33

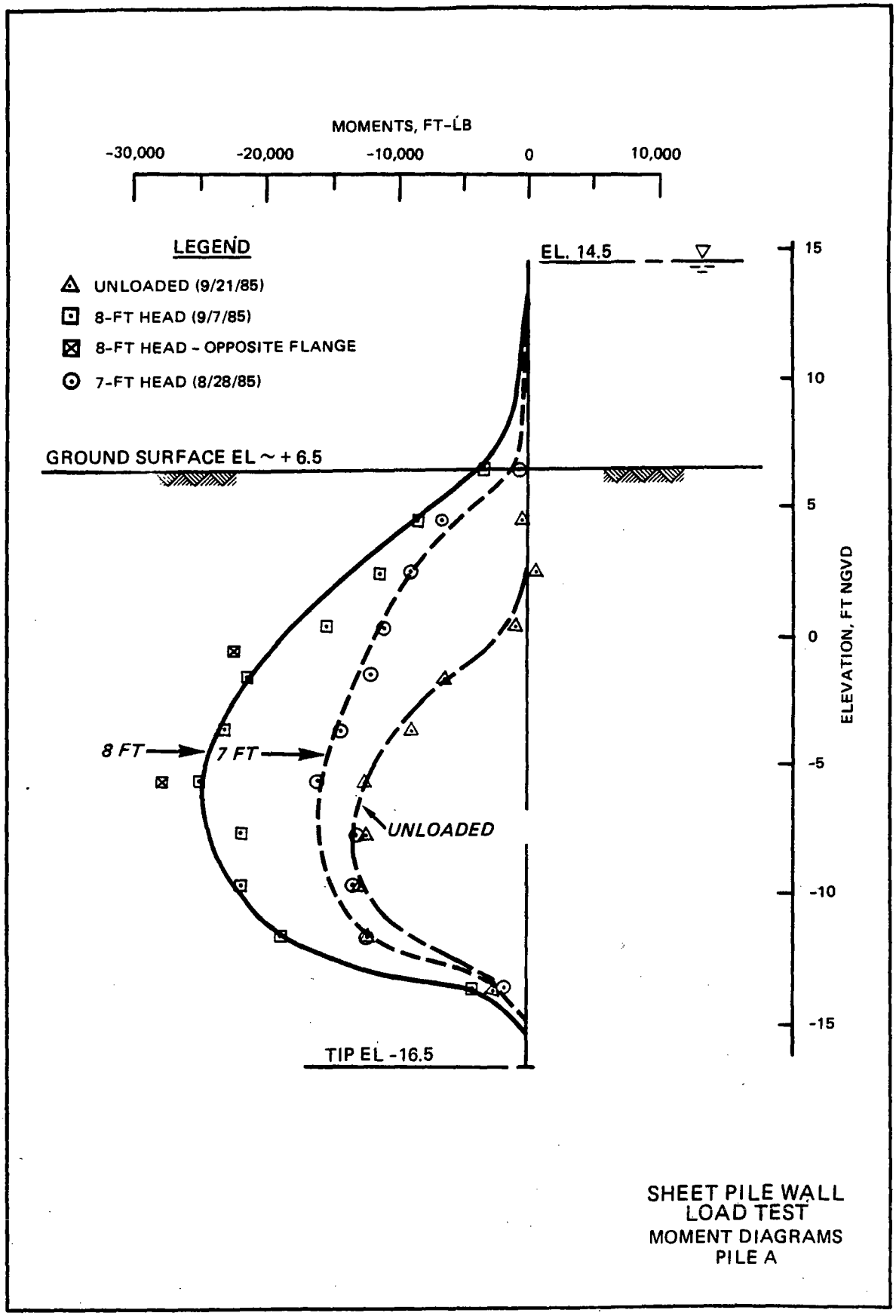
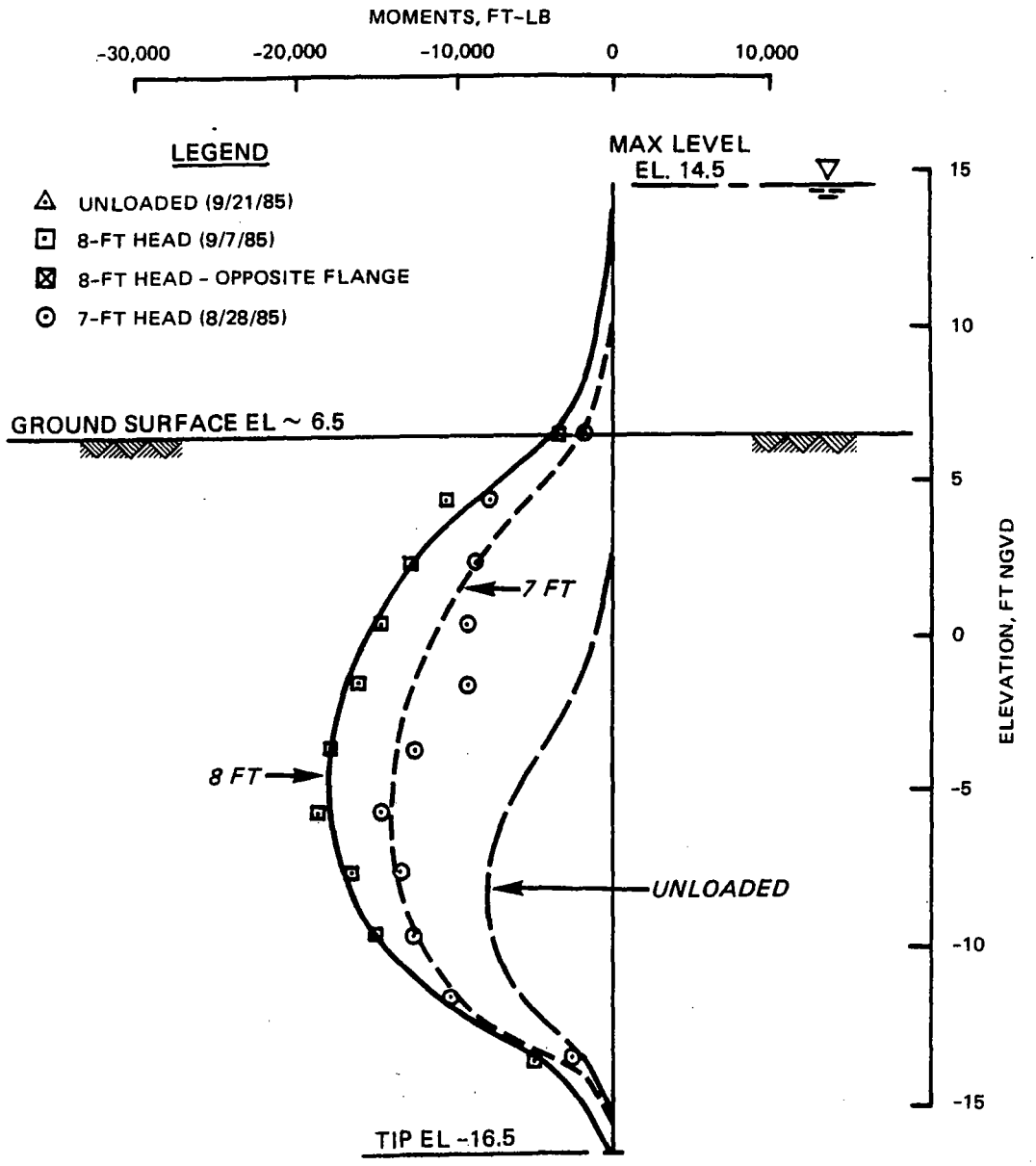

MOMENTS, FT-LB
-30,000
-20,000
-10,000
0
10,000
LEGEND
UNLOADED (9/21/85)
8-FT HEAD (9/7/85)
8-FT HEAD - OPPOSITE FLANGE
7-FT HEAD (8/28/85)
EL. 14.5
GROUND SURFACE EL ~ + 6.5
8 FT
7 FT
UNLOADED
TIP EL -16.5
15
10
5
0
-5
-10
-15
ELEVATION, FT NGVD
SHEET PILE WALL
LOAD TEST
MOMENT DIAGRAMS
PILE A

PLATE 34



SHEET PILE WALL
LOAD TEST
MOMENT DIAGRAMS
PILE B

PLATE 35

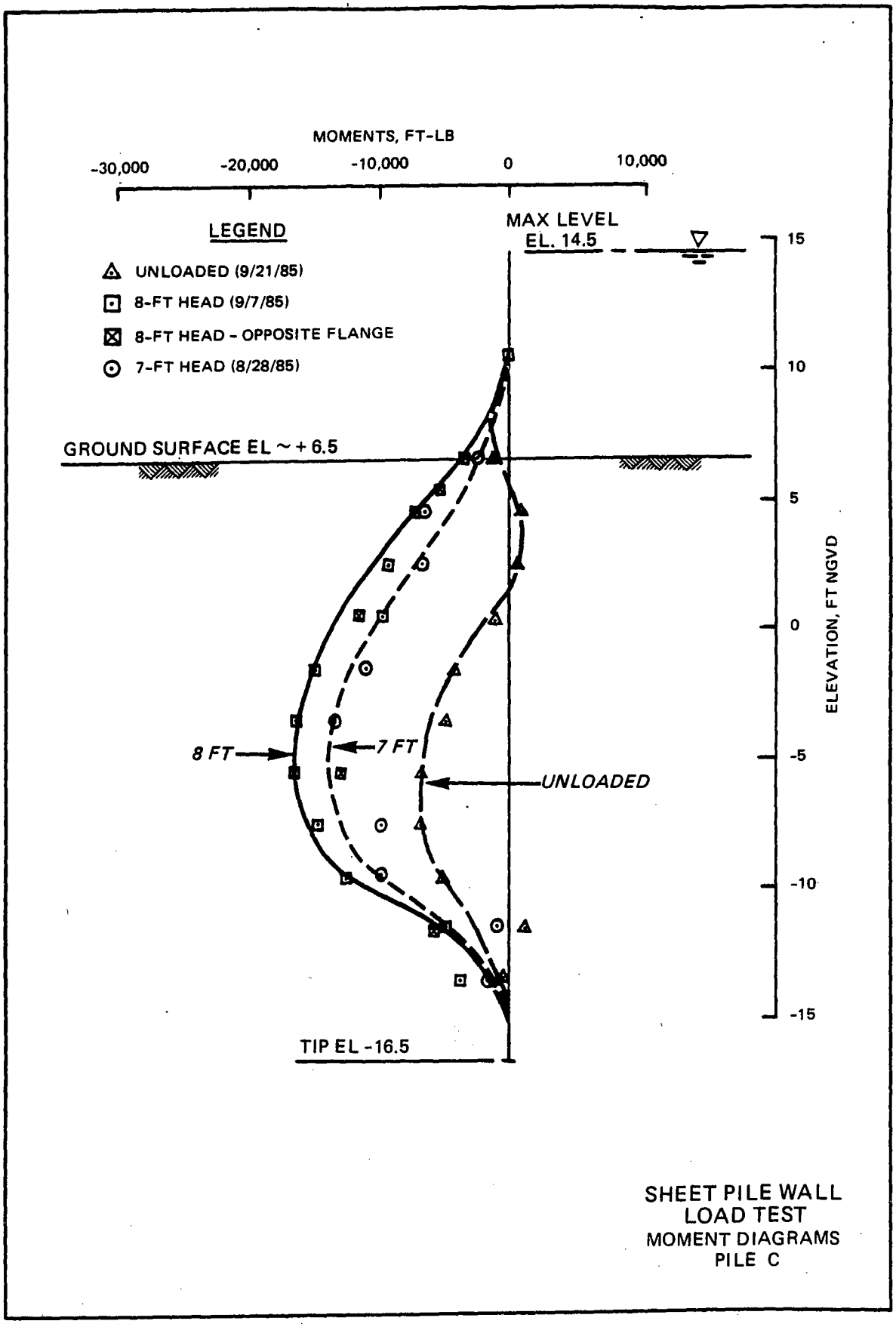
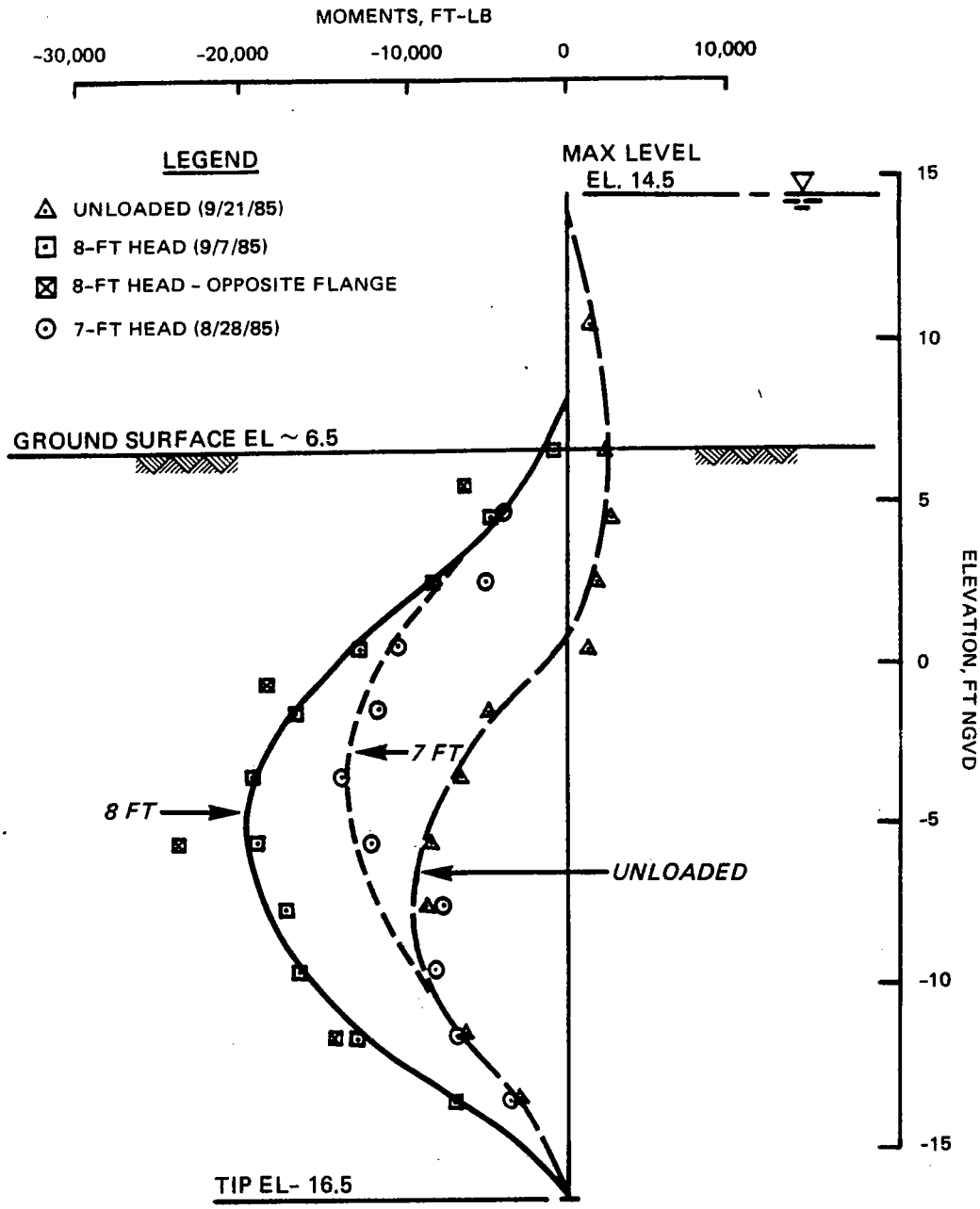

MOMENTS, FT-LB
-30,000
-20,000
-10,000
0
10,000
LEGEND
UNLOADED (9/21/85)
8-FT HEAD (9/7/85)
8-FT HEAD - OPPOSITE FLANGE
7-FT HEAD (8/28/85)
MAX LEVEL
EL. 14.5
GROUND SURFACE EL ~ + 6.5
TIP EL -16.5
8 FT
7 FT
UNLOADED
15
10
5
0
-5
-10
-15
ELEVATION, FT NGVD
SHEET PILE WALL
LOAD TEST
MOMENT DIAGRAMS
PILE C

PLATE 36



SHEET PILE WALL
LOAD TEST
MOMENT DIAGRAMS
PILE D

PLATE 37

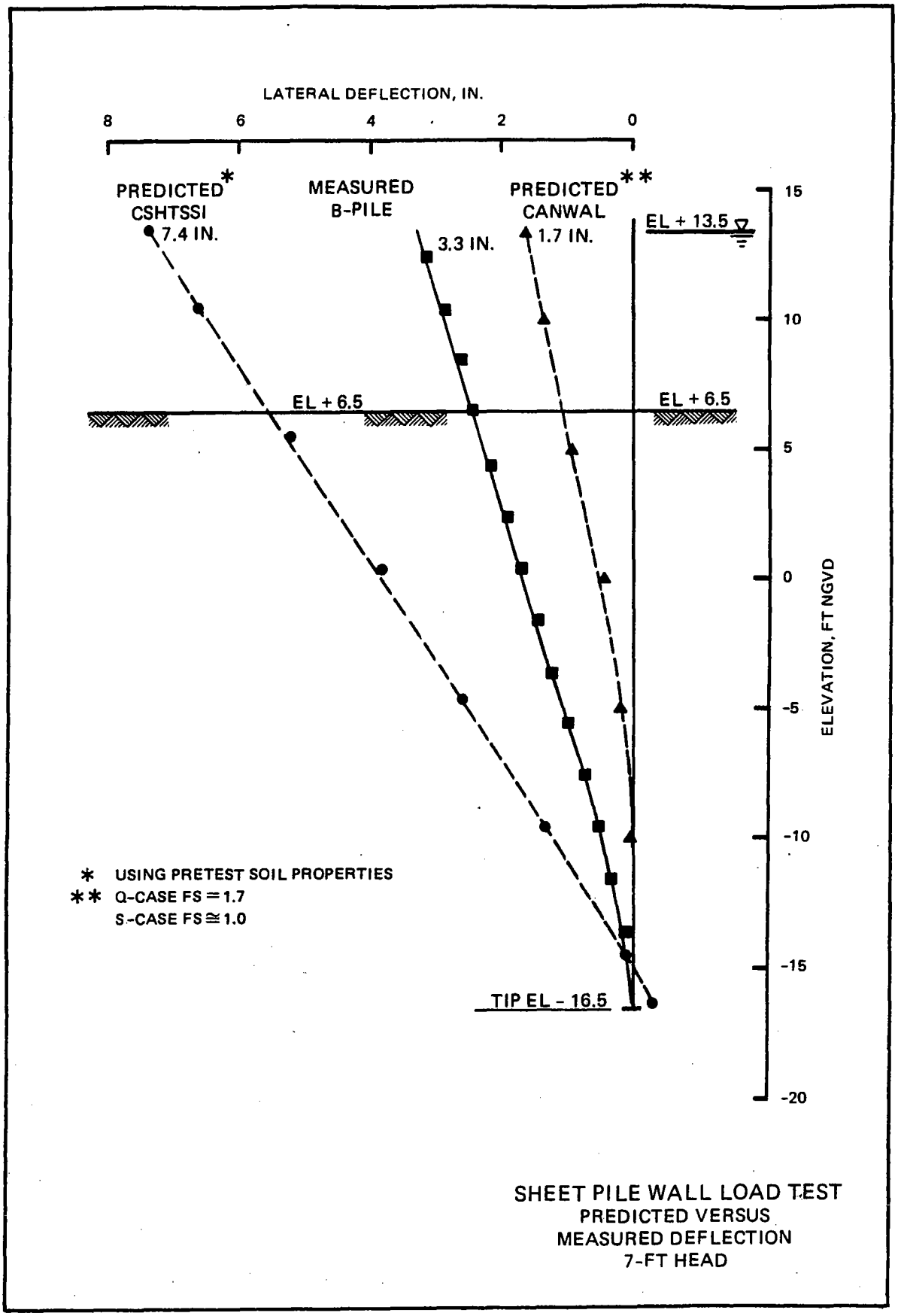
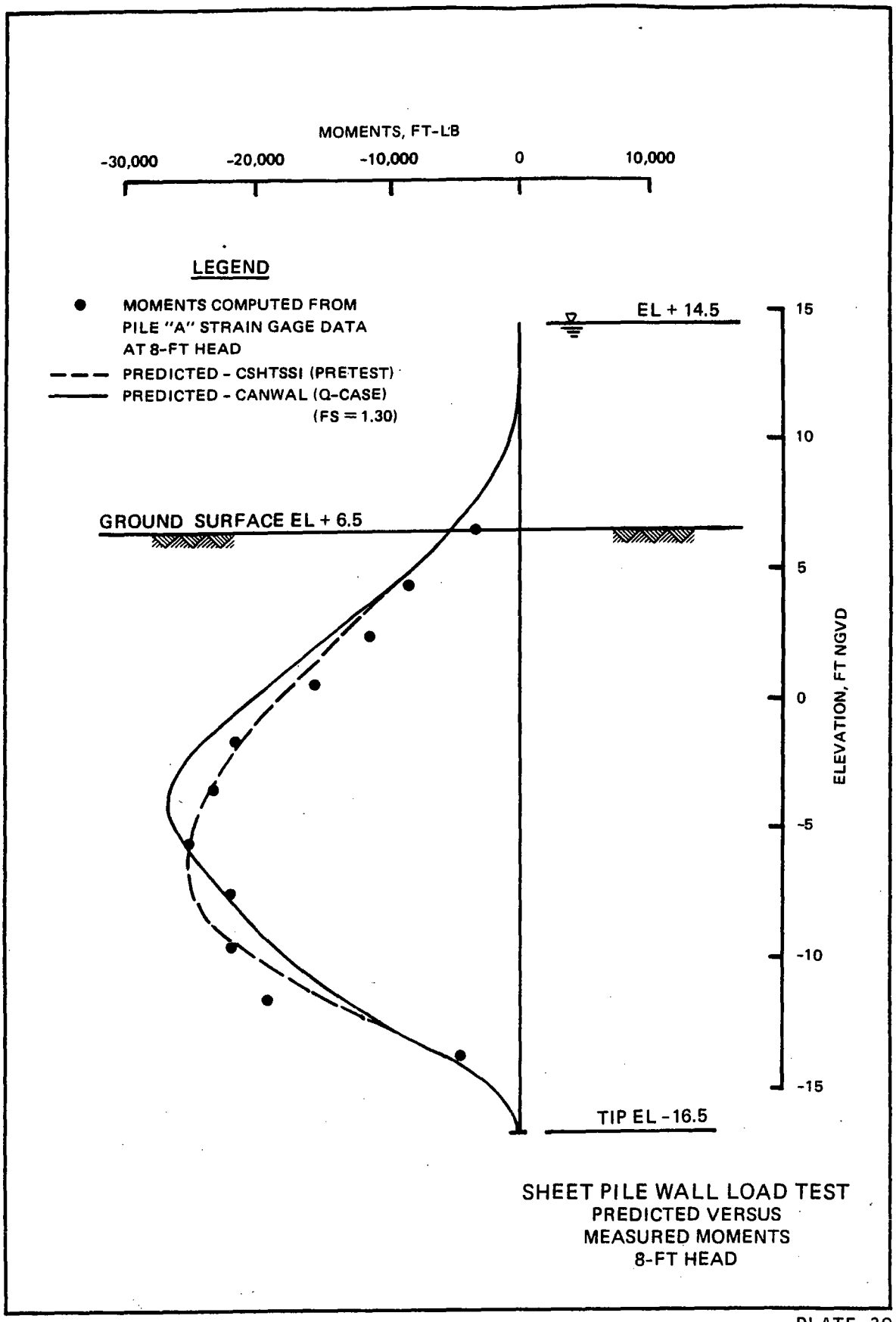
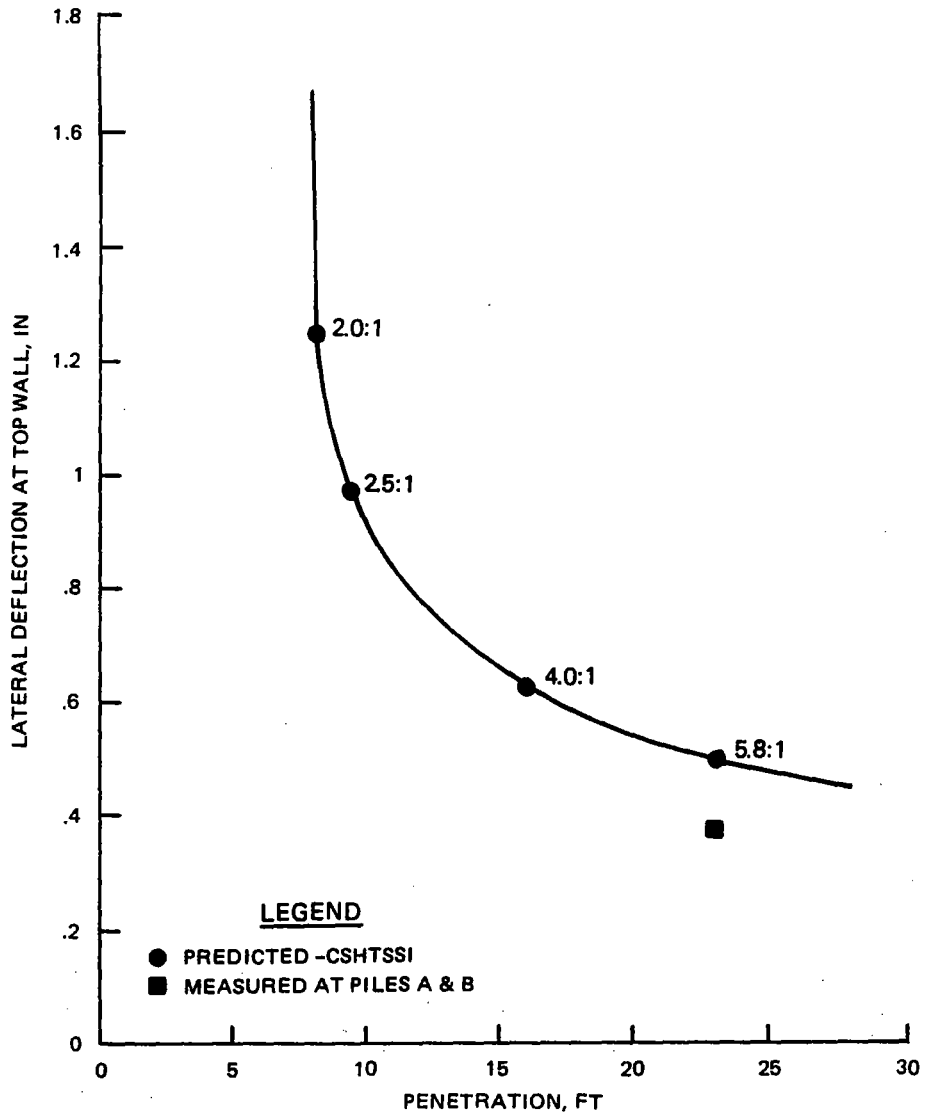

LATERAL DEFLECTION, IN.
8
6
4
2
0
PREDICTED*
CSHTSSI
7.4 IN.
MEASURED
B-PILE
3.3 IN.
PREDICTED**
CANWAL
1.7 IN.
EL + 13.5
EL + 6.5
EL + 6.5
15
10
5
0
-5
-10
-15
-20
ELEVATION, FT NGVD
TIP EL - 16.5
* USING PRETEST SOIL PROPERTIES
** Q-CASE FS = 1.7
S-CASE FS ≅ 1.0
SHEET PILE WALL LOAD TEST
PREDICTED VERSUS
MEASURED DEFLECTION
7-FT HEAD

PLATE 38



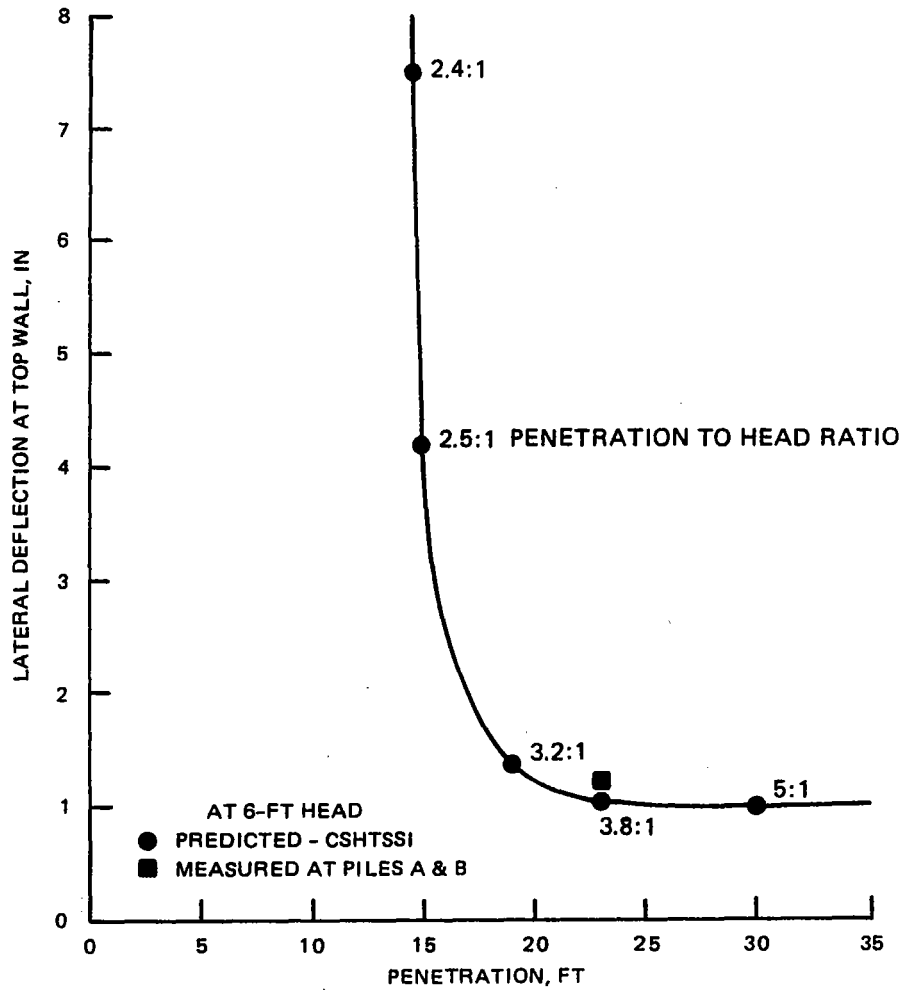
SHEET PILE WALL LOAD TEST
PREDICTED VERSUS MEASURED MOMENTS
8-FT HEAD

PLATE 39



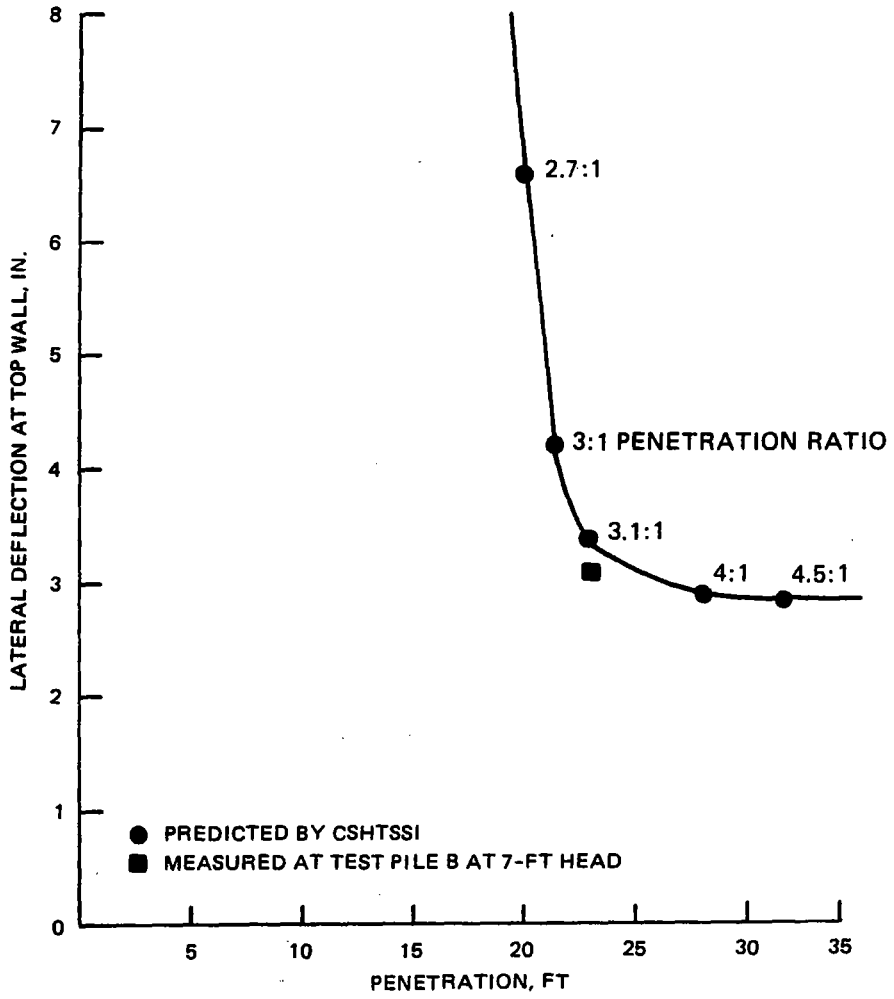
SHEET PILE WALL LOAD TEST
PENETRATION VERSUS PREDICTED
DEFLECTION AT 4-FT HEAD

PLATE 40



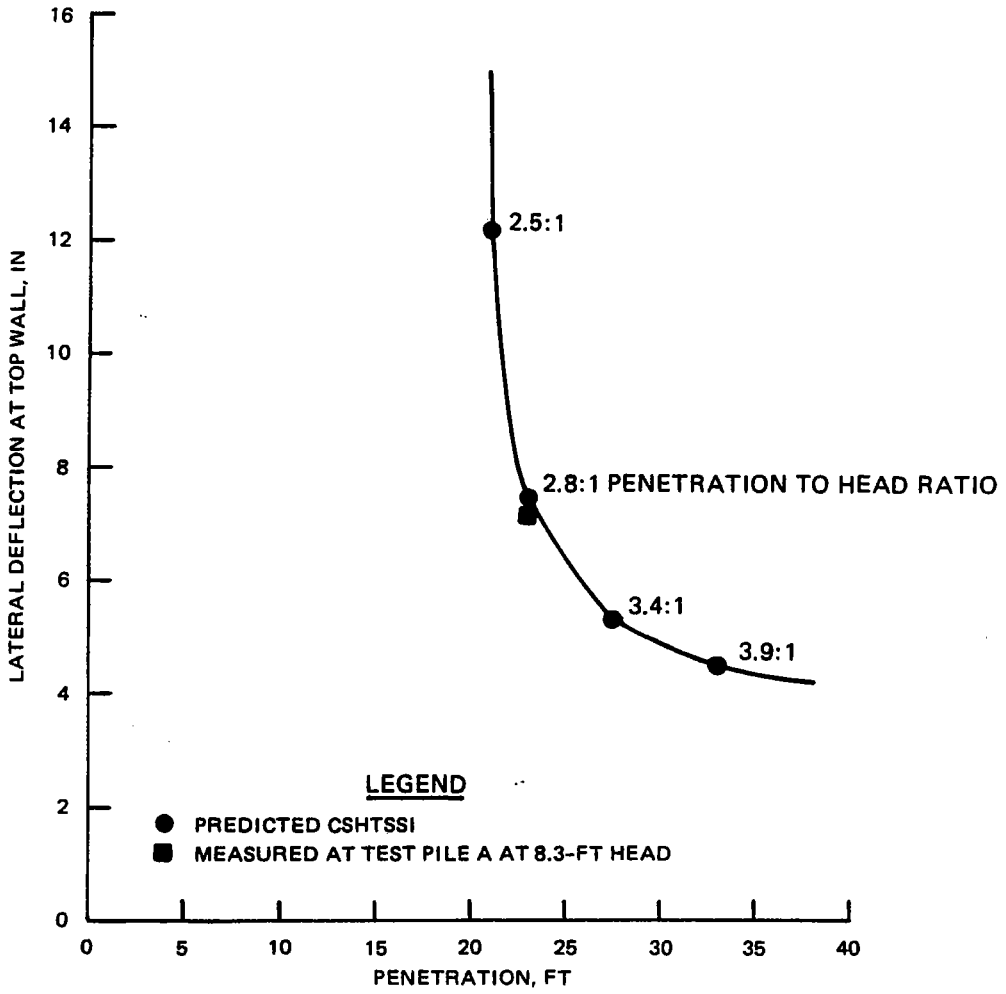
SHEET PILE WALL LOAD TEST
PENETRATION VERSUS PREDICTED
DEFLECTION (CSHTSSI) AT 6-FT HEAD

PLATE 41



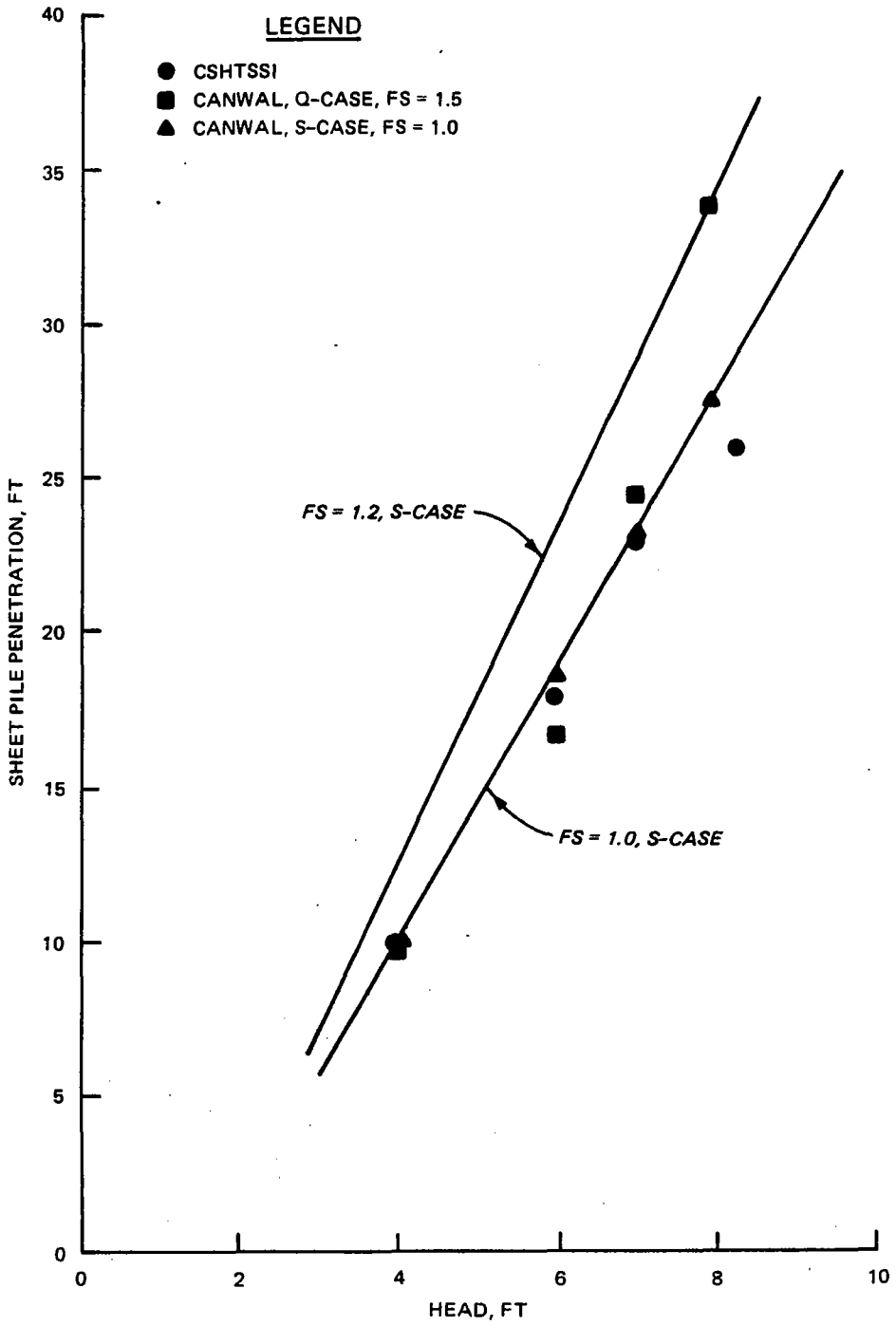
SHEET PILE WALL LOAD TEST
PENETRATION VERSUS PREDICTED
DEFLECTION (CSHTSSI) AT 7-FT HEAD

PLATE 42



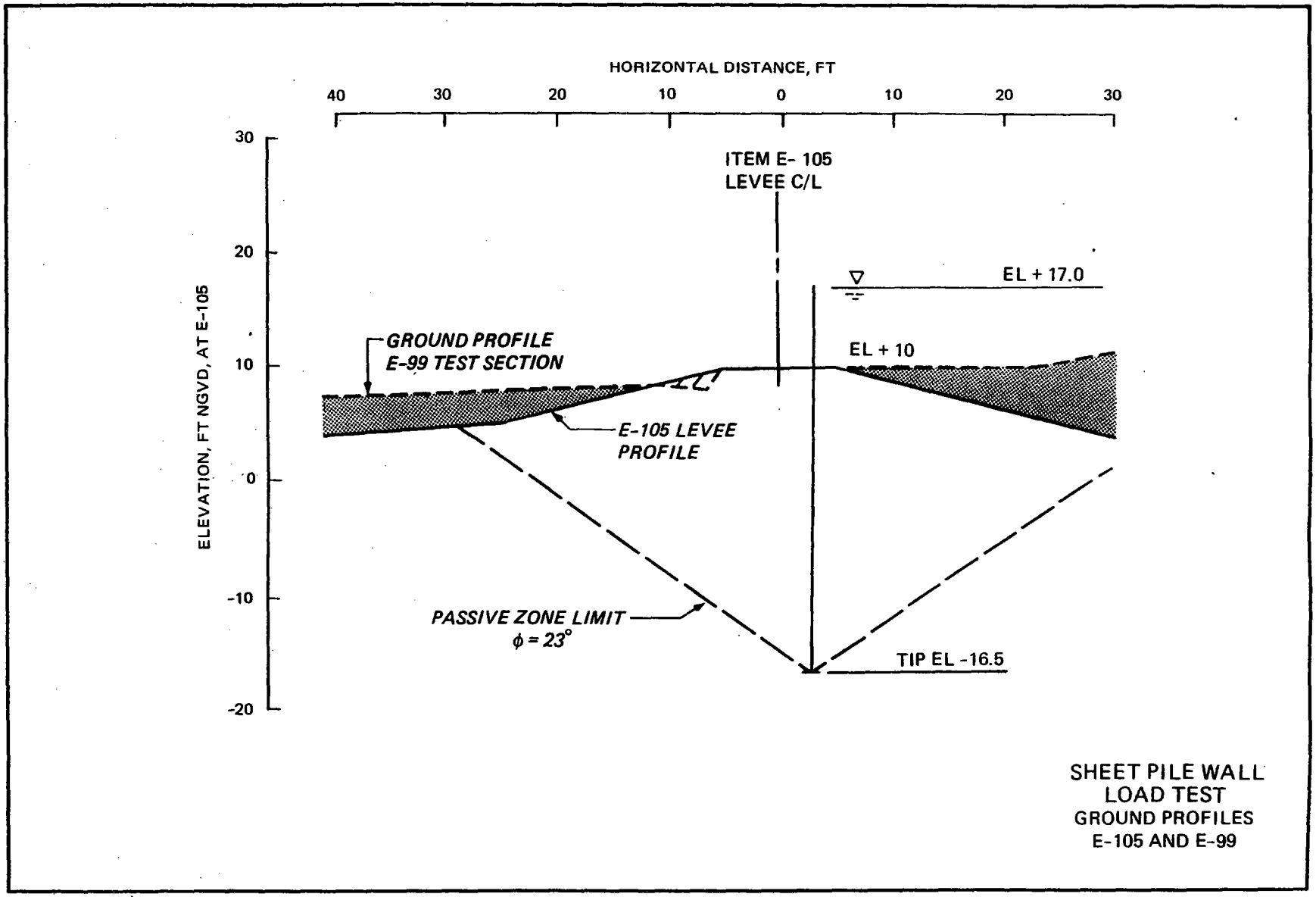
SHEET PILE WALL LOAD TEST
PENETRATION VERSUS PREDICTED
DEFLECTION (CSHTSSI) AT 8.3-FT HEAD

PLATE 43



SHEET PILE WALL LOAD TEST
REQUIRED SHEET PILE
PENETRATION VERSUS HEAD

PLATE 44



SHEET PILE WALL
LOAD TEST
GROUND PROFILES
E-105 AND E-99

PLATE 45

Appendix A

Computer Analysis Printouts

Analysis No.	Program	Case	Factor of Safety	Design Head (ft)
1	CANWAL	Q	1.25	8
2	CANWAL	S	1.5	8
3	CANWAL	S	0.9	8
4	CANWAL	Q	1.7	7
5	CANWAL	S	1.0	7
6	CSHTSSI	PRETEST	N/A*	7
7	CSHTSSI	POSTTEST	N/A*	4
8	CSHTSSI	POSTTEST	N/A*	6
9	CSHTSSI	POSTTEST	N/A*	7
10	CSHTSSI	POSTTEST	N/A*	8.3

NOTES

1) All analyses except No. 2 are for a cantilever sheet pile wall with about 23 ft of penetration. Based on Analysis No. 2, 44 ft of penetration was computed.

2) N/A* (Not Applicable): Factor of safety is not input into the CSHTSSI program, only a penetration.

3) Pretest estimates of soil properties for the CSHTSSI program were based on the design strength data shown in Plate 4 and the CSHTSSI user's guide. Post-test estimates of soil properties were values calculated after the fact from the test wall performance. See Analysis No. 7 (page 2) for example E_s computation.

4) CANWAL Program: WES Library No. X0026. This program determines the required penetration of a cantilever retaining wall using the method of planes and a limit equilibrium type of analysis.

5) CSHTSSI Program: WES Library No. X0070. User's guide also available as WES Instruction Report K-83-3. This is a program for soil-structure interaction analysis of sheet pile retaining walls which predicts wall deflections, moments, etc.

```
*NEW
*FORT
*RUN WESLIB/CORPS/X0026,R
*****************************
*  CORPS PROGRAM  #  X0026   *
*        VERSION  # 83/10/01 *
*****************************

 TYPE NAME OF INPUT DATA FILE
=RBJ4

                    CANTILEVER RETAINING WALL STABILITY

 DATA FILE= RBJ4
ITEM E-99, Q-CASE
FS=1.25, 8FT HEAD
```

FS/LS WATER ELEV	PS WATER ELEV	UPPER RANGE	LOWER RANGE	FSWATER GROUND EL	FS	NUMBER STRATA
14.50	4.00	-15.00	-20.00	14.50	1.25	6

FLOODWALL ANALYSIS

TENSION CRACK ELEVATIONS

FS/LS	PS
3.38	3.38

AREA	SUM FORCE	MOM ARM	MOMENT
X(1)	2430.68	24.51	59567.56
X(2)	5873.15	10.54	61925.19
X(3)	3408.47	0.83	2819.73

TRIAL ELEV= -15.00 SUM OF FORCES= -0.89 SUM OF MOM= 4671.31

TRIAL ELEV= -20.00 SUM OF FORCES= -0.00 SUM OF MOM= -18252.28

TRIAL ELEV= -16.02 SUM OF FORCES= -38.11 SUM OF MOM= 971.22

TRIAL ELEV= -17.02 SUM OF FORCES= -1704.12 SUM OF MOM= -6149.81

DESIGN ELEV= -16.16 SUM OF FORCES= -33.99 SUM OF MOM= 462.11

ELEVATION (FT)	NET DIAGRAM (LBS/SQ FT)
14.50	0.
13.50	62.50
12.50	125.00
11.50	187.50
10.50	250.00
9.50	312.50
8.50	375.00
7.50	437.50

ANALYSIS 1 (PG. 1)

```
*LIST RBJ4

 1020 ITEM E-99, Q-CASE
 1030 FS=1.25, 8FT HEAD
 1040 -1 14.5 4 -15 -20 14.5 1.25 6 -40
 1050 0 0
 1060 0 0 0 0 0 0 0 0 14.5
 1070 0 104 200 200 0 104 200 200 6.5
 1080 0 42 200 200 0 42 200 200 4
 1090 0 45 500 500 0 45 500 500 -1
 1100 0 44 350 350 0 44 350 350 -5
 1110 0 42 500 500 0 42 500 500 -14
 1120 0 14.5 100 14.5 200 14.5 9999.9 0
 1130 0 12 57 12 73 9 80 6.5 100 6.5 110 6.5
 1140 113 4.5 117 5 140 4.3 200 4.3 9999.9 0
 1150 0 4 100 4 200 4 9999.9 0
 1160 0 -1 100 -1 200 -1 9999.9 0
 1170 0 -5 100 -5 200 -5 9999.9 0
 1180 0 -14 100 -14 200 -14 9999.9 0
 1190 0 -40 100 -40 200 -40 9999.9 0


*NEW
*FORT
*RUN WESLIB/CORPS/X0026,R
*******************************
*  CORPS PROGRAM  #  X0026    *
*        VERSION  # 83/10/01 *
*******************************

 TYPE NAME OF INPUT DATA FILE
=RBJ4

                    CANTILEVER RETAINING WALL STABILITY

 DATA FILE= RBJ4
ITEM E-99, Q-CASE
FS=1.25, 8FT HEAD


FS/LS WATER **  FS  WATER ** UPPER ** LOWER **  FSWATER ** FS ** NUMBER
    ELEV     **    ELEV    ** RANGE ** RANGE ** GROUND EL**    ** STRATA

  14.50             4.00    -15.00   -20.00      14.50      1.25      6

                         FLOODWALL ANALYSIS
```

ANALYSIS 1 (PG. 2)

```
1190 0 -50 100 -50 200 -50 9999.9 0


*NEW
*FORT
*RUN WESLIB/CORPS/X0026,R
*******************************
*  CORPS PROGRAM  #  X0026    *
*         VERSION  # 83/10/01 *
*******************************

 TYPE NAME OF INPUT DATA FILE
=RBJ5
```

CANTILEVER RETAINING WALL STABILITY

```
 DATA FILE= RBJ5
ITEM E-99, S-CASE
FS=1.5 , 8FT HEAD
```

FS/LS WATER ELEV	PS WATER ELEV	UPPER RANGE	LOWER RANGE	FSWATER GROUND EL	FS	NUMBER STRATA
14.50	4.00	-30.00	-35.00	14.50	1.50	6

FLOODWALL ANALYSIS

AREA	SUM FORCE	MOM ARM	MOMENT
X(1)	4102.81	43.07	176690.97
X(2)	13090.78	14.74	193020.41
X(3)	8987.97	1.82	16347.51

TRIAL ELEV= -30.00 SUM OF FORCES= 3.91 SUM OF MOM= 60354.79

TRIAL ELEV= -35.00 SUM OF FORCES= -0.00 SUM OF MOM= 24468.83

TRIAL ELEV= -38.41 SUM OF FORCES= -0.00 SUM OF MOM= -10819.23

TRIAL ELEV= -37.41 SUM OF FORCES= 0.00 SUM OF MOM= 513.52

DESIGN ELEV= -37.45 SUM OF FORCES= 0.00 SUM OF MOM= 18.06

ELEVATION (FT)	NET DIAGRAM (LBS/SQ FT)
14.50	0.
13.50	62.50
12.50	125.00
11.50	187.50
10.50	250.00
9.50	312.50
8.50	375.00
7.50	437.50
6.50	500.00

ANALYSIS 2 (PG. 1)

```
*1040 1 14.5 4 -30 -35 14.5 1.5 6 -50
*RESAVE RBJ5
DATA SAVED-RBJ5
*LIST RBJ5

1020 ITEM E-99, S-CASE
1030 FS=1.5 , 8FT HEAD
1040 1 14.5 4 -30 -35 14.5 1.5 6 -50
1050 0 0
1060 0 0 0 0 0 0 0 0 14.5
1070 23 42 0 0 23 104 0 0 6.5
1080 23 42 0 0 23 42 0 0 4
1090 23 45 0 0 23 45 0 0 -1
1100 23 44 0 0 23 44 0 0 -5
1110 23 42 0 0 23 42 0 0 -14
1120 0 14.5 100 14.5 200 14.5 9999.9 0
1130 0 12 57 12 73 9 80 6.5 100 6.5 110 6.5
1140 113 4.5 117 5 140 4.3 200 4.3 9999.9 0
1150 0 4 100 4 200 4 9999.9 0
1160 0 -1 100 -1 200 -1 9999.9 0
1170 0 -5 100 -5 200 -5 9999.9 0
1180 0 -14 100 -14 200 -14 9999.9 0
1190 0 -50 100 -50 200 -50 9999.9 0


*NEW
*FORT
*RUN WESLIB/CORPS/X0026,R
*******************************
*  CORPS PROGRAM  #  X0026.  *
*         VERSION  # 83/10/01 *
*******************************

 TYPE NAME OF INPUT DATA FILE
=RBJ5

                  CANTILEVER RETAINING WALL STABILITY

 DATA FILE= RBJ5
ITEM E-99, S-CASE
FS=1.5 , 8FT HEAD


FS/LS WATER **  PS  WATER ** UPPER ** LOWER **  FSWATER ** FS ** NUMBER
    ELEV     **    ELEV    ** RANGE ** RANGE ** GROUND EL**    ** STRATA
```

ANALYSIS 2 (PG. 2)

```
*OLD RBJ5
*LIST RBJ5

1020 ITEM E-99, S-CASE
1030 FS=1.5 , 8FT HEAD
1040 1 14.5 4 -30 -35 14.5 1.5 6 -50
1050 0 0
1060 0 0 0 0 0 0 0 0 14.5
1070 23 42 0 0 23 104 0 0 6.5
1080 23 42 0 0 23 42 0 0 4
1090 23 45 0 0 23 45 0 0 -1
1100 23 44 0 0 23 44 0 0 -5
1110 23 42 0 0 23 42 0 0 -14
1120 0 14.5 100 14.5 200 14.5 9999.9 0
1130 0 12 57 12 73 9 80 6.5 100 6.5 110 6.5
1140 113 4.5 117 5 140 4.3 200 4.3 9999.9 0
1150 0 4 100 4 200 4 9999.9 0
1160 0 -1 100 -1 200 -1 9999.9 0
1170 0 -5 100 -5 200 -5 9999.9 0
1180 0 -14 100 -14 200 -14 9999.9 0
1190 0 -50 100 -50 200 -50 9999.9 0


*OLD RBJ5
*1030 FS=0.9, 8FT HEAD
*1040 1 14.5 4 -15 -20 14.5 0.9 6 -50
*RESAVE RBJ5
DATA SAVED-RBJ5
*LIST RBJ5

1020 ITEM E-99, S-CASE
1030 FS=0.9, 8FT HEAD
1040 1 14.5 4 -15 -20 14.5 0.9 6 -50
1050 0 0
1060 0 0 0 0 0 0 0 0 14.5
1070 23 42 0 0 23 104 0 0 6.5
1080 23 42 0 0 23 42 0 0 4
1090 23 45 0 0 23 45 0 0 -1
1100 23 44 0 0 23 44 0 0 -5
1110 23 42 0 0 23 42 0 0 -14
1120 0 14.5 100 14.5 200 14.5 9999.9 0
1130 0 12 57 12 73 9 80 6.5 100 6.5 110 6.5
1140 113 4.5 117 5 140 4.3 200 4.3 9999.9 0
1150 0 4 100 4 200 4 9999.9 0
1160 0 -1 100 -1 200 -1 9999.9 0
1170 0 -5 100 -5 200 -5 9999.9 0
1180 0 -14 100 -14 200 -14 9999.9 0
1190 0 -50 100 -50 200 -50 9999.9 0


*NEW
*FORT
*RUN WESLIB/CORPS/X0026,R
*******************************
*  CORPS PROGRAM  #  X0026    *
*        VERSION  # 83/10/01 *
*******************************

 TYPE NAME OF INPUT DATA FILE
=RBJ5

                    CANTILEVER RETAINING WALL STABILITY

 DATA FILE= RBJ5
ITEM E-99  S-CASE
```

ANALYSIS 3 (PG. 1)

```
*NEW
*FORT
*RUN WESLIB/CORPS/X0026,R
*******************************
*  CORPS PROGRAM  #  X0026    *
*        VERSION  # 83/10/01 *
*******************************

 TYPE NAME OF INPUT DATA FILE
=RBJ5

                    CANTILEVER RETAINING WALL STABILITY

 DATA FILE= RBJ5
ITEM E-99, S-CASE
FS=0.9, 8FT HEAD


FS/LS WATER ** PS  WATER ** UPPER ** LOWER **  FSWATER ** FS ** NUMBER
    ELEV    **    ELEV    ** RANGE ** RANGE ** GROUND EL**    ** STRATA

  14.50            4.00    -15.00   -20.00      14.50     0.90      6

                        FLOODWALL ANALYSIS



AREA     SUM FORCE    MOM ARM      MOMENT

X(1)       2704.74      26.06     70492.81
X(2)       8289.62       9.22     76431.23
X(3)       5584.24       1.08      6042.67


      ELEV= -15.00  SUM OF FORCES=     -0.00  SUM OF MOM=  16132.71


 TRIAL ELEV= -20.00  SUM OF FORCES=     -0.00  SUM OF MOM= -16733.52


 TRIAL ELEV= -17.45  SUM OF FORCES=     -0.05  SUM OF MOM=   2659.15


 TRIAL ELEV= -18.45  SUM OF FORCES=     -1.98  SUM OF MOM=  -4265.18


DESIGN ELEV= -17.84  SUM OF FORCES=     -0.63  SUM OF MOM=    104.25


  ELEVATION      NET DIAGRAM
     (FT)        (LBS/SQ FT)
    14.50           0.
    13.50          62.50
    12.50         125.00
    11.50         187.50
    10.50         250.00
     9.50         312.50
     8.50         375.00
     7.50         437.50
     6.50         500.00
     6.50         500.00
     5.50         320.62
```

ANALYSIS 3 (PG. 2)

```
1160 0 -1 100 -1 200 -1 9999.9 0
1170 0 -5 100 -5 200 -5 9999.9 0
1130 0 -14 100 -14 200 -14 9999.9 0
1190 0 -29 100 -29 200 -29 9999.9 0


*NEW
*FORT
*RUN WESLIB/CORPS/X0026,R
*****************************
*  CORPS PROGRAM  #  X0026   *
*         VERSION  # 83/10/01 *
*****************************

 TYPE NAME OF INPUT DATA FILE
=RBJ3

                  CANTILEVER RETAINING WALL STABILITY

 DATA FILE=.RBJ3
ITEM E-99, 0=CASE
FS=1.7, 7FT HEAD


FS/LS WATER **  PS  WATER ** UPPER ** LOWER **  FSWATER ** FS ** NUMBER
    ELEV     **    ELEV    ** RANGE ** RANGE ** GROUND EL**    ** STRATA

  13.50            4.00     -15.00   -20.00      13.50     1.70      6

                        FLOODWALL ANALYSIS


TENSION CRACK ELEVATIONS
    FS/LS          PS
     0.91          4.27


AREA     SUM FORCE    MOM ARM       MOMENT

X(1)       2022.48      24.50     49546.03
X(2)       4637.71      11.09     51424.79
X(3)       2664.66       0.90      2388.19

 TRIAL ELEV= -15.00  SUM OF FORCES=      14.68  SUM OF MOM=   4793.88

 TRIAL ELEV= -20.00  SUM OF FORCES=       0.00  SUM OF MOM= -11841.67

 TRIAL ELEV= -16.44  SUM OF FORCES=      25.14  SUM OF MOM=    985.02

 TRIAL ELEV= -17.44  SUM OF FORCES=   -1066.14  SUM OF MOM=  -4396.51

DESIGN ELEV= -16.62  SUM OF FORCES=      49.42  SUM OF MOM=    509.43


  ELEVATION      NET DIAGRAM
    (FT)        (LBS/SQ FT)
   13.50            0.
   12.50           62.50
```

ANALYSIS 4 (PG. 1)

SEC MOD= 30.20 CUBIC IN/FT OF WALL
MOMENT OF INERTIA= 184.20 IN. TO THE 4TH PER FOOT OF WALL
ELASTIC MODULUS= 29000000. LBF/SQ IN.
WEIGHT OF THE PILE HAS BEEN NEGLECTED

THE MAXIMUM BENDING MOMENT OCCURS AT -3.70 FT AND IS 20452.47 LBF-FT.
THE SHEAR FORCE IS -2.19 LBF.

* ELEVATION * (FEET)	SHEAR FORCE (LBF)	BENDING MOMENT (LBF-FT)	BENDING STRESS (LBF/SQ.IN)	DEFLECTION FROM TANGENT THRU DEFL REF PT (INCHES)
13.500	0.	0.	0.	-1.675
13.499	0.0	0.0	0.0	-1.675
13.000	7.8	1.3	0.5	-1.627
12.000	70.3	35.2	14.0	-1.532
11.000	195.3	162.8	64.7	-1.437
10.000	382.8	446.6	177.5	-1.342
9.000	632.8	949.2	377.2	-1.247
8.000	945.3	1733.1	688.6	-1.153
7.000	1320.3	2860.7	1136.7	-1.059
6.000	1627.2	4363.0	1733.6	-0.966
5.000	1787.9	6073.9	2413.5	-0.874
4.000	1907.1	7924.9	3149.0	-0.784
3.000	1984.5	9874.2	3923.5	-0.697
2.000	2020.0	11879.9	4720.5	-0.613
1.656	2022.5	12575.8	4997.0	-0.585
1.000	2013.4	13900.1	5523.2	-0.533
0.	1981.8	15897.9	6317.0	-0.458
-1.000	1950.0	17863.8	7098.2	-0.387
-2.000	1212.3	19444.9	7726.5	-0.323
-3.000	474.5	20288.3	8061.6	-0.264
-3.698	-2.2	20452.5	8126.8	-0.227
-4.000	-205.7	20421.0	8114.3	-0.212
-5.000	-807.7	19910.8	7911.6	-0.167
-6.000	-1015.2	18995.9	7548.0	-0.128
-7.000	-1181.0	17894.3	7110.3	-0.096
-8.000	-1305.3	16647.7	6615.0	-0.069
-9.000	-1465.9	15260.9	6063.9	-0.047
-10.000	-1691.2	13683.6	5437.2	-0.030
-11.000	-1931.3	11873.6	4718.0	-0.018
-12.000	-2186.3	9816.0	3900.4	-0.010
-13.000	-2406.6	7519.3	2987.8	-0.004
-13.934	-2615.2	5155.5	2048.6	-0.002
-13.936	-2615.2	5150.3	2046.5	-0.002
-14.000	-2613.7	4983.4	1980.1	-0.002
-15.000	-2197.3	2516.4	999.9	-0.000
-16.000	-1043.7	834.5	331.6	-0.000
-16.619	39.7	509.2	202.3	0.
-16.620	41.7	509.3	202.4	0.

THE MAXIMUM DEFLECTION IS -1.67 IN. & OCCURS AT ELEVATION 13.5 FT.

****

ANALYSIS 4 (PG. 2)

```
1020 ITEM E-99, Q-CASE
1030 FS=1.7, 7FT HEAD
1040 -1 13.5 4 -15 -20 13.5 1.7 6 -29
1050 0 0
1060 0 0 0 0 0 0 0 0 13.5
1070 0 42 200 200 0 104 200 200 6.5
1080 0 42 200 200 0 42 200 200 4
1090 0 45 500 500 0 45 500 500 -1
1100 0 44 350 350 0 44 350 350 -5
1110 0 42 500 500 0 42 500 500 -14
1120 0 13.5 100 13.5 200 13.5 9999.9 0
1130 0 12 57 12 73 9 80 6.5 100 6.5 110 6.5
1140 113 4.5 117 5 140 4.3 200 4.3 9999.9 0
1150 0 4 100 4 200 4 9999.9 0
1160 0 -1 100 -1 200 -1 9999.9 0
1170 0 -5 100 -5 200 -5 9999.9 0
1180 0 -14 100 -14 200 -14 9999.9 0
1190 0 -29 100 -29 200 -29 9999.9 0


*NEW
*FORT
*RUN WESLIB/CORPS/X0026,R
*******************************
*  CORPS PROGRAM  #  X0026    *
*         VERSION  # 83/10/01 *
*******************************

 TYPE NAME OF INPUT DATA FILE
=RBJ3

                CANTILEVER RETAINING WALL STABILITY

 DATA FILE= RBJ3
ITEM E-99, Q-CASE
FS=1.7, 7FT HEAD


FS/LS WATER **  PS  WATER ** UPPER ** LOWER **  FSWATER ** FS ** NUMBER
    ELEV     **    ELEV    ** RANGE ** RANGE ** GROUND EL**    ** STRATA

  13.50            4.00    -15.00   -20.00      13.50      1.70      6

                    FLOODWALL ANALYSIS

TENSION CRACK ELEVATIONS
    FS/LS          PS
     0.91          4.27


AREA     SUM FORCE    MOM ARM      MOMENT

X(1)       2022.48      24.50     49546.03
X(2)       4637.71      11.09     51424.79
X(3)       2664.66       0.90      2388.19

 TRIAL ELEV= -15.00  SUM OF FORCES=      14.68  SUM OF MOM=    4793.88

 TRIAL ELEV= -20.00  SUM OF FORCES=       0.00  SUM OF MOM= -11841.67
```

ANALYSIS 4 (PG. 3)

```
*NEW
*FORT
*RUN WESLIB/CORPS/X0026,R
*******************************
*  CORPS PROGRAM  #  X0026    *
*        VERSION  # 83/10/01  *
*******************************

 TYPE NAME OF INPUT DATA FILE
=RBJ5

                 CANTILEVER RETAINING WALL STABILITY

 DATA FILE= RBJ5
ITEM E-99, S-CASE
FS=1.0, 7FT HEAD

FS/LS WATER **  PS WATER ** UPPER ** LOWER **  FSWATER ** FS ** NUMBER
    ELEV    **    ELEV    ** RANGE ** RANGE ** GROUND EL**    ** STRATA

  13.50            4.00    -15.00   -20.00      13.50      1.00      6

                      FLOODWALL ANALYSIS


AREA     SUM FORCE    MOM ARM      MOMENT

[illegible]  [illegible]9.78     24.57     52820.59
          [illegible]43.28      8.72     57056.80
          4393.50      0.98      4313.01

 TRIAL ELEV= -15.00  SUM OF FORCES=     -0.00  SUM OF MOM=   8101.98

 TRIAL ELEV= -20.00  SUM OF FORCES=     -0.00  SUM OF MOM= -21790.10

 TRIAL ELEV= -16.36  SUM OF FORCES=     -0.00  SUM OF MOM=   1789.61

 TRIAL ELEV= -17.36  SUM OF FORCES=     -0.00  SUM OF MOM=  -3679.04

DESIGN ELEV= -16.68  SUM OF FORCES=      0.00  SUM OF MOM=     76.80


  ELEVATION      NET DIAGRAM
     (FT)        (LBS/SQ FT)
    13.50           0.
    12.50          62.50
    11.50         125.00
    10.50         187.50
     9.50         250.00
     8.50         312.50
     7.50         375.00
     6.50         437.50
     6.50         437.50
     5.50         281.01
     4.50         124.51
     4.00          46.27
     4.00          46.27
```

ANALYSIS 5 (PG. 1)

-12.86	CONTN LD	-386.16	LBF/SQ FT
-13.74	CONTN LD	0.	LBF/SQ FT
-16.68	CONTN LD	2983.66	LBF/SQ FT
-16.68	CONTN LD	0.	LBF/SQ FT

PZ-27 PROPERTIES ARE AS FOLLOWS.

SEC MOD= 70.20 CUBIC IN/FT OF WALL
MOMENT OF INERTIA= 184.20 IN. TO THE 4TH PER FOOT OF WALL
ELASTIC MODULUS= 29000000. LBF/SQ IN.
WEIGHT OF THE PILE HAS BEEN NEGLECTED

THE MAXIMUM BENDING MOMENT OCCURS AT -6.94 FT AND IS 23065.27 LBF-FT.
THE SHEAR FORCE IS 2.50 LBF.

* ELEVATION * (FEET)	SHEAR FORCE (LBF)	BENDING MOMENT (LBF-FT)	BENDING STRESS (LBF/SQ.IN)	DEFLECTION FROM TANGENT THRU DEFL REF PT (INCHES)
13.500	0.	0.	0.	-2.078
13.499	0.0	0.0	0.0	-2.078
13.000	7.8	1.3	0.5	-2.021
12.000	70.3	35.2	14.0	-1.908
11.000	195.3	162.8	64.7	-1.795
10.000	382.8	446.6	177.5	-1.682
9.000	632.8	949.2	377.2	-1.569
8.000	945.3	1733.1	688.6	-1.456
7.000	1320.3	2860.7	1136.7	-1.344
6.000	1730.4	4390.0	1744.4	-1.233
5.000	2011.4	6274.0	2493.0	-1.124
4.000	2136.0	8360.7	3322.1	-1.016
3.403	2149.8	9641.9	3831.2	-0.953
3.000	2143.5	10506.9	4174.9	-0.911
2.000	2073.6	12621.9	5015.3	-0.809
1.000	1926.1	14628.2	5812.5	-0.712
0.	1701.3	16448.3	6535.8	-0.619
-1.000	1451.4	18022.4	7161.2	-0.532
-2.000	1233.3	19361.7	7693.4	-0.450
-3.000	1051.4	20501.1	8146.1	-0.375
-4.000	905.6	21476.6	8533.7	-0.306
-5.000	717.8	22298.3	8860.2	-0.245
-6.000	401.8	22869.4	9087.2	-0.190
-6.939	2.5	23065.3	9165.0	-0.145
-7.000	-26.1	23064.6	9164.7	-0.143
-8.000	-533.0	22790.9	9056.0	-0.103
-9.000	-1110.6	21975.0	8731.8	-0.071
-10.000	-1758.9	20546.1	8164.0	-0.045
-11.000	-2478.0	18433.6	7324.6	-0.027
-12.000	-3267.8	15566.6	6185.4	-0.014
-13.000	-4118.1	11874.9	4718.5	-0.006
-13.736	-4393.5	8707.2	3459.8	-0.003
-13.738	-4393.5	8698.4	3456.3	-0.003
-14.000	-4358.6	7552.2	3000.9	-0.002
-15.000	-3586.0	3495.5	1388.9	-0.000
-16.000	-1800.3	717.9	285.3	0.000
-16.679	-10.3	76.8	30.5	0.
-16.680	-7.3	76.8	30.5	0.

THE MAXIMUM DEFLECTION IS -2.08 IN. & OCCURS AT ELEVATION 13.5 FT.

ANALYSIS 5 (PG. 2)

```
1040 1 13.5 4 -15 -20 13.5 1.0 6 -50
1050 0 0
1060 0 0 0 0 0 0 0 0 13.5
1070 23 42 0 0 23 104 0 0 6.5
1080 23 42 0 0 23 42 0 0 4
1090 23 45 0 0 23 45 0 0 -1
1100 23 44 0 0 23 44 0 0 -5
1110 23 42 0 0 23 42 0 0 -14
1120 0 13.5 100 13.5 200 13.5 999.9 0
1130 0 12 57 12 73 9 80 6.5 100 6.5 110 6.5
1140 113 4.5 117 5 140 4.3 200 4.3 9999.9 0
1150 0 4 100 4 200 4 9999.9 0
1160 0 -1 100 -1 200 -1 9999.9 0
1170 0 -5 100 -5 200 -5 9999.9 0
1180 0 -14 100 -14 200 -14 9999.9 0
1190 0 -50 100 -50 200 -50 9999.9 0

*OLD RBJ5
*1120 0 13.5 100 13.5 200 13.5 9999.9 0
*RESAVE RBJ5
DATA SAVED-RBJ5
*LIST RBJ5

1020 ITEM E-99, S-CASE
1030 FS=1.0, 7FT HEAD
1040 1 13.5 4 -15 -20 13.5 1.0 6 -50
1050 0 0
1060 0 0 0 0 0 0 0 0 13.5
1070 23 42 0 0 23 104 0 0 6.5
1080 23 42 0 0 23 42 0 0 4
1090 23 45 0 0 23 45 0 0 -1
1100 23 44 0 0 23 44 0 0 -5
1110 23 42 0 0 23 42 0 0 -14
1120 0 13.5 100 13.5 200 13.5 9999.9 0
1130 0 12 57 12 73 9 80 6.5 100 6.5 110 6.5
1140 113 4.5 117 5 140 4.3 200 4.3 9999.9 0
1150 0 4 100 4 200 4 9999.9 0
1160 0 -1 100 -1 200 -1 9999.9 0
1170 0 -5 100 -5 200 -5 9999.9 0
1180 0 -14 100 -14 200 -14 9999.9 0
1190 0 -50 100 -50 200 -50 9999.9 0


*NEW
*FORT
*RUN WESLIB/CORPS/X0026,R
*******************************
*  CORPS PROGRAM  #  X0026    *
*        VERSION  # 83/10/01 *
*******************************

 TYPE NAME OF INPUT DATA FILE
=RBJ5

                CANTILEVER RETAINING WALL STABILITY

 DATA FILE= RBJ5
ITEM E-99, S-CASE
FS=1.0, 7FT HEAD


FS/LS WATER **  PS  WATER ** UPPER ** LOWER **  FSWATER ** FS ** NUMBER
    ELEV     **    ELEV    ** RANGE ** RANGE ** GROUND EL**    ** STRATA
```

ANALYSIS 5 (PG. 3)

```
=N
    DO YOU WANT TO CONTINUE?  ENTER 'YES' OR 'NO'
=Y
    SOLUTION COMPLETE.
    DO YOU WANT RESULTS WRITTEN TO YOUR TERMINAL," TO A FILE, OR BOTH?
    ENTER 'TERMINAL', 'FILE', OR 'BOTH'
=T
```

```
    PROGRAM CSHTSSI - SOIL-STRUCTURE INTERACTION ANALYSIS
    OF CANTILEVER OR ANCHORED SHEET PILE RETAINING WALLS
    DATE:  4/12/86                          TIME: 12:33: 7

    III.--SUMMARY OF RESULTS

    III.A.--HEADING
      'E-99 I-WALL TEST, PRETEST SOIL DATA
      7FT HEAD, 23FT PENTR


    III.B.--MAXIMA
                                        MAXIMUM      ELEV       MAXIMUM      ELEV
                                       POSITIVE      (FT)      NEGATIVE      (FT)
    AXIAL DISPLACEMENT (IN)   :        0.           13.50      0.           13.50
    LATERAL DISPLACEMENT (IN):         7.44E 00     13.50     -2.69E-01    -16.50
    AXIAL FORCE (LB)          :        0.           13.50      0.           13.50
    SHEAR (LB)                :        1.73E 03    -10.32     -1.55E 03      5.50
    BENDING MOMENT (LB-FT)    :        0.           13.50     -1.41E 04     -3.50

    DO YOU WANT COMPLETE RESULTS OUTPUT? ENTER 'YES' OR 'NO'.
=Y


    IV.--COMPLETE RESULTS

    IV.A.--HEADING
      'E-99 I-WALL TEST, PRETEST SOIL DATA
      7FT HEAD, 23FT PENTR


    IV.B.--COMPLETE RESULTS
           <----DEFLECTIONS--->       AXIAL                  BENDING      SOIL
     ELEV       AXIAL     LATERAL      FORCE       SHEAR      MOMENT     PRESSURE
     (FT)        (IN)        (IN)       (LB)        (LB)     (LB-FT)       (PSF)
```

ANALYSIS 6 (PG. 1)

```
 1000 'E-99 I-WALL TEST, PRETEST SOIL DATA
 1010 7FT HEAD, 23FT PENTR
 1020 WALL 13.5 -16.5 29.E6 184.2 7.94
 1030 RIGHTSIDE
 1040 6.5 104 0 200 0 1 7.4 7.5
 1050 -1 107 0 500 0 1 18.6 4
 1060 -5 106 0 350 0 1 13 9
 1065 -14 104 0 500 0 1 18.6 2.5
 1070 LEFTSIDE
 1080 6.5 104 0 200 0 1 7.4 7.5
 1090 -1 107 0 500 0 1 18.6 4
 1100 -5 106 0 350 0 1 13 9
 1105 -14 104 0 500 0 1 18.6 2.5
 1110 WATER 62.5 13.5 4.5
 1120 FINISH


*NEW
*FORT
*RUN WESLIB/CORPS/X0070,R
*******************************
* CORPS PROGRAM #  X0070     *
*       VERSION # 86/03/12   *
*******************************



    PROGRAM CSHTSSI - SOIL-STRUCTURE INTERACTION ANALYSIS
    OF CANTILEVER OR ANCHORED SHEET PILE RETAINING WALLS
    DATE:  4/12/86                          TIME: 12:32:22

    ARE INPUT DATA TO BE READ FROM TERMINAL OR FILE?
    ENTER 'TERMINAL' OR 'FILE'.
=F
    ENTER INPUT FILE NAME (6 CHARACTERS MAXIMUM).
=RBJ1A
    INPUT COMPLETE.
    DO YOU WANT INPUT DATA ECHOPRINTED TO YOUR
    TERMINAL, TO A FILE, TO BOTH OR NEITHER?
    ENTER 'TERMINAL', 'FILE', 'BOTH', OR 'NEITHER'.
=N
    DO YOU WANT TO EDIT INPUT DATA?  ENTER 'YES' OR 'NO'.
=N
    INPUT COMPLETE. DO YOU WANT TO CONTINUE?  ENTER 'YES' OR 'NO'.
=Y
    DO YOU WANT A LISTING OF NONLINEAR SPRING DATA GENERATED BY CSHTSSI?
    ENTER 'YES' OR 'NO'.
```

ANALYSIS 6 (PG. 2)

PROGRAM CSHTSSI - SOIL-STRUCTURE INTERACTION ANALYSIS
OF CANTILEVER OR ANCHORED SHEET PILE RETAINING WALLS
DATE: 5/12/86 TIME: 15: 5:19

III.--SUMMARY OF RESULTS

III.A.--HEADING
'E-99 I-WALL TEST
4FT HEAD, 23FT PENTR

0.4" Measured at Pile "B"

III.B.--MAXIMA

	MAXIMUM POSITIVE	ELEV (FT)	MAXIMUM NEGATIVE	ELEV (FT)
AXIAL DISPLACEMENT (IN) :	0.	10.50	0.	10.50
LATERAL DISPLACEMENT (IN):	4.90E-01	10.50	0.	10.50
AXIAL FORCE (LB) :	0.	10.50	0.	10.50
SHEAR (LB) :	4.29E 02	-9.37	-5.00E 02	6.50
BENDING MOMENT (LB-FT) :	8.35E-03	-16.50	-3.63E 03	-2.50

DO YOU WANT COMPLETE RESULTS OUTPUT? ENTER 'YES' OR 'NO'.
=Y

IV.--COMPLETE RESULTS

IV.A.--HEADING
'E-99 I-WALL TEST
4FT HEAD, 23FT PENTR

IV.B.--COMPLETE RESULTS

ELEV (FT)	<----DEFLECTIONS---> AXIAL (IN)	LATERAL (IN)	AXIAL FORCE (LB)	SHEAR (LB)	BENDING MOMENT (LB-FT)	SOIL PRESSURE (PSF)
10.50	0.	4.90E-01	0.	0.	0.	0.
9.50	0.	4.66E-01	0.	-31.	-10.	0.
8.50	0.	4.43E-01	0.	-125.	-83.	0.
7.50	0.	4.19E-01	0.	-281.	-281.	0.
6.50	0.	3.95E-01	0.	-500.	-666.	0.
6.50	0.	3.95E-01	0.	-500.	-666.	-252.72
5.50	0.	3.72E-01	0.	-489.	-1162.	-331.95
4.50	0.	3.49E-01	0.	-462.	-1639.	-407.50
3.50	0.	3.26E-01	0.	-425.	-2083.	-417.05

ANALYSIS 7 (PG. 1)

```
*LIST RBUZE ----

1000 'E-99 I-WALL TEST
1010 4FT HEAD, 23FT PENTR
1020 WALL 10.5 -16.5 29.E6 184.2 7.94
1030 RIGHTSIDE
1040 6.5 104 0 200 0 1 11.1 2.5
1050 -1 107 0 500 0 1 27.8 2.5
1060 -5 106 0 350 0 1 19.4 2.5
1065 -14 104 0 500 0 1 27.8 2.5
1070 LEFTSIDE
1080 6.5 104 0 200 0 1 11.1 2.5
1090 -1 107 0 500 0 1 27.8 2.5
1100 -5 106 0 350 0 1 19.4 2.5
1105 -14 104 0 500 0 1 27.8 2.5
1110 WATER 62.5 10.5 4.5
1120 FINISH


*NEW
*FORT
*RUN WESLIB/CORPS/X0070,R
*******************************
* CORPS PROGRAM #  X0070     *
*       VERSION # 86/03/12   *
*******************************
```

$$E_S = 48q_u = \frac{(48)(400\ \frac{LB}{FT^2})}{(144\ \frac{IN^2}{FT^2})(12\ \frac{IN}{FT})(1FT\ STRIP)} = 11.1\ LB/IN^3/\ FT\ STRIP$$

d =INTERACTION DISTANCE (FT.)

```
    PROGRAM CSHTSSI - SOIL-STRUCTURE INTERACTION ANALYSIS
    OF CANTILEVER OR ANCHORED SHEET PILE RETAINING WALLS
```


ANALYSIS 7 (PG. 2)

```
-RBJ2E
    INPUT COMPLETE.
    DO YOU WANT INPUT DATA ECHOPRINTED TO YOUR
    TERMINAL, TO A FILE, TO BOTH OR NEITHER?
    ENTER 'TERMINAL', 'FILE', 'BOTH', OR 'NEITHER'.
=N
    DO YOU WANT TO EDIT INPUT DATA?  ENTER 'YES' OR 'NO'.
=N
    INPUT COMPLETE. DO YOU WANT TO CONTINUE?  ENTER 'YES' OR 'NO'.
=Y
    DO YOU WANT A LISTING OF NONLINEAR SPRING DATA GENERATED BY CSHTSSI?
    ENTER 'YES' OR 'NO'.
=N
    DO YOU WANT TO CONTINUE?  ENTER 'YES' OR 'NO'.
=Y
    SOLUTION COMPLETE.
    DO YOU WANT RESULTS WRITTEN TO YOUR TERMINAL," TO A FILE, OR BOTH?
    ENTER 'TERMINAL', 'FILE', OR 'BOTH'.
=T



    PROGRAM CSHTSSI - SOIL-STRUCTURE INTERACTION ANALYSIS
    OF CANTILEVER OR ANCHORED SHEET PILE RETAINING WALLS
    DATE:  4/30/86                          TIME:  8:10: 1

    III.--SUMMARY OF RESULTS

    III.A.--HEADING
      'E-99 I-WALL TEST
      '6FT HEAD, 23FT PENTR
```

Measured 1.2" at Pile "B"

```
    III.B.--MAXIMA
```

	MAXIMUM POSITIVE	ELEV (FT)	MAXIMUM NEGATIVE	ELEV (FT)
AXIAL DISPLACEMENT (IN) :	0.	12.50	0.	12.50
LATERAL DISPLACEMENT (IN):	1.06E 00	12.50	0.	12.50
AXIAL FORCE (LB) :	0.	12.50	0.	12.50
SHEAR (LB) :	8.97E 02	-9.37	-1.12E 03	6.50
BENDING MOMENT (LB-FT) :	8.62E-03	-16.50	-7.82E 03	-2.00

```
    DO YOU WANT COMPLETE RESULTS OUTPUT? ENTER 'YES' OR 'NO'.
=N
```

ANALYSIS 8 (PG. 1)

```
*SAVE RBJ2E
DATA SAVED-RBJ2E
*OLD RBJ2E
*1010 `6FT HEAD, 23FT PENTR
*1020 WALL 12.5 -16.5 29.E6 184.2 7.94
*1110 WATER 62.5 12.5 4.5
*RESAVE RBJ2E
DATA SAVED-RBJ2E
*LIST RBJ2E

1000 `E-99 I-WALL TEST
1010 `6FT HEAD, 23FT PENTR
1020 WALL 12.5 -16.5 29.E6 184.2 7.94
1030 RIGHTSIDE
1040 6.5 104 0 200 0 1 11.1 2.5
1050 -1 107 0 500 0 1 27.8 2.5
1060 -5 106 0 350 0 1 19.4 2.5
1065 -14 104 0 500 0 1 27.8 2.5
1070 LEFTSIDE
1080 6.5 104 0 200 0 1 11.1 2.5
1090 -1 107 0 500 0 1 27.8 2.5
1100 -5 106 0 350 0 1 19.4 2.5
1105 -14 104 0 500 0 1 27.8 2.5
1110 WATER 62.5 12.5 4.5
1120 FINISH


*NEW
*FORT
*RUN WESLIB/CORPS/X0070,R
*****************************
* CORPS PROGRAM #  X0070    *
*       VERSION # 86/03/12  *
*****************************



    PROGRAM CSHTSSI - SOIL-STRUCTURE INTERACTION ANALYSIS
    OF CANTILEVER OR ANCHORED SHEET PILE RETAINING WALLS
    DATE:  4/30/86                          TIME:  8: 9:19

    ARE INPUT DATA TO BE READ FROM TERMINAL OR FILE?
    ENTER 'TERMINAL' OR 'FILE'.
=F
    ENTER INPUT FILE NAME (6 CHARACTERS MAXIMUM).
=RBJ2E
```

ANALYSIS 8 (PG. 2)

```
    DO YOU WANT A LISTING OF NONLINEAR SPRING DATA GENERATED BY CSHTSSI?
    ENTER 'YES' OR 'NO'.
=N
    DO YOU WANT TO CONTINUE?  ENTER 'YES' OR 'NO'.
=Y
    SOLUTION COMPLETE.
    DO YOU WANT RESULTS WRITTEN TO YOUR TERMINAL," TO A FILE, OR BOTH?
    ENTER 'TERMINAL', 'FILE', OR 'BOTH'.
=T



    PROGRAM CSHTSSI - SOIL-STRUCTURE INTERACTION ANALYSIS
    OF CANTILEVER OR ANCHORED SHEET PILE RETAINING WALLS
    DATE:  4/29/86                          TIME: 16:21:12

    III.--SUMMARY OF RESULTS

    III.A.--HEADING
      'E-99 I-WALL TEST
      '7FT HEAD, 23FT PENETRATION

                                  <-- Measured 3.2" at Pile "B"
    III.B.--MAXIMA

                                    MAXIMUM      ELEV        MAXIMUM      ELEV
                                    POSITIVE     (FT)        NEGATIVE     (FT)
    AXIAL DISPLACEMENT (IN)   :     0.           13.50       0.           13.50
    LATERAL DISPLACEMENT (IN):      3.40E 00     13.50      -2.06E-01    -16.50
    AXIAL FORCE (LB)          :     0.           13.50       0.           13.50
    SHEAR (LB)                :     2.46E 03    -11.27      -1.55E 03     5.50
    BENDING MOMENT (LB-FT)    :     0.           13.50      -1.72E 04    -5.99


    DO YOU WANT COMPLETE RESULTS OUTPUT? ENTER 'YES' OR 'NO'.
=N



    DO YOU WANT TO PLOT RESULTS
    ENTER 'YES' OR 'NO'
=N
    OUTPUT COMPLETE.
    DO YOU WANT TO EDIT INPUT DATA FOR THE PROBLEM JUST COMPLETED?
    ENTER 'YES' OR 'NO'.
=N
    DO YOU WANT TO MAKE ANOTHER 'CSHTSSI' RUN?  ENTER 'YES' OR 'NO'
=N
```

ANALYSIS 9 (PG. 1)

```
                                  .1 7.5
1050 -1          500       27.8 5.0
1060 -5 106 0 350 0 1 19.4 2.5
1065 -14 104 0 500 0 1 27.8 2.5
1070 LEFTSIDE
1080 6.5 104 0 200 0 1 11.1 7.5
1090 -1 107 0 500 0 1 27.8 5.0
1100 -5 106 0 350 0 1 19.4 2.5
1105 -14 104 0 500 0 1 27.8 2.5
1110 WATER 62.5 13.5 4
1120 FINISH


*OLD RBJ1
*1010 '7FT HEAD, 23FT PENETRATION
*1020 WALL 13.5 -16.5 29.E6 184.2 7.94
*1110 WATER 62.5 13.5 4.5
*RESAVE RBJ1
DATA SAVED-RBJ1
*LIST RBJ1

1000 'E-99 I-WALL TEST
1010 '7FT HEAD, 23FT PENETRATION
1020 WALL 13.5 -16.5 29.E6 184.2 7.94
1030 RIGHTSIDE
1040 6.5 104 0 200 0 1 11.1 7.5
1050 -1 107 0 500 0 1 27.8 5.0
1060 -5 106 0 350 0 1 19.4 2.5
1065 -14 104 0 500 0 1 27.8 2.5
1070 LEFTSIDE
1080 6.5 104 0 200 0 1 11.1 7.5
1090 -1 107 0 500 0 1 27.8 5.0
1100 -5 106 0 350 0 1 19.4 2.5
1105 -14 104 0 500 0 1 27.8 2.5
1110 WATER 62.5 13.5 4.5
1120 FINISH


*NEW
*FORT
*RUN WESLIB/CORPS/X0070,R
*****************************
* CORPS PROGRAM #  X0070    *
*       VERSION # 86/03/12  *
*****************************
```

ANALYSIS 9 (PG. 2)

```
    DO YOU WANT TO CONTINUE?  ENTER 'YES' OR 'NO'.
=Y

    SOLUTION COMPLETE.
    DO YOU WANT RESULTS WRITTEN TO YOUR TERMINAL," TO A FILE, OR BOTH?
    ENTER 'TERMINAL', 'FILE', OR 'BOTH'.
=T


    PROGRAM CSHTSSI - 'SOIL-STRUCTURE INTERACTION ANALYSIS
    OF CANTILEVER OR ANCHORED SHEET PILE RETAINING WALLS
    DATE:  4/ 7/86                                TIME: 13:32: 5

    III.--SUMMARY OF RESULTS

    III.A.--HEADING
      'E-99 I-WALL TEST, A PILE
      8.3 FT HEAD, 23 FT PENTR

    III.B.--MAXIMA
```

7.7" Measured at Pile "A"

	MAXIMUM POSITIVE	ELEV (FT)	MAXIMUM NEGATIVE	ELEV (FT)
AXIAL DISPLACEMENT (IN) :	0.	14.50	0.	14.50
LATERAL DISPLACEMENT (IN):	7.81E 00	14.50	-4.79E-01	-16.50
AXIAL FORCE (LB) :	0.	14.50	0.	14.50
SHEAR (LB) :	2.75E 03	-9.64	-2.32E 03	3.50
BENDING MOMENT (LB-FT) :	6.00E-02	-16.50	-2.42E 04	-3.50

```
    DO YOU WANT COMPLETE RESULTS OUTPUT? ENTER 'YES' OR 'NO'.
=Y


    IV.--COMPLETE RESULTS

    IV.A.--HEADING
      'E-99 I-WALL TEST, A PILE
      8.3 FT HEAD, 23 FT PENTR


    IV.B.--COMPLETE RESULTS
```

ELEV (FT)	<----DEFLECTIONS---> AXIAL (IN)	LATERAL (IN)	AXIAL FORCE (LB)	SHEAR (LB)	BENDING MOMENT (LB-FT)	SOIL PRESSURE (PSF)
14.50	0	7.81E 00	0	0	0	0

ANALYSIS 10 (PG. 1)

```
*LIST RBJ2

1000 'E-99 I-WALL TEST, A PILE
1010 8.3 FT HEAD, 23 FT PENTR
1020 WALL 14.5 -16.5 29.E6 184.2 7.94
1030 RIGHTSIDE
1040 6.2 104 0 200 0 1 11.1 10.0
1050 -1 107 0 500 0 1 27.8 10.0
1060 -5 106 0 350 0 1 19.4 10.0
1065 -14 104 0 500 0 1 27.8 10.0
1070 LEFTSIDE
1080 6.2 104 0 200 0 1 11.1 10.0
1090 -1 107 0 500 0 1 27.8 10.0
1100 -5 106 0 350 0 1 19.4 10.0
1105 -14 104 0 500 0 1 27.8 10.0
1110 WATER 62.5 14.5 4.5
1120 FINISH


*NEW
*FORT
*RUN WESLIB/CORPS/X0070,R
*****************************
* CORPS PROGRAM #  X0070    *
*       VERSION # 86/03/12  *
*****************************




    PROGRAM CSHTSSI - SOIL-STRUCTURE INTERACTION ANALYSIS
    OF CANTILEVER OR ANCHORED SHEET PILE RETAINING WALLS
    DATE:  4/ 7/86                          TIME: 13:30:38

    ARE INPUT DATA TO BE READ FROM TERMINAL OR FILE?
    ENTER 'TERMINAL' OR 'FILE'.
=F
    ENTER INPUT FILE NAME (6 CHARACTERS MAXIMUM).
=RBJ2
    INPUT COMPLETE.
    DO YOU WANT INPUT DATA ECHOPRINTED TO YOUR
    TERMINAL, TO A FILE, TO BOTH OR NEITHER?
    ENTER 'TERMINAL', 'FILE', 'BOTH' OR 'NEITHER'.
```

ANALYSIS 10 (PG. 2)