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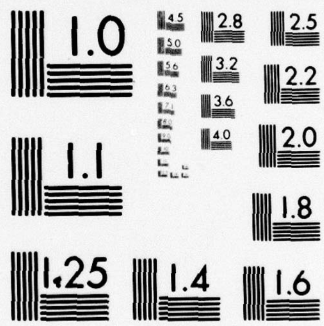

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MISCELLANEOUS PAPER SL-79-18

NONDESTRUCTIVE TESTING OF CONCRETE T-WALLS, ATCHAFALAYA BASIN PROTECTION LEVEES, NEW ORLEANS DISTRICT

by

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- Levees
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- Ultrasonic tests
- T-walls

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

Nondestructive testing measurements were made on two concrete inverted T-walls constructed in the east and west protection levees of the Atchafalaya Basin. These T-walls are to accommodate a 36-in. crude oil pipeline that will cross the basin. Ultrasonic velocity measurements were made through the upright portion of the walls where visible seams of apparent inadequate compaction and exposed reinforcing steel caused concern for the structural integrity of the walls. Measurements were also made to determine if there ~~(Continued)~~ CONT'

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20. ABSTRACT (Continued)

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were any defects in critical areas such as near the intersections of the vertical wall and the base slab. In each wall there is a section of concrete which houses the casing collar where the pipeline passes through the walls. The wall surfaces in these areas were alleged to have been patched and smoothed with a neat cement grout to cover numerous surface irregularities. Velocities obtained in these particular areas of both walls confirm the presence of inferior quality material. The measurements made in other areas of the east wall produced only one velocity that is indicative of concrete of questionable quality. Four of the 32 velocities obtained from the other areas of the west wall indicated inferior quality concrete.

Attempts to make determinations concerning the continuity of the foundation piles using the pulse-echo technique were not successful.

PREFACE

The nondestructive testing (NDT) reported herein was authorized by DA Form 2544 No. LMNED-79-45 dated 11 January 1979 and LMNED-79-45A dated 15 February 1979, from the U. S. Army Engineer District, New Orleans (NOD), to the U. S. Army Engineer Waterways Experiment Station (WES). The work was performed by members of the staff of the Structures Laboratory (SL) under the direction of Mr. Bryant Mather, Acting Chief, SL, Mrs. Katharine Mather, Chief, Engineering Sciences Division (ESD), and Mr. B. R. Sullivan, Chief, Engineering Physics Branch (EPB). Members of the staff of the NOD as well as WES, all of whom are mentioned in the report, participated in the work. Mr. Henry T. Thornton, Jr., was project leader and prepared this report.

Special recognition is given to Mr. Herb Albert, NOD, whose input and assistance were essential to the successful completion of this investigation.

Commanders and Directors of the WES during the conduct of this investigation and publication of this report were COL J. L. Cannon, CE, and COL N. P. Conover, CE. Technical Director was Mr. F. R. Brown.

CONTENTS

CONVERSION FACTORS, U. S. CUSTOMARY TO METRIC (SI) UNITS OF MEASUREMENT

U. S. customary units of measurement used in this report can be converted to metric (SI) units as follows:

Multiply	By	To Obtain
inches	2.54	centimetres
feet	0.3048	metres
feet per second	0.3048	metres per second

NONDESTRUCTIVE TESTING OF CONCRETE T-WALLS, ATCHAFALAYA BASIN PROTECTION LEVEES, NEW ORLEANS DISTRICT

PART I: INTRODUCTION

1. Nondestructive testing (NDT) measurements were made on two concrete inverted T-walls constructed in the east and west protection levees of the Atchafalaya Basin. These T-walls are to accommodate the Weeks Island-St. James 36-in.* crude oil pipeline that will cross the basin, intersecting the east and west protection levees near Belle River and Centerville, La., respectively. The initial contact with the Waterways Experiment Station (WES) by New Orleans District (NOD) was a request for an ultrasonic velocity survey of the upright portion of the T-walls in areas where visible seams of apparent inadequate compaction and exposed reinforcing steel caused concern for the structural integrity of the walls (see Photos 1, 2, 3, and 4).

* A table of factors for converting U. S. customary units of measurement to metric (SI) units is presented on page 3.

PART II: ULTRASONIC VELOCITY TESTS AND RESULTS

2. On 14 December 1978 ultrasonic velocity measurements were made through portions of the walls in an attempt to delineate areas of concrete of inferior quality. The measurements were made by Mr. Henry T. Thornton, Structures Laboratory (SL), WES, assisted by Messrs. Herb Albert and Wade Wright, NOD. The equipment and procedures used to make the ultrasonic velocity measurements are described in CRD-C 51-72 of the Corps of Engineers' Handbook for Concrete and Cement.

3. Figures 1 and 2 show the locations and dimensions for stations established on the wall for making the ultrasonic velocity measurements. Station locations were selected to yield information on possible unseen defects in critical areas, i.e., near intersections between the base of the wall and the slab, and also to determine the extent and severity of visible defects. The general intent of the data station layout at both sites was to have a horizontal line of stations located at intervals along the wall on or near the poorly consolidated areas (between 4 and 6 ft above the slab), and to have a second horizontal line of stations near the intersection of the vertical wall and the slab (6 in. to 2 ft above the slab). Other stations were located according to the need to investigate specific areas. The stations in the horizontal lines near the base of the upright are designated 1B, 3B, 5B, etc., and lie on the same lines vertically as the corresponding stations above them. Stations designated by the letters A through K were located in suspect areas not covered by the previously mentioned horizontal lines of stations (Photos 5 and 6). The face of the protected side of each wall has a vertical slope of 39/64 in. per ft. Therefore, any change in vertical elevation on the wall is accompanied by a change in distance through the wall section. For evaluation purposes the velocities obtained from data stations at the same elevation at each wall are grouped. Consequently, there are several groups of velocities reported for the east wall, and several groups reported for the west wall. This was done to separate velocities by elevation or area.

East Levee Wall

4. Table 1 gives the results of the ultrasonic velocity measurements made through the T-wall on the east levee. Five groups of velocities are reported. Each group represents a series of measurements made through the wall at one elevation (see Figure 1). The distances through which each group of measurements was made are as follows:

Group	Distance, ft
1	1.64
2	1.56
3	1.84
4	1.77
5	1.80

Of the 28 measurements (groups 1 and 2) made through or near the visible seam, only station No. 25 produced a velocity that is indicative of concrete of questionable quality. The 15 measurements made along the base of the vertical wall (groups 3 and 4) were indicative of excellent quality concrete. Stations A through E (group 5) were located in an area where the wall surface was alleged to have been patched and smoothed with a neat cement grout (see Photo 2). Velocities obtained at these stations confirm the presence of inferior quality material. The mean velocity for group 5 is 13 percent lower than that of groups 1-4 collectively.

West Levee Wall

5. Table 2 gives the results of velocity measurements made through the T-wall on the west protection levee. These velocities are reported in four groups with path lengths through the wall as follows:

Group	Distance, ft
1	1.49
2	1.59
3	1.77
4	1.80

Velocities obtained at stations 3, 11, and 15 of groups 1 and 2 indicate areas of inferior quality concrete located along the visible seam in the west wall. The 11 measurements made along the base of the vertical wall (group 3) produced 1 velocity (station 11B) which is considerably lower than the others. This anomaly goes without explanation except for the possibility of incomplete consolidation. It is noted that station 11, which is directly above station 11B, also produced a low velocity. It is also noted that stations 9B and 10 are very near the lowest velocities in their respective groups, although they are within one standard deviation of their respective group means. The point is that these stations are all very close to that section of concrete which houses the casing collar (see Photo 7 and Figure 2). The additional steel reinforcing and irregular form shape could have contributed to incomplete consolidation in this area. Stations A through K were established to provide data in the allegedly patched and smoothed-over area in the west wall (see Photo 3 and Figure 2). As in the east wall, the velocities obtained from this group of stations generally confirm the presence of inferior quality concrete. The mean velocity for group 4 is 15 percent lower than the mean of groups 1-3 collectively.

PART III: PULSE-ECHO TESTS ON PILES

6. During the course of this investigation, the testing party learned that there was some concern on the part of NOD about the continuity of some of the prestressed concrete piles that were driven to serve as foundation for the T-wall structures. Two rows of piles were driven on 4-ft centers to depths of approximately 80 ft under each wall; 34 piles (14 by 14 in.) under the east wall and 40 piles (12 by 12 in.) under the west wall. Figure 3 shows a typical section through a wall. On 16 January 1979, with verbal authority from NOD, Messrs. Henry Thornton and Dan Wilson returned to the east protection wall and attempted to make determinations concerning the continuity of the foundation piles using the pulse-echo technique. This technique is in the developmental stage. It entails the introduction of an excitation pulse at the surface of a structure and receiving at the same surface reflections, or echoes, returning from boundaries within the structure. In this case the boundaries would be the end of the pile or cracks if any were present. Attempts to excite the piles through the 2.5-ft base slab were unsuccessful. Through the efforts of Messrs. Herb Juneau and Carl Rebouche, NOD, a small portion of a pile was exposed by excavating adjacent to the base slab (see Photo 8). This was done to facilitate actual contact with the pile in the hope that a shear mode measurement in direct contact with the pile would produce better results than the previous indirect (through the slab) longitudinal test. This was not the case. Although the efforts made in the excavation, and in the testing, were good, the small portion of pile exposed and the very close and undesirable working conditions made it very difficult to perform the test properly. Little confidence, if any, was generated for this method of testing in this particular application, and an oral report was made, as such, to NOD. The desire for information on the condition of the piles and the fact that the shear mode pulse-echo tests had been made under undesirable conditions prompted a request by NOD to reevaluate the applicability of the shear mode test if it could be done under more favorable conditions, i.e., more extensive excavation with more pile area exposed. On receiving this request, a decision was made to do calibration tests

on companion piles which had not been driven. On 23 January 1979 Messrs. Henry Thornton and Michel Alexander travelled to the precast pile yard of Marine Concrete Structures, Inc., Metairie, La. Both shear mode and longitudinal mode pulse-echo measurements were made on cracked and uncracked piles. No difficulty was encountered in the measurements. Both shear and longitudinal echoes were received from the ends of the piles, and from the crack in the pile (see Photos 9 and 10). The results of these tests were considered to be excellent. With these results, and with expectations of having better access to the driven piles at the site, it was decided that there was at least an even chance for success. On 21 February 1979 Messrs. Thornton and Alexander returned to the east wall. More extensive excavation had been performed, but the exposed portions of the piles were still small (see Photo 11). After 2 days of intensive, exhaustive testing with no success the work was terminated. It was concluded that the damping factors of the surrounding soil and the 2.5-ft concrete cap were so high that the pile could not respond to the exciting impulse in either mode of test. An impulse of much higher energy than that available at the time would be required to excite piles in such an environment.

Table 1

East Wall Velocity Measurements

Group 1

Station	Velocity fps
1	15,920
2	15,920
3	15,770
4	15,620
5	15,470
6	15,470
7	15,400
8	16,080
9	16,080
10	16,080
11	16,080
12	16,160
13	16,080
14	15,470

Mean 15,830
Std Dev 285

Group 2

Station	Velocity fps
15	15,445
16	15,600
17	15,920
18	15,145
19	15,145
20	15,920
21	15,295
22	15,445
23	15,600
24	15,760
25	14,715
26	16,250
27	15,145
28	15,445

Mean 15,490
Std Dev 395

Group 3

Station	Velocity fps
1B	15,335
3B	15,595
5B	16,140
7B	15,930
9B	15,725
11B	15,860
13B	15,725

Mean 15,760
Std Dev 255

Group 4

Station	Velocity fps
15B	15,525
17B	15,805
18B	15,945
20B	15,665
22B	15,260
24B	15,460
26B	15,665
28B	15,325

Mean 15,580
Std Dev 235

Group 5

Station	Velocity fps
A	13,045
B	13,140
C	13,435
D	13,635
E	14,635

Mean 13,580
Std Dev 635

Overall Mean and Standard Deviation

	Excluding Group 5	Including Group 5
Mean	15,655 fps	15,435 fps
Std Dev	345 fps	745 fps

Table 2

West Wall Velocity Measurements

Group 1 Station	Group 1 Velocity fps	Group 2 Station	Group 2 Velocity fps
1	15,360	11	14,455
2	15,360	12	15,435
3	13,670	13	15,590
4	15,205	14	15,745
5	15,520	15	14,070
6	15,520	16	15,900
7	15,685	17	16,225
8	14,750	18	15,590
9	15,360	19	16,060
10	14,750	20	16,225
10A	14,900		
Mean	15,100	Mean	15,530
Std Dev	570	Std Dev	725

Group 3 Station	Group 3 Velocity fps	Group 4 Station	Group 4 Velocity fps
1B	16,105	A	14,285
3B	15,820	B	12,675
5B	15,475	C	12,855
7B	15,965	D	13,140
9B	15,275	E	11,920
11B	14,645	F	10,975
13B	15,680	G	12,415
15B	15,965	H	12,765
17B	15,820	J	15,235
19B	15,965	K	15,055
20B	15,680		
Mean	15,670	Mean	13,130
Std Dev	415	Std Dev	1355

Overall Mean and Standard Deviation

	Excluding Group 4	Including Group 4
Mean	15,410 fps	14,955 fps
Std Dev	635 fps	1280 fps

EAST LEVEE WALL

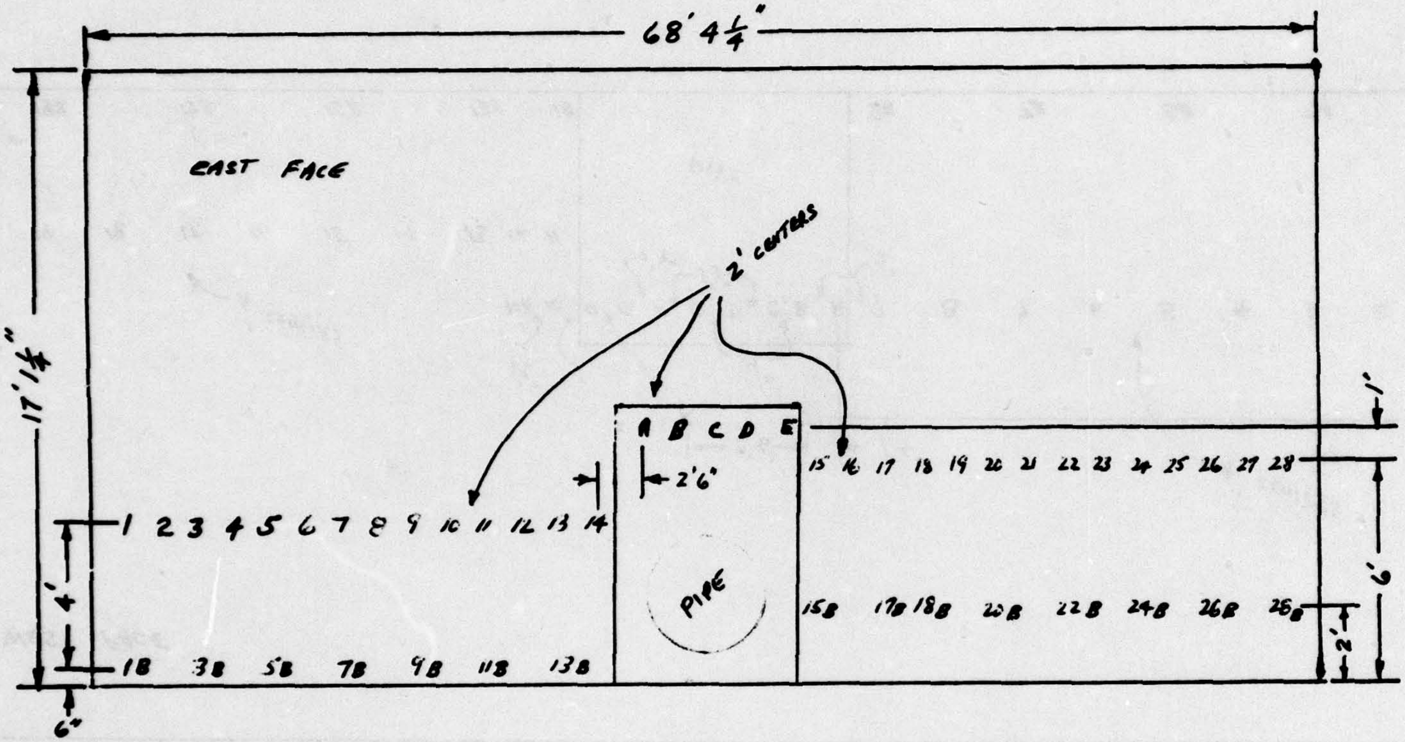

Figure 1. Location of velocity measurements through wall (not to scale)

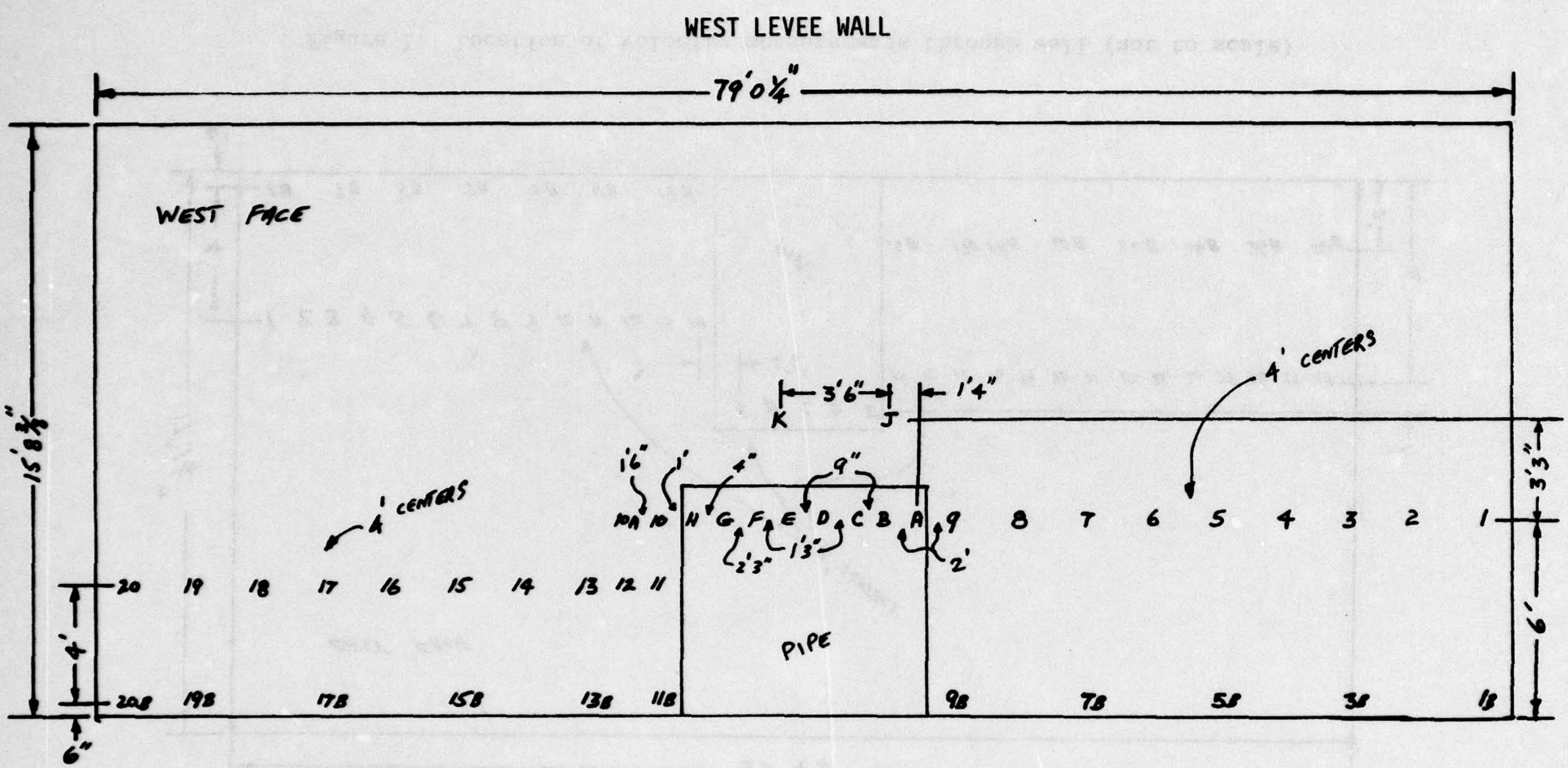

Figure 2. Location of velocity measurements through wall (not to scale)

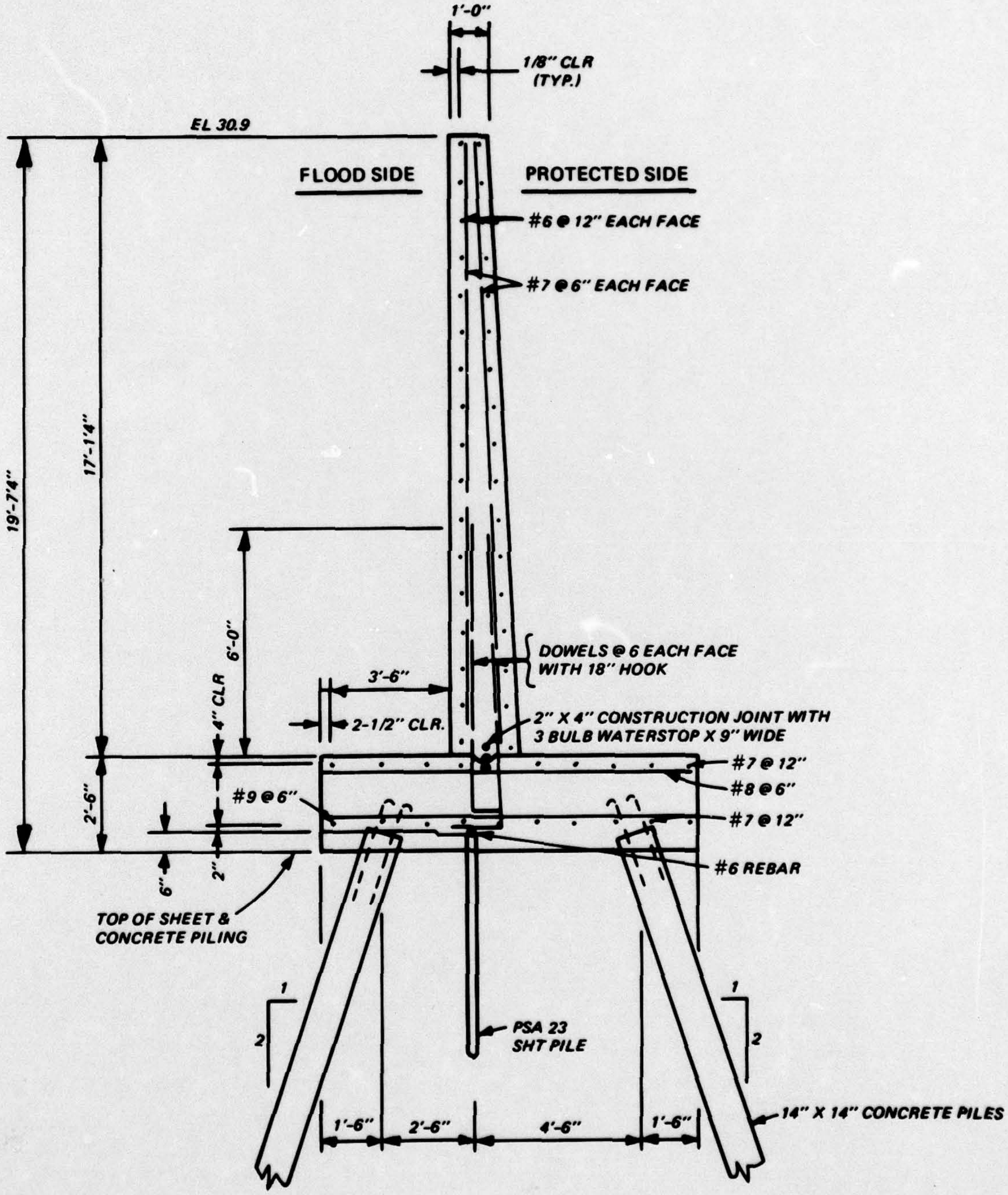

Figure 3. Typical section through T-wall

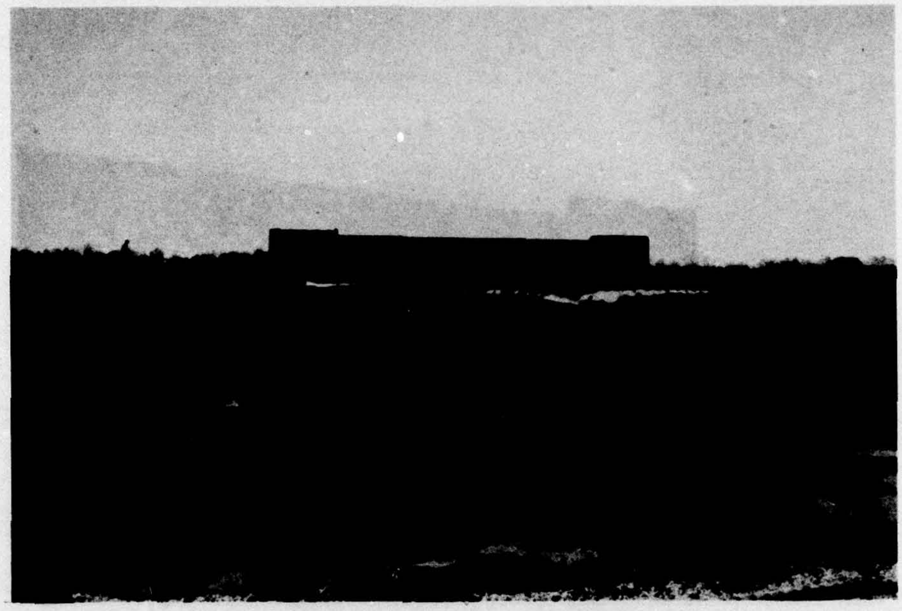

Photo 1. Inverted T-wall, east protection levee

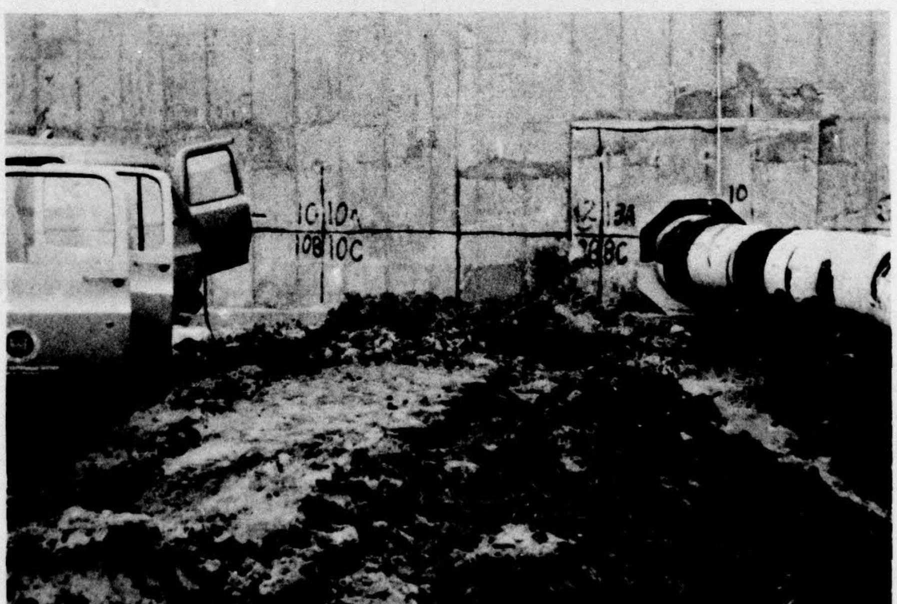

Photo 2. T-wall, east levee; note station numbers and letters on wall

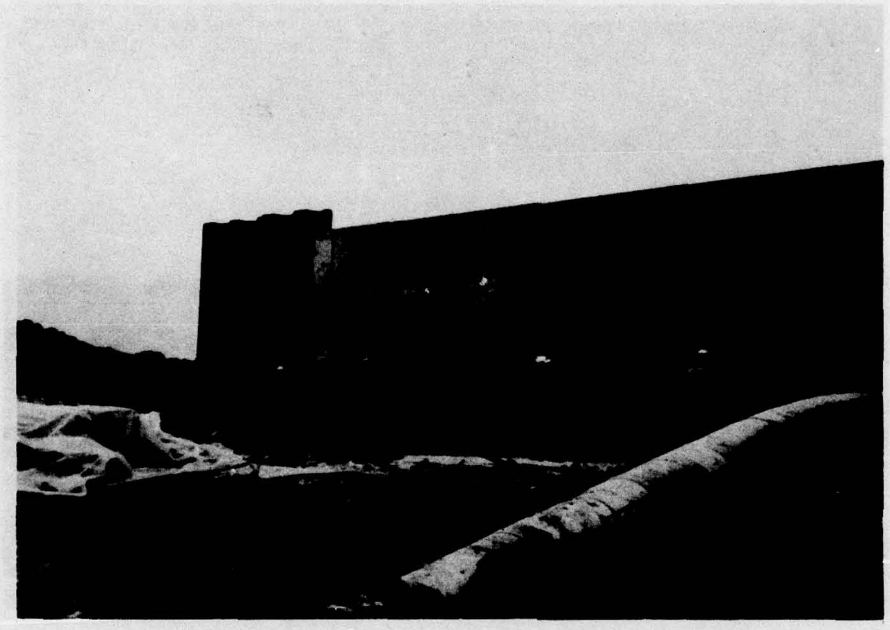

Photo 3. Laying out data stations,
west levee T-wall

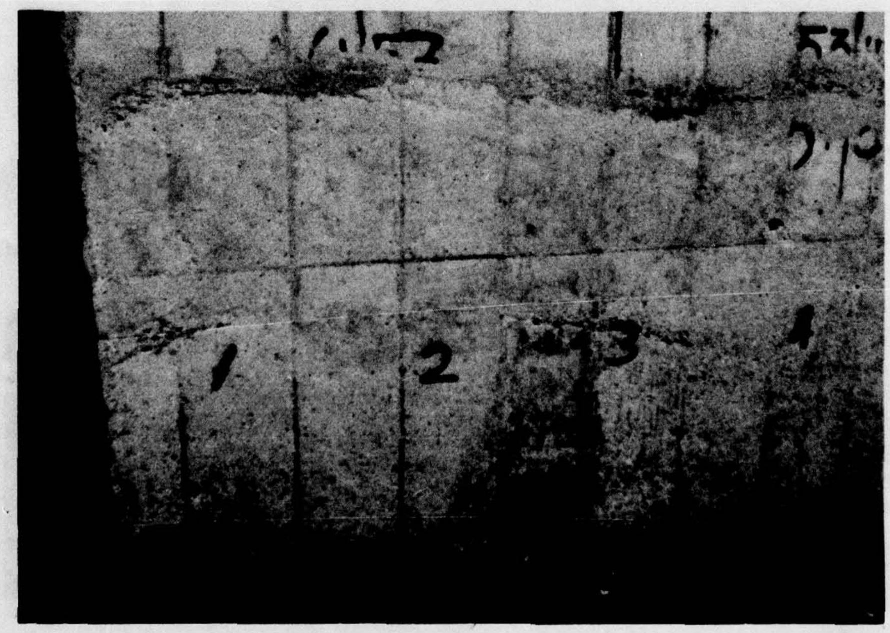

Photo 4. Flood side, west T-wall. Note seam
near station numbers

Photo 5. Flood side, west T-wall

Photo 6. Flood side, west T-wall

Photo 7. View showing the vertical section of concrete that houses the casing collar

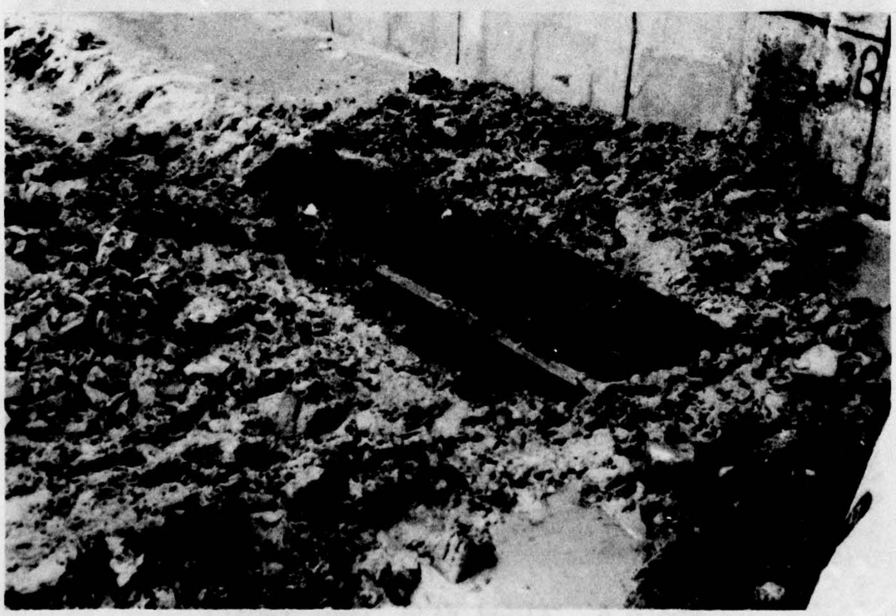

Photo 8. Portion of pile exposed by excavation

Photo 9. Companion pile, Metairie yard

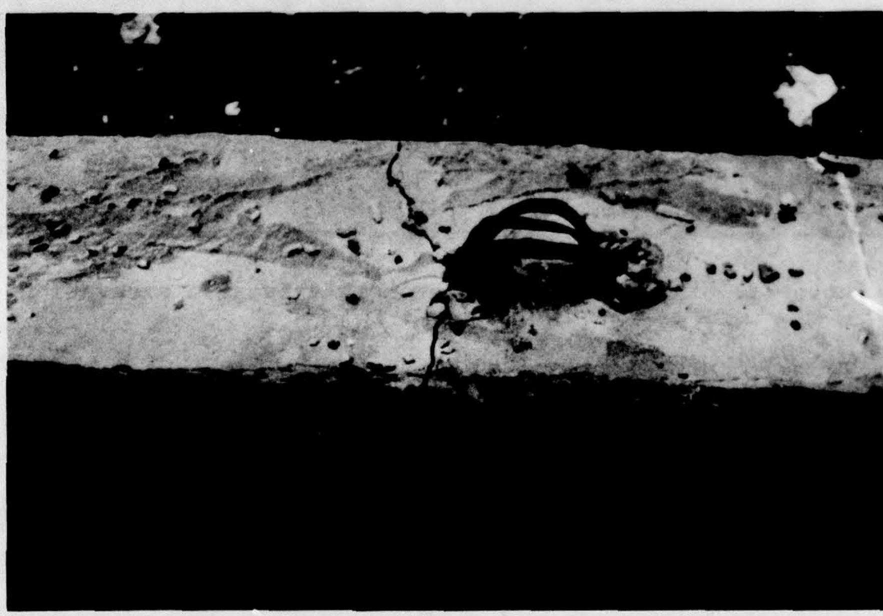

Photo 10. View showing cracked pile

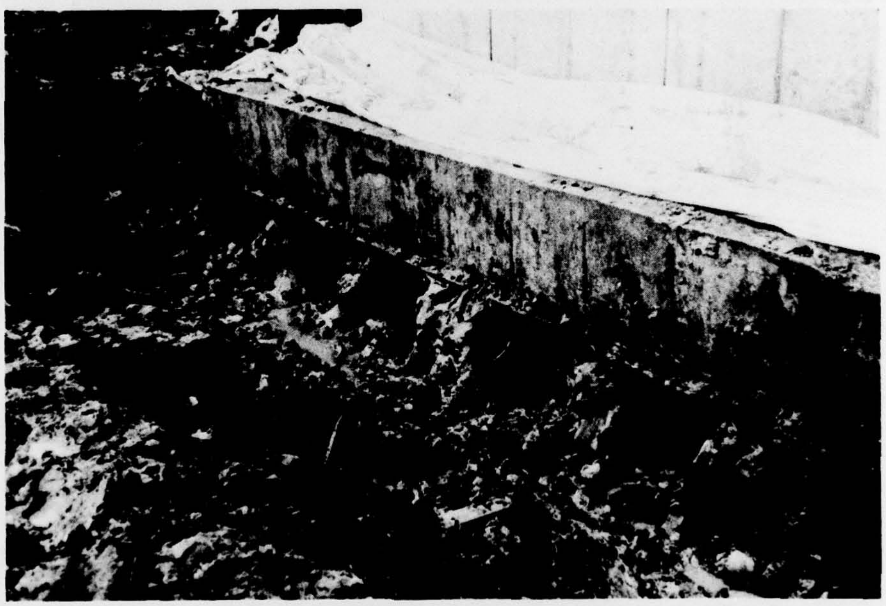

Photo 11. Exposed piles after more extensive excavation

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