AD-A166 339 HIGH POINT PIER ANTIGUA WI(U) NAVAL FACILITIES ENGINEERING COMMAND WASHINGTON DC CHESAPEAKE DIV NOV 82 CHES/NAVFAC-FPO-1-82(31) 1/1

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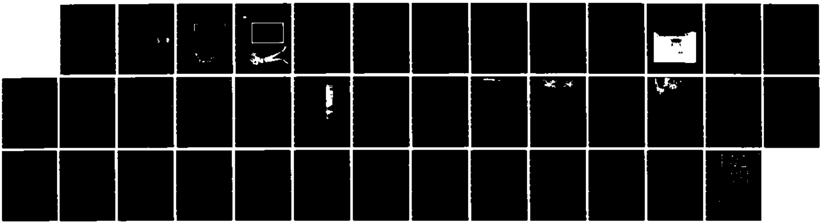

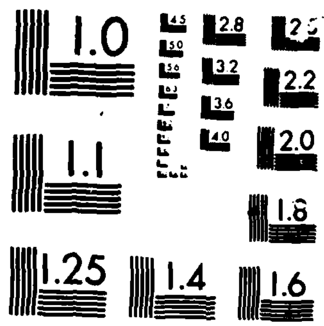

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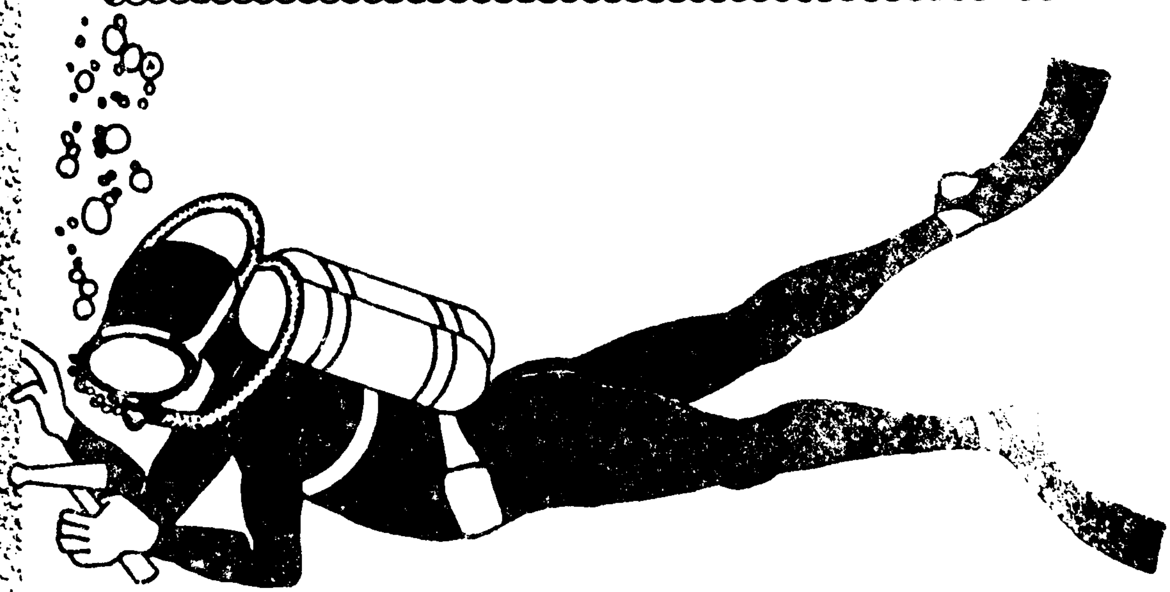
HIGH POINT PIER

ANTIGUA, W.I.

FPO-1-82(31)

NOVEMBER 1982



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UNDERWATER FACILITIES INSPECTIONS & ASSESSMENTS

HIGH POINT PIER

ANTIGUA, W.I.

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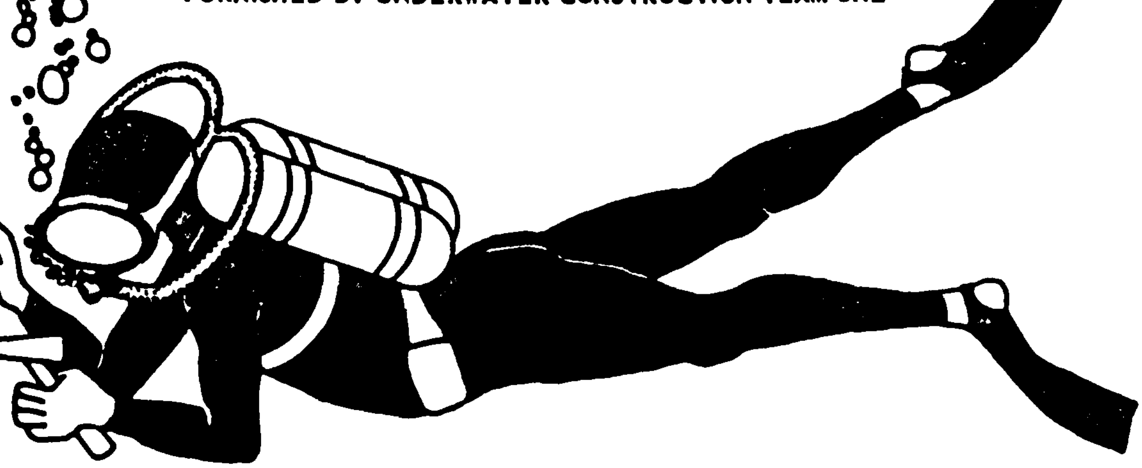

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Unclassified

SECURITY CLASSIFICATION OF THIS PAGE

REPORT DOCUMENTATION PAGE

1a. REPORT SECURITY CLASSIFICATION
Unclassified

1b. RESTRICTIVE MARKINGS

2a. SECURITY CLASSIFICATION AUTHORITY

3. DISTRIBUTION AVAILABILITY OF REP.
Approved for public release; distribution is unlimited

2b. DECLASSIFICATION/DOWNGRADING SCHEDULE

4. PERFORMING ORGANIZATION REPORT NUMBER

5. MONITORING ORGANIZATION REPORT #
FPO-1-82(31)

6a. NAME OF PERFORM. ORG.
Robert Taggart Inc.

6b. OFFICE SYM

7a. NAME OF MONITORING ORGANIZATION
Ocean Engineering
& Construction
Project Office
CHESNAVFACENGCOM

6c. ADDRESS (City, State, and Zip Code)

7b. ADDRESS (City, State, and Zip)
BLDG. 212, Washington Navy Yard
Washington, D.C. 20374-2121

8a. NAME OF FUNDING ORG.

8b. OFFICE SYM

9. PROCUREMENT INSTRUMENT INDENT #
N62477-80-C-0161, Task 4

8c. ADDRESS (City, State & Zip)

10. SOURCE OF FUNDING NUMBERS

PROGRAM ELEMENT #	PROJECT #	TASK #	WORK UNIT ACCESS #

11. TITLE (Including Security Classification)
Underwater Facilities Inspections & Assessments at High Point Pier Antigua, WI

12. PERSONAL AUTHOR(S)

13a. TYPE OF REPORT

13b. TIME COVERED FROM TO

14. DATE OF REP. (YYMMDD) 82-11

15. PAGES 34

16. SUPPLEMENTARY NOTATION

17. COSATI CODES

FIELD	GROUP	SUB-GROUP

18. SUBJECT TERMS (Continue on reverse if nec.)
Underwater inspection, Mooring inspection, High Point Pier Antigua, W.I.

19. ABSTRACT (Continue on reverse if necessary & identify by block number)
The objective of the underwater facility assessment conducted at the High Point Pier in Dutchman Bay, Antigua, W.I. was to provide a generalized structural condition report of that structure. The pier was inspected by a detail from Underwater Construction Team One (UCT-ONE) under the (Con't)

20. DISTRIBUTION/AVAILABILITY OF ABSTRACT
SAME AS RPT.

21. ABSTRACT SECURITY CLASSIFICATION

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Jacqueline B. Riley

22b. TELEPHONE
202-433-3881

22c. OFFICE SYMBOL

DD FORM 1473, 84MAR

SECURITY CLASSIFICATION OF THIS PAGE

BLOCK 19 (Con't)

engineering supervision of the Chesapeake Division, Naval Facilities Engineering Command (CHESNAVFACENGCOM).

The High Point Pier is property of the government of Antigua and is used by the U.S. Navy, the U.S. Air Force, and by Panamanian commercial interests. It is of unknown age and the above water structure has suffered significant damage over the years, although there are signs of some attempts at rejuvenations.

EXECUTIVE SUMMARY

The objective of the underwater facility assessment conducted at the High Point Pier in Dutchman Bay, Antigua, W.I. was to provide a generalized structural condition report of that structure. The pier was inspected by a detail from Underwater Construction Team One (UCT-ONE) under the engineering supervision of the Chesapeake Division, Naval Facilities Engineering Command (CHESNAVFACENGCOM).

The High Point Pier is the property of the government of Antigua and is used by the U. S. Navy, the U. S. Air Force, and by Panamanian commercial interests. It is of unknown age and the above water structure has suffered significant damage over the years, although there are signs of some attempts at rejuvenation.

The pier is basically supported by H-beam steel piles which are topped with concrete jackets and caps that support a reinforced concrete deck. Shoreward of the pile-supported structure is an aggregate-filled section contained within steel sheet piling to provide support for the roadway leading from the shore to the structural section of the pier.

Except for two missing H-piles, the underwater elements of the pier H-beam structure are in relatively good condition with an average capacity of more than 80% of their original vertical load-carrying ability. The concrete jackets, caps, and particularly the decking are severely deteriorated, however, as is the steel sheet piling leading to the shore.

Although the load carrying capacity is not significantly diminished it is recommended that the concrete work above water be carefully inspected to determine which jackets should be repaired or replaced to prevent further deterioration of the encased steel H-beams. The two missing H-beam piles at the seaward corners of the pier should be replaced. Additionally, the pile caps and decking should be repaired or replaced to restore the pier to working condition.

The deterioration of the sheet piling leading out to the pier structure from the shore is such that complete replacement is recommended. It appears impractical to remove the old piling and it is therefore recommended that new piling be driven completely surrounding the old piling, spaced a foot or more outboard of the old piling, with the space between filled with an inert

material. At the intersection of the existing sheet piling and the H-beam supported structural pier, it may be necessary to nest the new piling directly against the remnants of the existing sheet piling.

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LIST OF FIGURES

1.0 INTRODUCTION

This report is a product of the Underwater Inspection Program conducted by the Ocean Engineering and Construction Project Office (FPO-1), Chesapeake Division, Naval Facilities Engineering Command (CHESNAVFACENGCOM) under NAVFAC's specialized Inspection Program.

The program sponsors task-oriented engineering services for the inspection, analysis, design, and monitoring of repairs for the submerged portions of selected Naval Waterfront Facilities. The facility inspection reported on herein differs somewhat from others in this program in that the High Point Pier is not U. S. Navy property but belongs to the government of Antigua; the inspection was performed at the request of that government.

The inspection of the High Point Pier, Figure 1-1, was conducted by

OVERALL VIEW OF OFFSHORE PORTION OF HIGH POINT PIER

FIGURE 1-1

Underwater Construction Team One (UCT-ONE) with engineering assistance provided by CHESNAVFACENGCOM. Using data, engineering information, and photographs furnished by the Navy, this report has been prepared by Robert Taggart Incorporated under Task 4A of Contract N62477-80-C-0161.

SCOPE OF WORK

This task included primarily the assessment of the conditions of the underwater elements of the pier structure at High Point on Dutchman Bay on the island of Antigua together with the preparation of recommendations and cost estimates for restoration of the pier to a safe operating condition. The quality of inspection had to be sufficient to provide an adequate general assessment of the facility and to identify areas of sufficient damage or deterioration to warrant immediate repair or future detailed investigation.

REPORT CONTENT

Reported herein are a description of the facility, the inspection procedures, the results of the inspection, and an analysis of the findings accompanied by pertinent charts, drawings, and photographs. Recommendations and cost estimates for repair of those elements of the pier exposed to seaway action are included with details of calculations and cost estimates covered in the Appendix.

2.0 FACILITY LOCATION AND DESCRIPTION

The island of Antigua, originally a part of the British West Indies, at one time was the primary British naval base in the Caribbean region. The repair base, now referred to as Lord Nelson's Dockyard, has been partially restored as a tourist attraction and shows evidence of a period of ship maintenance and repair activity during the time when Nelson was Officer in Charge of that facility.

Antigua lies 200 NM ESE of the U.S. Virgin Islands. The area in which the High Point Pier is located is on the northeast coast of the island, east of the village of St. Johns, in the region covered by the chart, Figure 2-1.

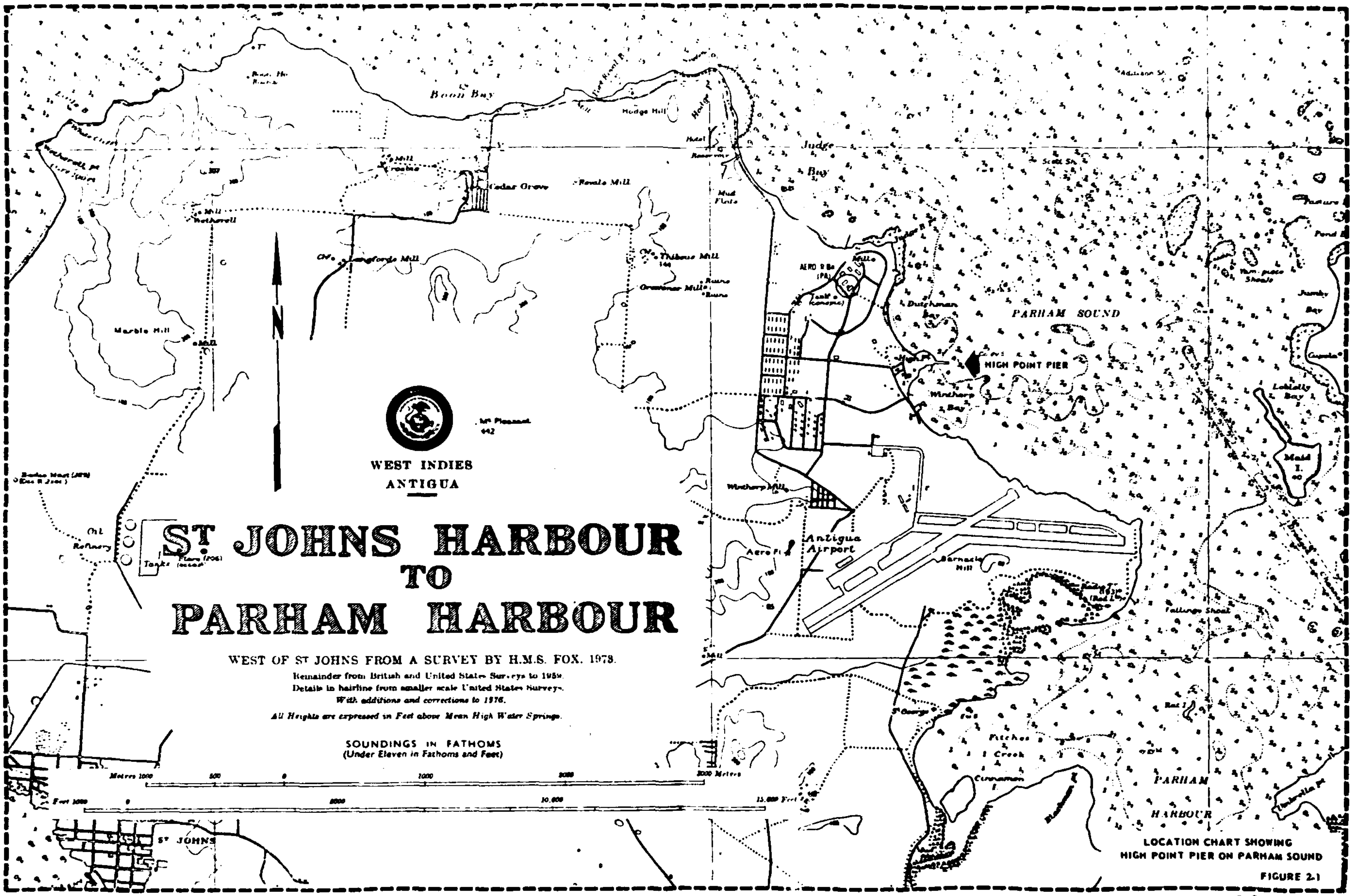
FACILITY LOCATION

On the peninsula shown in Figure 2-1 are the U. S. Naval Station and a U. S. Air Force facility adjoining the Antigua airport. The High Point Pier juts out into Parham Sound on the eastern side of the peninsula. The point on which it is located separates Dutchman Bay to the north, and Winthorp Bay to the south which constitute inshore sections of Parham Sound.

The detailed location map, Figure 2-2, shows the juxtaposition of the pier, the Naval Station, and the Antigua Air Station facilities that adjoin the airport. The road system leading from these installations to the pier provides adequate access for its use by both activities for loading and discharging small ships. In addition to the U. S. government utilization, the pier serves Panamanian commercial interests and is also used by local oil companies.

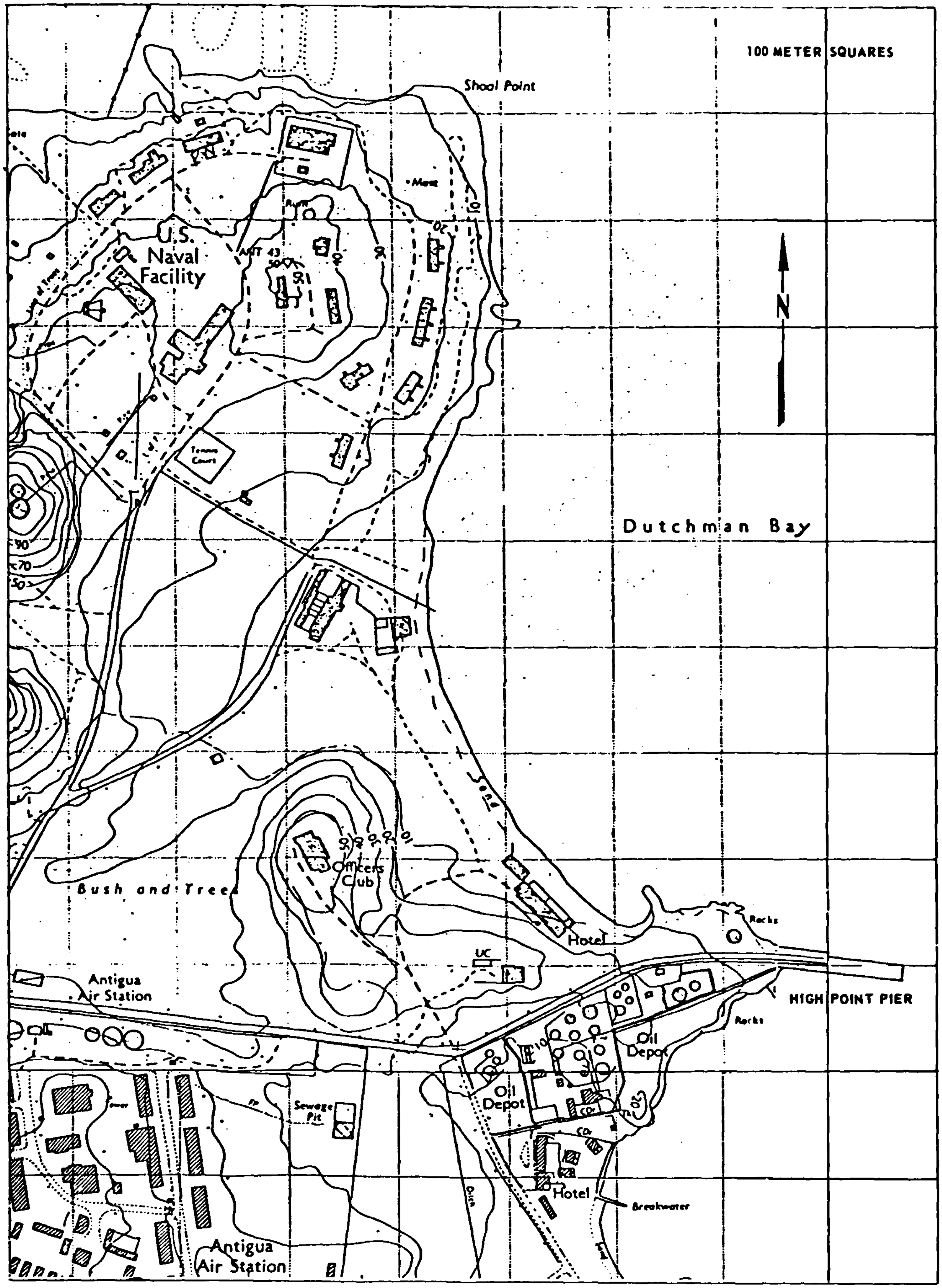
FACILITY DESCRIPTION

The offshore portion of the pier is approximately 52 feet wide and extends out into the bay about 235 feet from the end of the inshore portion. It comprises 18 bents spaced 13.7 feet on centers; a typical bent is depicted in the sectional view of Figure 2-3. As can be seen, a bent is formed of eight H-beam steel piles, each of which is topped by a two-foot tapered concrete jacket. Above the jackets are poured-in-place steel-reinforced pile caps, extending transversely across the pier with longitudinal stringers running between them; both the pile caps and stringers support the steel-reinforced poured concrete deck which is 2.5 feet deep. The pile caps are



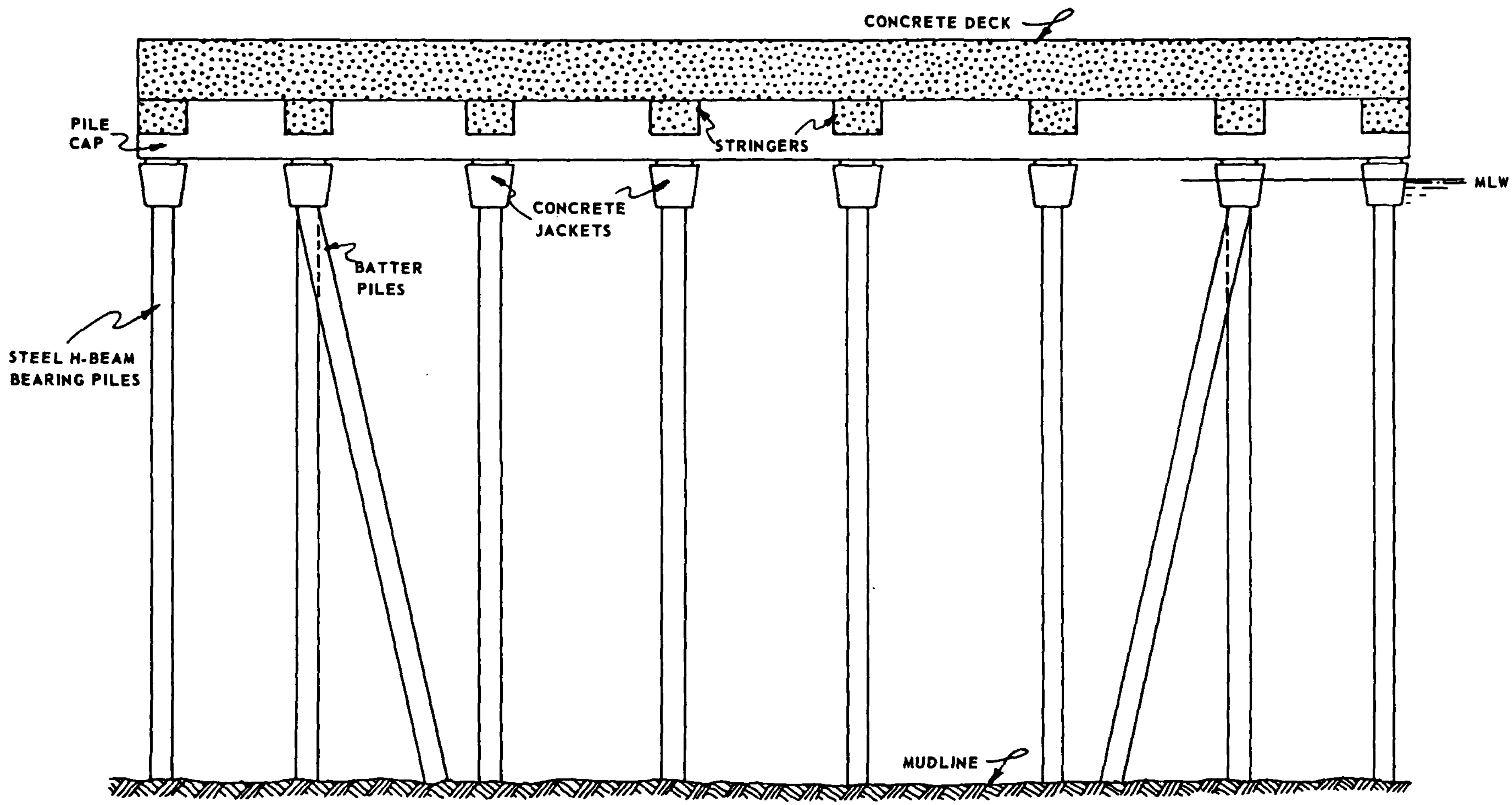
LOCATION CHART SHOWING
HIGH POINT PIER ON PARHAM SOUND

FIGURE 2-1



DETAILED LOCATION MAP

FIGURE 2-2



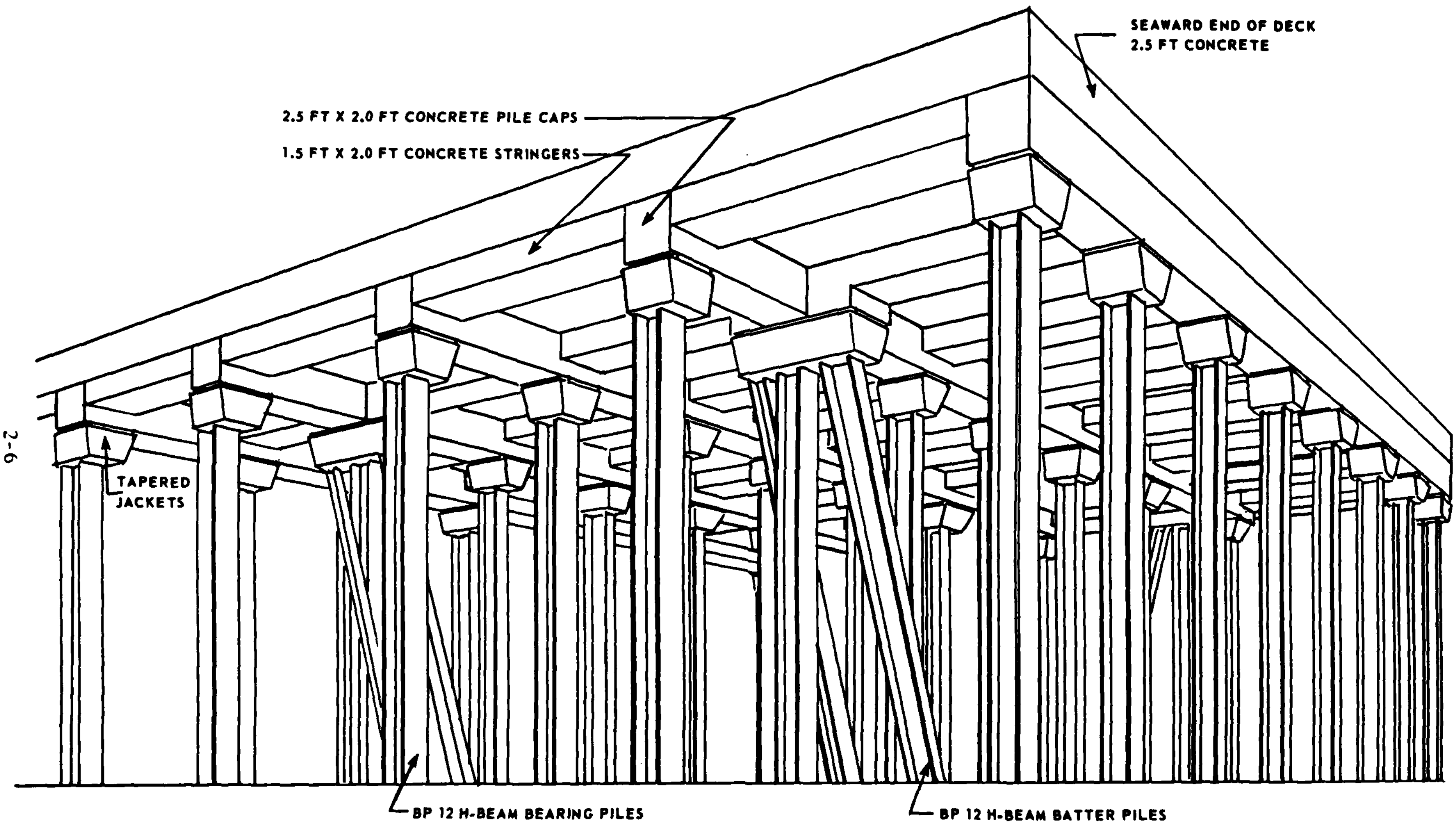
SECTIONAL VIEW OF HIGH POINT PIER

FIGURE 2-3

52 feet in length by 2.5 feet in depth by 2.0 feet in width. The intercoastal stringers are 1.5 feet in depth by 2.0 feet in width with a center spacing of 7.1 feet. Two pairs of steel H-beam batter piles, of the type shown in Figure 2-3, are installed on 6 of the 18 bents to provide lateral sway bracing. Figure 2-4 shows an overall perspective view of the underside of the pier structure.

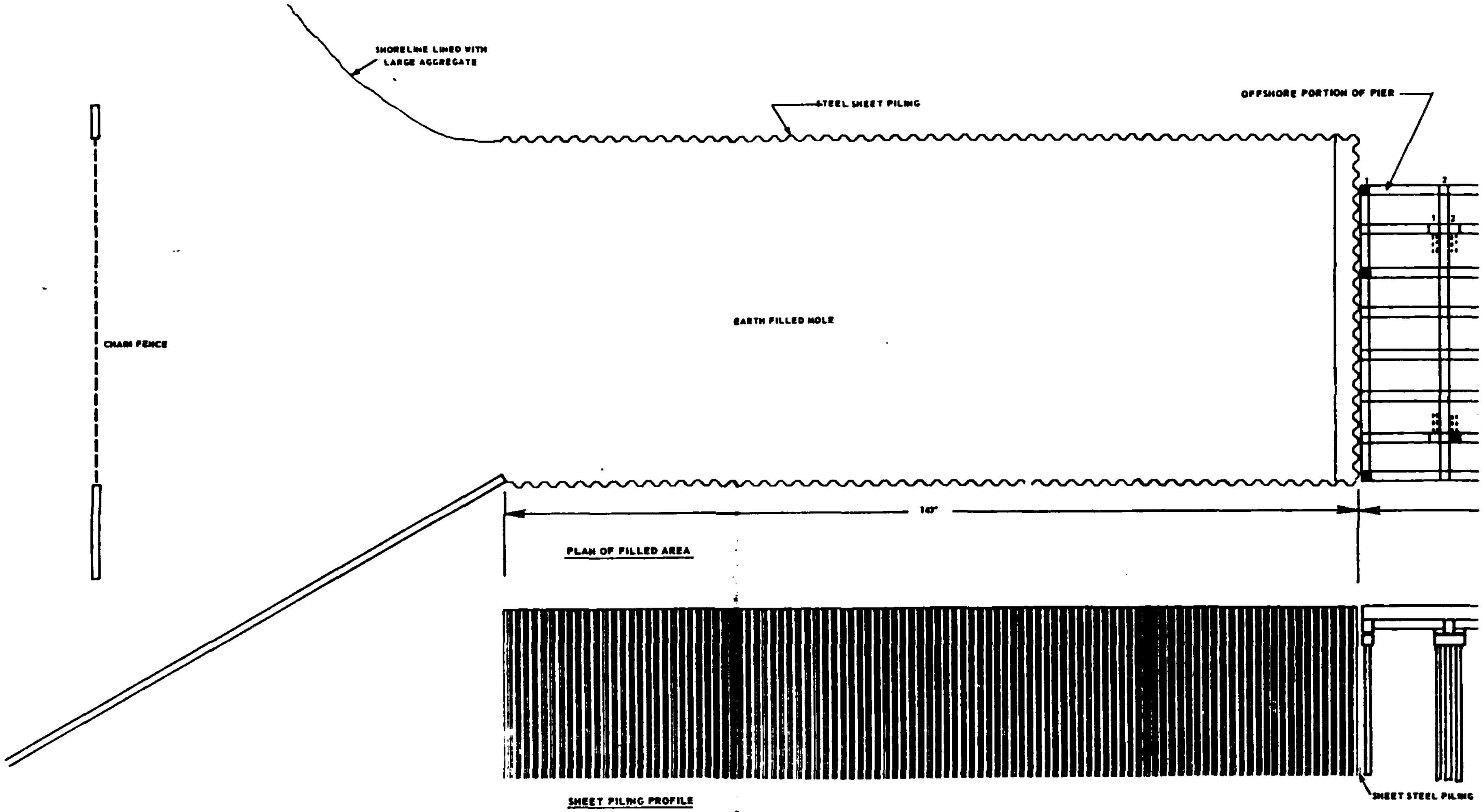
The mean low waterline is at about mid-depth on the pile jackets and the tidal range averages only about one foot. These concrete jackets thus serve to protect the top of the H-piles from tidal surge and the normally minor wave action to which the pier is exposed.

The onshore portion of the pier is essentially an earth-filled mode surrounded by steel sheet piling to provide level access to the surface of the offshore portion of the pier. The configuration of the sheet piling is illustrated in the plan view and profile of Figure 2-5. The mating plan view and profile of the offshore portion is given in Figure 2-6 which also indicates the numbering system for the piles and the piles on which a Level II inspection was conducted.



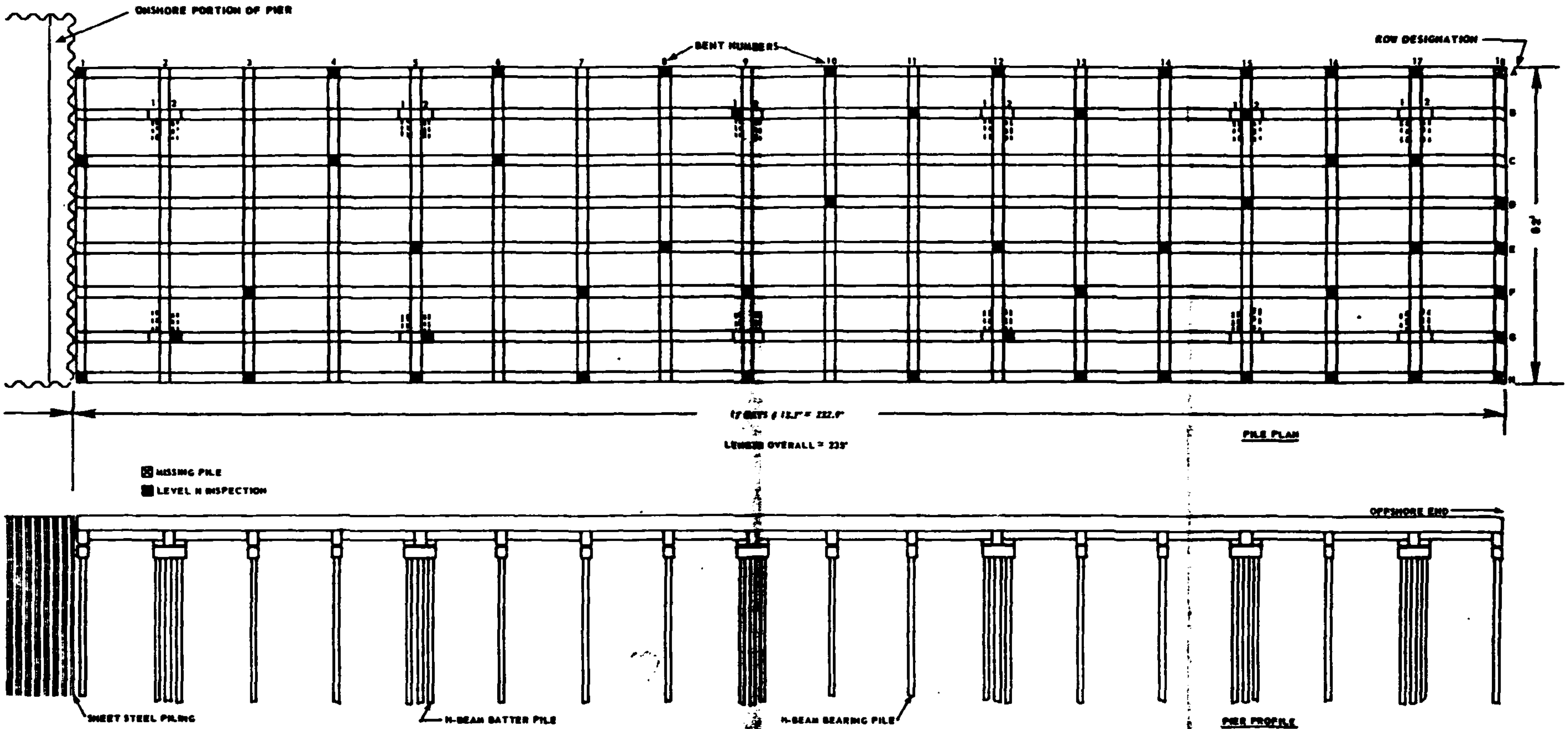
HIGH POINT PIER - VIEW FROM UNDERSIDE

FIGURE 2-4



ONSHORE PORTION OF HIGH POINT PIER
ANTIGUA, W. I.

FIGURE 2-5



OFFSHORE PORTION OF HIGH POINT PIER
ANTIGUA, W. I.

FIGURE 2-6

3.0 INSPECTION TECHNIQUES AND PROCEDURES

The inspection of the High Point Pier was performed by a detachment of divers from UCT-ONE between 23 and 28 August 1982. The inspection consisted of a visual and photographic survey of pier superstructure, a Level I swim-by and photo reconnaissance of the underwater structure of the offshore portion and of the sheet steel piling surrounding the onshore portion, and a Level II inspection of steel H-beam pile structure.

PIER SUPERSTRUCTURE SURVEY

The decking and mooring fittings of the offshore portion of the High Point Pier are in extremely poor condition as can be seen in the photograph, Figure 3-1. Although there were no drawings available, it appears that at one time a utility tunnel ran part way out along the south edge of the deck. The pier edge is reasonably intact along most of the offshore portion periphery, Figure 3-2, but, in way of the tunnel, the deck has collapsed as shown in Figure 3-3.

At one point in its life, probably after the collapse of the utility tunnel, a new curbing section was installed about three feet inboard of the deck edge to prevent vehicles from falling into the destroyed region.

Viewed from a small boat running around the pier, most of the eighteen pile caps seem to be in relatively good condition, as evidenced in Figure 3-4, and all pile jackets were found to be intact except for those at the two outboard corners, piles 18A and 18H, which were missing. The stringers, which run intercostally between the pile caps, were mostly in place except for several of those along the deck edges, i.e., between the caps in rows A and H. There was no trace of these missing stringers which indicated that they were not poured integrally with either the pile caps or the deck, nor was there any evidence of a reinforcing bar connection between these structural elements.

It may be that the original design did not call for stringers along the north and south deck edges except in a few specific locations. This conclusion has been drawn from reviewing a series of photographs, some of which show continuity of the pier sides at stringer level and some of which do not; the on-site inspection reports did not mention the outboard stringer condition.

As shown earlier in Figure 2-5, the onshore portion of the High Point Pier comprised a steel sheet pile bulkhead surrounding a fill of aggregate

... ER EDGE IN ... GOOD CONDITION

FIGURE 3-2

... OFFSHORE PI... FROM DECK LEVE...

FIGURE 3-1

DETERIORATED SHEET PILING
ON NORTH SIDE OF PIER

FIGURE 3-6

SUBSTITUTE DECKING IN BAY
OF RUSTED SHEET PILING

FIGURE 3-5

WATER LEVEL VIEW OF BENT 4H
CAP, STRINGER, AND DECK

FIGURE 3-4

and earth. Above the water surface this sheet pile structure was corroded to the point where it no longer served its purpose as evidenced in Figures 3-5, 3-6, and 3-7. The extensive corrosion had allowed large amounts of the fill to spill out through the bulkhead on to the surrounding sea floor. Despite efforts to halt the subsidence by covering the surface with old steel plate, the level of the surface at the periphery of the onshore portion was well below the design level of the remainder of the pier. It was also evident that this deterioration was continuing and would eventually prevent further use of the pier.

LEVEL I SWIM-BY

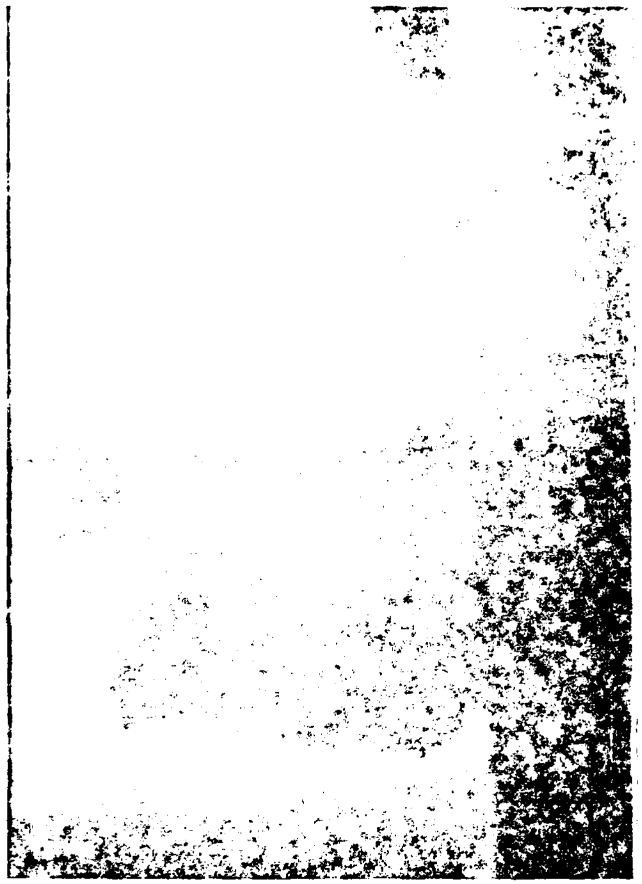
As mentioned previously, there were no valid drawings of the pier available. A rough drawing that was presented to the inspection team showed a structure supported by 24- by 24-inch concrete piles with no batter piling. The actual structure employing steel H-piles was not visible from the surface but was defined by the underwater survey. The tapered jackets atop the piles were measured and photographed during this survey, Figure 3-8, and the batter pile locations were determined, Figure 3-9. The drawings of the pier given in the foregoing section of this report were prepared from observations and measurements made during the Level I inspection.

The reason for the missing jackets on piles 18A and 18H, Figure 3-10, was also explored. No trace was found of pile 18A but pile 18H had been bent over just above the sea floor, Figure 3-11, and the entire length was lying on the bottom with the jacket broken away from the steel H-beam. Evidently both of these corner piles had been damaged by ship contact and were moved away to prevent such occurences in the future. The pier did not appear to have been adversely affected structurally by this loss of support.

The Level I inspection of the sheet piling surrounding the onshore portion of the High Point Pier revealed that the corrosive deterioration extended well below the waterline. Although the underwater deterioration was not so extensive as that above the surface, there were numerous holes where corrosion had taken place and the earth and aggregate had spilled out through the retaining bulkhead on to the sea floor. It was evident that there was no part of the sheet piling that could be considered serviceable for any extended length of time.

TYPICAL CONCRETE JACKET
ATOP H-BEAM BATTER PILES

FIGURE 3-[illegible]



UNDERWATER VIEW OF CONCRETE
JACKET ATOP ON H-PILE

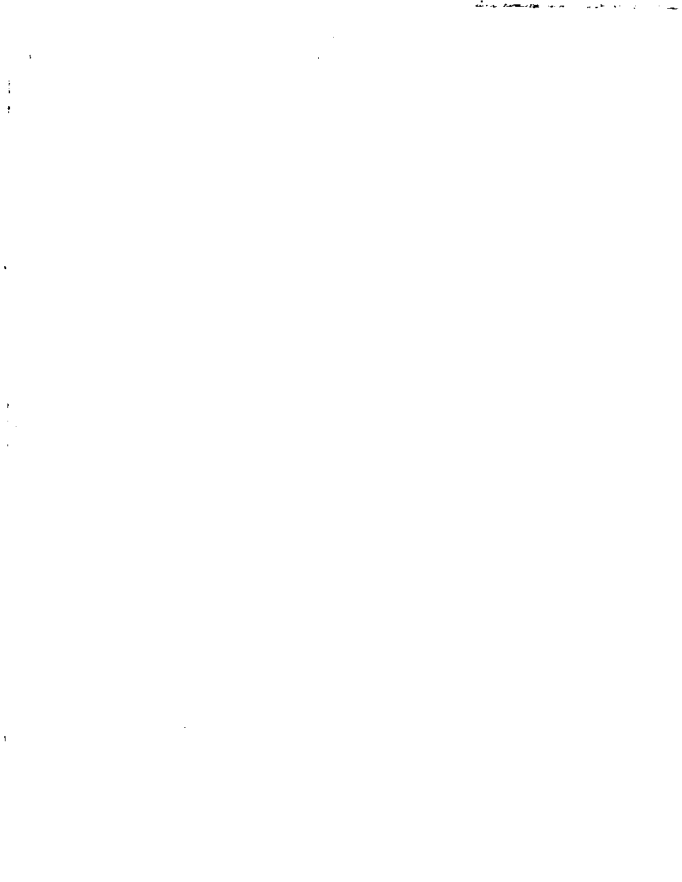
FIGURE 3-6

WATER LEVEL [illegible]
SOU[illegible] PILE[illegible]

FIGURE 3-[illegible]

OUTBOARD END OF PIER
PILE 12H MISSING

FIGURE 3-10



[illegible]

FIGURE 3-11

FLANGES OF [illegible]
CLEANED FOR [illegible]

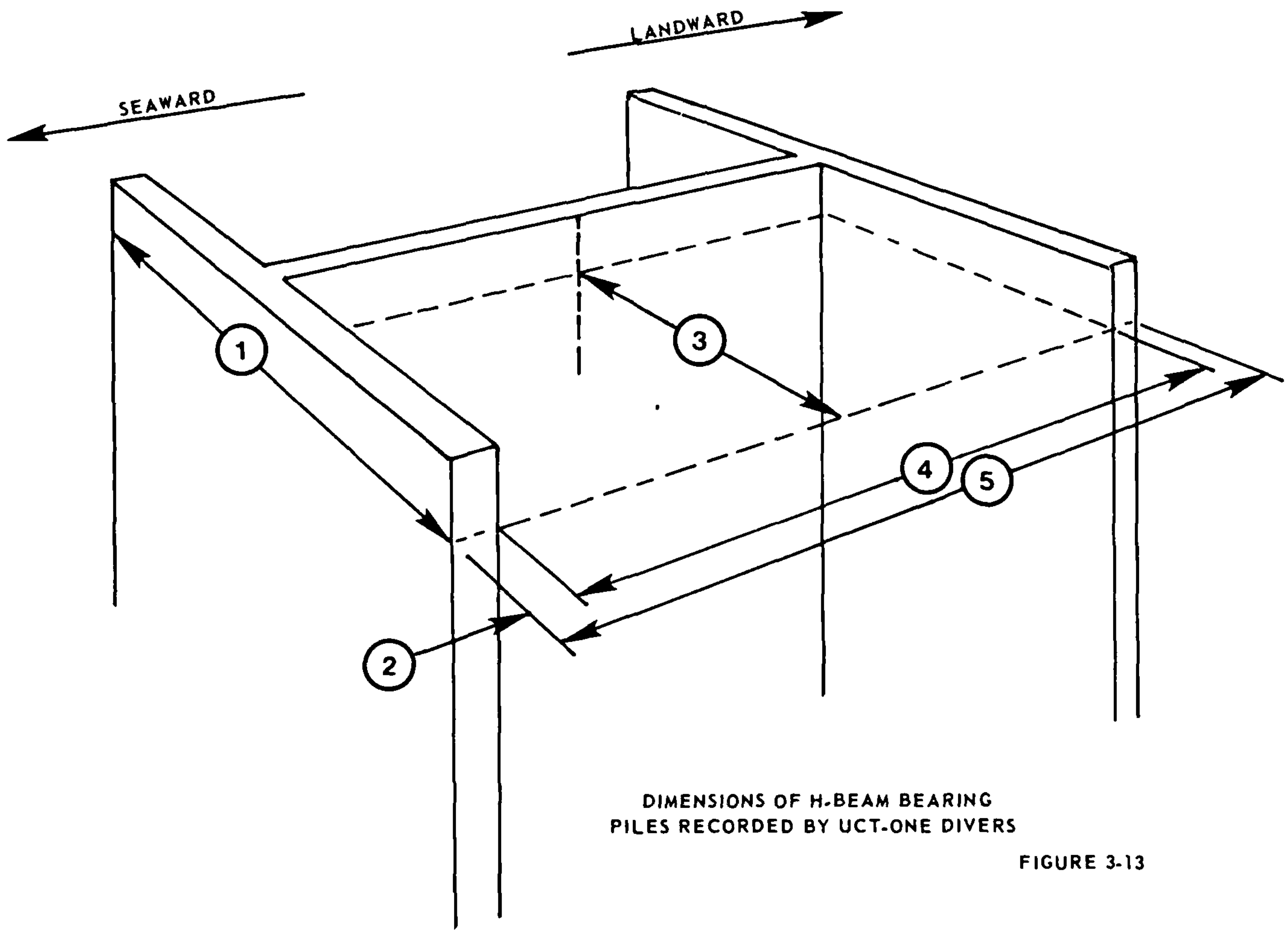
FIGURE 3-12

LEVEL II SURVEY

The thickness of marine growth on the piling ranged from 2 inches at the surface to 8 inches at the mudline. It was initially intended to remove this growth in the areas to be inspected by use of a hydraulically powered scrubbing tool. However, the tool failed early in the cleaning process and it was necessary to resort to chisels, scrapers, and other hand tools to remove the marine growth and corrosion.

Thickness measurements were initially attempted with a Krautkramer D-meter but the pitting of the steel surfaces was such that this instrument could not be utilized as intended. As a result, all measurements were made with calipers, scales, or carpenters' rules. After cleaning, Figure 3-12, these measurements were made within 12 inches of the junction of the H-pile and its jacket and within 24 inches of the mudline on selected piles.

The measurements on the H-beams were made and recorded in accordance with those diagrammed in Figure 3-13. The H-bearing piles can be identified



DIMENSIONS OF H-BEAM BEARING PILES RECORDED BY UCT-ONE DIVERS

FIGURE 3-13

by their dimensions as AISC* BP 12 H-beams which have flange and web thicknesses of 0.607 inches and a weight of 74 pounds per foot. These beams are sometimes identified as HP 12 x 74. The piles selected for Level II measurement are identified by the solid squares in Figure 2-6.

Except for the two piles that were missing, the steel supports for the High Point Pier were found to be in surprisingly good condition. There was some pitting and a few H-beam flanges had corroded down to a knife-edge condition but, generally speaking, the loss of material from corrosion was less than might have been anticipated.

Depth measurements were made on alternate sides of the pier for every other bent from waterline to mudline. Measurements were also made from the mudline to the pier deck. These measured values in feet are listed below together with the calculated height of the deck above water.

Bent Number	North (or A) Side			South (or H) Side		
	Deck Ht.	Depth	Freeboard	Deck Ht.	Depth	Freeboard
18	----	26.0	---	----	26.0	---
17	30.6	25.3	5.3	----	----	---
16	----	----	---	29.2	24.0	5.2
15	29.5	24.5	5.0	----	----	---
14	----	----	---	29.6	24.0	5.6
13	26.7	21.6	5.1	----	----	---
12	----	----	---	28.5	23.2	5.3
11	25.8	20.8	5.0	----	----	---
10	----	----	---	28.4	23.5	4.9
9	25.3	20.0	5.3	----	----	---
8	----	----	---	28.5	23.5	5.0
7	26.1	21.0	5.1	----	----	---
6	----	----	---	28.6	23.5	5.1
5	25.6	20.5	5.1	----	----	---
4	----	----	---	28.2	23.0	5.2
3	24.2	19.3	4.9	----	----	---
2	----	----	---	26.9	23.0	3.9
1	20.8	16.0	4.8	24.3	19.5	4.8

*AMERICAN INSTITUTE OF STEEL CONSTRUCTION

4.0 ANALYSIS OF MEASURED DATA

The analysis of the measurements consisted first of tabulating the linear cross section measurements in decimal form from the original measurements that were given in inches and eighths. These measured data were then compared with the AISC BP 12 dimensions to eliminate those that were obviously inaccurately measured or recorded. The results were next examined for indications of major pile deterioration and then averaged in various ways to permit calculation of the remaining pier support capability.

RETABULATION AND EDITING OF MEASURED DATA

The cross section measurements of the piles derived from those reported by UCT-ONE divers are tabulated on the following page and include some 470 measurements. The columns are headed by a number which relates to the dimensions denoted on Figure 3-13. It can be seen that dashed lines have been drawn through 89 of these measurements. This indicates that the reported values do not meet certain criteria related to the original H-beam cross section as defined in the AISC handbook. The AISC dimensions, and the rational for deletion, are listed below:

1 Breadth of Flange - AISC 12.217 inches. Reported measurement deleted if it is greater than the AISC dimension or if it is less than a reasonable deterioration, i.e., less than 11.00 inches.

2 Flange Thickness - AISC 0.607 inches. Reported measurement deleted if it is greater than the AISC dimension.

3 Flange Edge from Web - AISC 5.805 inches. Reported measurement deleted if it is greater than the AISC dimension plus the AISC web thickness or if (1)÷2 — (3) is negative.

4 Distance Between Flanges - AISC 10.908 inches. Reported measurement deleted if it is less than AISC dimension or greater than AISC depth below.

5 Depth of Beam - AISC 12.122 inches. Reported measurement deleted if it is less than AISC dimension (4) or if it is greater than AISC depth.

This resulted in the deletion of 89 measurements from those reported leaving a balance of 381 measurements used in the analysis.

Antigua High Point Pier
Edited UCT-ONE Measurements
of H-Beam Bearing Piles

Bent/ Pile	Measurements in Inches at Surface					Measurements in Inches at Mudline				
	①	②	③	④	⑤	①	②	③	④	⑤
18G	12.03	0.50	5.88	11.00	12.00	12.00	0.56	5.75	~~10.88~~	12.00
18F	-----	----	----	-----	-----	12.19	0.56	6.00	11.00	12.06
18E	-----	----	----	-----	-----	12.06	~~0.62~~	5.56	~~10.81~~	12.06 7
18D	-----	----	----	-----	-----	12.12	~~0.62~~	5.56	~~10.88~~	12.06
17A	12.00	0.38	5.75	11.00	11.81	12.00	0.44	5.56	11.00	12.00
17C	11.25	0.56	5.56	~~11.75~~	12.00	12.00	0.56	5.56	11.12	11.75
17E	12.00	0.44	5.50	~~10.88~~	11.81	11.75	0.38	5.75	10.94	11.75
17H	11.88	0.56	5.38	11.00	~~12.12~~	12.00	0.56	5.81	11.00	11.88
16A	~~12.25~~	0.44	~~5.06~~	11.00	11.88	~~12.25~~	0.50	5.75	11.00	12.06
16C	~~12.75~~	0.50	6.00	~~10.75~~	11.81	~~12.62~~	0.44	5.75	10.81	12.00
16F	11.38	0.38	5.25	11.00	11.56	12.00	0.50	~~5.12~~	10.94	12.00
16H	12.00	0.44	5.62	11.00	11.44	-----	----	----	-----	-----
15A	12.00	0.38	~~5.12~~	11.00	11.88	12.00	0.50	5.75	11.12	11.75
15B	11.50	0.19	5.38	11.25	12.12	11.88	0.38	5.62	11.12	12.00
15D	~~12.50~~	0.25	5.50	11.12	11.75	~~12.25~~	0.12	5.50	11.12	12.00
15H	11.88	0.25	5.62	11.38	11.88	12.00	0.50	5.75	11.25	12.00
14A	12.00	0.25	5.62	11.00	11.75	12.00	0.50	~~5.00~~	11.25	12.50
14E	12.12	0.38	5.94	11.00	12.00	12.12	0.44	5.75	11.00	12.00
14H	11.75	0.06	5.25	11.25	11.75	11.25	0.38	5.62	11.50	12.00
13B	11.88	0.25	5.88	11.25	11.75	11.88	0.25	5.62	10.94	11.88
13F	12.00	0.44	5.75	11.00	12.00	12.00	0.50	5.31	11.12	~~12.50~~
13H	~~12.25~~	0.25	5.75	11.25	11.88	12.00	0.44	5.88	11.25	11.88
12A	12.00	0.38	5.75	11.12	11.88	12.00	0.38	5.88	11.00	12.00
12E	12.00	0.38	5.75	11.12	12.00	12.00	0.38	5.88	11.12	11.88
12G2	~~12.38~~	0.50	5.75	11.00	11.88	~~12.50~~	0.50	5.62	11.00	12.00
11B	11.75	0.25	5.75	11.06	11.88	11.88	0.50	5.69	~~10.88~~	12.00
11H	12.00	~~0.62~~	~~5.00~~	~~10.50~~	11.50	12.00	~~0.69~~	~~5.00~~	~~10.50~~	12.00
10A	12.00	0.38	5.62	11.00	11.75	~~12.25~~	0.50	5.62	11.00	12.00
10D	11.88	0.12	5.62	11.25	12.00	12.00	0.38	5.62	11.88	~~10.88~~
9B1	12.00	0.38	5.62	11.12	11.88	11.75	0.31	5.62	11.12	11.88
9F	11.88	0.12	5.88	11.00	11.62	11.88	0.31	5.62	11.06	11.75
9H	12.00	0.12	5.75	11.00	12.00	11.94	0.25	~~6.06~~	11.12	12.00
8A	11.75	0.50	5.62	~~10.75~~	12.00	12.00	0.38	5.75	~~10.75~~	12.00
8E	12.00	~~0.75~~	~~5.00~~	~~10.50~~	12.00	12.00	~~0.75~~	~~5.00~~	~~10.50~~	12.00
7F	12.00	~~0.62~~	~~5.00~~	~~10.50~~	11.75	12.00	~~0.75~~	~~5.00~~	~~10.50~~	12.00
7H	11.00	0.25	~~4.75~~	~~10.50~~	11.75	12.00	~~0.75~~	~~5.00~~	~~10.50~~	12.00
6A	12.00	K.E.	5.75	11.50	12.00	11.94	0.44	5.75	11.50	12.00
6C	12.00	~~0.62~~	~~5.00~~	~~10.50~~	11.75	12.00	~~0.75~~	~~5.00~~	~~10.50~~	12.00
5H	11.38	K.E.	5.50	11.25	12.00	11.62	K.E.	5.56	11.50	11.88
5G2	~~10.00~~	K.E.	~~4.50~~	11.50	11.50	11.75	K.E.	~~5.00~~	~~10.50~~	11.75
5E	12.00	~~0.75~~	~~5.00~~	~~10.50~~	12.00	12.00	~~0.75~~	~~5.00~~	~~10.50~~	12.00
4A	12.00	~~0.75~~	~~5.00~~	~~10.50~~	12.00	11.00	K.E.	~~4.50~~	~~10.50~~	12.00
4C	11.75	0.25	5.50	11.00	12.00	11.75	0.06	5.62	11.12	11.75
3H	12.00	K.E.	5.25	11.12	11.81	12.00	K.E.	5.50	11.25	11.94
3F	12.00	0.50	~~5.00~~	11.00	12.00	12.00	0.50	~~5.00~~	11.00	12.00
2G2	~~10.00~~	0.50	~~5.00~~	11.00	12.00	12.00	0.50	~~5.00~~	11.00	~~12.75~~
1A	~~10.50~~	0.25	~~5.00~~	11.00	12.00	12.00	K.E.	~~4.50~~	11.25	11.50
1C	~~6.12~~	K.E.	~~3.75~~	11.12	~~12.12~~	11.25	K.E.	~~4.75~~	~~10.81~~	~~12.12~~
1H	12.00	0.25	5.62	11.25	11.75	12.00	0.19	5.62	11.25	12.00

K.E.: Knife Edge

DERIVATION OF MEAN VALUE H-PILE

The mean values of the edited dimensions of the 49 H-piles measured are as follows:

Measurement	①	②	③	④	⑤
Surface	11.866	0.301	5.636	11.129	11.858
Mudline	11.907	0.352	5.673	11.147	11.944
Average	11.888	0.327	5.655	11.137	11.900
AISC Dimensions	12.217	0.607	5.805	10.908	12.122

The measurements at the top and bottom of the piles are not significantly different so it can be assumed that the average of these two values is equally applicable and therefore overall mean values of top and bottom measurements are valid for deriving the average sectional configuration.

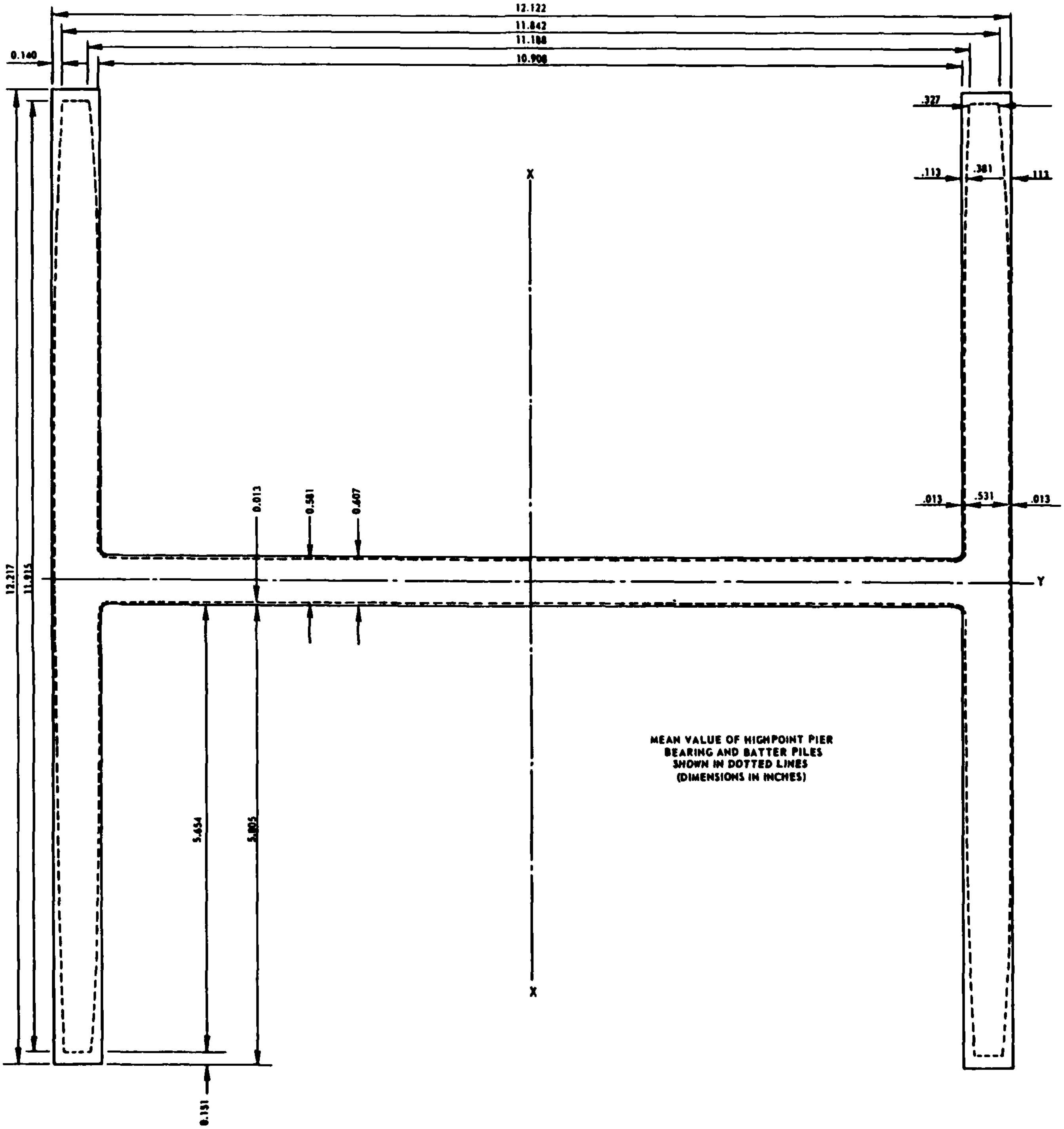
There are a number of ways in which an H-pile representing a mean of the measured values can be derived. If the average values above are used the conclusions are misleading. This is in part due to the inclusion of those readings where a knife-edged flange was indicated. Other measurements show that when subtracting the one flange thickness from the depth minus the distance between flanges, an invalid thickness for the other flange is obtained. It is also evident that measurements obtained at the outer ends of the flanges will show more erosion of material than would be anticipated closer to the web.

Taking these various considerations into account, a revised average cross-section configuration has been derived from selective measurements which is shown in Figure 4-1. This section would have equivalent values to those measured averages and to those of the AISC dimensions as shown below:

Measurement	①	②	③	④	⑤
Figure 4-1 Pile	11.915	0.327	5.667	11.188	11.842
Average Measurements	11.888	0.327	5.655	11.137	11.900
AISC Dimensions	12.217	0.607	5.805	10.908	12.122

CALCULATION OF LOAD CARRYING CAPACITY

The bearing load which each pile can carry is dependent upon the structural properties of the H-beam in its weakest direction. These include the cross-section area, A, the moment of inertia about the Y-Y axis, I_{YY}, the section modulus, S, the radius of gyration, r, and the length of unsupported



DERIVED H-PILE CROSS-SECTION
COMPARED WITH AISC DIMENSIONS

FIGURE 4-1

pile, ℓ. Values of ℓ were given at the end of the previous section.

For columns with values of ℓ/r less than 120 the allowable stress given by AISC is:

$$f = 17000 - 0.485 \left(\frac{\ell}{r}\right)^2 \text{ p.s.i.}$$

All of the piles in the High Point Pier fall in this category.

In the table on the following page are calculated values of A in in^2, I_{yy} in in^4, S in in^3, r in inches, and f in kips per square inch. The calculations employ all of the measured values for the two sections of each pile except for the flange width (2). For any pile where any of the measurements to be used were considered invalid, the calculation is not recorded. This reduces the number of calculated results to 45 out of the original 94 sets of measurements made by the UCT-ONE divers.

The allowable bearing load in kips is the product of the cross-section area and the allowable stress, or $f \times A$. There are three ways in which the average allowable bearing load can be calculated from the data available. First, the values of $f \times A$ can be calculated for each of the sets of properties given in the referenced table and the results averaged. Second, one can use the mean values of all of the 381 valid measurements, calculate the properties from those mean values, and derive the allowable bearing load. Third, the properties of the mean pile illustrated in Figure 4-1 can be calculated and the allowable bearing load derived therefrom. The results of these three methods are compared below with a new pile of the same average length.

Method	1	2	3	New
Area, in^2	15.08	15.62	18.18	21.45
Inertia, in^4	105.55	107.77	121.00	184.70
Modulus, in^3	17.71	18.10	20.30	30.20
Gyradius, in	2.66	2.63	2.58	2.91
Stress, ksi	11.58	12.01	11.82	12.33
Bearing load, kips	175	187	215	264
% of new pile	66.3	70.8	81.4	100.0

It is believed that the third method of mean pile characteristics derivation most accurately represents the average condition of the High Point Pier. On this basis it can be stated that the support structure can carry a load approximately 80% of the original capacity of the pier.

CALCULATED PILE LOADING

In calculating the load carried by each of the vertical piles, the batter

Antigua High Point Pier
H-Beam Bearing Pile Properties
Calculated from UCT-ONE Measurements

Bent/ Pile	Calculated at Surface					Calculated at Mudline				
	A	I_{YY}	S	r	f	A	I_{YY}	S	r	f
18G	15.00	145.1	24.12	3.11	12.12	-----	-----	-----	-----	-----
18F	-----	-----	-----	----	-----	15.01	160.1	26.25	3.26	12.81
18E	-----	-----	-----	----	-----	-----	-----	-----	----	-----
18D	-----	-----	-----	----	-----	-----	-----	-----	----	-----
17A	15.22	116.7	19.46	2.77	11.17	21.68	144.6	24.10	2.58	10.30
17C	-----	-----	-----	----	-----	17.35	91.3	15.23	2.29	8.51
17E	-----	-----	-----	----	-----	12.25	109.5	18.64	2.99	12.00
17H	-----	-----	-----	----	-----	14.74	126.7	21.13	2.93	11.80
16A	-----	-----	-----	----	-----	-----	-----	-----	----	-----
16C	-----	-----	-----	----	-----	-----	-----	-----	----	-----
16F	16.05	69.4	12.20	2.08	7.69	-----	-----	-----	----	-----
16H	13.64	63.7	10.63	2.16	8.39	-----	-----	-----	----	-----
15A	-----	-----	-----	----	-----	13.12	90.8	15.14	2.63	10.95
15B	18.33	110.6	19.24	2.46	10.05	17.57	123.2	20.74	2.65	11.02
15D	-----	-----	-----	----	-----	-----	-----	-----	----	-----
15H	13.22	70.1	11.80	2.30	9.09	14.63	108.1	18.02	2.72	11.33
14A	17.36	108.4	18.07	2.50	10.56	-----	-----	-----	----	-----
14E	14.76	148.3	24.48	3.17	13.00	18.94	148.5	24.52	2.80	11.87
14H	19.94	69.4	11.82	1.87	5.45	5.74	59.3	10.55	3.21	13.11
13B	7.29	69.8	11.76	3.10	13.60	18.17	131.5	22.15	2.69	12.50
13F	17.50	144.1	24.02	2.87	13.04	-----	-----	-----	----	-----
13H	-----	-----	-----	----	-----	10.26	90.7	15.12	2.97	13.32
12A	14.68	109.5	18.26	2.73	11.96	14.64	144.0	24.00	3.14	13.18
12E	16.12	126.8	21.14	2.81	12.22	11.79	109.4	18.24	3.05	12.95
12G2	-----	-----	-----	----	-----	-----	-----	-----	----	-----
11B	12.40	110.8	18.87	2.99	13.62	-----	-----	-----	----	-----
11H	-----	-----	-----	----	-----	-----	-----	-----	----	-----
10A	17.36	108.4	18.07	2.50	10.82	-----	-----	-----	----	-----
10D	16.11	105.0	17.68	2.55	11.08	-----	-----	-----	----	-----
9B1	17.57	109.8	18.31	2.50	12.53	14.60	102.8	17.51	2.65	13.03
9F	8.69	86.6	14.58	3.16	14.20	15.28	92.6	16.27	2.52	12.58
9H	17.50	144.1	24.02	2.87	13.61	-----	-----	-----	----	-----
8A	-----	-----	-----	----	-----	-----	-----	-----	----	-----
8E	-----	-----	-----	----	-----	-----	-----	-----	----	-----
7F	-----	-----	-----	----	-----	-----	-----	-----	----	-----
7H	-----	-----	-----	----	-----	-----	-----	-----	----	-----
6A	11.75	72.1	12.02	2.48	10.72	11.03	71.0	11.89	2.54	11.01
6C	-----	-----	-----	----	-----	-----	-----	-----	----	-----
5H	12.81	92.1	16.20	2.68	12.92	10.17	49.8	8.57	2.21	11.01
5G2	-----	-----	-----	----	-----	-----	-----	-----	----	-----
5E	-----	-----	-----	----	-----	-----	-----	-----	----	-----
4A	-----	-----	-----	----	-----	-----	-----	-----	----	-----
4C	20.00	135.5	23.08	2.60	11.55	13.07	85.2	14.52	2.55	11.34
3H	24.96	102.4	17.08	2.03	10.66	19.53	100.3	16.72	2.27	11.93
3F	-----	-----	-----	----	-----	-----	-----	-----	----	-----
2G2	-----	-----	-----	----	-----	-----	-----	-----	----	-----
1A	-----	-----	-----	----	-----	-----	-----	-----	----	-----
1C	-----	-----	-----	----	-----	-----	-----	-----	----	-----
1H	14.55	72.4	12.07	2.23	11.66	17.55	108.4	18.07	2.49	12.70

pile load bearing capacity and the weight of the batter pile jackets and cap extension can be neglected. It can be assumed that each pile supports a section of the deck with an area equal to the product of the cap spacing and the stringer spacing. Using a concrete density of 150 pounds per cubic foot, the following dead load per pile is calculated:

Deck:	13.7	x 7.14	x 2.5	x 150	=	36682
Cap:	7.14	x 2.5	x 2	x 150	=	5355
Stringer:	11.7	x 1.5	x 2	x 150	=	5264
Jacket:	1.75	x 2	x 2	x 150	=	1050
			Total Dead Load		=	48351#

or less than 50 kips per pile.

Since the average pile capacity, in the present condition of the pier, is on the order of 215 kips, there remains ample structural capacity to support the pier itself and additional working loads that may be imposed up to about 1600 pounds per square foot of deck.

5.0 ASSESSMENT AND RECOMMENDATIONS

ASSESSMENT

The offshore portion of the High Point Pier on Parham Sound, Antigua is in reasonably good condition underwater. With the exception of two easily replaceable steel H-piles, the structure can support approximately 80% of its original design load. This is sufficient to support about 1600 pounds per square foot of vertical loading in addition to the load of the existing pier superstructure.

Above water, the offshore portion of the pier is in poor condition. The deck is out of level in many areas and severe spalling has occurred all around the deck edge. Additionally, there are areas in way of former utility tunnels where the deck has collapsed into the tunnel, thus reducing the working area available on the deck. Furthermore, all of the mooring fittings on the pier are in a state of disrepair to the point where replacement is necessary.

However, as nearly as could be determined, the underdeck concrete structure has not deteriorated to any major extent. With a few exceptions, the pile caps are intact and are serving their structural function. A number of the intercostal stringers, running longitudinally between the bent caps, are missing. This condition exists primarily under the deck along the north and south sides of the pier where replacement is not difficult.

The sheet piling that is designed to contain the fill constituting the onshore portion of the pier is corroded throughout its length. The above water areas of this piling are almost totally destroyed. Underwater, the damage is not quite as great but numerous holes in the piling have permitted the fill to pour out leaving the remaining fill unsupported. This reduces the usable width of the roadway on top of the fill to a fraction of that originally available.

RECOMMENDATIONS

The offshore portion of the pier requires minimal underwater work consisting primarily of replacing the two missing piles at the outboard corners. It is recommended that new HP 12 x 74 piles be driven in these locations after removing the remaining pile. Because of the apparent susceptibility of this area to ship damage, the steel H-piles should be fitted with poured, reinforced concrete jackets 24 inches square and extending 10 feet down from the bottom level of the cap. Cost of replacement of these two piles is estimated at $7,200 as developed in the Appendix.

The decking of the offshore portion of the pier appears to be structurally capable of performing its intended function. However, the deterioration that has begun will continue unless repairs are undertaken which will both prevent further deterioration and improve considerably the utility and appearance of the pier. It is suggested that the collapsed portions of the deck be removed and that the utility tunnels, which apparently are not required, be filled with aggregate. Furthermore, it is suggested that the entire offshore portion of the pier be covered with a 4-inch layer of reinforced concrete extending 6 inches outboard of the existing 52 by 235 foot deck on the north, east, and south sides of the pier. Poured at the same time should be a 6-inch wide by 4-foot deep facing of reinforced concrete which would extend down to the bottom level of the existing stringers. The reinforcing for this facing should be securely attached to the existing face and the forms should extend beneath the existing deck so as to pour replacements for missing stringers along the north and south faces.

The cost for the additions and repairs suggested above has not been estimated since there are several options as to how much of this work may be accomplished.

Around the onshore portion of the High Point Pier, it is recommended that a completely new sheet pile bulkhead be driven, spaced about one foot out from the old piling. Bethlehem DP1 piling, or equal, is recommended which has a weight of 32 pounds per square foot of wall. This new piling would necessarily be nested into the existing piling along the east side which interfaces with the offshore portion of the pier.

The space between the existing sheet piling and the new piling should be filled with gravel or other inert material to maintain separation and reduce the corrosive influence of the old piling on the new piling. If the deck level of the offshore portion of the pier is to be raised, it is recommended that the new piling be cut off level with the deck and that the newly filled area of the onshore pier be paved over to the level of the top of that piling.

The cost of new piling for the onshore portion of the High Point Pier is estimated at $207,300. Costs for fill and paving have not been estimated.

The pier should be reinspected at three to five year intervals to ensure that no further deterioration in the support structure is taking place. However, it is indicated by its present condition and apparent age that the High Point Pier is not subjected to overly destructive environmental or operational effects.

APPENDIX

REPAIR COST ESTIMATE

UNDERWATER REPAIRS - OFFSHORE PORTION

Replace steel H-piles 18A and 18H:		
2 piles x 35 feet/pile x 74 pounds/foot		
x $1.00 per pound	=	$ 5,200
Remove existing pile	=	200
Pour 24 inch square by 10 foot jackets:		
2 piles x 10 feet/pile x 0.148 cy/foot		
x $600/cy	=	1,800
Total		$ 7,200

NEW SHEET PILING - ONSHORE PORTION

North Side:		
147 feet x (26 + 5)/2 feet x 32 pounds/ft^2		
x $1.00/pound	=	72,900
South Side:		
147 feet x (29.5 + 5)/2 feet x 32 pounds/ft^2		
x $1.00/pound	=	81,100
East End:		
60 feet x (29.5 + 26)/2 feet x 32 pounds/ft^2		
x $1.00/pound	=	53,300
Total		$207,300

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