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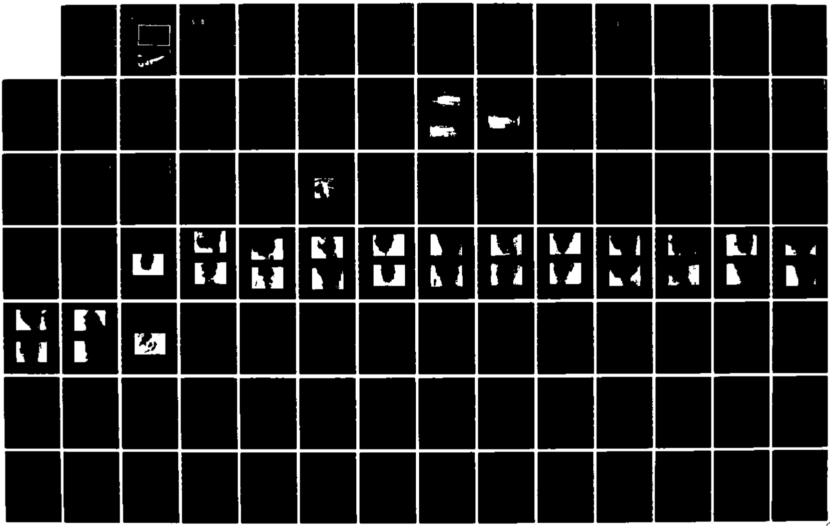

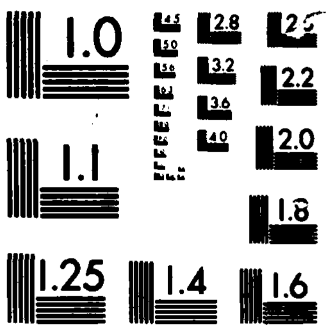

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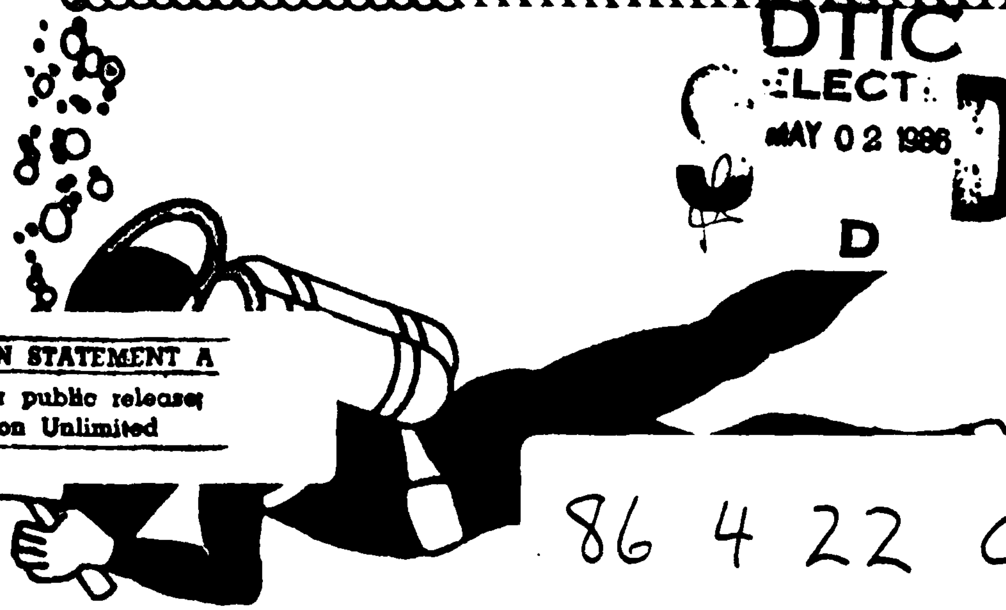
UNDERWATER FACILITIES INSPECTIONS & ASSESSMENTS

AD-A167 862

PIER J/K
NORTH ISLAND
NAVAL AIR STATION
SAN DIEGO, CALIF.

FPO-1-81-(21) AUGUST 1981



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OCEAN ENGINEERING AND CONSTRUCTION PROJECT OFFICE
CHESAPEAKE DIVISION
NAVAL FACILITIES ENGINEERING COMMAND
WASHINGTON, D.C. 20374

(1)

UNDERWATER FACILITIES INSPECTIONS AND ASSESSMENTS

PIER J/K
NORTH ISLAND
NAVAL AIR STATION
SAN DIEGO, CALIF.

FPO-1-81-(21) AUGUST 1981

PERFORMED FOR:

OCEAN ENGINEERING AND CONSTRUCTION PROJECT OFFICE
CHESAPEAKE DIVISION
NAVAL FACILITIES ENGINEERING COMMAND
WASHINGTON, D.C. 20374

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An underwater inspection of Pier J/K at the Naval Air Station, North Island, San Diego, California was conducted between June 15 and August 28, 1981. The object was to provide that quality of inspection that would allow the engineer diver to assess the general physical condition of the piling supporting (Con't)

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BLOCK 19 (Con't)

the pier.

All of the 791 concrete piles were observed in their entire lengths. Ninety of those piles were cleaned by commercial divers for closer inspection.

A condition of moderate to severe sulphate deterioration of the concrete was found in the piling to such an extent that it is recommended that the pier live load be restricted to 100 psf (pounds per square foot) and truck cranes in excess of 15 tons capacity be prohibited.

The pier is adequately supported against earthquake forces (as defined in NavFac P-355) applied perpendicular to its principal axis. However, the piles would not be expected to support the pier in the event of earthquake forces applied parallel to the principal axis.

It is recommended that useful life be considered no greater than five years.

FOREWORD

All structures have their own unique character. This is particularly true of marine structures where even identical elements located in close proximity will exhibit differences in the course of time. Variations in marine environment are compelled by a spectrum of altering conditions; these include temperature variations, pollutant concentrations, electrolytic conditions, biological conditions, variations in the structures' building materials, and variations in the concentration of the aggressive salt water ions. They all serve to produce a unique structure.

It is hoped that this fact will be given appropriate attention when establishing procedures for the inspection of marine structures under the Specialized Inspection Program. There is a need to accomodate change in procedure as directed by what is learned as the inspection progresses and the exercise of professional engineering judgement.

It is difficult to approach an inspection such as this underwater observation of Pier J/K without some preconceived notion of what will be found; however, the inspection is best served if the observer is aware of the importance of keeping an open mind and being prepared to encounter conditions that serve to alter preconceptions.

The inspection of Pier J/K provided an example in this regard. The engineer encountered a condition of sulphate deterioration of the reinforced concrete piles most unusual in San Diego Harbor. As a result, the inspection procedure was modified to address this unexpected condition more closely.

EXECUTIVE SUMMARY

An underwater inspection of Pier J/K at the Naval Air Station, North Island, San Diego, California was conducted between June 15, and August 28, 1981. The object was to provide that quality of inspection that would allow the engineer diver to assess the general physical condition of the piling supporting the pier.

All of the 791 concrete piles were observed in their entire lengths. Ninety of those piles were cleaned by commercial divers for closer inspection.

A condition of moderate to severe sulphate deterioration of the concrete was found in the piling to such an extent that it is recommended that the pier live load be restricted to 100 psf (pounds per square foot) and truck cranes in excess of 15 tons capacity be prohibited.

The pier is adequately supported against earthquake forces (as defined in NavFac P-355) applied perpendicular to its principal axis. However, the piles would not be expected to support the pier in the event of earthquake forces applied parallel to the principal axis.

It is recommended that useful life be considered no greater than five years.

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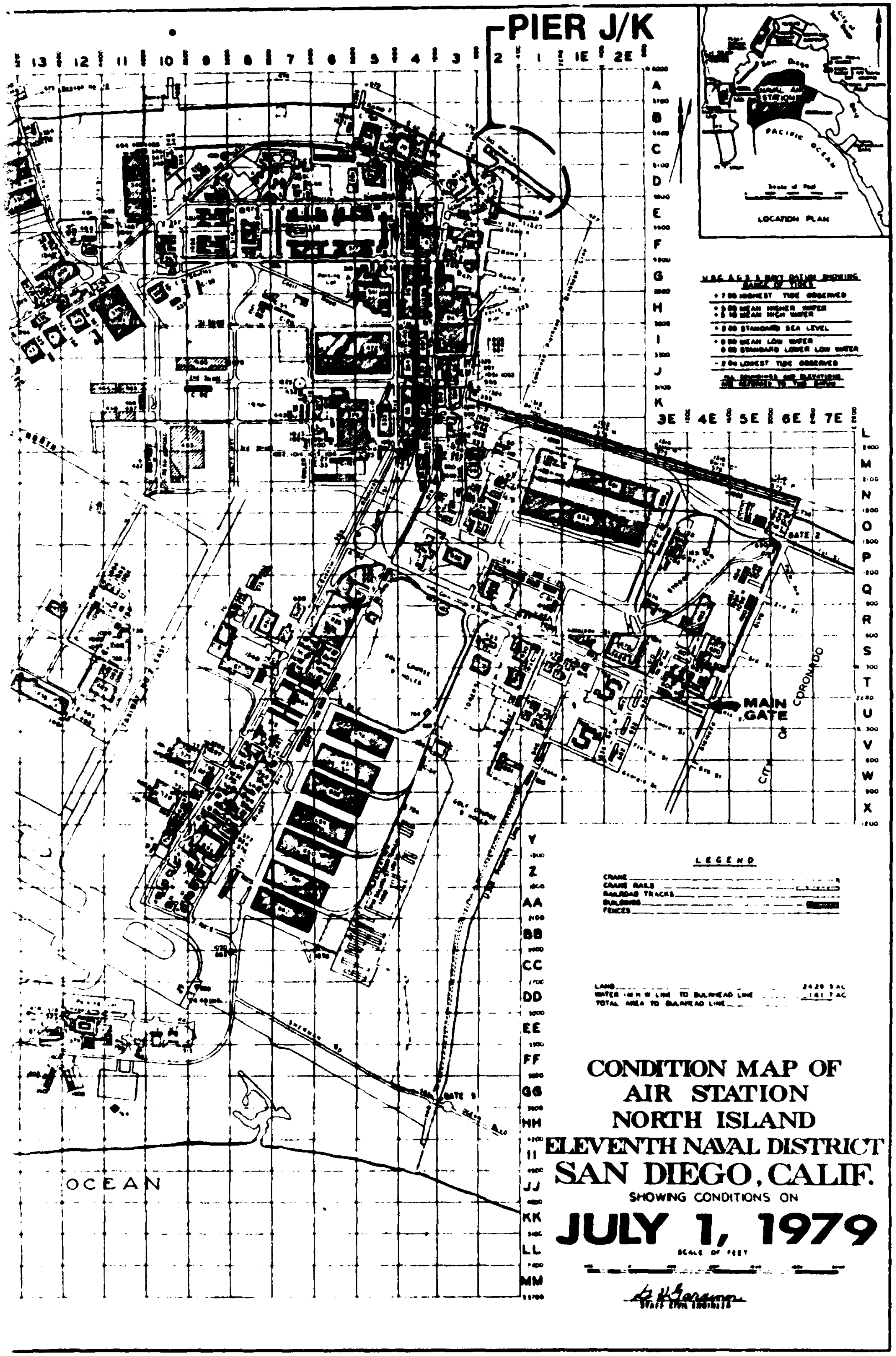

PIER J/K
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PACIFIC OCEAN
MAIN GATE
CITY OF CORONADO
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CRANE RAILS
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SAN DIEGO, CALIF.
SHOWING CONDITIONS ON
JULY 1, 1979
SCALE OF FEET

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SECTION 1 - INTRODUCTION

1.1 CONTRACT DATA

Contract N62477-81-C-0124 - Ocean Engineering Services in Support of Underwater Facility Assessments at Various Locations.

The Contract provides all required technical, non-personal engineering services for ocean engineering services in support of underwater facility assessments at various locations, as directed by the Officer in Charge, and as specifically described in the Scope of Work attached thereto, dated 1 May, 1981.

1.2 INTRODUCTION TO THE PROJECT

This inspection and assessment has been prepared under the Underwater Inspection Program conducted by the Ocean Engineering and Construction Project Office (FPO-1), Chesapeake Division, Naval Facilities Engineering Command, as part of NAVFAC's Specialized Inspection Program.

The program addresses engineering services in support of inspection, analysis and design of repairs of the submerged portions of Navy Waterfront Facilities.

This report covers the inspection of Pier J/K at the North Island Naval Air Station, San Diego, California. The inspection was specifically oriented to the assessment of the physical condition of the reinforced concrete piling supporting the pier.

Pier J/K occupies a very special position in the history and tradition associated with Naval Aviation. Naval Air grew up on North Island to a greater extent than any other location in the country.

The wooden pier built for Glenn Curtiss occupied the site, and in 1921 was torn down to provide room for Pier J -- later to be J/K.

The LANGLEY, Aircraft Carrier No. 1, was home-ported in San Diego at Pier J from 1924 until its reconversion in 1936.

The pier is a significant historical facility and dear to the hearts of all associated with the development of Naval Aviation.

1.3 DESCRIPTION OF THE INSPECTION

It was planned that the engineer/divers would provide a Level I inspection (essentially a "swim-by" overview) of all of the piles in the pier, followed by a Level II inspection (a more detailed inspection for damage) of 50 percent of the 791 piles. At the outset, evidence of severe sulphate-associated erosion of the piles was observed with so random a pattern that a Level II inspection of all the piles was instituted.

Finally, the heavy biological growth (3 - 6 inches) was cleaned from 90 piles by commercial divers and closely inspected by the engineers.

SECTION 2 - ACTIVITY DESCRIPTION

2.1 LOCATION

The Naval Air Station, North Island, San Diego, California, is located on the east side of the entrance to San Diego Bay. It occupies the westernmost extension of the peninsula which includes the City of Coronado and the Silver Strand, and which provides the southern limitation of San Diego Bay. The Station comprises 2429.5 acres of land inboard of the mean high water line.

The dominant waterfront location of North Island with an unbroken shoreline more than eight miles in length, is particularly well suited to the complex mission of the Activity and its supported fleet and shore-based units. The coastal environment permits both direct air access to ships offshore without overflight of urban development, and convenient deep water access for berthing of aircraft carriers and other large ships.

2.2 HISTORY

The first government acquisition at North Island was made in 1893 when 18.05 acres at the extreme southwestern tip of the island were condemned for the construction of a jetty needed to protect the channel from siltation.

In 1901, an additional 38.56 acres adjacent to the jetty was condemned for the purpose of establishing a coast defense fort. Fort Pio Pico, a substation of Fort Rosecrans, remained until 1919. Its mission was the protection of the harbor entrance. This was the first military reservation on North Island.

In December 1910, Lt. Theodore G. Ellyson, the first Naval Aviator, was ordered to undergo flight training at the Curtiss Aviation Company on North Island. The Coronado Beach Company agreed to allow Curtiss to use North Island for a three-year period without cost. Curtiss, in 1911, constructed a landing field at the southeast side of North Island adjacent to the present location of Pier J/K.

The old Army/Curtiss dock, a wooden deck supported on wooden piles located at the northeast corner of the Station was torn down in 1921 to make room for Pier J, a reinforced concrete pier, supported on precast conventionally reinforced concrete piling. Most of this original construction remains today.

In 1924, the USS LANGLEY Aircraft Carrier No. 1 first arrived at North Island and its berthing at Pier J. The LANGLEY was originally built in 1912 at Mare Island as the Collier Jupiter. It remained home-ported at San Diego until it was converted to a tender in 1936. During its tenancy at North Island, Pier J became known as the Langley Pier. Significant additions were made to the pier in 1930 and 1958.

The morning of December 7, 1941, as the Japanese were attacking Pearl Harbor, the SARATOGA -- just out of dry dock -- was at Pier J/K taking on aircraft.

During the second World War and Korean conflict, North Island served the needs of the Naval Air Forces in the Pacific.

Since 1967, Naval Air Station North Island has continued as a very complex facility supporting fleet operations, training, repair and rework, supply and other activities of air and surface.

2.3 MISSION

The mission of the Naval Air Station North Island is to maintain and operate facilities and provide services and material to support operations of activities and units of the Operating Forces of the Navy and other Activities, and Units as designated by the Chief of Naval Operations.

NAS North Island possesses a unique combination of physical features which would be impossible to duplicate elsewhere in California. A deep water port with carrier berthing adjacent to an air field in a climate where air operations are possible year long, are basic advantages and most useful for the performance of the Station's complex mission.

SECTION 3 - PROJECT DESCRIPTION

3.1 DESCRIPTION OF THE FACILITY

Pier J/K is shown in Photographs 1 through 3 and in plan on Figure 1. Typical cross-sections are shown in Figures 2, 3 and 4. It is located at the northeastern corner of North Island.

The first section of the pier indicated as Region I on Figure 1 was constructed in 1921. It provided approximately 26,200 square feet of plan area in a distorted "T" shape. Structurally, the pier was designed as a slab and beam system supported by pile cap beams spaced at 10 feet o.c. Provision for railroad service on the pier was made. While the pier generally was supported by 14 inch square conventionally reinforced piles, the railroad rails were supported by heavy girders and 18 inch square piles. Batter piles were provided in the N-S direction on the cross of the "T" only -- leaving the pier deficient for lateral forces in the E-W direction.

Over the years, many alterations have been made to the pier. Only the principal changes will be mentioned here.

The utility services required of Pier J/K have increased over the years as the Navy's utility requirements for berthed vessels have increased. This has resulted in the circuitous routing of utility lines and their placement in difficult locations. The pier is low in the water -- deck elevation +10 MLLW -- and the presence of the deep railroad girders further complicates the crossing over of the lines which can only be supported under the deck.

Regions II amounting to about 23,000 square feet were added in 1930 as east and west extensions of the pier. It was in this configuration that the pier served the large aircraft carriers during the Second World War. Regions II is supported by 16 inch square conventionally reinforced piles.

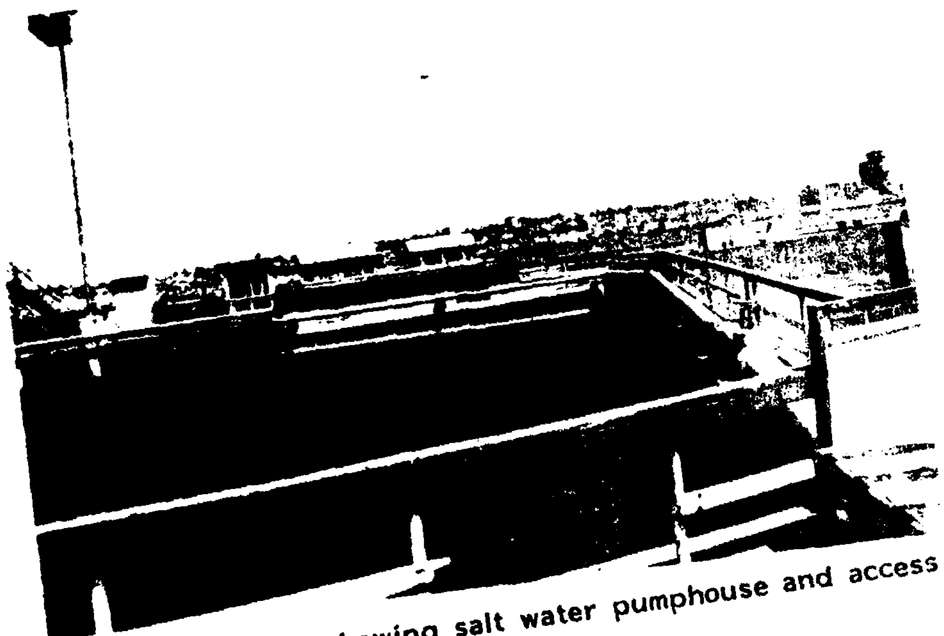
Regions III were constructed in 1958, providing an additional 6,700 square feet of pier area in two locations. Support was provided by 16 inch octagonal prestressed piles. Regions III piles are in good structural condition.

The balance of the facility is made up of two derrick platforms at the west end of the pier, whose mission has since been abandoned, a pump house at the base of the stem of the "T" which is currently operating and a transformer platform adjacent to the south side of the cross of the "T" supporting operating transformers.

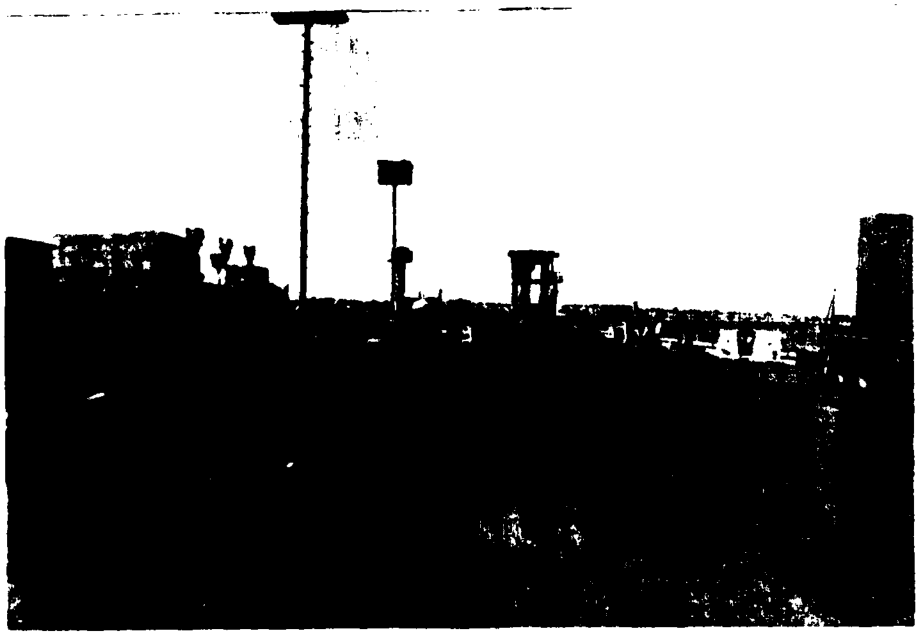
The total deck area provided by Regions I, II and III is approximately 56,000 square feet. The total number of piles under the three Regions is 791. There are nine 14 inch square piles under the salt water pump house which were included in this inspection. The piles supporting the derrick platforms and the transformer platform were not inspected closely but were observed to be 16 inch octagonal prestressed piles in good condition.

The cor :rete in Regions I and II has not fared well. It is apparently composed of Type I cement which in current practice is not considered suitable for salt water use. It was the only cement available on the West Coast until about 1940.

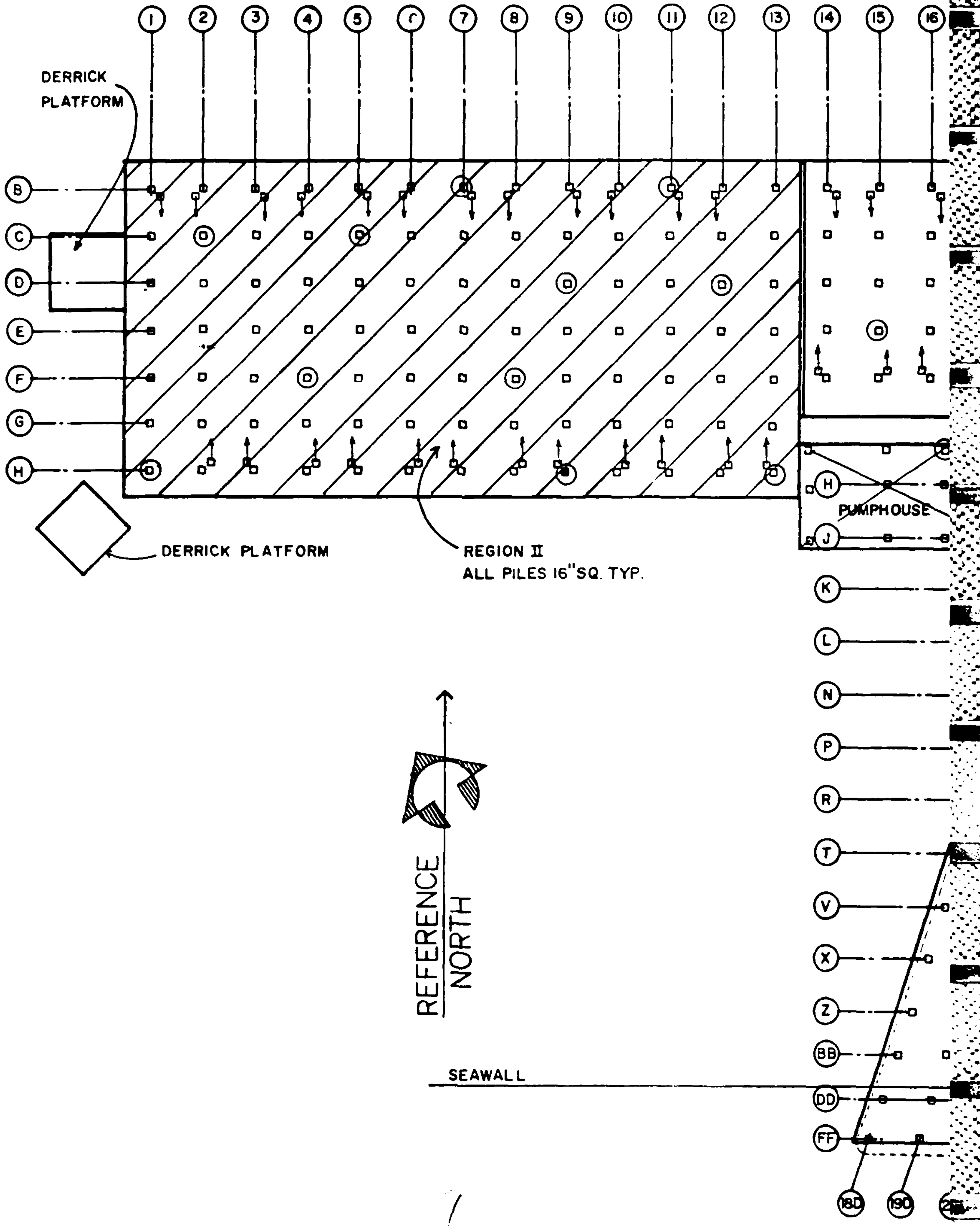
1. Western extension of Pier J/K showing derrick platforms and Bents 1 through 11.



2. View to the north showing salt water pumphouse and access to Pier J/K from the land.



3. View to the west of J/K pier deck from the vicinity of Bent 60.



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DERRICK
PLATFORM
B
C
D
E
F
G
H
DERRICK PLATFORM
REGION II
ALL PILES 16"SQ. TYP.
H
PUMPHOUSE
J
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L
N
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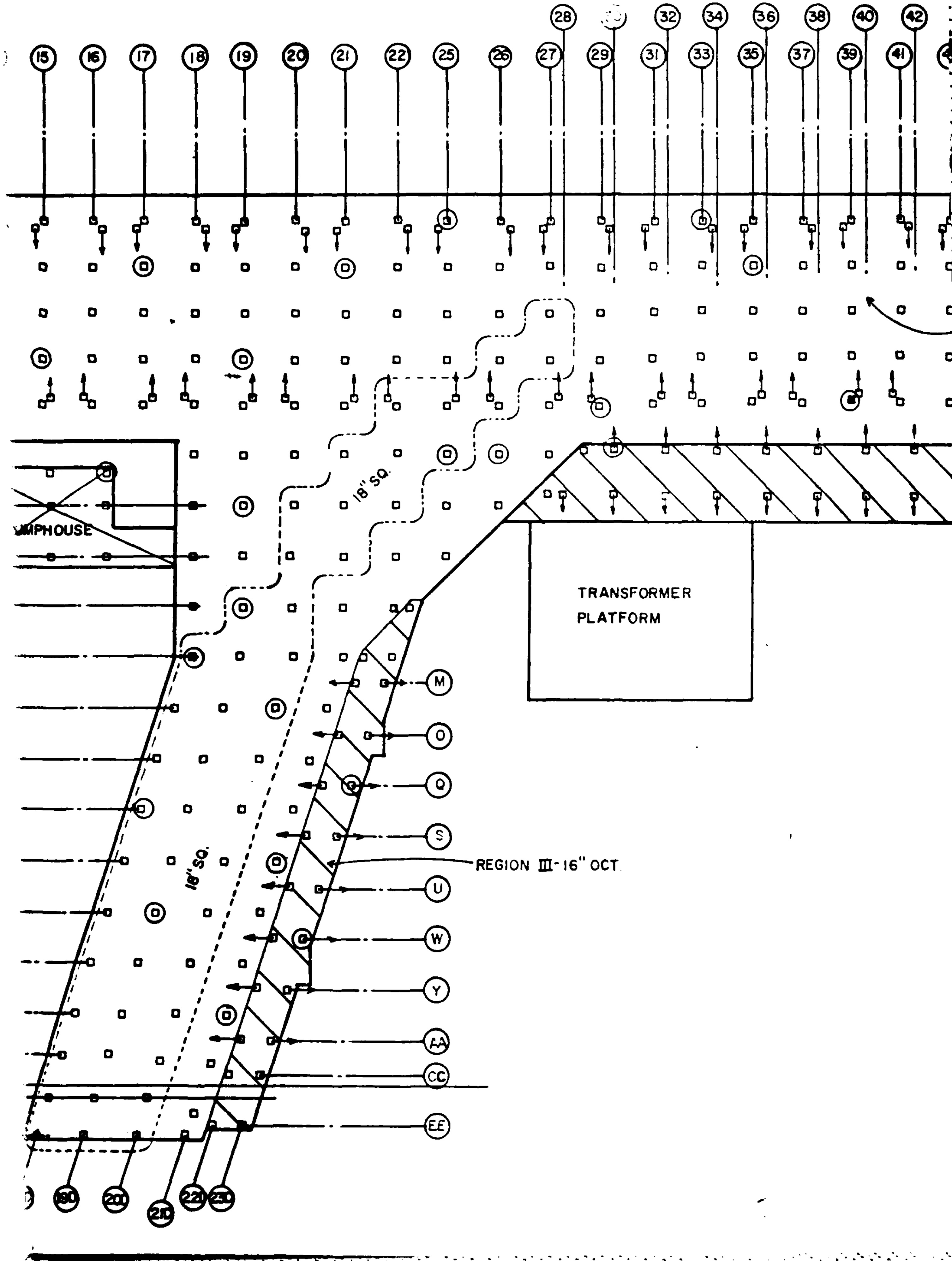
R
T
V
X
Z
BB
DD
FF
18D
19D
REFERENCE
NORTH
SEAWALL



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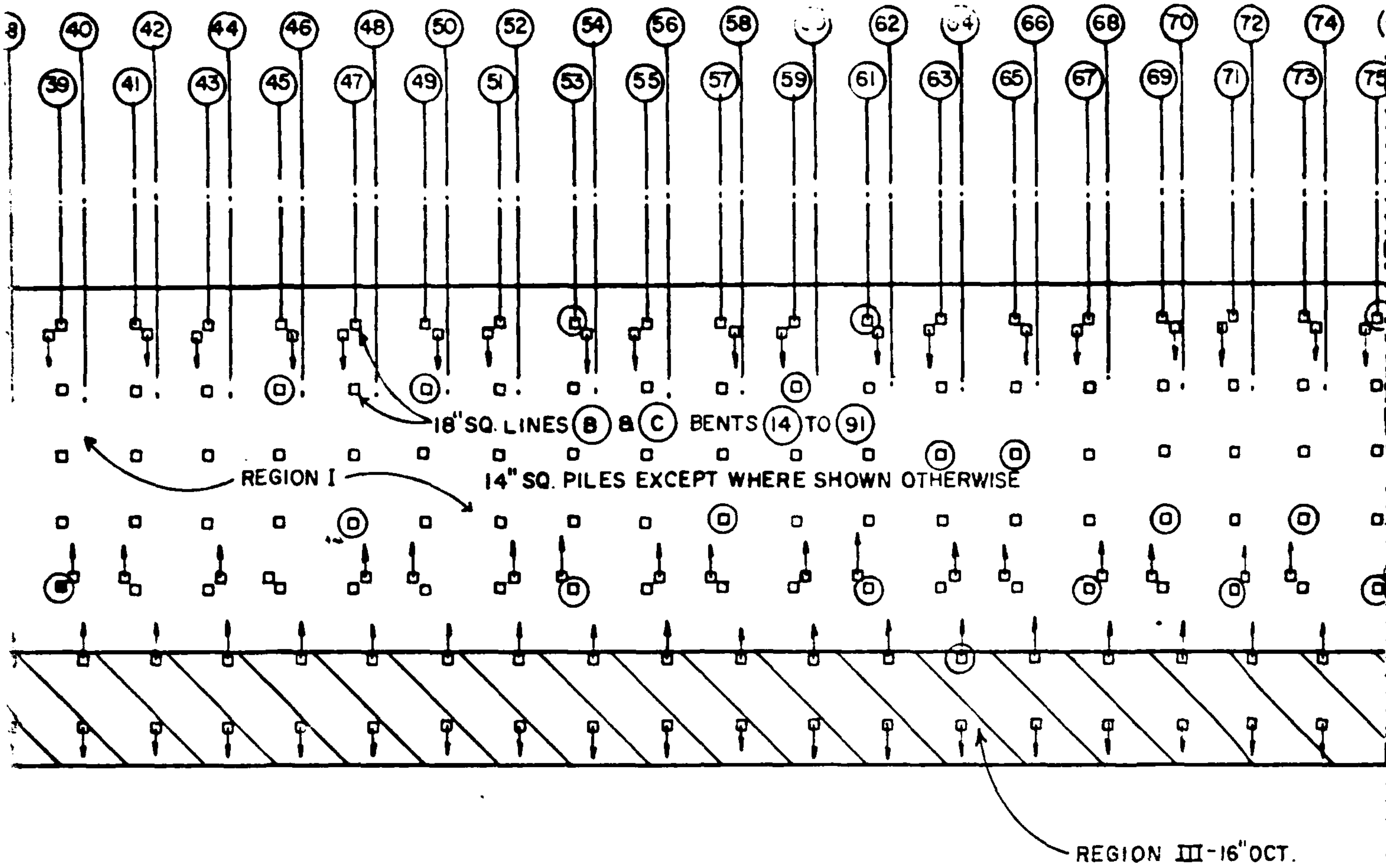
18" SQ.
MPHOUSE
TRANSFORMER
PLATFORM
M
O
Q
S
REGION III - 16" OCT.
U
W
Y
AA
CC
EE
18" SQ.
190
200
210
220
230



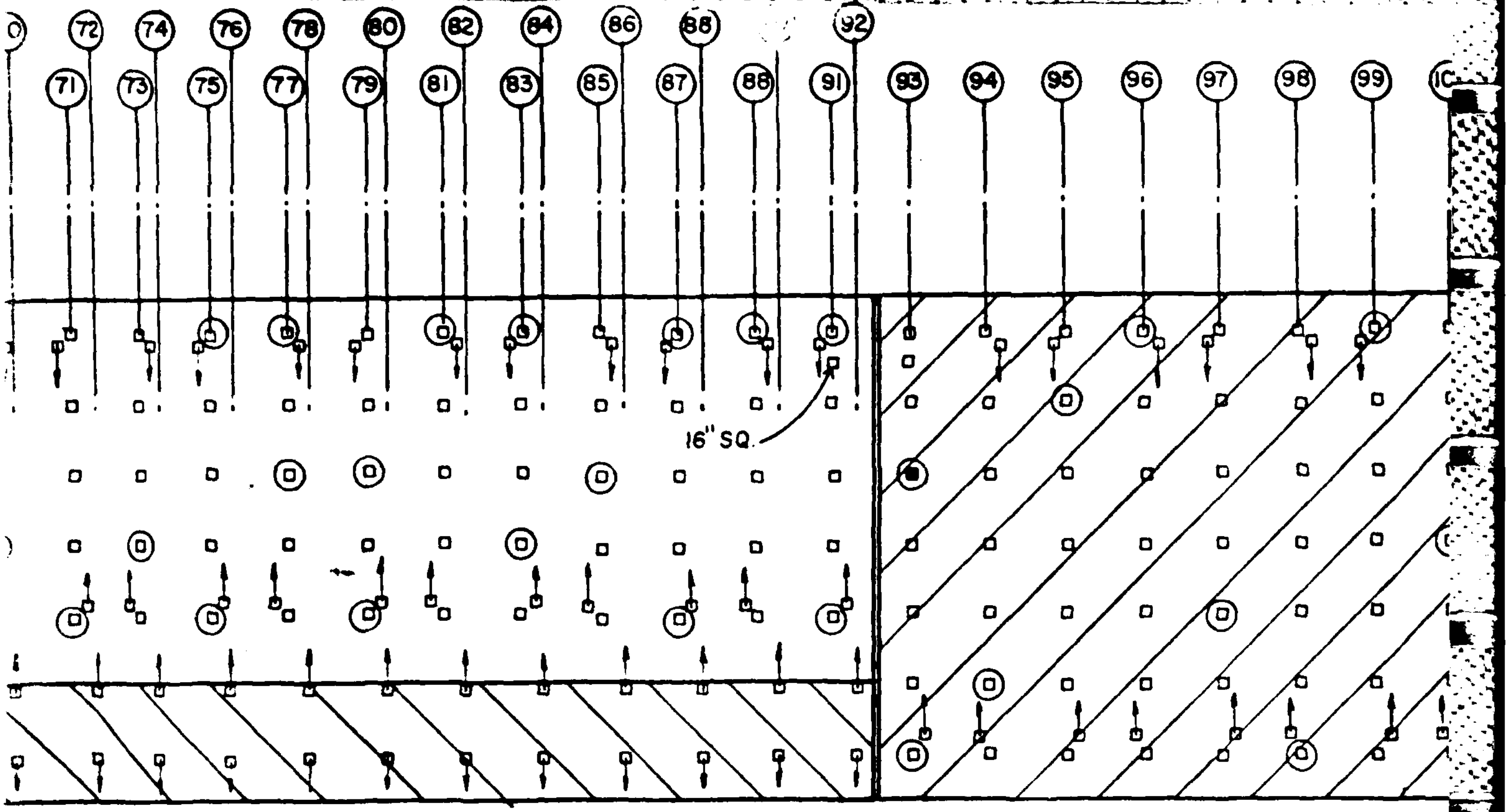
REGION	LEGEND	TYP. VERTICAL PILE	VERTICAL PILE AT TRACK GIRDER	BATTER
I		14" SQ. w/EXCEPTIONS	18" SQ.	1
II		16" SQ.	16" SQ.	1
III				1

LEGEND:

CLEAN FULL HEIGHT

BAND 2'-0" HIGH 3 SIDES IN 2 LOCATIONS, ONE HIGH, ONE LOW

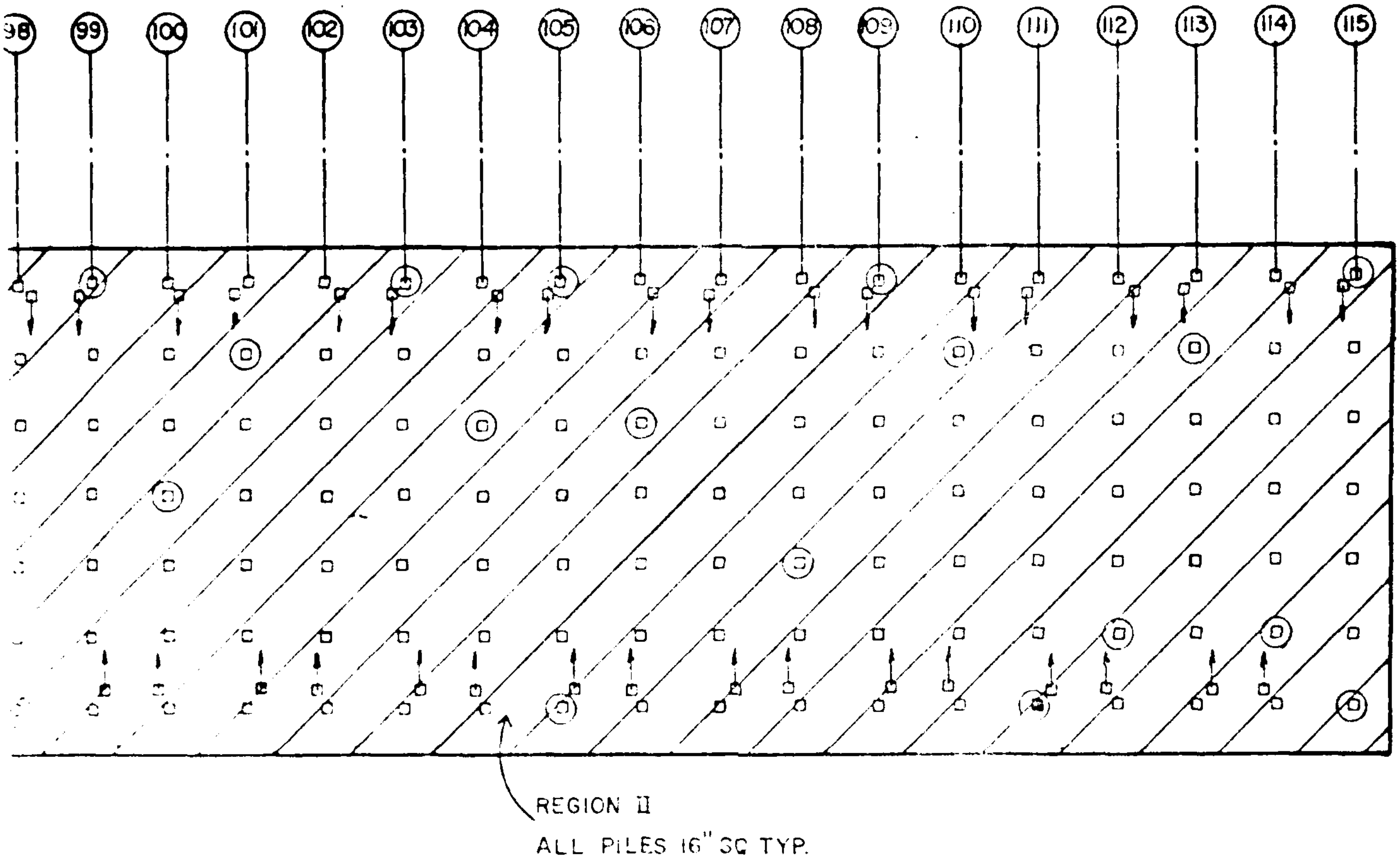
BATTER PILE



III-16" OCT.

AT	BATTER PILES	Y&D REFERENCE	DATE
	14" SQ.	CONTRACT-4087Y	1921
	16" SQ.	109161-63	1930
	16" OCT.	804706-27	1958

LOW



PIER J & K NORTH ISLAND

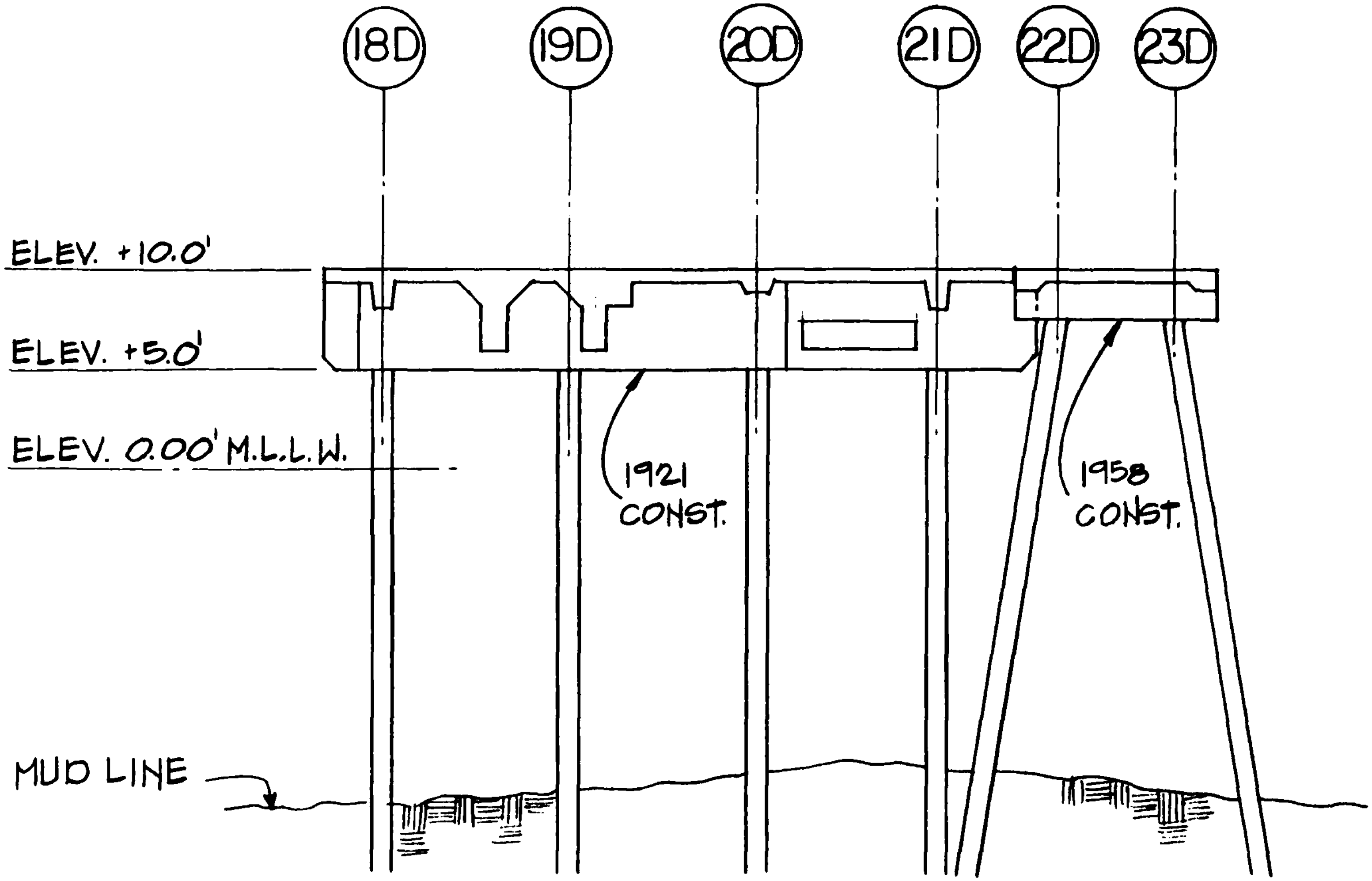
NAVAL AIR STATION, SAN DIEGO, CALIFORNIA

PILE LAYOUT PLAN

Blaylock-Willis and Associates
STRUCTURAL ENGINEERS SAN DIEGO, CALIFORNIA

DATE SEP. 21, 1981

FIG. 1



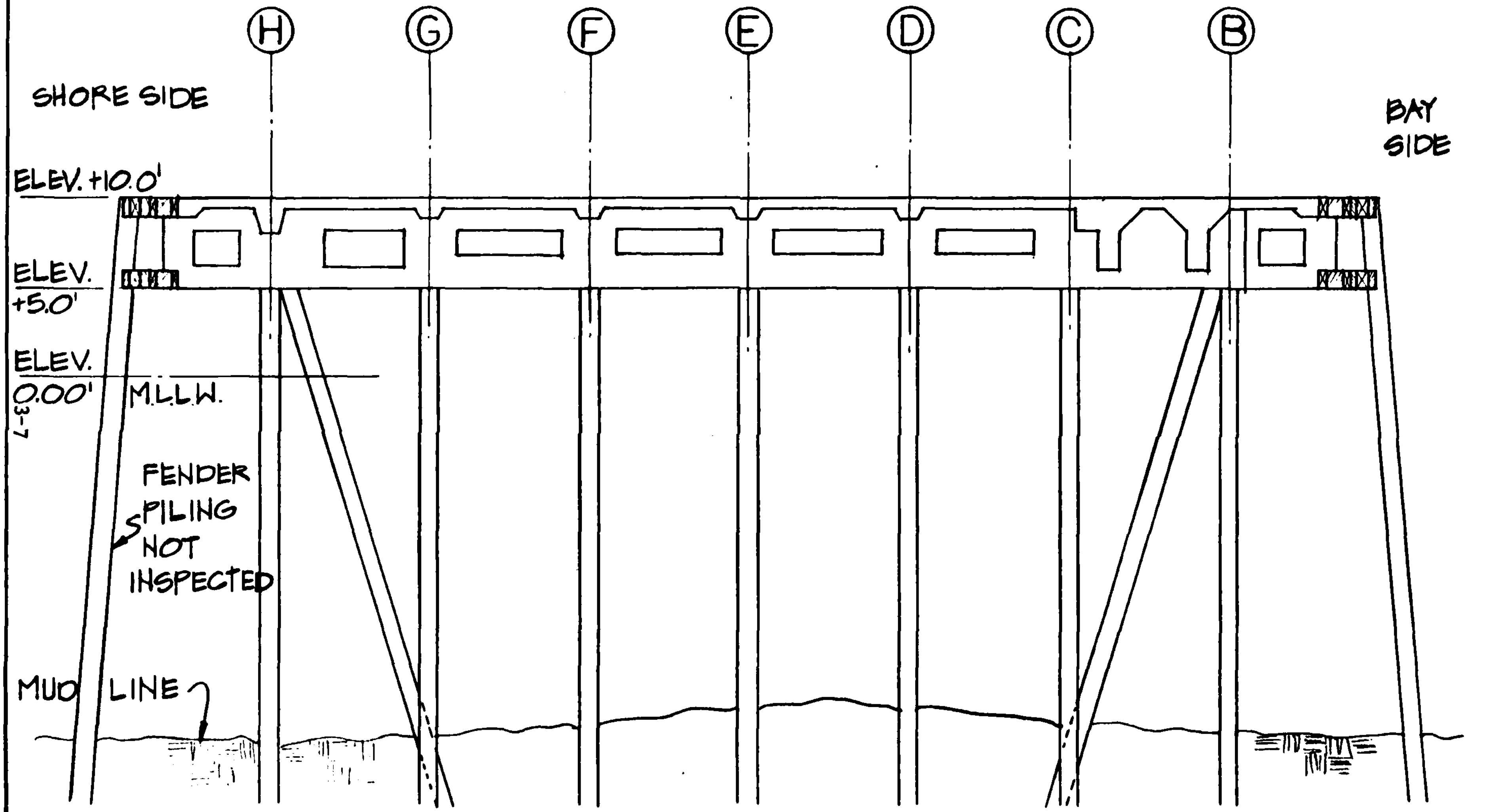
SOUTH ELEVATION L TO CC

1/8" = 1'-0"

FIG. 2

PIER J & K
NORTH ISLAND, SAN DIEGO, CA.

Blaylock-Willis and Associates
STRUCTURAL ENGINEERS
SAN DIEGO, CALIFORNIA



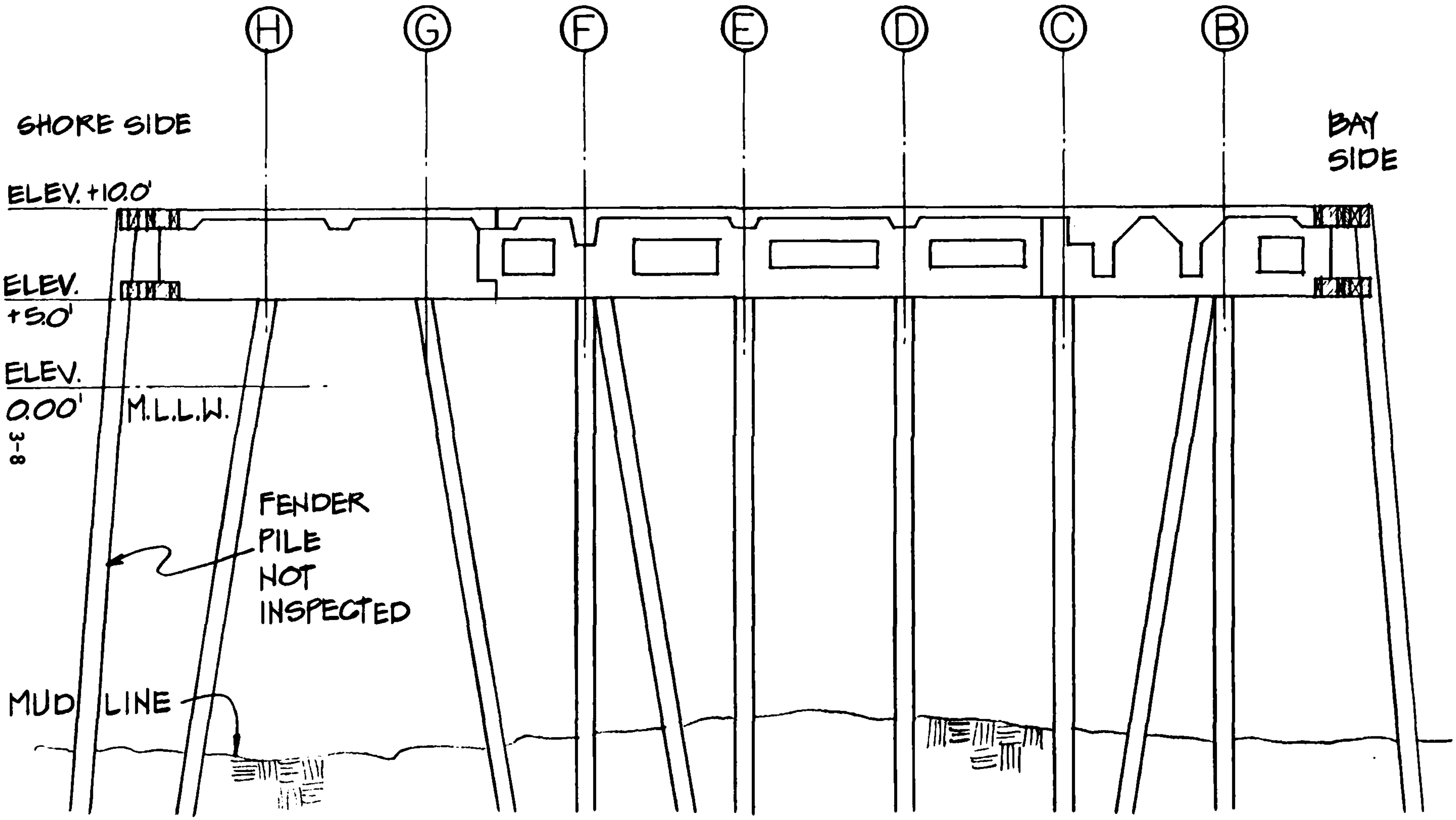
BENTS 1 THRU 13 & 93 THRU 115 (1930 CONSTRUCTION)

FIG. 3

1/8" = 1'-0"

PIER J & K
NORTH ISLAND, SAN DIEGO CA

Blaylock-Willis and Associates
STRUCTURAL ENGINEERS SAN DIEGO, CALIFORNIA



BENTS 27 THRU 92 (1921 CONSTRUCTION)

FIG. 4

1/8" = 1'-0"

PIER J & K
NORTH ISLAND, SAN DIEGO, CA.

Blaylock-Willis and Associates
STRUCTURAL ENGINEERS SAN DIEGO, CALIFORNIA

The underside of Regions I and II in later years has shown advanced signs of deterioration. Apparently some sulphate decomposition, coupled with severe rusting of the lower reinforcing steel had caused considerable concern to the activity.

The term "ravelling" is used in this report in discussing sulphate activity to describe the surface appearance of the concrete piles resulting from the loss of surface aggregate. The term is associated with concrete surfaces (asphaltic and Portland cement) where the bonding agency of the matrix is so reduced that the surface aggregates are easily abraded away or simply fall out.

In 1973, W. H. Stockly and Associates was retained as A&E to update the utilities and provide structural repairs where they were indicated. The structural repairs consisted of removing or cleaning rusted reinforcing bars and replacing the lost concrete cover with gunite. Although this type of repair was not expected to provide a service life in excess of fifteen years, these repairs presently are in good condition.

"Beams, like the deck underside, appear in good condition. Some rust stains were evident at caps but the caps appear in fairly good condition."[14]

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(14) *Bibliography, Page 2*

3.2 INSPECTION PROCEDURE

The Scope of Work required a Level I General Inspection (swim-by overview) of each of the piles and then a Level II Detail Inspection of 50 percent of the piles in the facility. The general pattern of inspection to be followed and the specific location of piles to be inspected in detail to be determined by mutual agreement between the on-site government representative and the structural engineer diver.

In addition, 90 piles were to be cleaned of marine growth as follows:

1. Six piles were to be scraped in their entire exposed lengths and wire-brushed. These were designated as "cleaned" piles. (See photograph 4.)

2. 84 piles were to be scraped in bands 2 feet high and extending around three sides of the pile. The location of each band was selected, but in general they were located just below low water and just above the mud line. These were designated as "banded" piles. All scraping was accomplished using hand scrapers.

The inspection took place between June 15 and June 24, 1981, with a single last dive occuring August 28, 1981. In general, the inspection team was composed of one civil/structural engineer diver and a civil engineer tender, although on three occasions a second civil/structural engineer was in attendance. The engineer divers used scuba gear.

The cleaning was accomplished by a San Diego commercial diving firm, Marine Services, Inc., who provided at any one time a working crew

4. Hydraulically-powered rotary wire brush used to clean six concrete piling after heavy marine growth removed by hand scrapers.

of at least four -- two divers, one tender, one boat operator. The divers used Kirby masks with surface-supplied air from the work boat -- an ex-military LCM converted for diving operations.

Early on, it was apparent that conducting the inspection from a boat small enough to get under the pier was not feasible as the pier and its utilities are so low in the water and the wakes of passing vessels so violent that a small craft under the pier would be dangerous. The inspection proceeded with the tender on pier-side and communication by voice.

SECTION 4 - STRUCTURAL ASSESSMENT

4.1 OBSERVED CONDITIONS

The morning of the first day was spent marking the pier bents for location. Inspection of the piles commenced in the afternoon when it became quickly apparent that swim-by surveillance might not reveal the type of information needed.

The first piles observed exhibited different characteristics above water or in the splash zones than in the regions that are continuously wet. The upper areas appeared firm to the geologist's pick while the below-water concrete exhibited soft places that could be chipped away. It was then decided to attempt to chip away at each pile just below the low-water line and at the mud line. Easy observation was prevented, of course, by the marine growth, but the soft concrete problem seemed of such magnitude and the possibility of the presence of piles that had lost considerable cross-section or exhibited softness to a considerable depth seemed so likely a possibility, that additional inspection effort seemed in order.

The soft concrete encountered varied from pile to pile and varied at different locations on the same pile -- even at the same elevation. The concrete when chipped off was revealed to be unusually white in color -- brighter than the expected gray of Portland cement paste, but often nearly white as with gypsum. Dryed, it crushed easily to a powder between the fingers.

The damage described was limited to the piles of Regions I and II. Region III and the various platforms are supported by 16 inch octagonal piles, probably prestressed, whose concrete is hard to the pick.

It has since been decided that the softness was due to the chemical reaction between tricalcium aluminate in the cement and sulphate ions in the salt water as well as a reaction between calcium hydroxide in the cement and sulphate ions. This subject is treated more fully in Section 4 of this report under 4.2 DISCUSSION OF PERTINENT CHEMICAL DAMAGE.

The appearance of the soft concrete where it had been cleaned gently was deceptive -- it appeared sound in many places until struck with the pick. This was surprising to the observers who have associated sulphate attack with a raveled surface appearance.

Incidentally, the adjacent concrete sheet pile bulkhead exhibits this raveled appearance and is also soft to the pick. To this observer, it is typical sulphate attack appearance.

During the course of the initial inspection, the 90 piles to be cleaned or banded were selected. Their locations were indicated to the commercial divers who proceeded with the cleaning operation.

For the final inspection of the cleaned or banded piles, it was decided that the following nomenclature would be used to describe the degree of hardness encountered:

1. Hard: Pick rebounds without making significant indentation. Usually accompanied by a ringing sound clearly heard in the water.

2. Firm: Pick rebounds with a small indentation.

3. Moderate Soft: With 6 blows, 1/4 inch of material can be removed.

4. Soft: 6 blows can remove 1/2 inch of material.

5. Very Soft: 6 blows removes corner of the pile or 1 inch of material.

6. Extremely Soft: Noticeably softer than "5."

The selection of hardness category was probably subject to some bias as the inspector was seeking out damage. However, at best the inspection has shown the piling to be damaged to an extent which considerably lessens their ability to support loads.

In the course of the inspection, the inspection party was visited by CDR. Franklin Hartman, Staff Civil Engineer, and Mr. Don Lydy, Facilities Planner. On the second visit, samples of the damaged concrete were obtained for CDR. Hartman.

The record of pile condition is given in Table I.

TABLE I - RECORD OF PILE CONDITION

PILE NO.	DESCRIPTION
1-H	Top - Firm Bottom - Medium Soft
2-C	Top - Firm Bottom - Medium Soft
4-F	Top - Firm Bottom - Soft
7-B	Top - Medium Soft Bottom - Firm
8-F	Top - Firm Bottom - Soft
9-D	Top - Very Soft. All corners spalled top and bottom Bottom - Very Soft
9H	Pile entirely cleaned, from a distance under water pile appears round. Cleaning operation had removed entire surface of pile. Extremely Soft. Possible with pick to dig in 3 in. exposing corner rebar.
11-B	Top - Very Soft. All corners gone, reinforcing steel exposed. Bottom - Very Soft. Similar to 9-H
12-D	Top - Very Soft Bottom - Very Soft
13-H	Top - Very Soft. Corners spalled Bottom - Very Soft
15-E	Top - Very Soft Bottom - Very Soft
17-C	Top - Very Soft Bottom - Soft
19-E	Top - Soft Bottom - Soft
19-H	Top - Very Soft Bottom - Very Soft
19-K	Top - Very Soft Bottom - Soft

TABLE I - RECORD OF PILE CONDITION (continued)

PILE NO.	DESCRIPTION
21-C	Top - Very Soft
	Bottom - Very Soft
25-B	Top - Very Soft
	Bottom - Very Soft
25-G	Top - Soft
	Bottom - Soft
26-G	Top - Soft
	Bottom - Very Soft All corners spalled
29-F	Top - Medium Soft
	Bottom - Soft
30-G	Top - Hard
	Bottom - Firm
33-B	Top - Medium Soft
	Bottom - Medium Soft
35-C	Top - Soft
	Bottom - Soft
39-F	Top - Fully cleaned, extremely soft all corners spalled. Cleaning effort has eroded 50% of surface.
41-B	Top - Firm
	Bottom - Firm
41-C	Top - Firm
	Bottom - Medium Soft
45-C	Top - Very Soft
	Bottom - Very Soft
47-E	Top - Medium Soft
	Bottom - Medium Soft
49-C	Top - Soft
	Bottom - Soft
53-B	Top - Soft
	Bottom - Soft
53-F	Top - Firm
	Bottom - Medium Soft
57-E	Top - Firm
	Bottom - Soft

TABLE I - RECORD OF PILE CONDITION (continued)

PILE NO.	DESCRIPTION
59-C	Top - Firm Bottom - Soft
61-B	Top - Medium Soft Bottom - Medium Soft
61-F	Top - Medium Soft Bottom - Medium Soft
63-D	Top - Medium Soft Bottom - Medium Soft
65-D	Not cleaned, top firm, bottom extremely soft
67-F	Top - Firm Bottom - Soft
69-E	Top - Soft Bottom - Soft
71-F	Top - Soft Bottom - Very Soft
73-E	Top - Very Soft Bottom - Very Soft
75-B	Top - Very Soft Bottom - Very Soft
77-B	Top - Very Soft Bottom - Firm
75-F	Top - Very Soft Bottom - Very Soft
77-D	Top - Very Soft Bottom - Very Soft
79-D	Top - Soft Bottom - Very Soft
79-F	Top - Soft Bottom - Very Soft
81-B	Top - Very Soft Bottom - Soft
83-B	Top - Very Soft Bottom - Very Soft

TABLE I - RECORD OF PILE CONDITION (continued)

PILE NO.	DESCRIPTION
83-E	Top - Firm
	Bottom - Very Soft
85-D	Top - Soft
	Bottom - Very Soft
87-B	Top - Very Soft
	Bottom - Soft
87-F	Top - Soft
	Bottom - Soft
89-B	Top - Soft
	Bottom - Soft
91-B	Top - Firm
	Bottom - Soft
91-F	Top - Not cleaned Soft
	Bottom - Soft
93-D	Fully cleaned. Firm, soft, variable hardness in pile
93-H	Top - Soft. Not cleaned
	Bottom - Soft
94-G	Top - Very Soft
	Bottom - Soft
95-C	Top - Very Soft
	Bottom - Very Soft
96-B	Top - Very Soft. Very large spall south side
	Bottom - Very Soft
97-F	Top - Soft
	Bottom - Extremely Soft
98-H	Top - Very Soft
	Bottom - Very Soft
99-B	Top - Very Soft
	Bottom - Very Soft
98-B	Top - Very soft. Not cleaned
	Bottom - Very Soft
100-E	Top - Medium Soft
	Bottom - Very Soft

TABLE I - RECORD OF PILE CONDITION (continued)

PILE NO.	DESCRIPTION
115-H	Top - Extremely Soft
	Bottom - Extremely Soft
101-C	Top - Soft
	Bottom - Soft
103-B	Top - Very Soft
	Bottom - Very Soft
104-D	Top - Very Soft
	Bottom - Extremely Soft. Good for pictures
105-B	Top - Extremely Soft
	Bottom - Extremely Soft. Good for pictures
105-H	Not Cleaned, top soft, bottom soft
106-D	Top - Soft
	Bottom - Very Soft
108-B	Top - Very Soft
	Bottom - Very Soft
109-B	Top - Soft
	Bottom - Extremely Soft
108-F	Top - Very Soft
	Bottom - Extremely Soft
110-C	Top - Very Soft
	Bottom - Soft
111-H	Cleaned Pile. Places very soft - visibility 10-inches
112-G	Top - Very Soft
	Bottom - Very Soft
114-G	Top - Extremely Soft. Heavilly spalled at bottom
	Bottom - Extremely Soft
115-B	Top - Soft
	Bottom - Very Soft
16-B	Top - Very Soft
	Bottom - Very Soft
L-18D	Top - Soft
	Bottom - Very Soft

TABLE I - RECORD OF PILE CONDITION (continued)

PILE NO.	DESCRIPTION	PILE NO.	DESCRIPTION
20D-H	Top - Soft	16-B	Top - Very Soft
	Bottom - Soft		Bottom - Very Soft
18D-R	Top - Soft	18D-L	Top - Soft
	Bottom - Very Soft		Bottom - Very Soft
23D-Q	Top - Hard	20D-H	Top - Soft
	Bottom - Hard		Bottom - Soft
23D-W	Top - Hard	18D-R	Top - Soft
	Bottom - Hard		Bottom - Very Soft
21D-T	Top - Soft	23D-Q	Top - Hard
	Bottom - Soft		Bottom - Hard
19-V	Top - Soft	23D-W	Top - Hard
	Bottom - Soft		Bottom - Hard
21D-Z	Top - Soft	21D-T	Top - Soft
	Bottom - Soft		Bottom - Soft
		19-V	Top - Soft
			Bottom - Soft
		21D-Z	Top - Soft
			Bottom - Soft

MEASUREMENT OF PILE LENGTHS

	PILE	LENGTH
1.	BB-18D	9'-11" (Seawall)
2.	R-18D	15'-6"
3.	1-H	25'-5"
4.	1-B	35'-8"
5.	13-H	19'-8"
6.	26-B	32'-6"
7.	61-B	35'-1"
8.	87-H	33'-10"
9.	92-H	33'-0"
10.	115-A	40'-10"
11.	115-H	35'-9"

Photographs 5 through 32 are all underwater photographs taken at the cleaned areas of the designated concrete piles. Marine growth was removed as described in Section 3.2 INSPECTION PROCEDURE.

5. Bottom photo of Pile 9-H showing the result of hand picking of an already badly ravelled surface. The surface shown is in excess of 3 inches below the original surface of the concrete. From a short distance in the water, the pile appears round due to its loss of its corners.

6. Pile 9-H on the bottom showing another corner of the pile than shown in Photo 4. The corner concrete has been chipped off at the surface of past cracking. Apparently, some autogenous healing has occured as the result of FE_2O_3 deposition and probably some $CACO_3$ production. This has healed the crack and kept the steel bar from completely corroding.

7. The pile at the northeast corner of the salt water pump house. The photo is of the top and shows the considerable erosion of the corner of the pile.

8. At the top of Pile 9-H showing "bleeding" rust stain.

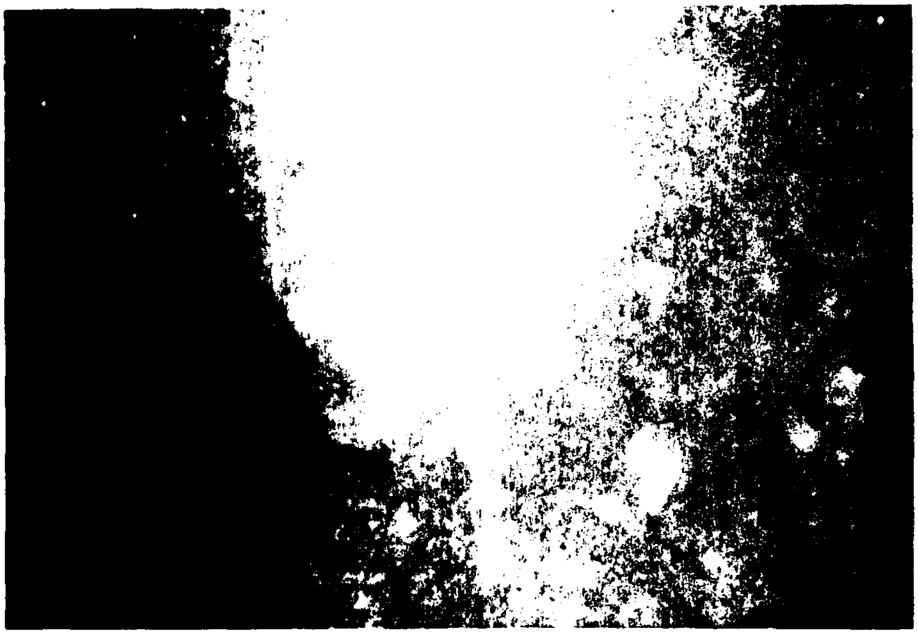
9. Another area at top of Pile 9-H previous to picking. See Photo 10.

10. The top of Pile 9-H after picking showing further indentation of already ravelled surface.

11. This is the pile at northeast corner at the salt water pump house, photo taken at the bottom showing old erosion.

12. Northeast pile at the salt water pump house showing the results of the half dozen blows of the pick.

13. Photo shows an area at top of Pile L-18D. Previous to picking the reinforcing bar now exposed was covered by soft deteriorated concrete.

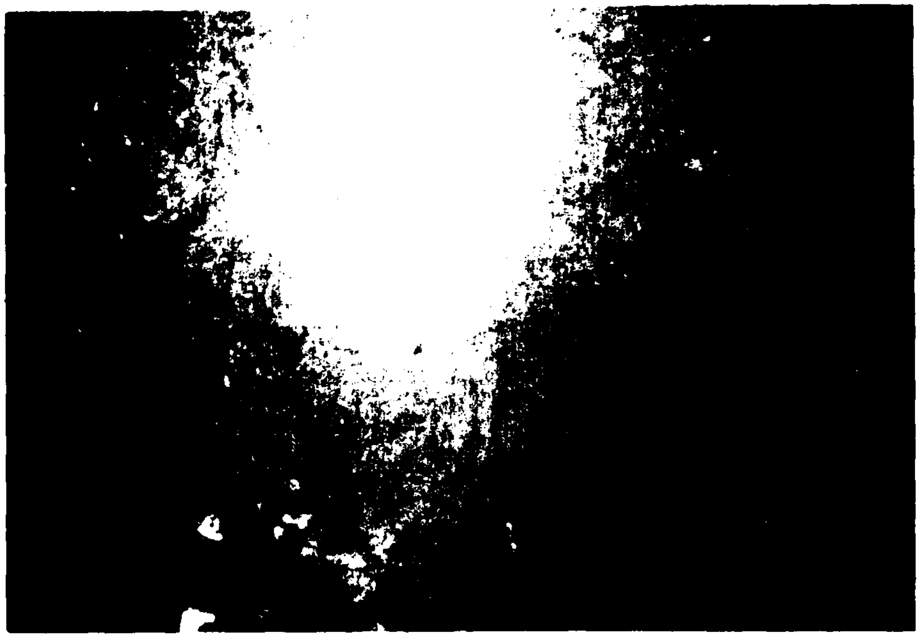


14. Pile L-18D at the bottom. Photo is of a bottom corner of the 18 inch square pile before picking. See Photo 15.

15. Pile L-18D at the bottom showing indentation in concrete made by several blows of the hand pick.

16. Pile 11-B at top. Evidence of rusting of the reinforcing steel is shown by rust stain.

17. Pile 11-B at top showing two areas of indentation made by hand pick.



18. Pile 11-B at bottom. The reinforcing steel has rusted and swelled spalling off its concrete cover on entire side of 16 inch square pile.

19. Top of Pile 13-H showing extensive removal of soft surface concrete by hand pick.

20. Bottom of Pile 13-H showing indentation from picking. The surface of the corner reinforcing steel bar is exposed.

21. Bottom of Pile 13-H before using hand pick. See photo 22.

22. Bottom of Pile 13-H after using hand pick. Note whiteness of the exposed surface of the indentation.

23. Photo of the top of 15-E showing pick marks. Note the biological growth on the right where pile was not cleaned. This growth is typical on all piling.

24. The bottom of Pile 15-E showing corner spall made with hand pick.

25. The top of Pile 21-C showing result of picking at corner of pile on a surface already ravelled by sulphate attack.

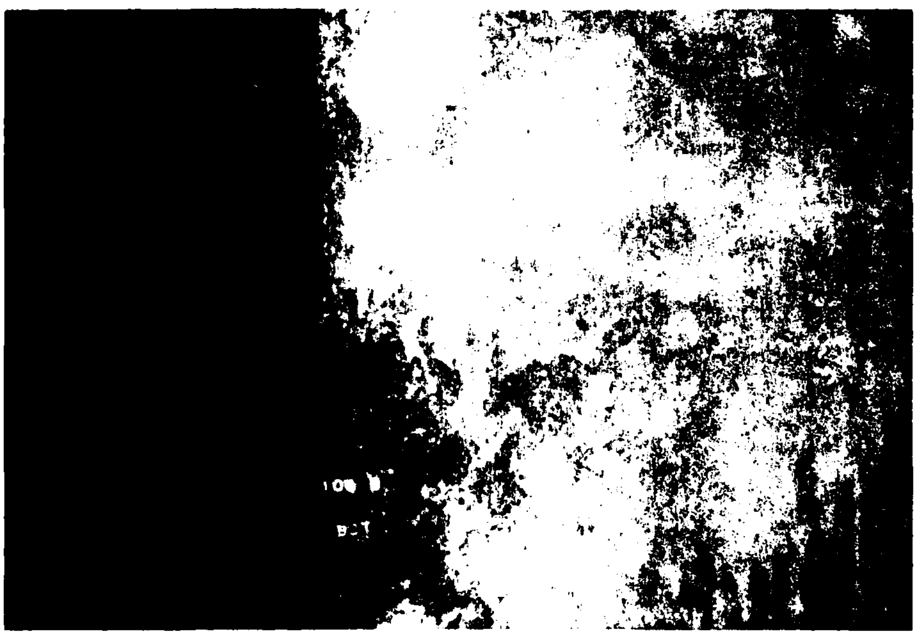
26. The top of Pile 21-C showing the result of picking to expose the corner reinforcement bar.

27. The top of Pile 39-F showing a large corner spall which resulted from rusting of the corner bar. This pile was cleaned in its full length. The hand scraper and wire brush removed approximately 50% of the surface material during cleaning.

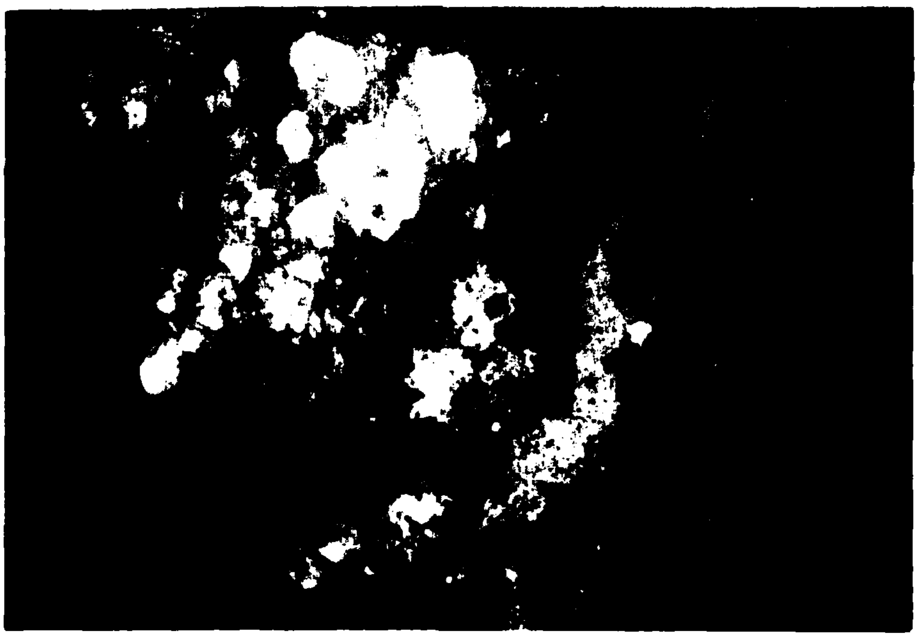
28. The bottom of Pile 39-F showing the indentation made with the hand tool. Iron rust bleed is in evidence.

29. The bottom of Pile 39-F at another corner than shown in Photo 28.

30. The bottom of Pile 39-F showing past ravelling and new indentation from hand pick.



31. The bottom of Pile 105-B showing past ravelling of a corner of the pile and new indentation from hand pick.



32. The bottom of Pile 114-G showing the result of abrasion during cleaning and an indentation made by the hand pick.

4.2 DISCUSSION OF PERTINENT CHEMICAL DAMAGE

This discussion is predicated on information found in the attached Bibliography; in discussions with Peter Hawkins, Chemical Engineer of the California Portland Cement Company; Robert Tobin, Civil Engineer of the Portland Cement Association; and the experience of many years of observation of concrete structures and their problems by the writer.

The evidence of deterioration observed by the Blaylock-Willis and Associates' divers at Pier J/K during the period June 15 to August 28, 1981, is sufficient to indicate that there is considerable loss of strength in the piling in question, as the concrete in many places is soft enough to be chipped away with an archeologist's pick and is unusually white in color. In general, where a gray matrix of the cement-water paste would be expected, there is a white material which has the appearance of gypsum and which in all probability is gypsum. The evidence is considered insufficient to accurately delineate the complete chemical composition of the damaged area or the decomposition process. This would have to be the result of a chemical analysis. "The mechanism of concrete corrosion is extremely complex for it depends on a certain number of parameters which are not always easy to isolate and which react in varying degrees according to the composition and the exposure of the material."[3] However, research has led the writer to believe that the reactions described later in this report could be the cause of the damage -- at least those reactions appear to fit the evidence.

The damage to the piling is somewhat surreptitious -- many of the damaged piles appear to be sound; there is not in many cases the surface appearance

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(3) *Bibliography, Page 65*

(ravelling) associated with sulphate attack. However, chipping with a pointed instrument, in this case an archeologist's pick, removed material in the below-water region.

The literature makes reference to the aggressive ions in salt water. This reference is to the chlorine, the sulphate and the magnesium ions. The sulphate ion particularly has been the cause of much deterioration of concrete structures in the past.

One of the four principal compounds in cement is tricalcium aluminate ($3CaO.AL_2O_3$) which has the abbreviation "C_3A." Apparently this compound is the principal target of attack for the sulphate ion, such that restricting the percentage of C_3A in the cement composition serves to reduce the amount of damage from sulphate attack.

".....Sulphate-resisting portland cement has a low content of tricalcium aluminate.......which is the compound in portland cement that is least able to resist chemical attack.

"The most promising cement of this type, as recommended by the U.S. Bureau of Reclamation, has less than 50 percent C_3A and less than 12 percent C_3A+C_4AF, in which less than 4 percent is C_3A. It has, after curing, a low content of hydrated lime. A requirement of ASTM Standard C150 for Type V cement is that the content of C_4AF plus twice the amount of C_3A shall not exceed 20 percent. The above-mentioned value of C_3A is based on chemical analysis rather than x-ray diffraction which gives a lower result. Portland cements approaching this composition, particularly with respect to C_3A, will give excellent service in cement-rich, densely compacted, properly cured concrete.

"This cement is designed to resist attack by mineral sulphates in ground waters and subsoils, which contain sulphur trioxide in amounts up to 0.1 percent and 0.5 percent respectively. The characteristics of the cement .....indicate its suitability for use in aggressive environments such as heavily polluted or humid industrial atmospheres, sea water, factories and sewers....."[2]

Present-day Portland cements are divided into five types. The literature presents a somewhat confusing picture of the percentage of C_3A in the various cements. This is partly the result of the use of different means of determining this percentage, chemical analysis as opposed to x-ray diffraction. The Portland Cement Association shows the C_3A percentage to be somewhat less than the limitations delineated in ASTM C150 or CSA A5. They describe these percentages as typical with the implication that the American Portland cements are well within the restricting criteria.[1,5]

A long-term study resulting in two excellent references was conducted by the Portland Cement Association in which several hundred samples of various mixes of Portland cement were exposed to sulphate soils. The study was conducted over a period of twenty years and results in part in the following conclusion:

"....conclusion No. 3[6] may now be supplemented to state that in addition, a C_3A content of about 5.5 percent as corrected for minor oxides and about 3.5 percent as determined by x-ray diffraction are fairly good values for separating superior and poor performance of the 7-bag concrete."[7].......in soils containing a high percentage of sulphate ion.

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(2) *Bibliography, Page 19*
(1) *Bibliography, Page 16*
(5) *Bibliography, Page 28*
(6) *Bibliography, Page 33*
(7) *Bibliography, Page 14*

Type I normal cement has approximately 11 percent of C_3A. Type II cement, which is considered to have some moderate sulphate attack-resistance capability, has 5 percent C_3A according to PCA's typical table and 8 percent according to the ASTM C150 limitations. Type V sulphate-resisting cement has a C_3A content of 4 percent typically, and 5 percent the ASTM limitation.

Hawkins relates that only Type I was available on the West Coast of the United States through the 1930's. About 1940, Type II cement became available and approximately a decade later, or at least in the later '40's, Type V cement became available.

The observations at Pier J/K included the evidence that although the material was softening, it was also swelling, and where past spalling cracks had occurred at the corners of the square piles, many of these cracks had healed, indeed were filled with a gypsum-like material or with oxides or iron - hemotite (FE_2O_3) which is red, magnitite (FE_3O_4) which is gray-black, or ferrous oxide ($FE\ O$), also black and really incompletely oxidized iron. Also some autogenous healing (deposition in the crack of efflorescence as the result of limestone ($CaCO_3$) production) may have taken place.

While the sulphate ion in its reaction with C_3A affects the concrete, the chlorine ion is principally responsible for the rusting of the steel as its presence ".....causes the loss of passivity provided by the normal alkali protection of free lime in hydrated cement....."(3)

It was apparent from observing the steel uncovered that little chloride ion or oxygen had been able to penetrate through the softened cover material to the steel as several of the bars, while covered with very soft material,

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(3) *Bibliography, Page 177*

still exhibited their surface deformations. This evidence is consistent with the physical facts regarding the ettringite crystal. Ettringite has the formula "$3CaO \cdot AL_2O_3 \cdot 3CaSO_4 \cdot 31H_2O$." Obviously, with all the water of crystallization in it the ettringite is a much larger crystal than the parent C_3A so that swelling, increased density and spalling seem like logical results of the sulphate attack.

To the observer's eye, the piles at Pier J/K exhibit evidence which is not entirely consistent with what has been described above in regard to the presence of ettringite and in regard to the description of sulphate deterioration expressed in some of the literature.

"The deterioration of marine structures constructed with mortar or concrete are of chemical and physical nature. If the structure is fully immersed, the attack on the material by sea water is essentially chemical. It is related to the dissolution of lime and to the expansive formation of ettringite which lead to erosion, swelling, cracking and spalling. In alternating immersion and exposure conditions the attack is of chemical and physical nature. The mechanical action of the waves, the swelling and shrinkage caused by the alternate saturation and drying, atmospheric conditions (wind, exposure to the sun, freezing) and the electrochemical corrosion of steel reinforcement are physical processes which add to the chemical destruction processes."(3)

In the presence of ettringite infested concrete, the writer would expect to see a raveled surface. Many of these concrete piling, while soft to the archeologist's pick, exhibited smooth, undamaged surfaces even after cleaning with hand scrapers. Incidentally, the adjacent quaywall, which is con-

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(3) *Bibliography, Page 64*

structed of reinforced concrete sheet piling does exhibit badly ravelled surfaces and soft surface materials, the appearance generally associated with sulphate decomposition. The above reference would lead to the expectation that the sulphate damage would be greater in the tidal range. It speaks of the mechanical action of the waves and swelling and shrinkage due to saturation and drying. The inspection of these piles indicated very clearly that concrete material in the region below low water exhibited the greater damage, that indeed the tidal range concrete was quite sound. Although this evidence may not be consistent with the literature, we submit that the greatest opportunity for sulphate damage to be progressed should be favored by the material in the water for the longest period of time.

The matter of gypsum occurring in the concrete is of some interest. The literature suggests that another sulphate reaction with the cement is possible. That is the formulation of gypsum $(CaSO_4.2H_2O)$[4] from calcium hydroxide which is $Ca(OH)_2$. To begin with, there is a small amount of gypsum already present in the unhydrated cement.

"The final grinding is done with a 3 to 5 percent addition of gypsum, which retards the hydration of the aluminate component of the cement and renders it fit for use; raw cement otherwise would have a tendency to flash set on the addition of water."[2]

However, the amount of white substance which we presume to be gypsum evidenced in the damaged concrete was much higher than that percentage. The best evidence supports the presence of ettringite and gypsum with other chemical reactions also taking place. All of our references point out

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(2) *Bibliography*, Page 6
(4) *Bibliography*, Page 525

the fact that the nature of chemical activity between salt water and the cement particle is very complex with the principal culprit being the sulphate ion.

4.3 DISCUSSION OF PERTINENT BIOLOGICAL DAMAGE

At least one of the previous reports of inspection of Pier J/K has suggested the presence of damage due to water-borne biological species. Any considerable discussion of this subject is considered beyond the scope of this report. However, a few comments regarding the various phyla present at the Pier limited by the circumscribed knowledge of the observer -- of salt water biology -- would not be out of order.

The only recognizable animal observed to be occupying the interior of the concrete columns was a species of *Polychaeta* which we would guess to be the *Pareurythoe Californica.* [8] It was revealed on several occasions in the column cross section when chipping off corners of the columns.

It is reasoned that the swelling of the surface of the columns is due to the growth of ettringite which causes the corners to spall away from the cross section at a depth of an inch or two. The resulting crack -- a 45 degree diagonal across the corner, provides habitat for the crack dwellers including the *Polychaeta.* But then this hardly constitutes damage from bio species. The damaging crack occurred before the worm occupied it.

No species resembling *Pholadidae*[8] were observed or were burrows or holes purported to be the result of their presence observed.

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(8) *Bibliography, Page P138*
(8) *Bibliography, Page P126*

4.4 STRUCTURAL REVIEW OF PILING

The concrete piles supporting the 1921 original pier and the 1930 addition are conventional reinforced piling. The 1958 addition used prestressed concrete piles which are presently in excellent condition.

Because of the observed damage to the 1921 and 1930 piling, most of the attention of this report is directed to them.

Any structural pile performs its function as a column. Therefore, the design criteria that is applicable to the design of columns applies to the design of structural piling.

The years between 1920 and 1981 have witnessed changes in the methods of designing reinforced concrete columns as well as a great change in the definition of the lateral forces to which piles may be subjected.

It is unfair to criticize the design of a structure designed to the requirements of codes developed before the present "state-of-the-art," but it is certainly proper to show where previous designs no longer conform to present requirements. It is intended here to check the original designs and compare them to currently applicable working stress design, assuming that the piling concrete and reinforcing are sound.

Unfortunately, the exact design cross section of the typical Region I (1921) pile is not available, so that assumptions must be made as to the amount and configuration of its reinforcing. The piles measure

14 inches square. It is assumed that the requirements of the ASCE Special Committee Report of 1916[9] applies to the original design. The 1921 dredged depth also must be assumed as no firm information regarding this figure is available. The figure EL -25 MLLW is suggested by the work of other engineers concerned with Pier J/K. A higher bottom elevation would favor the pile as a slender compression element, but the fact that the Aircraft Carrier LANGLEY, and later the first RANGER and the LEXINGTON were both berthed alongside would suggest a deeper dredge elevation so that -25 is used with the understanding that it is probably generous to the original design. Present mudline elevation of the north side of Region I is about EL-23 to EL-27 MLLW as shown on NAVFAC Drawing 6003912 (1973).

The section properties of the 1921, 14 inch pile (see Figure 5) are assumed as follows:

1. Clear cover for the principal reinforcement equal to 1-1/2 inches. This is small for a salt water pile by present standards (DM 25.6[15] requires 3 inches), but could have been satisfactory for that day. The lesser cover disfavors the steel which rusts in the presence of too little cover, but favors the design of a buckling member because the Moment of Inertia (I) and the Radius of Gyration (r) of the transformed area are increased.

2. The effective diameter is equal to 11 inches. This is the clear distance inside the cover, and conforms to the total net area criteria of the time.[10]

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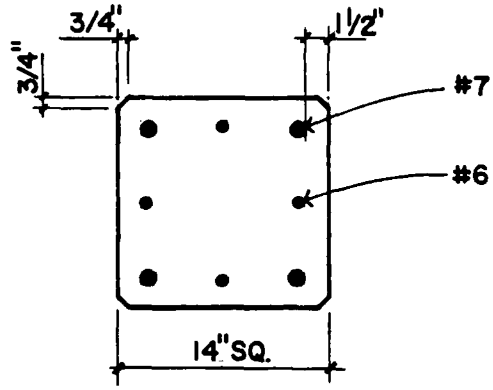
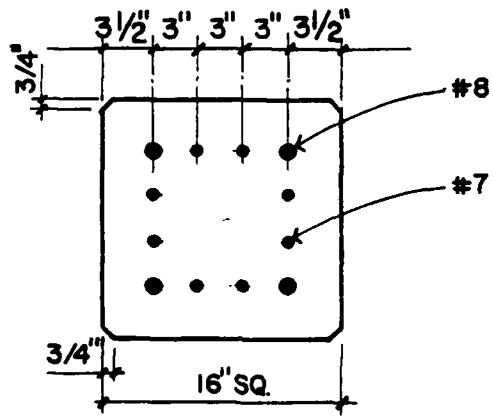
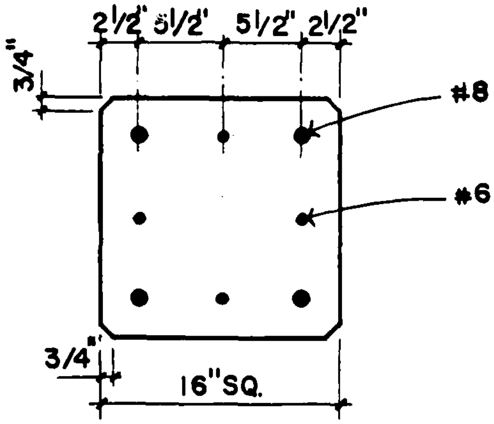
(9) *Bibliography, Page 1688*
(15) *Bibliography, Page 8*
(10) *Bibliography, Page 373*



1921 PILE CROSS SECTION SHOWING ASSUMED REINFORCEMENT



1930 PILE-UPPER 17'



1930 PILE-BELOW 17'

FIG. 5

PIER J/K
NORTH ISLAND, SAN DIEGO, CA.

Blaylock-Willis and Associates
STRUCTURAL ENGINEERS SAN DIEGO, CALIFORNIA

3. Longitudinal reinforcing is equal to 4 percent (*4 - #7 and 4 - #6*) of the effective area and in a square pattern. This is the upper limiting percentage of steel (p) allowed by the Special Committee Report.

4. The 28-day compressive concrete strength (f'_c) is equal to *3000 psi*.

The surface of the mudline is incapable of providing lateral support for buckling members so that the unbraced length of the pile should be considered to extend some distance below the mudline. Assuming upper fixity (an analogous pin) to occur at the base of the cap beam at El +5 MLLW and the mudline at EL -25 MLLW, the buckling length must be in excess of 30 feet. DM 25-6 would have us add another 7 feet.

Our authority for treatment of long columns, the Los Angeles Building Ordinance applicable in 1918, limits the slenderness ratio (ℓ/d) of long columns to $\ell/d = 30$. The ℓ/d of the 1921 piles is:

$$30 \times 12/11 = 32.7$$

without consideration of unbraced distance below the mudline. It would appear that the 1921 piles do not conform to the slenderness requirements of their own time.

Neglecting slenderness for the moment, the load capacity (P) of the column by the 1916 Special Committee Report is given as:

$$P = f_c A[1+(n-1)p]$$

$$= .225 \times 3000 \times 121 \ [1+(10-1).04]$$

$$= 111{,}100 \text{ lbs or } 111.1^k$$

Actual load by tributary area:

$$\text{Dead} = 260 \text{ psf}$$

$$\text{Live} = \underline{550} \text{ psf}^{(11)}$$

$$\text{Total} = 810 \text{ psf}$$

$$P \text{ actual} = 9' \times 10' \times 810 = 72.9^k$$

which is less than the design capacity of 111.1^k. Referring again to the Los Angeles Building Ordinance formula for long concrete columns and solving for the unbraced length, ℓ

$$\text{Reduction} = 1.6 - 1/25 \ (\ell/d)$$

$$\text{or } 72.9^k / 111.1^k = 1.6 - 1/25 \ (\ell/11)$$

$$.66 = 1.6 - \ell/275$$

$$\ell = 21.5 \text{ feet}$$

or a bottom elevation of -16.5 MLLW, much higher than the depths observed in the water.

Checking the 14 inch columns by later (1963) working stress criteria[12]

$$P = .85 \ Ag \ (0.25 \ f'_c + fs \ p_g \ )$$

where:

$$P_g = 4.16/196 = .021$$

using steel with a yield point of *32,000 psi*:

$$P = .85 \times 196 \ (0.25 \times 3000 + 12{,}800 \times 0.021)$$

$$= 169.8^k$$

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(11) *Bibliography, Page 10*
(12) *Bibliography*

Applying the ACI 318-63 long column criteria assuming the displacement of the ends of the column is prevented and single curvature is the deflected shape, with unbraced length equal to 30 feet, the load reduction factor (R) is:

$$R = 1.07 - 0.008\ h/r$$

$$= 1.07 - 0.008 \times 30 \times 12/4.0 = 0.35$$

and

$$0.35 \times 169.8^k = 59.4^k$$

which is less than the actual load computed above of 72.9^k.

The 16 inch square piles of Region II are detailed in Sheets 1 through 3 of the plans entitled, "Extension of Station Pier, July 11, 1930." (See Figure 5.) They show the upper 17 feet of the pile to be reinforced with *4 - #8* and *8 - #7* with lesser reinforcement *4 - #8* and *4 - #6* below. This does not appear to be good design as the region of the greatest bending under the effects of lateral forces is in the lower length of the pile. Addressing these piles with the 1930 criteria [13]:

$$P = (A'_c + A_s n)\ f_c$$

$$= (248 + 7.9 \times 10)\ .2 \times 3000$$

$$= 327 \times 600 = 196.2^k$$

Referring to the long column reduction formula of the 1930 Code using the core area as defined (the area inside of the cover concrete) and an unbraced length (h) of 30 feet:

$$P' = P(1.33 - h/120R)$$

$$= P(1.33 - 30 \times 12/120 \times 2.5)$$

$$= 196.2^k \times .12 = 23.5^k$$

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(13) *Bibliography*

Checking the load capacity of the 16 inch square columns by the ACI 318-63:

$$P = .85 A_g (0.25 f'_c + f_s p_s)$$

$$= .85 \times 256 (750 + 12,800 \times .031) = 249.5^k$$

Applying the long column reduction:

$$P = 249.5 \times 0.44 = 110.8^k$$

Further, referring to unbraced criteria of DM 25.6[15] for an estimate of the unbraced length:

$$d = 1.8 (EI/n_h)^{.2}$$

$$d = 1.8 (3 \times 10^6 \times 5461/50)^{.2} = 7.6'$$

$$h/r \text{ becomes } 37.6 \times 12/4.6 = 98.1$$

$$R = 1.07 - .008 \times 98.1 = .285$$

$$P = 249.5 \times .285 = 71.1^k$$

very close to 72.9^k, and considered satisfactory. It is therefore concluded that the 16 inch piles would satisfy their intended purpose so long as the concrete and reinforcement is in good condition and no seismic forces are applied to the pier in the longitudinal direction.

As described at the beginning of the section, the comparison made here of the original designs with current working stress design is made assuming undamaged concrete and reinforcing. This assumption is unfortunately not the case. Both concrete and reinforcing have sustained damage in the 1921 and the 1930 sections.

Furthermore, no formal recognition of current seismic design criteria has been made in these calculations. Seismic forces applied to the piles will result in cantilever bending which will further stress them.

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(15) *Bibliography, page 3*

4.5 FINDINGS AND CONCLUSIONS

The conclusions to be drawn from this investigation of the Pier J/K piles include the following:

The 14 inch piles in Region I do not meet the gravity load design requirements of their own time or of the present time. The 16 inch piles in Region II do not meet the gravity load design requirements of their own time, but come very close to meeting those requirements of the present time. However, neither pile would be expected to resist the combined stresses generated by both gravity and a design earthquake as defined in NAVFAC P-355[16].

Sulphate deterioration has infested the Region I and Region II piling, considerably reducing their ability to support loads. While this investigation is not considered to be completely comprehensive (chemical analysis, testing of core samples and some investigation below the mudline would be needed for that) it is the feeling of the writer that there is sufficient evidence to restrict live loading to the pier.

It remains to be determined what restriction to make to the future loading on Pier J/K. The sulphate deterioration, of course, will continue. However, the pier presently and for the next few years does have some reserve live load capacity. The question is how much. The depth of chemical damage is limited. The diver engineer observed that the concrete clearly became harder as chipping progressed deeper from the surface. However, in many cases, the concrete was

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(16) *Bibliography, Section 1*

soft beyond the plane of the reinforcing steel. What performance can be expected from a brittle material long column of varying hardness where the reinforcing steel is separated from the competent concrete by soft material is very much in question.

If we assume an average of 3 inches of damaged concrete on a critical pile with the damaged material still acting to provide cover for the reinforcing steel and bulk to a member susceptible to buckling, a percentage reduction in gravity load capacity can be estimated. It is assumed that the steel cross section on the average is impaired to the extent of 20 percent of its original load carrying value. The 3 inch reduction on all sides of the gross concrete section reduces the 14 inch column to an 8 inch section and its area from 196 to 64 square inches. This is a 67 percent reduction. In the 14 inch columns, we computed a steel load capacity (unreduced for slenderness) of 44.8^k. The 20 percent decrease reduces this figure to 35.8^k. Total load then would change from 169.8^k to 77.1^k, a 55 percent reduction with 45 percent of capacity remaining.

For the 16 inch columns, the steel load capacity, unreduced, was 86.3^k. Decreased by 20 percent it becomes 69.1^k. The concrete capacity reduces from 163.2^k to 63.7^k and the total load capacity reduces from 248.5^k to 132.8^k, a 47 percent reduction leaving the column with 53 percent of its original capacity.

Under conditions of seismic forces applied longitudinally (east to west) to the pier, the piles act as vertical cantilevers subjected to bending loads as well as the gravity loads described above.

The further investigation of reduction in lateral force capacity considering the lateral forces acting alone, the damage as described above, and the load reduction a function of the Moment of Inertia of the uncracked, transformed section of the pile, shows the remaining bending capacity of the pile to be approximately 29 percent of its undamaged capacity. This serious reduction is compounded when gravity and seismic forces are combined.

4.6 RECOMMENDATIONS

The literature addresses recommendations for the repair of reinforced concrete piling which have been damaged by sulphate attack. A popular one appears to be the jacketing of the deteriorated piling with new reinforcing concrete outboard of the old cross section. The writer would be apprehensive of recommending a repair of this nature. It cannot be presumed that the sulphate attack will stop at the mudline. Any repair continuing below the mudline would require exposing additional length of the piles, additional length of deteriorated columns susceptible to buckling. The repairs would be exorbitantly expensive and hazardous to the repair crew. Repair of the facility is not considered appropriate.

Considering the apparent load capacities, it would appear that Pier J/K has a reserve of live load capability in the vicinity of 100 pounds per square foot. It is then our recommendation that the pier be posted for a live load of that magnitude and that the 15 ton crane limitation recommended by the Ferver Engineering Company[11] be retained.

It is further recommended that the pier be considered to have a remaining useful life no greater than five years.

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(11) *Bibliography*

5.1 PERSONNEL ON PROJECT

During the course of the inspection, varous of the personnel listed were at the site.

1. Chesapeake Division Personnel:

   Walter J. Tudor, Professional Engineer, EIC

   Wade Casey, Assistant EIC

2. Blaylock-Willis and Associates Personnel:

   A. J. Blaylock, Civil/Structural Engineer

   Carl Teyssier, Civil Engineer

   Daniel McNaughton, Civil/Structural Engineer

3. Marine Services, Inc. Personnel:

   Thomas Devine, President, Commercial Diver

   Mark Biddy, Commercial Diver

   George Benny, Commercial Diver

   Walter Mynatt, Boat Operator

   Randy Lowen, Commercial Diver

   John Starkey, Commercial Diver

   Tony Wells, Photographer, Commercial Diver

5.2 LOG OF UNDERWATER INSPECTIONS

DIVING REPORT - PIER J/K - June 15, 1981

Blaylock-Willis Personnel: A. J. Blaylock, Dan McNaughton

ChesDiv Personnel: Wade Casey, Walter Tudor

Marine Services Personnel: George Benny, Tom Devine, Walt Mynatt

The day was hot and sunny, all day. The temperature reached a record for this date. The water temperature was estimated at 74°.

The fleet oiler, CIMMARON was berthed on the north side of the pier. It went to sea at 1330. Barges were berthed on the south side of the pier, but presented little obstruction to diving.

Our plan was to make a dive at J/K this morning and mark the ends of the pile cap bents with their numbers so that we and the commercial divers who will commence cleaning on Tuesday, June 16, can make quick determination of our locations throughout the program.

We had previously prepared a plan layout of the pier from drawings of previous Pier J/K projects. Our plan was intended as a working sheet with all piles located.

Early in the day, we discovered that our drawing was not accurate -- there being more piles than we had shown, some in unexpected locations. Apparently, previous "as-built" drawings had been made by working from a boat. The complexity and the low elevation of crossing utility lines would make the locating of piles nearly impossible between bents 13 and 29. We intend to correct our drawing before we finish the program.

We arrived at the pass office at 0730, got our passes and met Casey and Tudor. We spent a little time discussing our plans and proceeded to the Station Civil Engineer's office. Don Lydy directed us to check with the CIMMARON before entering the water.

Met Tom Devine, president of Marine Services, and his superintendent, George Benny at the pier. We confirmed that Devine's cleaning crew would commence work at 0730 tomorrow, that I would mark piles to be cleaned entirely (6) and piles to be banded (84) and confirm that their work was proper and satisfactory as it progressed.

Tom had brought a steel work boat for our use, which proved to be too unwieldy, so that we used it very little in marking or diving.

The pier and its utilities are so low in the water and the wakes of passing vessels so violent, that the use of a small boat under the pier becomes dangerous. It became quickly evident that both marking and diving could be best accomplished from the water and the fender system.

We proceeded to mark the bent lines commencing at the west end, Bent 1, and proceeded east. In the course of the morning, we marked the southern end of each pier line and the northern end of some of the lines.

I went into the water at 1030 and remained until 1230, marking piles. Dan worked from the wales and blocks. Went back into the water at 1335 with Wade Casey for the purpose of making a quick surveillance swim-by of all the piles.

It quickly became evident that that type of inspection was not in order. The piles above water or in the splash zone exhibit different characteristics than in the region where they are continuously wet. The upper region concrete appears hard to blow of a geologist's pick while the below-water concrete can be chipped away. It was then decided to look at all the piles to at least some small distance below LLW and a significant number to the mudline.

Wade and I started at line BB inspecting piles as described. We looked at all piles on the stem of the pier through Line J and all under the pump house. He remained with me throughout the afternoon until we emerged at 1445.

The piles below water are soft to the pick or diver's iron - although the softness and its depth vary from pile to pile, and varies at different locations on the same pile -- even at the same elevations. The concrete has not the usual gray appearance of Portland cement paste, but is white as with gypsum. Dryed, it can be crushed to a powder between the fingers.

Pier J/K is composed of three sections built at different times. Region I was constructed in 1921; Region II was constructed in 1930; and Region III in 1958. The Regions I and II are supported on square piles. Region III is supported on octagonal piles. All of the damage described is limited to Regions I and II. The octagonal piles are probably prestressed -- no single evidence of damage, chemical or physical, was observed during the three days of initial investigation to any of these piling.

Wade and I found five piles in the Region I area that showed significant softness and selected two to be cleaned entirely and eight to be banded.

We noted that no diagonal piles were shown on the working drawings which had been provided to us.

Dan and I brought Devine's boat around to the west and departed the Station at 1530.

A. J. Blaylock

DIVING REPORT - PIER J/K - June 16, 1981

Blaylock-Willis Personnel: A. J. Blaylock, Carl Teyssier

Chesdiv Personnel: Wade Casey, Walter Tudor

Marine Services Personnel: Mark Biddy, John and Randy. Tom Devine made one visit this day. Walt Mynatt.

The weather was very hot, a "Santa Ana" condition. Water visibility was 18" to 3'. Temperature of water 74° to 76°.

We entered the Base at 0720. Spoke to the commercial divers, indicated where we wanted piles cleaned. They had their big work boat on site and commenced the cleaning activities about 0830.

I entered the water at 0820 at the western extremity of the pier and proceeded to inspect the piles proceeding back and forth laterally across the pier, working to the east. Out at 0930.

During the first two hours of diving, I encountered several piles that indicated damage at such locations that it was difficult to see how it could have occurred due to mechanical means. Upon chipping these piles, I found that the exposed surfaces were white as of gypsum, identical to the experience on Monday. Came out of the water at 0936 at Line 13 and marked drawing for location of further cleaning and banding by the commercial crew. (In our lexicon, the term "cleaning" means cleaning the pile in its total height on all four sides. "Banding" is cleaning of two sections 24" high on three sides.) On the first dive, we noted specifically: (1) significant damage to pile 9H, (2) damaged southwest corner pile 11B, (3) line 12 piles B, C and D - considerable erosion throughout their length, and (4) line 13, B, F and H - significant damage.

Knocked off concrete samples at piles 9H and 13H. Had discussion with Wade and Walter about my observations and my curiousity that the cleaned cross sections appeared so white. [Later discussion with Peter

Hawkins indicates that what I was observing was indeed gypsum, the result of sulphate reaction with hydrated lime in the cement paste.)

Returned to the water at 1108 and emerged at noon, having observed the piles through line 21.

By this time, enough piles had been observed to realize that there was very little difference in the condition of the piles in Region I and Region II from one pile to the other.

I reentered the water at 1305, emerged at 1438. Returned at 1500 to review the piles cleaned by the cleaning crew. Out of the water at 1530. Left the Station at 1550.

A. J. Blaylock

DIVING REPORT - PIER J/K - June 17, 1981

Blaylock-Willis Personnel: A. J. Blaylock, Carl Teyssier

Chesdiv Personnel: Wade Casey, Walter Tudor

Marine Services Personnel: Mark Biddy, John Starkey, Randy, Walt Mynatt. Tom Devine made one visit this day.

On Base at 0730. The weather was somewhat cooler at North Island. Water visibility was 18" to 3', except that late in the day visibility was down to less than 12". Water temperature was 78°.

We discussed the day's activities with the commercial divers and laid out piling to be cleaned and banded. We were somewhat apprehensive for the condition of the young men during the cleaning because the weather is hot and the water is warm, and the work is very hard. We don't want to get anybody into trouble.

I entered the water at 0830 with Wade Casey and Walt Tudor to show them the piles that had been cleaned and banded, and the damage that had been noted in Monday's and Tuesday's reports. Out of the water at 0900.

Returned to the water at 0915 on grid line 65. Emerged at pile line 72 at 0957. Returned to the water at 1030. Walt Tudor in at 1040. Both emerged at 1130.

In the early afternoon, the wind came around to the southwest and was much cooler. I went into the water at 1310. Noted that the piles appeared to be in somewhat better condition between lines 94 and 97, but thereafter they appeared to be of the same quality as observed previously.

Out of the water at 1420. Returned at 1445 with Wade Casey. Out of the water at 1550 at line 115, having observed all the piles.

We stopped and discussed the project with the Station Facilities Planner, Don Lydy, and departed the Base at 1640.

Throughout the dive, there were barges tied up to the south side of the pier. However, they presented very little obstruction to diving activities.

A. J. Blaylock

DIVING REPORT - PIER J/K - June 18, 1981

Blaylock-Willis Personnel: A. J. Blaylock, Carl Teyssier

Chesdiv Personnel: Wade Casey, Walter Tudor

Marine Services Personnel: Mark Biddy, John and Randy. Tome Devine made one visit this day. Walt Mynatt.

The weather continued somewhat cooler this day. Water visibility was 18" to 3'. Water temperature was 78°.

Arrived at the Base at 0735. We spoke to the divers and transferred the remaining pile information to their drawing, so at that point they were informed of all of the piles to be cleaned and banded.

We spoke to Wade and Walter, and Wade left for Public Works Center to look for current plans. Walter was in the water with us off and on during the day. Wade returned late in the afternoon.

Spent part of the morning exposing rebars on piles 9H and 13H in preparation for video tape activities on Monday. Spent time with the commercial divers, helping with pile locations and took time to closely inspect the piles for typical damage, anticipating having to describe that damage to Peter Hawkins. I observed that in some places, the reinforcing steel had rusted and spalled off a section of the concrete outboard of its position. It appeared that the crack thus formed may have healed with iron corrosion. In some places this was red and obviously hemotite. In other places it was black which means it was either magnitite or ferrous oxide (FeO).

Peter Hawkins' later description of the development of the gypsum answered two questions. It accounted for the soft white material, and it also accounted for the obvious density of the material which in some places protected the steel reinforcing from any corrosion - the gypsum occupying more volume than the parent materials. The reinforcing steel bars observed appeared to be 6's or 7's.

I entered the water at 0900, out at 1000. In at 1045, out at 1145. In at 1340, out at 1450. Departed the Base at 1600.

One of the bars exposed on pile 13H had deformation very evident, so it was obvious that it had not corroded over the years. Its deformations were very similar to those shown for the Emeron Steel Producing Division, or the California Steel Company.

I shall measure the distance between the deformations and see if I can determine whose steel was used.

A. J. Blaylock

DIVING REPORT - PIER J/K - June 22, 1981

Blaylock-Willis Personnel: A. J. Blaylock, Carl Teyssier

Chesdiv Personnel Walt Tudor (Wade Casey left on Friday, 6/19)

Marine Services Personnel: John Starkey, Randy, Walt Mynatt. Tom Devine made one visit this day.

Weather: Hot and sunny all day. We are experiencing very hot days for June.

Water Temperature: Approaching a record, est. 78° today.

We arrived at the pass office at 0710 and the pier at 0730. We discussed the day's planned activities with the Marine Services personnel and Chesdiv personnel. Blaylock and Tudor entered the water at 0910. We commenced the investigation of the piles that had been cleaned and banded. It was decided that the folowing nomenclature would be used throughout out inspection of the piles. We have decided on six categories of hardness:

1. Hard: Pick rebounds without making significant indentation. Usually accompanied by a ringing sound clearly heard in the water.
2. Firm: Pick rebounds with a small indentation.
3. Moderate Soft: With 6 blows 1/4" of material can be removed.
4. Soft: 6 blows can remove 1/2" of material.
5. Very Soft: 6 blows removes corner of the pile or 1" of material.
6. Extremely Soft: Noticeably softer than "5."

Inspection commenced at the base of the pier stem at line zebra; however, workman was doing chipping hammer work that prevented proper communication with the diver's recorder so that we decided to delay the inspection of the stem section until later.

Proceeded to pile 1H and commenced inspection from there.

For a record of the day's inspection, see the attached.

Out of the water at 1055. CDR. Hartman, Staff Civil Engineer, and Don Lydy, Facilities Planner, arrived during the day and spoke to us. Walt

Tudor was present. We discussed our findings and the chemistry that we presume is resulting in the pile deterioration. Returned to the water at 1215. Out at 1600. Off Station at 1645.

A. J. Blaylock

DIVING REPORT - PIER J/K - June 23, 1981

Blaylock-Willis Personnel: A. J. Blaylock, Carl Teyssier

Chesdiv Personnel: Walt Tudor

Marine Services Personnel: John Starkey, Randy, Walt Mynatt. Tom Devine made one visit this day.

Weather: Hot and sunny all day.

Water Temperature: 78°.

We were on Station at 0730. CDR. Hartman had planned for a small boat so that I could show him at low tide this morning the exposed sections of deterioration exhibited by piling L-18D, 13H, and 9H. However, at 0830, the Commander and Don Lydy arrived in a very large launch with far too much free board for proper viewing of the piling. Blaylock entered the water skinning and exhibited with the pick how soft the concrete was. Spalled off two large corner spalls for CDR. Hartman.

Departed from the water at 0910. AJB back in the water with scuba at 0920. A record of the day's investigation is attached.

Out of the water at 1100. In at 1235. Walt Tudor came in at 1305. I departed from the water at 1535. Spoke with the commercial divers who had only a few piles left to clean and band (but at the deep end of the pier). Off Station at 1605.

A. J. Blaylock

DIVING REPORT - PIER J/K - June 24, 1981

Blaylock-Willis Personnel: A. J. Blaylock, Carl Teyssier, Dan McNaughton

Chesdiv Personnel: Walter Tudor

Marine Services Personnel: Tom Devine, George Benny, Tony Wells-Cameraman, John Starkey, Walt Mynatt

Weather: Hot and sunny all day

Water Temperature: 78°.

We came aboard the Station at 0750. We had expected Marine Services to be there at this time to commence video taping. In their absence, AJB entered the water at 0815. At various locations on the east end of the pier, we measured the depth of the mudline relative to the pier surface. Also checked for the size of extra piles at lines 91 and 93. Proceeded to line 19 with the intention of confirming pile sizes and location in this area when at 0845 Marine Services' working barge arrived.

We proceeded to make a video tape of the four piling in the vicinity of the pump house that we determined was proper for this exercise. Those piles were L-18D, northeastern pile under pump house, 9H and 13H. The first three piles had been cleaned entirely.

We were in and out of the water as required to properly perform the video taping. AJB manipulated the hammer. Tony Wells used the camera. We finished taping at 1021 and proceeded to get still pictures of the attached selected piling. In general, Tony took three exposures of each shot so that in the course of the morning we used three rolls of 24 shots and one roll of 36. However, all rolls were not entirrely consumed. We commenced the still photography at 1105. We broke for lunch at 1125. Back in the water at 1217. Photography was over at 1420 and we got out of the water.

McNaughton and Teyssier entered the water at 1445 for the purpose of finishing the inspection of the piles on rows K to Z, as well as to check the locations and sizes of piles in question at the middle section. However, as the tide came higher and the boat wakes appeared to be more frequent, we decided it was unsafe to continue the work in this region, so that Dan and Carl came out of the water before all of the work had been completed. They were out at 1600 and we departed from the Station at 1630. The few remaining piles in the stem area yet unchecked must be done at a later date.

A. J. Blaylock

PIER J/K NORTH ISLAND NAVAL AIR STATION
VIDEO TAPED PILES
JUNE 24, 1981

	Pile
1.	L-18D
2.	SWP (Salt Water Pumphouse)
3.	13-H
4.	9-H

June 24, 1981

PIER J-K NORTH ISLAND NAVAL AIR STATION

COLOR STILL PICTURES - PILES

Pile

1. L-18D
2. SWP (Salt Water Pumphouse)
3. 13-H
4. 9-H
5. 11-B
6. 15-E
7. 21-C
8. 39-F
9. 105-B

PIER J-K NORTH ISLAND NAVAL AIR STATION

	Pile	Depth	
1.	BB-18D	9'-11"	(Seawall)
2.	R-18D	15'-6"	
3.	1-H	25'-5"	
4.	1-B	35'-8"	
5.	13-H	19'-8"	
6.	26-B	32'-6"	
7.	61-B	35'-1"	
8.	87-H	33'-10"	
9.	92-H	33'-0"	
10.	115-A	40'-10"	
11.	115-H	35'-9"	

DIVING REPORT - PIER J/K - August 8, 1981
Blaylock-Willis Personnel: A. J. Blaylock, Carl Teyssier
Marine Services Personnel: Tom Devine
Weather: Suny after 1100, with cool breeze
Water Temperature: 75°

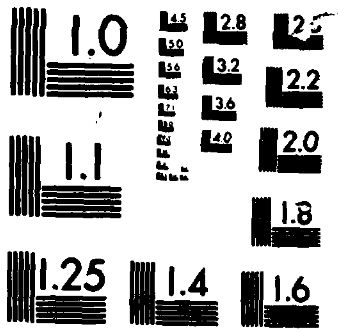
Entered Station at 0730 and proceeded to Pier J/K. Several ships were moored to the east-west extensions of the pier but were not obstructions to the dive.

I entered the water at 0815 and inspected the piles on the stem of the pier which had not been formally inspected in the sequence through June 24.

Out of water at 0930. Departed Station at 1000.

A. J. Blaylock

AD-A167 862 UNDERWATER FACILITIES INSPECTIONS AND ASSESSMENTS: PIER 2/2
J/K NORTH ISLAND..(U) BLAYLOCK-WILLIS AND ASSOCIATES
SAN DIEGO CA AUG 81 CHES/NAVFAC-FPO-1-81-(21)
UNCLASSIFIED N62477-C-81-0124 F/G 13/2 NL



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