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Creosoted Piling Investigation for the San Francisco-Oakland Bay Bridge: A Twenty-Five Year Study

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16. ABSTRACT

I. Introduction

Research Project 0.00138 concerning a life study of pressure creosoted fender piling for piers E-4 and E-5 of the San Francisco-Oakland Bay Bridge was instigated in 1934 as a result of a discussion between Mr. T.E. Stanton, Materials and Research Engineer of the California Division of Highways, and Mr. Richard Alpine of the Southern Pacific Company's Creosoting Plant in Oakland.

The objective was to organize a combined investigation between the Southern Pacific Company and the Division of Highways to determine the relative values of different weights of full cell pressure treatment in creosoted piling.

Piling was furnished under the Bay Bridge Builders Order No. 3579. Pressure treatment at the Southern Pacific treatment plant was maintained above the minimum of 12 pounds per cubic foot required by the Bay Bridge Specifications. The actual records were lost by fire.

The 120 piles employed were numbered individually before treatment and given permanent numbers after driving. An increment borer was employed to take core samples of each, and these samples were measured to determine the creosote penetration. Exhibits 1 and 2 in the Appendix identify the pilings and their position in each fender.

An initial report was issued on August 6, 1934. Subsequent examinations and reports were issued July 31, 1945, August 4, 1954, and August 20, 1959.

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STATE OF CALIFORNIA
DEPARTMENT OF PUBLIC WORKS
DIVISION OF HIGHWAYS

CREOSOTED PILING INVESTIGATION
FOR THE
SAN FRANCISCO-OAKLAND BAY BRIDGE
A Twenty-Five Year Study

March 1960

State of California
Department of Public Works
Division of Highways
Materials and Research Department

March 1960

Research Project 0.00138
Lab. Auth. 66-R-6024

F. W. Panhorst
Assistant State Highway Engineer
Department of Public Works
Sacramento, California

Dear Sir:

Submitted for your consideration is a report of:

CREOSOTED PILING INVESTIGATION

FOR THE

SAN FRANCISCO-OAKLAND BAY BRIDGE

A Twenty-Five Year Study

Study initiated under direction of . . . . . T. E. Stanton
. . . . . E. R. Hoffman
Work performed by and Reported by E. R. Hoffman and L. S. Hannibal

Very truly yours,

F. N. Hveem
Materials and Research Engineer

ERH/LSH:mw
cc: IOJahlstrom
ALElliott
HCWood (SFOBB)

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CREOSOTED PILING INVESTIGATION

SAN FRANCISCO - OAKLAND BAY BRIDGE

I. INTRODUCTION

Research Project 0.00138 concerning a life study of pressure creosoted fender piling for piers E-4 and E-5 of the San Francisco-Oakland Bay Bridge was instigated in 1934 as a result of a discussion between Mr. T. E. Stanton, Materials and Research Engineer of the California Division of Highways, and Mr. Richard Alpine of the Southern Pacific Company's Creosoting Plant in Oakland.

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II. SUMMARY AND CONCLUSIONS

The one concrete finding of this study is that it is reasonable to expect a 25 year service life from creosote pressure treated Douglas fir piles when subjected to salt water tidal conditions as found in the San Francisco Bay.

The 1945 examination showed marine borer attack in pile 103, pier E-4 (Exhibit 1), and that similar attack was evident in some of the fender timbers. A few bracing blocks were deteriorated.

The 1954 investigation showed pile 103 badly deteriorated. Diagonal bracing blocks showed additional marine borer attack. Fender E-5 (Exhibit 2) indicated ship damage, and the bases of the fenders also showed increased deterioration.

The 1959 investigation showed marine borer activity in seven piles to pier E-4 and six piles in E-5. Ship damage to piling had occurred at both piers, while decay* and splitting in piling tops had occurred with twelve piles on pier E-4 and one pile on the north end of pier E-15. Several diagonal braces and pile blocks were completely gone. The ship fenders were damaged in several locations. Galvanized bolts at the water line were showing distress.

No correlation is apparent between the depth of penetration of the creosote and the borer attack.

Life comparisons of this piling to the piling at the Carquinez Bridge and Dumbarton Bridge areas indicate that the service life of piling is markedly increased by the occasional presence of fresh water which kills the borers.

* The USDA forest pathologist for the west coast reports that the decay is due to the fungus Tremetes Serialis and is specific to Douglas fir and particularly to piling in the San Francisco Bay Area.

III. DISCUSSION

The Bay Bridge Specifications covering the creosoted Douglas fir piling employed for the pier fenders conform closely to the January 1930 Standard Specifications of the Division. Test reports are no longer available at the Laboratory due to the loss of such reports in the Laboratory fire of 1954, but the creosote conformed to ASTM test D28-24. The Southern Pacific Company treated 18 to 20 piles in each charge. A copy of their original treatment record is appended to this report. The minimum retention of creosote required by the specifications was 12 pounds per cubic foot of timber subjected to treatment. The average quantity of creosote actually injected per charge varied from 12.5 to 16 pounds per cubic foot. Measurements by means of an increment borer showed that a penetration of creosote ranging from 3/4 to 2 3/8 inches was obtained. It is to be noted that the green or wet piling were segregated and treated separately in charge number 160A and 162B. This includes piling numbers 94 to 113 and 117 to 121 inclusive. A longer bath and pressure period was employed for these piles. All charges were subjected to a short vacuum period after treatment to free the pile charge from dripping preservative. Such a practice is standard for full cell treatment.

The piles were delivered to the site and driven between May 14 and June 15, 1943. Pile number 73 was not driven due to a defect. After driving the assigned numbers for the piling were attached by means of number stamped copper plates, and the accompanying diagrams were prepared showing the location of the various piles about piers E-4 and E-5. These piers are immediately east of Yerba Buena Island in the ship channel area where the water depth is approximately 45 feet. The driving depth in the bay mud is reported to be 18 to 20 feet.

Pile 103, which first showed marine borer damage in 1945, was from the wet or green piling stock. The increment borer report shows a minimum penetration depth of 3/4 inch of creosote in this pile. The factors which contributed to the attack by the marine borers could have been due to some surface defect or damage at the water line associated with the minimum depth of penetration for the creosote, or since the piling is bolted to horizontal bracing in the tidal zone a slight spreading of the bolt hole opening could have exposed untreated wood. The net result is that the untreated core wood of this pile has been completely eaten out from the bracing level downward some 42" or more in depth. The cross sectional loss of core area is estimated at 60%.

The bulk of the other pilings which show marine borer attack suggest that such attack is probably more recent, and that the attack is also associated with the bolted horizontal bracing in the tidal zone. Wave action, chafing, and straining of the bolted joints, and loss of small saddle blocks have given marine

borer larvae access to untreated core wood in or about those bolt holes where the bolts have not maintained a tight seal.

Reports from various sources indicate that in the San Francisco Bay Area the bulk of marine borer attack is confined essentially to the tidal zones and that a minus tide normally exposes most of the attack zone. Inspection was made during such a minus tidal period. In most instances it was necessary to scrape the piling to remove the accumulation of marine shell life in order to expose the borer openings.

Thumping of the piling also revealed several cavities which were not otherwise apparent from the exterior. The probing of the cavities with the handle of the hoe scraper or geological pick indicated roughly the approximate amount of uncreosoted core wood which was missing from the defective piles. In most instances this loss represented 15 to 50% of the cross sectional area, leaving the pile as a hollow shell for a distance of several feet.

Damage by ship or barge collision was also noted. In one instance, as photographed, the piles had been bruised and partially split. The untreated core wood was showing some evidence of attack where the tie bolts had opened up the piling at the time of impact.

Decay was noted in several of the pile heads, and this consisted of "brown crumbly rot" sometimes improperly referred to as "dry rot". The piles were not provided with metal caps. Fine cracks and splits from weathering or ship damage had permitted this decay to gain entry into the piling. Two piles on the south side of pier 4 showed attack to a depth of three feet or more. The U. S. Forestry pathologist for the Pacific coast reports that this fungus attack is commonly attributed to Tremetes serialis and is more or less specific to the Douglas fir piling in the San Francisco Bay Area.

The attached piling charts indicate those pilings which show marine borer or other damage. The percentage values indicate the approximate cross sectional content of core wood deteriorated.

The major portions of the photographs are of marine borer damaged piling. In a number of instances the handle of a small geological pick which was employed for timber testing has been inserted in the opening to show the extent of the cavity.

Secondary observations made during the trip are that most vertical fender timbers have completely deteriorated where these were in the tidal zone. The diagonal bracings are still quite sound.

The galvanized bolts employed to tie the bracings and piling together are showing deterioration due to salt water. These bolts were originally heavily galvanized, but in some instances no galvanizing exists, and the salt water has corroded the steel away an eighth of an inch into the parent metal.

IV. INSPECTION PARTIES

June 28, 1945, inspection party

Mr. D. Ewing Marsh, Maintenance Superintendent, S. F. Bay Bridge

Mr. Richard Alpen, Manager, Southern Pacific Co. Creosoting Plant

Mr. Ralph Kipp, Jr. Testing Engineer

Mr. E. R. Hoffman, Associate Highway Engineer

June 2, 1954, inspection party

Mr. D. Ewing Marsh, Maintenance Superintendent, S. F. Bay Bridge

Mr. Larry Svoboda, Chemist, Southern Pacific Co.

Mr. Frank Mattos, Creosoting Consultant, Southern Pacific Co.

Mr. John Beaton, Supervising Highway Engineer

Mr. Ralph Kipp, Assistant Steel Inspector

Mr. E. R. Hoffman, Associate Highway Engineer

Mr. R. J. Ivy, Supervising Bridge Engineer

May 25, 1959, inspection party

Mr. D. Ewing Marsh, Maintenance Superintendent, S. F. Bay Bridge

Mr. M. W. Gerwertz, Engineer and Manager, South Bay Bridges

Mr. Suszka, Associate Bridge Engineer

Mr. Robert Anderson, Assistant Bridge Engineer

Mr. Larry Svoboda, Chemist, Southern Pacific Wood Department

Mr. E. R. Hoffman, Associate Highway Engineer

Mr. L. S. Hannibal, Senior Mechanical Engineer

V. REFERENCES

1. "A Proposed Standard for the Evaluation of Wooden Piles in Sea Water", Dockweiler-Stover.

2. "Extending the Life of Wood Piles in Sea Water", C. M. Wakeman-L. L. Whiteneck.

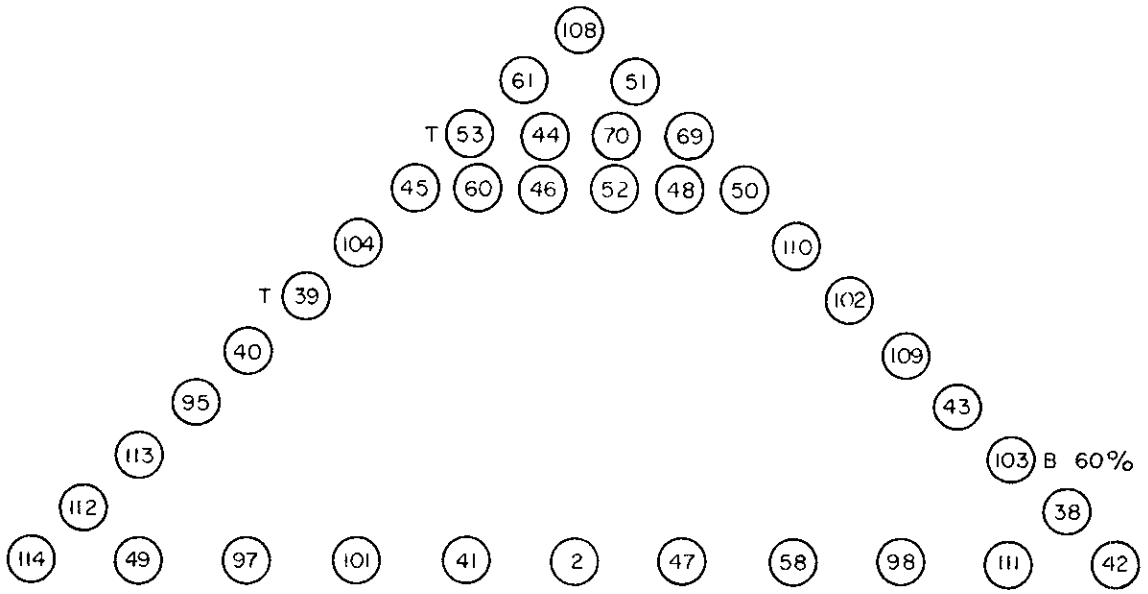
VI. APPENDIX

Exhibit 1	Piling arrangement Pier E-4
Exhibit 2	Piling arrangement Pier E-5
Exhibit 3 - 6	Photographs of Marine Borer Damage
Exhibit 7	Southern Pacific Creosoting Records

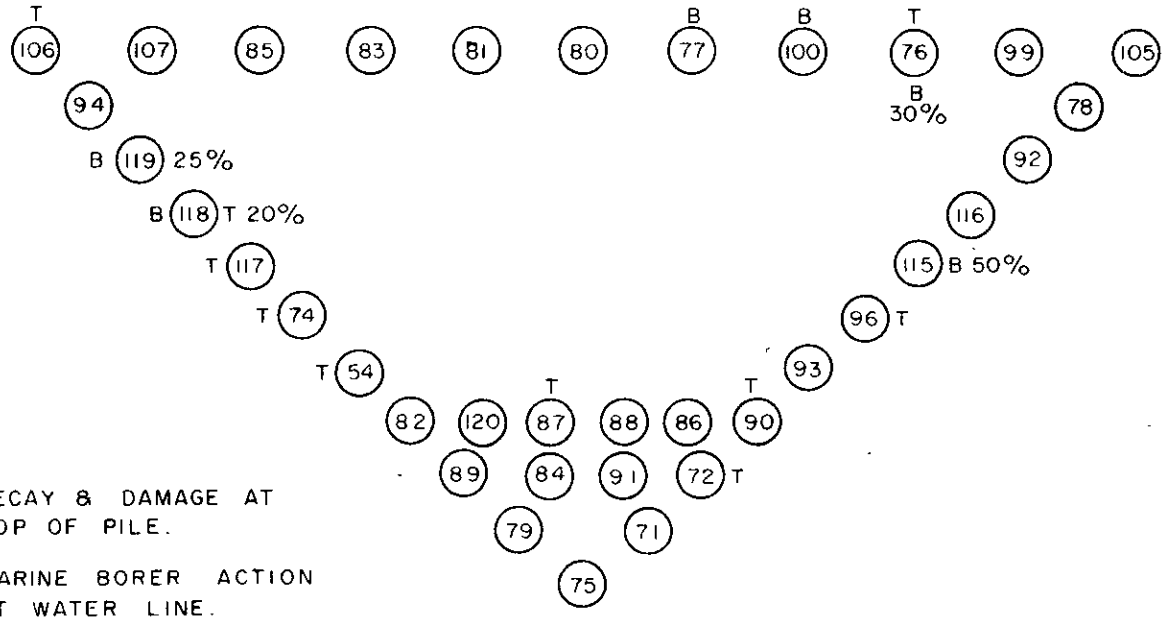
Exhibit 1

STATE OF CALIFORNIA — DIVISION OF HIGHWAYS
MATERIALS & RESEARCH DEPARTMENT

NUMBERING ON PILES OF FENDER OF PIER E-4



NORTH END OF PIER



T - DECAY & DAMAGE AT TOP OF PILE.

B - MARINE BORER ACTION AT WATER LINE.

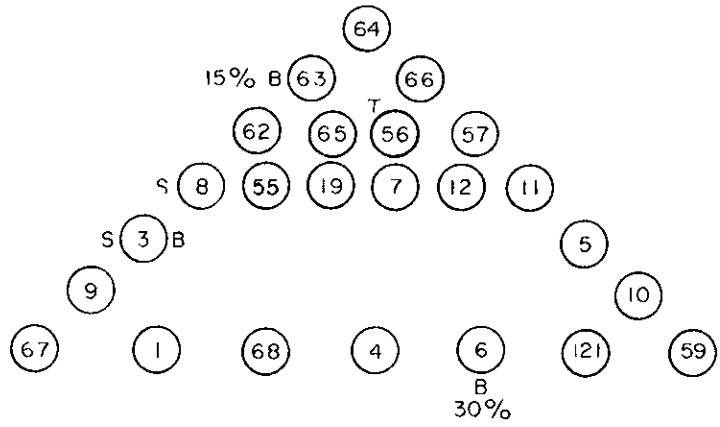
S - SHIP DAMAGE

SOUTH END OF PIER

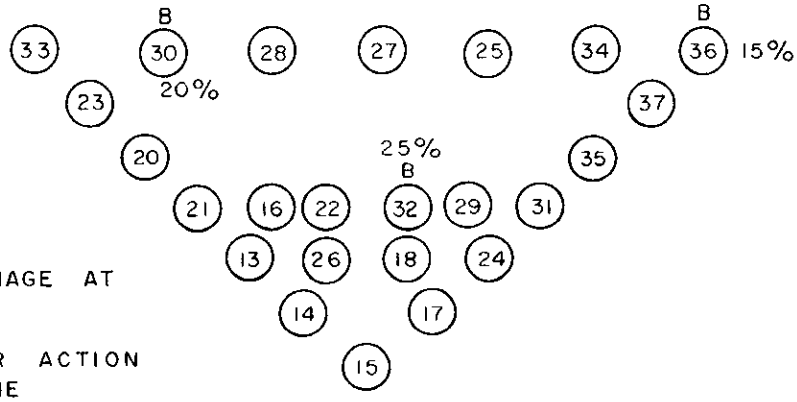
Exhibit 2

STATE OF CALIFORNIA-DIVISION OF HIGHWAYS
MATERIALS & RESEARCH DEPARTMENT

NUMBERING ON PILES OF FENDER OF PIER E-5



NORTH END OF PIER



T - DECAY & DAMAGE AT TOP OF PILE

B - MARINE BORER ACTION AT WATER LINE

S - SHIP DAMAGE

SOUTH END OF PIER

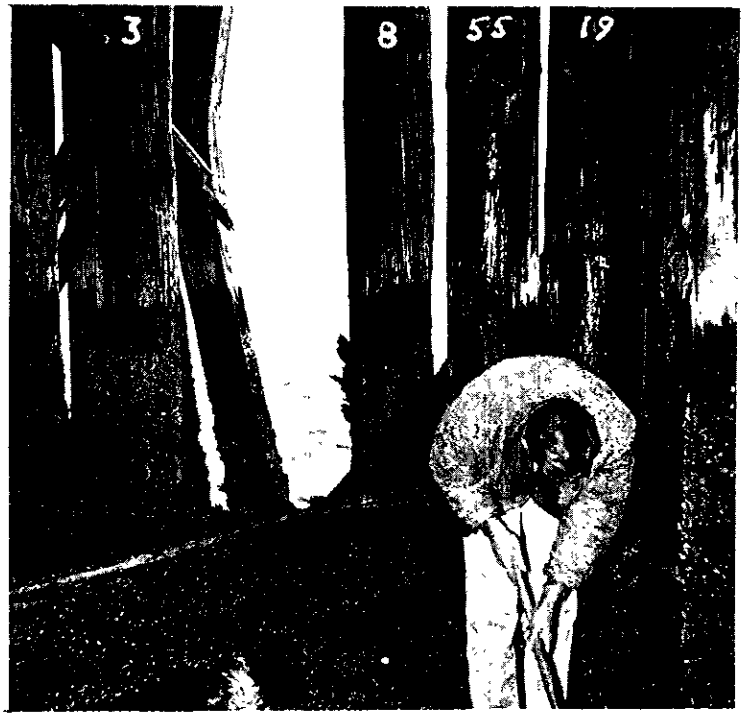
Pile 103, North End Pier E-4.
Inspector holding pick handle in
cavity caused by marine borers.

Pile 103. Close up of marine
borer damage.

Inspector indicates opening in Pile 115. South End of Pier E-4.

Inspector indicates opening in Pile 119. Number 118 also had a small opening.

The probe points to opening in Pile 6. Note deteriorated bracing.



Piles 3 and 8 damaged by ship.
Pier E-5 North End.

Opening in Pile 30.
Pier E-5, South End.

A small opening was found in Pile 36
at East apex of Pier E-5, South End.

Exhibit 7
S-3057

SOUTHERN PACIFIC COMPANY

WOOD PRESERVING PLANT -- RECORD OF TREATMENT

Month of May 1934

Retort	B	B	A	A	A	A	B
Charge Number	134	135	136	148	150	160	162
Date Going In	3-24	3-25	3-26	3-31	4-2	4-7	4-9
Date Coming Out	3-25	3-27	3-27	4-2	4-3	4-9	4-10
Charge In At	5:20P	9:45P	1:10A	10:25P	3:30A	4:30A	6:50A
Bath Began At	5:35P	10:00P	1:25A	10:40	3:45A	5:30	7:05
Bath Ended At	8:50A	2:20	6:25P	11:15P	12:20A	6:10P	3:20A
Oil Pressure Began At	9:00A	2:30P	6:35P	11:15P	12:30A	6:25A	3:30A
Oil Pressure Ended At	8:05P	11:50	3:40A	1:50A	4:50A	12:45A	7:00P
Retort Drained At	8:25	12:10A	4:00	2:10	5:10	1:05	7:20
Final Vacuum Began At	8:30	12:15	4:05	2:15	5:15	1:10	7:25
Final Vacuum Ended At	9:30	1:15	5:05	3:15	6:15	2:10	8:25
Charge Out At	9:35P	1:20	5:10A	3:20A	6:20A	2:15	8:30
Total Time of Treatment	29:15	27:35	28:00	28:55	26:50	45:45	37:40
Temp. Oil during Bath	190	190	190	190	190	190	190
Temp. Oil during Pressure	180	180	180	180	180	180	180
Pressure with Air	0	0	0	0	0	0	0
Pressure with Oil	125	125	125	100	100	125	125
Condensation End of Bath	7"	7"	7"	7"	6"	8"	
Lbs. inj. M.T.	30000	30000	30000	27300	26700	38000	38100
Total cu.ft.	-	-	-	2183	2132	2286	2355
Injected #/cu.ft.	14.0	13.9	15.2	12.5	12.5	16.6	16.2
Final Vacuum	28	28	28	28	28	28	28
Material in Charge	Piles	Piles	Piles	Piles	Piles	Piles	Piles