IMPROVED MATERIALS SYSTEMS
IN MARINE PILING
AFTER NINE YEARS OF EXPOSURE
IN YAQUINA BAY - NEWPORT, OREGON

STATE STUDY - RESEARCH

by

H. M. LAYLOR
Research Project Coordinator
Oregon State Highway Division

OREGON STATE HIGHWAY DIVISION
Materials and Research Section
Salem, Oregon 97301

February 1990

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INTRODUCTION

From 1979 to 1983 the Oregon State Highway Division participated with the FHWA in a demonstration Project[1] to evaluate the feasibility of manufacturing precast, prestressed marine piles from advanced structural materials. The materials that were evaluated included polymer concrete, polymer impregnated concrete, internally sealed concrete, and latex modified concrete. In addition to the prestressed piles, miniature, conventional concrete piles with epoxy coated rebar were evaluated. Included in the report are:

A description of the laboratory work that preceded the preparation of the specifications.

A description of the manufacturing processes and problems for each system.

A two year performance evaluation on each system.

After manufacture, the polymer concrete piles were structurally unsatisfactory since nearly 1/3 of the prestressing force was lost to elastic shortening, shrinkage and creep.

NINE YEAR RESULTS

During June 1989, a field survey was conducted to determine the conditions of the piling. The survey consisted of visual inspection, copper-copper sulfate half-cell (CSE) potentials[2] and chloride sampling. The detailed results are in Appendix 1.

POLYMER IMPREGNATED CONCRETE

The CSE potentials ranged from -69 millivolts (mv) above the splash zone to -449 mv in the splash zone. Potentials more negative than -350 mv are associated with a 90% probability of active corrosion on conventional structures. The most negative potential measured was at a crack. This suggests that the crack may have been caused by corrosion since the original cracks were filled with resin.

[1] W. J. Quinn, "USE OF IMPROVED STRUCTURAL MATERIALS SYSTEMS IN MARINE PILING", FHWA-RD-OR-83-3, 1983.

[2] Note: CSE potentials on non-conventional materials are suspect, since these materials may have a high internal resistance. Unless there is evidence to the contrary, only cores with imbedded steel will reveal active corrosion.

The average chloride content at the 1/8 to 1 inch depth was 5.2 pounds per cubic yard. At the 1 to 2 inch depth it was 1.4 pounds per cubic yard. A chloride content of 1.25 pounds per cubic yard at the level of the rebar is enough to cause corrosion of steel in conventional Portland cement concrete. Three of the five chloride samples taken at the 1 to 2 inch level were well above the threshold value.

The chloride levels and the pattern of the CSE potentials (Appendix 1) are similar to those found on corroding conventional piling in a similar environment. Consequently, there is no reason to discount the CSE potential readings due to high internal resistance of the beams.

INTERNALLY SEALED CONCRETE

The CSE potential range was from -169 mv to -367 mv. As above, there is no reason to discount the CSE potential readings.

The average chloride content at the 1/8 to 1 inch depth is 5.3 pounds per cubic yard. The average at the 1 to 2 inch depth is 1.26 pounds per cubic yard. Two of the five 1 to 2 inch samples were above the corrosion threshold.

The chloride samples and the CSE potentials show that the internal sealing is effective in reducing chloride intrusion and suppressing CSE potentials. If there is interest in this technique, potential profiles over the next three years could yield data that may give a better indication of the effectiveness of this technique.

EPOXY COATED REBAR IN CONVENTIONAL CONCRETE (MINIATURE PILE)

The CSE potentials were from -219 mv to -439 mv.

The average chloride content at the 1/8 to 1 inch depth was 14.2 pounds per cubic yard. The average at the 1 to 2 inch depth was 6.4 pounds per cubic yard.

Visual inspection did not reveal any cracking or delaminations that were caused by corrosion.

The main piles that support the miniature piles had very similar potentials and chloride levels.

The measured CSE potentials are not consistent with what is reported in the literature for epoxy coated rebar in concrete. The probability of active corrosion is high. Since there is a very high interest in epoxy coated bar in concrete, a miniature pile will be obtained for forensic analysis.

POLYMER CONCRETE

The CSE potentials were from -444 mv to -693 mv. These potentials are not consistent with this environmental exposure. The values are suspect.

The average chloride content at the 1/8 to 1 inch depth is 0.49 pounds per cubic yard. The average at the 1 to 2 inch depth is 0.26 pounds per cubic yard.

The low chloride levels suggest that this is an effective method of controlling chloride intrusion.

The chloride levels and potentials are inconsistent. No conclusions about the presence or absence of active corrosion can be made.

LATEX MODIFIED CONCRETE

The CSE potentials were from -134 mv to -447 mv.

The average chloride content at the 1/8 to 1 inch depth is 5.6 pounds per cubic yard. The average at the 1 to 2 inch depth is 1.17 pounds per cubic yard. One of the five samples exceeded threshold.

The chloride samples show that this material is a more effective chloride barrier then conventional PCC.

If there is interest in this technique, coring would yield data that could identify active corrosion.

CONCLUSIONS

Visual examination of the piling did not reveal cracking or delaminations that were caused by corrosion of the steel.

CSE potentials show possible corrosion activity on all but the polymer concrete pile.

If the chloride concentrations of the miniature piles are used as a base for chloride comparison, all of the other systems show reduced rates of chloride intrusion.

Further study of the miniature pile with the epoxy coated rebar will be made. The results of the study will be a separate report.

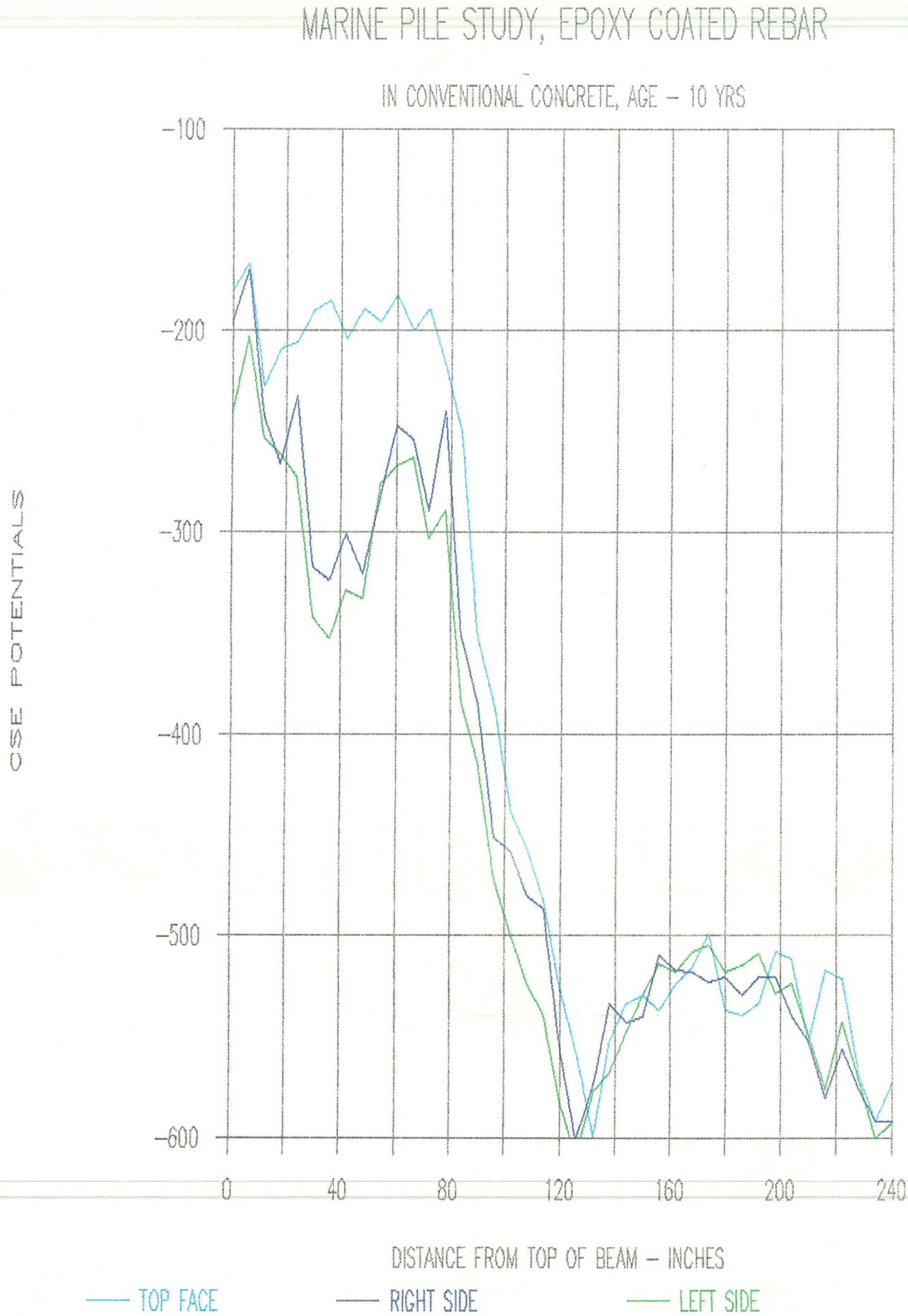
HLM
hml/pile/9yearfin.rpt

APPENDIX 1

CHLORIDE CONTENT (#Cl/yd^3) AFTER 9 YEARS EXPOSURE

	Location	Depth 1/8" - 1"	Depth 1" - 2"
Dolphin 1			
Polymer Impregnated Concrete Piling	Center Leg	5.2	2.5
		3.1	1.9
	North Leg	2.7	0.42
		6.7	1.9
	West Leg	8.4	0.13
Dolphin 2			
Internally Sealed Concrete Piling	Center Leg	3.9	1.2
		0.29	0.19
	West Leg	6.6	1.1
		9.0	2.3
		6.6	1.5
Dolphin 3			
Portland Cement Concrete Piling	North Leg	10.8	4.2
		14.6	6.0
	East Leg	18.4	*
	West Leg	*	8.8
		11.9	6.4
		13.0	6.8
Dolphin 4			
Polymer Concrete Piling	North Beam	0.59	0.23
	South East Leg	0.35	0.28
	South West Leg	0.61	0.22
		0.39	0.29
Dolphin 5			
Latex Modified Concrete Piling	North East Leg	4.8	1.2
		6.7	2.3
	North West Leg	5.7	0.73
		8.3	0.81
	South West Leg	2.3	No Sample

* The Sample was contaminated with debris from the surface of the piling.



MARINE PILE STUDY, EPOXY COATED REBAR
IN CONVENTIONAL CONCRETE, AGE – 10 YRS
CSE POTENTIALS
-100
-200
-300
-400
-500
-600
0
40
80
120
160
200
240
DISTANCE FROM TOP OF BEAM – INCHES
TOP FACE
RIGHT SIDE
LEFT SIDE