LETTER REPORT

Second Supplement to Technical Note N-1032, July 1969

EFFECTIVENESS OF ZINC COATING ON REINFORCING STEEL IN CONCRETE EXPOSED TO A MARINE ENVIRONMENT

By

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Letter Report - Second Supplement to Technical Note N-1032

References: (a) Technical Note N-1032, "Effectiveness of Zinc Coating on Reinforcing Steel in Concrete Exposed to a Marine Environment," June 1969
(b) Letter Report, Supplement to Technical Note N-1032, June 1970

Information contained herein covers the period June 1970 to June 1971. The enclosed Table 2, taken from reference (b), shows parameters for all of the walls discussed in reference (a). Walls with numbers containing asterisks are reported herein, namely, No's. 102, 110, 105, 106, 107, and 108.

Sea water applications daily to the north faces of the walls was terminated about July 1970 because the sea water well system failed. It was hoped a new source of sea water could be developed; however, such was not the case. In view of the fact that almost a year elapsed during which no sea water spray was applied, it was decided to terminate the experiment. Accordingly, the walls were inspected, destroyed, and the reinforcing steel was inspected on 2 June 1971.

The condition of the walls and the embedded steel are described below in decreasing order of apparent adversity.

Wall No. 105 - air entrained concrete
- welded reinforcements (no zinc)

(a) Concrete - no visible cracks or deterioration

(b) Reinforcing Steel - The upper portions of all horizontal bars were covered with red rust. The vertical bars were covered with red rust except for randomly located and significantly large areas that were virtually rust free. The weldments were not corroded. Corrosion products were not voluminous; however, they appeared to have migrated into the entrained air voids, thus, perhaps, relieving the stress usually induced in the concrete by the expansive corrosion products.

Wall No. 106 - concrete not air entrained
- reinforcing steel contacts insulated and tied (no zinc)

(a) Concrete - no visible cracks or deterioration. There was one rust stain about 2" in diameter on the north face of the wall in the upper east quadrant.

Table 2. Variables for Walls (Source: Technical Note 1032)

Wall No.	Concrete[a]		Date Cast 1966	Reinforcing Steel			
	No AEA	With AEA		Zn Coated	Sand Blasted	Welded	Tied Insul.
101	X		11 Apr	X[b]		X	
109	X		18 May	X[c]		X	
102*		X	13 Apr	X[b]		X	
110*		X	18 May	X[c]		X	
103	X		12 Apr	X[b]			X
111	X		18 May	X[c]			X
104	X		11 Apr		X	X	
105*		X	13 Apr		X	X	
106*	X		12 Apr		X		X
107*	X		12 Apr		NO STEEL		
108*		X	13 Apr		NO STEEL		

*Existent as of June 1970 and crack free.

[a] AEA means air-entraining agent.

[b] Each bend and weld and bar ends were touched up with zinc-enriched paint employing a silicious vehicle

[c] No touch up with zinc-enriched paint employing a silicious vehicle.

Note: Walls were transferred from fog room to field site 28 days after casting. For walls cast in April, sea spray was begun 16 May 66; for walls cast in May, sea water spray was begun 20 June 66.

(b) Reinforcing Steel - The upper two horizontal bars were extensively covered with red rust. On the remaining horizontal bars there were scattered red rust areas. The two outer vertical bars and the upper ends (in the horizontal plane) of the remaining vertical bars showed red rust; however, the inner vertical bars were almost free of corrosion.

Wall No. 110 - air entrained concrete, welded and galvanized reinforcing steel

(a) Concrete - no visible cracks or deterioration

(b) Reinforcing Steel - White products of zinc corrosion were scattered on all bars. The vertical (turned down) ends of all horizontal bars were covered with red rust.

Wall No. 102 - air entrained concrete, welded and galvanized steel

(a) Concrete - no visible cracks or deterioration

(b) Reinforcing Steel - The horizontal bars contained extensive white products of zinc corrosion, and scattered small areas of red rust throughout. The vertical bars showed zinc corrosion for a distance of about 1.5 inches on either side of the joints. There were only scattered traces of red rust. The weldments were corrosion free.

Wall No.'s 107 and 108 - contained no reinforcing steel. Wall No. 107 contained no air entrainment. Wall No. 108 was air entrained concrete. In both walls the concrete had no visible cracks or deterioration.

Summary

Although the above-mentioned walls are discussed in apparent order of decreasing adversity, the degree of adversity in all cases is so low as to be of little real consequence. Therefore, it is difficult to draw sound conclusions concerning the relative condition of the reinforcing steel. Red rust is more dramatic than white "rust". Based on information in references (a) and (b), the air-entrainment provided more protection to the concrete than did the zinc coating on the steel. In no case did the zinc coating prevent the formation of red rust.

Wall No. 106 may have been in the most vulnerable condition as evidenced by migration of rust to one spot on one outer surface; however absence of visible cracks in the concrete supports the apparent evaluation summarized as follows:

Apparent Order of Decreasing Adversity

Wall No.	Concrete	Steel
105	air entrainment	welded joints no zinc coat
106	w/o air entrainment	tied & insulated joints no zinc coat
110	air entrainment	zinc coated, welded joints
102	air entrainment	zinc coated, welded joints
107	w/o air entrainment	no steel
108	air entrainment	no steel

It would appear from the above that the zinc coating was beneficial in protecting the steel in air-entrained concrete; however, this cannot be considered a firm conclusion as the evidence is not strong. That is, the amount of corrosion products did not appear to be excessive and the concretes did not crack.