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CRITICAL ISSUES RELATED TO CORROSION INDUCED DETERIORATION PROJECTION FOR CONCRETE MARINE BRIDGE SUBSTRUCTURES

PROBLEM STATEMENT

Corrosion induced deterioration of reinforced concrete bridge structures in Florida, particularly those located along the coastline and exposed to sea or brackish waters, is a pervasive economic, societal, and technical problem. This damage arises because sea salts (in particular, chlorides) progressively diffuse into the concrete, and once this species achieves a critical concentration at the reinforcement depth, corrosion, concrete cracking, and spalling occur. If this attack is left unaddressed, then bridge structural integrity is eventually compromised.

Life-cycle models for predicting deterioration of reinforced concrete structures and for projecting repair and rehabilitation requirements are now available. A critical parameter in such models is the threshold chloride concentration that initiates corrosion of the embedded reinforcement, c_{th}. Presently, there is variability in the literature as to the magnitude of this parameter with reported values differing by more than a factor of ten. Chloride thresholds for concretes fabricated using local Florida materials tend to be relatively high compared to those reported in the rest of the United States.

OBJECTIVES

The objective of the present study was (1) to better define the chloride threshold and variables upon which it depends, and (2) to investigate the utility of cements of high alkalinity for elevating the chloride threshold

FINDINGS AND CONCLUSIONS

Researchers determined that time-to-corrosion, T_i, for “identical” specimens varied over a relatively wide range. Also, T_i was lowest for specimens that were prepared using cement of “normal” alkalinity (equivalent alkalinity 0.52 (designation NA)), intermediate for a “low” alkalinity cement (equivalent alkalinity 0.36 (designation LA)), and highest for “high” alkalinity (equivalent alkalinity 0.97 (designation HA)). Because the equivalent alkalinity of cements typically utilized in Florida bridge construction is comparable to that of the NA type and because deterioration from alkali silica reaction is not normally a problem in Florida, improved corrosion resistance can be realized using cements of the HA type. The time-to-corrosion for specimens with the HA cement, compared to the NA ones, increased by approximately a factor of three for water-cement ratio 0.37 and by a factor of ten for water-cement ratio 0.41.

The threshold chloride concentration to cause passive film breakdown and onset of active corrosion, c_{th}, increased with increasing T_i. Consequently, the concrete specimens that utilized the HA cement exhibited the highest c_{th}, although all data conformed to a common trend. Local chloride concentrations in the concrete measured from powder drillings taken along the top side of the upper rebar trace varied from 4.31 to 23.52 kg/m^3. This range exceeds what is typically assumed to initiate reinforcement corrosion in North American bridge deck concretes (0.60-0.75 kg/m^3 (1.0-1.3 pcy)) by a factor of 6-39. On the other hand, the general literature reports the range for c_{th} as 0.66-9.71 kg/m^3, which, while overlapping, is still less than determined for the present specimens. In situations where observations were made, corrosion was found to have initiated at an air void in the concrete that impinged upon the reinforcement. This finding indicates that microstructure of the reinforcement-concrete interface affected c_{th}.

BENEFITS

With the use of high alkalinity cement in coastal Florida bridges and through the development of more corrosion resistant micro-structures (self-compacting concretes), corrosion-related maintenance costs can be reduced substantially with no additional materials or construction expense.

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