Florida Department of Transportation Research

Modeling Reinforced Concrete Durability

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Many Florida bridges are built of steel-reinforced concrete. Florida's humid and marine environments subject steel in these structures to corrosion once water and salt penetrate the concrete and contact the steel. Corroded steel takes up more space than the original steel, resulting in cracked and spalling concrete which further exposes the steel, and requires expensive repairs and corrosion control techniques.

The Florida Department of Transportation (FDOT) has responded with corrosion prevention practices, such as very low permeability concrete and increased concrete cover thickness over reinforcing steel. This increases initial cost but saves money over time, since the bridge's service life is significantly extended. So, it is important to understand how a specific design can increase service life for the specific environment in which the bridge will be built.

In this project, the University of South Florida researchers developed a next-generation model to predict the progress of corrosion-related damage to reinforced concrete. The new approach represents a major improvement over current practice and is a major advance compared to the qualitative approaches used in the past.

The researchers developed an innovative approach to corrosion damage prediction called potential-dependent threshold (PDT), integrating corrosion initiation and propagation in one concept. In this work, they identified a feature critical to PDT that had been largely ignored in other models but was needed for more realistic projections. That feature accounts for an effect called macrocell coupling. To determine the effect's extent and more accurate input parameters, experiments were conducted with mortar and concrete specimens in the most realistic conditions to date.

The model incorporates many advanced features, such as full probabilistic treatment of damage prediction calculations, including statistical

Severe corrosion damage to reinforcing steel in this column has caused the overlying concrete to spall.

variability in surface concentration, of chloride diffusivity, and of corrosion threshold via impact of variations in surface concentration and incorporation of PDT. Calculations with and without PDT led to a correction factor for calculations performed without PDT. The model accounts for the type of rebar material, the detrimental effect of chloride flow obstruction, and the geometric aggravation caused by corners and curvature in the concrete surface. The model also allowed for environmental aggressiveness as a function of elevation above water or location of structural component, permitting specific design for different bridge parts and avoiding over-specification for the regions with less aggressive conditions.

The model requires user input on the types of bridge substructure components, structural configuration, construction materials, and service environment to generate a corrosion-related damage function for a period of 200 years.

Advanced methods like those developed in this report can lead to better bridge designs, longer service life, and lower maintenance, resulting in significant savings over the life of a bridge.

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For more information, visit http://www.dot.state.fl.us/research-center