

EXECUTIVE SUMMARY

This investigation was aimed at determining the present condition of Florida bridges built with Epoxy-Coated Rebar (ECR), and establishing a prognosis for the future corrosion-related durability of these structures. There are at present over 300 bridges built with ECR in Florida, and the observation of severe corrosion at five major bridges using ECR in the Florida Keys created concern about the condition of the rest and their expected durability.

About 30 large bridges were selected for detailed examination, including a few plain rebar structures for comparison. Portions of the substructure of the selected bridges were examined in detail in the field. The tests included coring for concrete samples, extraction of rebar specimens, and detailed electrochemical characterization of the substructure element to assess the potential for corrosion development. Additional tests were conducted in the laboratory to determine chloride ion penetration rates, concrete characteristics, and the condition of the rebars and their epoxy coating.

Additional laboratory tests were conducted using reinforced concrete specimens and liquids representing the concrete moisture chemistry. These tests were aimed to determine the susceptibility of the coated metal for corrosion development between a partially disbonded coating and the metal, and to establish whether the low mechanical adhesion between ECR and concrete could lead to early crack development compared with similar corrosion in plain rebar.

The field examinations revealed that, except for the five ECR structures already showing corrosion, none of the other ECR structures examined had indications of severe corrosion in progress. In many of the structures examined the extent of chloride penetration was still too small to have caused corrosion initiation.

Virtually all the ECR structures examined showed dramatic reduction of the adhesion bond between the epoxy coating and the underlying rebar metal. This reduction was

observed for all structures five years or older at the time of the examination, whether chloride contamination had taken place or not. The laboratory tests confirmed that the chemical makeup of the concrete pore solution and the electrochemical service conditions of the rebar in the service environment are conducive to extensive loss of adhesion.

Previous and present laboratory tests also revealed that corrosion propensity is significantly aggravated by the presence of disbondment crevices between the metal and the coating. It was concluded that the disbondment is the first step in the ECR degradation leading to eventual corrosion of the steel upon chloride contamination of the concrete.

The laboratory tests indicated also that both ECR and plain rebar would tend to create concrete spalls after essentially the same amount of corrosion products was generated.

Based on the above observations, and on the chloride penetration measurements, a computational model was applied to predict the time to development of corrosion spalls in the structures examined in this study. The model assumed that there is a corrosion initiation period (while the chloride content at the rebar builds up to a threshold value) followed by a corrosion propagation period which ends with spalling of the concrete cover.

The length of the initiation period is determined by the diffusivity of chloride ions in the concrete, which is obtained by analysis of the field-extracted cores. The diffusivity values measured spanned a large range (a factor of one hundred from best to worst). The bridges with the lowest diffusivity tended to be built with modern concrete formulations approaching that of the current FDOT 346 concrete with fly ash cement replacement. For those bridges the model predicted times to spall that can be on the order of 50 to 100 years or more if adequate rebar cover exists. The bridges with the highest diffusivity included those in the Florida Keys. The model predicted for those bridges times to spall on the order of a few years, which was in agreement with the observed events.

The prognosis of corrosion performance indicated therefore that bridges such as the Sunshine Skyway and about one third of the structures examined can be expected to experience service spans approaching or exceeding the current 75-year design goal before extensive corrosion-related repairs are needed. Another third includes bridges that might begin to show signs of corrosion distress within the next decade. Bridges in the remaining third (some of which are already showing damage) should be monitored frequently for possibility of immediate repair needs.

The extended life of the best performing group is ascribed primarily to the concrete quality and concrete cover depth used, and not to the presence of ECR. The experience in the Florida Keys suggests that in cases of highly permeable concrete the use of ECR did not provide significant additional protection.

The investigation results also indicated that materials guidelines emphasizing the use of low permeability concrete (such as FDOT Section 345 Class V designation), and construction design guidelines specifying ample rebar cover, are the most practical approach to attain long term durability in Florida marine substructure service.

The ECR structures presently undergoing corrosion will necessitate continuing attention. Newly acquired results continue to support the use of sacrificial sprayed zinc anodes as a cost-effective alternative to simple gunite repairs of the presently corroding ECR structures.