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Corrosion of reinforced concrete exposed to marine environment

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Abstract

The corrosion behaviour of reinforcing steel bars (rebars) was investigated in four different concrete mix designs commonly used in coastal cities in Argentina. Various exposure conditions were studied. Two water/cement ratios and various chloride ions contents where taken into account. Electrochemical parameters characteristic of the corrosion process were evaluated over approximately 1000 days, together with mechanical, chemical and physical properties of the concrete mixes. Rebars in contact with a good quality concrete exposed to a seashore

environment remained passive, even when its surface chloride concentration reached 0.75% with respect to cement content. Their performance was even better than that of standard-quality uncontaminated concrete. When immersed in a saline solution, all rebars corroded actively, although the corrosion rate depended on the concrete quality and the initial chloride concentration. Rebars were likely to achieve active corrosion when the resistivity was lower than 10 kΩcm, and likely to present a passive behaviour when concrete resistivity was higher than 30 kΩcm. Furthermore, a correlation between the chloride threshold (Cl_{TH}) value for rebar corrosion initiation and the electrical resistivity of concrete is proposed. Cl_{TH} may vary from 0.44 to 2.32% relative to the weight of cement when the electrical resistivity of concrete increases from 2 to 100 kΩcm. In parallel, the performance of three rebar coatings is analyzed by means of electrochemical methods. The coatings represent those commonly used when repairing concrete structures affected by corrosion in the coastal regions of Argentina: an epoxy rust conversion coating, a zinc-rich epoxy, and a sprayed zinc coating. Two exposure conditions were investigated: immersion and an indoors atmosphere. In the dry condition the three coatings presented a satisfactory performance characterized by E_{corr} values in the passive range and low corrosion rates (CR). On the other hand, the performance of the coatings in the wet condition depended on their formulations. The rust conversion coating showed active E_{corr} values and CR values higher than those measured on the uncoated bars. The zinc-rich epoxy and the sprayed zinc coatings presented E_{corr} values typical of active zinc, indicating a certain degree of cathodic protection provided to the reinforcing steel. Besides, the electrical resistance (R) values showed that in this condition, coatings do not provide a barrier type of protection. Finally, the performance of a surface-applied migrating corrosion inhibitor (MCI) based on an alkylaminoalcohol was evaluated. Two water/cement ratios, various Cl^- contents and two exposure conditions were investigated. The results show that when concrete is exposed to the seashore environment the inhibitor is able to reduce the corrosion rate only when the initial chloride content is below 0.16% in weight relative to cement content. Efficiency increases as the water/cement ratio increases. When concrete is immersed in a saline solution, no beneficial effect associated to the use of the inhibitor could be appreciated, regardless of w/c or initial chloride content in concrete.

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