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Comparison between surface and bulk hydrophobic treatment against corrosion of galvanized reinforcing steel in concrete

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ABSTRACT

The effectiveness of bulk hydrophobic treatment against corrosion of galvanized steel reinforcement in concrete specimens with w/c = 0.45 and w/c = 0.75 was compared with that of surface treatment, even in the presence of cracks 0.5 and 1 mm wide in the concrete cover. In this case surface hydrophobic treatments were applied both before and after cracking as a preventive and a restorative method against reinforced concrete deterioration, respectively. The obtained results in terms of water absorption, electrochemical measurements, chlorides penetration, and visual observations carried out on reinforced concrete specimens during the exposure to wet–dry cycles in 10% NaCl solution showed that bulk hydrophobization is the most effective treatment in improving the corrosion resistance of galvanized steel reinforcements in concrete also in the presence of cracks. Surface hydrophobization is very effective just in the first few exposure cycles to the aggressive environment and when used as a restorative method which is able to cancel the deleterious effect of cracks only 0.5 mm wide.

1. Introduction

Weathering is the most important harmful factor for building materials causing their deterioration, detectable through exfoliation, scaling, crumbling and reinforcement corrosion. Weathering is in general related to water penetration into porosity of materials, since water acts as the main carrier of aggressive agents, as chlorides for reinforcement corrosion, and water is essential for most deterioration reactions [1].

A water droplet in contact with concrete, that is a porous hydrophilic material, wets the solid surface by spreading itself and penetrates the cementitious matrix by means of capillary forces following the Washburn equation, $p = (2\ \gamma/r_c)\ \cos\ \sigma$, where γ is the liquid surface tension, r_c is the capillary pore radius, and σ is the contact angle. The contact angle is less than 90°, p is positive and water fills the pore spontaneously. Since the molecular attraction between water and the concrete pore walls may be lowered by using hydrophobic agents, such as those currently named silanes and siloxanes [2], surface hydrophobic treatments or the introduction of hydrophobic agents directly in the mixture should involve an increase in durability. Previous works have shown that hydrophobic admixtures protect steel reinforcement from corrosion only in sound concrete, while in cracked concrete it can induce a catastrophic corrosion [2]. This unexpected result has been ascribed to a greater oxygen diffusion through an unsaturated hydrophobic cementitious matrix that, in this way, can feed more quickly the cathodic reaction controlling the corrosion process [3]. However, if the reinforcement is galvanized, in which case it has been already experimented that passivation is mainly promoted by oxygen [4], the use of hydrophobic admixture always improves the corrosion resistance of galvanized steel reinforcements in concrete, even in the presence of concrete cracks, especially when high w/c ratios are used [5]. In this work, the effectiveness of bulk hydrophobic treatment against corrosion of galvanized steel reinforced in concrete specimens with w/c = 0.45 and w/c = 0.75 was compared with that of the surface treatment, even in the presence of cracks 0.5 and 1 mm wide. In this case surface hydrophobic treatments were applied both before and after cracking as a preventive and a restorative method against reinforced concrete deterioration, respectively.

2. Experimental

2.1. Materials

A commercial Portland-limestone blended cement type CEM II/A-L 32.5 R according to EN-197/1 was used. Natural sand with 6 mm maximum size and gravel with 11 mm maximum size were used as fine and coarse aggregates, respectively, to manufacture concretes. A 45% aqueous emulsion of an alkyl-triethoxy-silane was used as a hydrophobic silane-based admixture to manufacture bulk hydrophobic cementitious materials. A commercial hydrophobizing agent

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