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Numerical modelling of the effect of creep on corrosion-induced cracking in reinforced concrete

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Abstract:

Corrosion induced cracking is the most widely encountered and studied long-term deterioration process in reinforced concrete. Naturally occurring corrosion rates are so low that rust accumulates often over tens of years at the surface of the reinforcement bars before sufficient pressure in the surrounding concrete is generated to induce cracking in the concrete cover. To speed up the process in laboratory tests, corrosion setups with impressed currents have been developed in which the corrosion rate is controlled to be so high that cracking of the concrete cover occurs within a few days. Extrapolating the results of these accelerated tests to those of naturally occurring corrosion requires an understanding of the influence of long-term creep deformations of concrete on the corrosion induced cracking process. In mathematical models in the literature, creep deformations are often ignored for accelerated but considered for natural corrosion rates in the form of a constant creep coefficient, which is used to reduce the Young modulus of concrete.

In this work, three numerical models of increasing complexity are proposed to investigate the effect of creep on corrosion induced cracking. The simplest approach is based on an elastic axisymmetric thick-walled cylinder combined with a plastic limit on the radial pressure induced by the accumulation of rust. The model with intermediate complexity comprises a thick-walled cylinder model divided into an inner cracked and an outer uncracked layer. The most complex model consists of a thick-walled cylinder discretised by a three-dimensional network (lattice) approach implemented in the finite element program OOFEM (http://www.oofem.org). Basic creep is predicted in all three approaches by means of the B3 model developed by Bažant and co-workers. Time dependence of strength of concrete is modelled using CEB-FIP Model code expressions. Preliminary results of the modelling indicate that creep has a noticeable influence for both accelerated and natural corrosion, but less than constant creep coefficients often used in the literature predict.