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Mechanical and reliability analyses of reinforced concrete structures subjected to corrosive effects caused by chloride ions penetration

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ABSTRACT

Structural durability is an important design criterion, which must be assessed for every type of structure. In this regard, especial attention must be addressed to the durability of reinforced concrete (RC) structures. When RC structures are located in aggressive environments, its durability is strongly reduced by physical/chemical/mechanical processes that trigger the corrosion of reinforcements. Among these processes, the diffusion of chlorides is recognized as one of major responsible of corrosion phenomenon start.

Reinforcements' depassivation occurs when the chloride concentration at the reinforcement surface reaches a threshold value. Consequently, geometrical structural shape and mechanical proprieties of constituent steel are modified. The present work presents a formulation based on the Finite Element Method for the mechanical analysis of reinforced concrete structures subjected to corrosive effects due to chloride penetration. Mazars's damage model and elastoplastic positive isotropic hardening approach are used to simulate physical nonlinearities of concrete and steel, respectively. Fick's second law is used to model the chloride diffusion inside the structure and empirical laws are applied to represent the corrosion rate of reinforcements' steel along time.

The corrosion phenomena, as well as the mechanical proprieties of reinforced concrete, have a high level of randomness. Therefore, this problem is only properly addressed in the probabilistic context. Then, a polynomial response surface meta-model is built from the original mechanical model in order to represent the limit state equations. Monte Carlo's Simulation Method is applied on the obtained limit state equation to determinate the failure probability. Hyper-static structures are analysed in order to determine the probability of structural system failure, which is the main contribution of this study. Beams, localized in a saturated chloride environment, subjected to self-weigh and accidental loads are considered. The obtained results indicate that the progressive structural collapse due to corrosion is considerable different from the classical scenario when this chemical effect is not accounted.

Keywords: Mazars' damage model; Fick's second law; Reinforcements' corrosion; Progressive collapse.

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