MODELING OF CONCRETE CRACKING INDUCED BY STEEL CORROSION EXPANSION

*Santiago Guzmán[1], Jaime C. Gálvez[2] and José M. Sancho[3]

[1] ETS Ingenieros Caminos, Canales y Puertos. Universidad Politécnica Madrid
C/ Profesor Aranguren s/n
28040 Madrid, Spain
guzman.s@industrial.initec.es

[2] ETS Ingenieros Caminos, Canales y Puertos. Universidad Politécnica Madrid
C/ Profesor Aranguren s/n
28040 Madrid, Spain
jcgalvez@caminos.upm.es

[3] Universidad CEU San Pablo
Escuela Politécnica Superior, Campus Montepríncipe
Boadilla del Monte, 28668 Madrid, Spain
jmsancho@ceu.es

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ABSTRACT

Durability of reinforced and precast concrete is not an innovative aspect in the scientific-technical world and it is concerned with in numerous codes, standards and recommendations. In fact, we can say that durability studies have accompanied the life of modern concrete since its very beginning. The reparation of the durability problems is very expensive. For example, according to the Federal Highway Administration, approximately 30% of the American bridges were either structurally deficient or functionally obsolete in 2001. It was estimated that US$90 billion will be required to rehabilitate or replace these bridges [1].

Among degradations sources we can consider: corrosion (either due to carbonation or chloride ingress), freezing and thawing cycles, abrasion, thermal gradients, chemical attacks, dissolutions processes and alkali-aggregate reactions [2]. Evidently every isolated process can interact with each other increasing structural damage this way [3].

This paper is focused on the problem of the chloride-induced corrosion of the rebar in reinforced concrete, with special application to the slabs and decks of the bridges. High superficial concentrations may be usual in these structures (marine environments or de-icing salts in roadway bridges, e.g.). Like any aggressive agent such as water, gases or other dissolved ions, chloride induced deterioration is very conditioned by possibilities of transport through concrete mass.

In the case of models for the chloride induced corrosion, the common service life involves two time periods: the first is the time for chloride diffusion and the second is the time for corrosion damage. According to Monte Carlo analysis, failure probability is based on time depending on materials properties and stochastic distribution of external loads: cover depth, chloride content analysis, surface chloride concentration, apparent diffusion coefficient based on Fick's second law (because of chemical reactions taking place between the penetrating agent and concrete, see ASTM C1556-04), chloride

corrosion initiation concentration (may depends on composition of concrete and environmental parameters) and time to corrosion damage [[1]].

This paper presents a model for the chloride diffusion in the concrete taking into account the pore structure of the concrete, the internal humidity and the temperature. The model accomplishes the concentration of the chloride, the gradient of the concentration, the temperature and the humidity. The model also models the presence of cracks in the concrete.

Based on the results of chloride diffusion a corrosion rebar is assumed and the radial expansion of the corroded reinforcement simulated. The possible cracking around the rebar is modeled with an embedded cohesive model [4]. The model has been implemented in the FEAP Finite element code. The steel radial expansion is simulated by means of a temperature increase. Figure 1 shows the finite element mesh of a studied case and Figure 2 shows the crack pattern.
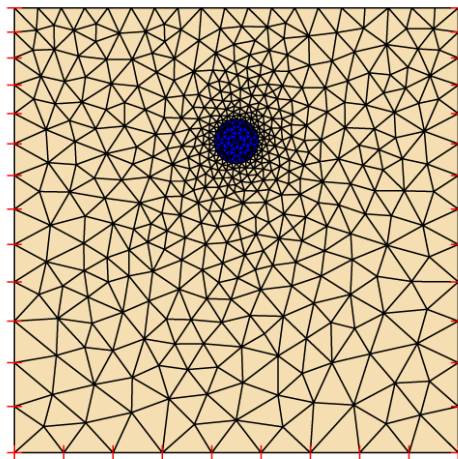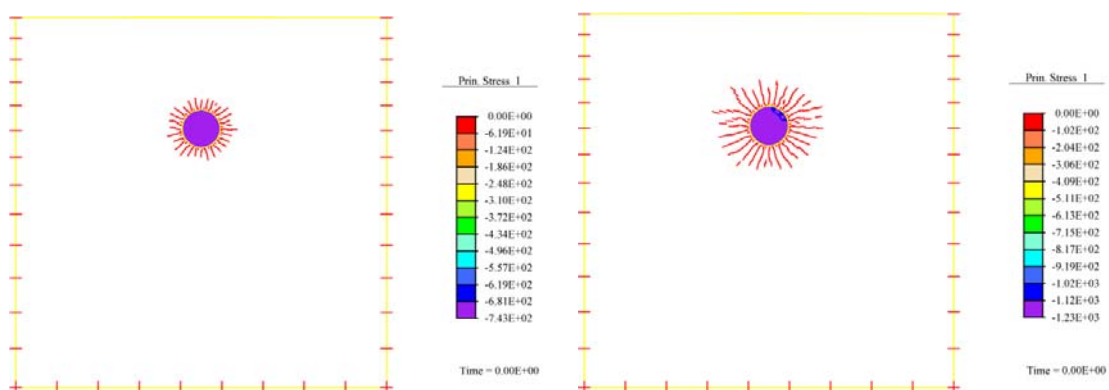

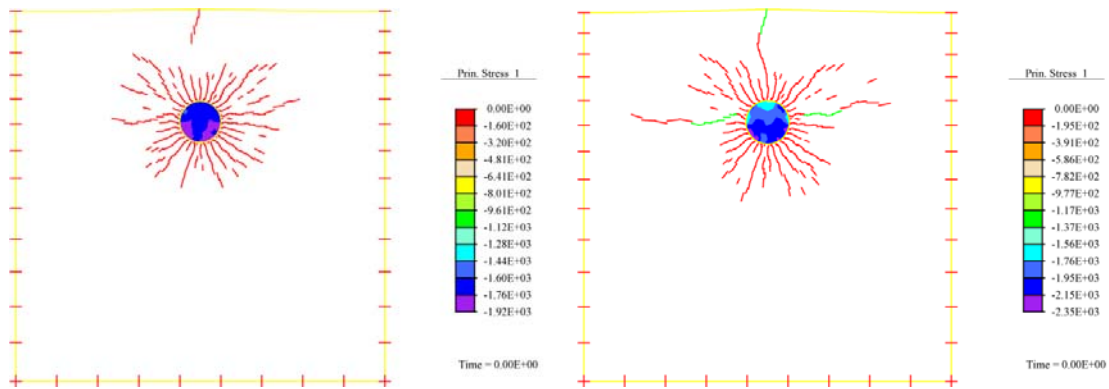**Figure 1. Finite element mesh of the rebar and concrete.**

Figure 2. Crack patterns for studied case (25ºC, 50ºC, 100ºC and 150ºC)

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