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NUMERICAL MODELLING OF THE LOAD CARRYING CAPACITY DEGRADATION IN CONCRETE BEAMS DUE TO REINFORCEMENT CORROSION

*** P.J. Sánchez[1−3], A.E. Huespe[1], J. Oliver[2] and S. Toro[3]**

[1] International Center for Computational Methods in Engineering (CIMEC)
Güemes 3450, 3000
Santa Fe, Argenina
psanchez@intec.unl.edu.ar
ahuespe@intec.unl.edu.ar

[2] Technical University of Catalonia (UPC)
Campus Nord, modul C-I
Gran Capitán s\n, 08034
Barcelona, España
xavier.oliver@upc.es

[3] GIMNI - Universidad Tecnológica Nacional
Facultad Regional Santa Fe
Lavaise 610, 3000
Santa Fe, Argentina
storo@frst.utn.edu.ar

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ABSTRACT

In this contribution, we present a FE model suitable to simulate the evolution of the mechanical degradation mechanism in RC members due to reinforcement corrosion, such as: expansion of the corroded bars, crack pattern distribution, loss of steel-concrete bond adherence, net area reduction of the steel fiber cross section and the effects of the above mentioned mechanisms on the structural load carrying capacity. The proposed numerical model has been applied to beams, through two succesive and coupled mesoscopic mechanical analyzes, as follows:

(i) Analysis of the structural member cross section:, we simulate the reinforced fiber expansion due to the volume increase of the steel bars as a consequence of corrosion. Damage distribution and cracking patterns in the concrete is evaluated, which defines the concrete net section loss in the structural member.

(ii) Mesoscopic analysis of the structural member: considering the results of the previous analysis, it is evaluated the mechanical response of the structural member subjected to an external loading system. This evaluation determines the global response and the macroscopic mechanisms of failure.

Each component of the RC structure is modeled by means of a suitable FE formulation. For the concrete, a cohesive (damage) model based on the Continuum Strong Discontinuity Approach (*CSDA* [1]) is used. Steel reinforcement are simulated by means of a standard elasto-plastic model. The interface is simulated using contact-friction elements with the friction degradation as a function of the degree of corrosion attack

A consistent coupling between the two analyzes in points *(i)* and *(ii)* is also proposed. It is based on transfer, from one domain of analysis (cross section) to the other (structural member), the average value of the damage variable, "d", across horizontal slices of the cross section model.

A set of numerical simulations are addressed in order to test the performance of the described finite element formulations. Some of the RC beams, experimentally investigated by Rodriguez et al. [2], have been analyzed. We follow very closely the guidelines and material characterization reported in [3].

Figure 1-(a) shows, for the beam type 11-4 and at the final stage of analysis, the iso-displacement curves, the FE mesh in the deformed configuration and the damage distribution in the cross section. A complete degradation of the surrounding concrete is observed for the applied expansions level. It can be noted that the main local failure mechanism is an inclined crack pattern. For the same specimen and at the structural member level, Figure 1-(b) depicts the obtained damage distribution, the trajectory of macro cracks as contour lines of displacement (in the x-direction) and the contour fill of the axial σ_{xx} stress. A vertical macro crack, located at the center of the beam, has been identified as the fundamental macroscopic failure mechanism determining the limit load. In the Figure 1-(c) we show the vertical load vs. the mid span vertical displacement curves. A good agreement with the experimental data (Rodriguez et al. [2]) and numerical results of Coronelli et al. [3], has been obtained.

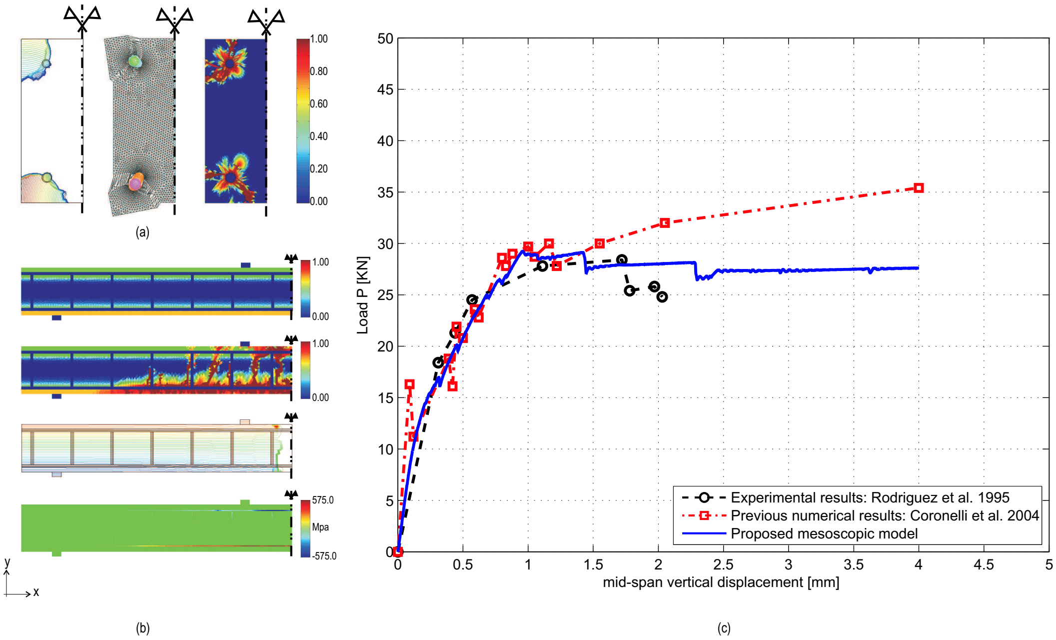

Figure 1: Numerical results. Beam type 11-4

Summarizing, we present two different mesoscopic model. A coupling strategy between them is also proposed. Following such methodology, the most relevant corrosion mechanisms can be simulated.

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