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Cracking study of a reinforced concrete beam

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Abstract

Reinforced concrete beam behaviour is studied during cracking by means of a finite element model. Dynamic and static experimental test results made in E.T.S. Ingenieros Industriales of Madrid have been used to develop this work. A detailed description of the model has been done as well as a sensibility analysis in order to define cracking parameters. Model and experimental test results have been compared. Finally, the evolution of a crack in concrete beam has been simulated using VCCT (Virtual Crack Closure Technique).

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Keywords: reinforced concrete, cracking, finite elements, VCCT

1. Introduction

The main objective of this project is to simulate the global behaviour (statics and dynamics) of a reinforced concrete beam under different cracking levels, using only one finite element model.

Previously, some finite element models of the same concrete beam were done in the Structures Department of the E.T.S.I.I.M, in order to reproduce both static and dynamic behaviour. However, these models only succeeded in the simulation either static or dynamic behaviour separately.

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So, the objectives of this project are the following ones:

- Predict the global behavior of a reinforced concrete beam under different degradation levels by means of a finite element model. Thus, it will not be needed to resort to experimental tests continuously.
- Make the finite element model validation through a comparison between simulation and test results.
- Perform a sensibility analysis to determine the correct value of cracking parameters.
- Analyze a single crack evolution, once concrete beam is degraded, by means of VCCT (*Virtual Crack Closure Technique*).

Because of the complexity of this problem, an implicit non-linear calculation will be implemented using MSC.Marc, which is a software based on implicit non-linear analysis developed by MSC.Software.

1.1. Modeling Theory

Two aspects are very important to take into account when a reinforced concrete beam is being modelled: reinforcements model and concrete behaviour law. Marc options used in the model are described below:

- REBAR elements: this option defines material, relative position, number, orientation and section area of the reinforcements.
- ISOTROPIC, PLASTICITY and CRACK DATA define the concrete behaviour law in tension and compression.

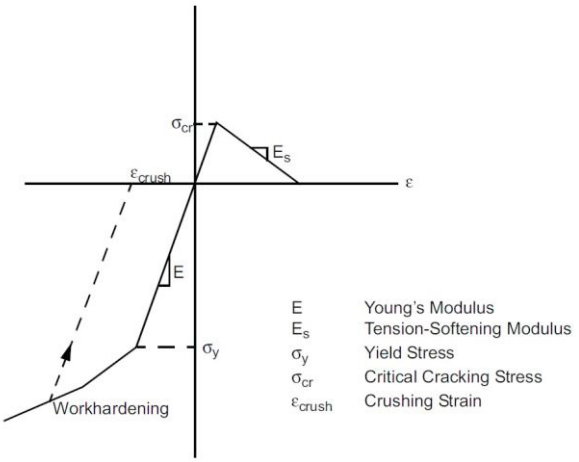

Fig.1 Concrete behavior law

ISOTROPIC option defines elastic zone by means of Young Modulus (E) and Poisson Coefficient (ν).

PLASTICITY option controls concrete plasticity when it works in compression through Yield Stress (σ_y) value.

CRACK DATA option allows simulating cracking in the concrete when it is working under tension. Two parameters are defined: Critical Cracking Stress (σ_{cr}) and Tension Softening Modulus (E_s). For higher stress values than Critical Stress, cracking conditions are reached. Then, tension softening shows how concrete elements are not able to carry load once they have been degraded.

- INSERT option defines displacements compatibility between concrete and reinforcement elements. REBAR elements are embedded and tied into concrete ones.

2. Experimental Test Campaign

The tested concrete beam is 4.54 m length and rectangular cross sectioned (0.22 m x 0.32 m). Reinforcements are placed as it is shown in the picture below.