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DIFFERENT COLLAPSE MODES IN RC BEAMS: A UNIFIED FRACTURE MECHANICS APPROACH TO INTERPRET EXPERIMENTAL TRANSITIONS

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ABSTRACT

There exists a wide literature on reinforced concrete beams models involving separately the three possible failure mechanisms: flexure, shear and crushing. However, the study of the transition between these mechanisms inside a consistent theoretical framework is still an open question, in particular with reference to the experimentally known size effects. The main issue of the present analysis is to get a consistent modelling of shear cracks propagation and diagonal tension failure, linking this kind of failure with the flexure and crushing failures and to show some of the results of a wide experimental campaign to validate the theoretical/numerical model.

The theoretical basis of the present work is the bridged crack model, proposed by Carpinteri for the study of reinforced concrete beams by Fracture Mechanics. Since the first works [1, 2] the model has undergone developments in several directions. The problem of the size effect and the brittle-ductile transitions were analysed with reference to the problem of minimum reinforcement in [3, 4, 5, 6]. A first extension to cohesive stresses was presented in [7]. Then, a model combining cohesive stresses and reinforcing bars was developed in [8, 9]. More recently, the model has been further extended analysing concrete crushing by Fracture Mechanics concepts [10] and leading to a first development to analyse in a consistent way the flexural and crushing failures. Then, to extend the model to account for the shear cracks formation and to evaluate the diagonal tension failure load, some hypotheses about the crack trajectory and the evaluation of the stress-intensity factors have been added and a criterion for concrete crushing has been introduced [11]. In this way all the different collapse modes have been merged together into a unified general model, so that the simulation of the transitional phenomena is naturally accomplished. The model predicts the failure load, the collapse mode and, for shear cracks, the crack initiation point and the crack trajectory.

A series of experimental tests on 80 beams has been performed to validate the model and discuss its governing parameters. These tests include 5 steel bar and 4 steel fibers reinforcements percentages, and a study of the relation between the quantity of reinforcements and the failure crack trajectory and initiation point is shown. The

proposed model captures the most important trends in the crack propagation and allows for a rational explanation, inside a coherent theoretical framework, of the relations between cracking processes and failure in reinforced concrete beams.

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