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A CRACK-LENGTH CONTROL SCHEME FOR THE ANALYSIS OF SNAP-BACK INSTABILITY IN THE DELAMINATION OF STRENGTHENED BEAMS

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ABSTRACT

Strengthening of concrete structures by means of externally bonded reinforcement is an effective technique that relies on the composite action between a reinforced or prestressed concrete element and the externally bonded reinforcement [1].

In spite of the increase in global stiffness of the retrofitted beam, generally, the ductility of a strengthened tensile or flexural member decreases with respect to the unstrengthened one. This is especially the case for premature debonding failures and high strengthening ratios. In this context, although a significant amount of scientific work has been carried out in the last few decades towards the analytical description of the stress state at the bi-material interface (see e.g. [2-4] for an overview), a full analysis of the mechanical response of strengthened flexural members from the onset of edge delamination until their final collapse has received a minor attention [5,6].

A numerical analysis of the full-range behaviour of strengthened beams in bending is herein proposed to study the stages of nucleation and propagation of interfacial cracks between the external reinforcement and the concrete substrate. This is achieved by modelling the nonlinear interface behaviour according to a cohesive law accounting for Mode-Mixity [6,7]. The numerically obtained load vs. mid-span deflection curves for three-point bending beams show that the process of FRP delamination is the result of a snap-back instability, which can be interpreted in the framework of Catastrophe Theory [8,9]. To capture the softening branch with positive slope, a crack length control scheme is proposed in the finite element framework. The main advantage of this approach, as compared to the arc-length control scheme, relies in the fact that the classical Newton-Raphson numerical procedures for the solution of the set of nonlinear equations governing the problem has not to be modified.

The results of a wide parametric study exploring the effect of the relative reinforcement length, the mechanical percentage of reinforcement and the beam slenderness are collected in useful diagrams (see e.g. Fig. 1). Finally, an experimental assessment of the proposed model completes the paper.

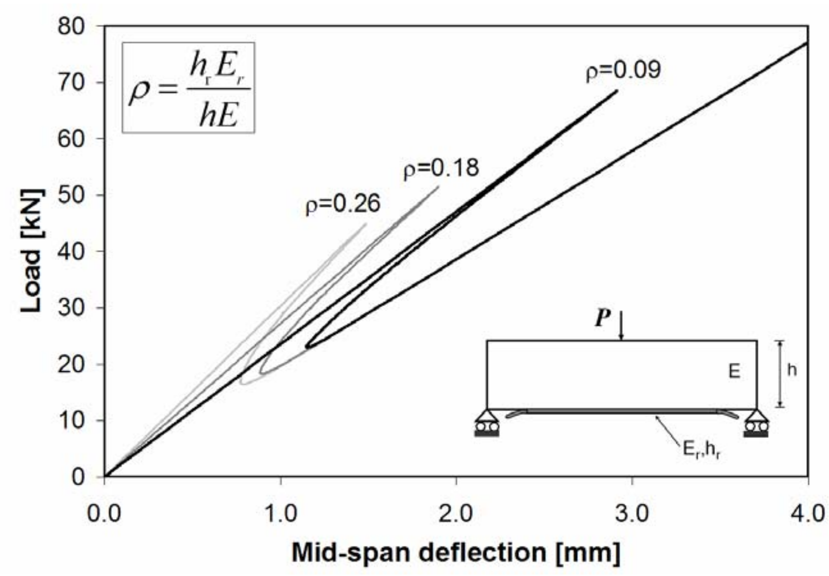

Figure 1: Numerically predicted snap-back instability due to edge debonding as a function of the mechanical percentage of reinforcement.

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