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DEVELOPMENT OF A FIBRE FLEXURE-SHEAR MODEL FOR SEISMIC ANALYSIS OF RC FRAMED STRUCTURES

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ABSTRACT

Currently the accurate simulation of the behavior of reinforced concrete (RC) structures subjected to strong motion is still a challenging and open problem. In particular, the determination of the shear strength and deformation response is still far from reaching a mature state of development.

Most of the state of the art on seismic design and assessment procedures require either static or dynamic nonlinear analyses using frame elements where the nonlinearity is traditionally introduced with lumped plasticity models or with distributed-inelasticity models, the so-called fibre beam-column elements. Whilst existing fibre modelling approaches of RC elements allow a reasonably accurate prediction of flexural response, the determination of its shear counterpart needs further developments. The few existing fibre modelling strategies that predict shear response have not yet proven to be applicable to a wide range of structural cases and/or easily calibrated and implemented. These considerations encouraged the current research on the development of a flexure-shear model for seismic analysis of RC framed structures.

A bi-axial fibre constitutive model was developed according to the Modified Compression Field Theory (MCFT) [1]: it stands out as a model able of accurately predicting the shear strength of RC panels subjected to monotonic and cyclic loads. Some modifications were introduced in the model to improve its behaviour when used for predicting the response of RC beam-column elements. For the section state determination the following assumptions were made: the longitudinal and shear strains were assumed known for each fibre, according to plane section assumption and Timoshenko beam theory, respectively; the transversal strains were determined for each fibre from equilibrium conditions (zero transversal stress), with an iterative procedure. Finally, the determination of the longitudinal and shear stresses for each fibre was obtained through the static condensation of the material stiffness matrix. The developed flexure-shear model was implemented in a 2D fibre beam-column element formulated according to a displacement-based approach. To avoid shear locking phenomena, the linear shape functions were enriched by the introduction of a bubble function.

The flexure-shear formulation was verified against experimental tests on RC short piers tested at the University of California San Diego (Figure 1, on the left), and on RC walls tested at the Imperial College (Figure 1, on the right). Comparisons with experimental results on shear-sensitive elements subjected to cyclic loading showed significant improvement in response predictions when the flexural formulation (Figure 2) is replaced by the developed fibre-shear formulation (Figure 1). Moreover, compared to other models [2] able to predict the shear response, the one herein described does not need empirical test-matching calibration; only engineering parameters are required as input (e.g. material strength, reinforcement geometrical ratio).

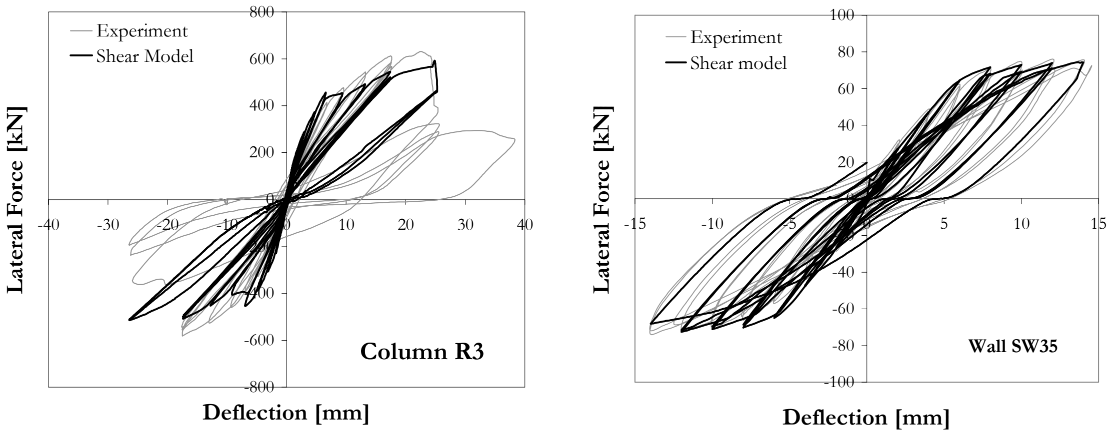

Figure 1 Force-displacement responses of the RC column R3 and the wall SW35 using the implemented fibre-shear model

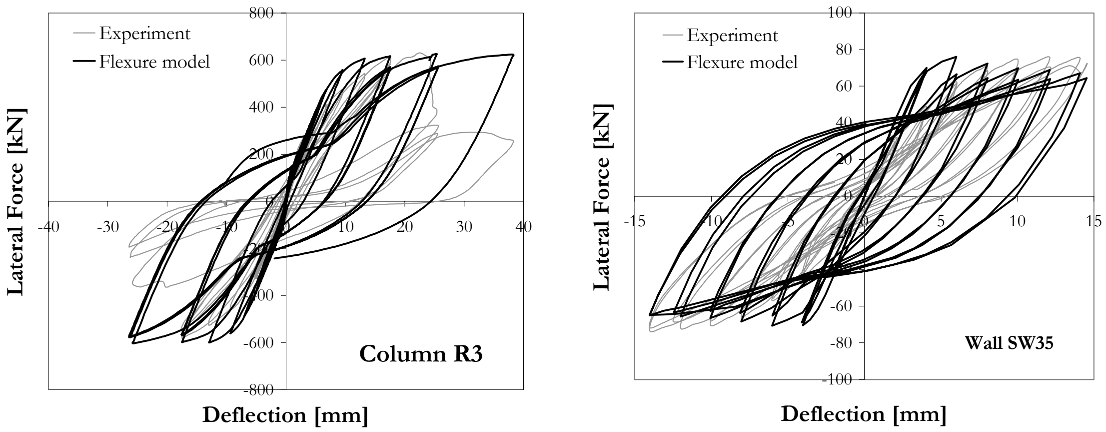

Figure 2 Force-displacement responses of the RC column R3 and the wall SW35 using a fibre-flexure model

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