Semana de Engenharia 2010
Guimarães, 11 a 15 de Outubro

FLEXURAL MODELLING THE CYCLIC BEHAVIOUR OF FRP STRENGTHENED RC STRUCTURES

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KEYWORDS
CFRP, Timoshenko Fibre Model, FEM, Constitutuve model.

ABSTRACT

The CFRP strips are used to increase the flexural resistance of columns and beams (for the negative bending moments in case of the beams) and strips of wet lay-up CFRP sheets are applied to increase the concrete confinement of columns and to increase the shear resistance of beams and columns. A Numerical constitutive model is proposed and the performance of it is assessed carrying out experimental research with column-beam joint prototypes submitted to cyclic load configurations. In case of RC shell structures with deficient flexural reinforcement and stiffness, due to incorrect design and/or construction, applying NSM post-tensioned CFRP strips can upgrade the structure in terms of the necessary flexural reinforcement and can uplift this structure up to restore its desired geometrical configuration

INTRODUCTION

Previous experimental research showed that carbon fibre reinforced polymer (CFRP) laminate strips (herein as CFRP strips) applied according to the Near Surface Mounted Technique (NSM) can increase significantly the flexural resistance of reinforced concrete (RC) columns (Barros *et al.* 2006), the flexural resistance of RC beams and slabs (Blaschko and Zilch 1999) and the shear resistance of RC beams (Nanni *et al.* 2004, De Lorenzis and Rizzo 2006). NSM is a strengthening technique based on bonding FRP bars (rods or strips) into pre-cut grooves opened on the concrete cover of the elements to strength. NSM strips installed in the column faces submitted to tensile stresses give, however, neglected contribution for the increase of the concrete confinement of RC columns of deficient transversal reinforcement (steel hoops) and detailing. To increase the concrete confinement of RC columns, the technique based on embracing the columns with wet lay-up FRP sheets is the most current one (Barros and Ferreira 2005).

The main objective of the research is to develop a numerical program able of simulating, with enough accuracy, the behaviour of RC buildings strengthened with CFRP systems, when submitted to cyclic load configurations (Chang and Mander 1994) and taking into account the damage and the strain and stress fields installed in the existing materials when strengthening interventions are executed.

NUMERICAL APPROACH

Fibrous Model

Every structural element is discretized in fibres along its longitudinal direction. The response of each fibre depends on the mechanical characteristics. A constitutive material model is applied to every fibre at material level, according to the material characteristic and, a response is generated from each fibre. The collective response of the fibres in turn produces the response at structural level.

Constitutive Laws

All cyclic hysteretic curves are enveloped by monotonic loading curve. Degradation in stress and strain is of vital importance during every cycle. Plastic strain and unloading stiffness decide the shape of hysteretic branches. Debonding of materials and crack formation will be considered for buckling and pinching effect.

RESULTS

The proposed numerical response are compared with experiments carried out at University of Minho, at material and structural level (Fig 1). The layered model for slabs and shells will be implemented in FEMIX. To validate the proposed models and calibrate the model parameters, the simulation is presented in Figure 1.

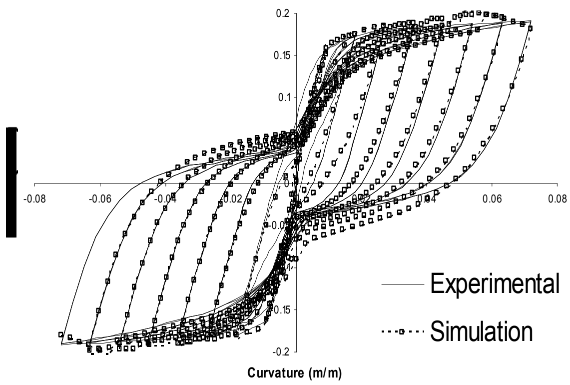

Figure 1: Numerical Simulation

EXPERIMENT AND FUTURE WORK

One of the phase of this research will be experimental phase. RC column-footing and column-beam prototypes, strengthened by CFRP(Fig. 2), will be submitted to constant axial compressive load and lateral cyclic load for the evaluation of the performance of these strengthening techniques and to obtain data to calibrate the developed numerical model. This experimental program (Fig. 3) will be composed of series of tests to assess the influence of: concrete strength class; percentage of longitudinal reinforcement ratio; percentage of existent steel hoops; percentage of CFRP strips; percentage of FRP to confine the concrete; arrangement of FRP to confine the concrete; geometry of the column cross section.

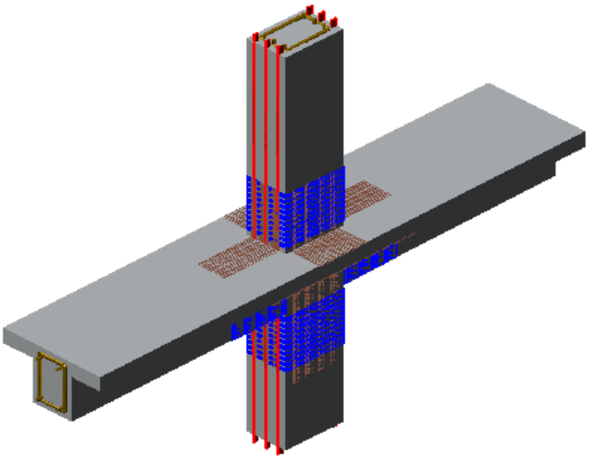

Figure 2: Schemaytic diagram for strengthening

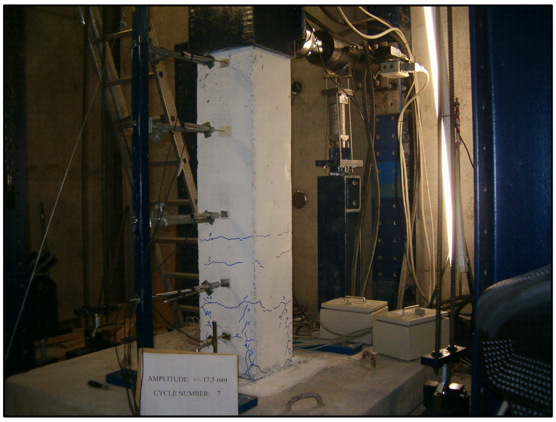

Figure 3: Experimental program

CONCLUSIONS

The research will contribute to enhance the quality of the design guidelines that fib and ACI are working. It will allow to design and assess the performance of CFRP-based strengthening strategies for RC structures of insufficient resistance to seismic loadings. It will contribute to the consolidation of the excellence of this research group in the field of the use of FRP systems for the strengthening of the built patrimony. This strengthening intervention does not affect the structure appearance, which is an important aspect for this research project.

ACKNOWLEDGEMENTS

The study reported in this paper forms a part of the research program PTDC/ECM/74337/2006 supported by FCT. The first author would like to acknowledge the FCT –for financial support provided under the Doctrol grant (SFRH/BD/61677/2009).

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