Universidade do Minho

Escola de Engenharia

Semana da Escola de Engenharia
October 24 - 27, 2011

NON-LINEAR MATERIAL BEHAVIOUR OF RC STRUCTURES SUBJECTED TO CYCLIC LOADS

Rajendra Varma, Joaquim Barros and Jose Sena-Cruz
ISISE, Department of Civil Engineering
E-mail: rajendra@civil.uminho.pt

KEYWORDS
Plane stress element, Smeared crack model, Rotating crack mode, Biaxial concrete behaviour, Cyclic constitutive models.

ABSTRACT

A cyclic constitutive model to simulate the biaxial behaviour of reinforced concrete was implemented into FEMIX computer program, which is based on the finite element method. This model allows the simulation of the nonlinear concrete behaviour in plane stress elements submitted to cyclic loading. The biaxial model assumes a rotating crack criterion to simulate the characteristic cyclic features of concrete in terms of nonlinear unloading and reloading curves with reloading stiffness degradation. In addition, the partial unloading/reloading rules were also incorporated in both tension and compression states. Using experimental results it was verified that the implemented model can predict with high accuracy the behaviour of RC structures subjected to cyclic loading.

INTRODUCTION

Plane stress finite elements are used in the scope of FEM-based design to analyse bridges, high rise buildings, offshore structures and and all type of structures that have essentially three inplane stress components. Constitutive material models for concrete proposed by Chang and Mander [1] were implemented in Femix to predict the response of RC structures in condition of biaxial stresses.

ROTATING SMEARED CRACK MODEL

To predict the non-linear behaviour of RC planar structures, smeared rotating crack model is followed, being simple and yet numerically stable. The rotating crack proposal of Gupta and Akbar [2] was implemented in the Femix computer code. In biaxial analysis for predicting the response of RC structures, an equivalent uniaxial model is used to generate the response of the constituting materials in each direction. In this approach, the direction of principal stresses is calculated for every load increment, anew; without retaining the previous principal stress orientation.The recent principal stress orientation of it may not coincide with the previous one, still the newly generated crack pattern follows predominant crack pattern at that point. The rotating crack approach introduces implicit shear softening and shear-normal stress coupling, without the need of choosing shear interface modeling, which is necessary in other crack models.

MODEL APPRAISAL

To validate the implemented model, a barbell-shaped shear wall B2, tested by Oesterle et al. [3] at the Portland Cement Association, was used for the numerical analysis. The isolated shear wall B2 (see Fig. 1) was approximately 1/3-scale model of full size walls, and was composed of wall web and boundary elements which were sandwiched between stiff base block and stiff top slab. The wall was tested like a vertical cantilever with reversing horizontal displacements applied through the top slab. The boundary element was 4570 mm high, 305 mm long and 305 mm thick; the vertical reinforcement is composed by 12ϕ20. On the other hand, the wall web was 4570 mm high, 1910 mm long and 102 mm thick, and was reinforced with 12ϕ6 in the vertical direction. The horizontal reinforcement was placed uniformly throughout the wall web at 203 mm and, was extended inside the boundary elements. Fig. 2 shows the relationship between the horizontal force and the corresponding displacement experimentally and numerically obtained.

Universidade do Minho

Escola de Engenharia

Semana da Escola de Engenharia
October 24 - 27, 2011

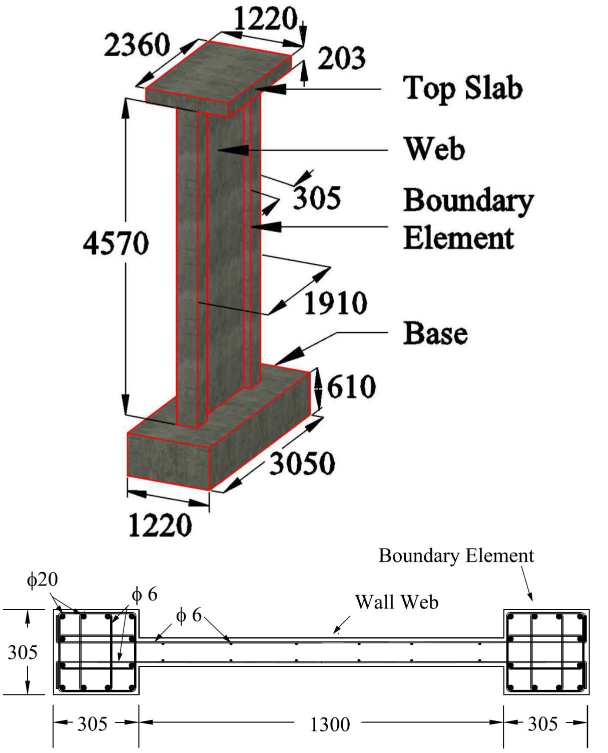

Figure 1: Nominal Dimension and Cross-sectional details of Shear-wall B2

Up to the last cycle the present model predicts with high accuracy the obtained results not only in terms of maximum peak load in each cycle, but also during the unloading and reloading phases.

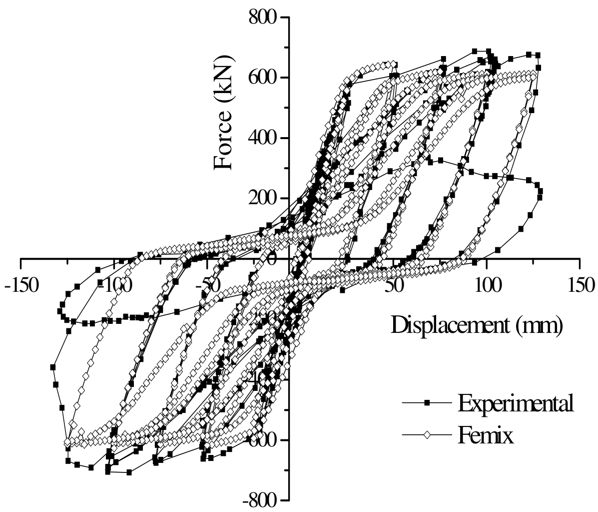

Figure 2: Force vs. Deflection Curve for Shear-wall B2

ACKNOWLEDGEMENT

The authors wish to thank Portuguese Foundation for Science and Technology (FCT) for the support given through the doctoral grant SFRH/ BD/61677/2009.

REFERENCES

Chang, G. A., & Mander, J. B. (1994). Seismic energy based fatigue damage analysis of bridge columns Part I-Evaluation of seismic capacity. Report No. NCEER-94-0006, USA.

Gupta, A.K. &Akbar, H. (1983). A Finite Element for the Analysis of Reinforced Concrete Structures. *International Journal for Numerical Methods in Engineering*, Vol. 19, pp. 1705-1712.

Oesterle, R.G., Fiorato, A.E., Johal, L.S., Carpenter, J.E., Russell, H.G., Corley, W.G. , (1976). Earthquake-resistant structural walls—Tests of isolated walls, Report to the National Science Foundation, Construction Technology Laboratories, Portland Cement Association, Skokie, Illinois, November, 315pp.

AUTHORS' BIOGRAPHIES

RAJENDRA KUMAR VARMA was born in in India, and graduated in Bachelor of Technology of Civil Engineering from IIT guwahati, India. He is a PhD Student of ISISE, DEC University of Minho, Portugal, since April 2007.His research interests are numerical modeling of RC structures. E-mail address:rajendra@civil.uminho.pt.

JOAQUIM BARROS is an ISISE member, Associate Professor at the Structural Division of the DEC, University of Minho. He is a member of ACI Committees 440 and 544, a member of TG 8.3 and fib TG 9.3, and a Council member of the IIFC He is supervisor of the PhD thesis. E-mail address:barros@civil.uminho.pt.

JOSE SENA-CRUZ is an ISISE member, Assistant Professor at the Structural Division of the DEC, University of Minho. He is the secretary of the RILEM TC DUC 234. He is co-supervisor of the PhD thesis. E-mail address:jsena@civil.uminho.pt.