Continuous microplane theory and interface approach for failure form analysis of steel fiber reinforced concrete

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ABSTRACT

A fracture energy-based microplane constitutive theory for fiber reinforced concrete (FRC) is presented and considered to evaluate the properties of the discontinuous bifurcation condition under different scenarios of stress states, fiber content and fiber directions. The constitutive model considers a cap-cone yield surface of C^1 continuity at the microplane level. Its evolution in the post-peak regime is described by means of a fracture energy-based work softening which is defined differently for mode I and II type of failure. The effect on the post-peak ductility introduced by the fiber content is taken into account by means of the fracture energy properties for Mode I and II type of failure, while the directional properties of the steel fibers are considered through the relative directions between microplanes and fibers.

Main objective of the discontinuous bifurcation analysis in this work is to evaluate the capabilities of the microplane theory to capture the directional enrichment provided by steel fibers to the ductility and also, to reproduce the particular microcrack directions which (in the realm of the smeared crack approach) are mathematically represented by the spectral properties of the critical localization tensor. Firstly, the localized failure features in the form of discontinuous bifurcation of FRC are identified by means of numerical and geometrical analyses. Mono and multidirectional fiber distributions and different steel fiber contents are considered in the localized failure analysis to be performed on stress states corresponding to critical strengths of FRC under both uniaxial and biaxial tension and compression. Then, FE analysis are performed to evaluate the accuracy of the microplane constitutive theory predictions on localized failure behaviors of FRC panels. To this end, the microplane model predictions in terms of overall load-displacement responses as well as of microcracks evolutions and their directions are compared with the FE predictions obtained with the interface model for FRC previously proposed by the authors [1], [2]. In the last case, the crack evolutions and their directions and described in the framework of the discrete crack approach.

REFERENCES

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[2] A. Caggiano, G. Etse, E. Martinelli, "Zero-thickness interface model formulation for failure behavior of fiber-reinforced cementitious composites", *Computers & Structures,* **98-99**, 23-32 (2012)