On the modelling of fracture processes in cohesive-frictional materials

P. Grassl[1]*** and C. Zhou**[1]

[1] James Watt School of Engineering, University of Glasgow, Oakfield Avenue, G128LT Glasgow, United Kingdom, Peter.Grassl@glasgow.ac.uk

In recent experiments, it has been shown that for tensile fracture with lateral compressive stresses, the fracture energy in tension is increased considerably [1]. For reinforced concrete structures, these types of fracture processes with combinations of tensile and compressive stresses occur during shear and splitting failure modes. The effect of lateral compressive stresses on the fracture process in tension is often not explicitly considered in fracture models for quasi-brittle materials [2]. The aim of the present work is to investigate this phenomenon by means of meso-scale analyses to obtain a better understanding. Furthermore, it is aimed to investigate if the concrete damage plasticity model 2 (CDPM2) presented in [3] is capable to reproduce the effect of lateral compressive stresses on tensile fracture observed in experiments and meso-scale analyses.

For the meso-scale lattice approach, a damage-plasticity constitutive model is combined with an auto-correlated random field of strength and fracture energy [4]. Initially, the lattice approach is compared with experimental results in uniaxial tension and uniaxial compression. The results show a good agreement between simulations and experiments. Then, cells with periodic lattices and periodic boundary conditions are loaded in two steps. Firstly, compression is applied. Next, the cell is extended in the lateral direction while keeping the compressive stress constant. It is shown that with increasing compressive stress applied, the post-peak energy dissipation in tension increases. Postprocessing of the results of the analyses reveals that this increase is due to greater frictional energy dissipation and greater number of cracks than for pure tension.

The findings of the meso-scale analyses and the experiments reported in the literature are then used to investigate the response of the macroscopic constitutive model CDPM2. Special attention is paid to the ductility measures of the damage part of CDPM2 and the way the effective stresses are split into tensile and compressive parts. Then, this model is used for finite element simulations of a concrete beam failing in shear for which the results were reported in Leonhardt and Walther [5].

References

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