Early predictions of fracture in plain concrete in DEM calculations

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ABSTRACT

Fracture is a fundamental phenomenon in concrete. Its understanding is of major importance for the safety of structures and material behaviour optimization. It is characterized by complicated micromechanical processes, including the nucleation, growth and coalescence of micro-cracks which lead to strain localization and later to macro-cracks. It strongly depends upon a heterogeneous structure of materials over many different length scales, changing e.g. in concrete from the few nanometres (hydrated cement) to the millimetres (aggregate particles).

In this paper, an early prediction of fracture in plain concrete was discussed within a discrete continuum. The calculations were performed with the discrete element method (DEM). The open-source code YADE was used that was formulated at Grenoble University. A linear contact under compression was used. The tangential contact forces satisfied the cohesive-frictional Mohr-Coulomb condition. The model already proved its effectiveness in describing fracture in concrete at both the macro- and meso-scale [1], [2]. Concrete was modelled as a composite stochastic material wherein four important phases were distinguished: aggregate, cement matrix, interfacial transition zones (ITZs) and macro-voids. The calculations were carried out for uniaxial tension and bending to find an energetically favourable macro-crack**.**

Different criteria were checked in cross-sections of concrete specimens during loading to predict the most preferable macro-crack's location, based on different criteria: minimum bond strength [3], maximum tensile principal stress, maximum elastic energy, minimum strain energy density and a maximum ratio between the stressing level and strength. A special optimization algorithm was worked out to find the position of a macro-crack among a dozen possible paths [3]. The ultimate crack pattern was detected in early loading stages (it developed from the beginning of deformation). Thus, the macro-crack was identified significantly earlier than e.g. based on broken bonds.

REFERENCES

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