Domain decomposition methods for fracture mechanics problems and its application to fiber reinforced concrete

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ABSTRACT

Strain hardening ultra high performance fiber reinforced cementitious composites (UHPFRCC) exhibit increased strength, ductility, and energy absorption capacity when compared to their quasi-brittle, unreinforced counterparts [1]. A mesoscale finite element model can depict the underlying causes for the structural response of UHPFRCC and thus help to optimize the fiber content, the fiber dimensions, and the fiber orientation. The mesoscale model can either be used directly or as a representative volume element for a macroscopic model. We present a two-dimensional and a three-dimensional mesoscale finite element model to simulate the structural response of strain hardening UHPFRCC. The mesoscale model employs an implicit gradient enhanced damage model [2] for the cement matrix and a local bond stress-slip model for the bond between the cement matrix and the steel fibers. The steel fibers are modeled discretely as one-dimensional truss elements that are coupled to the cement matrix via bond elements. The tensile stress-strain response of UHPFRCC is a consequence of local matrix cracking and bond failure. Both phenomena can be depicted when modeling the cement matrix, the steel fibers, and the fiber-to-matrix bond explicitly.

The second part of the talk deals with the efficient modeling of fracture and the prediction of crack initiation, propagation, merging, and branching through the computational domain. Phase-field models [3] and gradient enhanced damage models can solve fracture mechanics problems by integrating a set of partial differential equations for the system and thus avoid the explicit treatment of discontinuities. The main attributes of these approaches are their simplicity and generality. However, they require a fine discretization in the region where the crack evolves. A finite element tearing and interconnecting (FETI) [4] approach for the diffusive crack models is presented to distribute the computational cost among multiple processors and thus speed up the overall computation.

REFERENCES

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