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Mesoscale Concrete Modelling with Combined Concrete Damage Plasticity Model and Cohesive Zone Model under Uniaxial Tension and Compression

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Despite of concrete being the most widely used composite material in the society, its mechanical behavior and damage evolution under complex loading conditions is still not fully understood. Recently, Wang [1] has shown that mesoscale models with zero-thickness cohesive elements for interfacial transition zone (ITZ) and inside mortar can provide a good approximation to the concrete behavior under uniaxial tension but not for uniaxial compression. In this work, a 3D mesoscale synthetic concrete model that combines cohesive zone for ITZ and concrete damage plasticity (CDP) for mortar is proposed.

Computationally, the synthetic models, containing coarse aggregates, mortar and pores are generated with a Matlab code by random placing of spherical particles with prescribed aggregate size distribution. The synthetic models are meshed similarly to image-based ones using Simpleware, and an in-house FORTRAN code is for the first time developed to insert zero-thickness cohesive elements in ITZ only. A bilinear constitutive law is adopted for ITZ, while modified CDP model [2] is adopted for mortar solid elements. Displacement boundary conditions are applied on rigid plates, which are in contact with a 50 mm concrete cube, reflecting an experimental setup used for model validation.

With this formulation, no previous knowledge of nucleating crack location and propagation direction is required. The model is solved successfully by Abaqus Standard. The resulting stress-strain curves are in excellent agreement with experiment data, demonstrating the model ability to simulate uniaxial tension, compression and other complex loading conditions. The observed crack formation and propagation confirm expected patterns from experiments. The model allows for introduction of strain rate dependence and stiffness recovery, which will be used in planned future work simulating more complex loading conditions, such as multiaxial and cyclic loadings.

REFERENCES

[1] X. Wang and M. Zhang and A. P. Jivkov, Computational technology for analysis of 3D meso-structure effects on damage and failure of concrete. *International Journal of Solids and Structures*, Vol. **80**, pp. 310–333, 2016.

[2] Y. Huang, D. Yan, Z. Yang, 2D and 3D homogenization and fracture analysis of concrete based on in-situ X-ray Computed Tomography images and Monte Carlo simulations. *Engineering Fracture Mechanics*, Vol. **163**, pp. 37–54, 2016.