A continuum material model for concrete

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Abstract

A thermodynamically consistent constitutive model for concrete is presented. The model is based on proper expressions for the specific Gibbs free energy and the complementary form of the dissipation potential. Damaging of the material is described by a symmetric positive definite second order damage tensor. Invariant theory is used in construction of the potential functions which guarantees that the proper symmetry behaviour is satisfied and no artificial symmetrisation operations need not to be done. Especially, the failure surface is formulated in such a way that it will mimic the behaviour of the well known Ottosen$j$s four parameter failure surface. While testing the model against the experimental results found in literature, the results were in good agreement in uniaxial tensile and compressive loadings as well as in biaxial compression. Besides the correct failure stress states, the model predicts the correct failure modes of concrete: axial splitting along the direction of uniaxial compression and tensile damaging normal to the direction of tension, which is extremely important in analysing complex loading paths. The predictions of the proposed model are compared to the Concrete Damaged Plasticity (CDP) model available in the commercial finite element software Abaqus in uniaxial and equibiaxial cases. Addition of the plasticity component is also discussed as well as issues related to the regularization of the model for reliable computation in the strain-softening range.

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