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FRACTURE ENERGY-BASED GRADIENT PLASTICITY FORMULATION FOR CONCRETE

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ABSTRACT

Failure behavior of quasi-brittle materials like concrete varies from brittle to ductile with increasing confinement. To model this complex failure behavior mathematical formulations are required that are capable to predict the dramatic change from the volume controlling to the surface controlling failure mode that takes place when the governing stress state moves from the high confinement regime to the uniaxial or biaxial tensile regime. In this work a fracture energy-based gradient plasticity formulation is presented. Gradient plasticity allows describing material damage processes that involve a region of the material with non-zero thickness which is defined by the gradient characteristic length. On the other hand, fracture mechanics-based continuum theories are able to describe the fracture energy features of the material during brittle type of failures. The combination of these two theories allows to take into account both the degradation process due to the damage of the material located in between cracks as well as the material damage due to the cracking process.

After describing the main features of the proposed material theory the predictions of the model are illustrated and compared with experimental data on concrete specimens. These results demonstrate the capabilities of the proposed model to predict brittle and ductile failure modes of concrete.

Finally, the model predictions of localized failure modes by means of the geometrical method are evaluated. To this end, the localization condition of the proposed fracture energy-based gradient plasticity theory is reformulated to obtain the localization ellipse that is compared with the Mohr circle corresponding to the considered stress states. The results of the geometrical localization analysis demonstrate the model capability to describe the transition from localized to ductile failure mode depending on the confining pressure.