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MODELING OF CRACK BEHAVIOR OF CEMENTITIOUS MATERIALS UNDER CYCLIC LOADS

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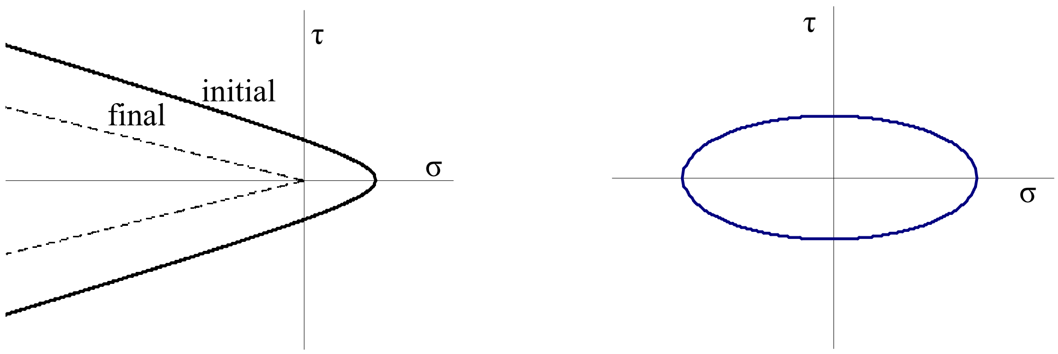
ABSTRACT

An elastoplastic model that describes the fracture behavior of quasi-brittle materials under normal and shear stresses is presented. Cracks in cementitious materials, such as concrete and masonry, exhibit a complicated behavior under cyclic load reversals. It can be influenced by the shear dilatation of crack interfaces due to surface roughness and joint compaction under combined shear and compression due to the loss of interface material. Different approaches including nonlinear contact formulations, elastoplastic models, or damage-mechanics models have been proposed to describe such behavior. While all these models have their own merits, none can account for all the important properties of a crack in cementitious materials. The model presented here uses an elastoplastic formulation and geometric description to account for the opening and closing of a tensile crack upon normal stress reversals, the Coulomb friction, mixed-mode fracture energies, and the cyclic behavior of a rough crack interface including the reversible shear dilatation and irreversible joint compaction upon shear reversals.

The present constitutive model is based on the work of Mehrabi and Shing (1997) but with major improvements to capture the cyclic behavior in a more accurate manner. An efficient and robust stress update algorithm based on an elastic predictor-plastic corrector approach (Ortiz ad Simo 1986) has been developed and implemented. The yield surface is represented by a hyperbolic function as shown in Figure 1a. The direction of the incremental plastic displacement vector under compression and shear is defined by an elliptical plastic potential as shown in Figure 1b. The model has been implemented in a line interface element

in a finite element code. Numerical analyses have been performed to evaluate the performance of the model under different combinations of normal and shear stresses and displacements. The numerical results appear to be in good agreement with experimental results. Figure 2 presents a comparison of numerical and experimental results on the cyclic shear test of a masonry mortar joint conducted by Mehrabi and Shing (1997).



(a) Initial and final yield surfaces (b) Plastic potential

Figure 1. Interface model for fracture

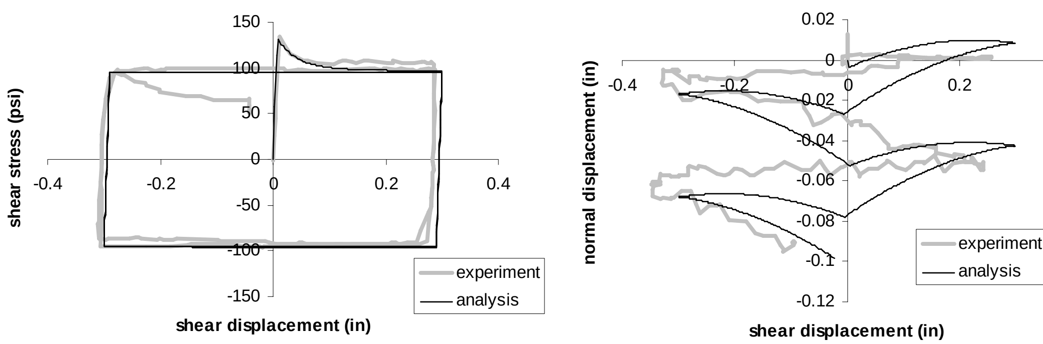


Figure 2. Comparison of numerical and experimental results on mortar joint test

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