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Modelling of Progressive Failures in Quasi-Brittle Media Via a Temporal Stress-Redistribution Mechanism

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Abstract: A new method is proposed to simulate progressive failure processes in heterogeneous brittle materials such as concrete, ceramics, rocks etc., by considering the time-dependence of stress redistributions induced by local breakages. Two mechanisms of stress redistribution are incorporated into the proposed model in order to account for the influence of each local breakage on the remaining specimen: (1) One is the immediate release of internal forces in the breaking element, which is assumed to happen within an infinitesimal time when compared with the characteristic time of external loadings. The release of such internal forces is hence suddenly applied to the remaining specimen, which is considered to take time to deform correspondingly due to material viscosity. This deformation delay is implemented by introducing a viscous force (VF) field prevailing in the entire specimen. (2) The other is the gradual release of previously stored VF fields, whose characteristic time is assumed to be material-dependent. Here the release of VF is approximated as stepwise for simplicity. The proposed model is found to be capable of overcoming the unreasonably-low-ductility problem encountered in many existing lattice models when it comes to the uniaxial tensile test. Furthermore, the force-displacement response obviously depends on the ratio of the VF releasing time to the characteristic time of external loading, showing trends agreeing with experimental observations. Compared with results without viscosity, the failure pattern is more scattering, and the force-displacement curve has a higher peak load and a more ductile post-peak tail.

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