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Coupling microplane-based damage and continuum plasticity models for analysis of damage-induced anisotropy in plain concrete

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Abstract

A novel plastic-damage constitutive model for plain concrete is developed in this paper. For this purpose, the microplane theory is proposed for overcoming the deficiency of available anisotropic continuum plastic-damage models in reproducing the true anisotropic nature of damage in multidimensional loadings. Based on the microplane theory, the degeneration process in concrete is considered along with plastic deformations. Using the principle of strain energy equivalence, a transformation between the nominal and effective states of material is achieved, that results in a decoupled formulation for damage and plasticity. A yield function with multiple internal variables and a non-associative flow function are employed to describe the plastic behavior of concrete. In order to discriminate between the behavior of concrete in tension and compression, stress tensor is decomposed into tensile and compressive parts, and two sets of microplanes are defined for each material point, leading to corresponding independent anisotropic damage tensors in tension and compression. Several numerical examples are analyzed using the proposed model and robustness and accuracy of the formulation are assessed using the available experimental tests. In addition, superiority of the proposed model over the available isotropic and anisotropic formulations is demonstrated by comparisons between the different approaches. The effects of three different cubature schemes on the response of concrete specimens are also analyzed.

Keywords: concrete plasticity, damage mechanics, anisotropic damage,

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