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A Damage-Plasticity Concrete Model for Damage Modeling of Reinforced Concrete Structures

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Abstract : This paper addresses the modeling of two critical behaviors of concrete material in reinforced concrete components: (1) the increase in strength and ductility due to confining stresses from surrounding transverse steel reinforcements, and (2) the progressive deterioration in strength and stiffness due to high strain and/or cyclic loading. To improve the state-of-the-art, the author presents a new 3D constitutive model of concrete material based on plasticity and continuum damage mechanics theory to simulate both the confinement effect and the strength deterioration in reinforced concrete components. The model defines a yield function of the stress invariants and a compressive damage threshold based on the level of confining stresses to automatically capture the increase in strength and ductility when subjected to high compressive stresses. The model introduces two damage variables to describe the strength and stiffness deterioration under tensile and compressive stress states. The damage formulation characterizes well the degrading behavior of concrete material, including the nonsymmetric strength softening in tension and compression, as well as the progressive strength and stiffness degradation under primary and follower load cycles. The proposed damage model is implemented in a general purpose finite element analysis program allowing an extensive set of numerical simulations to assess its ability to capture the confinement effect and the degradation of the load-carrying capacity and stiffness of structural elements. It is validated against a collection of experimental data of the hysteretic behavior of reinforced concrete columns and shear walls under different load histories. These correlation studies demonstrate the ability of the model to describe vastly different hysteretic behaviors with a relatively consistent set of parameters. The model shows excellent consistency in response determination with very good accuracy. Its numerical robustness and computational efficiency are also very good and will be further assessed with large-scale simulations of structural systems.

Keywords : concrete, damage-plasticity, shear wall, confinement
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