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APPLICATION OF COUPLED ELASTO-PLASTIC-DAMAGE MODEL WITH NON-LOCAL SOFTENING TO CONCRETE MATERIALS

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ABSTRACT

The analysis of concrete elements is complex due to their stiffness degradation during cyclic loading caused by strain localization in the form of cracks and shear zones. The determination of the width and spacing of strain localization is crucial to evaluate the material strength at peak and in the post-peak regime.

The aim of the present paper is to show the capability of two different coupled elasto-plastic-damage continuum models to describe strain localization and stiffness degradation in concrete elements subject cyclic loading during bending, uniaxial compression and extension. First, a coupled elasto-plastic-damage model based on the idea by Pamin and de Borst. [1] was used [2]. Second, a coupled elasto-plastic-damage model using the formulation proposed by Carol et al.[3] and Hansen and Willam [4] was considered.

To describe properly strain localization, to preserve the well-posedness of the boundary value problem, to obtain FE-results free from spurious discretization sensitivity and to capture a deterministic size effect, a integral-type non-local theory [5], [6] was used as a regularization technique in a softening regime [7]. It is achieved by weighted spatial averaging over a neighbourhood of each material point of a suitable state variable. Thus, stress at a certain material point depends not only on the state variable at that point but on the distribution of state variables in a finite neighbourhood of the point considered (the principle of a local action does not hold – the non-local interaction takes place between any two points).

The first coupled model combines non-local damage with hardening plasticity and assumes that total strains are equal to strains in undamaged skeleton. Plastic flow can occur only in undamaged specimens, thus an elasto-plastic model is defined in terms of effective stresses. As a consequence, the damage degradation does not affect plasticity. In the second model, plasticity and damage are connected by two loading functions describing the behaviour of concrete in compression and tension. The model assumes that the damage approach can better simulate the behaviour of concrete under tension while plasticity is more suitable to describe the concrete behaviour under compression. According to this assumption, a failure envelope is created by combining a Drucker

Prager formulation in compression with a damage formulation based on a conjugate force tensor and pseudo-log damage rate in tension. Theoretical mesh-independent solutions were compared with corresponding laboratory tests.

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