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Concrete under cyclic loading - a continuum damage model and a temporal multiscale approach

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The durability of concrete structures and its performance over the lifetime is strongly influenced by many interacting phenomena such as e.g. mechanical degradation due to fatigue loading, loss of prestress, degradation due to chemical reactions or creep and shrinkage. Failure due to cyclic loading is generally not instantaneous, but characterized by a steady damage accumulation.

Many constitutive models for concrete are currently available, which are applicable for specific loading regimes, different time scales and different resolution scales. A key limitation is that the models often do not address issues related to fatigue on a structural level. Very few models can be found in the literature that reproduce deterioration of concrete under repeated loading-unloading cycles.

The objective of this paper is the presentation of numerical methods for the simulation of concrete under fatigue loading using a temporal multiscale method.

First, a continuum damage model for concrete is developed with a focus on fatigue under compressive stresses [1]. This includes the possibility to model stress redistributions and capture size effects. In contrast to cycle based approaches, where damage is accumulated based on the number of full stress cycles, a strain based approach is developed that can capture cyclic degradation under variable loading cycles including different amplitudes and loading frequencies. Second, a multiscale approach in time is presented to enable structural computations of fatigue failure with a reduced computational effort. The damage rate within the short time scale corresponding to a single cycle is computed based on a Fourier based approach [2]. This evolution equation is then solved on the long time scale using different time integration schemes.

REFERENCES

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