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Thermodynamically consistent interface model of bond in reinforced concrete applicable to general loading conditions

A. Baktheer[1], M. Aguilar[1], M. Vořechovský[2], J. Hegger[1] and R. Chudoba[1]

[1] Institute of Structural Concrete, RWTH Aachen University,
Mies-van-der-Rohe-Straße 1 , 52074 Aachen , Germany,
[2]Institute of Structural Mechanics, Brno University of Technology,
Veveří 95, 602 00 Brno, Czech Republic

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Realistic methods for characterization of fatigue loading resistance represent a paramount requirement for an economical and reliable structural design of reinforced concrete (RC) structures. The behavior of RC structural elements subjected to fatigue loading can only be accurately characterized if the local degradation mechanisms that affect the bond strength and lifetime under fatigue loading are considered.

In this paper we briefly introduce a consistent constitutive model capturing the behavior of a 3D interface under both monotonic and cyclic loading. The model accounts for the interaction of dissipative effects during a combined sliding and decohesion/compression loading. The interplay of decohesion and sliding is introduced through a smooth pressure-sensitive threshold function with tensile and compressive *caps* and non-associative flow potential that provides the possibility to couple the damage evolution upon sliding and decohesion/compression. To capture the fatigue behavior in heterogeneous structures, the model consistently reflects the dissipative mechanisms of fatigue damage evolution at subcritical load levels using a cumulative measure of deformation as a damage-driving variable.

The generic formulation of the proposed constitutive model makes it applicable at different structural scales to simulate consistently both the monotonic and fatigue behavior. Envisioned applications include: 1) Fatigue pull-out behavior of metallic and non-metallic fibers embedded in concrete or externally bonded to concrete, with the ability to reflect the effect of lateral pressure/tension. 2) Microplane model for concrete with the dissipative mechanisms of the interface models injected at the microplane level. 3) Discrete lattice or particle mesoscale model with the inter-aggregate interaction represented by the described interface model. 4) Discrete crack models, including XFEM and embedded crack models, cohesive-zone models, semi-analytical models for shear crack propagation. The focus of this contribution is on the application of the interface model to the bond fatigue behavior between concrete and reinforcement. A systematic calibration and validation procedure will be included for selected examples, e.g. a pull-out and push-in response of concrete-steel interface under monotonic, cyclic and fatigue loading subjected to lateral pressure/tension captured with a consistent set of material parameters.