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Macroscopic variation of reinforcement slip in two-scale modelling of reinforced concrete

Adam Sciegaj[1,2,⋆], Fredrik Larsson[2], Karin Lundgren[1], Filip Nilenius[1] and Kenneth Runesson[2]

[1] Dept. of Architecture and Civil Engineering, Chalmers University of Technology, SE-41296 Gothenburg, Sweden, adam.sciegaj@chalmers.se

[2] Dept. of Industrial and Materials Science, Chalmers University of Technology, SE-41296 Gothenburg, Sweden, adam.sciegaj@chalmers.se

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Crack growth in reinforced concrete does not indicate structural failure; however, its prediction is of practical importance since it directly influences the durability of the structure. The cracks allow for ingress of harmful substances, e.g chlorides, which in turn can cause corrosion of the reinforcement. In order to predict crack development, including the crack width, it is necessary to account for the bond-slip between the reinforcement bars and the concrete [1].

The framework of Variationally Consistent Homogenization [2] is used to construct a two-scale model of reinforced concrete, whereby the steel reinforcement, the concrete matrix and the steel/concrete interface are studied in detail. It is then assumed that the slip, in addition to the concrete displacements, possesses both a macroscopic and a fluctuation component. The pertinent large-scale and sub-scale problems are established in a variationally consistent fashion. For the sub-scale problem Dirichlet boundary conditions are chosen for the sake of simplicity.

Numerical results comprise FE^2 analyses of a reinforced concrete deep beam subjected to four point bending. The force-deflection relation, crack widths, and the strain field are evaluated for different macroscopic mesh size. The results are compared with those obtained when the macroscopic slip component is ignored as a model assumption (which significantly simplifies the macroscale problem). It is concluded that it is important to account for the macroscopic slip component. In particular, it will lead to more accurate prediction of the crack width.

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