MULTI-SCALE PLASTICITY MODELS OF CONCRETE CAPABLE OF PREDICTING SIZE-EFFECT, CRACK-SPACING AND OPENING

Adnan Ibrahimbegovic

Sorbonne Universités/ TU Compiègne, France
e-mail: adnan.ibrahimbegovic@utc.fr

In this work we present the theoretical formulation and finite element implementation of novel plasticity and damage models for RC structures capable of describing the crack-spacing and opening. The finite element models of this kind can accommodate a large variety of different failure mechanisms (cracking of concrete, relative sliding between the steel reinforcement and concrete due to bond slip and yielding of reinforcement) that occur at different scales. Moreover, by appealing to recent advances in representing the localized failure under heterogeneous strain field along with the corresponding random field description of material parameters, the model can provide a sound, probability-based interpretation of the size effect in localized failure of massive structures.

Besides the novelties in theoretical formulation, that allows combining the diffuse micro cracks in the fracture process zone with the macro crack, the model also provides the novel combination of the discrete approximation ingredients. Namely, the heterogeneities of the strain field in localized failure of reinforced concrete are best captured by judicious combination of embedded discontinuity finite elements (ED-FEM) for representing the micro and macro cracks in concrete and extended finite elements (X-FEM) for representing the bond slip along a particular reinforcement. The latter feature is the most important for enforcing the proper stress redistribution between steel and concrete, the corresponding crack spacing and the crack opening thus produced.

Another crucial ingredient of our solution strategy concerns the operator split solution procedure, which separates the global step providing the total strain field from the local step providing the inelastic strain. The latter allows for numerical implementation of the proposed method within the typical finite element code architecture.

The results that can be obtained with the proposed model are of direct interest for durability studies of reinforced concrete structures. The same methodology can be directly applied to other fiber reinforced composite structures.