ABSTRACT

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In reinforced concrete (RC) structures, adequate bond between the reinforcement and concrete must be ensured to build an ideal composite system, which helps to complement the deficient tensile capacity of concrete by reinforcement. Identifying the bond strength and required development length is an ongoing research subject in the field of RC with advances in the concrete and reinforcement materials, consequently requiring a continuous need for additional experimental efforts. Finite element analysis (FEA) provides opportunities to explore structural behavior of RC structures beyond the limitations of experimental testing. Despite that, there is a paucity of research studies particularly aiming at simulating the reinforcement-concrete bond-zone behavior and related failure mechanism as a result of FEA. Instead, most of the existing numerical studies associated with RC bond has centered on proposing a bond (or interface) constitutive model for use in FEA that, by itself, can characterize bond resistance, typically represented by the bond strength-slip displacement relationship. This class of bond models is useful for simulating the global behavior of RC structures, but is limited in its ability to reproduce local bond resistance considering different geometrical and material aspects (e.g., concrete strength, reinforcement deformations and coating, and confinement level). As an attempt to fill such lack of research, this study proposes a finite element (FE) modeling approach that can apply to reproduce local bond-zone behavior in reinforced concrete as a result of FEA. The proposed FE model is developed in a physics-based way such that it represents the detailed geometry of the bond-zone, such as ribs on the deformed reinforcement and surrounding concrete. The explicit representation of the bond-zone enables to simulate the radial and shear stress developed in concrete due to the presence of the reinforcement ribs (i.e., dowel action), which is the main cause of bond failure. Accordingly, special attention is given to the selection and calibration of a concrete model to reproduce robust nonlinear response. The power of the proposed modeling approach is its ability to predict bond failure and damage patterns, only based on the physical and material properties of the bond area.

Thus, the successful implementation of this approach is expected to serve to the development of new design specifications for bond of concrete with new and improved materials.