Study of Joint Elements with Application to the Simulation of Push-out and Torsion Tests of Steel Bars Embedded in Concrete Specimens

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ABSTRACT

In this work, a numerical study of joint elements based on the behavior of pair of nodes has been carried out, with application to the simulation of the push-out tests presented in [1] and torsion tests. Those are an extended version of the joint elements presented in [2], which were programmed to reproduce the expansive behavior of the oxide in two-dimensional simulations. Initially, they were zero-initial thickness elements defined by their length and normal direction. In the current version, the formulation of the elements has been generalized, leading to two families of prisms and hypercubes, which can be used in two and three-dimensional problems. They are implemented within the finite element framework COFE (*Continuum Oriented Finite Element*), which incorporates elements with an embedded adaptable crack [3] to reproduce fracture of concrete according to the standard cohesive model [4].

As an application, three-dimensional simulations of push-out tests have been carried out in this study. In the tests the specimens were slices obtained from concrete prisms reinforced with a smooth steel tube, in which the tube was pushed out of the concrete, thus adherence and friction are the main resisting mechanisms contributing to bond strength. They were performed within the framework of a general study of cracking of concrete due to reinforcement corrosion. In order to reproduce the behavior observed in the experiments, several constitutive laws have been programmed for the joint elements, with cohesive softening and friction. In particular, combinations of linear and exponential softening with constant and variable friction have been implemented. In addition, other examples, such as torsion of a steel bar embedded into concrete, are simulated in order to investigate the stability of the elements.

In the presentation, the main aspects of the elements are discussed, with special focus on their formulation and stability. As an application, the results of simulations of push-out and torsion tests are analyzed.

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