Bond failure simulation using hybrid-mixed stress finite elements

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ABSTRACT

Concrete-steel bond failure is commonly disregarded in most computer-based reinforced concrete (RC) structural simulations. Nonetheless, this effect may influence cracking patterns, stiffness distribution, resistance degradation and energy dissipation, both for older constructions with smooth reinforcing steel bars and for modern structures with standardized ribbed bars.

The hybrid-mixed stress (HMS) model used in this paper is characterized by imposing all field equations in a weighted residual form [1]. As a consequence of not having pre-set conditions on the approximation functions, it is possible to use convenient and efficient hierarchical bases that result in sparse governing systems, may dismiss numerical integration schemes in many occasions and allow for very effective p-refinement procedures. This is the case of the orthonormal Legendre functions used in this work [2]. When compared to the traditional displacement-based formulation, the HMS model normally outputs solutions with improved quality for the stress fields by means of coarser meshes of elements large in dimension (macro-elements).

The main goal of this work is to continue the previous research done on bond failure within the framework of the conventional finite element formulation [3], in which the bond model worked as expected but the stress fields in the surrounding concrete presented poorer quality. This paper presents a novel formulation based on the HMS model that allows considering bond failure in the behaviour of RC structures subjected to cyclic loading. The main theoretical aspects of the formulation are presented and discussed and the proposed model is validated against results from experimental tests or from other numerical results obtained with alternative formulations. The validation results confirm that the bond model combined with the HMS formulation fulfils the initial expectations and the quality of the results are adequate.

REFERENCES

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