Congress on Numerical Methods in Engineering CMN2017
Valencia, 3-5 July, 2017

High-fidelity numerical analysis of experimental tests on concrete specimens via mixed strain-displacement FE

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ABSTRACT

The experimental characterization of brittle and quasi brittle materials such as concrete is a complex and challenging topic. In this framework, numerical analysis can represent a powerful tool to study and validate the possible tests outcome and identify crucial parameters that influence the results.

The mixed ε-u strain-displacement finite element is a novel technique for the study of localization propagation and failure. This formulation has been proven to outperform the standard displacement based FEM. In problems involving strain softening materials, the proposed method not only alleviates the issues of mesh-bias dependence and stress locking, but also it is capable of effectively predicting peak loads, localization onsets and failure mechanisms [1,2,3,4].

In this contribution, an experimental application to pull-out tests on concrete specimens is presented [5]. The first one is a 2D pull-out test of a T-shaped flange embedded in a plain concrete panel. Mode I tensile failure is modelled with an elasto-plastic constitutive law based on the Rankine yield criterion. The enhanced accuracy of the mixed formulation allows us to recover the experimental crack pattern and, hence, enables us to discuss the crucial role of different boundary conditions.

The second example is a 3D pull-out test of a steel bolt in cylindrical anchorage. In this test, the performance of the proposed formulation is compared to the one of the irreducible displacement-based finite elements. It appears that the mixed formulation provides fairly accurate results even in the cases of coarse meshes and that the standard formulation is severely affected by the discretization adopted, resulting in significantly over-dissipative results.

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