An improved interface material model for the in-plane cyclic response of masonry

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Abstract

A large portion of old European buildings and historical structures are made of unreinforced masonry. Although it is one of the oldest construction materials, the assessment and prediction of the highly non-linear mechanical response of masonry structures is still a challenge. Masonry consists of units and dry or mortar joints. The properties of each constituent and their arrangement within the structure can result in a different mechanical response of the material. Among various modelling approaches for studying masonry structures, micromodels describe this material at the level of its constituents. These micromodels provide satisfactory results, but are computationally expensive. However, simplified micromodels, that describe masonry as elastic expanded bricks and lump the non-linearities in zero-thickness interfaces located in between the bricks, can represent a good compromise between accuracy and computational cost (1). In this work, an interface material model, originally presented in the context of the Discrete Element Method (2), has been implemented, improved and tested in an implicit Finite Element Code. The original interface accounts for mode-mixity in tension-shearing and combines cohesive and frictional behaviour in compression-shearing. In order to increase the robustness of the model, a smoothening of the function defining the frictional contribution is proposed. Furthermore, the consistent tangent stiffness has been derived to achieve fast convergence in full-scale analyses. Finally, the model has been enhanced with a compressive plastic-damage cap, to include crushing as a failure process in the interface material model. The improved interface material model has been used to simulate full-scale laboratory tests of a wall and a spandrel subjected to cyclic loading. The numerical outcomes are in good agreement with experimental tests: the capacity of the systems is successfully captured and energy dissipation adequately described. Satisfactory results in simulating different local failure mechanisms and reproducing the complex in-plane response of masonry are demonstrated. Finally, a critical comparison with other existing material models is carried out, highlighting capabilities and limitations of the proposed model in simulating the evolution of the damage in masonry structures.

References

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