An Improved Partition of Unity-based Mesoscopic Masonry Model

B. Vandoren* and H. Degée

Construction Engineering Research Group (CERG)
Faculty of Engineering Technology
Hasselt University
Agoralaan Gebouw H, 3590 Diepenbeek, Belgium
e-mail: bram.vandoren@uhasselt.be

ABSTRACT

Over the past two decades, various strategies have been proposed for the robust and efficient modelling of masonry structures. These strategies are traditionally categorised according to the modelling scale: macroscale and mesoscale models [1]. In macroscale models, the material properties of mortar and bricks are homogenised into one orthotropic material, whereas in mesoscale models both masonry constituents are explicitly modelled, allowing to investigate failure modes and crack paths in an accurate way. Evidently, the higher modelling detail of mesoscale models comes with a higher computational cost.

A viable way to improve the efficiency of mesoscale finite element models, is by using the partition of unity method [2]. Under the assumption that cracks follow the weaker mortar joints, a partition of unity-based masonry model allows these mortar joints to be introduced on-the-fly, i.e. only when a critical stress state is exceeded, reducing the total number of degrees of freedom. The use of a partition of unity model also offers interesting opportunities for modelling masonry structures with irregular bond patterns, since mortar joints and potential brick cracks do not longer have to coincide with the finite element borders [3].

Although simulation efficiency increases when using a partition of unity-based mesoscopic masonry model, it was shown by Vandoren et al. [4] that the model still deals with robustness issues due to the presence of loose bricks caused by total failure of the surrounding mortar joints. Therefore we propose an improved partition of unity-based masonry model, in which non-critical joints are deactivated in order to avoid rigid body modes of the bricks, reducing the condition number of the stiffness matrix. Joint behaviour is governed by a combined damage-plasticity constitutive law [5], allowing an additive split of the inelastic deformation into a recoverable and unrecoverable part. The performance and stability of this novel approach will be demonstrated by several numerical examples, including shear wall tests and settlement simulations.

REFERENCES

[1] P.B. Lourenço. “Computational strategies for masonry structures”, PhD thesis, Delft University of Technology (1996).

[2] B. Vandoren, K. De Proft, A. Simone and L.J. Sluys, “Mesoscopic modelling of masonry using weak and strong discontinuities”, *Comput. Methods Appl. Mech. Engrg.*, **255**, 167-182 (2013).

[3] A. Simone, C.A. Duarte, E. Van der Giessen, “A generalized finite element method for polycrystals with discontinuous grain boundaries”, *Int. J. Numer. Methods Engrg.*, **67**, 1122-1145 (2006).

[4] B. Vandoren, K. De Proft, A. Simone and L.J. Sluys. “Modelling crack initiation and propagation in masonry using the partition of unity method”, In *Proceedings of the 8th International Conference on Fracture Mechanics of Concrete and Concrete Structures*, 1558-1566 (2013).

[5] K. De Proft, L.J. Sluys and W.P. De Wilde, “A discrete model for cyclic mode I loading”, *Journal of Computational and Applied Mathematics*, **168**, 135-144 (2004).