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Advances in partition of unity-based mesoscopic masonry models

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ABSTRACT

Although partition of unity enrichment techniques have proven to be powerful and versatile for many engineering applications, their use in numerical masonry models is still very limited [1]. Nevertheless, partition of unity-based masonry models offer interesting opportunities for the efficient and robust modelling of masonry failure, in particular when a mesoscale model is used, i.e. a model in which bricks and mortar joints are modelled as separate entities [2]. In this contribution we therefore propose and review some promising applications of partition of unity-based mesoscopic masonry models. For instance, since joints and other discontinuities (e.g. potential brick cracks) do not longer have to coincide with the finite element borders, the real joint thickness can be explicitly modelled without using conforming meshes, see Figure 1 (left). Moreover, failure of masonry structures with irregular bond patterns (e.g. rubble masonry) can be simulated using a simple background mesh [3], as illustrated in Figure 1 (center).

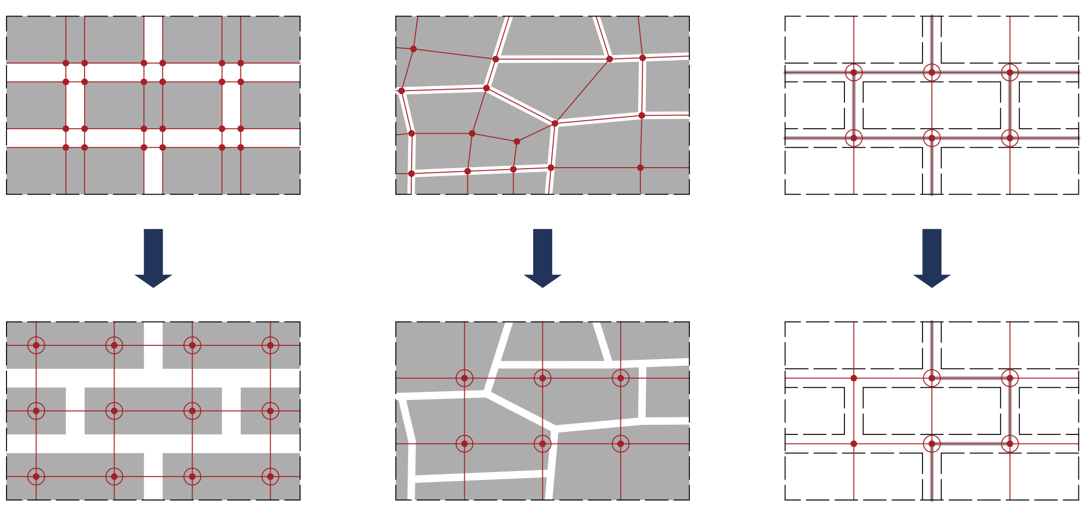

Figure 1: Applications of partition of unity-based mesoscopic masonry models (bottom row), compared to traditional finite element-based masonry models (top row). Left: modelling the real joint thickness without using conforming meshes. Center: modelling rubble masonry using a simple background mesh. Right: on-the-fly introduction of critical mortar joints. Nodes containing enhanced degrees of freedom are indicated with a circle.

Another promising application of partition of unity-based masonry models is the on-the-fly introduction of joints and brick cracks, i.e. these discontinuities and their corresponding degrees of freedom are only activated when a critical stress state is exceeded, see Figure 1 (right). However, it was shown by Vandoren et al. [4] that this approach deals with robustness issues due to the presence of loose bricks caused by total failure of the surrounding mortar joints. In this contribution we therefore propose an improved 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. The performance and stability of this novel approach will be demonstrated by several numerical examples, including shear wall tests and settlement simulations.

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