Numerical modelling of masonry wall failure by multiple embedded discontinuity finite elements

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Masonry walls, i.e. structures built by stacking units like bricks or stones bound by mortar, have been used in construction since ancient times. Naturally, the load bearing capacity of masonry structures is of major interest in construction engineering, and has been extensively studied experimentally and, especially during the present computer age, numerically as reviewed by D'Altri et al. [1]. The modeling approaches can be classified as Block-based Models, Continuum Models, Macroelement Models, and Geometry-based Models [1]. The present work adopts the Continuum modelling approach based on the Embedded Discontinuity Finite Element Method (EDFEM) [2].

A Matlab-based method to automatically generate 2D masonry walls with either regular bricks or polygonal stones bound with mortar is developed. The mortar failure is modelled by pre-embedded multiple discontinuity finite elements, while the units (bricks or stones) failure is according to the principal stress criterion (mode I) with a single embedded discontinuity representing a crack. In the present failure model, crack opening is inelastic and the failure process is dealt with similarly to that in the computational multisurface plasticity models.

The modelling approach is demonstrated with numerical examples on in-plane failures of masonry walls found in literature. A simulation example is shown in Fig. 1 where a masonry wall is diagonally compressed with a constant velocity boundary condition. The failure mode is shown as the crack opening magnitude.

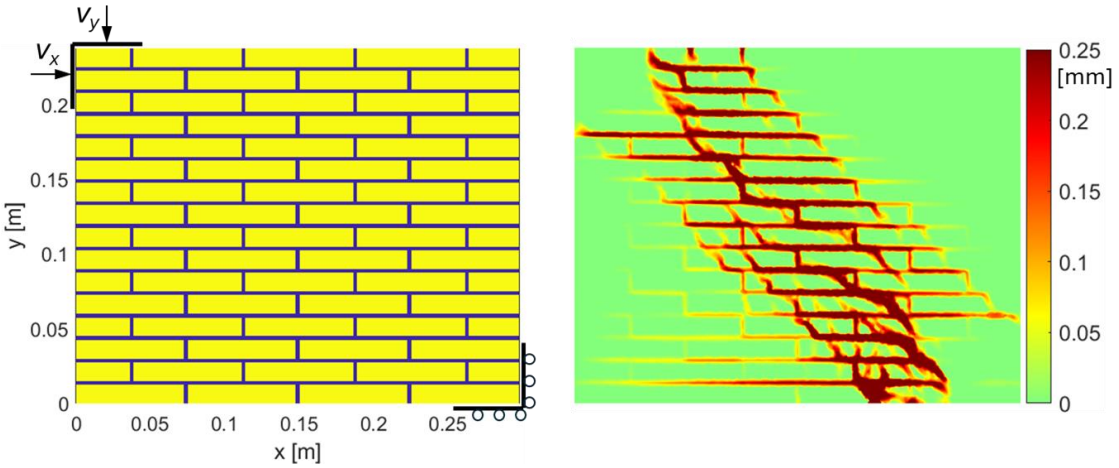

Figure 1. Masonry wall and boundary conditions (left), and the failure mode in terms of crack opening magnitude (right).

[1] A.M. D'Altri, V. Sarhosis, G. Milani et al. Modeling Strategies for the Computational Analysis of Unreinforced Masonry Structures: Review and Classification. *Arch. Computat. Methods. Eng.* 27, 1153–1185, 2020. https://doi.org/10.1007/s11831-019-09351-x.

[2] T. Saksala. Numerical modelling of concrete fracture processes under dynamic loading: Meso-mechanical approach based on embedded discontinuity finite elements. *Eng. Fract. Mech.* 201, 282-297, 2018. https://doi.org/10.1016/j.engfracmech.2018.07.019.