Numerical analysis of mixed-mode fracture of brickwork masonry with embedded discontinuity elements

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ABSTRACT

One of the common pathologies of brickwork masonry structural elements and walls is the cracking associated with the differential settlements and/or excessive deflections of the slabs along the life of the structure. The scarce capacity of the masonry in order to accompany the structural elements that surround it, such as floors, beams or foundations, in their movements makes the brickwork masonry to be an element that frequently presents this kind of problem. This problem is a fracture problem, where the wall is cracked under mixed mode fracture: tensile and shear stresses combination, under static loading. Consequently, it is necessary to advance in the simulation and prediction of brickwork masonry mechanical behaviour under tensile and shear loading. The quasi-brittle behaviour of the brickwork masonry can be studied using the cohesive crack model whose application to other quasi-brittle materials like concrete has traditionally provided very satisfactory results.

To study the mechanical behaviour of brickwork masonry, and especially its failure, it is important to note that this is a composite material whose mechanical and resistant properties depend on the properties of its constituent materials. In addition, the geometric arrangement in rows of brick and mortar, as well as the interface between them, makes these characteristics depend largely on the direction under consideration, since the joints can be assumed a priori to be planes of weakness. Is therefore highly important the orientation of the brickwork masonry in relation with the direction of the loads, as well as with the direction of crack growth.

This paper presents the adaptation, for anisotropic materials, of a model that employs a finite element with embedded discontinuity based on the cohesive crack model, which does not require remeshing nor the previous calculation of the crack path. This numerical approach proposed by the authors has shown good performance in the simulation of mixed mode fracture in isotropic materials [3], and in this work is extended to simulate the behaviour of orthotropic anisotropic materials. The additional degrees of freedom defining the crack opening are determined at the crack level, thus avoiding the need of performing a static condensation at the element level. The need for a tracking algorithm is avoided by using a consistent procedure for the selection of the separated nodes, and by letting the crack embedded in the finite element to adapt itself to the stress field while the crack opening does not exceed a small threshold value. Numerical simulations of an experimental campaign carried out by the authors on small brick panels are presented to show the ability of the proposed model to simulate fracture of masonry.

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