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MODELING MASONRY MICROSTRUCTURE THROUGH VIRTUAL BLOCK CLUSTERS

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ABSTRACT

Masonry is a characteristic example of heterogeneous material, where stone blocks or bricks are joined together through mortar layers. For simple structures it is possible to consider explicitly the microstructure by using suitable models for the different phases. However, this approach is not well suited for large buildings, since it requires a significant amount of modeling and computing time. For this reasons, several continuum constitutive models have been developed, based on empirical data or numerical homogenization of the microstructure [1, 2]. A continuum model is indeed sufficient in most regions of a building, excluding those where localization occurs, as the zones near to the corners of the openings or where macroscopic cracks appear. There, the details of the microstructure may become important. A multiscale model [3, 4], which uses a homogenized continuum at the macroscopic level and a discrete model in the critical regions, should benefit of the favorable features of both approaches.

In the present work, we develop a continuum model for masonry in which the constitutive behavior of the material element is obtained through the (virtual) power equivalence with a representative set of rigid blocks interacting through deformable interfaces (see Fig. 1). We call this assembly of blocks, “Virtual Block Cluster” (VBC). This technique is analogous to the one developed for molecular dynamics in [5, 6], where a Virtual Atomic Cluster was introduced. For the homogenization, either Cauchy or Cosserat continua [7, 8] can be considered, the latter allowing a richer description of the microstructure. The continuum model is then discretized through standard finite elements, so that a VBC is associated with each integration point. The interfaces representing the mortar layers in the VBC can be conveniently modeled as beds of no-tensile springs [9]. A generalized interface model, which includes an elastic-perfectly plastic shearing behavior of the interfaces, has shown its capability to reproduce the most significant features of masonry structures [10] and is used in the present work.

Numerical examples for simple structures will be presented, so that the results obtained through the continuum model based on VBC can be compared to those obtained through the explicit modeling of the microstructure. Since both smeared and discrete models are

based on the same microstructural model (i.e. rigid blocks and the interfaces described above), it will be possible to develop and implement a consistent version of the concurrent multiscale approach.

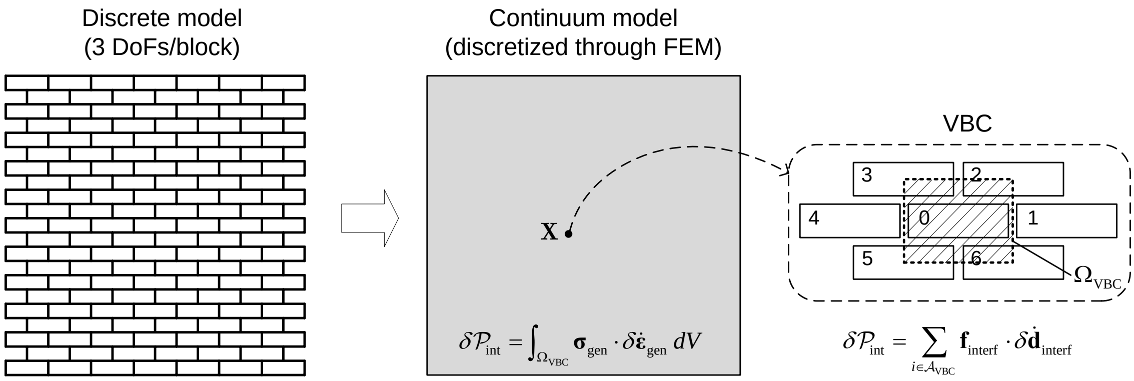

Figure 1. Discrete model and continuum model where the constitutive law is computed through a virtual brick cluster associated with each material element.

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