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Fabrizio Greco, Lorenzo Leonetti, Raimondo Luciano, Paolo Nevone Blasi

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An adaptive multiscale strategy for the damage analysis of masonry modeled as a composite material

Fabrizio GRECO[(a)*], Lorenzo LEONETTI[(b)], Raimondo LUCIANO[(c)], Paolo NEVONE BLASI[(d)]

[(a), (b), (d)] Department of Civil Engineering, University of Calabria, ITALY

[(c)] Department of Civil and Mechanical Engineering, University of Cassino and Southern Lazio, Italy,

[(a)] f.greco@unical.it

[(b)] lorenzo.leonetti@unical.it

[(c)] luciano@unicas.it

[(d)] paolo.nevoneblasi@unical.it

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Abstract

In recent years, multiscale models have been successfully employed for investigating the overall mechanical behavior of several heterogeneous structures, such as concretes and composite materials, even in the presence of damage growth and other nonlinear phenomena, with the final aim of reducing the typically huge computational cost of fully microscopic models. In this paper, a novel concurrent multiscale method is applied to masonry structures, able to overcome the limitations of existing masonry homogenization approaches in the presence of strain localization; this method is devoted to the damage analysis of periodic masonries under in-plane loading, based on a multilevel domain decomposition approach equipped with an adaptive zooming-in criterion for detecting the zones affected by strain localizations. The validity of this strategy is assessed by performing multiscale numerical simulations on a three-point bending test and comparing the related results with those obtained from direct numerical simulations, carried out by using a full-scale microscopic model. Finally, additional comparisons have been carried out with experimental and numerical results taken from the literature.

1. Introduction

Despite being one of the oldest construction materials, masonry still represents a relevant research topic in structural mechanics, due to several practical applications in civil engineering, with particular reference to the preservation and restoration of cultural heritage items, especially those located in regions of high seismic hazard. As a matter of fact, large resources have been destined for improving the estimation of the seismic vulnerability of unreinforced masonries (see [1,2]) as well as for developing efficient and sustainable seismic upgrade measures, as those are based on the common fiber reinforced polymers (FRPs) and the more recently introduced fiber reinforced cementitious matrix materials (FRCMs) (see for instance [3–7] and [8,9], respectively). Both the above-mentioned tasks necessarily require the development of accurate structural analyses, able to capture the peculiar mechanical feature of the masonry material. Indeed, the investigation of the mechanical behavior of masonry is very complex due to its intrinsic heterogeneous nature; as a matter of fact, masonry can be considered as a two-phase composite material made up by different constituents at the mesoscopic level (mainly bricks and mortar joints; see, for instance, [10]). The bond existing between such phases is usually not perfect, and many damage mechanisms may arise within the single phases as well as at

* Corresponding author.

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