Accepted Manuscript

Multiscale failure analysis of periodic masonry structures with traditional and fiber-reinforced mortar joints

Fabrizio Greco, Lorenzo Leonetti, Raimondo Luciano, Patrizia Trovalusci

PII: S1359-8368(16)33257-7

DOI: 10.1016/j.compositesb.2017.03.004

Reference: JCOMB 4938

To appear in: *Composites Part B*

Received Date: 29 December 2016

Revised Date: 2 February 2017

Accepted Date: 7 March 2017

Please cite this article as: Greco F, Leonetti L, Luciano R, Trovalusci P, Multiscale failure analysis of periodic masonry structures with traditional and fiber-reinforced mortar joints, *Composites Part B* (2017), doi: 10.1016/j.compositesb.2017.03.004.

Multiscale failure analysis of periodic masonry structures with traditional and fiber-reinforced mortar joints

Fabrizio GRECO[(a)], Lorenzo LEONETTI[(b)], Raimondo LUCIANO[(c)], Patrizia TROVALUSCI[(d)]

[(a)]) Department of Civil Engineering, University of Calabria, Rende, Italy, email: f.greco@unical.it

[(b)] Department of Structural and Geotechnical Engineering, Sapienza University of Rome, Rome, Italy, email: lorenzo.leonetti@unical.it

[(c)] Department of Civil and Mechanical Engineering, University of Cassino and Southern Lazio, Rende, Italy, email: luciano@unicas.it

[(d)] Department of Structural and Geotechnical Engineering, Sapienza University of Rome, Rome, Italy, email: patrizia.trovalusci@uniroma1.it

Keywords: Masonry; Fiber-Reinforced Mortar; Cohesive Fracture; Multiscale Modelling.

Abstract

In this paper, a novel adaptive multiscale model is proposed for accurately predicting the nonlinear mechanical response of periodic brick masonry due to crack initiation and propagation under general in-plane loading histories. Such a model relies on a two-level domain decomposition technique, used in conjunction with an adaptive strategy able to automatically zoom-in the zones incipiently affected by damage localization, with the aim of reducing the typically high computational effort associated with fully microscopic models. The proposed switching criterion is based on the numerical determination of microscopically informed first failure surfaces taking into account higher-order deformation effects. In order to assess the validity of the proposed strategy, a sensitivity analysis is carried out on a shear wall sample by varying the required input numerical parameters. An additional application of the proposed multiscale model is then presented for investigating the role of the fiber content in fiber-reinforced mortars (FRMs), recently introduced for masonry construction and rehabilitation, on the overall response of a deep beam sample.

1 Introduction: an overview of modeling approaches for masonry structures

In the last decades, the need of mitigating impacts of natural hazards on cultural heritage artefacts has inspired a huge number of repair and strengthening techniques for traditional masonry structures, also relying on the adoption of fiber-reinforced composite materials [1–4]. Fabric-reinforced cementitious matrix (FRCM) composite systems have emerged as a more sustainable alternative to the most used fiber-reinforced polymer (FRP) materials for restoration and rehabilitation of existing masonry buildings, especially those of historical and architectural interest [5–7]. The use of a cementitious matrix allows for a better chemical, mechanical and aesthetical compatibility with the masonry substrate and offers a potential fire protection. Nowadays, reinforcing fibers are available in a wide variety of materials and may be grouped into four classes: steel (low carbon or stainless), mineral (glass, basalt, etc.), synthetic organic (carbon, aramid, PBO, etc.) and natural organic, including both plant and animal fibers. Among them, natural fibers are gaining more and more attention by virtue of their low cost and low environmental impact, in terms of levels of embodied energy and CO_2 production. However, in the presence of exposed brickworks, strengthening of masonry with externally bonded composite materials is often not desirable and/or allowed, so that less intrusive rehabilitation techniques should be used. Considering that the mortar joints are at the same time the weakest and the easiest to replace component in masonry structures, the process of repointing is widely