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MULTISCALE CONSTITUTIVE RELATION FOR PERIODIC MASONRY

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ABSTRACT

The development of adequate stress analyses for masonry structures represents an important task not only to verify the stability of masonry constructions, as old buildings, historical town and monumental structures, but also to properly design effective strengthening and repairing interventions.

The analysis of masonry structures is not simple at least for two reasons: the masonry material presents a strongly nonlinear behaviour, so that linear elastic analyses generally cannot be considered as adequate; the structural schemes which can be adopted for the masonry structural analyses are more complex than that adopted for concrete or steel framed structures, as masonry elements are often modelled by two- or three-dimensional elements.

The main problem in the development of accurate stress analyses for masonry structures is the definition and the use of suitable material constitutive laws. Taking into account the heterogeneity of the masonry material, which results from the composition of blocks joined together by mortar beds, the models proposed in literature can be classified in the three different types briefly described below.

Micro-models consider the units and the mortar joints separately, characterized by different constitutive laws [1-2]. Macro-models are based on the use of macromechanical, i.e. phenomenological, constitutive laws for the masonry material [3-4]. Micro-macro, i.e. multiscale, models consider different constitutive laws for the units and the mortar joints; then, a homogenization procedure is performed obtaining a macro-model for masonry which is used to develop the structural analysis. This approach can lead to effective models which can be successfully adopted in structural analyses [5-8].

With the aim of reproducing the behaviour of masonry panels, in this work a micro-macro modelling of masonry walls is presented in the framework of the uncoupled multiscale approach [9]. In particular, a damage model for masonry material characterized by periodic structures is derived from micromechanical analysis, via homogenization technique. For old masonries the strength of the mortar is lower than the strength of the bricks. Thus. it can be assumed that damage can develop only in the mortar material [7].

A linear elastic behaviour is considered for the blocks and a special nonlinear constitutive law is adopted for the mortar beds. In particular, the mortar constitutive law accounts for the

coupling of the damage and friction phenomena occurring in the mortar beds during the loading history; it can be remarked that the proposed model of the mortar is itself based on a micromechanical analysis of the damage process of the mortar material.

Then, a nonlinear homogenization procedure is proposed; it is based on the technique of the superposition of the effects and the use of the finite element method. The presented methodology is implemented in a numerical code.

Finally, numerical applications are performed in order to assess the performances of the proposed model and of the developed procedure in reproducing the mechanical behaviour of masonry material. In Figure 1, the behaviour of the masonry unit cell subjected to a shear strain history is reported.

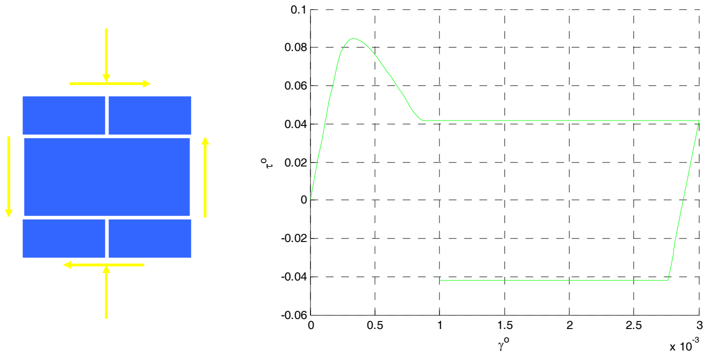

Figure 1: Behaviour of the masonry unit cell subjected to a shear strain history.

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