8th. World Congress on Computational Mechanics (WCCM8)
5th European Congress on Computational Methods in Applied Sciences and Engineering (ECCOMAS 2008)
June 30 –July 5, 2008
Venice, Italy

GENERALIZED PLANE APPROACHES TO THE HOMOGENIZATION OF HETEROGENEOUS BI-DIMENSIONAL SOLIDS

N. Cavalagli, * F. Cluni and V. Gusella

Department of Civil and Environmental Engineering, University of Perugia
Via G. Duranti, 93 - 06125 Perugia - IT
Corresponding author: cluni@strutture.unipg.it

Key Words: *Homogenization, Heterogeneous materials, Generalized plane states.*

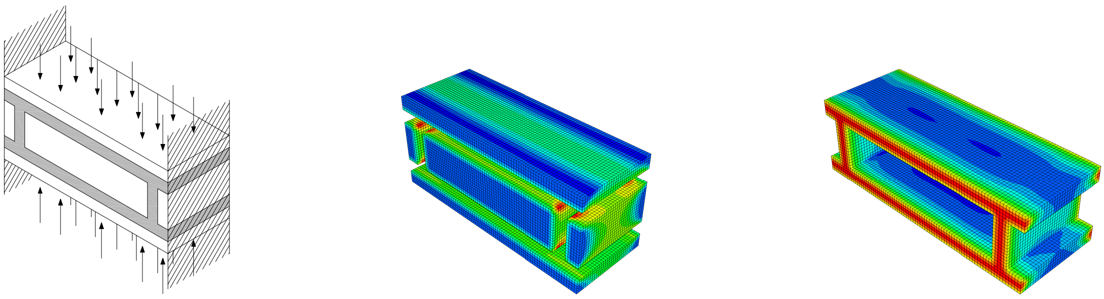
ABSTRACT

The paper presents the results of an ongoing research about the homogenization of bi-dimensional solids constituted by a heterogeneous material and loaded in their plane. It is assumed that these solids are non layered but they are set up by inclusions in a matrix: this is typical of the masonry walls where the inclusions are the bricks or stones and the matrix is the mortar.

When the wall is loaded by in-plane forces, the different mechanical characteristics of the phases give different out-of-plane behaviour and originate a 3-D stress state which have an important influence in the plastic behaviour and damage evolution [1, 2]. In Figure 1 the numerically evaluated stress state of a masonry cell loaded in a vertical direction and bounded to the sides are shown.

In the homogenization framework it is necessary to take into account this aspect, therefore a 3-D finite element analysis should be performed. Nevertheless this approach is very expensive, since the heterogeneity and uncertainties of the micro-structures should be considered [3].

In order to overcome this aspect, the following 2-D approaches are considered: the classical plane stress and the generalized plane strain [4]. In particular, the latter one, already applied by Pegon and Anthoine [5, 6], has allowed to take into account in a in-plane analysis the out-of-plane effects due to the material's heterogeneities (see Figure 2).



(a) (b) (c)

Figure 1: 3D model of a masonry cell (a). Out-of-plane stresses in the brick (b) and in the mortar (c).

(a) (b)

Figure 2: Generalized plane strain model of a masonry cell (a). Out-of-plane stresses in the brick and in the mortar (b).

This procedure is extended to analyse the non-periodic masonry walls. The analyses are performed in the elastic domain.

Moreover, in order to estimate the collapse surface, the generalized plane strain state and the Dvorak's model [7] are used, adopting the Lubliner's concrete plasticity model [8] as the yield surface for each phase. This approach overcomes the shortcoming of the plane stress which does not take into account the out-plane stress component.

The obtained results permit to compare the different numerical models in the multiscale modelling of heterogeneous bi-dimensional solids, highlighting their advantages and reliability in the inelastic RVE estimate.

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