The FE-Meshless multiscale approach applied to masonry structures

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Heterogeneous structures have an overall response that is strongly dependent on the inelastic events developing at the local level. In these structures, the most relevant kinematical and mechanical phenomena take place at a scale which is small if compared to the dimensions of the entire structure. In literature, a mesoscopic and a macroscopic scales of interest are distinguished, directly linked to as many theoretical approaches. The mesoscopic approach [1] considers materials and their interfaces individually, but many difficulties arise in the mesh creation and a fine discretization of the structure is needed, which leads to prohibitive computational costs. The macroscopic approach considers the structure as constituted by a fictitious homogeneous and continuous material. The multiscale techniques belong to the second approach and couple different scales of interest by means of apposite transition laws capable to exchange informations between different consecutive scales [2].

This work relates with the multiscale first order computational homogenization technique applied to masonry structures. A unit cell (UC) is assumed constituted by an elastic bulk volume surrounded by weak joints, which are simulated by zero-thickness elasto-plastic interface models.

At a single time step, the FE solution of the fictitious homogenized structure provides strains at all quadrature points. The corresponding macrostress field associated to the strain is obtained by solving a Boundary Value Problem (BVP) of the UC at the mesoscale level. The solution of the BVP is approached by means of a meshless strategy [3] instead of a classical finite element procedure, that is usually time-consuming. By imposing Taylor-Voigt type boundary conditions on the UC, the macroscopic stress is evaluated averaging the UC boundary tractions, according to the Hill-Mandel principle.

Localization is faced at both the quadrature point level and at the element level. At the quadrature point level plastic bands are localized applying a continuous-discontinuous bifurcation theory [4] based on the spectral analysis of the acoustic tensor associated to the stiffness matrix. At the element level inelastic response is obtained smearing the plastic zones at the quadrature points over the element area, considering the localized and not localized fraction areas.

The proposed model has been implemented on a research oriented finite element analysis program to run 2D simulations in plane-stress conditions for heterogeneous periodic structures. Qualitatively good results are obtained in comparison with numerical data available in literature.

References

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