MESOSCALE MODELING OF BUILDING MATERIALS

Gianluca Mazzucco[*], Beatrice Pomaro[*], Beaudin Freinrich Dongmo[*], Jiangkun Zhang[*], Valentina A. Salomoni[**], Carmelo E. Majorana[*]

[*] Department of Civil, Environmental and Architectural Engineering (DICEA), University of Padova, Via F. Marzolo 9, 35131 Padova, Italy
E-mail: gianluca.mazzucco.@dicea.unipd.it, carmelo.maiorana@dicea.unipd.it
[**] Department of Management and Engineering (DTG), University of Padova, Stradella S. Nicola 3, 36100 Vicenza, Italy
E-mail: valentina.salomoni@unipd.it

ABSTRACT – Building materials such as concrete, or concrete asphalt are very heterogeneous composite materials and frequently represented as homogeneous media upon definition of a Representative Elementary Volume (REV). Normally, this approach is not able to evaluate clearly the interaction between the different material phases. More recently, the mesoscale formulation has proved to be effective in studying composite materials into the REV by making the phases explicit, subdividing the materials in three principal components: coarse aggregates, the matrix (the binder and the fine aggregates), and the Interface Transition Zone “ITZ”, that is the thin layer usually present between aggregates and matrix. At this scale the local interactions between inclusions and matrix are visible, and the complex triaxial stress states present in the material can be observed.

The mesoscale modelling generally requires: a correct geometry reconstruction, and a correct material behavior description. In this work the use of Industrial Tomography and of specific random distribution algorithms will be illustrated as possible tools to obtain numerically the correct grading curves in agreement with the material mix design.

At the mesoscale the mechanical behavior of the matrix can be very different based on different loading conditions. For example, during a monotonic loading condition the material heterogeneity causes a local stress concentration and a local material confinement, so increasing the material strength. During a cyclic loading, on the other hand, the traction cracks grow during positive loads, while decreasing the material stiffness; conversely, when the load changes in sign the cracks closure occurs and the material stiffness is typically recovered. Moreover, under long-term loading the creep effects generally characterize cementitious/asphalt composite materials, with resulting not negligible viscous strains. Specifically, what is envisaged, at the mesoscale, is a local material deterioration in timeclose to inclusions, and not recoverable strains even for external loads below the material strength.

In this framework, to take into account these features of the material behavior, a specific visco-elasto-plasto-damage constitutive model is developedfor concrete cement and concrete asphalt materials.

From a numerical point of view, by using a classic continuum discretization with the Finite Element Method, evaluating the material behavior at the mesoscale implies that the

ITZ thickness has to be homogenized with a necessarily larger thickness (then the real one of about 5 to 50 micrometers) but still very thin. This leads to very fine, computationally costly meshes. A possible solution to overcome this issue is to use a cohesive contact formulation; in this way the real ITZ thickness can be used and the explicit ITZ discretization is not needed. In this work a new cohesive contact formulation, specifically conceived for the ITZ layers, is shown.

Some experimental vs numerical comparisons are also illustrated to show the ability of this modelling procedure to evaluate correctly the mechanical behavior in time of these materials, and its predictability.