Computational methods for confined concrete composites at the mesolevel through the aid of 3D advanced measurement techniques

*Carmelo E. Majorana[1], †Gianluca Mazzucco[1],
Beatrice Pomaro[1], Giovanna Xotta[1], Nico De Marchi[1], Valentina A. Salomoni[1,2]
[1] Department of Civil, Environmental and Architectural Engineering (DICEA), University of Padova, Via F. Marzolo 9, 35131 Padova, Italy
[2] Department of Management and Engineering (DTG), University of Padova, Stradella S. Nicola 3, 36100 Vicenza, Italy

*Presenting author: carmelo.maiorana@dicea.unipd.it
†Corresponding author: gianluca.mazzucco@dicea.unipd.it

Abstract

The realistic modelling of concrete composites encompasses the definition of the correct geometrical reconstruction of samples and the development of a sound model for the service loads of interest. This work moves from pioneer studies of concrete at the mesoscale level [1] and presents an exhaustive methodology to handle the problem with the 3D continuum technique of Finite Elements at the mesoscale and for medium-high load cases, close to failure in confined conditions due to material heterogeneities. At the scale of concrete constituents it becomes important to reproduce the real particle packing, which is related to the w/c ratio and therefore, practically, to concrete workability and final strength. Also, at this scale local confinement effects are due to aggregate inclusions, which can lead to non-homogeneous plastic behaviours within the cement paste (softening or hardening) depending on the exerted confinement level.
The former aspect is addressed with a three-step process: i) by combining the laser scanner techniques with solid modelling CAD software to extract the solid model of real aggregates; ii) by developing a robust algorithm to place polydispersed ellipsoidal particles, assumed circumscribed to real aggregates, within the surrounding cement matrix; the algorithm includes an overlapping detection tool for an optimized compaction of inclusions; iii) by using computer tomography (CT) to exactly reproduce the tested specimens in terms of geometry of the inclusions and their placement.
The latter issue comprises the development of a damage-plasticity model for the cement paste [2] which consists in the combination of the non-associated plasticity model by Menétrey-Willam [3], where the yield surface is described in function of the second and the third invariant of the deviatoric stress tensor, with the plastic potential defined in [4]. Damage enters in compliance with the plastic-damage combination theory based on the effective stress, as a scalar isotropic variable which is function of the plastic strain. Comparisons with uniaxially loaded concrete samples fairly good prove the soundness of the model, also in terms of damage pattern mechanisms and their evolution around inclusions.

Keywords: **confined concrete, damage-plasticity, solid modeling**

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