14th World Congress in Computational Mechanics (WCCM)
ECCOMAS Congress 2020
19 – 24 July 2020, Paris, France

INFLUENCE OF ENTRAPPED AIR IN CEMENTITIOUS MATERIALS ON DAMAGE PROPAGATION.

Gianluca Mazzucco[1], Beatrice Pomaro[1]*, Valentina A. Salomoni[2] and Carmelo E. Majorana[1]

[1] Department of Civil, Environmental and Architectural Engineering, University of Padova, Via F. Marzolo 9 – 35131 Padova, Italy, gianluca.mazzucco@dicea.unipd.it, beatrice.pomaro@dicea.unipd.it, carmelo.maiorana@dicea.unipd.it
[2] Department of Management and Engineering, University of Padova, Stradella S. Nicola 3 – 36100 Vicenza, Italy, valentina.salomoni@unipd.it

Key Words: *Finite Element Method, Concrete, Mesoscale, Aggregates, Entrapped air.*

The increasing attention to numerical issues related to material modeling is still a strong incentive to develop sound mechanical models that can explain material behavior up to failure.
A procedure to handle a robust geometric meso-scale reconstruction of concrete materials is here proposed, based on X-ray Computed Tomography (XCT). XCT as advanced detection technique has been adopted by several authors who aimed to investigate the behavior of concrete at the meso level, with satisfactory results [1, 2].
This study applies XCT on concrete made with calcareous aggregates: solid models have been generated with such technique and discretized in space to be numerically studied via the Finite Element (FE) method and the numerical results compared with uniaxial compression tests on the same scanned specimens. For the numerical analyses a specific non-associated elasto-plastic constitutive behavior, coupled with damage, has been developed for the cement matrix, whereas the coarse aggregates have been treated as elastic. The surface roughness of coarse aggregates has an obvious effect on the interfacial bond strength [4]. Therefore a contact algorithm for the thin interface region known as Interfacial Transition Zone (ITZ) between aggregates and cement paste has been included in the numerical analyses. The presence of voids in cured concrete, in particular, is discussed in order to appreciate the influence of air segregation in ordinary concrete strength, when damage evolution and cracking mechanisms are evaluated included explicit ITZ modeling.
While entrained air bubbles (dimension of voids below 0.1cm and spherical, typically) can be beneficial to concrete, especially for freezing/thawing cycles, and can be intentionally created by adding a liquid admixture specifically designed for this purpose, entrapped air voids (> 0.1cm) are usually irregular in shape and are created during improper mixing, consolidating and placement of concrete. Air pockets, or irregularly sized air voids can have negative effects on product appearance, strength and durability therefore they are usually removed with proper vibration techniques.

REFERENCES

[1] E. Garboczi, Three-dimensional mathematical analysis of particle shape using x-ray tomography and spherical harmonics: application to aggregates used in concrete, *Cement and Concrete Research*, 32, 10, 1621–1638, 2002.
[2] Y. Huang, Z. Yang, W. Ren, G. Liu and C., Zhang, 3D meso-scale fracture modelling and validation of concrete based on in-situ X-ray Computed Tomography images using damage plasticity model, *International Journal of Solids and Structures*, 67-68, 340–352, 2015.
[3] L. Hong, X. Gu and F. Lin, Influence of aggregate surface roughness on mechanical properties of interface and concrete, *Construction and Building Materials*, 65, 338–349, 2014.