Efficient mesh generation of real concrete mesostructures from CT scan images using contrast enhancers

P. Carrara*, **R. Kruse***, **T. Leusmann****, **H. Budelmann**** **and L. De Lorenzis***

* Technische Universität Braunschweig, Institute of Applied Mechanics, Bienroder Weg 87, Braunschweig, Germany. e-mail: p.carrara@tu-bs.de, r.kruse@tu-bs.de, l.delorenzis@tu-bs.de
** Technische Universität Braunschweig, Institute of Building Materials, Concrete Construction and Fire Protection, Beethovenstr. 52, Braunschweig, Germany. e-mail: t.leusmann@ibmb.tu-bs.de, h.budelmann@ibmb.tu-bs.de.

ABSTRACT

Concrete is a composite material whose structure at the mesoscale, i.e. at a scale where the cementitious matrix, aggregates and pores are separately identified, plays a significant role on the observed macroscopic behavior. In particular, it is nowadays widely accepted that a deeper understanding of the aging processes in concrete (e.g., cracking or chemical degradation) can be gained by modeling explicitly its mesostructure [1].

To date, the mesostructure of concrete is mainly obtained through artificial generation [2] or 3D imaging techniques such as the X-ray computed tomography (CT) [3]. While the former is usually computationally expensive and/or oversimplified, the latter has become an attractive option in the past few years. However, the identification of the various phases, i.e. the *segmentation* process, is not trivial [3], especially because of the limited contrast between cementitious matrix and aggregates due to their similar composition. Also, since the dimensions of the inclusions in concrete span a few orders of magnitude (from 0.1 mm up to 35-40 mm), a threshold length above which the heterogeneities are explicitly modeled is needed. Another challenge to be faced is the generation of meshes as input for the numerical codes. In particular, the large amount of degrees of freedom generated by directly converting the voxelized CT images into voxel-based hexahedral meshes often limits the possibility of analyzing a representative volume of the material [3]. Hence, a technique to describe the voxelized images through surfaces and volumes should be adopted to allow for a standard mesh generation.

In the present work, we explore the possibility to add highly absorptive baryte powder into the concrete mix to enhance the contrast between the cementitious matrix and the aggregates, allowing for an easier segmentation and mesh generation. A threshold length for the explicit description of the heterogeneities is chosen accounting for the CT image resolution and the maximum aggregate size. Calorimetry and mechanical tests are performed in order to ensure that the concrete mix is not appreciably affected by the presence of baryte. The results of both normal (i.e., without baryte) and modified concrete are compared to demonstrate the validity of the method.

Acknowledgments. The authors gratefully acknowledge Dale P. Bentz of the U.S. NIST for the useful suggestions and the discussion provided.

REFERENCES

[1] Roelfstra, P. E., Sadouki, H. and Wittmann, F. H. Le beton numerique. Mater. Struct. (1985) **18**:309–317.

[2] Wu, T., and Wriggers P. Multiscale diffusion–thermal–mechanical cohesive zone model for concrete. *Comp. Mech.* (2015) **55**(5):999–1016.

[3] Carrara, P., Wu, T., Kruse, R. and De Lorenzis L. Towards multiscale modeling of the interaction between transport and fracture in concrete. *RILEM Tech. Let.* (2016) **1**:94–101.