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Computational generation of mesoscale concrete finite element models from voxel dataset

Koussay Daadouch[1,*], Vladislav Gudžulić[1] and Günther Meschke[1]

[1] Institute for Structural Mechanics, Ruhr University Bochum
Universitätstraße 150, 44801 Bochum, Germany
koussay.daadouch@rub.de, www.sd.ruhr-uni-bochum.de

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Modeling concrete on a mesoscale level offers unique insights into many complex processes occurring at this level. However, it also represents a considerable challenge due to its heterogeneous and disordered nature, comprised primarily of aggregates, hardened mortar paste, and interfacial transition zones. Many efforts have been made in the past to create numerical mesoscale concrete models either by virtually generating inclusions of random shape, size, and distribution to represent the aggregates or by using computed tomography (CT) scans of real concrete specimens [1]. Although models generated using CT scans accurately represent the aggregates in a concrete specimen, they are computationally very demanding. The authors of [2] proposed a concrete meso-structure generation tool (CMG), a reliable and inexpensive method to generate high-quality voxelized virtual mesoscale concrete models mimicking the data obtained from CT scans of actual specimens. Such data type is suitable for direct implementation in numerical applications such as finite cell or discrete element method. However, intricate processing is required to convert the voxel dataset into a high-quality finite element mesh that respects the boundaries between different phases and has no intersecting geometries. To this end, we present a program that generates finite element models using a voxel dataset regardless of its origin, whether it is virtually generated or obtained by scanning actual specimens. The program is tested using models generated by the CMG, and the robustness of the obtained finite element models is demonstrated by fracture simulations of concrete utilizing zero-thickness cohesive interface elements.

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