

Digital Image based numerical modeling for strength evaluation of concrete

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Concrete is a non-homogeneous mix of coarse aggregates, sand, cement, air-voids and interfacial transition zone (ITZ) around aggregates. Adoption of these complex structures and material properties in numerical simulation would lead us to better understanding and design of concrete. This dissertation is concerned about mesoscale modeling of concrete and shape analysis of coarse aggregates using digital camera and CT images. The digital image helps in quantifying structural elements at mesoscale and captures shape and texture of coarse aggregates.

In this work, the mesoscale model of concrete has been prepared using digital camera and X-ray CT image. Firstly, two-dimensional (2D) shape analysis of coarse aggregates has been performed using digital images. The parameters for shape analysis, such as, circularity, sphericity, roundness, roughness, solidity, rectangularity, aspect ratio and fullness are used to characterize the shape of 2D coarse aggregates. Secondly, these images are converted into computer model and numerically simulated using commercially available finite element software. The mesoscale models are simulated under the influence of compressive displacement. The effect of shape and distribution of aggregates, continuous and discrete ITZ thickness, voids, and variation of mortar strength has been investigated. Thirdly, the effect of shape and distributions of steel fibers has been investigated. The compressive response of fiber reinforced concrete (FRC) at meso level has been numerically evaluated. The discrete fibers are distributed in between aggregates in the digitally modeled mesoscale concrete. The orientation, shape, distribution, aspect ratio, and material properties of fibers are considered for the strength evaluation of FRC. Finally, the three dimensional model is also made from 2D CT scan images and finite element analysis is carried out for evaluation of compressive and tensile strength of concrete cube.

The present study shows that imaging systems like digital camera and CT scans are fast, efficient and reliable in finding realistic structure of mesoscale concrete and actual shape and texture of coarse aggregates. The digital imaging techniques can be adopted in engineering evaluation for quality control of concrete.