Meso-scale fracture behaviour of concrete with fractal aggregate shapes: An FDEM approach

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Abstract

This study develops a meso-scale numerical investigation on the role of the aggregate shape and packing in concrete fracture using a representative volume element (RVE). Aggregates are first generated and distributed based on 3D Voronoi tessellation and Spherical Harmonics (SH). Their shape indices (e.g., aspect ratio, sphericity, convexity and roundness) are similar to X-ray scanned aggregates by controlling the SH power spectrum with certain fractality. The solid fraction of dense yet separated aggregates in the randomly shaped domain can be very high, over 0.7. The collective generated aggregate samples are imported in a second step into the mortar, which is represented by a continuous phase filling the pore spaces of packed aggregates. The meso-scale model includes specialised concrete fracture elements, including cohesive elements in mortar, aggregates, and interface transition zones (ITZ), enabling the simulation of crack initiation and propagation. Parametric studies are performed targeting aggregate sizes and packing, elastic modulus, and fracture energy in different phases, to assess their role on the tensile strength of concrete. The proposed numerical framework is shown to be suitable for theoretical optimisation of concrete meso-structure based on given aggregates.