2D modeling of compressive failure in recycled aggregate concrete using the mesh fragmentation technique

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The internal structure of concrete is made of different component phases and weak interfaces distributed at the mesoscopic level which are highly related to the complex mechanical behaviors observed in the material. Particularly, the numerical prediction of its compressive failure is a challenging topic involving aspects such as initiation and coalescence of microcracks, dilatancy, localized deformations and degradation [1]. However, a continuum macroscale model that describes more closely such aspects requires a high level of complexity. Therefore, multiscale models equipped with damage or plasticity models have been used to better understand the influence of the distinct phases of the concrete on the fracture process. Such models can be especially useful for recycled aggregate concrete, which presents even more complex meso-structure due to the various components, such as natural aggregates, new and old cement mortars, and several interfacial transition zones.

Therefore, in order to investigate the compressive failure process in recycled aggregate concrete elements, this work employs an extension of the mesh fragmentation technique developed by Manzoli et al. [2]. The material is represented in a mesoscale level, as proposed by Rodrigues et al. [3]. Once the mesh fragmentation technique is applied, interface elements are inserted into the standard finite element mesh to define the potential fracture paths. However, in this study, the interface element type is a two-layer condensed high aspect ratio element. The two layers are respectively ruled by tensile and frictional shear constitutive models, allowing to describe the compressive failure as a combination of both processes, as proposed by Gimenes et al. [1].

Following this approach, the tensile damage model layer enables the representation of fracture propagation in mode I, corresponding to the debonding (opening) between the material elements due to tensile stress. Complementarily, the frictional shear layer represents fracture propagation in mode II, corresponding to the sliding process in the failure surface.

Since the study is mainly focused on the mechanical behavior of recycled aggregate concrete, it is reasonable to assume the mesh fragmentation should be applied to the aggregate elements as well, to account for possible fracture propagation through the recycled aggregates, as observed in experimental findings [4].

In this work, numerical compression tests are carried out in specimens respectively made of mortar, natural aggregate and recycled aggregate modeled concrete. The numerical results obtained are compared qualitatively and quantitatively with experimental results from the literature [4], indicating that the proposed approach is suitable for describing the failure process of natural aggregate concrete (NAC) and recycled aggregate concrete (RAC) in compression. Furthermore, it is observed that the cracking process differs for RAC and NAC, providing better understanding of the participation of each component phase into the composite failure process.

References

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