Boundary layer in discrete models based on Voronoi tessellation

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ABSTRACT

The material in the vicinity of the solid boundary often has different material properties to that lying further from the boundary due to various effects. In concrete, one of the main effects is that the boundary layer typically contains a lower amount of larger mineral aggregates and more small aggregates and mortar compared to the interior material [1]. The boundary layer thickness is determined by the sieve curve of the material and is independent of the size of the specimen/member. The presence of the boundary layer may affect the elastic and inelastic mechanical behavior of concrete members.

In the numerical analysis of concrete members using discrete models, the boudary layer is present as well. The paper focuses on a specific type of discrete mesoscale model with random geometry where every model node represents one larger aggregate and its surroundings. Specifically, the focus in this paper is placed on models with geometry generated via Voronoi or similar tessellation [2,3]. It is demonstrated that the boundary layer affects mechanical behavior of the model. For a positive Poisson's ratio, the boundary layer becomes more compliant than the bulk material, while, for a negative Poisson's ratio, it becomes stiffer. In the nonlinear regime, the boundary layer is weaker and less ductile than the interior material. All of these phenomena are consequences of geometrical bias in the boundary layer. While the elements inside the specimen are oriented with the same probability in any direction, the boundary layer has more elements oriented along the boundary.

When the discrete model is understood to be only some kind of discretization technique, the presence of a boundary layer with a thickness that is related to the discretization density is inconvenient. Viewing the discrete particle model as a meso-level model mimicking real material structure, the aforementioned boundary layer might also be viewed as realistic. However, the underlying origin of the boundary layer in the numerical model is completely different from a real heterogeneous solid. Because there are no experiments known to the author that evaluate the boundary layer effect, it is not possible to determine its appropriateness in the model.

The contribution shows and quantify effect of the boundary layer on elastic end inelastic behavior of models of simple concrete specimens. It is based on recent journal paper [4].

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