Three-dimensional lattice modelling of hydro-mechanical coupling in unsaturated materials

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ABSTRACT

This work involves three-dimensional lattice modelling of hydro-mechanical coupling in unsaturated porous particulate materials. The aim is to understand the link between the material's microstructure and the macroscopic response for coupled hydro-mechanical processes. In particular, the influence of fluid retention and transport on the mechanical response is studied.

The microstructure of the porous material is idealised by randomly arranged transport and mechanical lattice elements based on a dual Voronoi-Delaunay tessellation representing the pore-structure and particle interactions. For the pore structure, a three-dimensional network model of pipes and spheres representing throats and pores, respectively, is used. The locations of the pipes connecting the spheres are determined by the edges of the Voronoi tetrahedra. Random distributions for the diameters of throats and pores are used to consider the heterogeneity of the microstructure. This transport approach is capable of describing complex macroscopic responses, such as hydraulic hysteresis [1], by applying appropriate rules for determining whether each individual pore is filled with liquid or gas. For the particle interactions, the locations of the mechanical elements are chosen as the edges of the Delaunay tetrahedra [2]. With this chosen dual tessellation of transport and mechanical elements, the mid-crosssections of mechanical elements are surrounded by transport elements. This geometrical relationship is used to model the coupling between the transport and mechanical approaches.

The influence of the pore fluids on the mechanical response is considered by adding a force to the mechanical particle interaction. This force is determined from the fluid pressures (liquid or gas pressure) in the pores located at the mid-crosssection of the mechanical element. An additional force is included in the case where all the pores located at the mid-crosssection of a mechanical element are gas-filled, to represent the influence of a water bridge formed between particles in the pendular state [3].

The coupled model will be used to investigate the mechanical behaviour of porous materials for drying and wetting paths in the form of saturation dependent bulk and shear moduli. Furthermore, the onset of the inelastic response for triaxial tests will be studied.

REFERENCES

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