Extension of the Material Point Method for unsaturated soils: 1 point - 3 phase MPM formulation

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ABSTRACT

Problems involving large deformations or history-dependent constitutive models are of interest in the geotechnical field, in particular in applications associated with unsaturated soils. This is the case of collapse behaviour of low density soils or the unrestrained swelling of expansive clays. Rain induced instability of unsaturated slopes is a further example of large displacements. In this case the slide run-out is directly associated with the risk evaluation of the instability.

Finite element methods find difficulties to reproduce large deformations due to mesh tangling, while particle-based methods and, in particular the Material Point Method (MPM) [1], offers an interesting alternative. MPM discretizes the media into a set of material points which move through a fixed finite element grid. This dual description prevents mesh distortion problems and contact between different bodies is automatically solved.

In this work, the extension of the MPM formulation to model unsaturated soil problems is presented. In this approach, the soil is understood as a unique medium integrated by three distinct phases (solid, liquid and gas). All phases are combined and interact within each material point and balance and momentum equations are formulated and numerically solved within the framework of a general purpose MPM code. Special attention is given to the application of the boundary conditions and a discussion is also included.

Finally, the whole instability process of a slope on unsaturated soil subjected to rain infiltration is analysed. In order to take into account the soil strength variation depending on the water content, an elastoplastic constitutive model is implemented and formulated in a net stress-suction framework.

REFERENCES

[1] D. Sulsky, S.J. Zhou, H.L. Schreyer, "Application of a particle-in-cell method to solid mechanics", *Comput. Phys. Commun*, **87**, 236–252 (1995).