THM modelling of slides using the Material Point Method

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ABSTRACT

Some historical catastrophic landslides cannot be explained without considering thermo-hydro-mechanical coupling effects in the shear band where strains are localized and in its vicinity [1]. As an example the sliding surface of the Vaiont rock landslide, reviewed in references [2] and [3], was located in layers of high plasticity clay. Frictional work dissipates in heat which causes pore water pressure increments in the clay band due to water dilation and soil stiffness. This in turn reduces the effective strength and can produce the slide acceleration and high velocities at large displacements. The problem is highly coupled and the amount of pore water pressure increment depends strongly on the permeability of the band [2].

A strong discontinuity approach is used for modelling the failure surface. The discontinuity is traced on the MPM mesh with particles which are displaced during the solution. The surface strength is a function of relative displacement and normal stress. Temperature and pore water pressure are carried by particles. Also plastic work generated heat is introduced as a source term.

As the band thickness is very small, compared with the overall dimensions of a landslide, it is difficult to model accurately pore pressure generation-dissipation behaviour in the band. In order to solve this issue an analytical solution for the excess pore pressure generated during the sliding within the band [4] is coupled with the numerical MPM solution.

Some preliminary results for Vaiont case are shown. MPM is very well suited for this kind of problems because of the changing of slide geometry during the displacement is naturally included in the calculations.

REFERENCES

[1] Vardoulakis, I. Dynamic thermo-poro-mechanical analysis of catastrophic landslides. G*éotechnique* **52** (3), 157-171. (2002).

[2] Alonso, E.E , Pinyol, N.M. "Criteria for rapid sliding I. A review of Vaiont case", *Engineering Geology* **114** 198–210 **(**2010).

[3] Pinyol, N.M., Alonso, E.E "Criteria for rapid sliding II. Thermo-hydro-mechanical and scale effects in Vaiont case", *Engineering Geology* **114** 211–227 **(**2010).

[4] Pinyol, N.M. and Alonso, E.E. (2010) "Fast planar slides. A closed form thermo-hydro-mechanical solution". *International Journal for Numerical and Analytical Methods in Geomechanics* 34: 27-52. (2010)