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Landslide modelling with a material instability criterion

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Soil behaviour is generally well simulated with the help of elasto-plastic models: the relationship which links the loading applied to the material and the associated response depends on the loading path, but not really on the rate of loading. Engineers commonly use methods based on a plasticity criterion to predict failure of soils slopes. But in some cases, these methods do not allow the prediction or the understanding of the real phenomena. As an example: at Petacciato in Italy, a landslide occurred on a slope less than 10°. For this reason, we will consider an other criterion: the Hill's sufficient condition of stability. This criterion has been chosen because it allows the analysis of all failure modes. So it is the first to be reached. According to Hill, a stress strain state is unstable if it is possible to obtain a deformation in a given loading direction without any additional external energy. Eventually, a system of volume V is stable if:

$$\int_V \underline{d\sigma} \,.\, \underline{d\varepsilon}\, dV > 0$$

which gives in the local form: for any couple ($\underline{d\sigma}$, $\underline{d\varepsilon}$) linked by their constitutive relation:

$$d^2W = \underline{d\sigma} \,.\, \underline{d\varepsilon} > 0$$

So we will study this criterion under this last form. Firstly, we will present an analytical and a numerical study which gives the bifurcation domain, as well as the cones of unstable direction for Darve's octolinear and non-linear constitutive relation. All this is carried out in 3D condition. Then, we will show that a fully hydro-mechanical coupled simulation allows the accurate simulation of the failure mechanisms of the Petacciato (Italy) and Trévoux (France) landslides.

References

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