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Constitutive modelling of a rock joint until failure

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Considering a rock joint where normal and tangential stresses are named σ and τ respectively whereas the two adjacent blocks are splitted by the relative displacements u (in the normal direction) and γ (in the tangential one), the goal of this work is to set a correct incremental relation, $\begin{pmatrix} d\sigma \\ d\gamma \end{pmatrix} = f\begin{pmatrix} du \\ d\gamma \end{pmatrix}$, to describe the behaviour of the rock joint.

This incremental relation is moreover non linear and calibrated on the behaviour of the joints along two special loading paths : one shear at constant normal relative displacement (dγ = cste and du = 0) (a constant-volume shear, named CND path) and one compression at constant tangential relative displacement (du = cste and dγ = 0) (an oedometric compression, named CTD path) : see Darve & Roguiez, 1999 for such examples. Because of the lack of exhaustive experimental data on such paths in the case of rock joints the choice was made to use the results of numerical simulations to calibrate the constitutive relation.

These simulations were realized thanks to an open source software (Kozicki & Donzé, 2008) using the Discrete Element Method (Cundall & Strack, 1979). The rock joint itself is simulated and several numerical tests are performed. CND and CTD paths are for example simulated and the curves $\sigma(\gamma)$ and $\tau(\gamma)$, for the CND one, and the curves σ(u) and τ(u), for the CTD one, are shown. From these curves the parameters of the relation are defined, so that the relation could reproduce these results. It is shown that the current state in shearing of the rock joint influences the behaviour of the joint, and that a pertinent variable to describe this influence is the ratio τ/σ (and not the value of the tangential relative displacement γ for example). This fact is taken into account in the definition of the parameters of the relation.

All these results are compared to and confirmed by some experimental data, showing the ability of our numerical model to reproduce the behaviour of a rock joint.

Once all parameters are defined thanks to these "calibration" paths, the performance of the constitutive relation is verified by performing simulations of other paths (like constant normal stress shear, or constant normal rigidity shear), but also by performing directional probes. Simulations by the numerical model and the constitutive relation itself are compared and show good agreement.

Finally the behaviour of the relation, now defined and validated, is studied in the sense of stability, through the "second order work criterion" (Darve & al, 2004) which is proposed as a stability criterion for rockfalls.

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