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MODELLING THE ASPERITY DEGRADATION OF A SHEARED ROCK JOINT USING FEM

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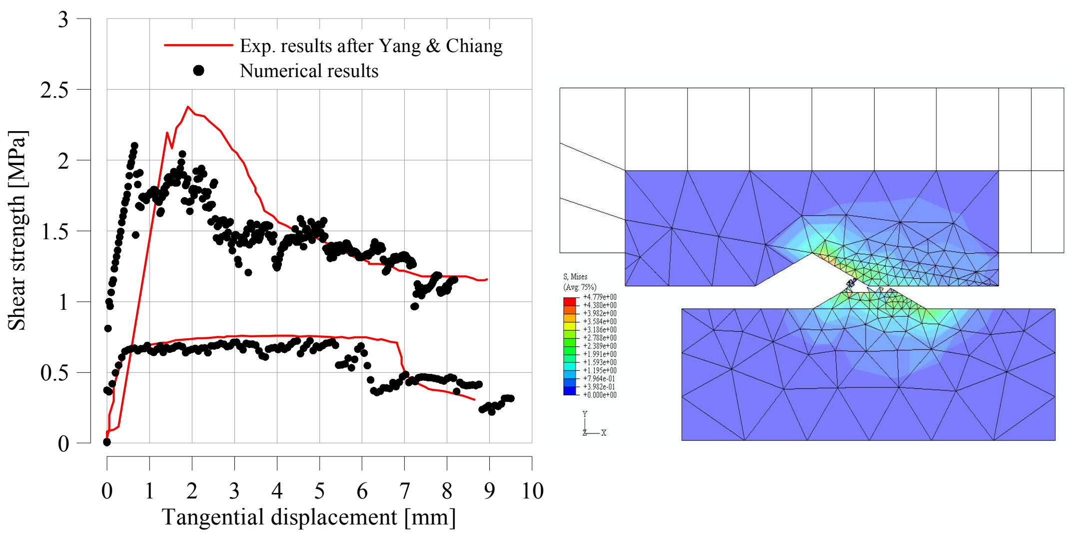
ABSTRACT

Rock masses naturally include discontinuities, which are inherent of their geological history. These discontinuities are usually considered as a weakness of the rock mass and can be critical for their stability in case of cutting or excavation for example. It is thus of prime importance to understand and predict the mechanical behaviour of natural discontinuities. Many researches have been conducted since the 1960s and it is known that the roughness of the discontinuity and its progressive degradation under shearing mainly governs its mechanical behaviour [1]. Many numerical investigations on rock joints have also been performed, especially using Finite Element Method (FEM) codes even though the degradation of the joint asperities can not easily be captured with this method. To overcome this issue, Distinct Element Method (DEM) and hybrid FEM-DEM have been used (e.g. in [2]). Indeed, removal of distinct particles with DEM is easily feasible but users of FEM are not always familiar with DEM.

The latest version of the FEM code Abaqus (6.7) incorporates an element removal function allowing one to simulate erosion or damage. However, this function is only accessible for the explicit version and dynamic analysis. Some numerical results are presented herein in order to show that a quasi static shear on a rock joint can satisfactorily be reproduced using dynamic analysis incorporating the asperity degradation. In order to eliminate the difficulty inherent to the joint morphology, a simple joint geometry has been chosen to start with. The experimental study performed by Yang & Chiang [3] has been considered since they have used simple saw tooth geometry and they provide comprehensive data and results. The material is described as an elasto-plastic material having a Drucker Prager criterion without hardening. The mechanical properties are chosen consistent with data provided by Yang & Chiang [3]. However, the authors do not provide all properties so that some are adjusted to calibrate the model (e.g. friction angle, Young's modulus). The contact is frictional ($\mu = 0.64$) with an elastic behaviour, defined by a tangential stiffness (k_s = 10 MPa/mm), before sliding occurs.

Dynamic analysis results in significant instabilities or oscillations of the computed shear strength. This phenomenon is well known in structural dynamics and is usually limited

using some damping. Several damping options are available in Abaqus 6.7, however, even though the amplitude of the instabilities can be reduced, it is difficult to totally eliminate them and residual oscillations can be seen in see Figure 1 (a). The onset of the damage is defined by a maximum amount of plastic strain the material undergoes before breaking (herein 5%). Then, the damaged material stiffness drops with strain until total degradation, for which degraded elements are removed. The model is calibrated for a shear test under a normal stress of 0.39 MPa (Figure 1 (a)) and a prediction is made under a normal stress of 1.47 MPa. It can be seen that the numerical results are very close to the experimental data. The qualitative response is fully satisfactory since the major features of the mechanical behaviour are captured (elastic zone, plateau or peak and breakage). Moreover, the failure mode is consistent with the experimental results (see Figure 1(b)). From a quantitative point of view, the model provides a good estimation of both peak and residual shear strength under two values of normal stress, meaning that the failure criterion can be predicted. The next stage of this research is to study a more realistic joint morphology and perform numerical tests on larger specimens.



(a) (b)

Figure 1. (a): Evolution of shear strength versus tangential displacement (numerical and experimental results). Experimental data alter Yang & Chiang [3]. (b): View of the degradation of the contact asperity during shearing.

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