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A coupled DEM-DFN approach to rock mass strength characterization

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An enhanced version of the discrete element method (DEM) has been specifically developed for the analysis of fractured rock masses [Scholtes L, Donze F, 2012]. In addition to the discrete representation of the intact medium which enables the description of the localized stress-induced damage caused by heterogeneities inherent to rocks, structural defects can be explicitly taken into account in the modeling to represent pre-existing fractures or discontinuities of size typically larger than the discrete element size. From laboratory scale simulations to slope stability case studies, the capability of this approach to simulate the progressive failure mechanisms occurring in jointed rock are presented is assessed on the basis of referenced experiments and in situ observations. For instance, the challenging wing crack extension, typical of brittle material fracturing, can be successfully reproduced under both compressive and shear loading path, as a result of the progressive coalescence of micro-cracks induced by stress concentration at the tips of pre-existing fractures.

In this study, the dedicated DEM is coupled to a discrete fracture network (DFN) model to assess the influence of DFN properties on the mechanical behavior of fractured rock masses where progressive failure can occur. The DFN model assumes the distribution of fractures barycentres to be fractal and the distribution of fracture sizes to follow a power-law distribution [Davy P, Le Goc P, Darcel C, Bour O, de Dreuzy JR, Munier R, 2010]. The proposed DEM/DFN model is used to characterize the influence of clustering and size distribution of pre-existing fractures on the strength of fractured rock masses. The results show that the mechanical behaviour of fractured rock masses is mainly dependent on the fracture intensity. However, for a given fracture intensity, the strength can exhibit a 50 per cent variability depending on the size distribution of the pre-existing fractures. This difference can be attributed to the different mechanisms that involve sliding and crushing of blocks in the case of large interconnected fractures or progressive failure of the rock matrix through coalescence of cracks in the case of small unconnected fractures. Clustering of fractures was found to influence the spatial variability of the mechanical properties and therefore to have a scale effect on strength. The results outline the relevance of three parameters, the power-law exponent of the fracture size distribution, the clustering fractal dimension which fixes the fracture-to-fracture correlation number and the fracture intensity, to characterize the mechanical behaviour of rock masses.

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