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Construction of Discrete Fracture Networks based on data from 3D geological reconstructions of outcrops.

Ondřej Švagera (1), Petr Kabele (2), Zita Bukovská (1), Jan Jelínek (1), Václav Nežerka (2), Igor Soejono (1), Michael Somr (2), and Jan Zeman (2)

(1) Czech Geological Survey, Prague, Czech Republic, (2) Czech Technical University in Prague, Faculty of Civil Engineering, Prague, Czech Republic

Understanding the distribution of brittle structures throughout a rock mass is one of very important factors for safety assessment of underground facilities, e.g., deep geologic repositories for spent nuclear waste. In spite of the importance of geological data, in the initial stages of the evaluation process it is often not feasible to perform extensive drilling campaigns or geophysical measurements. To address the problem, we have developed a methodology which allows us to construct Discrete Fracture Network (DFN) models of fractured rock mass using limited surface outcrop data.

In order to fully exploit the information potential of rock outcrops, an enhanced procedure of structural data acquisition based on 3D photogrammetry has been proposed. First, using high-resolution digital images obtained in the field, realistic 3D models of outcrops are reconstructed and placed in correct geographical position and orientation. Subsequently, fractures are visualised via faces of the triangulated mesh and their spatial characteristics, such as trace length, dip, and strike can be extracted. The greatest benefit of the adopted approach is that properly oriented, reconstructed and geographically emplaced outcrop model can be used repeatedly as the need for more structural data arises.

The acquired structural-geological data are used to construct 3D DFN models of the fractured rock mass. The DFN modelling employs common statistical distributions of fracture size (power law distribution) and orientation (Fisher distribution). In order to honour the field observations, fracture volume density (P_{30}) and the parameters of the fracture size distribution are obtained by minimizing objective functions, which quantify the discrepancy between the observations and model reproductions at the outcrops. Once the model parameters are identified, any number of DFN realizations can be created by a random process respecting the adopted statistical distributions. The algorithms for DFN identification and reconstruction have been implemented using Python programming language in an in-house specialized software DFraM.

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