Investigating the Effective Parameters on Modeling the Hydraulic Conductivity Variations in Fractured Environment Using Distinct Elements Method

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Abstract: One of the most important and challenging issues regarding underground spaces such as tunnels and caverns, is to estimate the amount of water entering to an underground space. A real estimation of the leakage is a very influential factor in the success of a project performance. Hydraulic conductivity can play a significant role on subsurface water flow. Lugeon and Lofran tests are routinely used to estimate hydraulic conductivities. In this study, distinct fractured network was employed to evaluate hydraulic conductivity. For this purpose, pre-processing was initially carried out on the data collected on the joints. These joints were divided into three groups of sub-horizontal, sub-vertical and bedrock joints. Afterwards, Poisson, exponential and logarithmic distributions were considered. A proper distribution for the joints was obtained using the exponential distribution with the highest agreement. Taking into account the initial conditions of the model, the DFN of the joints was created by 3DEC software. In the process of solving the problem, the DFN was considered with different eliminating filters, among which a 6-meter filter was selected as the appropriate one for removing the small fractures. DFN was validated using Watson & Williams test results and P-value test. The construction of the Representative Elementary Volume model was performed by using the 7 meters blocks. It is the optimum dimension describing the area, properly. Finally, results were verified with the data obtained from the Lugeon test; showing a relatively high correlation.

Keywords: Discrete Fracture Network, Cavern, Finite Difference, Hydraulic Conductivity, Pumped storage power plant, Roudbar Lorestan dam.

INTRODUCTION

In engineering applications, groundwater seepage analysis is one of the most important stages of fundamental projects such as water supply, dams and hydraulic structures and watering and drainage systems. Due to their complex structures, modelling of the fracture networks is a difficult task. Most of the models used to describe the fracture networks have some general defects. The most important factor leading to water seepage in underground spaces is hydraulic conductivity. Hydraulic conductivity in each region depends on the physical properties of fractures in that area. Distinct Fracture Network is the most useful method for flow investigations in broken masses (Jing et al., 2002). The two-dimensional modelling of the fracture network was first carried out by Long et al. (1985) about thirty years ago. There are several methods for estimating permeability in fractured rocks, including a method proposed by Snow (1969). A semi-analytic method was used by Xu et al., (2015) for the back analysis of hydraulic conductivity values around the rock caverns. In 2011, Sun applied a combination of analytical methods and artificial neural networks to estimate hydraulic conductivity values in six boreholes (Sun et al., 2011). Lee et al. (2003) described their findings regarding the application of the Distinct Fractures Network (DFN) for geomechanical and hydrological couple modelling of fractures rocks. In this research, the amount of water seepage into the rock mass is determined applying the concept of a DFN and utilizing the distinct element code in 3DEC software. One of the most important issues discussed here is the study of different factors affecting on the results, as well as the duration of the implementation of DFN model and Representative Elementary volume.

METHODS

In this study, the concept of DFN was used to evaluate the hydraulic conductivity in the study area. The network of fractures is based on the Monte Carlo statistical algorithms. The data used for modelling are the physical properties of the joints and fractures of cavern of the pumped storage power plant of Roudbar Dam, Lorestan. Among the several proposed models, a method based on the Watson Williams test has been evaluated due to its best compatibility. The block model produced by the DFN method was employed to determine the size of the representative volume. Finally, by applying the pressure head to the constructed block, the values of the tensor of hydraulic conductivity were obtained.

FINDINGS AND ARGUMENT

In this research, the following results were obtained after the construction of several models with various fracture networks in terms of number and dimensions:

A three dimensional model having 7 meters length with fractures bigger than 10 meters, can clearly represent the properties of the fractured environment (Figs. 1and 2). Obtaining the tensor values of anisotropic hydraulic conductivity coefficients was the most important achievement of this study. These coefficients can be used in various seepage and injection related operations.

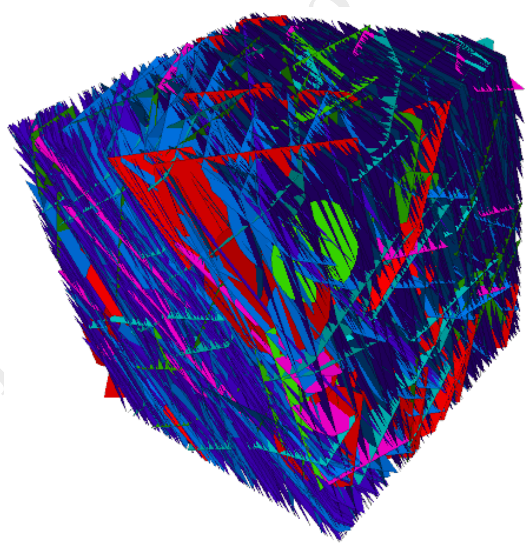

Fig. 1. 3D DFN model with a dimension of 10m

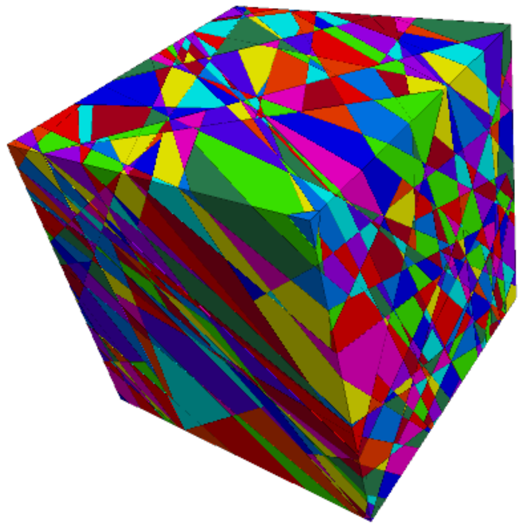

Fig. 2. Fractures block model with a dimension of 7 meters

CONCLUSIONS

In this study, DFN method was used to construct a reliable model to obtain tensor values of hydraulic conductivity coefficients. DFN is a promising method for obtaining flow and hydrogeological issues in fractured environments. At the same time, DFN can be used as an independent method to obtain hydraulic conductivity coefficients and seepage quantity. It is very important to obtain a small size model that can represent the main characteristics of the modelling environment. Modelling in a discrete environment is totally different from other media in terms of modelling parameters such as model running time and the bugs. The important aspect of this study is that the hydraulic conductivity values have been considered as anisotropic parameters. It is mainly due to the difference between the coefficients of hydraulic conductivity which leads to a big difference in obtaining seepage values under isotropic and anisotropic conditions.

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