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Uncertainty analysis in the discrete fracture network generation in order to reduce the risk of simulation based on probability distribution functions: A case study of Emamzadeh Hashem tunnel

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Abstract

Rock mass consists of intact rocks and discontinuities such as fractures, which have a significant impact on the mechanical and hydraulic properties of the rock mass. For example, in sensitive analyzes such as tunnel stability simulation. Therefore, it is very important to determine the exact parameters of stone jointing, such as orientation and length. Using Discrete Fracture Network is one of the common methods to simulate jointed rock. Since the construction of the fracture network is done using statistical distribution functions, the uncertainty in the construction of the fracture network has always been one of the great challenges of engineers. In this study, the fracture network of Emamzadeh Hashem tunnel was constructed by a code developed in MATLAB and 3DEC software, and the influence of statistical distribution functions on the uncertainty in the construction of the fracture network was investigated. The results indicate that a negative exponential distribution can lead to relatively large errors in constructing the fracture network, especially when used to generate the fracture dip direction. Also, the results of the parametric study showed that the use of statistical distribution functions that have the variance of the data in their PDF (Probability Distribution Function) can increase the accuracy in the production of fracture parameters such as slope, slope direction and effect length, and to reduce the uncertainty in the production of the fracture network.

Key words: *Discrete Fracture Network, Uncertainty analysis, 3DEC, statistical distribution functions.*

Extended Abstract:

1. Introduction

A rock mass is a combination of virgin rock and discontinuities such as seams, layered plates, faults and other weak plates. To analyze the effect of fracture on the hydraulic and mechanical behavior of the rock mass, it is necessary to describe the fracture geometry of the jointed rock mass (Wittke 2014). With the advancement of science, researchers used the new methods of separate fracture network to simulate the jointed rock mass. In these methods, it is possible to simulate fractures with limited length and arbitrary orientation. In order to build a separate fracture network, information such as the density, orientation, length and opening of fractures is needed. Therefore, in this research, the uncertainty in the production of the fracture network has been studied. For this purpose, the fracture network was created using a code developed in MATLAB based on the Monte Carlo technique and compared with the results of the 3DEC software and the data of Imamzadeh Hashem tunnel.

2. Materials and methods

or the purpose of modeling, in the first step, fracture data of Imamzadeh Hashem tunnel was collected in 3-meter sections and entered into DIPS software, and then based on the concentration and intensity of the fracture pole in different areas of Strivenet, four groups of dominant cracks were identified in the region. he minimum parameters required to construct the fracture network are directional, effect length and fracture density. These parameters are generally determined by field surveys, borehole information, or using virtual survey equipment such as LiDAR. in this study, a computational code has been developed in MATLAB software to construct a fracture network. This code has the ability to consider normal, log-normal, power, exponential and uniform statistical functions. Also, in the developed code, it is possible to display the fracture planes in three dimensions, and all the parameters of each fracture can be output as an Excel file. In this study, using the Monte Carlo technique and based on the code developed in MATLAB, 10 random models for the fracture network of Imamzadeh Hashem tunnel were created. have became Using the FISH programming language in the 3DEC software, 10 random fracture networks of Imamzadeh Hashem tunnel were created, which are shown in Figure 6. These ten different grids are generated by changing random numbers as described for the developed code..

3. Tests results

In this study, in order to evaluate the effect of statistical distribution functions on the uncertainty in the construction of the fracture network with the code developed for each of the slope parameters, slope direction and length-effect, 10 different scenario models based on the presented parameters are considered in Table 2. It has been done to be able to investigate the effect of different parameters on the uncertainty in the construction of the fracture network.

4. Conclusion

Uncertainty in the construction of the fracture network in important analyzes such as tunnel stability can have a significant effect on the simulation results. However, in previous studies, a detailed

evaluation of the effect of different statistical functions on the production of jointing parameters such as slope, direction and length of the effect has not been provided. In this study, using a code developed in MATLAB software and also 3DEC software, the effect of statistical distribution functions on the construction accuracy of the fracture network of Imamzadeh Hashem tunnel has been investigated. The results of this study showed that the most errors in the generation of jointing parameters by the developed code and 3DEC software occur when the negative exponential distribution function is used. On the other hand, by reducing the mean and variance of the normal distribution, the accuracy of the code developed to generate the slope and the direction of the fracture slope decreases. he results of this study indicate that the use of exponential distribution in the production of the Imamzadeh Hashem tunnel fracture network can cause relatively large errors. In order to investigate more precisely, a parametric study of the effect of different statistical functions on the production of fracture parameters (slope, slope direction and effect length) was done. the results showed that:

The use of distribution functions such as normal, which directly considers the variance of the data in the PDF function, can greatly increase the accuracy of the developed code in generating the fracture parameters.Reducing the variance of the data has a significant effect on the accuracy of the code when generating fracture parameters using normal distribution. The greatest effect of various statistical functions is in producing the minimum value of fracture parameters and in most cases the developed code correctly calculates the maximum value. Negative exponential and power distribution functions in which the variance is not included directly in the PDF function can cause the most error in the generation of fracture parameters.

The only place where increasing the variance of the data increases the accuracy of the developed code is related to the use of negative exponential distribution to generate the direction of the fracture slope. Of course, it should be noted that in this case, the average value of the data has increased, and in most models, with the increase of the average data, the accuracy of the code decreases when using the negative exponential distribution. According to the results of this research, the use of the developed code can reduce the uncertainty in the construction of the fracture network. Especially when exponential or power functions are used to generate fractures, using the developed code instead of other software increases the accuracy of the fracture network. It should be noted that although the use of statistical methods is very suitable in some cases for the purpose of constructing a fracture network, the use of geostatistical methods can reduce uncertainty in the construction of fractures, especially determining their location in space. Although the use of truncated density functions can limit the production values in a more realistic range, attention should also be paid to the variance values of the primary data. If the variance of the data in a joint group is high, this can increase the error in the generation of joint parameters. Therefore, in these cases, it is better to divide each group of joints into several smaller parts based on the variance values of the data and produce them separately. In this way, the error caused by the variance of the data is reduced and the compatibility between the primary data and the fractures produced by the statistical method is increased.

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