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Study on the Variation of Joint Rock Mass Behavior with Different Joint Strike Angles Based on MBC Model

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1. Introduction

It is well known that the mechanical behavior of jointed rock mass is strongly affected by the property and geometry of joints. When the construction of a large-scale cavern is conducted, it is necessary to pay great attention to not only the imposed loading condition and the material properties of intact rock mass, but also the geological condition and mechanical characteristics of the joints. A numerical model of rock mass with joints is necessary in order to establish a rational design method and construction control.

The MBC (Micromechanics-Based Continuum) model assuming that the sliding and opening of joints is governing mechanism of the jointed rock mass behavior was proposed for the jointed rock mass by Yoshida and Horii. To examine the performance of the proposed method, some analyses of underground excavation, for example the problems of Shiobara power station cavern constructed by the Tokyo Electric Power Co., Ltd.[1], and Okawachi power station cavern constructed by the Kansai Electric Power Co., Ltd.[2], were carried out. Analytical results, such as the distribution of displacements of rock mass and the changes of tensile stress of PS anchors, were computed and compared with the measurement data showing good agreements.

However, only the joints having their strike parallel to the tunnel axis are considered to be the distributed joints in the analyses. The variation of jointed rock mass behavior with different joint strike angles during an excavation process was not carried out. The joint strike angle is considered to be one of the important properties for the behavior of the jointed rock mass. Thus, in the present paper, the variation of the behavior of the jointed rock mass with different joint strike angles during the excavation process is attempt to be understood by the MBC model.

2. Variation of jointed rock mass behavior with different joint strike angles

A finite element mesh whose size is 50m x 50m x 35m with a circle tunnel (radius = 5m) is considered as a tunnel excavation problem. The layers are seven and the numbers of finite elements and nodes are 980 and 1043, respectively. Initial stress state is assumed to be hydrostatic pressure, 10 MPa, and the joint dip angle for all analyses is set to be vertical. The parameters used for the MBC model in this study are listed in Table 1.

Table 1 Summary of input parameter

Input Parameters	Values
elastic modulus of intact rock mass, E	200,000 kgf/cm2
Poisson's ratio, ν	0.25
frictional angle on the joint surface, Φ	25 degree
joint strike angle, β	0, 15, 30, and 45 degree counter-clockwise from the tunnel axis
effective joint length/ average distance between joints, a/d	10, 15, 20
joint undulation angle, α	18 degree

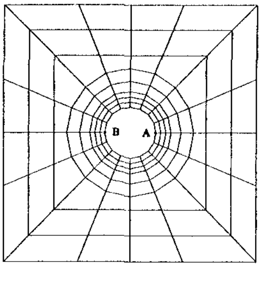

Fig.1 The first cross section of analytical mesh

In order to understand variation of jointed rock mass behavior with different joint strike angles, the convergence between point A and point B on the tunnel wall in the first cross section shown in Fig. 1 is computed and plotted using different values of a/d (joint effective length/ average distance between joints) together with the measurement data of tunnel having a horse-shoe shape, in Fig. 2. The convergence of both analytical result and

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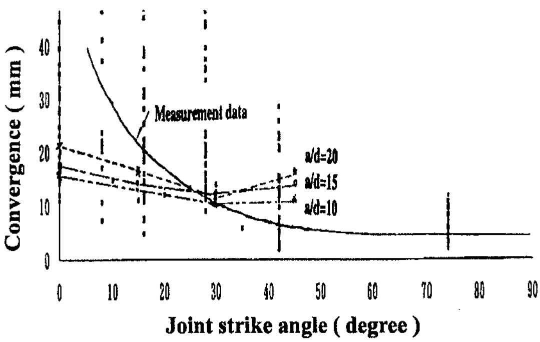

Fig.2 Convergence between point A and point B

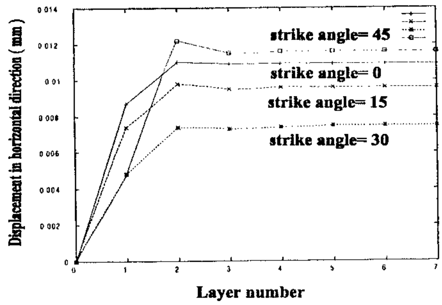

Fig.3 Variation of Displacement in horizontal direction during the excavation process

measurement data increases with decreasing the strike angle of joint. The tendency of the behavior of jointed rock mass between the analytical result and measurement data is very close. But the analytical result increases under the strike angle more than 30 degree for all a/d. The difference between analytical results and measurement data is considered to be due to the different shape and size of tunnel and the initial pressure condition.

Next, the variation of displacement at point B in horizontal direction for the case of a/d= 20, as an example, is plotted at each layer excavation in Fig. 3. From the figure, it is found that the displacement reaches a constant value after the excavation of the 4th layer. This is considered as the negligible influence on the deformation of jointed rock mass at the first cross section due to the excavation of latter portion. Furthermore, it is also noticeable that the displacement increment for strike angle 45 degree is large compared with the other cases when the 2nd layer is excavated. Since the directions of the deformation of joint are very different in all cases, we can not compare them. The deformation of joint having 45 degree of strike, however, is the largest among them.

In addition, the region in which joints deform is plotted in Fig. 4 for 0 degree of joint strike and Fig. 5 for 45 degree of joint strike. Generally, both the region in which joints deform and the total magnitude of joint opening displacement for 45 degree is smaller than 0 degree case.

In the present paper, the variation of the jointed rock mass behavior with different joint strike angles based on the MBC model is understood and advanced analyses based on real situation in site is needed to be carried in future task.

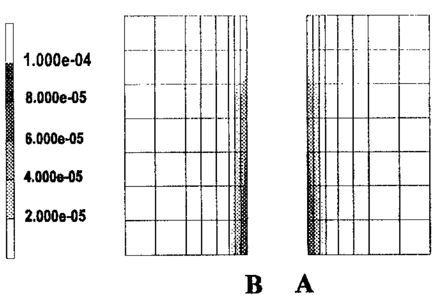

Fig.4 Joint opening displacement (strike angle 0 degree)

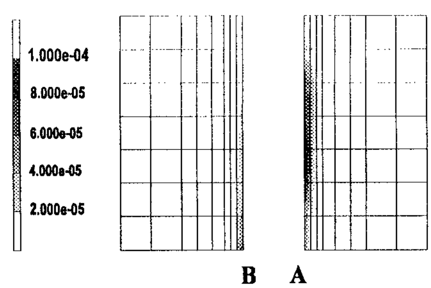

Fig.5 Joint opening displacement (strike angle 45 degree)

References

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