Research on the stability of tunnels excavated along anisotropic rock mass

Van Binh Nguyena[[1]](#footnote-1), Van Diep Dinha

aHanoi University of Mining and Geology, Hanoi, Vietnam

**Abstract:** *Coal output of underground mines in Quang Ninh area is gradually growing and expected to account for nearly 90 percents of total coal production in 2030. The amount of tunnels excavated along sedimentary stratification will therefore increase. The main characteristics of carboniferous sedimentary is heterogeneous, anisotropic with various types of geological structures such as faults, crumpled rocks, layered strata, ... Rock mass surrounding the tunnels is often destroyed, squeezed, etc. which cause large movements inside drift from the roof, floor and side walls and even a collapse of support structure. These effects are usually asymmetric over the vertical axis of tunnel.**The objective of this study is to determinate the failure zone and convergence displacement developed in rock mass surrounding tunnels considering the heterogeneity and anisotropy of rock mass.*

*Keywords:* tunnel; bedding joints; convergence; inclined stratification; anisotropic.

1. Introduction

The amount of tunnel excavated along sedimentary rock mass in Quanninh coal area is more and more increasing. Rock mass in Quangninh is characterized by bedding between rock layers. Unlike the initial rock mass, behaviour of sedimentary rock mass surrounding a tunnel depends on both initial rock and discontinuities between rock layers. Generally, dip angle of bedding can be varied arbitrarily from 00 to 900 corresponding to horizontal and vertical beddings. The main characteristics of sedimentary rock mass is therefore in-heterogeneous, anisotropic.

…………………

2. Evaluation of rock mass properties

The constitutive model using Hoek-Brown failure criterion has been adopted for the rock mass surrounding tunnel (Barton, 1972). The joints strength through Barton - Bandis failure criterion (Barton and Bandis, 1990).

In this paper, a range of GSI values changing from 10 to 80 has been adopted which covers rock mass quality varying from very poor to very good. The uniaxial compressive strength of intact rock (*σci*) was chosen from 10 to 80 MPa, the modulus ratio MR = 500 and the geomaterial constant mi=7. The deformation modulus of intact rock (*Ei*) is determined as follows (Hoek and Diederichs, 2006):

*Ei* = *MR* *σci* (1)

The deformation modulus of rock mass (*Rrm*) were calculated on the basic of the following relationship:

 (2)

All rock mass and discontinuities parameters are presented in Table 1. Totally, there are 320 parametric calculations using Phase2 software, thus covering most of the possible situation that could be encountered in practice.

Table 1. Rock mass and discontinuities parameters

|  |  |
| --- | --- |
| Descriptions | Values |
| *Rock mass material* |  |
| Modulus ratio MR | 500 |
| Unit weight *γ* (MN/m3) | 0.024 |
| Poisson’s ratio of rock, *μ* | 0.25 |
| Uniaxial compressive strength of intact rock *σci* (MPa) | Changed for eight cases: *σci* = 10; 20; 30; 40; 50; 60; 70; 80 MPa |

3. Numerical analyses

This section deals with the variations of convergence displacement of the tunnel boundary after excavation considering the influence of bedding angle, discontinuities parameters and rock quality. These variations were determined at the final state when the tunnel without support structures reached a steady state. In order to investigate effects of layered joints on the displacement at the perimeter of tunnel, 3 key points are chosen (see Figure 1).

1

2

3

*β*

Figure 1. Location of measuring points of convergence displacement

3.1. Influence of discontinuities on rock mass behaviour

Two different numerical analyses of isotropic and anisotropic rock mass corresponding to the cases of rock mass without and with discontinuities have been conducted in order to highlight the effect of discontinuities.

…………………

3.2. Influence of dip angle of rock layers

Evidently, the stability of tunnel strongly depends on the dip angle of rock layers. Figure 2 is the convergence displacement at tunnel crown (point 1), which means the vertical displacement after excavation.

…………………

4. Conclusions

In this study, a numerical analysis using the finite element software has been conducted to investigate the effect of dip angle and rock mass quality on the convergence displacement of surrounding rock mass. Some interesting conclusions arising from numerical simulations are given in the following points:

- Excavation of tunnel through initial rock mass without joints causes smaller yielded elements zone than that observed in the cases of stratified rock mass. In addition, the convergence displacement calculated from the anisotropic rock mass with joints are larger than that obtained in isotropic rock mass without joints.

…………………

Acknowledgment

This study was supported by a grant ……

References

Barton, N. (1972). A model study of rock-joint deformation. *International Journal of Rock Mechanics and Mining Sciences*, 9: 579-602.

Barton, N., Bandis, S. Review of predictive capabilities of JRC-JCS model in engineering practice. International Symposium on Rock Joints, Loen 1990, 603-610.

Hoek, E., Diederichs, M.S. (2006). Empirical estimation of rock mass modulus. *International Journal of Rock Mechanics and Mining Sciences*, 43: 203-215.

1. \* Corresponding author. Tel.: +84-987-768-365;Email:nguyenvanbinh@humg.edu.vn [↑](#footnote-ref-1)