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Causes of Overbreak in Tunneling: A case study of the Alborz Tunnel

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CAUSES OF OVERBREAK IN TUNNELING: A CASE STUDY OF THE ALBORZ TUNNEL

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ABSTRACT: Drilling and blasting is widely used in underground excavation projects, where the amount of damage to the surrounding rock mass is crucially important due to its impact on the safety of working environment and operational costs. The causes of overbreak are categorized into three groups namely: geological parametres, drilling accuracy and charging parametres. The present paper focuses on the special case of the Alborz Tunnel of Iran where a discontinuity surface located above the tunnel contour line caused excessive amounts of overbreak in the study area. After introducing the disconformity surface above the tunnel contour line, its impact on the occurrence of excessive amounts of overbreak is discussed. Possible case scenarios for future excavations are pointed outand the problems which may be encountered in each case scenario are predicted. Also, the impact of this special situation on the difficulties faced in working with rock mass classification systems is discussed.

INTRODUCTION

As a result of damage to surrounding rock mass, overbreak can be quantified as the extra cost of additional removal of muckpile and installation of extra support tunnel face with anarea of seventy square metres is located in sandstone. After a sixty-metre length of advance in sandstone, a layer of weak argillite appeared above the tunnel axis having a weak bond with sandstone which led to occurrence of excessive overbreak. Field examination of the sandstone and argillite layers revealed the existence of a disconformity surface just above the tunnel axis which is shown in Figure 1. The estimated argillite thickness above the tunnel axis is between two and three metres based on the drilled holes for rock bolting and penetration speed of the bit. The special case of this cause of overbreak is going to be discussed in this paper.

Figure 1: Location of the Alborz Tunnel

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OVERBREAK OCCURANCE

The main reason for the occurrence of excessive overbreak in the Northern face of the Alborz Tunnel in the study area is due to theexistence of a disconformity surface just above the tunnel contour as depicted in Figure 2. The current excavation face is 635 metres into the tunnel from the Northern portal. However, the occurrence of overbreak which led to discovery of the disconformity surface started from 575 metres into the tunnel from the Northern Portal as shown in Figure 3.

Due to the dip and dip direction of the disconformity surface, the occurrence of overbreak in the start point is almost 1.5 metres above the contour line of the tunnel (Figure 4) and decreases gradually till the point where the disconformity surface reaches the contour line of the tunnel.

Figure 2: Argillite and sandstone layers along with disconformity surface

POSSIBLE SCENARIOS OF CAUSING OVERBREAK AS EXCAVATION ADVANCES

As discussed, the special geological condition namely existence of a disconformity surface above the contour line of the tunnel was the main reason for occurrence of overbreak in the Northern excavation face of the Alborz Tunnel.

The distance of the surface of the disconformity from the contour line (overbreak area) is gradually decreasing with respect to the dip of the disconformity surface. Therefore, the first scenario can be the gradual decrease of overbreak area as the excavation face advances. However, there will be overbreak occurrences till the surface of disconformity reaches the contour line. Then, the main problem will be the existence of a weak layer of argillite in the tunnel crown. Finally, the argillite layer will pass through the contour line to gradually climb down the excavation face till it disappears. The occurrence of overbreak in this possibility is shown in Figure 5. The second scenario is that the argillite layer could be the bottom of a fold which means that the argillite layer is going to gradually increase its distance from the contour line causing a gradual increase of overbreak as the excavation advances. In this case, the exact values of overbreak may occur in reverse order (gradual increase) from the axis of the fold till the argillite layer separates from the contour line by 1.5 metres or more. However, this possibility is very unlikely to happen as there are no joint sets in the argillite layer.

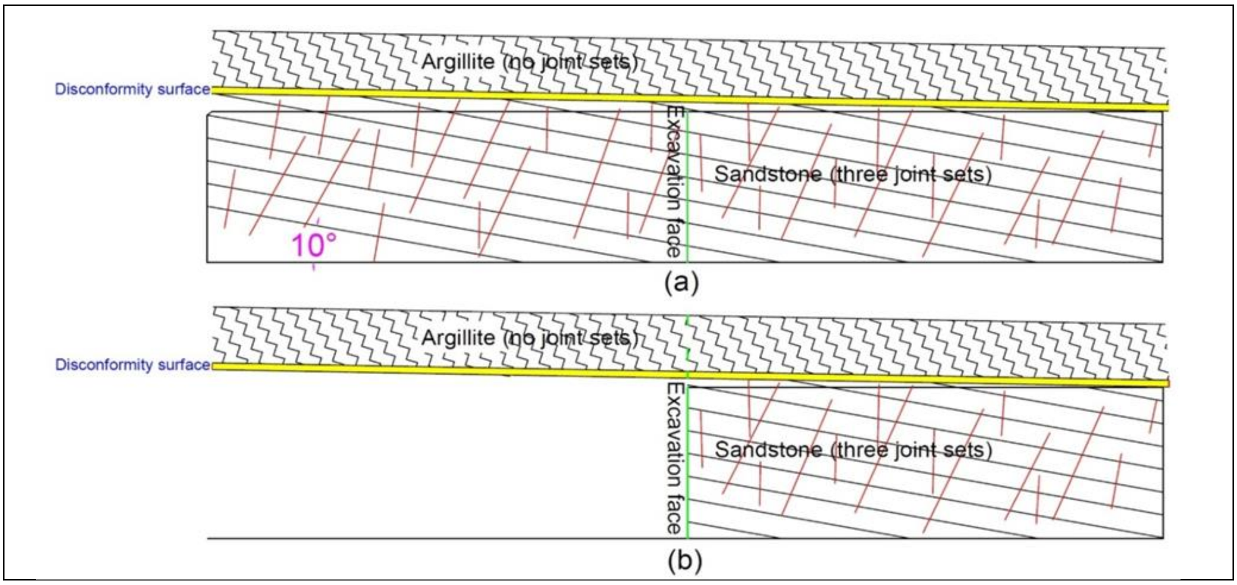

Figure 3: a) Existence of disconformity surface just above the tunnel contour b) Occurrence of excessive overbreak due to existence of disconformity surface above contour line

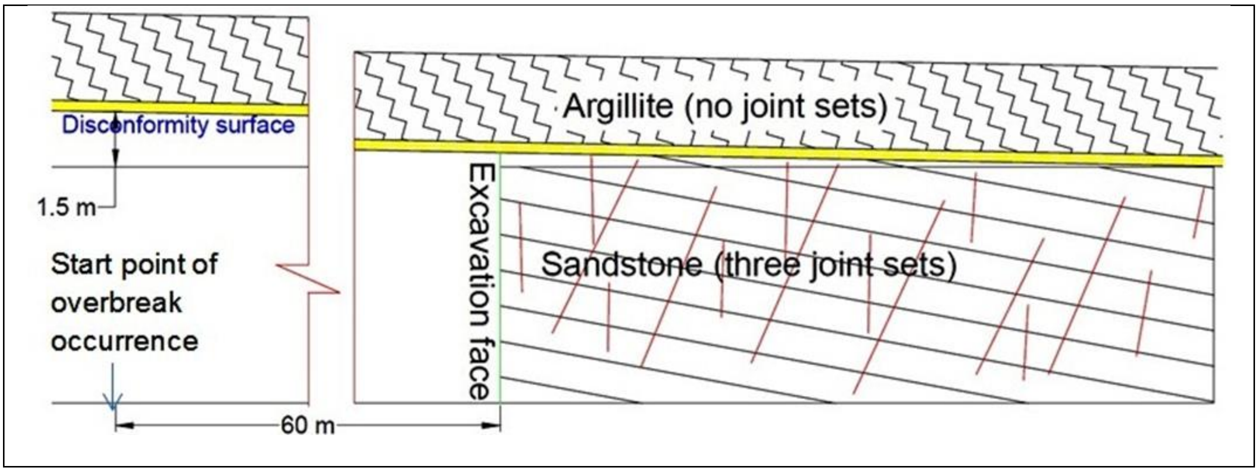

Figure 4: the start point of overbreak occurrence

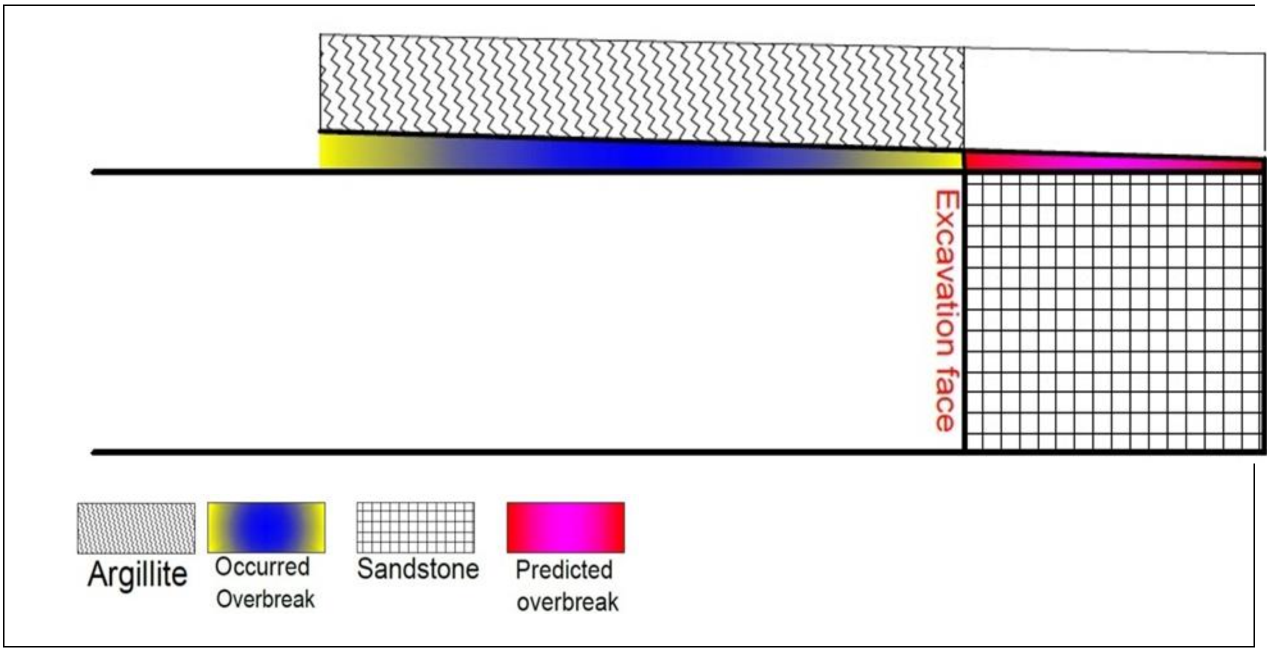

Figure 5: Predicted overbreak in the first case scenario

INCOMPETENCY OF ENGINEERING ROCK CLASSIFICATION SYSTEMS

Incompetency of rock classification systems in the rock formations consisted of alternation of weak and strong layers of rocks is discussed by Gonbadi et al. (2009). They reported the incompetency of the RMR system in the Shemshak formation and proposed a solution based on the modeling results taking the thickness and orientation of weak layers into account. In the study area of this paper, in the distance of 60 metres and more from the excavation face, the tunnel face was situated in the sandstone and before the occurrence of overbreak as shown in Figure 3. At this stage the existence of the weak argillite layer was unknown. Thus, the RMR rock classification was resorted to by the authors. According to RMR classification the surrounding sandstone was found to be classified as fair rock (class III).

Based on this classification system, for a ten-metre span tunnel, the advance in the top heading would be 1.5 to 3 metres. The support system will consist of systematic bolting of 4 metres long bolts, spaced 1.5 to 2 metres in the crown and walls. Wire mesh along with 50 to 100 mm of shotcrete in crown and 30 mm inside would secure the tunnel. No installation of steel sets would be needed (Bieniawski 1989). This combination of the support system was successful in keeping the working environment a safer place. However, the most important feature in this particular case was the excessive amount of overbreak rather than any long term stability problem. No solution to such a problem is offered by classification systems.

CONCLUSIONS

The rate of overbreak occurring in construction of underground structures is one of the most important parametres to be dealt with. The occurrence of overbreak leads to imposing additional costs to the project as well as decreasing the safety of the working environment. An exciting situation was encountered during the excavation of the Northern end of the Alborz Tunnel. The existence of a disconformity surface just above the tunnel contour leading to excessive amounts of overbreak is discussed in this paper and the followings are concluded:

- The existence of a disconformity surface just above the contour line is explored and demonstrated.
- The uncommon behavior of surrounding rock mass was explained by identification of the

disconformity surface.

- The role of the disconformity surface on the occurrence of overbreak and its amount is discussed and predictions are made for the occurrence of overbreak in the future excavations.
- Two possible case scenarios about the occurrence of overbreak are introduced and discussed separately.
- Problems with applying rock mass classification systems in such conditions are highlighted.

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