ISERME 2024 Proceedings
2nd September 2024 – Sapporo, Japan
https://doi.org/10.31705/ISERME.2024.46

Prediction of Overbreak Phenomenon in Tunnel Blasting Using ORF Index

*Sato[1] N, Im[2] H, Nakazawa[1] Y, Jang[3] H, Ohtomo[1] Y and Kawamura[1]Y
[1]*Division of Sustainable Resource Engineering of Engineering, Hokkaido University*
[2]*Western Australian School of Mines: Minerals, Energy and chemical Engineering, Curtin University*
[3]*Principal Engineer, Hanwha Mining Services Australia; Adjunct Senior Researcher, Western Australian School of Mines, Curtin University*
*Corresponding author – Email: sato.naru.i2@elms.hokudai.ac.jp

Abstract

In the drill and blast method, one of the most critical issues is overbreak. Overbreak leads to decreased work efficiency and increased operational costs, and it is recognized as a problem that needs to be addressed. Although several factors contributing to overbreak have been proposed, the specific parameters with the most significant impact are still unclear. However, it is evident that the geological conditions of the rock mass have a significant influence. In this study, the Overbreak Resistance Factor (ORF) was adopted to predict the occurrence of overbreak and to create an indicator for it. As a result, we were able to predict the occurrence and grasp the trends of overbreak. Geological data were collected from a mountain tunnel in Japan, and overbreak data were gathered from the 3D CG model of the tunnel face, which was constructed using Structure from Motion (SfM). Using these datasets, an overbreak prediction model using an Artificial Neural Network (ANN) was developed, and sensitivity analysis was performed to create an overbreak chart based on the influence of different parameters.

Keywords: Tunnel, Overbreak, ANN, SfM, ORF

Abbreviations:

ORF- Overbreak Resistance Factor; SfM- Structure from Motion; ANN- Artificial Neural Network

1. Introduction

Problems caused by overbreak include delays in the construction schedule, increased costs due to additional shotcrete. These issues are carefully considered at all tunnel blasting sites, and reducing overbreak should always be a primary goal [1]. Several parameters are thought to influence the occurrence of overbreak, but their precise roles have not yet been fully elucidated. Overbreak causative factors can be broadly categorized into uncontrollable geological parameters and controllable blasting parameters [2]. The Rock Mass Rating (RMR) evaluates compressive strength, discontinuities, and groundwater inflow. These rock mass conditions suggest an influence on the occurrence of overbreak [3,4]. Jang et al.,The Overbreak Resistance Factor (ORF) is suggested to forecast and control potential overbreak during tunnel blasting operations [5]. In this study, the ORF methodology was used to predict overbreak and visualize its relationship with geological parameters and their impact. This serves as an indicator for considering the optimization of blasting design, providing insight into the trends and types of influential parameters on overbreak at each site.

2. Materials and Methods

Geological parameters were set using the "Face Observation Record" employed in Japanese mountain tunnels. Eight items were adopted in total, including crack attack angles and face conditions. The targets are Tunnel A and Tunnel B. As shown in Figure 1, the measurement of overbreak volume was conducted using a 3D CG model created with SfM. The average

value of each of the three sections, obtained by dividing the face into three parts, was used as the overbreak volume. ANNs were adopted for the creation of multiple prediction models, and the profile method using sensitivity analysis was employed for calculating the impact.

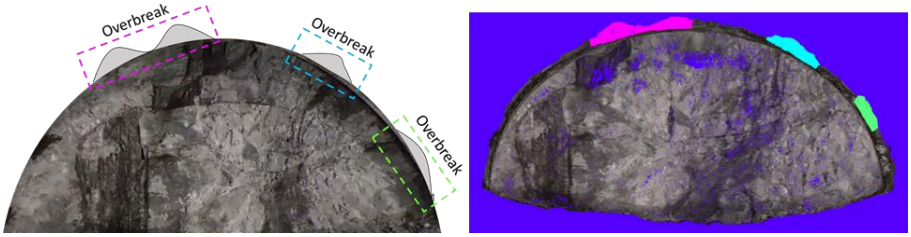

Figure 1 Measurement of overbreak

3. Results and Discussion

In the ANN model, all models showed R-value of 0.7 or higher, with the best models at each site achieving 0.75 or higher. The results of the impact evaluation showed differences in the parameters with high impact between Tunnel A and Tunnel B, and further investigation is needed to assess the accuracy of the impact evaluation. As shown in Figure 2, The creation of ORF charts allowed for the visualization of the occurrence of the overbreak. In cases where the ORF score is low, a higher occurrence of overbreak is observed.

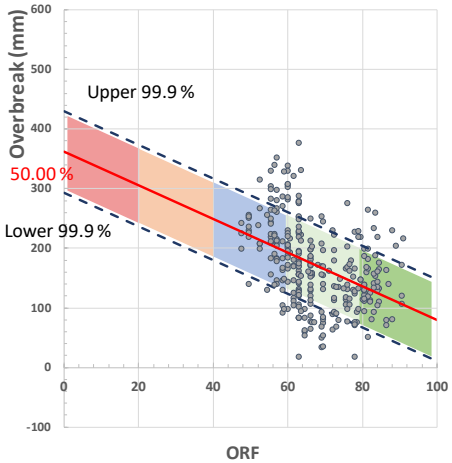

Figure 2 ORF grade chart

References

[1] Maerz, N. H, et al, "Overbreak and underbreak in underground openings Part 1: measurement using the light sectioning method and digital image processing," Geotechnical & Geological Engineering, vol. 14, pp. 307-323, 1996.

[2] Ibarra, J. A, et al, "Overbreak and underbreak in underground openings part 2: causes and implications," Geotechnical & Geological Engineering, vol. 14, pp. 325-340, 1996.

[3] Bieniawski, Z.T, "Engineering Rock Mass Classifications," John Wiley and Sons, 1989.

[4] Koopialipoor, M, et al, "A neuro-genetic predictive model to approximate overbreak induced by drilling and blasting operation in tunnels," Bulletin of Engineering Geology and the Environment, vol. 78, pp. 981-990, 2019.

[5] Jang, H, Kawamura, Y, and Shinji, U, "An empirical approach of overbreak resistance factor for tunnel blasting," Tunnelling and Underground Space Technology, vol. 92, pp. 103060, 2019.