KSCE Journal of Civil Engineering (2022) 26(10):4330-4337
DOI 10.1007/s12205-022-0848-0
pISSN 1226-7988, eISSN 1976-3808
www.springer.com/12205

Case-Based Learning, Prediction, and Prevention of Geohazards

Prediction of Vertical Alignment of the MSP Borehole using Artificial Neural Network

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ARTICLE HISTORY

Received 5 August 2021
Revised 15 December 2021
Accepted 8 June 2022
Published Online 27 August 2022

KEYWORDS

Multi-setting smart-investigation of the ground and pre-large hole boring (MSP)
Vertical sagging
vertical alignment prediction
Artificial neural networks
Peak particle velocity

ABSTRACT

The multi-setting smart-investigation of the ground and pre-large hole boring method (MSP) has been widely used to secure a free face to effectively reduce the peak particle velocity (PPV) at tunnel construction. MSP generally involves drilling a 50-m borehole in the sub-horizontal direction using a 0.9-ton hammer bit at the end of MSP rod. As the borehole length increases, the hammer bit begins to vertically sag as a result of its heavy weight. If the alignment of the borehole diverges from its intended target, borehole reconstruction is inevitable, which leads to extensive time delays and extra costs. Though the borehole height is a crucial factor in determining whether reconstruction is required, there is currently no quantitative method to predict the vertical alignment of the borehole. We gathered 2,630 datasets from 13 tunnel construction sites where MSP had been applied, and developed a prediction model about the borehole height using artificial neural networks. In testing with 25% of those datasets, the mean absolute error was 0.008 m and the coefficient of determination between the measured and predicted values was 0.9998. The prediction model demonstrated good agreement with the actual measurements and can contribute to preventing unnecessary reconstruction events.

1. Introduction

Blasting is the most effective excavation method for tunnel construction due to its efficiency in terms of cost and schedule. However, undesirable side effects, such as blast-induced vibration and noise, often cause environmental conflicts. According to the National Environmental Dispute Resolution Commission (2021), environmental disputes caused by ground vibration and noise at construction sites accounted for approximately 76% of the overall environmental disputes in 2020 in South Korea. Among the undesirable effects, ground vibration can cause damage to neighboring buildings and create dangers to humans and the construction period and costs significantly increase due to ground vibration. Therefore, it is crucial to control the ground vibration to avoid those undesirable results.

A free face is one of the key factors to reduce ground vibrations since it reduces the surplus energy beyond the energy used for rock mass breakage and displacement. Thus, peak particle velocity (PPV), which is the peak velocity of the ground vibration, decreases when the number of free faces increases. Additionally, a free face improves the blasting efficiency since it provides space for broken rocks to move into.

The multi-setting smart-investigation of the ground and pre-large hole boring method (MSP) is one of the method which makes the free face in tunnel. A MSP machine generally excavates a long (50-m) and large (382-mm) horizontal borehole using a 0.9-ton hammer bit. This borehole is generated before the blasting, so it is called the pre-large hole. The pre-large hole effects of reducing PPV and increasing the blasting efficiency have been verified through several previous studies. Lee et al. (2012) demonstrated that pre-large hole blasting is highly efficient in terms of excavation rate and rock fragmentation, when low-vibration explosives are used. Choi et al. (2016) found that the vibration caused by pre-large hole decreased by up to 79.3% compared to the vibration caused by V-cuts in a gneiss area. Kang et al. (2007) applied pre-large hole to generate PPVs within the management standard of 0.3 cm/s and confirmed an excellent vibration reduction effect. Kim et al. (2012) confirmed a vibration reduction of 21.9% – 42% by applying pre-large hole. These studies imply that the pre-large hole is necessary when blasting is performed to

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