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Research Paper

Tracking of horizontal alignment of the long and large diameter uncharged hole in NATM tunnel

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Abstract

The long and large diameter uncharged hole boring (LLB) method is a cut blasting method that minimizes blast-induced vibrations by creating long and large diameter uncharged holes at the excavation face of tunnels prior to tunnel excavation. Drilling in this method typically uses a 50 m long with a 382 mm diameter hammer bit in the horizontal direction at the tunnel face. However, the significant weight and uni-directional rotation of the rod head, as well as variables such as geological characteristics, machine conditions, and inexperienced operators result in significant deviation from the target borehole alignment that hinders the vibration-dampening effect of the uncharged holes. Furthermore, since there is no method to verify the alignment of the boreholes until main tunnel construction, borehole misalignment is often not discovered until weeks after construction, which requires tunnel construction to cease until the equipment can be remobilized and an additional borehole be created, causing significant delays and increased costs for the entire tunnel project. In this study, the borehole alignment tracking and ground exploration system (BGS) is developed to predict and monitor the quality and alignment of boreholes for cut blasting methods such as the LLB methods immediately after boring. The BGS was subsequently tested at a subway construction site to evaluate its performance in the field. The measurements yielded by the BGS were compared with manually measured boring positions at every 5 m along the borehole. Although the BGS showed a maximum deviation of approximately 12% at a local point where the hole surface was relatively rough, the accuracy for the final boring position was approximately 97%, demonstrating excellent precision of the alignment tracking system. The BGS demonstrates excellent performance in predicting ground conditions and the boring quality of a cut hole immediately after drilling, and shows promise in various other applications for monitoring borehole alignment.

Keywords: Tunnel blasting; LLB method; Drilling deviation; Vertical sagging; Horizontal alignment tracking; BGS

1 Introduction

Blasting is used to excavate a rock mass for construction of tunnel structures because of its cost-effectiveness. However, this method has several drawbacks, including blast-induced vibrations and noise (Singh et al., 2016; Gu et al., 2017; Aygar, 2020; Bhagade et al., 2021; Hong et al., 2022). Cut blasting methods have been proven to reduce blast-induced vibrations in tunneling (Xie et al., 2018). In particular, the long and large-diameter uncharged hole boring (LLB) method, referred as multi-setting and smart-investigation of the ground and pre-large hole boring (MSP) method in previous works (Kim & Lee, 2021a, 2022; Kim et al., 2021b), is a cut blasting method that reduces blast-induced vibrations using long and large-diameter uncharged holes. In this method, large-diameter uncharged holes with the diameter of 382 mm are drilled at a tunnel excavation face, and typically drilled at least 50 m in the horizontal direction at a time, considering the mobilization/demobilization time of the LLB machine, which includes many large accessories.

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