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Fundamental Study of the Influences of Discontinuities on Rock Slope Displacement Due to Excavation

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Abstract

In the Higashikagoe limestone quarry, discontinuities are thought to be one of the factors contributing to the deformation of the rock slope. In this study, we investigated the impact of discontinuities and dip angles on slope deformation through numerical simulations, developing four models: a model without any discontinuity and three models with discontinuities of different dip angles. Results showed that discontinuities significantly influence deformation, with forward movement observed in models with discontinuities, aligning with field measurements. This suggests that discontinuities are critical to the deformation of the rock slope in the Higashishikagoe quarry.

Keywords: Mining, Numerical Simulation, Rock Slope, Discontinuities

1. Introduction

In the Higashikagoe limestone quarry in Minamifurano, Japan, continuous deformation of the rock slope has been observed. Previous studies have found that excavatio cause the deformation of these rock slopes [1]. However, one aspect that remains unclear in these studies is the impact of discontinuity on displacement caused by excavation, especially considering the presence of faults in the Higashikanotsu quarry. This study aims to clarify the impact of the presence and dip angles of discontinuity on the displacement of the rock slope.

2. Analytical Methods

As shown in Figure 1(a), we created the following four models for numerical simulation using Finite Difference Method (FDM): a Continuum Model' with no discontinuities, three models incorporating a single, zero-thickness discontinuity with different angles— a 'Vertical Model' with vertically dipping discontinuity, an 'Inward Model' with inward-facing dipped discontinuity, and an 'Outward Model' with outward-facing dipped discontinuity. As shown in Figure 1(b), ten measurement points were placed on the rock slopes to analyze the displacement resulting from excavation. Within these models, excavation analyses were conducted under gravity, and compared each of the displacement results to clarify the impact of discontinuity under different conditions.

3. Results and Discussion

As shown in Figure 2, our results showed that in the Continuum Model, upward (+z) and backward (+x) displacements increased at the slope as excavation progressed. However, in the vertical and Outward models, the increase in upward displacement at the slope above the discontinuity stopped, and forward (-x) displacement increased after the excavation level passed down the discontinuity. In the inward model, downward (-z) and forward displacements above the discontinuity increased after the excavation level passed down the discontinuity.

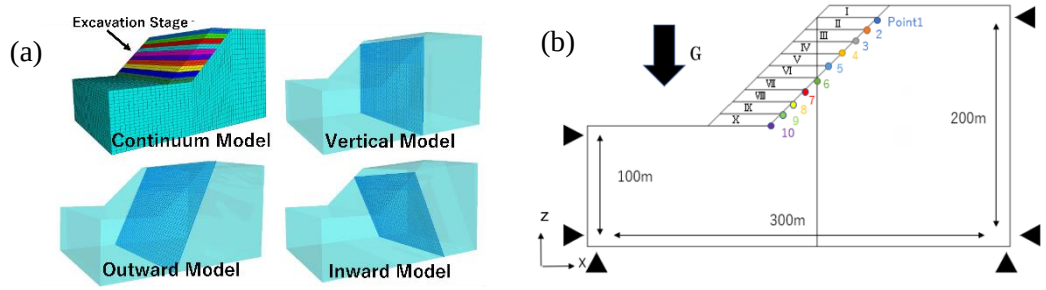

Figure 1 (a) 3D models and (b) Schematic diagram of models

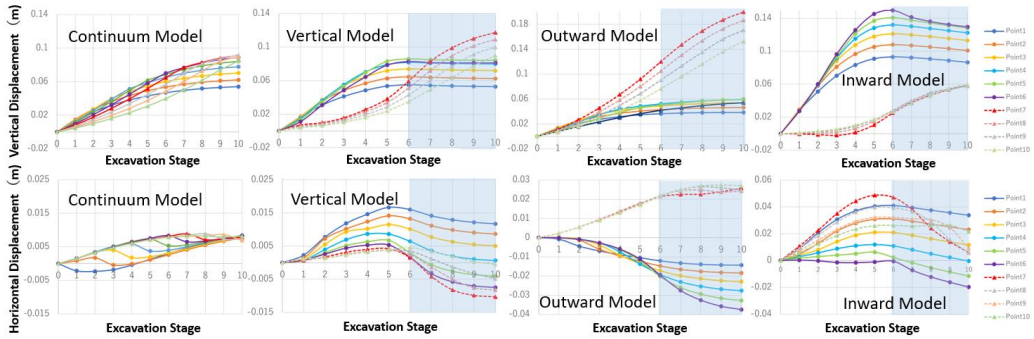

Figure 2 Displacement Analysis Results

Additionally, for comparison with the measured results by the Automated Polar System (APS) at the Higashikagoshi quarry, we calculated the change in distance between Point 5 and the reference point which we placed 300m away from the slope from the analysis results. As shown in Figure 3, the results show that the distance increased with excavation progression in the continuum model. However, in all models with discontinuity, the distance decreased, which is similar to the forward deformation behavior observed in the measurement result. These results suggest that the presence of discontinuities significantly contributes to the deformation of the rock slope.

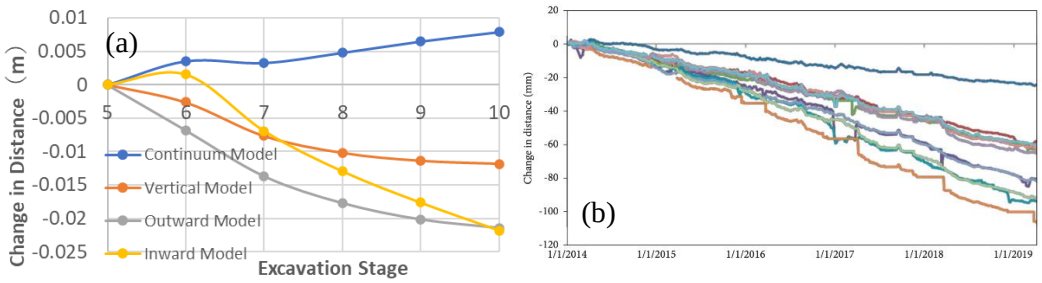

Figure 3 Change in distance (a) Analytical Results (b) Measurement Results

This study elucidated the qualitative effects of the presence and orientation of discontinuities on the deformation behavior of the rock slope, demonstrating similarities with measurement results at the Higashishikagoe limestone quarry.

References

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