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Abduction of Toe-excavation Induced Failure Process from LEM and FDM for a Dip Slope with Rock Anchorage in Taiwan

W.-S. Huang (1), M.-L. Lin (1), H.-C. Liu (2), and H.-H. Lin (2)

(1) National Taiwan University, Department of Civil Engineering, Taipei, Taiwan (mlin@ntu.edu.tw, +886-2-23649254), (2) Central Geological Survey, Ministry of Economic Affairs , Taipei , Taiwan

On April 25, 2010, without rainfall and earthquake triggering a massive landslide (200000 m3) covered a 200m stretch of Taiwan's National Freeway No. 3, killing 4 people, burying three cars and destroying a bridge. The failure mode appears to be a dip-slope type failure occurred on a rock anchorage cut slope. The strike of Tertiary sedimentary strata is northeast-southwest and dip 15° toward southeast. Based on the investigations of Taiwan Geotechnical Society, there are three possible factors contributing to the failure mechanism as follow:(1) By toe-excavation during construction in 1998, the daylight of the sliding layer had induced the strength reduction in the sliding layer. It also caused the loadings of anchors increased rapidly and approached to their ultimate capacity; (2) Although the excavated area had stabilized soon with rock anchors and backfills, the weathering and groundwater infiltration caused the strength reduction of overlying rock mass; (3) The possible corrosion and age of the ground anchors deteriorate the loading capacity of rock anchors.

Considering the strength of sliding layer had reduced from peak to residual strength which was caused by the disturbance of excavation, the limit equilibrium method (LEM) analysis was utilized in the back analysis at first. The results showed the stability condition of slope approached the critical state (F.S.≈1). The efficiency reduction of rock anchors and strength reduction of overlying stratum (sandstone) had been considered in following analysis. The results showed the unstable condition (F.S. <1).

This research also utilized the result of laboratory test, geological strength index(GSI) and finite difference method (FDM, FLAC 5.0) to discuss the failure process with the interaction of disturbance of toe-excavation, weathering of rock mass, groundwater infiltration and efficiency reduction of rock anchors on the stability of slope. The analysis indicated that the incremental load of anchors have similar tendency comparing to the monitoring records in toe-excavation stages. This result showed that the strength of the sliding layer was significantly influenced by toe-excavation. The numerical model which calibrated with monitoring records in excavation stage was then used to discuss the failure process after backfilling. The results showed the interaction of different factors into the failure process.

Keyword: Dip slope failure, rock anchor, LEM, FDM, GSI, back analysis