Failure Investigation of a Geosynthetic-Reinforced Soil Slope Subjected to Heavy Rainfall

by Dr Ng Soon Min

Dr Ng Soon Min is currently a committee member of Geotechnical Engineering Technical Division (GETD).

A webinar titled "Failure Investigation of a Geosynthetic-Reinforced Soil Slope subjected to Heavy Rainfall" was organized by Geotechnical Engineering Technical Division (GETD) on 15th September 2021. The webinar was delivered by Professor Yang Kuo-Hsin from Department of Civil Engineering at the National Taiwan University (NTU) and has attracted 146 participants.

Prof Yang commenced the talk by introducing the background of the failed geosynthetic-reinforced soil (GRS) slope located at Taichung, Taiwan. The 26 m high and 60 m long GRS slope has an inclination angle of approximately 63° was constructed in four-tier and backfilled with low plasticity silty clay with more than 60% fines. The GRS slope first exhibited excessive deformation after typhoons and heavy rainfall from 2010 to 2012. The slope collapsed in 2013 due to two sequential typhoon events with a total accumulated rainfall of more than 600 mm. A compound failure mode was observed where the failure surface partially cut through the reinforced zone and partially passed along the interface between the weathered sandstone and intact shale. The overview of the GRS slope failure is shown in Figure 1.

The speaker then discussed on the conventional limit equilibrium analysis used to back analyzed the failed GRS. It was observed that this approach has some disadvantages such as misinterpretation on the failure mechanism, inaccurate factor of safety and unable to consider drainage in the remedial measures. Hence, the coupled hydro-mechanical finite element analysis that consider the theories of unsaturated soil mechanics was adopted. This approach was able to predict the failure timing accurately and demonstrated good agreement for both the observed and predicted failure surface, deformation and phreatic surface as illustrated in Figure 2.

Prof Yang continued the discussion on the parametric studies conducted to examine the three remedial measures namely soil nail stabilized weathered layer, efficient drainage system and good draining backfill to improve the drainage capacity and slope stability of the GRS slope during rainfall. All the remedial measures were found to be able to enhance the slope stability during rainfall effectively. The results also demonstrated that efficient drainage system and good draining backfill measures can improve the drainage capacity of the GRS slope and this facilitate the pore water pressure dissipation especially at the toe of the slope.

In his closing remark, Prof Yang emphasized that the lesson learnt from this case study is not meant to discourage the application and promotion of GRS structures when granular backfill is not available on site. Instead, it is intended to highlight that when designing a GRS structure with marginal backfill, consideration should be taken on some key aspects such as possible unstable rock slopes, design and construction of the drainage system and evaluation of the slope stability as presented.

Figure 1: Multi-tier reinforced slope failure in Taichung, Taiwan on 1st Sept 2013

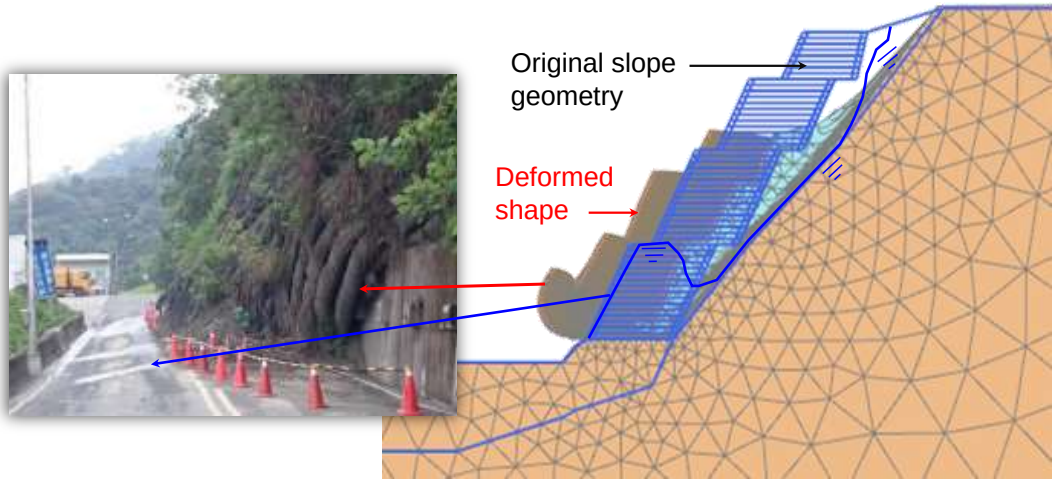

Figure 2: Model validation for deformed mesh and phreatic surface