Case Study: Provo Canyon Substation Cut, 2005

Rebecca Black, Michael Freeman, Lizzy Roper

Background:

In 2005 a project began to reconstruct a five-mile stretch of highway which led up Provo Canyon, connecting US-189 Wildwood to Deer Creek. The existing highway was a 2 lane road, and it was widened to 4 lanes. This project came with many geotechnical challenges due to its location. The highway traverses between a rocky cliff and the Provo River, and runs over a large historic landslide area known as the Hoover Slide. Additionally, the presence of Manning Canyon Shale created problems for the project that were unforeseen in the original design. Manning Canyon Shale has a low friction angle and little to no cohesion for residual strength. For the section of the reconstruction known as the Substation cut, 15-foot soil nails were placed (8 ft. triangular spacing) in order to stabilize the slope. During the construction of the cut, a large region of Manning Canyon shale was discovered. However, because the soil nails were tested and shown to provide adequate pullout resistance, the design was not changed. On Christmas Eve a large portion of the wall failed, causing a need for reconstruction and reevaluation of the slope as well as a lawsuit in the years following the project.

Analysis:

There are several reasons why this failure could have occurred. However, because the substation cut was located outside of the Hoover Slide area, the Hoover Slide was probably not a contributing factor. The failure was likely in part due to the large pocket of Manning Canyon Shale combined with the heavy rainfall in the days prior to the failure. Manning Canyon Shale exhibits drastically different properties when exposed to weathering. It can become highly plastic when wet, which could explain why the slope failed only after a period of heavy rainfall. We performed a UTEXAS analysis of the slope and calculated a factor of safety of 0.757 for this area. The inputs for this were obtained from Clifton Farnsworth, a current BYU professor who worked on the project as a field engineer for UDOT. The cut slope was 1:1.33 H:V and had a maximum height of 100 ft. The soil is approximately 40 ft of silt with gravel and cobbles over very dense sandy gravel and cobbles. Underneath this was the Manning Canyon shale zone. Several assumptions were used in the analysis, including the capacity of the soil nails used. Certainly in the original design an adequate factor of safety was used, but unanticipated actual conditions contributed to the failure of the slope. It is evident that this is a location needing careful engineering to prevent failure.

Conclusion:

To prevent the slope from sliding further or causing more problems for construction, a berm was placed in front of the slope failure as well as through the zone that Manning Canyon Shale was found. To provide a lasting fix for the site the upper portion of the slope was laid back to relieve the loading on that area. Temporary soil nails were used during the removal of the failure zone. A reinforced soil berm was then constructed all along this area to keep a failure of this type from occurring again. Although it was a very unfortunate failure, much was learned about construction in zones of Manning Canyon Shale and about the soil types that are found in the Provo Canyon area. Hopefully this will prevent the extensive cost and time increase that happens when a failure like this occurs during a construction project.

References:

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