Case Study: Xiaolin Landslide, Taiwan Slope Failure

CEEn 544--Seepage and Slope Stability

Jenny Blonquist, Pedro Garcia, and Elise Estep

Overview

In August of 2009, Typhoon Morakot landed in Taiwan bringing approximately 2749 mm (108 inches) of rainfall, breaking all previous records. Typhoon Morakot proved to be one of the worst typhoons Taiwan had ever experienced. This disastrous event resulted in over 600 deaths and approximately US$ 5 billion in damages. The increase in rainfall triggered over a dozen landslides. One of the largest landslides caused by Morakot was at Xiaolin village, located at the base of a mountain, in Kaohsiung, Taiwan. Around 6:16 am, about 1676.5 mm (66 inches) had accumulated. The landslide dammed a nearby river for nearly an hour before being breached and flooding areas downstream. Xiaolin village was completely wiped out. Over 400 people were dead or missing. This case study will closely examine the landslide characteristics, causes, and analysis for the Xiaolin landslide.

Causes and Analysis

While the Xiaolin landslide was primarily triggered by the tremendous amount of precipitation that occurred over a short period of time, the geological characteristics also contributed to failure. After many studies, this was considered a deep-seated landslide. The geologic structure was primarily made up of muddy sandstone (mudstone), shale, and clayey materials with some gravels and sands mixed in. Experiments conducted on the mudstone showed that weathering caused a decrease in shear strength for this material. Studies have also shown that the underlying layers were affected by a flexural slip mechanism on a dip slope. This slip mechanism is believed to have been the sliding surface of the landslide and made up of impermeable material. Weathering also played a significant role in the initiation of the landslide, leaving fractured openings for water to enter the failure surface. The increased water most likely collected at the impermeable layer causing pore water pressure to build up and contributed to the failure. Because the landslide moved so quickly (45-75 mph), it is unlikely the clayey materials had time to drain. Thus, high pore pressure was steady during movement, which decreased the effective stress of the landslide.

Nearby seismic stations recorded a Mw = 4.6 caused the 27 million cubic meters of volume from the landslide. Once the resulting dam created by the landslide was breached, the debris and material wipe out the surround areas. The Xiaolin landslide claimed 465 lives. This brought a lot of media attention and questions about future prevention. A lot of analyses have been conducted using DEM's and other discrete element modeling methods.

References

https://link.springer.com/content/pdf/10.1007%2Fs10346-013-0394-4.pdf

http://web.nchu.edu.tw/pweb/users/feng/research/9712.pdf

https://blogs.agu.org/landslideblog/2009/09/27/photos-and-text-from-a-visit-to-the-shiaolin-landslide-in-taiwan/

A kinematic model of the Hsiaolin landslide calibrated to the morphology of the landslide deposit (Lo. et al 2011)