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CE EN 544 Case Study

The 1979 Abbotsford Landslide Case Study

Overview

In 1979, there was a massive landslide near Dunedin, New Zealand, in Abbotsford, that caused significant damage to both infrastructure and houses in the area. After a few weeks of more subtle movement, catastrophic failure of the slope occurred, carrying roughly 5 million cubic meters of material and destroying 69 houses. Estimated cost of damages totaled roughly NZ $10 million, or $7.5 million USD. Though the slide occurred in the evening, around 9:00PM, no loss of life occurred. Though the geologic nature of the slope and its foundation were the main factors in its failure, various manmade factors accelerated the slope's failure, including a leaky water main uphill of the slide area and a sand quarry at the toe of the slope.

Geologic Background

The foundation directly underneath the slide failure surface is composed of a formation known as the Abbotsford Formation. This formation is about 250 meters thick and is composed of a weak mudstone that is riddled with sand lenses and relatively thin clay montmorillonite layers. On top of the Abbotsford Formation is a thinner, roughly 100 meter thick layer of a weak, non-cohesive sand that has been classified as clayey to silty sand.

Causes of the Slope Failure

There were numerous factors that worked together to cause the Abbotsford Landslide. Perhaps most importantly, the geology and topography of the area were significant contributors to the failure. The weak clay layers were found to be nearly at their residual strength, with φ' values between 5 and 10 degrees. Furthermore, the site was on a dip slope. The weak foundation as described above dipped towards Miller Creek at between 7 and 10 degrees. Interestingly enough, in 1951, a report based on a geological survey by the University of Otago showed that the area was unsuitable for development due to its instability, but that report was either lost or ignored. The development of the area added ended up further contributing to its eventual failure. First, a leaky water main at the head of the slide increased the pore water pressure. This, along with increased rainfall in the area, caused a rise in the groundwater level of the area which further reduced the slope's strength. In addition to the aforementioned issues, there was a sand quarry at the toe of the slope. About 300000 cubic meters of sand had been excavated from the toe area of the slope. Fortunately, the quarry had been closed for about a decade. If it had not, failure could have occurred much earlier.

Stability Analysis

Limit equilibrium analysis was performed on five different cross sections of the slide area. The failure surface was found to be the bedding plane between the Abbotsford Formation and the sand layer above it. Due to the weakness at this plane, the failure surface was not circular, but followed the bedding plane itself due to its significant weakness. The clay layer's shear strength was found to be between 0kPa and 20kPa, showing the weakness of that bedding plane. Furthermore, due to the leaky water main above the slope and the increased rainfall, the bedding plane was submerged by the ground water by between 3 meters and 20 meters, depending on the slope cross-section location. Lastly, the excavation of 300000 cubic meters of sand at the southern toe of the slide area is expected to have lowered the stability of the overall location by 1%, but the excavation in combination with the water table rise would have equaled around a 2-3% decrease in slope stability per 1-meter rise.

Bibliography

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