Hannah Polanco
Amelia Theobald

Case Study: Woodway Landslide, 1997

Background

On January 15, 1997 a landslide occurred in Woodway, Washington (about 20 miles south of Seattle). It consisted of two slides at at 10:30PM, and a smaller, secondary slide at 5:30AM on January 16th. The first slide fell onto the train tracks at the base of the slope. This displaced soil, about 3 feet of debris, created an obstacle for oncoming trains. One such train attempted to pass through the debris which triggered a second pulse, sweeping five freight cars into the water and leaving 20-25 feet of debris on the tracks. The next morning, a smaller slide from the same scarp added to the damage.

Analysis

The main cause of this landslide was the record rainfall during the previous month, what is now called the "Holiday Storm." Higher precipitation always hits the Seattle area in late December/early January, but in the winter of 1996-1997, the 7-day total exceeded 7 inches, saturating the steep slopes that lined Puget Sound more than average. This heavy precipitation period was followed by a particularly dry few days as well, during which the landslide occurred.

The soil in this area is mostly composed of sands and silts laying on top of the Whidbey Formation. According to an engineering geologist from a geology and environmental consulting company, Whidbey Formation is "very compact, contains clay mineralogy, and structural weaknesses. The very compact silt/clay units allow groundwater to perch on top of them causing saturation of the overlying sediments." When combined with heavy rainfall and the presence of the Whidbey Formation, the soil on this slope had very little chance of maintaining its cohesion seeing that very little water could adequately drain through the formation.

We ran a UTEXAS analysis using soil characteristics found in a finite element analysis from the U.S. Geological Survey Bulletin. According to this analysis, the slope factor of safety (0.928) was too low to be considered stable. It also showed a very similar failure pattern when compared to the real failure surface reported by the Landau Associates geotechnical company. The analysis done in the U.S. Geological Survey Bulletin reports that using Bishop's circle will yield a FS of 1.11 for dry conditions; using the finite-element factor method the factor of safety was 1.04. The engineers used different combinations of saturation levels among the different soils to find possible scenarios where the FS would achieve failure (0.928).

The train tracks were cleared, but much of the debris was left in place, now creating a small embankment on the west side of the tracks on top of the continental shelf. The scarp where the slope failed is still visible using Google Earth although the entire slope is now covered in mature vegetation.

Conclusion

The Woodway landslide was heavily affected by rainfall and the geological characteristics of that area. The analysis run on this area showed the soil was not above an acceptable factor of safety, but was not on the verge of failure under dry conditions. However, once the soil was more saturated than it had been in times past, it did fail. The factor of safety of the slope at failure was around 0.928 as found using the UTEXAS software and using Bishop's method as explained in the U.S. Geological Survey Bulletin. The region is currently being monitored for conditions that could incite another slide.

References

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2. U.S. Geological Survey Bulletin https://pubs.usgs.gov/bul/b2180/b2180.pdf
3. Weather Reports http://weather-_warehouse.com/WeatherHistory/PastWeatherData_SeattleTacomaIntlArpt_Seattle_WA_December.html