**Case Study: Slope Stabilization of Trunk Highway 2 in Crookston, Minnesota**

CEEn 544 – Seepage and Slope Stability

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**Background**

A slope between Trunk Highway 2 (TH2) and the Red Lake River in Crookston, Minnesota has failed multiple times in recent years. The most recent slope failure (Sept 2003) damaged several homes and businesses along TH2. Now, the unstable slope threatens to damage TH2 itself, which is a significant arterial road in northern Minnesota. The City of Crookston requested a slope stabilization design which would protect TH2 and other businesses along the river.

**Analysis**

Initial slope stability analyses were performed using UTEXAS to identify the current factor of safety of the slope. Three cross-sections were considered (A, B, and C). The clay was approximately 60 to 80 ft thick with very low shear strengths. The sponsor of this project developed their own slope stability analyses in 2006 using c = 0 and φ = 16° for residual strengths. We made a slight change to this data and used φ = 15°. The piezometric line was estimated based on a linear interpolation between given elevations of the nearby river and elevations of significant pore pressures measured by soil testing (CPT). The failure surface was defined based on where the geologists identified the failure surface from the 2003 failure. Factors of safety obtained from the UTEXAS analyses are summarized in Table 1.

 The team decided to pursue a drilled shaft reinforcement option for stabilizing the slope. L-Pile provided the amount of resistance available in the shaft based on assumed soil displacement values. These values were estimated based on inclinometer data provided by the sponsor. The resistance values were then used as inputs in UTEXAS for post-reinforcement slope stability analyses. The clay material properties remained the same as in the pre-reinforcement slope stability analyses. Post-reinforcement factor of safety values are summarized in Table 1.

**Table 1. Factor of Safety Values for Pre- and Post-Reinforcement**

|  |  |  |  |
| --- | --- | --- | --- |
|  | A | B | C |
| Current Condition | 1.11 | 1.18 | 1.23 |
| Extreme Condition | 1.06 | 1.05 | 1.16 |
| Reinforced Condition | 1.47 | 1.33 | 1.47 |
|  |  |  |  |

**Conclusion**

Based on the analyses performed using UTEXAS and L-Pile, the drilled shaft approach is sufficient for achieving the desired FS = 1.3. The final governing factor of safety was 1.33. This factor of safety corresponds to the extreme condition with a 3 ft. diameter shaft penetrating 75 ft. into the ground from the slope surface.

**References**

Arndt, B. Michael (1977). Stratigraphy of offshore sediment, Lake Agassiz-North Dakota: North Dakota Geological Survey, Report of Investigation No. 60, 58 p.

“Landslide Problem Returns to Crookston”, http://www.valleynewslive.com/story/25555128/landslide-problem-returns-to-crookston (May 19, 2014), accessed October 2014.

Saeed Hosseinian\*, Masoud Cheraghi Seifabad (2013). “Optimization the Distance between Piles in Supporting Structure Using Soil Arching Effect,” Journal of Civil Engineering and Urbanism Volume 3, Issue 6: 386-391.