GEOMORPHIC PROCESSES
15-GEO-504

Laboratory #6: Infinite Slope Analysis of Hillslopes

Purpose:

1. Introduction to the theory, power, and shortcomings of the engineering approach to hillslope stability analysis.

2. Familiarization with the infinite slope analysis technique.

3. Investigation of the influence of hillslope gradient, elevated ground water levels, and surcharging on hillslope stability.

References:

Carson, M.A., and Kirkby, M.J. 1972. *Hillslope Form and Process*. Cambridge: Cambridge University Press. 475p.

Fleming, R.W. 1975. Geologic perspective -- the Cincinnati example. *In* Proceedings of Sixth Ohio Valley Soils Seminar, *Slope Stability and Landslides*. p. 1-22.

Fleming, R.W.; Johnson, A.M.; and Hough, J.E. 1981. Engineering Geology of the Cincinnati Area. in: *Geological Society of America Annual Meeting 1981, Guidebook for Fieldtrips*: 3:543-570.

Discussion:

The infinite slope analysis assumes that the failing mass is of infinite lateral extent and of uniform thickness, and that the failure surface is perfectly planer. Although none of the conditions can be perfectly met in nature, as was mentioned in class, there are several setting in which the infinite slope analysis yields reasonable results. The geometry and nature of local landslides on the Kope Formation are discussed by Fleming (1975) and Fleming *et al* (1981). According to Fleming, failure occurs at the colluvium-bedrock interface. Because of the nature of the colluvial cover developed on the Kope in the local area, the failure mass is of reasonably uniform thickness and the lateral extent of the slide is large in comparison to its depth--making the slides amenable to the infinite slope analysis.

In the infinite slope analysis, it is assumed that the normal and tangential forces on the upslope side and downslope side of an element of the slope are equal. This allows the calculation of the factor of safety (*FS*) based on the consideration of one slope element.

Procedure:

1. In class we derived *FS* for an infinite slope where the height of the ground water table above the failure surface, h_w, was equal to the thickness of the slide mass, *H*. Carefully and completely derive an equation for *FS* as a function of *H*; h_w; slope angle, β; dry unit weight,

γ_d; saturated unit weight, γ_s; cohesion coefficient, *c*; angle of internal friction, ϕ; and surcharge, *q* (a surcharge is a stress that is exerted uniformly over the slope surface). Assume flow lines are parallel to the surface of the slope.

2. Given:

   H = 20 feet

   β = 20°

   γ_d = 90 lbs/ft^3

   γ_s = 130 lbs/ft^3

   c = 100 lbs/ft^2

   ϕ = 25°

   Note: These are reasonable values for residual soils (see Carson and Kirkby, 1972, p. 90-93].

   a. Make a plot of *FS* versus h_w.

   b. At what h_w would expect the slope to fail?

   c. Hold h_w at the critical value calculated above and make a plot of *FS* versus slope angle, β.

   d. Recalculate *FS* for the critical value of h_w calculated above only this time assume a value of q = 1500 pounds per square foot.

Analysis and Question:

1. On what type of slope will the application of a surcharge increase *FS* and on what kinds of slopes will it decrease *FS*?

2. Discuss the assumptions made in the infinite slope analysis and discuss their validity in respect to the local hillslopes.

3. Assume we have a forested hillslope. One acre of the forest is covered with 200 trees weighing one tone each. The roots at the shear plane have a shear strength of 50 psf. Calculate the effect of the roots on slope stability. What other effects might the trees have on slope stability.