Applying Slope Stability - Exercises

Spreadsheet Calculations

- Open MS Excel-based Slope Stability calculator.
- Note that there are three basis slope stability analyses.
- All are very simple, but instructive.
- These are intended for educational purposes ONLY!
- We will work through a series of examples together.

Infinite Slope

Application

- Reasonable for shallow surficial failures.

- Shallow is relative, might apply to cases where a long, continuous translational failure might occur.

- Assumes that surface and groundwater is parallel to failure plane.

Influence of Slope Angle

- Depth of Slide Plane=5 feet
- Water Table Height=0 feet (dry)
- Unit Weight=100 pcf
- Friction Angle=30 degrees
- Cohesion=0
- Other Properties all set to 0.
- Determine FS for Slope Angles of 10, 20, and 30°.
- The steeper the slope, the less stable a slope is.

Influence of Shear Strength

- Slope Angle is 20°.
- Depth of Slide Plane=5 feet
- Water Table Height=0 feet (dry)
- Unit Weight=100 pcf
- Other Properties all set to 0.
- Determine FS for:
  - Friction angle=20°, Cohesion =0 psf
  - Friction angle=20°, Cohesion =100 psf (trace of cohesion)
- A tiny bit of cohesion goes a long way – be careful…

Influence of Water

- Slope Angle is 20°.
- Depth of Slide Plane=5 feet
- Friction Angle=30 degrees
- Cohesion=0
- Unit Weight=100 pcf
- Other Properties all set to 0.
- Determine FS for:
  - Water Table Height=0 feet (dry)
  - Water Table Height=2.5 feet
  - Water Table Height=5 feet (saturated)
- Water has major destabilizing influence on stability (reduced effective stress)

Influence of Water

- Slope Angle is 20°.
- Depth of Slide Plane=5 feet
- Friction Angle=30 degrees
- Cohesion=100 psf
- Unit Weight=100 pcf
- Other Properties all set to 0.
- Determine FS for:
  - Water Table Height=0 feet (dry)
  - Water Table Height=2.5 feet
  - Water Table Height=5 feet (saturated)
- When cohesion is present (if real), less sensitive to changes in water.

Influence of Seismicity

- Slope angle = 20°
- Depth of Slide Plane=5 feet
- Water Table Height=0 feet (dry)
- Unit Weight=100 pcf
- Friction Angle=30 degrees
- Cohesion=0
- Other Properties all set to 0.
- Determine FS for Horizontal accelerations of 0.1, 0.2 g's
- The higher the seismicity, the less stable a slope is.

Influence of Vegetation – Shallow Soils

- Slope angle = 20°
- Depth of Slide Plane=5 feet
- Water Table Height=0 feet (dry)
- Unit Weight=100 pcf
- Friction Angle=30 degrees
- Cohesion=0
- Other Properties all set to 0.
- Determine FS for:
  - Root reinforcement = 160 psf, Tree Surcharge= 120 psf (old growth)
  - Root reinforcement = 160 psf, Tree Surcharge= 0 psf (harvest)
  - Root reinforcement = 0 psf, Tree Surcharge= 0 psf (fallow)
- Roots matter for shallow soils. Surcharge effect of trees may be rather small.

Influence of Vegetation – Deeper Soils

- Slope angle = 20°
- Depth of Slide Plane=25 feet
- Water Table Height=0 feet (dry)
- Unit Weight=100 pcf
- Friction Angle=30 degrees
- Cohesion=0
- Other Properties all set to 0.
- Determine FS for:
  - Root reinforcement = 0 psf, Tree Surcharge= 120 psf (old growth)
  - Root reinforcement = 0 psf, Tree Surcharge= 0 psf (harvest)
- Vegetation makes no mechanical difference for moderately deep slides.

Forensics

- A translational landslide has occurred on 30° slope.
- The depth of failure is approximately 15 feet. Seeps and springs are found 5 feet above the shear plane.
- Unit weight of soil is 100 pcf. The failure occurred after heavy rainfall (drained conditions, c'=0 psf).
- Find the drained friction angle of the soil.

Planar Wedge

Application

- Common for Road Cuts and Fills.
- May be underconservative for gentle slopes.
- Good "rule-of-thumb" for stability.

Stability and Right-of-Way

- Slope Height = 20 feet
- Backslope Angle = 10°
- Water Table Elevation = 10 feet
- Unit Weight=100 pcf
- Friction Angle=30 degrees
- Cohesion=100 psf
- Other Properties all set to 0.
- Determine maximum slope angle for FS=1.3.

Stability and Right-of-Way

- Let's consider a big rainstorm. The slope is now saturated.
- Slope Height = 20 feet
- Backslope Angle = 10°
- Water Table Elevation = 20 feet
- Unit Weight=100 pcf
- Friction Angle=30 degrees
- Cohesion=100 psf
- Other Properties all set to 0.
- Determine maximum slope angle for FS=1.3.

Loading from Heavy Equipment

- Slope Height = 20 feet
- Slope Angle = 45°
- Backslope Angle = 0°
- Water Table Elevation = 20 feet
- Unit Weight=100 pcf
- Friction Angle=30 degrees
- Cohesion=100 psf
- Other Properties all set to 0.
- Equipment weights 50,000 lbs
- Determine FS for:
  - Surcharge clearance of 5, 10, 20, 30, 40 feet
- There is a range of influence for a surcharge. The closer to the slope, the more dangerous.

Method of Slices

Ordinary Method of Slices

- Considers rotational (circular) failure geometry.
- Allows consideration of water, multiple soil types.
- Can use approach to size a rock buttress.

Forensics

- A slope failure occurs in winter months after heavy rainfall.
- The headscarp daylights at approximately 120 feet from the toe.
- Slope height is 50 feet with angle of 30°, backslope angle of 10°.
- Water seeps and springs noted at 15 feet of elevation at slope face.
- Unit weight of soil is 100 pcf. Drained conditions (c'=0 psf).
- Determine the drained friction angle. It is necessary for repair.

Repair

- We need to size a rock buttress for repair.
- Rockfill has unit weight of 130 pcf. It's friction is 45° with no cohesion.
- How wide of a buttress is necessary?
- How many cubic yards of rockfill are required per foot of length of the landslide?

Questions?