Geomorphology

Lecture 2:
Slopes and Slope Processes
Including Mass Wasting

Anthony Newton

Types of Slopes

Slope Processes and Landforms

• Gravity is the main agent
  • mass movement

• Debris will rest until its angle of repose/friction angle is exceeded

• Wide range of scales

Mass Movement

Downhill movement of surface materials (boulders, cobbles, sand, mud, soil, clay) often, but not always, mixed with moisture from rain, flood, snowmelt etc.

Forces acting on a slope
Mohr-Coulomb Failure Criteria

- **Mohr-Coulomb Failure Criteria**
- \( R = cA + W \cos B \tan \phi \)
- \( A = \) block/grain-to-slope contact area
- \( W = \) block/grain weight
- \( B = \) slope angle
- \( c = \) cohesion
- \( \phi = \) friction angle
- \( u = \) uplifting force (water)
- \( v = \) weight of water

Shear Strength

- **Shear Strength**
- Shear strength (sliding resistance) is the resistance to shear
- Reduced by:
  - increased slope angle \( (B \) and \( \phi \))
  - decrease in cohesion \( (c) \)
  - increase weight \( (W) \)
  - add water \( (v \) and \( u) \)

Factor of Safety

- **Factor of Safety**
- Factor of Safety \( (F_S) \) is ratio of resisting forces \( (S) \) and driving forces (shear, \( s) \)
- \( F_S = \frac{S}{s} \)
- When \( s > S \), slope is unstable, \( F_S < 1 \)
- When \( s < S \), slope is stable, \( F_S > 1 \)
- If \( F_S \) close to 1, then slope is poised for failure

Falls/topples

- **Falls/topples**
- Debris sourced from slopes generally > 70-90°
- No water used in transport, but ice often responsible for weakening rock.
- Gravity dominates
- Scree can accumulate at base of free faces

Slides

- **Slides**
- Movement of material as a mass along a discrete surface
  - bedding planes
  - faults
- Water can play an important part, as it lubricates the slip surface \( (v \) and \( u) \)

Translational/Planar slide

- **Translational/Planar slide**
- slide along a a slip surface
Rotational slump/slide

- movement along a plane, but with a curved slip surface
- occur on a variety of scales
- often after heavy rains

Rotational/circular slump/slide

Early Holocene rotational landslide
Svinavatn, northern Iceland

Flows

- often but not always occur on steep slopes
- material flows by internal deformation under own weight
- the more fine particles the further the flow will travel
- often occur when material becomes saturated and exceeds its liquid limit

Earth-flow/Debris-flow

- movement of coarse soil, stones downslope
- water often provides lubrication
- often occur on volcanoes or after earthquakes
Aberfan, Wales, October 1966

- collapse of spoil heap with slope angle of 14°
- occurred after heavy rain
- killed 144 people, including 116 children

Mud-flows

- quicker and more fluid than earth-flows
- flow over low angles
- often in areas of low vegetation cover
- volcanic mudflows - lahars
- Scotland 2005 - closure of A85 etc

Soil/Talus Creep

- slow nearly continuous process on slopes > 6°
- tilted walls, poles, fences
- soil accumulation behind walls
- formation of terraces/terracettes

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Soil/Talus Creep Processes

- main process - wetting and drying or freeze/thaw
- rain splash
- cracks - fill with material from upslope

- Humid temperate rates: 1-2 mm/year
- Humid tropics: 5-10 mm/year

Reduction of Mass Wasting Hazards

- Geomorphological mapping
  - “If slope has failed before, it will fail again”
- Terrain Analysis
  - slopes >20° degrees at particular risk
- Engineering Studies
  - can establish Factor of Safety
- Public Education, Zoning, Land Use
  - keep people from living on unsafe slopes
  - land management