lecture 8 (second half) 11/10/08 and lecture 9 (first half) 11/17/08

Mass Wasting Hazards

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Sources

Chapter 10 - Mass Movements
p, 246-272
also http://myweb.cwpost.liu.edu/vdivener/notes/mass_wasting_22.htm

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Mass Wasting

Mass Wasting causes, on average, about $1.5 billion in damage annually in the U.S. and around 25 deaths.

Downslope Driving Forces vs. Frictional Resisting Forces

The rock of the Earth's crust is covered by a mantle of loose, unconsolidated sediments and soil produced by the weathering of bedrock. ***Gravity*** acting on those loose materials can cause them to move, en masse, down slope - Mass Wasting.

Depending on the slope angle, a portion of the force of gravity is directed down the slope. A portion of the force of gravity presses the sediments against the bedrock and works with friction to prevent downhill sliding.

The steepest slope angle that loose materials can lie on without sliding down is called the ***angle of repose***. The angle of repose varies with the size and shapes of the sediment and also with the water content of the sediment.

Water plays a major role in the stability of slopes. The angle of repose for sand will increase when damp due to ***cohesion*** between the particles resulting from the charge imbalance in water molecules (water molecules attract one another). When saturated, ***pore pressure*** works in opposition to the weight of grain-on-grain, reducing the frictional resisting force.

Factor of Safety

The Factor of Safety is the ratio of frictional resisting force to downslope driving force. A Factor of Safety of 1 is when resisting force equals the driving force. Under that condition the slope is at the angle of repose and mass wasting will occur with small increases in slope moisture. So FS=1 (or less) is ***unstable***.

If the resisting force is greater than the driving force (FS > 1) then the slope is ***stable***, the slope angle is less than the angle of repose.

Slope failure can occur as a result of:

I) Processes that increase shear stress (driving forces)

a) loading the slope (increasing its weight) by
- increasing the water content
- building on it

b) earthquake shaking

c) undercutting (oversteepening) by
- stream erosion
- road or building excavation

d) subsurface collapse
- sinkhole
- mine collapse

II) Processes that decrease the shear strength (frictional resisting forces)

a) increased pore pressure (water pressure in void spaces)
- increasing load of water and saturation
- compaction (from vibration)

b) fissuring - fracturing (frost wedging)

c) dissolution of cements in sedimentary rocks

d) removal of vegetation and roots that hold the soil
- by fire
- by clearing for building

Mitigation: The risk of slope failure can be reduced by:

I) drainage control
- surface channels to prevent infiltration on slope
- covering slope with impermeable barrier (cement)
- subsurface drainage to remove groundwater & reduce pore pressure

II) grading
- cut and fill to reduce slope

III) slope supports
- concrete retaining walls
- gabions (stone-filled wire baskets)
- piles (concrete, steel, or wooden beams driven into the ground)

Landslide Correction - for slopes that already have a history of moving
- drainage, drainage, drainage!
  at the head of the slide and in the water-bearing zone

Warning Systems: landslides and lahars require monitoring via:
- human inspection
- tilt meters
- geophones to measure vibrations
- groundwater monitoring wells

Types of Mass Wasting

- In **flows**, the material behaves as a fluid. It deforms internally
  Soil creep, earthflows, and mudflows are examples.
- In **slides**, the material moves as a solid mass that slips along one or more surface(s).
  Slumps, landslides, and rockslides are examples.
- In **falls**, blocks fall down a cliff face, then typically break up on contact and flow outward.
  Rockfalls.

Flows

earthflow: saturated fine-grained sediments (clay, silt, and fine-sand)
surface may only be partly disturbed
speeds: imperceptible to 10 mph

debris flow: > 50% of particles coarser than sand
saturated sandy/gravelly mix carrying boulders
speeds: 3 to 30 ft/sec

mudflow: > 50% of particles finer than sand
saturated muddy matrix carrying boulders
from stiff mud to muddy water consistency

clay absorbs water
water is a bipolar molecule
water molecules are attracted to the negatively charged surfaces of clay particles

quick-clay structure - "House of Cards"
holds large amount of water
if disturbed, house of cards collapses
squeezes the water, the sediment liquifies

lahars - volcanic mudflows: a mix of water and volcanic ash, often unleashed when volcanic eruption melts snowpack. They rage down the stream valleys carrying logs and boulders along the way.

Slides & Falls

slump (rotational slide): downhill sliding along a curving basal surface
toe of the slump often terminates in earthflow or mudflow
head of slump rotates into the hillslope allowing water to pond, aiding future sliding

rockslide (translational slide): a block of rock slides along bedding or jointing
water is responsible for weathering that allows the block to break free
water pressure often responsible for allowing block to slide (overcome friction)

rockfall: rock breaks loose (weathered loose) along jointing (fractures) and falls down steep cliff

debris avalanche: broken up rock mass, often from a rockfall, flows across valley from base of cliff; may flow up far side of valley

snow avalanche: mass of snow sliding/flowing downslope, burying everything in path

Case Studies
see the notes on the updated (11/26) lecture slides (WebCT)