Mass Movements

GE 4150 – Natural Hazards

http://www.ngi.no/vr2005/eng/big_image/kom850x4.jpg
Mass Movements

• Large volumes of material move downslope under the pull of gravity.
• The mass must overcome:
  – Friction- resistance to motion of a body that keeps it from moving over another body, and
  – Inertia- tendency of a body to remain at rest until external force is applied
Creep

- Slowest moving and most widespread
- Downward movement of soil and bedrock
- Why does soil move:
  - Swelling
  - Expands (clays)
  - Heating from the sun
External Processes

- Addition of high mass material on a slope (sediment deposition, buildings)
- Steeping the slope (due to construction or faulting)
- Removing support from lower portions of the slope (stream erosion)
Internal Causes

- Inherently weak materials such as clays
- Water weakens materials
- Decrease in cohesion
- Geological Structures (previous mass movements)
Weak Materials

• Clay crystals are very small
• Form in sheets
• Strength is lessened by:
  – Water absorbed in the exterior of clays
  – Water absorbed between the sheets
Quick Clays

- Occur in Scandinavia, Eastern Canada, and the Northeast U.S.
- Begin as fine rock flour scoured off the landscape by glaciers and deposited in nearby seas
- Glaciers retreat, isostatic rebound lifts sediment
- Freshwater passes through the clays and can collapse by a jarring event, such as vibrations from construction equipment
Water

- Adds weight, making the mass heavier
- Clays absorb water
- Piping- water flowing underground erodes material, therefore making the ground less stable
- Dissolve content, weakening the mass
- Pore water pressure- pressure builds due to trapped water beneath the surface
- Water tables- as they rise the ground becomes unstable
Vaoint, Italy 1963

- Dam was built in 1960, the reservoir impounded 150 million m$^3$ of water
- Dangers at the site
  - Rocks folded into a syncline
  - Fractures split the rocks apart
  - Slide surfaces were present in the rock from old slides
  - Some rock layers contained layers of clays
  - Limestone was present creating caverns
  - Water rising created elevation pore-water pressures
Vaoint, Italy 1963

- In addition the region had heavy rain raising the water table
- The rain added large weight on the slopes
- On October 9 the south wall of the reservoir failed and killed 3,000 people in 7 minutes. The slide was 1.1 miles long and 1 mile wide and had a volume of 240 million $m^3$. The valley was filled with debris up to 500 feet
- A wall of water entered the village over 230 feet high
Cohesion

- Rocks expand and create fractures increasing the porosity
- Porosity - void spaces in the material
- Reduces strength of the mass causing the mass to move
Geologic Structures

- Ancient slide surfaces - create slick surfaces
- Rock Orientation
- Weaknesses in the rocks
Common Triggers

- Heavy rains
- Earthquakes
- Thawing of frozen ground
- Construction
Types of Mass Movement

• Falls - falls downward from a topographic high
• Sliding - mass slips down and out
• Flowing - mass behaves like a fluid flowing down and out
• Subsidence - downward collapse of the surface
Figure 10.16
Mass-movement speed versus moisture content.
Falls
- Free-fall
- Dominantly vertical downward movement
- Move as separate blocks

Flows
- Flow over landscape
- Move as very viscous fluids
- Turbulence within moving mass

Slides
- Slide on top of basal slip surface that may be planar or curved
- Move as a semisolid mass
- Some preslide coherence maintained within moving mass

Subsides
- Collapse into void
- Dominantly vertical downward movement
- Move as separate blocks
Falls

• Occur when elevated rock masses separate along joints or weaknesses

• Yosemite 1996- 162,000 ton of mass gives way in two separate pieces. Each slide down 540 ft and are launched into the air for a 1640 ft drop reaching a speed of 270 mph before hitting the valley floor
Yosemite

• The mass shattered into a cloud of rock, rolled across the valley and part of the way up the opposite wall before flowing down the canyon
• The falling mass pushed air ahead of it which knocked down over 1000 trees and covered 50 acres with a thin blanket of rock
• One person was killed by the air blast
Slides

- Landslides slide atop a basal surface which may be planar or curved
Flows

• Behave like fluids
• Water content varies between dry and wet
• Velocities range from creep (very slow) to over 200 mph
• Within the moving masses, internal movements dominate and slip surfaces are absent or short lived
La Conchita, Californina

- 1995- 1st a slump occurred moving slow enough for people to move, but destroyed nine houses. 2nd a few days later a debris flow destroyed 5 more homes.
- 2005- 15% of the 95 slide mass remobilized into a highly fluid debris flow traveling 22 mph. The flow overran a retaining wall and moved into La Conchita moving 10 mph, destroying 13 houses, damaging 23 others, and killing 10 people. The flow occurred after 15 days of heavy rains.
Subsidence

- Ground moves downward
- Surface either sags gently or drops catastrophically
- Occurs from the slow compaction of loose water-saturated sediments or the rapid collapse of overlying earth into caves
- Causes: Delta compaction (Louisiana), Groundwater withdrawal (Mexico City), Oil withdrawal (Houston), Long-term subsidence (Venice)
Sinkholes

- Occur in Southeastern U.S.
- Limestone is composed of organic material (shells, skeletons etc) and is formed in shallow warm ocean waters
- As water runs through limestone the organic material is dissolved and caverns are formed
- During drought, water may be removed leaving caverns underground which cannot support the mass above, therefore creating sinkholes
Snow Avalanches

- Also move as creep, fall, slide, and flow
- Speeds up to 230 mph recorded in Japan
- Mass movements initiate when snowfall builds to 0.5-1.5 m, but may not fail until 2-5 m.
- Two types:
  - Loose powder avalanches- low amount of cohesion, fails at a point source, runs downhill, and spreads out laterally
  - Slab avalanches- slabs of cohesive snow break free from their poorly anchored bases. Turn into flows downslope
Mitigation