Beauty and Disaster on the Sea to Sky Highway (Optional but worth it!)

- Saturday, October 27th 8:30 to 5-6ish
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Landslides 2

Connect Assessment

Connect Assessment for landslides closes on Saturday

Goals for Today

1) Define Angle of repose
2) Assess the balance between the strength of the slope and the destabilizing forces acting on it (Factor of Safety)
3) Compare and contrast landslide causes and landslide triggers
4) List and describe several external causes of landslides

Video

Reminder: Why we do this.

http://www.youtube.com/watch?v=YKoMTKsqivE

Mass Movements

Angle of Repose

- Steepest angle a slope can maintain without collapsing
- The exact angle varies depending on material

Image from Wikimedia Commons

Photo: Eric Carlson

Angle of Repose Activity

Stability of Slopes

Forces involved:

Driving Force

- Gravity
- Manifests as Shear stress (τ)
  - "Shearing" is motion from side to side, but across a plane
  - Component of the force of gravity parallel to the slope

Stability of Slopes

Resisting forces

Friction – Resistance to sliding (proportional to normal force/stress)

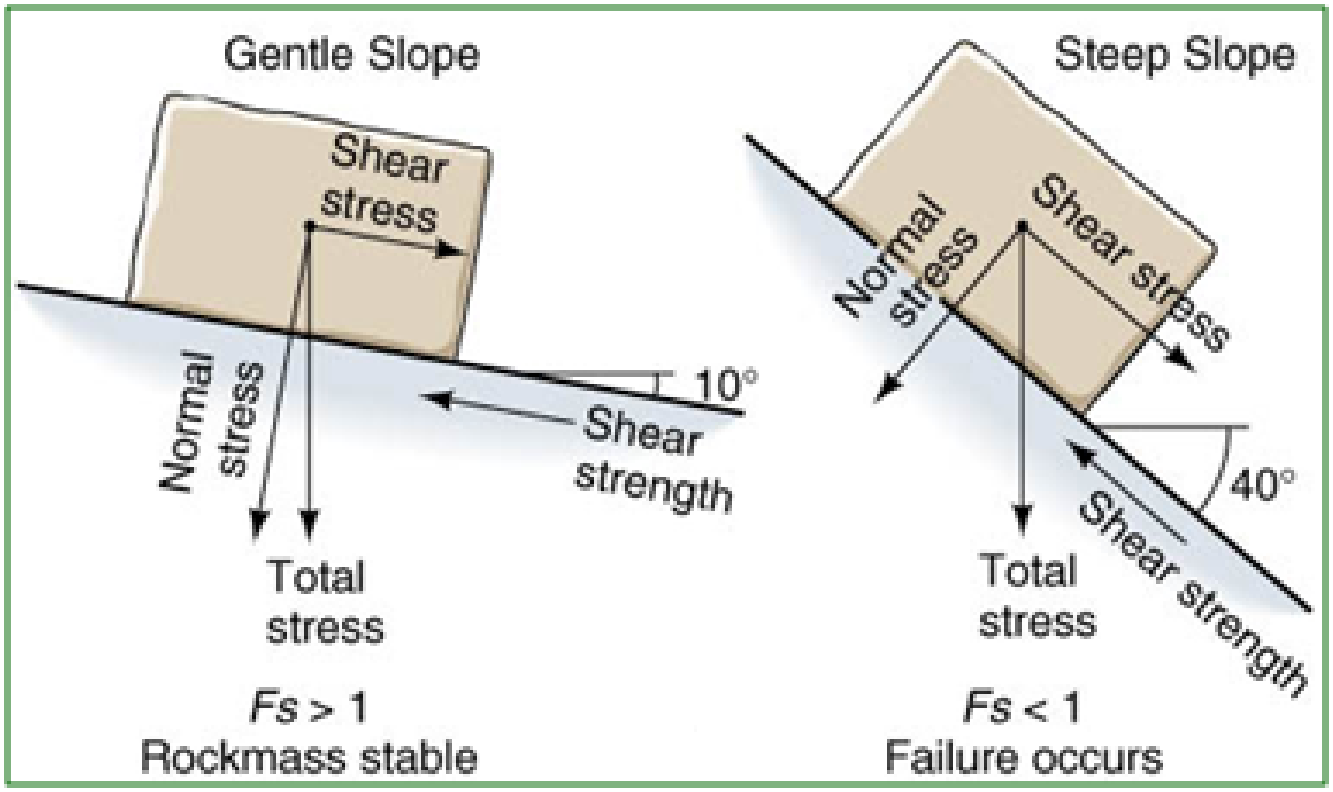
Cohesion – How the material holds together

– These Manifest as Shear strength (τ_f)

- Shear strength is the slope's ability to resist shearing motion

Diagram

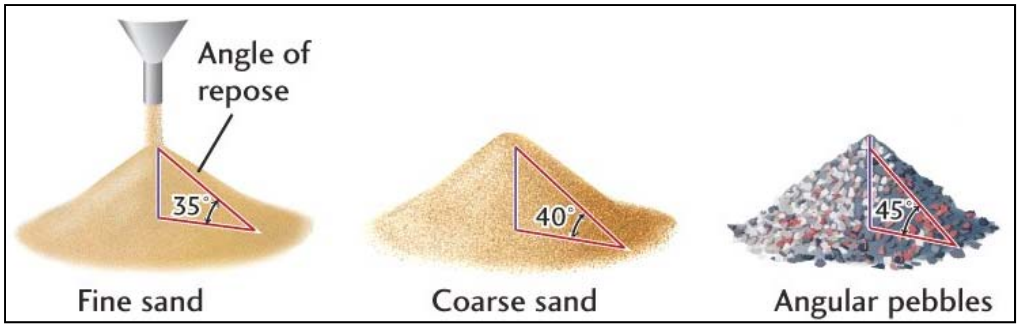
Stability of Slopes



Stability of slopes

Resisting forces prevent slopes from failing

Frictional Strength



Cohesive Strength

Shear Strength: Cohesion & Friction

$$\tau_F = (\sigma \tan \phi + c)$$

Granular Rocks
(Interlocking Grains)

Basalt
Diabase
Gabbro
Marble

Gneiss
Schist

Clastic Rocks
(Grains Cemented Together)

Sandstone
Shale

Sediment
(Unattached Grains)

L.I. hill sediment
L.I. plain sediment

Stability of Slopes

We can model the stability of any slope by comparing

Resisting forces (Shear Strength-τ_f)

to Driving forces (Shear Stress-τ)

If driving forces are greater than resisting - motion can occur

In other words… when shear *strength* is surpassed by shear *stress*

Stability of Slopes

The Factor of Safety (F_s)

the ratio of Shear strength (τ_f resisting forces)

To Shear stress (τ driving forces)

$$F_s = \frac{\tau_f}{\tau}$$

$$F_s = \frac{\tau_f}{\tau}$$

$F_s >> 1.0$ stable slope

$F_s < 1.0$ Fail!

Stability of Slopes

Angle of Repose (better!)

- At the angle of repose Shear Stress is exactly balanced by shear strength
- FoS is equal or just above 1.0

Mass Movements

Cause vs. Trigger

Causes are factors (often long term) leading to instability of a given slope

They reduce the shear strength of a slope

But do not initiate movement

Mass Movements

Triggers are factors (usually short events) that translate instability into motion

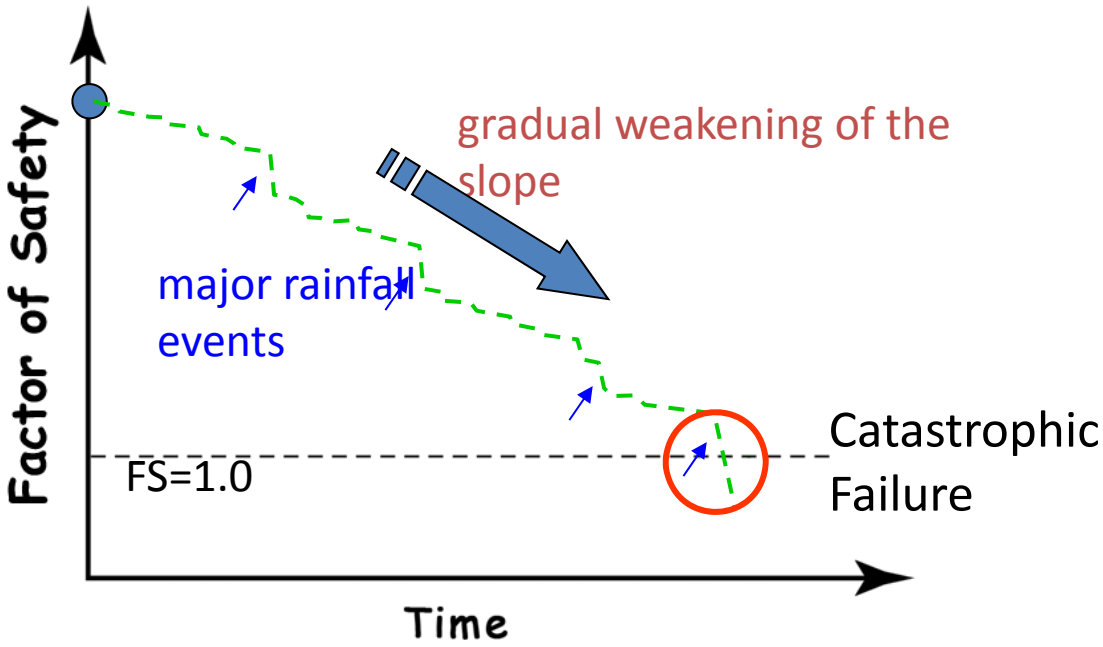
There can be many causes, but only one trigger

Mass Movements

Paper

Landslide Processes

Cause: makes slope susceptible to movement without actually initiating failure.



Trigger: initiates failure.

Mass Movements

Causes of Mass Movement

1) External Causes

- Factors outside of the slope that affect stability

1) External Causes

a) High Slope Angle

- You must have a slope to have mass movement
- Steeper slopes = more movement

1) External Causes

b) Undercutting

- The lower part of the slope is removed
- Removes material supporting the slope
- Caused by roads, rivers, buildings, etc.

Photo USGS

Photo by Flickr user: Earthwatcher

Photo USGS

1) External Causes

c) Overloading

- Adding weight
- Caused by buildings, roads, landslides, trees, me, etc.

Overloading

http://www.youtube.com/watch?v=Nw0aO1zVfkc

~0:30-1:33

b) and c)

Overloading and Undercutting together

Diagram

1) External Causes

d) Vegetation

- Roots bind loose material
- Removal of vegetation can make slopes unstable.


Photo by John Clague

1) External Causes

d) Vegetation

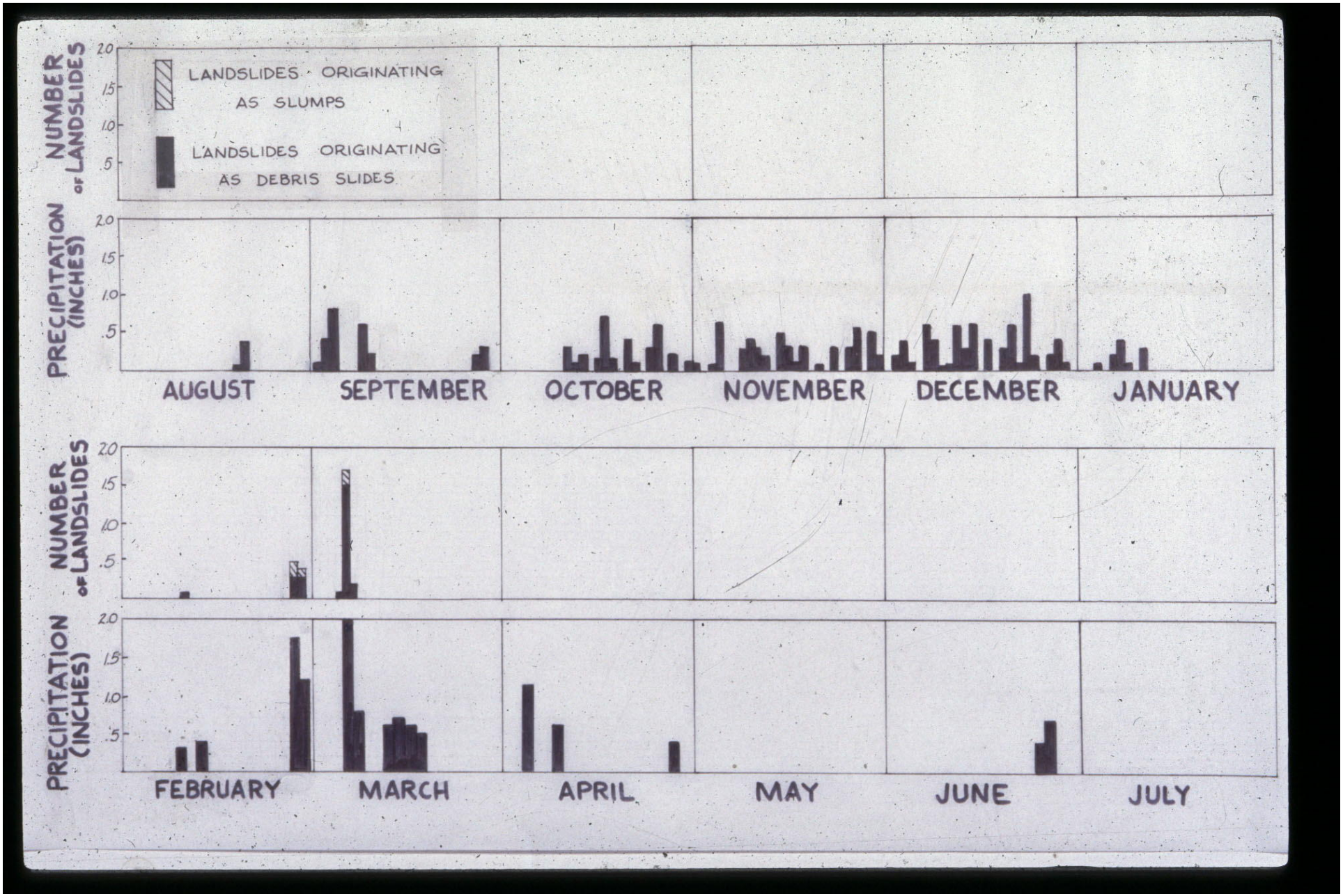
- Heavy trees can increase instability (which is “c) overloading”)

1) External Causes

e) Climate

- If average temperature and rainfall is high
  - More water
  - Increased weathering of rocks
    - more fractures
    - more soil
    - Etc.
- If average temperature is around 0 degrees… see internal causes…

Rainfall in Puget Sound



Video?

http://www.youtube.com/watch?v=KdeFqRBg_nI

Think about this one on your commute home today!

Next Class…

Internal Causes and the Rissa Quick Clay Slide (Awesome!)

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