

Geomorphology 362/598

Homework exercise: Factor of Safety Calculation for slope stability

I REderived this equation in the class notes for the Factor of Safety (FS) for the infinite slope case:

$$FS = \frac{c' + h\vec{g}\cos^2\theta(\rho_b - \rho_w m)\tan\phi}{\rho_b h\vec{g}\sin\theta\cos\theta}$$

where

c' is the (effective) cohesion (as reduced by loss of surface tension)

h is the thickness of the potential slide

\vec{g} is acceleration of gravity

θ is the dip angle of the potential failure plane

$\rho_b = v_r\rho_r + m(1 - v_r)\rho_w$ is the wet bulk density

v_r is the volume fraction of solid material

ρ_w is water density (1000 kg/m³)

ρ_r is rock density

m is the portion of saturated thickness of the slide; $m = 1$ for a fully saturated slide and $m = 0$ for a completely dry slide

ϕ is the angle of internal friction

$$FS > 1 \rightarrow \text{STABLE}; FS < 1 \rightarrow \text{UNSTABLE}; FS = 1 \rightarrow \text{CRITICAL}$$

Using that equation, answer the following. Show your work.

You are a landslide guru and a couple of different projects for estimating slope stability have been contracted to your company. You make the following observations:

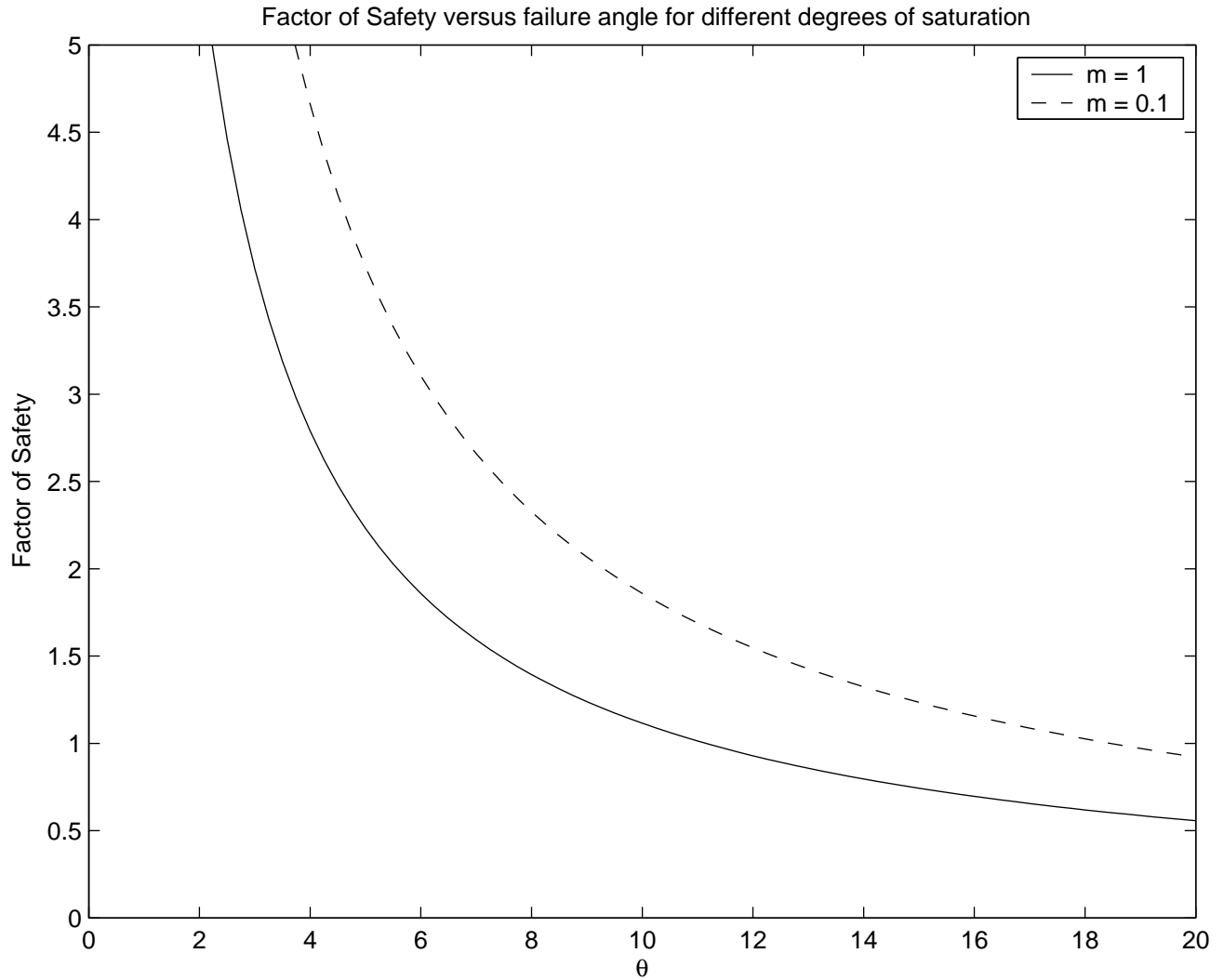
Density of rock in the slope: 2670 kg/m³

Cohesion of material in the slope: 11900 kg s⁻² m⁻²

Angle of internal friction: $\phi = 15^\circ$

Volume fraction of solid material $v_r = 0.6$

1. If a 10 m thick slide mass is 50% saturated above a 17° potential failure surface, is it safe?
2. If the 10 m thick slide mass is unsaturated above a 17° potential failure surface, is it safe?
3. It is impractical to completely dry the above slide out ($m > 0$). What saturation is the maximum to have a safe slide?



The above figure shows a plot of FS versus θ for the general parameters (ρ_r , c' , v_r , and ϕ and slide thickness of 10 m) specified on the previous page given saturations of $m = 1$ and $m = 0.1$. Use this chart for the following 2 questions.

4. If this is in Oregon or Washington where the hill is completely saturated in the winter, what is the maximum stable slope ($FS = 1$) if the thickness of the potential slide mass is 10 m?

5. If the slide is in Arizona where the maximum saturation of the hill is only 10% of the slide thickness (again, $h = 10$ m), what is the maximum stable slope?