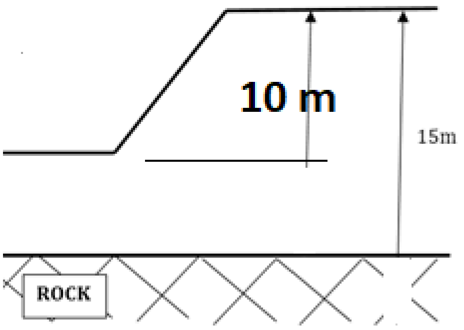
EXAMPLE 1. A saturated clay embankment has a height of 10 m. A rock layer located at a depth of 15m from top of the embankment. The side of embankment make an angle of 35° with the horizontal. Undrained cohesion and unit weight of the soil are 50 kN/m² and 18.62 kN/m³ respectively.

a) Determine factor of safety against sliding.

b) What is the nature of the critical surface?

SOLUTION 1.

homogenous soil type c>0, ϕ=0



a) $Fs = \dfrac{c_u}{\gamma H m}$ or $Fs = \dfrac{c_u}{\gamma H} Ns$ $\quad \left(\dfrac{1}{m} = Ns \right)$

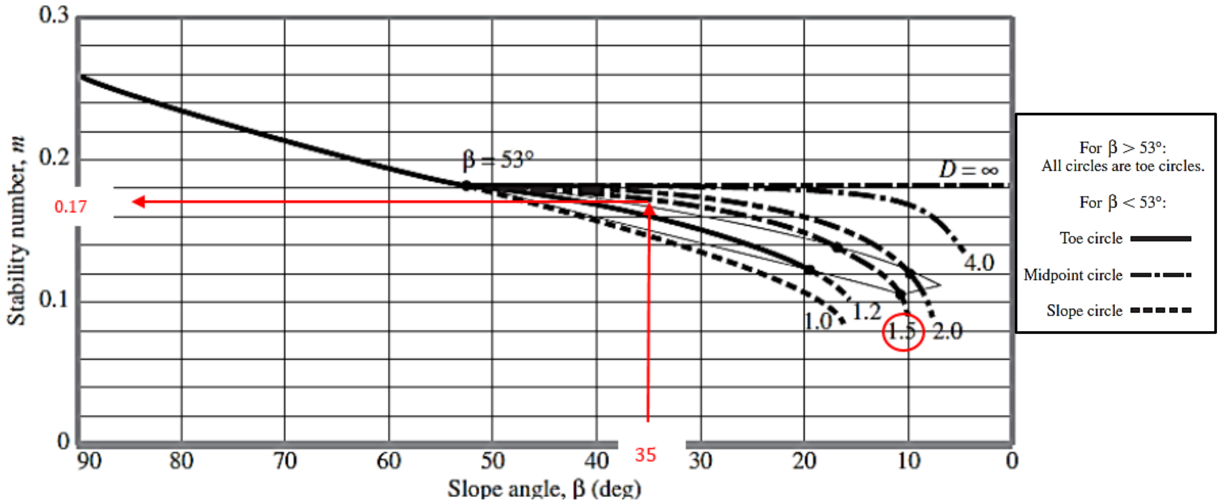
$$cu = 50 kN/m^2$$

$$\gamma = 18.62 kN/m^3$$

$$H = 10m$$

$$D = \frac{H + H'}{H}$$

$$D = \frac{10+5}{10} = 1.5$$

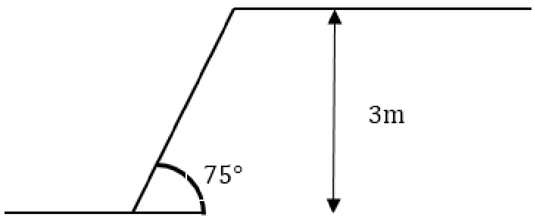


D=1.5 and β=35° from the Taylor's chart; m=0.17

$$Fs = \frac{c_u}{\gamma H m} = \frac{50}{(18.62)(10)(0.179)} = 1.58$$

b) Midpoint circle failure surface.

c) **<u>EXAMPLE 2.</u>**



A cut slope is shown in figure

If unconfined compression strength of the soil is 60kN/m^2 and unit weight of the soil is 17kN/m^3, find the factor of safety of the slope against sliding.

<u>SOLUTION 2.</u>

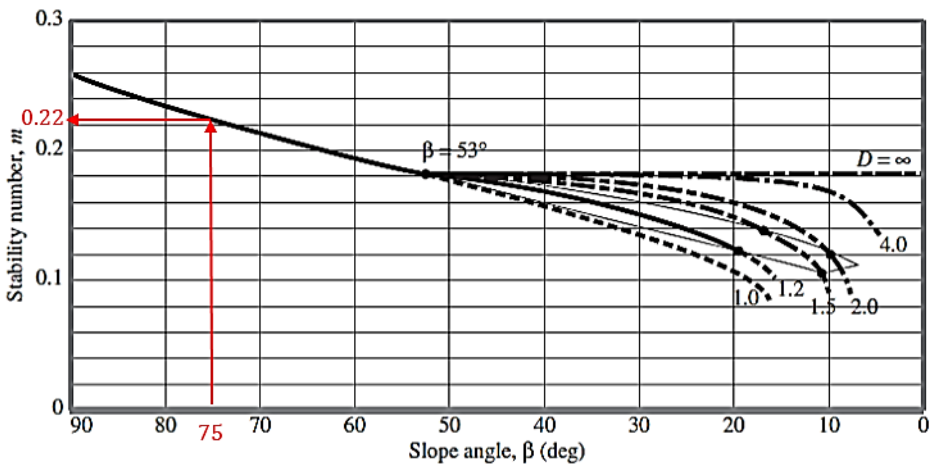
homogenous soil type c>0, ϕ=0

$$q_u = 60kN/m^2$$

$$c_u = \frac{q_u}{2} = 30kN/m^2$$

$$\gamma = 17kN/m^3$$

$$H = 3m$$



β=75° from the Taylor's chart; m=0.22

$$Fs = \frac{c_u}{\gamma H m} = \frac{30}{(17)(3)(0.221)} = 2.66$$

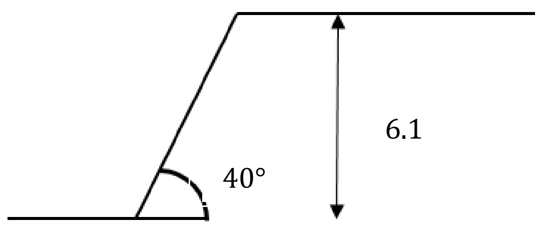
EXAMPLE 3.

A cut slope was excavated in a saturated clay. Slope failed when cut reached 6.1m depth. Rock is very depth in the soil profile.

a) Determine undrained cohesion of the clay.
b) Calculate factor of safety of the slope when slope has 5 m depth and 30.

SOLUTION 3:

homogenous soil type c>0, ϕ=0

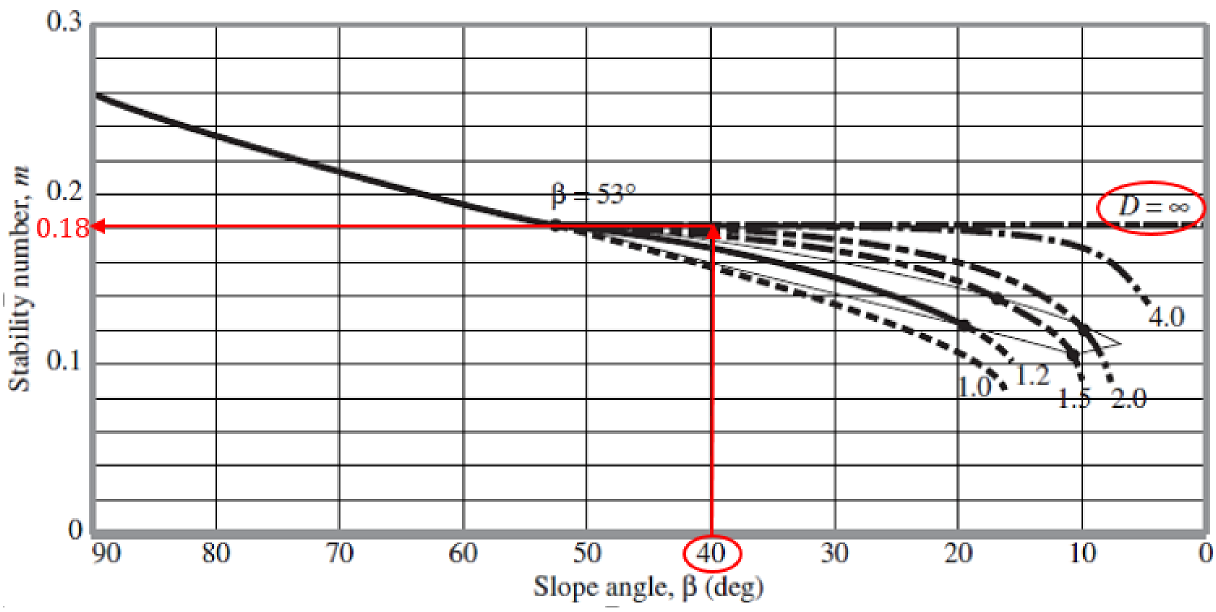


a) If slope failed; FS=1

$\gamma = 17.29 kN / m^3$

$H = 6.1m$

$D = \infty$



D= ∞ and β=40° from the Taylor's chart; m=0.18

$$Fs = \frac{c_u}{\gamma H m}$$

$$1 = \frac{c_u}{(17.29)(6.1)(0.18)} = 2.66$$

$$c_u = 19 kPa$$

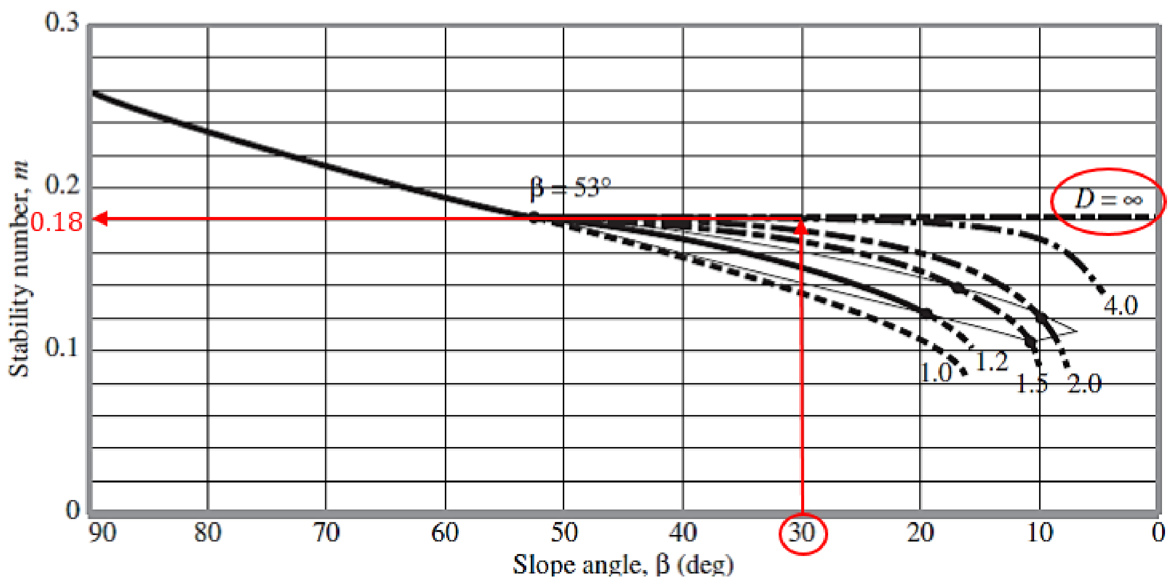
b)

$$c_u = 19 kPa$$

$$\gamma = 17.29 kN/m^3$$

$$H = 5m$$

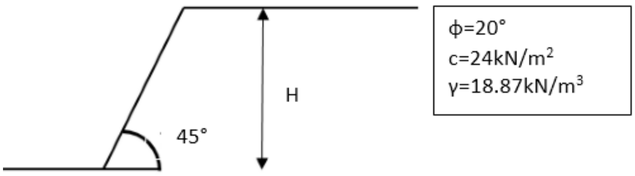
$$D = \infty$$



D= ∞ and β=30° from the Taylor's chart; m=0.18

$$Fs = \frac{c_u}{\gamma H m} = \frac{19}{(17.29)(5)(0.18)} = 1.77$$

EXAMPLE 4.



A cut slope is shown in figure.

a) Determine critical height of slope

b) If H=10m, calculate factor of safety.

SOLUTION 4.

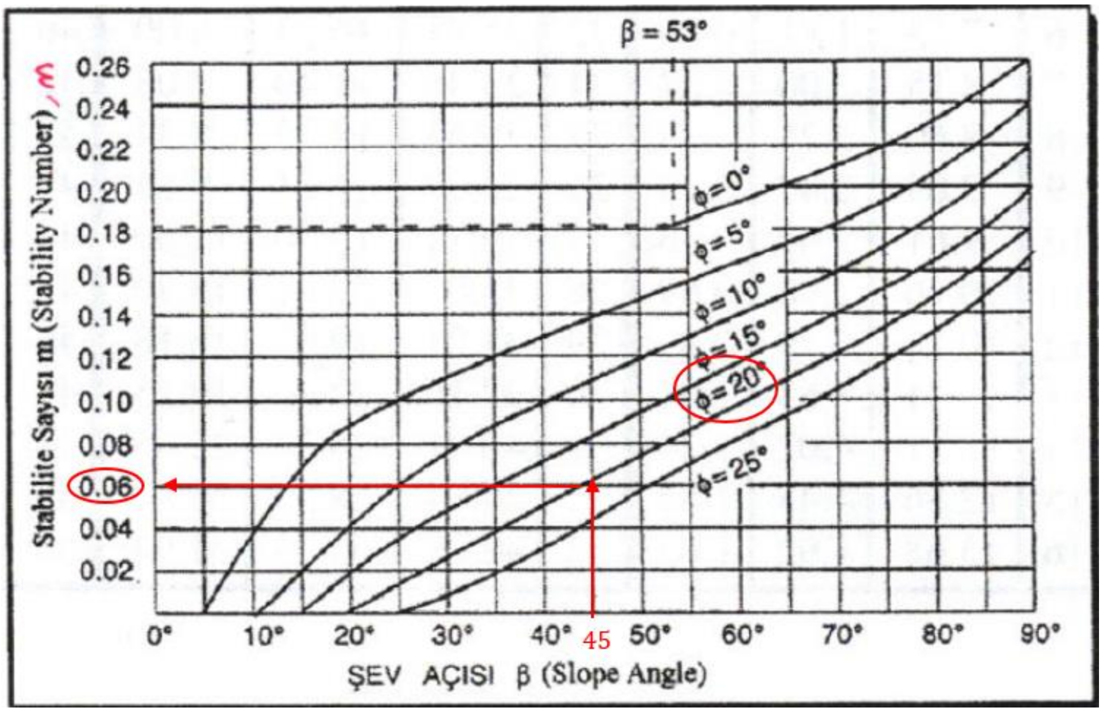
homogenous soil type c>0, ϕ>0

a) $Fs = \dfrac{\tan\phi}{\tan\phi_d}$

FS=1 for critical height

$$FS = \frac{\tan\phi}{\tan\phi_d}$$

$$1 = \frac{\tan 20}{\tan\phi_d} \rightarrow \phi_d = 20°$$



ϕd=20 ° and β=45° from the Taylor's chart; m=0.06

$$FS = \frac{c_u}{\gamma Hm}$$

$$1 = \frac{24}{(18.87)(H_{cr})(0.06)} = 1.77$$

$$H_{cr} = 20.51m$$

b)

$$c = 24kPa$$

$$\varphi = 20°$$

$$\gamma = 18.87kN / m^3$$

$$H = 10m$$

Trial-error

For FS=1.4

$$FS = \frac{\tan\phi}{\tan\phi_d}$$

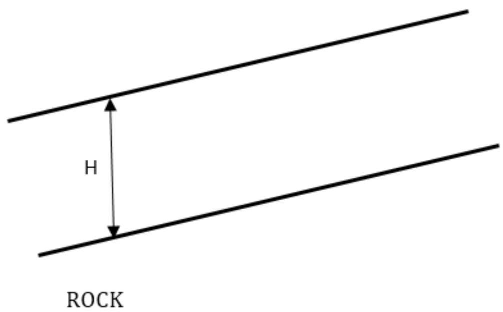
$$1.4 = \frac{\tan 20}{\tan\phi_d} \rightarrow \phi_d = 14.57°$$

ϕd=14.57 ° and β=45° from the Taylor's chart; m=0.09

$$FS = \frac{c_u}{\gamma Hm} = \frac{24}{(18.87)(10)(0.09)} = 1.4$$

Both factor of safety is equal each other. Than the FS is 1.4

EXAMPLE 5.



Refer to figure above.

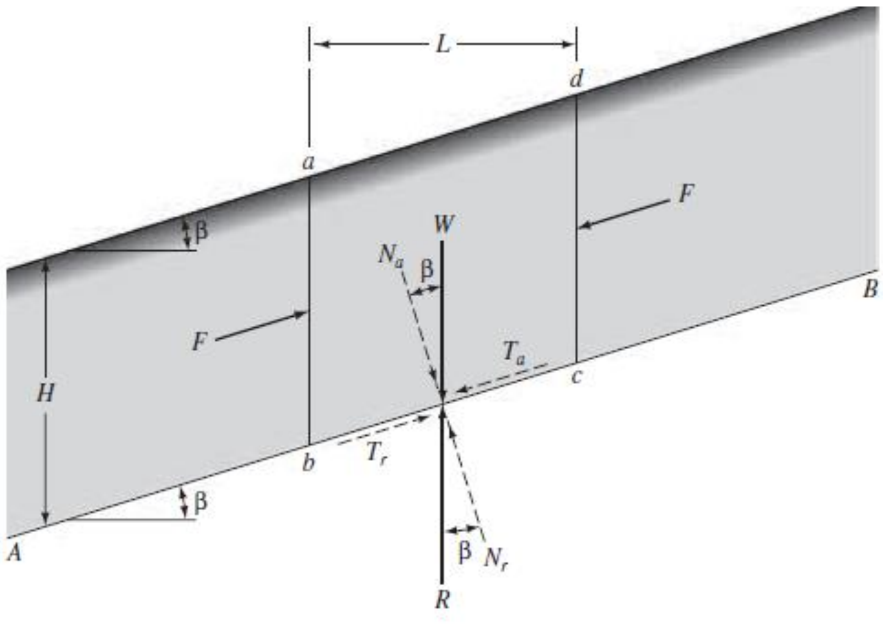
a) For the infinite slope, given γ_{dry} =19 kN/m^3, c=20 kPa, ϕ=25°**.** If H=8m and β=20°, what will be the factor of safety of the slope against sliding?

b) For the infinite slope, given γ_{dry} =19 kN/m^3, c=20 kPa, ϕ=25°**.** If β=30° find the height *H* which will have a factor of safety of 2.5

c) For the infinite slope with **seepage** given γ_{sat}=20 kN/m^3, c'=20 kPa, ϕ'=25°**.** If β=30° find the height *H* which will have a factor of safety of 1.5

d) For the infinite slope, given γ_{dry} =19 kN/m^3, c=0, ϕ=30°**.** If H=9.5m and β=28°, what will be the factor of safety of the slope against sliding?

SOLUTION 5.



a)

$$W = \gamma LH (weight\ of\ \ the\ \ slice)$$
$$W = (19)(L)(8) = 152L\ \ kN\ /\ m$$
$$\sigma = \frac{N_a}{area} = \frac{\gamma LH.\cos\beta}{\frac{L}{\cos\beta}} = \frac{152L\cos^2\beta}{L} = 152\cos^2\beta\ \ (normal\ \ stress\ \ at\ base\ \ of\ \ the\ \ slice)$$
$$\tau = \frac{T_a}{area} = \frac{\gamma LH.\sin\beta}{\frac{L}{\cos\beta}} = \frac{152L\sin\beta\cos\beta}{L} = 152\sin\beta\cos\beta\ \ (shear\ \ stress\ \ at\ \ base\ \ of\ \ the\ \ slice)$$

$$\tau_d = c_d + \sigma\tan\phi_d$$
$$152\sin\beta\cos\beta = c_d + (152\cos^2\beta)\tan\phi_d$$
$$c_d = \frac{c}{FS} = \frac{20}{FS}$$
$$\tan\phi_d = \frac{\tan\phi}{FS} = \frac{\tan 25}{FS}$$
$$152\sin 20\cos 20 = \frac{20}{FS} + (152\cos^2\beta)\frac{\tan 25}{FS}$$
$$FS = 1.69$$

or;

$$FS = \frac{c}{\gamma H\cos^2\beta\tan\beta} + \frac{\tan\phi}{\tan\beta}$$
$$1.5 = \frac{20}{(19)(H)(\cos^2 30)(\tan 30)} + \frac{\tan 25}{\tan 30}$$
$$H = 3.5m$$

b)

$$FS = \frac{c}{\gamma H\cos^2\beta\tan\beta} + \frac{\tan\phi}{\tan\beta}$$
$$1.5 = \frac{20}{(19)(H)(\cos^2 30)(\tan 30)} + \frac{\tan 25}{\tan 30}$$
$$H = 3.5m$$

c)

$$FS = \frac{c'}{\gamma_{sat} H \cos^2 \beta \tan \beta} + \frac{\gamma'}{\gamma_{sat}} . \frac{\tan \phi'}{\tan \beta}$$

$$1.5 = \frac{20}{(20)(H)(\cos^2 30)(\tan 30)} + \frac{(20 - 9.81)}{20} \frac{\tan 25}{\tan 30}$$

$$H = 2.1m$$

d)

$$c = 0$$

$$FS = \frac{\tan \phi}{\tan \beta}$$

$$FS = \frac{\tan 30}{\tan 28}$$

$$H = 1.1m$$