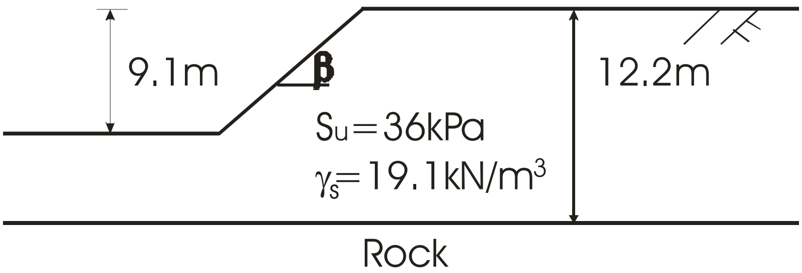
# SOLUTION OF QUESTIONS Q3 –Q5

## Q3




Find the side slope angle β for F=1.4

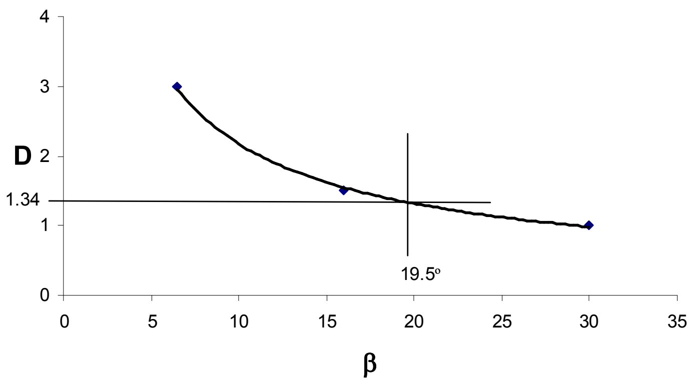
Assume 10% reduction in Su to account for tension cracks:
$S_u^A = 0.9 \times 36 = 32.4\text{kPa}$

Stability Number, $N = \dfrac{S_u}{F\gamma H} = \dfrac{32.4}{1.4 \times 19.1 \times 9.1} = 0.133$

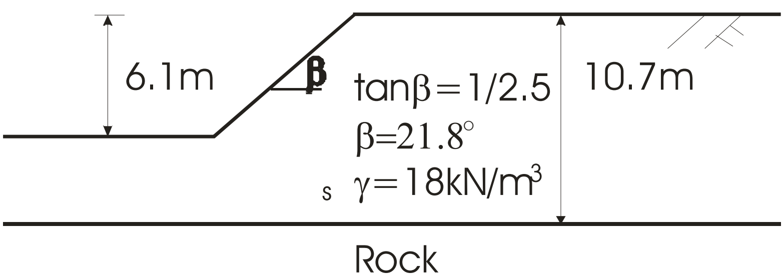
Depth factor $D = \dfrac{12.2}{9.1} = 1.34$

From stability graph:

| N | D | β |
|---|---|---|
| 0.133 | 1 | 30º |
| 0.133 | 1.5 | 16º |
| 0.133 | 3 | 6.5º |



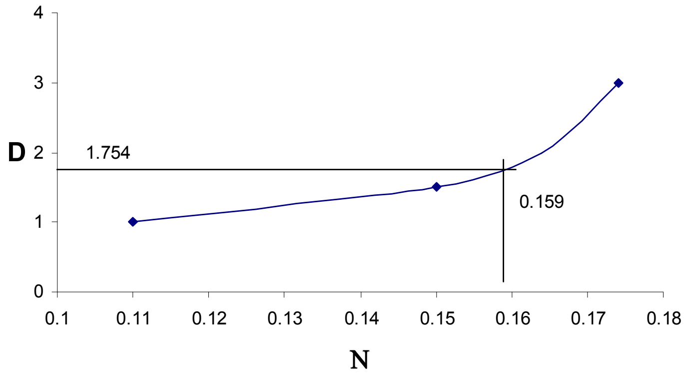

(a) Assuming F=1 calculate Su



$$D = \frac{10.7}{6.1} = 1.754$$

From the stability graph:

| β | D | N |
|---|---|---|
| 21.8° | 1 | 0.11 |
| 21.8° | 1.5 | 0.15 |
| 21.8° | 3 | 0.174 |




$$N = 0.159 = \frac{Su}{18 \times 6.1} \quad Su = 17.4\text{kPa}$$

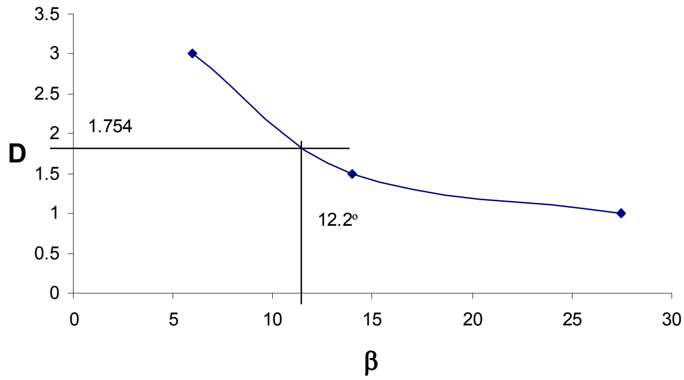
(b) Value of β for F=1.25

$$N = \frac{17.4}{1.25 \times 18 \times 6.1} = 0.1268$$

From the stability graph:

| N | D | β |
|---|---|---|
| 0.1268 | 1 | 27.5° |
| 0.1268 | 1.5 | 14° |
| 0.1268 | 3 | 6.0° |

Hence β=12°




(c) Cutting submerged to original ground level, F=?

When the slope is submerged, stability coefficients may be used if the unit weight is 'adjusted' to reflect the fact that below the external water level submerged unit weight $\gamma'$ applies. Unless the external water level is at, or above, the crest of the slope there will be some degree of approximation involved in this procedure. In this question the water level is at or above crest level, and $\gamma'$ may be used for the unit weight in the full slope

(i)

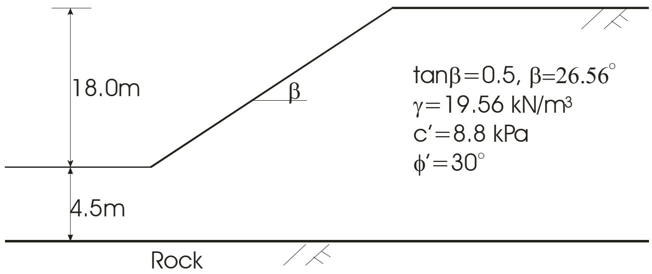
Use submerged unit weight: 18-9.81=8.19

$$F = \frac{S_u}{N\gamma H} = \frac{17.4}{0.1268 \times 8.19 \times 6.1} = 2.75$$

(ii) The answer is the same at the top of the slope or 4 m above. Water above the original water table has no effect on stability as it has no moment about the centre of rotation.

F=2.75

**Q4**




(a) If $r_u = 0.39$ what is F

$N = \dfrac{8.8}{19.56 \times 18} = 0.025$, $\phi' = 30^o$ and $D = \dfrac{18+4.5}{18} = 1.25$, hence values of m and n in table are valid and m=1.956 n=1.915.

$F = 1.956 - 1.915 \times 0.39 = 1.21$

(b)

(i) F=1.4, $r_u = ?$

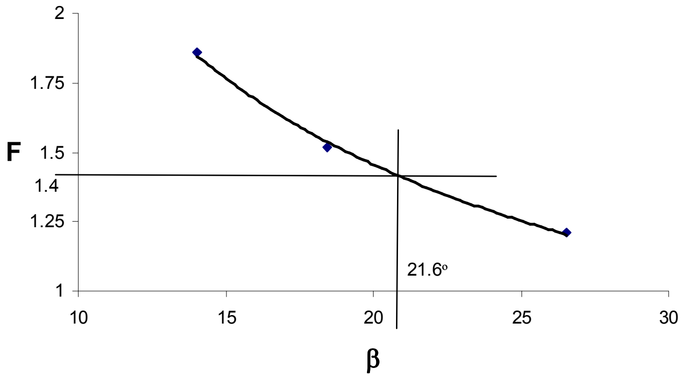
$1.4 = 1.956 - 1.915 \times r_u$

$r_u = 0.29$ (reduced by 0.1)

(ii) F=1.4, $\beta = ?$

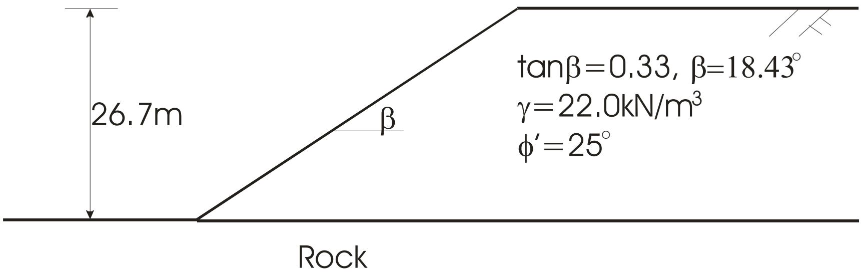
| β | Slope | F |
|---|---|---|
| 26.56° | 2:1 | 1.21 |
| 18.43 ° | 3:1 | 1.5176 |
| 14.04 ° | 4:1 | 1.859 |

So $\beta = 21.6^o$



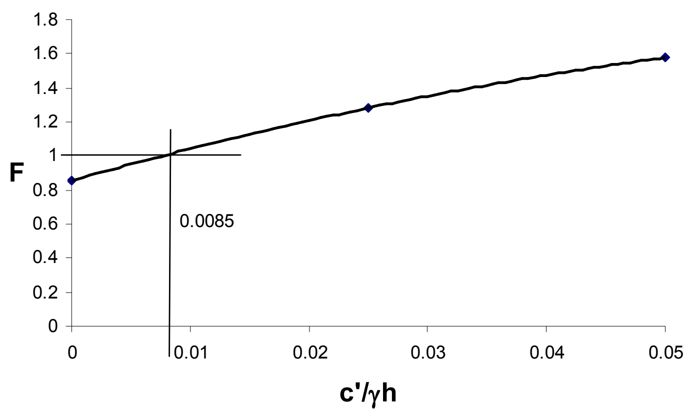
**Q5**

What is c’ if F=1?




$$F = m - n\,r_u$$

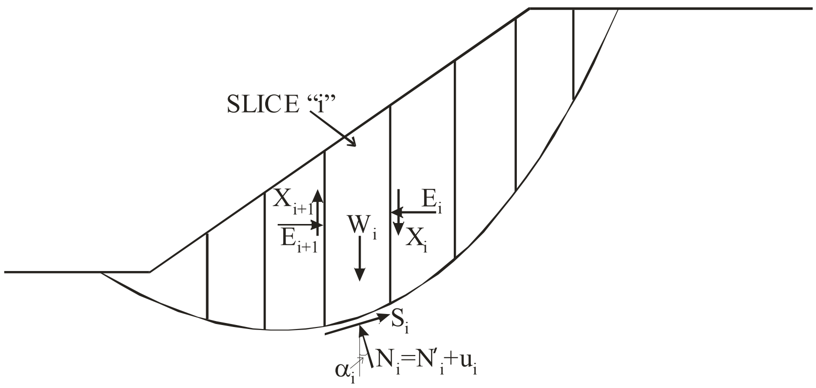
| $\frac{c'}{\gamma H}$ | m | n | $F\ (r_u = 0.35)$ |
|---|---|---|---|
| 0 | 1.399 | 1.554 | 0.8551 |
| 0.025 | 1.845 | 1.696 | 1.2814 |
| 0.05 | 2.193 | 1.757 | 1.578 |




$$\frac{c'}{\gamma H} = 0.0085 \text{ for F=1}$$

Hence $c' = 0.0085 \times 22 \times 26.7 = 5\text{kPa}$

## Q6




The Conventional method assumes that X=E=0.

Resolving parallel to the base of each slice and summing for all slices:

$$\sum_{i=1,n} W_i \sin\alpha_i = \sum_{i=1,n} S_i = \sum_{i=1,n} \frac{c_i L_i + (N_i - U_i)\tan\phi_i}{F}$$

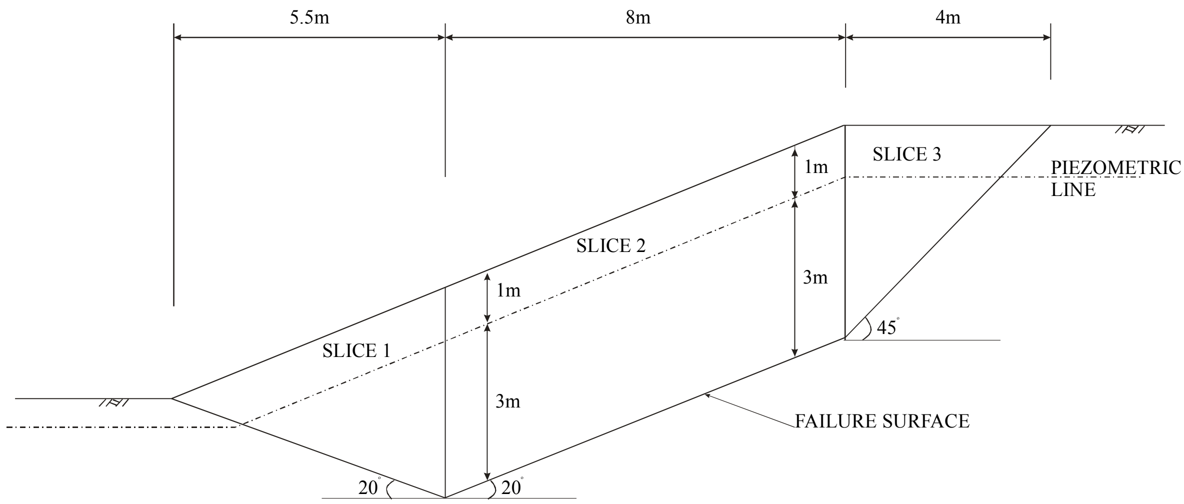
Resolving forces perpendicular to the base of slice "i":

$$W_i \cos\alpha_i = N_i$$

Substituting in previous equation and rearranging gives:

$$F = \frac{\sum_{i=1,n}\left[c_i L_i + \left(W_i \cos\alpha_i - U_i\right)\tan\phi_i\right]}{\sum_{i=1,n} W_i \sin\alpha_i}$$

## Q7



Slice 1:

$\alpha_2 = -20^\circ$

$W_1 = 0.5 \times 4 \times 5.5 \times 20 = 220.0$

$U_1 = 0.5 \times {}^3\!/_4 \times 5.5 \times 3 \times {}^{9.8}\!/_{\cos 20} = 64.52$

$W_1 \sin\alpha_1 = -75.24$

$W_1 \cos\alpha_1 - U_1 = 142.21$

Slice 2:

$\alpha_2 = 20^\circ$

$W_2 = 4 \times 8 \times 20 = 640$

$U_2 = 8 \times 3 \times {}^{9.8}\!/_{\cos 20} = 250.3$

$W_2 \sin\alpha_2 = 218.9$

$W_2 \cos\alpha_2 - U_2 = 351.10$

Slice 3

$\alpha_3 = 45^\circ$

$W_3 = 0.5 \times 4 \times 4 \times 20 = 160.0$

$U_3 = 0.5 \times 3 \times 3 \times {}^{9.8}\!/_{\cos 45} = 62.4$

$W_3 \sin\alpha_3 = 113.1$

$W_3 \cos\alpha_3 - U_3 = 50.7$

$$\tan\phi' = \frac{-75.24 + 218.9 + 113.1}{142.21 + 351.1 + 50.7} = 0.47$$

$\phi' = 25^\circ$