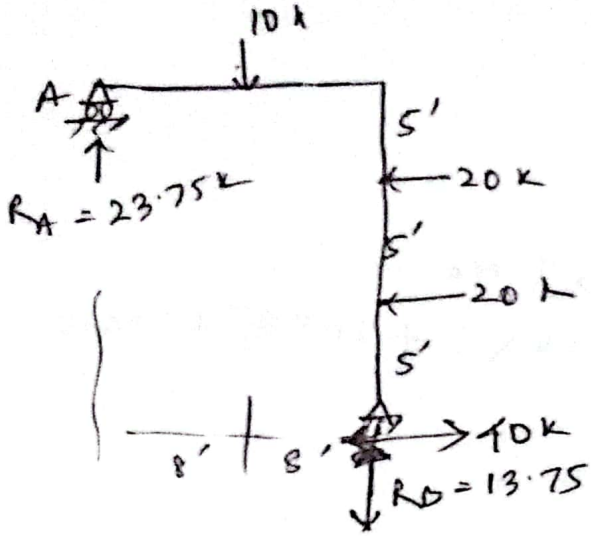
BPDB '24

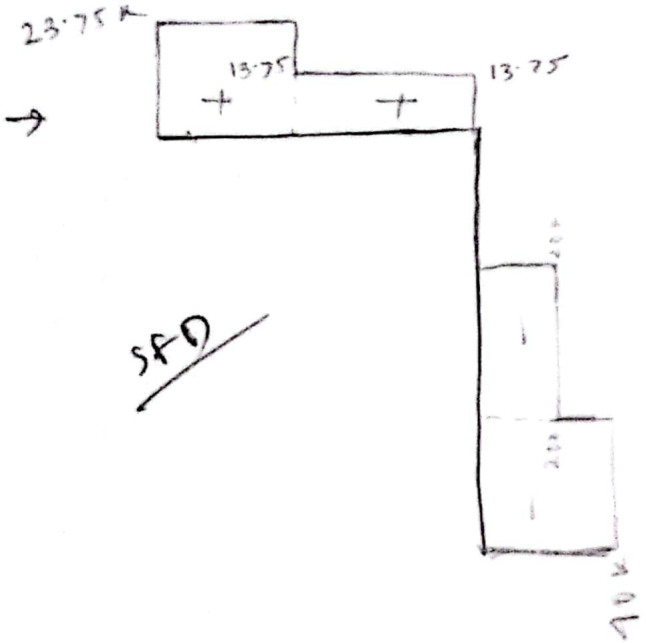
1. Draw shear force and bending moment diagram.

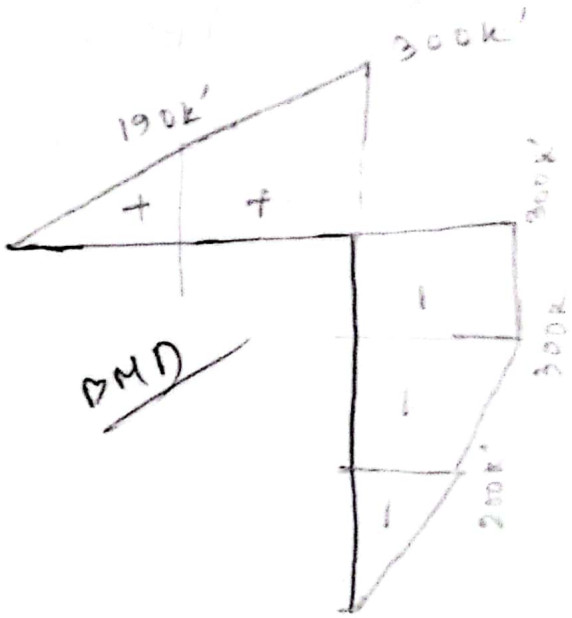


$\rightarrow \Sigma H_D = 0$

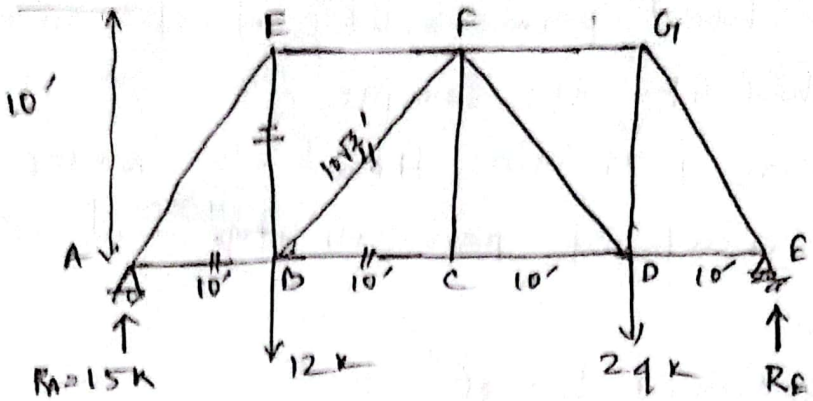
$\Rightarrow R_A \times 16 - 10 \times 8 - 20 \times 10 - 20 \times 5 = 0$

$\Rightarrow R_A = 23.75\ K$





P.2.

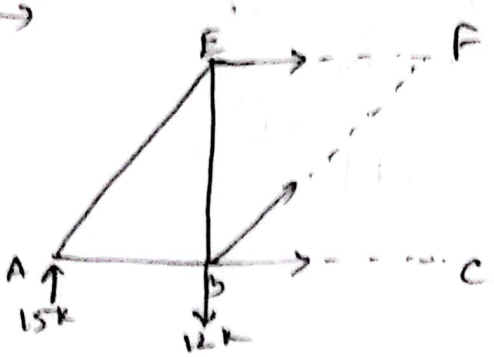


$\Sigma M_A = 0$

$\Rightarrow 12\times10 + 24\times30 - R_E\times40 = 0$

$\Rightarrow R_E = 21\ K.$

$\therefore R_A = 15\ K.$



$\Sigma M_F = 0$

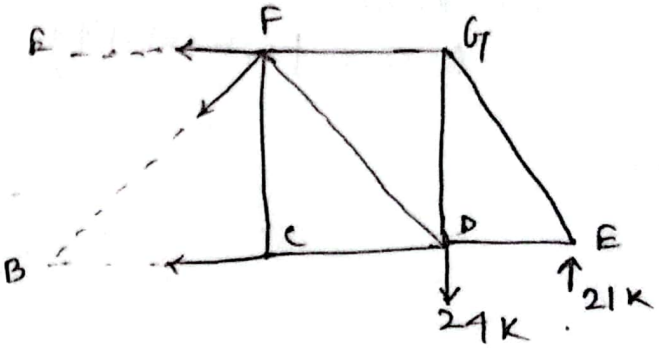
$\Rightarrow 15\times20 - 12\times10 - BC\times10 = 0$

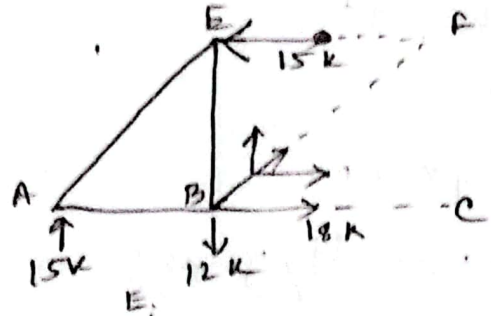
$\Rightarrow \boxed{BC = +18\ K.}$

$\Sigma M_B = 0$

$\Rightarrow 21\times20 - 21\times30 - EF\times10 = 0$

$\Rightarrow \boxed{EF = -15\ K.\ [\text{compression}]}$



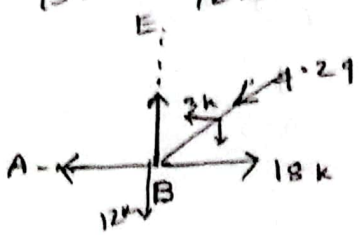


$\Sigma F_X = 0$

$\Rightarrow 18 + BF_X - 15 = 0$

$\Rightarrow BF_X = -3\ k\ [\text{Compression}]$

$\therefore \boxed{BF = -\frac{3\times10\sqrt{2}}{10} = -4.24\ K \text{ Compression}}$



$\Sigma F_K = 0$

$\Rightarrow 18 - 3 - BA = 0$

$\Rightarrow \boxed{BA = 15\ K.}$

$\Sigma F_Y = 0$

$\Rightarrow BE - 12 - \frac{4.24\times10}{10\sqrt{2}} = 0$

$\Rightarrow \boxed{BE = 15\ K}$

P.3. In a static head permeability test sample dia is 4", height of sample 6", vol. of water collected 60 in^3 in 1.75 min. Head of water is 12". find the coefficient of permeability (ft/year) and velocity (ft/sec).

→ Given data,

length of specimen, $L = 6" = 0.5'$

Area of specimen, $A = \frac{\pi}{4}\left(\frac{4}{12}\right)^2 = \frac{\pi/36}{} = 0.087\ ft^2$.

vol. of water collected, $V = 60\ in^3$

$= \frac{5}{144}\ ft^3$.

time, $t = 1.75$ min

$= 105$ s.

Head of water, $h = 12" = 1'$

We know,

Co.eff of Permeability, $K = \frac{VL}{Aht}$

$= \frac{\frac{5}{144} \times 0.5}{\pi/36 \times 1 * 105}$

$= 1.89 \times 10^{-3}\ ft/s$

$= \frac{1.89 \times 10^{-3}}{\frac{1}{365 \times 24 \times 3600}}$

$= 59751.31\ ft/year$.

$\therefore$ Velocity, $v = KI$ $\quad \left| I = \frac{h}{L} = \frac{1'}{0.5'} \right.$

$= 1.89 \times 10^{-3} * \frac{1}{0.5}$

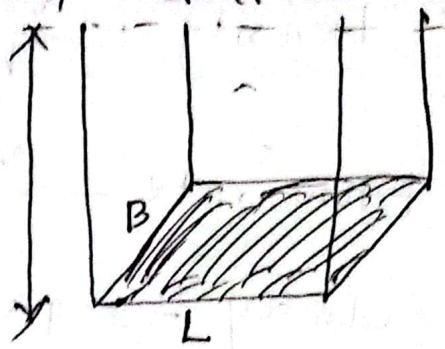
$= 3.78 \times 10^{-3}\ ft/s$ (Ans)

P.4. Sewage influent to a clarifier 2000 m^3/day, surface overflow rate 32 m^3/m^2/day, depth 2.4 m. Width 5 m. find the length and detention time.

→ Here, SOR = 32 m/day.

$$= \frac{32}{24 \times 3600} \text{ m/s}$$

$$= 3.7 \times 10^{-4} \text{ m/s}.$$



Discharge, Q = 2000 m^3/day

$$= \frac{2000}{24 \times 3600} = \frac{5}{216} \text{ m}^3/\text{s}.$$

We know,

$$\text{SOR} = \frac{Q}{BL}$$

$$\Rightarrow 3.7 \times 10^{-4} = \frac{\frac{5}{216}}{L * 5}$$

$$\Rightarrow L = 12.51 \text{ m}.$$

$$\text{Detention time, } t = \frac{\text{volume}}{\text{Discharge}} = \frac{BLH}{Q}$$

$$= \frac{5 \times 12.51 \times 2.4}{5/216}$$

$$= 6485.18 \text{ s}.$$

P.5. Headway of a road is 2.4 s. velocity 60 mile/hr. find density and flow rate.

→ Density = $\frac{\text{vehicle}}{\text{km}}$ [যেখানে 1 km এ কয়টি vehicle]

Flow rate = $\frac{\text{vehicle}}{\text{hr}}$ [1 hr এ কয়টি vehicle যাবে]

Headway = 2.4 s [2.4 s এ একটি vehicle যাবে]

[2.4 s = 1 vehicle
1 — 2.4
∴ 1 hr — $\frac{3600}{2.4}$
= 1500]

∴ flow rate, $q = \frac{3600}{2.4}$

$= 1500 \ \frac{\text{vehicle}}{\text{hr}}$

∴ Density = $\frac{q}{v_s}$ $\left[\frac{\text{vehicle}}{\text{hr}} * \frac{\text{hr}}{\text{km}}\right) = \frac{\text{vehicle}}{\text{km}}$ [$q = v_s \cdot k$] density.

$= \frac{1500}{60 \times 1.61}$

$= 15.53$ vehicle/km.

P.6. pH 7.5 of a water sample. Hardness and alkalinity is 30 mg/L and 250 mg/L. list the ions that will present in the sample and reason behind it.

→ এটি list না করে CO_3^{2-}, HCO_3^- Alkalinity কেন বলতে পারলে।

GTCL'16: same type problem.

[**] The pH 7.5 and $CaCO_3$ alkalinity 332 mg/L. find the value of carbonate and bicarbonate alkalinity and carbonate and bicarbonate concentration.

→ Given. Total alkalinity = 332 mg/L.

$pH = 7.5$; $pOH = 6.5$

$\therefore [H^+] = 10^{-7.5}$ mole/L $\quad [OH^-] = 10^{-6.5}$ mol/L

$= 10^{-7.5} \times 1$ gm/L $\quad = 10^{-6.5} \times 17$ gm/L

$= 10^{-7.5} \times 10^{-3}$ mg/L $\quad = 10^{-6.5} \times 17 \times 10^{-3}$ mg/L

$= 3.16 \times 10^{-11}$ mg/L $\quad = 5.37 \times 10^{-9}$ mg/L

Total Alkalinity = $\left(HCO_3^- + CO_3^{2-} + OH^- - H^+\right)$ as $CaCO_3$

Now,

H^+ Alkalinity as $CaCO_3 = \left(\frac{3.16 \times 10^{-4}}{1} \times 50\right)$ mg/L

$= 1.58 \times 10^{-9}$ mg/L

OH^- alkalinity as $CaCO_3 = \frac{5.37 \times 10^{-9}}{\frac{17}{1}} \times 50$

$= 1.58 \times 10^{-8}$ mg/L

HCO_3^- Alkalinity as $CaCO_3 = \dfrac{50000 * \left\{\frac{A}{50000} + [H^+] - \frac{K_w}{[H^+]}\right\}}{1 + \frac{2K_2}{[H^+]}}$

A = Total alkalinity = 332 mg/L

$[H^+]$ = Concentration = $10^{-7.5}$ mole/L

$K_D = 10^{-14}$, $K_2 = 4.68 \times 10^{-11}$ (Lower value)

$= 331$ mg/L

$\therefore$ CO_3^{2-} Alkalinity $= 332 - (3B1 + 1.58 \times 10^{-8} - 1.58 \times 10^{-9})$

$= 0.994$ mg/L.

Now, for concentration, (mol/L)

$\therefore$ wt of CO_3^{2-} $= \dfrac{CO_3^{2-} \text{ Alkalinity} * \text{Equivalent wt}}{50}$

$= \dfrac{0.994 * 60/2}{50}$ mg/L

$= 0.5964$ mg/L

1 mol CO_3^{2-} = 60 gm

60 x 10^3 mg = 1 mol

1 mg = $\frac{1}{60 \times 10^3}$ mol

$\therefore 0.5964 = \frac{0.5964}{60 \times 10^3}$ mole/L

Concentration $= 9.94 \times 10^{-6}$ mole/L.

$\therefore$ HCO_3^- Concentration $= \left(\dfrac{331 * \frac{61}{1}}{50}\right)$ mg/L

$= 403.82 * \dfrac{1}{61 \times 10^3}$

$= 6.62 \times 10^{-3}$ mole/L.

P.7. * CBR problem :- (BPDB '24)

$$CBR = \frac{\text{Pressure sustained by the specimen at 2.5 mm or 5 mm penetration}}{\text{pressure sustained by the std. specimen at same penetration.}} \times 100$$

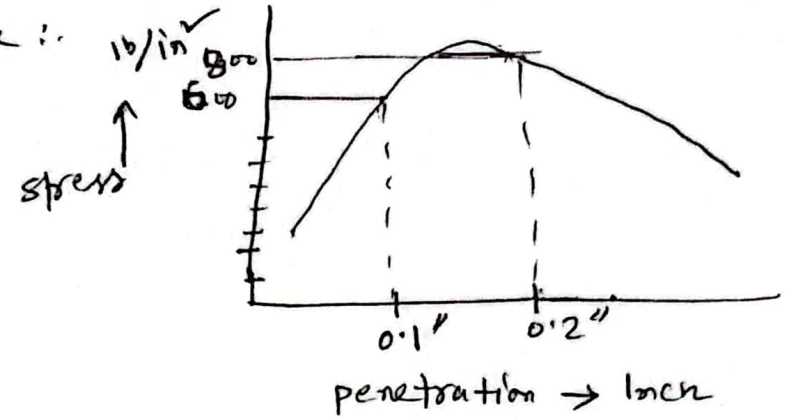
for 2.5 mm penetration std. stress = 70 kg/cm² = 996 lb/in²

5 mm " " " = 105 kg/cm² = 1494 lb/in²

Graph Value :-

2.5 mm = 0.1"

5 mm = 0.2"



Value exact করতে হবে,

from graph. for 0.1" penetration, ~~stress = 1200 lb/in² = 110 kg/cm²~~

$$CBR = \frac{600}{996} \times 100 = 60\%$$

for 0.2" penetration, $CBR = \frac{800}{1496} \times 100 = 53.55\%$

So, selected CBR = 60%.

Calculate the factor of safety against shear failure along the slip circle shown in Fig. Ex. 10.6 Assume cohesion = 40 kN/m², angle of internal friction = zero and the total unit weight of the soil = 20.0 kN/m³.

Solution

Draw the given slope *ABCD* as shown in Fig. Ex. 10.6. To locate the center of rotation, extend the bisector of line *BC* to cut the vertical line drawn from *C* at point *O*. With *O* as center and *OC* as radius, draw the desired slip circle.

Radius $OC = R = 36.5$ m, Area $BECFB = \frac{2}{3} \times EF \times BC$

$$= \frac{2}{3} \times 4 \times 32.5 = 86.7 \text{ m}^2$$

Therefore $W = 86.7 \times 1 \times 20 = 1734$ kN

W acts through point G which may be taken as the middle of FE.

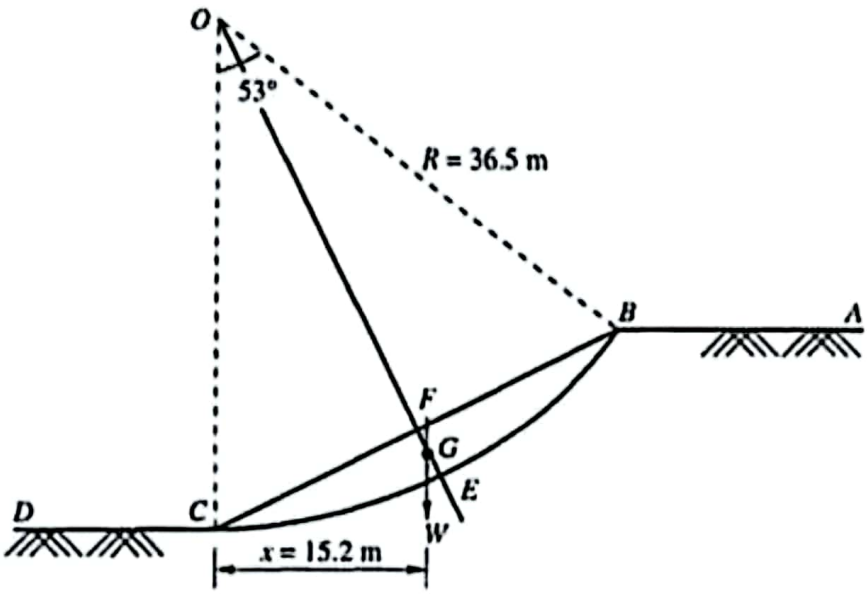


Figure. Ex. 10.6

From the figure we have, $x = 15.2$ m, and $\theta = 53°$

Length of arc $BEC = R\theta = 36.5 \times 53° \times \frac{3.14}{180} = 33.8$ m

$$F_s = \frac{\text{length of arc} \times \text{cohesion} \times \text{radius}}{W \times} = \frac{33.8 \times 40 \times 36.5}{1734 \times 15.2} = 1.87$$