253

1(a)

$l_{eff} = 5.5\,m$

$A_{total} = 6293 \times 2 + 500 \times 16 \Rightarrow 20586\,mm^2$

$$\bar{y}_t = \frac{6293 \times 2 \times 200 + 500 \times 16 \times 8}{20586} = 125.386\,mm$$

$$I_{zz} = 2 \times \left\{ 15082.8 \times 10^4 + 6293 \times (200 - 125.386)^2 \right\} + \frac{500 \times 16^3}{12} + 500 \times 16 \times (125.38 - 8)^2$$

$I_{zz} \Rightarrow 482.12 \times 10^6\,mm^4$

$$I_{yy} = 2 \times \left\{ 5040.8 \times 10^4 + 6293 \times (150 + 24.2)^2 \right\} + \frac{500^3 \times 16}{12} \Rightarrow$$

$\Rightarrow 558.69 \times 10^6\,mm^4$ $\qquad \{ I_{min} = I_{zz} \}$

$$r_{min} = \sqrt{\frac{482.12 \times 10^6}{20586}} \Rightarrow 153.03\,mm$$

$$\lambda = \frac{5500}{153.03} = 35.93 \qquad \left\{ \lambda = \frac{l_{eff}}{r_{min}} \right\}$$

$$f_{cd} = 211 + \frac{198 - 211}{40 - 30}(35.93 - 30) = 203.291\,N/mm^2$$

$P = A_g \times f_{cd} \Rightarrow 20586 \times 203.291 \Rightarrow 4184.99\,\underline{kN}$

12

Scanned with CamScanner

(b) Total rolling Resistance ⇒ $90 \times 18.5 + 105 \times 31.5$

⇒ 4972.5 kg

$55 \times 18.5 \Rightarrow$ ~~955kg~~ 1017.5 kg

net rolling resistance ⇒ $4972.5 - 1017.5$ = ~~4049.5~~ 3955 kg

available drawbar pull ⇒ ~~4049.5~~ $14.8 -$ ~~4.0495~~ 3.955

⇒ ~~10.7525~~ 10.895

~~$W \sin\theta = 10.7525$~~ {for uniform speed}

{$\sin\theta = \tan\theta \rightarrow$ small angle}

~~$\tan\theta = \frac{10.7525}{50}$~~

$\tan\theta = \frac{10.895}{50} = 21.69\%$

$\boxed{\tan\theta = 21.69\%}$ Ans

(c) $A_g = (115 + 150 - 8) \times 8 = 2056\ mm^2$

(i) gross yielding:-

$T_{dg} = 2056 \times \frac{250}{1.1} \Rightarrow 467.272\ kN$

(ii) Net section Rupture.

only one leg connected, shear lag effect will present.

$A_{go} = 888\ mm^2$

$A_{nc} \Rightarrow 1168\ mm^2$

$T_{dn} = A_{nc} \frac{f_u 0.9}{\gamma_{m1}} + \beta \times \frac{A_{go} \times f_y}{\gamma_{m0}}$

$$\beta = 1.4 - 0.076\left(\frac{115}{8}\right)\left(\frac{250}{410}\right)\times\left(\frac{115}{140}\right)$$

$\beta = 0.8527$

$$\left\{\beta = 1.4 - 0.076\left(\frac{b_s}{L_c}\right)\times\left(\frac{f_y}{f_u}\right)\times\left(\frac{w}{t}\right)\right.$$

12

$$T_{dn} = 1163 \times \frac{0.9 \times 410}{1.25} + 0.8527 \times \frac{833 \times 250}{1.1}$$

$T_{dn} = 516.83$ KN

1 (d) **Design of lug Angle :-** lug Angles are small piece of angle connected to the main Angle so that the distribution of stresses is uniform and shear lag effected is countered.

(a) lug Angle connected to Angle section

i) design force for lug angle to gusset plate connection is 20% is Excess of what carried by outstanding leg of main Angle. let it is P.

$$A_g = \frac{P \times \gamma_{m0}}{f_y}$$

form here a section is selected.

ii) Now bolt specification selected and no of bolts are calculated to lug angle to gusset connection.

iii) Net sectional area strength is checked for this connection

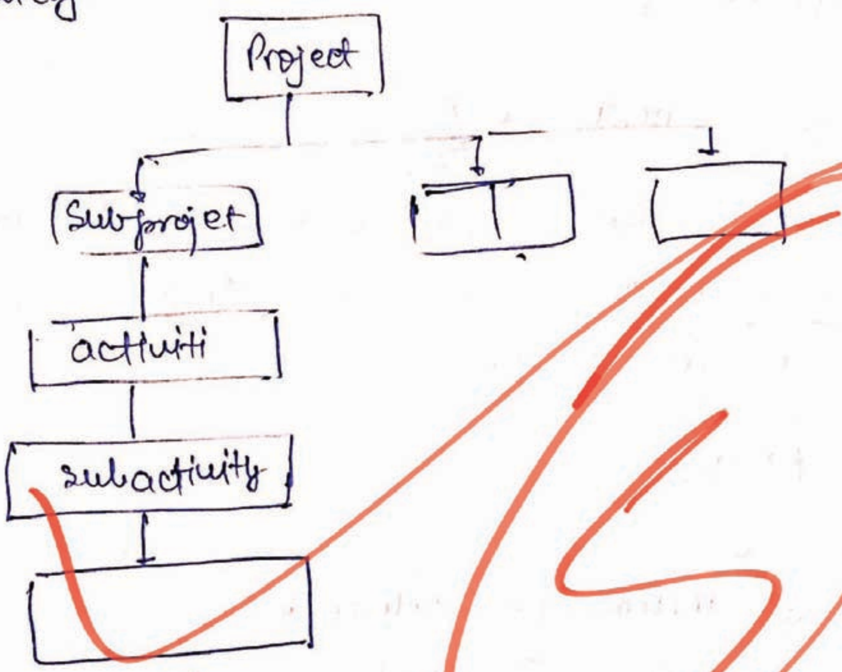
(b) lug angle to main Angle connection

i) when lug angle connected to main angle design force is 40% Excess of what carried by main angle.

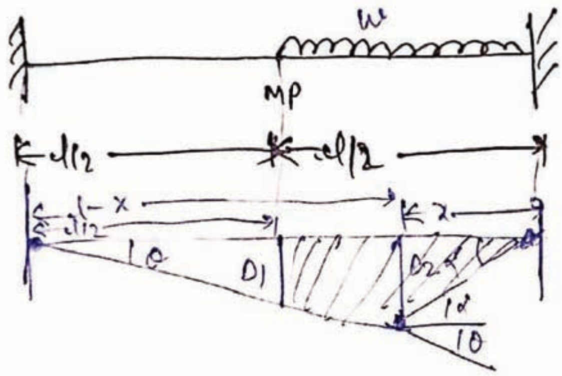
ii) Now No. of bolts are calculated and connection is done.

Note → when lug angle is connected to channel section design force is 10% Excess of force carried by outstanding area and 20% Excess of force carried by outstanding used to connection with channel.

(e) **work Break down structure** :- work break down is the process in which the project is divided to its least possible activity so that the schedule of work can be prepared very accurately.



2(a)(ii)



$$M_p(\theta + \alpha + \theta + \alpha) = \left\{\frac{1}{2} \times \left(\frac{d}{2} - x\right) \times (\Delta_1 + \Delta_2) + \frac{1}{2} \times \Delta_2 \times x\right\} \times w$$

$$(d-x)\theta = x\alpha \qquad \Delta_1 = \frac{d}{2}\theta$$

$$\alpha = \left(\frac{d-x}{x}\right)\theta \qquad \Delta_2 = (d-x)\theta$$

$$2M_p(\theta+\alpha) = \left\{\frac{1}{2}\left(\frac{d}{2}-x\right) \times \left[(d-x)\theta + \left(\frac{d}{2}\theta\right)\right] + \frac{1}{2} \times (d-x)\theta \times x\right\} \times w$$

$$2M_p\left[\phi + \left(\frac{d-x}{x}\right)\phi\right] = \left\{\frac{1}{2}\left(\frac{d-2x}{2}\right)\phi\left(\frac{3d-2x}{2}\right) + \frac{x(d-x)\phi}{2}\right\} w$$

$$2M_p\left(\frac{d}{x}\right) = \frac{w}{2}\left\{\frac{(d-2x)(3d-2x)}{4} + x(d-x)\right\}$$

$$M_p = \left(\frac{w}{4d}\right)\left\{\frac{3d^2 - 2dx - 6dx + \cancel{4x^2} + 4xd - \cancel{4x^2}}{4}\right\} x$$

$$M_p = \frac{w}{16d}(3d^2 - 4xd)x$$

for M_p to max $\frac{dM_p}{dx} = 0$

$$\frac{dM_p}{dx} = 0 \qquad (3d^2 - 8xd) = 0$$

$$x = \frac{3d}{8}$$

$$M_p = \frac{w}{16d}\left(3d^2 - 4 \times \frac{3d}{8} \times d\right) \times \left(\frac{3d}{8}\right)$$

$$\boxed{w = 28.44 \frac{M_p}{d^2}}$$

10

Scanned with CamScanner

(ii) $T_E = 15$ month

$\sigma = 3$ months.

(a) $T_S = 15$ months.

$$z = \frac{T_S - T_E}{\sigma} = \frac{15-15}{3} = 0$$

for $z = 0$ $\boxed{p = 50\%}$ Ans

(b) $T_S = 18$ months.

$$z = \frac{18-15}{3} = 1$$

$\boxed{p = 84.13\%}$ Ans

(c) $T_S = 12$ month

$$z = \frac{12-15}{3} = -1$$

$p = 100 - 84.13 =$

$\boxed{p = 15.87\%}$ Ans

10

(b)

No. of bolts = 8

16mm dia, M 4.6

for each bolt

$$T_S = \frac{\frac{200}{\sqrt{2}}}{8} = 17.67 \text{ KN}$$

$$T_T = \frac{\frac{200}{\sqrt{2}}}{8} = 17.67 \text{ KN}$$

design tensile strength of bolt

i) gross area $\rightarrow \frac{\pi}{4} \times 16^2 \times \frac{250}{1.1} = 45.69\,kN$

ii) Net area: $\frac{\pi}{4} \times 16^2 \times 0.78 \times \frac{400 \times 0.9}{1.25} = 45.15\,kN$

$$\boxed{T_{dT} = 45.16\,kN}$$

design shear strength of bolt-

$F = \frac{\pi}{4} \times 16^2 \times 0.78 \times \frac{400}{\sqrt{3} \times 1.25} = 28.97\,kN$

Check

$$\left(\frac{T_T}{T_{dT}}\right)^2 + \left(\frac{T_s}{T_{ds}}\right)^2 \le 1$$

$\left(\frac{17.67}{45.16}\right)^2 + \left(\frac{17.67}{28.97}\right)^2 = 0.525 < 1$ hence connection is safe.

Design of bolts for Angle -

$T_d = 200\,kN$

double shear.

$f_s = 0.78 \times \frac{\pi}{4} \times 16^2 \times 2 \times \frac{400}{\sqrt{3} \times 1.25} \Rightarrow 57.948\,kN$

$F_b = (d \times t)\, f_b$

$f_b = 2.5 \times K_b \times \frac{f_{up}}{1.25}$

$$K_b = \min \begin{cases} \frac{e}{3d_0} \\ \frac{p}{3d_0} - 0.25 \\ \frac{f_{ub}}{f_{up}} \\ 1 \end{cases}$$

take $K_b = 0.5$

$f_b = 410\,N/mm^2$

$F_b = 82\,kN$

$R_v = 57.948\,KN$

No of bolts required $= \frac{200}{57.948} = \underline{3.45}$

Provide 4 bolts.

$e = 1.5d_0 = 1.5 \times 18 = 27$

$p = 2.5d = 2.5 \times 16 = 40$

$\boxed{\begin{array}{l} \text{take } e = 35mm \\ \text{take } p = 50mm \end{array}}$

c (i) $D = 1.2m$

$t = 12mm$

size of weld $= \underline{8mm}$

$p \rightarrow$ internal pressure.

hoop stress $\Rightarrow \frac{pd}{2t}$

total force in 1m length $= F = \left(\frac{pd}{2\cancel{t}}\right) \times (\cancel{t} \times l)$

$F = \frac{pdl}{2}$

force on each weld $\Rightarrow \frac{pdl}{4}$

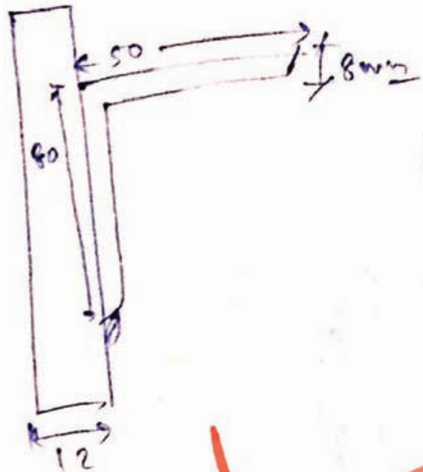
$\frac{pdl}{4} =$ weld strength

$\frac{pd\cancel{l}}{4} = \frac{410}{\sqrt{3} \times 1.25} \times \cancel{l} \times 8 \times 0.7$

$p = 3.53\,N/mm^2$

$\boxed{p_{safe} = 2.35\ N/mm^2}$ Ans

(iii) ISA 80 × 50 × 8 (Fe410)



(a) design strength of member

i) $T_{dg} = \frac{A_g \times f_y}{\gamma_{m0}}$

$A_g = (80 + 50 - 8) \times 8 = 976 mm^2$

$T_{dg} = \frac{976 \times 250}{1.1} = \underline{221.81 kN}$

ii) net strength

welding is done → $A_g = A_n$ ⇒ $976 mm^2$, but shear lag effect present hence effective net area ⇒ 0.7×976

⇒ $683.2 mm^2$

T_{dn} ⇒ $\frac{A_{ne} \times f_u \times 0.9}{\gamma_{m1}}$ ⇒ $\frac{683.2 \times 0.9 \times 410}{1.25} = 201.68 kN$

hence $\boxed{T_d = 201.68 kN}$

(b) design of weld (moment free connection)

$P_1 + P_2 = 201.68 kN$

$P_1 ⇒ P \times \frac{(80 - 27.3)}{80} = 132.85 kN$

$P_2 = P \times \left(\frac{27.3}{80}\right) = \underline{68.82 kN}$

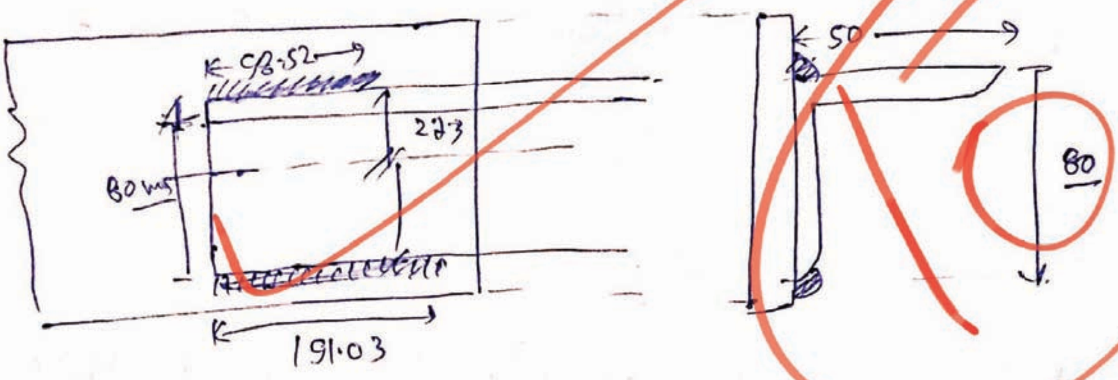
$l_{eff1} ⇒ \frac{132.85 \times 10^3}{\frac{410}{\sqrt{3} \times 1.25} \times 6 \times 0.7} = 167.03 mm$

Scanned with CamScanner

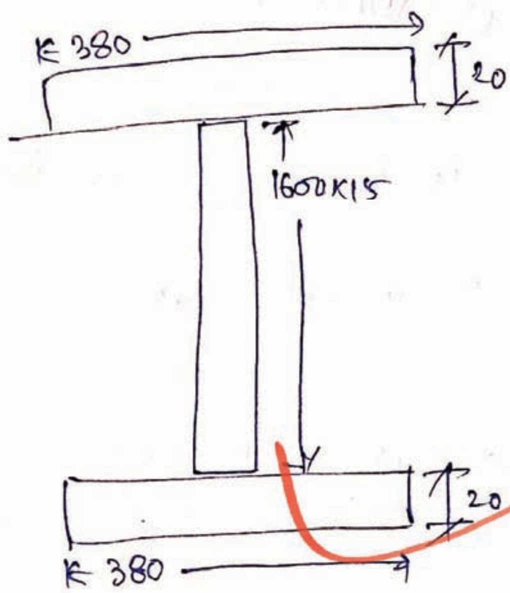
$$l_{eff2} = \frac{68.82 \times 10^3}{\frac{410}{\sqrt{3} \times 1.25} \times 6 \times 0.7} \Rightarrow 86.52\,mm$$

$l_1 = l_{eff1} + 2s = 191.03\,mm$

$l_2 = 98.52\,mm.$



3 (a) (i)



$\frac{b}{t_f}, \frac{h}{t_w}$

$h \Rightarrow 1600\,mm$ $\quad t_f = 20\,mm$

$b \Rightarrow 190\,mm$ $\quad t_w = 15\,mm$

$$\frac{h}{t_w} = \frac{1600}{15} \Rightarrow 106.67 > 84$$

$$\frac{b}{t_f} = \frac{190}{20} \Rightarrow 9.5 > 9.4$$

hence section is compact section, No mechanism will form only hinges will form.

$$M_p = \frac{\beta \cdot Z_p f_y}{\gamma_{m0}} \le \frac{1.2\, Z_e f_y}{\gamma_{m0}}$$ for Compact section $\beta = 1.0$

$Z_p = \Sigma A\bar{y}$

$\bar{y}_t \Rightarrow 1000\,\text{mm}$

$Z_p = \{380\times20\times810 + 800\times15\times400\}\times2 \Rightarrow 21.912\times10^6\ \text{mm}^3$

$M_p = 1.0\times\frac{21.912\times10^6\times250}{1.1} \Rightarrow 4980\ \text{kN-m}$

$I_e \Rightarrow \frac{15\times1600^3}{12} + 2\times\left[\frac{380\times20^3}{12} + 380\times20\times810^2\right] \Rightarrow 1.0776\times10^{10}\ \text{mm}^4$

$Z_e \Rightarrow 13.142\times10^6\ \text{mm}^3$

$\frac{1.2 Z_e f_y}{\gamma_{m_0}} = \frac{1.2\times13.142\times10^6\times250}{1.1} = 3584.17\ \text{kNm}$

$\boxed{M_p = 3584.17\ \text{kN-m}}$ Ans

(ii) different types of vibrator

i) form vibrator
ii) needle vibration
iii) table vibrator
iv) slab vibrator

(a) Needle vibrator :- i) This vibration is generally used in compaction of concrete.
ii) Concrete of medium to high workability is required.
iii) it can compact upto 500 mm depth of concrete.

(b) form vibrator - i) This type of vibrator is fitted with form work of concrete.
ii) max depth of concrete → 450mm,

iii) Precaution should be taken at time of concreting so that there is no damage to form work.

ⓒ Slab vibrator → i) this type of vibrator used for slab compaction work.

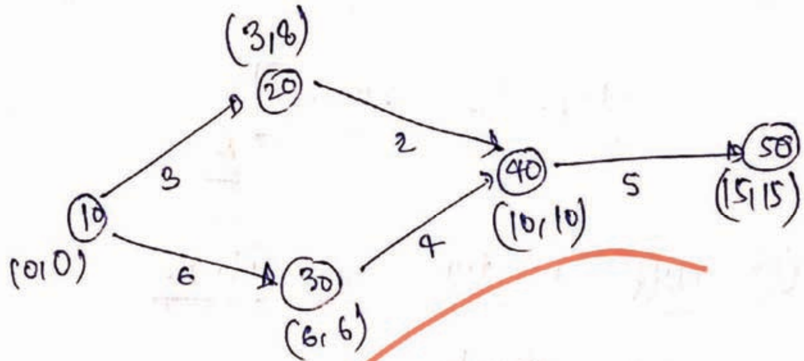
ii) depth of concrete should be 150-250 mm.

iii) high workable concrete.

ⓓ table vibrator → i) this type of vibrator is used for very high workable concrete.

ⓑ

Activity	Cost slope
10-20	4000
10-30	2000
20-40	3000
30-40	2500
40-50	5000



i) $T_N = 15$ ~~days~~ weeks

Normal cost ⇒ 96000₹

Indirect cost ⇒ 3000×15 = 45000₹

Total cost ⇒ 141000₹

(ii) Critical path (10-30) → (30-40) → (40-50)

crashing 10-30 → by 3 days.

crashing 30-40 → by 2 days.

Scanned with CamScanner

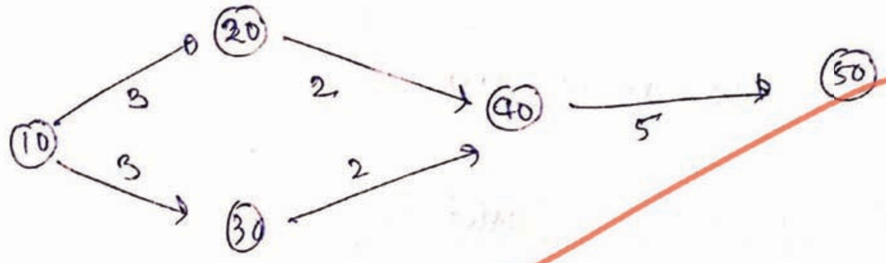
Now $T = 10$ days

Normal cost = 96000₹

Crash cost ⇒ $2000 \times 3 + 2500 \times 2 = 11000$₹

Indirect cost = $3000 \times 10 = 30000$₹.

total ⇒ 137000₹



(iii) Now critical path

(10-20) → (20-40) → (40-50)

(10-30) → (30-40) → (40-50)

crashing (40-50) by 1-day.

Ts = 9 days.

Normal cost ⇒ 96000₹

Crashing cost = $2000 \times 3 + 2500 \times 2 + 5000 = 16000$₹

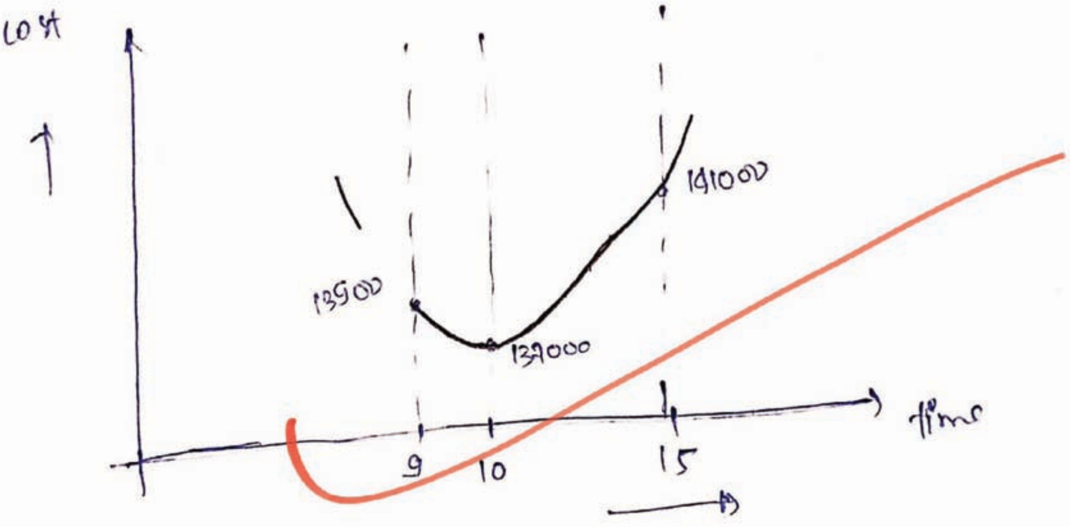
Indirect cost = $3000 \times 9 = 27000$₹

Total ⇒ 139000 ₹

hence minimum cost = 137000₹

optimum duration ⇒ 10 days.

20



cost v/s time curve

ⓒ Design of laterally supported beam:

$L_{eff} = 6m$

$M_u = 150 kN\text{-}m$ $\quad V_u = 210 kN$

$(Z_p)_{required} \Rightarrow \dfrac{150 \times 10^6 \times 1.1}{250} \Rightarrow 660 \times 10^3 \, mm^3$

take ISLB 350

$(Z_{p2}) = 851.11 \times 10^3 \, mm^3$

(i) Bending capacity

$\dfrac{d}{t_w}$ $\quad \dfrac{b}{t_f}$

$\dfrac{d}{t_w} = \dfrac{350}{7.4} = 47.29 < 84\epsilon$ $\qquad \epsilon = \sqrt{\dfrac{f_y}{250}} = \sqrt{\dfrac{250}{250}} = 1$

$\dfrac{b}{t_f} = \dfrac{165/2}{7.9} = 7.23 < 9.4$

hence plastic section

$$M_p = \frac{\beta_b \times Z_p \times f_y}{\gamma_{m0}} \le \frac{1.2 Z_e f_y}{\gamma_{m0}}$$

$$\Rightarrow 1.0 \times \frac{851.11 \times 10^3 \times 250}{1.1} \le \frac{1.2 \times 751.9 \times 10^3 \times 250}{1.1}$$

$$\Rightarrow 193.43 \text{ kN-m} \le 205.06 \text{ kN-m}$$

$$\boxed{M_p = 193.43 \text{ kN-m}}$$

(ii) check ~~shot~~ shear capacity

$$V_d = A_w \times f_{sw} \Rightarrow \left(d_1 \times t_w / \times \frac{250}{\sqrt{3} \times 1.1}\right) \Rightarrow 350 \times 7.4 \times \frac{250}{\sqrt{3} \times 1.10} = 339.84 \text{ kN}$$

$V_d = 339.84$ kN

$0.6 V_d = 203.904 < 210$ kN

hence high shear case.

Moment capacity of ~~the~~ section will change

$$M_{dv} = M_d - \beta (M_d - M_{fd})$$

$$\beta = \left(\frac{2V}{V_d} - 1\right)^2 \qquad M_{fd} = M_d - \frac{t_w \times d_1^2 \times f_y}{4 \gamma_{m0}}$$

$$\beta = \left(\frac{2 \times 210}{339.84} - 1\right)^2 \Rightarrow 0.0556$$

$$M_{fd} = 193.43 - \frac{7.4 \times 350^2 \times 250}{4 \times 1.1 \times 10^6} \Rightarrow 141.92 \text{ kN-m}$$

$$M_{dv} = 193.43 - 0.0556 (193.43 - 141.92)$$

$\boxed{M_{dv} = 190.56}$ > 150 kN hence safe

(iii) web buckling at support:

$d' = h - 2(R + t_f)$

$\Rightarrow 350 - 2(16 + 11.4) = 295.2\,mm$

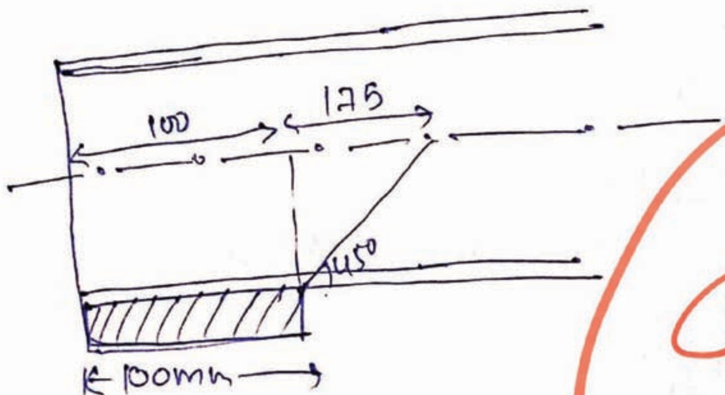
$b = 100 + 175 = 275\,kN$

$\lambda = \dfrac{2.45 \times 295.2}{7.4} \Rightarrow 98.134$

$f_{cd} \Rightarrow 121 + \dfrac{107 - 121}{100 - 90}(98.134 - 90) \Rightarrow 109.614\,N/mm^2$

$P = 109.614 \times 275 \times 7.4 = 223.064 > 210\,kN$

hence safe



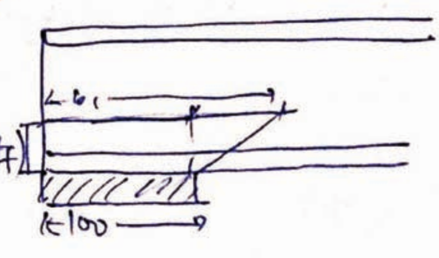
(iv) web bearing

$b_1 \Rightarrow 100 + 2.5(16 + 11.4) \Rightarrow 168.5\,mm$

$F = \dfrac{168.5 \times 7.4 \times 250}{1.1} \Rightarrow 283.386\,kN$

$> 210\,kN$

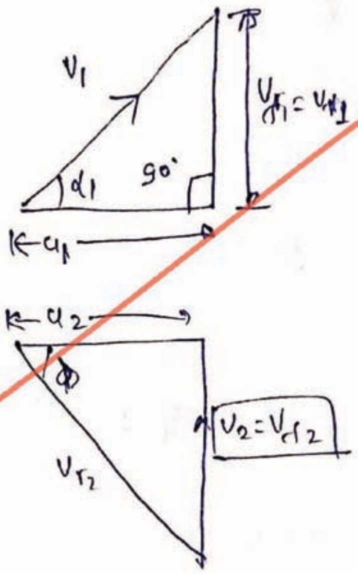
hence safe



5 (a) $90°$ at inlet, Francis turbine.

$90°$ at outlet, for max power.

hydraulic efficiency $= \dfrac{\cancel{m}(V_{w_1} u_1)}{\cancel{m}\, g H}$



$$\eta_H \Rightarrow \frac{V_{w_1} u_1}{g H}$$

$$H = \frac{V_{w_1} u_1}{g} + \frac{V_2^2}{2g}$$

$$\eta_H = \frac{V_{w_1} u_1}{\left(\dfrac{V_{w_1} u_1}{\cancel{g}} + \dfrac{V_2^2}{2\cancel{g}}\right) \times \cancel{g}}$$

$V_2 = V_{f2} = V_{f1}$

$V_{w_1} = u_1$

$\tan\alpha_1 = \dfrac{V_{f1}}{u_1} = \dfrac{V_{f2}}{u_1}$

$$\eta_H = \frac{1}{1 + \dfrac{V_2^2}{2 V_{w_1} u_1}}$$

$$\eta_H = \frac{1}{1 + \dfrac{V_{f2}^2}{2 u_1^2}} = \frac{1}{1 + \dfrac{\tan^2\alpha_1}{2}}$$

$$\boxed{\eta_H = \frac{2}{2 + \tan^2\alpha_1}}$$ Ans

(b)

$\bar{x} = 29600 \ m^3/sec$

$\sigma = 14860 \ m^3/sec$

Risk = 10% $n = 50$ year

$R = 1 - \left(1 - \frac{1}{T}\right)^n$

$0.1 = 1 - \left(1 - \frac{1}{T}\right)^{50}$

$\boxed{T = 475 \text{ years}}$

i) $y_t = -\ln \ln \left(\frac{T}{T-1}\right) = 6.16$

$x = \bar{x} + K_T \sigma$

$K_T = \frac{y_T - y_n}{S_n} \Rightarrow \frac{6.16 - 0.5380}{1.1193} \Rightarrow 5.022$

2

$x \Rightarrow 29,600 + 5.022 \times 14860 \Rightarrow \boxed{104238.5 \ m^3/sec}$ Ans

(ii) $FOS = \frac{125000}{104238.58} = 1.2$

safety margin $\Rightarrow \boxed{20761.46 \ m^3/sec}$ Ans

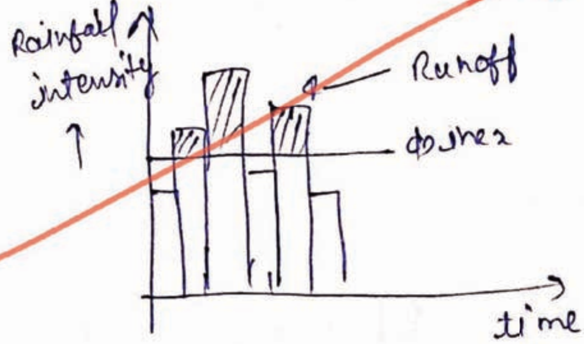
(c) Infiltration index :- it represents the avg. rate of infiltration of water into soil mass. There are generally two types of infiltration index

(a) ϕ- index

(b) W- index

(a) ϕ- index → it represents the rainfall rate above with rainfall volume is equal to the runoff volume. It is the maximum value of infiltration index.

$$\boxed{\phi = \frac{P-R}{t}}$$



(b) w- Index - it is modification over ϕ-index. in this intial loss are also considered like Interception losses, Evaporation, seepage loss etc.

$$\boxed{w = \frac{P-R-S}{t}}$$

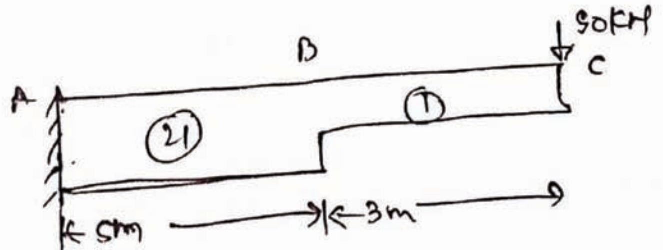
Now $f_p = 3.0 + e^{-2t}$

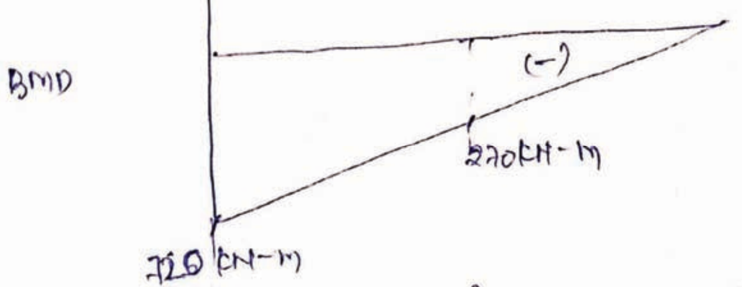
$f = \int_0 f_p \cdot dt$

$f = \int_0^{0.5} \left(3.0 + e^{-2t}\right) dt \Rightarrow$ 1.816cm

$\boxed{f = 18.16 mm}$ Ans

(d)

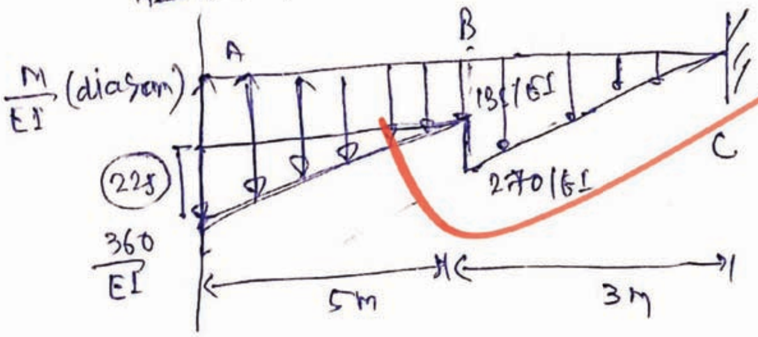




BMD (-)ve, loading downward in Conjugate beam

free → fix

fix → free



MA=0
VA=0

$$V_B = \frac{1}{2} \times 5 \times \left(\frac{360}{EI} + \frac{135}{EI}\right) \Rightarrow \frac{2475}{2EI} \ (\downarrow)$$

$$\boxed{\theta_B = \frac{2475}{2EI} \ (cw)} \Rightarrow \boxed{4.95 \times 10^{-3} \text{ Radians}}$$

$$M_B \Rightarrow \frac{135}{EI} \times 5 \times 2.5 + \frac{1}{2} \times \frac{225}{EI} \times 5 \times \frac{5 \times 2}{3} \Rightarrow \frac{7125}{2EI}$$

Shear in Conjugate beam = Slope in Real Beam

BM in Conjugate Beam = deflection in real beam.

$$\boxed{\delta_B \Rightarrow 0.01425 \text{ m} \ (\downarrow)}$$

$$V_C \Rightarrow \frac{1}{2} \times 5 \times \frac{(360 + 135)}{EI} + \frac{1}{2} \times 3 \times \frac{270}{EI} = \frac{3285}{2EI}$$

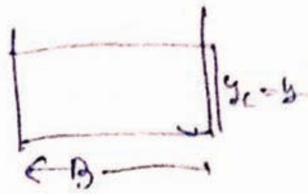
$$\boxed{\theta_C = \frac{3285}{2EI} = 6.57 \times 10^{-3} \text{ radians} \ (cw)}$$

$$M_C \Rightarrow \frac{135 \times 5}{EI} \times 5.5 + \frac{1}{2} \times \frac{225}{EI} \times 5 \times \left(\frac{5 \times 2}{3} + 3\right) + \frac{1}{2} \times 3 \times \frac{270}{EI} \times 2 \Rightarrow 8085/EI$$

$$\boxed{\delta_C = 0.03234 \text{ m} \ (\downarrow)}$$

Ans

(e) Rectangular channel.



$S_0 = 0.0064$

$Q = 20\,m^3/sec$ $\qquad Q = AV$

$n = 0.015$ $\qquad$ when flow is critical. $F = 1$

$V_c = \sqrt{g y_c} = \sqrt{gy}$

$\sqrt{gy} = \frac{1}{n} (R)^{2/3} \sqrt{S}$ $\qquad R = \frac{By}{B+2y}$

$\sqrt{9.81}\sqrt{y} = \frac{1 \times \sqrt{0.0064}}{0.015} \left(\frac{By}{B+2y}\right)^{2/3}$

$0.5872\sqrt{y} = \left(\frac{By}{B+2y}\right)^{2/3}$

$20 = By \times \sqrt{gy}$

$6.385 = (y)^{3/2} \times B$ $\qquad B = \frac{6.385}{(y)^{3/2}}$

$0.5872\sqrt{y} = \left(\frac{\frac{6.385}{(y)^{3/2}} \times y \quad \frac{1}{\sqrt{y}}}{\frac{6.385}{(y)^{3/2}} + 2y}\right)$

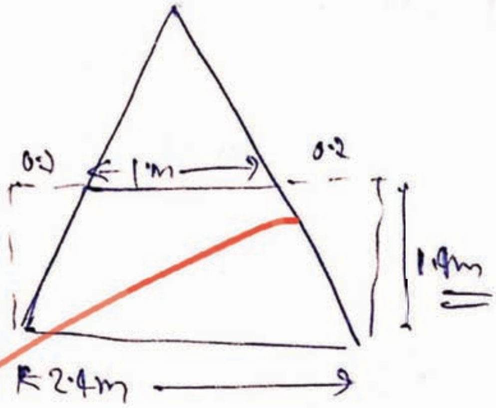
$6.5872\, y = \frac{6.385}{\frac{6.385}{y^{3/2}} + 2y}$

$\boxed{y_c = y = 1.736m}$

$\boxed{B = 2.791m}$ Ans

6

8(a)(ii) $y = 1.4m$



$A \Rightarrow \frac{1}{2} \times 1.4 \times (2.4+1) \Rightarrow 2.38 m^2$

$T = 1m$

$\frac{Q^2 T}{g A^3} = 1$ {for critical flow}

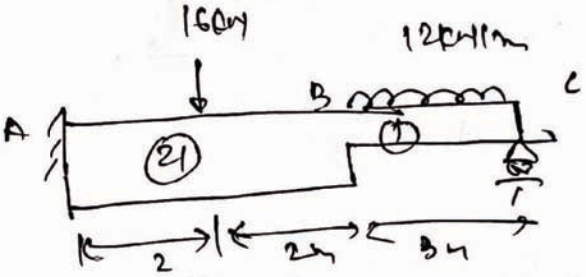
$\frac{Q^2 \times 1}{9.81 \times 2.38^3} \Rightarrow$ $\boxed{Q = 11.5\ m^3/sec}$

$V = Q/A = 4.83 m/sec$

$E_c \Rightarrow y + \frac{V^2}{2g} = 1.4 + \frac{4.83^2}{2 \times 9.81} \Rightarrow 2.59m$

$\boxed{E_c = 2.59m}$

(b) (1) fixed End moments



$M_{FAB} = -8 kN\text{-}m$

$M_{FBA} = +8 kN\text{-}m$

$M_{FBC} \Rightarrow -9 kN\text{-}m$

$M_{FCB} \Rightarrow +9 kN\text{-}m$

(2) distribution factors

B	BA	$\frac{8EI}{4}$	$\frac{2}{1}$	3	$\frac{2}{3}$
	BC	$\frac{3EI}{3}$			$\frac{1}{3}$

Non Sway

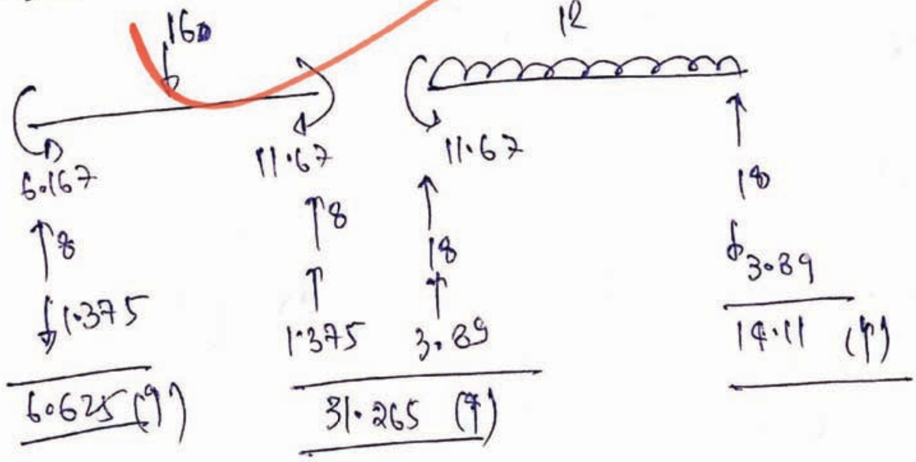
A	(2/3) B	(1/3)	C
AB	BA	BC	CB
-8	+8	-9	9
			-9
		-4.5	
-8	+8	-13.5	0
	+3.67	+1.833	
+1.833			
-6.167	11.67	-11.67	0

$M_{AB} = -6.167$ kN-m

$M_{BA} = 11.67$ kN-m

$M_{BC} = -11.67$ kN-m

$M_{CB} = 0$



$\boxed{R = 31.265 \text{ kN}}$

Sway Analysis

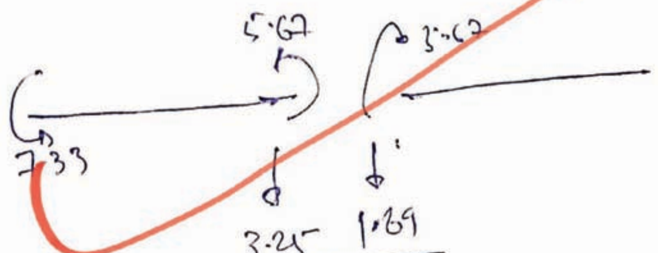
$MF_{AB} : MF_{BA} : MF_{BC} : MF_{CB}$

$-\frac{6EI\times2\times\Delta}{4^2} : -\frac{6EI\times2\Delta}{4^2} : +\frac{6EI\Delta}{3^2} : \frac{6EI\Delta}{3^2}$

$-\frac{\cancel{2}}{\cancel{16}\,8} : \frac{-\cancel{2}}{\cancel{16}\,8} : \frac{1}{9} : \frac{1}{9}$

$-9 : 9 : +8 : +8$

A		B		C
	AB	BA	BC	CB
	—	2/3	1/3	—
	-9	-9	+18	+8
				-8
			-4	
	-9	-9	+4	0
		+3.33	+1.67	
	+1.67			
	-7.33	-5.67	+5.67	0



$R' = 5.14$ kN

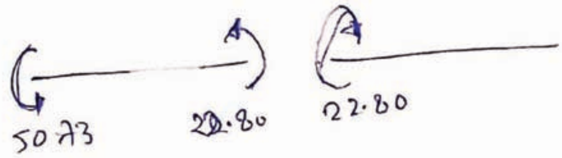
$X \Rightarrow \frac{R}{R1} = \frac{31.265}{5.14} \Rightarrow 6.08$

MAB = -50.73 kN-m

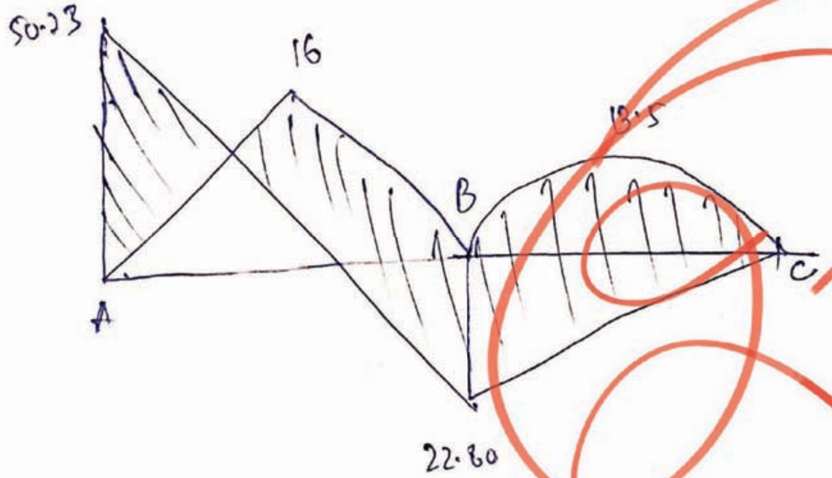
MBA = -22.80 kN-m

MBC = +22.80 kN-m

MCB = 0



BMD



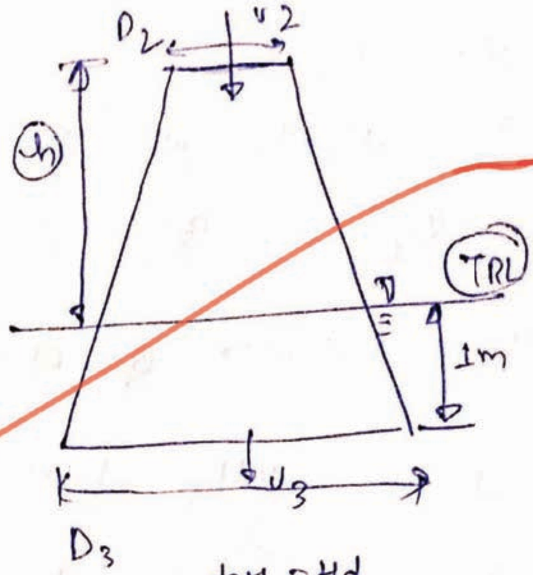
(c) (i) $P = 15000\,kW$ $\quad \frac{P_{atm}}{\rho g} = 10.6m$

$N = 160\,rpm$.

$H = 30m$

$$H = \frac{V_{w_1} u_1}{g} + \frac{V_2^2}{2g}$$

$$30 = \frac{V_{w_1} u_1}{g} + \frac{V_2^2}{2g}$$



$h+1 = H_d$

$$\frac{P_2}{\rho g} + \frac{V_2^2}{2g} + z_2 = \frac{P_3}{\rho g} + \frac{V_3^2}{2g} + z_3 + h_L$$

$$\frac{P_3}{\rho g} = \frac{P_{atm}}{\rho g} + 1$$

$$\frac{P_3}{\rho g} = (10.6 + 1) = 11.6m$$

$$\frac{P_2}{\rho g} + \frac{V_2^2}{2g} + H_d = 11.6 + \frac{V_3^2}{2g} + 0 + (h_{f1}) \rightarrow 0$$ {assuming friction loss zero}.

$$\frac{P_2}{\rho g} + \frac{V_2^2}{2g} + H_d = 11.6 + \frac{V_3^2}{2g}$$

$$H_d = 11.6 + \left(\frac{V_3^2 - V_2^2}{2g}\right) - \frac{P_2}{\rho g}$$

3

(ii) Trobules in centrifugal Pumps

① air in the pump instead of liquid to be pumped. → due to this pump will not able to lift the liquid. to remove the air in the pump priming is done.

② incrustration of debris (sand) in pumps.

③ Initial starting speed not provided.

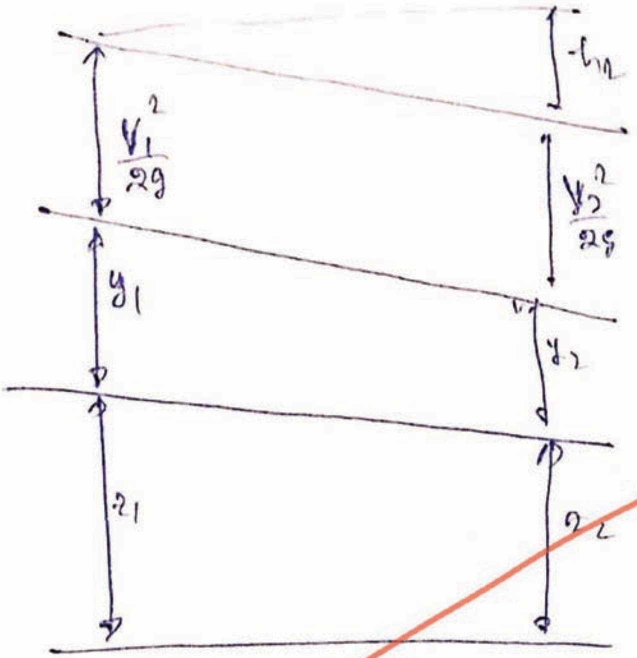
④ height is pump is such that the ~~cav~~ chances of cavitation are ~~very~~ more.

$$\sigma = \frac{NPSH}{H_m}$$

$\sigma > \sigma_c$ for avoiding cavitation.

③ ~~Le~~

8(a)(i)



$$E = z + y + \frac{v^2}{2g}$$

$$\frac{dE}{dx} = \frac{dz}{dx} + \frac{dy}{dx} + \left(\frac{d}{dx}\frac{v^2}{2g}\right)$$

$$\frac{dE}{dx} = -S_0 + \frac{dy}{dx} + \frac{d}{dx}\left(\frac{V^2}{2g}\right)$$

$$-S_f = -S_0 + \frac{dy}{dx} + \frac{d}{dx}\left(\frac{V^2}{2g}\right)$$

$$S_0 - S_f = \frac{dy}{dx} + \frac{d}{dx}\left(\frac{V^2}{2g}\right)$$

$$\frac{dy}{dx} = \frac{S_0 - S_f}{1 - F_r^2}$$

$$\frac{dy}{dx} = \frac{S_0 - S_f}{1 - \frac{C^2 S_0}{g}}$$

$$\frac{dy}{dx}\left(1 - \frac{C^2 S_0}{g}\right) = S_0 - S_f$$

$$dy\left(1 - \frac{C^2 S_0}{g}\right) = (S_0 - S_f)\, dx$$

$$dy\left(\frac{1}{S_0} - \frac{C^2}{g}\right) = \left(1 - \frac{S_f}{S_0}\right) dx$$

$V = C\sqrt{RS}$

for wide Rectangular Channel.

$R = y$

$V = C\sqrt{y S_0}$

$$F_r^2 = \frac{Q^2 T}{g A_c^3} \Rightarrow \frac{Q^2 \times B}{g \times B^3 \cdot y^3}$$

$$\Rightarrow \frac{A^2 v^2 \times T}{g A^3 A}$$

$$\Rightarrow \frac{C^2 \cdot y S_0 \times B}{g \times B y}$$

$$F_r^2 = \frac{C^2 S_0}{g}$$

$\cancel{S_f = Cy}$ $\quad Q = By \times C \times (y)^{1/2} \cdot \sqrt{S_f}$

$$\frac{Q}{BCy^{3/2}} = \sqrt{S_f}$$

$$S_f = \frac{Q^2}{B^2C^2(y)^3}$$

$$S_0 = \frac{Q^2}{B^2C^2(y_n)^3} \qquad \frac{S_f}{S_0} = \left(\frac{y_n}{y}\right)^3$$

$$dy\left[\frac{B^2C^2(y_n)^3}{Q^2} - \frac{C^2}{g}\right] = \left(1 - \frac{y_n^3}{y^3}\right)\cdot dx$$

$$dy\left[\frac{B^2C^2(y_n)^3}{B^2 \times y_n^2 \times C^2 y_n S_0} - \frac{C^2}{g}\right] = 1-$$

$$dy\left(\frac{1}{S_0} - \frac{C^2}{g}\right) = dx\left(1 - \frac{y^3}{y_n^3}\right)$$

$$\frac{dx}{\frac{1}{S_0} - \frac{C^2}{g}} = \frac{dy}{\left(1 - \frac{y_n^3}{y^3}\right)}$$

7