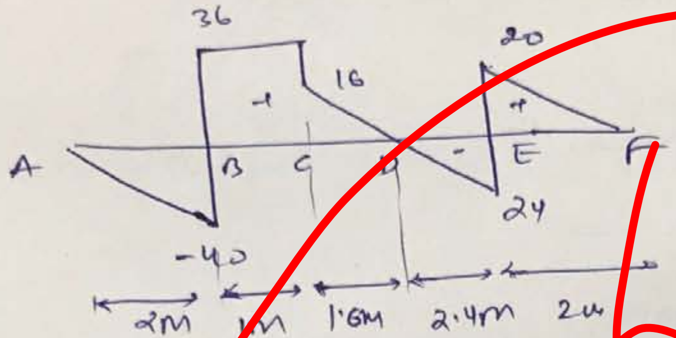
Test 3

Q 1 (~~a~~)

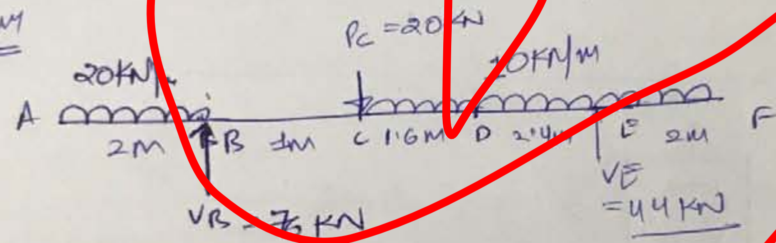
(d)



AB $L = \left(-\frac{dV}{dx}\right)$

$= -\frac{(-40-0)}{2} = \underline{20KN/M}$

Loading diagram



$V_B = (36+40) = 76KN$

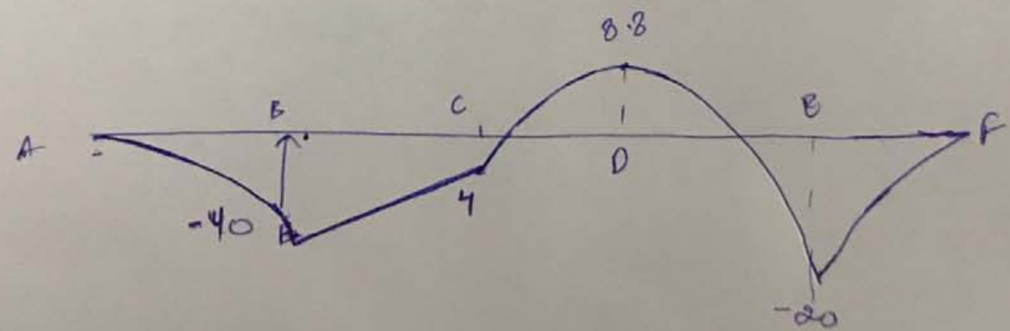
$P_C = 36-16 = 20KN$

~~BD~~ CE $L = -\frac{dV}{dx} = \frac{-(-24-16)}{4} = 10KN/M$

EF $L = -\frac{dV}{dx} = \frac{(0+20)}{2} = 10KN$

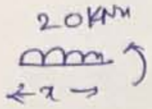
$V_E = (24+20) = 44KN$

BMD



M_x AB

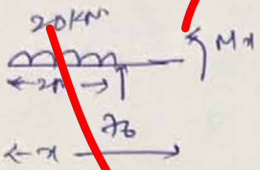
$(0 \le x \le 2)$



$M_x = -\frac{20x^2}{2}$

BC

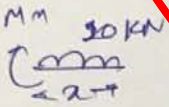
$(2 \le x \le 3)$



$M_x = 76(x-2) - 20\times2\times(x-2+1)$

FE

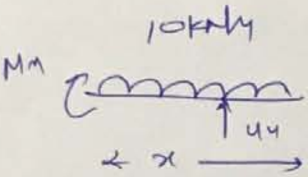
$0 \le x \le 2$



$M_x = -\frac{10x^2}{2}$

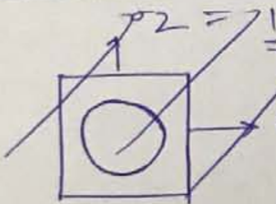
FD

$2 \le x \le 4m$



$M_x = 44(x-2) - \frac{10x^2}{2}$

(e)

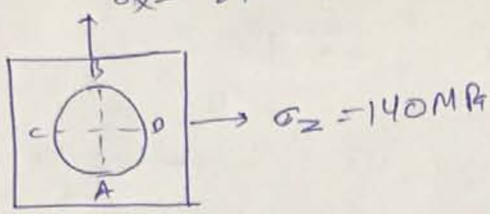


$\sigma_1/\sigma_2 = \frac{(\sigma_x+\sigma_y)}{2} \pm \frac{1}{2}\sqrt{(\sigma_x-\sigma_y)^2+4\tau_{xy}^2}$

$= \frac{(84+140)}{2} \pm \frac{1}{2}\sqrt{(84-140)^2+4\times0^2}$

$\sigma_1 = 140 MP$

Q1 (e)



since shear stress = 0.

$\therefore \sigma p_1 = 140\,MPa = \sigma_z$

$\sigma p_2 = 84\,MPa = \sigma x$

$$\frac{(\Delta L_{AB})}{L_{AB}} = \frac{\sigma x}{E} - \frac{V\sigma z}{E} = \left(\frac{84 - \frac{1}{3}\times 140}{70\times 10^3}\right) = \frac{\Delta L_{AB}}{225}$$

(a) $\boxed{(\delta L)_{AB} = 0.12\,mm}$ increase

(b) $$\frac{(\delta L)_{CD}}{L_{CD}} = \frac{\sigma z}{E} - \frac{V\sigma x}{E} = \frac{140 - \frac{1}{3}\times 84}{70\times 10^3} = \frac{\Delta L_{CD}}{225}$$

$\boxed{(\delta L)_{CD} = 0.36\,mm}$ (increase)

(c) $$\epsilon_y = \frac{\sigma y}{E} - \frac{V\sigma x}{E} - \frac{V\sigma z}{E}$$

$$\frac{\Delta t}{t} = 0 - \frac{\frac{1}{3}(140+84)}{70\times 10^3}$$

$\boxed{\Delta t = -0.0192\,mm}$

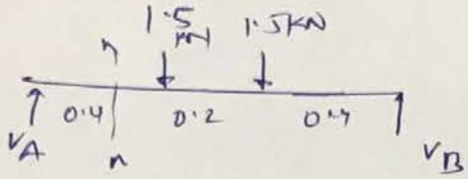
(d) $$\frac{\Delta V}{V} = \frac{(\sigma x + \sigma y + \sigma z)}{E}(1-2\nu)$$

$$\Delta V = \frac{(140+84+0)}{70\times 10^3} * \left(1 - 2\times\frac{1}{3}\right) * (380 * 380 \times 18)$$

$= \underline{\underline{2772.48\,mm^3}}$

~~Q1(c)~~

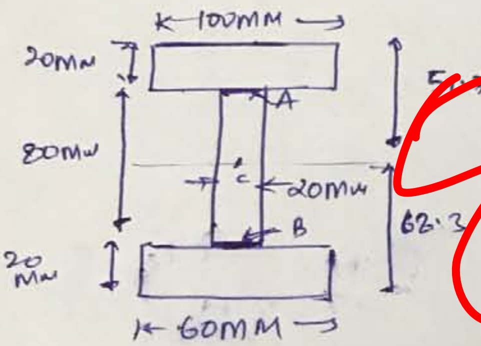
Q 1(c)



$V_A * (0.4+0.2+0.4) = 1.5 * 0.6 + 1.5 * 0.4$

$V_A = 1.5KN$

$\therefore V_A$ (at n–n) section $= V =$ 1.5KN



at A , $(\tau)_A = \left(\frac{VQ}{It}\right) = \frac{(1.5\times10^3) * (100*20) * (57.2-10)}{(8.63\times10^{-6} * 10^{12}) * 20}$

$= 0.7248 N/mm^2$

at B , $\tau_B = \frac{VQ}{It} = \frac{1.5\times10^3 * (60\times20) * (62.3-10)}{8.63\times10^{-6}\times10^{12} * 20}$

$= 1.013 N/mm^2$

Q1(a)

$$(\tau_{max})_{Al} = \frac{16T}{\pi D^3(1-K^4)}$$

$$(\tau_{max})_{steel} = \left(\frac{16T}{\pi d^3}\right)$$

$$\frac{(\tau_{max})_{Al}}{(\tau_{max})_{steel}} = \frac{d^3}{D^3(1-K^4)} = \frac{50^3}{76^3\left(1-\left(\frac{60}{76}\right)^4\right)}$$

if $(\tau_{max})_{Al} = 70\,MPa$

$\therefore (\tau_{max})_{steel} = 150\,MPa > 120\,MPa$ not ok

if $(\tau_{max})_{steel} = 120\,MPa$

$\therefore (\tau_{max})_{Al} = 55.88\,MPa < 70\,MPa$ ok

$$\therefore (\tau_{max})_{steel} = \frac{16T}{\pi d^3}$$

$$120 = \frac{16T \times 10^6}{\pi * (50)^3}$$

$$\boxed{T = 2.945\,KNm}$$

Q1(b) stress in steel $(\sigma_s) = P/A$

$$140 = \frac{P}{(480)}$$

$$P = 67.2\,KN$$

stress in bronze $= (2P/A) = 120$

$$\frac{2 \times P}{650} = 120$$

$$\boxed{P = 39\,KN}$$

stress in Al $= (2P/A) = 80$

$$\frac{2 \times P}{320} = 80 \Rightarrow P = 12.8\,KN$$

$$(DL)_T = (D)_{st} + (D)_b + (D)_{Ae}$$

$$3.0 = \left(\frac{PL}{AE}\right)_{st} + \left(\frac{PL}{AE}\right)_b + \left(\frac{PL}{AE}\right)_{Ae}.$$

$$\cancel{3 = (P\times10^3)\,\frac{1\times10^3}{480\times200\times10^3}}$$

$$3 = \frac{(P\times10^3)\times1\times10^3}{480\times200\times10^3} + \frac{(2P\times10^3)\times2\times10^3}{650\times70\times10^3} + \frac{(2P\times10^3)\times1.5\times10^3}{320\times83\times10^3}$$

$$\boxed{P = 84.61\ kN}$$

$$\therefore \boxed{\text{largest load} = 12.8\ kN}$$

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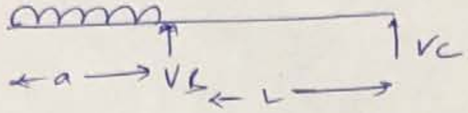
Q4 (b)

w per unit len



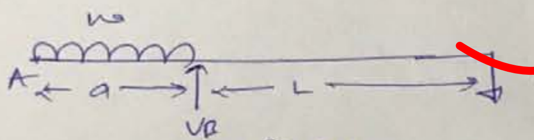
$\Sigma M_C = 0 \Rightarrow \quad V_B \times (L) = w \times a \times (L + \frac{a}{2})$

$$V_B = \frac{wa(2L+a)}{2L}$$

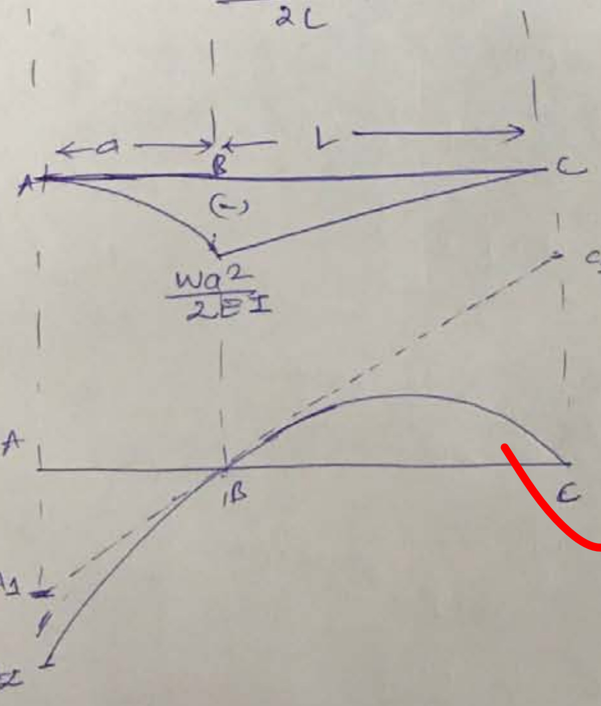
$$V_C = wa - \frac{wa(2L+a)}{2L}$$

$$= \frac{2Lwa - 2Lwa - wa^2}{2L}$$

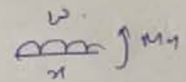
$$= \left(\frac{-wa^2}{2L}\right)$$



BMD / EI

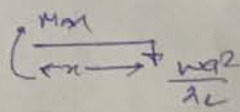


AB



$M_x = -\frac{wx^2}{2}$

CB



$M_x = -\frac{wa^2 x}{2L}$

$$\delta_{C/B} = CC_1 = -\frac{1}{2} \times \frac{wa^2}{2EI} \times L \times \frac{2L}{3}$$

$$= -\frac{2wa^2L^2}{12EI} = \left(-\frac{wa^2L^2}{6EI}\right)$$

$$\theta_B * L = +\frac{wa^2L^2}{6EI}$$

$$\theta_B = \left(\frac{wa^2L}{6EI}\right)$$

$$\theta_B \times a = AA_1 = \left(\frac{wa^3L}{6EI}\right)$$

$$\delta_{A/B} = A_1A_2 = -\frac{1}{3}\left(\frac{wa^2}{2EI}\right) \times a * \left(\frac{3a}{4}\right)$$

$$= -\left(\frac{wa^4}{8EI}\right)$$

$\therefore$ deflection at A = $A_1A_2 + AA_1$

$$= \left(\frac{wa^4}{8EI} + \frac{wa^3L}{6EI}\right)$$

Q 4(C)

$$\delta_{max} = 2MM = \delta$$

$$2MM = \delta_{static}\left(1 + \sqrt{1 + \frac{2h}{\delta_{static}}}\right)$$

$$2 = \delta_{static}\left(1 + \sqrt{1 + \frac{2 * 10}{\delta_{static}}}\right)$$

$$\delta_{static} = 0.167MM$$

$$\frac{PL}{AE} = 0.167MM$$

$$\frac{P * 4 \times 10^3}{600 * 200 \times 10^3} = 0.167$$

$$\boxed{P = 5 KN}$$

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$$\sigma_{max} = \sigma_{static}\left(1+\sqrt{1+\frac{2h}{\delta_{static}}}\right)$$

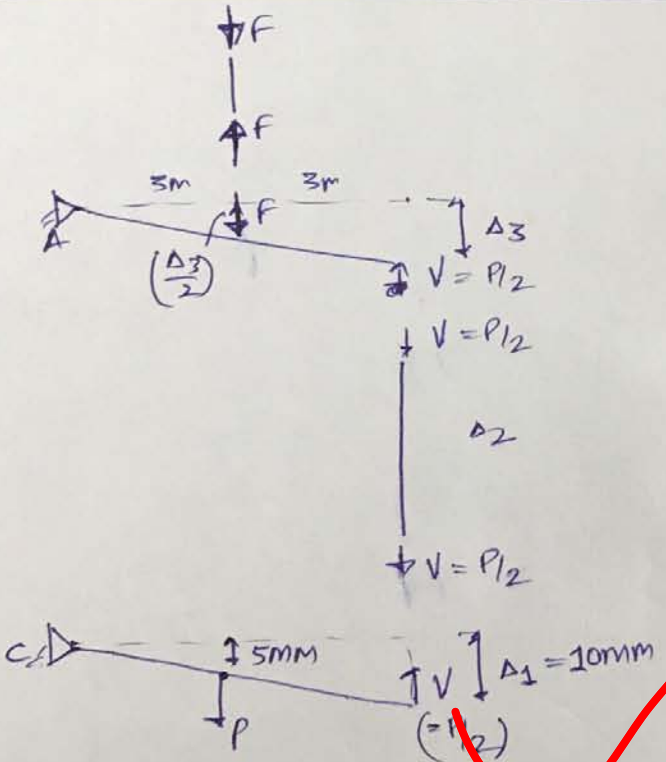
$$= \frac{P}{A}\left(1+\sqrt{1+\frac{2h}{\delta_{static}}}\right)$$

$$= \frac{(5\times10^3)}{600}\left[1+\sqrt{1+\frac{2\times10}{0.07}}\right]$$

$$= 99.99 \ N/mm^2$$

$$\boxed{\sigma_{max} \cong 100 \ N/mm^2}$$

Q 4(a)



$$\frac{5}{3} = \frac{\Delta_1}{6}$$

$$\boxed{\Delta_1 = 10mm}$$

$\Sigma M_C = 0$

$P \times 3 = V \times 6$

$V = P/2$

$\Sigma M_A = 0 \Rightarrow F \times 3 = V \times 6$

$F \times 3 = P/2 \times 6$

$$\boxed{F = P}$$

$$\frac{\Delta_3}{2} = \frac{FL}{AE}$$

$$\Delta_3 = \left(\frac{2FL}{AE}\right) \quad ; \Delta_2 = \frac{VL}{AE}$$

$$\Delta_1 = \Delta_2 + \Delta_3$$

$$10 = \left(\frac{2FL}{AE}\right)_{Alumi} + \left(\frac{VL}{AE}\right)_{steel}$$

$$10 = \left(\frac{2 \times P \times 2 \times 10^3}{500 \times 70 \times 10^3}\right) + \frac{P}{2} \times \frac{2 \times 10^3}{(300 \times 200 \times 10^3)}$$

$$\boxed{P = 76.363 kN}$$

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Q5 (a)

$V = 65\,kmph$

$V_b = (65-15) = 50\,kmph$

$OSD = d_1 + d_2 + d_3$ (2 way)

$d_1 = (v_b t) = \frac{50}{3.6} * 2 = 27.78\,m$

$d_2 = (b + 2s)$

$s = 0.2 V_b + L = 0.2V + 6$

$= 0.2 \times 50 + 6 = 16\,m.$

$T = \sqrt{\frac{4s}{a}} = \sqrt{\frac{4 \times 16}{3.28/3.6}} = \underline{8.381\,sec}$

$b = v_b T = \frac{50}{3.6} \times 8.381 = \underline{116.41\,m}$

$2s = 16\,m \times 2 = 32\,m.$

$d_2 = 116.41 + 32 = \underline{148.41\,m}$

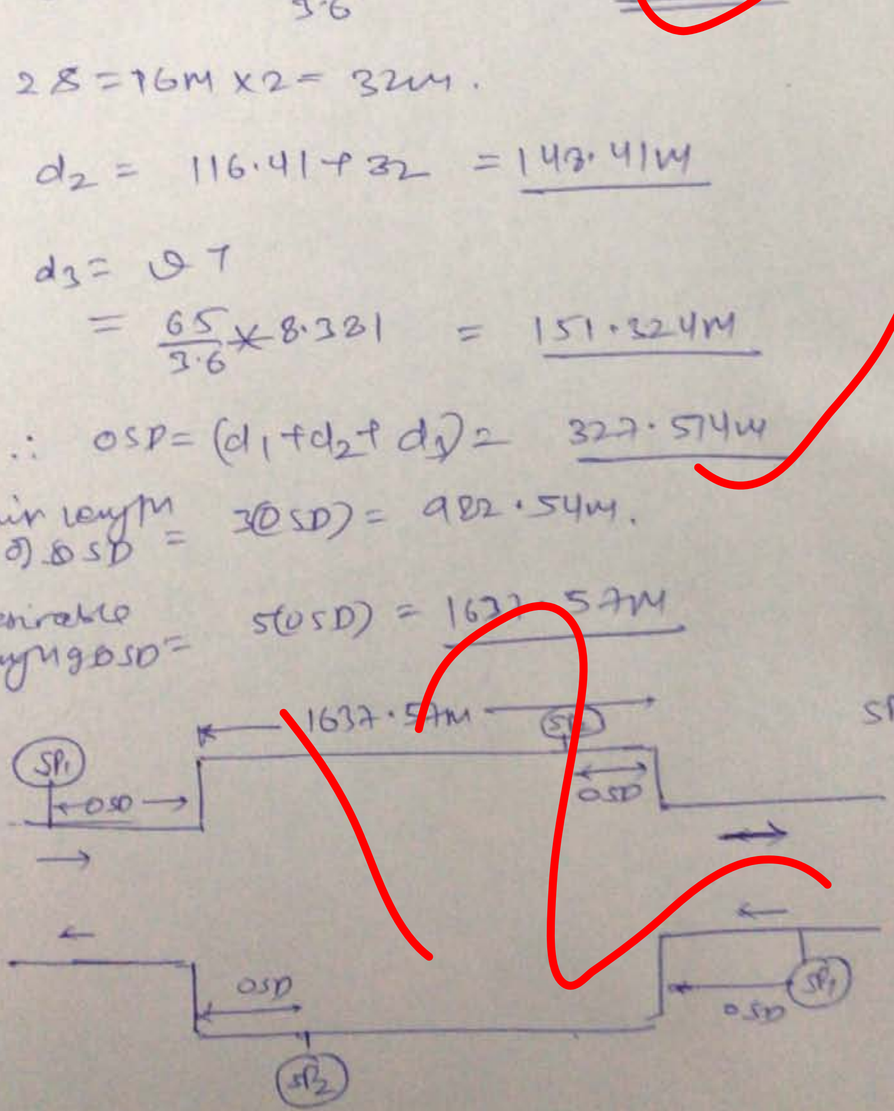
$d_3 = v T$

$= \frac{65}{3.6} * 8.381 = \underline{151.324\,m}$

$\therefore OSD = (d_1 + d_2 + d_3) = \underline{327.574\,m}$

min length of OSD $= 3(OSD) = 982.54\,m.$

desirable length of OSD $= 5(OSD) = \underline{1637.57\,m}$



SP_1 – overtaking zone starts

SP_2 – overtaking zone ends.

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Q5 (c)

$$H = \frac{(h_B - h_A) + (h_B' - h_A')}{2}$$

$$= \frac{1.63 - 1.03 + 1.54 - 0.95}{2}$$

$$\boxed{H = 0.595\,m}$$

B is at lower elevation than A.

$$\therefore (RL)_B = (RL)_A - H$$

$$= (450) - 0.595$$

(i) $\boxed{(RL)_B = 449.405\,m}$

(ii) Combined correction $C = -0.0673\,d^2$

$$= -0.0673 \times (0.8)^2\ m$$

$$= -0.043072\,m$$

(iii) Total error $= (h_B) - (h_A + H)$

$$= 1.63 - (1.03 + 0.595)$$

$$= 0.005\,m$$

Error = combined error due to refraction & curvature + collimation error

$0.005 = +0.043072 + (E_{CL})$

$$\boxed{E_{CL} = -0.038072}$$

Q5 (d) (a) $FoS = \frac{\tan\phi}{\tan\beta}$

$$1.3 = \frac{\tan 35}{\tan\beta}$$

b) $\boxed{\beta = 28.3070^{\circ}}$

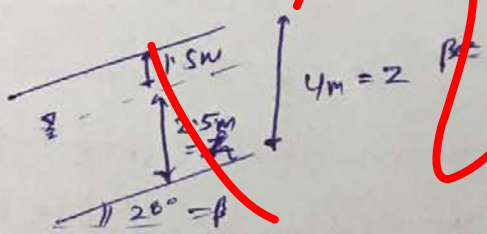
(b) $$fos = \left(1 - \frac{h}{z}\frac{\gamma_w}{\gamma_{avg}}\right)\frac{\tan\phi}{\tan\beta} \quad \left(\gamma_{avg} = \gamma_{sat} \text{ here}\right)$$

$$1.3 = \left(1 - \frac{\gamma_w}{\gamma_{sat}}\right)\frac{\tan\phi}{\tan\beta}$$

$$1.3 = \left(1 - \frac{9.81}{19}\right)\frac{\tan 35}{\tan\beta}$$

$$\boxed{\beta = 14.6^{\circ}}$$

(c) $$fos = \left(1 - \frac{h}{z}\frac{\gamma_w}{\gamma_{avg}}\right) * \frac{\tan\phi}{\tan\beta}$$



Assume $\gamma_{avg} = \gamma_{sat} = 19\ kN/m^3$

$$fos = \left(1 - \frac{2.5}{4} * \frac{9.81}{19}\right)\frac{\tan 35}{\tan 28}$$

$\boxed{fos = 0.892}$

Q5 (e) (i) Intercepting trap:

for collecting sewage coming from a building or a community

(ii) Gully trap: used in toilets in households to trapping wells and stop the backflow of gases and odour

(iii) floor trap: for trapping sediments

Q5 (b). factors controlling highway alignment

1. Population
2. cities / towns ~~[illegible]~~ through which highway is passing
3. cost of construction.
4. production happening in the region

While aligning roads in hilly areas,
hair pin bends must be avoided,
proper sight distance to be provided,
proper gradient and superelevation for rainfall drainage purpose.
Extra width ~~for~~ at curves.

Q 6 (a)

(a) comfort conditi

$$L_s = 2\sqrt{\frac{N v^3}{c}} \quad , N = \frac{1}{30} + \frac{1}{40} = \frac{7}{120}$$

$$= 2\sqrt{\frac{\frac{7}{120} * (85/3.6)^3}{0.6}}$$

$$= \underline{71.55m}$$

(b) Head light sight req

Assume $L > SSD$

$$SSD = vt + \frac{v^2}{2f} = \frac{85}{3.6} \times 2.5 + \frac{(85/3.6)^2}{2 \times 9.81 \times 0.35}$$

$$= \underline{140.21m}$$

$$L = \frac{NS^2}{1.5 + 0.035S} = \frac{7/120 * 140.4^2}{1.5 + 0.035 \times 140.21}$$

$$= \underline{178.98m} > 140.21m \quad OK$$

$\therefore$ Adopt $\boxed{L = 179m}$

Q 6 (b) (i)

line	latitude (m)	depart (m)	correction in lat (m)	correction in dep	corrected latitude	corrected departure
AB	0.	183.79	-0.056	+0.07	~~183.794~~ -0.056	183.86
BC	128.72	98.05	-0.05	+0.0613	128.67	98.111
CD	177.76	-140.85	-0.07	0.086	177.69	-140.764
DE	-76.66	-154.44	-0.053	+0.065	-76.713	-154.375
EF	-177.09	0.00	-0.054	+0.067	-177.144	+0.067
FA	-52.43	13.02	-0.077	0.02	-52.442	13.1
	$e_L = 0.3$	$e_D = -0.37$				

correction in latitude $(C_L) = \frac{l_1}{\Sigma l} \times e_L = \frac{l_1}{975.947} * (-0.3)$

$L = \sqrt{lati^2 + Dep^2}$

$L_{AB} = \sqrt{0^2 + 183.79^2} = 183.79\ m.$

$L_{BC} = 161.27\ m$

$L_{CD} = 226.8\ m$

$L_{DE} = 172.42\ m$

$L_{EF} = 177.09$

$L_{FA} = 54.037\ m$

$\therefore \Sigma l = (L_{AB} + L_{BC} + L_{CD} + \ldots - L_{FA})$

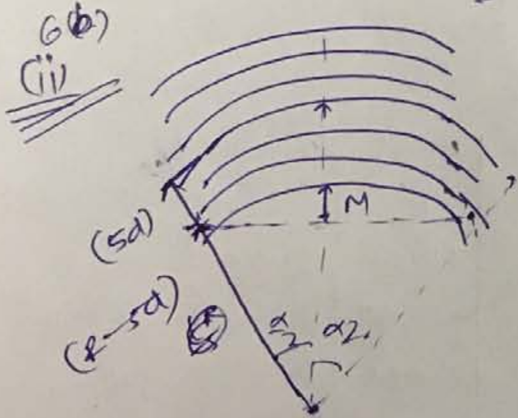
$= \underline{975.947\ m}$

correction in depar $= \frac{l_1}{975.47} * + 0.37$

For CD, $\tan\theta = \frac{\text{Departure}}{\text{Latitude}} = \frac{-140.704}{177.69}$

$\boxed{\theta = 321^\circ 36' 51''}$

6(b)
(ii)



$L = 100\ m$
$S = 200\ m$

$d = \frac{3.5}{2}$
$= \underline{1.75\ m}$

$\frac{\left(\frac{\alpha}{2}\right)}{360} = \frac{S/2}{2\pi(R - 5d)}$

$\frac{\alpha_2}{720} = \frac{200/2}{2\pi(500 - 5 \times 1.75)}$

$\left(\frac{\alpha}{2}\right) = 11.663^\circ$

$$M = (R - 6d) - (R - 5d)\cos(\alpha/2)$$

$$= (500 - 6\times 1.75) - (500 - 5\times 1.75)\cos(11.661)$$

$$\boxed{M = 8.29m}$$

Q6 c(i)

$$q_u = 2c = 3.8t/m^2$$

$$\boxed{c = 1.9t/m^2}$$

$$d = 0.3m$$

$$Q_{safe} = \frac{Q_{up}}{F} = \frac{q_c(A_b) + \alpha\bar{c}(A_s)}{F}$$

$$= \frac{9\times 1.9\times \frac{\pi}{4}\times 0.3^2 + 0.95\times 1.9\times(\pi\times 0.3\times 19)}{3}$$

$$= 11.177\,t$$

$$\boxed{Q_{safe} = 109.65\,kN}$$

(ii) Two methods are

(a) Differential free swell test (kerosene used)

(b) free swell test (water used).

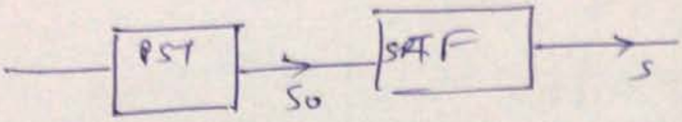
8

10

1

Q 7(a)

(i)



$S_0 = 160 \, mg/L$

$OLR = 160 \, gm/m^3/day = \frac{160 \times 10^{-3}}{10^{-4}} = 1600 \, kg/ham/d$

$SLR = 2000 \, l/m^2/day$

$Q_0 = 4.5 \, MLD$

(1) surface area $= \frac{Q_0}{SLR}$

$= \frac{(4.5 \times 10^6)}{2000} =$

$\underline{SA = 2250 \, m^2}$

(2) volume $(V) = \frac{Q_0 S_0}{OLR}$

$= \frac{(4.5 \times 10^6) \times (160)}{160 \times 10^3}$ $\frac{(l/d) \times (mg/l)}{(mg/m^3/d)}$

$\boxed{V = 4500 \, m^3}$

$\therefore H = \frac{V}{SA} = \frac{4500}{2250} = \underline{\underline{2m}}$

$\boxed{H = 2m}$

efficiency $= \eta = \frac{100}{1 + 0.0044\sqrt{u}} = \frac{100}{1 + 0.0044\sqrt{1600}}$

$\downarrow$ (kg/ham/day)

$\boxed{\eta = 85.03\%}$

7(a) (ii) Total volume of septic tank $= V_T = V_1 + V_2$

$V_1 = (Q_0) t_D$

$Q_0 = (70 \times 10^{-3}) * (100)$ (m^3/d)

$= 7 m^3/d$

$V_1 = 7 \times \frac{24}{24} = \underline{7 m^3}$

Assume Rate of accumulation of sludge (RAS) $= 50 l/c/yr$.

Assume cleaning period (CP) $=$ 6 months.

$\therefore V_2 = (RAS) \times CP$

$= (50 \times 10^{-3}) \times 100 \times \left(\frac{6}{12}\right)$

$= \underline{\underline{2.5 m^3}}$

$\therefore V_T = (V_1 + V_2) = 7 + 2.5$

$\boxed{V_T = 9.5 m^3}$

7(b) $W = 7m$

$R = 60m$

$V = 40$ kmph.

Length of transition curve

(i) $L_s = \frac{v^3}{CR}$

$C = \frac{80}{75 + V} = \frac{80}{75 + 40} = \underline{0.696}$

$L_s = \frac{(40/3.6)^3}{0.696 * 60} = \underline{\underline{32.9 m}}$

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(ii) $W = eN(w + w_e)$ (Assume rotation at inner edge)

$$e = \frac{V^2}{225R} = \frac{40^2}{225 \times 60} = \underline{\underline{0.1185}} \geq 0.07$$

$\therefore e = 0.07$ $\quad \therefore w_e = \frac{nl^2}{2R} + \frac{V}{9.5\sqrt{R}}$

$N = 60$

$\therefore$ ~~[illegible]~~ Assume $l = 6.1m$

$$\therefore w_e = \frac{2 \times 6.1^2}{2 \times 60} + \frac{40}{9.5\sqrt{60}} = \underline{\underline{1.164m}}$$

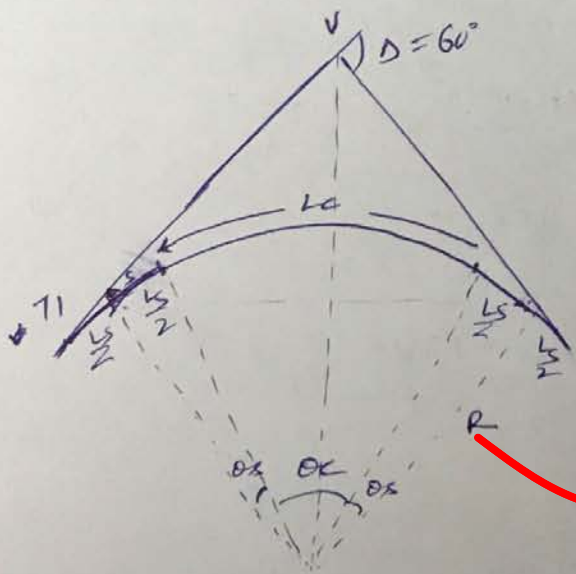
$$\therefore L_s = 0.07 \times 60\,(7 + 1.164)$$

$$= \underline{\underline{34.3M}}$$

(iii) $L_s = \frac{V^2}{R} = \frac{40^2}{60} = \underline{26.67m}$

$\therefore (L_{max}) = 34.3m$

Take $\boxed{L = 35M}$



Shift of curve

$$= \frac{Ls^2}{24R} = \frac{35^2}{24 * 60}$$

$$= \underline{\underline{0.85M}}$$

$$\frac{\theta_s}{360} = \frac{L_s/2}{2\pi R}$$

$$\frac{\theta_s}{360} = \frac{35/2}{2\pi * 60} \Rightarrow \theta_s = 16.71^\circ$$

$\Delta = (2\theta_s + \theta_c)$

$\theta_c = 60 - 2 \times 16.71$

$\theta_c = 26.58°$

$$\frac{\theta_c}{360} = \frac{L_c}{(2\pi R)}$$

$$\frac{26.58}{360} = \frac{L_c}{2\pi \times 60}$$

$L_c = 27.83m$

$\therefore$ Total length of curve $= L_c + (2L_s)$

$= 27.83 + 2 \times 35$

$= \underline{97.83m}$

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Tangent length $VT_1 = (R + s) \tan(\Delta/2) + \frac{L_s}{2}$

$= (60 + 0.85) \tan(30) + 17.5$

$\boxed{VT_1 = 52.63m}$

$\underline{Q7(c)(ii)}$ $\alpha = \frac{l}{R} = \left(\frac{s}{nD}\right)$

$$n = \frac{(20-10) + (20-10)}{2} = 10$$

$$\frac{(2 \times 10^{-3})}{R} = \frac{(1.68 - 1.602)}{10 \times 80}$$

$\boxed{R = 20.513m}$

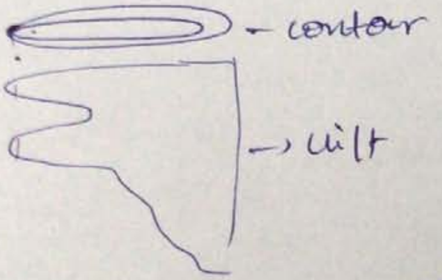
Q7 c(i) ① contours cannot cross each other, except in case of overhanging cliff.

② closed contours with increasing values represent a hill and with decreasing values represent valley.

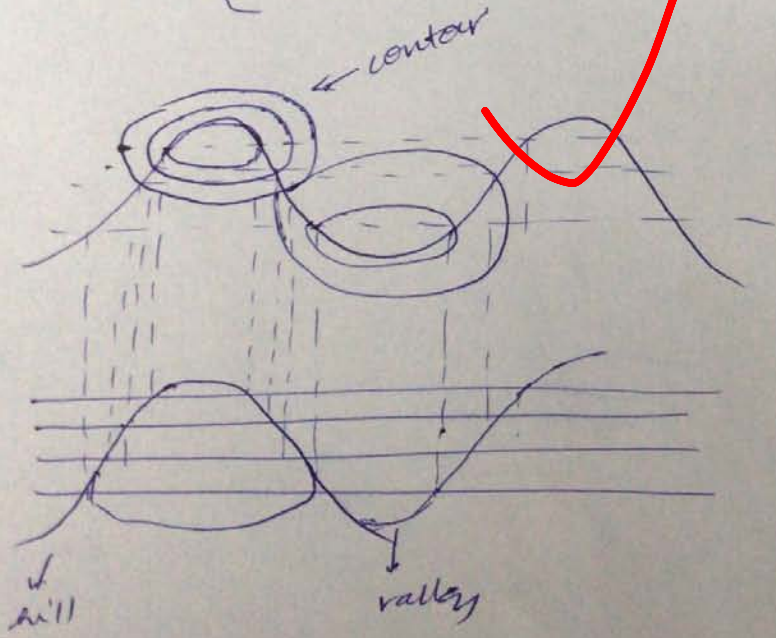
③. very closed spaced contours represents steep slope

④ large spaced contours represents relatively flat ground.

①



②



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③