Ques - 1, 2, 3, 5, 6

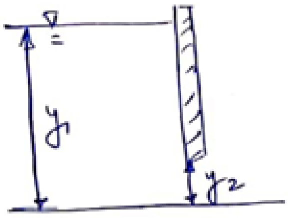
233/300

Section - A

NAME :
ROLL NO :
FST - 1 (PAPER - 2)
DATE :

Q-1-a) $B = 2m$, $y_1 = 2.5m$, $y_2 = 0.5m$

Case 1) Neglecting losses



from continuity

$\cancel{B} \times V_1 \times y_1 = \cancel{B} V_2 y_2$

$V_1 \times 2.5 = V_2 \times 0.2$

$\Rightarrow \boxed{V_2 = 12.5 V_1}$

Applying energy conservation at two sections

equating $\boxed{E_1 = E_2}$

$$\therefore \quad y_1 + \frac{v_1^2}{2g} = y_2 + \frac{v_2^2}{2g}$$

$$2.5 + \frac{v_1^2}{2g} = 0.2 + \frac{(12.5 v_1)^2}{2g}$$

$$2.3 = \frac{1}{2g}(155.25) v_1^2$$

$\Rightarrow v_1 = 0.539 m/s$ and $v_2 = 12.5 v_1 = 6.739 m/s$.

$\therefore Q = (B \times y_1 \times v_1) = (2 \times 2.5 \times 0.539) = 2.695 m^3/s$ Ans.

Case 2: considering losses:

$\therefore E_1 = E_2 + \text{losses}$ $\quad \because (h_L = 10\% \text{ of } y_1)$

$$y_1 + \frac{v_1^2}{2g} = y_2 + \frac{v_2^2}{2g} + 0.1(y_1)$$

$$2.5 + \frac{v_1^2}{2g} = 0.2 + \frac{(12.5 v_1)^2}{2g} + 0.1 \times 2.5$$

$$\Rightarrow 2.05 = \frac{155.25 v_1^2}{2g}$$

12

$\therefore v_1 = 0.5089 m/s$ and $v_2 = 12.5 v_1 = 6.362 m/s$.

Scanned with CamScanner

$\therefore Q = (B \times y_1 V_1) = (2 \times 2.5 \times 0.5089) = \underline{2.5445\ m^3/s}$ Ans.

1.b) $d = 8\,cm$

$V_{3cm} = 1.3 V_{1cm}$

Soln:

$\because \dfrac{u - \bar{u}}{V_*} = 5.75 \log_{10}\left(\dfrac{y}{k_s}\right) + 8.5$ for rough Turbulent regime

@ $y = 3\,cm$ from wall

$$\frac{1.3\,V_{1cm}}{V_*} = 5.75 \log\left(\frac{0.03}{k_s}\right) + 8.5 = 5.75 \log_{10}\left(\frac{30 \times 0.03}{k_s}\right) \quad —①$$

@ $y = 1\,cm$

$$\frac{V_{1cm}}{V_*} = 5.75 \log_{10}\left(\frac{0.01}{k_s}\right) + 8.5 = 5.75 \log_{10}\left(\frac{30 \times 0.01}{k_s}\right) \quad —②$$

dividing eq ① by ②

$$\frac{1.3\,V_{1cm}}{V_{1cm}} = \frac{\log_{10}\left(\frac{0.9}{k_s}\right)}{\log_{10}\left(\frac{0.3}{k_s}\right)} \quad —③$$

Also from velocity distbn:

$$\frac{1.3V - \bar{u}}{V_*} = 5.75 \log_{10}\left(\frac{3}{4}\right) + 3.75 \quad @\ y = 3cm.$$

$$\Rightarrow \frac{1.3V - \bar{u}}{V_*} = 3.0316$$

and $\dfrac{V - \bar{u}}{V_*} = 5.75 \log_{10}\left(\dfrac{1}{4}\right) + 3.75 = \underline{0.288}$

$\therefore$ putting these value in eq ①

$$\frac{3.0316}{0.288} = \frac{\log_{10}\left(\frac{0.9}{k_s}\right)}{\log_{10}\left(\frac{0.3}{k_s}\right)} \Rightarrow 10.526 = \frac{\log_{10} 3 + \log_{10}\left(\frac{0.3}{k_s}\right)}{\log_{10}\left(\frac{0.3}{k_s}\right)}$$

$$\Rightarrow 9.5264 \log_{10}\left(\frac{0.3}{k_s}\right) = \log_{10} 3$$

$$\Rightarrow 1.1222 = \frac{0.3}{k_s} \qquad \Rightarrow \underline{k_s = 0.267\,m}$$

from eq ③

$$\Rightarrow 1.3 \log_{10}\left(\frac{0.3}{k_s}\right) = \log_{10} 3 + \log_{10}\left(\frac{0.3}{k_s}\right)$$

$$\Rightarrow 0.3 \log_{10}\left(\frac{0.3}{k_s}\right) = \log_{10} 3$$

$$\Rightarrow \underline{k_s = 7.704 \times 10^{-3}\,m} \quad \text{or} \quad \underline{0.7704\,cm} \quad \text{(Ans)}$$

12

Scanned with CamScanner

1-c) Area = 2ha

(E+P) loss = 1.5mm/day

water req = 6cm

3

Soln: Total water loss in entire duration of irrigation = 1.5×90 = 135mm or 13.5cm

∴ Total water reqd in 90 days of irrigation = (13.5+6) = 19.5cm

∴ Volume of Pond needed to be dug = $(19.5 \times 10^{-2} \times 2 \times 10^4)$ = 3900 m^3 Ans

1-d)

i) Smoke: fumes or loops of air containing dust and particulate matter in it can be termed as smoke.

Smoke may also be defined as the rising plumes of dust packets in the atmosphere containing particles of relatively finer size.

ii) fumes: fumes are also the rising gases of relatively lesser density generated as a ~~at~~ action of high temperature burning of substance. fumes mostly contain gases with very minute percentage of dust particles.

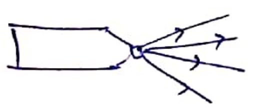
iii) Fly ash: It is a waste-product that is generated from cement industry and is categorised as the unburnt cement clinkers.

Fly ash can be categorised as:

a) class C fly ash b) class F fly ash.

iv) Mist: Mist is the smoke enveloped with moisture or water droplets and can be ~~cha~~ categorised as suspension of gaseous particles in water.

v) spray: very fine droplets of water coming out from a nozzle whose surface area is enhanced is termed as spray.



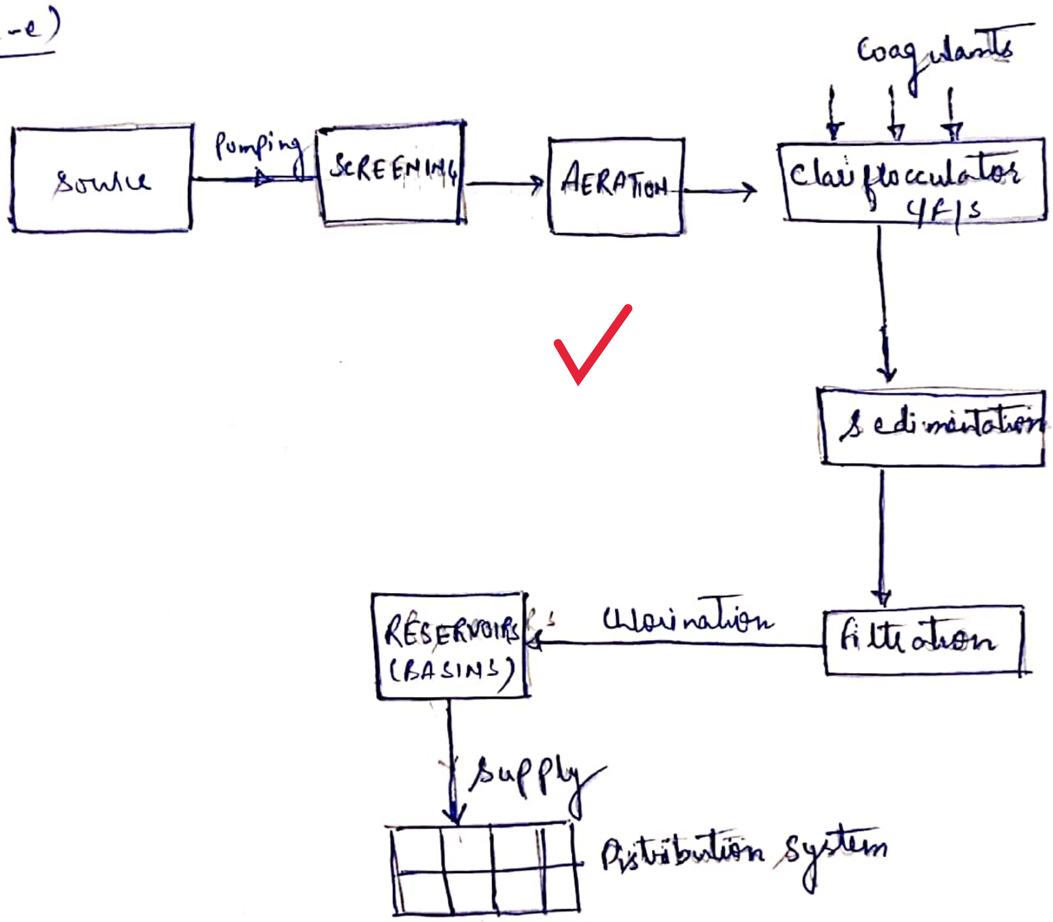
spray

7

b) <u>opacity</u> : The durability or the thickness of a surface which may be painted or varnished is called as its <u>opacity</u>.

It is a property which imparts strength, soundness and durability to the surface.

1-e)



<u>chemicals (coagulants) added during coagulation in clariflocculators</u> are:

1) Alum $(Al_2(SO_4)_3 \cdot 18H_2O)$

$$Al_2(SO_4)_3 \cdot 18H_2O + 3Ca(OH)_2 \longrightarrow \underset{\text{(Sticky ppt)}}{2Al(OH)_3} + \underset{\text{(hardness)}}{3CaSO_4} + 6CO_2\uparrow + H_2O$$

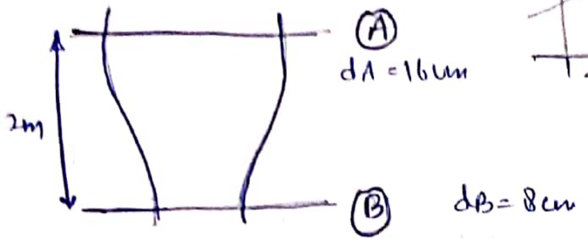
2) <u>copperas</u> $(FeSO_4 \cdot 7H_2O)$

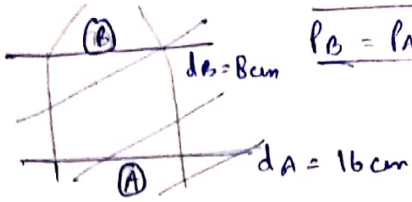
$$FeSO_4 \cdot 7H_2O + Ca(OH)_2 \longrightarrow Fe(OH_2) \xrightarrow{O_2} \underset{\text{(ppt)}}{Fe(OH_3)}$$

7

Scanned with CamScanner

Q-2-A) SG of oil = 0.8





$\underline{P_B = P_A + 0.981\ N/cm^2}$

Soln: from continuity

$A_A \times V_A = A_B \times V_B$

$\frac{\pi}{4} \times 16^2 \times V_A = \frac{\pi}{4} \times 8^2 \times V_B \Rightarrow \underline{V_B = 4V_A}$

Applying energy eqn b/w A and B

$\frac{P_A}{\rho g} + \frac{V_A^2}{2g} + Z_A = \frac{P_B}{\rho g} + \frac{V_B^2}{2g} + \cancel{Z_B} \rightarrow$ datum

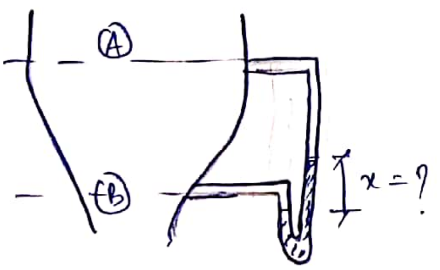
$\cancel{\frac{P_A}{\rho g}} + \frac{V_A^2}{2g} + 2 = \cancel{\frac{P_A}{\rho g}} + \frac{0.981 \times 10^4}{800 \times 9.81} + \frac{(4V_A)^2}{2g}$

$\Rightarrow 0.75 = \frac{1}{2g}(16V_A^2 - V_A^2)$

$\Rightarrow V_A = 0.99045\ m/s$

$\therefore Q = A_A \times V_A = \frac{\pi}{4} \times (0.16^2) \times 0.99045 = 0.019914\ m^3/s$ or $\underline{19.914\ l/s}$ Ans

Case 2: Gauges replaced by U-Tube Manometer



$A_A = \frac{\pi}{4} \times 0.16^2 = 0.0201\ m^2$

$A_B = \frac{\pi}{4} \times 0.08^2 = 5.0265 \times 10^{-3}\ m^2$

$\because Q_{th} = \frac{A_1 A_2}{\sqrt{A_1^2 - A_2^2}} \times \sqrt{2gh}$

$0.019914 = \frac{0.0201 \times 5.0265 \times 10^{-3}}{\sqrt{(0.0201)^2 - (5.0265 \times 10^{-3})^2}} \times \sqrt{2 \times 9.81 \times h}$

$\Rightarrow 3.83408 = \sqrt{2 \times 9.81 \times h}$

$\Rightarrow h = 0.74924\ m.$

20

Scanned with CamScanner

$\because h = x\left[\frac{S_H}{S} - 1\right]$

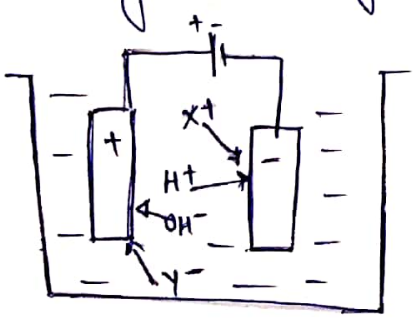
$\Rightarrow 0.74924 = x\left[\frac{13.6}{0.8} - 1\right]$

$\Rightarrow$ x (difference in readings) = 0.04683 or 4.683 cm Ans.

2-b-i) Corrosion: corrosion is a phenomena in which metal surface on coming in contact with moisture and oxygen present in the air forms respective metal oxides, which tends to accumulate over the metal surface kya 'rust'. This phenomena of development of skin of metal oxide over the surface of metal is kya 'corrosion'. Corrosion tends to cause pitting and Tuberculation in metal pipes and thus reduces their discharge carrying capacity.

Methods to prevent corrosion:

1) Cathodic Protection
2) ~~Anoidic~~ Anoidic Protection (Reducing The SA of anodes)
3) Galvanazing
4) Painting The metal surfaces
5) Reducing the voltage supply Through electrolytic solution.



6) By Regularly cleaning The exposed surfaces of dirt and moisture.

6

Scanned with CamScanner

2-b-ii) Population = 150

water supply = 120 l/c/day

Soln: Assuming 80% of water supplied gets converted to waste water

$\therefore Q_{waste} = 0.8 \times 120 \times 150 = 14400$ l/day

Since septic tanks consists of [digestion Tank + sedm Tank]

$\therefore V_{septic} = V_{dig} + V_{sedm}$

Assuming To (detention Time of 24hrs)

$\therefore V_{sedm} = Q_0 \times T_0 = 14400 \times 10^{-3} \times \frac{\cancel{24}}{\cancel{24}} = \boxed{14.4 m^3}$

→ Assuming Rate of accumulation of sluge 30 l/c/year and desludging period as 1 year

$\therefore V_{dig} = 30 \times 150 \times 10^{-3} \times 1 = \boxed{4.5 m^3}$

$\therefore V_{septic\ Tank} = (14.4 + 4.5) = \boxed{18.9 m^3}$

Assuming depth of Tank as 1.5m

$\therefore A_{Tank} = \left(\frac{V}{\cancel{H}}\right) = \left(\frac{18.9}{1.5}\right) = 12.6 m^2$

$\therefore A = \frac{\pi}{4} \times D^2$ (assuming circular tank configⁿ)

$\Rightarrow \boxed{D \simeq 4m}$

$\therefore$ Provide septic tank of dia 4m and height 1.5m + 0.3m (FB)

10

Q-c) Given: for $T = 200$ yrs $x_T = 600\ m^3/s$

and for $T = 100$ yrs $x_T = 450\ m^3/s$.

$x_T = ?$ for $T = 500$ yrs

Soln: Using Gumbell's Approach:

$\because x_T = \bar{x} + k_T \sigma$ where k_T (frequency factor) $= \left(\frac{y_T - y_n}{S_n}\right)$

and $y_T = -\ln\left(\ln\left(\frac{T}{T-1}\right)\right)$

$\therefore$ for $T = 200$ yrs $(y_T)_{200} = -\ln\left(\ln\left(\frac{200}{199}\right)\right) = \underline{5.2958}$

$T = 100$ yrs $(y_T)_{100} = -\ln\left(\ln\left(\frac{100}{99}\right)\right) = \underline{4.6}$

$\therefore x_{100} = 450\ m^3/s$ and $x_{200} = 600\ m^3/s$.

$\Rightarrow x_{200} = 600 = \bar{x} + \left[\frac{y_{200} - y_n}{S_n}\right]\sigma$ — ①

$x_{100} = 450 = \bar{x} + \left(\frac{y_{100} - y_n}{S_n}\right)\sigma$ — ②

Subtracting eq ② from ①:

$(600-450) = (y_{200} - y_{100}) \times \left(\frac{\sigma}{S_n}\right)$

$\Rightarrow \left(\frac{\sigma}{S_n}\right) = 215.579$

and $x_{500} = \bar{x} + k_{500} \times \sigma$ and $y_{500} = -\ln\left(\ln\left(\frac{500}{499}\right)\right) = \underline{6.2136}$

$x_{100} = \bar{x} + k_{100}\,\sigma$

from: $\therefore x_{500} - x_{100} = (y_{500} - y_{100}) \times \left(\frac{\sigma}{S_n}\right)$

$x_{500} - x_{100} = (6.2136 - 4.6) \times 215.579$ $\because \left[\frac{\sigma}{S_n} = 215.579\right]$

$\therefore x_{500} = x_{100} + 347.858$

$\Rightarrow x_{500} = (450 + 347.858) = \underline{797.858\ m^3/s}$ Ans

20

Q.3-a)

Given: $SP = 5.5MW$ @ $N = 150\,rpm$ @ $H = 5.5m$

$\eta_g = 93\%$ and $\eta_o = 88\%$

$D_o = 4.5m$ $D_b = 2m$, $\eta_h = 94\%$, $V_{w_2} = 0$

Soln:

$\because \eta_{gen} = \left(\frac{GP}{SP}\right) \Rightarrow SP = \left(\frac{5MW}{0.93}\right) = \overline{5.376\,MW}$

and $\eta_o = \left(\frac{SP}{WP}\right) \Rightarrow WP = \frac{SP}{\eta_o} = \left(\frac{5.376}{0.88}\right) = \overline{6.1095\,MW}$

and $\eta_h = \left(\frac{RP}{WP}\right) \Rightarrow RP = 0.94 \times WP = 0.94 \times 6.1095 = \overline{5.7429\,MW}$

→ Mean dia of runner $= \left(\frac{D_o + D_b}{2}\right) = \left(\frac{4.5+2}{2}\right) = \overline{3.25m}$

$\therefore u = \left(\frac{\pi D_{avg} \times N}{60}\right) = \left(\frac{\pi \times 3.25 \times 150}{60}\right) = \overline{25.525\,m/s}$

$\because RP = \left(\frac{V_{w_1} u_1}{g}\right)$

and $\boxed{WP = \dot{m} g H = \rho Q g H}$

$\therefore 6.1095 \times 10^3 = \cancel{10^3} \times 9.81 \times Q \times 5.5$

$\Rightarrow Q\,(\text{discharge}) = \overline{113.233\,m^3/s}$

$\therefore RP = \dot{m}\,[V_{w_1} u_1] = 5.7429 \times 10^6\,W$

$\Rightarrow V_{w_1} = \left(\frac{5.7429 \times 10^6}{\rho \times 113.233 \times 25.525}\right) = \overline{1.987\,m/s}$

from discharge eqn:

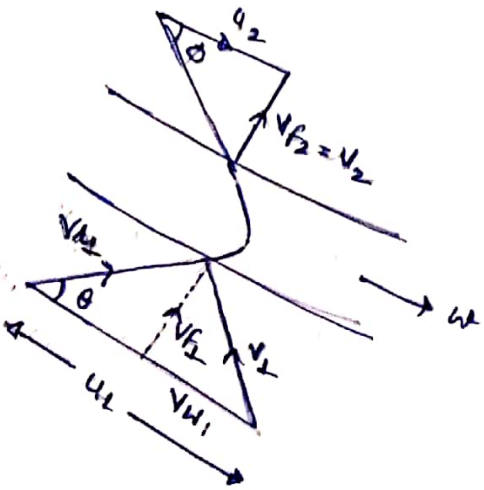
$\because \frac{\pi}{4}(D_o^2 - D_b^2) \times V_{f_1} = Q = 113.233$

$\Rightarrow \overline{V_{f_1} = 8.872\,m/s}$

$\therefore$ from inlet velocity triangle

$\tan\theta = \left(\frac{V_{f_1}}{u_1 - V_{w_1}}\right) = \left(\frac{8.872}{25.525 - 1.987}\right)$

$\therefore \theta = \tan^{-1}(0.3769) = \overline{20.6525^\circ}$ Ans.



Scanned with CamScanner

$\because V_{f_1} = V_{f_2} = 8.872 \, m/s.$

and $u_2 = u_1 = \left(\frac{\pi D_{avg} \times N}{60}\right) = \underline{\overline{25.525 \, m/s.}}$

$\therefore$ from outlet velocity triangle

$$\tan\phi = \left(\frac{V_{f_2}}{u_2}\right) = \left(\frac{8.872}{25.525}\right)$$

$$\Rightarrow \overline{\underline{\phi = 19.166^\circ}} \quad \text{Ans.}$$

20

b) CCA = 20,000 ha

Crops.	Base Period (days)	ATI = 10% × CCA (ha)	delta (cm)	Duty $\left(\frac{8.64 \times B}{\Delta}\right)$
Rice	151	6000	132	988.36
Wheat	~~120~~ 151	4000	85	1534.87
Maize	181	3000	104	1503.692
Sugarcane	365	2000	247	1276.76
Pulses	120	3000	90	1152

Duty calcn:

for Rice $= \left(\frac{8.64 \times 151}{1.32}\right) = 988.36$ ha/cumecs

for wheat $= \left(\frac{8.64 \times 151}{0.85}\right) = 1534.87$ ha/cumecs

Illy for others

discharge requirements:

Crops	$Q (m^3/s) = (A/\text{Duty})$
Rice	6.071
Wheat	2.606
Maize	1.995
Sug	1.5664
Pulses	2.604

Scanned with CamScanner

Combination of discharges

Month	Rice	Wheat	Maize	Sug	Pulse	Design discharge (m^3/s)
JAN	6.071	2.606	1.995	1.5664	—	12.2384
FEB	6.071	2.606	1.995	1.5664	2.604	$\boxed{14.8424}$ Max^m.
MAR	6.071	2.606	1.995	1.5664	2.604	14.8424
AP	6.071	—	1.995	"	2.604	12.2364
MAY	6.071	—	—	"	2.604	10.2414
JUNE	—	—	—	"	—	~~10.2414~~ 1.5664
JULY	—	—	—	"	—	~~10.2414~~ 1.5664
AUG	—	—	—	"	—	~~10.2414~~ 1.5664
SEP	—	—	—	"	—	~~10.2414~~ 1.5664
OCT	—	—	—	"	—	~~10.2414~~ 1.5664
NOV	—	2.606	1.995	1.5664	—	6.1674
DEC	—	2.606	1.995	1.5664	—	6.1674

$\because$ $Q_0 = Q_{Max} = 14.8424$

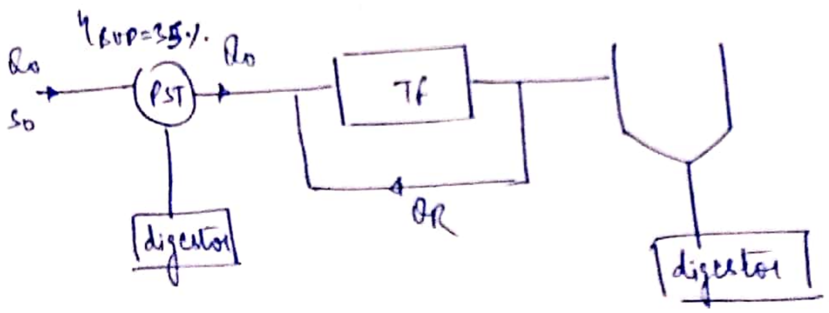
$\therefore$ Actual discharge required at canal head work including time factor and losses $= \left(\dfrac{14.8424}{0.5 \times 0.9}\right) = \underline{32.983\ m^3/s}$ (Ans)

18

Q.3-c) $P = 30,000$

Soln: i) domestic sewage produced $= 120 \times 30000 \times 200 \times 10^{-6} = 720\ kg/day$

ii) Industrial sewage $= 3 \times 10^5 \times 800 \times 10^{-6} = 240\ kg/day$



BOD entering To filter $= 0.65 \times (240 + 720) = 624\ kg/day$

Total discharge entering filter $(Q_0) = (3 \times 10^5 + 120 \times 30000) = \underline{39 \times 10^5\ l/day}$

Scanned with CamScanner

Organic loading rate to filter = 10,100 kg/ha-m/day

$\therefore$ Volume of filter needed = $\left(\frac{624}{10,100}\right)$ = $\underline{0.0624 \text{ ha-m}}$

$\because R = 1 \Rightarrow (Q_R = Q_0)$

$\therefore$ Area of filter unit needed = $\left(\frac{Q_R + Q_0}{HLR}\right) = \left(\frac{39 \times 2 \times 10^5}{170 \times 10^6}\right) = \underline{0.04588 \text{ ha}}$

$\therefore$ depth of filter reqd = $\left(\frac{V}{A}\right) = \left(\frac{0.0624}{0.04588}\right) = \underline{1.36 \text{ m}}$

~~Assuming dia of filter as 3m~~

and $\frac{\pi}{4} d^2 = 0.04588 \times 10^4$

$\Rightarrow$ dia of filter = 24.17m $\simeq$ $\underline{25\text{m}}$ (~~day~~)

$\therefore$ Provide High rate filter of dia = 25m and depth = 1.36 m.

FROM NRC EQN:

$$\eta = \frac{100}{1 + 0.0044\sqrt{\frac{W_0}{V_1 F_1}}}$$

where $F_1 = \frac{1+R}{(1+0.1R)^2}$ @ $R = 1$

$\Rightarrow \underline{F_1 = 1.65}$

$$\therefore \eta = \frac{100}{1 + 0.0044\sqrt{\frac{624}{0.0624 \times 1.65}}} = \underline{74.485\%} \quad \text{Ans.}$$

So (Initial BOD entering to filter) = $\left(\frac{624 \times 10^6}{39 \times 10^5}\right)$ = 160 mg/lit.

$\therefore$ BOD effluent (S) = $\left(\frac{100 - 74.485}{100} \times 160\right)$ = $\underline{40.824 \text{ mg/lit}}$ Ans.

20

Scanned with CamScanner

Section-B

5-a) i) $MPV = (10''+30''+10''+20''+0''+40''+0''+10''+30''+0''+10'')/11 = \underline{14.545''}$

$\therefore$ value of angle $= 43^\circ 20' 14.545'' \simeq \underline{43^\circ 20' 14.55''}$

$\Rightarrow$ ~~Maxm error in observation~~ $=$ ~~0.05'' 0.005''~~

$\therefore$ ~~Probable error in obsvn = Maxm error / 2~~

$\therefore$ Probable error (e_s) $= \pm 0.6745 \sqrt{\dfrac{\sum(x_i-\bar{x})^2}{n-1}} = \underline{\pm 9.2303''}$ (Ans)

6

ii) Best value of obsvn lies in MPV

$\therefore MPV = \left(\dfrac{4\times3\times1810 + 9\times6\times1808}{4\times3+9\times6}\right) = \underline{1806.545}$ (LU)

5-b) $\phi' = 25^\circ$ $\sigma_r = 100\,kPa$, $u=0$

from Triaxial Test results :

$\bar{\sigma}_1 = \bar{\sigma}_3 \tan^2(45+\frac{\phi'}{2}) + 2c' \tan(45+\frac{\phi'}{2})$

$\therefore \bar{\sigma}_1 = \sigma_1$ and $\bar{\sigma}_3 = \sigma_3$ $(\because u=0)$

$\therefore 100 = \sigma_3 \tan^2(45+\frac{25}{2}) + 2c' \tan(45+\frac{25}{2})$ — (1)

$-\quad 50 = \sigma_3 \tan^2(45+\frac{25}{2}) + 2c' \tan(45+\frac{25}{2})$ — (2)

$\Rightarrow 50 = \sigma_3 \tan^2(45+\frac{25}{2})$

$\Rightarrow \underline{\sigma_3 = 20.293\,kN/m^2}$ (Ans)

2

Scanned with CamScanner

(i) Bitumen: It is byproduct obtained from fractional distillation of Petroleum.

Bitumen has wide applications in pavement ~~construction~~ construction from coating, as binder to surface dressing.

It is a petroleum product that is soluble in non-polar solvents such as CS_2.

ii) Cutback Bitumen: Bitumen whose viscosity has been reduced by addition of some volatile diluent say (napthalene).

It comes in various forms:

SC (slow curing)
MC (Medium curing)
RC (Rapid curing)

iii) Emulsified Bitumen: Bitumen which is made aqueous in a suspension of water is termed as emulsified bitumen.

Bituminous emulsion has the biggest advantage that it sets during raining seasons also and ~~it~~ is used for filling of road patches etc.

It comes under three forms:

1) SS (slow setting)
2) MS (Medium setting)
3) RS (Rapid setting)

iv) Surface dressing: It is a process adopted to compact the top surface of WBM with binder so as to achieve smooth riding surface and a dense compacted subgrade is attained.

(dressed surface)

7

Scanned with CamScanner

5-d)

$N = 12$

$d = 133\,m$ (heel divergence)

$\alpha = 4°45'49''$ $\quad \beta = 1°8'00''$

$h = 1.418\,m.$

1

i) $CL = 4GN = 4 \times 1.676 \times 12 = 80.448\,m = LR + SL$

$R_o = 1.5G + 2GN^2 = 1.5 \times 1.676 + 2 \times 1.676 \times 12^2 = 485.202\,m.$

$SL = \sqrt{2R_o d} = \sqrt{2 \times 485.202 \times 0.133} = 11.36\,m.$

$\therefore LR = (CL - SL) = 80.448 - 11.36 = \underline{\overline{69.087\,m}}$ Ans.

---

5) e <u>Negative Skin friction</u>

In case of loose soils, organic clays or fill soils under external loading starts showing settlement (vertical) and cause the pipes also to sink providing shear stresses on the skin of piles, ultimately leading to ~~tip~~ collapse of entire structure placed over the piles by causing excessive settlement.

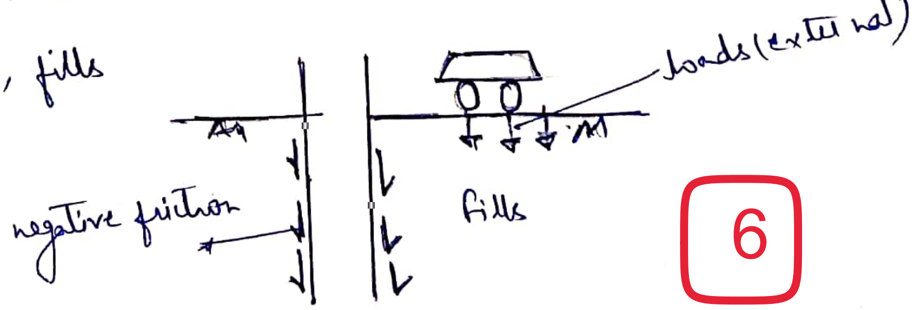
This skin friction developed on piles due to subsiding soil acting against the stability is k/a 'Negative skin friction'

<u>Reasons/causes behind Negative skin friction</u>

a) Heavy external loads to Traffic

b) sudden lowering of water Table

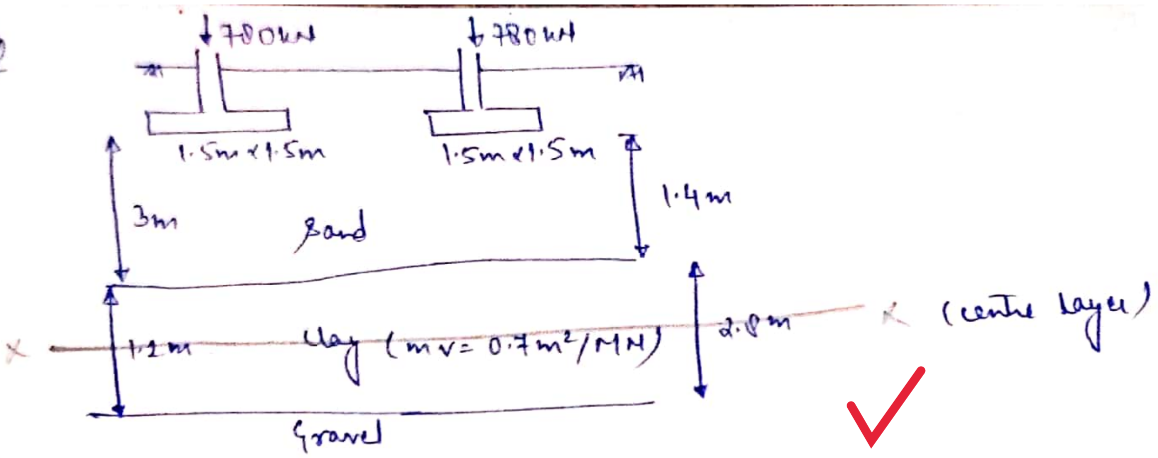
c) presence of organic clays, fills



6

Scanned with CamScanner

6-a)



Soln: Assuming load distn of 1V : 0.5H

$$\therefore \Delta\sigma_A = \frac{780}{(1.5+3.6)^2} = 29.988 \text{ kN/m}^2 \quad \text{and} \quad \Delta\sigma_B = \frac{780}{(1.5+2.8)^2} = 42.184 \text{ kN/m}^2$$

$$\therefore \Delta H_A = H_{0_A} m_v \Delta\sigma_A = 1.2 \times 0.7 \times 10^{-3} \times 29.988 \times 10^3 = 25.1899 \text{ mm}$$

$$\Delta H_B = H_{0_B} \times m_v \Delta\sigma_B = 2.8 \times 0.7 \times 10^{-3} \times 42.184 \times 10^3 = 82.68 \text{ mm}$$

$\therefore$ Total differential settlement $= (\Delta H_B - \Delta H_A) = (82.68 - 25.1899) = 57.49$ mm

$\because$ settlement (diff) of 10 mm occuring in 2 years

$$\therefore \% U_1 = \left(\frac{10}{57.49} \times 100\right) = 17.394\% \qquad \therefore T_v = \frac{\pi}{4} \times (0.1739)^2 \quad \because U < 60\%$$

$$= 0.02376$$

$\therefore$ from eqn of time factor $\quad T_v = \frac{C_v \times t}{d^2}$

$$\Rightarrow 0.02376 = C_v \times \frac{2}{(2.8/2)^2} \qquad \Rightarrow C_v = 0.02328 \text{ m}^2/\text{year}$$

Maxm differential settlement $= 24$ mm

$$\therefore \% U_2 = \frac{24}{57.49} \times 100 = 41.746\%$$

$$\Rightarrow T_v = \frac{\pi}{4} \times (0.41746)^2 = 0.1368 \quad (\because U < 60\%)$$

$\therefore$ from eqn $\quad T_v = \left(C_v \frac{t}{d^2}\right)$

$$0.1368 = 0.02328 \times \frac{t}{(2.8/2)^2}$$

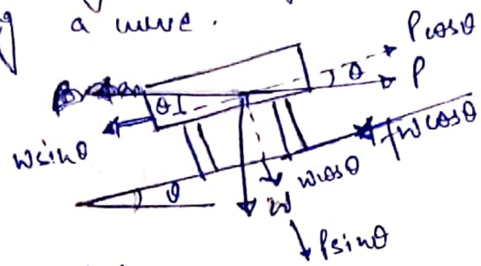
$t = 11.52$ yrs $\quad$ doors will get jammed

(Ans)

19

Scanned with CamScanner

6-b-i) Considering outer edge and inner edge of road and vehicle negotiating a curve.



FROM FBD of vehicle

Resolving forces:

$\Sigma x = 0$

$$P\cos\theta - fW\cos\theta = W\sin\theta - f(P\sin\theta)$$

→ dividing by $(\cos\theta)$ both sides

$$P - fW = W\tan\theta + fP\tan\theta$$

$$\Rightarrow (P - fP\tan\theta) = W(\tan\theta + f)$$

$$\Rightarrow P[1 - f\tan\theta] = W[\tan\theta + f]$$

$$\Rightarrow \frac{P}{W} = \left(\frac{\tan\theta + f}{1 - f\tan\theta}\right) \qquad \because (\tan\theta \approx e)$$

$$\therefore \frac{P}{W} = \frac{e+f}{(1-ef)} \qquad \text{for } \theta \leq 10\% \ (1-ef \approx 1)$$

$\boxed{8}$

$$\Rightarrow \frac{P}{W} = e+f \quad \text{and} \quad \because P = \frac{mv^2}{R}$$

$$\therefore e+f = \frac{mv^2}{R \times mg} \quad \Rightarrow e+f = \frac{v^2}{gR} \quad \text{or} \quad \frac{(v\times3.6)^2}{3.6^2 \times g \times R}$$

$$\because (V = v \times 3.6)$$

$$\therefore \boxed{e+f = \frac{V^2}{gR \times 3.6^2}} \quad \text{or} \quad \boxed{e+f = \frac{V^2}{127R}} \quad \text{(proved)}$$

---

ii) $V_D = 96$ km/hr. $a = 2.5$ kmph/sec $T_R = 2$ sec.

Soln: a) for one way traffic

$\because V_A$ (overtaking vehicles) $= V_D - 16 = 96 - 16 = 80$ km/hr. $= (V_B)$

and $a = \dfrac{2.5 \times 10^3}{3600} = 0.6944 \, m/s^2$

$\therefore OSD = (d_1 + d_2)$ where $d_1 = \left(\dfrac{V_B \times T_R}{3.6}\right) = (80 \times 0.278 \times 2) = \underline{44.48 m}$.

and $d_2 = v_B \times T + \frac{1}{2} a T^2$ where $T = \sqrt{\dfrac{4S}{a}}$

Scanned with CamScanner

Assuming length of wheel base (L) = 6m as per IRC

$\therefore s = (0.2V_B + L) = (0.2 \times 80 + 6) = 22m$

$\therefore T = \sqrt{\frac{4 \times 22}{0.6944}} = \underline{11.257 \text{ sec}}$

$\therefore d_2 = \left(V_B \times T + \frac{1}{2} a T^2\right) = \left(0.278 \times 80 \times 11.257 + \frac{1}{2} \times 0.6344 \times 11.257^2\right) = \underline{294.35m}$

$\therefore OSD = d_1 + d_2 = (44.48 + 294.35) = \underline{333.832m}$ Ans.

9

b) <u>for Two-Way Traffic</u>

$OSD = d_1 + d_2 + d_3$

$d_1 \rightarrow$ remains same

$d_2 \rightarrow$ remains same

$d_3 = V_c \times T = 0.278 \times 96 \times 11.257 = \underline{300.426 m}$

$\therefore OSD = (333.82 + 300.426) = \underline{634.246 m}$ Ans

---

Q-6-c-i) $T_0 = 20°c$ $P_0 = 70N$ $W = 0.9 kg$ $A = 0.028 cm^2$

Soln:

1) <u>correction due to Pull</u> $= \frac{(P_m - P_0)L}{AE} = \frac{(100-70) \times 114.095}{2.1 \times 10^7 \times 0.025} = \underline{6.519 \times 10^{-3} m}$

2) <u>correction due to Temp</u> $= -(L \alpha \Delta T) = 114.095 \times 1.15 \times 10^{-5} \times (12-20) = \underline{-0.010496 m}$

3) <u>correction due to sag</u> $= -\left\{3 \times \left[\frac{9^2 \times 30}{24 \times 100^2}\right] + \left[\frac{\left(\frac{9}{30} \times 24.095\right)^2 \times 24.095}{24 \times 100^2}\right]\right\}$

$= \underline{-0.03562 m}$

4) <u>correction due to slope</u> $= \frac{-h^2}{2L} = \frac{-2.5^2}{2 \times 114.095} = \underline{-0.027389 m}$

$\therefore C_{net} = (C_1 + C_2 + C_3 + C_4) = (6.519 \times 10^{-3} - 0.010496 - 0.03562 - 0.027389) = \underline{-0.06698 m}$

$\therefore$ corrected length $= 114.095 + C_{net} = (114.095 - 0.066986) = \underline{114.028 m}$

10

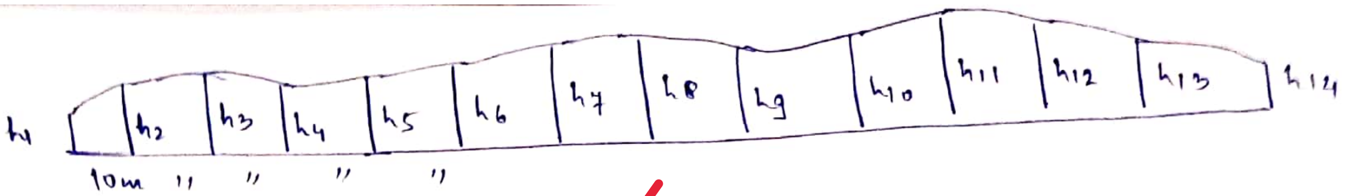
→ <u>Correction for chain length</u>

$L' \times l' = l \times L$

$\therefore l = \left(\frac{l \times L'}{L}\right) = \left(\frac{114.028 \times 30.0150}{30}\right) = \underline{114.085 m}$ Ans

Scanned with CamScanner

6.c.ii)



Offsets @ 10m (for all)

a) Trapezoidal Rule : $= \frac{10}{2}\left[(h_1 + h_{14}) + 2(h_2 + h_3 \dots + h_{13})\right]$

$$\text{Area} = 5\left[(8.25+12) + 2(13.85+12.25+10.85+12.25+13.6+15.25+16.85+14.95+17.35+20.05+15.9+12.25)\right]$$

$$\therefore \text{Area} = 1855.25\,m^2$$

b) Simpson's $1/3^{rd}$

i) h_1 as first offset

$$\therefore \text{Area} = \frac{10}{3}\left[(8.25+12.25) + 4(13.85+10.85+13.6+16.85+17.35+15.9] + 2[12.25+12.25+15.25+14.95+20.05]\right] + \underbrace{\frac{10}{2}\left[12.25+12\right]}_{\text{Trapezoidal}}$$

$$\text{Area} = 1866.5833\,m^2$$

ii) h_{14} as first offset

$$\text{Area} = \frac{10}{3}\left[(12+13.85) + 4(12.25+20.05+14.95+15.25+12.25+12.25) + 2(15.9+17.35+16.85+13.6+10.85\right] + \underbrace{\frac{10}{2}\left[13.85+8.25\right]}_{\text{Trapezoidal}}$$

$$\text{Area} = 1853.67\,m^2$$

10

Scanned with CamScanner