Transportation Eng (Railway Math)

'40: Main curve 4°

Branch curve 7°

Broad Guage Yard

Speed Limit of Branch 30 km/hr $= 8.33\ ms^{-1}$

Permissible cant deficiency 75 mm

Speed Limit of Main Line = ?

Soln: Branch line: Radius of curvature, $R = \frac{1719}{\theta}$ m

$= \frac{1719}{7}$ m

$= 245.57$ m

Super Elevation, $SE = \frac{Gv^2}{Rg}$

$= \frac{1.676(8.33)^2}{245.57 \times 9.81}$ ~~= .0288 m~~

$= .0483$ m

$= 48.3$ mm

$\therefore$ Negative S.E. $= 48.3 - 75 = -26.7$ mm

Main Line: Max^m S.E. = 26.7 mm

$\therefore$ Theoretical S.E. $= 26.7 + 75$ mm $= 101.7$ mm

$= .1017$ m

Now, S.E. $= \frac{Gv^2}{Rg} \Rightarrow .1017 = \frac{1.676 \times v^2}{429.75 \times 9.81}$ | $R = \frac{1719}{4} = 429.75$ m

$\therefore v = 16\ ms^{-1}$

$\therefore$ Max^m Permissible Speed of main line = $16\ ms^{-1}$ or 57.6 km/hr

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Resistance	Name	Value
1. Friction	R_1	$'0016W = 16\times10^{-4} W$
2. Wave ann, track Irregularity & speed	R_2	$'00008 WV = 8\times10^{-5} WV$
3. Wind, atmospheric	R_3	$6\times10^{-7} WV^2$
4. Gradient	R_4	$\frac{W\times \% \text{ of slope}}{100}$
5. Curve Resistance (B.G.)	R_5	$'0004WD = 4\times10^{-4} WD$
(M.G.)		$3\times10^{-4} WD$
(N.G)		$2\times10^{-4} WD$
6. ~~Acceleration~~ Starting	R_6	$0.15 W_1 + 0.005 W_2$
7. Acceleration	R_7	$'028 aW$

$R = \frac{1719}{\theta}$ (m) $= \frac{5730}{\theta}$ (ft)

$S.E. = \frac{Gv^2}{Rg}$

$e + f = \frac{v^2}{Rg}$

$e = \frac{(.75\, v_{design})^2}{Rg}$

$e_{max} = '067 = 1 \text{ in } 15$

$f_{max} = 0.15$

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136: B.G Line

Curve 6°

Wt 1200 tons

Curve Resistance = ?

Soln: Curve Resistance (B.G.) = $4\times10^{-4}\times WD$

$= 4\times10^{-4}\times1200\times6$

$= \boxed{2.88 \text{ tons}}$

135: Broad Gauge

Curve 6°

Max^m speed 50 km/hr = 13.89 ms^{-1}

Equilibrium cant = ?

Soln: Rad. of curvature, $R = \frac{1719}{\theta} = \frac{1719}{6} = 286.5$ m

Equilibrium cant $= \frac{Gv^2}{Rg} = \frac{1.676\times13.89^2}{286.5\times9.81} = 0.115$ m

$= \boxed{115 \text{ mm}}$

33: Rad. of curvature, $R = 400 m$

Speed, $v = 80 km/hr = 22.22 ms^{-1}$

Design Rate of S.E., $e = ?$

Check for Co-eff. of friction.

Soln: for design purpose,

Rate of S.E, $e = \frac{(.75 v)^2}{Rg} = \frac{(.75 \times 22.22)^2}{400 \times 9.81}$

$= 0.0708$

$e = .0708 = 1 \text{ in } 14.12 > 1 \text{ in } 15$ (Not OK)

So, we take $e_{max} = 1 \text{ in } 15 = .067$

Check for f^n co-eff:

$$e + \mu = \frac{v^2}{Rg}$$

$$\Rightarrow .067 + \mu = \frac{(22.22)^2}{400 \times 9.81}$$

$$\therefore \mu = .059 < .15 \quad \text{OK}$$

Ans: $e = .067 = 6.7\% = 1 \text{ in } 15$

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'29': Curve Rad., $R = 170\ m$

Design speed, $v = 100\ km/hr = 27.78\ ms^{-1}$

Fr^n Factor, $\mu = 0.09$

Rate of S.E. = ?

Sol^n: $e = \frac{(.75\ v_{design})^2}{Rg} = \frac{(.75 \times 27.78)^2}{170 \times 9.81}$

$= 0.26 > 0.067$ (Not ok)

Again, $e + \mu = \frac{v^2}{Rg}$

$\Rightarrow \mu = \frac{v^2}{Rg} - e = \frac{(27.78)^2}{170 \times 9.81} - .067$

$= 0.396 > .09$ (Not ok)

So, we need to revise design speed.

$\therefore e + \mu = \frac{v^2}{Rg}$

$\Rightarrow .067 + .09 = \frac{v^2}{170 \times 9.81}$

$\therefore v = 16.18\ ms^{-1} = \boxed{58.25\ km/hr}$

Ans: S.E. = .067 & $v_{design} = 58.25\ km/hr$

'28: Broad Guage

Curve 2°

Max^m sanctioned speed, $v = 96 km/hr = 26.67\ ms^{-1}$

Cant Deficiency = 75mm

Max^m speed to be provided = ?

Soln: Rad. of curvature, $R = \frac{1719}{\theta} = \frac{1719}{2} = 859.5\ m$

$$S.E. = \frac{Gv^2}{Rg} = \frac{1.676 \times (26.67)^2}{859.5 \times 9.81} = 0.1414\ m$$

$= 141.4\ mm$

Actual Cant = Theoretical cant + Cant deficiency

$= 141.4 + 75$

$= 216.4\ mm = .2164\ m$

$$\text{Actual Cant} = \frac{G v_a^2}{Rg}$$

$$\Rightarrow .2164 = \frac{1.676 \times v_a^2}{859.5 \times 9.81}$$

$\therefore v_a = 33\ ms^{-1}$ = **118.8 km/hr**

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Transportation Engineering

'40: Speed, $v = 80$ km/hr $= 22.22\ ms^{-1}$

Upward Gradient, $G = +2\% = +.02$

Perception & brake rxn time = 2.5 ~~sec~~

Co-eff. of frn, ~~coef~~ $f = 0.36$

Safe Stopping Distance = ?

Soln: $SSD = 2.5v + \frac{v^2}{2g(f+G)}$

$= 2.5 \times 22.22 + \frac{22.22^2}{2 \times 9.81 \times (.36 + .02)}$ ~~= 1259.74 m 1304 m~~

$= \boxed{1300\ m}$

'36: No. of flight per day = 5

Seat capacity = 100

Avg. passangers per flight = 68

Avg. distance travelled per flight = 250 km

Passanger Load Factor (PLF) = ?

Soln: $PLF = \frac{\text{Passanger km travelled}}{\text{Seat km available}} = \frac{68 \times 5 \times 250}{100 \times 5 \times 250}$

$= 68\%$

31: Design speed, $v = 50$ km/hr $= 13.89\ ms^{-1}$

(i) 2way 2Lane, SSD = ?

(ii) 2way 1Lane, SSD = ?

Soln: Assume, perception time, $t = 2.5$ s

Friction Factor, $\mu = 0.4$

(i) $SSD = vt + \frac{v^2}{2g\mu} = 2.5 \times 13.89 + \frac{13.89^2}{2 \times 9.81 \times 0.4}$

$= 59.3$ m

(ii) SSD = 2 × 59.3 = 118.6 m

32: Plate Bearing Test

Plate dia = 30 cm

Base thickness = 20 cm

~~Deflection~~ Deflection = 0.5 cm
~~Pressure~~

~~Deflection of subgrade = 1 K~~

Pressure for 0.5 cm deflection of subgrade = 1 kg/cm²

" " " " " Base = 4 kg/cm²

Wheel load = 5443 kg

Tyre pressure = 6 kg/cm² for 0.5 cm deflection

Design pavement

30th:

$W_{wet} = 2.45$ kg

$Vol^m = 1200\ cm^3$

$w = 12\%$

$\rho_{wet} = 1.94$ gm/cc

OMC = 22%

% compaction = ?

Soln: $\rho_{wet(lab)} = \frac{W_{wet}}{Vol^m} = \frac{2.45 \times 10^3}{1200}$

$= 2.04$ gm/cc

$\therefore \rho_{dry(lab)} = \frac{\rho_{wet}}{1+w} = \frac{2.04}{1+.12} = 1.82$ gm/cc

$\rho_{wet(field)} = 1.94$ gm/cc (given)

$\therefore \rho_{dry(field)} = \frac{1.94}{1+.22} = 1.59$ gm/cc

$\therefore$ % compaction $= \frac{\rho_d\ (field)}{\rho_d\ (lab)}$

$= \frac{1.59}{1.82}$

$= \boxed{87.36\%}$

WRE Math

'40: Soil holds 140 mm/m betn FC & PWP

Root Depth = 30 cm

Allowable Depletion of water = 35%

Daily water use by crop = 5mm/day

Area = 60 ha = 60×10^4 m^2 ; [1 Ha = 10^4 m^2]

Water diverted = 28 l.p.s

Application Efficiency, η_a = 40%

Soln: Moisture holding capacity of root zone = 140 mm/m × 30cm

= 140 mm/m × .3 m

= 42 mm

= 4.2 cm

(i) Allowable moisture depth = Allowable depletion depth betn irrigations = 4.2 × 35% = 1.47 cm

Daily use of water by crop = consumptive use

= 5 mm/day = 0.5 cm/day

(ii) Frequency of irrigation = $\frac{1.47 \text{ cm}}{0.5 \text{ cm/day}}$ = 2.94 days

≈ 3 days

(iii) Net application depth of water = Net water depth to be applied after 3 days = 3×0.5 = 1.5 cm

Field irrigation requirement = $\frac{1.5}{40\%}$ = 3.75cm

(iv) volm of water required = 3.75 cm × 60 ha

= .0375 m × 60×10^4 m^2

= 22,500 m3

Vol^m of water reqd for 4 Ha plot = 3.75 × 4 ha

= 1500 m^3

@ 28 l.p.s, Time reqd = $\frac{1500 \text{ m}^3}{28 \text{ L/s}}$

$= \frac{1500 \text{ m}^3}{28 \times 10^{-3} \text{ m}^3/\text{s}}$

= 53571.43 s

= 14.88 hrs

'28: FC = 25 %

PWP = 10 %

$\gamma_{dry\ soil}$ = 14.72 KN/m^3

Depth of root zone, d = 0.75 m

Storage capacity of soil = ?

Water supplied when MC = 14 %

η_a = 75 %

Reqd water depth to be applied = ?

Sol^n: Max^m storage capacity = Available moisture,

$$h = \frac{\gamma_d}{\gamma_w} d \, [FC - PWP]$$

$$= \frac{14.72}{9.81} \times .75 \times [.25 - .1]$$

= .1688 m

= 16.9 cm (Ans)

Since moisture is allowed to fall to 14 %, the deficiency created, $h = \frac{\gamma_d}{\gamma_w} d \, [FC - MC]$

$$= \frac{14.72}{9.81} \times .75 \times [.25 - .14]$$

= .1238 m = 12.38 cm

$\therefore$ N.I.R = 12.38 cm

$\eta_a = 75\%$

$\therefore$ F.I.R. $= \frac{12.38}{.75} = 16.5$ cm (Ans)

'31': $Q = 15$ cumec

$A = 34$ hec.

$t = 4$ hr

water stored in root zone, $h = 0.3$ m

$\eta_a = ?$

Soln: ~~$V = AQ = 34$ hec $\times 15$ m³/s $= 34\times10^4\times15$~~

Volm of water $= Qt = 15$ m³/s $\times 4\times3600$ s

$= 21.6\times10^4$ m³

$\therefore$ Application Depth $= \frac{Vol^m}{A} = \frac{21.6\times10^4 \text{ m}^3}{34\times10^4 \text{ m}^2}$

$= 0.635$ m

$\therefore \eta_a = \frac{\text{Output}}{\text{Input}} = \frac{0.3}{0.635} = 47.22\%$ (Ans)

35: $A = 3.5$ hec.

Duty = 850 hec/cumec

$\eta_{pump} = 50\%$

Water level difference = 9 m

Min^m H.P. of pump req^d = ?

Sol^n: Discharge, $Q = \frac{A}{Duty} = \frac{3.5 \text{ hec}}{850 \text{ hec/cumec}} = 4.12 \times 10^{-3}$ cumec

∴ Water lifted per sec $= 4.12 \times 10^{-3}$ m3

$= 4.12 \times 1000 \times 10^{-3}$ kg $= 4.12$ kg

∴ Work done per sec $= \underbrace{4.12}_{m} \times \underbrace{9.81}_{g} \times \underbrace{9}_{h}$

∴ Power $= 363.754$ N/s

$= 364$ Watt

∴ Power of pump req $= \frac{P}{\eta} = \frac{364}{.5}$

$= 728$ Watt

1HP = 746 Watt

$= \frac{728}{746}$ H.P.

$\approx$ **1 HP**

40: $Q = \frac{3 \text{ hec.}}{864 \text{ hec./cumec}} = 3.47 \times 10^{-3}$ m3/s

∴ Power $= 3.47 \times 10^{-3}$ m3/s $\times 10^{3}$ kg/m3 $\times 9.81$ m s^{-2} $\times 8$ m

$= 272.5$ Watt

∴ Power req^d of pump $= \frac{272.5}{.84} = 324.4$ Watt

$= \frac{324.4}{746}$ HP

= **0.44 HP**

Ans.

136:

$A_{kharif} = 5000$ Ha

$A_{Robi} = 5000$ Ha

~~Δ_{kharif}~~

water reqd for kharif, $\Delta_{kharif} = 2\frac{1}{2}'' = 2.5 \times 2.54$ cm $= 6.35$ cm

$\Delta_{Robi} = 1\frac{1}{2}'' = 3.81$ cm

Base period of kharif, $B_{kharif} = 3$ wk $= 3 \times 7 = 21$ days

$B_{Robi} = 4$ wk $= 28$ days

Discharge = ?

Kharif:

$\therefore$ Duty, $D_{kharif} = \frac{864 B}{\Delta}$

$= \frac{864 \times 21}{6.35}$

$= 2857.3$ Ha/cumec

$\therefore$ Discharge, $Q_{kharif} = \frac{A}{D} = \frac{5000}{2857.3}$

$= 1.75$ cumec

Robi:

Duty, $D_{Robi} = \frac{864 \times 28}{3.81} = 6349.61$ Ha/cumec

$\therefore$ Discharge, $Q_{Robi} = \frac{A}{D} = \frac{5000}{6349.61} = 0.787$ cumec

$P = \frac{dA}{dy}$

'35, '37 | Design surface drainage channel in non alluvial soil

$Q = 12\,m^3/s$ or $10\,m^3/s$

$v = 1\,m/s$

side slope, $= 0.5 : 1$

Bed slope $= 1 : 6000$ or $1 : 5000$

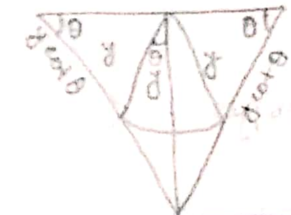
$n = 0.0225$

Solⁿ: Let us assume the channel to be triangular.

Here, $\theta = \tan^{-1}\left(\frac{1}{0.5}\right)$

$= \tan^{-1} 2 = 63.43°$

$= 1.107^c$



$\therefore A = y^2\theta + y^2 \cot\theta$

$P = 2y\theta + 2y\cot\theta$

$R = \frac{y}{2}$

~~$\therefore A = y^2\theta + y^2\cot\theta$~~

$Q = \frac{1}{n} A R^{2/3} S^{1/2}$

$= \frac{1}{.0225} \times (y^2\theta + y^2\cot\theta) \times \left(\frac{y}{2}\right)^{2/3} \times \left(\frac{1}{5000}\right)^{1/2}$

$= 44.44 \times (y^2 \times 1.107 + y^2 \times 0.5) \times y^{2/3} \times 0.63 \times .014$

$= 0.4\, y^{2/3} \times 1.607\, y^2$

$= 0.64\, y^{8/3}$

$\Rightarrow 10 = 0.64\, y^{8/3}$

$\Rightarrow y^{8/3} = ~~18.75~~\; 15.625$

$\therefore y = ~~18.75^{3/8}~~ \Rightarrow 15.625^{3/8} = 2.8$

Q2: Design a concrete lined channel.

$Q = 350$ cumec

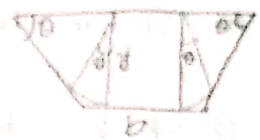
$S = 1 : 5000$

$H : V = 1.5 : 1$

$n = 0.014$

$v = 2 ms^{-1}$ [can not exceed]

Soln: Assume, Trapezoidal channel.



$\theta = \tan^{-1}\left(\frac{1}{1.5}\right) = 33.7^\circ = 0.59^c$

$A = by + y^2\theta + y^2 \cot\theta$

$P = b + 2y\theta + 2y\cot\theta$

$R = \frac{A}{P}$

$v = \frac{1}{n} R^{2/3} S^{1/2}$

$\Rightarrow 2 = \frac{1}{.014} \times R^{2/3} \times \left(\frac{1}{5000}\right)^{1/2}$

$\therefore R = 2.79$ m

$A = \frac{Q}{v} = \frac{350 \ m^3/s}{2 \ m/s} = 175 \ m^2$

$A = 175 = by + y^2\theta + y^2 \cot\theta$

$= by + y^2 \times 0.59 + y^2 \times 1.5$

$\therefore 175 = by + 2.09y^2 \quad \ldots \quad (1)$

$R = \frac{A}{P} \Rightarrow 2.79 = \frac{175}{P} \quad \therefore P = 62.72$ m

$P = 62.72 = b + 2y\theta + 2y\cot\theta$

$= b + 2y \times 0.59 + 2y \times 1.5$

$= b + 1.18y + 3y$

$\therefore 62.72 = b + 4.18y$

$\therefore b = 62.72 - 4.18y \quad \ldots (2)$

(1) $\Rightarrow 175 = (62.72 - 4.18y)y + 2.09y^2$

$= 62.72y - 4.18y^2 + 2.09y^2$

$= 62.72y - 2.09y^2$

$\therefore y = 26.9\,m$ or $3.1\,m$

As 26.9 m is unfeasible, $y = 3.1\,m$
([illegible] b - ve [illegible])

(2) $\Rightarrow b = 62.72 - 4.18 \times 3.1$

$\therefore$ **$b = 49.8\,m$**

Using free board of 0.75 m,

Total depth of lined canal $= 3.1 + 0.75$

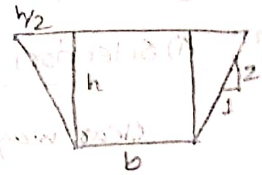
$=$ **$3.85\,m$**

'34,'33,'30: Design a regime channel using Lacy's Theory

$Q = 50$ cumec

$f = 1.0$

Assume reasonable values for missing data.



Soln: Velocity, $v = \left(\frac{Qf^2}{140}\right)^{1/6}$

$= \left(\frac{50 \times 1^2}{140}\right)^{1/6} = 0.84 \ ms^{-1}$

Area, $A = \frac{Q}{v} = \frac{50}{0.84} = 59.4 \ m^2$

Hydraulic Radius, $R = \frac{5v^2}{2f} = \frac{5 \times 0.84^2}{2 \times 1} = 1.77$ m

Perimeter, $P = 4.75\sqrt{Q} = 4.75\sqrt{50} = 33.6$ m

For a trapezoidal channel with ½ H : 1V slopes,

$P = b + \sqrt{5}h$

$A = bh + \frac{1}{2}h^2$

Now, $A = 59.4 = bh + 0.5h^2$ ...... (1)

$P = 33.6 = b + \sqrt{5}h \Rightarrow b = 33.6 - \sqrt{5}h$ ...... (2)

(1) $\Rightarrow 59.4 = (33.6 - \sqrt{5}h)h + 0.5h^2$

$= 33.6h - \sqrt{5}h^2 + 0.5h^2$

$= 33.6h - 1.74h^2$

$\therefore$ **$h = 1.97$ m** or 17.34 → Not feasible

$\therefore$ **$b = 33.6 - \sqrt{5} \times 1.97 = 29.2$ m**

Bed slope, $S = \frac{f^{5/3}}{3340 Q^{1/6}} = \frac{1^{5/3}}{3340 \times 50^{1/6}} = \frac{1}{6410}$ = **1 in 6410**

31| Design & sketch a guide bank to train river

Max^m discharge, $Q = 17,000$ cumec

Highest flood level, HFL = 288 m

River bed level = 280 m

Avg. dia of river sand = 0.25 mm

Sol^n: A) Selection of dimension :

Clear way, $L = 1.2P$

$= 1.2 \times 4.75\sqrt{Q}$

$= 1.2 \times 4.75 \times \sqrt{17000} = 743.2\ m \approx 744\ m$

u/s length of guide bank $= 1.25L$

$= 1.25 \times 744 = 930\ m$

d/s " " " " $= 0.25L = 186\ m$

Radius of u/s curved portion, $R_1 = 0.45L$

$= 0.45 \times 744$

$= 334.8\ m$ curved by 130°

" " d/s " ", $R_2 = 0.225L$

$= 167.4\ m$ curved by 60°

Assuming : Top width, $B = 5\ m$

Free board $= 1.5\ m$

Side slope of GB = 2:1 (H:V)

∴ Top level of GB = HFL + Free board

$= 288 + 1.5 \approx 290\ m$

∴ Ht of GB above river bed level $= 290 - 280 = 10\ m$

∴ Depth of flow, ~~y~~ $= 288 - 280 = 8\ m$

B) Design :

Thickness of stone pitching, $t = 0.06\, Q^{1/3}$

$= 0.06 \times (17000)^{1/3} = 1.55$

" " Launching apron $= 1.9t = 1.9 \times 1.55 = 2.95$ m

Silt factor, $f = 1.76\sqrt{d_{mm}} = 1.76 \times \sqrt{.25} = 0.88$

Scour depth, $R = 0.47\left(\frac{Q}{f}\right)^{1/3}$

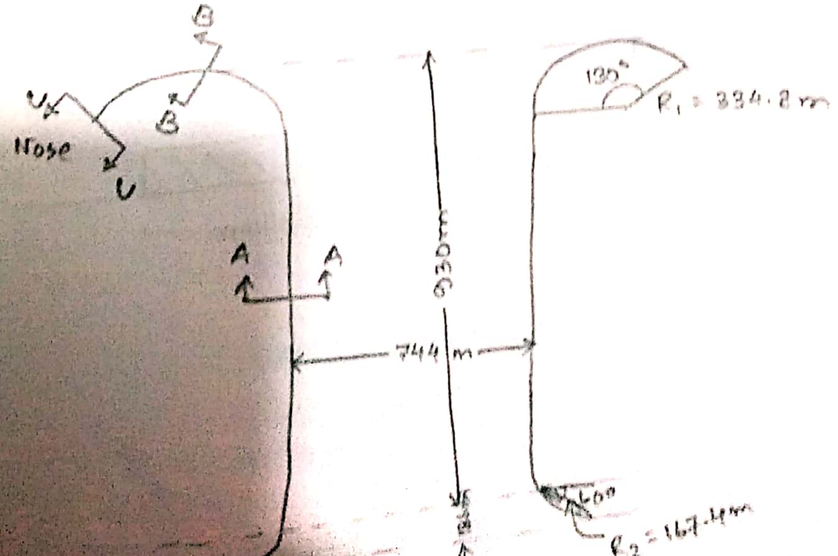
$= 0.47\left(\frac{17000}{0.88}\right)^{1/3} = 12.61$ m

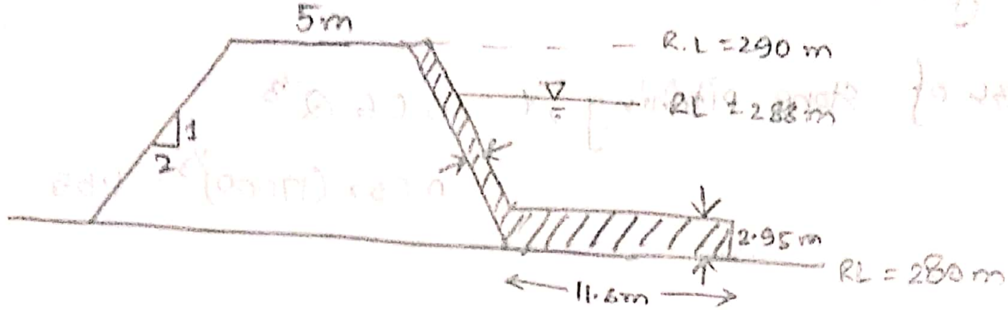
Length of apron at,

Nose $= 1.5\,(2.25R - y) = 1.5\,(2.25 \times 12.61 - 8) = 30.6$ m

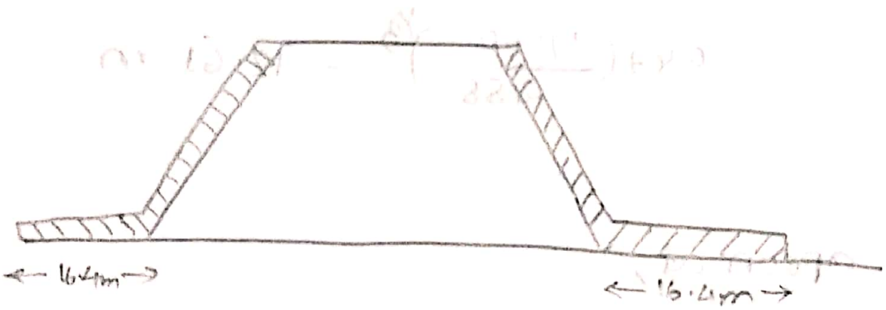
Curved reaches $= 1.5\,(1.5R - y) = 16.4$ m

Straight " $= 1.5\,(1.25R - y) = 11.6$ m

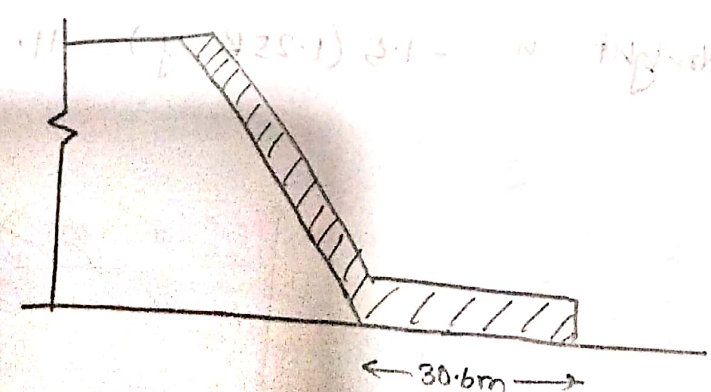




Sxn A-A



Sxn B-B



Sxn C-C

RCC MATH

40: (Nilson 3.2)

$b = 12\ in$

$d = 18\ in$

$A_{st} = 6\#10 = 7.59\ in^2$

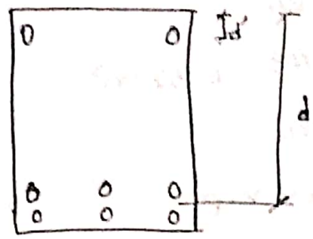
$A'_{st} = 2\#9 = 2\ in^2$

$d' = 2.5\ in$

$f_y = 50\ ksi$

$f'_c = 5\ ksi$

$M_{design} = ?$



Soln: $\rho_{max} = .85\ \beta_1 \frac{f'_c}{f_y} \frac{\epsilon_u}{\epsilon_u + .004}$; $\beta = .8$ for $f'_c = 5\ ksi$

$= .85 \times .8 \times \frac{5}{50} \times \frac{.003}{.003 + .004}$

$= .029$

$\rho = \frac{A_{st}}{bd} = \frac{7.59}{12 \times 18} = .035 > \rho_{max}$; so, should be considered doubly reinforced

— Supplimentary

$\therefore M_n = (A_{st} - A'_s) f_y (d - \frac{a}{2}) + A'_s f'_s (d - d')$ ...... ①

Now, $f'_s = E_s \times \epsilon_u \times \frac{c - d'}{c}$ ~~$= 29 \times 10^6 \times .003 \times$~~ ...... ②

But, $a = \frac{(A_{st} - A'_s) f_y}{.85 f'_c b} = \frac{(7.59 - 2) \times 50}{.85 \times 5 \times 12} = 5.48\ in$; $c = \frac{a}{\beta_1} = \frac{5.48}{.8} = 6.85$

② $\Rightarrow f'_s = 29 \times 10^6 \times .003 \times \frac{6.85 - 2.5}{6.85} = 55248\ psi > 50{,}000\ psi$

so, $f'_s = f_y = 50\ ksi$

① $\Rightarrow M_n = (7.59 - 2) \times 50 \times (18 - \frac{5.48}{2}) + 2 \times 50 \times (18 - 2.5)$

$= 5815.17\ k\text{-}in \approx 485\ k\text{-}ft$

$\therefore$ Design Moment Capacity, $M_{design} = \phi M_n$; $c/d_t = \frac{6.85}{18} = .38$

$\therefore \phi = .9 - \frac{.005}{.6 - .375} \times (.9 - .65)$

$= .89$

$= .89 \times 485$

$\approx$ **427 k-ft**

Q: Col^n dim^n 18 in × 18 in

[Nilson 16.2]

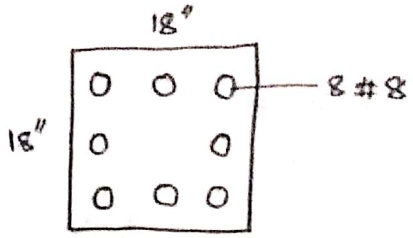
$f'_c = 4$ ksi

$A_s = 8\#8 = 6.32\ in^2$

$f_y = 50$ ksi

DL = 225 kip

LL = 175 kip



All. soil pres, $q_a = 5$ ksf

Design a square footing, base 5' below grade

Sol^n: Avg. unit wt of conc. & soil = $\frac{100+150}{2}$; [Assume, soil unit wt 100 pcf]

= 125 pcf

∴ Pressure @ 5' = 5 × 125 = 625 psf

∴ Bearing pressure available to carry col^n service

Load, q_e = 5000 − 625 = 4375 psf = 4.375 ksf
[Eff. soil pressure]

Total Load (Unfactored) = 225 + 175 = 400 kip

∴ Footing area reqd, $A_{req} = \frac{400\ \text{kip}}{4.375\ \text{kip/ft}^2} = 91.5\ ft^2$

$\sqrt{91.5} = 9.56$; Assume a square footing of 9.5' × 9.5'

∴ $A = 9.5^2 = 90.3\ ft^2$

Factored Load = 1.2 × 225 + 1.6 × 175 = 550 kip

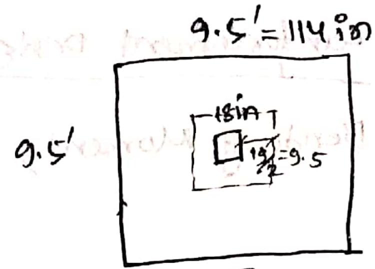
∴ Upward pressure = $\frac{550}{90.3}$ = 6.1 kip/ft²

Trial calculation suggests, Footing eff. depth, d = 19 in

Punching shear check:

Critical perimeter, $b_o = (18+d) \times 4$

$= (18+19) \times 4 = 148 \text{ in}$



$\therefore$ shear force on critical perimeter $= 6.1 \text{ kip/ft}^2 \times \left[9.5^2 - \left(\frac{18+19}{12}\right)^2\right] \text{ft}^2$

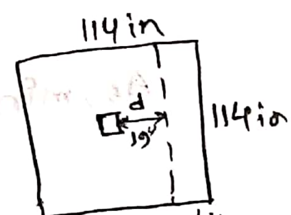
$\therefore V_{u1} = 6.1 \times 80.74 = 492 \text{ kips}$

$\therefore$ Corresponding Nominal shear strength $= 4\lambda\sqrt{f'_c}\, b_o d$

$= 4 \times 1 \times \sqrt{4000} \times 148 \times 19$

$\therefore V_c = 711385 \text{ lb} = 711 \text{ kip}$

$\therefore \phi V_c = .75 \times 711 = 534 \text{ kip} > V_{u1} (= 492 \text{ kip})$ OK



$\frac{L}{2} - \frac{a}{2} - d$

$= \frac{114}{2} - \frac{18}{2} - 19$

$= 29 \text{ in}$

Beam shear check:

Nominal shear strength, $V_c = 2\lambda\sqrt{f'_c}\, L d$

$= 2 \times 1 \times \sqrt{4000} \times (9.5 \times 12) \times 19$

$= 273979 \text{ lb}$

$= 274 \text{ kip}$

$\therefore \phi V_c = .75 \times 274 = 205.5 \text{ kip}$

$\therefore$ Factored shear force on this sxn $= 6.1 \text{ kip/ft}^2 \times \left(9.5 \times \frac{29}{12}\right) \text{ft}^2$

$\therefore V_{u2} = 140 \text{ kip}$

$\therefore \phi V_c > V_{u2}$ OK

Reinforcement Design:

Here, Bending Moment, $M_u = \frac{wL^2}{2}$

$\frac{L}{2} - \frac{a}{2} = \frac{114}{2} - \frac{19}{2}$
$= 48 \text{ in}$
$= 4 \text{ ft}$

$= \frac{(6.1 \times 9.5) K/ft \times (4 ft)^2}{2}$

$= 464 \text{ k-ft}$

$= 5560 \text{ k-in}$

Steel Area, $A_s = \frac{M_u}{\phi \times f_y (d - a/2)} = \frac{5560}{0.9 \times 60 \times (19 - \frac{2}{2})}$; Assume, $a = 2$ in

$= 5.72 \text{ in}^2$

$A_{s,min} = \frac{3\sqrt{f'_c}}{f_y} \times bd$

$= \frac{3\sqrt{4000}}{60{,}000} \times 114 \times 19$

$= 6.84 \text{ in}^2$

Not less than $A_{s,min} = \frac{200}{f_y} \times bd$

$= \boxed{7.22 \text{ in}^2}$ (Governs)

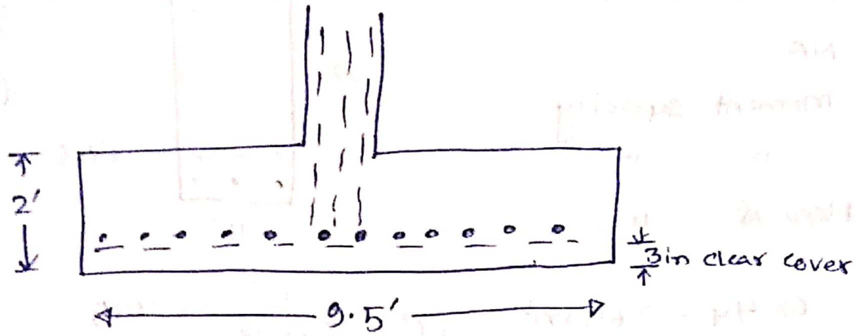
∴ We take, 12 # 7 bars

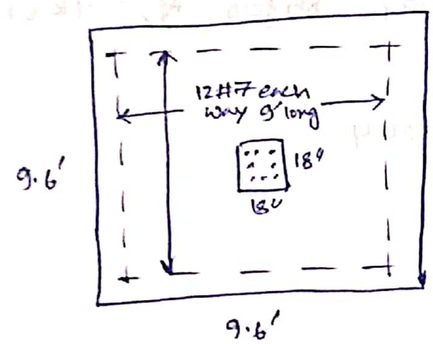
∴ Thickness of footing $= d + 2 \times d_b + \text{Clear cover}$

$= 19 + 2 \times .75 + 3$

$= 23.5 \text{ in}$

$\approx 2 \text{ ft}$





Supplimentary of previous math

$\rho = \frac{A_{st}}{bd} = .035$

$\rho' = \frac{A_s'}{bd} = .0093$

$\rho_{max} = .85\,\beta_1 \frac{f_c'}{f_y} \frac{\epsilon_u}{\epsilon_u + .004} = .029 < \rho$; so doubly reinforced

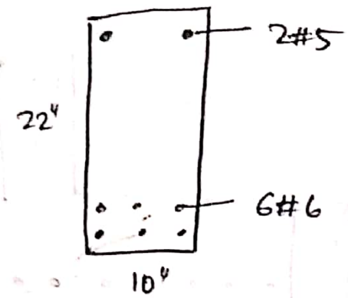
Min^m tensile reinf. ratio, for comp. steel to yield $\bar{\rho}_{cy} = .85\,\beta \frac{f_c' d'}{f_y d} \frac{\epsilon_u}{\epsilon_u - \epsilon_y} + \rho'$

$= .85 \times .8 \times \frac{5}{50} \times \frac{2.5}{18} \times \frac{.003}{.003 - .00207} + .0093$

$= .04 \rightarrow$ Compression steel will not yield

Max^m Reinf ratio, $\bar{\rho}_{max} = \rho_{max} + \rho' = .029 + .0093 = .0383 > \rho (= .035)$ ok

38: (i) Max^m & min^m Steel Ratio
(ii) Depth of NA
(iii) Allowable moment capacity
(iv) Nominal " "
(v) Design Flexural "



$f'_c = 4ksi$

$f_y = 60ksi$

Sol^n: Here, $A_{st} = 6 \times .44 = 2.64 \, in^2$; $\rho = \frac{2.64}{10 \times 18} = .015$

$A_s' = 2 \times .31 = .62 \, in^2$; $\rho' = \frac{.62}{10 \times 18} = .0034$

$d = 22-4 = 18 \, in$

$\rho_{max} = .85 \beta_1 \frac{f'_c}{f_y} \frac{\epsilon_u}{\epsilon_u + .004}$; $\beta_1 = .85$ for $f'_c = 4ksi$

$= .85 \times .85 \times \frac{4}{60} \times \frac{.003}{.003 + .004}$

$\therefore \boxed{\rho_{max} = ~~.0181~~ \; .0207}$

$\rho_{min} = \frac{3\sqrt{f'_c}}{f_y} \geq \frac{200}{f_y}$

$= \frac{3\sqrt{4000}}{60,000} \geq \frac{200}{60,000}$

$= .00316 \geq .0033$

$\therefore \boxed{\rho_{min} = .0033}$

As $\rho_{min} < \rho < \rho_{max}$; we analyze as singly reinforced beam.

Det^n of All. Mom. Cap.

$f_c = .45 f'_c = .45 \times 4000 = 1800 \, psi$

$f_s = .4 f_y = .4 \times 60000 = 24000 \, psi$

$n = \frac{E_s}{E_c} = \frac{29 \times 10^6}{57000\sqrt{f'_c}} \approx 8$

$r = \frac{f_s}{f_c} = \frac{24000}{1800} = 13.33$

$\therefore k = \frac{n}{n+r} = \frac{8}{8+13.33} = 0.375$

$\therefore j = 1 - k/3 = 0.875$

$\therefore M_s = A_s f_s jd = 2.64 \times 24000 \times .875 \times 18$

$= 997920$ lb-in

$= \boxed{83.16 \text{ K-ft}}$

Detn of nominal moment capacity:

$a = \frac{A_s f_y}{.85 f'_c b} = \frac{2.64 \times 60}{.85 \times 4 \times 10} = 4.66$ in

$\therefore M_n = A_s f_y (d - a/2) = 2.64 \times 60 \times (18 - \frac{4.66}{2})$

$= 2482.2$ K-in

$= \boxed{206.85 \text{ K-ft}}$

Design Flex. Cap.:

$c = a/\beta_1 = \frac{4.66}{.85} = 5.48$ in

$c/d_t = \frac{5.48}{18} = .305 < .375$

so, $\phi = 0.90$

$\therefore M_{design} = \phi M_n = 0.9 \times 206.85 = \boxed{186.17 \text{ K-ft}}$

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'37'. Rect beam, $b = 250 mm = '25 m$

$d = 500 mm = '5 m$

$DL = 15.3 kN/m$

$LL = 36 kN/m$

$L = 6.5 m$

$f'_c = 28 MPa$

$f_y = 414 MPa = 414 \times 10^6 Nm^{-2} = 414 \times 10^3 kNm^{-2}$

$P_{max} = '0278$

Steel Area = ?

Soln:

$w = 1.2 DL + 1.6 LL = 1.2 \times 15.3 + 1.6 \times 36 = 76 kN/m$

$\therefore M = \frac{wL^2}{(12)} = \frac{76 \times 6.5^2}{12} = 267.4 kN-m$

8 उत्तर

$M = \phi P f_y bd^2 (1 - '59 P \frac{f_y}{f'_c})$

$\Rightarrow 267.4 = 0.9 \times P \times 414 \times 10^3 \times '25 \times '5^2 (1 - '59 P \times \frac{414}{28})$ [we take, $\phi = 0.9$]

$= 23287.5 P (1 - 8.72 P)$

$= 23287.5 P - 203150.2 P^2$

$\therefore P = 0.1017$ or, 0.0129

P should be less than P_{max} ; so $P = '0129$

$\therefore A_{s\,req} = P bd = '0129 \times 250 \times 500$

$= 1612.5 mm^2$

check for ϕ : $a = \frac{A_s f_y}{'85 f'_c b} = 112.2 mm$; $c = a/\beta_1 = a/'85 = 132 mm$

$c/d_t = 132/500 = '26 < '375$ $\therefore \phi = 0.9$ ok

37:

$b_f = 700\ mm$

$h_f = 150\ mm$

$b_w = 250\ mm$

$d = 650\ mm$

$A_{st} = 8\ \phi\ 32\ mm = 6434\ mm^2$

$f'_c = 23\ MPa$

$f_y = 414\ MPa$

$M_u = ?$

Soln:

$$a = \frac{A_s f_y}{.85 f'_c b_f} = \frac{6434\ mm^2 \times 414\ KN/mm^2}{.85 \times 23\ KN/mm^2 \times 700\ mm} = 194.6\ mm$$

$a > h_f$; so we consider T-beam

Now,

$$a = \frac{A_s f_y}{.85 f'_c b_w} = \ldots = 545\ mm$$

$$M_{flange} = .85 f'_c h_f (b_f - b_w)(d - h_f/2)$$

~~$= .85 \times 23 KN/mm^2 \times (700 - 250) mm \times (650 - \frac{545}{2}) mm \times 545 mm$~~

$$= .85 \times 23\ KN/mm^2 \times 150\ mm \times (700 - 250)\ mm \times (650 - \frac{250}{2})\ mm$$

$$= 760 \times 10^6\ KN-mm$$

$$= 760 \times 10^3\ KN-m$$

$$A_{sf} = \frac{.85 f'_c h_f (b_f - b_w)}{f_y} = \frac{.85 \times 23 KN/mm^2 \times 150\ mm \times (700 - 250) mm}{414\ KN/mm^2}$$

$$= 3187.5\ mm^2$$

$$\therefore A_{sw} = A_s - A_{sf} = 6434 - 3187.5 = 3246.5\ mm^2$$

'37: $b_f = 700$ mm

$h_f = 150$ mm

$b_w = 250$ mm

$d = 650$ mm

$A_{st} = 8\ \phi\ 32$ mm $= 6434\ mm^2$

$f'_c = 23$ MPa

$f_y = 414$ MPa

$M_u = ?$

Soln: $a = \frac{A_s f_y}{.85 f'_c b_f} = \frac{6434\ mm^2 \times 414\ KN/mm^2}{.85 \times 23\ KN/mm^2 \times 700\ mm} = 194.6\ mm$

$a > h_f$; so we consider T-beam

Now, $a = \frac{A_s f_y}{.85 f'_c b_w} = \ldots\ldots = 545$ mm

$M_{flange} = .85 f'_c h_f (b_f - b_w)(d - h_f/2)$

~~$= .85 \times 23 KN/mm^2 \times (700 - 250) mm \times (650 - \frac{545}{2}) mm \times 545\ mm$~~

$= .85 \times 23\ KN/mm^2 \times 150\ mm \times (760 - 250)\ mm \times (650 - \frac{250}{2})\ mm$

$= 760 \times 10^6$ KN-mm

$= 760 \times 10^3$ KN-m

$A_{sf} = \frac{.85 f'_c h_f (b_f - b_w)}{f_y} = \frac{.85 \times 23 KN/mm^2 \times 150\ mm \times (700 - 250) mm}{414\ KN/mm^2}$

$= 3187.5\ mm^2$

$\therefore A_{sw} = A_s - A_{sf} = 6434 - 3187.5 = 3246.5\ mm^2$

$\therefore M_{web} = A_{sw} f_y (d - a/2)$

$= 32465 mm^2 \times 414 \; KN/mm^2 \times \left(650 - \frac{545}{2}\right) mm$

$= 507.4 \times 10^6 \; KN-mm$

$= 507.4 \times 10^3 \; KN-m$

$\therefore M = M_f + M_{web} = (760 + 507.4) \times 10^3 \; KN-m$

$= \boxed{1266 \times 10^3 \; KN-m}$

136: Rect Beam

DL = 1.05 kip/ft

LL = 2.47 kip/ft

L = 18 ft

b = 10 in

t = 20 in

f_y = 60,000 psi

f'_c = 4000 psi

A_s = ?

Soln: $w = 1.2\,DL + 1.6\,LL = 5.212$ K/ft

$\therefore M = \frac{wL^2}{8} = \frac{5.212 \times 18^2}{8} = 211$ K-ft

Assume Effective depth, d = 20 - 3 = 17 in

$\therefore M = \phi \rho f_y b d^2 (1 - .59 \rho \frac{f_y}{f'_c})$ [We take $\phi = 0.9$]

$\Rightarrow 211 \times 12$ K-in $= .9 \times \rho \times 60$ K-in$^2 \times 10 \times 17^2 \times (1 - .59 \times \rho \times \frac{60}{4})$

$\Rightarrow 2532$ k-in $= 156060\rho(1 - 8.85\rho)$

$\Rightarrow 2532 = 156060\rho - 1381131\rho^2$

$\therefore \rho = .0034$ or $.0196$

Now, $\rho_{max} = .85\,\beta_1 \frac{f'_c}{f_y} \frac{\epsilon_u}{\epsilon_u + .004} = .85 \times .85 \times \frac{4}{60} \times \frac{.003}{.003 + .004}$

$= .0207$

So, $\rho = .0196$

$\therefore A_s = \rho bd = .0196 \times 10 \times 17 =$ **3.33 in^2**

Check for ϕ: $a = \frac{A_s f_y}{.85 f'_c b} = 5.88$

$c = a/\beta_1 = 6.91$

$c/d_t = \frac{6.91}{17} = .41$; $.6 > .41 > .375$

$\therefore \phi = .9 - \frac{.41 - .375}{.6 - .375} = 0.86$

$\therefore$ we take 6 #7 bars, A_s = ~~2×1.27~~

$6 \times .61 = 3.66 \ in^2$

which is more than the required $3.33 \ in^2$

Spiral spacing: $s \leq \frac{\pi d^2 f_y}{.45 D_c f'_c \left(\frac{A_g}{A_{ch}} - 1\right)}$ [centre to centre pitch]

Min^m #3 bar

$s_{max} = 3$ in [clear spacing]

$s_{min} = 1$ in

D_c = Dia of col^n − 2× [clear cover] → 1.5 in

Scanned with CamScanner

'36: Design col^n & spiral

$DL = 500$ kip

$LL = 25$ kip

$f'_c = 4.5$ ksi

$f_y = 60$ ksi

$\rho = 3\% = .03$

Sol^n: $P_u = 1.2DL + 1.6DL = 1.2 \times 500 + 1.6 \times 25 = 640$ kips

$P_u = \alpha\phi[.85(A_g - A_s)f'_c + A_s f_y]$

$= A_g \alpha \phi [.85(1-\rho)f'_c + \rho f_y]$

$\Rightarrow 970 = A_g \times .85 \times .75 [.85 \times (1 - .03) \times 4.5 + .03 \times 60]$; [For spiral, $\alpha = .85$, $\phi = .75$]

$\therefore A_g = 276.13\ in^2$

Now, $A_g = \frac{\pi}{4} D^2 = 276.13\ in^2 \Rightarrow D = 18.75$ in

we take 19 in Dia ; so, $A_g = 283.53\ in^2$

$\therefore 970 = .85 \times .75 \times [.85 \times (283.53 - A_s) \times 4.5 + A_s \times 60]$

$= 691.37 - 2.44 A_s + 38.25 A_s$

$\Rightarrow 278.63 = 35.81 A_s$

$\therefore A_s = 7.78\ in^2$; we take 8 #9 bars, $A_s = 8\ in^2$

Spiral design: $D_{core} = 19 - 2 \times 1.5 = 16$ in

$A_{ch} = \frac{\pi}{4} \times 16^2 = 201.06\ in^2$

$\therefore \rho_{s,min} = 0.45\left(\frac{A_g}{A_{ch}} - 1\right)\frac{f'_c}{f_y} = 0.45\left(\frac{283.53}{201.06} - 1\right) \times \frac{4.5}{60} = .0138$

we take #3 bar; $A_{sp} = .11\ in^2$

$\therefore$ spacing, $s = \frac{4 A_{sp}}{\rho_s D_c} = \frac{4 \times .11}{.0138 \times 16} = 1.99$ $\therefore$ we take #3 @ 2" c/c

~~RCC~~ MATH

Foundation Eng

'40': Square footing

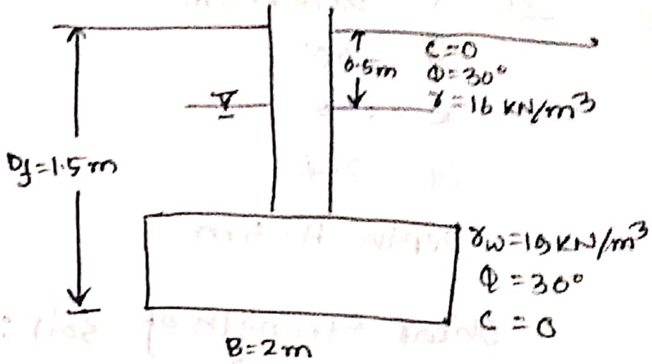
$N_c = 30$

$N_q = 18$

$N_\gamma = 15$

$FS = 3$

Gross allowable load capacity = ?
(Terzaghi)



Sol^n: $q = \gamma H_1 + \gamma'_w H_2 = 16 \times 0.5 + (19 - 9.8) \times 1 = 17.2 \text{ kN/m}^2$

$\therefore q_u = 1.3 c N_c + q N_q + .4 B \gamma'_w N_\gamma$

$= 1.3 \times 0 \times 30 + 17.2 \times 18 + .4 \times 2 \times (19 - 9.8) \times 15$

$= 420 \text{ kN/m}^2$

$\therefore q_{all} = \frac{q_u}{FS} = \frac{420}{3} = \boxed{140 \text{ kN/m}^2}$

#~~37~~: $c = 15 \text{ kN/m}^2$

$\phi = 30°$

$e = 0.6$

$G_s = 2.7$

Depth, $H = 5$ m

Shear strength of soil = ?

Sol^n: $\gamma_d = \frac{G_s \gamma_w}{1+e}$

$= \frac{2.7 \times 9.81 \text{kN/m}^2}{1 + 0.6}$

$= 16.55 \text{ kN/m}^2$

$\therefore$ Shear strength $= c + \sigma \tan \phi$

$= c + (\gamma H) \tan \phi$

$= 15 + (16.55 \times 5) \tan 30°$

$= \boxed{62.8 \text{ kN/m}^2}$

37: $c = \cancel{30}\ 15\ KN/m^2$

$\phi = 30^\circ$

$e = 0.6$

$G = 2.7$

Depth, $H = 5m$

Shear strength of soil : i) WT @ Ground surface

ii) WT @ 3 m depth

Soln : $\gamma_d = \frac{G_s \gamma_w}{1+e} = \frac{2.7 \times 9.81}{1+.6} = 16.55\ KN/m^2$

i) WT @ GL : $\sigma = \gamma' H$

$= (\gamma_d - \gamma_w) H$

$= (16.55 - 9.81) \times 5 = 33.7\ KN/m^2$

$\therefore$ Shear strength $= c + \sigma \tan\phi = 15 + 33.7 \tan(30^\circ)$

$= \boxed{34.46\ KN/m^2}$

(ii) WT @ 3m depth : $\sigma = \gamma_d H_1 + \gamma' H_2$

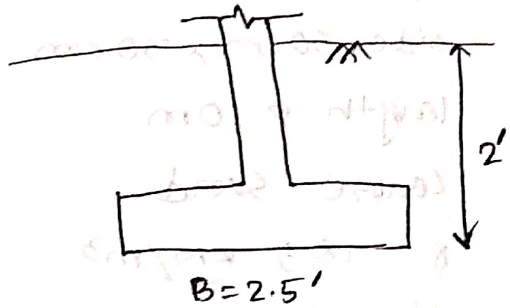
$= 16.55 \times 3 + (16.55 - 9.81) \times 2$

$= 63.13\ KN/m^2$

$\therefore$ Shear strength $= c + \sigma \tan\phi = 15 + 63.13 \tan(30^\circ)$

$= \boxed{51.45\ KN/m^2}$

331 Continuous Footing



$\gamma = 115 \text{ lb/ft}^3$

$c = 400 \text{ lb/ft}^2$

$\phi = 25°$

$D_f = 2 \text{ ft}$

$B = 2.5 \text{ ft}$

$FS = 4$

$N_c = 25.13, \; N_q = 12.72, \; N_\gamma = 8.34$

Gross allowable load per unit area, $q_{au} = ?$

Soln: $\sigma = \gamma D_f = 115 \text{ lb/ft}^3 \times 2 \text{ ft} = 230 \text{ lb/ft}^2$

$q_u = cN_c + qN_q + \frac{1}{2} B \gamma N_\gamma$

$= 400 \times 25.13 + 230 \times 12.72 + \frac{1}{2} \times 2.5 \times 115 \times 8.34$

$= 14176.48 \text{ lb/ft}^2$

$\therefore q_{au} = \frac{q_u}{FS} = \frac{14176.48}{4}$ ~~= 2513 lb = 2.513 kip/ft²~~

$= 3544.12 \text{ lb/ft}^2 = \boxed{3.54 \text{ kip/ft}^2}$

'31: Square concrete pile (Driven)

side 30 cm x 30 cm = 0.3 m x 0.3 m

length = 10 m

Coarse sand.

$\gamma = 18.5\ KN/m^3$

N = 20

load capacity, q = ?

Soln:

$q_u = q_{skin} + q_{bearing}$

$= A N_c A_{surface} + B N_c A_{tip}$

$= 2 \times 20 \times (4 \times 10 \times .3) + 400 \times 20 \times (.3 \times .3)$

$= 1200$ KN

$\therefore q = \frac{q_u}{FS} = \frac{1200}{4} = 300$ KN

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27, 29th: Design a square footing
Col^n load = 600 kips
FS = 3
Depth of footing, $D_f = 6'$
unconfined compressive strength, $Q_u = 3000\ lb/ft^2$ (clay material)
$f'_c = 3$ ksi
$f_y = 60$ ksi

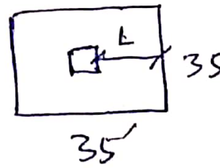
Sol^n: for the clay soil, $c = \frac{Q_u}{2} = \frac{3000}{2} = 1500\ lb/ft^2$

∴ Ultimate shear strength, $q_u = 1500\ lb/ft^2$

∴ Allowable shear load, $q_a = \frac{q_u}{FS} = \frac{1500}{3} = 500\ lb/ft^2$

∴ Area of footing reqd $= \frac{Load}{q_a} = \frac{600\times10^3\ lb}{500\ lb/ft^2} = 1200\ ft^2$

∴ We take ~~40' x 30'~~ 35' x 35' footing, thickness 2'.



Reinforcement design: $M_u = \frac{wL^2}{2} = \frac{(500\ lb/ft^2 \times 35\ ft) \times (\frac{35}{2} ft)^2}{2}$

~~= 612.5 kip~~ = 5360 kip - ft

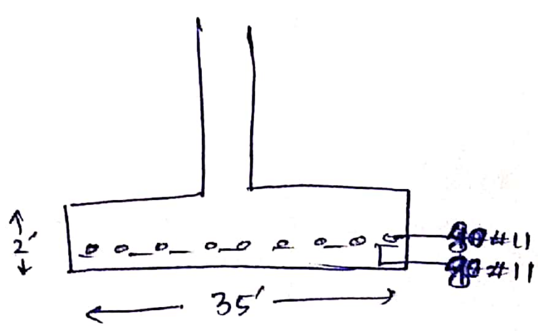
$A_s = \frac{M_u}{\Phi f_y (d - a/2)} = \frac{5360\times12\ kip\text{-}in}{.9\times 60K/in^2 \times (6-\frac{2}{2})\times12 in}$ [Let, a = 2']

= ~~238 in²~~ 19.85 in²

$A_{s,min} = \frac{3\sqrt{f'_c}}{f_y} bd \geq \frac{200}{f_y} bd$

= 82.8 in² ≥ 100.8 in²

∴ We take ~~55~~ 80 # 11 bars.



Scanned with CamScanner

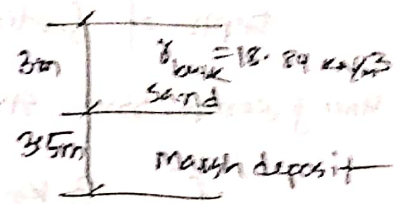
Ans: $\gamma_{bulk} = 18.84\ KN/m^3$

Thickness, $H_1 = 3.5m$ (compressible saturated marsh deposit)

Ht. of fill, $H = 3m$ (sand compaction)

Vol^m of compressibility, $m_v = 7 \times 10^{-4}\ m^2/KN$

Final settlement = ?



Sol^n: Increase of pressure on marsh deposit due to sand fill, $\Delta P = \gamma H$

$= 18.84 \times 3$

$= 56.52\ KN/m^2$

$\therefore$ settlement, $S = m_v\ \Delta P\ H_1$

$= 7 \times 10^{-4}\ m^2/KN \times 56.52\ KN/m^2 \times 3.5\ m$

$= \boxed{0.138\ m}$

38: Clay Layer thickness, $H = 4m$

Pressure, $P = 55\ KN/m^2$

% consolidation, $U = 50\%$

Double Drainage

$T_v = 0.196$

Co-eff. of permeability, $k = 0.020\ m/yr$

& Time, $T = 1\ yr$

Settlement, $s = ?$

Rate of flow per unit area, $= ?$

Solⁿ:

$$c_v = \frac{T_v d^2}{t} = \frac{0.196 \times \left(\frac{4}{2}\right)^2}{1} = .784\ m^2/yr$$

$$m_v = \frac{k}{\gamma_w c_v} = \frac{.02\ m/yr}{9.81\ KN/m^3 \times .784\ m^2/yr} = 2.6 \times 10^{-3}\ m^2/KN$$

$$s = m_v \Delta P H = 2.6 \times 10^{-3}\ m^2/KN \times 55\ KN/m^2 \times 4m = \boxed{0.572\ m}$$

Final settlement

∴ Settlement after 1yr = 50% of s = $\boxed{.286\ m}$

$s \propto \sqrt{t} \Rightarrow s^2 \propto t \Rightarrow s^2 = K t$

B.C: For $t = 1\ yr$, $s = .286\ m$ ∴ $K = .0818$

$$\therefore s^2 = .0818\ t \Rightarrow 2s \frac{ds}{dt} = .0818 \quad \therefore \frac{ds}{dt} = \frac{.0818}{2 \times .286}$$

$$= 0.143\ m/yr$$

∴ Discharge per unit area per surface $= \frac{.143}{2} = \boxed{.072\ m/yr}$ (2 way drainage)

'37: Layer thickness, t = 2m (clay)

Loading, $\Delta P = 0.5\ kg/cm^2 = \frac{0.5 \times 9.81 \times 10^4}{10^3}\ KN/m^2$

Time, t = 1 yr $= 49.05\ KN/m^2$

Avg. consolidation, U = 50%

Double drainage

$\therefore d = t/2 = 1\ m$

(i) Co-eff of consolidation, $c_v = ?$

(ii) Co-eff. of permeability, k = 3 mm/yr = ·003 m/yr

Settlement after 1 yr, $s_1 = ?$

(iii) 90% consolidation, $T_{v_2} = 0.848$

Time, $t_2 = ?$

Soln: (i) $T_{v_1} = \frac{\pi}{4}\left(\frac{U}{100}\right)^2 = \frac{\pi}{4} \times \cdot 5^2 = 0.196$

$c_v = \frac{T_{v_1} d^2}{t} = \frac{\cdot 196 \times (1m)^2}{1 yr} = \boxed{\cdot 196\ m^2/yr}$

(ii) $m_v = \frac{k}{c_v \gamma_w} = \frac{\cdot 003\ m/yr}{\cdot 196\ m^2/yr \times 9.81\ KN/m^3} = 1.56 \times 10^{-3}\ m^2/KN$

Final settlement, $s_f = m_v \Delta P H = 1.56 \times 10^{-3}\ m^2/KN \times 49.05\ KN/m^2 \times 2m$

$= 0.153\ m$

$\therefore$ Settlement after 1 yr, s_1 = 50% of s_f = ·0765 m

$= \boxed{76.5\ mm}$

(iii) $c_v = \frac{T_{v_2} d^2}{t_2} \Rightarrow t_2 = \frac{\cdot 848 \times 1^2}{\cdot 196} = \boxed{4.32\ yr}$

'31,'35: Layer thickness, $H = 5m$ (clay)

Initial, $e_0 = 1.50$

Effective Overburden Pressure, $\sigma' = 120\ kN/m^2$

Increase of pressure, $\Delta\sigma = 120\ kN/m^2$

Final void, $e = 1.44$

Co-eff. of vol^m compressibility, $m_v = ?$

Final settlement, $S_f = ?$

Sol^n: change of void, $\Delta e = e_0 - e = 1.5 - 1.44 = 0.06$

Co-eff. of compressibility, $a_v = \frac{\Delta e}{\Delta P} = \frac{.06}{120\ kN/m^2} = 5 \times 10^{-4}\ m^2/kN$

Co-eff. of vol^m ,, , $m_v = \frac{a_v}{1+e_0} = \frac{5 \times 10^{-4}}{1+1.5} = \boxed{2 \times 10^{-4}\ m^2/kN}$

Final settlement, $S_f = m_v \Delta\sigma H$

$= 2 \times 10^{-4}\ m^2/kN \times 120\ kN/m^2 \times 5m$

$= \boxed{0.12\ m}$

'30'. Consolidation, U = 50 %

H_1 = 3 cm = '03 m (single Drain)

t_1 = 30 min

H_2 = 4 m (Double Drain)

t_2 = ?

Sol^n:

$c_v = \frac{T_v d^2}{t} \Rightarrow d^2 = \frac{c_v}{T_v} t$ ~~$\Rightarrow \frac{H^2}{4} = c_v$~~

$\therefore d^2 \propto t$

$\therefore \frac{d_1^2}{t_1} = \frac{d_2^2}{t_2}$

$\Rightarrow \frac{'03^2}{30 min} = \frac{(\frac{4}{2})^2}{t_2}$

$\therefore t_2 = 133333.33$ min

= **92.6 days**

'38: $\omega = 10\%$

Cyllnder Dia, $D = 15\ cm = '15\ m$

Depth, $H = 12.5\ cm = '125\ m$

Air content = 5 %

$M_{wet} = ?$

If $G = 2.68$

$e = ?$

$\gamma_d = ?$

Soln: Volm, $V = \pi r^2 H = \frac{\pi}{4} D^2 H = \frac{\pi}{4} \times ('15)^2 \times ('125) = 2.2 \times 10^{-3}\ m^3$

'33: $\gamma_d = 1600\ kg/m^3$ (sand)

$n = 0.381$

$e = ?$

$G_s = ?$

$e > n$

$e = \frac{n}{1-n}$

Soln: $e = \frac{n}{1-n} = \frac{'381}{1-'381} = \boxed{0.62}$

$\gamma_d = \frac{G_s \gamma_w}{1+e}$, ~~$e = \frac{G_s \gamma_w}{\gamma_d} - 1 =$~~

$\Rightarrow 1600 = \frac{G_s \times 1000}{1+0.62}$ $\therefore G_s = \boxed{2.584}$

'32: W = 27.5 lb

V = '22 cft

ω = 15.2%

G_s = 2.67

$\gamma_d, \gamma_{bulk}, S, e = ?$

Solⁿ: $\gamma_{bulk} = \frac{W}{V} = \frac{27.5 \text{ lb}}{'22 \text{ cft}} = 125 \text{ lb/cft}$

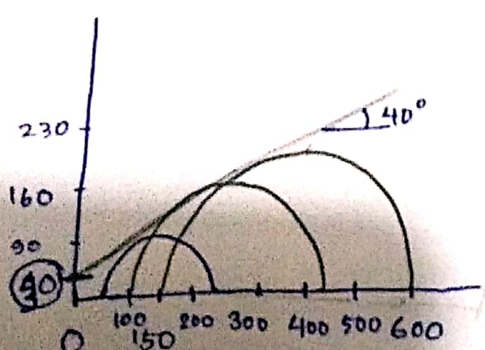
$\gamma_d = \frac{\gamma_{bulk}}{1+\omega} = \frac{125}{1+.152} = 108.51 \text{ lb/cft}$

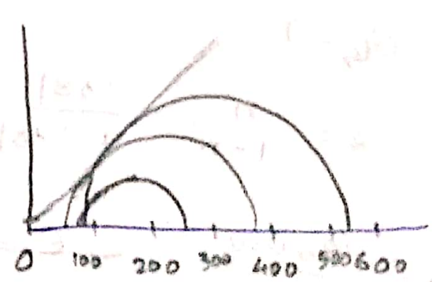
$\gamma_d = \frac{G_s \gamma_w}{1+e} \Rightarrow 108.51 = \frac{2.67 \times 62.4}{1+e}$ $\therefore e = 0.535$

$S = \frac{\omega G_s}{e} = \frac{.152 \times 2.67}{.535} = 0.758 = 75.8\%$

'37|

σ_3 (kN/m²)	d	u	σ_3'	σ_1	σ_1'
50	180	−20	70	230	250
100	320	50	150	420	370
150	450	70	80	600	530
			$(\sigma_3 - u)$	$(\sigma_3 + d)$	$(\sigma_1 - u)$





$\Phi = \sin^{-1} \frac{\sigma_1/\sigma_3 - 1}{\sigma_1/\sigma_3 + 1} = 40°$

c = 30 kN/m² (Graph

$\Phi = \sin^{-1} \frac{\sigma_1'/\sigma_3' - 1}{\sigma_1'/\sigma_3' + 1} = 47.54°$

c = 20 kN/m² (Graph)

Environment

'38: Q = 500,000 gpd = 500000 × 4.5 L/day = 2.25×10^6 L/day

Chlorine requirement = 0.3 mg/L = 0.3×10^{-6} kg/L

Chlorine available in bleaching = 33.33 %

Soln: Chlorine required per day = $2.25 \times 10^6 \times 0.3 \times 10^{-6}$ kg

= 0.675 kg

∴ Bleaching to be applied = $\dfrac{0.675 \text{ kg/day}}{.3333}$

= **2.025 kg/day**

'38: $BOD_5 = 200$ mg/L @ 20°C

$R_{20} = 0.18 \text{ day}^{-1}$ @ 20°C ; R থাকলে log এর base 10 হবে

$BOD_1 = ?$ @ 12°C

$BOD_5 = ?$ @ 12°C

Soln: $R_{12} = R_{20}(1.047)^{12-20} = .18 \times 1.047^{-8} = 0.125$

$BOD_5 = BOD_U(1 - 10^{-R_{20}t})$

∴ $BOD_U = \dfrac{200}{1 - 10^{-(.18 \times 5)}}$ = ~~337 mg/L~~ 228.8 mg/L

∴ @ 12°C : $BOD_1 = BOD_U(1 - e^{-K_{12}t}) = 228(1 - e^{-.125 \times 1})$ = ~~39.6 mg/L~~ = 26.9 mg/L

@ 12°C : $BOD_5 = BOD_U(1 - e^{-K_{12} \times 5})$ = ~~156.62 mg/L~~ = 106.3 mg/L

'37: $P_{2015} = 7000$

i) $r = 1\%$; $P_{2020} = ?$

ii) Fire fighting water demand @ 2025 = ?

Soln: i) $P_{2020} = P_{2015}(1+r)^5 = 7000(1+.01)^5 = 7357$

ii) $P_{2025} = 7000(1+.01)^{10} = 7732$

Knichling's Formula: FF water demand $= 3182\sqrt{P}$; [P in thousand]

$= 3182\sqrt{7.732}$

~~279799 L/min~~

$= 8848$ L/min

'37: BOD Loading $\frac{f_1 \cdot BOD}{V_1} = 750\ g/m^3/d$

$= .75\ kg/m^3/d$

Re-circulation Ratio, $R = 0.7$

BOD removal efficiency, $E = ?$

Soln: $Rf_1 = \frac{1+R}{(1+0.1R)^2} = \frac{1+.7}{(1+.1\times.7)^2} = 1.48$

$E = \frac{100}{1+0.44\sqrt{\frac{f_1 BOD}{V_1 \cdot Rf_1}}} = \frac{100}{1+0.44\sqrt{\frac{.75}{1.48}}}$

$= 76.15\%$

36: Design a septic tank for small residential area

Person, $P = 300$

Daily sewage flow, $q = 85$ L/person/day

Assume Reasonable values

Soln: Assume, Temp, $T = 25°C$

$C = 0.06 \, m^3$

$N = 3$ years

Sedimentation: Retention time, $t_{po} = 1.5 - 0.3 \log(pq)$

$= 1.5 - 0.3 \log(300 \times 85)$

$= 0.178$ days

Volm, $V_{so} = 10^{-3}(pq)\, t_{po}$

$= 10^{-3} \times 300 \times 85 \times 0.178$

$= 4.54 \, m^3$

Sludge Digestion: Digestion time, $t_d = 30(1.035)^{35-T}$

$= 30(1.035)^{35-25}$

$= 42.3$ days

Volm, $V_d = 0.5 \times 10^{-3} \, p \, t_d$

$= 6.345 \, m^3$

Scanned with CamScanner

Sludge storage: Vol^m, V_{sl} = CPN

$= 0.06\ m^3 \times 300$ person $\times$ 3 yrs

$= 54\ m^3$

∴ Total effective tank vol^m = $V_p + V_d + 1.4 V_{sl}$

$= 4.54 + 6.345 + 1.4 \times 54$

$= 86.5\ m^3$

Tank effective depth:

Assume a X-sxn Area, $A = 10 \times 3 = 30\ m^2$

∴ Sedimentation depth, $d_p = \frac{4.54}{30} = 0.151 m < 0.375 m$

∴ Sludge depth, $d_{sl} = \frac{54}{30} = 1.8 m$

∴ Scum depth, $d_{ss} = \frac{0.4 \times 54}{30} = 0.72 m$

∴ Total depth $= 1.8 + .72 + .151$

$= 2.67\ m$

∴ we design septic tank 10m x 3m x 3m

'35: $BOD_1 = ?$ @ $37°C$

$BOD_U = 100$ mg/L

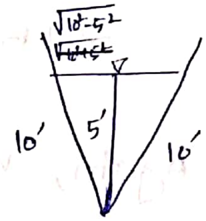
$K_{20} = 0.1$

Sol^n: $K_{37} = K_{20}(1.047)^{37-20} = 0.1 \times 1.047^{17} = 0.218$

$\therefore BOD_1 = BOD_U(1 - e^{-K_{37}t}) = 100 \times (1 - e^{-.218}) = $ **19.61 mg/L**

'35: $n = .015$

$S = .018$



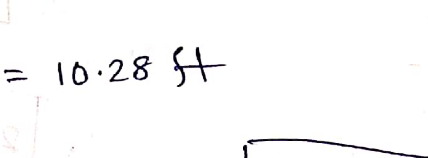
i) $A = \frac{1}{2} \times 2\sqrt{10^2 - 5^2} \times 5$ ~~$= 25\sqrt{5} = 55.9$ ft²~~
$= 25\sqrt{3} = 43.3$ ft²

$P = 20'$

$\therefore R = A/P = \frac{43.3}{20} =$ ~~2.8 ft~~ 2.165 ft

$\therefore V = \frac{1}{n} R^{2/3} S^{1/2} = \frac{1.486}{.015} \times 2.165^{2/3} \times .018^{1/2}$ = ~~17.75 ft/s × 1.486~~
= **22.24 ft/s** ~~= 26.38 ft/s~~

ii) Dia $= \frac{3}{4} \times 10 = 7.5$ ft



$\theta = 2\cos^{-1}\frac{.75}{3.75} = 156.93°$

$A = \frac{d^2}{8}(\theta - \sin\theta) = \frac{7.5^2}{8}(2.74^c - .4) = 16.45$ ft²

$P = \frac{d}{2}\theta = \frac{7}{2} \times 2.74^c = 5.14$ ~~ft~~ $\times 2 = 10.28$ ft

$\therefore R = A/P = \frac{3.2}{2}$ ft $= 1.6$ ft

$\therefore V = \frac{1}{n} R^{2/3} S^{1/2} = \frac{1.486}{.015} \times \left(\frac{3.2}{2}\right)^{2/3} \times .018^{1/2}$ = ~~19.43 ft/s × 1.486~~ = **18.18 ft/s** ~~= 28.87 ft/s~~

31: Calculate dimensions of a rect settling tank

$Q = 120\ m^3/hr$

$V_s = 0.75\ m/hr$

$T = 2\ hr$

Soln: Assume, $L = 4B$

Now, $V_s = \frac{Q}{LB}$

$\Rightarrow LB = \frac{120\ m^3/hr}{0.75\ m/hr} = 160\ m^2$

Again, $\frac{Vol^m}{T} = Q$

$\Rightarrow \frac{LBH}{2hr} = 120\ m^3/hr$

$\Rightarrow 160\ m^2 \times H = 240\ m^3$

$\therefore H = 1.5\ m$

Now, $LB = 160$

$\Rightarrow 4B \times B = 160$

$\therefore B = 6.32\ m$

$\therefore L = 25.3\ m$

$\therefore$ **25.3m × 6.32m × 1.5m**

29.28: Design a standard filter

$Q = 8\ ML/day = 8 \times 10^6\ L/day$

Sewage $BOD_5 = 210\ mg/L$

Final effluent reqd $BOD_5 = 30 mg/L$

Organic loading rate reqd $= 320\ gm/m^3/day$

Soln: Assume, Primary sedimentation removes 30% of BOD

No re-circulation, $Rf_1 = 1$

∴ BOD after primary sedimentation $= (1-.3)\times 210 = 147\ mg/L$

∴ BOD to be removed $= \frac{147-30}{147} \times 100\% = 80\%$

∴ BOD load applied, $F_1\ BOD = 8\times10^6\ L/day \times 147\times10^{-6}\ kg/L = 1176\ kg/day$

$$\therefore E = \frac{100}{1+0.44\sqrt{\frac{F_1\ BOD}{V_1 . Rf_1}}}$$

$$\Rightarrow 80 = \frac{100}{1+0.44\sqrt{\frac{1176}{V_1 . 1}}}$$

∴ $V_1 = 3643\ m^3$

Assume, filter depth, $H = 1.5\ m$

∴ Area, $A = \frac{V_1}{H} = 2430\ m^2 = \frac{\pi}{4} D^2$

∴ $D = 55.6\ m \approx 56\ m$

∴ Hydraulic loading rate = $\frac{8 \times 10^6 \text{ L/day} \times 10^{-3} \text{ m}^3/\text{day}}{2430 \text{ m}^2}$

$= 3.3 \text{ m}^3/\text{m}^2/\text{day} < 4$ (OK)

∴ Organic loading rate = $\frac{F_1 \text{ BOD}}{V_1}$

$= \frac{1176 \text{ kg/day}}{3643 \text{ m}^3}$

$= .3228 \text{ kg/m}^3/\text{day}$

$= 322.8 \text{ gm/m}^3/\text{day}$ (OK)

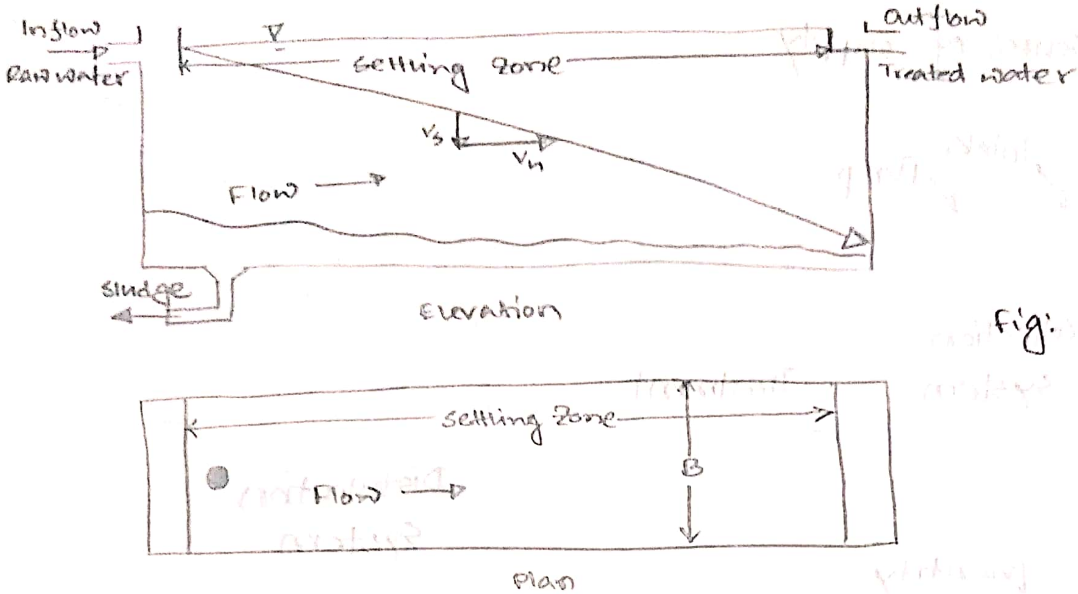


Fig: Settling Tank

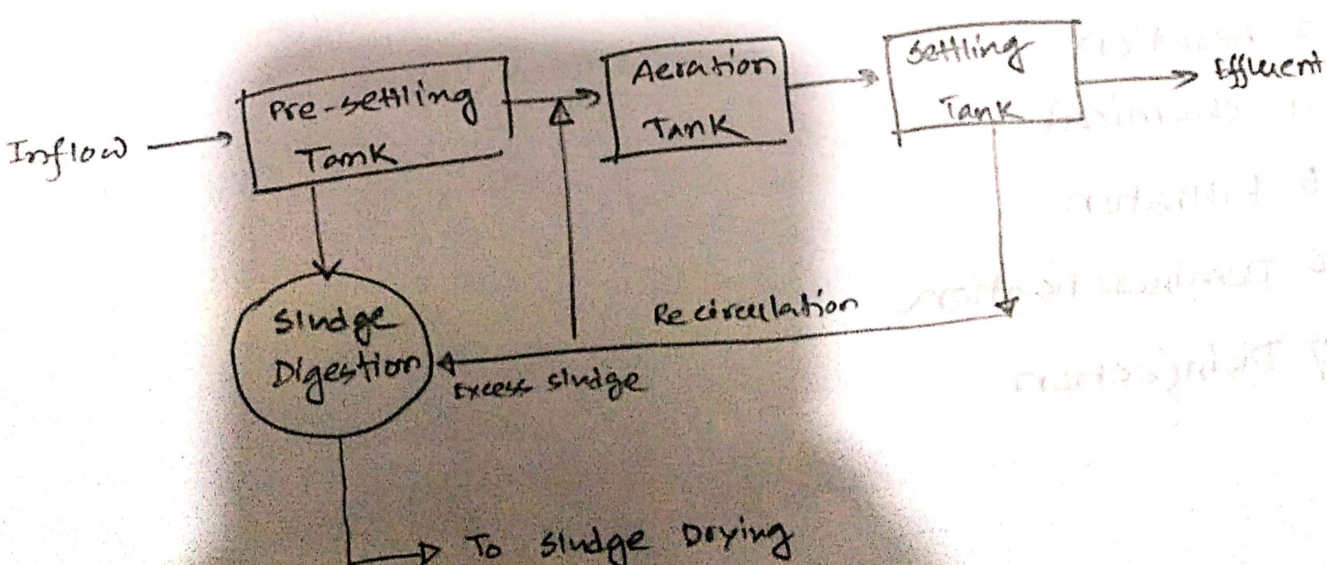
Depth = 1.5 – 2 m

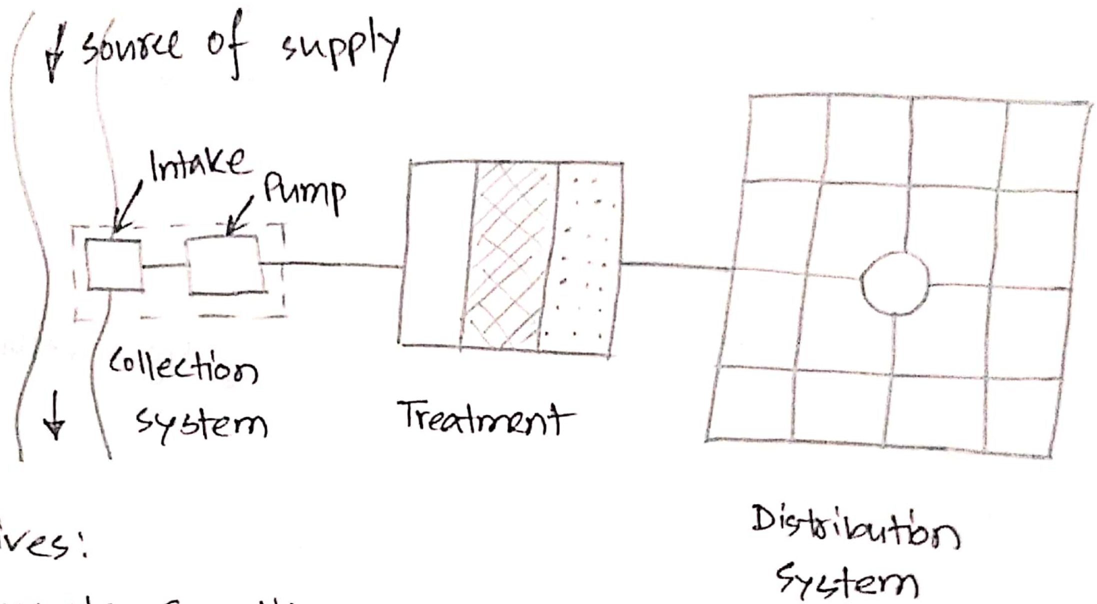
L/B = 3 – 8

T = 1 – 3 hr $= \frac{V}{Q}$

v_s = 0.2 – 1 m/hr $= \frac{Q}{BL}$

1. Inlet
2. Settling zone
3. Sludge accumulation zone
4. Outlet





Objectives:

1. Adequate quantity
2. Safe & wholesome water
3. Easily available

Treatments:

1. Screening
2. Sedimentation
3. Aeration
4. Chemical
5. Filtration
6. Demineralisation
7. Disinfection

Aerobic decomposition:

Organic waste + Oxygen → Oxidized waste + Energy
(Catabolism)

" + Energy → New bacterial cells
(Anabolism)

Bacteria + Oxygen → Oxidized waste + Energy
(Autoxidation)

Anaerobic:

1st stage: Acid forming bacteria:
Organicmatters, Fats, carbs → Volatile & Org. Acids

2nd stage: Methane forming bacteria:
Acids, ammonia → Methane & CO_2