Design of Municipal Wastewater Treatment Plant

Submitted by

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DESIGN OF A WATER TREATMENT PLANT FOR A FLOW OF 12 MLD

1. CASCADE AERATOR

a) Inlet Shaft :

Assuming water velocity to be 0.75 m/s.

$\therefore 1.2 \times 12 \text{ MLD} = \frac{1.2 \times 12 \times 10^6 \times 10^{-3}}{24} = 600 m^3/h = 0.166 m^3/s$.

$\Rightarrow$ Area of shaft $= Q/V = \frac{0.166}{0.75} = \underline{0.22 m^2}$.

$\Rightarrow \pi/4 \, d^2 = 0.22 \Rightarrow d = 0.53 m$

$\therefore$ Diameter of shaft $= 0.53 m$.

Adopting diameter $= \underline{0.6 m \text{ or } 600 mm}$.

The shaft's bell mouth dia $= \underline{0.8 m}$.

b) Size & number of steps :

Assuming, space requirement to be $0.03 m^3/m^3 h$.

Area of cascade $= 0.03 \times \left(\frac{600}{1.2}\right) = 15 m^2$.

If Da is the diameter then,

$$15 = \pi/4 \left(Da^2 - 0.8^2\right)$$

$\Rightarrow Da = \underline{4.44 m}$.

Assuming no. of steps to be 5.

$\therefore$ Size of tread $= \frac{4.443 - 0.8}{5 \times 2} = 0.364 m \simeq \underline{40 cm}$.

Actual size of aerator $= 5 \times 2 \times 0.4 + 0.8 = \underline{4.8\,m}$.

Assuming rise of each step $= \underline{0.3\,m}$

Height of total rise of steps $= 0.3 \times 5 = \underline{1.5\,m}$.

c) Size of Collecting Launder :

Flow in launder $= Q/2 = \dfrac{12 \times 10^3 \times 1.2}{2 \times 24 \times 3600} = 0.0833\,m^3/s$.

Assuming velocity in the launder $= 0.8\,m/s$.

Area requirement $= \dfrac{0.0833}{0.8} = \underline{0.1042\,m^2}$.

Width of launder $= 0.8\,m$ (Assumed)

Height of water (SWD) $= \dfrac{0.1042}{0.8} = 0.13\,m$

Free board in Launder $= 0.2\,m$ (assumed)

Depth of launder $= 0.13 + 0.2 = 0.33$

say, $0.4\,m$.

Size of launder $= \underline{0.8 \times 0.4\,m}$ (Width x height)

d) Inlet pipe connecting inlet shaft :

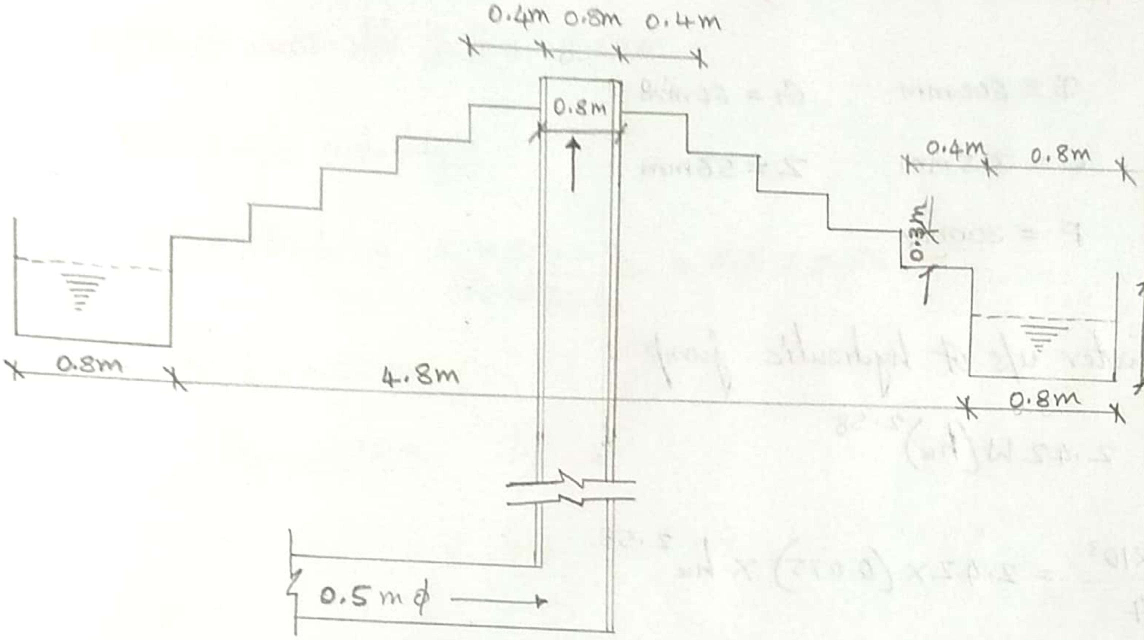
$$Q_1 = Q_2 = V_2 A_2$$

$$\Rightarrow \frac{1.2 \times 12 \times 10^3}{3600 \times 24} = 1.2 \times \pi d^2/4 \Rightarrow d = 0.42\,m$$

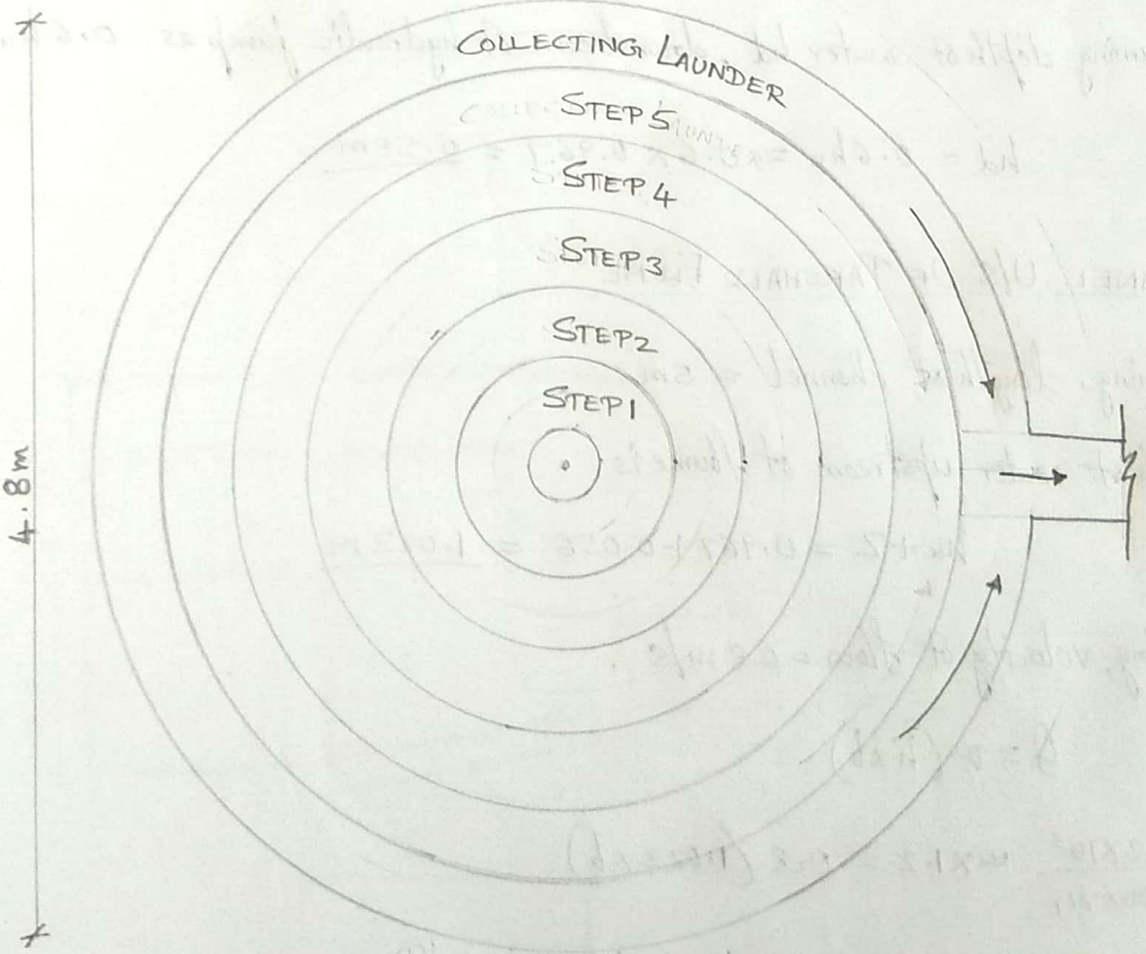
say, $\underline{0.5\,m \simeq 500\,mm}$.

Scanned by CamScanner

1. CASCADE AERATOR



a) Section of Cascade aerator



b) Plan of Cascade aerator

2. PARSHALL FLUME

Dimensions of Parshall flume for $Q = 12\,MLD$ (from table

$W = 75mm$ $B = 600mm$ $G = 60mm$

$A = 460mm$ $C = 315mm$ $Z = 56mm$

$D = 391mm$ $F = 300mm$

Depth of water u/s of hydraulic jump :

$$Q = 2.42\,W (h_u)^{2.58}$$

$$\Rightarrow \frac{1.2 \times 12 \times 10^3}{3600 \times 24} = 2.42 \times (0.075) \times h_u^{2.58}$$

$$\Rightarrow h_u = \underline{0.967\ m}.$$

Assuming depth of water hd, downstream of hydraulic jump as $0.6 h_u$

$$\therefore\ h_d = 0.6 h_u = 0.6 \times 0.967 = \underline{0.58m}.$$

3. CHANNEL U/S OF PARSHALL FLUME

Assuming, length of channel = 5m.

Depth of water upstream of flume is .

$$h_u + Z = 0.967 + 0.056 = \underline{1.023\,m}$$

Assuming, velocity of flow = 0.8 m/s .

$$Q = v\,(h \times b)$$

$$\Rightarrow \frac{12 \times 10^3}{3600 \times 24} \times 1.2 = 0.8\,(1.023 \times b)$$

$$\Rightarrow \underline{b = 0.204\,m}.$$

4. Channel D/S of Parshall Flume to Distribution Chamber

Length of channel = 5m (assumed)

depth of water d/s (h_d) = 0.58m.

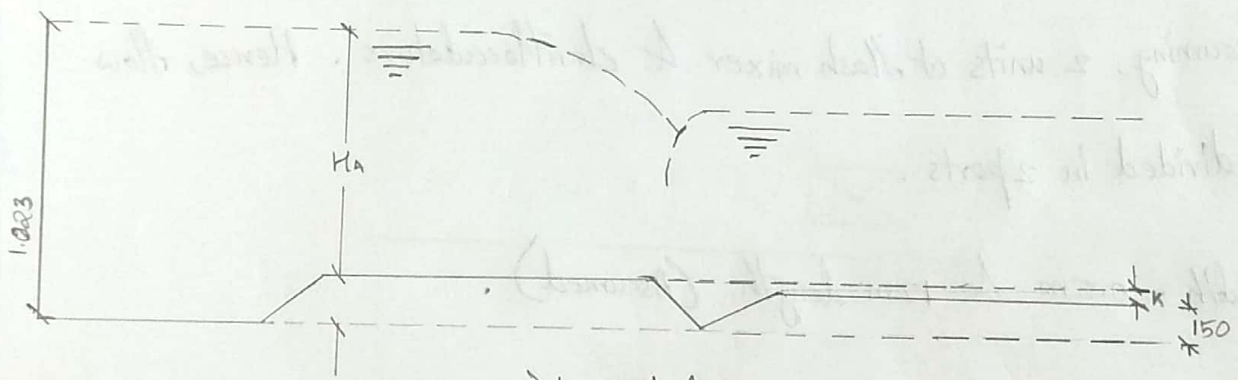
for 0.8 m/s velocity,

$$Q = v \times h \times b \Rightarrow \frac{12\times10^3\times1.2}{3600\times24} = 0.8\times0.58\times b$$

$$\Rightarrow b = 0.359m$$

Say, 0.36m.

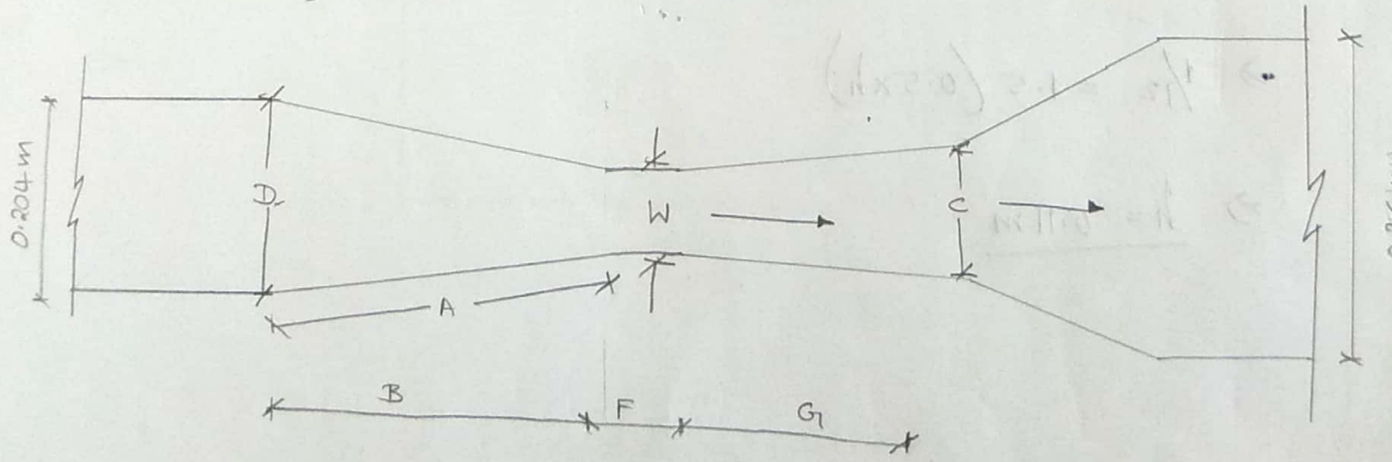
2. Parshall Flume



a) Longitudinal Section

W = 75mm ; B = 600mm ; G = 60mm ; A = 460mm ; C = 315mm ; Z = 56mm ;

D = 391mm ; F = 300mm



b) Plan

5. DISTRIBUTION CHAMBER

Assuming, 10 seconds detention time.

$$\frac{12\times10^3}{3600\times24}\times10 = 1.389m^3 \quad [V=Q\times t]$$

Assuming, SWD = 1 m.

$\therefore$ Area = $\underline{1.389m^2}$.

Size = $\underline{1.2\times1.2m}$

6. CHANNEL BETWEEN DISTRIBUTION CHAMBER AND FLASH MIXER

Assuming, 2 units of flash mixer & clariflocculators. Hence, flow is divided in 2 parts.

Width = 0.5m & 12m length (Assumed).

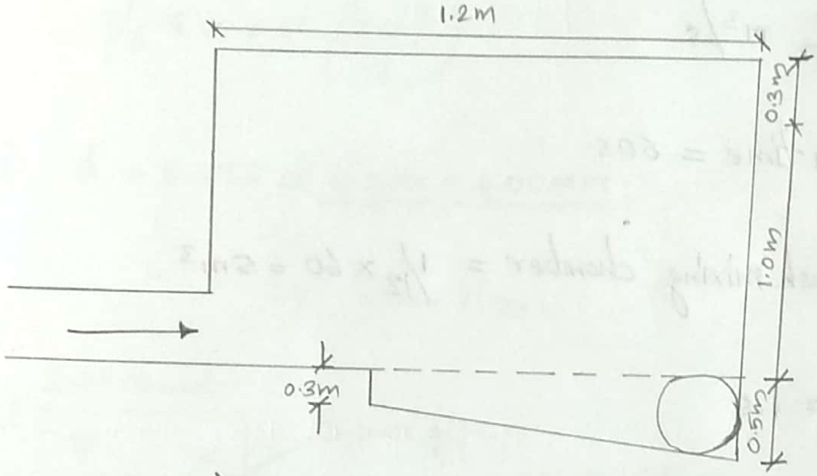
Flow per unit = $1/6 \times 1/2 = 1/12\ m^3/s$

Assuming, $v = 1.5m/s$.

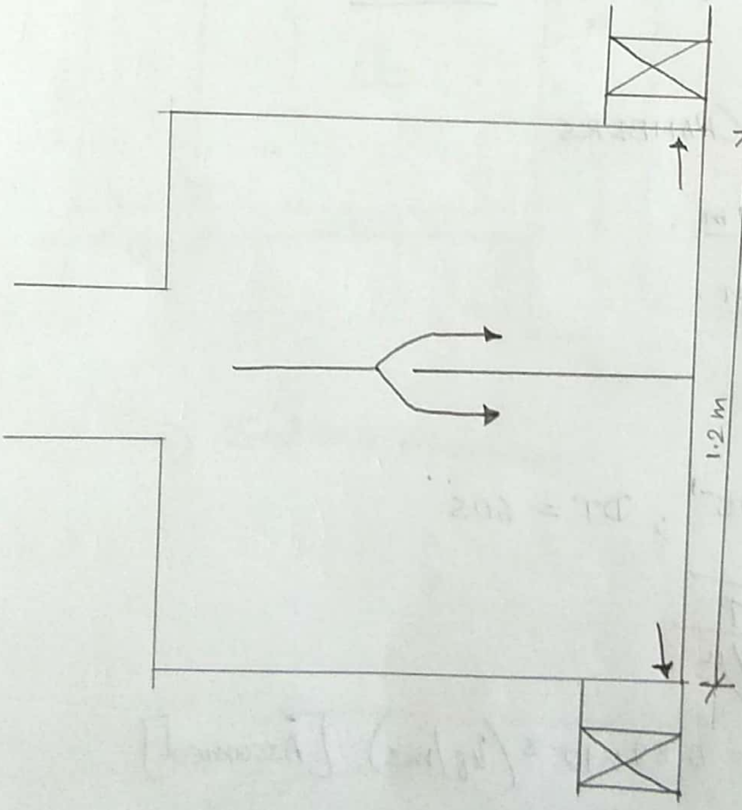
$\Rightarrow 1/12 = 1.5(0.5\times h)$

$\Rightarrow \underline{h = 0.11m}$

3. DISTRIBUTION CHAMBER



a) Section of distribution chamber



b) Plan of distribution Chamber

7. FLASH MIXER

a) Size of Chamber:

Flow per unit $= 1/12 \ m^3/s$

Assuming, detention time $= 60s$

$\therefore$ volume of flash mixing chamber $= 1/12 \times 60 = 5m^3$.

Adopting, $h/dia = 1.5$

$\Rightarrow \frac{\pi d^2}{4} \times 1.5d = 5 \Rightarrow d = \underline{1.62m}$.

& $SWD = 1.5 \times 1.62 = \underline{2.43m}$.

b) INLET & OUTLET CHAMBERS

Size $= \underline{1m \times 1m}$.

$h = \underline{2.43m}$.

c) Power Requirement:

Assuming, $G = 300s^{-1}$, $DT = 60s$

We know, $G = \sqrt{\frac{P}{V\mu}}$

@ $T = 25°C$, $\mu = 0.89 \times 10^{-3} (kg/ms)$ [Assumed].

$\Rightarrow 300^2 = \frac{P}{5 \times 0.89 \times 10^{-3}}$

$\Rightarrow P = \underline{400.5 \text{ watts}}$.

d) Outlet pipe :

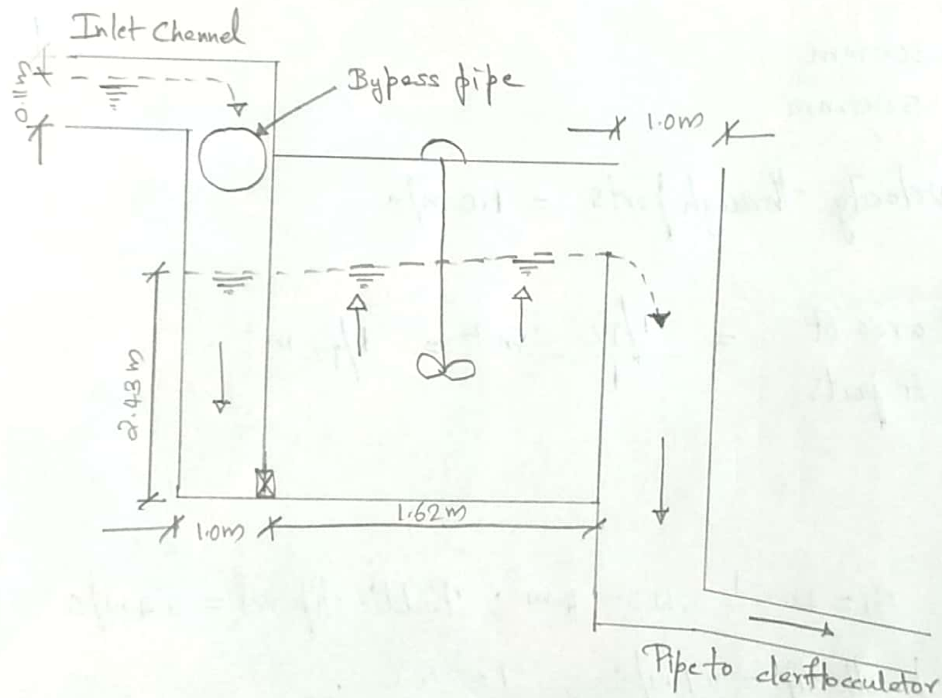
Let velocity in the pipe be 1.5 m/s .

∴ for 20% overload :-

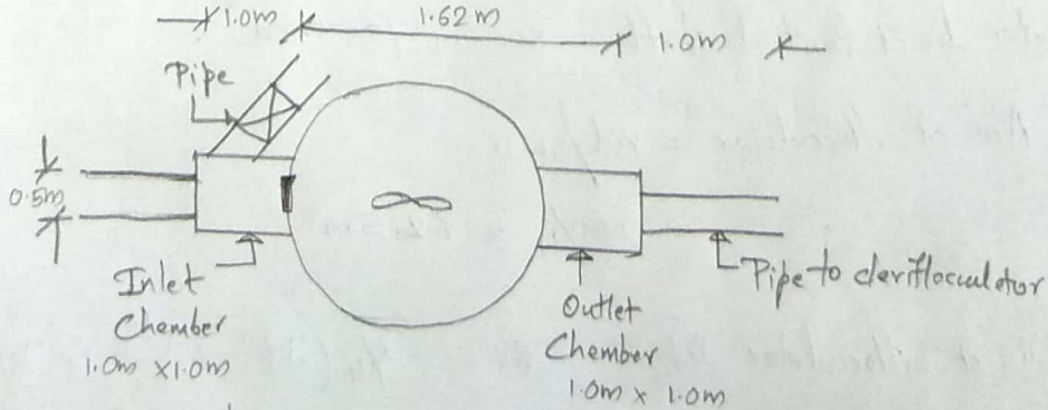
$$1/6 * = 1.5 \left(\frac{\pi d^2}{4}\right)$$

$$\Rightarrow d = 0.376 \simeq \underline{0.4\,m = 400mm}.$$

4. FLASH MIXER



a) Section of flash mixer



b) Plan of flash mixer

8. CLARIFLOCCULATOR

a) Central Shaft :

Assuming, $v = 1.2 \, m/s$

$$\text{Dia of shaft} = \left(\frac{4Q}{v\pi}\right)^{1/2} = \left(\frac{4 \times 1/12}{1.2 \times 3.14}\right)^{1/2} = 0.29 \, m$$

Say, 300mm.

$\therefore$ ID = 300mm
OD = 500mm.

Assuming, velocity through ports = 1.0 m/s.

$\therefore$ Total area of opening of ports $= \frac{1/12}{1} \, m^2 = 1/12 \, m^2$.

b) Flocculator :

DT = 30min ; $G = 40 s^{-1}$; SWD = 4m ; Paddle tip vel = 0.4m/s
Water vel @ paddle tip = 0.1 m/s ; T = 25°C.

Design Calculations :-

Vol of flocculator $= \left(1/12 \times 1/1.2\right) \times 30 \times 60 = 250 \, m^3$.

Outer dia of central shaft = 800mm (assumed).

Area of flocculator = vol/SWD

$= 250/4 = 62.5 \, m^2$.

Dia of flocculator Df $\Rightarrow 62.5 = \pi/4 \left(Df^2 - 0.8^2\right) \Rightarrow$ Df = 8.956m.

Power requirement :

$$G = \sqrt{\frac{P}{\mu\, vol}} \Rightarrow P = G^2 \mu\, vol$$

$$\Rightarrow P = 40^2 \times (0.89 \times 10^{-3}) \times 250 = \underline{356 \text{ watts}}.$$

Also,

$$P = \frac{C_d A_p \rho (V-v)^3}{2} \quad [\text{for single paddle per arm}]$$

$$\Rightarrow 356 = \frac{1.8 A_p \times 997 (0.4 - 0.1)^3}{2}$$

$$\underline{A_p = 14.694 \, m^2}.$$

Since, there are 2 units;

Area of blade per unit $= 14.69/2 = 7.34 \, m^2$.

Assume 3 blades per drive unit & height of each blade $= 2m$.

$$\text{width} = \frac{7.347}{2 \times 3} = 1.22 \, m.$$

Let,

3 blades per arm & 4 arm per unit ;

each blade of 1.5m length & 0.1m width

$$A_p = 3 \times 4 \times 2 \times \cancel{1.5}^{2} \times 0.1 = \cancel{\quad} \; 4.8 \, m^2$$

$$V = \frac{2\pi r n}{60}$$

$$P = \frac{C_D \rho}{2} \Sigma a_p \left[\frac{2\pi r n}{60} - 0.25 \times \frac{2\pi r n}{60}\right]^3$$

$$\Rightarrow 356 = \frac{1.8 \times 997}{2} \times 12 \times 0.2 \left[0.75 \times \left(\frac{2\pi n}{60}\right)\right]^3 \times \left(3^3 + 2^3 + 1^3\right)\Big]$$

$\Rightarrow n = 2.11 rpm \simeq 2 rpm$.

Total area of blades $= 24 \times 0.3 \times 2$

$= 4.8 m^2$.

c/s of flocculator $= (8.956 - 0.8) \times 2 = 16.312 m^2$.

$$\frac{\text{Area of blades}}{\text{c/s area of flocculator}} = \frac{16}{68.2} = 23.4\%$$

Bottom slope of flocculator = 1 in 12.

c) Clarifier :

D.T = 2.5h ; Surface overflow rate - $36 m^3/m^2.d$

Wier loading - $300 m^3/m.d$; SWD - 3m.

Design details:-

$$\text{vol of tank} = \left(\frac{1}{12 \times 1.2}\right) \times 2.5 \times 3600 = 625 m^3.$$

$$\text{Area of clrafier} = \frac{625}{3} = 208.33 m^2.$$

If 0.2 thickness partition b/w clarifier & flocculator;

outer dia of flocculator $= 8.956 + 0.4 = 9.356 m$.

$$208.33 = \pi/4 \left(D_c^2 - 9.356^2\right)$$

$$D_c = 18.78 m.$$

Say, 18.8m.

Check for Surface Overflow rate (SOR):

$$SOR = \frac{6\times10^3\ m^3/d}{208.33} = 28.8\ \frac{m^3/d}{m^2} < 36\ m^3/m^2d \longrightarrow \underline{\text{Hence OK.}}$$

Weir loading for 20% overload:

$$W.L = \frac{6\times10^3 \times 1.2}{\pi\times18.8} = 121.9\ m$$

W.L < permitted value of 300 m $\longrightarrow$ <u>Hence, OK.</u>

<u>Design for V notches:-</u>

$$q = \frac{8}{15}(C_d)\sqrt{2g}\left(\tan\frac{\theta}{2}\right)h^{5/2}$$

For, 90° V notch, the above equation reduces to

$$q = 1.417\,h^{5/2}$$

If the total depth of the V notch is 10 cm & water head is 8 cm

$$q = 1.417\times(0.08)^{5/2} = 2.565\times10^{-3}\ m^3/s.$$

For more uniform flow, spacing of 0.3 m c/c.

$$\text{no. of notches} = (18.8\times\pi)/0.3 = \underline{196.8 \simeq 197.}$$

d) Peripheral Launder:

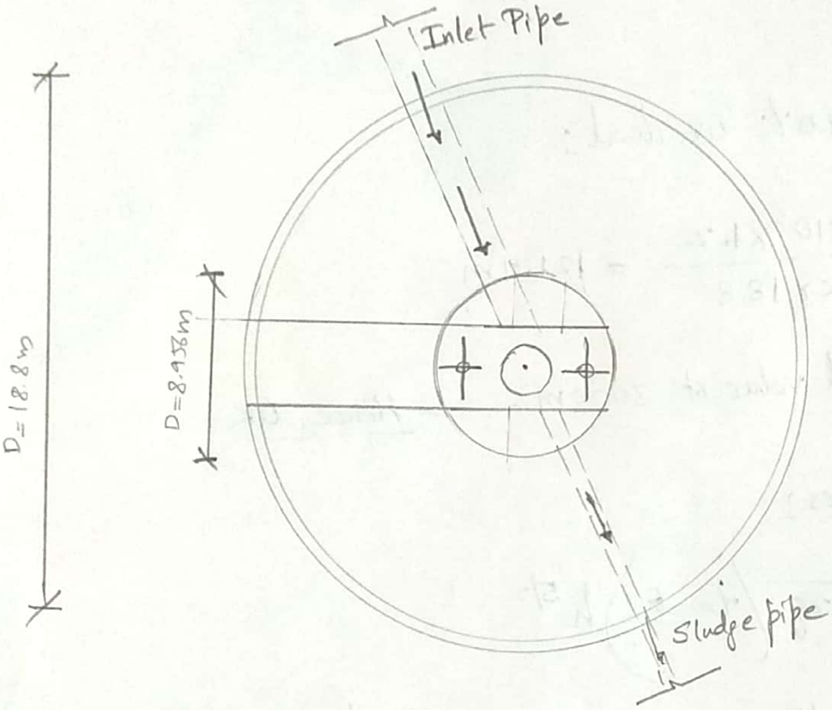
Let velocity = 0.5 m/s ; width = 0.3 m.

$$\left(\frac{1}{12}\right)\times\frac{1}{2} = 0.5\times(0.3\times h)$$

$$\Rightarrow h = 0.277\ m.$$

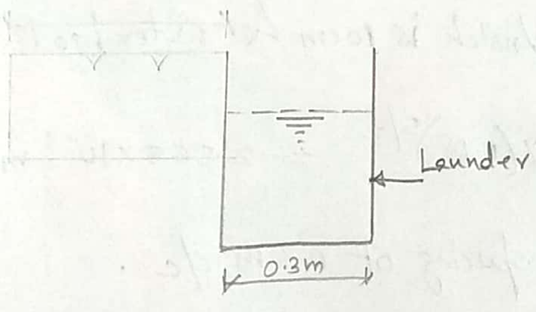
Provide free board = 0.3 m.

5. CLARIFLOCCULATOR

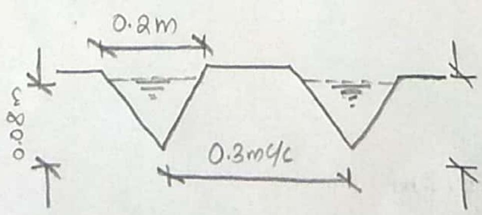


a) Plan of clarifloculator

b) Plan of trough & Launder



c) Section of V notches



9 RAPID GRAVITY FILTERS

Data:

Flow = 12 MLD

Rate of filtration = $5 \, m^3/m^2 h$.

No. of beds = 1

Design Details

Flow per bed = 12 MLD = $500 m^3/h$

Area of 1 bed = $\frac{500}{5}$ = $100 m^2$

provide size of bed = $12 \times 9 \, m^2$

Ratio of L/W = 12/9 = 1.33

This is in range of 1.11 to 1.66 ; hence O.K.

a) Sand

provide depth of sand = 75cm

effective size = 0.5mm

uniformity coefficient = 1.5

d_{10} size = 0.50 mm

d_{60} size = 0.75 mm

b). Gravel

Depth of gravel = 0.45m

size of gravel at top = 2 to 5mm

size of gravel at bottom = 50mm

c). Depth of water

Depth of water above sand surface = 2m

Free board = 0.5m

Total depth of filter box = 0.75 + 0.45 + 2 + 0.5

= 3.7m

d). Under drain system

Provide 2 sections per filter bed

Hence provide 2 units of under drain systems per bed.

Area of filter per section = 12 × 4.5

$= 54 \, m^2$

Under drain section orifice area required = 0.3% of filter area

$= \frac{0.3}{100} \times 54 = 0.162 \, m^2$

Lateral area = 2 × orifice area

$= 2 \times 0.162 = 0.324 \, m^2$

Manifold area = 1.5 × lateral area

$= 1.5 \times 0.324 = 0.486 \, m^2$

$\frac{\pi}{4} d_m^2 = 0.486$

$\Rightarrow d_m = 0.786 \, m$; say $d_m = 800 \, mm$

Diameter of lateral = 80mm (assumed)

Area of lateral = $\frac{\pi}{4} \times 0.08^2 = 5.0265 \times 10^{-3} \, m^2$

No. of laterals = $\frac{0.324}{5.0265 \times 10^{-3}} = 64.45$

say 66

So provide 33 no. of laterals on either side of manifold.

If dia. of orifice is 12 mm;

Area of each orifice = $\frac{\pi}{4} \times 0.012^2$

$= 1.13 \times 10^{-4} \, m^2$

$\therefore$ No. of orifices per lateral = $\frac{0.162}{66 \times (1.13 \times 10^{-4})} = 21.72$

Say 22

$\therefore$ size of pit for 800mm dia manifold will be 0.9 m (width) × 0.9 m (ht.)

Length of each lateral = $\frac{4.5 - 0.8}{2} = 1.85 \, m$

$\frac{\text{Length of lateral}}{\text{Dia of lateral}} = \frac{1.85}{0.08} = 23.125 < 60$; Hence; ok.

If twin orifices are provided per cross section of the lateral at an angle of 30° to vertical then

$$\text{Spacing of orifices} = \frac{1.85}{11} = 0.168$$

$$\simeq 170 \text{ mm c/c}$$

Thus; Size of manifold = 800 mm dia.

$$\text{Spacing of laterals} = \frac{12}{33} = 0.36 \text{ m}$$

$$= 360 \text{ mm c/c}$$

To summarise

No. of laterals on either side = 33
Size of laterals = 80 mm
Size of manifold = 800 mm
Size of orifices = 12 mm
No. of orifices per lateral = 22
Spacing of twin orifices per c/s = 170 mm c/c
Size of pit for manifold of 800 mm dia. = 0.9 m × 0.9 m.

e). Back washing of filter

Rate of back wash = 600 L/m².min.
Rate of air wash = 750 L/m².min. @ 0.35 kg/cm² pressure

f). Wash Water Troughs and Central Gullet

Assume back wash water rate as 600 L/m².min

Back wash water required per bed = $600 \times 12 \times 9$

$$= 64,800 \text{ L/min}$$

$$= 1.08 \text{ m}^3/\text{s}$$

Design of Troughs

No. of troughs on either side of gullet = 6 (assumed)

Total no. of troughs = 12

$\therefore$ flow per trough = $\frac{1.08}{12}$ m^3/s = 0.09 m^3/s

Assume flat bottom trough with zero slope and free fall.

Hence;

$$q = 1.376 b h_o^{3/2}$$

Assume width of trough as 0.3 m

$$h_o = \left[\frac{0.09}{1.376 \times 0.3}\right]^{2/3} = 0.362 \, m$$

say 0.4 m

Add free board = 0.15 m

Depth of trough = 0.55 m

clear spacing between troughs = $\frac{12 - 6 \times 0.3}{6}$ = 1.7

This is less than 2m; hence O.K.

The bottom of the trough will be 100mm above 50% expanded sand.

$\therefore$ The trough bottom height above unexpended sand bed

= 750 × 0.5 + 100

= 475mm or 0.475m

Design of Gullet.

Assume flat bottom gullet with zero slope and free fall.

Assume width of gullet = 0.6m.

$$Q = 1.376 b h_o^{3/2}$$

$$h_o = \left[\frac{1.08}{1.376 \times 0.6}\right]^{2/3} = 1.196 \, m$$

But adopt h_o = 1.2m. Add free board as 0.3m.

$\therefore$ Total depth of gullet below trough bottom is 1.5 m.

Air Scouring

Air flow rate per section = 750 L × 54 /min

= 40,500 L/min

= 40.5 m^3/min.

∴ Air flow rate per bed = 40.5 × 2

= 81 m^3/min @ 0.35 kg/cm^2 pressure.

No. of air blowers = 2 (1 working + 1 standby).

capacity of blowers for washing both section at a time;

= 81 × 1.5 for 50% overload

= 121.5 say 125 m^3/min. @ 0.35 kg/cm^2 pressure.

New size of filter bed:

provide gullet depth upto filter bottom.

Width of each bed = 4.5 + 4.5 + 0.8

= 9.8 m (Assuming 0.1 m thickness gullet)

∴ size of each bed = 12 m × 9.8 m

9). Wash Water Tank.

Vol. of water required for 10 min. back wash of filter bed

= 64,800 L × 10

= 648,000 L

= 648 m^3

For 10% extra quantity;

= 648 × 1.1 = 712.8 m^3

provide water depth as 4 m.

∴ Area required = 178.2 m^2

provide length of 30 m; width = 5.94 m.

provide inner dimensions of 30 m × 6 m

h). Wash Water Pumps

Since there's only one bed; to be back washed in 24 hrs; the wash water tank has to be filled up in 24 hrs. time.

$$\text{Rate of pumping} = \frac{64{,}800\,L \times 10}{24 \times 3600} = 7.5\ L/s$$

$$= 7.5 \times 10^{-3}\ m^3/s$$

Assume 7m head (range 6m to 8m) and add 10% other losses.

∴ Actual height of tank bottom w.r.t underdrain-

$$= 7 + 0.7 = 7.7$$

say 8m.

Assume suction head & SWD as 4m each.

Static head for pump = Suction head + ht. of tank + SWD + free board.

$$= 4 + 8 + 4 + 0.5 = 16.5\,m.$$

Assume length of delivery pipe = 25 m ; dia = 100 mm

frictional losses ; $h_f = 0.499\,m$.

∴ total head $16.5 + 0.499 = 16.99\ m$

say 17 m.

$$\text{pump BHP} = \frac{7.5 \times 10^{-3} \times 997 \times 17}{75 \times 0.7 \times 0.9}$$

$$= 2.69$$

say 15

provide two pumps (one as stand by) each of 15 BHP.

i) Filter Water inlet channel

$$Q = \frac{12 \times 10^3 \times 1.2}{24 \times 3600} = \frac{1}{6} \, m^3/s$$

Let velocity in the channel be 1 m/s & width be 0.5 m

$$\frac{1}{6} = 1.0 \times (0.5 \times h)$$

$$h = 0.333$$

Provide free board = 0.3m

$$\therefore h = 0.633m$$

Say 1m

j). Inlet pipe for each filter bed

Inlet flow per bed, $Q = \frac{1}{6} \, m^3/s$ (with 20% overload)

For a velocity of flow = 1.0 m/s;

$$\frac{1}{6} = 1.0 \; \pi \times \frac{d^2}{4}$$

$$d = 460 \, mm$$

k). Filter water outlet pipe per sections of filter bed

Outflow per section = $\frac{1}{12} \, m^3/s$ (with 20% overload)

For a velocity of flow = 1.2 m/s;

$$\frac{1}{12} = 1.2 \times \pi \frac{d^2}{4}$$

$$d = 0.297 \, m$$

Say 300 mm

l). Pure water outlet channel

outflow total = $\frac{1}{6} \, m^3/s$ (with 20% overload)

Let width of channel be 1m and velocity of flow be = 1 m/s

$$1/6 = 1.0 \times (1.0 \times h)$$

∴ SWD in channel = 0.166 m

Provide free board of 0.3m;

Total depth of channel = 0.166 + 0.3

= 0.466

Say ~ 0.5m

m o). Filter wash water inlet pipe from OHT

Wash water required = 1.08 m^3/s

for 20% overload; Q = 1.08 × 1.2

= 1.296 m^3/s

For a flow velocity of 3 m/s;

$$1.296 = 3 \times \pi \times \frac{d^2}{4}$$

Wash water pipe dia. = d

d = 0.742 m

∴ Adopt 750 mm dia. pipe.

n p). Filter wash water inlet pipe per section of filter.

$$Q = \frac{1.296}{2} = 0.648 \ m^3/s$$

$$0.648 = 3 \times \pi \times \frac{d^2}{4}$$

d = 0.524 m

∴ Adopt 550mm dia pipe.

o) Filter Backwash water storage lagoon.

Back wash water from the bed = $\frac{600 \times 12 \times 9}{10^3}$ $m^3/d \times 10$ mins

$= 648\ m^3/d$

provide 3 days detention time in the storage lagoon;

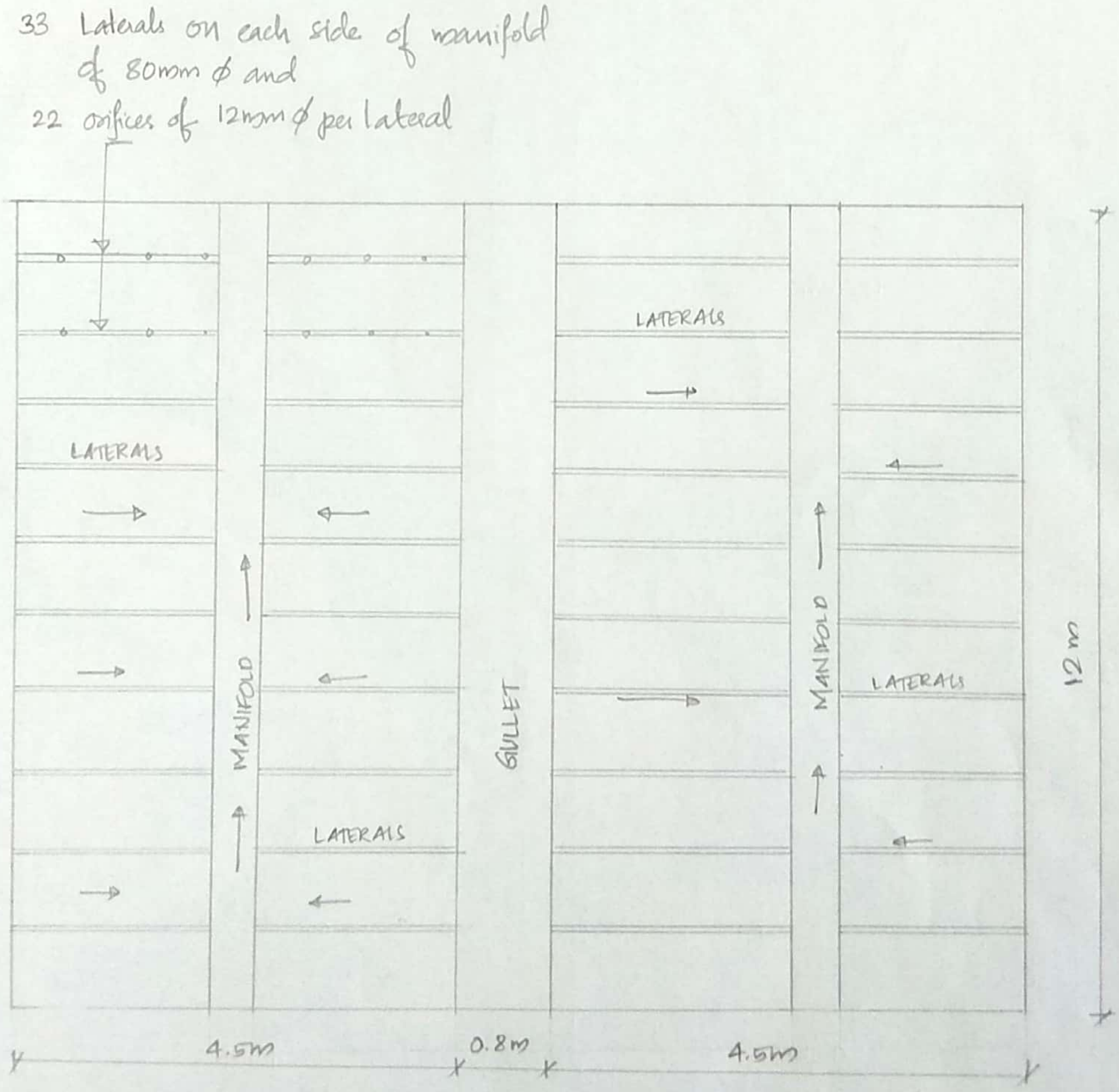
$\therefore$ vol. of tank = $648 \times 3 = 1944\ m^3$

If SWD = 3.5 m; area of lagoon = $555.43\ m^2$

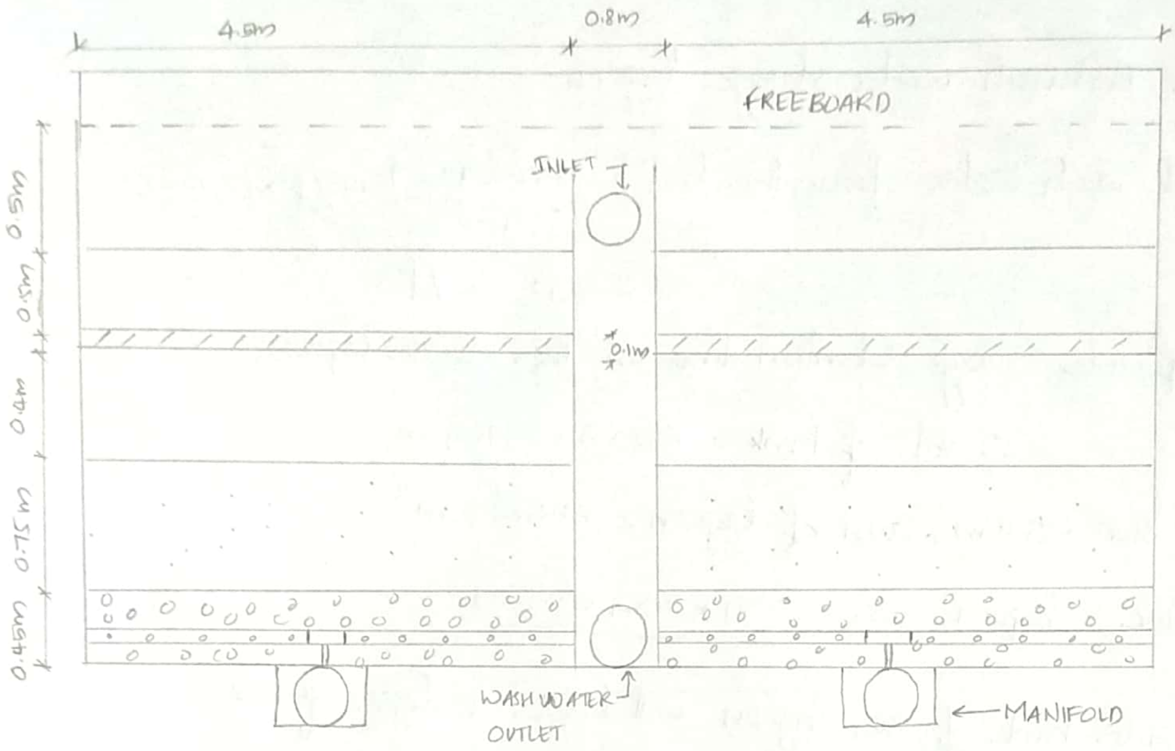
provide lagoon size 30m x 20m x 3.5m

The side bank of the lagoon will have a slope of 1:2.

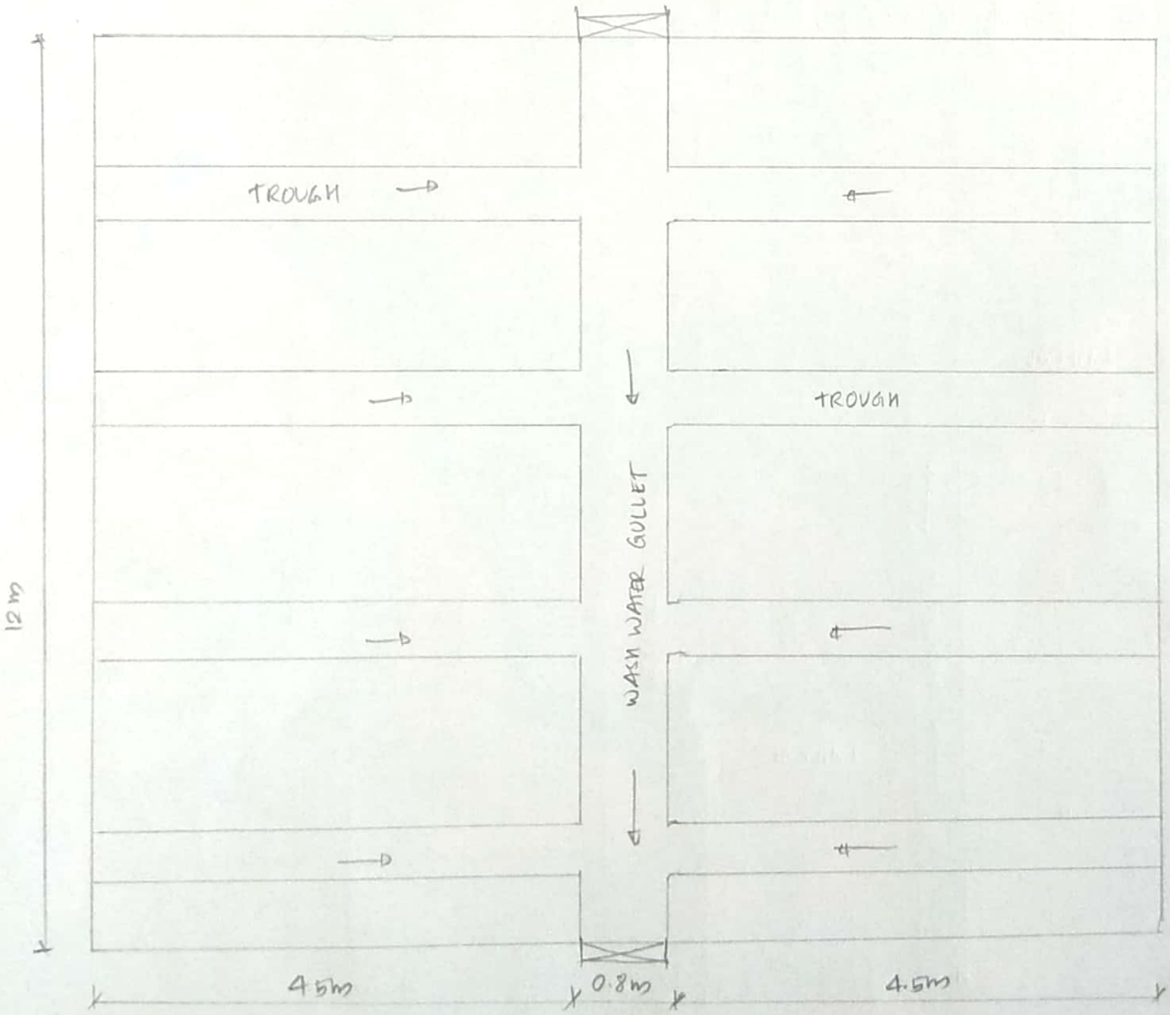
6. RAPID SAND FILTER



a) Plan of underdrain system



Elevation (c/s)



Plan

b) plan & c/s of RSF

10). CLARIFIER SLUDGE STORAGE LAGOON

Sludge wasted from clarifier = 3% of total vol. of water

∴ vol. of sludge produced per day = $12 \times 10^3 \times \frac{3}{100} = 360\ m^3/d$

provide 2 days Detention time;

∴ vol. of lagoon = $360 \times 2 = 720 m^3$.

If SWD of lagoon = 3m, then

Area of lagoon = $240 m^2$

provide lagoon of size 16m x 15m x 3m.

11). SLUDGE DRYING BEDS

Assuming vol. of sludge = 20% of inflow to the lagoon.

∴ vol. of settled sludge = $\frac{720 \times 0.2}{2}$

= $72\ m^3/d$

Let the dewatering, drying & removal cycle be of ~~10~~ 6 days & depth of application of sludge = 0.3m.

plan area = $\frac{72 \times 6}{0.3} = 1440 m^2$

Area of each bed = $144 m^2$ (provide 10 no. of beds)

of size 12m x 12m.

provide:

Sand depth = 0.3m.

E.S of sand = 0.5 – 0.75 mm.

Depth of gravel = 0.3m

Size of gravel = 3 to 6mm

Bottom slope of bed = 1%.

Outlet pipe from each bed = 200 mm dia.

12). PURE WATER SUMP

Let detention time = 1 hour.

$\therefore$ vol. of sump = $\frac{12\times10^3}{24}$ = 500 m^3

provide SWD of sump = 3m.

Area of sump = $\frac{500}{3}$ = 166.67 m^2

Say 13m x 13m.

13). CHLORINATION UNITS

a. Chlorinators

Total flow = 12 MLD.

Dose of chlorine = 2 mg/L.

chlorine requirement = $\frac{12\times10^3\times2}{10^3}$ = 24 kg/d.

b. Emergency chlorination.

provide no. of tanks = 2.

capacity of each tank = 12h.

Assume 25% is available chlorine; the bleaching powder required per day

= 24×4 = 96kg/d

or 48 kg for 12h.

Assume 10% strength of solution;

vol. of solution tank = 48×10 = 480L

= 0.48 m^3

Size of tank = 0.7×0.7×1m.

provide free board = 0.3m.

Actual size of the tank = 0.7m×0.7m × 1.3m.

c). Chlorine room and chlorine tonner room.

Chlorine requirement for 7 days;

$= 24\ kg/d \times 7 = \underline{168\ kg}$

∴ 1 tonner of 200kg will be installed and 1 tonner will be as stand by.

14. ALUM REQUIREMENT

Let avg. alum dose be:

70mg/L = Monsoon season.

30mg/L = Winter season.

10mg/L = Summer season.

Assuming 75% purity;

alum requirement (for worst season) $= \frac{12 \times 10^6 \times 70}{10^6 \times 0.75} = 1120 kg/d$

∴ Alum requirement for 90 days storage

$= 1120 \times 90$

$= \underline{1,00,800\ kg}$.

a. Alum solution tanks.

provide 2 tanks (1 tank as stand by) for $\underline{1120kg/d}$ capacity.

b. Preparation of solutions

Assuming strength of solution = 5%. & purity = 75%.

From Table 23.1; Requirement $= \frac{52.70}{0.75} = 70.27g$.

Quantity of water $= \frac{1120kg \times 10^3}{70.27 g/L} = 15.938\ m^3$

provide SWD = 3m.

Adopt tank size of 3x2x3 m

Provide free board of 0.3 m.

Actual size of tank = $\underline{3 \times 2 \times 3.3 \text{ m}}$.

Alum requirement for 7 days = $1120 \times 7 = \underline{7840 \text{ kg}}$.

c) Alum and TCL storage space.

i) Space for alum.

For 90 days + 7 days (temporary storage);

$$\text{alum requirement} = 1,00,800 + 7840$$
$$= 1,08,640 \text{ kg.}$$

Assume $1 m^3$ of alum weighs 1700 kg;

$$\text{vol.} = \frac{108640}{1700} = \underline{63.9 \text{ m}^3}$$

ii) Space for TCL

TCL required for 7 days storage;

$$= 96 \times 7 = 672 \text{ kg}$$

Assume $1 m^3$ of TCL weighs 1400 kg;

$$\text{vol.} = \frac{672}{1400} = 0.48 m^3$$

iii) Total volume of chemicals.

$$\text{vol.} = 63.9 + 0.48 = 64.38 m^3$$

Assume 20% extra;

$$\text{vol. of chemicals} = 64.38 \times 1.2$$
$$= 77.256 m^3$$

If 4 m is height of building, and 3 m is height of stacking;

area requirement = 25.752 m^2.

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15. CHEMICAL HOUSE

a). Overall building can be of RCC framed structure with brick panels in two floors.

b). Ground floor:

(i). space for chemical storage

(ii). space for laboratory.

(iii). space for toilet.

(iv). M.C.C. Room.

(v). space for office.

c). First floor.

(i). space for 2 alum solution tanks.

(ii). space for 2 TCL solution tanks.

(iii) space for chain pulley block.

d). Height of building.

Ground floor — 4m (normally)

First floor — 5m (normally)

16. FILTER HOUSE AND ANNEX.

(i). A block of 1 filter bed, having 2 sections, the size of each section is 12m × 4.5m with 0.8 m outer width of gullet. Thus size of one bed is 12m × 9.8 m.

(ii). An annex building will have ground and first floor.

17. CALCULATIONS FOR HEAD LOSSES IN VARIOUS UNITS:

Velocities (Max, limits, m/s)

(a). filter piping = 1 m/s

filter inlet = 1 m/s

filter outlet = 1.2 m/s

filter upwash = 3.0 m/s

filter waste water = 3.0 m/s

Air inlet = 0.6 m/min

(b). other systems

collecting channel in cascade aerator = 1m/s

channel from aerator to flash mixer = 1.5 m/s

flash mixer to floculator (pipe) = 0.8 to 1.8 m/s

clarifloculator launder = 0.6 m/s

filter feed channel = 0.9 m/s

Pure water channel = 1.5 m/s

Formulas used:

Hydraulic Gradient for channels:

$$S = \left[\frac{Q \cdot n \cdot (B+2D)^{2/3}}{(B \times D)} \right]^2$$

Hydraulic Gradient for pipes:

$$S = \left[\frac{3.5875 \cdot Q}{C \cdot D^{2.63}} \right]^{1.852}$$

Details of head losses in various channels for 120% of average flow.

S.No.	Channel Description	Flow (m^3/s)	Velocity (m/s)	Channel width, B (m)	Liquid depth, D (m)	Hydraulic gradient, S (m/m) #	Length of channel, L (m)	Headloss * $h_f = L \times S \times 1.1$ (m)
1.	Collecting launder of cascade aerator	$1/12$	0.8	0.8	0.13	1.36×10^{-4}	8.8	1.319×10^{-3}
2.	Aeration launder to flume	$1/6$	0.8	0.204	1.023	3.68×10^{-4}	5	2.04×10^{-3}
3.	Flume to distribution chamber	$1/6$	0.8	0.36	0.58	2.18×10^{-4}	5	1.199×10^{-3}
4.	Distribution chamber to flash mixer.	$1/12$	1.5	0.5	0.11	2.9×10^{-4}	12	3.828×10^{-3}
5.	Peripheral launders of clariflocculator	$1/24$	0.5	0.3	0.277	3.99×10^{-5}	30	1.32×10^{-3}
6.	Channel between launder & filter inlet channel including filter feed channel.	$1/6$	1.0	0.5	0.333	2.41×10^{-4}	55	0.014
7.	Pure water channel.	$1/6$	1.0	1.0	0.166	2.89×10^{-4}	45	0.014

* 10% extra head loss is considered to cover minor losses.

\# Assumed n = 0.014

Details of head losses in various pipes for 120% of average flow.

S.No.	Pipe location	Flow (m^3/s)	Value of C	Velocity of flow (m/s)	Dia. of pipe, D (m)	Hydraulic gradient, S (m/m)	Length, L (m)	Headloss $h_f = L \times S \times 1.1$ (m) *
1.	Inlet pipe from flash mixer to clariflocculator	1/6	100	1.5	0.4	6.62×10^{-3}	30	0.218
2.	central shaft of clariflocculator	1/12	100	1.2	0.3	7.44×10^{-3}	5	0.04
3.	Filter inlet	1/6	100	1.0	0.46	3.35×10^{-3}	0.5	1.842×10^{-3}
4.	Filter outlet upto weir chamber per section.	1/12	100	1.2	0.3	7.44×10^{-3}	5	0.0409
5.	Filter outlet from chamber to pure water	1/6	100	1.0	0.45	3.73×10^{-3}	1.0	4.101×10^{-3}
6.	Pure water pipe	1/6	100	1.0	0.45	3.73×10^{-3}	20	0.082
7.	Wash water pipe from wash water tank.	1.296	100	3.0	0.75	0.0138 $\cancel{5.29 \times 10^{-3}}$	50	0.759 ~~0.291~~
8.	Wash water inlet pipe per section.	0.648	100	3.0	0.55	0.0173 ~~0.0865~~	4	0.076
9.	Wash water outlet per bed	1.296	100	3.0	0.75	0.0138	54	0.821
10.	Rising main to wash water tank.	7.5×10^{-3}	100	-	0.10	0.0181	25	0.499

* providing 10% extra considering minor losses