STP-PD.Pro

Design of screen

Average rate of flow = 198000000 Liters

$$= \frac{50\times10^{6}}{10^{3}\times24\times60\times60}$$

Q = 2.2916 m^3/sec

Assumptions:

i. Manually cleaned screen
ii. Inclination of bars $=45^{o}$
iii. Size of bar $= 10$
iv. Clear spacing between the bars $=5000$ mm
v. Velocity of flow normal to screen $= 1.4137\text{mm/sec}$

Hence, Net submerged area of the screen

$$A = \frac{2.2916}{1} = 2.2916m^2$$

Gross submerged area of the screen

$$A= (1.93\times\sin45^{o}) = 1.6209m^2$$

Hence, Velocity of flow in screen chamber

$$V = \frac{2.2916}{1.6209} = 1.4137m/sec$$

Provide 244 No's of bars.

Gross width of screen chamber

$$W = (244\times6.31) + (245\times50)$$

$$= 13789.64m$$

$$\text{Liquid depth} = \frac{1.6209}{13789.64} = 0.0001m$$

Providing a free board of 0.3m,

Total depth of channel = (0.0001 + 0.3)

D = 0.3001m

Size of channel = 750mm×1550mm

Now, the liquid depth found above corresponds to the average rate of flow. Hence, the hydraulic radius or hydraulic mean depth,

$$m = \frac{0.0001 \times 13789.64}{(2 \times 0.0001) + 13789.64} = \frac{A}{P}$$

$$= \frac{1.378964}{27579.2802}$$

= 0.0001m

Using manning's formula,

$$V = \frac{1}{N} m^{2/3} i^{1/3}$$

$$\therefore 0.60 = \frac{1}{0.013} \times (0.29^{2/3}) \times (i^{1/3})$$

$$(i^{1/2}) = \frac{0.60 \times 0.013}{(0.29^{2}/3)}$$

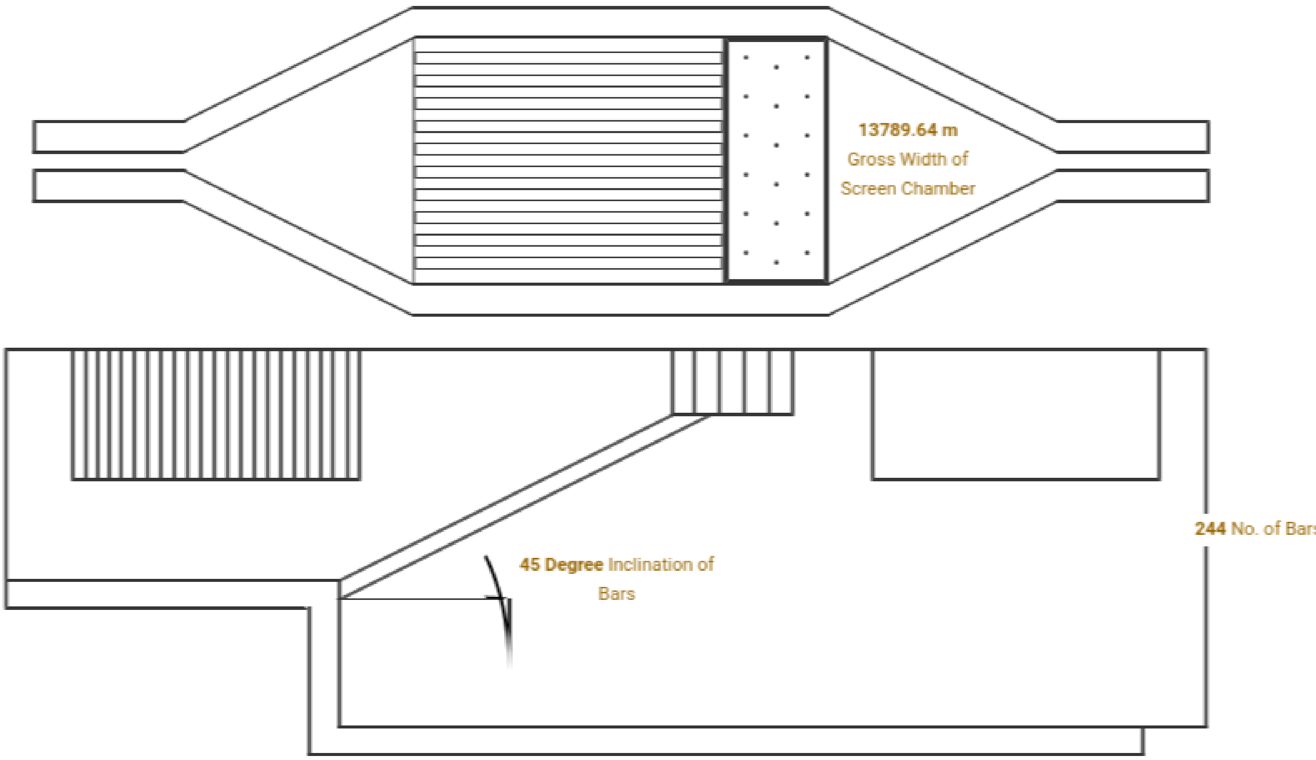
$$(i^{1/2}) = 0.01780$$

$$(i) = 0.02000674$$

Summary:

i. Provide 244 bars of 10 size at an inclination of 45^{o}
ii. Provide channel of depth 300.1mm and width 13789640mm with slope as 1 in 0.02000674

SCREEN CHAMBER



Design of grit chamber

Average flow = 198 MLD = (198×10^3) m^3/day
Specific gravity = (Ss) = 2.65
Kinematic viscosity = Kv= 0.00000114m^2/sec

Now, the settling velocity can be found out by using following formula:
$Vs = \frac{1}{18\ Kv}\times g\times d^2\times (Ss-1)$
Where, d = diameter of smallest grit particle to be removed and is taken as (2×10^{-4}) m

Putting all the values,
$Vs = \frac{1}{18\times1\times10^{-6}}\times9.81\times(2\times10^{-4})^2\times(2.65-1)$
Vs = 34786.7763m/sec
Now, Reynolds number,
$Re = \frac{Vs\times d}{Kv} = \frac{34786.7763\times2\times10^{-4}}{1\times10^{-6}}$
$= 6408090373.9612>1$
Hence, stokes's law is not valid. So, Vs can be found out by transition law for $1<6408090373.9612<10^3$

$\therefore Vs = [0.707(2.65-1)d^{1.6}Kv^{-0.6}]^{0.714}$
Assume,
$Vs = [0.707(2.65-1)\times(2\times10^{-4})^{1.6}\times(0.00000114)^{-0.6}]^{0.714}$
Vs' = 0.025
$Re' = \frac{65.9924\times2\times10^{-4}}{1\times10^{-6}} = 5$
$C_D = \frac{18.5}{Re^{0.6}} = \frac{18.5}{(6408090373.9612^{0.6})} = 0.0010$
$\therefore C_D = 0.0010$
Hazen's equation
Now, $Vs'' = \sqrt{\frac{4}{3}\times\frac{gd(Ss-1)}{Cd}}$

$$Vs = \sqrt{\frac{4}{3} \times \frac{9.81 \times 2 \times 10^{-4}}{0.0010} \times (2.65 \ - 1)}$$

Vs =65.9924 m/sec

Now, Displacement velocity =V_d= 10x65.9924= 10×65.9924= 659.9245m/sec

Area of grit chamber $= \frac{Qmax}{\text{Vd}}$

A =0.6875 m^2

Assuming depth of grit chamber

$H_o = 1.86$m

$\frac{Lo}{Ho} = \frac{Vd}{Vs} = 10$

∴Length of grit chamber

Lo = (10 x 1.86) = 18.60m

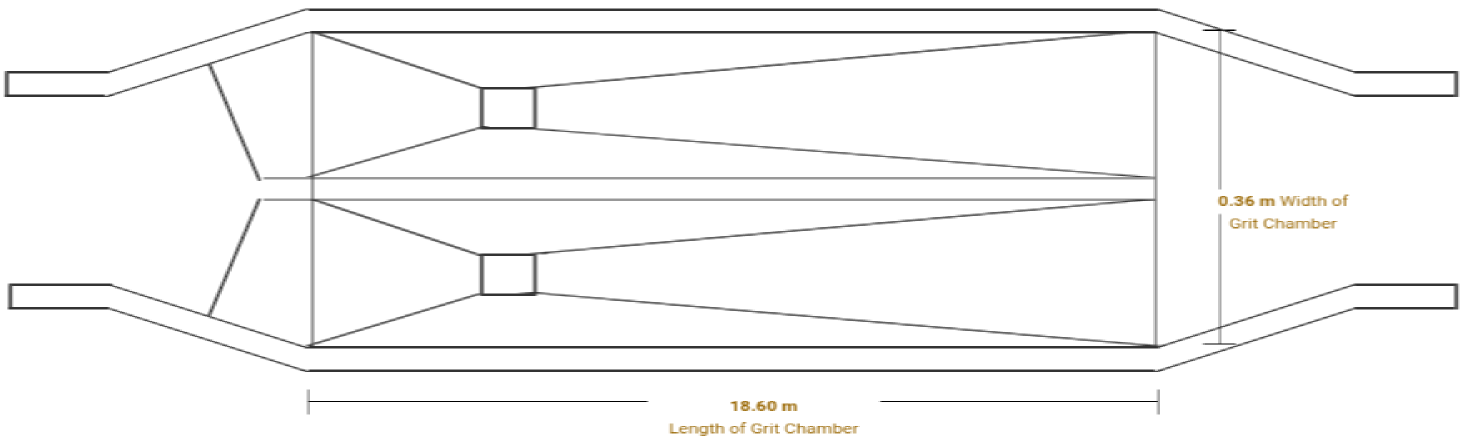
∴Width of grit chamber

$B = \frac{A}{Ho} = \frac{0.6875}{1.86} = 0.36$

Summary:

i. Settling velocity = Vs = 34786.7763m/sec
ii. Displacement velocity = Vd = 659.9245 m/sec
iii. Area of grit chamber = A = 0.6875^2
iv. Size of grit chamber =18.60m×0.36m×1.86

GRIT CHAMBER



Design of skimming tank

$Q = 198$ MLD

$= \frac{198 \times 10^6}{24\times60\times60\times10^3}$

$= 2.2916 m^3/sec$

Assume d = 2m and

minimum rising velocity of greasy material to be removed Vr = 0.25 m/min

$Vr = \frac{0.25 \text{ m/min}}{60} = 2.2916 m/sec$

Surface area of skimming tank

$A = 0.00622 \times \frac{198 \text{ MLD}}{0.25 \text{ m/sec}} = 3.4209$

For circular tank

$A = \frac{\pi}{4} d^2$

$d^2 = \frac{4 * 3.4209}{\pi}$

SKIMMINGTANK

Design of primary setting tank (PST)

Assumptions:

i. Surface overflow rate = $Q/_A$= 46
ii. Weir overflow rate = 250 m^3/m^2/day (W.O.R)
iii. Side water depth = 3.5

Design:

S.O.R = $Q/_A$

Area of tank A = $\frac{198000000 \times 10^3}{46}$ = 4304m^2

Provide, No. of tanks = 510

Area of each tank A' = 4304 /510=8

∴ volume of each tank, V = A'×S.W.D

= 8×3.5

V = 30m^3

Providing circular PST,

diameter of tank, d = $\sqrt{\frac{4A}{\pi}} = \sqrt{\frac{4 \times 8}{\pi}}$

d = 3.2774m

Check for W.O.R= $\frac{Q}{\pi d} = \frac{198000000 \times 10^3}{\pi \times 3.2774 \times 2}$

=37.6906m^3/m^2-day>150m^3/m^2-day

Hence, safe

Check for detention time,T = $\frac{V}{Q} = \frac{30}{198000000 \times 10^3/2}$ = 0.07day

Now, assuming slope of 1:12 (V: H),

Depth due to slope at centre = $\frac{12.25 \times 1}{12}$ = 1.6387 m

Hence,

Total depth = (S.W.D + Depth due to slope + Depth of sludge storage i.e. 25% of S.W.D)

=(3.5+1.6387+ (0.25×3.5)

D = 6.0137m

Design of sludge hopper:

Total suspended solids=300mg/l

Assume that 40% of solids are removed by grit chamber screens

Solids in clarifier = 300-(300×0.40) = 30mg/l

Assume that 60% of solids are removed by clarifier

Dry solids = Ms = 30-(0.60×30)

= 210.00kg/day

Assume that total solids consist of 70% volatile solids and 30% fixed solids.

Taking specific gravity of Vss =1 and of Fs = 2.5

∴ Ss = 1.2195

Assume that =0.03% of solids are dried in clarifier

∴ Ssl =0.7836

Now, volume of sludge = V = $\frac{Ms}{Sw \times Ssl \times Ps}$

Here, Sw =1000kg/m^3

Ps =0.03

$$V = \frac{480}{Sw \times Ssl \times Ps}$$

$V = 8.9320\ V\ m^3/day$

Assume that the frequency of cleaning of sludge hopper is 12 hours

$\therefore$ volume of hopper, V= $(8.9320\ V \times 0.5)$

$$V = 8.9320 m^3$$

Design of collection channel:

Assume velocity of flow in channel equal to 0.4m/sec

Area of channel $= {}^{Q}/_{2V}$

$A = 0.0028 m^2$

Assume,

width of the channel = 0.8m

$\therefore$ depth of channel, d = 0.0035m

Assuming,

freeboardf_f=0.3m,

$\therefore$ depth of channel, D =0.3 $_+$6.0137m

Now, $m = \frac{A}{P} = 0.0020$

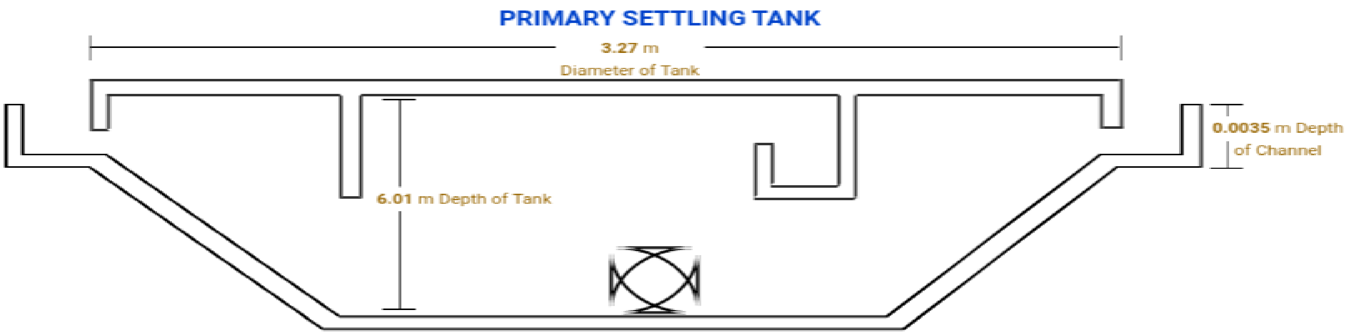
Assuming N =0.012for concrete channel

Manning's formula,

$V = \frac{1}{N} \times m^{2/3} \times i^{1/2}$

$v = \frac{1}{0.014} \times (m^{2/3}) \times (i^{1/2})$

$\therefore (i^{1/2}) = 0.0893$



Aeration tank

Flow rate (Q)=198

Capacity of aeration tank (m^3)

$C = (v_1+v_2) \times \frac{T}{2}$

Volume of flow of sewage in m^3/day

$V_1 = \frac{198\times10^6}{10^3}$ = 198000 m^3/day

Volume of returned sludge in m^3/day

30% recirculation

V_2 = 198000 × 0.30

= 59400.00

T = aeration period in hours = 4 hours

$C = (v_1+v_2) \times \frac{T}{24}$

$= (198000 + 59400.00) \times \frac{4}{24}$

= 42900.00 m^3

Assume depth of tank d = 2m

Area of tank $= \frac{C}{d}$

$= \frac{42900.00}{2}$

= 21450.00 m^2

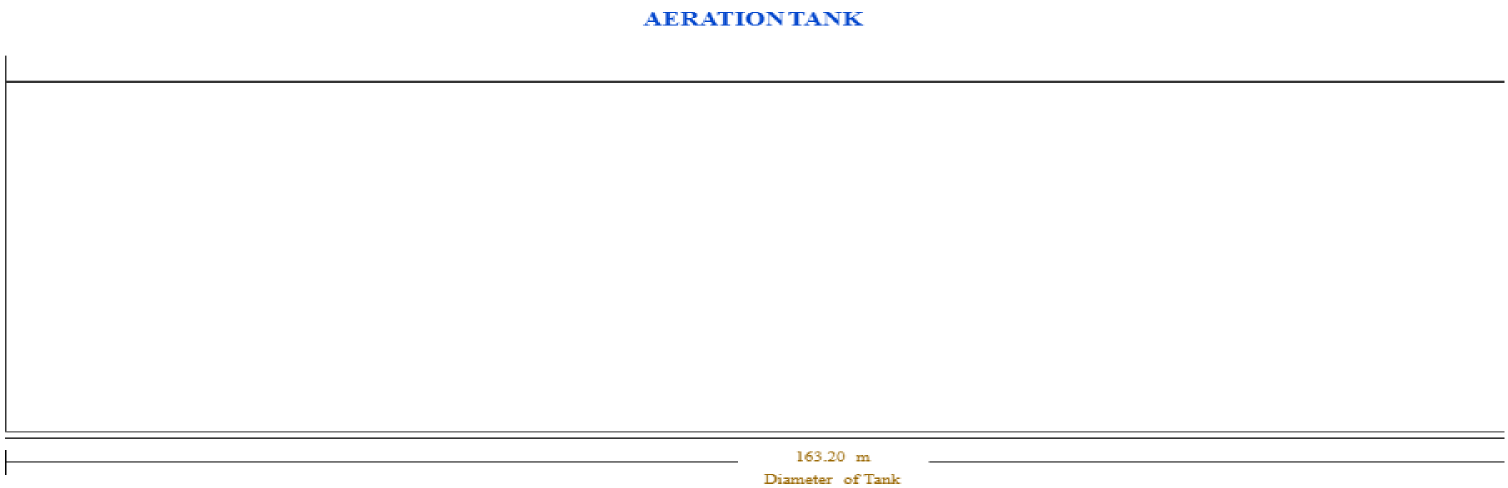
Diameter of tank = D

$A = \frac{\pi}{4}D^2$

$D^2 = \frac{4A}{\pi}$

$$D = \sqrt{\frac{4A}{\pi}}$$

D = 165.3022 m



Design of trickling filter

Influent B.O.D = 5 mg/l

Assume,

Effuluent B.O.D = 5.45 mg/l

Hence, overall efficiency of T.F = $\frac{5-5.45}{5}\times 100$ =-9.0000 %

Assume recirculation ratio, R = 2

Now, La = $\frac{Li+RLe}{1+R}$

Where, La = applied B.O.D

La = $\frac{5+(1\times 5)}{1+2}$ = 5.30 La mg/l

Assume depth of T.F = 3 m

Using Eucken Felder's formula for circulating areas of T.F,

$$\frac{Le}{La}=\frac{1}{1+18.6\,D^{0.67}\left(\frac{A}{Q}\right)^{0.5}}$$

Where, Le = effluent B.O.D = 5.45 Le mg/l

D = depth of T.F = 3m

A = 0.9946

Q = flow rate in MLD = 198 QMLD

Putting all the values,

$$\therefore \frac{5.45}{5.30}=\frac{1}{1+18.6\times(3)^{0.67}\times\left(\frac{0.9946}{50}\right)^{0.5}}$$

A = 0.9946 m^2

Now, A = $\frac{\pi}{4}d^2$ = 0.9946m^2

$D = 0.4593m$

Providing six trickling filters each having $D = 0.4593m$

diameter.

Check for hydraulic loading:

$$\text{Hydraulic loading rate} = \frac{Q+RQ}{A}$$

$$= \frac{198 + 2 \times 198}{0.9946}$$

$= 597172.9273$ lit/m^2-day

Which is within the limit of 10 to $40m^3/m^2$

Hence, safe

Check for organic loading:

$$\text{Organic loading rate} = \frac{influent\ B.O.D}{volume\ of\ T.F}$$

$$= \frac{5 \times flow\_rate\_tf}{0.9946 \times 2}$$

$= 497.6441$kg of B.O.D m^3-day

Which is within the limit 0.32 to 1kg B.O.D m^3-day?

Hence, safe

Design of central pipe and distributor system:

Here, the flow rate is assumed to become half when it enters in the central pipe

Hence, $Q = 99.00MLD$

Flow of central pipe = $(Q\times PF) + (R\times Q)$

$= (99.00\times2) + (2\times99.00)$

$=4.5833m^3/sec$

Assume velocity of flow equal to 0.5m/sec

Area $= \frac{(\frac{4.5833}{2})}{0.5} = 4.5833\text{m}^2$

$\therefore$ Diameter of pipe $= \sqrt{\frac{4A}{\pi}} = \sqrt{\frac{4\times4.5833}{\pi}} = 2.4152\text{m}$

Now, Vavg. $= {}^{Q}/_{A} = \frac{99.00 \times 10\text{^}3}{{}^{\pi}/_{4}\times(2.4152)^2\times86400} = 1.00\text{m/sec} = 1\text{m/sec}$

Hence, safe

Now, length of each arm $= \frac{0.4593}{2} - \frac{2.4152}{2}$

= -0.8098m

Provide 3 sections of 5.86 m

$A1 = \pi\ (R1^2 - r1^2)$

$=0.1032\text{m}^2$

Similarly,

$A2 = 0.3476\text{m}^2$

$A3 = 0.8056\text{m}^2$

And

Now, finding proportionate area for all the sections:

1st section $= \frac{A1}{A1+A2+A3}$

= 0.0821%

Similarly,

2nd section = 0.2766%

3rd section = 0.6411%

Now, finding discharge per section,

1^{st} section, Q1 =1.1458m^3/sec

2^{nd} section, Q2 =1.0516m^3/sec

3^{rd} section, Q3 =0.7346m^3/sec

Now, assume velocity of flow equal to 0.5m/sec

Finding diameter for each section:

1^{st} section, $A_1 = \frac{Q1}{V} = 0.0821\%\ m^2$

D_1 =1.7078m

Similarly,

2^{nd} section, D_2 =1.6361m

3^{rd} section, D_3 =1.3674m

Design of orifice:

Discharge through orifice is given by,

$Q = Cd \times A \times \sqrt{2gh}$

Where, Cd = 0.6

A = 0.0019m^2

H = 1m

$\therefore Q = 0.0016$

Now, no. of orifices required for each arm = $\frac{total\ discharge\ through\ each\ arm}{discharge\ of\ orifice}$

=694.0904

Now, finding the number of orifices in each section

1^{st} section, numbers = 10410

2^{nd} section, numbers =0

3^{rd} section, numbers =0

Design of under drainage system:

Assume spacing of under drain = 0.3c/c

Hence, no. of laterals =3.0622

Now, Average flow per filter = 1.1458m^3/sec

Hence, Discharge through each lateral,

=0.3741 m^3/sec

Assume, velocity of flow = 0.8m/sec

Hence, area of each lateral = $\frac{Q}{V}$ =0.6236

Check for average velocity,

Average velocity = $\frac{Average\ flow}{Area\ of\ all\ laterals}$

V= 0.6000m/sec

This is in the limit 0.6 to 0.9 m/sec

Hence, safe

Design of collecting channel:

Discharge in collecting channel = 1.1458m^3/sec

Assume velocity of flow = 0.6m/sec

Area of channel = 1.9097

Check for slope:

Assuming,

N = 1.9097 for concrete channel

$m = \frac{A}{P} = \frac{0.35 \times 1.18}{0.35 + (2 \times 1.18)} = 0.15$

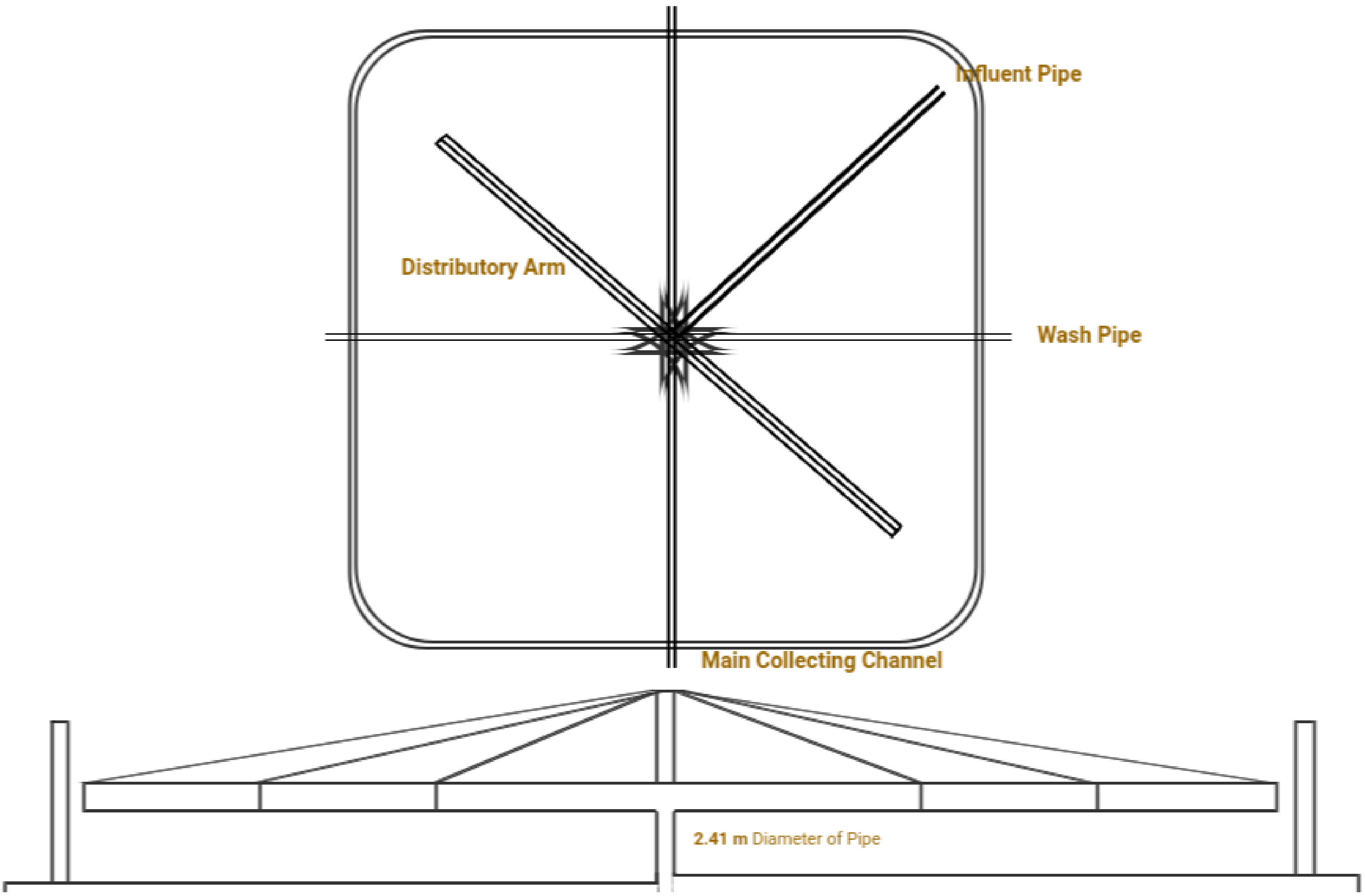
Using manning's formula,

$$V = \frac{1}{N} m^{2/3} i^{1/2}$$

$$i = 0.0004$$

$\therefore$ slope of the channel is say 1 in 5367

TRICKLING FILTER



Design of Secondary Settling tank (S.S.T)

Assume S.O.R = $46m^3/m^2$-day

Assume depth of S.S.T = D = 5m

Now, total flow through clarifier = (Q+RQ)

$= 2.2916m^3/sec$

Area of clarifier = $\frac{Q}{S.O.R} = 4304m^2$

Volume of clarifier = (A×D)

$= 21522m^3$

Now, Diameter of each clarifier

$= \sqrt{\frac{4A}{\pi}}$

D = 74.0152m

Provide two S.S.T of74.0152m diameter each

Now, floor slope is 1 in 12 (V'H)

∴ total depth =total_dept10

Check for detention time:

$T = \frac{V}{Q}$ =0.21day

This is within the limit of 5 to 10 hours

Hence, safe

Design of sludge hopper:

Assume special gravity of sludge = Ssl = 0.7836

Assume = 93% or solids are removed by the trickling filter

Assume that the production of solids in T.F is =0.4kg Vss per kg B.O.D

$\therefore Vs = 520kg/day$

Assume that the dry solids are =40%

$\therefore Ms = 208kg/day$

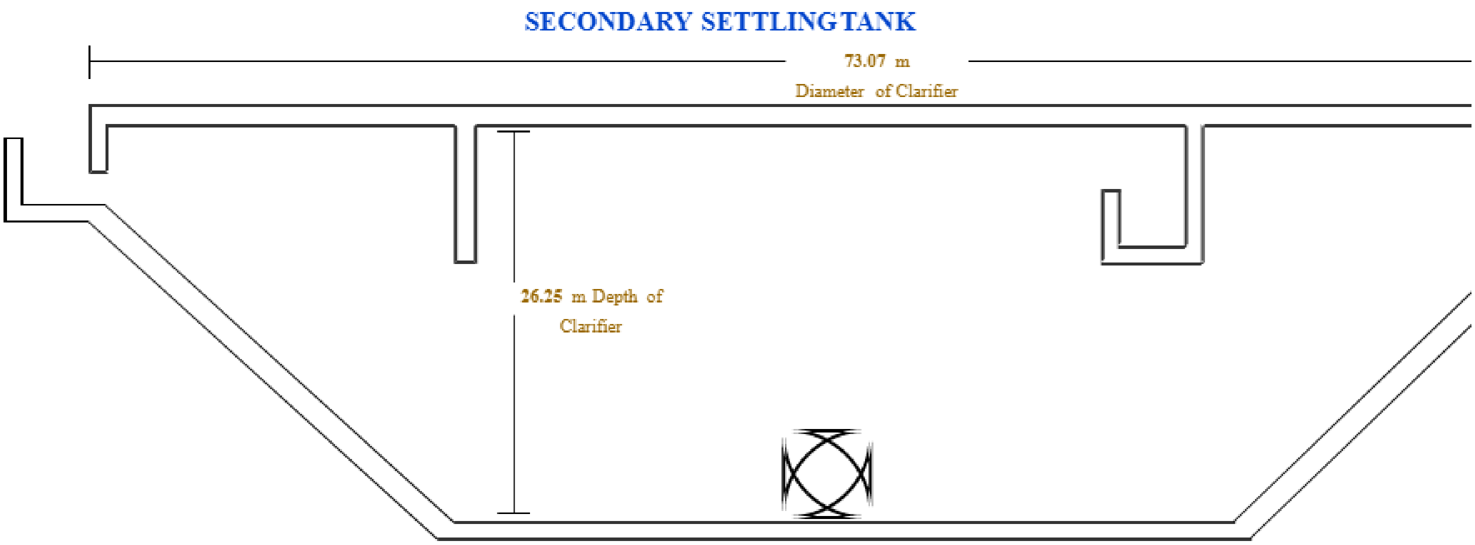
Take $Sw = 1000\ kg/m^3$

$Ps = 0.03$

$\therefore$ volume of sludge produced in S.S.T

$V = \frac{Ms}{Ssl \times Sw \times Ps}$

$V = 8.8480m^3/day$


SECONDARY SETTLING TANK
73.07 m
Diameter of Clarifier
26.25 m Depth of
Clarifier

Design of digester unit:

Volume of fresh sludge = Vf = $V_{PST} + V_{SST}$

$= 17.7800 m^3/day$

Volume of digestor sludge = Vd = $\frac{1}{3} \times rf$

$= 5.9266 m^3/day$

Assume that the time required for digestion is 50 days

Now,

$V = Vf \times T1 - \frac{2}{3}(Vf - V_d) \times T1 + (Vd \times T2)$

$= 632.1777 m^3$

Assume height of digester = 6m

$\therefore$ area of digestor = $70.2419 m^2$

$A = \frac{\pi}{4} d^2$

$\therefore d = 9.4550 m$

Total Vs = dry solids in S.C.T + Dry solids in P.S.T

= 345kg/day

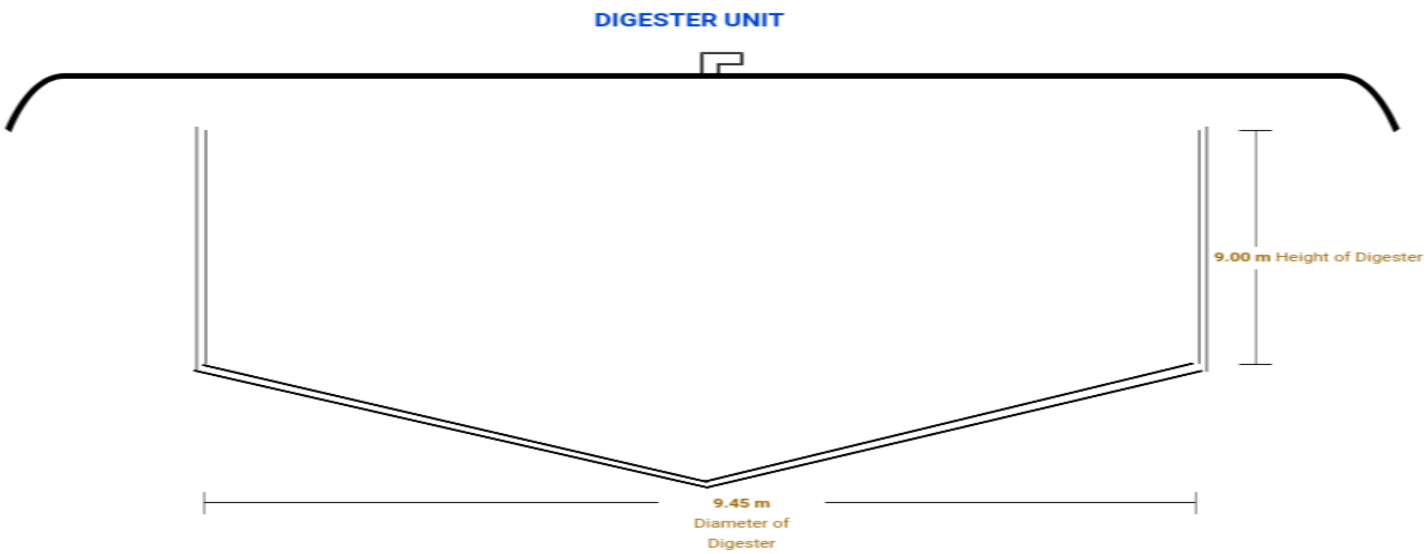
Now, volatile solid destroyed,

Vsd % = 50.00%

Vsd =189.47kg/day

Quantity of total gas produced during digestion = 142.10m

Quantity of methane gas produced during digestion = 2/3 × total gas = $94.73 m^3$


DIGESTER UNIT
9.00 m Height of Digester
9.45 m
Diameter of
Digester

Design of sludge drying beds;

Assume depth of sludge application = 0.3 m

Area of sludge drying bed, A= $\frac{rd}{0.3}$ =

= 19.7553m^2

Now,

assume length of drying bed, L =length_of_drying_bed_sbdm

Width of drying, W =$\frac{19.7553}{25}$= 0.7902m

Assume that the sludge cake will be removed after,

T=15 days

$\therefore$ provide =15numbers of sludge drying beds

SLUDGE DRYING BEDS