STP Design

Design of screen

Average rate of flow = 30000000 Liters

$$= \frac{50 \times 10^6}{10^3 \times 24 \times 60 \times 60}$$

Q = 0.3472 m^3/sec

Assumptions:

i. Manually cleaned screen
ii. Inclination of bars $= 45^o$
iii. Size of bar $= 10*50$
iv. Clear spacing between the bars $= 4$ mm
v. Velocity of flow normal to screen $= 1.1310 \mathrm{mm/sec}$

Hence, Net submerged area of the screen

$$A = \frac{0.3472}{0.8} = 0.4340 m^2$$

Gross submerged area of the screen

$$A = (1.93 \times \sin 45^o) = 0.3070 m^2$$

Hence, Velocity of flow in screen chamber

$$V = \frac{0.3472}{0.3070} = 1.1310 m/sec$$

Provide 19 No's of bars.

Gross width of screen chamber

W = (19×0.960) + (20×0.04)

= 19.04m

$$\text{Liquid depth} = \frac{0.3070}{19.04} = 0.0161 m$$

Providing a free board of 0.3m,

Total depth of channel = (0.0161 + 0.3)

D = 0.3161m

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,

$$m = \frac{0.0161 \times 19.04}{(2 \times 0.0161) + 19.04} = \frac{A}{P}$$

$$= \frac{0.306544}{38.1122}$$

$$= 0.0160\text{m}$$

Using manning's formula,

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

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

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

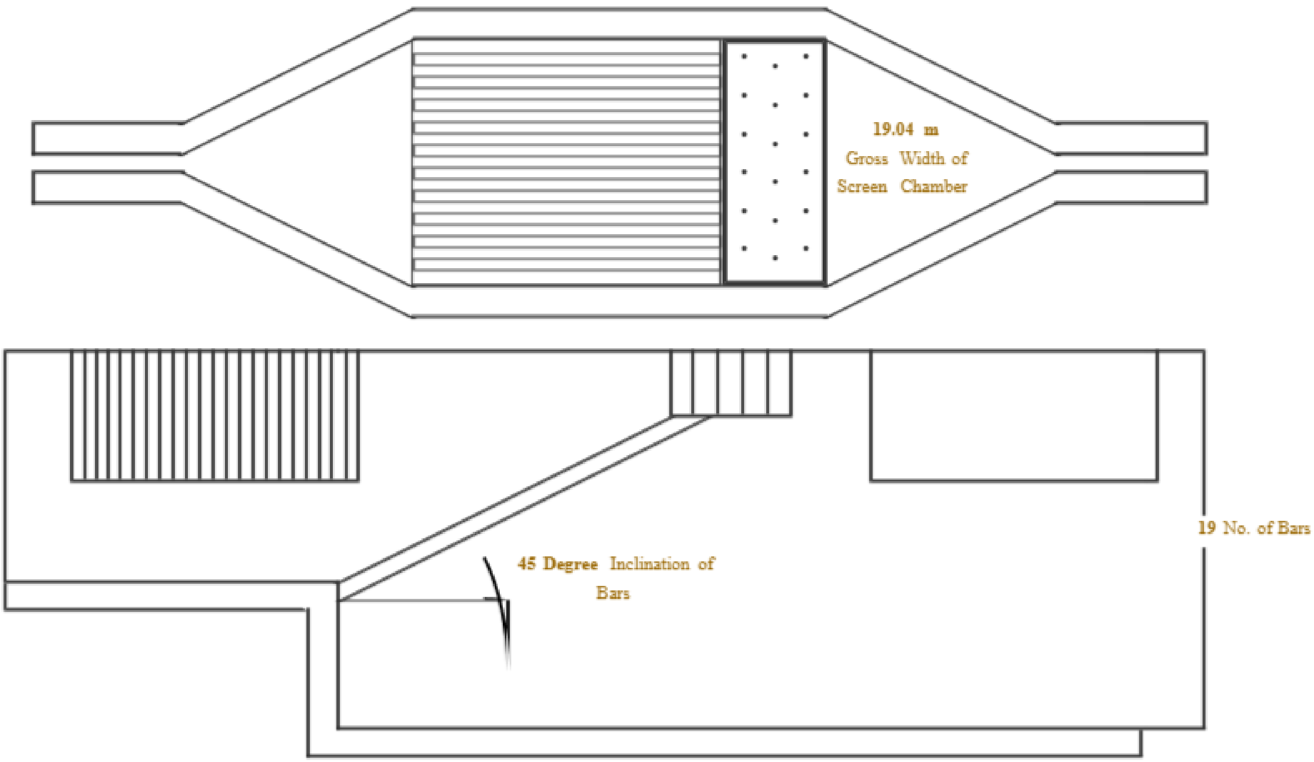
$$(i^{1/2}) = 0.01780$$

$$(i) = 18.80016544$$

Summary:

i. Provide 19 bars of 10*50 size at an inclination of 45°
ii. Provide channel of depth 316.1mm and width 19040mm with slope as 1 in 18.80016544

SCREEN CHAMBER



Design of grit chamber

Average flow = 30 MLD = (30×10^3) m^3/day
Specific gravity = (Ss) = 2.65
Kinematic viscosity = Kv= 0.000001m^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,

$Vs = \frac{1}{18\times1\times10^{-6}} \times 9.81 \times (2\times10^{-4})^2 \times (2.65 - 1)$

Vs = 0.0359m/sec

Now, Reynolds number,

$Re = \frac{Vs\times d}{Kv} = \frac{0.0359\times2\times10^{-4}}{1\times10^{-6}}$

$= 7.1940 > 1$

Hence, stokes's law is not valid. So, Vs can be found out by transition law for $1 < 7.1940 < 10^3$

$\therefore Vs = [0.707(2.65 - 1)d^{1.6}Kv^{-0.6}]^{0.714}$

Assume,

$Vs = [0.707(2.65 - 1) \times (2 \times 10^{-4})^{1.6} \times (0.000001\,)^{-0.6}]^{0.714}$

Vs' = 0.025

$Re' = \frac{0.0246\times2\times10^{-4}}{1\times10^{-6}} = 5$

$C_D = \frac{18.5}{Re^{0.6}} = \frac{18.5}{(7.1940^{0.6})} = 7.0969$

$\therefore C_D = 7.0969$

Hazen's equation

Now, $Vs'' = \sqrt{\frac{4}{3} \times \frac{gd(Ss-1)}{Cd}}$

$$Vs=\sqrt{\frac{4}{3}\times\frac{9.81\times2\times10^{-4}}{7.0969}\times(2.65\ -1)}$$

Vs =0.0246 m/sec

Now, Displacement velocity =V_d= 10x0.0246= 10×0.0246= 0.2468m/sec

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

A =42.1952 m^2

Assuming depth of grit chamber

$H_o = 2\text{m}$

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

∴Length of grit chamber

Lo = (10 x 2) = 20.00m

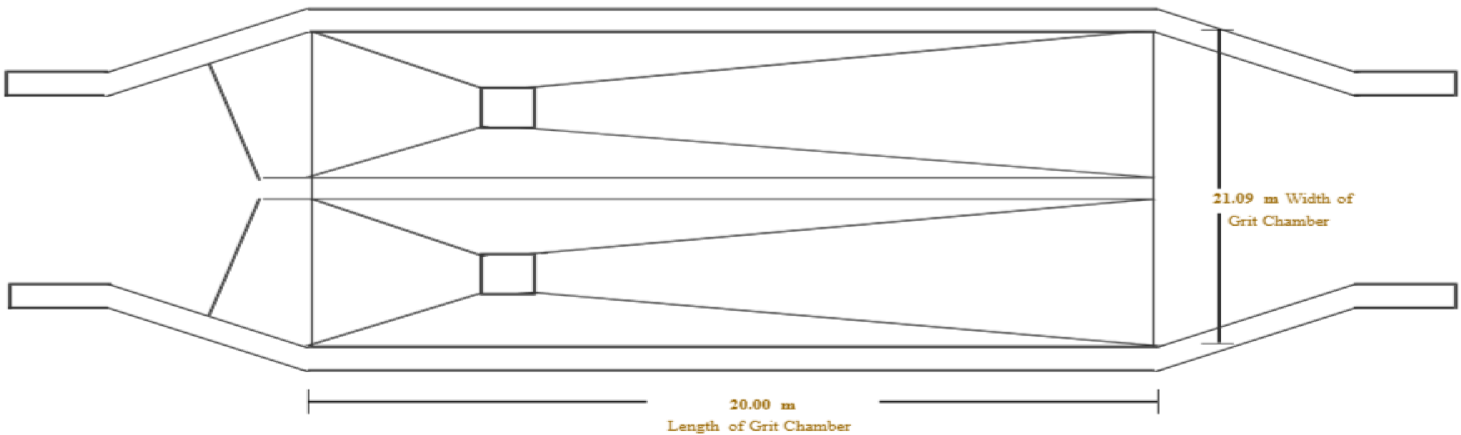
∴Width of grit chamber

$B = \frac{A}{Ho} = \frac{42.1952}{2} = 21.09$

Summary:

i. Settling velocity = Vs = 0.0359m/sec
ii. Displacement velocity = Vd = 0.2468 m/sec
iii. Area of grit chamber = A = 42.1952^2
iv. Size of grit chamber =20.00m×21.09m×2

GRIT CHAMBER



Design of skimming tank

Q = 30 MLD

$= \frac{30 \times 10^6}{24 \times 60 \times 60 \times 10^3}$

$= 0.3472 m^3/sec$

Assume d = 2m and

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

$Vr = \frac{0.25 \text{ m/min}}{60} = 0.3472 \text{m/sec}$

Surface area of skimming tank

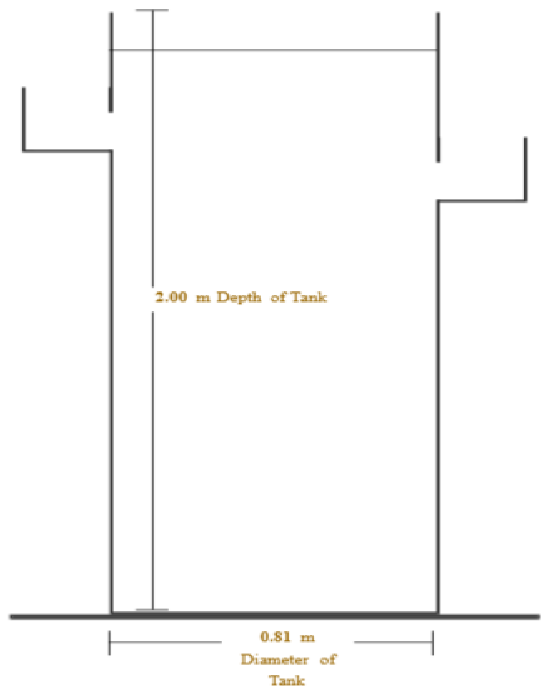
$A = 0.00622 \times \frac{30 \text{ MLD}}{0.25 \text{ m/sec}} = 0.5183$

For circular tank

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

$d^2 = \frac{4 * 0.5183}{\pi}$

SKIMMINGTANK



Design of primary setting tank (PST)

Assumptions:

i. Surface overflow rate = ${}^{Q}/_{A}$= 36

ii. Weir overflow rate = 244.97 m^3/m^2/day (W.O.R)

iii. Side water depth = 3

Design:

S.O.R = ${}^{Q}/_{A}$

Area of tank A $= \frac{30000000 \times 10^3}{36} =$ 833m^2

Provide, No. of tanks = 2

Area of each tank A' = 833 /2=417

∴ volume of each tank, V = A'×S.W.D

= 417×3

V = 1250m^3

Providing circular PST,

diameter of tank, d $= \sqrt{\frac{4A}{\pi}} = \sqrt{\frac{4 \times 417}{\pi}}$

d = 23.0283m

Check for W.O.R= $\frac{Q}{\pi d} = \frac{30000000 \times 10^3}{\pi \times 23.0283 \times 2}$

=207.2547m^3/m^2-day>150m^3/m^2-day

Hence, safe

Check for detention time,T $= \frac{V}{Q} = \frac{1250}{30000000 \times 10^3/2}$ = 0.08day

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

Depth due to slope at centre = $\frac{12.25\times1}{12}$ = 11.5141 m

Hence,

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

=(3+11.5141+ (0.25×3)

D = 15.2641m

Design of sludge hopper:

Total suspended solids=20mg/l

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

Solids in clarifier = 20-(20×0.40) = 20mg/l

Assume that 60% of solids are removed by clarifier

Dry solids = Ms = 20-(0.60×20)

= 80.00kg/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 =0.8027

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

Here, Sw =1000kg/m^3

Ps =0.03

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

$V = 3.3218\ V\ m^3/day$

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

$\therefore$ volume of hopper, V= $(3.3218\ V \times 0.5)$

$V = 3.3218 m^3$

Design of collection channel:

Assume velocity of flow in channel equal to 0.3m/sec

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

$A = 0.0005 m^2$

Assume,

width of the channel = 0.5m

$\therefore$ depth of channel, d = 0.0011m

Assuming,

freeboardf_f=0.3m,

$\therefore$ depth of channel, D =0.3 $_+$15.2641m

Now, $m = \frac{A}{P} = 0.0005$

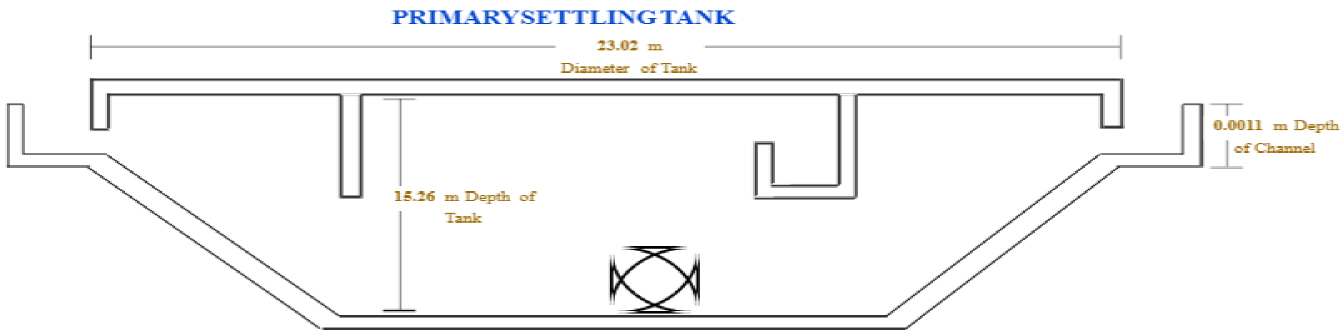
Assuming N =0.013for concrete channel

Manning's formula,

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

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

$\therefore (i^{1/2}) = 0.3591$



Aeration tank

Flow rate (Q)=30

Capacity of aeration tank (m^3)

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

Volume of flow of sewage in m^3/day

$V_1 = \frac{30\times10^6}{10^3}$ = 30000 m^3/day

Volume of returned sludge in m^3/day

30% recirculation

$V_2 = 30000 \times 0.30$

= 9000.00

T = aeration period in hours = 5 hours

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

$= (30000 + 9000.00) \times \frac{4}{24}$

$= 8125.00\ m^3$

Assume depth of tank d = 2m

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

$= \frac{8125.00}{2}$

$= 4062.50\ m^2$

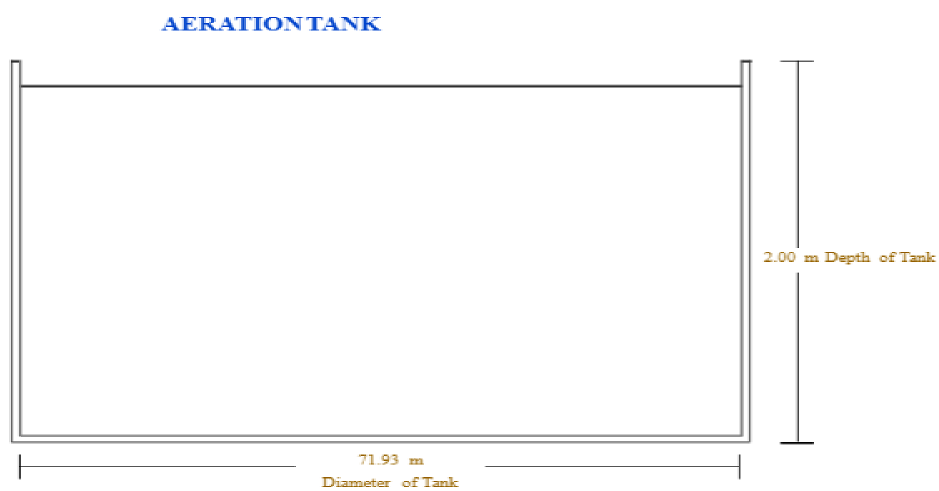
Diameter of tank = D

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

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

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

D = 71.9385 m



Design of trickling filter

Influent B.O.D = 230 mg/l

Assume,

Effuluent B.O.D = 20 mg/l

Hence, overall efficiency of T.F = $\frac{230-20}{230}$ ×100 =91.3043 %

Assume recirculation ratio, R = 2

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

Where, La = applied B.O.D

La = $\frac{230+(1\times 230)}{1+2}$ = 90.00 La mg/l

Assume depth of T.F = 2 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 = 20 Le mg/l

D = depth of T.F = 2m

A = 4196.1524

Q = flow rate in MLD = 30 QMLD

Putting all the values,

$$\therefore \frac{20}{90.00}=\frac{1}{1+18.6\times(2)^{0.67}\times\left(\frac{4196.1524}{50}\right)^{0.5}}$$

A = 4196.1524 m²

Now, A = $\frac{\pi}{4}d^2$ = 4196.1524m²

$D = 29.8344m$

Providing six trickling filters each having $D = 29.8344m$

diameter.

Check for hydraulic loading:

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

$$= \frac{30 + 2 \times 30}{4196.1524}$$

$= 21.4482$ lit/m^2-day

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

Hence, safe

Check for organic loading:

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

$$= \frac{230 \times flow\_rate\_tf}{4196.1524 \times 1}$$

$= 1.6443$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, $Q = 15.00$MLD

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

$= (15.00 \times 1.5) + (2 \times 15.00)$

$= 0.6076 m^3/sec$

Assume velocity of flow equal to 0.5m/sec

Area $= \frac{(\frac{0.6076}{1})}{0.5} = 1.2152\text{m}^2$

$\therefore$ Diameter of pipe $= \sqrt{\frac{4A}{\pi}} = \sqrt{\frac{4\times1.2152}{\pi}} = 1.2436\text{m}$

Now, Vavg. $= {}^{Q}/_{A} = \frac{15.00 \times 10^{\wedge}3}{{}^{\pi}/_{4}\times(1.2436)^2\times86400} = 1.00\text{m/sec} = 1\text{m/sec}$

Hence, safe

Now, length of each arm $= \frac{29.8344}{2} - \frac{1.2436}{2}$

$= 35.9177\text{m}$

Provide 3 sections of 5.86 m

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

$=450.2222\text{m}^2$

Similarly,

$\text{A2} = 1374.0922\text{m}^2$

$\text{A3} = 2275.1025\text{m}^2$

And

Now, finding proportionate area for all the sections:

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

$= 0.1098\%$

Similarly,

2^{nd} section $= 0.3351\%$

3^{rd} section $= 0.5549\%$

Now, finding discharge per section,

1st section, Q1 =0.1736m^3/sec

2nd section, Q2 =0.1545m^3/sec

3rd section, Q3 =0.0963m^3/sec

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

Finding diameter for each section:

1st section, $A_1 = \frac{Q1}{V}$ = 0.1098% m^2

D_1 =0.6647m

Similarly,

2nd section, D_2 =0.6272m

3rd section, D_3 =0.4952m

Design of orifice:

Discharge through orifice is given by,

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

Where, Cd = 0.6

A = 78.5714m^2

H = 1m

$\therefore$ Q = 208.8167

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

=0.0008

Now, finding the number of orifices in each section

1^{st} section, numbers = 0

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 =99.4480

Now, Average flow per filter = 0.3472m^3/sec

Hence, Discharge through each lateral,

=0.0034 m^3/sec

Assume, velocity of flow = 0.8m/sec

Hence, area of each lateral = $\frac{Q}{V}$ =0.0043

Check for average velocity,

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

V= 0.7999m/sec

This is in the limit 0.6 to 0.9 m/sec

Hence, safe

Design of collecting channel:

Discharge in collecting channel = 0.1736m^3/sec

Assume velocity of flow = 0.8m/sec

Area of channel = 0.2170

Check for slope:

Assuming,

N = 0.2170 for concrete channel

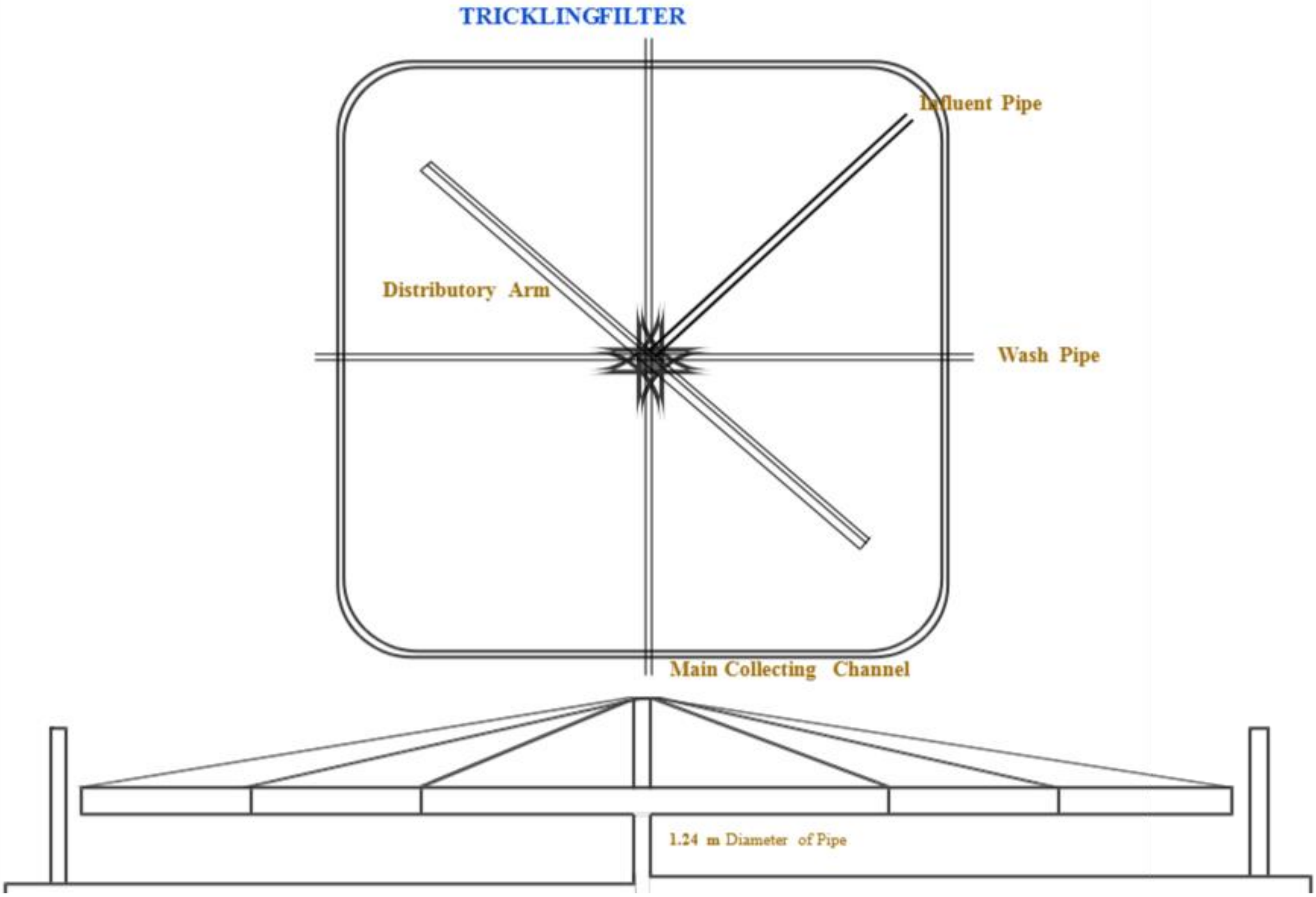
$m = \frac{A}{P} = \frac{0.35 \times 1.18}{0.35+(2 \times 1.18)} = 0.15$

Using manning's formula,

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

$$i = 0.0017$$

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


TRICKLINGFILTER
Influent Pipe
Distributory Arm
Wash Pipe
Main Collecting Channel
1.24 m Diameter of Pipe

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

Assume S.O.R = 36m^3/m^2-day

Assume depth of S.S.T = D = 3m

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

= 0.3472m^3/sec

Area of clarifier = $\frac{Q}{S.O.R}$ = 833m^2

Volume of clarifier = (A×D)

= 2500m^3

Now, Diameter of each clarifier

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

D = 32.5669m

Provide two S.S.T of32.5669m diameter each

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

∴ total depth =total_dept10

Check for detention time:

T = $\frac{V}{Q}$ =0.16day

This is within the limit of 5 to 10 hours

Hence, safe

Design of sludge hopper:

Assume special gravity of sludge = Ssl = 0.8027

Assume = 90% or solids are removed by the trickling filter

Assume that the production of solids in T.F is =0.5kg Vss per kg B.O.D

$\therefore$ Vs = 650kg/day

Assume that the dry solids are =5%

$\therefore$ Ms = 33kg/day

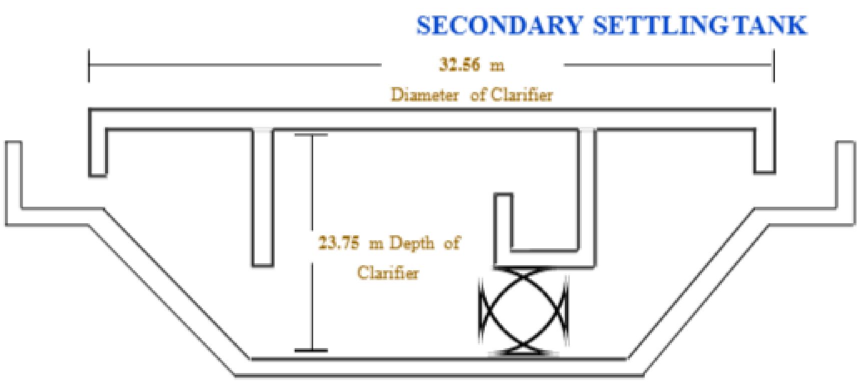
Take Sw = 1000 kg/m^3

Ps = 0.03

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

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

V = 1.3496m^3/day


SECONDARY SETTLING TANK
32.56 m
Diameter of Clarifier
23.75 m Depth of
Clarifier

Design of digester unit:

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

= 4.6714m^3/day

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

= 1.5571m^3/day

Assume that the time required for digestion is 50 days

Now,

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

= 207.6177m^3

Assume height of digester = 6m

∴ area of digestor = 34.6029m^2

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

∴ d = 6.6362m

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

= 85kg/day

Now, volatile solid destroyed,

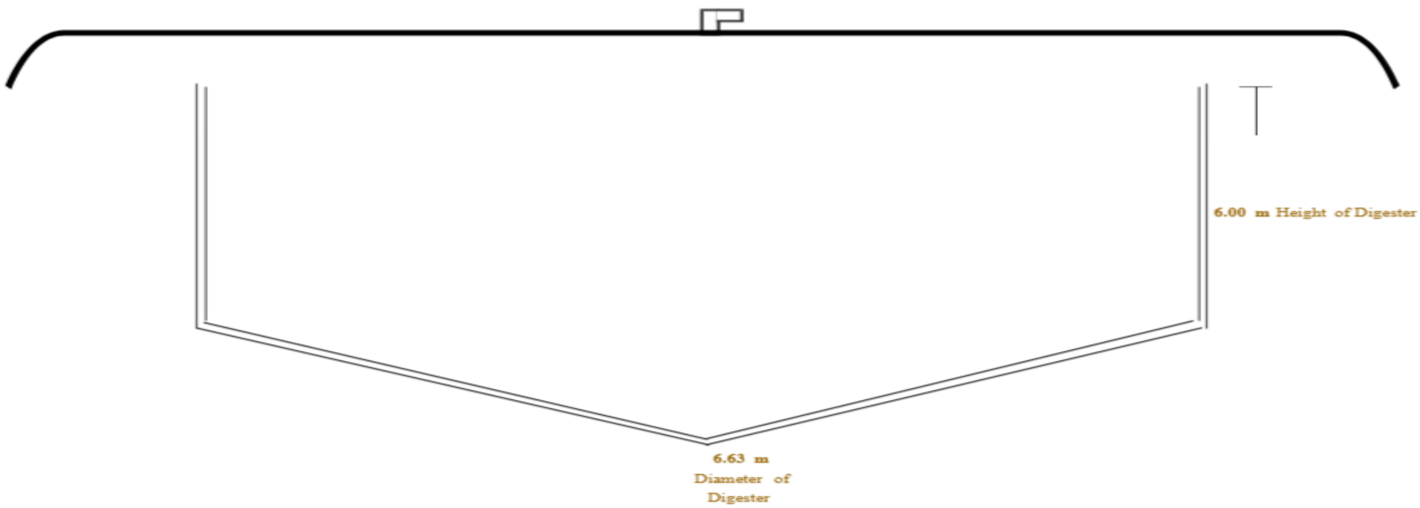
Vsd % = 55.00%

Vsd =46.75kg/day

Quantity of total gas produced during digestion = 35.06m

Quantity of methane gas produced during digestion = 2/3 × total gas = 23.37m^3

DIGESTER UNIT



Design of sludge drying beds;

Assume depth of sludge application = 0.3 m

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

= 5.1903m^2

Now,

assume length of drying bed, L =length_of_drying_bed_sbdm

Width of drying, W =$\frac{5.1903}{25}$= 0.2076m

Assume that the sludge cake will be removed after,

T=15 days

∴ provide =15numbers of sludge drying beds

SLUDGE DRYING BEDS