Treatment of Water

It is based upon the qualily of raw water and treated water.

TDS = 2000 mg/lit ⟶ (WTP) ⟶ (500 mg/lit)

$$\eta = \frac{2000-500}{2000} = 75\%$$

Treatment of water can be done by any of the following method:

(i) Screening.
(ii) Aeration.
(iii) Coagulation.
(iv) Floculation
(v) Sedimentation
(vi) Filteration.
(vii) Disinfection.
(viii) softening of water.
(ix) De-salimation.
(x) De-ferrisation.
(xi) De-fluoridation.
(xii) Fluroridation.

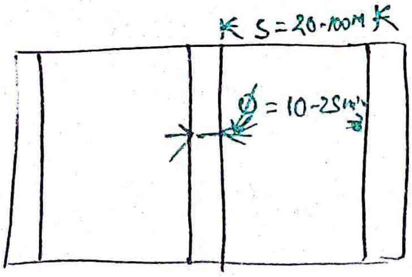
Screening

→ It is carried out to remove heavy solids [plants, animals, stones] from the water.
→ It is generally adopted for treatment of surface water.
→ Screening is done with the help of screens.

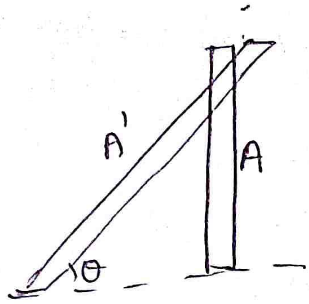
Screens
- → Coarse / Bar / Trash rack.
- → Fine

Coarse Screen.

→ These are in the form of bars [ϕ = 10-25mm, S = 20-100mm]
→ These are always placed at an inclination.
→ These screen are always placed of the screens by of 3-6V : 1H as it effective cleaning ranking mechanism moreover it also help in increasing the effeciency of screeing process.



Trash → Impurities removed by rack → Trash rack.



$A = PL$ $\quad A' = HL$

$A' = A$ — (i)

or $\sin\theta = \frac{A}{A'}$

$A' = \frac{A}{\sin\theta}$

$\boxed{\sin\theta < 1}$ $\quad A' > A$ — (ii)

Area of flow increases by keeping screens inclined.

→ When water passes through screen loss in heads takes place.

$$\boxed{h_L = \frac{K}{2g}\left[v^2 - u^2\right]}$$

K = constant that depend upon material of screen.
g = acceleration due to gravity.
U = velocity of approach.
V = velocity through screen.

$$\boxed{\frac{K}{2g} = 0.0729}$$

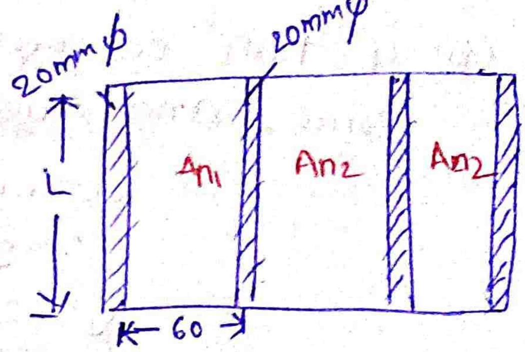
Q. A trash screen is provided for treatment of 50000 m^3/day of raw water, velocity through the screen is to be maintained at 0.8 m/s size of bars is 20mm and clear spacing is 60mm. compute.

(1) Headloss through the screen.

(2) Net and gross area of the screen.

(3) if half of the screen is clogged due to leaves and debris again compute the head loss.

Assume any data not given.



$d = 20mm$

$S = 60mm$

$S_{cc} = S + \frac{d}{2} + \frac{d}{2}$

$= 60 + 20$

$= 80mm.$

$Q = 50000\ m^3/day$

$V = 0.8\ m/sec.$

(2) $A_{net} = \frac{Q}{V} = \frac{50000\ m^3/day}{0.8\ m/sec} = \frac{50000}{24 \times 60 \times 60 \times 0.8} = 0.723 m^2$

$A_{net} = SLn = 0.723 m^2$

$A_T = S_{cc} L n$

$Ln = \frac{0.723}{S} = \frac{0.723}{S}$

(2) $A_T = S_{cc}\ LN$

$= 80 \times \frac{0.723}{S}$

$= 80 \times \frac{0.723}{60} = 0.964 m^2$

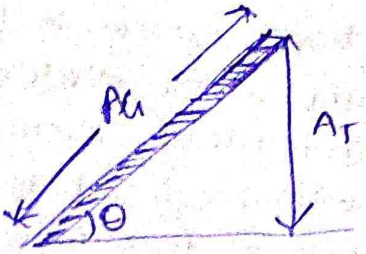
$U = \frac{Q}{A_T} = \frac{50000}{0.964} = 0.6 m/s.$

(i) $h = \frac{K}{2g}(V^2 - U^2) = 0.0729 \times (0.8^2 - 0.6^2)$

$h_L = 0.0284\ m$

(ii) θ is 45°

$\sin\theta = \frac{A_T}{A_G}$



$A_G = \frac{0.964}{\sin 45°} = 1.363 m^2$

(iii) If half screen is clogged total area will remain same, And Anet will be half.

U = Constant,

$V' = 2V$

$V' = 2 \times 0.8 = 1.6 m/s.$

$h_L' = \frac{K}{2g}[V'^2 - u^2]$

$= 0.0729 [1.6^2 - 0.6^2]$

$= 0.16 m$

(ii) Fine Screen

→ These screen are in the form of wire mesh.

→ Under normal treatment condition, fine screen are generally avoided as they get frequently clogged, required their frequent cleaning which in turn increase the operational cost. Hence it is generally recommeded to use coarse screen instead of fine screen to and to remove the fine suspended particle in following Sedimentation and filteration process.

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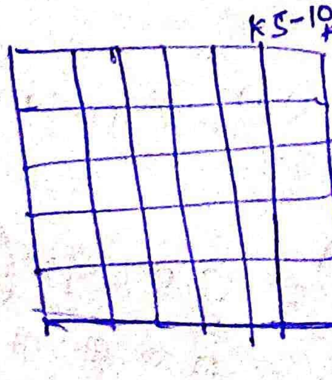


2. Aeration

In this process water is broad in intimate contact with air so it allow the ~~observation~~ ~~of~~ absorption of O_2 in carryout the removal of following dissolved impurities from the water.

→ It remove dissolve gases like CO_2, H_2S from the water.
→ It remove dissolve organic matter from water.
→ It remove volatile liquid like phenol & humic acid from water.
→ It remove dissolved minerals. Fe, Mn

→ It is generally adopted for the treatment of water which ~~has~~ has difficiency of O_2.
eg. ground water, water from bottom of lakes.

$$H_2S \xrightarrow[H_2O]{O_2} SO_4^{2-} \quad | \quad CO_2 \xrightarrow[CO_3^{2-}]{O_2} CO_3^{2-}$$

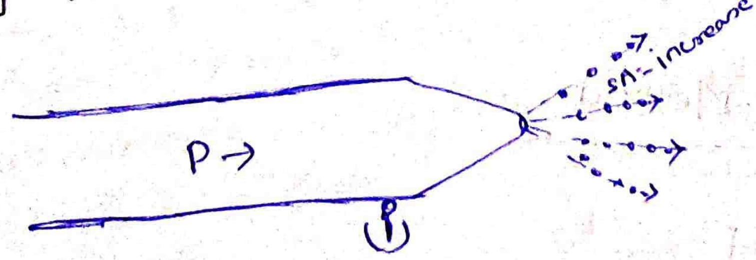
$$Fe_2^{2+} \xrightarrow[H_2O]{O_2} Fe(OH)_3 \downarrow + 8H^+$$

$$Mg^{2+} \xrightarrow[H_2O]{O_2} MnO_2 + 4H^+$$

→ By aeration taste, colour, odour, pH reduces but turbidity of water increases.

※ Aeration can be done by any of the following Method:-

(i) Spray Nozzle method.



(Requirement of power is more.)
→ uneconomical.

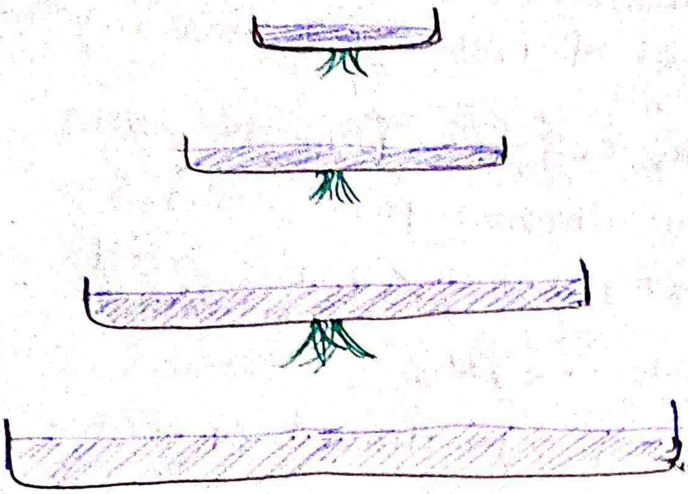
	(i)	(ii)
(a) V = constant	SA ↑	SA ↓
(b) SA = Constant	V ↓	V ↑

eg tap

(ii) Tray Tower Method.

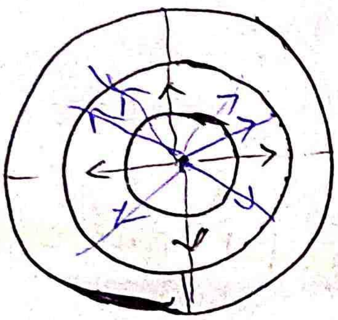
- more area required
→ So it is not suitable

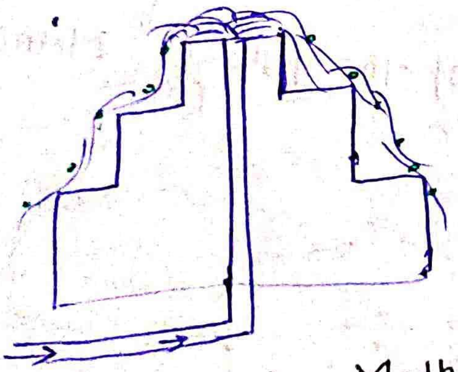
→ Its efficient is more.



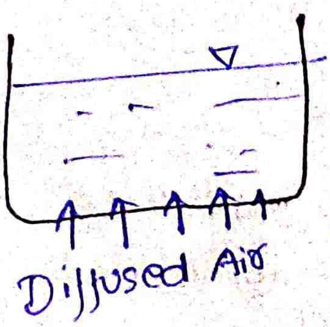
(iii) Cascade Aerator (~~Used for less treatment of water ex...~~

→ least efficient
→ No maintenance cost
→ Used on a large scale.





(iv) Diffused Air Method.



(3) SEDIMENTATION

→ It is the process of removal of suspended particle from water.

→ The entire theory of sedimentation based on **Specific Gravity. (G).**

$$G = \frac{\text{wt. of solid of given volume.}}{\text{wt. of standard fluid of same volume.}}$$

(standard fluid → water) $V_s = V_w$.

$$G = \frac{W_s}{W_w} = \frac{W_s}{V_s} \times \frac{V_s}{W_s} = \left(\frac{W_s}{V_s}\right)\left(\frac{V_w}{W_s}\right)$$

$$\boxed{G = \frac{\gamma_s}{\gamma_w}} = \frac{\rho_s}{\rho_w}$$

$G_s > 1$

$\gamma_s > \gamma_w$.

For inorganic solid, $G = 2.6 - 2.9$ (2.65)

For organic solid, $G = 1 - 2$ (1.2)

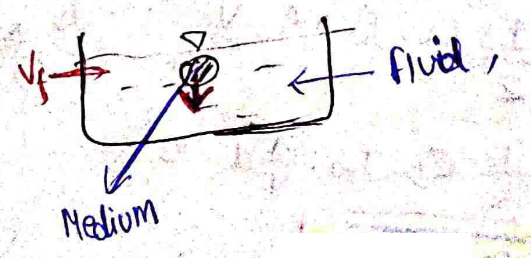
$\gamma_s > \gamma_w$: Solid are heavier than water.

→ Water is in flowing condition, so due to turbulence no settling takes place.

→ During sedimentation which opposes the tendency of settlement are taken proper care of.

(i) Turbulence/velocity of flow. ↓ - $\eta\uparrow$

(ii) Viscosity ↓ $\eta\uparrow$

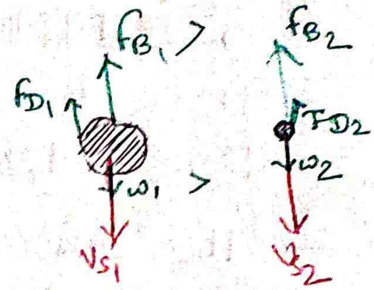


$\gamma_{liquid} = f(\text{temp})$

$\gamma_{liquid} \propto \frac{1}{T}$

$\tau_{gases} \propto T$

(iii) Size of particles. (d)



Stoke's law – valid (d < 1 mm)

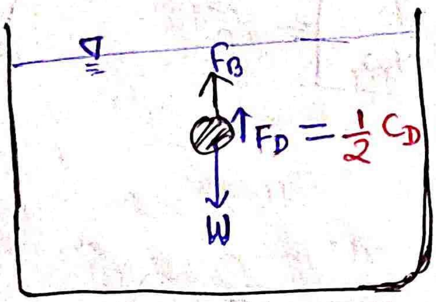
Assumption of stokes law:-

1) Particle under going settlement is spherical.

ii) Medium in which settlement is taking place is infinite.

(iii) Discrete settling takes place during settlement

अलग-अलग settling.



$$F_D = \frac{1}{2} C_D \rho_w A V_r^2$$

$$V_r = V_p - V_w \quad (V_w \to 0)$$

$$V_r = V_p$$

C_d = coefficient of drag.

For, $V_p = V_s$ – terminal velocity / settling velocity.

gravity accⁿ, acceleration, $a_p = 0$

$$\Sigma F_y = 0$$

$$W - F_B - F_D = 0$$

$$W - F_B = F_D.$$

Boyant weight, $B_w = F_D$

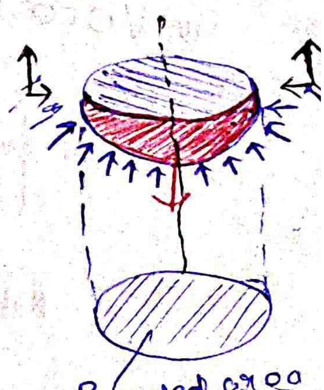
$$V_s \gamma_s - V_w \gamma_w = F_D \qquad [V_w = V_s]$$

$$V_s \gamma_s - V_s \gamma_w = F_D$$

$$V_s \gamma_w \left(\gamma_s/\gamma_w - 1 \right) = \frac{1}{2} C_D . \rho_w . A . V_s^2.$$

$$\frac{\pi d^3}{6} \gamma_w \left(\gamma_s/\gamma_w - 1 \right) = \frac{1}{2} C_D . \rho_w . \frac{\pi}{4} d^2 . V_s^2$$

$$V_s = \sqrt{\frac{4}{3} \frac{(G-1) g d}{C_d}}$$



Projected area

(i) For laminar flow condition. $(d < 0.1 mm)$, $(Re < 1)$

$$C_D = \frac{24}{Re} , \quad Re = \frac{\text{Inertial force}}{\text{Viscous force.}}$$

$$Re = \frac{\rho V d}{\mu} = \frac{Vd}{\nu}$$

$$\nu = \frac{\mu}{\rho}$$

$$V_s = \frac{(G-1)\gamma_w d^2}{18\mu} = \frac{(G-1) g d^2}{18\nu}$$

ν = kinematic viscosity m^2/sec.

Setting velocity can also be written as.

$$V_s = 418 (s-1) d^2 \frac{(3T+70)}{100}$$

V_s mm/sec, d mm, T °c

(ii) For Transition flow condition. $(0.1 < d < 1 mm)$
$1 < Re < 1000$

$$C_d = \frac{24}{Re} + \frac{3}{\sqrt{Re}} + 0.34$$

$$Re = \frac{\rho V_s \cdot d}{\mu}$$

Modified Hazen formula.

Or,
$$V_s = 418 (s-1) d \frac{(3T+70)}{100}$$

(iii) For Turblent flow Condition $(d > 1 mm)$
$Re > 10^4$.

$$C_d = 0.4$$

$$V^2 = \frac{4}{3} \frac{gd(s-1)}{C_d}$$

$$V_s^2 = \frac{4}{3 \times 0.4} \times gd(s-1)$$

$$V_s = 1.8 \sqrt{gd(s-1)}$$

* Bigger the size of particle more the effeciency of settlement.

* Viscosity & size of particle can be altered during operation.
* Size of particle normally altered, alternation in viscosity needs extra cost.

→ Sedimentation is carried out in the units termed as <u>sedimentation tank.</u>

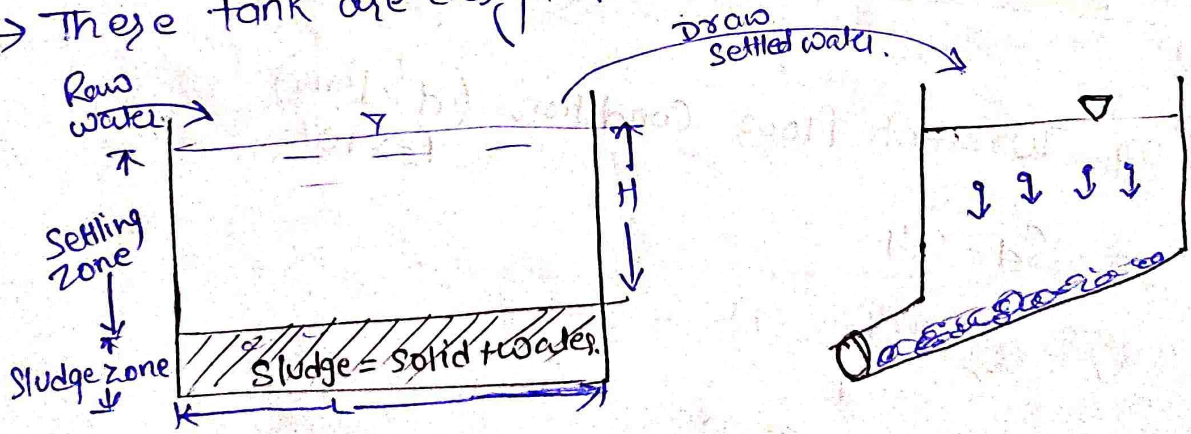
Two types :-
(i) Quiscent type / Fixed type / Fill & draw type.
(ii) Continuous flow type :- (a) Horizontal flow type
(b) vertical flow type.

* Quiscent type Sedimentation tank.

→ These are the type of tank in which the flow of water is completely stopped for 24 hours. during which the solid present in its get settled in the tank resulting in the formation of sludge which is further followed by the removal of settled water from the tank for the next treatment.

→ Detention time for these tank <u>are 24 hours,</u> cleaning <u>period is 6-12 hours.</u>

→ These tank are design for <u>max^m daily demand.</u>



Q_D = Desin discharge
= Q_{max}
= 1.8 Q_{avg} x daily demand
= 1.8 X (Population X Avg. per capita daily demand)

* Minimum unit is depend upon delention time. So minimum unit should be 3. Two for operation and one for standby.
* Max^m unit depend upon daily demand.

Continuous flow type.

→ In this type of tank in which flow of water is ensured to be continuous, for carrying out sedimentation. (either in horizontal or vertical)

Type:-

ⓐ Horizontal flow type.
- Rectangular tank
- Circular tank with radial flow.

ⓑ Vertical flow/or upper flow type.

* Rectangular tank with Longitudnal Flow.

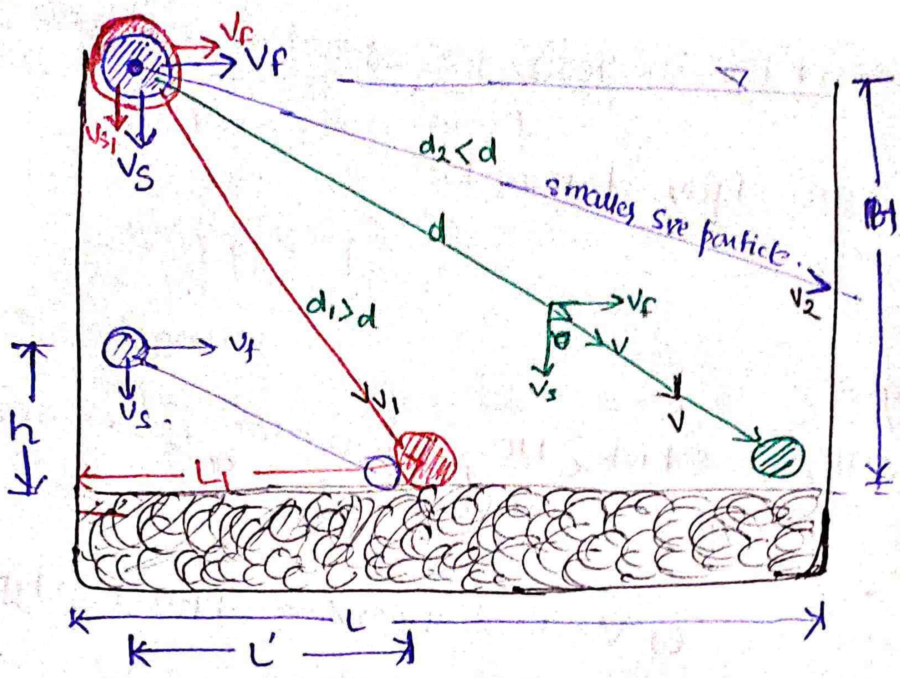
Assumption

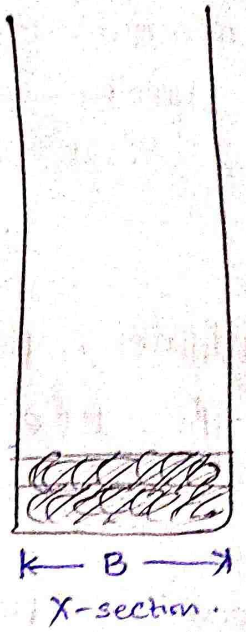
(i) A particle is assumed to be settled in the tank if it reaches the bottom of the settling zone.

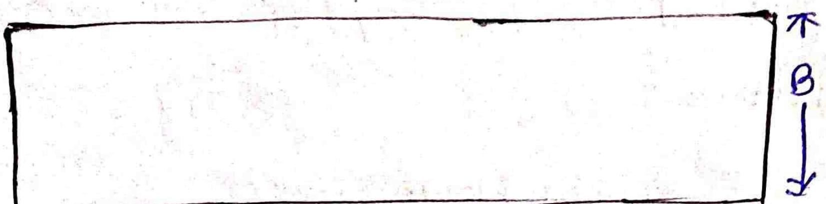
(ii) Concentration of particle of all the sizes is same at all the points of the vertical section at the inlent end.

size(mm)	conc mg/lit	%R
6	200	100%
5	50	100%
(4)	250	100%
2	150	<100%
1	350	<100%
	1000 mg/lit	

Concerned size of particle (4)







Lid(H)

time, $t_d = \frac{L}{V_f}$

$$t_d = \frac{H}{V_s}$$

$$V_f = \frac{Q_D}{X\text{-area}}$$

$$V_f = \frac{Q_D}{BH}$$

$$t_d = t_d$$

$$\frac{L}{V_f} = \frac{H}{V_s}$$

$$V_s = \frac{H V_f}{L}$$

$$V_s = \frac{\cancel{H} \times Q_D}{L \; B\cancel{H}}$$

$$V_s = \frac{Q_D}{LB}$$

$$V_s = \frac{Q_D}{\text{plan-area.}}$$

(ii) $d\ (h)$ $h < H$

$h < H$

$t_d' = \frac{h}{V_s}$, $t_d = \frac{H}{V_s}$

$h < H$

$t_d' < t_d$

⇒ 100% removal of concerned size of particles takes place in the tank.

$L' = V_f \cdot t_d'$, $L = V_f \cdot t_d$

$L' < L$

(iii) $d_1\ (H)$, $d_1 > d$, $V_{s_1} > V_s$

$t_{d_1} = \frac{H}{V_{s_1}}$, $t_d = \frac{H}{V_s}$

$V_{s_1} > V_s$

$t_{d_1} < t_d$

→ If particle of greater size than concerned size of particle than concerned size of particle it will settle quickly than concored size of Particle

(iv) $d_1\ (h)$, $h < H$

$t_{d_1}' < t_{d_1} < t_d$

100% removal of bigger sized particle also takes place in the tank.

$L_1 = V_f \cdot t_{d_1} < L = V_f \cdot t_d$

(v) $d_2(H)$, $d_2 < d$, $V_{s_2} < V_s$

$t_{d_2} = \frac{H}{V_{s_2}}$, $t_d = \frac{H}{V_s}$

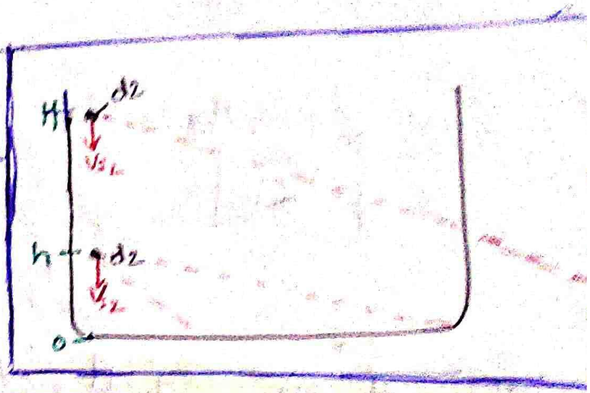
$\boxed{t_{d_2} > t_d}$

Or, $H_2 = V_{s_2} t_d$, $H = V_{s_2} t_{d_2}$ $(\because t_d < t_{d_2})$

$\boxed{H_2 < H}$

Or, $L = V_f . t_d$, $L_2 = V_f . t_{d_2}$

$\boxed{L_2 > L}$



(vi) $d_2(h)$, $d_2 < d$, $V_{s_2} < V_s$, $h < H$

$t_{d_2} = \frac{h}{V_{s_2}}$, $t_d = \frac{H}{V_s}$

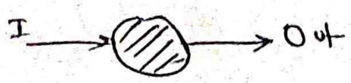
→ For some h & V_{s_2} for which $t_{d_2}' = t_d \Rightarrow \frac{h}{V_{s_2}} = \frac{H}{V_s}$ – settle

→ For some h & $V_{s_2} \Rightarrow t_{d_2}' > t_d$ (h - H) – not settle

→ For some h & $V_{s_2} \Rightarrow t_{d_2}' < t_d$ (0 - h) – settle

⇒ Smaller size particles are partially removed in sedimentation tank.

$\eta(\%) = f(I, O)$



$$\boxed{\eta\% = \frac{I - O}{I} \times 100}$$

% Removal of small size particle:

$$\%R = \frac{\left(\frac{W}{H}\right)h}{W} \times 100$$

$$\%R = \frac{h}{H} \times 100$$

$$\%R = \frac{V_{s2}}{V_s} \times 100 = \frac{\frac{(G-1)\gamma_w d_2^2}{18\mu}}{\frac{(G-1)\gamma_w d_1^2}{18\mu}} \times 100 = \frac{d_2^2}{d_1^2}$$

$$\%R = \frac{d_2^2}{d_1^2} \times 100$$ } only if flow is laminar ($d < g_{min}$)

Q

Size (mm)	Concentration	% R
6	200	100%
5	50	100%
(4)	250	100%
3	150	20%
1	350	15%

$$\eta(\%) = \frac{\left[(200+50+250)\times\frac{100}{100} + 150\times\frac{20}{100} + \frac{15\times350}{100}\right]}{1000} \times 100$$

$= 58.25\%$

$$\boxed{\eta\% = \sum_{i=1}^{n} \%C \times \%R}$$

→ Settling velocity of concerned sized particle is termed as Surface Overflow Rate and SOFR governs the effeciency of sedimentation tank. $\boxed{\eta \propto \frac{1}{SOFR}}$

Q. A tank having overflow rate of 2m/hr. is designed for treatment of flowing water sample

Type of particle	Velocity (m/hr) (V_s)	concentration (mg/lit)	%R
I	3	300	=100%
II	2	250	=100%
III	1	450 $\frac{1}{2}$	= 50%

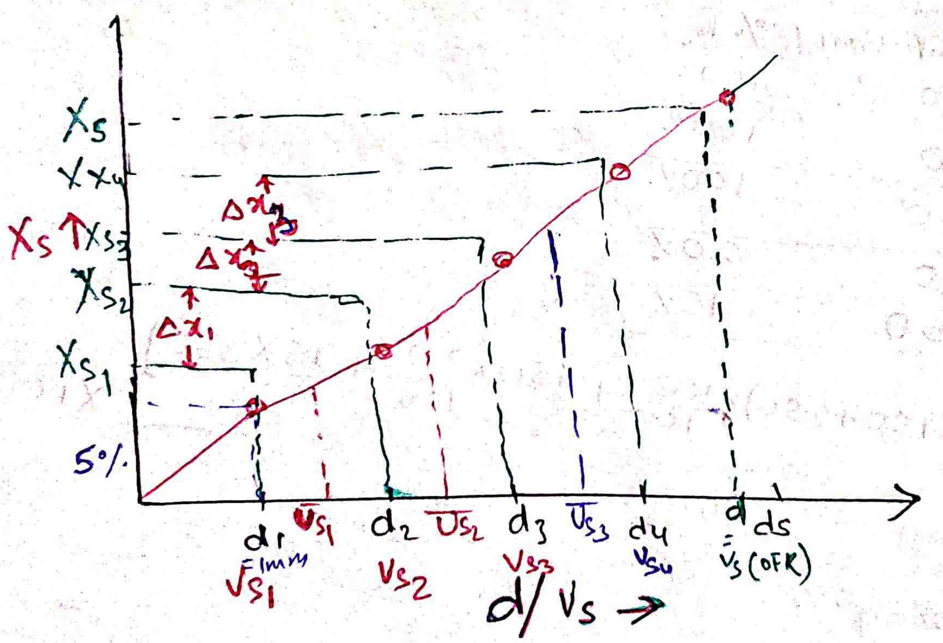
Find the concentration of particle in settled water. (water that comes out of tank.)

$$\%R = \frac{V_{s2}}{V_s} \times 100 = \frac{1}{2} \times 100 = 50\%$$

$$450 \times \frac{50}{100} = 225 \text{ mg/lit}$$

* If all size of particles present in water.

X_s = % finer = % of particles having size less than stated velocity.
size / velocity less than stated velocity.



mg/lit	(mm)
200	6
50	5
250	4
350	2
100	1

(S.Q.)

$$\bar{V}_{s1} = \frac{V_{s1} + V_{s2}}{2}$$

$$\bar{U}_{s2} = \frac{V_{s3} + V_{s2}}{2}$$

$$\bar{V}_{s3} = \frac{V_{s4} + V_{s3}}{2}$$

$$\eta(\%) = \Sigma \, \%C \times \%R$$

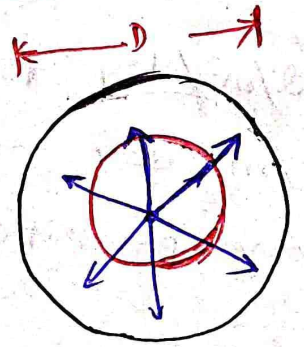
$$= (100 - X_s) \times 100 + \Delta x_1 \left(\frac{\overline{U_{s1}}}{V_s}\right) + \Delta x_2 \left(\frac{\overline{U_{s2}}}{V_s}\right) + \Delta x_3 \left(\frac{\overline{U_{s3}}}{V_s}\right) \ldots \ldots \Delta x_4 \left(\frac{\overline{U_{sx}}}{V_s}\right)$$

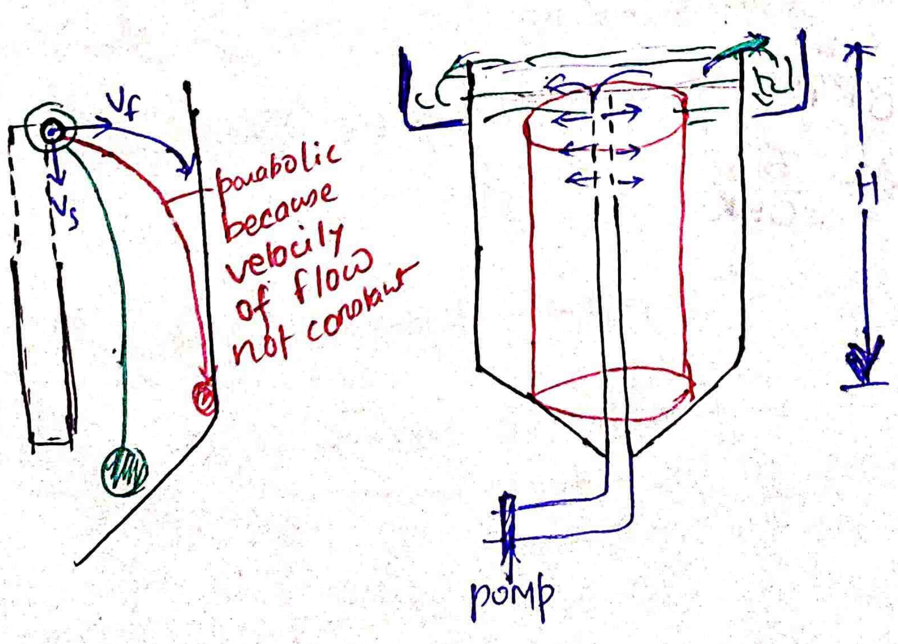
$$\boxed{\eta = (100 - X_s) + \sum_{i=1}^{n} \left(\frac{U_{si}}{V_s}\right) \Delta x_i}$$

$$\overline{U_{si}} = \frac{V_{si} + V_{si+1}}{2}$$

eg. $U_{s_1} = \frac{V_{s_1} + V_{s_2}}{2}$

(b) Circular tank with Radial flow.





* Efficiency of circular tank is less compared to ~~circ~~ rectangular tank.

→ In vertical flow type tank, setting velocity of particles remain constant during settlement but horizontal velocity of flow reduces as the particle move from center towards circumference due to increase in area ($2\pi r H$) hence the path followed by the particle during settlement in the tank is a parabolic path unlike the straight line path in the horizontal flow type tank.

$$V = D^2(0.011D + 0.785H)$$

Design data for Horizontal flow type tank.

1) Over flow rate

→ range = 12000 - 18000 $l/m^2/day$ (12 - 18 $m^3/m^2/day$) for plain sedimentation

→ 24000 - 30000 $l/m^2/day$ (24-30 $m^3/m^2/day$) for coagulation added sedimentation

$l/m^2/day$ - Discharge per unit area.

$$\text{Plan area} = \frac{Q_D}{OFR}$$

$$B.L \text{ or } \frac{\pi}{4}D^2 = \frac{Q_D}{OFR}$$

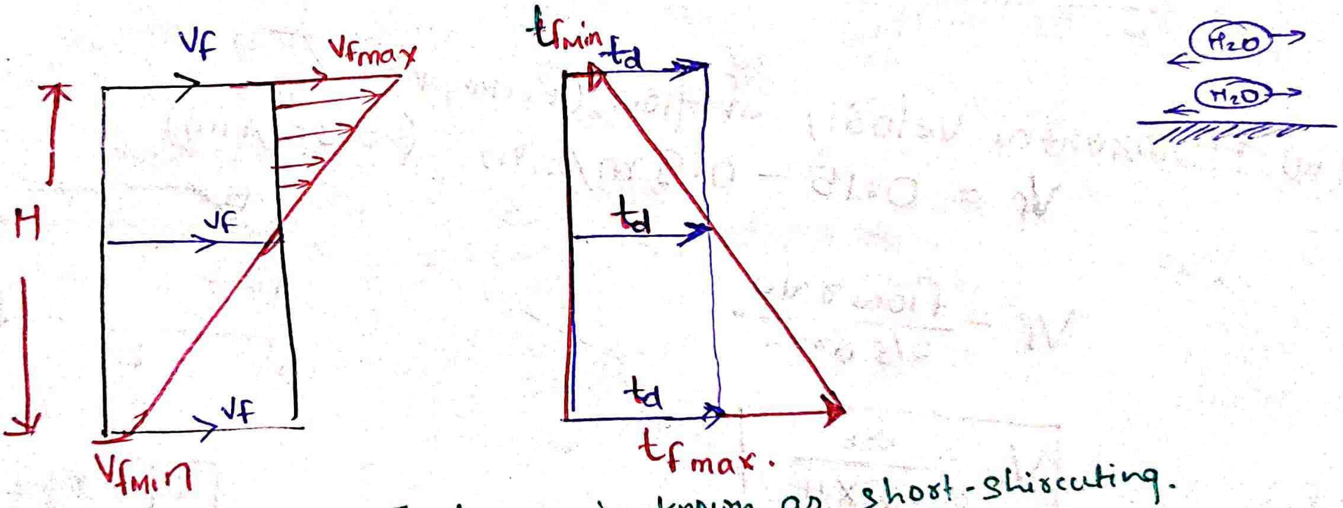
(ii) Dention time. (t_d) – avg. theoretical time taken by water to travel from inlet to outlet.

range = 4 to 8 hours plain sedimentation.
2 to 4 hours for coagulation aided sedimentation.

$$\boxed{\text{Volume} = Q_D \cdot t_d}$$

Volume = LBH – Rectangular tank
or
$= D^2(0.011D + 0.785H)$ – Circular tank.

$$H = \frac{\text{Volume}}{B \times L}$$



→ This process is known as short-shirccuting.

→ Flow through period: Actual time available with water along the height of tank to travel along the length of tank

→ Impact of shortshirccuting ie, it reduce efficiency of tank.

→ The theoretical detention time is calculated on the basis of avg velocity of flow. But in actual it is more in upper layer. ie results in lesser availability of actual time for particles to settle in upper layer hence these particle do not settle & result in reduced in efficiency of tank this is known as "Short circuting".

→ Extent of which is measured in terms of displacement efficiency.

~~η_d = Q Theoretical detention~~

$$\eta_d = \frac{\text{Avg. flow through period } (t_f\ avg) \times 100}{\text{The detention time } (t_d)}$$

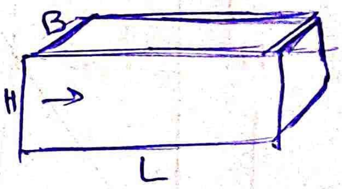
Displacement efficiency, $$\eta_d = \frac{\left(\frac{t_f max + t_f min}{2}\right)}{t_d} \times 100 > (30-35)\%$$

$\eta_d \uparrow \rightarrow t_{favg} \uparrow \rightarrow t_{fmin} \uparrow \rightarrow$ Short Circuiting $\downarrow$

$$\boxed{\eta_d \propto \frac{1}{SC}}$$

(iii) Horizontal velocity of flow, (Rectangular)

$V_f = 0.15 - 0.9\ m/min \quad (0.3\ m/min)$



$$V_f = \frac{\text{flow rate}}{\text{c/s area}}$$

$$\boxed{V_H = \frac{Q_D}{B \times H}}$$

$$\boxed{D_t = \frac{V}{Q_D}}$$

$$Q_D = \frac{V}{D_t} = \frac{LBH}{D_t}$$

$$V_H = \frac{LBH}{B \times H \times D_t}$$

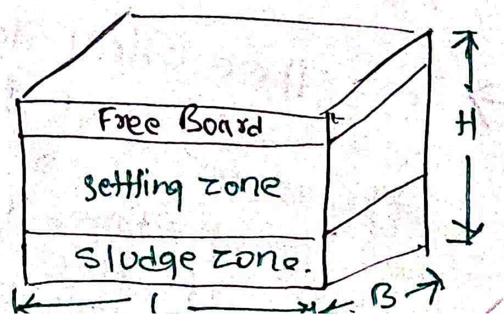
$$\boxed{L = V_H \cdot D_t}$$

(iv) $\frac{L}{B} = 4$

(v) $Q_D = Q_{MD}$

(vi) Free Board = 0.3 - 0.5 m

(vii) Sludge zone = 0.8 - 1.2 m.



Q Consider a plain primary sedimentation tank in a water treatment plan with SOFR = 40 m³/m²/day. the dia of the spherical particle which will have 80% theoretical removal effeciency in the tank ______ μm. Assume stokes law to be valid.

$\rho_w = 1000 kg/m^3$, $\rho_s = 2650 kg/m^3$, $\nu = 1.10 \times 10^{-6} m^2/s$.

~~SOFR = settling velocity for concerned particle.~~

~~$= 40 m^3/m^2/day$~~

~~$= \frac{40}{24 \times 60} m^3/m^2/sec$~~

~~$V_s = \frac{(G-1)\gamma_w d^2}{18\mu}$~~

Sol^n

$\% R = \frac{V_{s2}}{V_s} \times 100$

$80 \times V_s = V_{s2} \times 100$

$80 \times 40 = V_{s2}$

~~$V_{s2} = 32 m^3/m^2/day$~~

$V_{s2} = \frac{80 \times 40}{100} m^3/m^2/day$

$V_{s2} = \frac{80 \times 40}{100 \times 86400} m/sec$

$= 3.7 \times 10^{-4} m/sec.$

$V_{s2} = \frac{(G-1)\gamma_w d^2}{18\mu} = \frac{(G-1) g d^2}{18\nu}$ $\left(\nu = \frac{\mu}{\rho}\right)$

$3.7 \times 10^{-4} = \frac{(2.65-1)\, 9.81 \times d^2}{18 \times 1.1 \times 10^{-6}}$

$d = 2.127 \times 10^{-5} m$

$d = 21.27 \times 10^{-6} m$

$d = 21.27 \mu m.$

Q. A rectangular sedimentation basin is to handle 10 MLD of raw water. A detention basin of ~~length~~ width to length ratio of 1:3 is proposed to trap all particles larger than 0.04 mm in size assuming a relative density of 2.65 for the particles & 20°c temp as the avg. temperature compute the basin dimension. If the depth of tank is 3.5m. calculate detention time.

$\frac{B}{L} = \frac{1}{3}$

$3B = L$

$Q_D = 10$ MLD

$= 10 \times 10^6$ L/day

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

$Q_D = 0.1157 \ m^3/s$

$V_s = 418 (S-1) d^2 \left(\frac{3T + 70}{100}\right)$

$= 418 (2.65 - 1) \times (0.04)^2 \times \left(\frac{3 \times 20 + 70}{100}\right)$

~~= 2.304 × 10⁻⁶ m/~~

~~= 0.509 mm/sec~~

$= 1.43$ mm/sec

$= 1.43 \times 10^{-3}$ m/sec

$V_s = \frac{Q_D}{\text{plan area}}$

$\text{plan area} = \frac{Q_D}{V_s} = \frac{0.1157}{1.43 \times 10^{-3}}$

$= 80.909 \ m^2$ —(ii)

$(B \times L) = 80.899$

$(B \times 3B) = 80.899$

$3B^2 = 80.83$

$B = 5.19$ m

$L = 15.57$ m.

$D = 3.5$ m

$\frac{H}{V_s} = D_t = \frac{V}{Q_D} = \frac{5.19 \times 15.57 \times 3.5}{10 \times 10^6 \times 10^{-3}} = 0.028$ day

$= 40.72$ min

Q A settling basin is design to have surface over flow rate of 32.6 m/day. Determine the overall removal obtain for a suspension with size distribution as follow. G = 1.2 and water temp. is 20°C at which dynamic viscosity = 1.027 centipoise $\frac{NS}{m^2}$ $\rho_w = 0.997\ gm/cm^3$.

~~particle size~~

Particle size (mm)	0.1	0.08	0.07	0.06	0.04	0.02	0.01
weight fraction greater in size (%)	10	15	40	70	93	99	100

If all size of particles present in water

$$\eta = (100 - X_s) + \Sigma\left(\frac{V_{si}}{V_s}\right) \times \Delta x_i$$

Size (mm)	wt. fraction smaller in size (%)	Vs (mm/sec)
0.1	90	1.0581
0.08	85	0.677
0.07	60	0.51
0.06	30	0.38
0.04	7	0.17
0.02	1	0.04
0.01	0	0.01

(Δx_3 between 30 and 7; Δx_2 between 7 and 1; Δx_1 between 1 and 0; $\bar{U}_{s_3}$ between 0.38 and 0.17; $\bar{U}_{s_2}$ between 0.17 and 0.04; $\bar{U}_{s_1}$ between 0.04 and 0.01)

$$= V_s = \frac{(G-1)\gamma_w d^2}{18\mu}$$

$$V_s \times 10^3 = \frac{(1.2-1) \times 0.997 \times 10^{-3} \times 10^{6} \times 9.81 \times d^2 \times 10^{-6}}{18 \times 1.027 \times 10^{-2} \times 0.1}$$

$$V_s = 105.81\,d^2 \text{ mm/sec}$$

Over flow rate = 32.6 m/day $= \frac{32.6 \times 10^3}{86400} = 0.377 \approx 0.38$ mm/s.

$X_s = 30\%$

$\Delta x_1 = 1 - 0 = 1\%$; $\bar{U}_{s_1} = \frac{V_{s_1} + V_{s_2}}{2} = \frac{0.01 + 0.04}{2} = 0.025$ mm/sec

$\Delta x_2 = 7 - 1 = 6\%$; $\bar{U}_{s_2} = \frac{0.04 + 0.17}{2} = 0.105$ mm/s

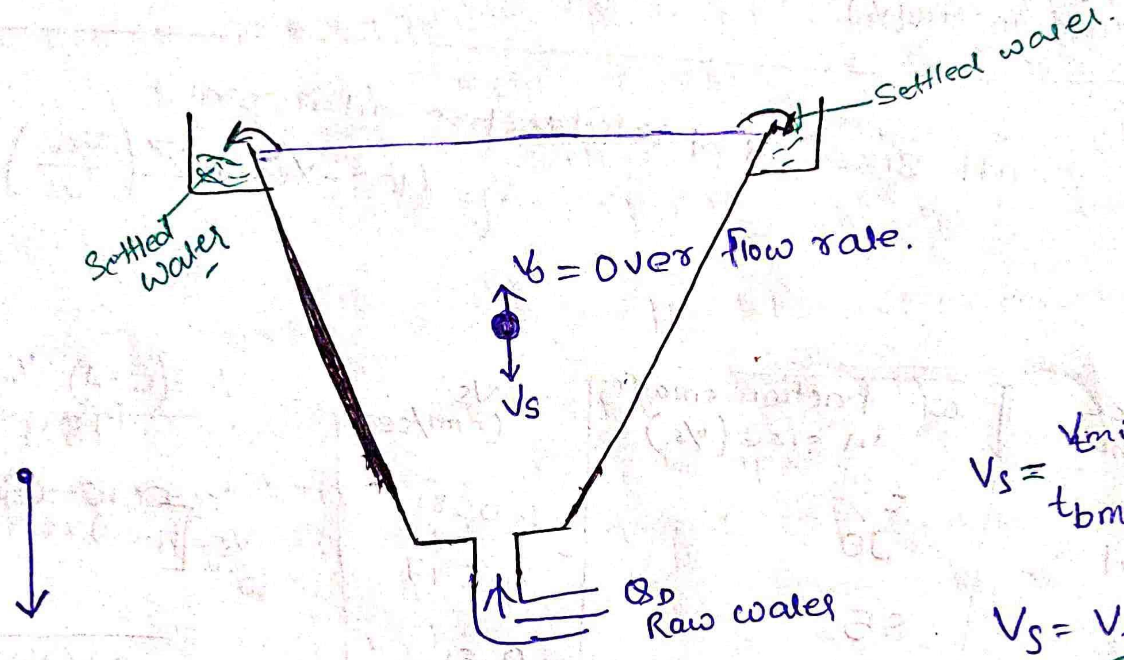
$\Delta x_3 = 30 - 7 = 23\%$; $\bar{U}_{s_3} = \frac{0.38 + 0.17}{2} = 0.275$ mm/sec.

$$\eta(\%) = (100 - X_s) + 1\times\left(\frac{0.025}{0.38}\right) + 6\times\left(\frac{0.105}{0.38}\right) + 23\times\left(\frac{0.275}{0.38}\right)$$

$$= (100-30) + 18.467$$

$$= 88.46\%$$

Vertical Flow Type Tank



$$V_s = \frac{V_{t\,min}}{t_{b\,max}}$$

$V_s = V_{t\,min}$ (top)