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31-8-22

Wastewater Engineering

waste water → Screens → Grit → Primary treatment → Secondary treatment

- Screens ↓ floating objects, inorganic solids
- Grit ↓ sand or debris
- Primary treatment ↓ Remove suspended solids
  - ↳ 60% of BOD left
- Secondary treatment ↓ Biological decomposition of wastewater
  - ↳ reduces BOD to 5-10%.

Secondary treatment:

- Anaerobic
  - anaerobic lagoons
  - Imhoff tanks
  - Septic tanks
  - (Imhoff tanks, Septic tanks) Raw sewage
- Aerobic
  - Activated sludge process
  - Trickling filters
  - Oxidation ponds

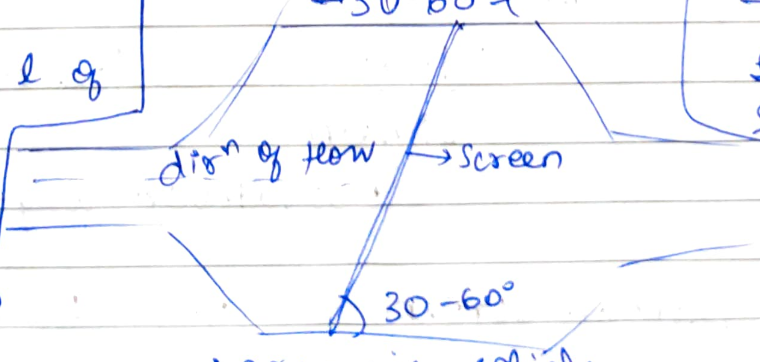
→ Tertiary treatment → Chlorination.

(1) Screens – first operation

problem – choking
needs frequent cleaning.

Coarse
spacing 50mm or more
→ collects 60 l of solids
↓
waste seperated is incinerated, dumping, burial.

Medium
6 - 40 mm
→ 30-60 l



Fine
1.5-3 mm
→ 15-20% suspended solids.
→ used for industrial wastewater

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Q Estimate the screen requirement for a plant treating a peak flow of 60 mld of sewage.

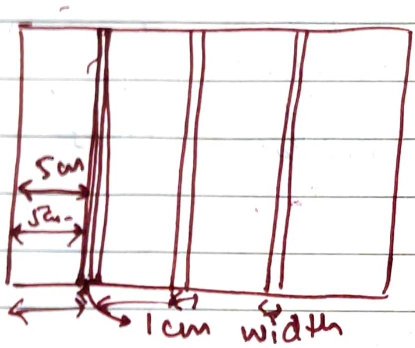
60 mld = $0.69\ m^3/s$.

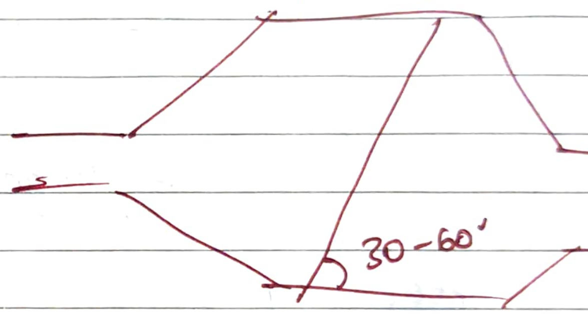
Discharge = Area x Velocity.

$0.69 = \text{Area} \times 0.8$

Area = $0.8625\ m^2$ → area of flow

↳ net area of screen opening.





5+1

6

5cm — 0.87

6 — ?

Gross area of screen → $\frac{0.87 \times 6}{5}$

(space + bar)

$= 1.044\ m^2$

~~bars~~ of screen (1 unit)

Gross area of screen (assuming angle).

(1 unit of 6 cm)

$= \frac{1.04}{\sin 60} = 1.2\ m^2$

↳ whatever angle is given.

Head loss through screen = $0.0729\,(V^2 - v^2)$

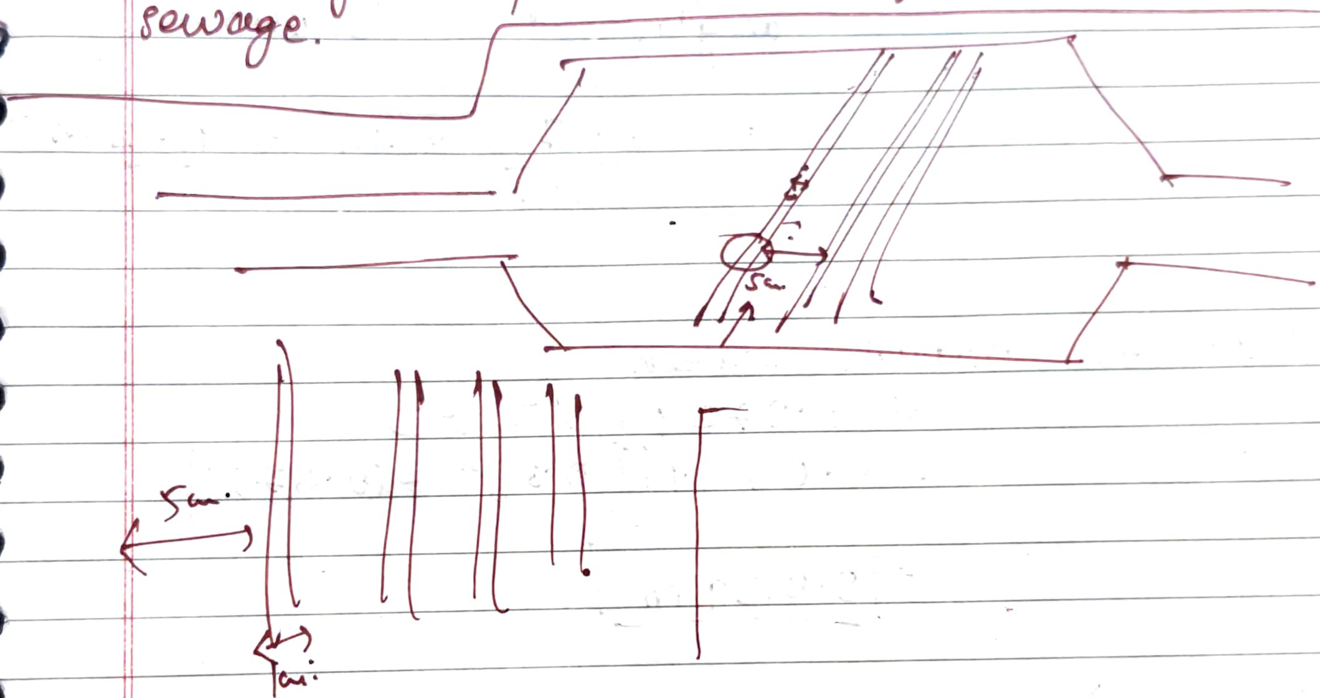
V ↓ vel. through the screen

v ↓ vel. above the screen.

velocity above the screen

$$= 0.8 \times \frac{5}{6} = 0.67.$$

Q Estimate the screen requirement for a plant treating a peak flow of 10 mld of sewage.



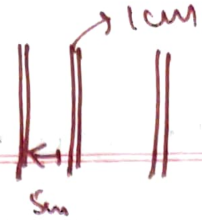
ans

$$10 \text{ mld} = \frac{1\cancel{0} \times 10^{\cancel{6}\,5} \times 10^{-3}}{24 \times 6\cancel{0} \times 6\cancel{0}} = \frac{100}{24 \times 36}$$

$$= 0.115 \ m^3/s.$$

Discharge = Area × vel. (0.8 assumed)

$$\text{Area} = \frac{0.115}{0.8} = 0.14375 \ m^2$$



Gross area of screen of 1 unit (bars) (6cm - 1gap+1bar) = $0.14375 \times \frac{6}{5}$

$= 0.1725\ m^2$

Gross area of screen assuming angle = $\frac{0.1725}{\sin 60}$

$= \frac{0.173}{1.73} \times 2. = 0.2\ m^2$

Head loss through screen

$= 0.0729\ (V'^2 - v^2)$

$= 0.0729 \left[(0.8)^2 - (0.67)^2 \right]$

$= \boxed{0.0139\ m}$.

Q peak flow 5 mld of sewage.

Discharge = $0.058\ m^3/sec$

Area = $\frac{0.058}{0.8} = 0.0725.\ m^2$.

Gross area = $\frac{0.0725 \times 6}{5} = 0.087\ m^2$

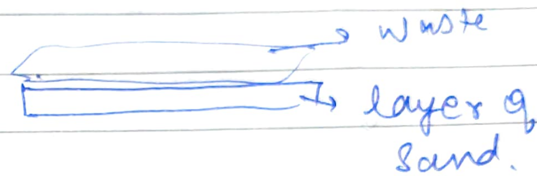
Gross area with angle = $\frac{0.087}{1.73} \times 2 = 0.1\ m^2$

$$\boxed{\begin{aligned}\text{Head loss} &= 0.0139\ m \\ &\approx 0.014\ m\end{aligned}}$$

Screenings

1. Inceneration → Dumping of waste at high temp. 700 - 800
2. Dumping → can directly dump it there is no organic waste.
3. Burial.

2. Dumping -



same for dumping

1. Before inceneration, moisture content of waste is reduced by sun drying method.

Grit Removal 7-9-22

- → It removes sand particles.
- → size b/w fine & coarse screen.
- → removes inorganic particles with sp. gravity more than water, more than 2.65.
- → ~~Sedimentation~~ for particle size ~~less~~ 0.2 mm & less

Design of sedimentation tank → depends on settling velocity

Also known as type I settling - physical

THEORY BEHIND TYPE I

1. Velocity of flow. → more area of flow, less V, more settling.
2. Viscosity of water ↗ warm water, less viscous fluid.
3. Size, shape & sp. gravity of the particle

↓ sp gravity ↑ settling easy.

STOKE'S LAW

Acc. to

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

g → 9.81 m/s

G → sp. gravity of particle

d → dia. of particle (m)

V_s → settling velocity

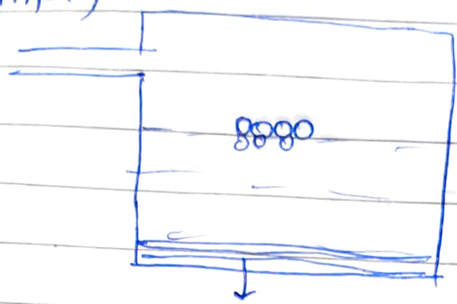
ν → kinematic viscosity

$\frac{\mu}{\rho_0}$ → μ → dynamic

Derivation (Imp.)

↑ Bouyancy

↓ Actual wt.



sludge zone (ν is constant)

Effective wt = Actual wt (Total wt) − Bouyancy

when Effective = Drag force. − particle starts settling

$$\text{Drag force} = C_D A \rho_w \frac{V^2}{2} \quad \text{①}$$

C_d = drag coefficient

A: Area of particle

ρ_w = density of water

V = vel. of fall

Effective wt = Actual wt − Bouyancy.

$$= \frac{4}{3}\pi r^3 \gamma_s - \frac{4}{3}\pi r^3 \gamma_w$$

$$= \frac{4}{3}\pi r^3(\gamma_s - \gamma_w) \quad \text{②}$$

particle starts settling when ① = ②

rticle

rticle,

$$\cancel{\frac{4}{3}\pi r^3(\gamma_s-\gamma_w)}$$

$$C_D A \rho_w \frac{V^2}{2} = \frac{4}{3}\pi r^3 (\gamma_s - \gamma_w)$$

$$C_D \pi r^2 \rho_w \frac{V^2}{2} = \frac{4}{3}\pi r^3 (\gamma_s - \gamma_w)$$

$$V_s^2 = \frac{8}{3C_D} r g \left(\frac{\rho_s}{\rho_w} - 1\right) \qquad (2r = d)$$

$$V_s^2 = \frac{4}{3}\frac{(\gamma_s - \gamma_w)}{\rho_w \cdot C_D} d. \qquad \text{——} \; (3)$$

$$V_s^2 = \frac{4}{3} g \frac{(\rho_s - \rho_w)}{\rho_w C_D} . d.$$

$$V_s^2 = \frac{\frac{4}{3} g d \left(\frac{\rho_s}{\rho_w} - 1\right)}{C_D}$$

$$V_s^2 = \frac{4}{3} \frac{g d (G-1)}{C_D} \qquad C_D = \frac{24}{R_e}$$

putting

Reynold's number

$$R_e = \frac{V_s - d}{V} \quad \text{——} \; (4)$$

$$V_s^2 = \frac{4}{3}\frac{g d (G-1)(V_s - d)}{\cancel{24}_{6} V}$$

$$\boxed{V_s = \frac{g}{18}(G-1)\frac{d^2}{V}}$$

(Correct → $Re = \frac{\rho V D}{\mu}$ $Re = \frac{VD}{\nu}$ (…)

1. For particle size less than 0.1 mm
   Laminar flow

$$C_D = \frac{24}{Re}$$

2. Transition (0.1 – 1mm)

$$C_D = \frac{18.5}{Re^{0.6}}$$

3. Turbulent settling. (> 1 mm)

$$Re > 10^3$$

$$\underline{C_D = 0.34 \text{ to } 0.4}$$

Grit chamber

V_f = Flow velocity = 0.2 – $\underline{0.3}$ m/s

water depth = $\underline{1}$ – 1.8 m

t_d Detention time = 40 – 60 s.

Length = velocity × Detention time

$L = V_f \times t_d$

q.2 **Q** A rect. grit chamber is designed to remove particles with a diameter of 0.2 mm
Sp. gravity = 2.65. settling velocity – 0.016 – 0.022
V_f = 0.3 m/s   flow = 10,000 m³/day

$$Q = \frac{10,000}{60 \times 60 \times 24} = \boxed{0.116 \ m^3/s}$$

$Q = A \times V_f$ $\qquad 0.\cancel{0}16 = A \times 0.3$

$\boxed{A = 0.385\, m^2}$ of water.

Assuming depth of water = 1 m.

$1 \times B = 0.385$ $\qquad \boxed{B = 0.385\, m}$

$\boxed{B \simeq 0.4\, m}$

For depth $\longrightarrow$

Freeboard	0.3 - 0.45 m ~~0.45 m~~
Water	1 - 1.8 m
Sludge zone.	0.75 m

Settling velocity = 0.02 m/s.

$$t_d = \frac{\text{Depth of water}}{V_s} = \frac{1}{0.02} = 50 \text{ seconds.}$$

Length of tank $= V_h \times t_d$

$= 0.3 \times 50$

$= 15\, m$ → to consider inlet & outlet, increase by 30%.

length = 15 + 30% of 15

= 19.5 ≃ 20 m.

L = 20 m $\qquad$ B = 0.4 m $\qquad$ H. = 1 + 0.75 + 0.45

= 2.2 m.

= 5000 m^3/day.

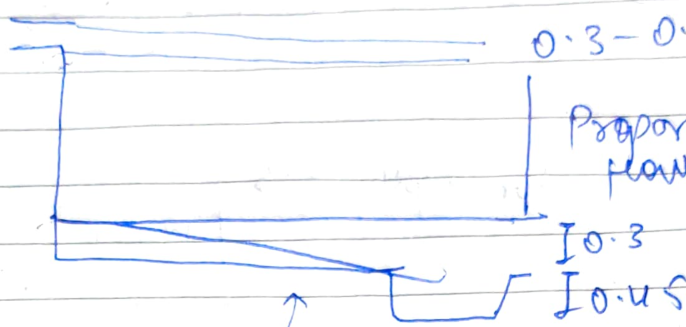
Critical scour velocity

$= 3 \text{ to } 4.5 \sqrt{g d (G-1)}$

0.17 to 0.26 m/s.

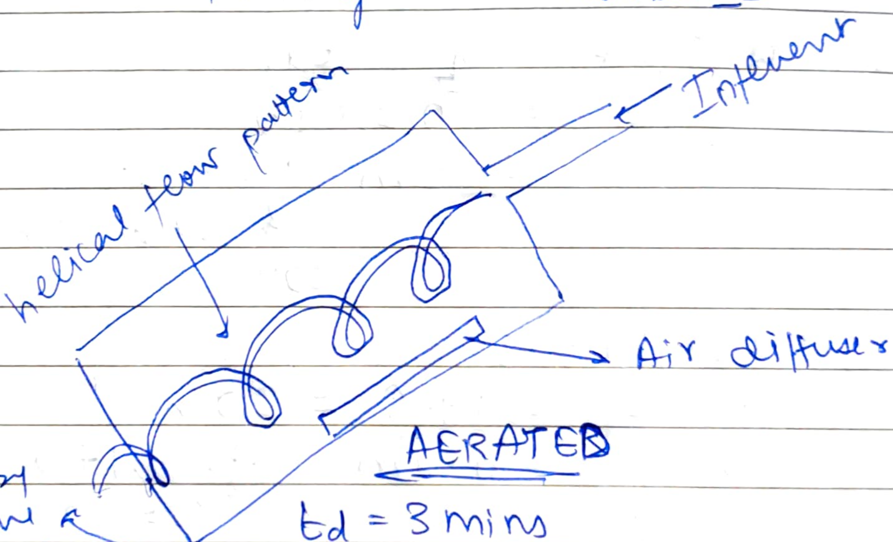
Grit chamber

Horizontal (non aerated) | Aerated.



Horizontal

- Rectangular
- Parabolic.



AERATED

$t_d = 3$ mins

controlled by adjusting the air feed range $0.15-0.45\ m^3/min$

roll velocity = .

Air diffusers are located - 0.45 m - 0.60 m above the tank

length to width ratio = 2.5 : 7

width to depth ratio : 1:1 to 1:5

Q

Freeboard = 0.3 m $Q = 20{,}000\ m^3/day$

$Q = \frac{20{,}000}{60 \times 60 \times 24} = \frac{200}{36 \times 24}$

$Q = 0.231\ m^3/day$. $V_t = 0.3$

$\boxed{A = 0.77\ m^2}$

Assume depth of water = 1 m.

$\boxed{B = 0.77\ m}$

For depth = $1 + 0.3 + 0.75 = 2.05\ m$.

Assume settling vel = 0.02 m/s. ← dont do this

$t_d = \frac{1}{0.02} \times \frac{100}{100} = 50s$ → assume $t_d = 60s$

Length = $V_t \times t_d = 50 \times 0.3$
$= 15m$.

30 % extra for inlet & outlet.
$= 19.5m$
$\simeq 20m$

$\boxed{L = 20\ m, \quad B = 0.77m \quad H = 2.05\ m}$

Sedimentation

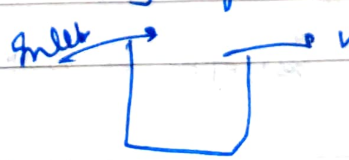
60-65% Suspended solids & 30-35% organic matter removed

1) Velocity of flow
2) Size & shape of particle → by adding particles - coagulation
3) Viscosity of flow.

Types of sedimentation

Intermittent   Continous flow

Short circuiting of sedimentation tank



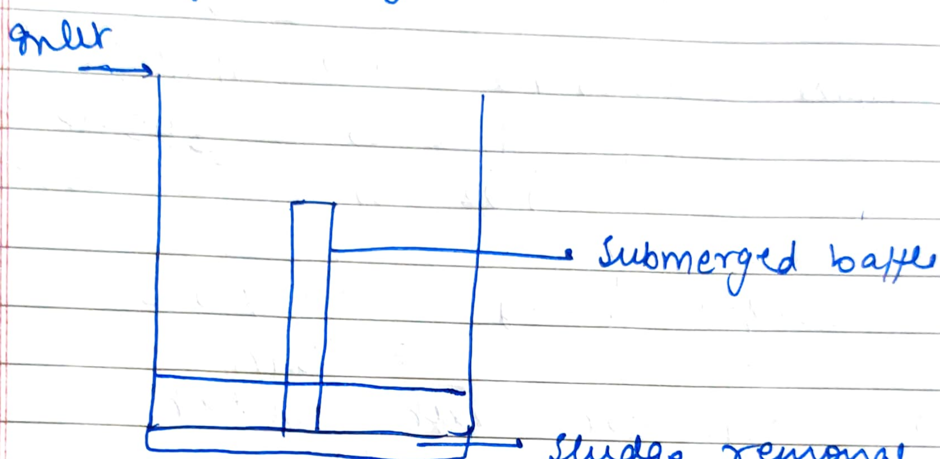
→ water flows out without settling.

actual avg. time taken by a batch of water in passing through a settling tank

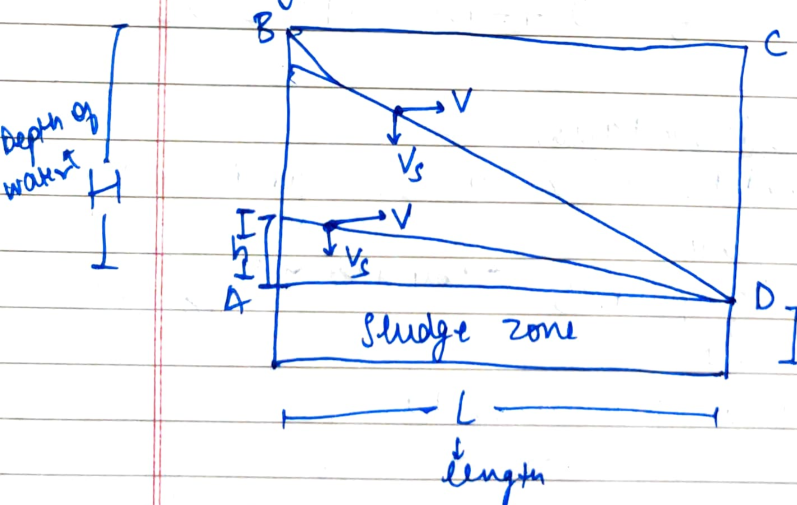
Displacement efficiency = Flowing through period / Detention time. → always less than tot

Construction Details

1. Inlet & outlet arrangement. → reduce short circuit
2. Baffles
3. Skimming troughs. → to remove oil & grease
4. Cleaning & sludge removal.



Design considerations.



Uniform vel. v

Discharge = Q

2.4 - 3.6 m height of sludge zone (3 m if not given)

flow vel. $v = \frac{Q}{BH}$ — ①

B → width, H → Depth of water

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From geometric considerations

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

$$V_s = \frac{VH}{L} \quad V \to Q/BH$$

$$V_s = \frac{QH}{BHL}$$

$$\boxed{V_s = \frac{Q}{BL}}$$

$\frac{Q}{BL}$ also known as overflow rate or surface loading
40,000-50,000 $l/m^2/d$ for primary sedimentation tank

Particles with $V_s > \frac{Q}{BL}$ will settle down

for tank with coagulation, $\frac{Q}{BL}$ is 50,000-60,000 $l/m^2/day$

→ t_d Detention Period -

$$t_d = \frac{\text{Volume of tank}}{\text{Rate of flow}} = \frac{BLH}{Q} \to \text{for rectangular tank.}$$

for circular tank, $t_d = \frac{d^2(0.11d + 0.785H)}{Q}$

d → dia. of tank.

9.5 DO 9.6 too

Q Design a suitable rect. sedimentation tank (provided with mechanical cleaning equipment) from treating the sewage from a city, provided with an assured public water supply system with a Max. Daily demand of 12 MLD. Assume suitable value of td + vel. of flow.

80% of MDD is turned to sewage.

$$12\,MLD \times \frac{80}{100} = 9.6\,MLD$$

assume det. time = 2 hrs

free board 0.3

① Q ② Assume vel.
③ C/S Area