Primary Sedimentation tank

**Purpose:**
1- Removal of 40 - 60 % of suspended solids
2- Removal of 25 - 35 % of B.O.D.
3- Sediment the organic and inorganic matters to improve the properties of the sewage and prepare it for the biological treatment.

**Types of primary sedimentation tanks:**
1- Rectangular tank.
2- Circular tank.

**Factors affecting sedimentation efficiency:**
1- Viscosity
2- Concentration of suspended solids
3- Retention period
4- Horizontal velocity
5- Temperature
6- Surface loading rate = 24 - 48 m³/m²/day
Effluent weir of rectangular sedimentation tank

Rectangular primary sedimentation tank
Primary sedimentation tank (Radial flow)

Circular primary sedimentation tank
7- Dimension of tank
8- Dead zones.

**Design criteria:**
1- Retention period = $T = 2 - 3$ hrs
2- Surface loading rate (S.L.R.) = 24 - 48 m³/m²/day
3- Horizontal velocity $\leq 0.3$ m/min
4- Effluent weir loading (E.W.L.) $\leq 600$ m³/m/day  ($\leq 25$ m³/m/hr)
5- $L = 3 - 5$ B
   $L \leq 40$ m
6- $d = 3 - 5$ m
7- $B = 2 - 3$ d
8- $\Phi \leq 40$ m
9- Bottom slope for circular tank $= 4 - 10$ %
   for rectangular tank $= 1 - 2$ %

$V = Q_d \times T$

S.L.R $= Q_d / S.A$

**Example:**
For a sewage treatment plant, the following data are given:
- $Q_{ave\ summer} = 18000$ m³/d
  - $S.L.R = 30$ m³/m²/d
It is required to design primary sedimentation tanks.

Solution:
$Q_d = 1.5 \times 18000 = 27000$ m³/d

**For rectangular tank:**
Assume $T = 2.5$ hr

$V = Q_d \times T$

$= 27000 \times \frac{2.5}{24} = 2812.5$ m³

$S.L.R = \frac{Q_d}{S.A}$

$S.A = \frac{27000}{30} = 900$ m²
\[ d = \frac{V}{S.A} \]
\[ = \frac{2812.5}{900} = 3.1 \text{ m} \]

Take \( n = 2 \)

\[ \therefore S.A \ of \ one \ tan \ k = \frac{900}{2} = 450 \text{ m}^2 \]

Assume length = 40 m

\[ b = \frac{S.A}{L} = \frac{450}{40} = 11.25 \text{ m} \]

Check:

1. \[ 1 - V_h = \frac{Q_d}{\text{cross sectional area}} = \frac{Q_d}{n \times b \times d} \]
   \[ = \frac{27000}{(2\times11.25\times3.1)\times24\times60} = 0.269 < 0.3 \text{ m/min safe} \]

2. \[ 2 - E.W.L = \frac{Q_d}{n \times b} \]
   \[ = \frac{27000}{2\times11.25} = 1200 \text{ m}^3/\text{m/d} > 600 \text{ unsafe} \]

\[ \therefore \text{take weir loading} = 600 \text{ m}^3/\text{m/d} \]

\[ \text{Length of weir} = \frac{Q_d}{\text{weir loading}} = \frac{27000}{2\times600} = 22.5 \text{ m} \]
Circular primary sedimentation tank:

\[ V = Q_d \times T \]

\[ = 27000 \times \frac{2.5}{24} = 2812.5 \ m^3 \]

S.L.R = \[ \frac{Q_d}{S.A} \]

\[ S.A = \frac{2700}{30} = 900 \ m^2 \]

\[ d = \frac{V}{S.A} \]

\[ = \frac{2700}{900} = 3.1 \ m \]

Take \( n = 2 \)

\[ \therefore \text{S.A of one tank} = \frac{900}{2} = 450 \ m^2 \]

\[ = \frac{\pi \phi^2}{4} \]

\[ \therefore \phi = 24 \ m \]

Chick:

\[ 1 - v_h = \frac{Q_d}{n \times \pi \times \phi \times d} \]

\[ = \frac{27000}{2 \times \pi \times 24 \times 3.1 \times (24 \times 60)} = 0.04 \ m/\min < 0.3 \ m/\min \text{ safe} \]

\[ 2 - E.W.L = \frac{Q_d}{n \times \pi \times \phi} \]

\[ = \frac{27000}{n \times \pi \times 24} = 179 \ m^3/\ m/\ d < 600 \text{ safe} \]

Example:
Estimate the volume of sludge produced per 27000 m3/d if the influent S.S 300 mg/l. The removal efficiency is 60%.
Solution:

Weight of dry solids = \( \frac{60}{100} \times 300 \times 27000 \times 10^{-6} = 4.86 \, t/d \)

Specific gravity of sludge = 1.03 \( t/m^3 \)

Volume of dry solids = \( \frac{weight}{S.G} = \frac{4.86}{1.03} = 4.718 \, m^3/d \)

Moisture content of sludge = 95% (5% solids)

Volume of sludge = \( \frac{4.718}{0.05} = 94.37 \, m^3/d \)

Design of hopper:

Volume of sludge per \( k = \frac{94.37}{2} = 47.18 \, m^3/d \)

Volume of sludge per hopper = \( \frac{47.18}{2} = 23.59 \, m^3/d \)

Assuming sludge withdrawal every 12 hours

Volume of sludge per hopper = \( \frac{23.59}{2} = 11.796 \, m^3/d \)

\[
V = \frac{h}{3} (a_1 + a_2 + \sqrt{a_1 + a_2})
\]

\[a_1 = 1 \, m \times 1 \, m\]

\[a_2 = \frac{B \times B}{2 \times 2} = \frac{11.25 \times 11.25}{2} = 31.64 \, m^2\]

\[11.796 = \frac{h}{3} (1 + 31.64 + \sqrt{1 + 31.64})\]

\[h = \frac{11.796 \times 3}{38.265} = 0.925 \, m \quad (h = 1 - 2)\]

For circular tank:

\[
V = \frac{\pi}{4} \left( \frac{\phi_s^2 + \phi_b^2}{2} \right) h
\]

\[\phi_s \geq 1 \, m\]

\[h = 1 - 2 \, m\]

\[\theta = 45^\circ - 60^\circ\]
Design of sludge withdrawal pipe:

Assume time of withdrawal 5 minutes (5 – 20 minutes)

\[ Q_{\text{sludge}} = \frac{11.796}{5 \times 60} = 0.039 \text{ m}^3 / \text{s} \]

\[ Q_{\text{sludge}} = A \times v \quad \text{v in sludge pipe} = 1 - 1.5 \text{ m} / \text{s} \]

\[ 0.039 = \frac{\pi \phi^2}{4} \times 1 \]

\[ \therefore \phi = 0.22 \text{ m} \approx 200 \text{ mm} \quad (\phi \geq 150 \text{ mm}) \]

\[ v_{\text{act}} = 1.24 \text{ m} / \text{s} \quad \text{safe} \]