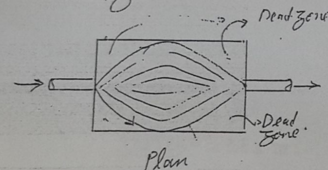
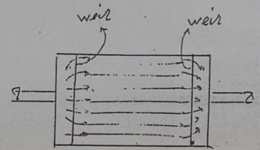
II معهد [1]
CE 442
د/ا.أ.ف

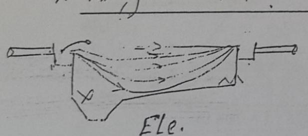
* Factors affecting efficiency of sedimentation

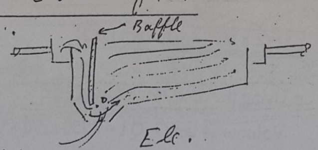
① Retention Period. $E \propto T$
② velocity of flow V_h $E \propto \frac{1}{V_h}$
③ Surface Loading Rate (over flow rate). $E \propto \frac{1}{S.L.R}$
④ size and shape of particle.
⑤ Density of Particle $E \propto \rho$
⑥ Density of fluid (water) $E \propto \frac{1}{\rho}$ water viscosity
⑦ Turbulance & Eddies
⑧ Increasing size of particles by using chemicals
⑨ Inlet and outlet arrangement in order to avoid dead zones.





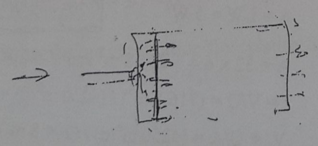
* using weirs at the inlet and outlet of tank





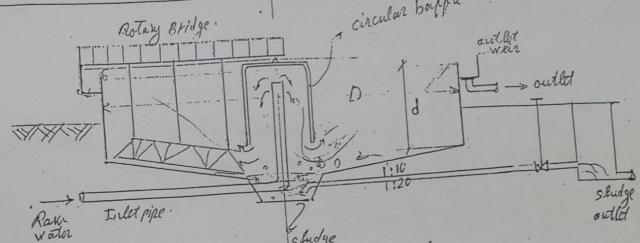
* Using Baffle at the begining of the Tank

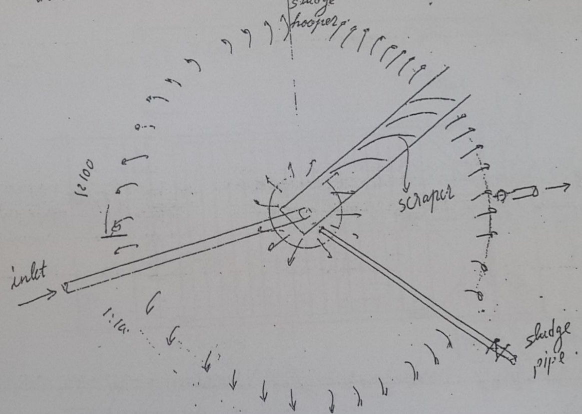
⑩ Dimensions of Tank. (width, Length, L/B, surface Area)
⑪ Concentration of suspended solids.
⑫ sludge collection & Removal.



حوض الترسيب الدائري [٢]

Circular Sedimentation Tank (Clarifier)





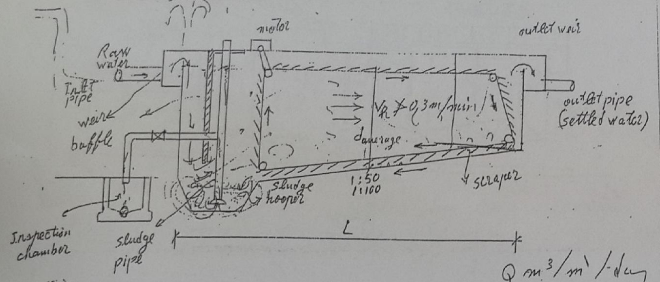
Design Criteria of Tank

the same as for rectangular tank, except.

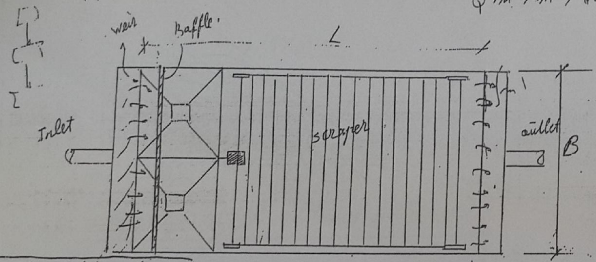
Diameter $\not> 35$ m

O.F.W $\not> 300$ m³/m'/day.

Rectangular type حوض الترسيب المستطيل



Q m³/m²/day



* **Design Criterion of Tank:**

1- Retention Period $T = 3 - 5$ hr.

2- depth $d = 3 - 5$ m

3- horizontal velocity $V_h \ngtr 0.3$ m/min

4- $\frac{L}{B} = 3 : 5$ max $L \ngtr 50$ m. $*n \geq 2$

max $B = 10 - 12$ m.

$\frac{B}{d} = 2 \rightarrow 3$

معدل التحميل السطحي — كمية المياه التي تستطيع أن تمر من مساحة معينة في اليوم.

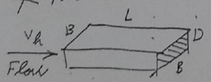
5- Surface loading rate $(O.F.R) = \frac{Q}{\text{Total surface area}} = 25 \rightarrow 40$ m³/m²/day

6- Allowable hydraulic load on outlet weir $\ngtr 300$ m³/m/day.

$= \frac{Q}{\text{Total length of weirs}}$ $\nless 150$ "

7- velocity of flow $\ngtr 0.3$ m/min

$V = \frac{Q_d}{\text{No. of Tanks} \times B \times D}$ (يعبر عن مقاطع التشغيل فقط)



* Surface Loading Rate (Over Flow Rate) معدل التحميل السطحي

$S.L.R (O.F.R.) = 25 \rightarrow 40$ m³/m²/day

كمية المياه التي تستطيع أن تمر من مساحة معينة في اليوم.

$$O.F.R = \frac{Q_d}{\text{No. of Tanks} \times \text{surface area}}$$

$$= \frac{Q_d}{n \times L \times B} \text{ in case of Rectangular.}$$

$$\frac{Q_d \frac{m^3}{day} \times \frac{day}{W.P.}}{OFR \ m^3/m^2/d \times \frac{day}{24 hr}} = \frac{Q_d}{n \times \frac{\pi D^2}{4}} \text{ in case of circular.}$$

ملاحظة هامة: دائماً الـ O.F.R تحسب لليوم مدته ٢٤ ساعة، والـ Q_d تحسب ساعات التشغيل الفعلية.

$$*Area = \frac{Q_d \ (m^3/day)}{O.F.R \ (m^3/m^2/day) \times \frac{W.P.}{24}} \longleftarrow \text{(في حالة التصميم)}$$

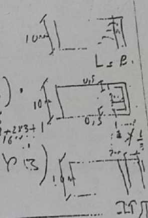
$$*O.F.R = \frac{Q_d}{Area \times \frac{W.P}{24}} \text{ (إذا طلب عمل check)}$$

* Over flow weir معدل التحميل على الهدار

$O.F.W \ngtr 300$ m³/m/day.

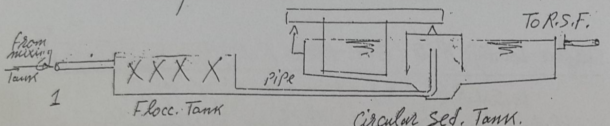
$$L = \frac{Q \ m^3/day}{O.F.W \ (m^3/m/day) \times \frac{W.P.}{24}} \longleftarrow \text{(في حالة التصميم).}$$

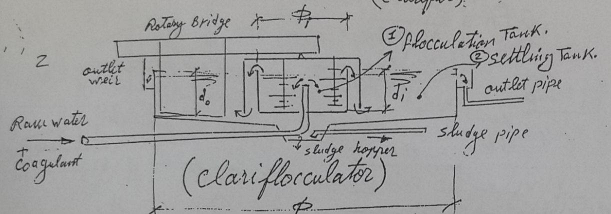
$$O.F.W = \frac{Q \ m^3/day}{L_m \times \frac{W.P.}{24}} \longleftarrow \text{(check إذا طلب)}$$



Clariflocculator

0





* **clariflocculator**

هو خزان يجمع بين عمليتي الـ flocculation (المزج البطيء) والـ sedimentation (الترسيب). وهو دائري.

Design Data

*** outer Tank**

* $T_o = 2.5 \rightarrow 3.5$ hr for sed. $+ \frac{1}{3} \rightarrow \frac{1}{2}$ hr for flocc.
* $d_o = 3 \rightarrow 5$ m.
* $\phi_o \not> 35$ m.
* $n_o \geq 2$

*** Inner Tank**

$T_i = \frac{1}{3} \rightarrow \frac{1}{2}$ hr.

$d_i = d_o - (0.5 - 1.0\ m)$.

$\phi_i = \left(\frac{1}{3} \rightarrow \frac{1}{2}\right) \phi_o$

$n_i = n_o \geq 2$.

*** Checks**

* $O.F.R = 25 - 40\ m^3/m^2/day = \dfrac{Q(m^3/d)/n_o}{\frac{\pi}{4}[\phi_o^2 - \phi_i^2]}$
* $V_h \not> 0.3\ m/min = \dfrac{Q(m^3/min)/n_o}{\pi \phi_i \times d_o}$
* hyd. ld. on outlet weir $= 150 \rightarrow 600\ m^3/m'/day = \dfrac{Q(m^3/d)/n_o}{\pi \phi_o}$

Example: It is required to design the number and dimensions of sedimentation tanks, given the following data:

Design flow	50000 m^3/d.
Retention Time	3 hrs.
Depth	4 m.
Working Period	24 hrs/day.

Solution:

$Q_{des.} = 50000\ m^3/d = \dfrac{50000\ m^3/d}{24\ hrs/d} = 2083\ m^3/hrs. = 34.72\ m^3/min.$

Volume $= Q \times T = 2083\ m^3/hr \times 3\ hr = 6250\ m^3$.

Total Area $= \dfrac{Volume}{Depth} = \dfrac{6250}{4} = 1562.5\ m^2$.

Rectangular

$\frac{L}{W} = 3:5 \qquad \frac{W}{d} = 2:3$.

Take $L = 4W$.

$\therefore L = 40\ m$ & $W = 10\ m$.

$\therefore a = 400\ m^2$.

$n = \dfrac{Area}{a} = \dfrac{1562.5}{400} = 3.9$.

Take $n = 4$.

$a = \dfrac{1562.5}{4} = 390.6\ m^2$.

$\therefore 390.6 = W \times 4W$

$\therefore W = 9.9\ m$.

$L = 39.5\ m$.

check: $S.L.R = \dfrac{Q}{n \times Area} = \dfrac{50000}{4 \times 9.9 \times 39.5} = 32\ m^3/m^2/d. > 25,\ < 40$

$\therefore$ O.K.

$V_h = \dfrac{Q}{n \times W \times d} = \dfrac{34.72\ m^3/min}{4 \times 9.9 \times 4} = 0.22\ m/min \not< 0.3\ m/min$

$\therefore$ O.K

Length of weirs Req. $= \dfrac{Q}{OFW} = \dfrac{50000}{300}$

$\therefore$ Length of each weir $= \dots$

Circular

Total surface Area $= n\left(\dfrac{\pi \phi^2}{4}\right)$.

Take $\phi = 31.6 \quad \therefore a = 962\ m$

$\therefore n = \dfrac{Area}{a} = \dfrac{1562}{962} = 1.6$ Take $n = 2$.

$\therefore \phi = \sqrt{\dfrac{1562.5}{2} \times \dfrac{4}{\pi}} = 31.6\ m$

$\therefore$ Check: $S.L.R = \dfrac{50000}{2 \times 962} = 26\ m^3/m^2/d. > 25,\ < 40$

$\therefore$ OK

$\therefore V_h = \dfrac{Q_{des.}}{n \pi \phi d} = \dfrac{34.72}{2 \times 31.6 \times 4} = 0.14\ m/min < 0.3\ m/min$

$\therefore$ O.K

O.F. Weir $= \dfrac{50000}{n \pi \phi} = \dfrac{50000}{2 \times \pi \times 31.6} = 198.5\ m^3/m'/d > 150$

$\therefore$ O.K

Example: Design the sedimentation tanks for a water treatment plant [2] of an daily output of 30000 m3 and working 24 hrs per day. The maximum surface loading rate in the sedimentation tank is 30 $m^3/m^2/d$ and depth is 4 m.

Sol:

$$S.L.R = \frac{Q\ m^3/day}{A\ m^2} = \frac{30000}{30} = 1000\ m^2.$$

$$\therefore Area = \frac{Q\ m^3/day}{S.L.R} = \frac{30000}{30} = 1000\ m^2.$$

$\therefore$ Volume = Area x depth.

$= 1000\ m^2 \times 4\ m$

$= 4000\ m^3$.

$$Time = \frac{Volume\ m^3}{Q\ m^3/d} = \frac{4000}{30000} = 0.133\ day.$$

$= 3.2$ hrs.

Rectangular

choose $a = 50m \times 10m = 500 m^2$

$$\therefore \text{No. of tanks } (n) = \frac{A}{a} = \frac{1000\ m^2}{500\ m^2} = 2 \text{ tank}.$$

$\therefore$ 2 tanks with L = 50 m, W = 10 m, d = 4 m.

Check

$$* V_h = \frac{\frac{30000}{24 \times 60}}{2 \times 10 \times 4} = 0.26\ m/min \not> 0.3\ m/min$$

O.K.

Circular.

choose $\phi = 35$ m.

$$\therefore a = \frac{\pi (35)^2}{4} = 962\ m^2.$$

$$\text{No. of Tanks } (n) = \frac{A}{a} = \frac{1000}{962} = 1.04$$

note that min n is 2

$$\therefore a_{actual} = \frac{A}{2} = \frac{1000}{2} = 500\ m$$

$\therefore$ actual $\phi = 25.2$ m.

Check

$$* V_h = \frac{Q_{des.}}{n \phi d} = \frac{\frac{30000}{24 \times 60}}{2 \times 25.2 \times 4} = 0.103\ m/min$$

(OK) < 0.3

$$* \text{Length of weir required} = \frac{Q\ m^3/day}{OFW\ m^3/m'/d.} = \frac{30000}{300} = 100\ m$$

$$\therefore \text{Length for each Tank} = \frac{100m}{2 \text{ (number of Tanks)}} = 50\ m$$

$$* \therefore OFW = \frac{30000\ m^3/day}{2 \times \pi \times 25.2} = 189.5\ m^3/m'/d.$$

$\therefore$ (OK) > 150, < 300

Example

Design the rectangular sedimentation tanks required for a water purification plant of a city of population 200,000 Cap. and an annual average water consumption of 180 L/c/d.

Solution

$$Q_{des.} = \frac{1.4 \times 180 \times 200000}{24 \times 1000} = 2100\ m^3/hr.$$

$= 2100 \times 24 = 50400\ m^3/d$.

Assume T (Retention time) = 3 hrs.

$\therefore$ Volume $= Q \times T = 2100\ m^3/hr \times 3\ hr$

$= 6300\ m^3$

Assume S.L.R (O.F.R) $= 30\ m^3/m^2/d$.

$$\therefore \text{Total Area} = \frac{Q}{S.L.R} = \frac{50400\ m^3/d}{30\ m^3/m^2/d} = 1680\ m^2.$$

$$\therefore depth = \frac{Volume}{Area} = \frac{6300}{1680} = 3.75\ m > 3m, < 5m$$

O.K

For Rectangular type:

$$\frac{L}{W} = 3:5, \quad \frac{W}{d} = 2:3, \quad n \geq 2$$

Take $W = 3d = 3 \times 3.75 = 11.25$ m.

$L = 4W = 4 \times 11.25 = 45\ m < 50\ m$

$$\therefore n = \frac{A}{a} = \frac{1680}{11.25 \times 45} = 3.3$$

Take $n = 4$.

$$\therefore \text{actual } a = \frac{1680}{4} = 420\ m^2 = 4W \times W \therefore W = 10.25\ m$$

$\therefore L = 4 \times 10.25 = 41$ m

$$V_h = \frac{Q_{des.}}{n \times W \times d} = \frac{\frac{50400\ m^3/day}{24 \times 60}}{4 \times 10.25 \times 3.75\ m^2} = 0.228\ m/min < 0.3\ O.K.$$

$$\text{Hyd. Load on Outlet Weir} = \frac{Q_{des.}}{n \times W}$$

$$\therefore n \times W = \frac{50400\ m^3/day}{900\ m^3/m'/day} = 168\ m.$$

$$\therefore \text{Length of weir for each Tank} = \frac{168}{4} = 42\ m.$$

Example: Design the number and dimensions of clariflocculators units, given the following data:

Design flow	60500	m^3/day.
Retention Time	3	hrs.
Flocc. Time	0.5	hr.
Depth	3	m.
W.P.	24	hr/day.

Solution

Outer Tank	Inner Tank.
$C_o = Q_d \times T_o$ $= \frac{60500}{24} \times 3 = 7562\ m^3$ Assume $d_o = 3\ m$. Total $A_o = \frac{C_o}{d_o} = \frac{7562}{3} = 2520\ m^2$ max $\phi_o = 35\ m \therefore a = 962\ m^2$ no. of Tanks $= \frac{2520}{962} = 2.6$ Take $n = 3$ $\therefore a_o$ actual $= \frac{2520}{3} = 840\ m^2$ $\therefore 840 = \frac{\pi \phi_{act}^2}{4}$ $\therefore \phi_{act_o} = 32.7\ m$	$C_i = Q_d \times T_i$ $= \frac{60500}{24} \times 0.5 = 1260\ m^3$. $d_i = 3 - 0.5 = 2.5\ m$. Total $A_i = \frac{C_i}{d_i} = \frac{1260}{2.5} = 504\ m^2$ $n = 3$. a_i actual $= \frac{504}{3} = 168\ m^2$. $\phi_{act} = 14.6\ m$.

Check: + $S.L.R\ (O.F.R.) = \frac{Q_d/n}{(A_o - A_i)} = \frac{60500/3}{\frac{\pi}{4}(32.7^2 - 14.6^2)} = 30\ m^3/m^2$ $\therefore$ O.K. > 25, < 40

$$* \ V_h = \frac{\frac{60500}{24 \times 60}\ \frac{m^3}{min}}{3[\pi \times 14.6 \times 3]} = 0.102\ m/min$$

$$* \ \text{Hyd. load on outlet weir} = \frac{60500/3}{\pi \times 32.7} = 196.2\ m^3/m'/d \quad > 150,\ < 300.$$