

Example:1

Design a grit chamber for population 50000 with water consumption of 135 LPCD.

Solution

Average quantity of sewage, considering sewage generation 80% of water supply, is

$$= 135 \times 50000 \times 0.8 = 5400 \text{ m}^3/\text{day} = 0.0625 \text{ m}^3/\text{sec}$$

Maximum flow = 2.5 x average flow

$$= 0.0625 \times 2.5 = 0.156 \text{ m}^3/\text{sec}$$

Keeping the horizontal velocity as 0.2 m/sec (<0.228 m/sec) and detention time period as one minute.

Length of the grit chamber = velocity x detention time

$$= 0.2 \times 60 = 12.0 \text{ m}$$

Volume of the grit chamber = Discharge x detention time

$$= 0.156 \times 60 = 9.36 \text{ m}^3$$

Cross section area of flow 'A' = Volume / Length = 9.32/12 = 0.777 m²

Provide width of the chamber = 1.0 m, hence depth = 0.777 m

Provide 25% additional length to accommodate inlet and outlet zones.

Hence, the length of the grit chamber = 12 x 1.25 = 15.0 m

Provide 0.3 m free board and 0.25 m grit accumulation zone depth, hence total depth

$$= 0.777 + 0.3 + 0.25 = 1.33 \text{ m}$$

and width = 1.0 m

Example :2

Design a horizontal flow grit chamber with rectangular cross section for treating maximum sewage flow of 10 MLD at maximum temperature of 34 °C during summer and minimum temperature of 15 °C in winter.

Solution

The settling velocity of the grit particle will be minimum at minimum temperature, i.e., 15 °C. At this temperature kinematic viscosity = $1.14 \times 10^{-2} \text{ cm}^2/\text{sec}$

In *first trial* assume Reynolds number 'R' less than or equal to 0.5.

$$V_s = \frac{g}{18} \left[\frac{S-1}{\nu} \right] D^2$$

$$V_s = \frac{981}{18} \left[\frac{2.65-1}{1.14 \times 10^{-2}} \right] 0.02^2$$

$$= 3.15 \text{ cm/sec}$$

$$\begin{aligned} \text{Reynolds Number } R &= v.D/\nu = 3.15 \times 0.02 / 1.14 \times 10^{-2} \\ &= 5.53 > 0.5 \end{aligned}$$

Therefore, V_s is not equal to 3.15 cm/sec because the equation for V_s is valid only for $R < 0.5$. Using $V_s = 3.15$ cm/sec, calculate R and C_D and then again V_s till it converges.

Subsequent Trial

$$V_s = 2.4 \text{ cm/sec}$$

$$R = 2.4 \times 0.02 / (1.14 \times 10^{-2}) = 4.21$$

$$\begin{aligned} C_D &= \frac{24}{4.21} + \frac{3}{\sqrt{4.21}} + 0.34 \\ &= 7.50 \end{aligned}$$

From equation

$$V_s = \sqrt{\left[\frac{4 \cdot 981}{3 \cdot 7.50} (2.65 - 1) 0.02 \right]}$$

$$V_s = 2.4 \text{ cm/sec} \quad \text{Hence, O.K.}$$

Now for $\beta = 0.06$, $f = 0.03$, and $D = 0.02$ cm

$$V_c = \sqrt{\left[\frac{8\beta}{f} g(S-1)D \right]}$$

$$V_c = \sqrt{\left[\frac{8 \times 0.06}{0.03} 981(2.65 - 1) 0.02 \right]}$$

$$= 22.76 \text{ cm/sec}$$

Now $Q = 10 \text{ MLD} = 0.116 \text{ m}^3/\text{sec}$

Therefore, C/S Area $A = Q/V = 0.116/0.227 = 0.51 \text{ m}^2$

If width of 1 m is provided, the depth required = 0.51 m

Provide total depth = 0.51 + 0.3 (free board) + 0.25 (space for grit accumulation)

$$= 1.06 \text{ Say } 1.1 \text{ m}$$

Now $V_o/V_c = H/L = 2.4/22.7$

Therefore theoretical length $L = 22.7 \times 0.51 / 2.4 = 4.824 \text{ m}$

Provide 2 m extra length for inlet and outlet

Therefore total length = 2 + 4.824 = 6.824 m say 6.9 m

Total working volume = 0.51 x 6.9 x 1 = 3.52 m³

Hence, Overall detention time = 3.52 / 0.116 = 30.34 sec (within 30 to 60 seconds)

15.6 Square Grit Chamber

The horizontal flow rectangular grit chamber faces the problem of sedimentation of organic matter along with grit particles, requiring external washing of the grit before disposal. This problem can be minimized by providing square shape of the grit chamber rather than long rectangular channel. Also, this shape will facilitate compact design of sewage treatment plant. Hence these days square grit chambers are used. In square grit chamber, the flow distribution may not be uniform due to non-ideal plug flow conditions, and hence continuous removal of grit is generally considered essential. These are designed based on overflow rates that are dependent on the particle size and temperature of wastewater. Minimum two number of grit chambers should be used to facilitate maintenance of the raking mechanism, whenever required. The grit deposited at the bottom is raked by rotating mechanism to a sump at the side of the tank, from which it is moved up by an inclined reciprocating rake or screw pump mechanism (Figure 15.5). While passing up the incline conveyer, organic solids are separated from grit and flow back into the basin. Thus, cleaner washed grit is obtained, compared to washed grit from separate grit washers.

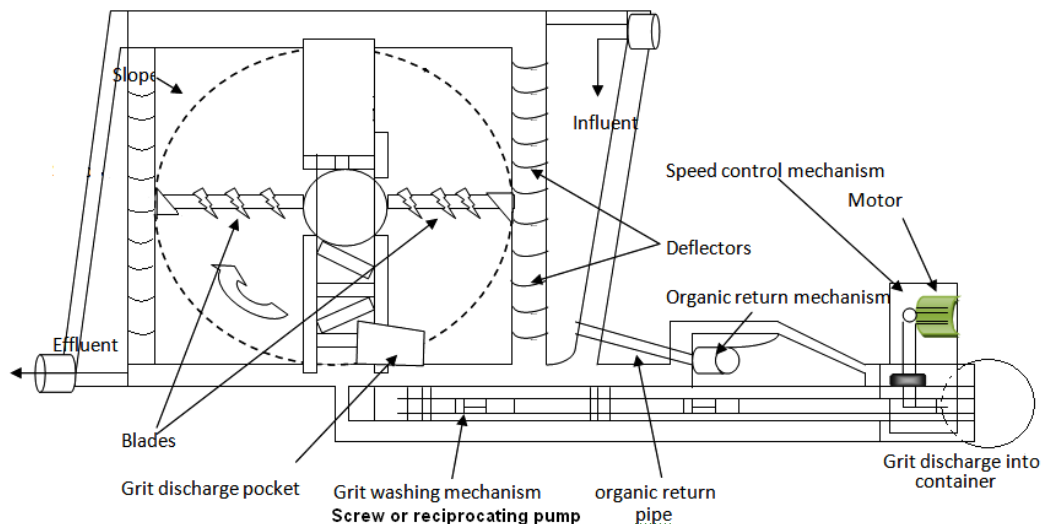


Figure 15.5 Square grit chamber

15.7 Aerated Grit Chamber

Excessive wear of grit handling equipment and necessity of separate grit washer can be eliminated by using aerated grit chamber. It is designed for typical detention time of 3 minutes at maximum flow. Grit hopper about 0.9 m deep with steeply sloping sides is located along one side of tank under air diffusers (Figure 15.6). The diffusers are located at about 0.45 to 0.6 m from the bottom. The size of particles removed will depend upon velocity

of roll or agitation. The air flow rate can be easily adjusted to control efficiency and 100% removal of grit can be achieved. Wastewater moves in the tank in helical path and makes two or three passes across the bottom of the tank at maximum flow (and more at less flow). Wastewater is introduced in the direction of roll in the grit chamber. The expansion in volume due to introduction of air must be considered in design. The aerated grit chambers are equipped with grit removal grab buckets, traveling on monorails over the grit collection and storage trough. Chain and bucket conveyers can also be used. Two grit chambers in parallel are used to facilitate maintenance. Typical design details for aerated grit chamber are provided below (Metcalf and Eddy, 2003):

Depth : 2 to 5 m

Length : 7.5 to 20 m

Width : 2.5 to 7.0 m

Width to depth ratio: 1:1 to 5:1

Detention time at peak flow: 2 to 5 min (3 minutes typical)

Air supply $\text{m}^3/\text{m} \cdot \text{min}$ of length : 0.15 to 0.45 (0.3 typical)

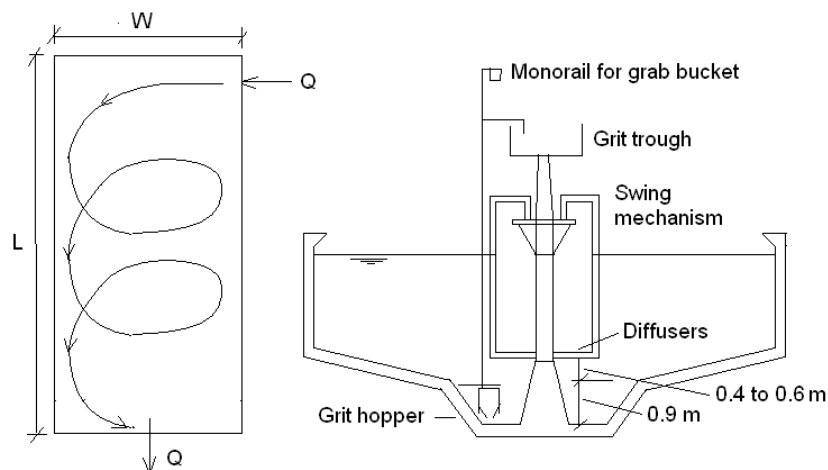


Figure 15.6 Aerated grit chamber (first figure showing the helical flow pattern of the wastewater in grit chamber and second showing cross section of grit chamber)

Example : 3

Design aerated grit chamber for treatment of sewage with average flow of 60 MLD. Consider the peak factor of 2.

Solution:

1. Average flow = 60 MLD = $0.694 \text{ m}^3/\text{sec}$, and Peak flow = $0.694 \times 2.0 = 1.389 \text{ m}^3/\text{sec}$
2. Volume of grit chamber

Provide two chambers to facilitate periodic cleaning and maintenance

Provide detention time = 3.0 m

Volume of each tank = $1.389 \times 3 \times 60 / 2 = 125.01 \text{ m}^3$

3. Dimensions of aeration basin:

Provide depth to width ratio of 1: 1.2

Provide depth = 3.0 m, hence width = $1.2 \times 3.0 = 3.6 \text{ m}$

Length = $125.01 / (3 \times 3.6) = 11.575 \text{ m}$

Increase length by 20% to account for inlet and outlet conditions.

Total length = $11.575 \times 1.2 = 13.89 \text{ m}$.

4. Determine the air-supply requirement

Consider $0.3 \text{ m}^3/\text{min.m}$ of length air supply

Air Requirement = $13.89 \times 0.3 = 4.17 \text{ m}^3/\text{min}$

Provide air swing arrangement at 0.5 m from floor

5. Quantity of grit :

Consider grit collection $0.015 \text{ m}^3/10^3 \text{ m}^3$

Volume of grit = $1.389 \times 60 \times 60 \times 24 \times 0.015 \times 10^{-3}$

$= 1.8 \text{ m}^3/\text{d}$

6. Check for surface overflow rate (SOR)

The settling velocity of the smallest particle = 2.4 cm/sec, the actual SOR in the grit chamber = $1.389 / (2 \times 3.6 \times 11.575) = 0.0167 \text{ m/s} = 1.67 \text{ cm/sec}$, which is less than the settling velocity of the smallest particle hence design is safe.

15.8 Vortex-Type Grit Chamber

These types of grit chambers are used in small plants and these require lesser area as compared to earlier types. In this grit is removed with vortex flow pattern. The wastewater enters tangentially and exit in the perpendicular direction of motion either from top or from side. Due to inertia the grit particle will remain in the chamber and liquid free from grit will only escape. The rotating turbine maintains constant velocity and helps in separating organic matter and grit. The centrifugal force on the grit particle can also be maintained without turbine by properly introducing wastewater in the tangential direction in the chamber. Toroidal flow path is followed by the grit particles due to action of propeller (Metcalf and Eddy, 2003). Grit particle settles by the action of gravity into hopper from where it is removed by a grit pump or air lift pump. Washed grit, free from the organic matter, can be obtained from this device.

Questions

1. Why separate grit chamber is provided in sewage treatment plant?
2. Describe different types of grit chambers.
3. Describe square grit chamber. Design a rectangular grit chamber and square grit chamber for treatment of sewage with average flow of 8.5 MLD and peak flow factor of 2.25.
4. Prepare notes on vortex type grit chamber.