completely digested, are withdrawn, leaving some sludge to keep the tank seeded with anaerobic bacteria. The removed sludge may be dried and disposed of in a sanitary manner. Further, *in order to ensure uniform distribution of solids in the different hoppers, the flow of sewage in the sedimentation compartment above, is reversed intermittently.*

**9.50.2. Design Considerations.** In designing Imhoff tanks, the following important design points may be kept in mind :

(A) ***Sedimentation Chamber.*** It is rectangular in shape with the following specifications :

(*i*) Detention period = 2 to 4 hours (usually 2 hours)

(*ii*) Flowing through velocity= should not be more than 0.3 m/minute.

(*iii*) Surface loading = should not exceed 30,000 litres/$m^2$ of plan area/day. It may, however, be increased to about 45,000 l/$m^2$/day for effluent coming from activated sludge plant, or where recirculation is adopted.

(*iv*) Length of the tank should preferably not exceed 30 m or so, as to provide good sludge distribution. Length to width ratio may vary between 3 to 5.

(*v*) Depth of this chamber should as far as possible be kept shallow, so as to permit sliding of the solids up to the slot before reaching the end of the sedimentation. In practice, a total depth of 9 to 11 m has been found sufficient for Imhoff tanks ; with the depth of sedimentation chamber as about 3 to 3.5 m or so. The free-board provided may be about 45 cm.

(B) ***Digestion Chamber.*** This chamber is generally designed for a minimum capacity of 57 litres per capita*. But in warmer climates, where shorter periods between sludge withdrawals are possible, it may be reduced to about 35 to 40 litres per capita.

(C) ***Gas Vent or Scum Chamber.*** The surface area of the scum chamber should be about 25 to 30 per cent of the area of the horizontal projection of the top of the digestion chamber. Sufficient area for escape of gases is necessary, so as to prevent troubles due to foaming. Moreover, the width of a vent should be 60 cm or more.

**9.50.3. Advantages and Disadvantages of Imhoff Tanks.** Imhoff tanks combine the advantages of both the septic as well as sedimentation tanks, and as such, they find use in case of small treatment plants requiring only primary treatment. They are quite economical, and do not require skilled attention during operations. The results obtained are quite good, with 60 to 65% removal of solids, and 30 to 40% removal of BOD. Moreover, there is no problem of sludge disposal, as in the case of sedimentation tanks. They suffer, however, from the following ***drawbacks :***

(*i*) Depth of tank is more, which may make the constructions costlier, especially in hard rocks or quick sands. At such places, these tanks may, thus become uneconomical.

*This is larger than that provided in separate digestion tanks because of the lack of control on temperature of digestion (since there is no heating arrangement in Imhoff tanks), and



(*ii*) Imhoff tanks may give out offensive odours, when improperly operated.

(*iii*) They are unsuitable and do not function properly where sewage is highly acidic in character.

(*iv*) These tanks have a tendency to foam or boil. This may cause the scum to go up to the top of the tank, and it may also force the sludge particles to enter the sedimentation chamber through the slot. The foaming may, thus, adversely affect the quality of the effluent.

(*v*) There is no adequate control over their operation. This makes them unsuitable for use in large treatment plants, where separate sludge digestion tanks are preferred in addition to sedimentation tanks. Imhoff tanks are, therefore, useful only for small cities and institutions, where it is not possible or economical to install separate sludge digestion tanks. **Mostly, however, they have become obsolete these days.**

**Example 9.37.** *Design an Imhoff tank to treat the sewage from a small town with 30,000 population. The rate of sewage may be assumed as 150 litres per head per day. Make suitable assumptions, wherever needed.*

**Solution.**

***Design of Sedimentation Chamber***

The sewage discharge per day

$$= 30{,}000 \times 150 = 4.5 \text{ M. litres/day} = 4500 \text{ cu-m/day}$$

Assuming a detention period of sewage in the sedimentation chamber as 2 hours, we have

The volume of sewage entering in two hours, *i.e.* the capacity of the sedimentation chamber

$$= 150 \times 30{,}000 \times \frac{2}{24} \text{ litres} = 3{,}75{,}000 \text{ litres} = 375 \text{ cu-m.}$$

Assume an effective depth of 2.2 m (effective depth includes part of the bottom sloping walls of the chamber) and a width of 4.3 m (say).

The length of the sedimentation chamber

$$= \frac{375}{2.2 \times 4.3} = 39.64 \text{ m ; say 40 m.}$$

This length is too large for a single tank. So let us adopt two tank units, each of length 20 m and width 4.3 m ; then

$$\frac{L}{B} = \frac{20}{4.3} = 4.65$$

which is between 3 to 5 and, therefore, satisfactory.

Now, discharge passing through each unit

$$= \frac{1}{2} \text{ of the total discharge} = \frac{4.5}{2} \text{ M. litres/day} = 2.25 \text{ M. litres/day}$$

*Check for velocity*

Length of tank = Velocity × Detention time

$\therefore$ 20 m = Velocity in m/min × (2 × 60 min.)

$\therefore$ Velocity in m/min

$$= \frac{20}{2 \times 60} = 0.17 \text{ m/min} < 0.3 \text{ m/min};$$

and, therefore, Safe.

*Check for Surface Loading*

$$\text{Surface loading} = \frac{Q}{BL} = \frac{2.25 \times 10^6}{4.3 \times 20} = 26{,}162 \ l/\text{m}^2/\text{day}$$

which is less than 30,000 $l/\text{m}^2$/day ; and, therefore, satisfactory. Hence, the dimensions chosen can be accepted.

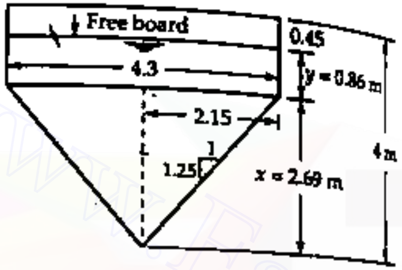


Fig. 9.60

Now let us decide the depth of the rectangular and sloping portions of the sedimentation chamber with its effective depth as 2.2 m.

With 4.3 m width and bottom sides sloping at 1 H : 1.25 V, the height of the sloping bottom = $x$ = 1.25 × 2.15 = 2.69 m (Fig. 9.60).

Now, with effective depth of 2.2 m, the height of the vertical portion below the liquid surface ($y$) is given by

$$y = 2.2 - \tfrac{1}{2}(2.69)^*$$

$$= 2.2 - 1.345 = 0.855 \text{ ; say } 0.86 \text{ m.}$$

Adding 0.45 m for the free board, the total depth of the sedimentation chamber up to bottom at the entrance of the slot

$$= 0.45 + 0.86 + 2.69 = 4.00 \text{ m.}$$

**Design of Gas Vent and Neutral Zone**

Provide a neutral zone of 0.45 m below this depth of 4 m. The tank, in general, is of 20 m length, but below this 4.0 m depth, it shall be divided into a number of compartments, say 4, each of length

$$\frac{20}{4} = 5 \text{ m.}$$

The area of gas vent has now to be provided on both sides of the sedimentation chamber. This width should be about 25 to 30% of the total width of the tank. Using an overall width of 6.5 m, the total width of the gas vent (i/c both sides of sedimentation chamber), assuming 15 cm thickness of chamber walls

$$= 6.5 - 4.3 - 2 \times 0.15 = 1.9 \text{ m};$$

*Effective depth of triang... rectangular



This is about $\frac{1.9}{6.5} \times 100 = 29.23\%$ of the total width, and therefore, OK (between 25 to 30%). Hence, 0.95 m width of gas vent will be provided on either side of the sedimentation chamber.

**Design of Digestion Chamber**

Assuming the capacity of the digestion chamber @ 40 litres/ capita, we have

The capacity of the digestion chamber

$$= 30{,}000 \times 40 = 12 \times 10^5 \text{ litres} = 1200 \text{ cu-m.}$$

Now, considering four compartments or units per tank (8 units in both tanks with 6.5 m width), we have

The capacity of each unit or compartment

$$= \frac{1200}{8} = 150 \text{ cu-m.}$$

Now, assume the depth of each hopper as 2.1 m, side slopes 1 : 1, and bottom section as

$$(6.5 - 2 \times 2.1 = 2.3 \text{ m}) \times (5 - 2 \times 2.1 = 0.8)$$

Capacity of each hopper

$$= \frac{h}{3}\left[A_1 + A_2 + \sqrt{A_1 A_2}\right]$$

where $h$ = 2.1 m

$A_1$ = 6.5 × 5 m = 32.5 m²

$A_2$ = 2.3 m × 0.8 m = 1.84 m² [See Fig. 9.61]

$\therefore$ Capacity of each hopper

$$= \frac{2.1}{3}\left[32.5 + 1.85 + \sqrt{32.5 \times 1.84}\right]$$

$$= 0.7[32.5 + 1.84 + 7.73] = 0.7[42.07] = 29.45 \text{ m}^3.$$

Balance capacity to be provided by rectangular portion of section 6.5 m × 5 m

$$= 150 - 29.45 = 120.55 \text{ m}^3.$$

$\therefore$ Height of this portion

$$= z = \frac{120.55}{6.5 \times 5} = 3.71 \text{ m.}$$

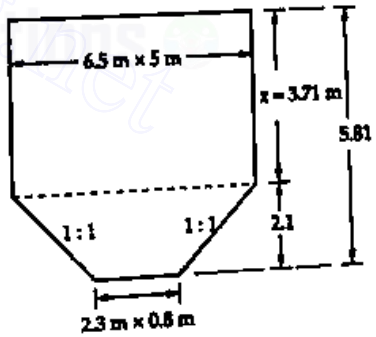


Fig. 9.61

$\therefore$ Total height of digestion chamber including neutral zone

$$= 0.45 + 3.71 + 2.1 = 6.26 \text{ m}$$

Total height of tank from top to bottom

= Height of sedimentation chamber + Height of sludge chamber

= 4 + 6.26 = 10.26 m.

This height is well within the practical limits (of 9 to 11 m) and hence the design is O.K. The plan, L-section and cross-section of the tank with these dimensions