# Flocculent Particles Settling (Type II Settling)

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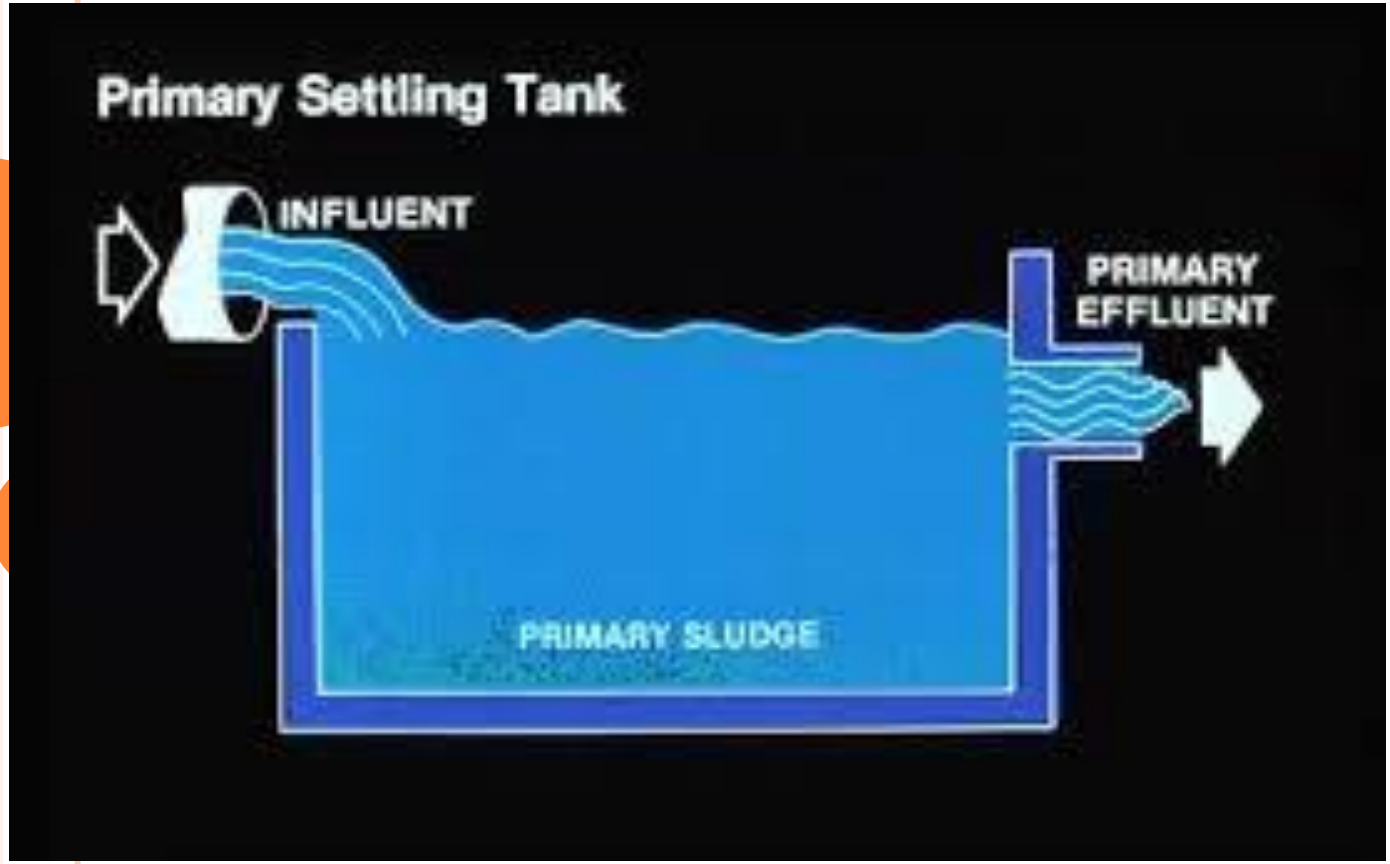
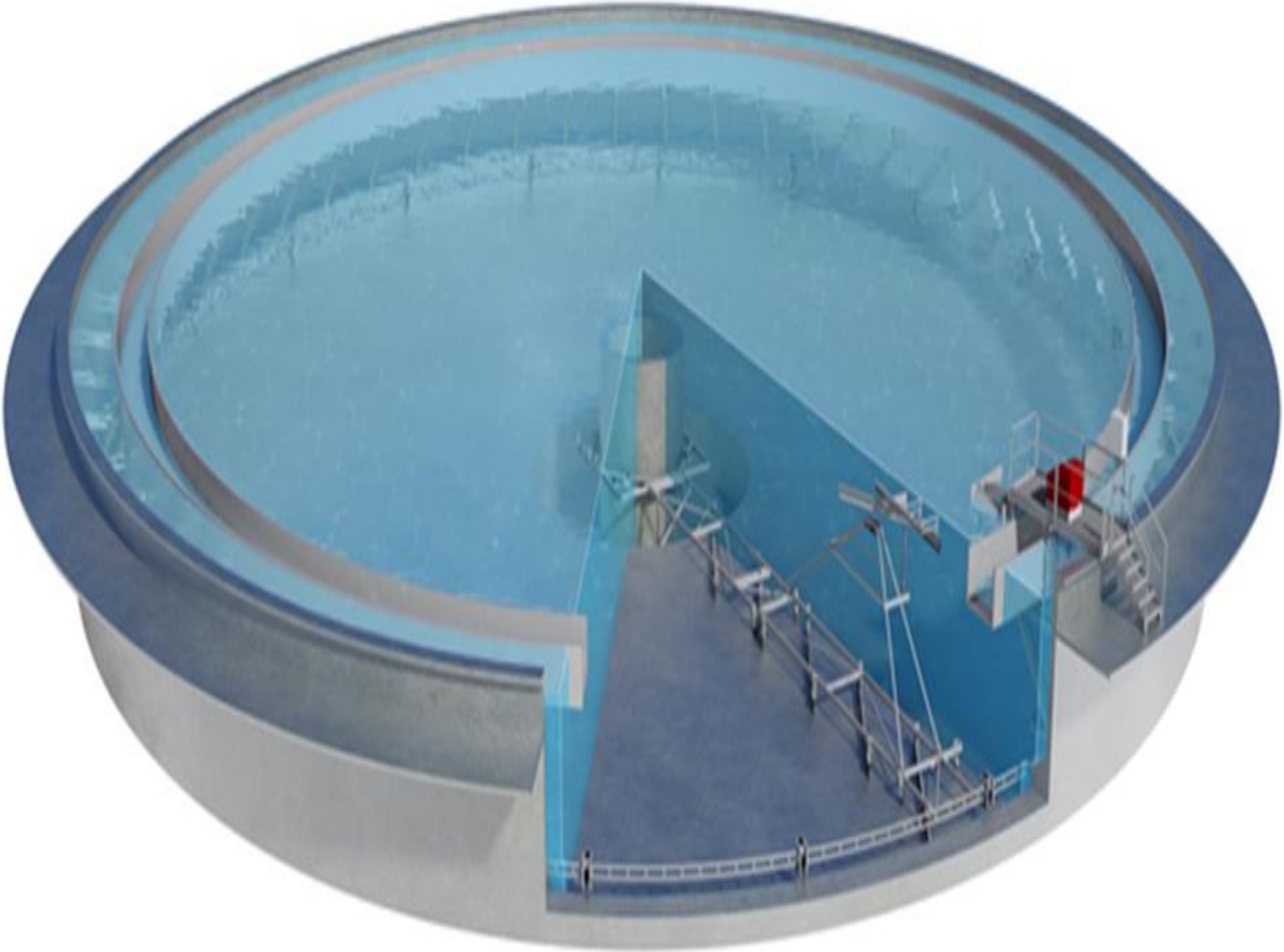


# Flocculent Suspensions

Flocculent particles such as those resulting from chemical precipitation or coagulation, or those found in biological treatment of wastewater will agglomerate while settling, with a resultant increase in particle size. The density of the composite particle may decrease due to the inclusion of water, but the overall result is generally an increase in settling velocity.

# Flocculent Suspensions

Type II settling involves flocculating particles in dilute suspension.Flocculating suspensions cannot be generalized in the same manner as discrete particle suspensions. The Stokes equation cannot be used because flocculating particles are continually changing in size, shape, and, if a large aggregate of particles collect, specific gravity because of entrapment of water in the interstitial space. So many factors contribute to the flocculation process that it has been impossible to develop a general formula for determining settling velocities.



# Flocculent Suspensions

Settling analyses of such suspensions are performed in columns at least 300 mm in diameter and equal in depth to the proposed clarifier. Samples are withdrawn at regular intervals from multiple ports along the column and analyzed for percent removal. This percent removal is plotted as shown in figures below. From this plot percent removal is determined at selected time interval as shown in the following examples.

Column settling test : is a laboratory settling columns , the suspension is thoroughly mixed and and placed in the column to designed depth at a certain time interval (5-10 min) samples are withdrawn from different ports . The (TSS) concentration is determined for each sample . Atest duration (1-3 hours) should yield suifficient data for design .the overall percent removal of solids at a given detention time and depth of a column is determine from the following equation .

$$\text{Percent removal} = \frac{h_1}{h_o}(100 + R_1) + \frac{h_2}{h_o}(R_1 + R_2) + \ldots\ldots + \frac{h_{N-1}}{h_o}(R_{N-1} + R_N)$$

Where :

h 1, h 2, …. ,hn = vertical distance from the top of the settling to the midpoint between two consecutive lines of isoremoval at desired detention time .

h o = total depth of settling column .

R1,R2 ,……Rn = consecutive isoremoval curves

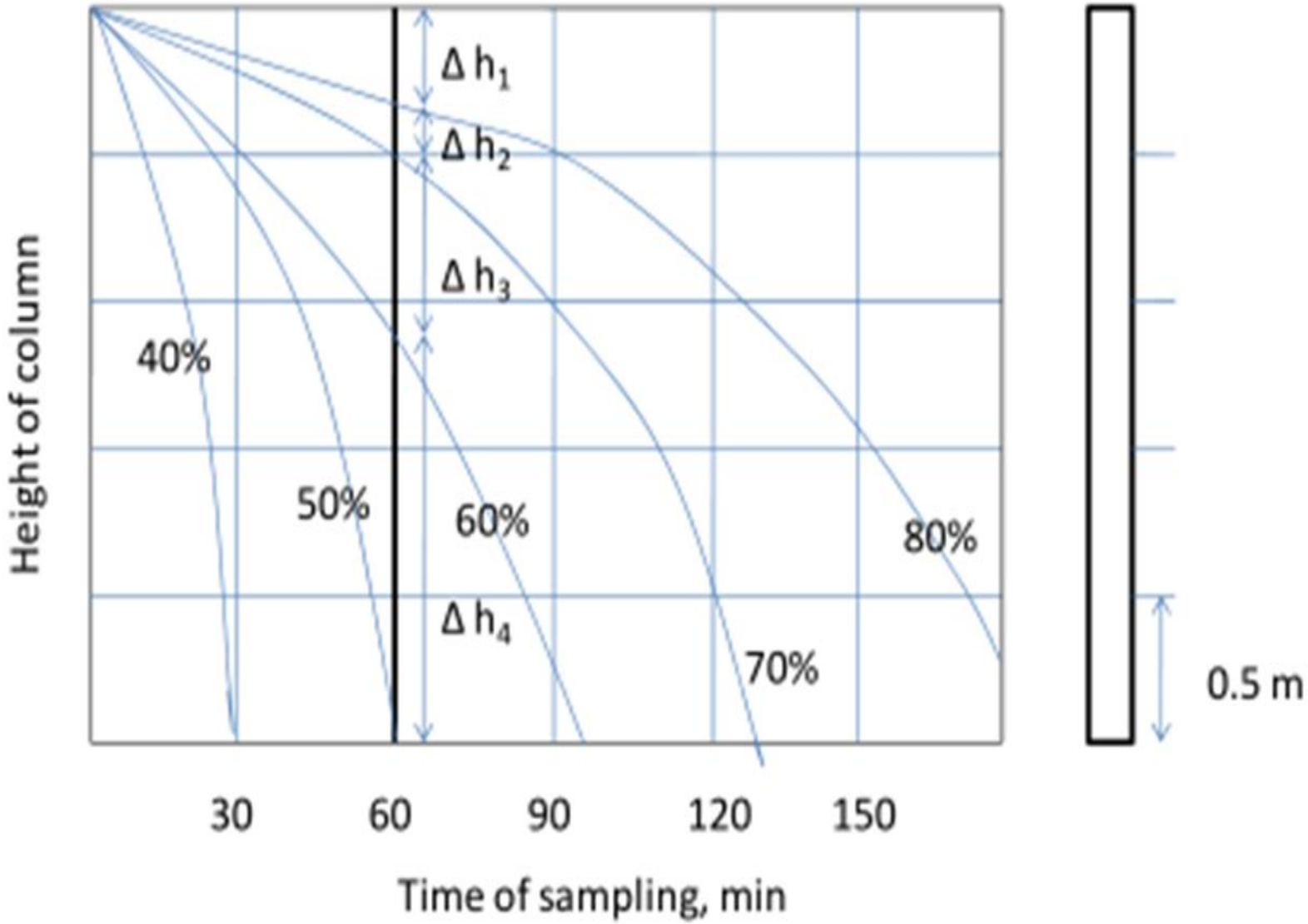



Figure 16.1. Results of the settling column study

Example2 :The settling test was performed in the settling column of height 2.5 m. Four numbers of ports were provided to the column at the height of 0.5 m from bottom. Samples were collected from these ports at every 30 min and the results obtained are plotted in the Figure 16.1. Determine the overall removal of solids after 1.0 h of settling.

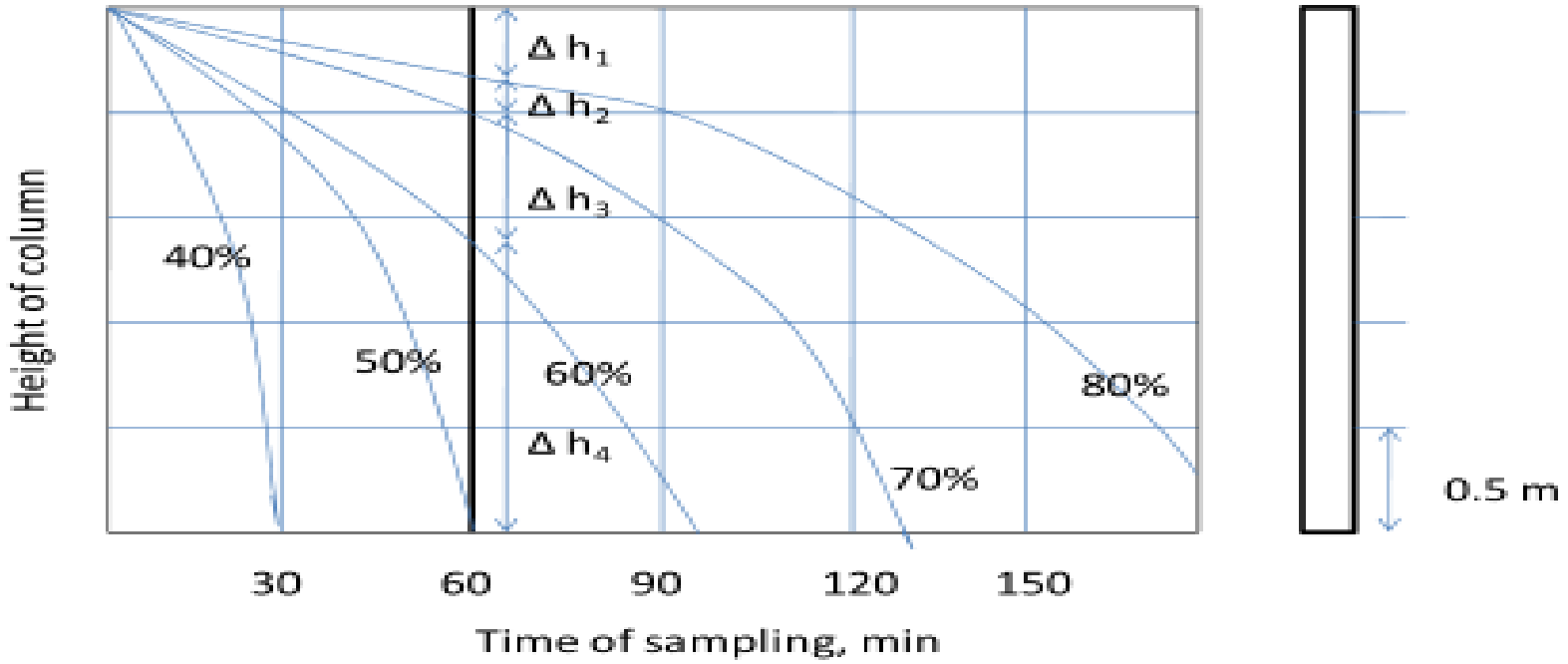



Figure 16.1. Results of the settling column study

**Solution**

$$\text{Percentage removal} = \frac{\Delta h_1}{h_5} \times \frac{(R_1 + R_2)}{2} + \frac{\Delta h_2}{h_5} \times \frac{(R_2 + R_3)}{2} + \frac{\Delta h_3}{h_5} \times \frac{(R_3 + R_4)}{2} + \frac{\Delta h_4}{h_5} \times \frac{(R_4 + R_5)}{2}$$

For curve shown in the Figure 16.1, the computation will be

$$\frac{\Delta h_1}{h_5} \times \frac{(R_1 + R_2)}{2} = 0.34(100+80)/(2.5 \times 2) = 12.24\%$$

$$\frac{\Delta h_2}{h_5} \times \frac{(R_2 + R_3)}{2} = 0.16\ (80 + 70)/(2.5 \times 2) = 4.8\%$$

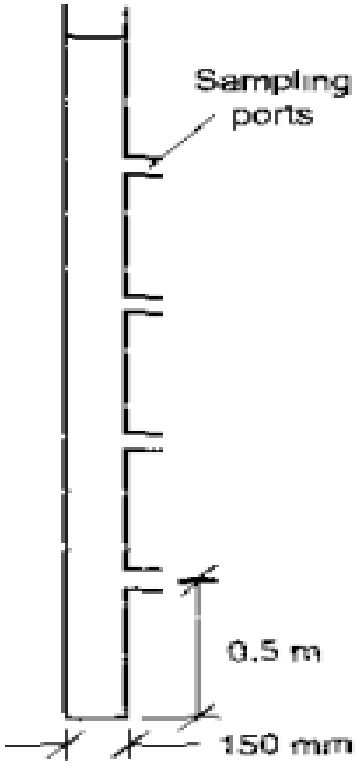
$$\frac{\Delta h_3}{h_5} \times \frac{(R_3 + R_4)}{2} = 0.66\ (70 + 60)/(2.5 \times 2) = 17.16\%$$

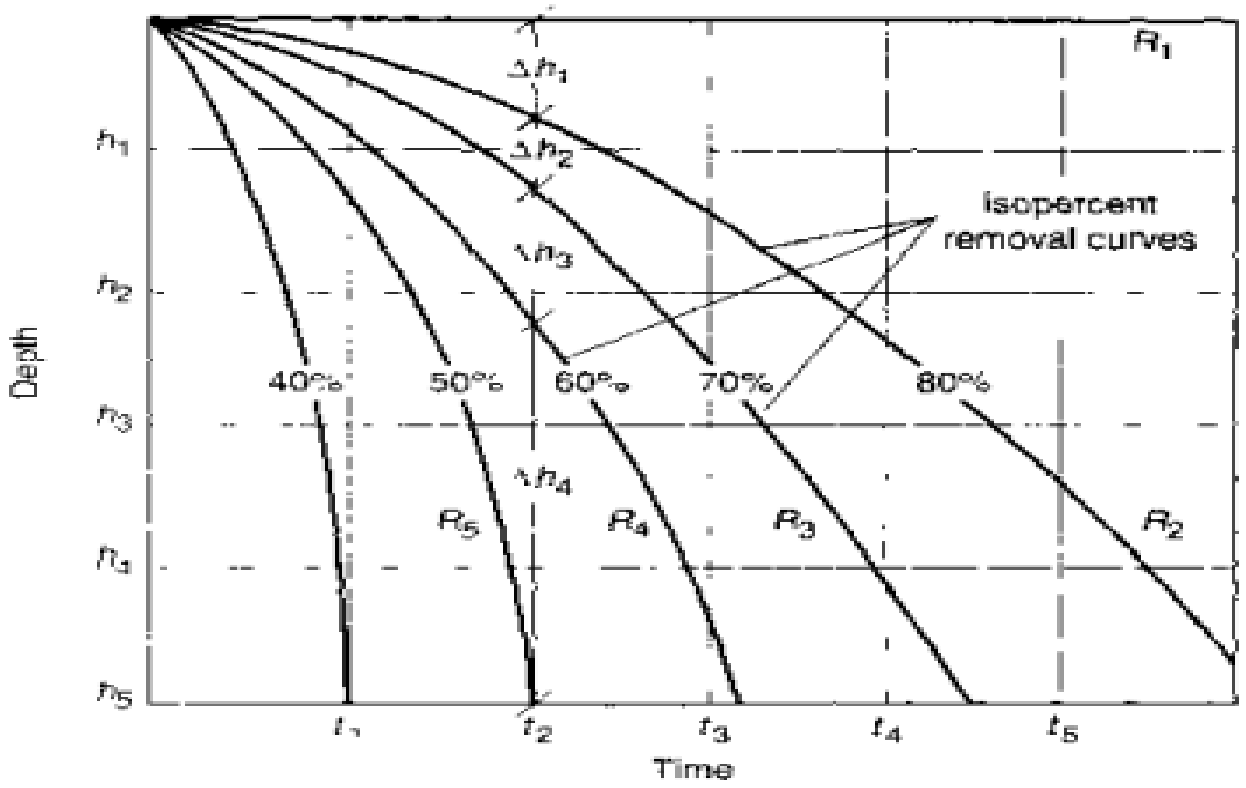
$$\frac{\Delta h_4}{h_5} \times \frac{(R_4 + R_5)}{2} = 1.34\ (60 + 50)/(2.5 \times 2) = 29.48\%$$

Therefore, total removal under quiescent settling condition is 63.68%. To achieve this removal the detention time recommended in settling tank is 1 x 1.5 = 1.5 h.

EXAMPLE 3:

Removal Of Flocculent Suspended Solids :Using the result of the settling test shown in figure to determine the overall removal of solids if the detention time is $t_2$ and the depth is $h_5$.



Solution :

$$\text{Percent removal} = \frac{\Delta h_1}{h_5} \times \frac{R_1 + R_2}{2} + \frac{\Delta h_2}{h_5} \times \frac{R_2 + R_3}{2} + \frac{\Delta h_3}{h_5} \times \frac{R_3 + R_4}{2} + \frac{\Delta h_4}{h_5} \times \frac{R_4 + R_5}{2}$$

For the curve shown in figure , a total removal for quiescent settling is 65.7 percent , the computations follow :

| $\frac{\Delta h_1}{h_5} \times \frac{R_1 + R_2}{2}$ | Percent removal |
|---|---|
| $0.2 \times \frac{100+80}{2} =$ | 18.00 |
| $0.11 \times \frac{80+70}{2} =$ | 8.25 |
| $0.15 \times \frac{70+60}{2} =$ | 9.75 |
| $0.54 \times \frac{60+50}{2} =$ | 29.70 |
| Total percent removal | 65.7 |

## Flocculent Suspensions:

In order to obtain equivalent results in an actual tank the laboratory results should be modified to reduce SOR by a factor of 1.5 and increase the design time by a factor of 2.

❖Thank you for your kind attention