جلسه ۱۸:

ته نشینی (۳)

درس: مهندسی تصفیه آب و فاضلاب

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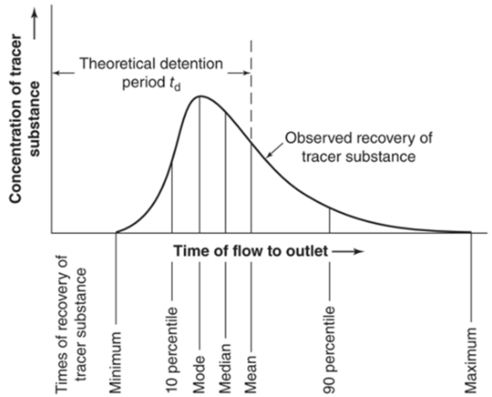
Short circuiting

- Even in well-designed basins, some of the inflow reaches the outlet in less than the theoretical detention period and some takes much longer to do so.
- The degree of short-circuiting and extent of retardation can be measured by adding a single but adequate amount of dye, electrolyte, or other tracer substance to the basin influent and observing the rise in concentration of the substance reaching the outlet as time passes.

Basin performance

- Dead spaces and short-circuiting effects



Scour

- If the shear stress (τ) caused at the liquid-sludge is too high, then the particles will lift again. So if velocity is higher than the "displacement velocity" scour will occur:

$$v_d = [(8/f)(\tau/\rho)]^{1/2} = (8/f)^{1/2} v_s$$

where v_d = displacement velocity, ft/s (m/s); f = Weisbach–Darcy friction factor, dimensionless; v_s = settling velocity of particles, ft/s (m/s).

It follows that v_d should be kept well below 18 v_s for $f = 2.5 \times 10^{-2}$.

Scour

Accordingly, the ratio of length to depth in rectangular basins or of surface area A to cross-sectional area a must be kept below

$$A/a = l_0/h_0 = (v_d t_d)/(v_0 t_0) = (8/f)^{1/2}(t_d/t_0)(v_s/v_0)$$

for $(t_d/t_0) = 1$. Then, where $v_s = v_0$, $l_0/h_0 \leq 18$.

To avoid scouring velocities, the ratio of length to depth, or surface area to cross-sectional area, must be kept below a value of

$$l_0/h_0 = A/a = V_d t_d / v_0 t_0 = (t_d/t_0)[(6k/f)C_D]^{1/2}$$

where t_d/t_0 equals unity for an ideal channel.

Example

- Find for alum floc (s_s= 1.1), 0.1 cm in diameter, the displacement velocity at which the floc can be removed without danger of resuspension and the length-to-depth ratio of the settling unit in which the removal can be effected. Assume a Weisbach–Darcy friction factor $f = 3.0 \times 10^{-2}$ and a temperature of 10°C.

Answer

$$v_d = \left[(8/f)(\tau/\rho)\right]^{1/2} = (8/f)^{1/2} v_s$$

$$v_d = \left[8/\left(3 \times 10^{-2}\right)\right]^{1/2} v_s$$

$$= 16.3 v_s.$$

- Referring to slide 4, for $d = 10^{-1}$ cm and s_s= 1.1

$$v_s = 3.0\,\text{cm/s}$$

Answer

- So:

$$v_d = 16.3 \times 3.0 = 48.9\,\text{cm/s}$$

$$v_d = \mathbf{1.60\,ft/s}$$

- And by assuming that v_s/v_0=1 and t_d/t_0=1 (ideal)

$$l_0/h_0 = (8/f)^{1/2}\left(t_d/t_0\right)\left(v_s/v_0\right)$$

$$l_0/h_0 = 16.3\left(t_d/t_0\right) = \mathbf{16.3}$$

General rules of thumb

- For plain sedimentation tanks (no lamella) the following generally works:
  - Surface loading/overflow rate = 40 $m^3/d.m^2$
  - Detention time = 2 hours
  - Depth of 3 m above the sludge zone
  - Length to width ratio > 6
  - Weir loading < 250 $m^3/d.m$
  - Velocity through the tank < 0.15 m/min

Normal performance

- Rivers can have anywhere from several hundred to several thousand mg/L of suspended material
- For plain sedimentation of 1 hr detention time, removal may be anywhere between 30-75%
- With a 2 hr detention time it will be 50-90%
- Very fine silt will not settle without coagulation

Homework

- Using the rules of thumb, design sedimentation tanks for a plant with a capacity of 10,000 m^3/day
  - Your answer should include: number of tanks (parallel), size and dimension of each tank, number of weirs and their length (keep in mind that a weir loads from both sides along its length)

Sedimentation improvement

- When suspended particles settle in a horizontal tube the maximum vertical distance traveled by the particles is equal to d, the depth of the tubes.
- Using many tubes will increase the amount of solids that settle
- Laminar flow through the tubes is maintained even at high flow rates by the increased drag force due to a relatively large surface area of the tubes.

Calculations

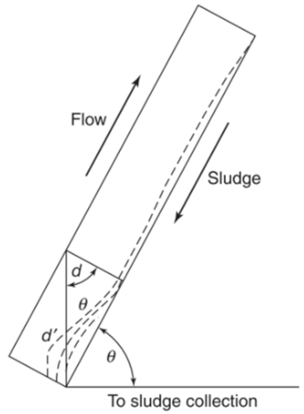
- Horizontal movement of water: $t_1 = \frac{L}{v_1}$
- Vertical fall of particle: $t_2 = \frac{d}{v_s}$
- To remove the particle: $\frac{L}{v_1}(\max) = \frac{d}{v_s}$

$$v_1\,(\max) = \frac{L v_s}{d}$$

Sedimentation improvement

- If the tubes are inclined at an angle θ the particles fall through a distance d, such that:

$$v_1 = \frac{v_s L \cos\theta}{d}$$



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Tube settles

- Since during the fall of the solids, the upward flow of water does not hinder it (as opposed to vertical falls without tube settlers) the speed of sedimentation increases
- The tubes can become dirty with time due to solids attaching to the walls, or due to biological growth
- Tube cleaning can be accomplished by providing air diffusers beneath, or a backwash system, which can be used to scrub about dirt when the influent flow is temporarily stopped.

Tube settles

- The velocity in the tube settler (flow direction) should not exceed 1.2 m/h

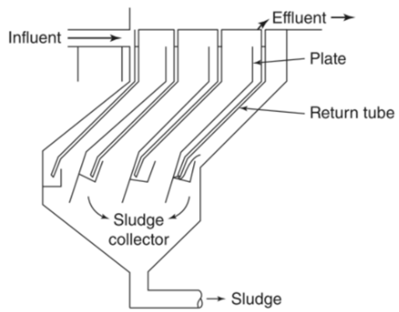
Desired effluent turbidity (JTU or NTU)	Basin overflow rate, L/min/m^2 (gpm/ft^2)	Tube settler overflow rate, L/min/m^2 (gpm/ft^2)
Water temperature 4.4°C		
1–3	———	———
1–5	80 (2.0)	100 (2.5)
3–7	80 (2.0)	120 (3.0)
5–10	120 (3.0)	160 (4.0)
Water temperature 10°C		
1–3	80 (2.0)	100 (2.5)
1–5	80 (2.0)	120 (3.0)
3–7	80 (2.0)	160 (4.0)
5–10	———	———

Lamella separator

- Some people use the word “lamella” and “tube settler” interchangeably.
- In the original Lamella design, parallel inclined plates and return tubes are used. In the original Lamella separators the flow of both influent and solids is concurrent whereas in tube settlers it is countercurrent. The water is introduced at the top of the module. It travels downward with the solids, which settle to the bottom of each plate and are carried by the flow to the sludge hopper

Lamella separator

- A return tube placed at the bottom of each plate carries the effluent back to the top of the unit and into an effluent launder.
- Using Lamellas can shrink tank size to one-fifth or even smaller



Tube/Plate/Lamella

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Inlet of the tank

- For high efficiency, inlets must distribute flow and suspended matter more or less equally
- Hydraulic equality does not necessarily ensure loading equality
- Usually several orifices are used at the inlet (distributed horizontally and vertically). The inlet velocity through each orifice should be less than 0.15m/s
- The nearest and furthest inlet orifices should have less than 2% difference in flow

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Outlet of the tank

- One or more outlet troughs/weirs are used
- Weir loading should be below 250 m^3/d.m). Volumetric flow rate relative to weir length determines the strength of outlet currents.
- Adjustable weir plates can be leveled from the water level in the tank.
- Tubular inserts (lamella) in advance of outlet weirs can intercept and deposit solids that might otherwise escape

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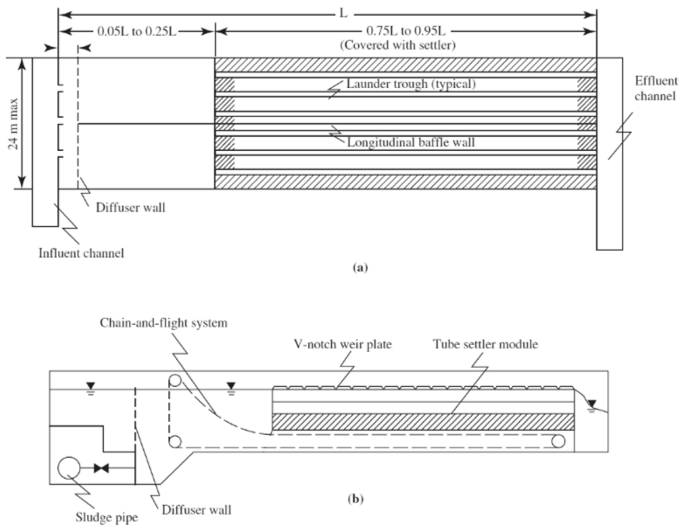

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