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SEC : B

Subject : Hydraulic Engineering

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Q 1
Ans

Solution:-

The pressure drop Δp is expected to ~~deep~~ depend upon the gate opening h, the overall depth d, the velocity V, density ρ and viscosity μ.

List the relevent variables:-

$\Delta p, h, d, V, \rho, \mu$

Write down dimensions:

Δp	$ML^{-1}T^{-2}$
h	L
d	L
V	LT^{-1}
ρ	ML^{-3}
μ	$ML^{-1}T^{-1}$

Number of Variables, $n = 6$
Number of independent dimensions:
$M = 3$ (M, L and T)

Number of non-dimensional grops: $n - M = 3$

Choose m (= 3) scaling Variables:

Geometric (d); Kinematic / time - dependent (V); dynamic / mass - dependent (ρ).

Form dimensionless groups by non-dimensionlising the remaining Variables: Δp, h and μ.

$\Pi_1 = \Delta p \, d^a V^b \rho^c$

$M^0 L^0 T^0 = (ML^{-1}T^{-2})(L)^a (LT^{-1})^b (ML^{-3})^c$

$= M^{1+c} L^{-1+a+b-3c} T^{-2-b}$

$M: \; 0 = 1 + c \quad \Rightarrow c = -1$

$T: \; 0 = -2 - b \quad \Rightarrow b = -2$

$L: \; 0 = -1 + a + b - 3c \quad \Rightarrow a = 1 + 3c - b = 0$

$\Pi_2 = \Delta p \, V^{-2} \rho^{-1} = \dfrac{\Delta p}{\rho V^2}$

$\Pi_2 = \dfrac{h}{d}$ (by inspection, since h is a length)

$\Pi_3 = \mu \, d^a V^b \rho^c$

$M^0 L^0 T^0 = (ML^{-1}T^{-1})(L)^a (LT^{-1})^b (ML^{-3})^c$

$= M^{1+c} L^{-1+a+b-3c} T^{-1-b}$

$M: \; 0 = 1 + c \quad \Rightarrow c = -1$

$T: \; 0 = -1 - b + 0 \quad \Rightarrow b = -1$

$L: \; 0 = -1 + a + b - 3c \quad \Rightarrow a = 1 + 3c - b = -1$

$\Rightarrow \Pi_3 = \mu \, d^{-1} V^{-1} \rho^{-1} = \dfrac{\mu}{\rho V d}$

Recognition of the Reynolds number suggests that we replace Π_3 by

$$\Pi_3' = (\Pi_3)^{-1} = \frac{\rho V d}{\mu}$$

Hence, dimensional analysis yields.

$$\Pi_3' = \left(\frac{\rho V d}{\mu}\right)_p = \left(\frac{\rho V d}{\mu}\right)_m$$

(a) From the last, we have a velocity ratio:

$$\frac{V_p}{V_m} = \frac{(\mu/\rho)_p}{(\mu/\rho)_m}\frac{d_m}{d_p} = \frac{0.002/800}{1.0\times10^{-6}} \times \frac{1}{5}$$

$$= \boxed{0.5}$$

Hence,

$$V_m = \frac{V_P}{0.5} = \frac{3.0}{0.5} = 6.0\ ms^{-1}$$

(b) The ratio of the quantities of flow is.

(C) Finally, For the pressure drop:.

$$\Pi_1 = \left(\frac{\Delta p}{\rho V^2}\right)_p = \left(\frac{\Delta p}{\rho V^2}\right) = \frac{(\Delta p)_p}{(\Delta p)_m}$$

$$= \frac{\rho_p}{\rho_m}\left(\frac{V_p}{V_m}\right)^2 = \frac{800}{1000} \times 0.5^{-2} = 0.2$$

Hence,

$$\Delta p_p = 0.2 \times \Delta p_m = 0.2 \times 60$$

$$= \boxed{12.0 \text{ kPa}}$$

Q 2
Ans Given data:-

Mav length depth = 78m

Specific gravity = 2.4

f_{av} = 788 T/m²

Hight of wave = 1.2m

Solution:-

(1) H Limiting = $\frac{f_{av}}{\gamma_w(G-w+1)}$

$= \frac{788 \times 1000}{1000(2.4-0+1)}$

H Limiting = **231.764**

(2) Top width "a":-

Free board = 1.5 x h x wave

= 1.5 x 1.2

Free board = **1.8**

Height of dam = HW + 1.8

= 78 + 1.8

HD = 79.8

a = 14% of H.D

= 0.14 x 79.8 = **11.172m**

(3) Base Width:-

$$b' = \frac{H_W}{\mu \cdot G} = \frac{78}{0.7 \times 2.4}$$

$$= 46.42\, m$$

$$= \boxed{47}$$

(4) For no tension criteria:-

$$b' = \frac{H_W}{\sqrt{G}} = \frac{78}{\sqrt{2.4}}$$

$$b' = \boxed{50.34}$$

(5) Depth of vertical portion on u/s side:-

$$h' = 2a\sqrt{G \cdot w}$$

$$= 2 \times 11.172\sqrt{2.4 - 0}$$

$$= 34.60$$

$$h' = \boxed{35\, m}$$

(7) Total Width of the base of the dam:-

$$b = b' + \frac{a}{16} = 50.34 + \frac{11.172}{16}$$

$$= \boxed{51.03}$$

(8) $\tan\theta = \frac{b'}{H} = \frac{50.34}{78}$

$$\theta = \tan^{-1}(0.64)$$

$$\theta = 32.8^\circ$$

(9) Depth of vertical portion on D/s (from WL on u/s side)

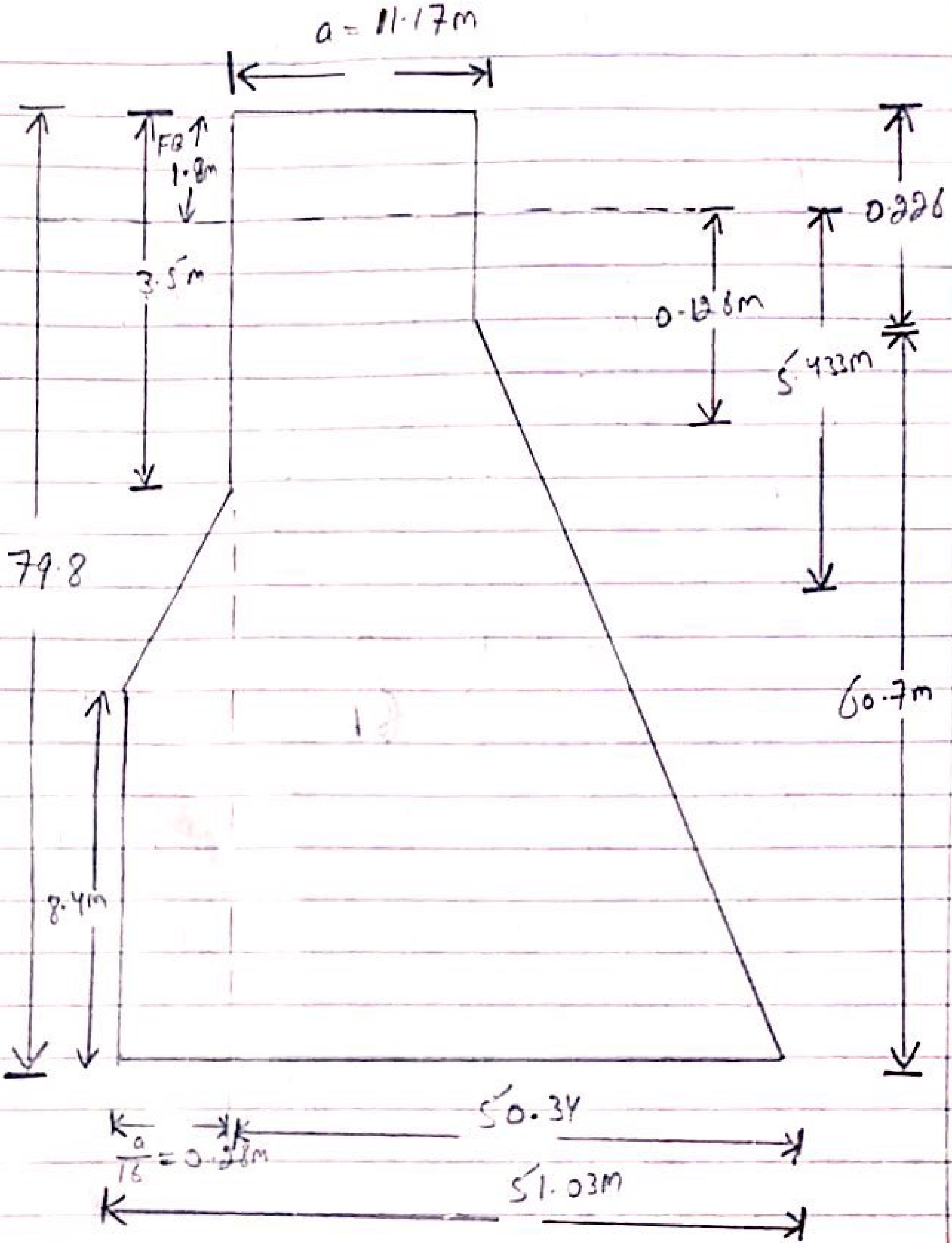
$$\tan\theta = \frac{a}{d'} = \frac{11.172}{d'}$$

$$\tan\theta = \frac{11.172}{d'}$$

$$\boxed{d' = 0.126}$$

(10) Depth of vertical portion

$$d = d' + FB = 0.126 + 1.8$$



a = 11.17m
FB
1.8m
3.5m
79.8
8.4m
0.226
5.433m
60.7m
50.34
51.03m

Q 3
Ans

Model analysis & Similitude:-

The prototype that I will take for my analysis is "Water turbine"

By means of model analysis or Dimensional analysis we take replica of prototype. on that model we conclude tests so whenever we are constructing actual "Water turbine" we will know the requirement for the considered "Water turbine". Dimensional analysis is an research work due to which we gathered information. By means of similitude is similarities b/w model and prototype. There are three types of similarities.

(1) Linear similarity.

(2) Kinematic similarity.

(3) Dynamic similarity.

- **Linear similarity:-** It is an ratio b/w length of prototype and length of model.

Mathematically:- $\frac{LP}{LN} = Lr = \frac{WP}{WN} = Lr$

$$\frac{A_p}{A_m} = \frac{L_p \times b_p}{L_m \times b_m}$$

* Kinematic Similarity:- It is the ratio of velocity b/w prototype and model.

$$= \frac{V_p}{V_{m_1}} = V_r = \frac{V_{p_2}}{V_{m_2}}$$

Kinematic similarity depends on the flow except forces.

* Dynamic Similarity:- Dynamic similarity is the ratio of ~~ratio~~ force b/w prototype & model.

$$\frac{F_{ip}}{F_{im}} = F_r = \frac{F_{vp}}{F_{vm}}$$

$$F_r = \frac{F_{gp}}{F_{gm}}$$

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Q 4

Ans The downward Velocity in a low dense fluid at equilibrium in Which the sum of the gravity force, buoyancy force and fluid drag force are equal to zero.

When a grain falls down in still water It obtains a constant velocity When the upward fluid drag force on the grain is equal to the downward submerged weight of the grain. This is also called Setting Velocity

Fall velocity effected due to the following terms:.

(a) Particle diameter.

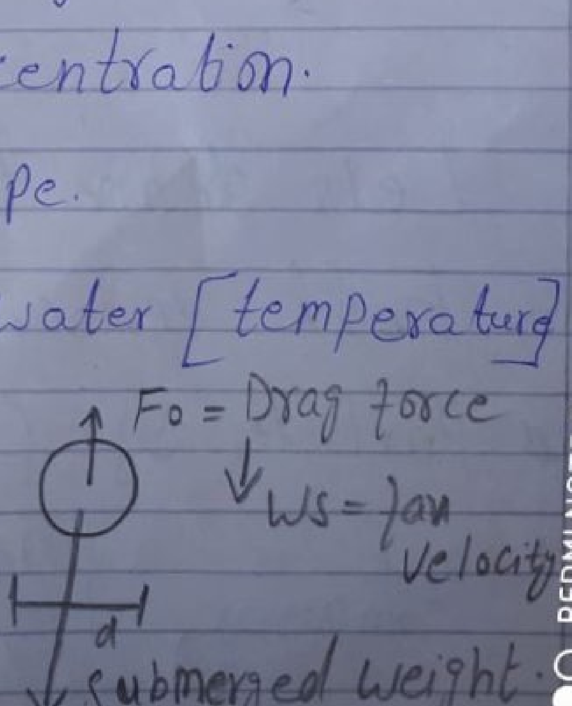
(b) Particle density.

(c) Particle Concentration.

(d) Particle Shape.

(e) Viscosity of water [temperature]

(f) Turbulance.



The force balance b/w the drag force and the submerged weight gives.

F_D = Submerged weight

$$\frac{1}{2}\rho C_D \frac{\pi}{4} d^2 w_s^2 = (\rho_s - \rho) g \frac{\pi d^3}{6}$$

$A = \frac{\pi d^2}{4}$ = projected Area

C_D = Drag Co-efficient

w_s = fall velocity of sediment

$$= \sqrt{\frac{4gd}{3C_D}\left(\frac{\rho_s - \rho}{\rho}\right)}$$

ρ = Density of Water

ρ_s = Density of sediment Particle

Lets define the terms by which Fall Velocity effected.

Particle Size (diameter) :-

Particle Size is a notion introduced for comparing dimensions of solid particles, liquid particles or gaseous

Particles.

* **Particle density:-** The particle density or true density of a particulate solid or Powder, is the density of the particles that Make up the powder.

* **Particle Shape:-** It defined by the relative dimensions of the long, intermediate and short axes of the particles.

* **Viscosity of Water:-** Viscosity defines a fluid's internal resistance to flow and may be though of as a measure of fluid friction.

* **Turbulance:-** Turbulance or turbulent flow is fluid motion characterized by chaotic changes in pressure and flow velocity. It is an contrast to laminar flow