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Section A

Paper Hydraulic Engineering.

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Qno1)

Ans :- Solution:-

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

Relavant variables :-

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

Dimensions :

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

Number of variable $n = 6$

Number of independent dimensions $m = 3$ (M, L & T)

Number of non dimensional group: $n - m = 3$

choose m (=3) scaling variables

geometric (d): Kinematic / time dependent (V);

dynamic / mass dependent (ρ)

From dimensionless groups by non dimensionlising the remaining variables : ΔP, h & 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: $0 = 1+c$ $\boxed{\Rightarrow c = 1}$

T: $0 = -2-b$ $\boxed{\Rightarrow b = -2}$

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

$$\Pi_1 = \Delta p\, V^{-2} \rho^{-1} = \frac{\Delta p}{\rho V^2}$$

$\Pi_2 = \frac{h}{d}$ (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: $0 = 1+c$ $\boxed{\Rightarrow c = -1}$

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

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

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

Recognition of the reynold number suggests that we replace Π_3 by

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

Hence dimensional analysis yields

$$\Pi_1 = f(\Pi_2, \Pi_3')$$

i.e. $$\frac{\Delta p}{\rho V^2} = f\left(\frac{h}{d}, \frac{\rho V d}{\mu}\right)$$

(a) Dynamic similarity requires that all non dimensional groups by the same in model & prototype; i.e

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

$$\Pi_2 = \left(\frac{h}{d}\right)_p = \left(\frac{h}{d}\right)_m$$ (automatic if similar shape i.e "geometric similarity)

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

From the last, we have a velocity ratio

$$\frac{V_P}{V_m} = \frac{(\mu/\rho)_p}{(\mu/\rho)_m} \frac{d_m}{d_p} = \frac{0.002/800}{1.0 \times 10^{-6}} \times 1/5 = 0.5$$

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

$$\frac{Q_P}{Q_m} = \frac{(\text{velocity} \times \text{area})_P}{(\text{velocity} \times \text{area})_m} = \frac{V_P}{V_m}\left(\frac{d_P}{d_m}\right)^2$$

$$= 0.5 \times 5^2 = 12.5$$

c) Finally, For the pressure drop

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

$$\Rightarrow \frac{(\Delta P)_P}{(\Delta P)_m} = \frac{\rho_P}{\rho_m}\left(\frac{V_P}{V_m}\right)^2 = \frac{800}{1000} \times 0.5^2 = 0.2$$

Hence

$$\Delta P_p = 0.2 \times \Delta P_m = 0.2 \times 60 = 12.0 \text{ KPa}$$

Q no 2)

Ans 2) Given :-

Maximum depth of water in reservoir

$= H = 69m$

Specific gravity of dam material $= G = 4.4$

Allowable compressive strength for dam masonary

$= \sigma_{all} = 697 T/m^2$

Height of wave $(H_w) = 2 m$

No uplift pressure $C_u = 0$.

Solution

(1) $H_{limiting} = \frac{\sigma_{all}}{\gamma_w (G - C_u + 1)} = \frac{697 \times 1000}{1000 (4.4 - 0 + 1)}$

$H_{limiting} = 126.72 m > H_w = 69m$

so it is low Gravity dam

(2) Top width "a"

Free board $= 1.5 h_{wave} = 1.5 \times 2m$

$F.B = 3m$

height of Dam $= H_D = H_w + F_B = 69 + 3$

$H_D = 72m$

$a = 14\%$ of H_D

$a = 0.14 \times 72 = 10.08m$

③ Base width "b" (without off set)

(i) For no sliding criteria

$$b' = \frac{Hw}{\mu G} = \frac{69}{0.7 \times 4.4}$$

$$\boxed{b' = 22.4m}$$

(ii) For no tension criteria

$$b' = \frac{Hw}{\sqrt{G}} = \frac{69}{\sqrt{4.4}}$$

$$\boxed{b' = 33m}$$

$$\boxed{\text{use } b' = 33m}$$

4) Depth of vertical portion on u/s side

$$h' = 2a\sqrt{G - C_4}$$

$$h' = 2 \times \overset{10.08}{\cancel{4.5}} \sqrt{4.4 - 0}$$

$$h' = (20.16)(2.09)$$

$$\boxed{h' = 42.28m}$$

(5) Upstream off set $= \frac{a}{16} = \frac{10.08}{16}$

$= 0.63m$

⑥ Depth below the water level to the end of inclined portion in u/s $= 3.14 a\sqrt{G}$

$= 3.14 \times 10.08\sqrt{4.4}$

$= (31.65)(2.09)$

$= 66.38$ m

⑦ Total width of the base of the dam

$b = b' + \frac{a}{16} = 33 + 0.63$

$b = 33.63$ m

⑧ $\tan\phi = \frac{b'}{H} = \frac{33}{69}$

$\phi = \tan^{-1}(0.47)$

$= 25.17$

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

$\tan\phi = \frac{a}{d'} = \frac{10.08}{d'}$

$\tan\phi = \frac{10.08}{d'}$

$\frac{33}{69} = \frac{10.08}{d'}$

$d' = \frac{(10.08)(69)}{33} = 21.07$

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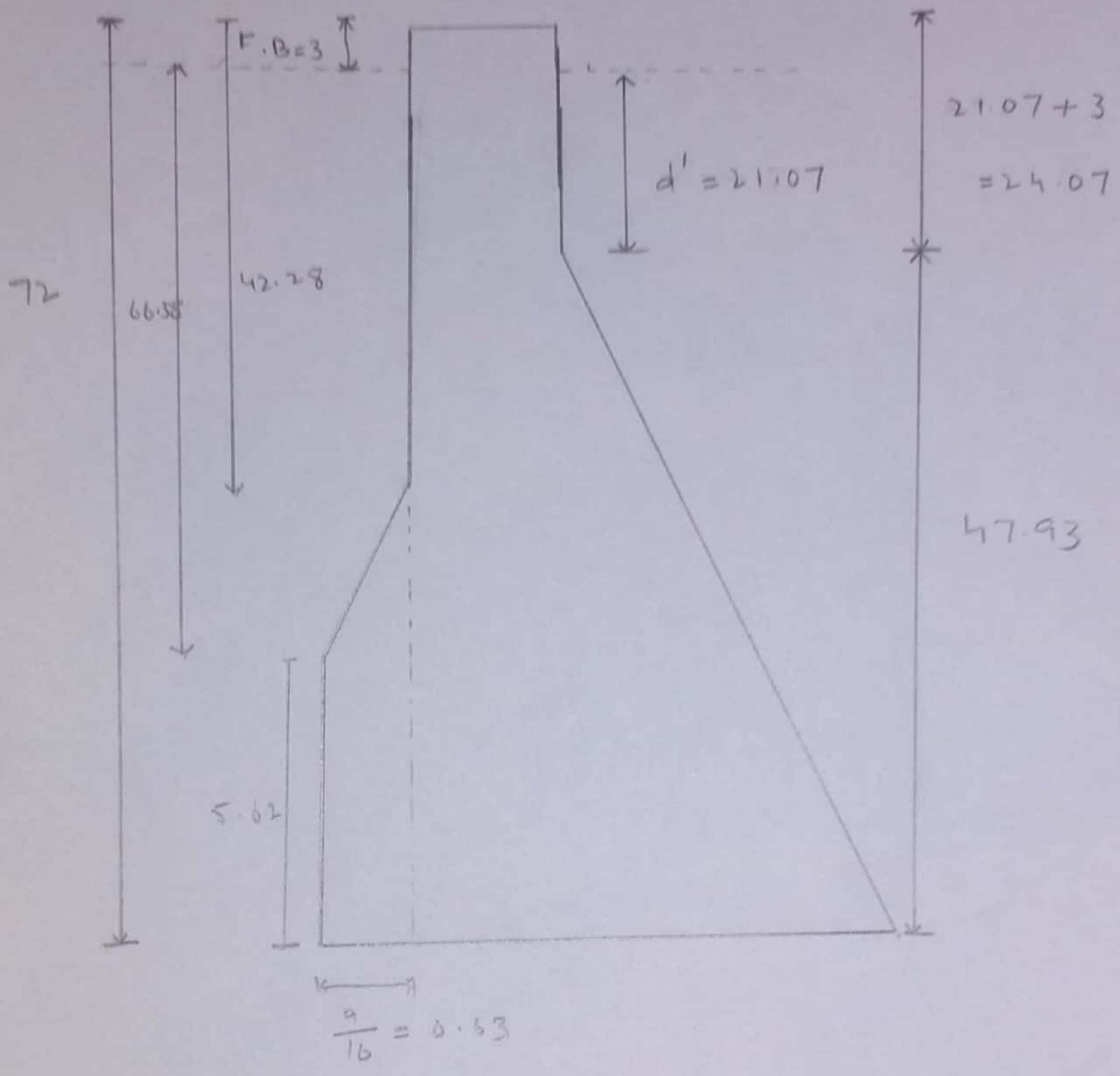
Depth of vertical portion

$$d = d' + F_B = 21.07 + 3 =$$

$$d = 24.07$$



Q no 3)

Ans 3) Purpose of dimension analysis:-

To obtain sealing law so that prototype performed can be predicted from model performance

To predict in the relationship b/w parameter

To generate non dimensional parameter that help in the design of experiment and in reporting of result

Fundamental dimension:-

There are the basic quantities For example

Time, T ; Distance, L ; Mass, M

Secondary Dimension:-

Those quanty which posses more than one fundamental dimension

velocity, L/T Acceleration, L/T^2

Density, M/L^3

Similitude:-

It is defined as similarity b/w the model & prototype in every respect which mean model & prototype have similar properties or model & prototype

have similar properties or model &
Prototype are completly similar
It is used intesting engineering model.

Example:
Consider a submarine modeled at 1/40th scale. The application operate in sea water at 0.5 C; moving at 5m/s. The model will be tested in fresh water at 20 °C

Q no 4
Ans (a) Fall velocity:-
when a grain fall 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 constant velocity is defined as the fall velocity of the grain

This is also called settling velocity

Fall velocity depends on
particle diameter
particle density
particle concentration
particle shape
viscosity of water (temprature)
Turbulance.

1) Particle Diameter;- The diameter of the particle is directly proportional to the fall velocity because greater the size of particle so it will tends to move faster as compared to the particle of small size thus there will

be more gravitional force on particle of greater size so it will fall quickly due to its weight

Particle Density:-
Density of the particle is directly proportional to the rate of fall velocity since particle with high density tends to settle down early compared with particle of low density.

Particle concentration:-
consentration of particle size will considerably effects it fall velocity as the section having greater concentration will be settled down at the place thus causing more fall velocity comparing with section of low concentration.

Particle shape:-
Particle having regular shape tends to be effected more then irregular shape since regular shape particles hence even surfaces which offer very little or no friction while particle with irregular shape offers more friction as the particle with smaller surface area are more likely to be effected due to their less resistance.

Viscosity of water:-

The effect of the viscosity of the fluid on the drag coefficient fall velocities etc enters through the reynold number. However when dealing with suspension it may be necessary to consider the effective viscosity of the suspension rather than that of the fluid. For dilute suspension of spheres, Einstein devolped the following eq

$$\frac{\mu_{susp}}{\mu} = 1 + k_e C$$

Turbulance of water:-

Turbulance of water effect the fall velocity of water in reservoir because the non linearity & zigzag path effect the flow of water & cause the variation in the flow.