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Section # A

Paper # Hydraulic Engineering.

Q1 Ans

Solution:-

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

List The relevant variable.

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

write the down dimension.

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 $m = 3$ (M, L and T)

Number of non-dimentional groups $= n-3 = 3$

Choose m $(=3)$ Scaling variable

geometric (d)

Kinematic/time-dependent (v)

dynamic/mass-dependent (ρ)

from dimension groups by non-dimensionlising the remaining variable Δp, h, and μ

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

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

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

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

$T . \quad 0 = -2-b \quad \Rightarrow b = -2$

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

$\Rightarrow \quad \pi_1 = \Delta p v^{-2} \rho^{-1} = \frac{\Delta p}{\rho v^2}$

$\Pi_2 = h/d$ by insection since h is a lenght

$\Pi_3 = \mu d^a v^b \rho^c$ (Probabbly obvious by now, but here goes anyway.

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

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

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

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

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

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

Recognition of the Reynolds number suggests that we replace Π_1 by

$\Pi_i = (\Pi_3)^{-1} = \frac{\rho v d}{\mu}$

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 ~~replace~~ non dimensional groups be the same in model and prototype i.e.

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

$$\Pi_2 = (h/d) = (h/d)$$ 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

$$\frac{v_p}{v_m} = \frac{(\mu/\rho)_p}{(\mu/\rho)_m}\frac{d_m}{d_p} = \frac{0.002/800}{1.0 \times 10^{-4}} \times 1/5 = 0.5$$

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

$$\frac{Q_p}{Q_m} = \frac{(\text{velocity} \times \text{area})_p}{(\text{velocity} \times \text{area})_m} = \frac{v_p}{v_m}\left(\frac{d_p}{d_m}\right)^2$$

$$\frac{VP}{Vm}\left(\frac{dp}{dm}\right)^2 = 0.5 \times 5^2 = 12.5$$

(c) finally for the pressure drop

$$\Pi_1 \left(\frac{\Delta P}{PV^2}\right)_p = \left[\frac{\Delta P}{PV^2}\right] \Rightarrow \frac{(\Delta P)p}{(\Delta P)m} = \frac{P_p}{Pm}\left(\frac{VP}{Vm}\right)^2$$

$$= \frac{800}{1000} \times 0.5^2 = 0.2$$

Hence $\Delta P_p = 0.2 \times \Delta Pm = 0.2 \times 60$

$= 12.0\ KPa$

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Given data:-

Maximum depth of water in reservoir = h = 78 m

Specific gravity of dam material = G = 4.3

Allowable compressive strength for dam masonary - σ_{all} = 780 T/m²

Height of wave = 2m

No uplift pressure = C_u = 0

Solution:-

$$H_{limiting} = \frac{\sigma_{all}}{\gamma_w (G - C_u + 1)} = \frac{780 \times 1000}{1000(4.3 - 0 + 1)}$$

$H_{limiting}$ = ~~1.813~~ 147.16 > H_w = 78m.

So it is low Gravity dam

(2) Top width : a"

free board = 1.5 h_{wave} = 1.5 × 2m

F.B = 3 m

Height of Dam = HD = HW + FB = 78 + 3

HD = 81m

a = 14% of HD.

a = 0.14 × 81 = 11.34 m.

(3) Base width b without offset

(i) for no sliding criteria.

$$b' = \frac{78}{0.7 \times 4.5}$$

$$b' = \frac{78}{3.01}$$

$$\boxed{b' = 25.91m}$$

(ii) for no tension criteria.

$$b' = \frac{HW}{\sqrt{G}}$$

$$b' = \frac{78}{\sqrt{4.3}}$$

$$b' = \frac{78}{2.07}$$

$$\boxed{b' = 37.68m}$$

(4) Depth of vertical portion on u/s side.

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

$$h' = 2 \times 1\cancel{0}.34\sqrt{4.3 - 0}$$

$$h' = 2 \times 11.34\,(2.07)$$

$$\boxed{h' = 46.94m}$$

(5) upstream offset $= \frac{a}{16} = \frac{11.34}{16}$

$$\boxed{= 0.708m}$$

(6) Depth below water level to the end of inclined portion in U/S.

$$U/S = 3.14 a \sqrt{G}$$
$$= 3.14 \times 11.34 \sqrt{4.3}$$
$$= 3.14 \times 11.34 \times 2.073$$
$$\boxed{= 73.81m}$$

(7) Total width of the base of the dam

$$b = b' + \frac{a}{16}$$
$$b = 37.68 + \frac{11.34}{16}$$
$$b = 37.68 + 0.708$$
$$\boxed{b = 38.38 m}$$

(8) $\tan\theta = \frac{b'}{H} = \frac{38.38}{78}$

$$\theta = \tan^{-1}(0.49)$$
$$\theta = 26.10$$

(9) Depth of vertical portion on D/s from WL on U/s slide)

$\tan\theta = \frac{11.34}{d'}$

$\frac{38.38}{78} = \frac{11.34}{d'}$

$d' = \frac{(11.34 \times 78)}{38}$

$d' = \frac{884.52}{38}$

$\boxed{d' = 23.27\ m}$

Depth of vertical portion

$d = d' + FB = 23.27 + 3$

$\boxed{d = 26.27\ m}$

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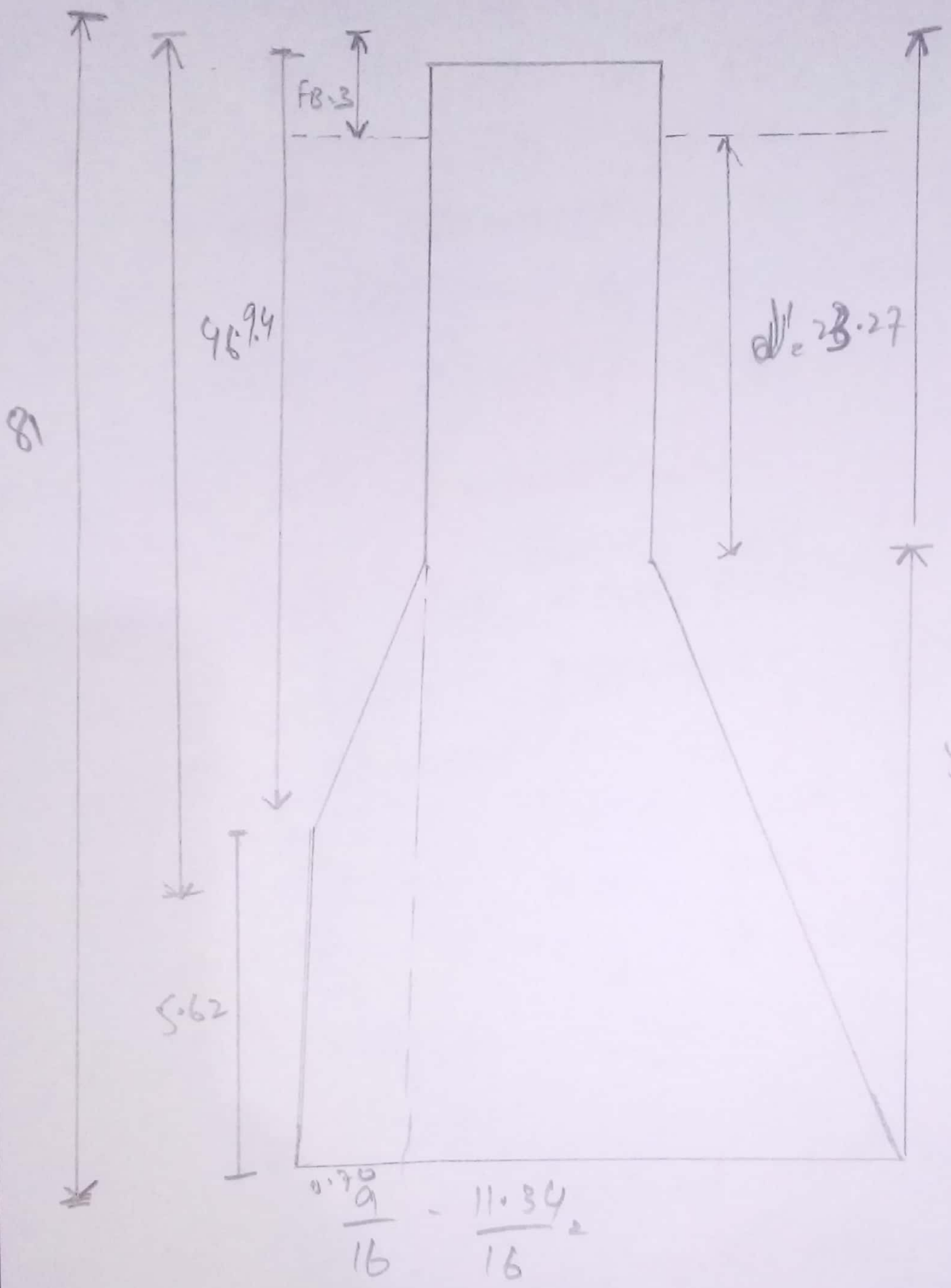


23.27 + 3
26.27

Q3

Ans 3

Purpose of dimension andlysis:-

To obtain sealing law so that prototype performed can be predicted in the rilationship 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 examples.

time, Distance Mass.

Secondary Dimension:.

Those quantiy which passes more than one fundamental dimension velocity L/T Acceleration L, Density M/L3

Similitudes:-

It is defined as Similarity b/w the model and propotype in every respect which mean model and prototype have similar properties or model and propotype have similar properties or model and prototype are completly similar It is used intersting engineering.

7) Turbellance of water:-

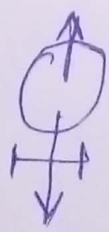
Turbulance of water effect the fall velocity of water in resistvoir because the non linearity and zigzag path effect the flow of water and cause the variation in the flow.

(Q4)
Ans fall velocity.

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 constant velocity is defined as the fall velocity of the grain. This is also called setting velocity.

fall velocity depend on

(i) particle diameter
(2) particle density
(3) particle concentration
(4) particle shape
(5) viscosity of water (temperature)
(6) Turbulence.



(2) Particle Diameter:-

The diameter of the Particles is directly proportional to the fall velocity. because greater the size of particles so it will tends to move faster as compared to the particles of small size thus there will be more gravitational force on particles of greater size so it will fall quickly due to its weight.

(3) Particle Density:-

Density of the particle is directional to the rate of fall velocity Since particles with high density tends to settle down early compared with particles of low density.

(4) Particle concentration:-

concentration of particle size will considerebly effect its 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.

(5) Particles shape:-

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

(6) 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 sphere, Eistein develped the following eq:

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

model.

Example:-

consider a submarine modelled 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.