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Section "A"

Hydraulic Engineering

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Ans 1:-

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.

List the relevant variables:

Δp, h, d, v, ρ, μ

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 dimension: m = 3 (M, L and T)

Number of non-dimensional groups: n - m = 3 choose m (=3), scaling variables:

Geometric (d)

kinamatic / time-dependent (V)

dynamic / mass - dependent (ρ)

Form dimension less group by non-dimensionalizing the remaining variables: Δp, h and μ.

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

?

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

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

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

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

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 lenght)

$\Pi_3 = \mu d^a V^b \rho^c$ (probably obvious by now, but here goes anyway)

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

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

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

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

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

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

Recognition of the Reynolds number suggest 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 be the same prototype i.e

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

$$\Pi_2 = \left(\frac{h}{d}\right)_n = \left(\frac{h}{d}\right)_m$$

(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:

$$\frac{V_P}{V_m} = \frac{(\mu/\rho)_P}{(\mu/\rho)_m} \frac{d_m}{d_P}$$

$$= \frac{0.002 / 800}{1.0 \times 10^{-6}} \times \frac{1}{5} = 0.5$$

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

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

$$\Rightarrow \frac{(\Delta P)_p}{(\Delta p)_m} = \frac{\rho_p}{\rho_m}\left(\frac{V_p}{V_m}\right)^2 = \frac{800}{1000} \times 0.5$$

$$= 0.2$$

Hence:

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

$$= 0.2 \times 60 = 12.0\ kPa$$

Ans 2:

Given data:

Max depth of water in reservoir

$H = 77m$

Specific gravity of dam $G = 3.7$

Allowable compressive stress for the Dam masonary $\sigma_{all} = 779$

Height of wave $= 2.1m$

No uplift pressure $C_u = 0$.

Solution:

1- $H_{limiting} = \dfrac{\sigma_{all}}{\gamma_w (G - C_u + 1)} = \dfrac{779 \times 1000}{1000(3.7 - 0 + 1)}$

$H_{limiting} = \dfrac{779\ 000}{4700}$

$H_{limiting} = 165.74 > 77$

Hence it is low gravity dam

2) Top width "a"

Free board = 1.5 h_{wave} = 1.5 × 2.1

Free board = 3.15 m

Height of Dam = H_D = $H_w + F_B$

= 77 + 3.15

H_D = 80.15

a = 14% of HD

a = 0.14 × 80.15

a = 11.22 m

3) Base width "b" (without off set)

For no sliding criteria

$$b' = \frac{H_w}{\mu G} = \frac{77}{0.7 \times 3.7}$$

b' = 29.7 m

for no tension criteria

$$b' = \frac{H_w}{\sqrt{G}} = \frac{77}{\sqrt{3.7}}$$

$$\boxed{b = 40.10\ m}$$

we use $b' = 40.10m$

4) Depth of verticle portion on U/S side

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

$$h' = 2 \times 11.22\sqrt{3.7 - 0}$$

$$\boxed{h' = 43.008m}$$

5) Upstream off set $= \frac{a}{16} = \frac{11.28}{16}$

$= 0.70m$

6) Depth below the water level to the end of inclined portion in U/S $= 3.14\, a\sqrt{G}$

$= 3.14 \times 11.22 \sqrt{3.7}$

$= \boxed{67.64\ m}$

7) Total width of the base of the dam

$b = b' + \frac{a}{16} = 40.10 + \frac{11.22}{16}$

$\boxed{b = 40.80\ m}$

8) $\tan \theta = \frac{b'}{H} = \frac{40.10}{77}$

$\theta = \tan^{-1}(0.52)$

$\theta = 27.47$

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

$\tan \theta = \frac{a}{d'} = \frac{11.2}{d'}$

$\frac{40.10}{77} = \frac{11.2}{d'}$

$$d' = \frac{11.2 \times 77}{40.10}$$

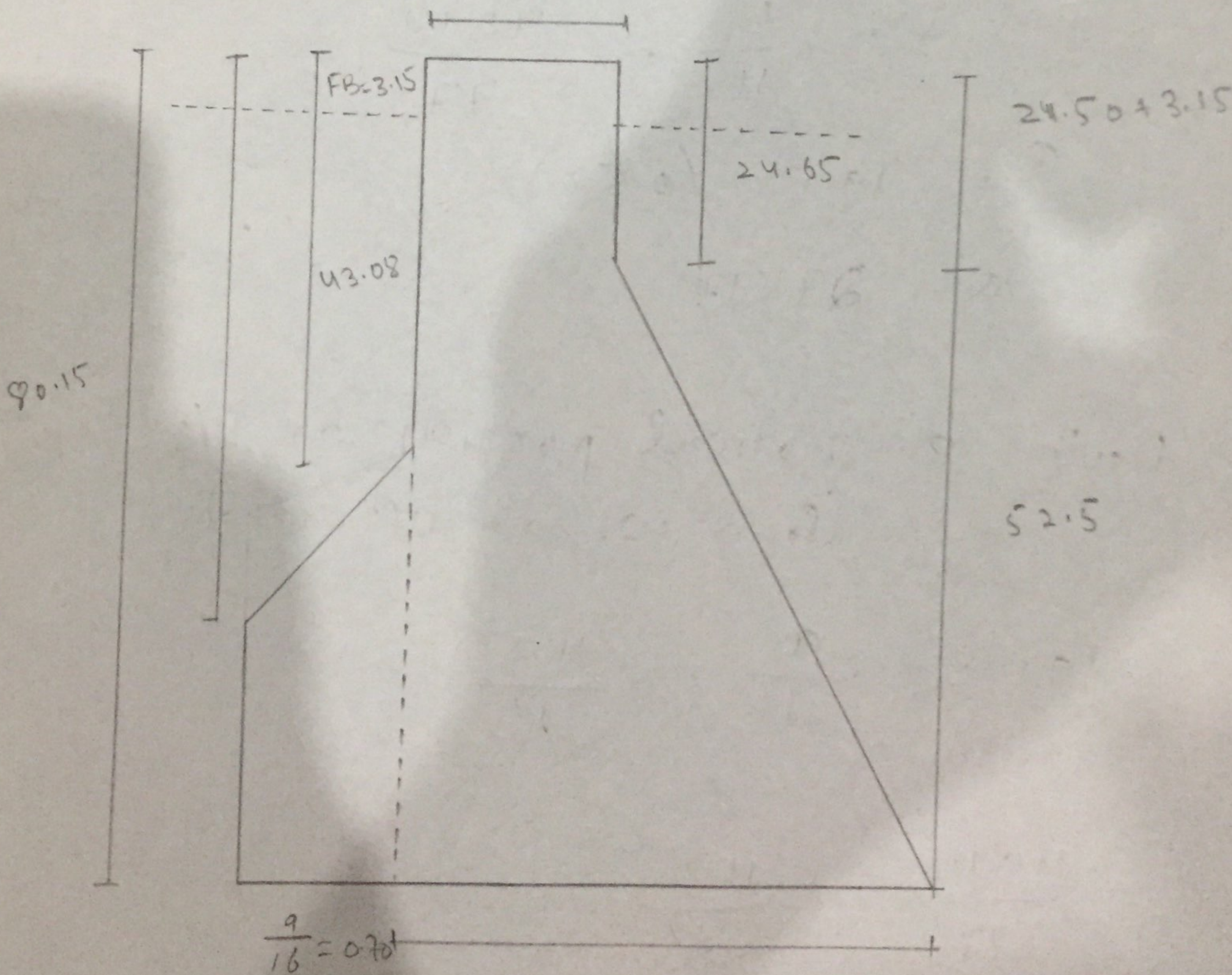
$$d' = 21.50$$

depth of vertical portion

$$d = d' + F_B$$

$$= 21.50 + 3.15$$

$$\boxed{d = 24.65}$$



Ans 3:

Dimension analysis is the analysis of the relationships between different quantities by identifying their base quantities.

Purpose of dimension alysis:

* To obtain scaling laws so that pototype performance can be predicted from model performance.
* To predict in the relationship between parameter.
* To generate non-dimensional paraters that help in the design of the experiment and in reporting of result

Fundamental dimension:

These are the basic quantities
for example.
Mass, Time, Distance etc.

secondary dimension:

Those quantity which posses more than one fundamental dimension velocity, L/T

Acceleration, L/T

Dansity, M/L^3

Similitude :-

Similitude is an indication of a relationship between a model and a prototype.

Pototype in case of hydraulic ~~stim~~ similitude is hydraulic structure or its a model study of a hydraulic structure.

Example:

consider a submerine modeled at 1/40" 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.

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Ans 4:-

Fall velocity:

when a grain particle is thrown in a 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 called the fall velocity of the grain or setting velocity.

Fall velocity depends on:

1) Particle diameter:

The diameter of the particle is directly proportional to the fall velocity because greater the size of particle it will ends to more faster as compared to the particle of small size, thus there will be more gravitation force on particle of greater size so it will fall quickly due to its weight.

2) 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 particles of low density.

3) Particle concentration:

concentration of particle size will considerably effect its fall velocity as the section having greater concentration will be settle down at the place thus cause more fall velocity comparing with section of low concentration.

4) Particle shape:
Particle having regular shapes tends to be effected more than irregular shape, since regular shape particles have even surfaces which often very little or no friction, while particles with irregular shape offers more friction as the particle will smaller surface area are more likely to the effected due to their less resistance.

5) Viscosity of water:
Fluid viscosity through porus media is approximated as inversely proportional to the kinamatic velocity, therefore increase in the velocity of a compound through porus media.

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

6) Turbulance of water:

Turbulance of water effect the fall velocity of water in reservior because the non-linearity & zig-zag part effect the flow of water and cause the variation in the flow.