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Section A

Semester 6th

Subject Hydraulic Engg

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Final paper.

Q. No 1

Given data:-

Velocity of paraffin in the prototype = 3.0 m/s

density of paraffin = 800 kg/m^3

Viscosity of paraffin = 0.002 kg/ms

Kinematic viscosity of water = 1.0×10^{-6} m^2/s

Required:-

velocity of water in model for dynamic similarity = ?

pressure drop in prototype if it is 60 kPa in model = ?

Ratio of quantities of flow in prototype & model = ?

Solution:-

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

List the relevant variables:-

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

Write down dimensions:-

Δp	M/LT^2
h	L
d	L
V	L/T
ρ	M/L^3
μ	M/LT

number of variables: $n = 6$

Number of independent dimensions:

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

Number of non-dimensional groups:

$n - m = 3$

Choose m = 3 scaling variables:

geometric (d);

Kinematic / time-dependent (V);

dynamic/mass-dependent (ρ).

Form dimensionless groups by non-dimensionalising the remaining variables: Δp, h & μ.

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

Recognition of the 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 be the same in model & prototype.

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

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

(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

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

$$= 0.5$$

Hence

$$V_m = \frac{V_p}{0.5} = \frac{3.0}{0.5}$$

$$= 6.0 \, m/s$$

(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,

$$\Delta P_p = 0.2 \times \Delta P_m$$

$$= 0.2 \times 60$$

$$= 12 \text{ KPa}$$

Date: ____________

Q. No 2

Sol:-

Maximum depth of water in reservoir (H) = 78

Specific Gravity of dam material (G) = 6.5

Allowable compressive strength of dam Masonry (Gall) = 788 T/m²

Height of wave (Hw) = 1.5m

$\mu = 0.7$

No uplift pressure $C_u = 0$

Step #01:-

$$H_{limiting} = \frac{G_{all}}{\gamma_w (G - C_u + 1)}$$

$$= \frac{788 \times 1000}{1000(6.5 - 0 + 1)}$$

$$H_{limiting} = 105.067\,m > H_w = 78m$$

So it is low Gravity Dam.

Step #02:-

Top width 'a'

Freeboard = 1.5 hwave
= 1.5 x 1.5
F.B = 2.25

height of Dam = HD = Hw + F.B
HD = 78 + 2.25
= 80.25m

a = 14% of HD
a = 0.14 x 80.25
a = 11.235m

Step #03:-

Base width "b'" (without off set)

(i) for No Sliding criteria

$$b' = \frac{Hw}{\mu G} = \frac{78}{0.7 \times 6.5}$$

b' = 17.14

b' ≅ 17m

(ii) For no tension Criteria:

$$b' = \frac{H_w}{\sqrt{G}} = \frac{78}{\sqrt{6.5}}$$

$$b' = 30.59$$

use

$$b' = 30m$$

Step # 04:-

Depth of vertical Portion on u/s side:-

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

$$h' = 2 \times 11.23\sqrt{6.5 - 0}$$

$$h' = 57.26$$

$$h' = 57m$$

Step # 05:-

upstream offset

$$= \frac{a}{16} \Rightarrow \frac{11.23}{16} \Rightarrow 0.701m$$

Step #06:-

Depth below the water level to the end of inclined portion in u/s $= 3.14 a \sqrt{C_7}$

$= 3.14 \times 11.23 \sqrt{6.5}$

$= 89.90 m$

Step #07:-

Total width of the base of the dam

$b = b' + \frac{a}{16} = 17 + \frac{11.23}{16}$

$b = 17.70 m$

Step #08:-

$\tan\theta = \frac{b'}{H} = \frac{17}{78}$

$\theta = \tan^{-1}\left(\frac{17}{78}\right)$

$\theta = 12.29°$

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Step # 09:-

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

$$\tan\theta = \frac{a}{d'} = \frac{11.23}{d'} \Rightarrow \tan\theta = \frac{11.23}{d'}$$

$$\frac{2}{3} d' = 11.23$$

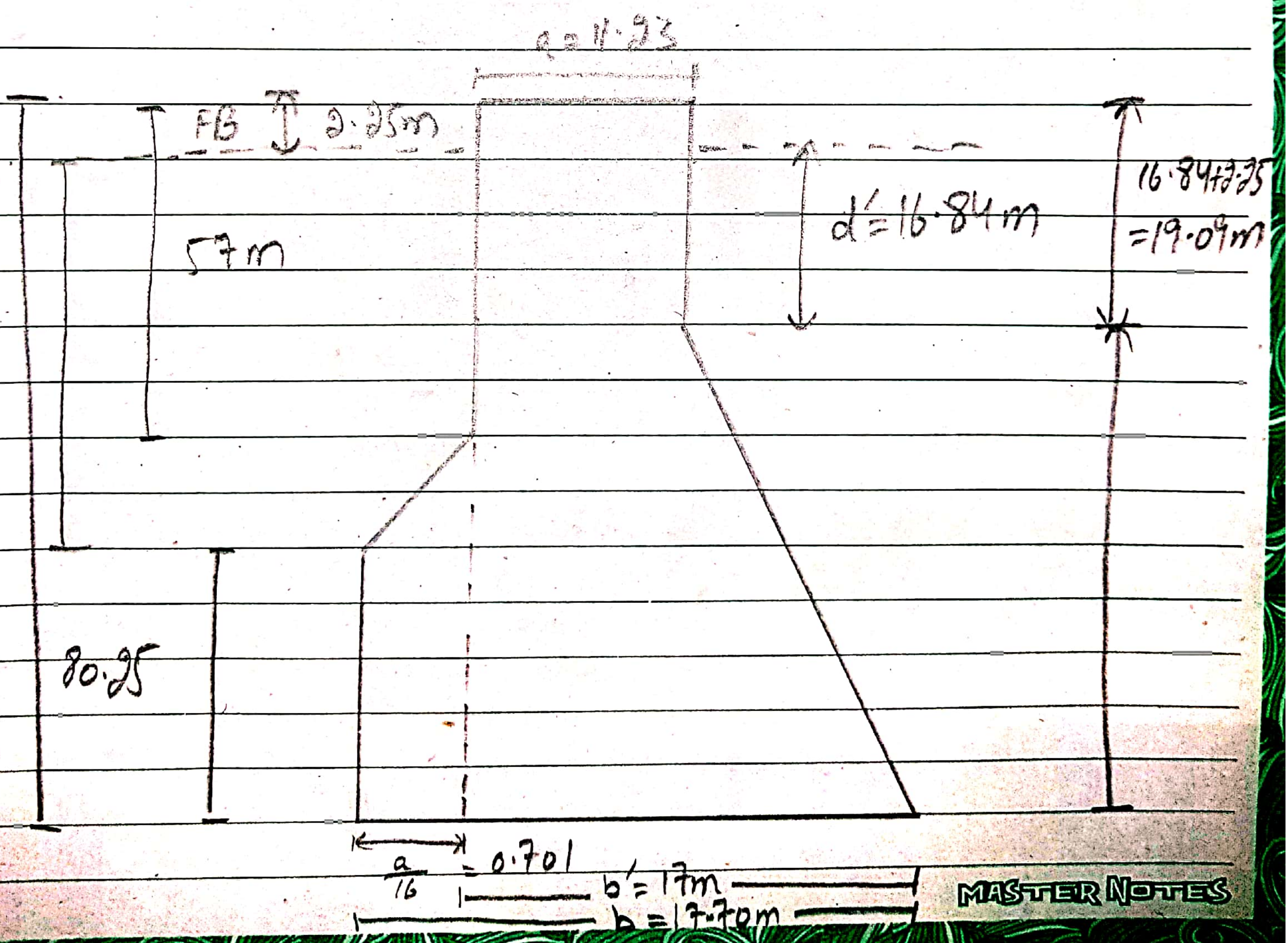
$$d' = \frac{11.23 \times 3}{2}$$

$$d' = 16.84\, m$$

depth of vertical portion

$$d = d' + FB = 16.84 + 2.25$$

$$d = 19.09\, m$$



Q No 3

Answer:-
Dimensional research is a statistical method using the dimensions of review

Purpose of dimension analysis:-

→ To receive the closing laws in order to determine system efficiency from sample data.

→ To estimate in variable relationshipe.

→ To create anti-dimensional parameter which aid in test design & transmission of results.

Fundamental dimension:-

There are the basic quantities for example

Time, T ; Distance, L ; Mass, M .

Secondary Dimension:-

Those quantity which passes more than one fundamental dimension velocity L/T ; Acceleration L/T ; Density M/L^3

Similitude:-

It is defined as similarity b/w the model & prototype in every aspect which means model & prototype have similar properties of model are completely similar.

- → It is used in testing engineering models.

For example:-

Find 1/30 scale size torpedo. The growth & job in 0.3°c moving ocean water at 4.5 m/s. The concept is to be checked in 15°c potable water.

Q. No 4

Fall Velocity:-

As a grain drops into still water it obtains a steady velocity as the grains upward fluid drag force becomes equivalent to the grains downward submerged weight.

This constant speed is known as the velocity of grain dropping. This is also termed velocity settling.

1) Particle diameter:-

The particle distance is roughly related to the dropping velocity as the particle size is bigger & that it appears to travel quickly relative to the tiny particles size & that there is more fundamental influence on the larger body & that it moves gradually due to its weight.

2) **Particle density:-** It is directly proportional to the applied of dropping velocity as high density particles appear to stabilize early relative to low-density particles.

3) **Particle concentration:-**

The intensity of the particle size would have a noticeable impact on its dropping velocity because the portion with a higher concentration would be deposited at the location, resulting in more dropping velocity relative to the low concentration segment.

4) **Particle Shape:-** Non-Spherical analogue particle fall up to 75% slower than equilent sphere Model show 100 um - non spherical vertical structure of modelled volcanic ash cloud is sensitive to particle shape.

5) Viscosity of water:-

The velocity of fluid through viscous dissipation is predicted as indirectly related to the viscosity of kinematic. Accordingly, a reduction in viscosity raises the velocity of a contrasted with porous material.

6) Turbulance of water:-

Water friction influences the decreasing water rate in the river as the anti-linearity & skimmy-zag direction impacts the movement of water allows the fluid to differ.