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ID	7802
SEMESTER	6th
SECTION:	A
SUBJECT	HYDRAULIC ENGINEERING
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EXAM:	FINAL TERM EXAM
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QUESTION: 01

Given data. pressure drop in Model = 60 KPa
Density of Paraffin = $800 Kg/m^3$
Viscosity of paraffin = 0.002 Kg/ms
Kinematic viscosity of water = $1.0 \times 10^{-6} m^2/s$
Velocity of paraffin in prototype = 3.0 m/s

Required:

a) Velocity of water in model = ?
b) Ratio of flow in prototype and Model = ?
c) pressure drop in prototype

Solution:

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

Now relevant variable we have:

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

By knowledge of dimensions we know

$\Delta p = ML^{-1}T^{-2}$ $\quad d = L$

$h = L$ $\quad V = LT^{-1}$

$\rho = ML^{-3}$ $\quad \mu = ML^{-1}T^{-1}$

Now, Number of variables $n = 6$

No. of independent dimensions $= m = 3$ (M, L, T)

No. of Non-dimensional groups $= n - m = 3$

Choose $m (=3)$, scaling variables

geometric (d), Kinematic/Time dependent (V)

dynamic/mass dependent (ρ).

From dimensionless groups by non-dimensionality

Remaining variables

$\Delta p, h, \mu$.

Now,

$$\pi_1 = \Delta p\, d^a V^b \rho^c$$

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

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

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

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

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

$\Rightarrow \pi_2 = \Delta p V^{-2} \rho^{-1} = \frac{\Delta p}{\rho V^2}$

$\pi_2 = h/d$ (By inspection, h is length)

$\pi_3 = \mu d^a V^b \rho^c$

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

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

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

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

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

$\Rightarrow \pi_3 = \mu d^{-1} V^{-1} \rho^{-1} = \mu / \rho V d$

Reynold's no suggest that we replace π_3 by $(\pi_3)^{-1} = \frac{\rho V d}{\mu}$

Hence dimensional analysis yields.

$\pi_1 = f(\pi_2, \pi_3')$

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

(d) Dynamic similarities require that all non-dimensional groups be same in model and prototype

$\pi_1 = (\Delta p/\rho V^2)_p = (\Delta p/\rho V^2)_m$

$\pi_2 = (h/d)_p = (h/d)_m$

$\pi_3' = (\rho V d/\mu)_p = (\rho V d/\mu)_m$

From last we have velocity ratio

$$\frac{V_p}{V_m} = \frac{(\mu/\rho)_p}{(\mu/\rho)_m}\frac{(d_m)}{(d_p)} = \frac{0.002/800}{1.0\times10^{-6}}\frac{\times 1}{\times 5} = 0.5$$

Hence

$$V_m = \frac{V_p}{0.5} = \frac{3.0}{0.5} = 6.0\,m/s$$

(b) Ratio of quantities of flow:

$$Q_p/Q_m = \frac{(\text{velocity} \times \text{area})_p}{(\text{velocity} \times \text{area})_m} = \frac{V_p}{V_m}\left(\frac{d_p}{d_m}\right)$$

$$= 0.5 \times 5^2$$

$$= 12.5$$

(c) 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

$$\Delta p_p = 0.2 \times \Delta p_m = 0.2 \times 60 = 12.0\,KPa.$$

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QUESTION: 02

Given Data:.

Maximum depth of water = 78 m = H_w

Specific gravity of dam material = G = 0.8

Allowable compressive strength = 780 T/m^2 = σ_{all}

Height of wave = h_{wave} = 1 m

$\mu = 0.7$ No uplift pressure = $C_u = 0$

Solution:

1- $$H_{limiting} = \frac{\sigma_{all}}{\gamma_w (G - C_u + 1)} = \frac{780 \times 1000}{1000(0.8 - 0 + 1)}$$

$$= 86.66 \text{ m} > H = 78 \text{m}$$

So its low gravity Dam.

2. Top Width "a"

Free board = 1.5 h_{wave}

= 1.5 × 1

F.B = 1.5 m

Height of Dam = H_D = H_W + F.B

= 78 + 1.5

H_D = 79.5 m

a = 14% of H_D

= 0.14 × 79.5

a = 11.13 m

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3. Base Width "b" (without offset)

(i) For No sliding criteria

$$b' = \frac{H_w}{\mu G} = \frac{78}{0.7 \times 8}$$

$b' = 1.39\ m$

(ii) For No Tension criteria

$$b' = \frac{H_w}{\sqrt{G}} = \frac{78}{\sqrt{8}}$$

$b' = 27.65$

use : $b' \approx 28\ m$

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

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

putting values

$h' = 2(11.13)\sqrt{8}$

$h' = 62.77\ m$

(5) Upstream off set :- $a/16$

putting values $a = \frac{11.13}{16} \Rightarrow a = 0.69$

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

putting values

$= 3.14\,(11.13)\sqrt{8}$

$= 98.53\ m$

Scanned with CamScanner

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(7) Total Width of Base of a dam

$b = b' + a/16$ ~~[crossed out]~~

putting values

$b = 28 + \frac{11.13}{16}$

$\boxed{b = 28.69}$

(8) $\tan \phi = \frac{b'}{H} = \frac{28}{78}$

$\phi = \tan^{-1} 0.35$

$\boxed{\theta = 19.29°}$

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

$\tan \theta = a/d' = \frac{11.13}{d'}$

$\tan \theta = \frac{11.13}{d'}$

$\frac{28}{78} d' = 11.13 \Rightarrow d' = 11.13 \times \frac{78}{28}$

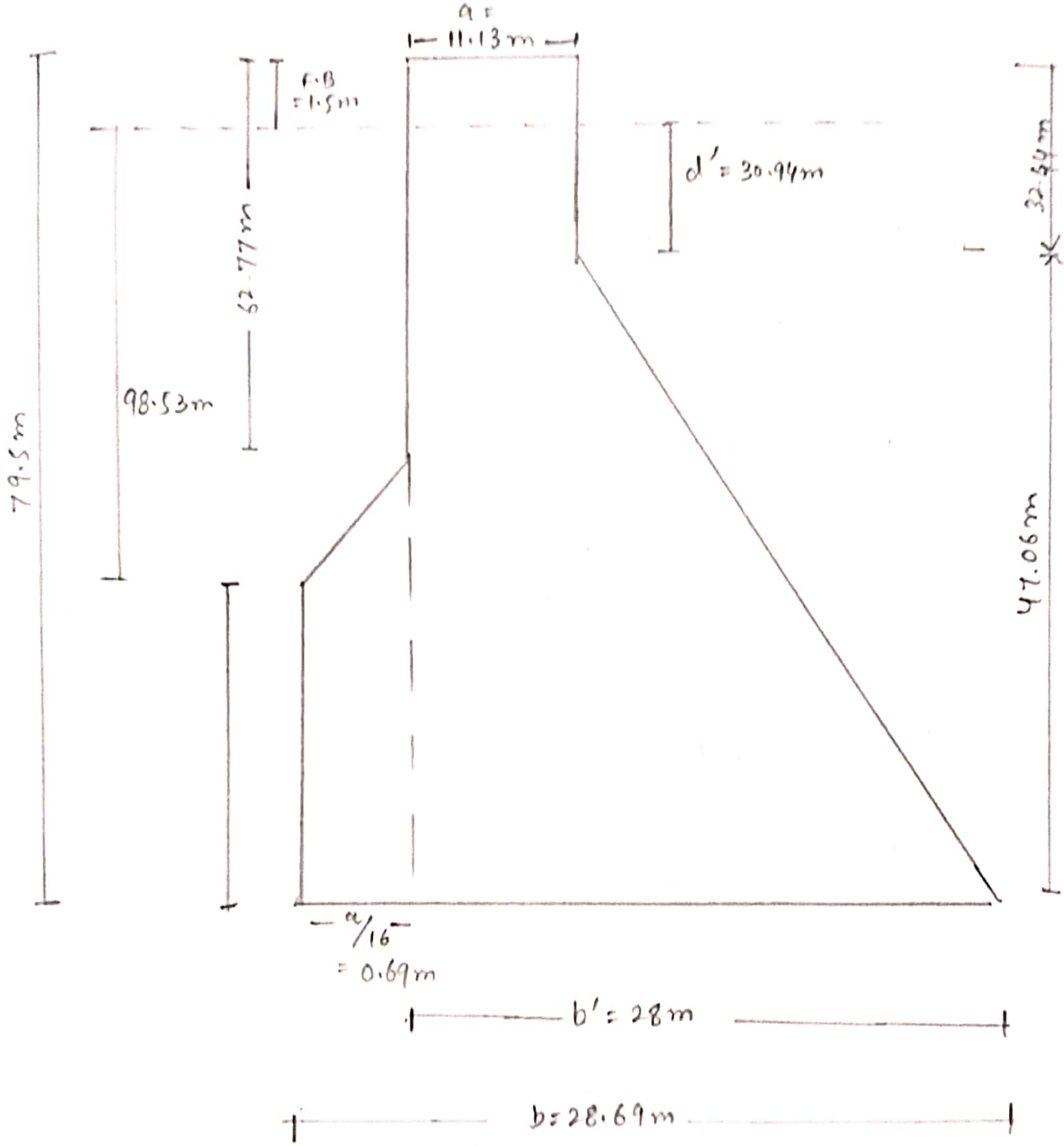
$d' = 30.94\ m$

depth of vertical portion

$d = d' + FB$

$= 30.94 + 1.5$

$\boxed{d = 32.44\ m}$


a = 11.13m
F.B =1.5m
d' = 30.94m
32.54m
62.77m
98.53m
79.5m
47.06m
a/16 = 0.69m
b' = 28m
b = 28.69m

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QUESTION: 03

Dimensional Analysis:-

It's a mathematical technique making use of study of dimensions. It deals with dimension of physical parameters involved in phenomenon.

First the physical parameters that influence phenomenon are determined and are grouped in dimensionless combinations so better understanding is made possible.

→ It provides a guide to those things that influence the phenomenon
It's used in research work for design and for conducting model tests.

Types of Dimension:-

1) **Fundamental Dimension / Quantities:**
They are basic quantities
for example.
Time (T)
Mass (M)
Distance (L)

2) **Secondary Dimensions:** These quantities possess more than one functional Dimension

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For example:

→ velocity is distance per unit time

L/T

METHODOLOGY :-

It follows basic principle that dimension of each term in equation on both sides are equal. such an equation is called dimensionally homogenous equation.

If no. of variable involved in phenomenon are known, then relation can be determined by.

(1) Rayleigh's Method

(2) Buckingham's π- Theorem

SIMILITUDE :-

"The similarity b/w model and its prototype in every respect which mean model and prototype have similar properties or model and prototype are completely similar.

There are three types of similarities

(1) Geometric similarity

(2) Kinematic similarity

(3) Dynamic similarity.

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Model Analysis:-

Experimental investigations are often performed on small scale called "Model Analysis".

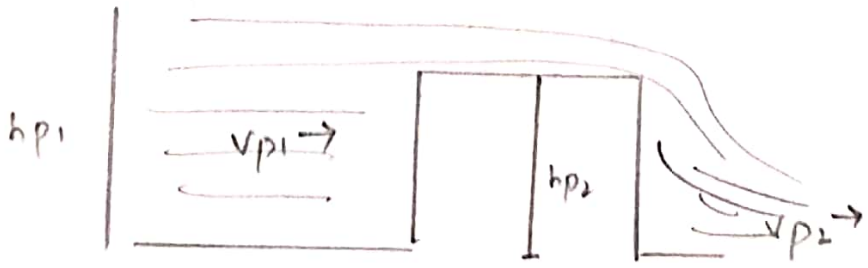
It's small scale replica of actual structure while prototype is actual structure of machine

→ Its necessary that ~~prototype~~ model should be smaller that prototype.

→ It's actually experimental method of finding solution to problem.

→ The performance of hydraulic structure can be predicted in advance

→ Merits of alternative design can be predicted with the help of model analysis to adopt economical and safe design.



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QUESTION: 04.

Fall velocity: "Falling grain in still water attains a constant velocity when upward fluid drag force on grain equals downward submerged weight of grain.

it's defined as fall velocity of the grain. also called settling velocity.

Fall velocity depends upon

(i) **Particle Diameter:-** Fall velocity and particle diameter has a direct relation. i-e if particle size increases the fall velocity also increases as compared to particles with smaller diameter.

(ii) **Particle Density:** Particle density and fall velocity are directly related i-e if density is increased fall velocity also increases and particles settle down more easily.

3. **Particle Concenteration:.** 7802 It effects fall velocity such that sections having greater concenteration will be settled having greater fall velocity than those having lower concenteration.

4. **Particle Shape:.** Irregular shape offers more resistance and friction. and are less likely to be effectual as compared to regular

5. **Viscosity of water:** Fluid velocity in inversly related to Kinematic velocity through porous media. i.e decrease in viscosity increase velocity of compound through porous media

6. **Turbulance of water:** It effects fall velocity because irregular & zig zag path effects flow of water and cause the variation in flow.