Final Term Paper

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Section	A
Subject	Hydraulic Engineering
Semester	6th
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Q:- 1/

Solution:-

List of Significant variables:-

μ, h, ΔP, d, V, ρ

Dimensions:-

$\mu = ML^{-1}T^{-1}$

$h = L$

$\Delta P = ML^{-1}T^{-2}$

$d = L$

$V = LT^{-1}$

$\rho = ML^{-3}$

Number of Independent dimension $\Rightarrow m = 3$ (M, L & T)

No: of variables $\Rightarrow n = 6$

No: of non-dimensional groups $\Rightarrow n - m = 3$

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So

$f(\pi_1, \pi_2, \pi_3) = 0$

d = geometric

$V = \frac{\text{kinematic}}{\text{time}} \Rightarrow$ flow

~~dynamic~~

$\rho = \frac{\text{dynamic}}{\text{mass}} \Rightarrow$ fluid.

$\Delta P, h, \mu \Rightarrow$ Remaining.

Now

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

Dimensional analysis.

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

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

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

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

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

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~~π_1~~ Hence

$$\pi_1 = \Delta P V^{-2} \rho^{-1}$$

$$\pi_1 = \frac{\Delta P}{\rho V^2}$$

For π_2 :-

$$\pi_2 = \frac{h}{d}$$

$$\pi_2 = h, d^{a_2}, V^{b_2}, \rho^{c_2}$$

$$M^0 L^0 T^0 = h (L)^{a_2} (LT^{-1})^{b_2} (ML^{-3})^{c_2}$$

$M = 0 = c_2 \Rightarrow c_2 = 0$

$L = 0 = a_2 + b_2 - 3c_2 \Rightarrow a_2 = b_2$

$T = 0 = -b_2 \Rightarrow b_2 = 0$

Hence

$$\pi_2 = \frac{h}{d}.$$

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Now For π_3

$$\pi_3 = \mu d^{a_3} V^{b_3} \rho^{c_3}$$

$$M^0 L^0 T^0 = (ML^{-1}T^{-1})(L)^{a_3}(LT^{-1})^{b_3}(ML^{-3})^{c_3}$$

$$= M^{1+c_3} L^{-1+a_3+b_3-3c_3} T^{-1-b_3}$$

Now

$M \Rightarrow 0 = 1 + c_3 \qquad \Rightarrow c_3 = -1$

$L \Rightarrow 0 = -1 + a_3 + b_3 - 3c_3 \qquad \Rightarrow a_3 = 1 + 3c_3 - b_3 = -1$

$T \Rightarrow 0 = -1 - b_3 + 0 \qquad \Rightarrow b_3 = -1$

Hence

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

$$\pi_3 = \frac{\mu}{\rho V d}$$

Now The relationship

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$$f(\pi_1, \pi_2, \pi_3) = f\left(\frac{\Delta P}{\rho V^2}, \frac{h}{d}, \frac{\mu}{\rho V d}\right)$$

Now

Reynold number $\Rightarrow R = \frac{\mu}{\rho V D}$

So

$$\pi_1 = \left(\frac{\Delta P}{\rho V^2}\right)_P = \left(\frac{\Delta P}{\rho V^2}\right)_m$$

we replace π_3 by π_3'

$$\pi_3' = (\pi_3)^{-1} = \frac{\rho V d}{\mu}$$

$$\pi_3' = \left(\frac{\rho V d}{\mu}\right)_P = \left(\frac{\rho V d}{\mu}\right)_m$$

we have

$$V_P = \left(\frac{\mu}{\rho}\right)_P \times d_m$$

$$V_m = \left(\frac{\mu}{\rho}\right)_m \times d_P$$

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Now

a) <u>Velocity:-</u>

Velocity of prototype (V_p) = 3.0 m/sec

From above equ:

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

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

Now

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

$$V_m = V_p/0.5$$

$$V_m = \frac{3.0}{0.5} = 6.0\ m/sec$$

$$\boxed{V_m = 6.0\ m/sec}$$

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b) Ratio of quantities of flow:-

$Q = AV$

$$\frac{Q_p}{Q_m} = \frac{(A \cdot V)_p}{(AV)_m} = \frac{V_p}{V_m}\left(\frac{d_p}{d_m}\right)^2$$

$$= 0.5 \times (5/1)^2$$

$$= 0.5 \times 5^2$$

$$\boxed{\frac{Q_p}{Q_m} = 12.5}$$

c) Value of pressure drop:-

$$\pi_1 = \left(\frac{\Delta P}{\rho V^2}\right)_p = \left(\frac{\Delta P}{\rho V^2}\right)_m$$

$$= \frac{(\Delta P)_p}{(\Delta P)_m} = \frac{\rho_p}{\rho_m}\left(\frac{V_p}{V_m}\right)^2 = \frac{800}{1000} \times (0.5)^2 = 0.2$$

$$\frac{(\Delta P)_p}{(\Delta P)_m} = 0.2$$

$$(\Delta P)_p = 0.2 \times (\Delta P)_p \Rightarrow 0.2 \times 60$$

$$\boxed{\Delta P_p = 12.0\ kPa}$$ Ans:

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Q:2/ Design/profile of Gravity Dam:-

Given data:-

1- Maxi depth of water = H = 78 m

2- Specific Gravity = G = 2.78

3- Allowable Compressive stress = σ_{all} = 780 T/m²

4- Height of wave = H_w = 3.9

$C_u = 0$, $\mu = 0.7$

Solution:-

(1) $$H_{limiting} = \frac{\sigma_{all}}{\gamma_w (G - C_u + 1)} = \frac{780 \times 1000}{1000(2.78 - 0 + 1)}$$

$$= \frac{780000}{3780}$$

$$\boxed{H_{limiting} = 206.349 m} > 78 m$$

So its Low Gravity Dam.

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⇒ **Top width "a":**

$$\text{Free board} = 1.5 \times H_w = 1.5 \times 3.9$$

$$\boxed{F.B = 5.85\,m}$$

$$\text{Height of Dam} = H_D = H_{water} + F.B =$$

$$78 + 5.85 = 83.85\,m$$

$$\boxed{H_D = 83.85\,m}$$

$$a = 14\% \text{ of } H_D$$

$$= 0.14 \times 83.85\,m$$

$$\boxed{a = 11.73\,m}$$

⇒ **Base width :- (b')**

i) = For No Sliding:

$$b' = \frac{H_{water}}{\mu G} = \frac{78}{0.7 \times 2.78} = 40.27 \simeq 41$$

$$\boxed{b' = 41\,m}$$

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iii) – **For No tension :-**

$$b' = \frac{H_{water}}{\sqrt{G}} = \frac{78}{\sqrt{2.78}} = 46.9 \simeq 47$$

~~b' = 47m~~ **b' = 47m**

So we will use b' = ~~30m~~ 47m

⇒ **Depth of vertical portion on upstream side.**

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

$$= 2 \times 11.73\sqrt{2.78 - 0}$$

$$h' = 38.9 \simeq 39 \text{ m}$$

~~h' = 39m~~ **h' = 39m**

⇒ **Up stream offsett:-**

$$\text{upstream offset} = \frac{a}{16}$$

$$= 11.73/16 = 0.73\text{ m}$$

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⇒ **Depth below the water level:-**

Depth below the water level to the end of inclined portion in upstream $= 3.14\, a \sqrt{G}$

$= 3.14 \times 11.73 \sqrt{2.78}$

~~= 9.5m~~ $= 61.1m$

⇒ **Total width of the base of the Dam:-**

$b = b' + \frac{a}{16} = 30 + \frac{11.73}{16} = 30.73$

$b = 30.73m$

⇒ **Inclination Angle:-**

$\tan\theta = \frac{b'}{H} = \frac{30}{78}$

$\theta = \tan^{-1}(0.38)$

$\theta = 20.80°$

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⇒ Depth of vertical portion on Down Stream:

$$\tan\theta = \frac{a}{d'} = \frac{11.73}{d'} \Rightarrow \tan\theta = \frac{11.73}{d'}$$

$$= 0.38\,d' = 11.73$$

depth of vertical portion = d

$$d' = \frac{11.73}{0.38} = 30.8$$

$$d = d' + F.B = 30.8 + 5.85 = 36.6\,m$$

$$\boxed{d = 36.6\,m}$$

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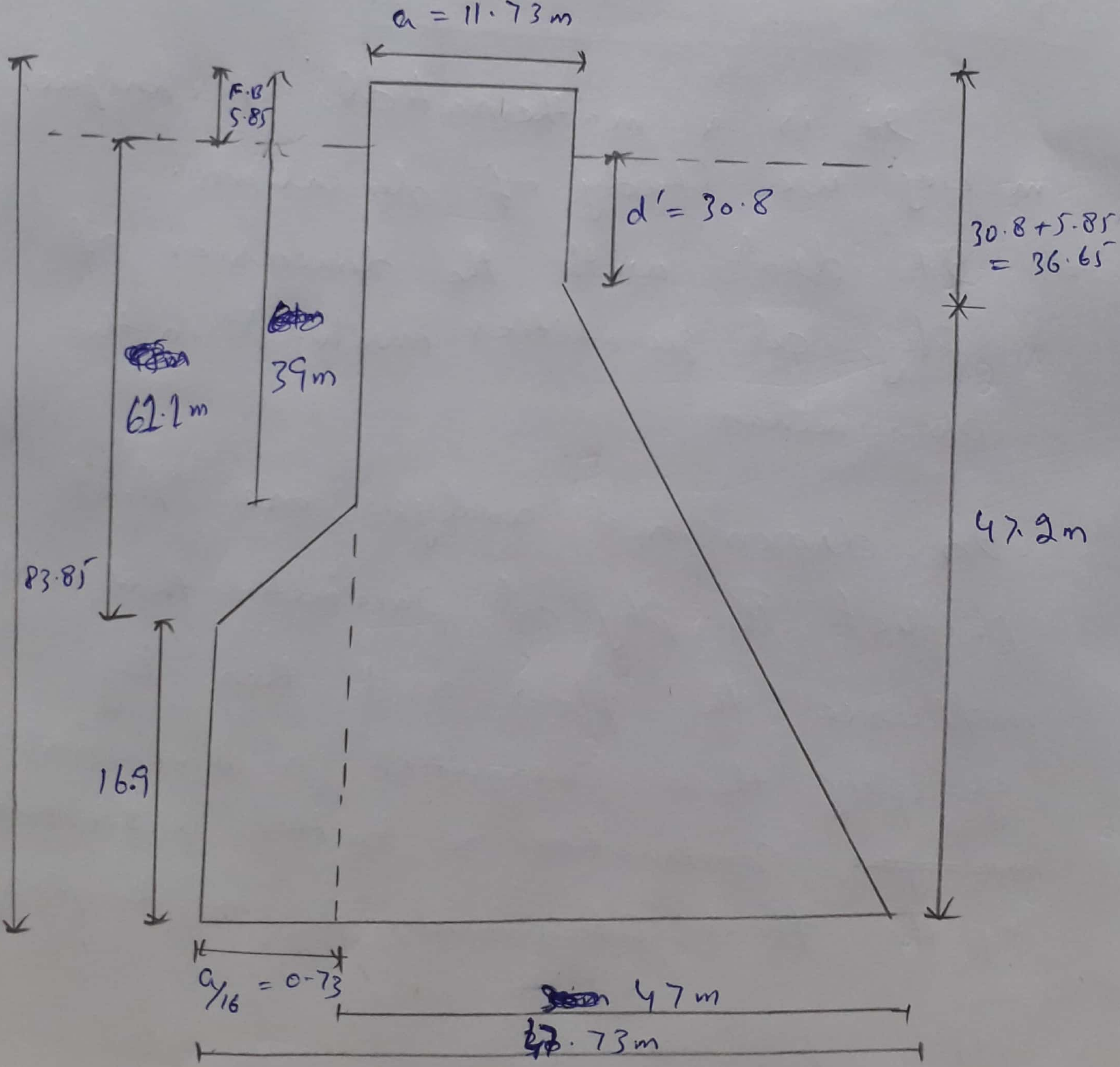

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Q:3/ Dimensional analysis:-

It is a mathematical technique making we study of dimensions.

→ It deal with the dimension of physical quantities involved in the phenomenan.

In dimensional analysis, one first predict the physical parameter that will influence the flow and then by grouping these parameters in dimensionless ~~analysis~~ combination a better understanding of the flow phenomenon is made possible

Types of Dimensions:-

1) Fundamental Dimensions:-

these are the basic quantities

e.g: Time, Distance, Mass

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Force = Mass × Acceleration

$$F = Mass \times \frac{meter}{sec^2}$$

$$F = Mass \times m\,sec^{-2}$$

$$F = M \times LT^{-2}$$

$$\boxed{F = MLT^{-2}}$$

Secondary Dimensions:-

These are those quantities which posses more then one fundamental quantities.

Like

$$Velocity = L/T$$

⇒ **Similitude:-**

It is defined as similerity b/w the model and prototype in every respect which mean model and

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prototype are Completly Similar.

Types of Similarities:-

① Geomatric Similarity:-

It is the Similarity of Shape. It is said to exist b/w model & prototypes if ratio of all Correspondi linear dimension in the model and prototype are equal.

② Kinematic Similarity:-

Similarity of motion.

It is said to be exist b/w model & Prototype. if ratio of velocities and accelaration at the Corresponding Point in the model & prototype are Equall.

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③ <u>Dynamic Similarity:-</u>

It is Similarity of forces, It is said to exist between models and prototype if the ratio of forces at the corresponding points in the model and prototype are equal.

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Q:41 Effect on fall velocity:-

Fall velocity:-

When a grain falls down in still water it obtain a constant velocity when the upward fluid drag force on the grain is equal to the down ward submerged weight of the grain. This constant velocity is defined as fall velocity.

Fall velocity depend upon:.

1) **Partical concentration:-**

Concentration of partical size will considrably effect its fall velocity as the section having greater concentration. will be setteled down at place

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thus causing the more fall velocity compacting with section of low concentrat

2) Partical diameter:-

The diameter of a sphere partical has same specific Gravity and the terminal uniform setling velocity as the given partical in the same sedimantatin.

3) Partical density:-

Density of the Partical is directly proportional to the rate of fall velocity since partical with high density tends to settle down early compared with the partical of density.

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4) **Partial Shape:-**

Partial having regular shape tend to be effected more then irregular shaps since regular shaps particals have even surfaces which offers very little or no friction while partical with irregular shape offers more friction as the partical with smaller surface area.

5) **Viscosity of water:-**

Fluid velocity through porous media is approximated as inversly proportional the kinematic viscosity.

$$F_D = 6\pi \eta r V_T$$

6) **Turbulance:-**

Turbulence of water ~~in~~ ~~reservoir~~ effect the fall velocity of

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