Final Paper

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Q.2 A Prototype gate valve which will control the flow in a pipe system conveying paraffin is to be studied in a model. List the significant variable on which the pressure drop across the value would depend. Perform dim-ensional analysis to obtain the relavent non-dimensional groups.
A 1/5 scale model is built to determine the pressure drop across the valve with water as the working fluid.

(a) For a particular opening when the velocity of paraffin in the prototype is 3.0 ms^{-1}. What should be the velocity of water in the model for dynamic similarity?

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(b) What is the ratio of the Quantities of flow in prototype and model?

(c) Find the pressure drop in the prototype if it is 60 kpa in the model?
(The density and viscosity of paraffin are 800 kgm^{-3} and 0.002 $kgm^{-1}s^{-1}$ as respectively. Take the kinematic viscosity of water as $1.0 \times 10^{-6} m^2 s^{-1}$)
The pressure drop Δp is expected to depend upon the gate opening h, the overall depth d, the velocity V, density ρ, and viscocity μ.

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 relavent variables:

ΔP, h, d, v, ρ, μ.

Dimesions:

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

Number of Non-dimensional groups, $n - m = 3$.

⇒ Choose $m = 3$ scaling variables

- gematric (d)
- Kinematic / Time - dependent (v)
- Dynamic / Time - Dependent (ρ).

⇒ For dimensionless groups by non-dimensionlessing 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: $0 = 1+c \Rightarrow c = -1$

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

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

$\Rightarrow \Pi_1 = \Delta p V^{-2} \rho^{-1} = \frac{\Delta p}{\rho V^2}$.

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

$\Pi_3 = \mu d^a V^b \rho^c$ (Probably 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: $0 = 1+c \Rightarrow c = -1$

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

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

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

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

$$\Pi_3 = f(\Pi_2, \Pi_3')$$

i-e:

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

(a) Dynamic analysis similarity requires that all non-dimensional groups be the same in model and prototype

i.e:

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

$$\Pi_3 = \left(\frac{h}{d}\right)_p = \left(\frac{h}{d}\right)_m$$

$$\Pi_3' = \left(\frac{\rho v d}{\mu}\right)_p = \left(\frac{\rho v d}{\mu}\right)_m$$

From the last we have a velocity ratio:

$$\frac{V_p}{V_m} = \frac{(\mu/\rho)_p}{(\mu/\rho)_m} \quad \frac{d_m}{d_p} = \frac{0.002/800}{1.0 \times 10^{-6}} \times \frac{1}{5}$$

$$= 0.5$$

Hence

$$V_m = \frac{V_p}{0.5} = \frac{3.0}{0.5} = 6.0 ms^{-1}$$

(b) The ratio of 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 the pressure drop:

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

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

Hence,

$$\Delta p_p = 0.2 \times \Delta p_m = 0.2 \times 60 = 12.0 \text{ kpa.}$$

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Q No ②: Design a practicle profile of gravity dam with the following data:

1: Maximum depth of water of the in the reserviour is (your first two digits of R)

2: Specific gravity of dam materials is G (can be of your own choice).

3: All the Allowable Compressive strength for the dam masonary is (your first T three digits of R T/m²)

4: Height of wave is Hw (can be of your own choice)

5: G and Hw is of your own choice but should be differ from one another.

Solution:

$\because 787, \quad \because G = 2.4 \quad C_u = 0.$

1: $H_{limiting} = \frac{\sigma_{all}}{\gamma_w (G - C_u + 1)} = \frac{120 \times 787 \times 1000}{1000(2.4 - 0 + 1)}$

$= 27776.47 m$

Let $H_w = 24000 m$

Thus $27776.47 > H_w = 24000$

2: Top width "a"

Free board $= 1.5 h_{wave} = 1.5 \times 24000$

Free board = 36000

Height of dam:

$= H_D = H_w + FB = 24000 + 36000$

HD = 60000

$a = 14\% \times$ of HD

$= 0.14 \times 60000 \Rightarrow$ **a = 8400**

3: Base width "b": (without offset)

(i) For no sliding criteria:

$$b' = \frac{Hw}{\mu G} = \frac{24000}{0.7 \times 2.4} = 14285.71$$

$$b' \approx 14286$$

(ii) For no tension criteria:

$$b' = \frac{Hw}{\sqrt{G}} = \frac{24000}{\sqrt{2.4}} = 15492.86$$

$$b' \approx 15493$$

4: Depth of verticle portion on U/S side:

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

$$h' = 2 \times 8400\sqrt{24 - 0}$$

$$h' = 26026.44$$

$$h' \approx 26027$$

5: Upstream offset:

$$\frac{a}{16} = \frac{8400}{16} = 525m.$$

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6: Depth below the water level to the end of inclind portion u/s =

$= 3.14 a \sqrt{9}$

$= 3.14 (8400) \sqrt{2.4}$

$= 40881.7 \, m.$

7: Total width of the base of the dam: $b = b' + \frac{9}{16} = 15493 + \frac{8400}{16}$

$$\boxed{b = 16018 \, m.}$$

8: $\tan \theta = \frac{b'}{H} = \frac{15493}{24000}$

$\theta = \tan^{-1}\left(\frac{15493}{24000}\right)$

$\theta = 32.84°$

9: Depth of the verticle portion: D/s:

$\tan \theta = \frac{9}{d'} = \frac{8400}{d'}$

$\left(\frac{15493}{24000}\right) d' = 8400$

$d' = \frac{8400 \times 24000}{15493} = \boxed{13012.32 m}$

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Depth of the Verticle Portion:

$$d = d' + FB = 13012.32 + 36000$$

$$= \boxed{49012.32 m}$$

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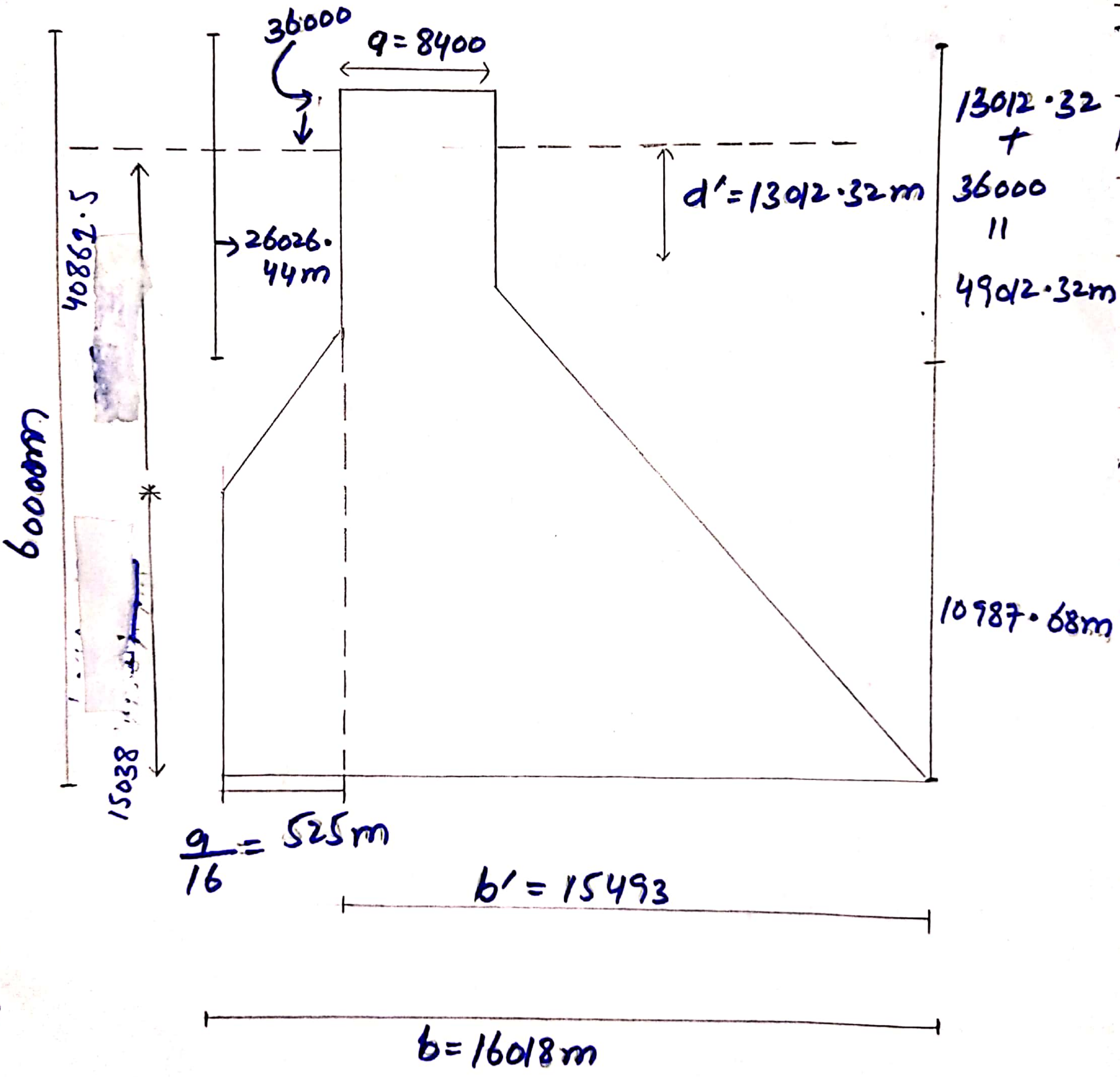

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Q No ③ Using any hydraulic model and explain the concept of Dimensional analysis and similitude. Each student should have separate model analysis.

Ans: In engineering and science, dimensional analysis is the analysis of the relationships between different physical quantities by identifying their base quantities (Such as length, mass, time and electric charge) and units of measures (such as miles vs kilometres or pounds vs kilogrames) and tracking these dimensions as calculations or comparions are performed. The conversion of units from one dimensional units to another is easier, with in the metric or SI ~~un~~ System than the others due to The regular 10 base in all units. Dimensional analysis are more specifically the factor labelled methode, also known as the unit factor methode is a widely used techniques for such conversions the rules of algebra.

Base quantities and their dimensions in three types of System of units:

	Type 1	Type 2	Type 3.
Base quantities & Dimensions	L, M, t	L, F, t	L, m, F, t.

Similitude and model Studies:

Simititude or dynamic Similarity, between two geomatrically similer Systems exists when the ratios of inertial force to the indivisual force components. in the first system are the same as the corresponding ratios in the second system. at the corresponding points and space hence for absolute dynamic similarity Reynolds, Froud and weber numbers must be the same in the two Systems if this can be achieved the flow pattern will be geomatrically similer i.e Dynamatic similarity exist.

Example:

Dimensional analysis similitude and hydralic module:

Example:

Derived an ~~equation~~ expressions for the discharge per unit crest length of Rectangular weir over which a fluid of density "ρ" and dynamic viscosity "μ" is flowing with a head the crest height is "P" By comparison with the discharge equation obtain from energy consideration:

$$q = \frac{2}{3}\sqrt{2g}\, C_d H^{3/2}$$

State the perimetre on which the discharge co-efficiant depends for a given crest profile.

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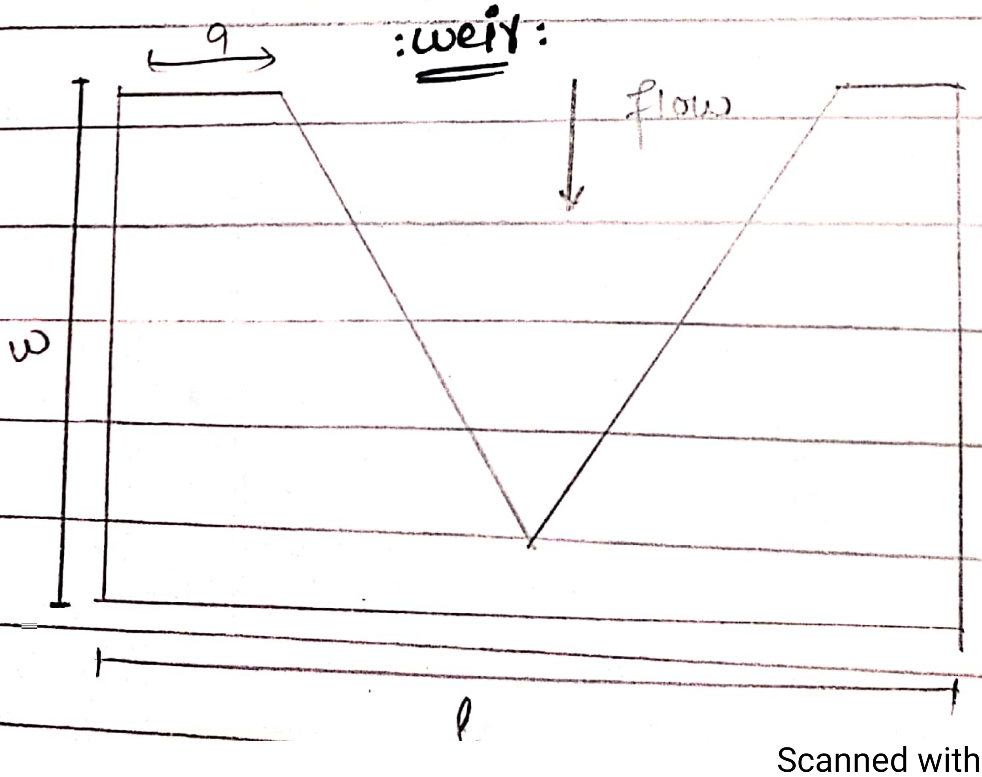
or $q = g^{\frac{1}{2}} H^{\frac{3}{2}} \phi \left[\frac{\rho g^{\frac{1}{2}} H^{\frac{3}{2}}}{H}, \frac{\rho g H^2}{6}, \frac{P}{H} \right]$

Hence

$$C_d = f\left[Re, We, \frac{P}{H}\right]$$

In addition, of course the discharge co-efficiant will depends on the crest profile and the influence of this factor togather with that of the non-dimensional groups in the above expression can only be found from experiments.



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Q NO (4) What will be the effect of Sediment particle dia, particle concentration, particle shape, viscosity of water, turbulance of water flowing and reservoiers on fall velocity explain Detail?

Ans: **Particle diametre:** The diametre of the particle is directly proportional to the fall velocity because greater the size of particle so it will tends to move faster as compared to the particle of small size thus there will be more gravitational force on particle of greater size so it will fall quickly due to it's weight.

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

⇒ **Viscosity of water:**

From the experiment study we can see that perimetre such as temperature and pressure changed the magnitude of viscosity, so the section of water having

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⇒ **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 particle of low density.

⇒ **Particle Concentration:**

Concentration of particle size will considerably effect it's fall velocity as the section having greater Concentration will be settled down at the place at the place thus causing more fall velocity comparing with section of low concentration particle shape.

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more temp and pressure will fall objectively more due to increase in the kinetic energy. so fall velocity will be more.

⇒ **Turbulance of water:**

Turbulance of water depends upon the different factors such as velocity, it will effect the fall velocity because of it's zigzag motion thus the velocity varies at every point which is why it effect the fall velocity, more over increase in the kinetic energy tends to effect the fall velocity compared with steady fluid.