- **NAME :-**
  Muhammad yaseen
- **I.D :-**
  7544
- **Section :-**
  "B" - senior
- **Subject :-**
  "Hydraulic Engineering"
- **Dept :-**
  Civil
- **Submitted to :-**
  Engr. FAWAD AHMAD

Q :- 1 :- **Given Data:-**

Velocity of parrafin = 3 m/s
Pressure in model = 60 kpa
Density of parrafin = 800 kg/m³
Viscosity of parafin = 0.002 kg/m.s
Kinematic viscocity of water = 1.0×10^{-6} m²/s

Solution:-

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

* List the revelant variables.

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

* dimensions are;

$\Delta p \rightarrow ML^{-1}T^{-2}$

$h \rightarrow L$

$d \rightarrow L$

$v \rightarrow LT^{-1}$

$\rho \rightarrow ML^{-3}$

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

* number of variable, $n = 6$
* number of independent = 3 (M, L and T)
* number of non-dimensional group = $n - m = 3$

Choose m (=3) scaling variable:

geometric (d); kimetic/time dependant (v), dynamic/mass dependent (ρ)

I.D: 7544

(3)

* form dimensionless group by non-dimensionlizing variable; $\Delta p, h, \mu$.

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

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

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

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

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

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

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

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

$\Pi_3 = \mu d^a v^b \rho^c$ (probably obiviously by now but here goes any way.

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

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

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

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

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

$$\Rightarrow \Pi_3 = \mu d^{-1} v^{-1} \rho^{-1} = \frac{\mu}{dv\rho}$$

Recognition of reynold's number suggest that we replace Π_3 by $\quad \Pi_3' = (\Pi_3)^{-1} = \frac{\rho v d}{\mu}$

hence dimensional analysis yield.

$$\Pi_1 = f(\Pi_2, \Pi_3')$$

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 and prototype

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

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

[automatic similar shape 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

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

hence

$$V_m = \frac{V_p}{0.5} = \frac{3}{0.5} = 6 \text{ m/s}$$

(b) The ratio of Quantity of flow

$$\frac{Q_p}{Q_m} = \frac{(\text{Velocity} \times \text{Area})_p}{(\text{Velocity} \times \text{Area})_m} = \frac{V_p}{V_m}\left(\frac{d_p}{d_m}\right)^2$$

$$\frac{Q_p}{Q_m} = 0.5 \times 5^2 = 12.5$$

(c) finally for pressure drop

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

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

$$\Pi_1 = \frac{800}{1000} \times 0.5^2 = 0.2$$

$$\Delta P_p = 0.2\, \Delta P_m$$

$$\Delta P_p = 0.2 * 60$$

$$\boxed{\Delta P_p = 12.0 \text{ kPa}}$$

Q:-02 :- Given Data:-

H_w, maximum depth of water in Reserviour = 75m
Specific gravity of dam material, $G = 2.567$
Allowable Compressive Strength for Dam masonary = 754 T/m²

Heigh of wave, $H_{wave} = 1.355$ m

$\mu = 0.75$

No uplift pressure, $C_u = 0$

Solution:-

(i) Hlimiting:- $= \dfrac{\sigma_{all}}{\gamma_w(G - C_u + 1)}$

$= \dfrac{754 * 1000}{1000(2.567 - 0 + 1)}$

$= \dfrac{754000}{1000(2.567+1)}$

$= 211.38\text{ m} > 75\text{m}$

So it is low gravity dam.

(ii) Top width "a"

free board $= 1.5 * h_{wave}$
$= 1.5 * 1.355$

$F.B = 2.03\text{m}$

height of Dam $= H + F.B = 75 + 2.03$
$H.D = 77.03\text{m}$

$a = 14\%$ of H.D

$a = 14\% * 77.03$

$a = \frac{14}{100} \times 77.03$

$\boxed{a = 10.78m}$

(3) Base width "b" "with Cutoff set"

(i) for no sliding Criteria:-

$b' = \frac{H_w}{\mu G} = \frac{75}{0.75 * 2.567} \cong 39m$

(ii) for no tension Criteria:-

$b' = \frac{H_w}{\sqrt{G}} = \frac{75}{\sqrt{2.567}}$

$b' = 46.8 \cong 47m$

Use $\boxed{b' = 47m}$

(4) Depth of vertical portion on U/s side:-

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

$h' = 2 * 10.78\sqrt{2.567 - 0}$

$\boxed{h' = 34.5m}$

1.0.7544 7

(5) upstream off-set $= \frac{a}{16}$

$$\frac{a}{16} = \frac{10.78}{16}$$

$$\frac{a}{16} = 0.673\,m$$

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

$$= 3.14 * 10.78\sqrt{2.567}$$

$$= 54.3\,m$$

(7) Total width of the base of the dam

$$b = b' + \frac{a}{16} = 47 + 0.673$$

$$\boxed{b = 47.673\,m}$$

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

$$\tan\theta = \frac{b'}{H} = \frac{47}{75}$$

$$\boxed{\theta = \tan^{-1}\left(\frac{47}{75}\right) = 32.07^\circ}$$

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

$$\tan\theta = \frac{a}{d'} = \frac{10.78}{d'}$$

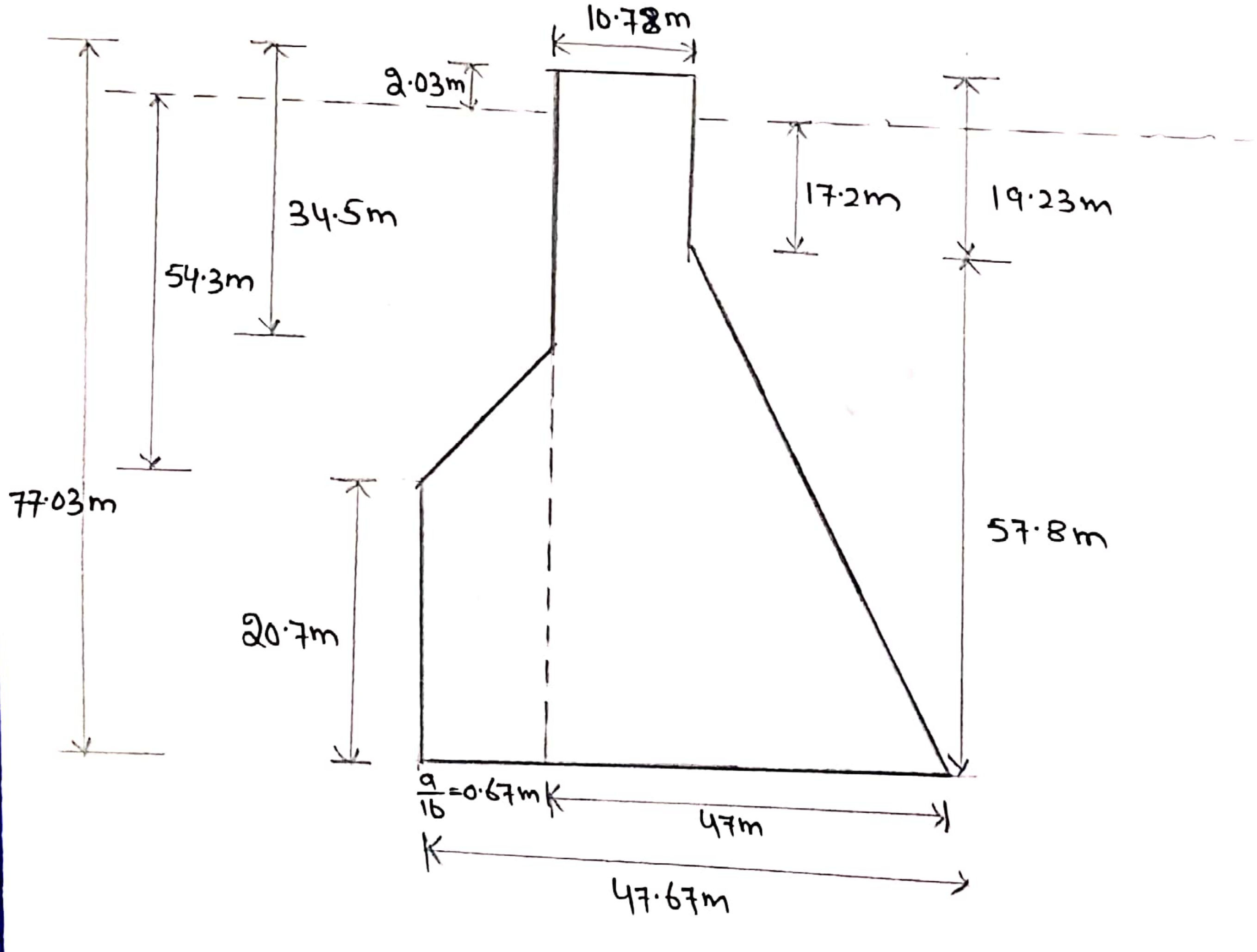
$$d' = \frac{10.78}{\tan 32.07^\circ} = 17.2\,m$$

Depth of vertical portion

$$d = d' + F.B$$

$$= 17.2 + 2.03$$

$$\boxed{d = 19.23\ m}$$



I-D = :7544

9

Q 3:- Similitude and Dimension Analysis

⊙ Analysis to turbomachines:-

* Pumps (centrifugal , axial flow)
* turbines (impulse, reaction)

⇒ Dimensional analysis useful to make generalization about turbomechanic or distinguish between them.

Relevant variables with reference to power (P)

* Impeller dia (D)
* Rotational speed (N)
* Flow (Q)
* Energy added or subtracted (H) $[H] = Nm/kg = m^2/s^2$
* Fluid property such as viscosity , (μ) density (ρ), Elasticity.

" Dimensional analysis for turbomechanics "

* Assume the following relationship among variables

$$f\{P, D, N, Q, H, \mu, \rho, E\} = 0$$

Buckingham's Theorm:-

Three fundamental dimension (M, L, T) and 8 variables imply that 8-3=5 π term can be formed.

Scanned with CamScanner

$I = D = 7544$

* select, ρ, D, and N as variables containing the 3. fundamental dimensions to be combined with the remaining 5 variables { P, Q, H, μ and E).

* possible to use other variables combination that contains the fundamental dimensions

ρ, D, N combined with μ yields.

$\Rightarrow$ $\Pi_1 = \mu^a \rho^b D^c N^d$

Solving the dimensional equation gives

$$\Pi_1 = \frac{\rho N D^2}{\mu} = Re$$

* Derive other Π-terms in the same manners

$\Rightarrow$ ρ, D, N combined with $E \rightarrow \Pi_2 = \frac{\rho N^2 D^2}{E} = \frac{N^2 D^2}{a^2} = M^2$

$\Rightarrow$ ρ, D, N Combined with $P \rightarrow \Pi_3 = \frac{P}{\rho N^3 D^5} = C_P$

$\Rightarrow$ ρ, D, N Combined with $Q \rightarrow \Pi_4 = \frac{Q}{N D^3} = C_Q$

$\Rightarrow$ ρ, D, N Combined with $H \rightarrow \Pi_5 = \frac{H}{N^2 D^2} = C_H$

* Summarizing the results;

$$\frac{P}{\rho N^3 D^5} = f'\{C_Q, C_H, Re, M\}$$

Scanned with CamScanner

I-D: 7544

11

OR;

$$\Rightarrow \frac{Q}{ND^3} = f''\{C_P, C_H, Re, M\}$$

$$\Rightarrow \frac{H}{N^2D^2} = f'''\{C_P, C_Q, Re, M\}$$

Previous analysis:

form a new π-term

$$\pi_3' = \frac{P}{\rho Q H} = \frac{C_P}{C_Q C_H} f^{IV}\{C_Q, C_H, Re, M\}$$

$\Rightarrow$ incompressible flow with C_Q & C_H held constant

$$\frac{P}{\rho Q H} = f^{V}\{Re\} = \eta_H$$

$\eta_H \Rightarrow$ hydraulic efficiency.

* **<u>Alternative Approach:-</u>**

Assume that relationship b/w P and ρ, Q, H is known, that μ includes both Re and mechanical affects

Assume relationships :- (incompressible flow)

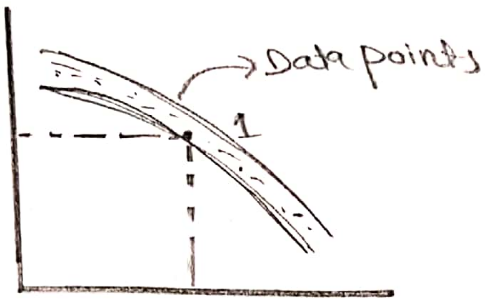
$$f\{D, N, Q, H, \mu\} = 0$$

Alternative:

$$\frac{H}{N^2D^2} = f'\left\{\frac{Q}{ND^3}, \eta\right\}$$

Typical plot of Experimental Data:-

$C_N = \frac{H}{N^2 D^2}$



$C_Q = \frac{Q}{ND^2}$

$$H \sim D^2$$
$$Q \sim D^3$$

Alternative Dimensionless term:-

Specific speed pumps:-

$$N_s = \frac{N\sqrt{Q}}{H^{3/4}}.$$

(represent actual speed when machine operates under unit head in unit flow)

* Common to relate η to N_s
* Characterize classes of Pumps

* **Specific speed (turbines)**

$$N_s = \frac{N\sqrt{P}}{\sqrt{\rho}\, H^{5/4}}$$

JD = 7544

* Application of Dimensional analysis to pipe friction :-

Assume the wall shear stress (τ_o) depends on
* mean velocity
* Dimeter (D)
* mean height of roughness projection.
* fluid density.
* fluid viscosity.

⇒ Relation should hold :

$$f\{\tau_o, v, d, e, \rho, \mu\} = 0$$

<u>Buckingham's Theorm</u>:-

⇒ v, d, ρ combine with τ_o yields

$$\pi_1 = \tau_o^a v^b d^c \rho^d$$

⇒ solving dimensional equation gives

$$\pi_1 = \frac{\tau_o}{\rho v^2}$$

further analysis gives.

$$\pi_2 = \frac{e}{d}, \quad \pi_3 = \frac{Vd\rho}{\mu}$$

⇒ following relation may derive.

$$\frac{\tau_o}{\rho v^2} = f'\left\{\frac{vd\rho}{\mu}, \frac{e}{d}\right\} = f\left\{Re, \frac{e}{d}\right\}$$

$\frac{e}{d}$ = relative roughness

Scanned with CamScanner

Hydraulically Smooth

rough flow

Darcy - Weisbach friction formula:-

frictional losses in pipe

$$h_L = f \frac{L}{d} \frac{V^2}{2g}$$

Energy equation:-

$$h_L = \frac{\tau_0 L}{\rho g R_h}$$

$$f = f''\{Re, \frac{e}{d}\}$$

Q4:- Factor affecting fall velocity of sediments:-

When a grains falls down in stillwater it obtain a constant velocity when the upward fluid drag force on the grain is equal to the downward submeged weight of grain. This constent velocity is defined as the fall velocity.

Factors affect this velocity are.

* Particals dia
* Particles density
* Particle concentration
* Shape of particle
* viscosity of water.
* Turbulency.

(i) particles diameter:-

The particles with greater dia will settle more quickly than the particles of smaller dia. Hence the fall gravity velocity of sediments is directly proportional diameter of particles. as usually greater the mass greater will be velocity.

$$V \propto d^2$$

ii) Particles density:-

The term density is defined as mass per unit volume. When mass increase density will also increased so sediment of higher density attains more velocity the low densed sediment. So density is directly proportional to fall velocity.

* in some case particle density is less than dispersed medium than particles floats.

iii) Particle concentration:-

Concentration of particles will considerabley effect its fall velocity as the section having greater concentration will be settled down at the place thus causing more fall velocity company with section of low concentration.

iv) Particle Shape:-

it has significance effect on the fall velocity. Particles having regular shape tends to be effected more than irregular shape. Since regular shaped particle have even surfaces which offer very little or low friction while particle with Smaller Surface area are more lightly to be effected due to less resistance.

(5) Viscosity of water:-

The fluid shear viscosity and elatisity both seem to have significant effect on the particle settling velocity. hence insuch cases increasing the fluid elasticity can help to reduce particle seettling velocity even at lower shear viscosity value.

(6) Turbulency of water:-

Turbulency of water depends upon the different factor such as velocity. It will effect the fall velocity because of its zig-zag motion thus the velocity varies at every point which is why its effect the fall velocity.