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Section: "A"

Semester:
6th

Subject:
Hydraulic Engineering

Final Team

# Q NO: 1

Ans : 1

## Solve:

The pressure drop $\Delta p$ is expected to upon the gate opening "h" the overall depth "d" the velocity "v" density "$\rho$" and viscocity "$\mu$"

### List of relevent variable with dimention

1. $\Delta P = ML^{-1}T^{-2}$
2. $h = L$
3. $d = L$
4. $V = LT^{-1}$
5. $\rho = ML^{-3}$
6. $\mu = ML^{-1}T^{-1}$

Number of variables $= n = 6$

Number of independ dimention $m = 3$ (MLT)

Number of non-dimention group $n - m = 3$

$m = 3$ scaling variables

From dimensionless group by non dimentionlising the remaing variable : $\Delta p$, $h$, $\mu$

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

$$\cancel{\Pi_1 = (\Delta p d^a V^b \rho^c)}$$

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

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

Now

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

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

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

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

$$\Pi_1 = \frac{\Delta p}{\rho V^2}$$

$$\Pi_2 = h/d \quad \text{by inspection}$$

h is Length

$$\Pi_3 = \mu d^a V^b \rho^c$$

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

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

$M:$ $0 = 1 + c$

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

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

$c = -1$
$b = -1$
$a = 1 + 3c - b$

$\Rightarrow$ Now

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

$$= \mu / \rho V d$$

Recognition of the Reynolds number suggest that we replace $\Pi_3$ by

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

P.T.O

Hence dimensional analysis

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

i-e

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

a => Dynamic similarity requires that all non-dimensional group be the same in model and prototype

i-e

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

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

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

automatic if similar shape

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

We have velocity ratio

$$\frac{U_p}{U_m} = \frac{(\mu/\rho)_p}{(\mu/\rho)_m} \times \frac{d_m}{d_p}$$

$$= \frac{0.002/800}{1.0 \times 10^{-6}} \times \frac{1}{5}$$

$$\boxed{\frac{U_p}{U_m} = 0.5}$$

Hence

$$U_m = \frac{U_p}{0.5}$$

$$U_m = \frac{3.0}{0.5}$$

$$\boxed{U_m = 6.0\ ms^{-1}}$$

b => The ratio of quantity of flow is

$$\frac{Q_p}{Q_m} = \frac{(\text{Velosity} \times \text{area})_p}{(\text{Velosity} \times \text{area})_m}$$

$$= \frac{V_p}{V_m}\left(\frac{d_p}{d_m}\right)^2$$

$$= 0.5 \times 5^2$$

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

c => Finally, for the pressure drop

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

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

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

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

$$\boxed{\Pi_1 = 0.2}$$

Hence

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

$$\Delta P_p = 0.2 \times 60$$

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

# Q No: 2

## Given Data

Max depth of water reservior = 78m
Specifi Gravity of Dam = G = 2.25

Allowable compression stress
for the Dam Masonary = Gav = 787 $\frac{T}{m^2}$

Hight of wave = 1.25

$U = 0.7$

No uplift pressure , $C_U = 0$

## Solve:

I: $H \text{ limiting} = \frac{G_{av}}{\gamma_w (G - C_U + 1)}$

$= \frac{787 \times 1000}{1000 (2.25 - 0 + 1)}$

H limiting = 242.153 > Hw
= 242.153 > 78

So it is low gravity Dam

## 2) Top width "a"

Free board = 1.5 h wave
= 1.5 x 1.25

F.B = 1.875 m

Hight of Dam = HD = HW + F.B

HD = 78 + 1.875
HD = 79.875

a = 14 % of HD
a = 0.14 x 79.875
a = 11.18

## 3:- Base width = b' (with out offset)

1:- For no sliding criteria

$$b' = \frac{Hw}{uG} = \frac{78}{0.7 \times 2.25}$$

$$\boxed{b' = 49.5 \, m}$$

iii) For no tension criteria

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

$$b' = \frac{78}{\sqrt{2.25}} = 52m$$

Use $\boxed{b' = 52\ m}$

4) Depth of vertical portion on U/s side

$$b' = 2a\sqrt{G - c_u}$$

$$= 2(11.18)\sqrt{2.25 - 0}$$

$$\boxed{b' = 33.54m}$$

P.T.O

5) Up stream Offset

$$\Rightarrow \frac{a}{16}$$

$$= \frac{11.18}{16}$$

$$= 0.699$$

$$= 0.7\,m$$

6) Depth below the water level to the end of inclind Portion is $U/s = 3.14\, a\sqrt{G}$

$$U/s = 3.14\, a\sqrt{G}$$

$$= 3.14(11.18\sqrt{2.25})$$

$$= 3.14(11.18\sqrt{2.25})$$

$$= 52.65$$

$$\boxed{U/s \cong 52.}$$

7 **Total width**

$$b = b' + \frac{a}{10}$$

$$= 52 + \frac{11.18}{16}$$

$$b = 52.69\ m$$

$$b \approx 52.7\ m$$

8) **$\tan\theta = \frac{b'}{H}$** $= \frac{52}{78}$

$$\tan\theta = \left(\frac{2}{3}\right)$$

$$\theta = \tan^{-1}\left(\frac{2}{3}\right)$$

$$\theta = 33.69^\circ$$

$$\boxed{\theta = 33.69^\circ}$$

So

9» Depth of vertical portion on D/s From WL on U/s side

$$\tan\theta = \frac{d}{d_1}$$

$$\tan\theta = \frac{11.18}{d'}$$

$$\tan\theta = \frac{11.18}{d'} \Rightarrow \tan\theta\, d_1 = 11.18$$

$$\frac{2}{3}\, d_1 = 11.18$$

$$d_1' = 11.18 \times \frac{3}{2}$$

$$d_1 = \cancel{\quad}$$

$$d_1' = 16.77\,m$$

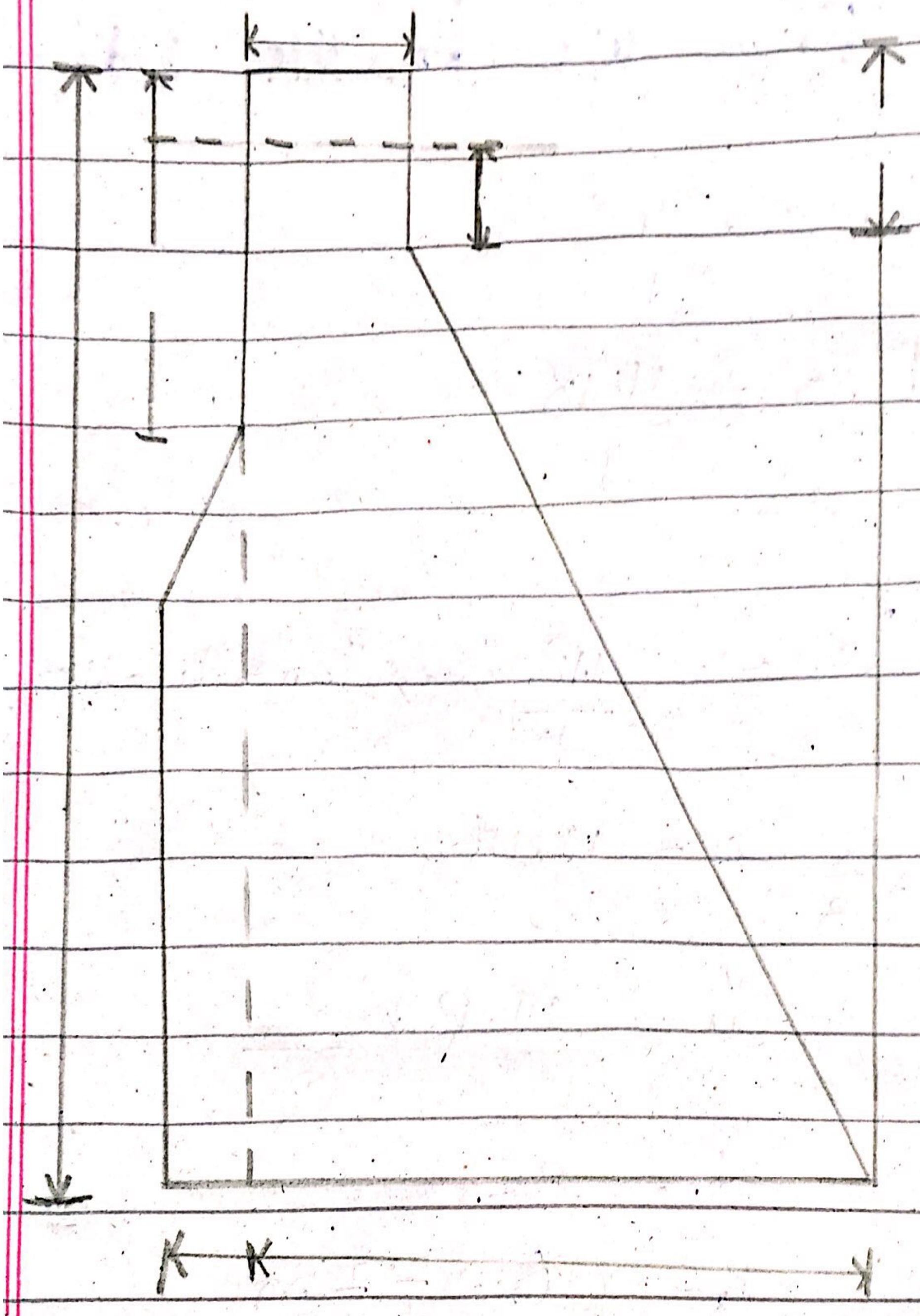
Depth on vertical portion

$$d = d' + FB$$

$$d = 16.77 + 1.875$$

$$d = 18.645$$

$$\boxed{d = 18.64}$$ ~~A~~



Q No: 4

## Fall velocity:

When a grain fall down in still water it obtain a constant velocity when the upward fluid drag force on the grain is equal to the dowoward submerged weight of the grain

This constant velocity is defined as the fall velocity of the grain

This is also called setting velocity.

## Fall velocity depends on

1. Particle dimeter
2. Partical density
3. Partical concontation
4. Partical shape
5. Viscosity of water
6. Turbulancy

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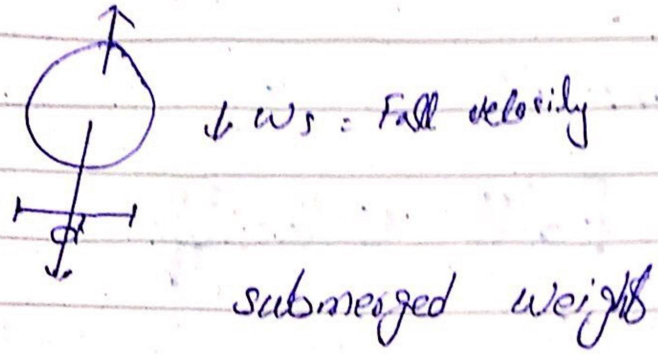



The force balance b/w the drage force and the submerged weight given

$$F_D = \text{Submerged weight}$$

$$\frac{1}{2}\rho C_D \frac{\pi d^2}{4} w_s^2 = (\rho_s - \rho) g \frac{\pi d^3}{6}$$

$$A = \frac{\pi d^2}{4} \Rightarrow \text{Project Area}$$

CD = Drag Coefficient.
ws = fall velocity of Sediment

$$W_s = \sqrt{\frac{4gd}{3C_D}\left(\frac{\rho_s - \rho}{\rho}\right)}$$

$\rho$ = density of water
$\rho_s$ = density of sediment particl

## 1 Particle Diameter:

The diameter of a sphere particle uniform setling velocity as the given particle in the same sedimentition.

## 2: Particle density

Particle density effected the settling fall velocity.

As air density increases with decresing altitude at about 1% per 80 meter (260 ft) for every 160 meter of fall the terminal speed decrease 1%

## 3: Particle Shape:

NON-spherical analoges Particel fall up to 75% slower then equilant sphere model

Show 100 µm non spherical particales travel 44% further then sphere vertical structure of modelled velocity volcanic ash cloud is sensitive to perticles shap.

## 4). Viscasity of Water:

Fluid velocity through porous media is approximated as inversely proportional to the kinematic viscosity

A decreas in viscosity there fore increase the velocity of a compand through porous media.

## 5. Turbulance of Water:

Turbulancy of water effect the fall velocity of water reservoir because the non-linearity and zig zag path effect the flow of water is cause the variation in the flow.

Q/NO:- 3

# Dimensional Analysis

Where all of the variables ($x$) are dimensional

$f(x_1, x_2 \ldots x_n) = 0$

Then the above phenomena can be represented a

$\psi(\pi_1, \pi_2 \ldots \pi_m = 0$

~~[illegible]~~ where all variable ($\pi$) are non-dimentional

The nature of $f$ an $\psi$ may be obtaind from experimt

## of Buckingham Pi Theorm

$f(x_1 x_2 \ldots x_n) = 0 \rightarrow \psi(\pi_1 \pi_2 \ldots \pi_n) = 0$

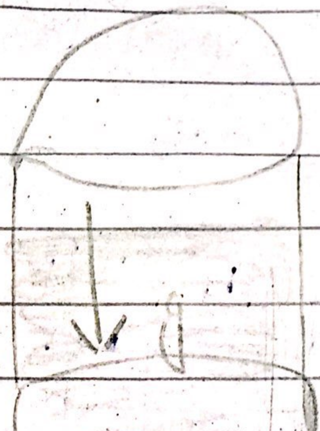
Where $m < n$; $m = n - K$

**Experiment show,**
**For viscous flow**

$$f = (v, g, h, \nu) = 0$$

| | M | L | T |
|---|---|---|---|
| $v$ | 0 | 1 | -1 |
| $g$ | 0 | 1 | -2 |
| $h$ | 0 | 1 | 0 |
| $\nu$ | 0 | 2 | -1 |

$m = 4$
$K = 2$
$n = 4$




Let's take the repeating variables
$g, h$

Non repeating variable

$V, \nu$

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| | L | T |
|---|---|---|
| U | 1 | -1 |
| g | 1 | -2 |
| h | 1 | 0 |
| v | 2 | -1 |

$f(U, g, h, v) = 0$

$n = 4$ $k = 2$ $m = 2$

Repla varl = g, h

Non-repl = U, v

$\pi_1 = x_{nr} (x_{r1})^{a_{11}} (x_{r2})^{a_{12}} (x_{r3})^{a_{13}} \cdots (x_{rk})^{a_{1k}}$

$\pi_1 = U (g)^a (h)^b$

$L^0 T^0 = LT^{-1} (LT^{-2})^a (L)^b = L^{1+a+b} T^{-1-2a}$

$= a = b = -1/2$

$\pi_1 = U / \sqrt{gh}$

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Similarly

$\pi_2 = V(g^a)(h^b)$

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

$2+a+b = 0 \quad -1-2a$

$a = -1/2, \quad b = -3/2$

$\pi_2 = V/\sqrt{gh^3}$

$\frac{U}{\sqrt{gh}} = Fr$ Found numb $\frac{V}{\sqrt{gh}} = \frac{U}{\sqrt{gh}} \frac{V}{\sqrt{h}} =$

$= \frac{Fr}{Re}$

We Also know

$f_2(Fr, Fr/Re) = 0$

$Fr = \omega(Fr/Re)$

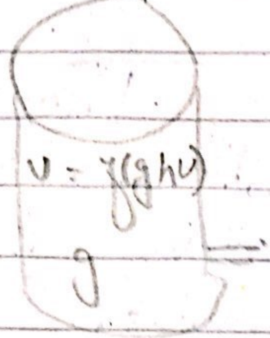
$Fr = \text{constant}$

$$Fr = \psi(Fr/Re)$$

Experiment necessary to find the nature of function

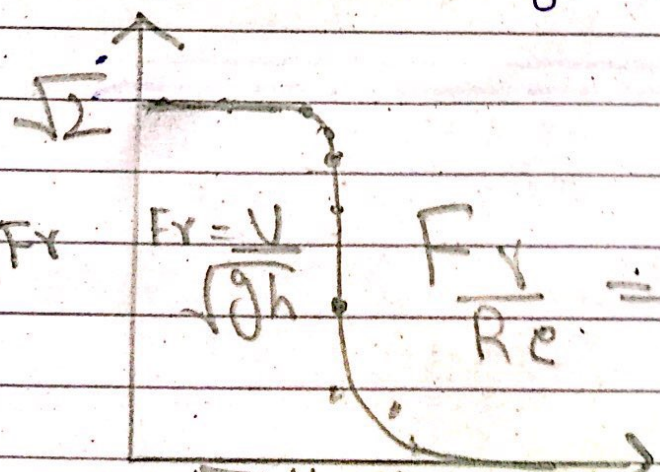
# Dimensional Analysis

I would like to do a laboratory experiment



We can vary h and measure v for few case

Finally I do a curve fitting




$$\frac{Fr}{Re} = \frac{V}{\sqrt{gh^3}}$$

Fitted curve

Paper — 25

# Conclusion

=> One figure is enough as opposed to many fig of dimensionl systeu

2) Tank size is irrelvant as long as our assumption arent violated

The plot developed from experimet in a small model may be used for similer bigger tank