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Subject: Hydrulic Engineering

Semester: 6th

Section: B

Instructor:-

SIR FAHAD.

Question No 1 7856 ①

Solution:

The presure 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 relevant variable.

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

Write down dimension.

Δp	$ML^{-1}T^{-2}$
h	L
d	L
V	LT^{-1}
ρ	ML^{-3}
μ	$ML^{-1}T^{-1}$

Number of Variable = $n=6$

Number of independent dimensions = $m=3$ (M, L and T)

Number of non-dimensional groups = $n-m=3$

Choose m(=3) scaling Variable.

geometric (d): kinematic/time - dependent (V):

dynamic/mass - dependent (ρ).

From dimensionless groups by non-dimenssionalising the remaining variable : ΔP, h and μ

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

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

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

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

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

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

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

$\pi_2 = \frac{h}{d}$ (by Inspection, since h is a length)

$\pi_3 = \mu d^a V^b \rho^c$ (Probably obvious by now, but here goes anyway...)

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

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

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

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

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

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

Recognition of the Reynolds number suggests that we replace π_3 by

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

i.e.

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

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

i.e.

$$\pi_1 = \left[\frac{\Delta P}{\rho V^2}\right] = \left[\frac{\Delta P}{\rho V^2}\right]$$

$$\pi_2 = \left(\frac{h}{d}\right) = \left[\frac{h}{d}\right]$$

$$\pi_3' = \left[\frac{\rho V d}{\mu}\right]_p = \left[\frac{\rho V d}{\mu}\right]_m$$

From the last, we have a velocity ratio

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

b) The ratio of the 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 for the pressure drop

$$\pi_1 = \left[\frac{\Delta P}{\rho V^2}\right]_p = \left(\frac{\Delta P}{\rho V^2}\right]_m \Rightarrow \frac{(\Delta P)_P}{(\Delta P)_m} = \frac{\rho_P}{\rho_m}\left[\frac{V_P}{V_m}\right]^2 = \frac{800}{1000} \times 0.5^2$$

$$= 0.2$$

Hence

$$\Delta P_p = 0.2 \times \Delta P_m = 0.2 \times 60 = 12.0\,kPa.$$

Question No 2 7856

Given Data:

Max depth = 78m

Specific Gravity = 2.4

$G_{av} = 785\ T/m^2$

Height of wave = 1.2m.

Solution:

$$H_{limiting} = \frac{G_{av}}{\gamma_w (G - w + 1)}$$

$$= \frac{785 \times 1000}{1000\,(2.4 - 0 + 1)}$$

$$H_{limiting} = 230.8$$

Top width: 'a'

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

$$= 1.5 \times 1.2$$

$$= 1.8$$

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Height of Dam = $H_w + F.B$

$78 + 1.8$

$HD = 79.8$

$a = 14\%$ of HD

$= 0.14 \times 79.8$

Base width

$$b' = \frac{H_w}{\mu G} = \frac{78}{0.7 \times 2.4}$$

$= 46.42m$

$= 47m$

For no tension Criteria

$$b' = \frac{H_w}{\sqrt{G}} = \frac{78}{\sqrt{2.4}}$$

$= 50.34$

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Depth of Vertical Portion on U/s Side.

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

$= 2 \times 11.17\sqrt{2.4 - 0}$

$= 34.60$

$= 35m$

Upstream off Set $= \frac{a}{16} = \frac{11.17}{16}$

$= 0.6$

Depth below the water level to the end of inclined Portion U/s

$= 3.14a\sqrt{G}$

$= 3.14 \times 11.17\sqrt{2.4}$

$= 54.33$

Total width of the Base of the dam

$b = b' + \frac{a}{16} = 50.34 + \frac{11.17}{16}$

$= 51.03$

$$\tan \theta = \frac{b'}{H} = \frac{50.34}{78}$$

$$\theta = \tan^{-1}(0.64)$$

$$= 44.80^\circ.$$

Depth of vertical Portion on D/s (from WL on U/s Side)

$$\tan \theta = \frac{a}{d'} = \frac{11.17}{d'}$$

$$\left(\frac{839}{1300}\right) \times d' = 11.17.$$

$$d' = 17.30\text{m}.$$

Depth of verticle Portion.

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

$$= 17.30 + 1.8$$

$$\boxed{= 19.1}$$

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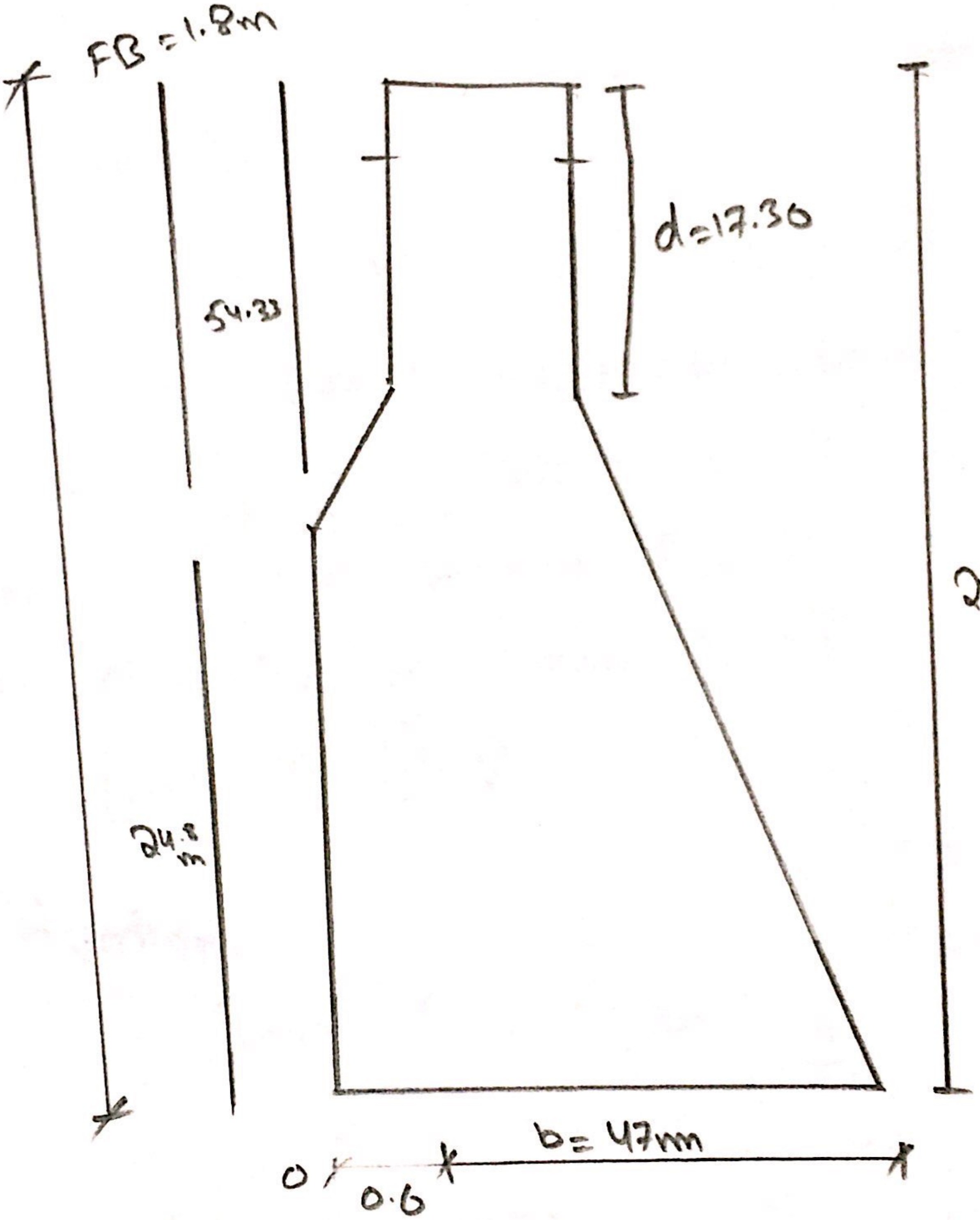


Question No 3 7856

Finding π group for drg on Sphare using step by step method.

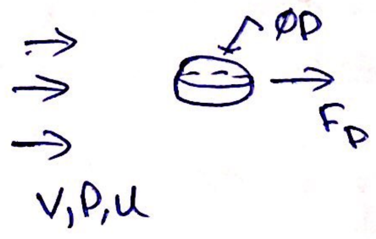
Statement:.

The drag F_D of ~~sh~~ sphare is a fluid flowing past the sphare is function of the vescocity. μ, the mass density ρ, the velocity flow V. and the diameter of Sphare D. use steps to find π group

Situation.

Drag Force (sphare)

$$FD = f(V, \rho, \mu, ...)$$



Goal:

Find π group (steps)

IDEA.

1. Apply π Buckingam theorm
2. follow Process

Action.

π Bukingham.

$\#\ \pi$'s = # VARS − Primary diminions

$= n - m$

$5 - 3 = 2$

Step By step Table.

F_D	$\frac{M.L}{T^2}$	F_D/D	$\frac{M}{T^2}$	$\frac{F}{\rho D^4}$	$\frac{1}{T^2}$	$\frac{F}{\rho D^2 V^2}$
V	L/T	$\frac{V}{D}$	$\frac{1}{T}$	V/D	$\frac{1}{T}$	—
ρ	M/L^3	ρD^3	M	—		—
μ	M/LT	μD	M/T	$\frac{\mu x}{\rho D x 2}$	$\frac{1}{T}$	$\frac{\mu D}{\rho D^2 V}$
D	L	—				

$$\frac{F}{(\rho v^2) D^2} = F\left(\frac{\mu}{\rho D V}\right)$$

$$CD = f(Re).$$

Question No 4 7856

Particle Diameter:

The diameter of the particle is directly proportional to the velocity because greater the size of particle so it will tends to move faster as compared to particles of small size thus there will be more gravitational force on particle of greater size so it will fall faster due to its weight.

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.

Viscosity of water:

From the experimental study we can see that Parameter such as temperature and Pressure changes the magnitude of viscosity So the section of water having more temperature 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 its zigzag motion thus the velocity varies at every Point which is why it effected the fall velocity moreover increase in the kinetic energy tends to effect the fall velocity Compared with steady fluid.

Particle Concentration:

Concentration of Particle Size will Considerable effect its fall velocity as the Section having greater Concentration will be Settled down at the place thus Causing more fall velocity Comparing with Section of low Concentration.

Particle Shape:

Particles having regular shapes tends to be ~~greater~~ effected more then irregular shapes since regular shapes particles have even surface which offers very little or no friction while Particles with irregular shape offer more friction, as the particle with Smaller surface are are more likely to be effected due to their less resistance.