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Subject : Hydroli engineering

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1:-

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 relevent variable-

Δp, h, d, V, ρ, μ

Write down dimensions

$\Delta p = ML^{-1}T^{-2}$ ∴ Distance = d = L

h L ∴ Time = T

d L

V LT^{-1}

ρ ML^{-3}

μ $ML^{-1}T^{-1}$

Number of variable $n = 6$

Number of independent dimensions = $m = 4$

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

Number of Non-dimensional group
$n - m = 3$

Choosen m(=3) Scaling variable.

geometric (d): kinetic/time-~~ind~~ dependent
(v), dynamic/mass - dependent (ρ)

From dimensionless groups by non-dimensi
non-dimensionalising the ~~m~~ remaining
variable: Δp, h and μ

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

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

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

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

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

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

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

$\Pi_2 = h/d$ (by inspection since h is a Length)

$\Pi_3 = \mu d^a v^b \rho^c$ (probly obvious by now, but have goes any way)

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

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

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

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

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

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

Recognition of the Reynolds number suggests that we replace that we replace Π_3 by

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

Hence dimensional analysis yields

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

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-dimentional groups be the same in model and prototype i.e

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

$$\Pi_2 = \left[\frac{h}{d}\right]_m = \left[\frac{h}{d}\right]_m$$ (automatic Similiarity Shape i.e 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

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

$$= 0.5$$

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

(b) The ratio of the Quantities of flow is

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

$$= \frac{V_p}{V_m}\left[\frac{d_p}{d_m}\right]^2 = 0.5\times5^2$$

$$= 12.5$$

(c) Finally, for the pressure drop

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

$$= \frac{P_p}{P_m}$$

$$\left[\frac{V_v}{V_m}\right]^2 = \frac{800}{1000} \times 0.5^2 = 0.2$$

Hence $\Delta p = 0.2 \times \Delta p_m = 0.2 \times 60$

$= 12.0 \text{ kpa}$

Question No - 2

Given:

Max depth = .78 m

Specetic gravity = 2.4

allowable compressive stress = 788 T/m^2

height of wave = 1.2 m

Solution:-

$$H \text{ limiting} = \frac{\sigma}{\gamma_w (G - cv + 1)}$$

$$= \frac{788 \times 1000}{1000 (2.4 - 0 + 1)}$$

$$H \text{ limeting} = 231.7$$

Top width : (a)

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

$$= 1.5 \times 1.2$$

$$= 1.8$$

Height of Dam = $H_w + f.B$

$$= 78 + 1.8$$

$$= 79.8$$

Height of Dam.

$$a = 14\%\ H.D$$

$$= 0.14 \times 79.8$$

$= 11.17\,m$

⇒ Base width:

$$b = \frac{H.W}{\mu G} = \frac{78}{0.7 \times 2.4}$$

$= 46.42\,m \approx 47\,m.$

for no tension criteria

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

$= 50.34$

Depth of verticale portion on u/s side:

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

$= 2\,(11.17)\ \sqrt{2.4-0}$

$= 34.60$

$= 35m$

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.

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

$$\boxed{b = 51.03}$$

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

$$\tan\theta = 0.64$$

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

$$\theta = 44.8^\circ$$

Depth of verticle portion on D/S (from WL on U/S side]

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

$$d' = 17.30m$$

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

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

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Depth of verticle port

$d = d' + f \cdot B$

$= 17.30 + 1.8$

$= 19.1$

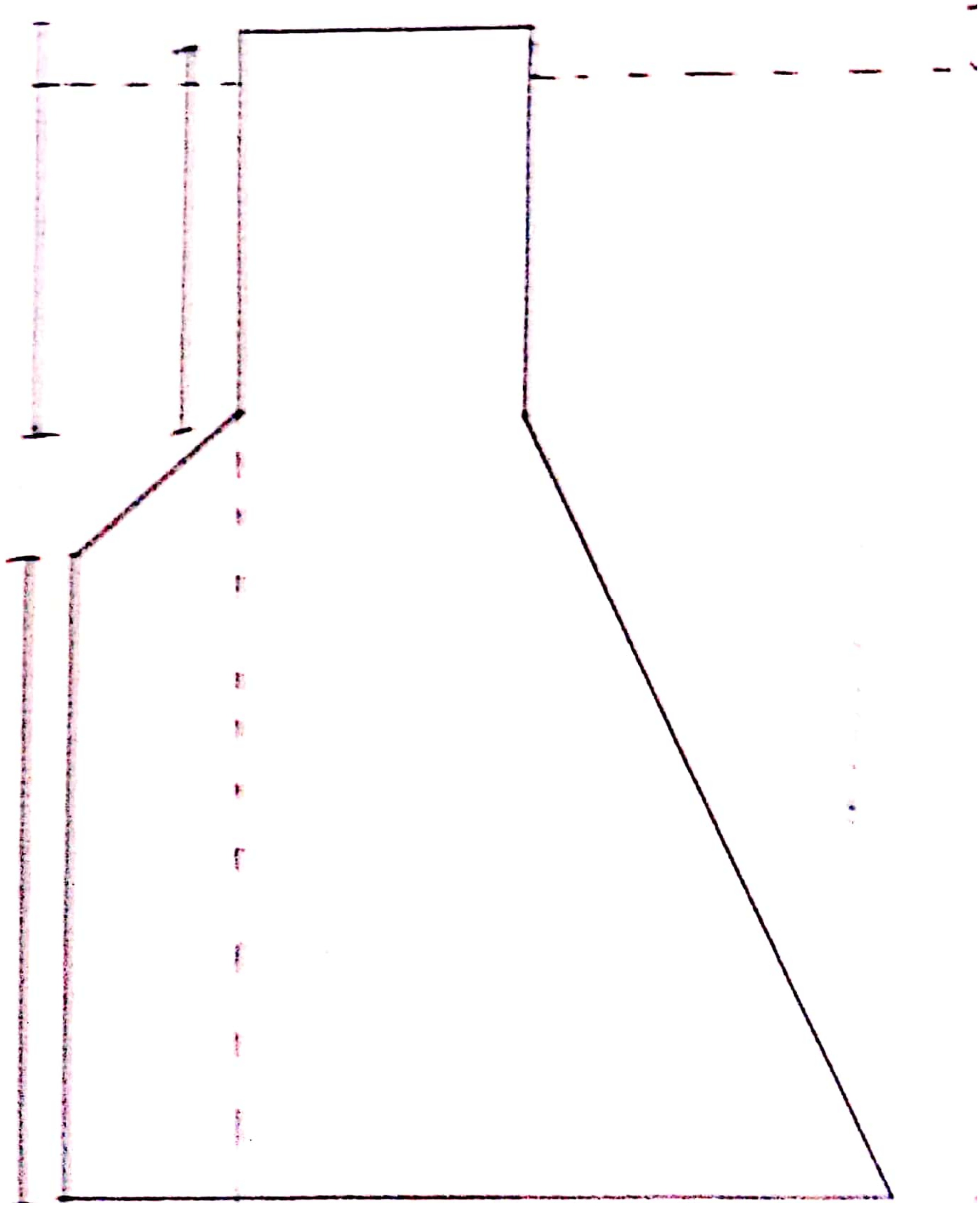

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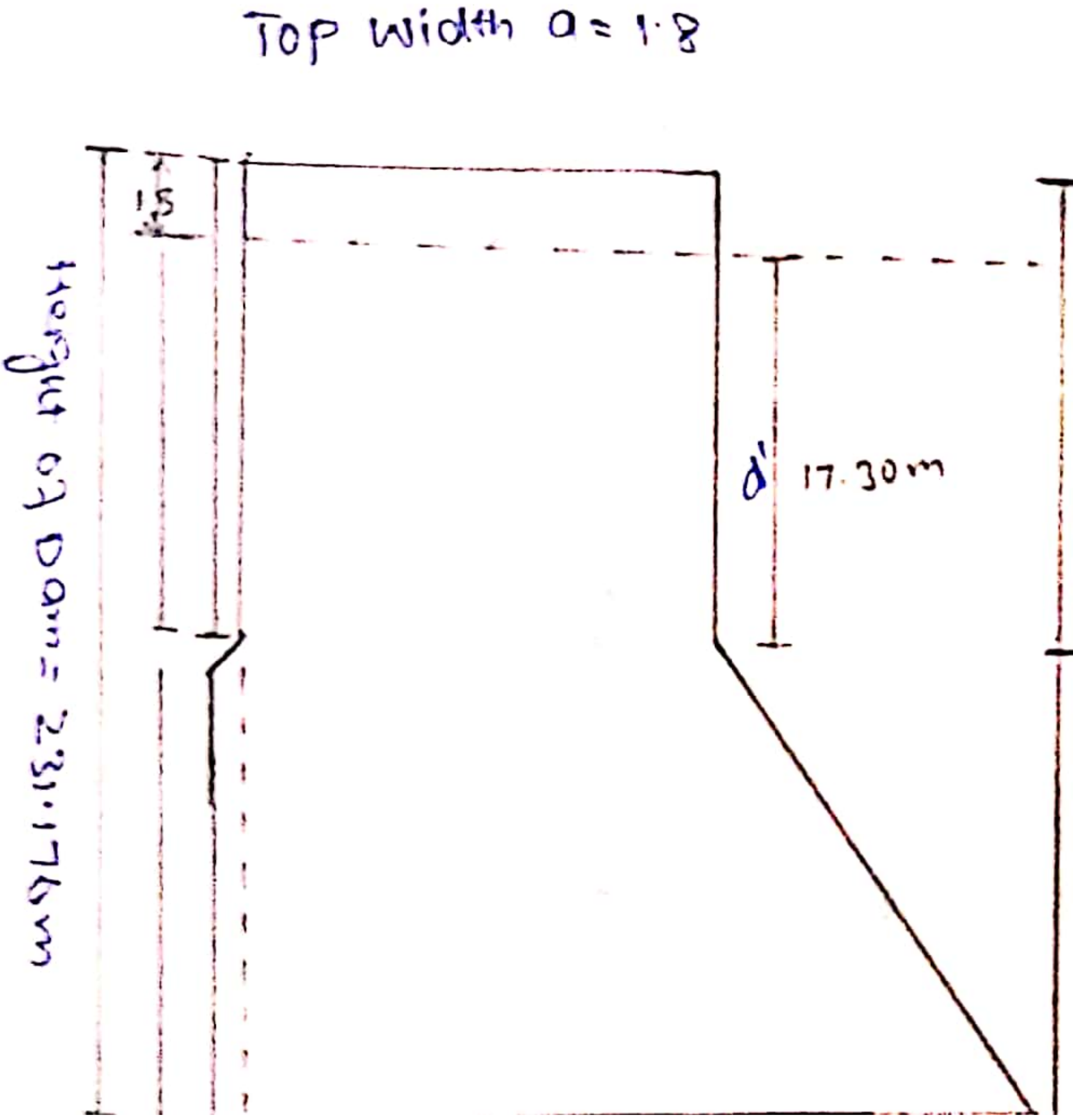
Diagram



Q No =3 :-

Answer:-

Dimension Analysis and similitude:

Buckingham π theorm:

the efficency η of a fluid depends upon density ρ, dynamic viscosity μ of the fluid, angular velocity ω, diameter D of the rutor and the dischage Q. Express the efficency η in terms of dimensionless parameter.

Step : 01

here η is a function of ρ, μ, ω, D, Q

$\eta = f(\rho, \mu, \omega, D, Q)$

depends.

Step : 02

variable < dependent (η) / Independent (ρ, μ, ω, D, Q)

the functional relationship b/w dependent and Independent variable can be written as

$$f \cdot (\eta, \rho, \mu, \omega, D, Q) = 0$$

Step : 03

total number of variable $n = 6$

Step : 04

Dimension of variable

Efficency $(\eta) = M^0 L^0 T^0$

Density $(\rho) = \frac{m}{V} = \frac{kg}{m^3}$ $M^1 L^{-3}$

$$\mu = \frac{N.s}{m^2} = \frac{kg.m}{s^2} = M^1 L^{-1} T^{-1}$$

Angular velocity $(\omega) = T^{-1}$

Dia $= m = L^1$

Discharge, $Q = L^3 T^{-1}$

Step : 05

Number of fundamental dimension for problem,

$m = 3$

contain $m+1$ variable

Step : 06

Number of π terms $= n - m$

$6 - 3$

$= 3$

$\Rightarrow f. C, n_1, n_2, n_3 = 0$ - (i)

Geometric property (b, D, H)

flow property (N, U), W, d

fluid property (μ, ρ)

Step : 07

$\pi_1 = D^{a_1} \omega^{b_1} \rho^{c_1}$

$\pi_2 = D^{a_2} \omega^{b_2} \rho^{c_2}$

$\pi_3 = D^{a_3} \omega^{b_3} \rho^{c_3}$

Step : 08

$$\pi_1 = D^{a_1} \, W^{b_1} \, \rho^{c_1} \, n$$

Subtituteng Dimension on both Sides

$$M^0 L^0 T^0 = L^{a_1} (T^{-1})^{b_1} (M_1 L^{-3})^{c_1} \, M^0 L^0 T^0$$

$$M^0 L^0 T^0 = M^{c_1} L^{a_1 - 3c_1} + T^{-b_1}$$

power $M = c_1 = 0$

power $L = a_1 - 3c_1 = 0$

$$a = 0$$

power of T

$$-b_1 = 0$$

$$b_1 = 0$$

Step : 09

substituting value of $a_1 \, b_1 \, a_1 \, c_1$ in $\pi_1 - u_2$

$$\pi_1 = D^0 \, w^0 \, \rho^0 \, n$$

$$\pi_1 = n$$

$$\pi_2 = D^{a_2} \, w^{b_2} \, \rho^{c_2} \, \mu$$

Sibstating Dimension

$$\ldots T^0 \quad L^{a_2} (T^{-1})^{b_2} (ML^{-3})^{c_2} \, M^1 L^{-1} T^{-1}$$

$$M^0 L^0 T^0 = M^{c_2+1} L^{a_2-3c_2-1} T^{-b_2-1}$$

power of M $c_2 + 1 = 0$ $\boxed{c_2 = -1}$

Power of L $a_2 - 3c_2 - 1 = 0$ $\boxed{a_2 = -2}$

power of T $-b_2 - 1 = 0$

$b_2 = -1$

$$\pi_2 = D^{-2} \omega^{-b} \rho^{-1} \mu$$

$$\pi_2 = \frac{\mu}{D^2 \omega \rho}$$

$$\pi_3 = D^{a_3} \omega^{b_1} \rho^{c_3} Q$$

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

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

Power of M = $\boxed{c_3 = 0}$

power of L $c_3 - 3c_3 + 3 \Rightarrow c_3 = -3$

power of T $-b_3 - 1$

$b_3 = -1$

$\pi_3 = \rho^{-1} \omega^{-2} D^{-3} \sigma$

$$\pi_3 = \frac{\sigma}{\omega D^3}$$

Substituting the value of π_1, π_2, π_3 in

$$f_1\left(\pi_1, \frac{\mu}{D^2 \omega \rho}, \frac{\sigma}{\omega D^3}\right)$$

$$\pi_1 = \phi\left[\frac{\mu}{D^2 \omega \rho}, \frac{\sigma}{\omega D^3}\right]$$

Q - No. 04 :-

Answer :-

particle Density :- Density of particle is directly proportional to the ratio of fall of velocity since particle with high density tends to settle down early.

particle Density α fall velocity

particle concentration :-

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

Turbulence of Water:-

Turbulence of Water depends upon the diffrent factor such as vescosity zigzag motion thus the velocity varies at every point which is why it effected fall velocity, moreover increase in K.E tends to effected the fall velocity compared with steady flow.

particle diameter:-

Dia of particle is directly proportionals to fall velocity i-e greater the size it will tend to settle faster so greater will be fou velocity

$$\text{particle Dia} \propto \text{fall velocity}$$

Particle shape :-

particle ~~shape~~ having regular Shape tends to be effected more then irregular shapes since regular shape particles have even Surface Which offer a very little or no friction While particle with irregular shape offer more friction. as the particle with Smaller shape area are more likely to be effected due to their less resistance

viscosity of water:-

from the experimental study We can see that parameter Such as temperatures and pressures will fall objectively more due to increase in kinetic energy so fall velocity Will be more

fall velocity $\propto$ viscosity of water