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Subject: ~~A~~ Hydrology

Semester: 6th

Q No 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.

Variable are

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

Dimensions:

$\Delta P = MLT^{-1}$

$h = L$

$d = L$

$V = LT^{-1}$

$\rho = ML^{-3}$

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

Number of variables, $n = 6$

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

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

Choose $m(=3)$ Scaling Variables:

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

dynamic
mass-dependent (ρ)

For dimensionless group by non-dimensionalising the remaining Variable, ΔP, h and μ.

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

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

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

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

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

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

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

$$\Pi = \frac{h}{d}$$ ~~for~~ h is length

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

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

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

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

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

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

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

Recognition of the Reynold number suggest that we replace Π_3 by

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

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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 similarities requires that all non-dimensional groups be the same in model and prototype i-e

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

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

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

From the last we have velocity ratio

$$\frac{V_p}{V_m} = \frac{(\mu/\rho)_p}{(\mu/\rho)_m} \cdot \frac{d_m}{d_p} = \frac{0.002/800}{1.0\times10^{-6}} \times \frac{1}{5} = 0.5$$

Hence

$$V_m = \frac{V_p}{0.5} = \frac{3.0}{0.5} = 6.0\,m/s$$

b) The ratio of Quantities 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 pressure drop

$$\pi_1 = \left(\frac{\Delta P}{\rho V^2}\right) = \left(\frac{\Delta P}{\rho V^2}\right) = \frac{(\Delta P)_p}{(\Delta P)_m} = \frac{\rho_p}{\rho_m}\left(\frac{V_p}{V_m}\right)^2$$

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

$$= 0.2$$

$$\Delta P_m = 0.2 \times 60 = 12.0\ KPa$$

ction

settle

step: 01

Here η is a foncation of

$f(\rho, u, \omega_1, D_1, Q)$

(6)

Q No 2

GIVEN:

Max depth = 78m

Specific Gravity = 2.4

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

Height of wave = 1.2m

Solution

①

$$H\ limiting = \frac{\sigma_{av}}{\gamma_w (G - C_v + 1)}$$

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

$$H\ limiting = 230.8$$

② Top width: 'a'

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

$= 1.5 \times 1.2$

$= 1.8$

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Height of Dam: Hw + F.B

78 + 1.8

$H_D = 79.8$

$a = 14\%$ of H_D

$= 0.14 \times 79.8$

$= 11.172m$

3) Base width:

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

$= 46.42m$

$= 47m$

4) for no tension Criteria:

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

$= 50.34$

4) Depth of Vertical Portion on U/s side:

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

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

$$= 34.60$$

$$= 35m$$

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

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

$$= 51.03$$

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

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

$$= \cancel{32}.\ 44.80^\circ$$

Depth of vertical portion on D/s (from WL on U/s side.

$$\tan\theta = \frac{a}{d'} = \cancel{4.05}\ \frac{11.17}{d'}$$

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

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

$$d' = 17.30\,m$$

depth of verticle portion

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

$$= 17.30 + 1.8$$

$$= 19.1$$

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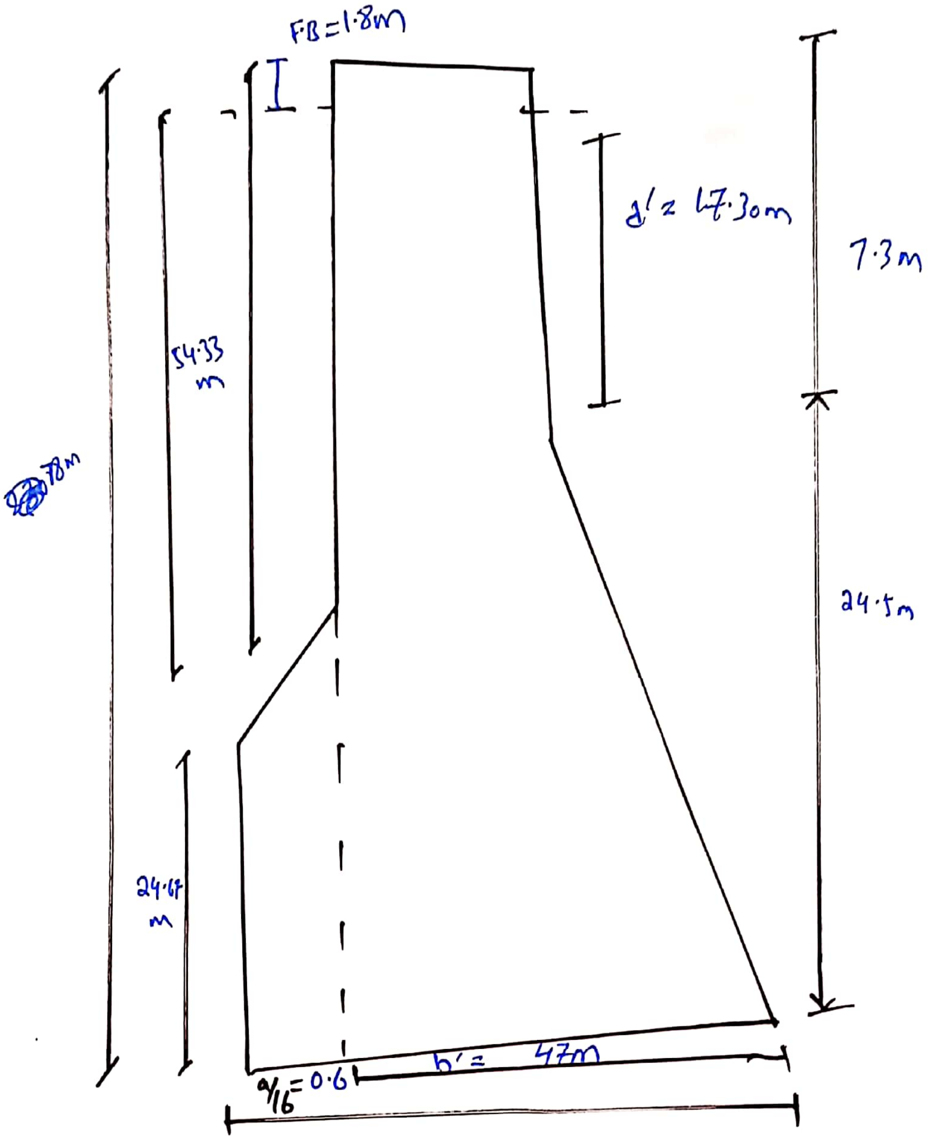

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Q3:

ANSWER:

DIMENSIONAL ANALYSIS AND SIMILITUDE:

Analysis using the fact that physical Quantities added to or equated with each other must be expressed in term length or time for inferences to be made about the relation between them

Buckingham π theorem:

The efficiency η of a fluid depends upon density ρ, dynamic viscosity μ of the fluid, angular velocity ω_1, diameter D of the rotor and the discharge Q. Express the efficiency η in terms of dimensionless Parameter.

Step: 01

Here η is a function of ρ, μ, ω, D,

$$\underbrace{\eta = f(\rho, \mu, \omega_1, D_1, Q)}_{\text{depends}}$$

Step: 02

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

The funcational relationship between dependent and independent Variable can be written as

$$f_1(\eta, \rho, \mu\ \omega, D, Q) = 0$$

Step: 03

Total number of variable $n = 6$

Step: 04

Dimension of Variable

Efficiency (η) $= M^0 L^0 T^0$

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

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

Angular velocity (ω) $= T^{-1}$

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 $= n - m$

$6 - 3$

$= 3$

$\Rightarrow f, C, \eta_1, \eta_2, \eta_3 = 0 \quad -(i)$

Geometric property (l, D, H)

flow property $(V, u), \omega, \alpha$

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

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$$\pi_1 = D^{a}, \omega^{b} \rho^{c_1} \eta$$

Substituting 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 $L = a_1 - 3c_1 = 0$

$c_1 = 0$

Power of T

$-b_1 = 0$

$b_1 = 0$

Step : 09

Substituting values of a, b_1, c_1 in π_1 - the

$$\pi_1 = D^0 \omega^0 \rho^0 \eta$$

$$\pi_1 = \eta$$

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

Sibstituting Dimension

$$M^0 L^0 T^0 = L^{a_2} (T^{-1})^{b_2} (ML^{-3})^{c_2} \; M^1 L^{-1} T^{-1}$$

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

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

Power of L $\quad a_2 - 3c_2 - 1 = 0$

$$\boxed{a_2 = -2}$$

Power of T $\quad -b_2 - 1 = 0$

$$b_2 = -1$$

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

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

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

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

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

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

Power of L $\quad \cancel{c_3} - 3c_3 + 3 \Rightarrow \quad c_3 = -3$

Power of T $\quad -b_3 - 1$

$$b_3 = -1$$

$$\pi_3 = D^{-3} \omega^{-1} \rho^0 Q$$

$$\pi_3 = \frac{Q}{\omega D_3}$$

Substituting the value of π_1, π_2, π_3 in

$$f_1 \left(\eta, \frac{\mu}{D^2 \omega \rho}, \frac{Q}{\omega D^3} \right.$$

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

Q 4 (17)

ANSWER:

Particle Density:

Density of the particle is directly proportional to the rate 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 cosiderably effect its fall velocity as the section having greater concentration will be settle down at the place thus causing more fall velocity comparing with section of low concentration.

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Particle Shape:

Particle having regular shape tends to be affected more than irregular shapes since regular shape particles have even surface which offer very little or no friction while particle with irregular shape offer more friction, as the particle with smaller surface 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 temperature and pressure changes the magnitude of viscosity of section of water having more temperature and pressure will fall objectively more due to increase in kinetic energy so fall

Velocity will be more

Fall velocity α Viscosity of water

Turbulence of water:

Turbulence of water depends upon the different factor such as velocity zigzag motion thus the velocity varies at every point which is why it effect fall velocity, morever increase in K.E tends to effect the fall velocity campared with steady flow.

Particle Diameter:

Dia of Particle is directly Proportional to fall velocity i-e

greater the size it will tend to settle faster so greater will be fall velocity

Particle Dia $\propto$ fall velocity