ID:: 7669

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Section:: B

Semester:: Senior.

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Hydraulic Engineering.

Q1) :- Given Data:-

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 relevant variables

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

Dimensions:-

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

h L

d L

v - LT^{-1}

ρ ML^{-3}

μ $ML^{-1}T^{-1}$

→ Number of variables $n = 6$.

→ Number of independent dimensions: ($m = 3$ (M, L, T)).

→ Number of non-dimensional groups: $n - m = 3$.

→ Choose m (= 3) scaling variables:

geometric (d); kinematic / time-independent (v); dynamic / mass-dependent (ρ)

→ Form dimensionless groups by non-dimensionlising the remaining variables: Δp, h & μ.

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

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

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

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

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

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

$\rightarrow \pi_1 = \Delta p V^{-2} \rho^{-1} = \frac{\Delta p}{\rho V^2}$

$\pi_2 = \frac{h}{d}$ (By inspection, since h is a length.).

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

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

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

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

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

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

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

Recognition of the Reynolds number suggests that we Replace 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. $\frac{\Delta p}{\rho V^2} = f\left(\frac{h}{d}, \frac{\rho V d}{\mu}\right)$

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Part (A)

(a). Dynamic similarity requires that all non-dimensional groups be the same in model and prototype; i-e.

$$\pi_1 = \left(\frac{\Delta P}{\rho V^2}\right)_p = \left(\frac{\Delta P}{\rho V^2}\right)_m.$$

$$\pi_2 = \left(\frac{h}{d}\right)_p = \left(\frac{h}{d}\right)_m$$ (automatic of similar 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,

$$\frac{V_p}{V_m} = \frac{(\mu/\rho)_p}{(\mu/\rho)_m}\frac{d_m}{d_p} = \frac{0.002/800}{1.0 \times 10^{-6}} \times \frac{1}{5} = 0.5$$

Hence,

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

(Part B):

(b). The ratio of quantities of flow is,

$$\frac{Q_p}{Q_m} = \frac{(\text{velocity} \times \text{area})_p}{(\text{velocity} \times \text{area})_m} = \frac{V_p}{V_m}\left(\frac{d_p}{d_m}\right)^2 = 0.5 \times 5^2 = 12.5$$

Part (c)

(c). Finally, for the pressure drop,

$$\pi_1 = \left(\frac{\Delta P}{\rho V^2}\right)_p = \left(\frac{\Delta P}{\rho V^2}\right)_m \rightarrow \frac{(\Delta P)_p}{(\Delta P)_m} = \frac{\rho_p}{\rho_m}\left(\frac{V_p}{V_m}\right)^2 = \frac{800}{1000} \times 0.5^2 = \boxed{0.2}$$

Hences,

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

———x———x———x———

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QNo:2. Given Data:. R = 7669.

Maximum depth of Reservoir = 76 m.

Allowable Compressive Strength = (T) = 766 T/m²

H_w = 2.5m

G = 3.5

Cu = 0. (Uplift Pressure).

μ = 0.7.

Solution:.

1). $H_{limiting} = \frac{6_{all}}{\gamma_w (G - C_u + 1)} = \frac{766 \times 1000}{1000(3.5 - 0 + 1)}$

$H_{limiting} = 170.22m > H_w = 76m.$

So, it is low gravity dam.

2). Top width "a"?

Free board = 1.5 hwave. = 1.5 × 2.5

$F.B = 3.75m.$

Height of Dam = H_D = H_w + F.B.

$H_D = 76 + 3.75$

$H_D = 79.75m$

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Now,

a = 14% of HD.

a = 0.14 × 79.75.

a = 11.16 m.

3). Base width "b" (without offset)

a): For No Sliding Criteria.

$b' = \frac{Hw}{\mu G} = \frac{76}{0.7 \times 3.5}$, **b' = 31.02** ≃ **b' = 32 m**

b): For No Tension Criteria.

$b' = \frac{Hw}{\sqrt{G}} = \frac{76}{\sqrt{3.5}}$, **b' = 40.62** ≃ **b' = 41 m**

(4) Depth of Vertical Portion on u/s side:

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

$h' = 2 \times 11.16\sqrt{3.5 - 0}$

h' = 41.75 m ≃ **h' = 42 m**

(5) Up Stream Offset, $= \frac{a}{16} = \frac{11.16}{16}$ **= 0.63 m**

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

$u/s = 3.14 \times 11.16\sqrt{3.5}$

u/s = 65.55 m

(7) Total width of the Base of the dam.

$$b = b' + \frac{a}{16} = 41 + \frac{11.16}{16}$$

$$\boxed{b = 41.69m}$$

(8) $\tan\theta = \frac{b'}{H} = \frac{41}{76}$, $\theta = \tan^{-1}(0.539)$

$$\boxed{\theta = 28.32°}$$

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

$$\tan\theta = \frac{a}{d'} = \frac{11.16}{d'}$$

$$\tan\theta \times d' = 11.16$$

$$\tan(28.32) \times d' = 11.16$$

$$d' = \frac{11.16}{0.539} \quad \boxed{d' = 20.70m}$$

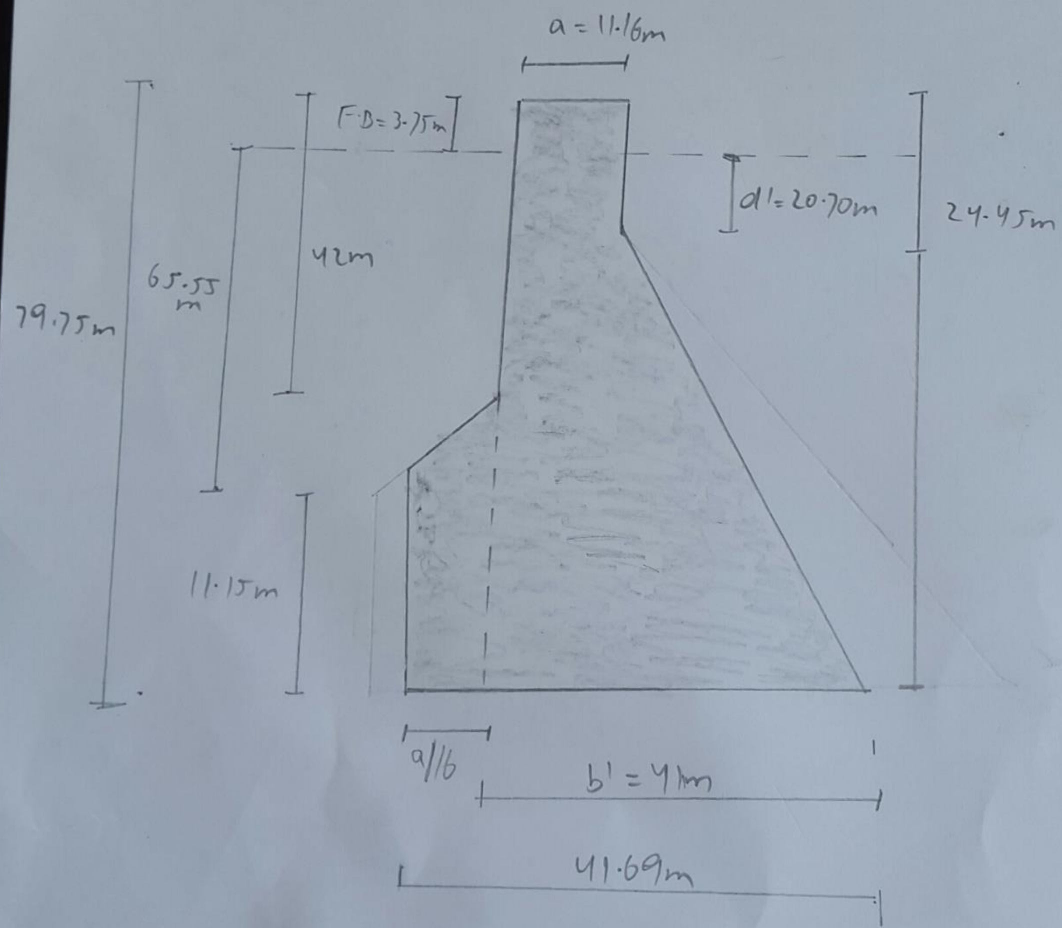
Depth of vertical portion.

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

$$d = 20.70 + 3.75$$

$$\boxed{d = 24.45m}$$

Sketch



a = 11.16m
F.D = 3.75m
d' = 20.70m
24.45m
42m
65.55 m
79.75m
11.15m
a/6
b' = 41m
41.69m

QNo:.3) Dimension Analysis and Similitude:.

Dimensional Analysis is directly primarily towards experimentation, the model laws being obtained by inspection of the dimensionless equations, whereas similitude Analysis and similarly theory expressions concentrate primarily on developing model laws of Similarity from which a dimensionless equation may be derived. Geometric Similarity requires that length ratios between model and Prototype are the same Kinematic Similarity is the correspondence of motion, in two kinematic Similar systems, particle motion will be similar. Dynamic Similarity occurs when the ratios of forces are same in the two systems.

• Laws of Similarities:.

Laws of Similarities for hydraulic model studies can be derived from dimensionless parameters for each of the above forces related to the inertia force as illustrated below.

→ Euler Number = Inertia force / pressure force.
→ Froude Number = (Inertia force / gravitational force)$^{1/2}$
→ Reynold Number = Inertia force / viscous forces.
→ Weber Number = (Inertia force / Surface tension force)
→ Mach Number = (Inertia force / Elastic force)

• Application of Similarity laws to Physical Models:-

In Applying the similarity laws to physical models, satisfying more than one law of similarity in a model investigation requires that the testing property of physical fluid may be variable over rather broad limits.

• Froude law of Similarity:-

The Froude parameter is used most in hydraulic engineering models involving turbulent free-surface flow conditions.

• Reynold Law of Similarity:-

Steady flow in pipes, or flow around a deeply submerged body, approximates the conditions assumed in formulating the Reynolds laws of Similarity.

• ~~Flow in Reservoir:-~~

• Forces on Dam:-

Different types of forces acts on a dam structure such as water pressure, self weight, wave pressure etc. Determination of various forces which acts on the structure is the first step in the design of dams. These forces are considered to act per unit length of the Dam

Forces on Dam:.

1): Water Pressure.
2): Uplift pressure or seepage loads.
3): Earth Quake forces.
4): Self wt of the Dam.
5): Silt pressure.
6):- Wave Pressure.
7): Ice Pressure.

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QNo:. 4) :. **Fall Velocity:.**

Ans:. **Particle Diameter:.**

The Diameter of particle is directly proportional to the fall velocity because greater the size of particles so it will tends to move faster as compared to the particle of small size thus there will be more gravitional force of greater size so, it will fall quickly due it's weight.

• Particle Density:.

Density of the particle is directly proportional to the fall velocity, since particle with high density tends to settle down early compared to the particle of low density.

• Particle Concentration:.

Concentration of particle size will considerably effect it's fall velocity as the section having greater concentration will be settled down at the place thus coming more fall velocity compairing with the section of low concentration.

- **Particle Shape:.**

Particles having regular shapes tends to be effected more then irregular shape. Since regular shape having even surface which offers very little or even no friction while particles with irregular shapes offers more friction as the particle with smaller surface area are more likely to be effected due to their less resistance.

- **Viscosity of water:.**

Water having less viscosity (or less viscous) will have greater fall velocity. And water having (more viscous) will have lower fall velocity.

- **Turbulence of water blowing:-**

Greater the Turbulence in water greater will be it's fall velocity. Lower the & turbulence lower will be the fall velocity.