SYED JAWWAD

7386

HYDRAULIC ENGINEERING

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Q#1

Sol:-

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.

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

write down dimensions.

$\Delta P \quad ML^{-1}T^{-2}$

$h \quad L$

$d \quad L$

$V \quad LT^{-1}$

$\rho \quad ML^{-3}$

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

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).

Form dimensionless groups by non-dimensionalising the remaining variables 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: $0 = 1+c$ → $c = -1$

L: $0 = -2-b$ → $b = -2$

T: $0 = -1+a+b-3c$ → $a = 1+3c-b = 0$

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

$\Pi_2 = \frac{h}{d}$ (by Inspection, since h is a length)

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

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

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

→ $c = -1$

M: $0 = 1+c$ → $b = -1$

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

→ $a = 1+3c-b = -1$

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

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

Recognition of the Reynold's 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,

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

ⓐ Dynamic Similarity requires that all Non-dimensional groups are to be in the Same model and Prototype

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

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

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

Hence

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

ⓑ The ratios of the quantities of the flow is

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

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(c) 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

$$\Delta p_p = 0.2 \times \Delta p_m = 0.2 \times 60 = 12.0 \text{ kPa}$$

Q#2

Given Data:-

Max Depth of Reservoir H = 73

Specific Gravity of Dam Material = G = 2.4

Allowable Compressive stress for Dam Masonry = 738 T

Height of wave = 1.2 m

$\mu = 0.7$ m

No uplift Pressure = Cu = 0

Sol:-

$$H\ limiting = \frac{G_a f}{\gamma_w(G - (u+1))} = \frac{738 \times 1000}{1000(2.4 - 0 + 1)}$$

H limiting = 217.058 > Hw = 73m

So it's low Gravity Dam

Top width "a"

Free board = 1.5 h wave = 1.5 × 1.2 = **1.8 m**

height of Dam = HD = Hw + F.B = 73 + 1.8

HD = 74.8m

a = 14% of HD

a = 0.14 × 74.8

a = 10.472m

Base width "b" (without offset)

(i) For no sliding Criteria

$$b' = \frac{Hw}{\mu G} = \frac{73}{0.7 \times 2.4}$$

b' = 43.45

b' ≅ 44 m

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ii) For No tension Criteria

$$b' = \frac{H_w}{\sqrt{G}} = \frac{73}{2.4}$$

$b' = 47.12m$

use $b' = 47.12m$

(4) Depth of Vertical Position On U/S Side

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

$$h' = 2 \times 10.472\sqrt{2.4 - 0}$$

$h' = 32.44m$

$h' = 33m$

(5) Upstream Off set:-

$$= \frac{a}{1.6}$$

$$= \frac{10.472}{1.6}$$

$= 0.6545m$

(6) Depth below the Water level to the End of Inclined Portion in U/S $= 3.14a\sqrt{G}$

$$= 3.14 \times 10.472\sqrt{2.4}$$

$U/S = 50.93m$

(7) Initial width of the base of the dam

$$b = b' + \frac{a}{16} = 47.12 + \frac{10.472}{16}$$

= ~~47.772~~

$= 47.12 + 0.6545$

$\boxed{b = 44.77m}$

(8) $\tan \theta = \frac{b'}{H}$

$\theta = \tan^{-1} \times \frac{47.12}{73}$

$\theta = 0.57m$

(9) Depth of Vertical Portion on D/S
(from WL on U/S Side)

$\tan \theta = \frac{a}{d'} = \frac{10.472}{d'}$

$\frac{2}{3} d' = 10.472$

$d' = \frac{10.47 \times 3}{2}$

$\boxed{d' = 15.708m}$

Depth of Vertical Portion

$d = d' + FB = 6.5 + 1.8$

$\boxed{d = 8.3}$

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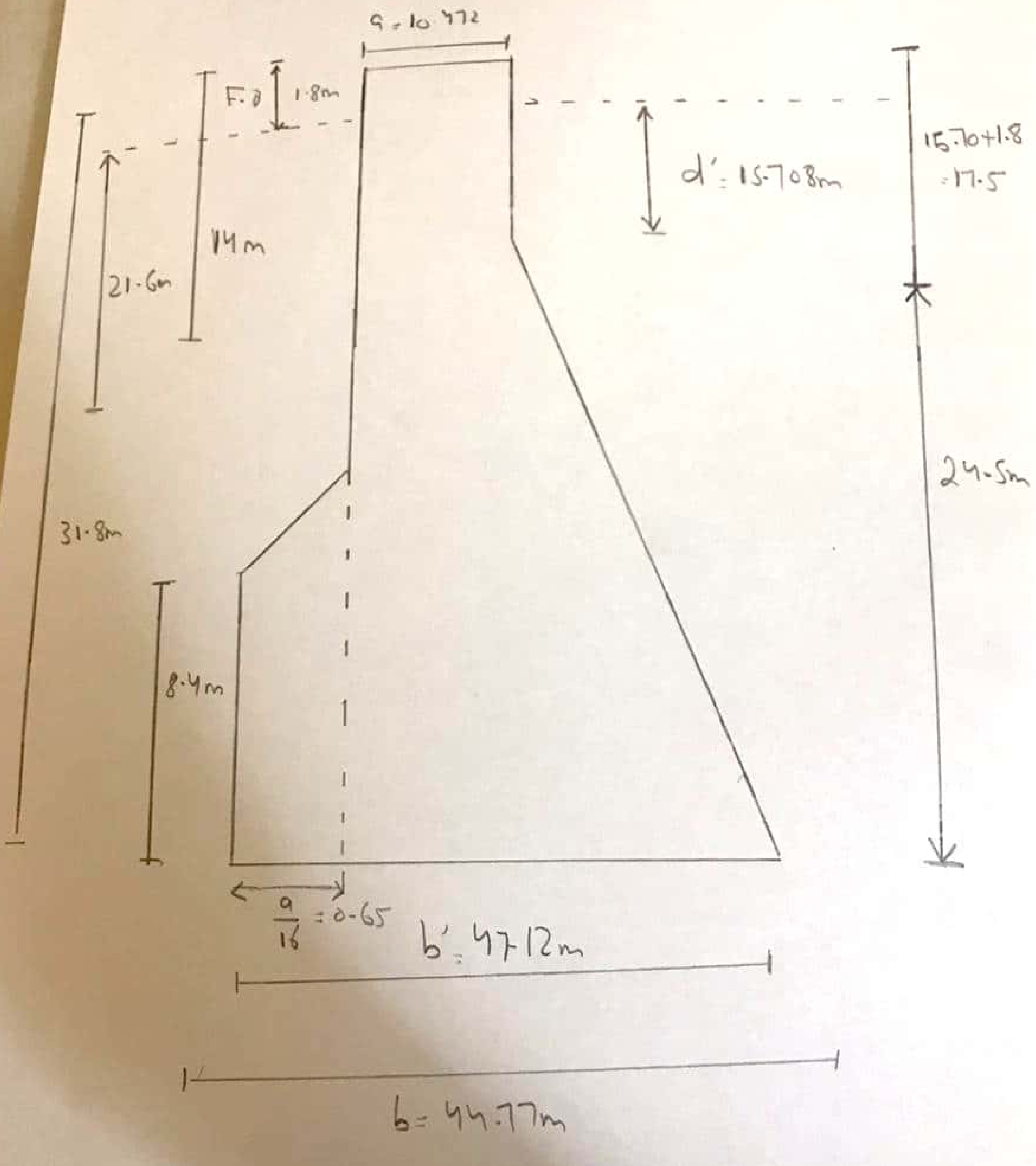

a = 10.472
F.B
1.8m
d' = 15.708m
15.70+1.8
= 17.5
14m
21.6m
24.5m
31.8m
8.4m
a/16 = 0.65
b' = 47.12m
b = 44.77m

Q3

Dimension analysis is a mathematical technique where we study Dimension.

Purpose:-

Sealing laws are obtained So that the model Performance Can be Predicted. Relationship between the Parameters is Predicted. A non-dimensional Parameter is generated which helps in Experiments, design and Report results.

FUNDAMENTAL DIMENSION:-

Basic Quantities e.g. Time (T), distance (L), mass (M) are refered as fundamental dimensions

SECONDARY DIMENSION:-

Quantities more than one fundamental dimension e.g Velocity (L/T), Acceleration $(L/T)^2$, Density (M/L^3) are refered as Secondary dimensions

SIMILITUDE:-

The Similarity between Model and Prototype and their Similar Properties is define as Similitude. It is Used to Test an Engineering Model

EXAMPLE:-

Consider a Submarine modeled at 1/40th Scale. The Application operate in Sea water at 0.5 C, moving at 5m/s. The model will be tested in fresh water at 20°C.

Q# 4

① PARTICLE DIAMETER:-

Particle diameter is directly related to the velocity by which it falls. ~~The great~~ If the size of the Particle is greater it will tend to be more faster than the smaller Particle. The gravitational force on the greater Particle is more so it will fall quickly because of it's weight.

② PARTICLE DENSITY:-

Density of the Particle also directly Proportional to the fall velocity. Particle with High Density is said to be easily Settle down as compare to Particle with low Density.

③ PARTICLE CONCENTRATION:-

The effect of fall Velocity has direct link with Concentration of Particle size. The Particle will ~~be~~ Settle down at a Place with greater Concentration and Cause More fall velocity as Compare to Particle with low concentration

VISCOSITY OF WATER:-

Viscosity of water is inversely proportional to the fluid velocity therefore a decrease in viscosity results in increase in velocity.

TURBULANCE OF WATER:-

The fall velocity of water in a reservoir is affected by the turbulence of water this is because the non-linear and zigzag pathways effects the flow of water

PARTICLE SHAPE:-

It is 75% slower than equivalent sphere model show 100 µm non spherical particles travels 44% further than sphere vertical structure of modelled volcanic ash cloud is sensitive to particle shape.