Q1

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.

the relevent variables

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

Write down dimensions.

Δp $ML^{-1}T^{-2}$

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 and T)

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

choose $m(=3)$ scaling variables

geometric (d); kinematic/time depend (V); dynamic/mass-dependent (ρ

From dimensionless groups by non dimensionlising the remaining variables: 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: $0 = 1+c$ $\Rightarrow c=-1$

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

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

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

$\Pi_2 = \frac{h}{d}$ (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 Reynold's number suggests that we replace Π_3 by

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

Hence, dimensional analysis yields

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

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

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

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

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

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

(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.

$$\Pi_1 = \left(\frac{\Delta p}{\rho V^2}\right)_p = \left(\frac{\Delta p}{\rho V^2}\right)_m \Rightarrow \frac{(\Delta p)_p}{(\Delta p)_m} = \frac{\rho_p}{\rho_m}\left(\frac{V_p}{V_m}\right)^2 = \frac{800}{1000}\times0.5^2 = 0.2$$

Hence

$$\Delta p_a = 0.2\times\Delta p_m = 0.2\times60 = 12.0\,kPa$$

Q2

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Given data

Max depth of reservoir is = 76 m

Specific gravity = 2.4

f_{av} = 764 T/m²

Hieght of wave = 1.2m

Sol

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

$= \frac{764 \times 1000}{1000(2.4 - 0 + 1)}$

H limiting = 224.70

2) Top width "a"

Free board = 1.5 × h.w

= 1.5 × 1.2

= 1.8

Hieght of dam = Hw + F.B

= 76 + 1.8

= 77.8

a = 14% of HD

= 0.14 × 77.8

= 10.892

3) Base width :→

$$b' = \frac{H_w}{\mu G} = \frac{76}{0.7 \times 2.4}$$

$$= 45.23 \text{ m}$$

$$= 46$$

4) For no tension criteria :

$$b' = \frac{H_w}{\sqrt{G}} = \frac{76}{\sqrt{2.4}}$$

$$\Rightarrow 49.05$$

Depth of vertical portion on u/s side:

$$h = 2a\sqrt{G \cdot \omega}$$

$$= 2 \times 10.893\sqrt{2.4 - 0}$$

$$= 33.74$$

$$= 34 \text{ m}$$

Upstream off set :

$$= \frac{a}{16}$$

$$= \frac{10.892}{16}$$

$$= 0.6$$

Depth of below the water level to the end of inclined portion

$$U/s = 3.14\, a\sqrt{G}$$

$$= 3.14 \times 10.892\sqrt{2.4}$$

$$= 52.92$$

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$\tan\theta = \frac{b'}{H} = \frac{49.05}{76}$

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

$= ~~[illegible]~~ \; 32.61^\circ$

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

$\tan\theta = \frac{a}{d'} = \frac{10.892}{d'}$

$d' = 16.87\,m$

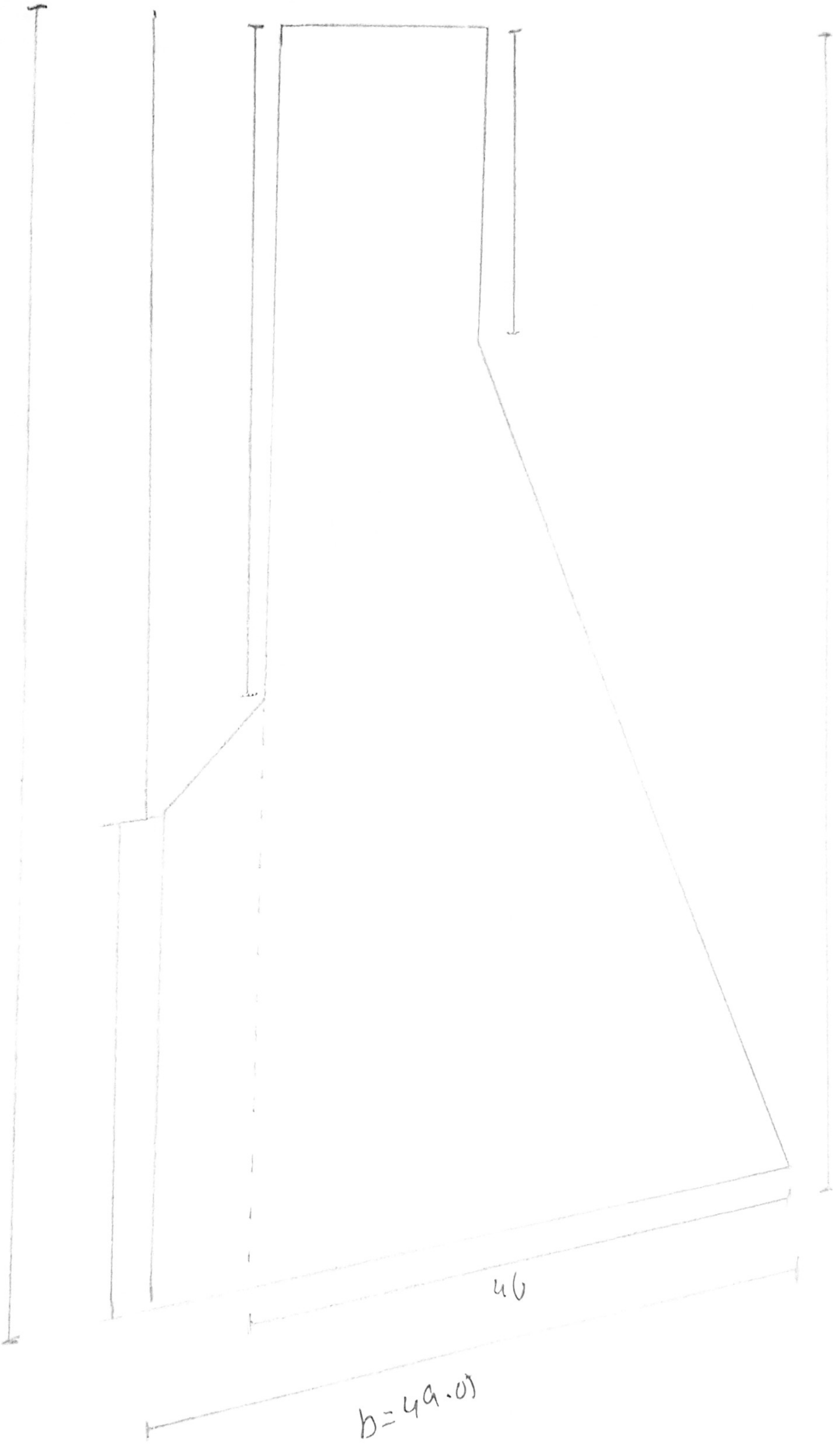
Depth of vertical portion

$d = d' + F.B$

$= ~~16.87 +~~$

$= 16.87 + 1.8$

$= 18.67$


46
b=49.01

Q3

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Ans

Dimension analysis is a mathematical technique making use of study of dimension

→ Purpose of dimension anylsis:
To obtain scaling law so that the prototype performance can be predicted from model performance. To predict in the relationship b/w parameter. To generate non dimensional parameter that help in the ~~relationship~~ design of experiment and in reporting of results.

=> Fundamental dimension:
There are the basic quantities

for example
Time, T : Distance, L : Mass, M.

=> Secondary dimension: Those quantity which posses more than one fundamental dimension.
Velocity, L/T, Acceleration L/T, Density M/L³

=> Similitude: It is defined as similarly b/w the model and prototype in every respect which means model and prototype are completely similar.
it is used in testing engineering model.

Example:
Consider a submarine modeled at 1/40th scale. The application operation in sea water at 0.5 C moving at 5m/s. The model will be tested in fresh water at 20C

Q4

Ans. Particle diameter:

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

2) particle density.

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

3) particle concentration:

Concentration of particle size will considerably 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.

4) Particle shape:

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