7875

Name : Fawad khan

ID/sec : 7875 / B

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Subject: Hydraulic Engineering

Teacher : Fawad Ahmed

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Question No: 01

Solution:-

The Pressure drop ΔP is expected to depend upon the gate opening h, the overall depth d, the velocity V, density ρ, viscosity μ.

List of Relevant Variables:-

ΔP, h, d, V, ρ, μ

Dimensions:-

$\Delta P = ML^{-1}T^{-1}$

$h = L$

$d = L$

$V = LT^{-1}$

$\rho = MLT^{-1}$

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

Number of variables; n = 6

Number of independent dimensions, m = 3 (M, L & T

Number of 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-dimensionalizing 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: $0 = -1+a+b-3c \Rightarrow a = 1+3c-b = 0$

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

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

$\Pi_3 = \mu d^a V^b \rho^c$ (Probably obvious by now, but here goes anyway)

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

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

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

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

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

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

Recognition of the Reynolds number suggests that we replace 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-dimensional groups be the same in model and prototype, i.e

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

$\Pi_3 = \left(\frac{h}{d}\right)_p = \left(\frac{h}{d}\right)_m$ (automatic if similar shape ie 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 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,

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

(b) The ratio of the quantities of Flow is

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

$$= 12.5$$

(c) Finally, for the Pressure drop

$$\Pi_1 = \left[\frac{\Delta p}{\rho v^2}\right]_p = \left[\frac{\Delta p}{\rho v^2}\right]_m \Rightarrow \frac{(\Delta p)_p}{(\Delta p)_m} = \frac{\rho_p}{\rho_m}\left(\frac{V_p}{V_m}\right)^2$$

$$= \frac{800}{1000} \times 0.5^2 = 0.2$$

Hence

$$\Delta P_p = 0.2 \times \Delta P_m = 0.2 \times 60 = 12.0\,kPa$$

QUESTION NO 02:

GIVEN:-

Max depth = 78m

Specific gravity = 2.4

$\rho_{av} = 7875 / m^2$

Height of wave = 1.2m

SOLUTION:-

(i) $H_{limiting} = \frac{\rho_{av}}{r_w (a-w+1)}$

$= \frac{787 \times 1000}{1000 (2.4-0+1)}$

$H_{limiting} = 231.47$

Top width, "a"

Free board = 1.5 x hwave

= 1.5 x 12

= 1.8

Height of Dam = Hw + F·B = 78 + 1·8

HD = 79·8

a = 14% of HD

= 0·14 × 79·8

= 11·172 m

3) Base width

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

= 46·42 m

= 47

4) For no tension criteria

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

= 50·34

Depth of vertical portion On U/s side

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

$= 2 \times 11.172\sqrt{2.4 - 0}$

$= 34.60$

$= 35m$

Upstream off set: $\frac{a}{16} = \frac{11.172}{16}$

$= 0.6$

Depth of 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

$b = b' + \frac{a}{16} = 50.34 + \frac{11.172}{16}$

$= 51.03$

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

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

$$= 44.80''$$

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

$$\tan \theta = \frac{a}{d_1} = \frac{11.172}{d'}$$

$$\tan \theta = \frac{11.172}{d'}$$

$$\left(\frac{839}{1300}\right) \times d' = 11.172$$

$$d' = 17.30\,m$$

Depth of vertical Portion

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

$$= 17.30 + 1.8$$

$$= 19.1$$

Question No (3)

Using any hydralic model & explain the concept of dimentioned analysis & similitude. Each shoud'n t should have seperate model analysis.

Answer:-

Dimention analysis is a mathematical the technique making use of study of dimention.

↳ Purpose of Dimention Analysis:-

- To obtain sealing laws so that Prototype performance can be predicted from model performance.
- To predict in the relationship between parameter.
- To generate non dimentional parameter that help in the design of experiment and in reporting of results

↳ "Fundemental Dimension":-

There are the basic quantities

For example

Time, T ; Distance, L ; Mass, M

↳ "Secondary Dimension":-

Those quantity which posses more then one fundamental dimenion velocity, L/T Acceleration, L/T^2

Density, M/L^3

Similitude:-

It is defind as similarity b/w the model and prototype in every respect which mean model and prototype have similar properties or model and prototyp are comptedlly similar.

- It is used in testing engineering model.

Example:-

Consider a submarine modeled at 1/40th scale. The application operate in sea water at 0.5c; moving at 5m/s'. The model will be tested in fresh water at 20°c.

Q No # 04

Ans: The downward velocity in a low dense fluid at equilibrium in which the sum of the gravity force, ~~By~~ buoncy force and fluid drag force are equal to zero.

Fall Velocity:

when a grain falls down in still water it obtains a constant velocity when the upward fluid drag force on the grain is equal to the downward submerged weight of the grain. This is also called setling velocity.

Fall Velocity effected due to

The following are the terms

a) Particle diameter

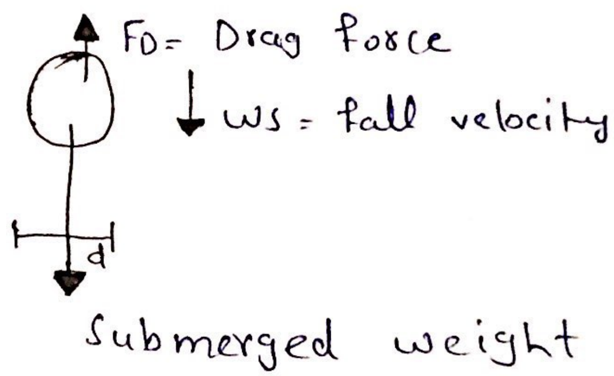
b) Particle density

c) Particle concentration

d) Particle shape

e) Viscosity of water [Temperature]

f) Turbulance



The force balance between the drag force and the Submerged weight gives

$$F_D = \text{Submerged weight}$$

$$\frac{1}{2} \rho C_D \frac{\pi}{4} d^2 w_s^2 = (\rho_s - \rho) g \frac{\pi d^3}{6}$$

$A = \frac{\pi d^2}{4}$ = Projected Area

C_D = Drag co-efficient

w_s = fall velocity of sediment

$$= \sqrt{\frac{4gd}{3C_D}\left(\frac{\rho_s - \rho}{\rho}\right)}$$

ρ = Density of water

ρ_s = Density of sediment Particle/m2.

"PARTICAL DIAMETER:-"

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

"PARTICLE DENSITY":-

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

"PARTICLE CONCENTRATION":-

Concentration of particle size will considerably effect its fall velocity as the section having greater concentration will be sittled down at the place thus causing more fall velocity comparing with section of low concentration.

"PARTICLE Density:-"

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

"PARticle Shape:-"

Particles having regular shapes tends to be effected more than irregular shapes particle have even surfaces which offer very little or no friction while Particles 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 so the section of water having more temperature and pressure will fall objectively more due to increase in the kinetic energy so fall ~~to~~ velocity will be more.

Turbulance of Water:-

Turbulance of water effect the fall velocity of water in reservoir because the non-linearity and zig zag path effect the flow of water and cause the variation in the flow.