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iD 7868

Section B

Semester 6^{th}

Hydraulic Engineering

Final Examination

Date 25^{th} June, 020.

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Question No 1 :- A prototype gate valve which will control the flow in a pipe system conveying paraffin is to be studied in a model. List the significient - . . . . . .

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.

Number of variables : $n = 6$

Number of independent dimensions :

$m = 3$ (M, L and T)

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

Choose $m\,(=3)$ scaling variables

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

Form dimenless group by non-dimensionlising the remaining variables : ΔP, h and μ.

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

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

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

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

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

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

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

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

$\Pi = \mu d^a V^b \rho^c$ (Probably obvious by now, but here goes any way...)

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

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

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

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

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

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

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

ie

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

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

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

$$\Pi_2 = \left[\frac{h}{d}\right]_m = \left[\frac{h}{d}\right]_m$$ (automatic 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 a velocity ratio

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

Hence

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

(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,

$$\Pi_1 = \left[\frac{\Delta P}{\rho V^2}\right]_p = \left[\frac{\Delta P}{\rho V^2}\right]_m \Rightarrow \frac{(\Delta P)_p}{(\Delta P)_m} = \frac{\rho_p}{\rho_m}\left[\frac{V_v}{V_m}\right]^2 = \frac{800}{1000} \times 0.5^2 = 0.2$$

Hence,

$$\Delta P = 0.2 \times \Delta P_m = 0.2 \times 60$$

$$= 12.0 \text{ kPa}$$

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Q2 :- Design a practical profile of gravity dam with the following data:

1. Maximum ....

Given data :-

Max depth = 78 m

Specific gravity = 2.4

Height of the wave = 1.2 m

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

$= \dfrac{786 \times 1000}{1000 (2.4 - 0 + 1)} \Rightarrow 231.176\, m$

② Top width "a"

Free board $= 1.5 \times h_{wave} \Rightarrow 1.5 \times 1.2$

$= 1.8$

Height of Dam $= H_w + F.B$

$= 78 + 1.8$

$= 79.8$

② Height of Dam =

$a = 14\%$ of H_D

$= 0.14 \times 79.8 = 11.172\, m$

(3) Base width :-

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

$= 46.42\ m$

$= 47 \approx 47$

(4) For no tension Criteria :-

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

$\Rightarrow 50.34$

(5) Depth of vertical portion on U/s side

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

$= 2(11.17)\sqrt{2.4-0}$

$= 34.60 \approx 35 m$

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

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

$$\boxed{b = 51.03}$$

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

$$\tan\theta = 0.64$$

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

$$\theta = 44.80^\circ$$

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

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

$$d' = 17.30\,m$$

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

Depth of vertical portion:

$$\left(\frac{834}{1300}\right) \times d' = 11.17$$

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

$$= 17.30 + 1.8$$

$$= 19.1$$

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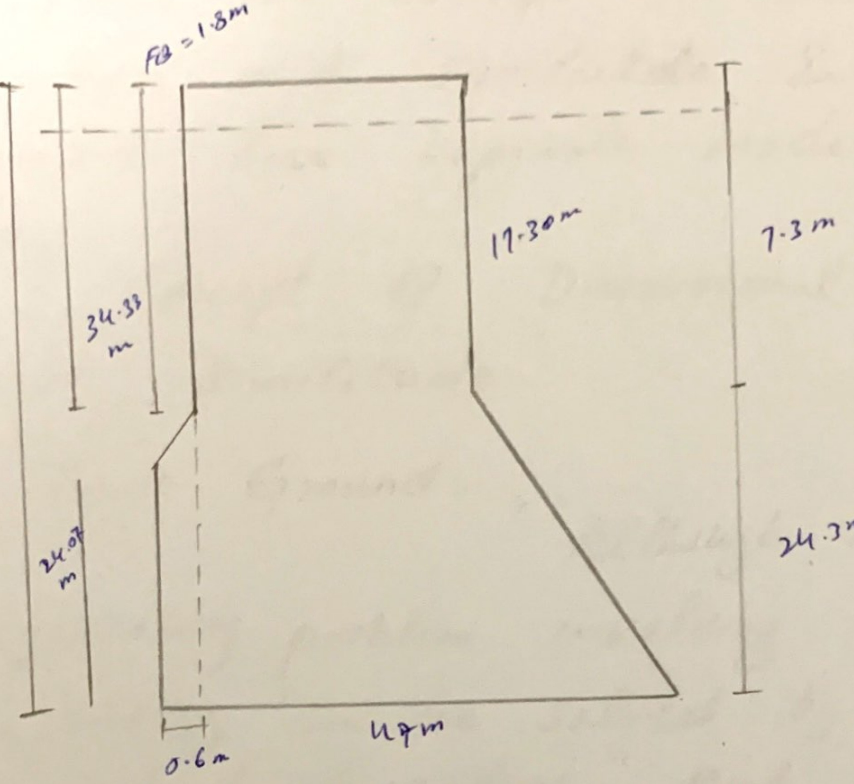
Diagram



Qno3. Using any hydraulic model and explain the concept of Dimensional analysis and similitude. Each Student should have seperate model analysis.

Ans :- Concept of Dimensional Analysis and similitude.

Back Ground :- " Although many practical engineering problem involving Hydraulic engineering can be solved by Equation and Analytical Procedure". But yet a large number of problems relay on experimental data for their solution.

Similitude is used to express measurement on laboratory can be used to describe the behavior of other system outside of laboratory.

Dimensional Analysis :-

Dimensional Analysis is a mathematical technique making use of study of dimensions.

It deal with dimension of physical

quntities involved in the Phenomena.
It is helpful in experimental work because it provide a guide to those things That.

Significally influence the phenomena. This mathematically technique is used in research work for design and for Conducting model test.

Types of Dimensions:

Fudamental Dimension (Fundamental Quntities) Secondary Dimension (Derived Quntities

e.g. velocity = L/T,

$$\text{Pressure} = \frac{\text{Force}}{\text{Area}}$$

$$P = \frac{F}{A}$$

$$\because [P] = \frac{[F]}{[A]}$$

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$$\because [P] = \frac{[F]}{[A]}$$

$$\therefore [P] = \frac{[L^1 M^1 T^{-2}]}{[L^2 M^0 T^0]}$$

$$\therefore [P] = [L^{-1} M^1 T^{-2}]$$

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⇒ Method of Dimensional Analysis :-

→ If the number of variables involved in physical phenomenan are known the relation of variable will be determined by,

(i) Rayleigh's Method

(ii) Buckingham's π - Theory

(i) Rayleigh's Method :-

It is used for determing expression for variable which depends upon Max 3 to 4 variable.

According Rayleigh's Method,

$$x = f(x_1, x_2, x_3)$$

$$x = k x_1^a, x_2^b, x_3^c$$

where

k = non-dimensional Constant

a, b, c = arbitrary Powers

⇒ Bucllingham π- Theorem:-

Since Raleigh theorem becomes laborious if variables are more than Fundamentals dimensions So the difficulty is overcome by Bucllingham method.

Mathematically:-

$$x_1 = f(x_2, x_3, x_4, x_n)$$

which can be written as.

$$f = (x_1, x_2, x_3, x_4, x_n) = 0$$

⇒ Similitude & model Analysis:-

Similitude:- It is a concept used in test of Engineering models. Usully it is impossible to obtain a pure theoritical Solution of hydraulic phenomenon. There fore experimental investigation are often performed on small scale models, which is called model analysis.

Model Analysis:-

It is Actually an experimental method of finding solution of Complex flow problem

Model:-

It is small scale replica of Actual structure.

Prototype:- The Actual structure of machine.

⇒ Electric Diaphragm Pump:-

Compact structure, small size, light weight convenient assembly and disassembly.

→ High transmission efficiency.

→ Smooth operation and low noise.

→ Long service life.

→ No leakage transmission medium.

→ Can with stand no load operation.

→ No need to irrigation water, can self-absorption.

→ Good passing performance, large particle impurities, mud etc.

⇒ Main Purpose :- → various highly toxic, inflammable and volatile liquids.

→ All kind of strong acid, strong alkali, strong corrosion liquid.

→ High temperature medium 150°C.

→ As a pressure feeding device in front stage of various filter presses.

→ Hot water recovery and circulation.

→ Loading and unloading of oil tanker, oil dept and oil products.

→ Pump pickles, mashed potatoes, chocolate etc.

→ Use pump to drain sewage and residual oil for tanker barge clearance.

Qno4:- What will be the effect of sediment particle diameter, particle density, particle concentration, -------

Answer:-

⇒ 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.

⇒ 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 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

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⟹ Particle shape :-
Particles having regular shapes tends to be affected more than irregular shapes since regular shapes particles have even surfaces which offers very little or no friction while particles with irregular shape offers more friction, as the particle with smaller surface area are more likely to be affected 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 velocity will be more.

⇒ Turbulance of water:-

Turbulance of water depends upon the different factors such as velocity it will effect the fall velocity because of its zigzag motion thus the velocity varies at every point which is why it effect the fall velocity moreover increase in the kinetic energy tends to effect the fall velocity compared with steady fluid.