Name: Ayub Khan

ID #: 7881

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Subjec: Hydraulic Engineering

Submitted to: Engr: Fawad Ahmad

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Signature:

Q:1: A prototype gate Valve, which will Controll the flow in Pipe System Conveying Paraffin is to be Studied in a model. List the Significant variable on which the Precessure drop Across the Valve would depend. Perform dimensional analysis to obtain the relevant non-dimensional group. (1)

A 1/5 Scale model is built to obtain or determine the Pressure drop across the Valve with water as the working fluid.

(a) For a Particular opening when the Velocity of Paraffin in the Prototype is $3.0\ m s^{-1}$, what Should be the Velocity of water in the model for dynamic. Similarity.

(b) what is the ratio of quantities of flow in prototype and model.

(c). Find the Pressure drop in Prototype if it is 60 kpa in the model.

Q, (2)

Solution: Given data.

Density, ρ = 800 kg/m^3

Viscocity of Paraffin = 0.002 $kg\,m^{-1}\,s^{-1}$

Kinematic viscosity of water = 1.0×10^{-6} $m^2 s^{-1}$

=> The Pressure drop ΔP is expected to depend upon the gate opening h, the over all depth d, the velocity v, density ρ and Viscosity μ.

List the relevent variables.

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

Write down the dimension:

ΔP	$ML^{-1}T^{-2}$
h	L
d	L
v	LT^{-1}
ρ	ML^{-3}
μ	$ML^{-1}T^{-2}$

(1) Q1 ③

Number of Variable, $n = 6$

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-dimensionlessing the remaining variables: Δp, h and μ.

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

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

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

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

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

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

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

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Q1 (4)

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

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

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

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

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

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

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

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

Recognition of the Rynold numbers Suggests that we replace Π_3 by

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

Hence dimensional analysis yields.

(1) Q1 (5)

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

i.e.

$$\frac{\Delta p}{\rho v^3} = f\left(\frac{h}{d}, \frac{\rho v d}{\mu}\right)$$

(a) Dynamic Similarity require that all non-dimensional group be the Same in model and Prototype. ie.

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

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

$$\Pi_3 = \left(\frac{\rho v d}{\mu}\right) = \left(\frac{\rho v d}{\mu}\right)$$

from the last, we have a velocity Ratio.

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

Q, (6)

Hence;

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

(b) The Ratio of quatities 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 Pressure drop.

$$\Pi_1 = \left(\frac{\Delta P}{\rho V^2}\right)_P = \left(\frac{\Delta P}{\rho V^2}\right) \Rightarrow \frac{(\Delta P)_P}{(\Delta P)_m} = \frac{\rho_P}{\rho_m}\left(\frac{V_P}{V_m}\right)^2$$

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

Hence

$$\Delta P_P = 0.2 \times \Delta P_m = 0.2 \times 60 = 12.0 \, kPa..$$

Q2 (1)

Qno2:

Given data.

Max depth = 78 m

Specific gravity = 2.4.

Allowable Compressive Stress = 788 T/m2.

Height of wave = 1.2 m.

Solution:

$$H_{limiting} = \frac{6}{\gamma_w (G - (c + 1))}$$

$$= \frac{788 \times 1000}{1000\,(2.4 - 0 + 1)}.$$

H limiting = 231.7

(2) TOP width = "a"

Free board = 1.5 x hwave

= 1.5 x 1.2

= 1.8.

Height of Dam = $H_w + F.B$

$= 78 + 1.8$

$= 79.8.$

② - Height of Dam.

$a = 14\% \ H.D.$

$= 0.14 \times 79.8$

$= 11.17 \ m$

=> ③ Base width :

$b = \frac{H.w}{\mu G} = \frac{78}{0.7 \times 2.4}$

$= 46.42 \ m \approx 47 \ m.$

④ For no tension Criteria

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

Q2 (3).

$= 50.34$

(5) Depth of verticle portion on U/S side:

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

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

$= 34.60$

$= 35\,m.$

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 $= 3.14a\sqrt{G}.$

$= 3.14 \times 11.17\sqrt{2.4}.$

$= 54.33$

Q2 (4)

Total width of the base of the dam.

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

$b = 51.03$

$\tan\theta = \frac{b'}{h} = \frac{50.034}{78}$

$\tan\theta = 0.64$

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

$\theta = 44.80°$

Depth of verticle Portion on D/S (from WL on U/S side].

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

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

$\left(\frac{839}{1300}\right) \times d' = 11.17.$

$d' = 17.30m$

Q2 (b).

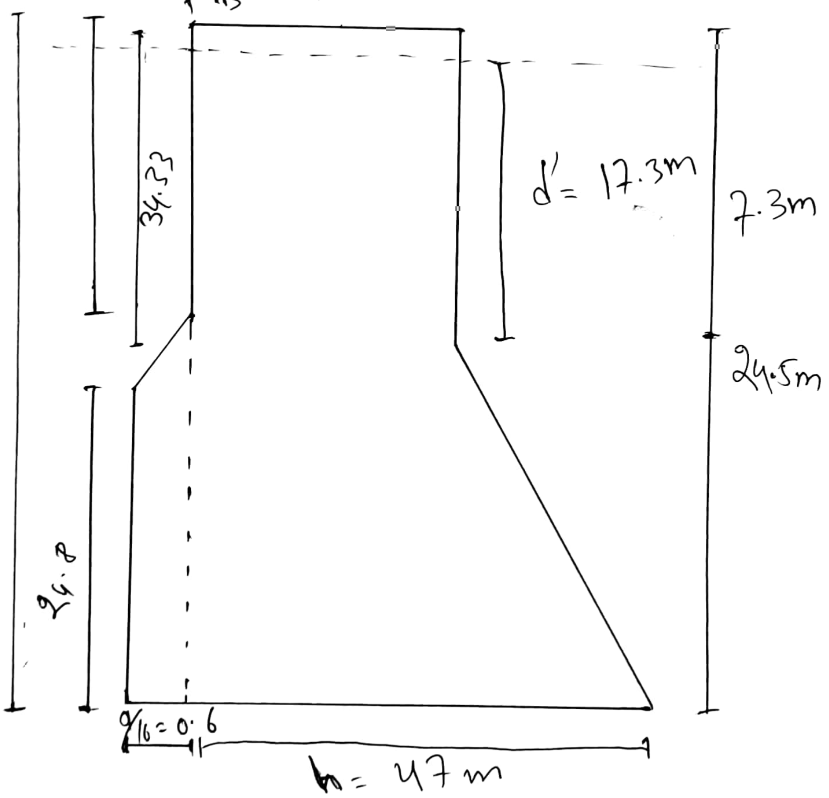
Depth of verticle Portion:

$$d = d' + f.B$$

$$= 17.30 + 1.8$$

$$= 19.1$$

f.B = 1.8m



Q3(1)

Qno3: Use any hydraulic model and explain the Concept of Dimensional analysis and Similitude.

Answer:

Concept of Dimensional analysis And Similitude.

Background:

Although many ~~Particles~~ Practicle Engineering Problem involving hydraulic Engineering Can be Solved by Equation and Analyticle Procedure. Similitude is used to expressed measure in Laboratory, & Can be use to describe the bahavior of other System outside the Laboratory.

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Q3 (a)

Dimensional Analysis:

Dimensional analysis is a mathematical technique making use of study of dimension.

deal with dimension of physical ~~equation~~ quantity solved in the phenomenon.

It is helpful in experimental work because it provides a guide to those things that significantly influence the phenomenon.

This mathematical technique is used in research work for designing and for conducting model test.

Types of dimension:

→ Fundamental dimension / Quantities.

→ Secondry dimension (derived Quantities)

Q3 (3)

Dimensioning of Power.

Common Symbol of Power = P.

S.I base Unit = $kg.m^2.s^{-3}$

unit = watt (N-m/sec).

Derivation:

$P = E/t$

$P = f.v$

$P = V.I$

$P = T.\omega$

ML^2T^{-3}.

or

Electric resistent Dimensioning.

Electric Resistance = $\frac{\text{Electric potential}}{\text{Electri Current}}$

$R = V/I$

$\therefore [R] = \frac{[V]}{[I]}$

$\therefore [R] = \frac{[L^2 M^1 T^{-3} I^{-1}]}{[I^1]}$

$\therefore [R] = [L^2 M^1 T^{-3} I^{-2}]$.

Q3 4

Method of Dimensional Analysis

→ If the number of variables involved in physical phenomenon are know, the relation of varible will be determined by;

① Rayleigh's Method.

(2) Buckingham's π -Theory.

① Rayleigh's method:

It is used for determining expression for variable which depends upon max 3 to 4 variables.

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

Q3 (b)

Buckingham π - Theorm:

Since Raleigh theorm becomes laborious if variables are more than fundamentals dimensions. So the difficulty is ~~ov~~ overcome by Buckingham method.

Mathematically:

$$x_1 = f(x_2, x_3, x_4, x_n)$$ which can be written as.

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

Q3 (b)

Similitude & model Analysis:

Similitude: It is a Concept used in test of Engineering models.

usually it is impossible to obtain a pure theoritical Solution of hydraulic Phenomenon. There fore experimental investegation are often performed on Small Scale models, which is called model analysis.

Model Analysis: is Actually an experimental method of finding Solution of Complex flow Problem.

Model: is Small Scalle replica of Actual Structure.

Prototype: The actual Structure or Machine.

Q3 (7)

Model Analysis of Ships in township basin.

In the analysis, A hydrodynamic model for the analysis of moored ships motion is presented in a realistic harbour with highly irregular geometry.

In each ~~field~~ region, the wave field is determined by using Boundary element method with corner contribution and Chebyshev point discretization.

Then the hydrodynamics coefficient were determined based on equation of motion with six different component of moored ship motion as surge, sway, heave, roll, pitch and yaw.

Q3 (8)

Moreover the Current numerical Scheme is implemented on realistic Pohang New Harbour, which is Situated in Pohang City, South Korea to analyse the wave field in Ship region under the various resonance frequency for mono chromatic incident waves.

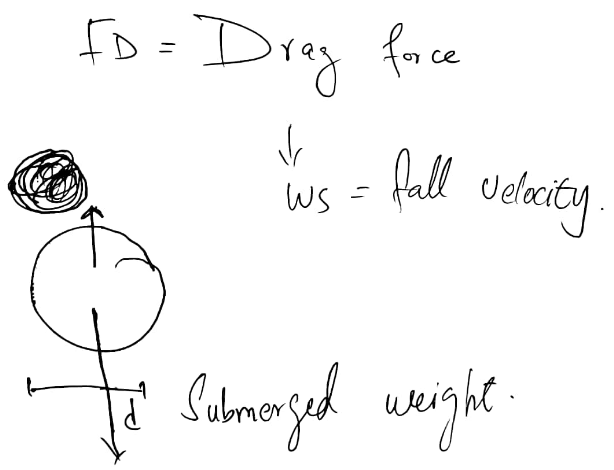
Q no 4: What will be the effect of Sediment Particles diameter, Particle density, Particle Concentration, Particle Shape, Viscosity of water, turbulant of water flowing in reservoir on fall velocity? Explain in details:

Answer: **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 Constant velocity is defined as " The fall ~~velocity~~ velocity of the grain, This is also Called Setting velocity.

Fall Velocity depends upon

1). Particle density
2). Particle diameter
3). Particle Consontration
4). Particle Shape
5). Viscosity of Water
6). Turbulance.



Now for the effect of above mentiond properties; We have.

Particle diameter:

The Particle Size is directly Proportional to the fall velocity, because greater the Size of particles, greater will be the Speed of fall velocity as Compared to Small particle.

It is because, Larger Particles are heavy and the tend to move fast downward.

And thus, the will be more gravity force on Particles of greater Size so it will fall quickly due it's weight.

(2) **Particle Density:**

Density of the Particle is directly Proportional to the rate of fall velocity settle down early Compared with Particle of low density.

(3): **Particles Concentration:**

Concentration of Particle 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.

Particle Shape:

Particle having regular Shape tends to be effected more than irregular Shapes Since regular Shapes Particles have even Surface which offers very little or no friction, ~~which~~ While Particle with irregular Shape offers 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 tempreture and Pressure Change the magnitude of viscosity, So the Section of water having more tempreture and Pressure will fall Objectively more due to increase in the K.E, 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. Therefore the velocity varies at every Point, Which is why it effect the fall velocity, moreover increase the K.E tends to effect the fall velocity, Compared with Steady fluid.