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ID 7809

SECTION A

SUBJECT Hydraulic Engineering

SUBMITTED To Engr Fawad Khan

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Question No # 1

A prototype gate valve which will control the flow in pipe system conveying paraffin is to be studied in a model. List the significant variables on which the pressure drop across the valve would depend. perform dimensional analysis to obtain the relevant non-dimensional group.

A 1/5 scale model is built to determine the pressure drop across the valve with water as working fluid.

(a) For a particular opening, when the velocity of paraffin in the

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prototype is 3.0ms⁻¹ What should be the velocity of water in the model for dynamic similarity.

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

(c) Find the pressure drop of the prototype if it is 60kpa in model.

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Solution :

Pressure drop depend upon the gate opening, the overal depth, the velocity, density and viscosity.

ΔP = pressure drop.
h = opening gate.
d = overall depth.
V = velocity.
ρ = density.
μ = viscosity.

It dimension are

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

$h = L$

$d = L$

$v = LT^{-1}$

$\rho = ML^{-3}$

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

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Number of variable $n = 6$

Number of independent dimensions $m = 3$

Number of non-dimensional grows $n - m = 3$

Choose $m (=3)$ scaling variable

geometric (d)

Kinematic/time-dependent (v)

dynamic/mass-dependent (ρ)

From dimensionless group by non-dimensionalising the remaining variable Δp, h and μ

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

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

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

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M $0 = 1 + c$ $c = -1$

T $0 = -2 - b$ $b = -2$

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

~~ans~~

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

$\Pi_2 = \dfrac{h}{d}$ (h = lengut)

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

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

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

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

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

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

$= -1$

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$$\Rightarrow \Pi_3 = M d^{-1} v^{-1} \rho^{-1} = \frac{M}{\rho v d}$$

According to Reynold number replace Π_3 by

$$\Pi_3' = (\Pi_3)^{-1} = \frac{\rho v d}{M}$$

Hence dimensional Analysis yields

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

i.e,

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

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

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

$$\Pi_2 = \left[\frac{h}{d}\right]_n = \left[\frac{h}{d}\right]_m$$

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

but

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we have velocity ratio

$$\frac{V_p}{V_m} = \frac{(\mu/\rho)_p}{(\mu/\rho)_m} \frac{d_m}{d_p}$$

$$\frac{V_p}{V_m} = \frac{0.002/800}{1.0\times10^{-6}} \times \frac{1}{5}$$

$$\frac{V_p}{V_m} = 0.5$$

Hence

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

$$\boxed{V_m = 6.0\,ms^{-1}}$$

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(b) Quantity of Flow ratio

$$\frac{Q_p}{Q_m} = \frac{(\text{velocity} \times \text{area})_p}{(\text{velocity} \times \text{area})_m}$$

$$\frac{Q_p}{Q_m} = \frac{V_p}{V_m}\left(\frac{d_p}{d_m}\right)^2$$

$$\frac{Q_p}{Q_m} = 0.5 \times 5^2$$

$$\boxed{\frac{Q_p}{Q_m} = 12.5}$$

No unit because it is ratio

(c) Pressure drop

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

$$\Pi_1 = \frac{(\Delta p)_p}{(\Delta P)_m} = \frac{\rho_p}{\rho_m}\left(\frac{V_p}{V_m}\right)^2$$

$$\Pi_1 = \frac{800}{100} \times 0.5^2 = \boxed{0.2}$$

Hence

$$\Delta P_p = 0.2 \times \Delta P_m$$

$$\Delta P_p = 0.2 \times 60$$

$$\boxed{\Delta P_p = 12\ kPa}$$

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Question No # 2

Design profile of gravity dam with the following data.

1. Maximum depth of water in the reservior is 78
2. Specific gravity of dam material is $G = 2.6$
3. Allowable compressive strenght for the dam masonary is 780 T/m²
4. Height of wave is Hw 1.4m

$M = 0.7$ $C_u = 0$

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Solution

(1) **H limiting** $= \dfrac{\sigma_{au}}{\gamma_w (G - C_u + 1)}$

$H_{limiting} = \dfrac{780 \times 1000}{1000(2.6 - 0 + 1)}$

$H_{limiting} = 216.6 \, m$

$H_{limiting} = 216.6 m > H_w = 78 m$

So it is low gravity dam.

(2) **Top width "a"**

Free board $= 1.5 \, h_{wave}$

$FB = 1.5 \times 1.4$

$FB = 2.1 \, m$

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Know

(H_D) Height of dam = $H_w + F_B$

$H_D = H_w + F_B$

$H_D = 78 + 2.1$

$H_D = 80.1\ m$

$a = 14\%$ of H_D

$a = 0.14 \times 80.1$

$a = 11.2\ m$

(3) Base width "b"

(i) For Non sliding criteria

$$b' = \frac{H_w}{MG}$$

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$$b' = \frac{78}{0.7 \times 2.6}$$

$$\boxed{b' = 42.8m}$$

(ii) For no tension criteria.

$$b' = \frac{Hw}{\sqrt{G}}$$

$$b' = \frac{78}{\sqrt{2.6}}$$

$$\boxed{b' = 48.3m}$$

use

$$\boxed{b' = 48.3m}$$

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(4) **Depth of verticle portion on u/s side**

$h' = 2a\sqrt{G - C_4}$

$h' = 2 \times 11.2\sqrt{2.6 - 0}$

$h' = 36.11 m$

(5) upstream offset

$= \frac{a}{16}$

$= \frac{11.2}{16}$

$= 0.7 m$

(6) Depth below the water level to the end of inclined portion in u/s

$= 3.14 a \sqrt{G}$

$= 3.14 \times 11.2 \sqrt{2.6}$

$= 56.7 m$

(7) Total width of the base of the dam

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

$b = 48.3 + \frac{11.2}{16}$

$b = 33.81 m$

(6) **Depth below the water level to the end of inclined portion in u/s**

$= 3.14 a \sqrt{G}$

$= 3.14 \times 11.2 \sqrt{2.6}$

$= 56.7 m$

(7) **Total width of the base of the dam**

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

$b = 48.3 + \frac{11.2}{16}$

$b = 33.81 m$

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(8) **Tan θ = b′ / H**

$$\tan\theta = \frac{48.3}{78}$$

$$\theta = \tan^{-1}\left(\frac{48.3}{78}\right)$$

$$\boxed{\theta = 31.76^{\circ}}$$

(9) **Depth of verticle portion on D/s (from WL on US side).**

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

$$\tan\theta = \frac{11.2}{d'}$$

$$\tan \theta = \frac{11.2}{d'}$$

$$\frac{48.3}{78} d' = 11.2$$

$$d' = \frac{11.2 \times 78}{48.3}$$

$$\boxed{d' = 18.08 \text{ m}}$$

Depth of verlicle Portion

$$d = d' + FB$$

$$d = 18 + 2.1$$

$$\boxed{d = 20.1 \text{ m}}$$

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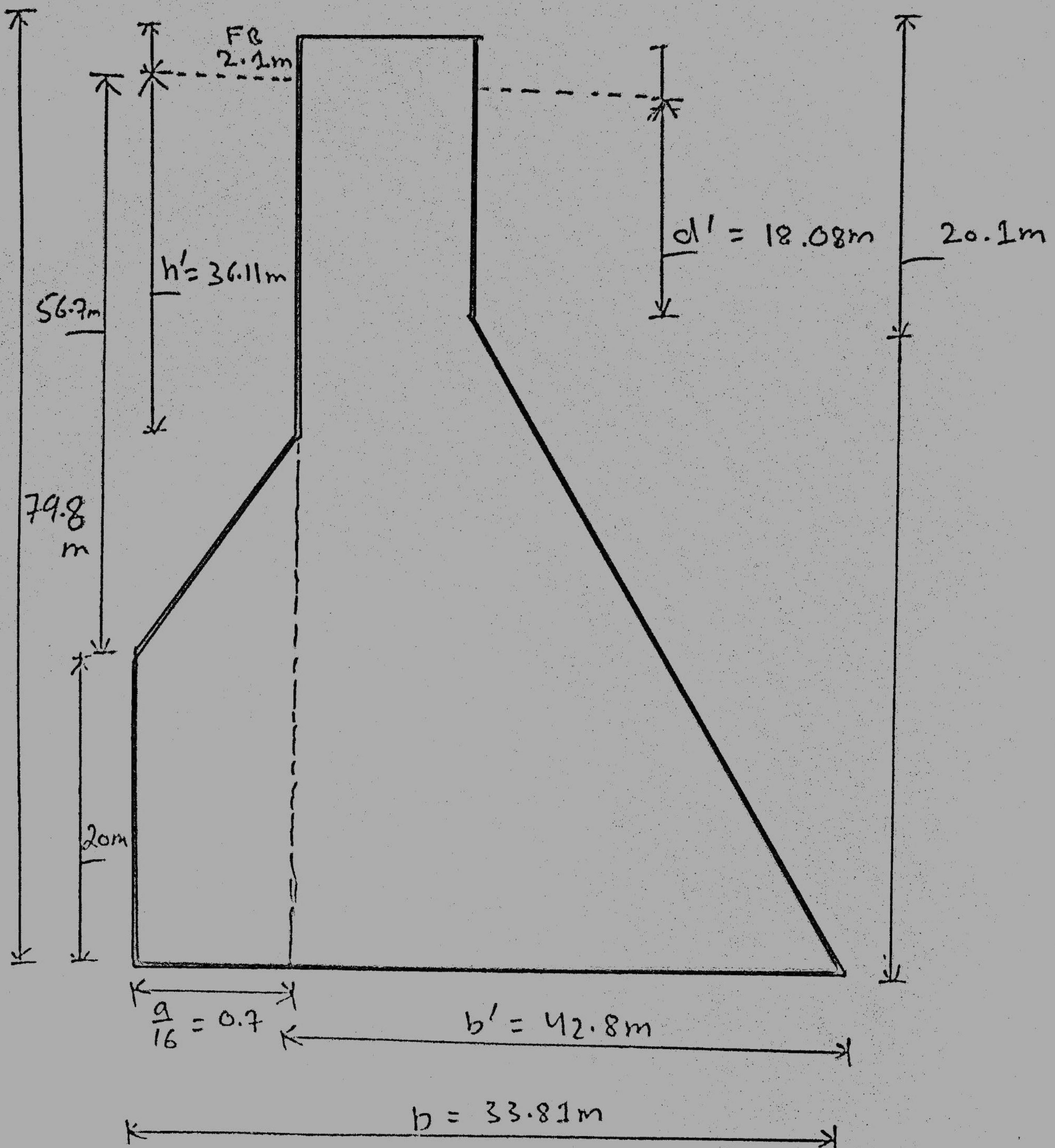

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Question No #3

Using Hydraulic model and explain the concept of Dimensional analysis and similitude.

Answer:

Dimensional Analysis

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

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Purpose of dimensional Analysis

→ To obtain scaling laws so that prototype reinforcement can be predicated from metal performance.

→ To predicate in relationship between parameters.

→ To generate non-dimensional ~~Prop~~ parameter that help in the design of experiment and reporting of result.

Fundamental dimension.

These are the basic quantilies.

For example

Time
Distance
mass etc.

Secondry dimension.

The quantity which posess more then one Fundamental dimension velocity, $\frac{L}{T}$, Acceleration, $\frac{L}{T}$ Density, M/L)

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Simitude:

It is define as the similarity b/w the model and prototype in every aspect which mean model and Prototype have similar Properlies or model and Prototype are completly similar.

Example

Consider a Submarine modified at 1/40 ft of 0.5 c moving at 5m/se. The model will be tested in Fresh wate at 20°

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Question No:# 4

what will be the effect of sediment particle diameter particle concentration, particle shape, viscosity of wall flowing in reservior on fall velocity Explain in details.

Answer:

Answer

Fall velocity.

when a grain fall down in still water it obtain a constant velocity when the upward fluid drag force on the grain is equal to the downward submerged weight of grain.

This Constant velocity is defined as the fall velocity of grain.
This is also called settling velocity.

Fall velocity depends upon

(1) Particle diameter

(2) particle density

(3) particle concentration

(4) particle shape

(5) viscosity of water (temperature

(6) Turbulence

Effects

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Particle diameter:

If the size of particle is grether it will move faster ~~FA~~ as compared to small particle thus there will be more gravitational force on the particle of grether size so it will fall quickly due to its weight

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Effects

Particle Concentration:-

when the suspended concentration of the sediment increase, the settling velocity of each particle decrease due to the modification of the flow induced by previous particles.

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Particle shape

Non- spherical analoge particle fall up to 75 % slower then equilant ~~sp~~ sphere

Model slower then equilant sphere model show 100 Mm non spherical particles travels 44 %. Further than Sphere verticle structure of modelled volcanic ash ~~should~~ cloud is sensitive to particle.

Viscosity of water.

Fluid through porous media is approximely as ~~increasing~~ inversly proportional to the ~~*~~ Kinematic viscosity. A decrease in viscosity therefore increase the velocity of a compound through porous media.

Turbulance of water:

Turbulance of water effect the fall velocity of the water in reservoir because the non-linearty and zig zag

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Path effect the flow of water and cause the variation in the flow.

Particle density

Particle density effect the ~~d~~ settling fall velocity As Air density increase with decreasing altitude at about 1% per 80 meter (260 ft) for every 160 meter of fall the terminal Speed decrease 1%.