FINAL PAPER

SUBJECT : HYDRAULIC ENGINEERING

SECTION : B

MODULE : 6^{th}

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DATE : 25 JUNE 2020

QUESTION 01

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.

List the relevant Variables

ΔP , h, d, V, ρ, μ

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

Number of non-dimensional groups, n - m = 3

⇒ Choose m = 3 scaling variables

- geometric (d)
- kinametic / time - dependent (V)
- Dynamic / mass - dependent (ρ)

=> For dimensionless groups by non- dimensionlessing the remaining variables ΔP, h and μ

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

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

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

So

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

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

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

$$\Rightarrow \Pi_2 = \Delta p V^{-2} \rho^{-1} = \frac{\Delta P}{\rho V^2}$$

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

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

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

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

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

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

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

Recognition of the Reynold's number suggests that we replace Π_3 by

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

Hence dimensional analysis yields.

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

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 by the same model and prototype.

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

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

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

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

$$V_m = \frac{V_p}{0.5} = \frac{3.0}{0.5} = 6.0 \, m/s.$$

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.

$$\Pi_2 = \left(\frac{\Delta P}{\rho V^2}\right)_p = \left(\frac{\Delta P}{\rho V^2}\right)_m \Rightarrow \frac{(\Delta P)_p}{(\Delta P)_m} = \frac{\rho_p}{\rho_m}\left(\frac{V_p}{V_m}\right)^2$$

Hence

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

$$= 12.0 \text{ KPa}$$

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QUESTION 02

GIVEN DATA:

- Maximum depth of watee in the Reservior $H = 78m$
- Specific Gravity of Dam Material $= G = 3.8$
- Allowable compressive stress for the dam masonary

  $\sigma_{av} = 785\ T/m$

- Hight of wave = ~~Dam~~ 2.5m
- No uplift pressure $C_u = 0$.

SOLUTION:

1. H limiting : $\dfrac{\sigma_{au}}{\gamma_w(G - (C_u + 1))} = \dfrac{785 \times 1000}{1000(3.8 - 0 + 1)}$

$= 163.54 > 78m$

So it is low gravity Dam.

2. Top Width "a"

Free board $= 1.5 \times h_{wave} = 1.5 \times 2.5$

$F.B = 3.75\ m$

Height of Dam, $H_D = H_w + F.B$

$= 78 + 3.75$

$H_D = 81.75m.$

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$a = 14\%$ of H_D

$= 0.14 \times 81.75$

$a = 11.445$

3. Base Width b'

i) For no sliding Criteria.

$$b' = \frac{H_w}{\mu G} = \frac{78}{0.7 \times 3.8}$$

$$= 29.32 \approx 30\,m$$

ii) For no tension Criteria,

$$b' = \frac{H_w}{\sqrt{G}} = \frac{78}{\sqrt{3.8}} = 40\,m.$$

use $b' = 40m.$

4. Depth of Vertical portion on U/s side

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

$$= 2(11.44)(\sqrt{3.8 - 0})$$

$$= 44.60 \approx 45\,m$$

5. upstream off set : $\frac{a}{16}$

$= \frac{11.44}{16}$

$= 0.715\,m.$

6. Depth below the water level to the end of inclined portion in u/s $= 3.14\, a \sqrt{G}$

$= 3.14\,(11.44)\sqrt{3.8}$

$= 70.02\,m.$

7. Total Width of the base of the dam.

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

$= 40 + \frac{11.44}{16}$

$b = 40.715\,m$

8. $\tan\theta = \frac{b'}{H}$

$= \frac{40}{78}$

$\theta = \tan^{-1}\frac{40}{78}.$

$\theta = 27.14°$

9. **Depth of Vertical portion on D/s**

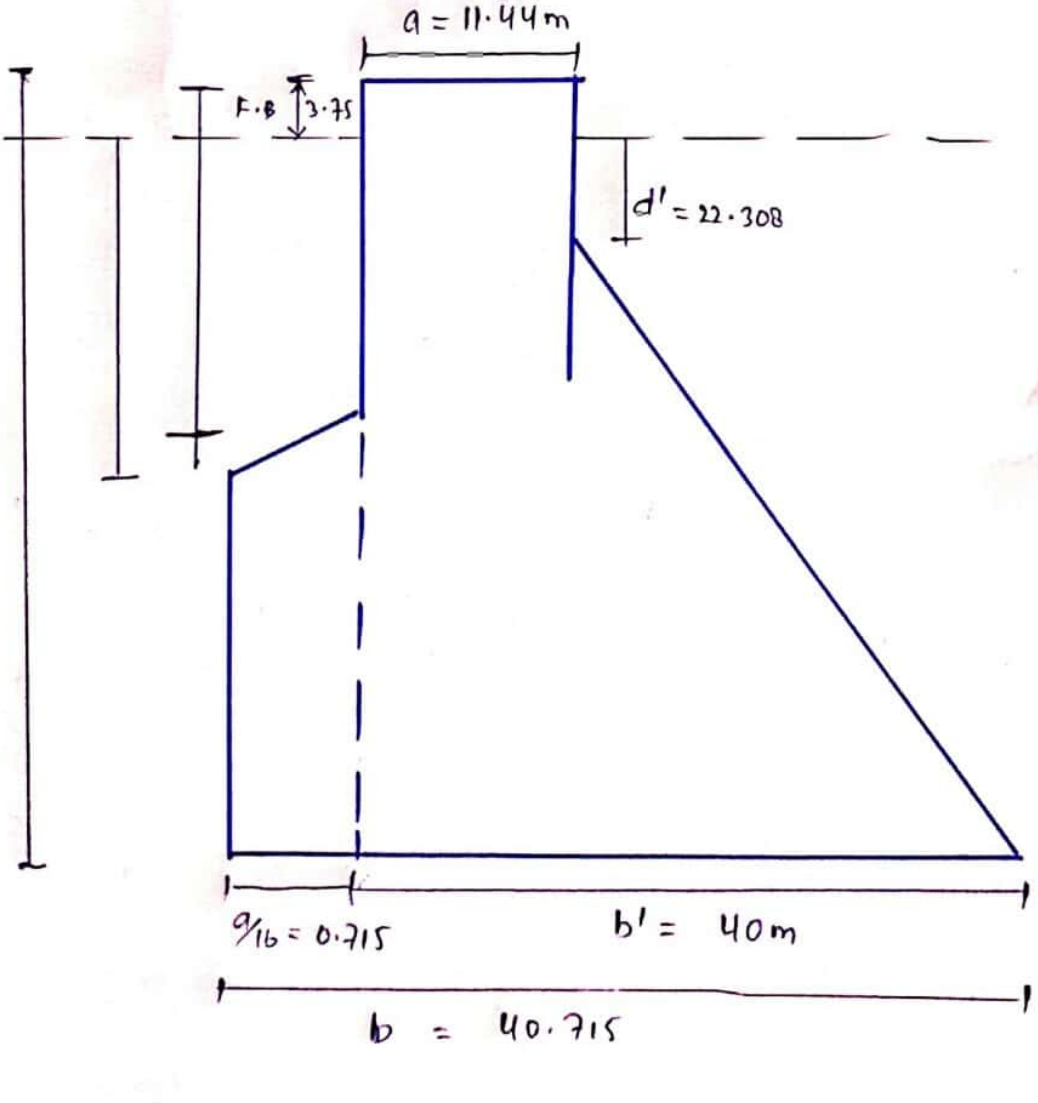
$$\tan\theta = \frac{a}{d'} = \frac{11.44}{d'}$$

$$\tan\theta = \frac{11.44}{d'}$$

$$\frac{40}{78} d' = 11.44 \Rightarrow d' = \frac{11.44}{0.512} \Rightarrow d' = 22.308\,m.$$

Depth of Vertical portion

$$d = d' + FB$$
$$= 22.308 + 3.75$$
$$= 26.058\,m$$



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QUESTION: 03

ANSWER :

DIMENSIONAL ANALYSIS:

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

- To generate non dimensional parameters that help in the design of experiments and in reporting of results.
- To obtain scaling laws so that prototype performance can be provided from model performance.
- To predict trends in the relationship between parameter.

Fundamental dimensions:

These are the basic quantities

- Time T
- Distance L
- Mass M.

Secondary Dimension:

These quantities which posses more than one fundamental dimension

- Velocity L/T
- Acceleration L/T^2
- Density M/L^3.

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SIMILITUDE :

Similitude is defined as similarity b/w model and prototype in every respect which means model and prototype have similar properties or model and propotype are completely similar

- It is used in testing of engineering models.

EXAMPLE :

An estuary model is built to horizontal scale of 1:500 and a verticle scale 1:50 : Tidal oscillations of amplitude 5.5m and tital period 12.4h are to be ~~represented~~ reproduced in the model what are the corresponding tidal characteristics in the model ?

Solution:

The speed of propagation or celerity of a gravity wave in which the wave length is very large in relation to the water depth y, as in the case of tidal oscillation is given by $c = \sqrt{gy}$. Thus estuary models must be operated according to the froude law. The tidal range is modelled according to verticle scale.

$$H_m = H_p \times \frac{1}{50} = \frac{5.5}{50} = 0.11m.$$

Tidal period , $T = L/c$.

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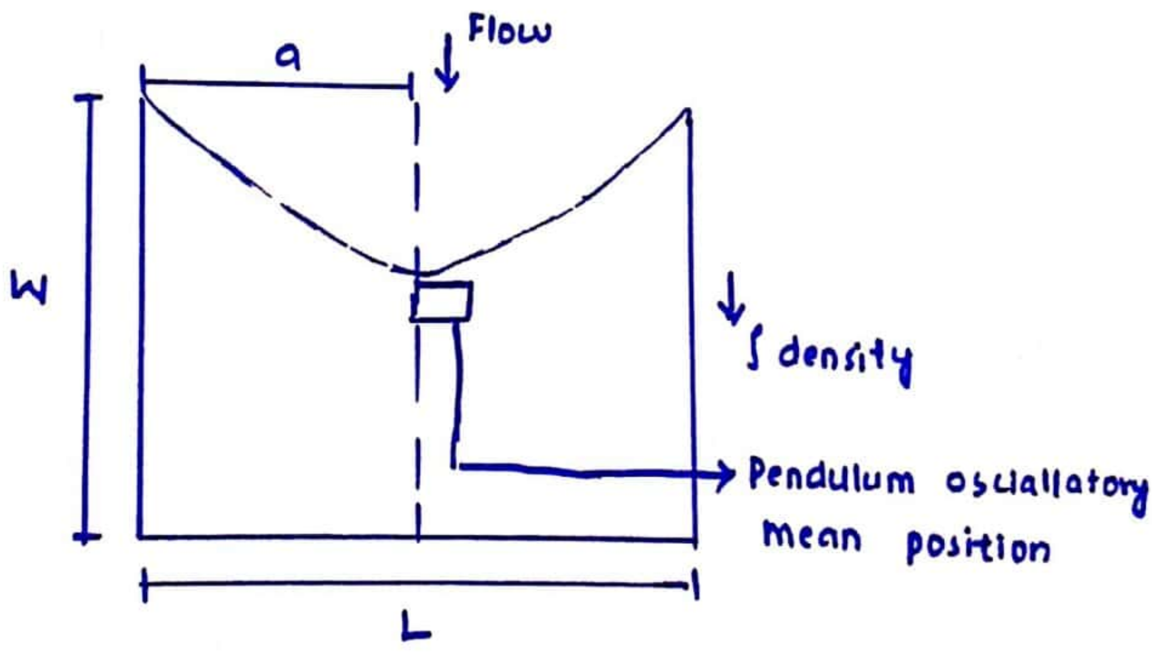
where L is the wave length, Hence

$$\frac{T_m}{T_p} = \frac{L_m}{L_p} \cdot \frac{C_p}{C_m} = \lambda_x \sqrt{\frac{Y_p}{Y_m}} = \frac{\lambda_x}{\lambda_y}.$$

Dimensional Analysis, from

$$T_m = \frac{12.4 \times 1/500}{\sqrt{1/50}} = 0.1754\ h$$

$$= 10.52\ min.$$



QUESTION 04:

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 of the ~~given~~ grain. This is also called settling velocity.

Fall velocity depends on:

1) Particle diameter
2) Particle density
3) Particle concentration.
4) Particle shape
5) Velocity of water
6) turbulence.

Following are the effects of sediments on the fall velocity or settling velocity.

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1. Particle Diameter:

It have significant effect on the fall velocity. The larger particles will settle more quickly as compared to the particles having small size.

2. Particle Density:

Those particle which have less density will slowely settle down as compare to particle having high density which will settle down faster.

3. Particle Concentration:

Concentration of particle size will considerably effect its fall velocity as the section having greator concentration will be ~~selected~~ 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 than irregular shapes since regular shapes particles have even surfaces which offers very little or no friction while irregular shape offers more friction as the particle with smaller surface area are more likely to be effected due to less resistance.

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5. **Viscosity of water:**
From experimental study we can see that parameter such as temperature and pressure changes the magnitude of viscosity so the section of water have more temperature and pressure will fall objectively more due to increase in the kinetic energy so fall velocity will be more.

6. **Turbulance:**
Turbulance of water depends upon the different factors such as velocity. It will effect the fall velocity because of its zig zag motion thus the velocity varies at every point which is why it effects the fall velocity.