FINAL EXAM

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SEC # A

Subject # Hydraulics Engineering

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Q No: 1 :-

Solution:

List the relevant variables:

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

write down dimensions

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

number of variables $n = 6$

No of independent dimension: $m = 3$ (M, L & T)

No 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-dimensionalising the remaining variables Δp, h and μ

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

Recognition of the Reynolds numbes suggest that we replace Π_3 by

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

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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 Similarly Requires That all non dimensional groups be the Same in model and prototype i.e

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

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

(automatic of similar Shape i.e geometric Similarity")

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

From The Cast we have a velocity Ratio

$$\frac{V_p}{V_m} = \frac{(\mu/\rho)_p \, d_m}{(\mu/\rho)_m \, d_p} = \frac{0.002/800}{1.0\times10^{-6}} \times \frac{1}{5} = 0.5$$

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

$$\frac{Q_p}{Q_m} = \frac{(\text{velocity} \times \text{area})}{(\text{velocity} \times \text{area})_m} = \frac{V_p}{V_m}\left(\frac{d_p}{d_m}\right)^2 = 0.5 \times 5^2 = \boxed{12.5}$$

P.T.O

(c) Finally, for the pressure drop

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

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

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

Hence

$$\Delta p_v = 0.2 \times \Delta p_m$$

$$= 0.2 \times 60$$

$$\Rightarrow \boxed{12.0\,kpa}$$

Q.No: 02

Design practical profile for a gravity Dam with the following data:

Given data

Maximum Depth of water in The Reservoir
$H = 78\,m$

Specific Gravity of Dam Material = $G = 2.21$

Allowable Compressive Stress for The Dam Masonary
$\sigma_{all} = 781\ T/m^2$

As one Tone = 1000kg

Height of wave = 1.32m

$\mu = 0.7$

No uplift pressure = $C_u = 0$

Solution:

① $H_{limiting} = \dfrac{\sigma_{all}}{\gamma_w(G - C_u + 1)}$ ∵ As $\gamma_w = 1000$

by putting values

$= \dfrac{781 \times 1000}{1000(2.21 - 0 + 1)} \Rightarrow 243.3$

$H_{limiting} = 243.3\,m > H_w = 78\,m$

So it is Low Gravity Dam

P.T.O

(2) Top width "a"

Free board = 1.5 h_{wave}

= 1.5 × 1.32

F.B = 1.98m

height of Dam = H_D = H_w + F.B

= 78 + 1.98

H_D = 79.98m

a = 14% of H_D

a = 0.14 × 79.98

a = 11.197 m

(3) Base Width : "b" (without off set)

(i) — For No Sliding Criteria

$$b' = \frac{H_w}{\mu G}$$ putting the values

$$b' = \frac{78}{0.7 \times 2.21}$$

b' = 50.42

b' = 50m

(ii) For no tension Criteria

$$b' = \frac{H_w}{\sqrt{G}} = \frac{78}{\sqrt{2.21}}$$

$$\boxed{b' = 52.46\,m}$$

(4) Depth of vertical portion on U/S side:

$$h' = 2a\sqrt{G - C_u} \quad \text{— formula}$$

putting values

$$h' = 2 \times 11.197\sqrt{2.21 - 0}$$

$$h' = 33.29\,m$$

$$\boxed{h' \approx 33\,m}$$

(5) Upstream off Set

$$\frac{a}{16}$$

$$= \frac{11.197}{16} \Rightarrow \boxed{[illegible]}$$

$$\boxed{0.699\,m}$$

P.T.O

→ Depth below the water Level to the end of inclined portion in u/s = 3.14 a√G

$$= 3.14 \times 11.197\sqrt{2.21}$$

$$= \boxed{52.26\,m}$$

→ Total width of the base of the dam

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

$$= 52.46 + \frac{11.197}{16}$$

$$\boxed{b = 53.15m}$$

→ $\tan\theta = \frac{b'}{H} = \frac{52.46}{78}$

$$\theta = \tan^{-1}(0.672)$$

$$\boxed{\theta = 33.90^\circ}$$

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

$$\tan\theta = \frac{a}{d'} = \frac{11.197}{\text{[struck out]}}$$

$$\Rightarrow \tan\theta = \frac{11.197}{d'}$$

$$0.672\, d' = 11.197$$

$$d' = \frac{11.197}{0.672}$$

$$\boxed{d' = 16.66\text{m}}$$

→ 8 Depth of vertical portion

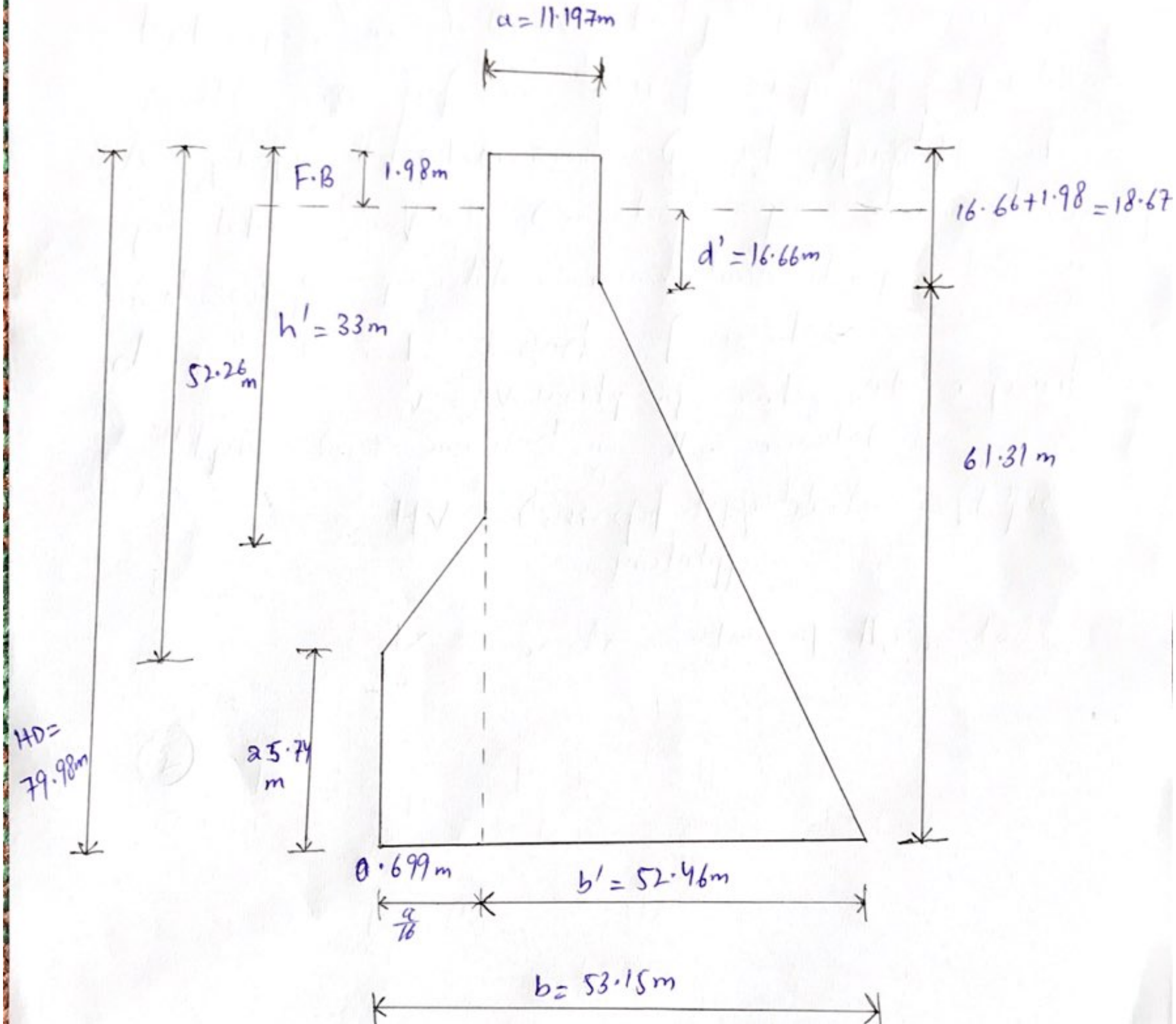
$$d = d' + FB$$

$$= 16.66 + 1.98$$

$$\boxed{d = 18.64\text{m}}$$

Q2 Continued → [7812] 9(A)

putted all values in the below gravity Dam diagram.



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(10)

Q No: 03

Dimensional analysis is a mathematical technique in which study of dimension is made use of in solving engineering problems. A physical phenomenon consist of different quantities which can be expressed in terms of fundamental quantities mass, time, temperature are designated as M, L, T

Hydraulic Similitude:

Solution of problems in hydraulic engineering is simplified by model analysis. Model analysis is also required for predicting performance of hydraulic structure like dam and spillway etc.

Example: (Hydraulic Model)

Consider a model of spillway is to be built to a scale ratio 1:50 across a flame of 70cm width. The prototype has a height of 16m and expected maximum head is 1.6m. Determine
(i) height and head required for the model.

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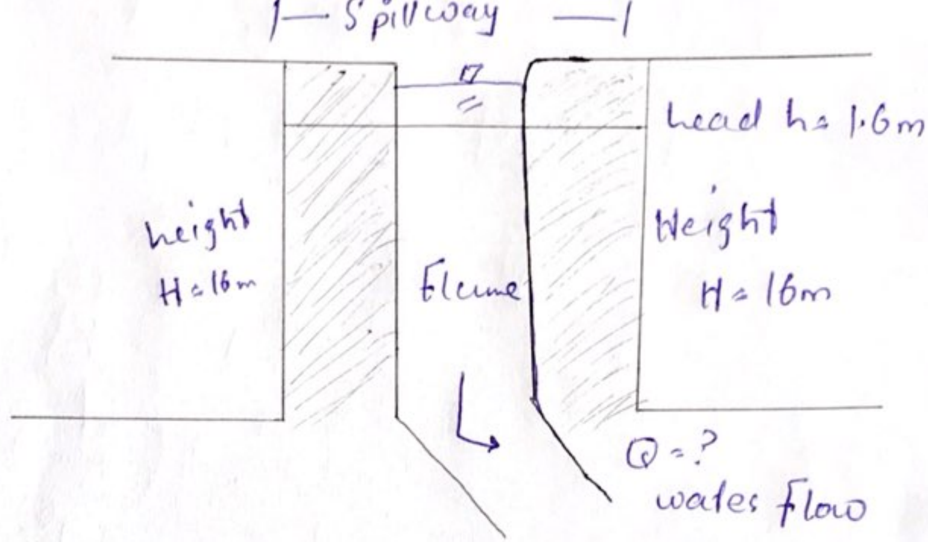
(ii) Flow per meter Length of the prototype if the model has a flow of 15 Litres per Second at a particular head



Solution:

Length of model L_m = 70cm = 0.7m

Height of prototype H_p = 16m

Head of prototype h_p = 1.6m

discharge of model = Q_m = 15 Litre/sec

$$\frac{\text{Length of model } L_m}{\text{Length of prototype } L_p} = \frac{1}{50} = L_r$$

(i) Height of model

$H_m = H_p \times L_r$

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$$16 \times \frac{1}{50} = \boxed{0.32m}$$

Head of model

$$H_m = H_p \times L_r$$

$$= 1.6 \times \frac{1}{50} = \boxed{0.032m}$$

(ii) Discharge over prototype

$$Q_r = L_r^{2.5}$$

$$\frac{Q_m}{Q_p} = \left(\frac{1}{50}\right)^{2.5}$$

$$Q_p = Q_m \times 50^{2.5}$$

$$Q_p = 15 \times 20^{2.5}$$

$$Q_p = 265,165 \text{ Liters}$$

Length of prototype

$$L_p = \frac{L_m}{L_r} = L_m \times 50$$

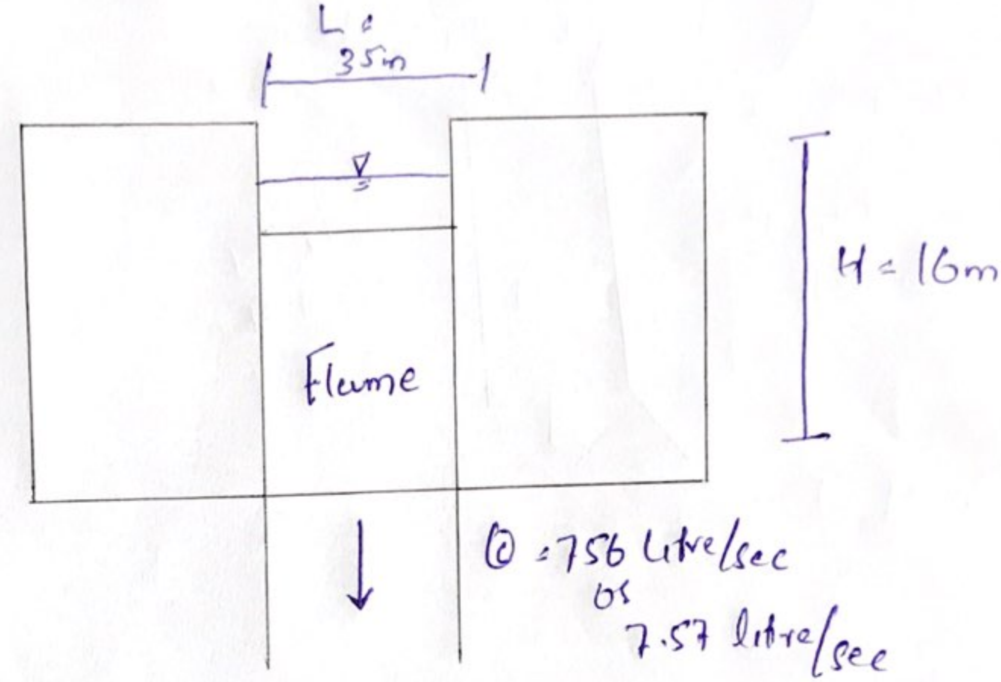
$$L_p = 0.7 \times 50 = 35m$$

Discharge per meter Length of prototype

$$\frac{Q_p}{L_p} = \frac{265,165}{35} \Rightarrow \boxed{7576 \text{ litre/sec}}$$

P.T.O

prototype



Q No: 04

Ans: (1) Sediment Particle Diameter: (Effect)

The effect of the Setting velocity of particles obviously affect the Sediment diameter b/c the density and viscosity of the fluid in which the Settling velocity is determined are both part of the Size velocity relation effect of the fluid on the Sediment diameter may not be as obvious.

(2) Particle Density:

It is density of Solid particles that collectively make up a Soil Sample. The value is commonly expressed in gm/cm³ particle density of Samples of Surface Soil Contain the humus in fair quantities are commonly b/w 2.5 — 2.6 gm/cm³

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(3) particle Shape:

A particle Shape Locate at a point that will fall on The Curve or b/w Two Curves So That a Shape Factor Can be Found directly b/w Shape factor Came. Such a Shape factor Curve express the effect of Shape on the hydraulic Characteristic of the particle.

(4) Sediment Concentration:

The general effect of Concentration on the fuel velocity of, particle has been widely Recognaised usually the data have shown the effect individly. The Size of particle is an important influence on the Concentration effect & a mixture of particle Size falling through a Long Sedimentation of Limited Cross-section in not likely maintaine a uniform distribution.

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(5) Turbulance of water flowing:

It is Caused by excesive Kinetic Energy in parts of a fluid Flow, which overcome the damping effect fluid viscosity. For This reason turbulance is commonly realised in Low viscosity of fluids. This increase the energy needed to pump fluid Through a pipe

(6) viscosity of water:

It is the property which control The rate of flow. when a liquid is in Contact with a Solid boundary The relative motion b/w The Liquide particles immadietly adjacent to The boundary. and The solid boundary does not exist

THE END