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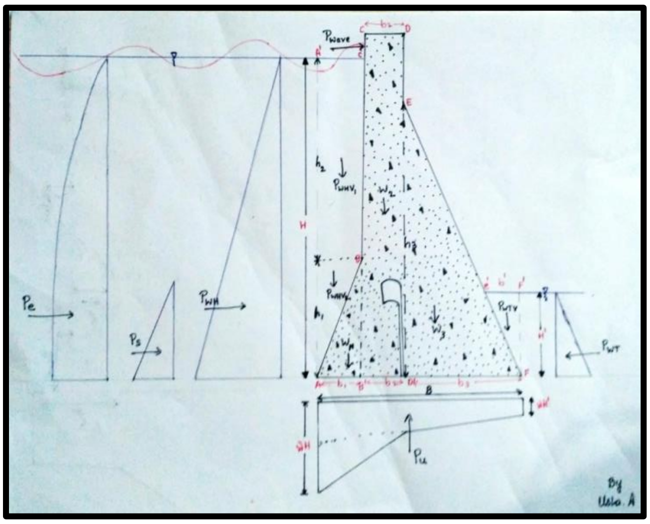
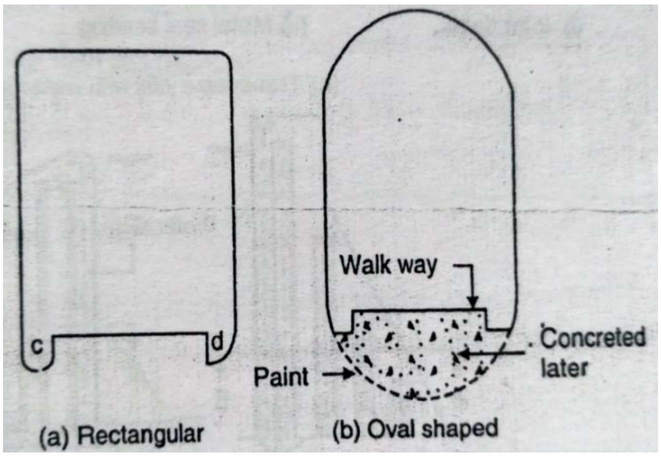
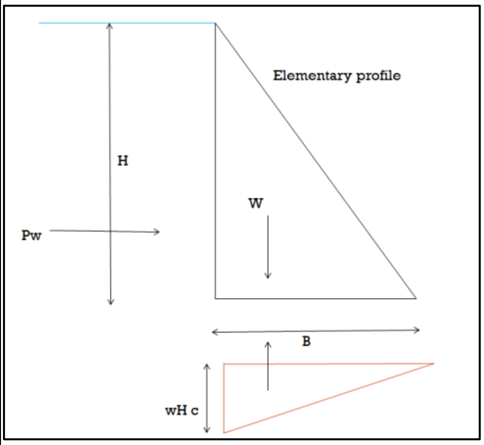
CMR
INSTITUTE
OF TECHNOLOGY

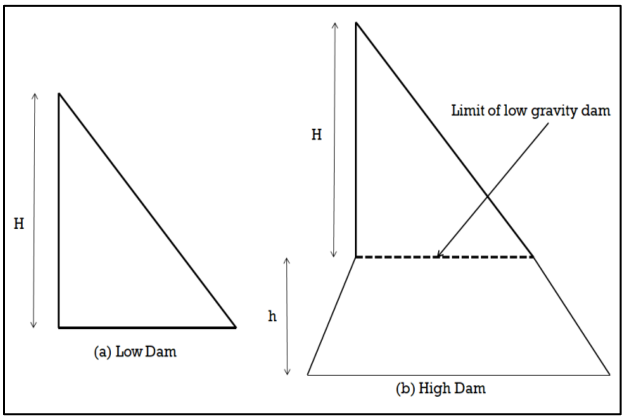
Department of Civil Engineering

17CV832 – HYDRAULIC STRUCTURES

Scheme and Evaluation

Q.No.	Question	Mark	CO	PO	RBL
1a	**List out the various forces acting on a gravity dam**	**5**	**CO1**	**PO2**	**L2**
Ans	The gravity dam is subjected to the following forces: 1. Water pressure 2. Weight of the dam 3. Uplift pressure 4. Pressure due to Earthquake forces 5. Ice pressure 6. Wave pressure 7. Silt pressure and 8. Wind pressure 				5
1b	**Write a note on Drainage galleries**	**5**	**CO1**	**PO2**	**L2**
Ans	Galleries are the horizontal or sloping openings or passages left in the body of the dam. They may run longitudinally (i.e. parallel to dam axis) or traversely (i.e. normal to the dam axis) and are provided at various elevations. All the galleries are interconnected by steeply sloping passages or by vertical shafts fitted with stairs or mechanical lifts. **Function and types of galleries in Dams** **(i) Foundation Gallery**  A gallery provided in a dam may serve one particular purpose or more than one purpose. For example, a gallery provided near the rock foundation, serves to drain off the water which percolates through the foundations. This gallery is called a foundation gallery or a drainage gallery. 1. It runs longitudinally and is quite near to the upstream face of the dam. Drain holes are drilled from the floors of this gallery after the foundation				1 2 (any 2)

	grouting has been completed. Seepages is collected through these drain holes. 2. Besides draining off seepage water, it may be helpful for drilling and grouting of the foundations, when this cannot be done from the surface of the dam. **(ii)Inspection Galleries** The water which seeps through the body of the dam is collected by means of a system of galleries provided at various elevations and interconnected by vertical shafts, etc. All these galleries, besides draining off seepage water, service inspection purpose. They provide access to the interior of the dam and are, therefore, called inspection purposes. They generally serve other purposes along with this purpose. 1. They intercept and drain off the water seeping through the dam body 2. They provide access to dam interior for observing and controlling the behavior of the dam. 3. They provide enough space for carrying pipes, etc. during artificial cooling of concrete 4. They provide access to all the outlets and spillway gates, valves, etc. by housing their electrical and mechanical controls. All these gates, valves, etc, can hence be easily controlled by men, from inside the dam itself.				2 (any 2)
2.	**Explain the concept of elementary profile of a gravity dam and how it is helpful in classifying a dam as low and high**	**5**	**CO1**	**PO2**	**L3**
Ans	An elementary profile of a dam will be triangular in section, having zero width at the water level at the top where water pressure is zero, and a maximum base width b, where the maximum water pressure acts. Thus, the section of the elementary profile is of the same shape the hydrostatic pressure distribution diagram. For reservoir empty condition, a right angled triangular profile will provide the maximum possible stabilizing force against overturning, without causing tension in the base. This is so because weight of the dam acts at distance b/3 from upstream face and is closer to it. If any other triangular profile is provided, its weight will act still closer to the upstream face to provide a higher stabilizing force, but tension will be developed at the toe when the dam is empty.  Base width of the elementary profile of dam $B = H / \sqrt{\rho - c}$ The principal stress at the toe of an elementary profile of a gravity dam is used to calculate limiting height of the dam. i.e.,				2.5

	$\sigma_1 = wH(\rho - c + 1)$ In this expression the only variable changing the value of σ_1 is H. The maximum value of this principal stress should not exceed the allowable stress (*f*) for the material. Thus, in the limiting case, **H = *f* /*w* (*ρ*+1)** The limiting height defines the distinction between a low and high gravity dam. A low gravity dam is the one in which the height H is less than that given in the equation. If the height of the dam to be constructed is more than that given in the equation, the dam is known as high gravity dam. For such dams, the section will have to be given extra slopes to the upstream and downstream sides, below the limiting height, to bring the compressive stress within the limits.  	2.5			
3.	**A solid gravity dam is to be constructed with concrete (1: 2: 4) having ultimate compressive strength of 16800 kN/m². Find out the height upto which the dam may be considered as a low dam. Assume factor of safety = 4 and specific gravity of concrete 2.4**	5	CO1	PO2	L4
Ans	Solution :- Equation for limiting height of the gravity dam $H = \frac{f}{W(\rho+1)}$ where H ← limiting height of the dam f ← Allowable stress of dam material, kN/m² W ← Unit weight of water, kN/m³ ρ ← Specific gravity of concrete Given data:- $f = \frac{16800}{4}$ kN/m² ρ = 2.4 H = ? W = 9.81 kN/m³ Factor of safety = 4 $= \frac{16800/4}{9.81(2.4+1)}$ **H = 125.92 m** ∴ The dam may be considered as low dam Up to the height of 125.9m.	2 2 1			
4.	**From the following data, design and sketch the practical profile of a gravity dam of stone masonry:** **Ground level = 130.50 m, HFL = 155.50 m,** **Wave height = 1.0 m,** **Specific Gravity of masonry = 2.25:** **Permissible stress in stone masonry = 1250 kN/m²**	10	CO1	PO3	L4

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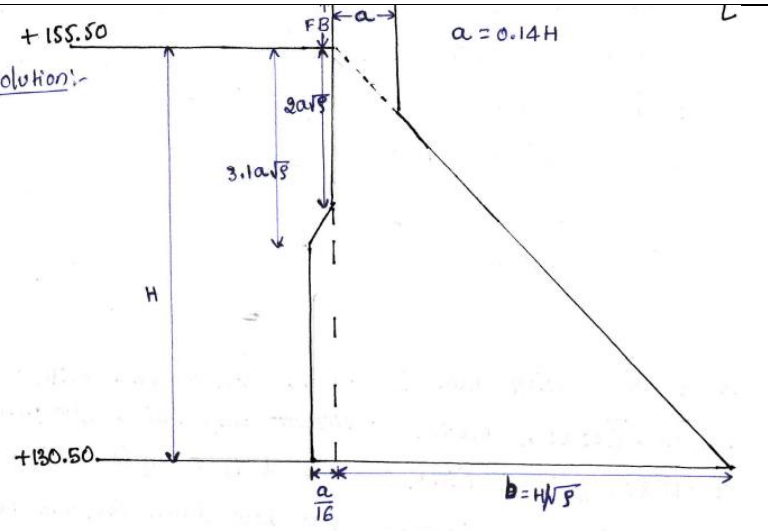
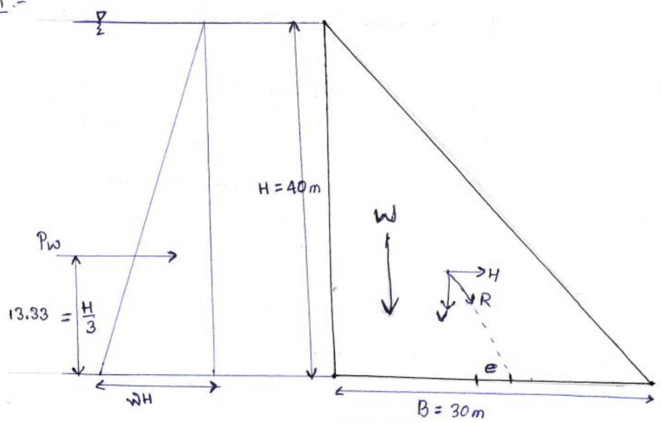
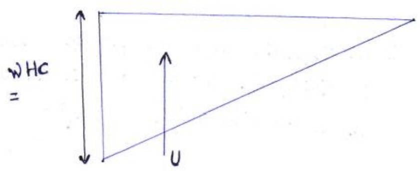
Ans	Given data:- h_w = Wave height = 1 m. H = Reservoir water depth = 25m. Free board F.B = 1.5 h_w = 1.5 m. ∴ R.L of top of the dam = 155.50 + 1.5 = 157 m. ∴ Height of the dam = 157 − 130.5 = 26.5 m. limiting height of the dam = $\frac{f}{w(\rho+1)}$ = $\frac{1250}{9.81(2.25+1)}$ = 39.21 m	3
	Since the height of the dam is < limiting height of the dam, the designed dam is low gravity dam. ∴ The dimensions of the practicle profile of the dam is calculated as per IS recommendation. depth of water H = 155.5 − 130.5 = 25 m. Top width of the dam a = 0.14 H = 3.5 m (Roadway width). Base width of the elementary profile = b = $H/\sqrt{\rho}$ = $25/\sqrt{2.25}$ = 16.67 m. upstream offset = $\frac{a}{16}$ = 0.22 m. ∴ Total Base width of the dam = 16.67 + 0.22, B = 16.89 m. Distance upto which the U/S slope is vertical from the U/S water level = $2a\sqrt{\rho}$ = $2 \times 3.5 \times \sqrt{2.25}$ = 10.5 m. Distance upto which the U/S slope is inclined from the U/S water level = $3.1\,a\sqrt{\rho}$ = $3.1 \times 3.5 \times \sqrt{2.25}$ = 16.275 m	4

	Solution:-  				3
5.	**A triangular section of a gravity dam having base width 30 m and height 40 m is stored with water up to top. Analyze the dam section and determine** **(i) Factor of safety against sliding** **(ii) Factor of safety against overturning** **(iii) The normal stresses in the base of the dam. Assume, co-efficient of friction between the base and foundation as 0.7, Uplift pressure intensity co-efficient as 0.45 and Unit weight of dam material = 24 kN/m.**	**10**	**CO1**	**PO2**	**L5**
Ans	Solution:-   Given data: $\mu = 0.7$ $c = 0.45$ $w_c = 24 kN/m^3$ $w = 9.81 kN/m^3$ $H = 40m$ $B = 30m$ $e = \frac{B}{2} - \bar{x}$; $\bar{x} = \frac{\Sigma M}{\Sigma V} = \frac{\Sigma RM + \Sigma OM}{\Sigma V}$ $\bar{x} = 11.097$ m				2 1

Sl.No	Dimension	Force (kN) H	Force (kN) V	Lever Arm (m)	Moment about toe (kN-m) RM (+ve)	Moment about toe (kN-m) OM (-ve)
1	self weight $W = \frac{1}{2} \times 30 \times 40 \times 24$	–	14400	20	288000	–
2	water pressure $P_w = \frac{1}{2} \times 9.81 \times 40 \times 40$	7848	–	13.33	–	104613.8
3	Uplift pressure $U = \frac{1}{2} \times 30 \times 9.81 \times 0.45 \times 40$	–	-2648.7	20.00	–	52974
		ΣH 7848	ΣV 11751.3		ΣRM 288000	ΣOM 157587.8

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i) Factor of safety against overturning

$$FSO = \frac{\Sigma RM}{\Sigma OM} = \frac{288000}{157587.8} = 1.82 > 1.5 \text{ SAFE.}$$

ii) Factor of safety against sliding

$$FSS = \frac{\mu \Sigma V}{\Sigma H} = \frac{0.7 \times 11751.3}{7848} = 1.05 > 1 \text{ SAFE.}$$

iii) The normal stresses in the base of the dam.

a) Normal stress at the toe

$$P_{n(toe)} = \frac{\Sigma V}{B}\left[1 + \frac{6e}{B}\right] = \frac{11751.3}{30}\left[1 + \frac{6 \times 3.9}{30}\right]$$

$$P_{n(toe)} = 697.24 \text{ kN/m}^2$$

b) Normal stress at the heel

$$P_{n(heel)} = \frac{\Sigma V}{B}\left[1 - \frac{6e}{B}\right] = 86.17 \text{ kN/m}^2$$

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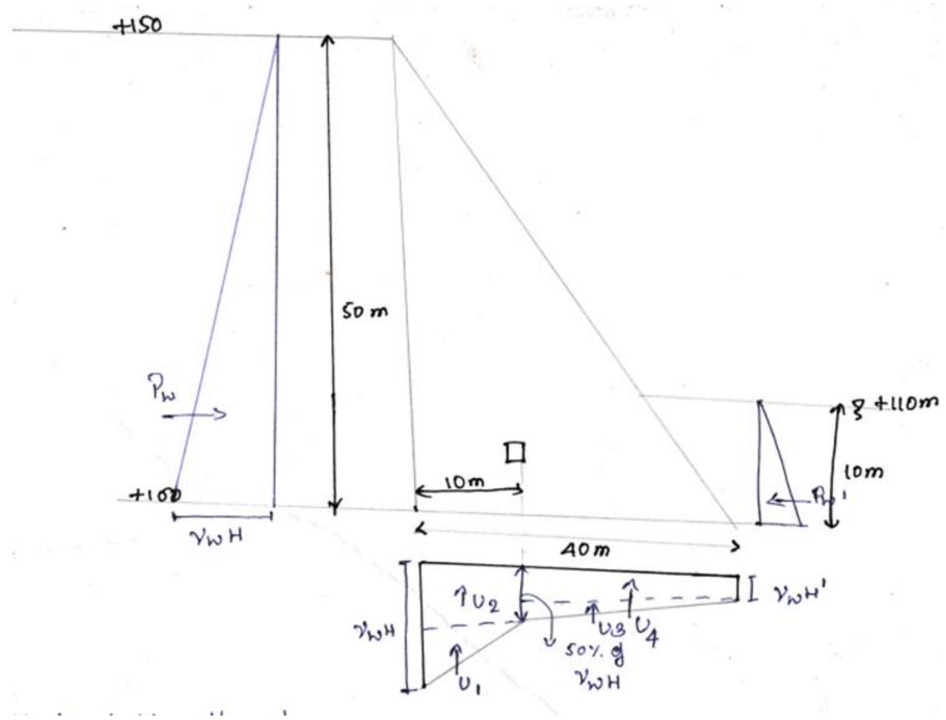
6	**Following data were collected from a concrete gravity dam:** **Maximum reservoir elevation = 150.00m** **Base level of the dam = 100.00m** **Tail water elevation = 110.00m** **Base width of the dam = 40.00m** **Location of drainage gallery = 10 m from vertical u/s**	10	CO1	PO3	L5

	face. Compute the hydrostatic thrust and uplift force per meter length of the dam at its base level. Assume 50% reduction in the net seepage head at the location of the drainage gallery.				
Ans	 (a) Hydrostatic thrust Horizontal force by Head water $P_w = \frac{1}{2} \times 9.81 \times 50 \times 50 = 12,262.5$ kN Horizontal force by Tail water $P_w' = \frac{1}{2} \times 9.81 \times 10 \times 10 = 490.5$ kN ∴ Total Hydrostatic thrust acting on gravity Dam per unit length $= P_w - P_w' \Rightarrow$ i.e., $P_w \times$ lever arm $= 12262.5 \times \frac{50}{3} = 204375$ kN-m $P_w' \times$ lever arm $= 490.5 \times \frac{10}{3} = 1635$ kN-m 202740 kN-m	3 3

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	(b) Uplift pressure per unit length acting on gravity dam (i) uplift p^r at Heel = $9.81 \times 50 =$ 490.5 kN (ii) uplift p^r at Gallery : $\frac{50}{100} \times 9.81 \times 50 =$ 245.25 kN (iii) uplift p^r at toe = $9.81 \times 10 = 98.1$ kN ∴ Total uplift p^r on gravity dam $U_1 = (\frac{1}{2} \times 245.25 \times 10) \times [(\frac{2}{3} \times 10) + 30] = 44962.5$ $U_2 = (245.25 \times 10) \times [\frac{10}{2} + 30] = 85837.5$ $U_3 = (\frac{1}{2} \times 30 \times 147.15) \times [\frac{2}{3} \times 30] = 44145.0$ $U_4 = (30 \times 98.1) \times (\frac{30}{2}) = 44145.0$ 219090 kN-m	4

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