NATIONAL UNIVERSITY OF SCIENCE AND TECHNOLOGY

FACULTY OF ENGINEERING

DEPARTMENT OF CIVIL AND WATER ENGINEERING

HYDRAULIC DESIGN II

ECW 5204

Main Examination Paper

March 2025

This examination paper consists of 5 pages

Time Allowed: **3 hours**

Total Marks: 100

Special Requirements: Graph paper

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INSTRUCTIONS

1. Answer all questions
2. Each question carries 25 marks
3. Use of calculators is permissible

MARK ALLOCATION

QUESTION	MARKS
1.	**25**
2.	**25**
3.	**25**
4.	**25**
TOTAL	**100**

QUESTION 1

a. List and explain factors that affect the selection of design flood in dam design **[5]**

b. With the aid of neat sketches, state and describe the spillway type applicable to gravity and earth dams respectively. Justify your selection. **[5]**

c. Fig 1 below shows a concrete gravity dam. Given that soil cohesion coefficient c = 1000kN/m^2, unit weight of concrete and water respectively γ_C = 24kN/m^3, γ_w = 9.81kN/m^3, and the coefficient of internal friction, tan φ=0.75.

i. Calculate all the forces affecting the stability of the dam **[8]**

ii. Illustrate how the forces affect the stability of the dam **[7]**

NB: All dimensions are in metres

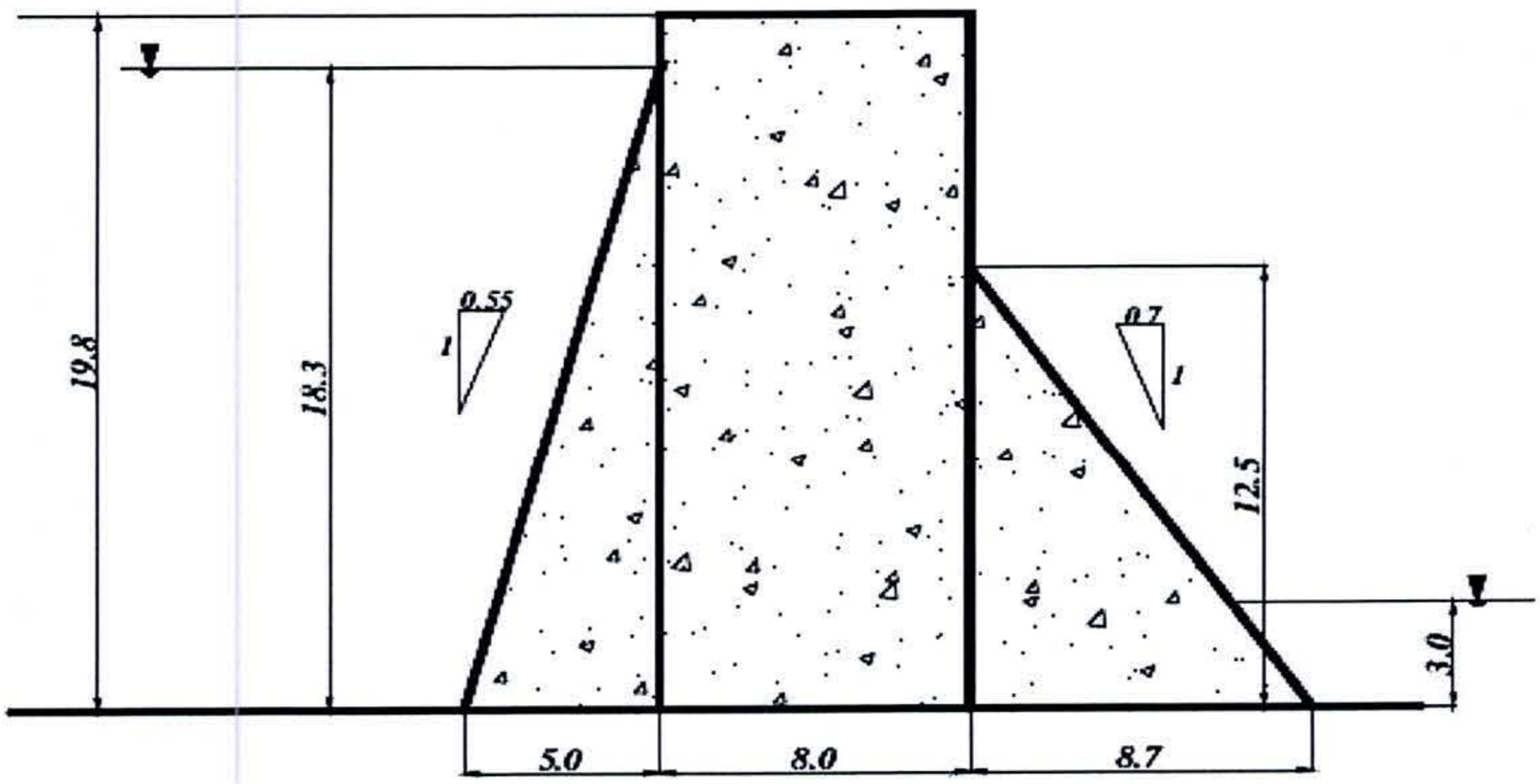


Fig 1

QUESTION 2

a. What are the factors to consider when designing a spillway? **[5]**

b. An overflow spillway 80 m wide carries a maximum (design) discharge of $400m^3/s$. Compute the static (design) head and define the crest profile for the spillway. Consider

a 3:1 upstream slope and a 2:1 down-stream slope for the crest profile. Assume a discharge coefficient of 2.22 based on model studies and a negligible approach velocity based on the dam height. **[10]**

c. The maximum design discharge over a spillway is 280 m^3/s, and the spillway and stilling basin are 12 m wide. The reservoir behind the spillway has a water-surface elevation of 60.00 m, and the river water surface elevation downstream of the stilling basin is 30.00 m. Assuming a 10% loss of hydraulic head in the flow down the spillway, find the elevation of the floor of the stilling basin so that the hydraulic jump forms in the basin. Design the stilling basin. **[10]**

QUESTION 3

a. Describe typical impacts on the environment by dam construction projects and suggest mitigation measures for these **[5]**

b. Describe the effects of sedimentation on reservoirs and measures that can be taken to minimize sediment input to a reservoir. **[10]**

c. A reservoir covers an area of 400 km^2 and has an average depth of 24.8 m. The inflow to the reservoir is from a river with an average flow rate of 3000 m^3/s and a typical suspended-sediment concentration of 150 mg/L. Estimate the rate at which sediment is accumulating in the reservoir, the rate at which the depth of the reservoir is decreasing due to sediment accumulation, and the average suspended sediment concentration in the water released from the reservoir. Assume that the accumulated sediment has a bulk density of 1600 kg/m3. **[10]**

QUESTION 4

(a) Draw and label a typical cross section through a zoned earth dam highlighting the measures taken to control seepage and embankment erosion. **[5]**

(b) A 30m high earth dam, as schematically shown in Figure 2, is constructed with a uniform material having a coefficient of permeability of 2 .00 x 10^{-6} m/s on a relatively impervious foundation. Compute the seepage rate in units of m^3/d per unit width of the

dam. Assume the phreatic surface emerges on the downstream slope at a distance of x = 30 m, as depicted in Figure 2.

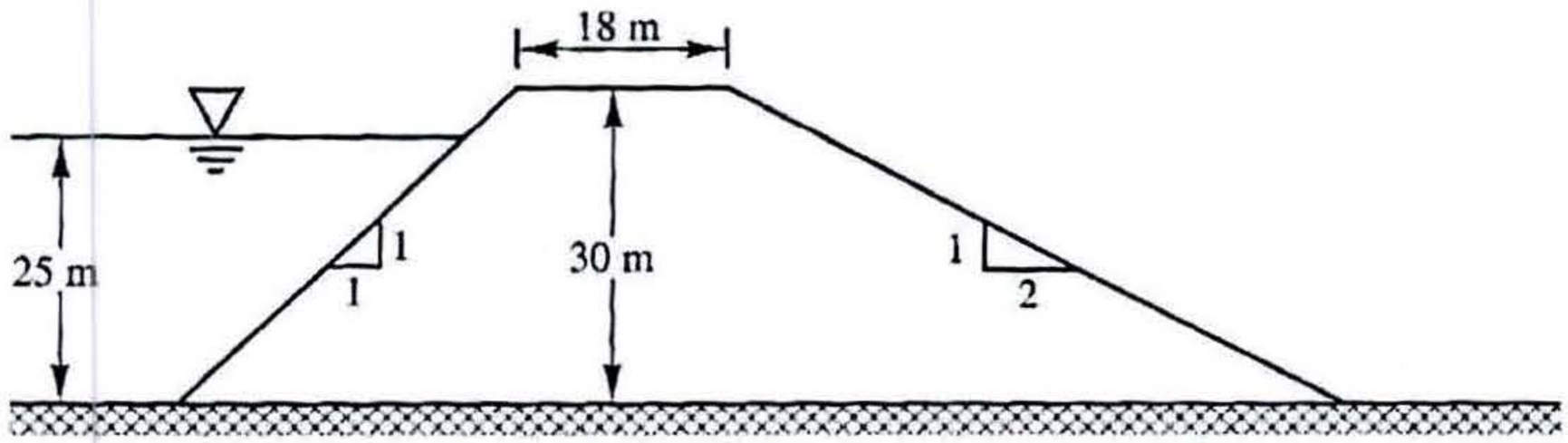


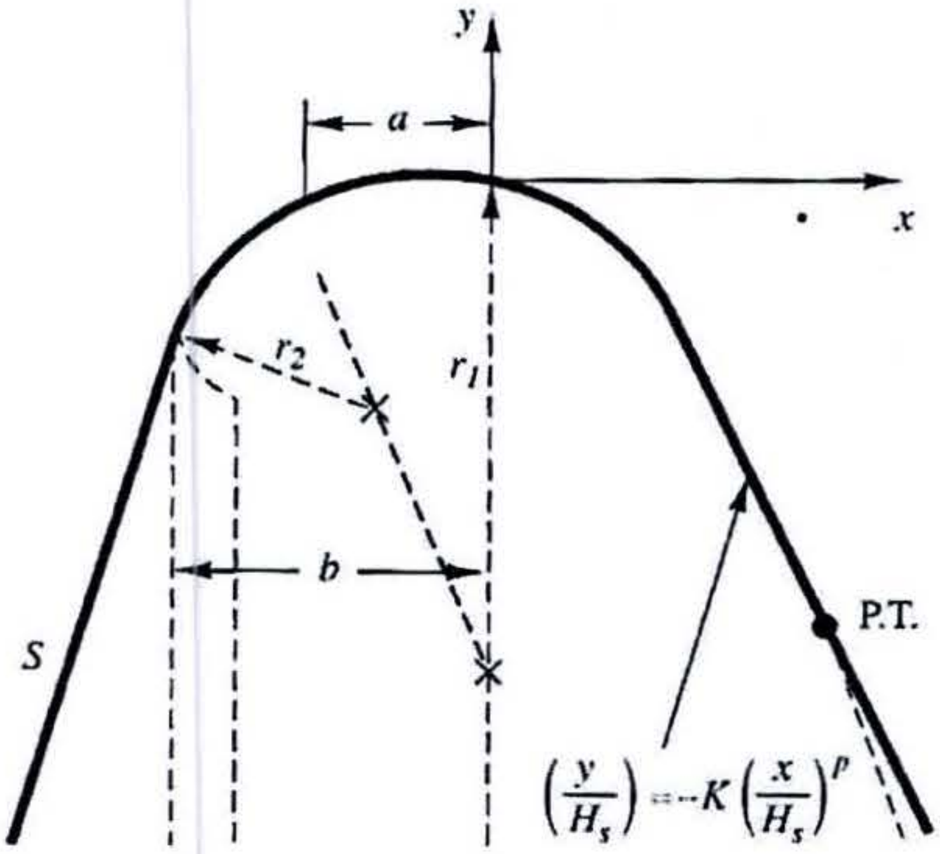
Figure 2

[10]

(c) The design flow for a proposed corrugated steel culvert is $5250l/s$. The maximum available headwater (H) is 3.2m above the culvert (inside bottom). The culvert is 40 m long and has a square-edged entrance and a slope of 0.3%. The outlet is not submerged (free discharge). Determine the required diameter. **[10]**

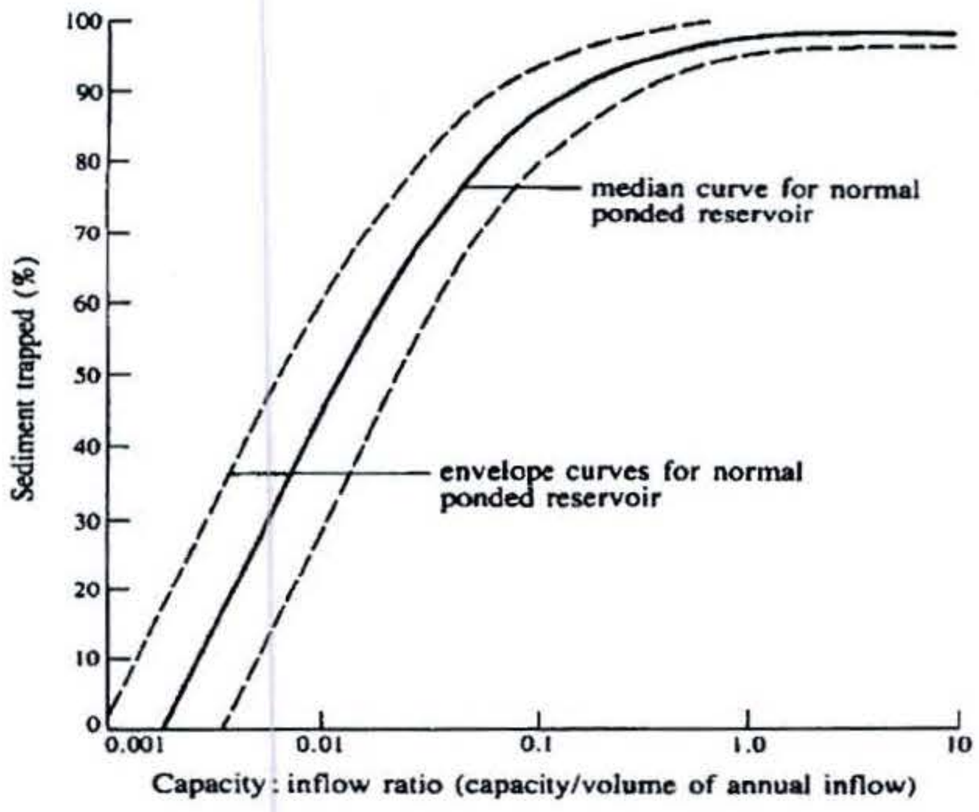
The End

USEFUL INFORMATION



Upstream slope (vertical /horizontal)

	3/0	3/1	3/2	3/3
a/H_s	0.175	0.139	0.115	0
b/H_s	0.282	0.237	0.214	0.199
r_1/H_s	0.50	0.68	0.48	0.45
r_2/H_s	0.20	0.21	0.22	–
K	0.500	0.516	0.515	0.534
p	1.850	1.836	1.810	1.776



$$H_{f(L)} = \frac{FK\left(\frac{L}{100}\right)\left(\frac{Q}{C}\right)^m}{D^{2m+1}}$$

$$h_f = 6.377 f L \frac{Q^2}{D^5}$$

Reservoir trap efficiency (Brune , 1953)