National Exams May 2017

04-Env-A3, Geotechnical and Hydrogeological Engineering

3 hours duration

NOTES:

1. If doubt exists as to the interpretation of any question, the candidate is urged to submit with the answer paper, a clear statement of any assumptions made.

2. This is an OPEN BOOK EXAM.
   Any non-communicating calculator is permitted.

3. FIVE (5) questions constitute a complete exam paper.
   The first five questions as they appear in the answer book will be marked.

4. Each question is of equal value.

   1. 20 marks total (5 items times 4 marks each)
   2. 20 marks total part (a) 10 marks and part (b) 10 marks
   3. 20 marks total part (a) 10 marks and part (b) 10 marks
   4. 20 marks total part (a) 10 marks and part (b) 10 marks
   5. 20 marks total part (a) 10 marks and part (b) 10 marks
   6. 20 marks total part (a) 10 marks and part (b) 10 marks

5. Some questions require an answer in essay format. Clarity and organization of the answer are important.

Question 1 (20 marks):

A sample of soil weighing 1.8 kg had a volume of 1.0 L. When dried out in an oven set to 105°C, its weight was reduced to 1.7 kg. The specific gravity of the solids was found to be 2.5. Determine the following:

a) Bulk unit weight
b) Dry density
c) Degree of saturation
d) Saturated unit weight
e) Porosity

Question 2 (20 marks):

Assume B = 10 m for a wide base concrete gravity dam, as shown in Fig. 1. Dam is resting on a D = 2.5 m thick layer of homogeneous and isotropic sandy soil that has a saturated hydraulic conductivity of $k = 5 \times 10^{-2}$ cm/h. Below the sandy soil is impermeable rock. The depth of water in the reservoir upstream of the dam is $h_w = 2.5$ m. Assume d = 1.5 m for the cut-off wall installed at the toe of the dam to control seepage.

a) Draw the flownet within the sandy soil and calculate the seepage rate per unit length of the crest of the dam; and
b) Calculate the hydrostatic water pressure distributions on the dam and comment on any stability concerns for the dam.

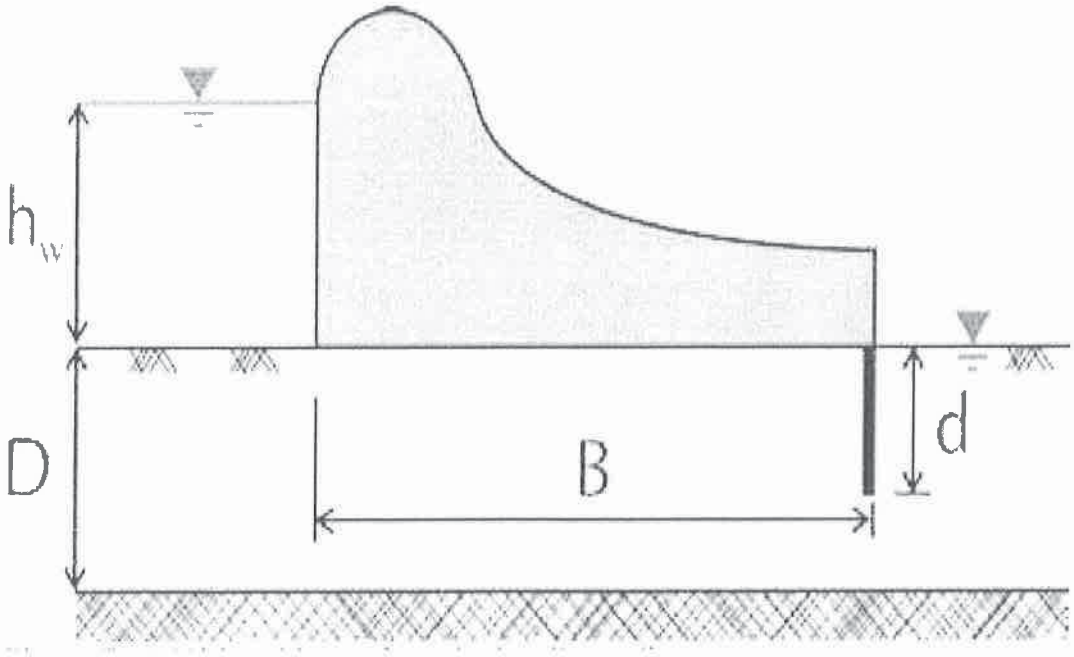


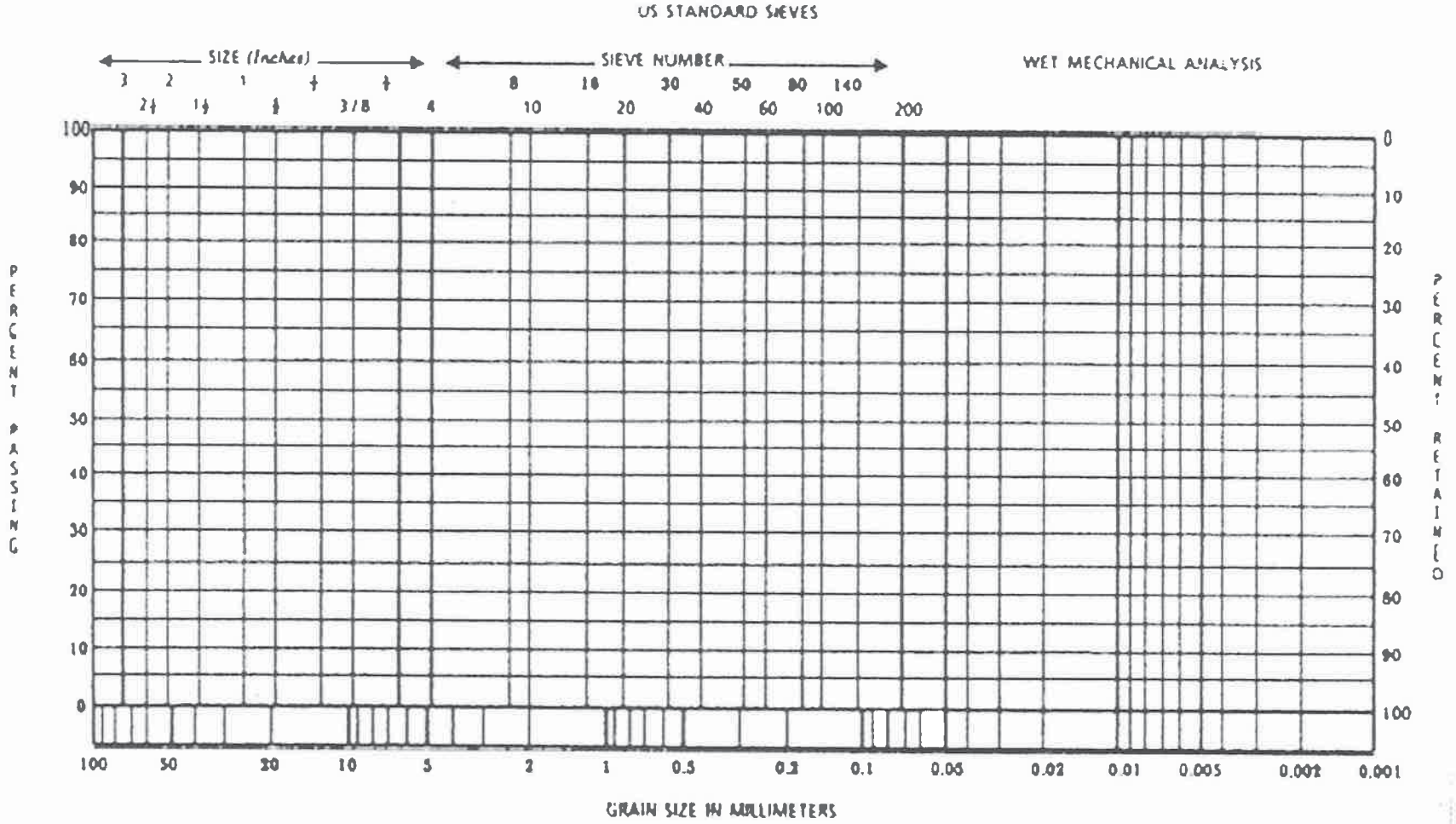
Figure 1: Cross-section of the concrete gravity dam

Question 3 (20 marks):

A particle size distribution test yields the following results:

Sieve Number	Mesh Opening (mm)	Sieve + Soil Mass (g)	Empty Sieve Mass (g)	Soil Retained on Sieve (g)
4	4.750	719.1	520.3	198.8
10	2.000	871.4	485.0	386.4
20	0.850	843.3	416.8	426.5
40	0.425	739.6	375.9	363.7
60	0.250	646.6	358.7	287.9
100	0.150	646.2	353.2	293.0
140	0.106	443.4	345.8	97.6
200	0.075	452.5	336.1	116.4
pan	---	520.0	302.5	217.5

a) Plot the soil particle size distribution on the supplied chart (next page) and calculate percent Gavel, percent Sand and percent Fines; and
b) Calculate the Coefficient of Uniformity and Curvature.



This blank chart is supplied for question 3, part a).

Question 4 (20 marks):

A 20-m thick layer of saturated clay soil, as shown in Figure 2, is resting on an impermeable bedrock layer. To expedite consolidation of the clay, it is proposed to place gravel fill with 20-m thickness, with unit weight of 20 kN/m^3, on top of the clay. Assume the void ratio of the clay e = 0.5 and specific gravity G_s = 2.5. The compression and recompression indices of the clay are 0.35 and 0.05. The pre-consolidation pressure of the clay is 100 kPa.

a) Calculate the effective vertical stress distribution profile within the clay layer immediately after the placement of the proposed fill; and
b) Calculate the ultimate primary consolidation settlement of the clay layer.

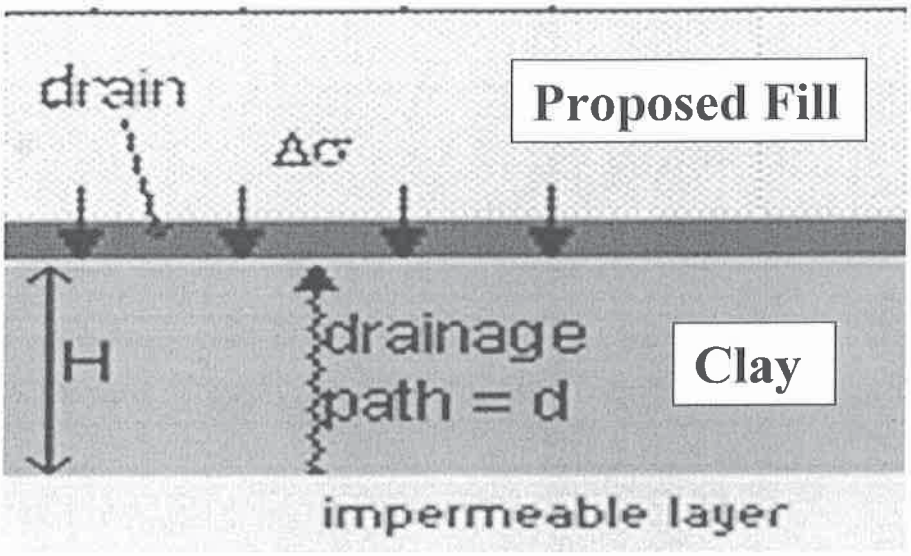


Figure 2: The clay layer and the proposed fill.

Question 5 (20 marks):

A drinking water well is to be developed in an unconfined aquifer. Assume the radius of influence of the well is about 2 km and the piezometric water levels outside this range are kept at an elevation 6 m above the impermeable levels, as shown in Fig. 3. The aquifer material is uniform and isotropic sand with saturated hydraulic conductivity of 2 cm/s.

a) Calculate drawdown at two observation wells, located at distances of 50 and 500 m from the pumping well, assuming a uniform pumping rate of 500 m^3/d; and
b) Calculate how long it would take for a conservative tracer to travel the distance between the two observation wells in part a) at this pumping rate.

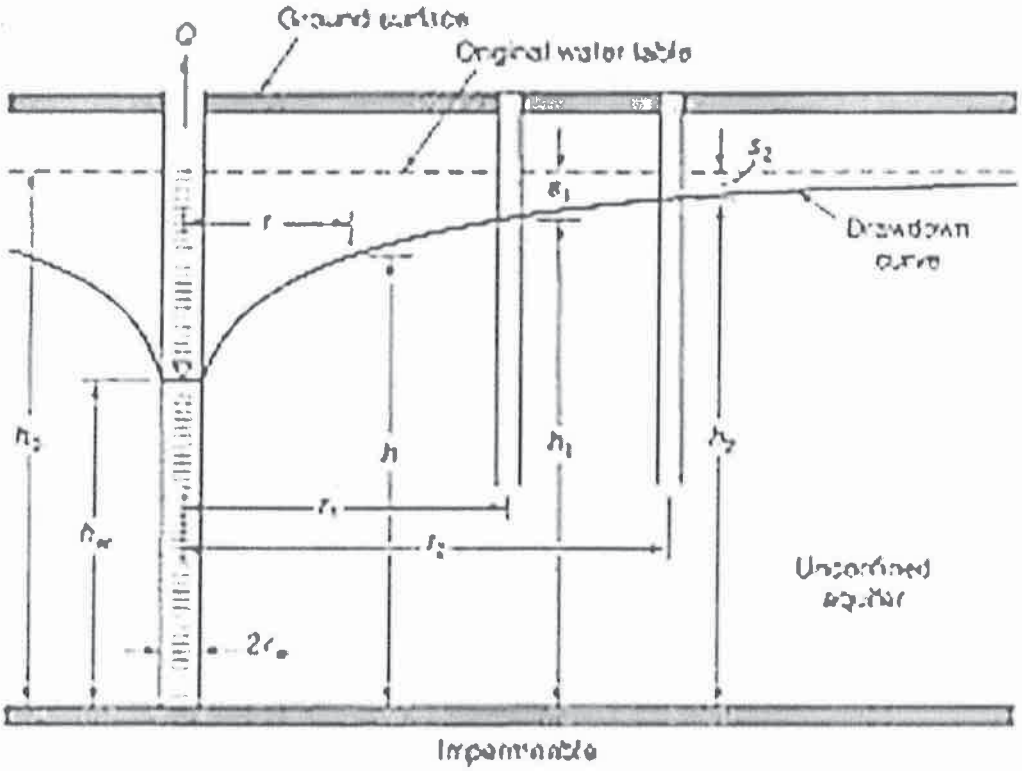


Figure 3: The pumping well.

Question 6 (20 marks):

A 3-m high proposed loam soil deposit will be placed on a firm base, as shown in Figure 4. The front face of the slope (AC) makes an angle of $\beta = 50°$ with the horizontal. Assume that the loam soil has a dry unit weight of $\gamma = 18$ kN/m^3, porosity of 25%, cohesion C = 25 kPa and angle of internal friction of $\varphi = 30°$.

a) Calculate the factor of safety against slope stability for a proposed failure plain AB that makes an angle of $\theta = 40°$ with the horizontal; and
b) Assuming that during major rain event the unit weight of the soil is expected to increase to fully saturated conditions and that the pore water pressure will build-up along the proposed failure plain AB; re-calculate the factor of safety for such conditions.

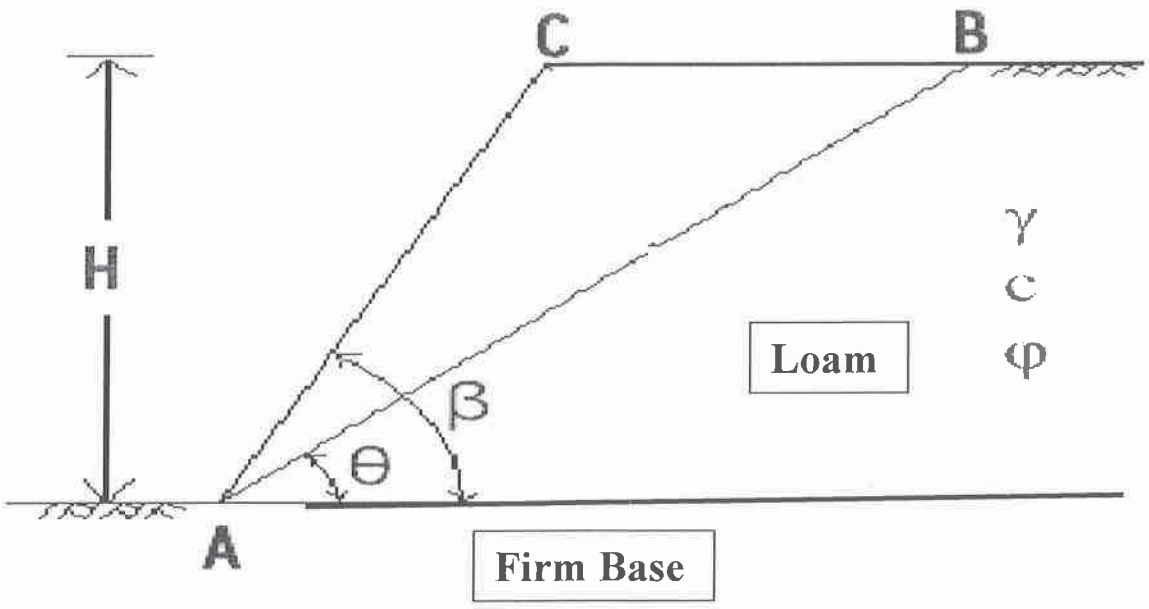


Figure 4: Earth slope.