National Exams May 2014

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.

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

Page 1 of 8

Question 1 (20 marks):

A sample of soil is compacted into a 1.0 L laboratory mold. The mass of the compacted soil is 1.820 kg and its moisture content is 7%. Assuming a specific gravity of solids of 2.6, calculate:

a) porosity,
b) degree of saturation,
c) density (kg/m^3),
d) dry unit weight (kN/m^3) and
e) saturated unit weight (kN/m^3)

Question 2 (20 marks):

The grain-size distribution of an inorganic soil is shown in Figure 1; and its liquid and plastic limits are 50% and 30%, respectively.

a) Classify the soil according to the USCS classification system (i.e. determine the group symbol and group name). (10 marks)
b) Explain why this soil may or may not be suitable as a cover material for a municipal solid waste landfill. (10 marks)

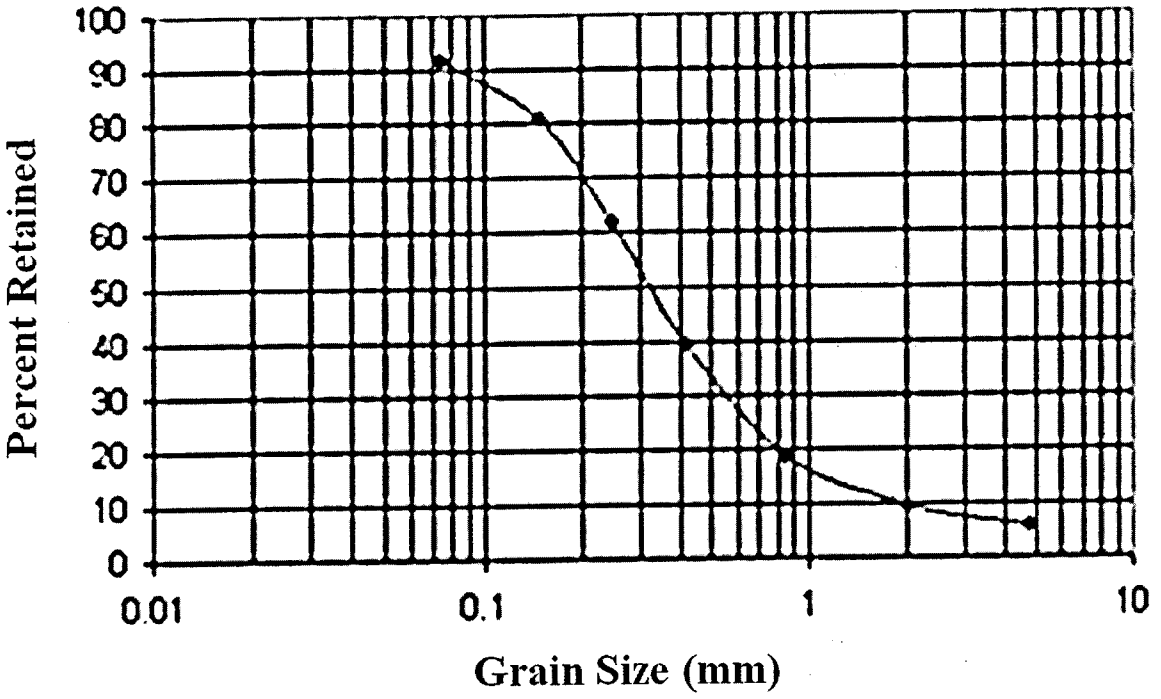


Figure 1: Grain-size distribution of the inorganic soil

Question 3 (20 marks):

Figure 2 (on page 5) shows the cross-section of a dam and reservoir resting on a sand-gravel soil with saturated hydraulic conductivity of 0.2 cm/s. The dam is approximately 150 m wide and is made of impervious material.

a) Calculate the volume of water that will seep beneath the dam through the sand-gravel soil in a day (m^3/day). (10 marks)
b) Calculate (approximately) the length "X" of a proposed impervious blanket (Figure 2) to reduce the seepage beneath the dam by half. (10 marks)

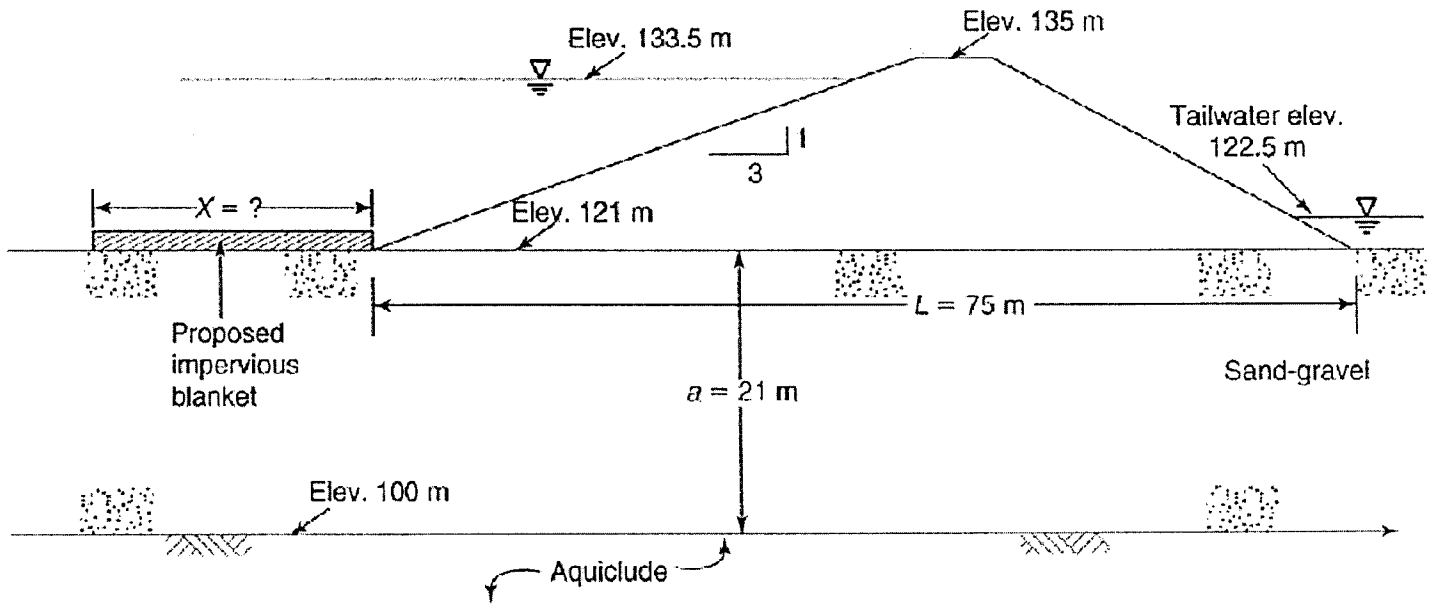


Figure 2 (related to Question 3 on page 4)): concrete dam and reservoir system

Question 4 (20 marks):

A 10-m thick normally-consolidated clay soil is resting on impermeable shale rock; a 7-m thick sandy soil is placed on top of the clay to expedite consolidation process. The unit weight of the sand is 17 kN/m^3 and the unit weight of the clay is 15 kN/m^3. For the clay layer, the initial void ratio is 1.0, the compression index of the clay is $C_c = 0.45$, the recompression index is $C_r = 0.15$, and the coefficient of consolidation is $C_v = 0.003\ cm^2\ s^{-1}$.

a) Compute the ultimate primary settlement of the clay layer. (10 marks)

b) Compute the time for 25% of primary consolidation to occur. (10 marks)

Question 5 (20 marks):

A 5-m high clay soil deposit is placed on a firm base at slope angle (β) = 45°, as shown in Fig. 3. Assume unit weight of clay is γ = 17 kN/m^3; cohesion C = 30 kPa; angle of internal friction φ = 0° (negligible); and groundwater table is below the firm base.

a) Calculate the factor of safety with respect to slope failure. (10 marks)

b) Calculate maximum slope angle β that would have a factor of safety with respect to slope failure of 1.5. (10 marks)

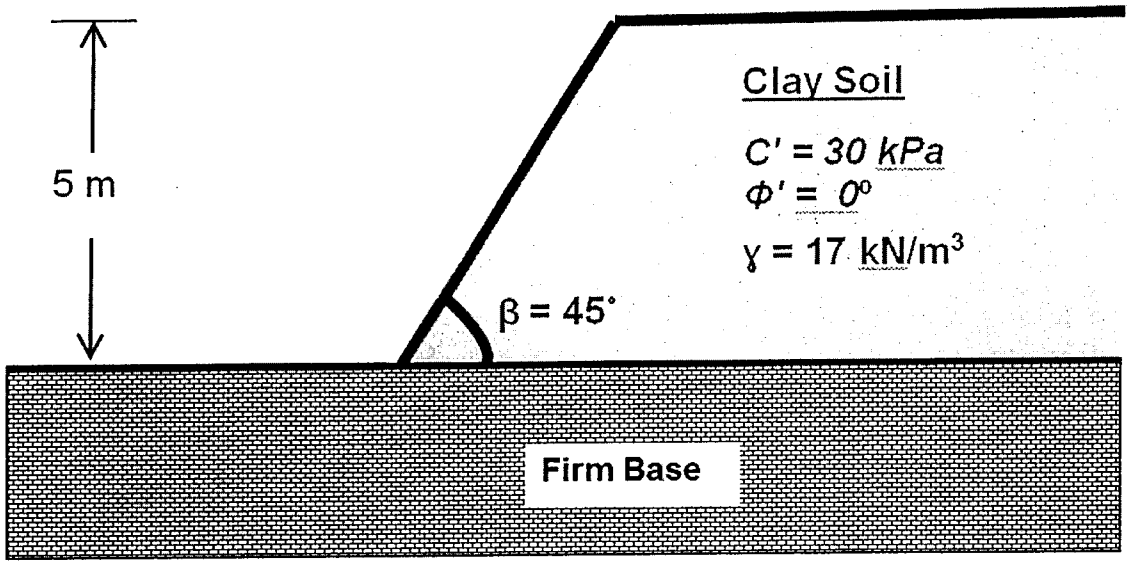


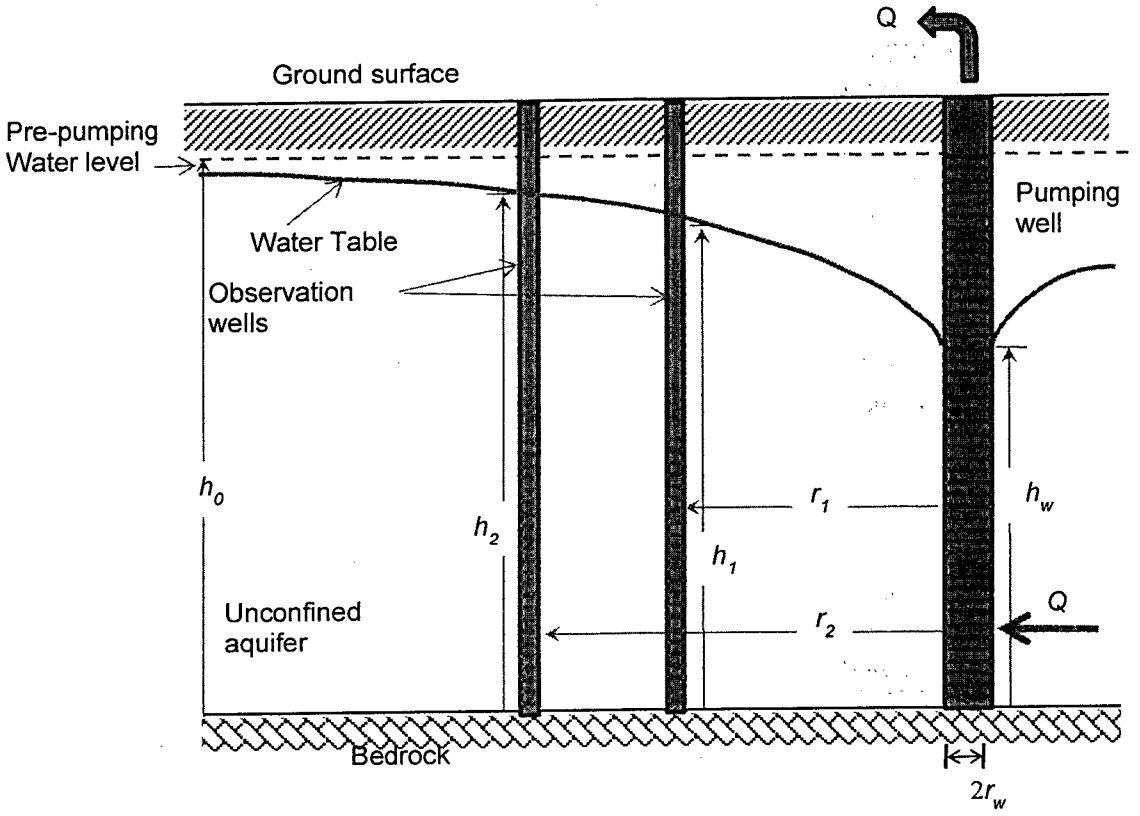
Figure 3

Question 6 (20 marks):

A single, 30 cm diameter, well draws from a nearly horizontal, unconfined sandy-gravely aquifer with a depth of 20 m below the ground surface. Two observation wells are located at radius $r_1 = 10$ m and $r_2 = 100$ m from the pumping well. The aquifer materials have a porosity of 0.35 and saturated hydraulic conductivity of 20 m/d. Without the well the water table is approximately horizontal and 2 m below the ground. Below the aquifer material is impermeable bedrock.

a) What is the maximum discharge (in m^3/day) that can be drawn from the well if the maximum allowable drawdown in the well, relative to the static level, is 2 m? (10 marks)

b) How long would it take for a conservative tracer to travel the distance between the observation wells? (10 marks)



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Marking Scheme

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