National Exams Dec 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 7

Question 1 (20 marks):

A sample of sandy soil is compacted into a 38 mm in diameter and 88 mm long cylindrical laboratory mold. The mass of the compacted soil is 0.185 kg and its degree of saturation is 33%. Assuming a specific gravity of solids of 2.5, calculate:

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

Question 2 (20 marks):

A proposed building site requires 10,000 m^3 of imported fill to be compacted to 95% Proctor compaction. A suitable borrow site has been located, and the soils there have a bulk unit weight of 16 kN/m^3 and water content of 5%. A Proctor compaction test on this soil gives maximum unit weight of 19.5 kN/m^3 and optimum water content of 10%. A contractor needs to excavate the soil from the borrow site and haul it with dump trucks. Each truck can carry 25 m^3 of soil per load, and operates on a 15-min cycle. The job must be completed in two days with the trucks working two 8-hour shifts per day.

a) How many cubic meters of soil must be excavated from the borrow site for this project? (10 marks)
b) Using a bulking factor of 30%, how many trucks will be required? (10 marks)

Question 3 (20 marks):

Figure 1 shows the cross-section of a concrete gravity dam and reservoir resting on a 30 m thickness layer of homogeneous and isotropic sandy soil on impervious rock. The saturated hydraulic conductivity of the sandy soil 2 x 10^{-4} m/s. The dam is approximately 20 m wide and is made of impervious concrete.

a) Using a flow net analysis, calculate the volume of water that will seep beneath the dam through the sandy soil in a day (m^3/day) and submit this figure (flow net) with your exam booklet. (10 marks)

b) Calculate maximum seepage flow velocity and the uplift water pressure distribution diagram beneath the dam. (10 marks)

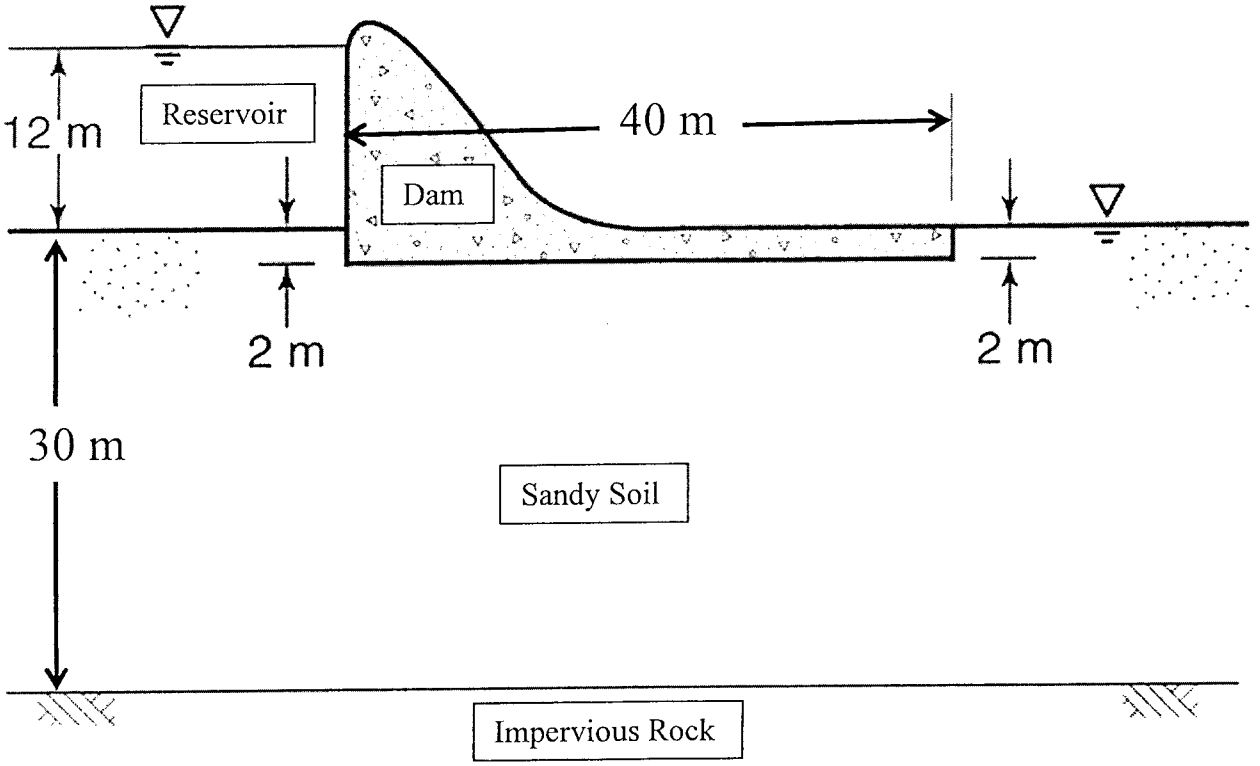

Figure 1: concrete dam and reservoir system.

Question 4 (20 marks):

A soil profile, shown in figure 2, consists of 7-m thick saturated stiff silty clay soil resting on 18-m thick saturated very stiff clay soil resting on glacial till; the groundwater table is the ground surface (top of the stiff silty clay). A contractor has proposed an 8.5-m thick sandy soil proposed fill to expedite the consolidation of the clay soil. The unit weight of the sand is 20.3 kN/m^3 and the unit weight of the stiff silty clay is 19 kN/m^3 and very stiff clay 19.5 kN/m^3.

a) Compute the total and effective vertical stresses at points A and B before the placement of the proposed fill. (10 marks)

b) Compute the effective vertical stresses and pore water pressures at points A and B immediately after the placement of the proposed fill. (10 marks)

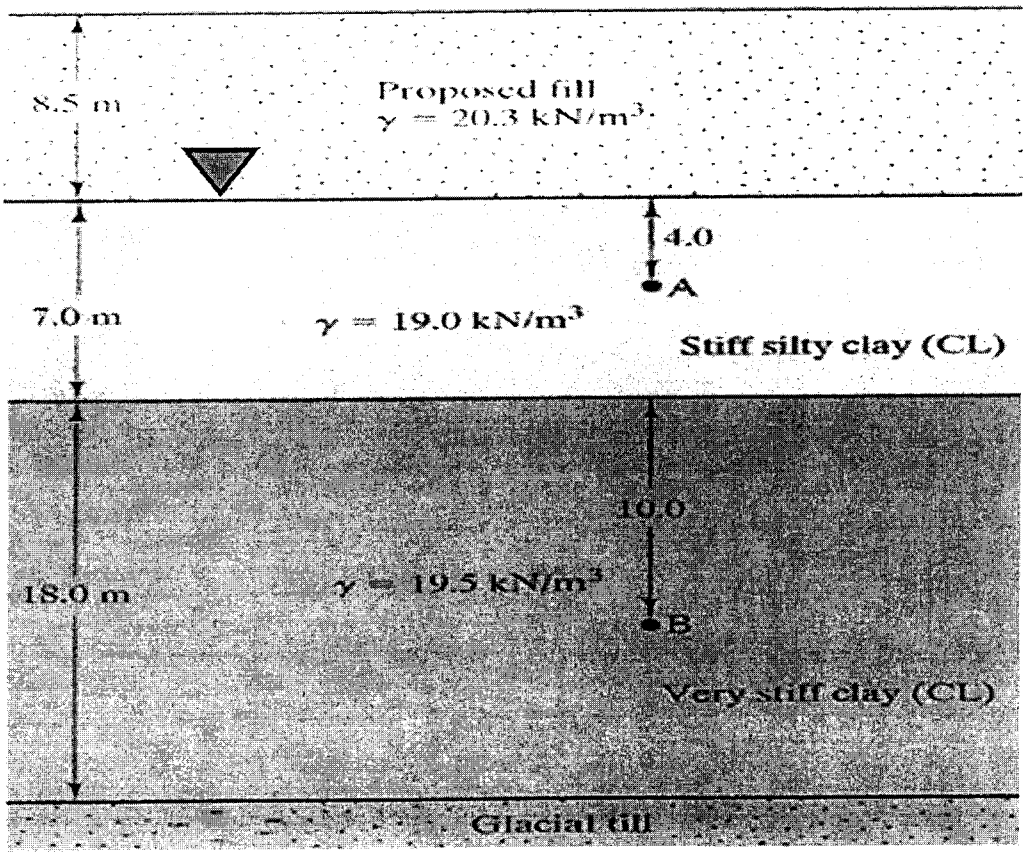

Figure 2: soil profile and the proposed fill.

Question 5 (20 marks):

Four runs were completed using a direct shear apparatus on a sandy soil. In all cases the samples have areas of 5 x 5 cm. The results are summarized in the table below:

Run Number	Normal Force (N)	Shear Force (N)
1	80	122
2	160	147
3	240	168
4	320	195

a) Calculate the shear strength soil properties, including cohesion and the angle of internal friction for this soil. (10 marks)

b) Discuss the advantages and limitations of the direct shear test compared to alternative methods (in-situ and laboratory) for determining the shear strength properties. (10 marks)

Question 6 (20 marks):

A well is to be developed in an unconfined aquifer for municipal water supply. You may assume that 4 km from the well the piezometric levels are not affected by the pumping well and remain constant at an elevation 7 m above the impermeable bedrock level. The aquifer material is homogeneous and isotropic with a saturated hydraulic conductivity of 5 cm/s and have a porosity of 35%. Two observation wells are located at radius r_1 = 10 m and r_2 = 50 m from the pumping well. Without the well the water table is approximately horizontal and 2 m below the ground. Below the aquifer material is impermeable horizontal bedrock.

a) What drawdown, relative to the static level, is expected in the observation wells at a uniform pumping rate of 100 m^3/d? (10 marks)
b) How long would it take for a conservative tracer to travel the distance between the observation wells at this pumping rate? (10 marks)

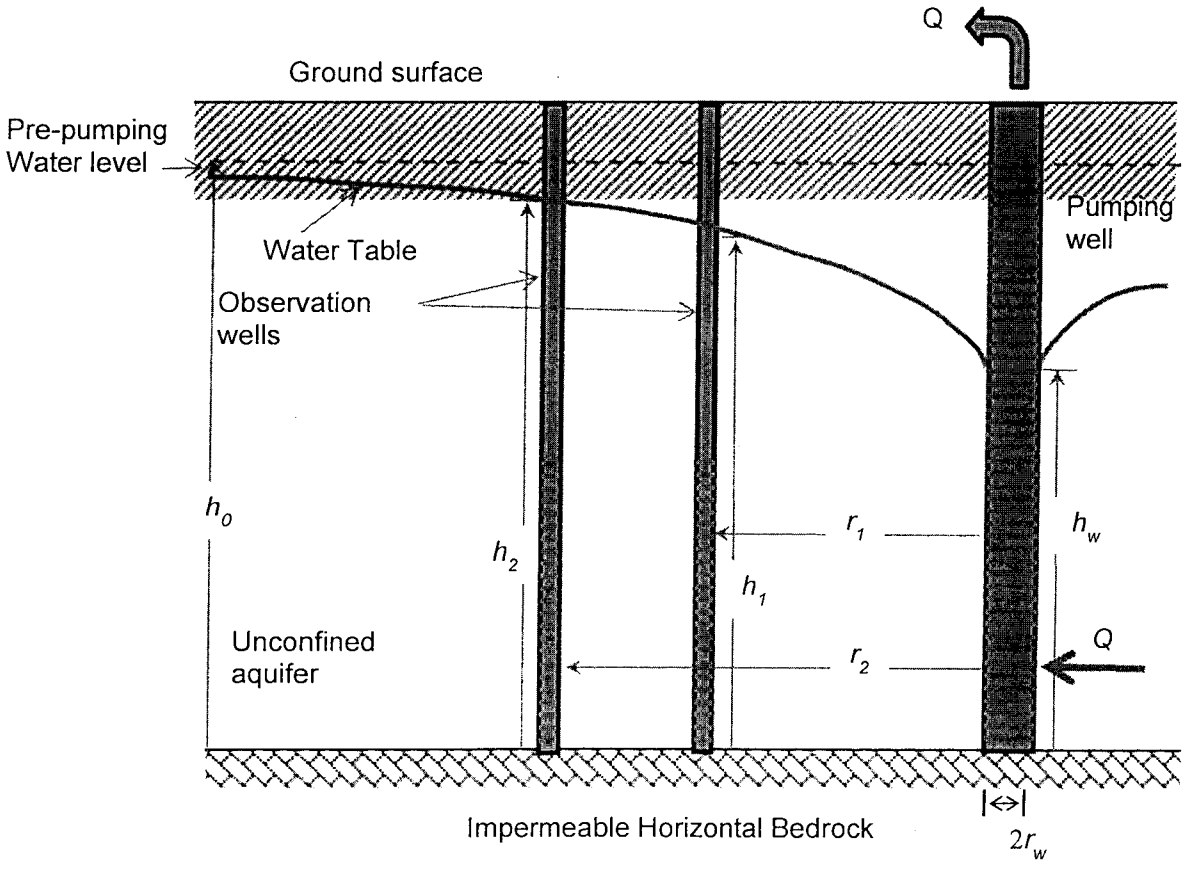

Figure 3: pumping well in unconfined aquifer.