

National Exams December 2018

18-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.

Question 1 (20 marks):

The hollow-stem auger is used to dig a borehole in the ground and rotated to dig down to the desired depth of 2 m below the ground surface. The driller removes the temporary plug and inserts the split-barrel sampler through the stem. The split-barrel sampler retrieves a cylindrical shape soil sample with a diameter of 50 mm and a length of 0.5 m. The weight of the collected soil sample is 1.750 kg and its moisture content is 20%. Considering a reasonable value for the specific gravity of solids, compute:

- a) **(5 marks)** degree of saturation,
- b) **(5 marks)** porosity,
- c) **(5 marks)** saturated unit weight, and
- d) **(5 marks)** dry unit weight.

Question 2 (20 marks):

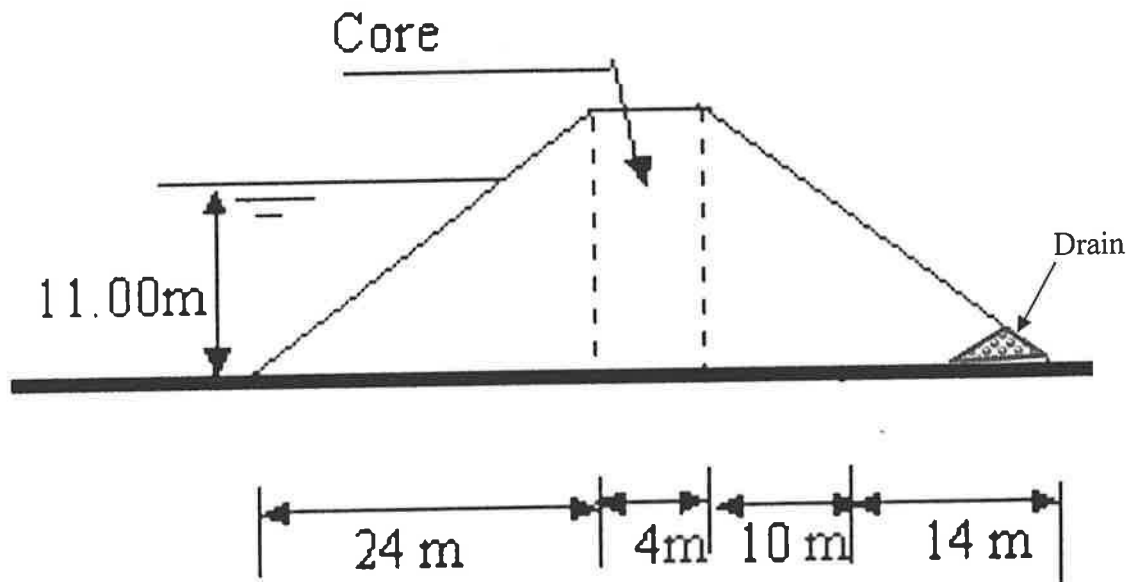
The construction of an Earth Dam will consist of 12,500 m³ of cut and 8,500 m³ of fill and will be a balanced earthwork job. The contractor will excavate and haul the soil with dump trucks from cut to fill area, then add enough water to bring the moisture content to optimum conditions before compaction. Haul roads are built to suit the required speed of construction, and this involves the size of the haulage units. The cut area has an average natural moisture content of 2%. The fill will be compacted to an average relative compaction of 95% based on a maximum dry unit weight of 21 kN/m³ and an optimum moisture content of 8% obtained from the modified Proctor test.

- a) **(10 marks)** Assume each truck can haul 30 m³ of soil per load, and travel with an average speed of 40 km/hr for an 80 km round-trip cycle between the cut & fill areas plus 15 min on each end for dumping and reloading, and that the job must be completed in seven days with the trucks working two 8-hour shifts per day. Using a bulking factor of 35%, how many truck loads will be required?
- b) **(10 marks)** What is the total weight of the newly constructed Earth Dam?

Question 3 (20 marks):

Figure below shows the cross-section of an Earth dam made of silty-loam soil with a clay core sitting on impermeable shale rock formation. The crest of the dam is approximately 50 m long (normal to the picture). Assume that the saturated hydraulic conductivity of the silty-loam soil is 24 cm/d and for the clay core is only 1 mm/d. There is a drain at the toe of the dam.

- a) (10 marks) Using a flow net analysis, calculate the volume of water that will seep beneath the dam/cutoff wall through the dam in a day,
- b) (10 marks) Calculate maximum seepage flow velocity through the dam.



Question 4 (20 marks):

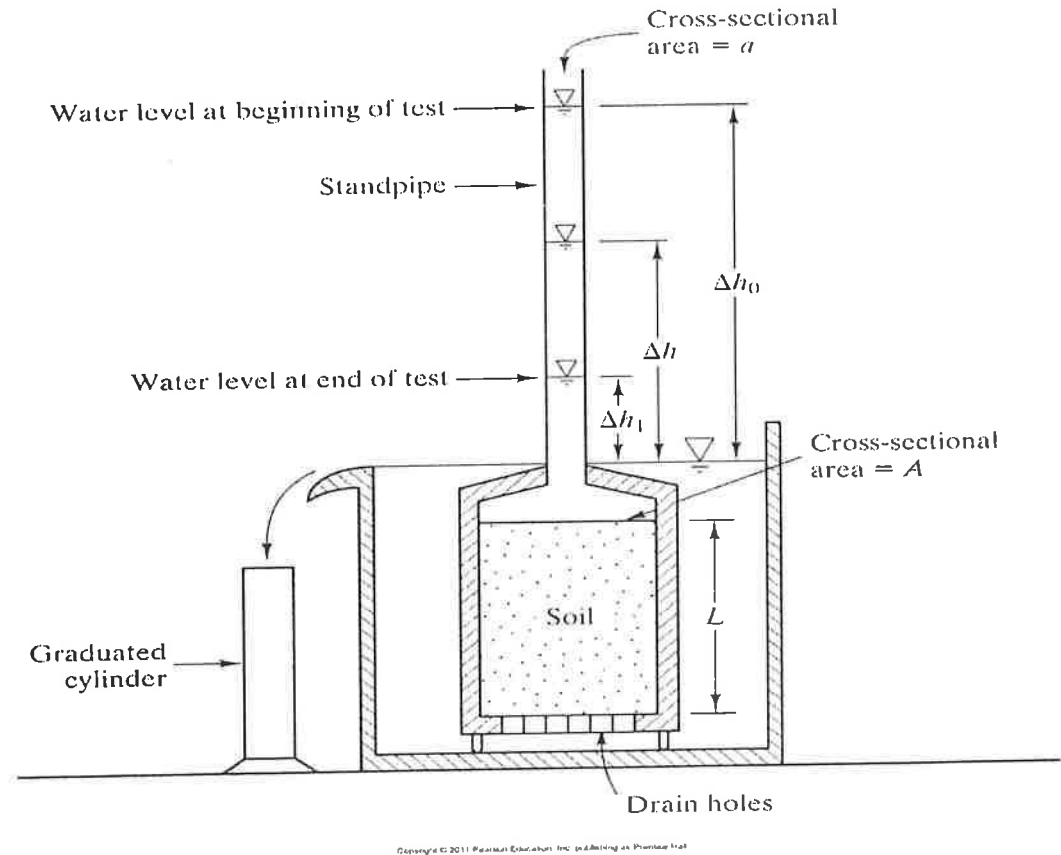
A 20-cm diameter, drinking water well draws from an unconfined aquifer located at a depth of 10 m below the ground surface underlain by impermeable shale rock formation. A monitoring well is located at distances of 20 m from the pumping well. The aquifer materials have a porosity of 0.30 and saturated hydraulic conductivity of 10 m/d. Without the well in operation, the water table is approximately horizontal and 5 m below the ground surface. Assume the radius of influence of the well is about 500 m.

- a) **(10 marks)** What is the maximum discharge (in L/s) that can be drawn from the well if the maximum allowable drawdown in the well, relative to the static level, is 1 m?
- b) **(10 marks)** How many days would it take for a conservative tracer that is injected in the observation well to reach the pumping well during a steady pumping rate of part (a)?

Question 5 (20 marks):

In a standard falling-head permeameter laboratory test, given $L = 5 \text{ cm}$, $a = 0.2 \text{ cm}^2$, $A = 30 \text{ cm}^2$ and hydraulic conductivity $K = 0.34 \text{ m/day}$,

- a) (10 marks) Calculate the time it would take for Δh to drop from 30 cm to 15 cm.
- b) (10 marks) How long would it take for the water level in the standpipe to drop an additional 5 cm from the part (a) scenario?



Question 6 (20 marks):

Figure below shows the cross section of a landfill leachate collection system. Leachate is ponding **0.5 m** above the top clay liner. The top clay liner is **1-m** thick and has a saturated hydraulic conductivity $K = 2.1 \times 10^{-8} \text{ cm/s}$. Below the top clay liner, is a gravel layer that collects the leachate so it can be pumped out and treated. The bottom clay liner protects groundwater below.

- a) **(10 marks)** Calculate total amount of leachate that must be collected and treated each year assuming the total surface area of the landfill base is **5000 m²**.
- b) **(10 marks)** Calculate approximate time it takes the leachate to penetrate through the top clay liner assuming porosity of clay $n = 10\%$.

