

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

Question 1 (20 marks):

An undisturbed block sample of clay weighs 100 kg and has dimensions of 0.5 m × 0.5 m × 0.5 m. Its moisture content is 30% and assuming the specific gravity of solids is 2.65, compute:

- a) (5 marks) void ratio,
- b) (5 marks) porosity,
- c) (5 marks) moisture content, and
- d) (5 marks) dry unit weight.

Question 2 (20 marks):

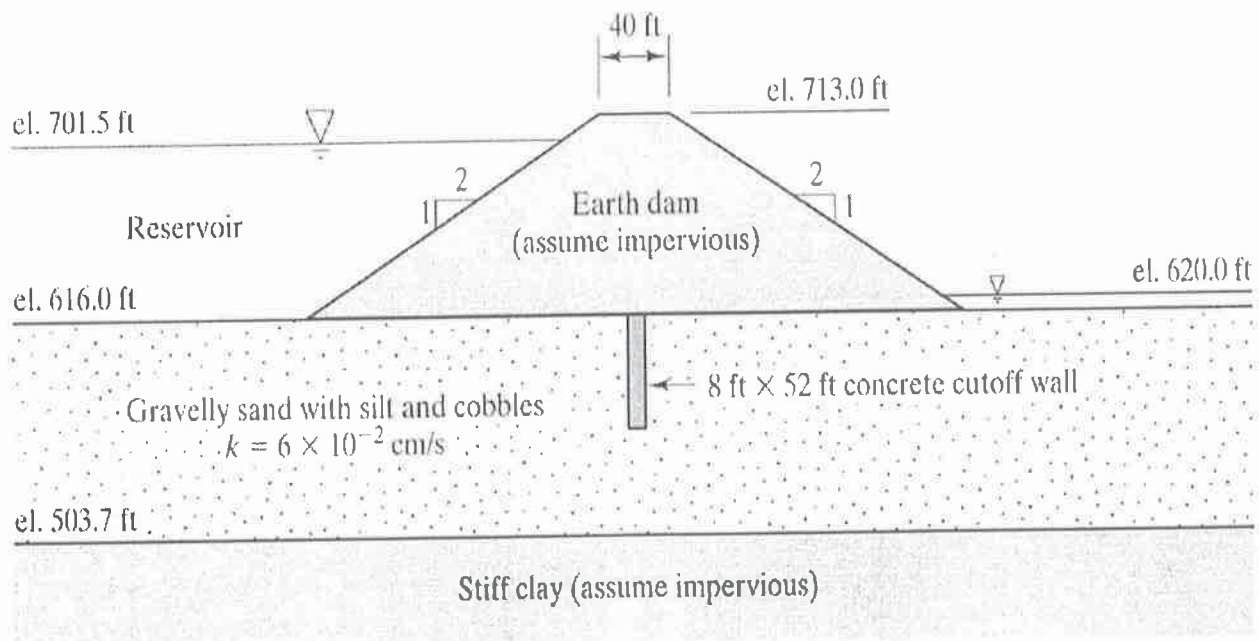
The grading plans for a new project site will consist of 100,000 m³ of cut and 80,000 m³ of fill and will be a balanced earthwork job. A contractor needs to excavate and haul the soil with dump trucks from cut to the fill area then add enough water to bring the moisture content to optimum conditions before compaction. The cut area has an average natural moisture content of 5%. The fill will be compacted to an average relative compaction of 95% based on a maximum dry unit weight of 19 kN/m³ and an optimum moisture content of 12% obtained from the modified Proctor test.

- a) **(10 marks)** Assume each truck can haul 40 m³ of soil per load, and operates on a 30-min round-trip cycle between the cut & fill areas, 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 25%, how many trucks will be required?
- b) **(10 marks)** Assume a tanker truck can carry 20 m³ of water, and operates on a 60-min round-trip cycle between the water station and the site, and that the job must be completed in seven days with the trucks working two 8-hour shifts per day. Compute the volume of water that will be required to bring these soils to the optimum moisture content before compaction and calculate how many tanker trucks will be required?

Question 3 (20 marks):

Figure below shows the cross-section of an Earth dam with a concrete cutoff wall. The crest of the dam is approximately 120 m long (normal to the picture).

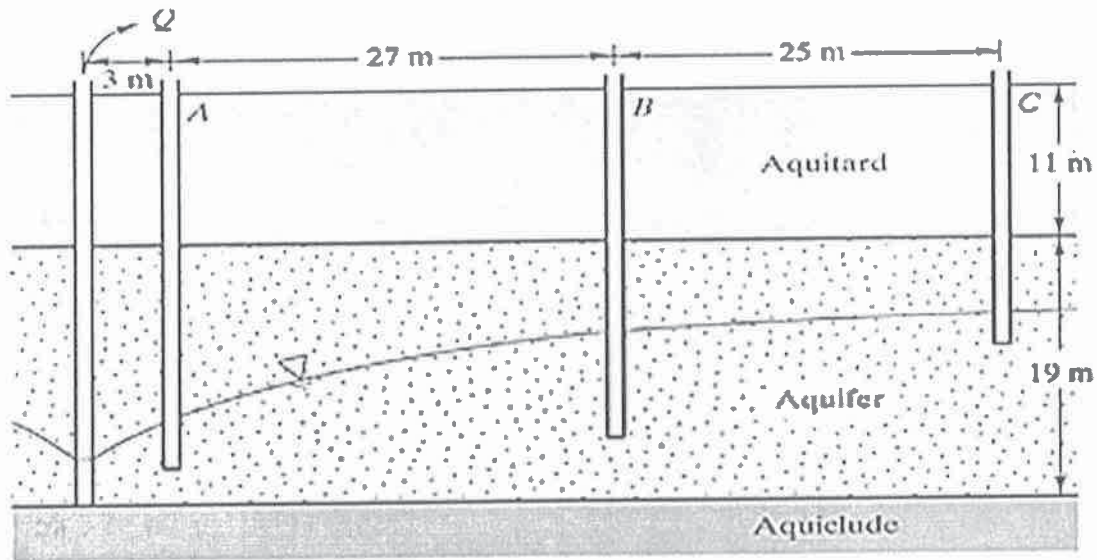
- (10 marks)** Using a flow net analysis, calculate the volume of water that will seep beneath the dam/cutoff wall through the gravelly sand with silt and cobbles soil in a day,
- (10 marks)** Calculate maximum seepage flow velocity beneath the dam.



Note: 1 ft = 0.305 m

Question 4 (20 marks):

After reaching steady-state conditions, the pump test yielded a flow rate of 20 L/s. The aquifer is an alluvial soil with medium-to-coarse silty sand texture. The water depth measured from the ground surface in the pumping well as well as the three observation wells A, B and C were all at 16.9 m before the pumping test started and dropped to 26.0, 23.5, 18.1 and 16.9 m, respectively at steady-state conditions. Using best available data:

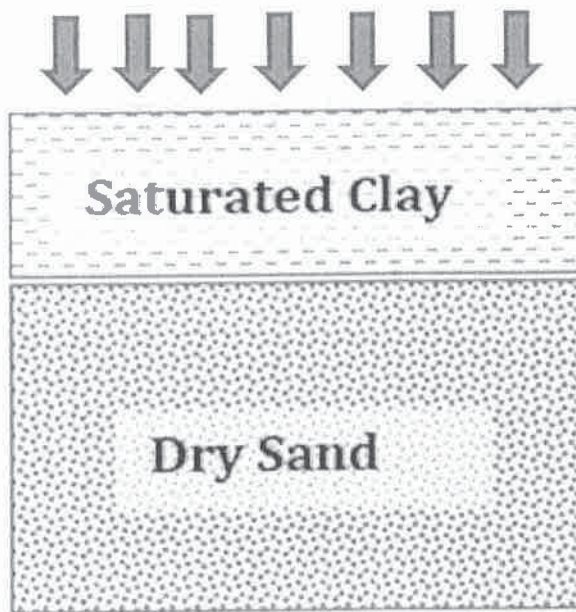


- (10 marks) Compute the hydraulic conductivity of the soil in the aquifer, and
- (10 marks) Compute how many hours would it take for a conservative tracer that is injected in the observation well A to reach the pumping well during this test?

Question 5 (20 marks):

A 1-m thick, fully-saturated clay is resting on a dry sand when a uniform load of 200 kN/m^2 is applied on the top surface of the clay using Sheepsfoot rollers to expedite consolidation process. For the saturated clay layer, the initial void ratio of 5.0, specific gravity of 2.65, pre-consolidation stress of 20 kN/m^2 ; the compression index of 0.5, the recompression index of 0.2, and the coefficient of consolidation of $0.001 \text{ cm}^2 \text{ s}^{-1}$.

- a) (10 marks) Compute the ultimate primary settlement of the clay layer; and
- b) (10 marks) Compute the time for 95% of primary consolidation to occur.



Question 6 (20 marks):

A falling-head hydraulic conductivity test is conducted on a 100 mm in diameter and 20 mm tall clay soil specimen, using the apparatus shown in figure below. The standpipe had an inside diameter of 5 mm and the water level in the bath surrounding the soil specimen was 100 mm above the laboratory counter top. During the test, the water level in the standpipe fell from an elevation of 500 mm to 250 mm above the counter top in 24 hours.

- a) **(10 marks)** Compute the hydraulic conductivity of this soil specimen and comment if this value seem reasonable? Why or why not?
- b) **(10 marks)** Compute the water level in the standpipe at 4 and 12 hours after the start of the falling-head test.

