National Exams May 2015

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.

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

Question 1 (20 marks):

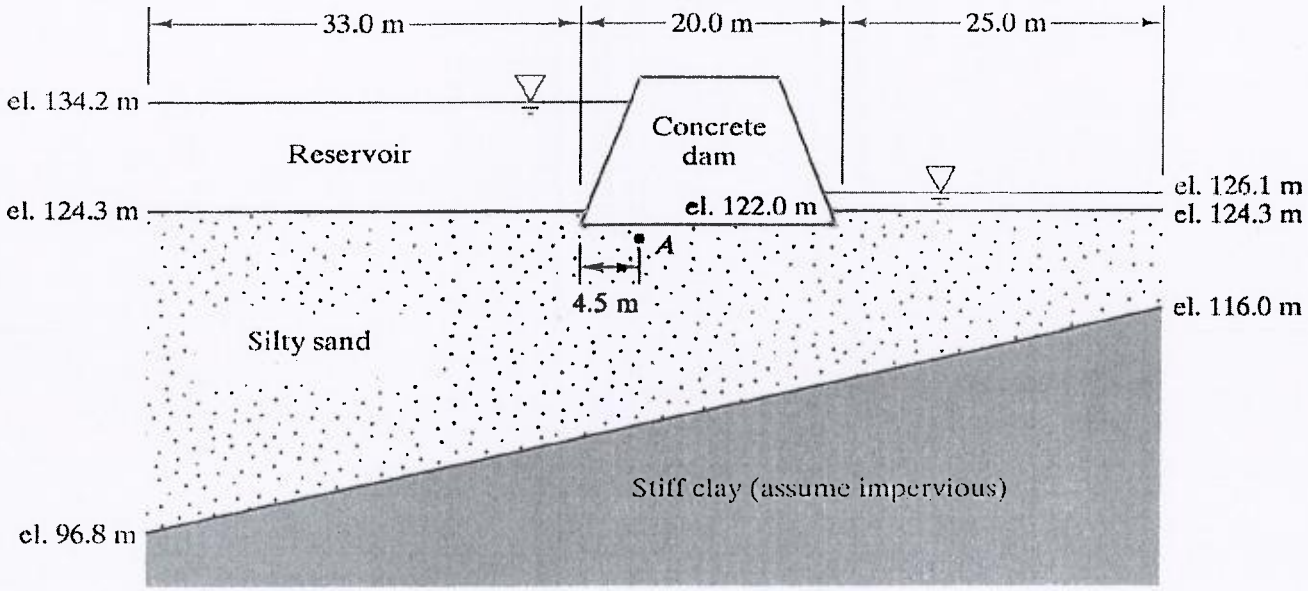
A sample of soil is compacted into a 1.0 L laboratory mold. The mass of the compacted soil is 1.850 kg and its moisture content is 12%. Assuming a reasonable value for specific gravity of the solid particles, calculate:

a) porosity,
b) degree of saturation,
c) density,
d) dry unit weight and
e) saturated unit weight

Question 2 (20 marks):

The figure below shows a 20 m long concrete dam holding back 9.9 m of water. The isotropic Silty sand soil immediately below the dam has a hydraulic conductivity of 1 cm/hr.

a) Sketch the flow net for the water flow under the dam
b) Use the results of your flow net to determine the flow per unit width under the dam.



Question 3 (20 marks):

A 2-m deep open drainage ditch is cut in a saturated clay with side slopes of 2.5 horizontal to 1 vertical. The saturated unit weight of the soil is 21 kN m^{-3} and its undrained cohesion is $C_u = 30$ kN m^{-2}.

a) If the undrained friction angle $\phi_u \approx 0$, determine the factor of safety of the side slopes on the left of figure below against shear failure.

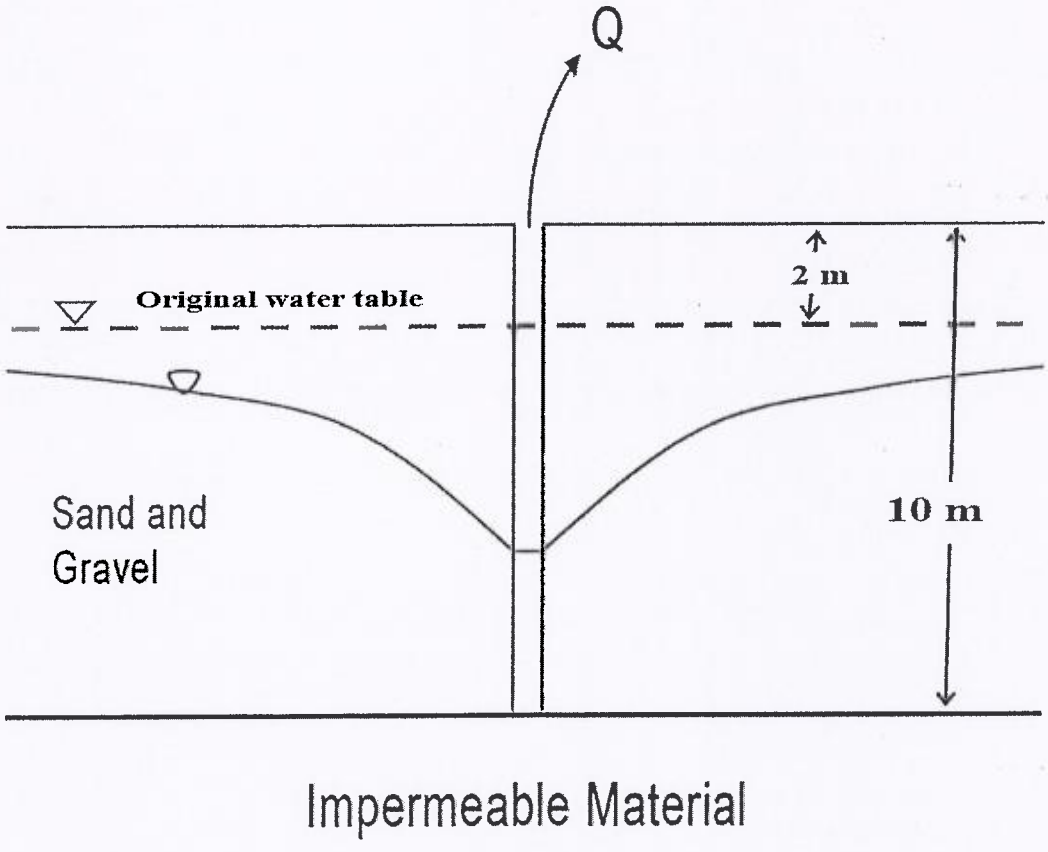
b) Discuss the effect of tile drainage pipes shown in the figure on slope stability.

Question 4 (20 marks):

A 10 m deep, 30 cm in diameter drinking water well draws from a nearly horizontal, unconfined sand and gravel aquifer with a thickness of 10 m that extends to the ground surface. The aquifer material has a saturated hydraulic conductivity of 75 m/d. Without the well in operation the water table is approximately horizontal and 2 m below the ground. The permeable aquifer layer is underlain by an impermeable stratum.

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 4 m?

b) During a steady-state pumping with a flow rate of 1.5 L/s calculate the drawdown depth, relative to the static level, at a distance of 5 m from the well.



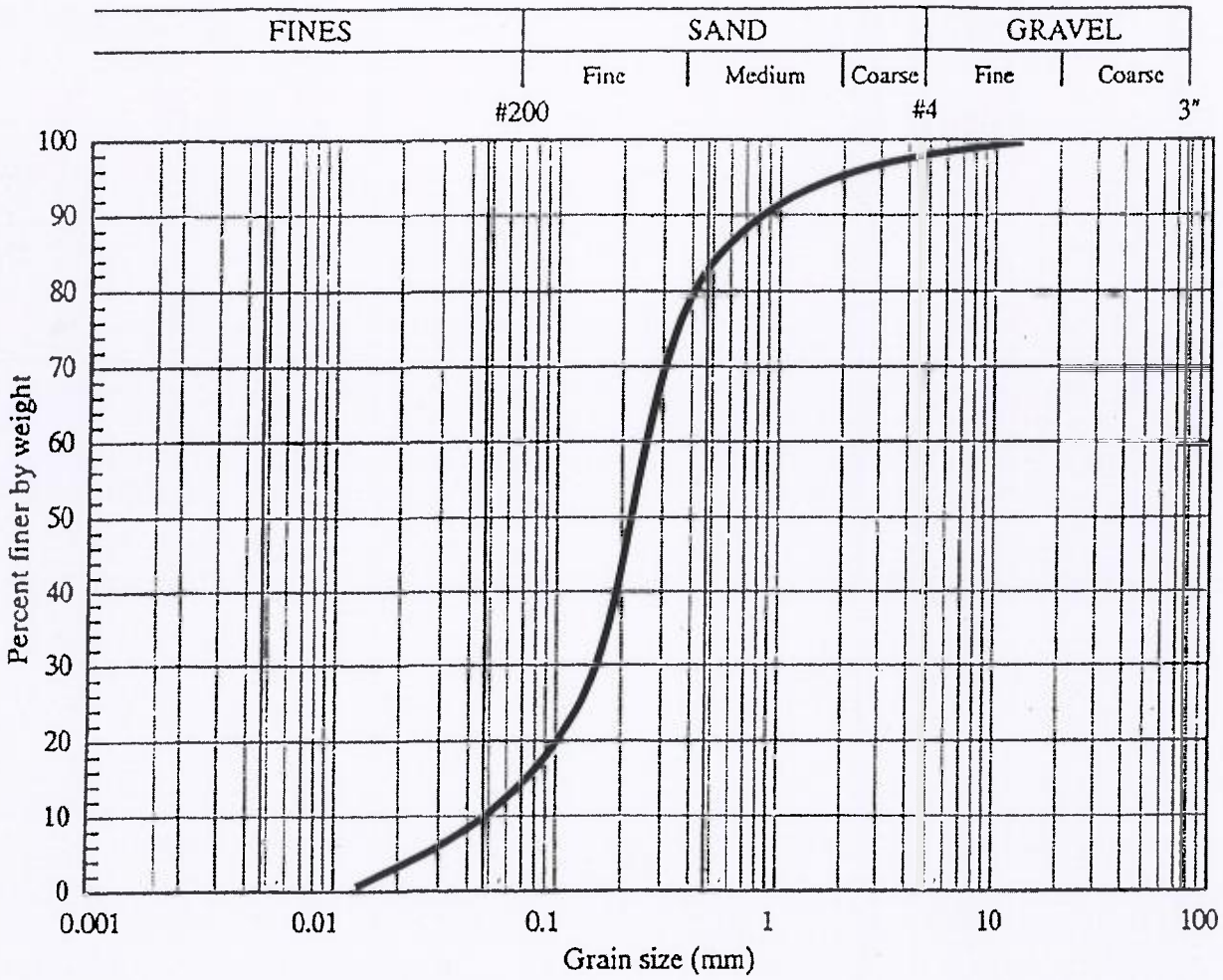
Note: the radius of influence of the well is approximately 300 m.

Question 5 (20 marks):

The grain-size distribution of an inorganic soil is shown in the Figure below; and its liquid and plastic limits are 40% and 30%, respectively.

a) Classify the soil according to the USCS classification system (i.e. determine the group symbol and group name).

b) Explain why this soil may or may not be suitable as a cover material for a municipal solid waste landfill.



Question 6 (20 marks):

A 700 kg point load is applied on a sandy soil at the ground surface. The groundwater level is at the ground surface and the sand is completely saturated. Assuming geostatic coefficient of lateral earth pressure of the sandy soil K = 0.3, porosity of the soil is 50%, the specific gravity of the soil is 2.7, and using a Poisson's ratio of 0.5 for this soil, compute:

a) The total vertical, lateral, and shear stresses at Point A, located at a depth of 0.5 m below the ground surface and directly under the applied load.
b) The principal stresses and the greatest shear stress for the soil element at Point A.