National Exams May 2016

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):

The unit weight of a soil sample in natural conditions is 17.0 kN/m^3 and its dry unit weight is 15.1 kN/m^3. Assuming a specific gravity of solids of 2.65, calculate the following properties of the soil in its natural conditions:

a) (4 marks) void ratio,

b) (4 marks) porosity,

c) (4 marks) degree of saturation,

d) (4 marks) moisture content, and

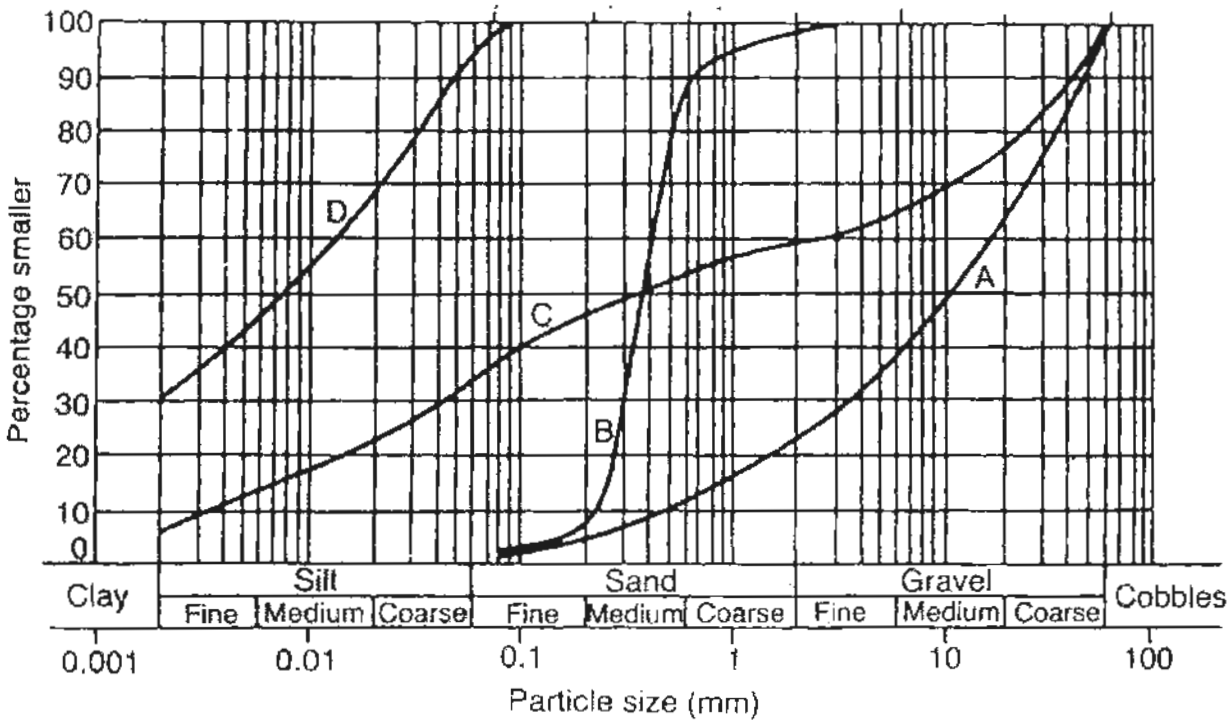
e) (4 marks) buoyant unit weight (kN/m^3).

Question 2 (20 marks):

The grain-size distribution of three inorganic soils (labeled A, B, and C) and one organic soil (labeled D) are shown in Figure below.

a) (10 marks) Which one of the three inorganic soils has the highest uniformity coefficient C_u and which one has the lowest coefficient of gradation C_c?

b) (10 marks) Classify soil D according to the USCS classification system; assume its liquid and plastic limits are 52% and 22%, respectively and determine the group symbol and group name.

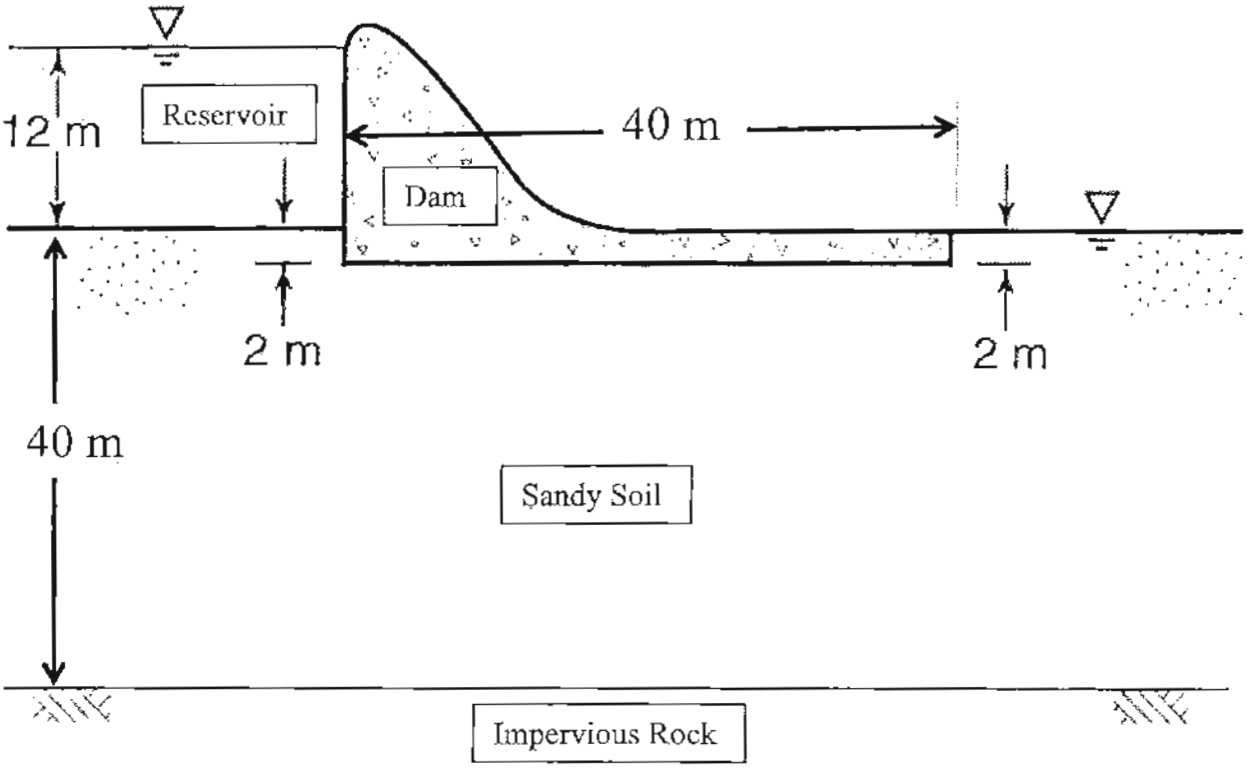


Question 3 (20 marks):

Figure below shows the cross-section of a concrete gravity dam and reservoir resting on a 40 m thickness layer of homogeneous and isotropic low-porosity (n = 5%) sandy soil on impervious rock. The saturated hydraulic conductivity of the sandy soil 10 m/d. The crest of the concrete gravity dam is approximately 20 m long (normal to the picture).

a) (10 marks) 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).

b) (10 marks) Calculate the uplift water pressure distribution beneath the dam and comment if the uplift force can cause any issues for this dam.

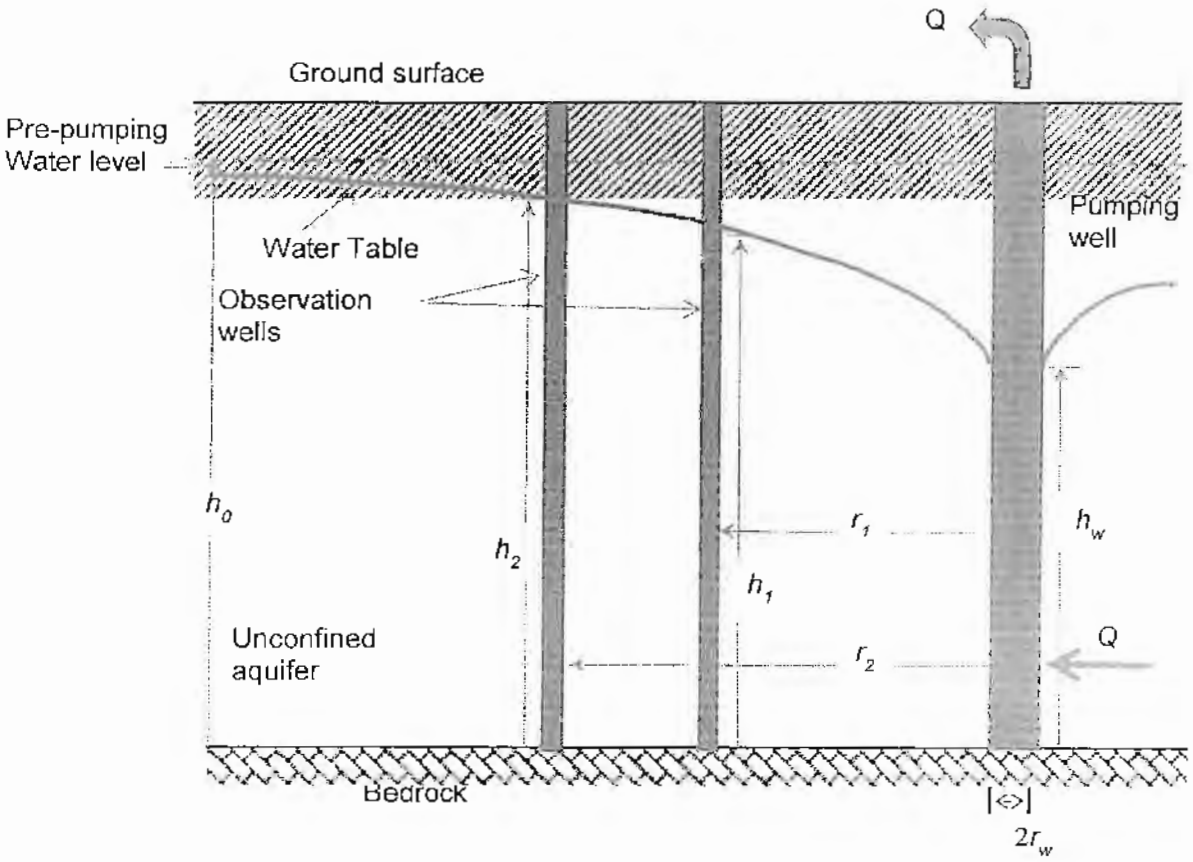


Question 4 (20 marks):

A single, 20 cm diameter, well draws from a nearly horizontal, unconfined aquifer consisting principally of sandy soils (porosity of 0.25, saturated hydraulic conductivity 10 m/d). Without the well the aquifer is 2 m below the ground surface and has a saturated thickness of 15 m below this. Below the sandy soil is a clay till with a saturated hydraulic conductivity of 10^{-6} cm/s.

a) (10 marks) What is the maximum discharge (in m^3/day) that can be drawn from the well if the maximum allowable drawdown in the well is 7.5 m?

b) (10 marks) For the discharge determined in part a, if source water protection requirements are to be put in place that limit the type of development within a 1 year time of travel of the well, what area would this apply to?

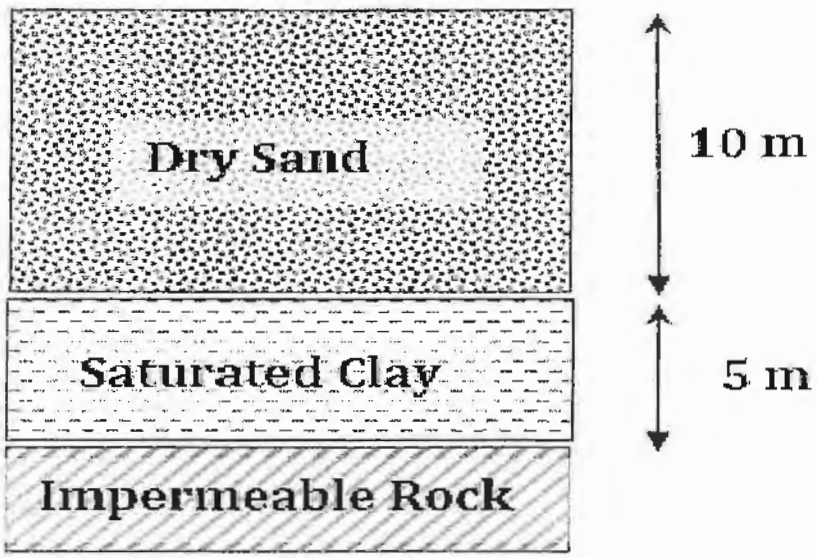


Question 5 (20 marks):

A 5-m thick, normally-consolidated, fully-saturated clay is resting on impermeable shale rock; a 10-m thick dry sandy fill with porosity of 10% and specific gravity of 2.65 is placed on top of the clay to expedite consolidation process. For the saturated clay layer, the initial void ratio e_0 = 3.2, specific gravity of solids G_s = 2.452, the compression index C_c = 0.551, the recompression index C_r = 0.3, and the coefficient of consolidation $C_v = 0.002\ cm^2\ s^{-1}$.

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

b) (10 marks) Compute the time for 90% of primary consolidation to occur.



Question 6 (20 marks):

A square concrete column foundation is 2 m x 2 m in plan view installed 1 m below ground surface in a dry sandy soil with: $\phi' = 20°$, $C' = 15$ kPa, $\gamma = 19.0$ kN/m^3. Assume the unit weight of the concrete is 24 kN m^{-3}.

a) (10 marks) Calculate the maximum allowable load P (in kN), applied at the center of the footing, assuming a minimum factor of safety of 3.0.

b) (10 marks) Calculate the factor of safety of the square foundation in part (a) if the as-built size is only 1.9 m x 1.9 m.