National Exams December 2019

04-Agric-A2, Soil Physics & Mechanics

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. Some questions require a written answer. Clarity and organization of the answer are important.

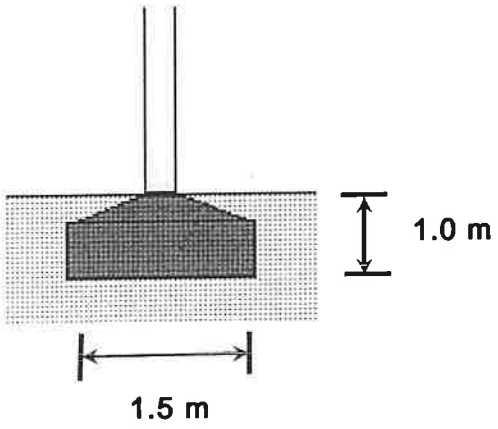
Question 1 (20 marks):

Calculate the factor of safety against bearing capacity failure of a 1.5 m in diameter circular concrete footing buried 1.0 m below the ground surface carrying 80 kN load and resting on loamy soil having the following strength characteristics: $c' = 20\ kN/m^2$, $\phi' = 15°$, and $\gamma = 23.0\ kN/m^3$. Using a unit weight of concrete of 24 kN/m^3, consider the following:

a) **(8 marks)** The average groundwater table is 5 m below the ground surface, what is the factor of safety against bearing capacity failure of this footing?

b) **(8 marks)** After looking at the seasonal groundwater level records, you realized the groundwater table could at some point in the expected design life of the structure rise to 2 m below the ground surface. What is the revised minimum factor of safety against bearing capacity failure of this footing?

c) **(4 mark)** What is the maximum allowable load for this footing assuming a minimum required factor of safety of 3 against bearing capacity failure?



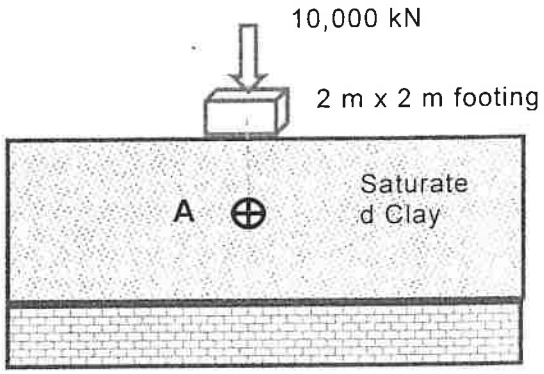
Question 2 (20 marks):

A 12-m thick normally-consolidated, completely saturated clay soil is resting on impermeable rock. For the clay soil, specific gravity of solids is 2.65, initial void ratio is 5.5, the compression index is Cc = 0.45 and recompression index is Cr = 0.15. A 2 m wide square footing is placed on the ground surface with 10,000 kN load.

a) **(8 marks)** Compute initial and final effective vertical stresses at midpoint of the clay layer straight below the centre of the square footing (i.e., Point "A") before and after the placement of the load;

b) **(8 marks)** Compute the ultimate primary consolidation of the clay layer straight below the centre of the footing; and

c) **(4 marks)** Calculate the change in the void ratio of the clay below the centre of the square footing due to the primary consolidation.



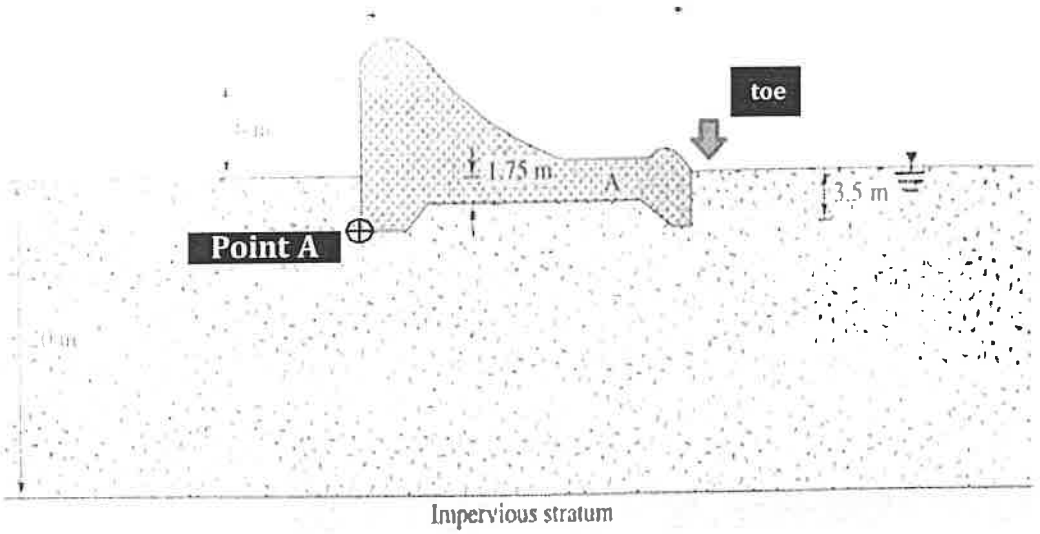
Question 3 (20 marks):

Figure given below shows the cross-section of a concrete Dam and the sandy soil with specific gravity of 2.65 and porosity of 30% underlain by impervious stratum. The sandy soil is fully saturated with a saturated hydraulic conductivity of 4.2×10^{-4} cm/s and the water level is at the ground surface on the downstream sides of the dam. The concrete dam crest is 100 m long (i.e., width of the dam perpendicular to the picture).

a) **(8 mark)** Calculate total seepage flow rate beneath the dam (m^3/hr)

b) **(8 mark)** Calculate groundwater piezometric head at Point A shown below (m)

c) **(4 mark)** Calculate the factor of safety against downstream heave at the toe of the dam.



Question 4 (20 marks):

A cylindrical soil sample, 75 mm in diameter and 150 mm length is retrieved from an agricultural field. The mass of the retrieved soil sample is 1400 g. After the soil is dried at 105 degrees Celsius in the oven for 24 hours, the mass of the soil is measured at 1196 g. Using a reasonable value for the Specific Gravity of the solids, calculate:

a) **(5 marks)** void ratio of the soil,

b) **(5 marks)** zero air-voids unit weight of the soil,

c) **(5 marks)** dry unit weight of the soil, and

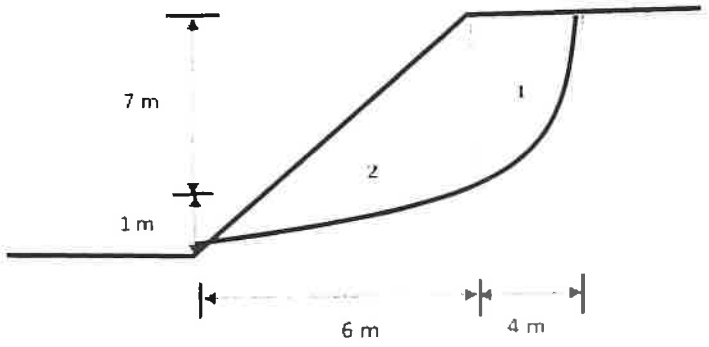
d) **(5 marks)** water content of the soil.

Question 5 (20 marks):

For the slope shown, the unit weight of the Sandy soil is $\gamma = 17\ kN/m^3$ with the angle of internal friction $\varphi' = 30°$. You may assume the soil is non-cohesive and dry.

a) **(15 marks)** Find the Factor of Safety for slope shear failure using the Ordinary Method of Slices for the failure plane shown in the diagram below and using the two labeled slices,

b) **(5 marks)** Discuss three geotechnical engineering design methods for improving the stability of the slope.



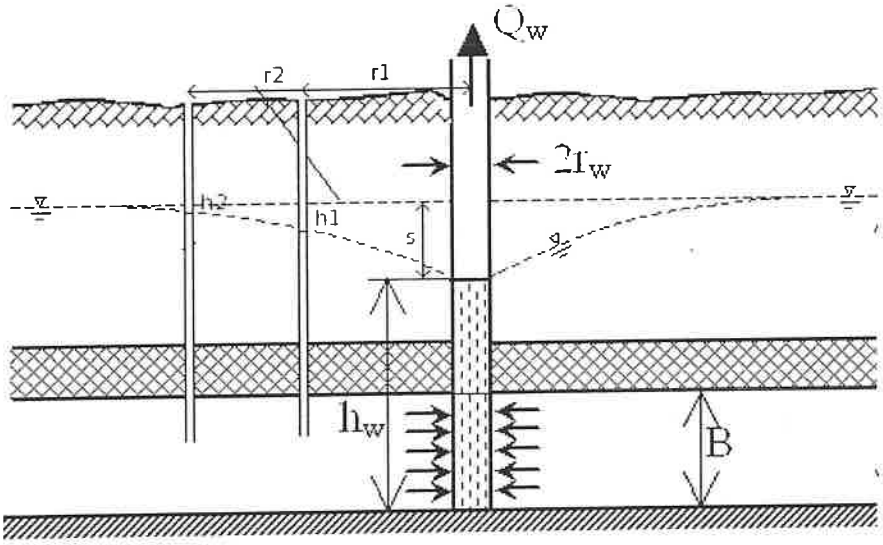
Question 6 (20 marks):

A confined aquifer with a porosity of 0.30, is B = 20 m thick. The potentiometric surface elevations at two observation wells - located at distances of r_1 = 100 m and r_2 = 1000 m from the 30 cm in diameter pumping well - are h_1 = 52 m and h_2 = 57 m. If the horizontal, isotropic saturated hydraulic conductivity of the aquifer is 10 m/day,

a) **(8 mark)** Determine the flow rate of the pumping well Qw, assuming steady axisymmetric radial flow.

b) **(8 mark)** What is the maximum discharge Qw that can be drawn from the well if the maximum allowable drawdown in the well is s = 5 m?

c) **(4 mark)** How long would it take for a trace chemical injected in the observation well, located at a distance of r_1 = 100 m, to reach the pumping well for the steady state flow rate you calculated for the part (b)?



1. 20 marks total part (a) 8 marks, part (b) 8 marks and part (c) 4 marks
2. 20 marks total part (a) 8 marks, part (b) 8 marks and part (c) 4 marks
3. 20 marks total part (a) 8 marks, part (b) 8 marks and part (c) 4 marks
4. 20 marks total (4 items times 5 marks each)
5. 20 marks total part (a) 15 marks, part (b) 5 marks
6. 20 marks total part (a) 8 marks, part (b) 8 marks and part (c) 4 marks