National Exams December 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.

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Question 1 (20 marks):

The moist weight of 2.83 L of soil is 54.3 N. If the moisture content is 12% and the specific gravity of soil solids is 2.72, find the following (**4 marks each**):

a) Dry unit weight (kN/m^3)

b) Zero-air-voids dry unit weight (kN/m^3)

c) Void Ratio

d) Degree of saturation (%)

e) Volume occupied by water (m^3)

Question 2 (20 marks):

Figure 1 shows a 20 m long dam holding back 4 m of water. The isotropic Silty sand soil immediately below the dam has a hydraulic conductivity of K_1 = 1 cm/hr.

a) **(10 marks)** Sketch the flow net for the water flow under the dam

b) **(10 marks)** Use the results of your flow net to determine the flow per unit width under the dam.

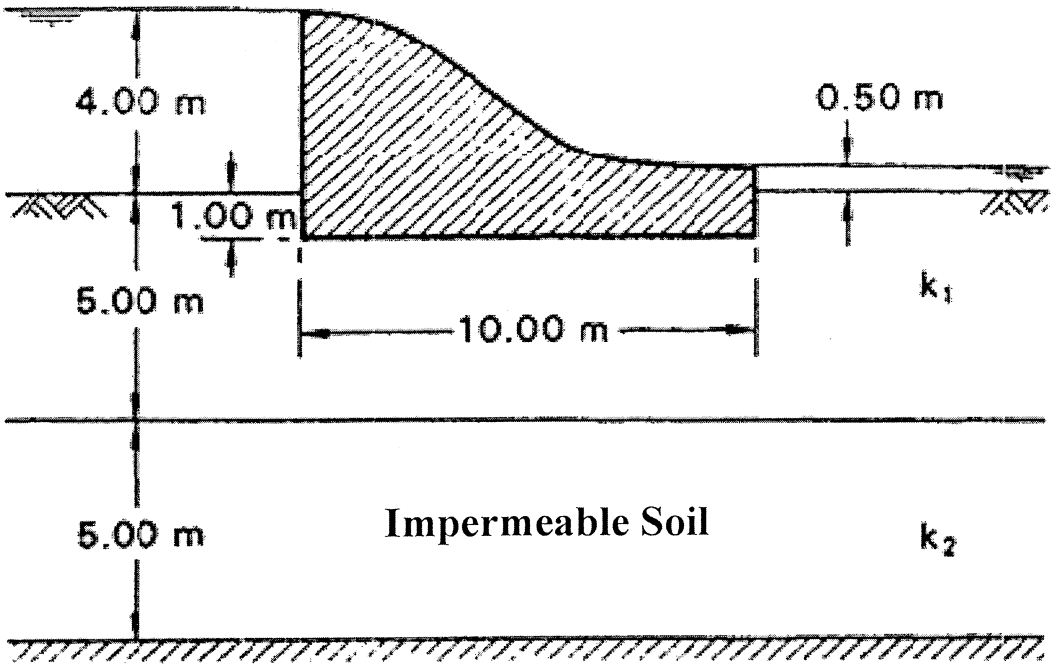

Figure 1

Question 3 (20 marks):

A contractor needs aggregate material for a residential building project to be compacted to achieve a minimum dry unit weight (γ_d) of **20 kN/m^3**. The total volume of the required material after compaction is **50 m^3**. This aggregate material is available for sale by weight at **$120 per metric ton** at a nearby stockpile yard in loose form with moist unit weight (γ) of **17 kN/m^3** at **30%** degree of saturation (S); assume specific gravity of aggregate solids (G_s) is **2.65**.

a) **(10 marks):** Calculate total weight and volume of the aggregate material that the contractor needs to purchase for this project;

b) **(10 marks):** Calculate the void ratio of the compacted material and the cost to purchase the aggregate material.

Question 4 (20 marks):

A well is to be developed in an unconfined aquifer as shown in Figure 2. You may assume that approximately **5 km** from the well, conditions are such that the piezometric levels are constant at an elevation **6 m** above the impermeable level as shown. The anisotropic aquifer material consists of a **4-m** thick sandy soil overlaying a **4-m** thick gravel with saturated hydraulic conductivities of **0.05** and **0.20 cm/s**, respectively.

a) **(10 marks)** Calculate equivalent horizontal K_x and vertical K_y hydraulic conductivities of the anisotropic aquifer.

b) **(10 marks)** What drawdown, at distances of **10** and **100 m** from the pumping well, can be expected at a uniform pumping rate of **50,000 L/day**?

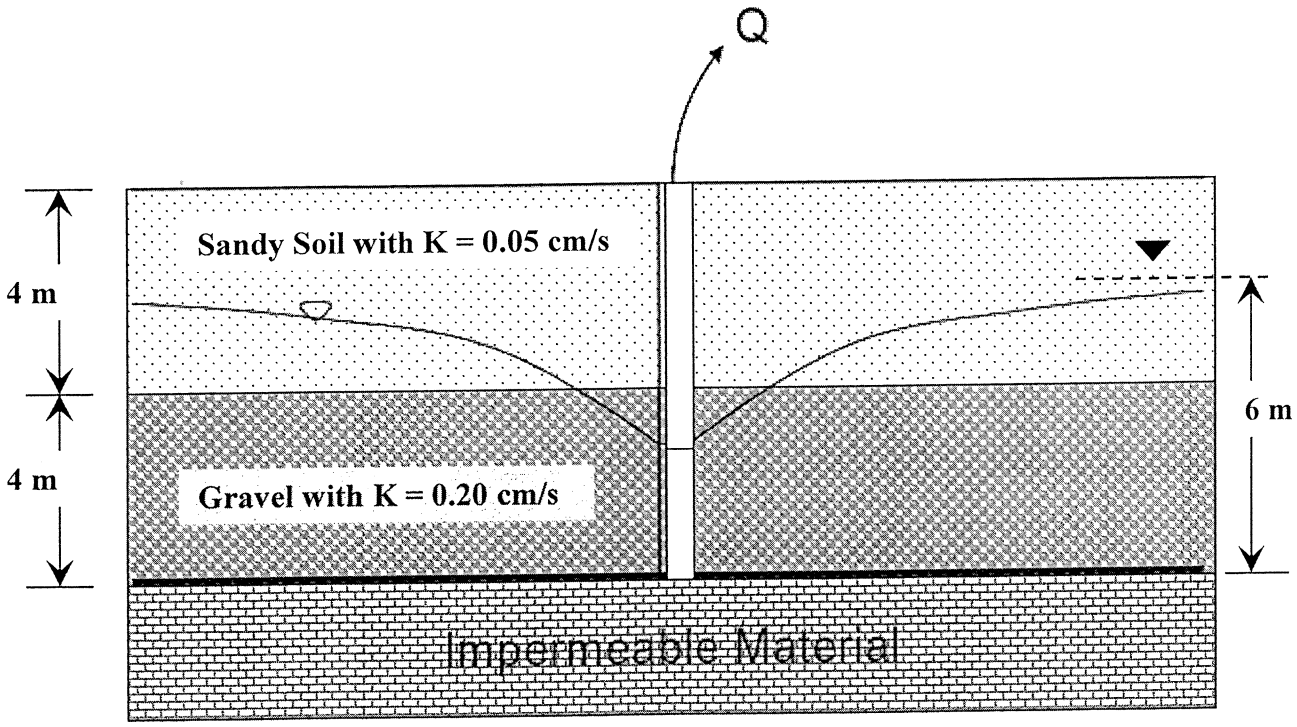

Figure 2

Question 5 (20 marks):

A retaining wall is shown in Figure 3. Assume H = 6 m, H_1 = 2 m, γ_1 = 16 kN/m^3, γ_2 = 19 kN/m^3, $\phi_1 = 32°$, $\phi_2 = 36°$, q = 15 kN/m^3.

a) **(10 marks)** Determine Rankine's active force per unit length of the wall and

b) **(10 marks)** Determine the location of the resultant force

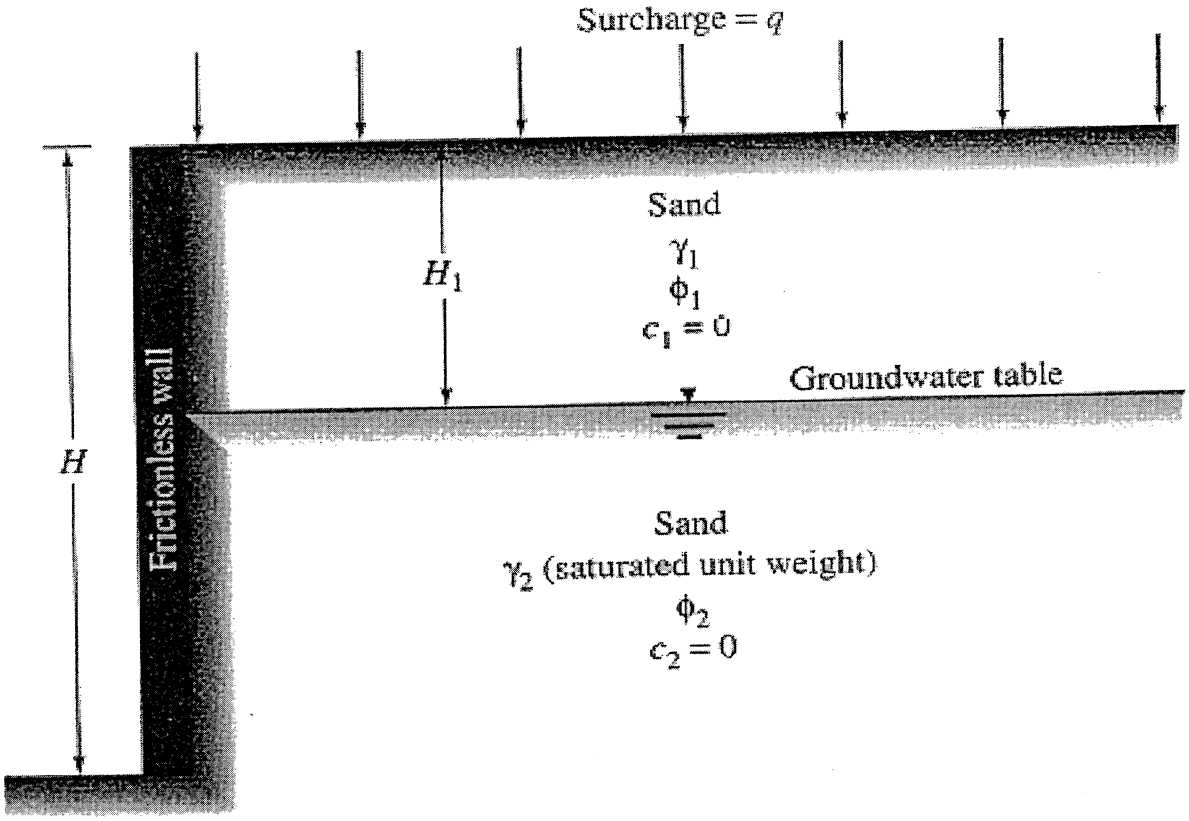

Figure 3

Question 6 (20 marks):

A 0.5-m thick reinforced concrete retaining wall supports a volume of sandy soil as shown in Figure 4. The unit weight of the reinforced concrete is **22 kN/m^3**. The effective shear strength parameters of the non-cohesive sandy soil are ϕ = **30°** and **c = 0**. The sandy soil is fully saturated due to heavy rainfall events and the water table is at the ground surface. Saturated unit weight of the sandy soil is **22 kN/m^3**. The surface of the wall is smooth and the friction between the wall and the sandy soil is negligible.

a) (10 marks) Calculate active forces of the soil on the wall; and

b) (10 marks) Determine the factor of safety against overturning.

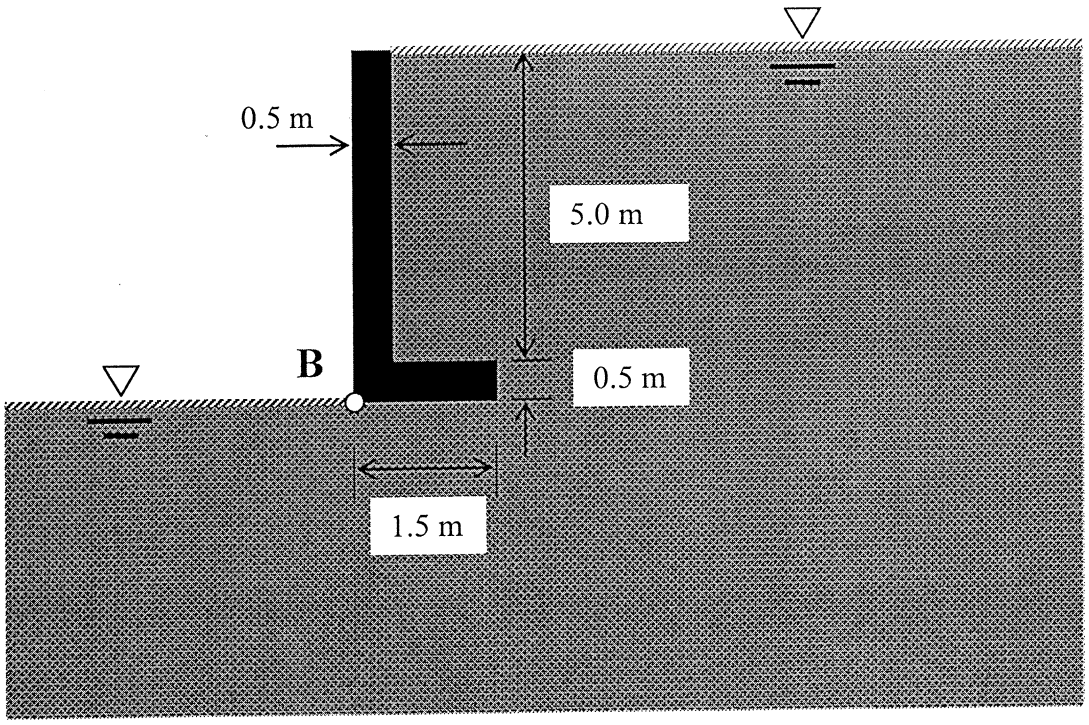

Figure 4