Problem 1 (25%)

(i) (15%) The specific gravity of solids and moist unit weight of a soil sample are 2.65 and 17.5 kN/m^3, respectively. From a laboratory test, the moisture content of this sample is determined to be 11.5%. Calculate the dry unit weight and degree of saturation for this sample. In addition, determine the amount of water (in kg) to be added per cubic meter (m^3) of soil such that the soil would become completely saturated.

(ii) (10%) Describe the laboratory tests that can be used to evaluate the moisture content and specific gravity of solids for a soil sample.

Problem 2 (20%)

(i) (10%) Suppose that a site consists of four horizontal layers, denoted as L1 (top), L2, L3, L4 (bottom). Their thicknesses are H_1, H_2, H_3 and H_4, respectively. Also, their corresponding coefficients of hydraulic conductivity in the horizontal direction are k_1, k_2, k_3 and k_4. Derive the equivalent coefficient of hydraulic conductivity. You must show the derivation process to receive the full credit.

(ii) (4%) Do you expect the coefficient of hydraulic conductivity in the vertical direction to be larger than, smaller than or the same as the coefficient of hydraulic conductivity in the horizontal direction for a particular soil? Why?

(iii) (6%) Describe how the particle size, void ratio and temperature affect the hydraulic conductivity.

Problem 3 (15%)

(i) (9%) Derive Rankine's passive earth pressure coefficient for the case of a retaining wall with a vertical backface and horizontal backfill. You must show the derivation process (including the associated Mohr's Circle) to receive the full credit.

(ii) (6%) Give and explain 3 stability checks that are performed in retaining wall design.

Problem 4 (20%)

A site consists of 2 layers. The top layer has thickness of 4 m, moist unit weight of 16.5 kN/m^3 and friction angle of 28 degrees. The bottom layer has thickness of 5 m, saturated unit weight of 17.5 kN/m^3 and friction angle of 34 degrees. The groundwater table is at 2 m.

(i) (6%) Plot the total stress, effective stress and pore water pressure against depth. Label your plots.

(ii) (4%) Estimate the total horizontal stress and effective horizontal stress for a soil element that is at 6 m below the ground surface.

(iii) (4%) Draw the total-stress and effective-stress Mohr's Circles for the soil element in (ii).

(iv) (6%) For the soil element in (ii), use the pole method to find the total normal stress, effective normal stress that act on a plane inclined at an angle of 30 degrees clockwise from the horizontal plane.

Problem 5 (20%)

(i) (8%) Define end-bearing piles and friction piles. Also, give the site conditions which we would use end-bearing piles and friction piles.

(ii) (6%) Define negative skin friction. Give 2 conditions which would lead to the presence of negative skin friction.

(iii) (6%) Piles are often used in groups. In the determination of load-bearing capacity of group piles, the concept of "group efficiency" would be used. Explain what group efficiency is and how denseness of sand in the field can affect the group efficiency.

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