PROFESSIONAL ENGINEERS ONTARIO
NATIONAL EXAMINATION – MAY 2002
98-CIV-B3 GEOTECHNICAL DESIGN

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.

   Any non-communicating calculator is permitted. This is an OPEN-BOOK exam. The candidate must indicate the type of calculator being used (i.e. write the name and model designation of the calculator, on the first inside left hand sheet of the exam workbook).

3. **For PART A answer both questions. For PART B answer two out of three questions.**

4. Questions have the values shown.

5. Candidates must identify clearly the source of design charts used and where applicable the source of assumed values used in the calculations.

6. In the absence of specific parameters required in the formulation and solution of problems, the candidates are expected to exercise sound engineering judgment and to clearly state their assumptions.

SECTION A ANSWER BOTH QUESTIONS

1. A 1.5m wide strip footing illustrated on Figure Q.1 is set 1.5m deep in a 4m thick sand layer. The sand is underlain by a 3m thick firm clay deposit, which lies on a rigid permeable rock substratum. The following properties have been determined for the subsurface:

$\phi' = 34°$, $E_u = 45$ MPa, $\gamma = 21$ kN/m^3.

Bulk unit weight	$\gamma = 19$ kN/m^3
Friction angle	$\phi' = 30°$
Cohesion	$C' = 10$ kPa
Undrained shear strength	$C_u = 100$ kPa
Undrained Poisson's ratio	$\nu_u = 0.5$
Undrained elastic modulus	$E_u = 30$ MPa
Compression indices	$C_c = 0.4$, $C_r = 0.03$
Coefficient of consolidation	$c_v = 0.45$ m^2/year
Initial void ratio	$e_o = 1.384$
Preconsolidation pressure	$P'_c = 130$ kPa

The free surface (water table) is located 0.5 m below the footing.

a. Determine the allowable load (F.S. = 3).

(Value 10)

b. Calculate the settlement that can be expected under a structural load of 100kN/m 1.5 years after application of the load, (neglect the settlement of the sand layer)

(Value 15)

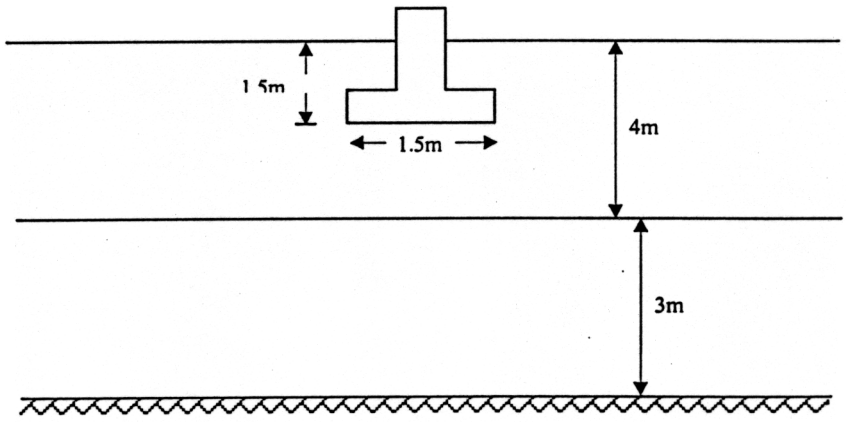

Figure Q.1

2. Calculate the allowable load that can be applied to a 5 by 15 group of steel "H" piles covering an area of 5 m by 15 m. The piles were driven into a loose fine sand with the following properties.

γ_d (dry unit weight) = 20 kN/m^3
G_s (Specific gravity of mineral) = 2.5
$\phi' = 30°$

The water table is at the ground surface. The piles are 6m long and have an exterior cross section of 200 x 200 mm. The contract requires a factor of safety of 2.0 against failure of individual piles based on shaft resistance only.

(Value 25)

SECTION B ANSWER TWO QUESTIONS ONLY

3. **Figure Q.3** illustrates the cross-section of a slope and a potential circular failure surface. The undrained shear strength of the soil is assumed uniform. Horizontal and vertical seismic acceleration factors of 0.2 and 0.1, respectively, can be expected in that area. Three layers of geosynthetic reinforcement are present in the top portion of the slope. The maximum resistance (tearing or pullout) expected from each geosynthetic layer at the location of the potential failure surface, is 100 kN/m.

   a. Calculate the short-term factor of safety corresponding to the failure surface illustrated on the figure, considering potential seismic loads (use a static analysis) and the reinforcement layers.

   (Value 15)

   b. Estimate the long-term factor of safety of that slope, without consideration for the seismic loads or the reinforcement layers.

   (Value 10)

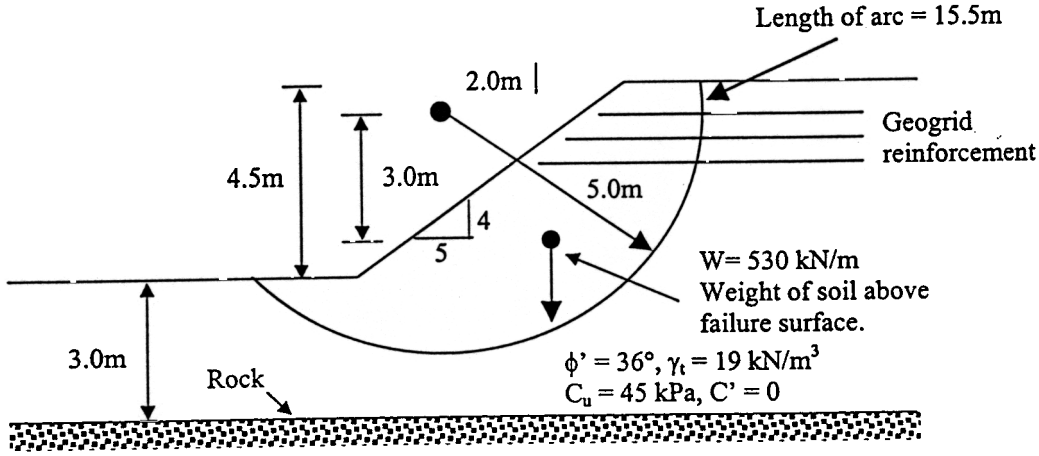

Figure Q.3

4. The space between two parallel sheet pile walls will be filled with dredged sand (γ_{sat} = 20 kN/m3, ϕ' = 20°). The sheet piles will be driven in a dense sand (ϕ' = 40° , γ_{sat} = 22 kN/m3). They will extend 4m above the surface, will be separated by 6m and will be anchored to each other, at 0.5m from the top. The anchors will be spaced every 2m along the length of the walls. **Consider the most unfavorable water pressure conditions** and calculate the required depth of penetration of the sheet piles in the dense sand, the force in the anchors and the maximum bending moment in the sheet piles.

(Value 25)

5. **Figure Q.5** illustrates a concrete (25kN/m^3) gravity retaining wall that supports a sloping sandy backfill (ϕ' = 28°, γ_t = 21 kN/m^3). The slope of the backfill is 20°. The water table behind the wall is horizontal and 2m above the base of the wall. In front of the wall the water table is at ground surface. The base of the wall rests on a dense sand (ϕ' = 35°, γ_t = 22 kN/m^3). The 4m high wall is symmetrical with a width of 1m at the top and 2m at the base. Assume that all the contact faces between the wall and the soil are very rough. **Make all necessary conservative assumptions regarding water pressure distributions.** What is the factor of safety of the wall?

(value 25)

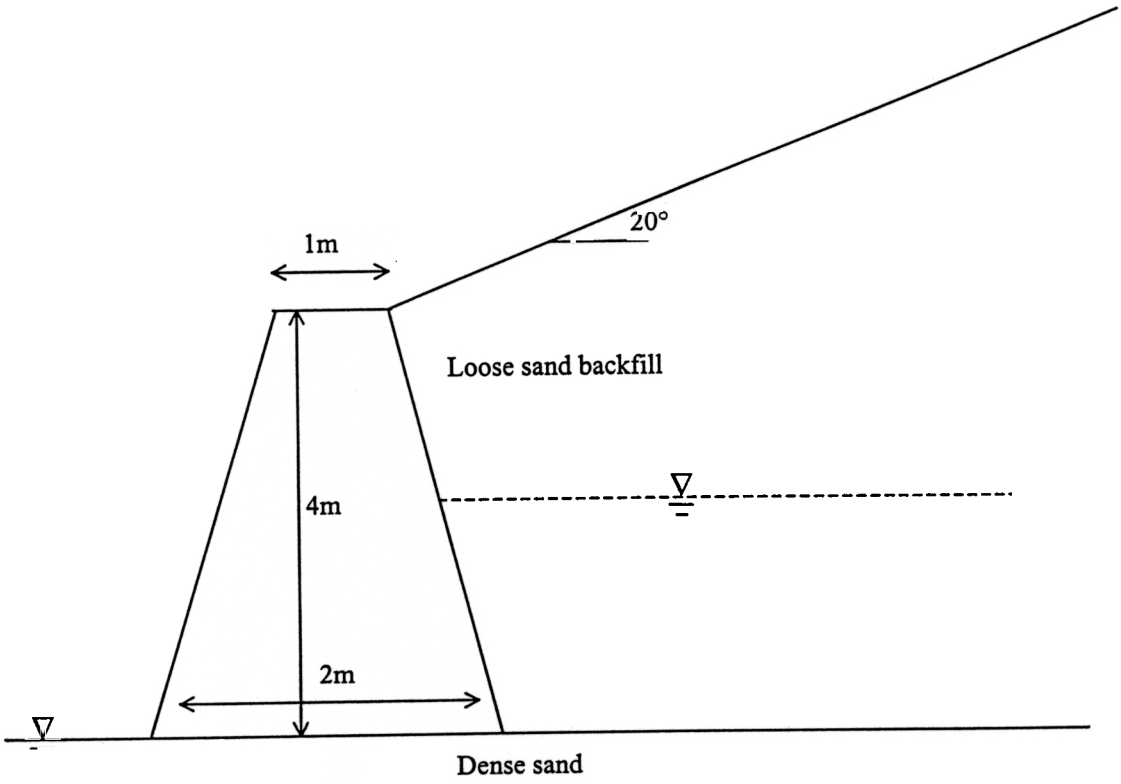

Figure Q.5