THE OPENUNIVERSITY OF SRI LANKA
BACHELOR OF TECHNOLOGY (CIVIL) – LEVEL 06
Final Examination 2013/2014

CEX6230 – GEOTECHNICS

Time allowed: Three Hours
Date: Monday, 1st September, 2014 Time: 0930-1230

Answer five questions. All questions carry equal marks.

1. A Drained Triaxial Test is performed on a normally consolidated clay soil. The specimen is initially consolidated, isotropically, by applying an all round cell pressure of 300kPa.

   A. The deviatoric stress is then increased while reducing the cell pressure, to satisfy the relationship: $\Delta D = -2\Delta\sigma_c$. ΔD is the increase in deviatoric stress; $-\Delta\sigma_c$ is the decrease in cell pressure. The specimen reaches its maximum shear stress at a Deviatoric Stress, D of 300kPa. Complete the table given below. (6 points)

$D = \sigma_1 - \sigma_2$ (kPa)	$\sigma_c = \sigma_2$ (kPa)	σ_1 (kPa)	$p = \frac{\sigma_1 + \sigma_2}{2}$ (kPa)	$q = \frac{\sigma_1 - \sigma_2}{2}$ (kPa)
0	300	300		
50				
100				
150				
200				
250				
300				

   B. Plot the following on the same graph, using a single graph sheet.

      i. The total stress path; name it as line AB. (2 points)

      ii. Mohr-Coulomb failure line; name it as line CD. (2 points)

   C. If the specimen fails at a Deviatoric Stress of 300kPa, compute shear strength parameters. (2 points)

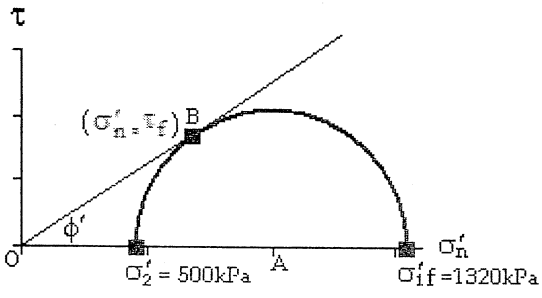
   D. If the above test was performed without allowing drainage, sketch on the same graph sheet the Total Stress Path (EF) and the Effective Stress Path (EH). (4 points)

   E. Pore-pressure parameter B is checked before performing the test in order to ensure that the specimen is completely saturated. Describe the procedure you would use to perform this test; indicate key pressure values. (4 points)

2.

   A. When a granular material is 'poured' on to a flat surface, they tend to form a conical heap. Explain why grains form a conical heap, without spreading on the surface. Candidates are expected to discuss the attributes that contribute towards forming a conical heap. (5 points)

   B. Figure below shows a Mohr's Circle of stress at failure, observed when a saturated loose sand was subjected to a deviatoric loading.



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i. Compute the angle of internal friction, ϕ'. (2 points)

ii. Compute the inclination of failure plane with respect to the horizontal plane. (3 points)

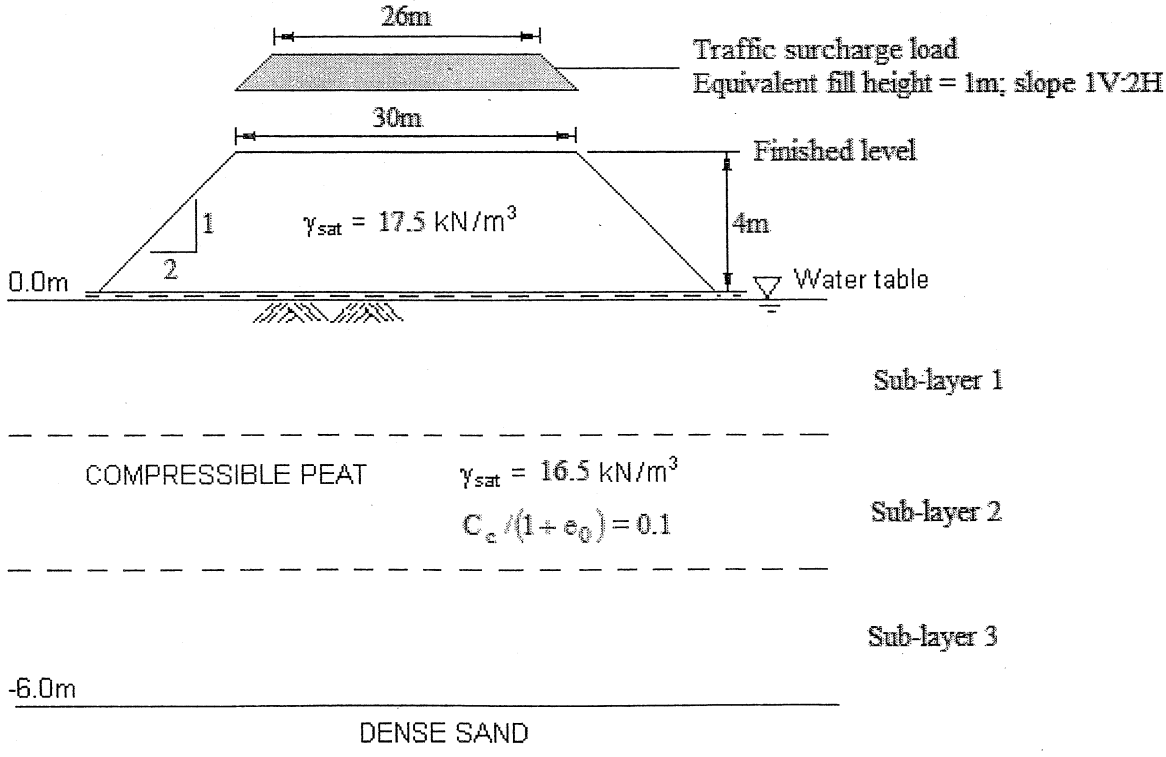
iii. Compute the stresses acting on the failure plane, in both parallel and perpendicular directions. (4 points)

C. Table below shows the angle of internal friction ϕ' values of various granular materials. Explain why blasted rock fragments produce a greater ϕ' value. (3 points)

Grain Size	State of Compaction	ϕ'	
		Rounded grains; uniform gradation	Angular grains, well graded
Medium Sand	Very loose	28 - 30	32 - 34
	Moderately dense	32 - 34	36 – 40
	Very dense	35 - 38	44 - 46
80% Gravel + 20% Sand	Loose	-	39
	Moderately dense	37	41
Blasted rock fragments		40-55	

D. Sketch the variation of Deviatoric Stress vs. Axial Strain and the variation of Volumetric Strain vs. Axial Strain for a very loose medium sand. Show the direction of compressive volumetric strain. (3 points)

3. Figure below shows a soil profile along a segment of a highway. A road embankment is to be constructed to a finished height of 4.0m, with compacted sea sand. Parameter $C_c/(1+e_0)$ is estimated as 1.1.



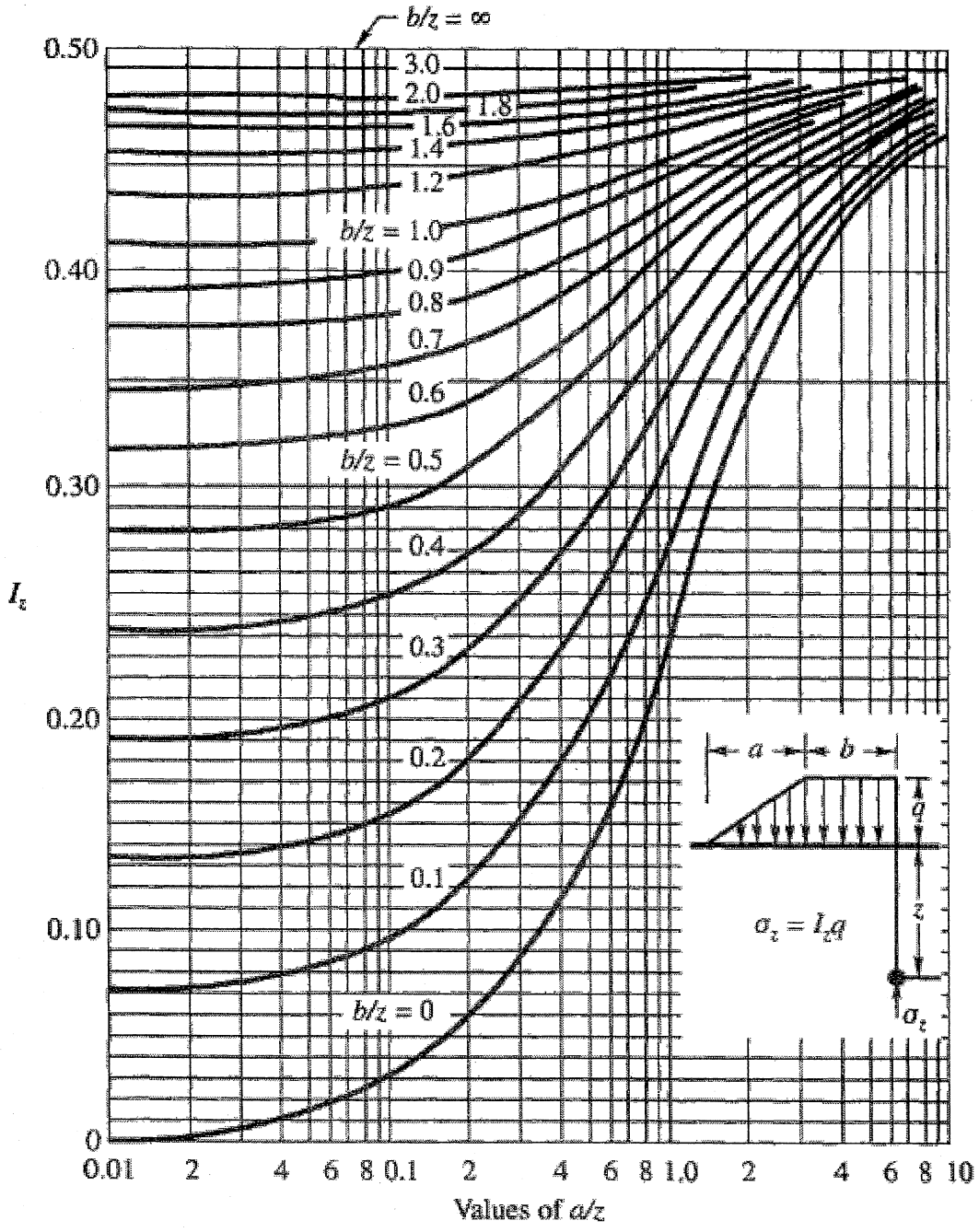
A. Complete the table given below considering that the compressible peat consists of three layers of 2m height. $\Delta\sigma$ can be obtained using the design chart given below. Candidates should note that the influence factor I_z is for half the embankment load. (6 points)

Depth to centre of sub-layer (m)	σ'_{V0} (kPa)	$\Delta\sigma$ (kPa)
-1		
-3		
-5		

B. Compute the total consolidation settlement by considering settlements of each layer. (6 points)

C. In order to maintain a finish level 4.0m, you are required to account for settlement and an additional 1m height of surcharge to account for traffic load. The surcharge equivalent to traffic load is removed after generated excess pore water pressures have dissipated. Explain how you would compute the exact fill height required to obtain the finish level of +4.0m. (4 points)

D. Discuss how you plan to accelerate settlement. (4 points)



4. Figure below shows an excavation retained by an anchored sheet-pile wall.

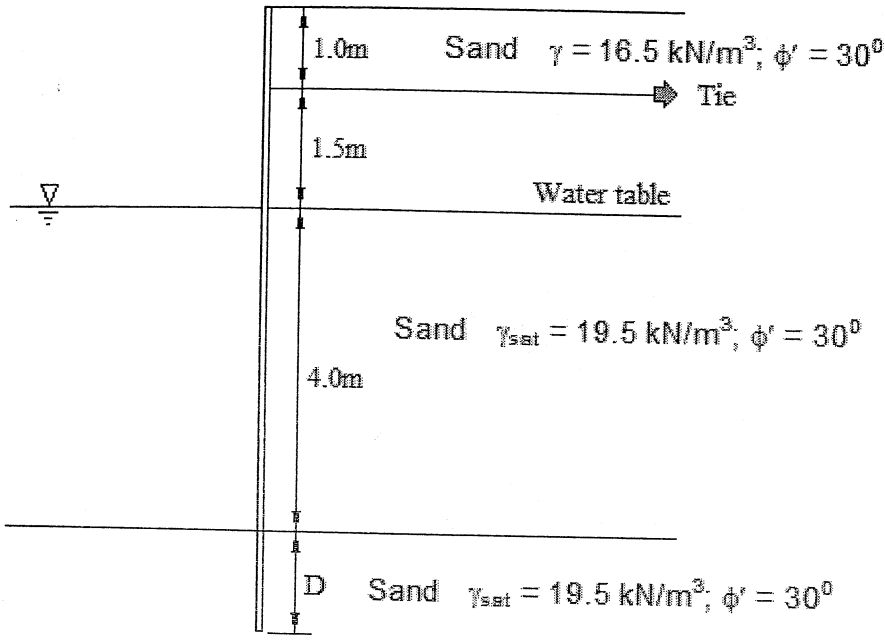
A. Compute the active and passive stresses at key depths. Using these data sketch the resulting pressure distribution with depth. Show principal values. (6 points)

B. Compute depth of penetration D, which is required to maintain equilibrium. (6 points)

C. Compute the required sheet-pile length after increasing D by 30%. (2 points)

D. Compute the force in an anchor if they are placed at a 2m distance apart. (4 points)

E. If the anchors are of 12mm diameter steel rods with a yield-strength of 410 N/mm^2, compute the safety factor provided for anchors. (2 points)



5.

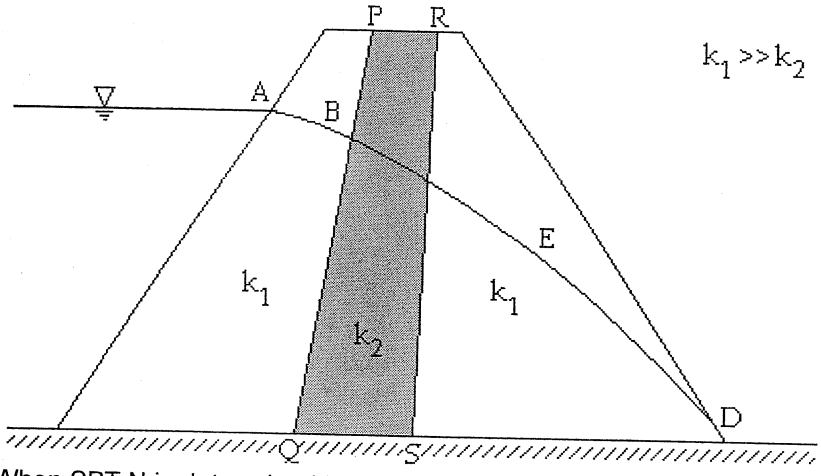
A. A saturated normally consolidated clay soil is loaded during construction of a road embankment. Discuss whether short-term or long-term stability need to be considered to ensure safe loading. Propose interventions to be carried out to ensure stability during construction. (5 points)

B. Velocity potential ϕ is expressed as $\phi = f(x, y, z) = -k\left(\frac{p}{\gamma_w} + z\right) + c$. Darcy's Law is expressed as $u = ki = -k\frac{\partial h}{\partial x}$. The Continuity Equation is expressed as: $\frac{\partial u}{\partial x} + \frac{\partial v}{\partial y} + \frac{\partial w}{\partial z} = 0.$

i. Define the terms: ϕ, p, z, u, k, and h. (3 points)

ii. Derive Laplace Equation: $\nabla^2\phi = \frac{\partial^2\phi}{\partial x^2} + \frac{\partial^2\phi}{\partial y^2} + \frac{\partial^2\phi}{\partial z^2} = 0$. (2 points)

C. Figure below shows earth embankment dam with a central clay core. Line ABED shows the phreatic surface when a clay core is not present. Sketch the phreatic surface on the same figure, when a clay core is present. Explain why the flow pattern changes when a clay core is present. (5 points)



D. When SPT N is determined in fine or silty sands, a correction for dilatation is made. The corrected SPT N is expressed as: $N = 15 + 0.5(N_0 - 15)$. N_0 is the measured SPT N. Discuss how this correction is made. Explain why this correction is made for fine or silty sands. (5 points)

6. Figure below shows a dam structure constructed on a river. The structure is founded on a clayey silt with a coefficient of permeability of 1 x 10^{-3} cm/s. The saturated unit weight of soil is 19 kN/m^3.

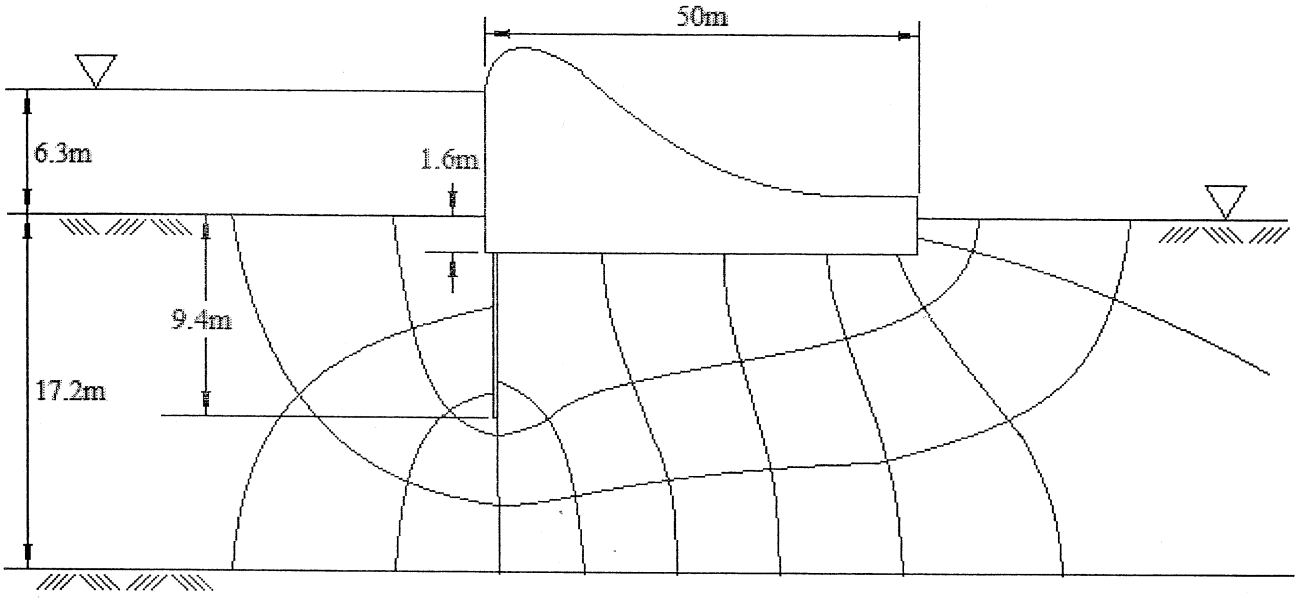
   A. Compute the flow occurring beneath the dam in m^3/s per meter length of dam. (4 points)

   B. Determine the uplift force acting on the structure, in kN per meter length of dam. (6 points)

   C. Identify the location where maximum hydraulic gradient occurs; estimate the maximum hydraulic gradient. (5 points)

   D. Compute the factor of safety provided against piping. (3 points)

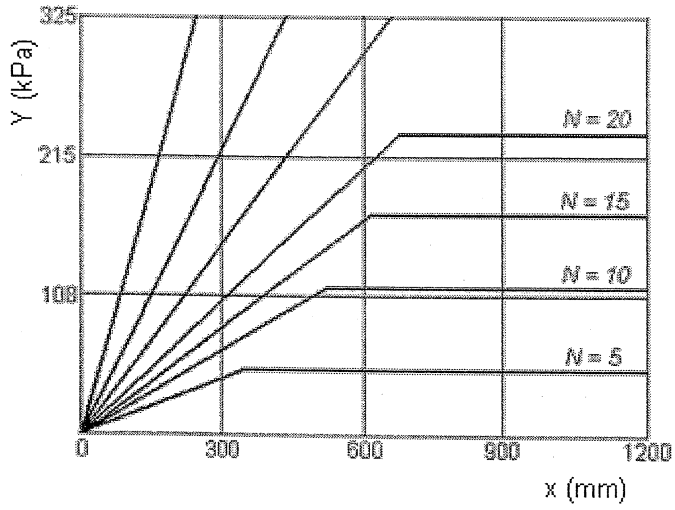
   E. If the factor of safety against piping is to be increased, suggest a viable method. (2 points)



7. When providing explanations, candidates are encouraged to use sketches.

   A. Discuss how pre-fabricated vertical drains accelerate consolidation settlement during pre-loading (5 points)

   B. Figure below shows a design chart used in the design of shallow foundations. List the three variables shown in the chart; discuss the purpose of this chart. Explain how parameter Y is modified to account for groundwater table. (5 points)



   C. Coefficient of Consolidation, c_v measures the rate at which primary consolidation takes place. Discuss how parameter c_v changes with vertical effective consolidation stress, σ'_v, drawing upon the relevant assumptions made in 1-dimensional consolidation theory. (5 points)

   D. Discuss the influence of negative skin friction on pile capacity; explain how its effect is quantified. (5 points)

8. Rain induced slope failures are a common occurrence in central hills of Sri Lanka. Such instabilities are usually triggered during extended wet weather periods.

   A. Discuss the mechanisms that cause landmass to accelerate its movement during extended wet weather periods. (4 points)

   B. Improving sub-surface drainage is considered effective in slowing down land movement. Explain the ground conditions under which such an intervention may be possible. (4 points)

   C. Discuss how forestation improves stability of sloping terrains. (4 points)

   D. Figure below shows a highway cut slope on a saturated clayey soil.

   E. Determine the safety against short-term failure. (5 points)

   F. Sketch the failure circle you have considered when assessing stability. (3 points)