# UNIVERSITY OF RUHUNA

**Faculty of Engineering**

End-Semester 6 Examination in Engineering: December 2015

**Module Number: CE6305** **Module Name: Geotechnical Engineering**

**[Three Hours]**

[Answer **all questions**, each question carries twelve marks]

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Q1. A proposed expressway is to be constructed over a low lying area. As this area is in the flood plain and frequently subject to flooding, it was decided to raise the finished road level by 6.0 m from the existing ground level. Proposed fill consists of a 1.0 m thick gravel blanket and a 5.0 m thick well compacted lateritic soil fill. The bulk unit weights of the gravel and lateritic soil can be taken as 20 kN/m$^3$ and 18 kN/m$^3$, respectively.

An extensive site investigation was carried out using several bore holes and the subsoil condition was idealized based on the results obtained from the site investigation as shown in Figure Q1.1. It was revealed that soft peaty soil layer of thickness 6.0 m overlies the dense sand. Water table was found to be at the ground surface. The cross section through the natural ground and the proposed road embankment is illustrated in Figure Q1.1. The void ratio versus effective stress graph obtained through laboratory oedometer tests on undisturbed samples of peat is presented in Figure Q1.2. Coefficient of consolidation was found to be 2.0 m$^2$/year. The bulk unit weight of soft peaty soil is found to be 14.0 kN/m$^3$. The ground water table is found to be at the existing ground level. The unit weight of water can be taken as 9.81 kN/m$^3$.

You may refer Table Q1.1 and Figure Q1.3 for necessary $T_v$ values.

a) Determine whether the peaty soil is normally consolidated or over consolidated.

[1.5 Marks]

b) What would be the expected primary consolidation settlement of the peaty soil due to construction of the embankment?

[2.5 Marks]

c) If permissible settlement after surfacing of the road is 300 mm, estimate how long should the contractor wait to start the surfacing.

[3.0 Marks]

d) To monitor the actual behavior of peaty soil, a stand pipe type piezometer is installed at the 1.5 m depth of the peat layer. What would be the expected water level in the piezometer after 1 year?

[3.5 Marks]

e) Estimate the secondary consolidation settlement after one log cycle of primary consolidation ($t_s/t_p = 10$). The modified secondary compression index ($C'_\alpha$) is 0.02.

[1.5 Marks]

Q2. There is a proposal to develop 25 acres of "Muthurajawela" marshy land for a "Waste to Energy" project. However, in order to initiate the project, it is necessary to get the approval from Sri Lanka Land Reclamation and Development Corporation (SLRDC) and Central Environmental Authority CEA).

a) As you are a junior engineer in the project, what is the information expected from this site investigation. List 4 factors?

[2.0 Marks]

b) What are the sources of gathering information? List 4 factors.

[2.0 Marks]

c) In order to find the coefficient of permeability of the silty sand which is used as drainage layer during ground improvement, the site engineer has arranged an experimental setup as shown in Figure Q2.1. Flow rate was found to be 2.0 $cm^3/s$ at the steady state condition. Cross sectional area of the soil sample is 10 $cm^2$. Porosity of the material is found to be 0.3. The unit weight of water can be taken as 9.81 $kN/m^3$.

i) Assuming that there is no any head loss from X to B and Y to C, determine the coefficient of permeability of the silty sand.

[4.0 Marks]

ii) Determine the actual velocity of the flow through the soil.

[1.5 Marks]

iii) Sketch the variation of pore water pressure along the setup from A to D

[2.5 Marks]

Q3. A cross section of a concrete dam is shown in Figure Q3.1. The up-stream water level is 5.0 m above the existing ground level whereas down-stream water level is 1.0 m above the existing ground level. There is a cutoff wall in the up-stream of the reservoir as shown in Figure Q3.1. The flow net has been drawn by trial and error manual sketching and presented in Figure Q3.1. The coefficient of permeability of foundation soil is 2.5 x $10^{-5}$ m/s.

a) List the factors affecting coefficient of permeability and describe 4 of them.

[2.0 Marks]

b) What is the advantage of providing a cutoff wall under the concrete dam?

[0.5 Marks]

c) If length of the concrete dam is 100 m, what would be the rate of seepage under the concrete dam?

[2.5 Marks]

d) What would be the pore water pressures at point 2 and point 6 of the concrete dam?

[4.0 Marks]

e) What would be the maximum exit gradient?

[0.5 Marks]

f) Is there any danger of piping? The unit weight of foundation soil is 18.5 $kN/m^3$. The unit weight of water can be taken as 9.81 $kN/m^3$.

[1.0 Marks]

g) If porosity of the foundation soil is 0.2, estimate the seepage velocity at Point **A**.

[1.5 Marks]

Q4. A slope is supported by a 3.0 m height retaining wall as shown in Figure Q4.1. The unexpected load on the retained side can be simplified as a uniformly distributed load of intensity 20 $kN/m^2$. Soil on the retained side consists of sandy soil with friction angle of 30°and saturated unit weight of 20 $kN/m^3$. The water table is at the ground surface. The unit weight of water can be taken as 9.81 $kN/m^3$.

To design this retaining wall, it is necessary to estimate the lateral force exerted from the retained side. In order dissipate pore water pressure behind the retaining wall, it

was decided provide weep holes at regular intervals as shown in Figure Q4.1. The Coulomb's trial wedge approach is used to estimate the lateral force.

a) Briefly explain why Rankine active pressure equation cannot be applied for this situation?

[1.0 Marks]

b) Briefly explain a method to estimate pore water force on the trial failure surface with suitable sketches.

[2.5 Marks]

c) If pore water force on the trial failure surface is 20 kN, determine the lateral force on the retaining wall by drawing a force polygon for the trial wedge shown in Figure Q4.1.
(*Note: You may plot to a scale of 1 mm = 1 kN*)

[5.0 Marks]

d) The client has requested not to provide weep holes in the retaining wall for the nice appearance of the surface. As you are a junior engineer in the project, would you agree for this request? Justify your answer with suitable calculations assuming that wall surface is smooth.

[2.5 Marks]

e) The client has an idea to construct a building in front of the retaining wall taking this retaining wall as one of the supporting wall. Therefore, it is not possible to provide weep holes in the retaining wall. Suggest a suitable method to improve the drainage behind the retaining wall.

[1.0 Marks]

Q5. a) In order to determine undrained shear strength parameters of a clayey soil, a junior technical officer has suggested to use Unconfined Compression (UC) test. Do you agree with this decision? Justify your answer with suitable sketches.

[2.0 Marks]

b) What are the main drawbacks of the direct shear test over the triaxial test? Briefly explain 2 factors.

[1.0 Marks]

c) In order to find the shear strength parameters of a silty clayey soil, three specimens of the soil were subjected to Consolidated Undrained (CU) triaxial test. Deviator stress, cell pressure and pore water pressures at failure are given in Table Q5.1. Draw Mohr circles and determine the shear strength parameters in terms of total stress and effective stress.

[5.0 Marks]

d) A Consolidated Drained (CD) triaxial test was conducted on a sandy soil sample. At failure, deviator stress was 300 kPa when cell pressure is around 100 $kN/m^2$.

i) Draw a Mohr circle and determine the shear strength parameters.

[2.0 Marks]

ii) Draw the failure plane and determine the angle that the failure plane makes with the major principal plane.

[1.0 Marks]

iii) Using the Mohr circle, determine the normal stress and shear stress on the failure plane.

[1.0 Marks]

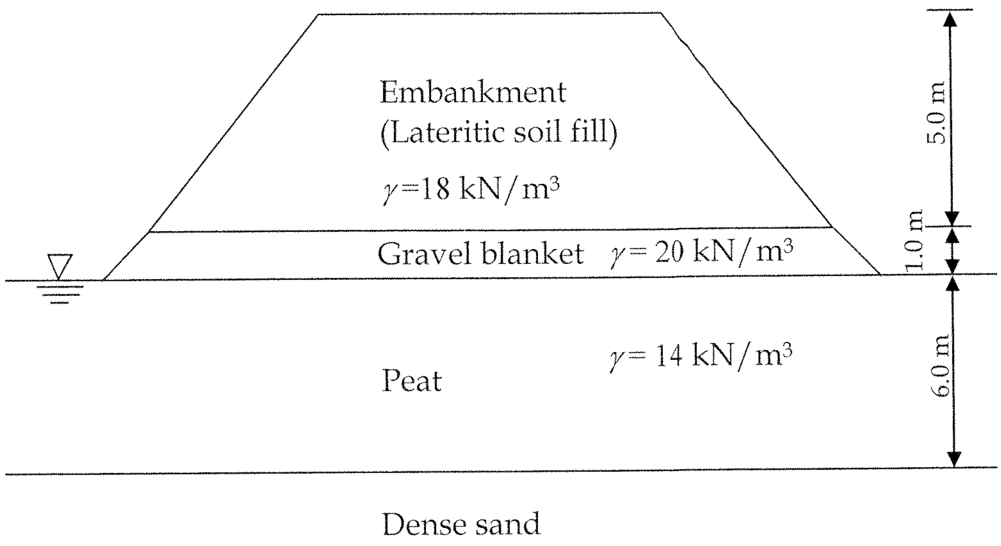


Figure Q1.1 Cross section of earth embankment

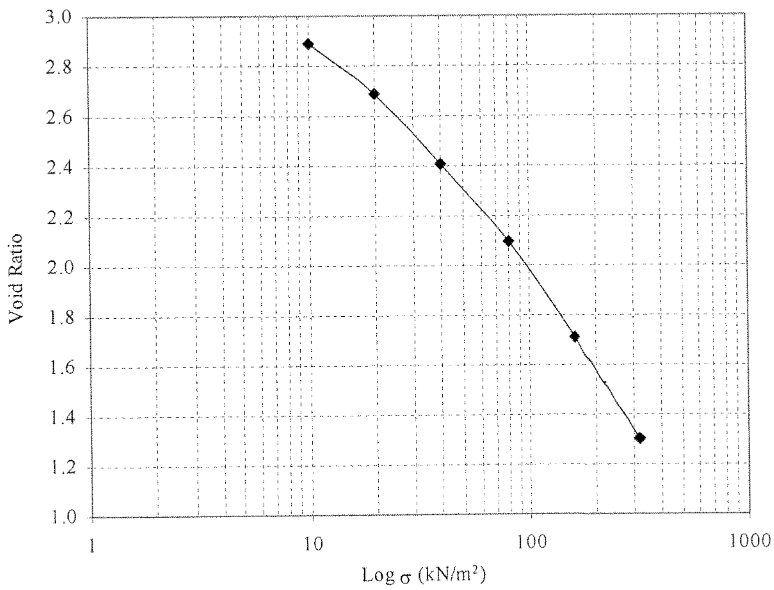


Figure Q1.2 Void ratio versus effective stress graph

Table Q1.1 Variation of $T_v$ with $U$

| $U$ (%) | $T_v$ | $U$ (%) | $T_v$ |
|---|---|---|---|
| 0 | 0 | 51 | 0.204 |
| 1 | 0.00008 | 52 | 0.212 |
| 2 | 0.0003 | 53 | 0.221 |
| 3 | 0.00071 | 54 | 0.230 |
| 4 | 0.00126 | 55 | 0.239 |
| 5 | 0.00196 | 56 | 0.248 |
| 6 | 0.00283 | 57 | 0.257 |
| 7 | 0.00385 | 58 | 0.267 |
| 8 | 0.00502 | 59 | 0.276 |
| 9 | 0.00636 | 60 | 0.286 |
| 10 | 0.00785 | 61 | 0.297 |
| 11 | 0.0095 | 62 | 0.307 |
| 12 | 0.0113 | 63 | 0.318 |
| 13 | 0.0133 | 64 | 0.329 |
| 14 | 0.0154 | 65 | 0.304 |
| 15 | 0.0177 | 66 | 0.352 |
| 16 | 0.0201 | 67 | 0.364 |
| 17 | 0.0227 | 68 | 0.377 |
| 18 | 0.0254 | 69 | 0.390 |
| 19 | 0.0283 | 70 | 0.403 |
| 20 | 0.0314 | 71 | 0.417 |
| 21 | 0.0346 | 72 | 0.431 |
| 22 | 0.0380 | 73 | 0.446 |
| 23 | 0.0415 | 74 | 0.461 |
| 24 | 0.0452 | 75 | 0.477 |
| 25 | 0.0491 | 76 | 0.493 |
| 26 | 0.0531 | 77 | 0.511 |
| 27 | 0.0572 | 78 | 0.529 |
| 28 | 0.0615 | 79 | 0.547 |
| 29 | 0.0660 | 80 | 0.567 |
| 30 | 0.0707 | 81 | 0.588 |
| 31 | 0.0754 | 82 | 0.610 |
| 32 | 0.0803 | 83 | 0.633 |
| 33 | 0.0855 | 84 | 0.658 |
| 34 | 0.0907 | 85 | 0.684 |
| 35 | 0.0962 | 86 | 0.712 |
| 36 | 0.102 | 87 | 0.742 |
| 37 | 0.107 | 88 | 0.774 |
| 38 | 0.113 | 89 | 0.809 |
| 39 | 0.119 | 90 | 0.848 |
| 40 | 0.126 | 91 | 0.891 |
| 41 | 0.132 | 92 | 0.938 |
| 42 | 0.138 | 93 | 0.993 |
| 43 | 0.145 | 94 | 1.055 |
| 44 | 0.152 | 95 | 1.129 |
| 45 | 0.159 | 96 | 1.219 |
| 46 | 0.166 | 97 | 1.336 |
| 47 | 0.173 | 98 | 1.500 |
| 48 | 0.181 | 99 | 1.781 |
| 49 | 0.188 | 100 | $\infty$ |
| 50 | 0.197 | | |

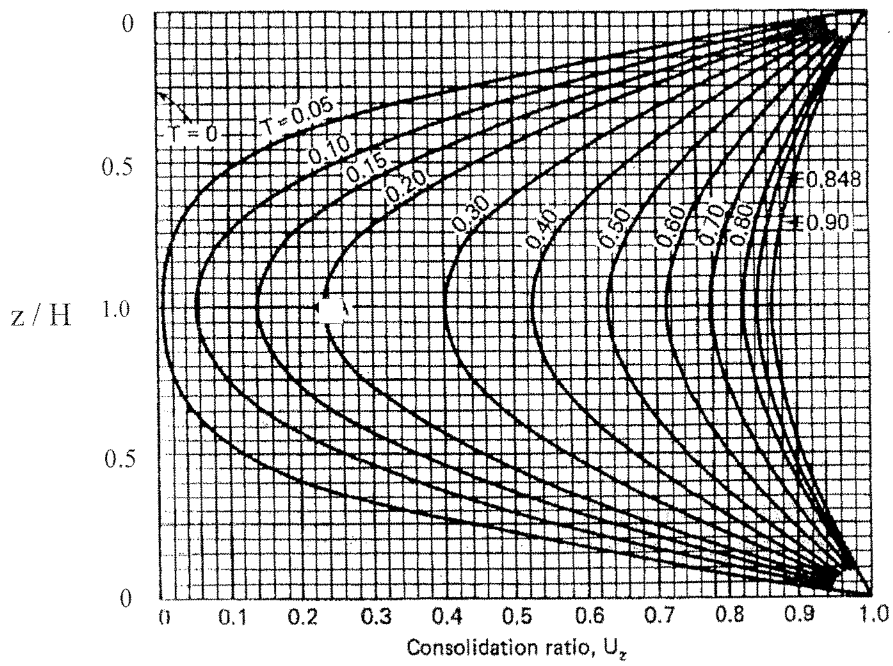


Figure Q1.3 Variation of $T_v$ with z / H and Uz

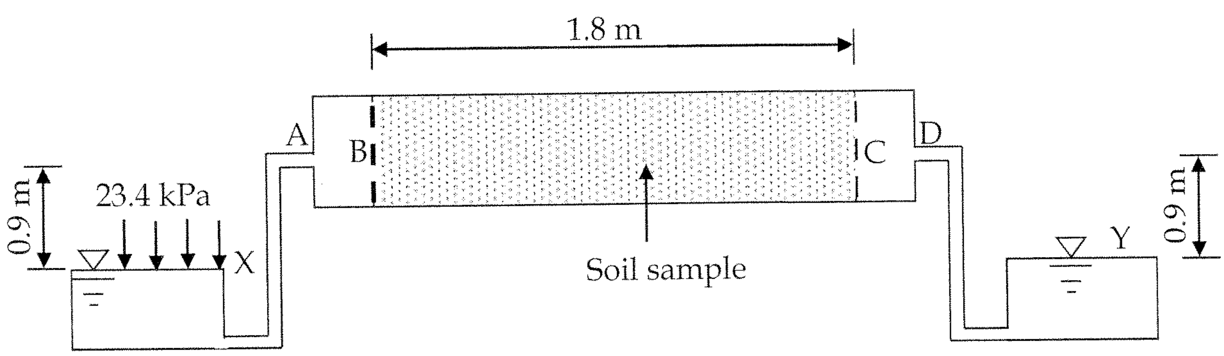


Figure Q2.1 Experimental setup

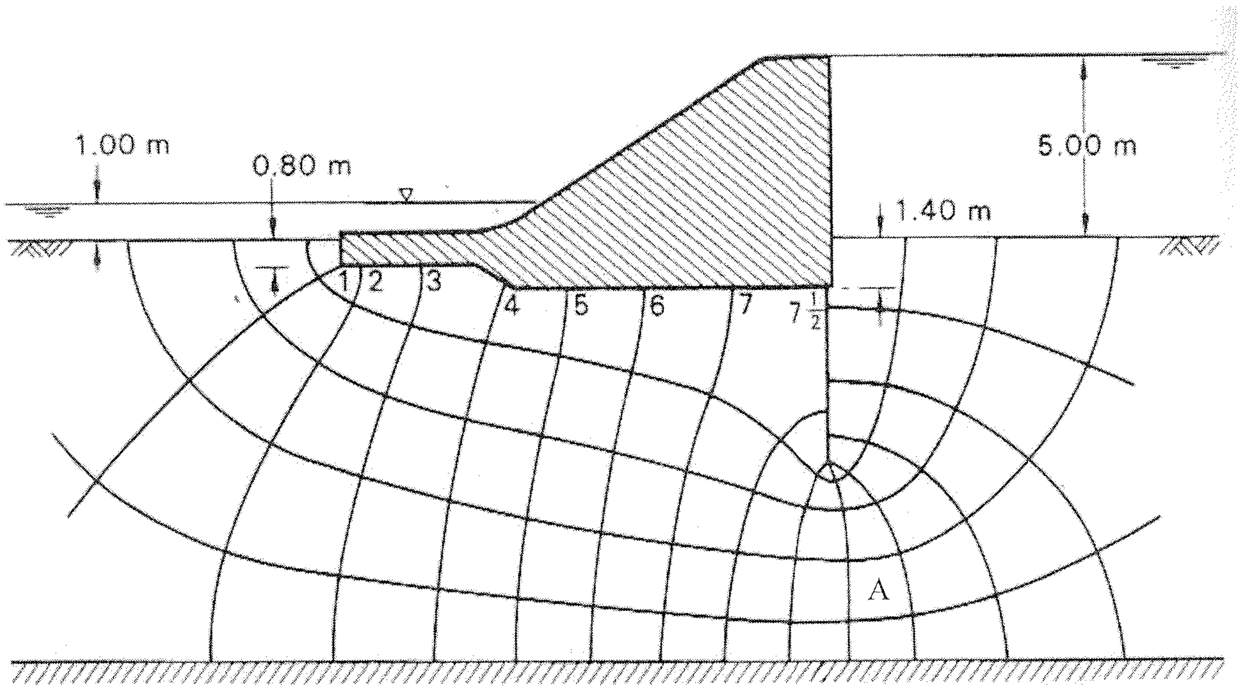


Figure Q3.1 – Flow net for the concrete dam

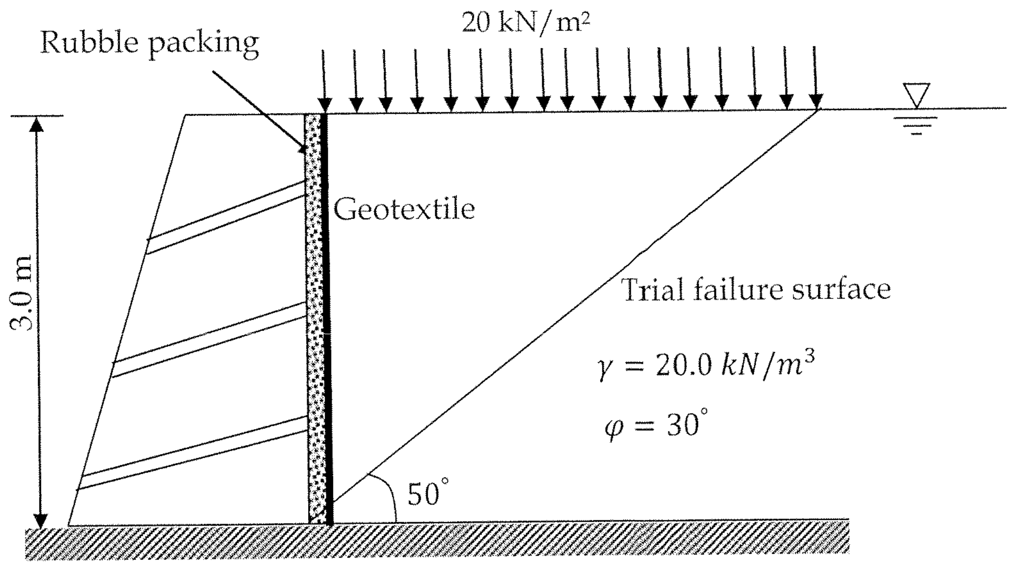


Figure Q4.1 Coulomb's trial wedge

Table Q5.1 Consolidated Undrained Triaxial test results

| Specimen | Cell pressure ($kN/m^2$) | Deviator stress ($kN/m^2$) | Pore water pressure ($kN/m^2$) |
|---|---|---|---|
| 1 | 50 | 85.67 | 12 |
| 2 | 100 | 157.82 | 30 |
| 3 | 150 | 225.46 | 50 |