UNIVERSITY OF RUHUNA

Faculty of Engineering

End-Semester 6 Examination in Engineering: November 2017

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

[Three Hours]

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

Q1. The 50% of the proposed Southern Expressway Extension Project from Matara to Beliatta section is to be constructed over a low lying area. Based on initial site investigations, it was realized that soft soil thickness varies upto 25.0 m. As such, contractor has proposed several techniques to construct the expressway over this low lying area. Preloading with a soil fill is one of the techniques adopted to improve soft soil thickness is less than 6.0 m.

Based on the borehole tests conducted at a site close to Beliatta area, sub surface soil profile was idealized as shown in Figure Q1.1. It can be seen that peaty clay layer of thickness 5.0 m is sandwitched between two sand layers. Water table was found to be at the existing ground level.

According to the plan and profile of the proposed expressway, road finished level is 2.0 m above the exiting ground level. In order to compensate the dead and live load (25.0 kN/m^2) of the expressway and accelerate the consolidation, 3.25 m height additional soil fill will be placed on the embankment as shown in Figure Q1.1. The bulk unit weight of the sand and peaty clay can be taken as 18.0 kN/m^3 and 15.0 kN/m^3 respectively. The compacted unit weight of the fill material can be taken as is 20.0 kN/m^3. The unit weight of water can be taken as 9.81 kN/m^3.

The compressibility characteristics of the soft peaty clay were determined by conducting a series of laboratory oedometer tests. Coefficient of consolidation (C_v) compression index (C_c) and void ratio were found as 4.0 m^2/year, 0.8 and 1.6, respectively.

You may refer Figure Q1.2 and Table Q1.1 for necessary calculations.

a) Describe a method to identify whether peaty clay is normally consolidated or overconsolidated with the aid of sketches.

[2.0 Marks]

b) What would be the expected primary consolidation settlement of the peaty clay layer due to construction of the embankment assuming that peaty clay is normally consolidated?

[2.0 Marks]

c) What would be the time required for 90% of the primary consolidation to be occurred?

[1.5 Marks]

d) If modified secondary compression index is 0.01, what would be the expected secondary consolidation settlement 3 year after the end of primary consolidation?

[3.0 Marks]

e) What would be the expected pore water pressure at a depth of 4.25 m from the existing ground surface 6 months after the end of embankment construction?

[4.0 Marks]

f) If excess soil is removed upto the road finished level after 90% of the primary consolidation, what would be the expected removable soil fill height?

[1.0 Marks]

g) What would be the expected Over Consolidation Ratio (OCR) of the peaty clay layer after removal of the soil fill upto the road finished level?

[1.5 Marks]

Q2. There is a proposal to construct an expressway through a marshy land. 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). As such, it was decided to conduct comprehensive site investigation.

a) As you are a junior engineer in the project, what are 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) What type of information should be included in a sub soil exploration report? List 4 factors.

[2.0 Marks]

d) In order to determine the shear strength parameters of soft peaty clay, undisturbed soil samples were collected and laboratory Consolidated Undrained (CU) triaxial test was conducted. The data gathered from the CU test is depicted in Table Q2.1.

i) What are the main drawbacks of the direct shear test over the triaxial test? List 2 factors.

[1.0 Marks]

ii) Based on the data presented in Table Q2.1, draw Mohr circles and determine the shear strength parameters in terms of effective stress.

[5.0 Marks]

e) For the same soil used for the CU test, laboratory technical officer has conducted Unconsolidated Undrained (UU) triaxial test only for one sample and results are presented in Table Q2.2.

i) Using the usual notations, prove that Mohr circles in terms of effective stress do not depend on the cell pressure.

[2.0 Marks]

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

[1.0 Marks]

Q3. A cross section of a concrete dam together with a cut off wall is shown in Figure Q3.1. The up stream water level is 6.3 m above the existing ground level where as down stream water level is at the existing ground level. In order to reduce the seepage, a cutoff wall has been constructed 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 5.0×10^{-3} cm/s. The unit weight of water can be taken as 9.81 kN/m^3.

a) Estimate the volumetric flow rate of water under the dam assuming dam width is 75 m.

[2.5 Marks]

b) Compute the uplift pressures along the base of the dam along Points **A, B, C, D** and **E**. Note that point **A** is just to right of the sheet pile.

[5.0 Marks]

c) If porosity of the foundation soil is 0.2, estimate the seepage velocity between Point **B** and **C**.

[2.5 Marks]

d) What would be the maximum exit gradient?

[1.5 Marks]

e) What would be the maximum seepage force?

[1.0 Marks]

f) Calculate the factor of safety against piping. The unit weight of foundation soil is 18.0 kN/m^3.

[2.5 Marks]

Q4. Due to limited Road of Width (ROW), it was decided to adopt 5.0 m height mass concrete type retaining wall with weep holes to support a slope in highway construction project as shown in Figure Q4.1. Bulk unit weight and shear strength parameters of the retained soil are found as 18.0 kN/m^3 and $c' = 10\ kPa, \varphi' = 30^\circ$, where c' and φ' are effective cohesion and effective friction angle. According to BS8002, interface friction angle (δ) and adhesion (c_w) between mass concrete retaining wall and retained soil can be taken as $\tan\delta = 0.75tan\varphi'$ and $c_w = 0.75c'$. Further, an obligatory surcharge of 10 kN/m^2 is placed on the slope of retained side. In order to design the retaining wall, Senior geotechnical engineer has requested to adopt Coulombs trial wedge approach as shown in Figure Q4.1. The trial failure surface is 40° to the horizontal ($\theta = 40^\circ$) and slope of the retained side is 10^0 to the horizontal($\beta = 10^0$). In order to facilitate for proper drainage, weep holes are provided in the retaining wall.

a) If perched water is risen upto the ground surface due to heavy rain, briefly explain a method to estimate pore water force on the trial failure surface with suitable sketches.

[2.0 Marks]

b) Assuming that you are a junior geotechnical engineer in the project, determine the resultant active force on the retaining wall for the trial wedge shown in Figure Q4.1. Pore water force on the trial failure surface is 80 kN. Area of the trial wedge is 19.75 m^2.
(Note: You may plot to a scale of 1 cm = 25kN)

[7.0 Marks]

c) In order to provide a nice appearance, a politician of the area requested to plaster surface of the retaining wall without providing weep holes. Do you agree with this decision? Justify your answer using a force polygon.

[2.0 Marks]

d) If the wall surface is smooth and slope of the retained side is flat ($\beta = 0^0$), what would be the expected active force on the retaining wall. Assume that perched water table is at the ground surface and weep holes are not provided.

[4.0 Marks]

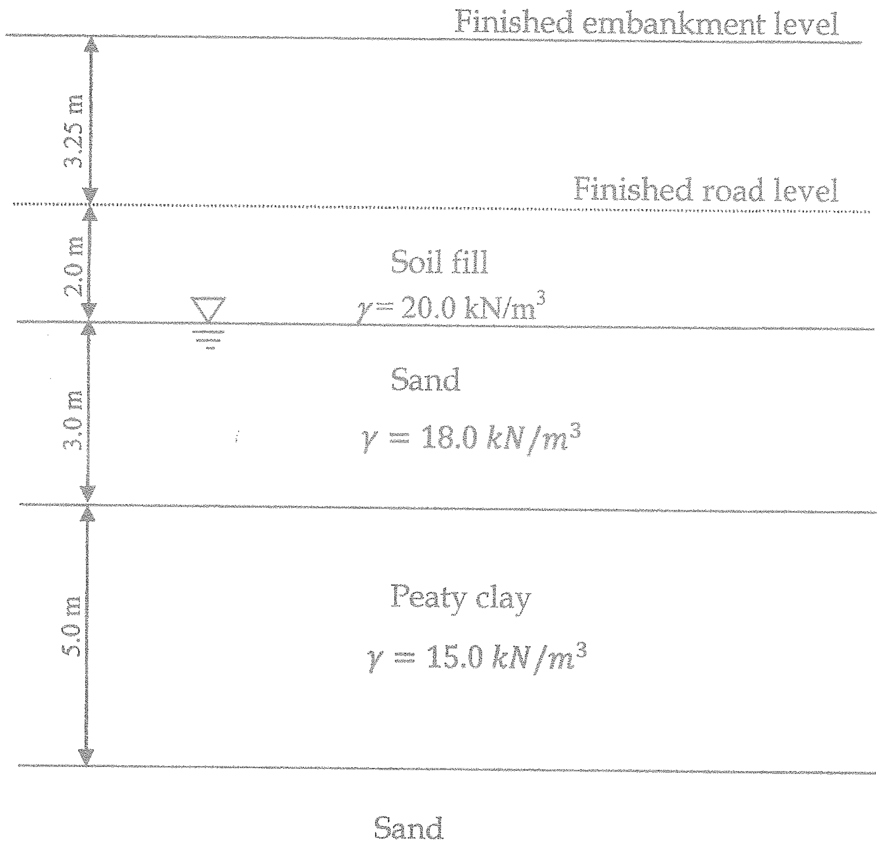

Figure Q1.1 Cross section of ground profile

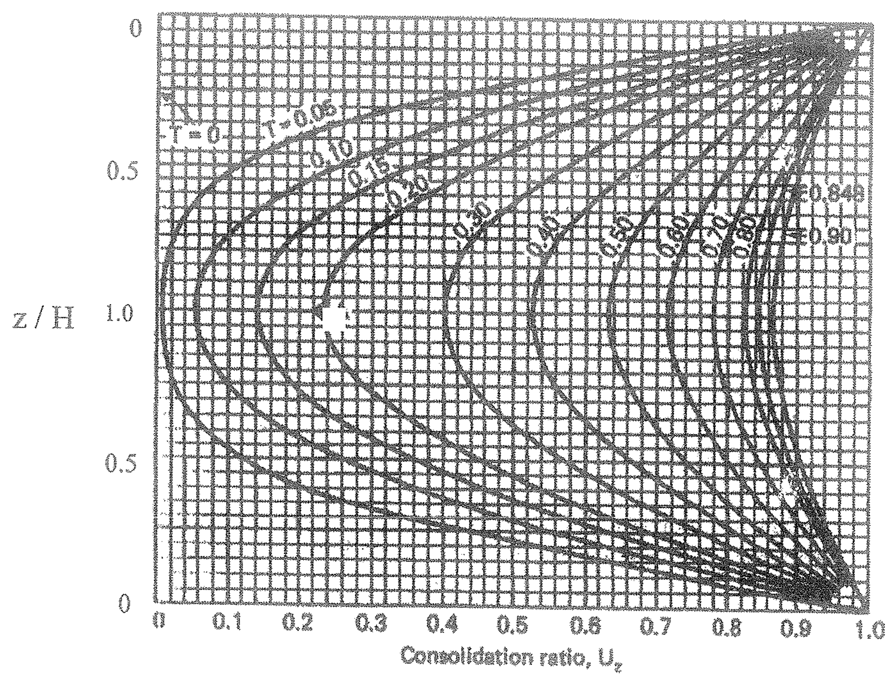

Figure Q1.2 Variation of T_v with z/H and U_z

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	∞
50	0.197		

Table Q2.1 Consolidated Undrained Triaxial test results

Specimen	Cell pressure (kN/m²)	Deviator stress (kN/m²)	Pore water pressure (kN/m²)
1	50	75.0	12.5
2	100	112.5	17.5
3	150	225.0	37.5

Table Q2.2 Unconsolidated Undrained Triaxial test results

Specimen	Cell pressure (kN/m²)	Deviator stress (kN/m²)
1	100	100.0

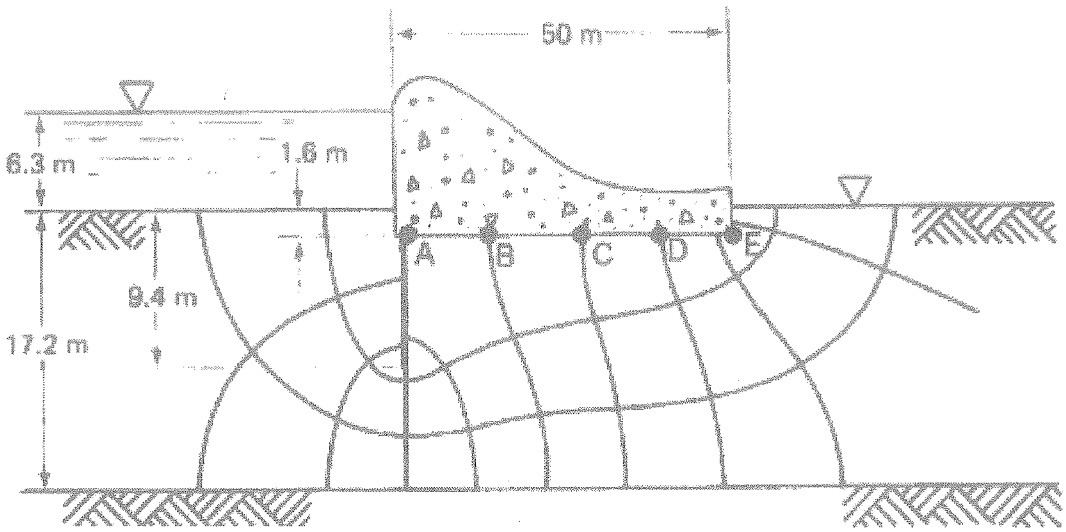

Figure Q3.1 – Flow net for the concrete dam and cutoff wall

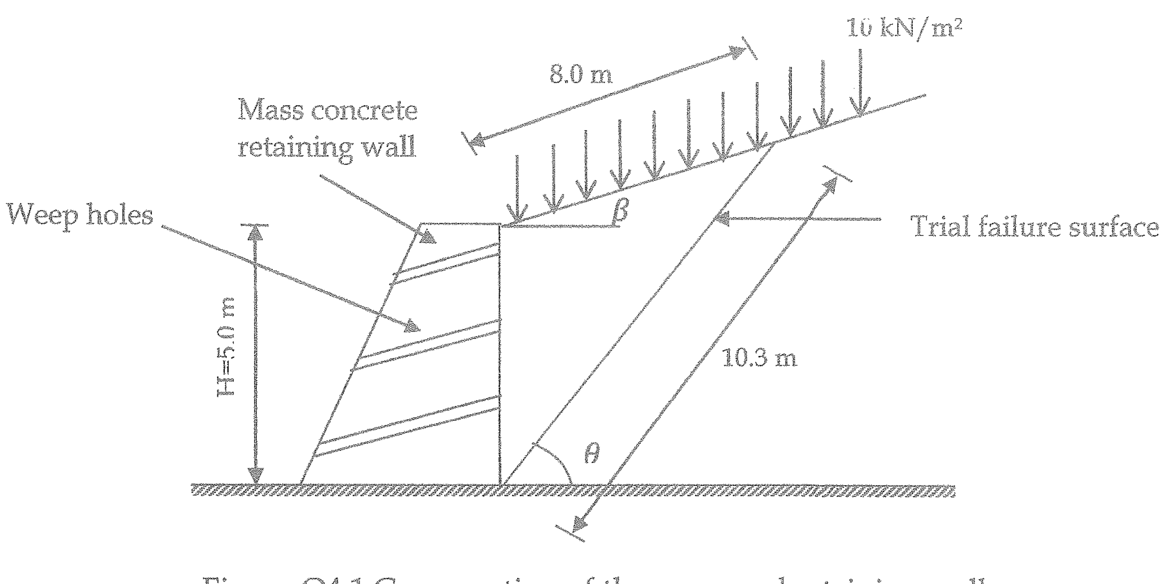

Figure Q4.1 Cross section of the proposed retaining wall