UNIVERSITY OF RUHUNA

Faculty of Engineering

Mid-Semester 6 Examination in Engineering: October 2015

Module Number: CE6321 **Module Name: Geotechnical Engineering**

[Two Hours]

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

Q1. Weras Ganga Basin Storm Water Drainage and Environment Improvement Projectwas introduced in order to improve the drainage system in suburbs of Colombo city area. Under this project many bridges, culverts, canals and gabion retaining structures etc. are expected to be constructed. Before starting the constructions, design engineer has decided to carry out comprehensive site investigation in order to do a proper design.

a) Assuming that you are a junior engineer in this project, what are the data expected from this site investigation.

[1.0 Marks]

b) Borehole logs BSB-9 and BSB-10 near Box culvert atPiriwena road are shown in Figure Q1.1 and Figure Q1.2.

i) Based on borehole logs, determine the soil profile at this location. Also indicate the average SPT-*N* value in each layer.

[2.0 Marks]

ii) What is the corrected SPT-*N* value at a depth of 4.0 m in BSB-10. You may assume that the unit weight of soil as16 kN/m^3 for entire depth for simplicity. The diameter of the borehole was found to be 75 mm. The safety hammer with energy ratio of 60 % was used to penetrate the sampler into the ground. There is no liner inside the sampler. The unit weight of water can be taken as 9.81 kN/m^3. Table Q1 may be referred for correction factors. Following equation with usual notations may be useful in the calculations.

$$C_N = \sqrt{\frac{95.76}{\sigma'_v}}$$

[1.0 Marks]

iii) As shown in the borehole logs, the sub contractor who carried out the site investigation took undisturbed samples from the same boreholes where SPT tests were conducted. Do you agree with this practice of taking undisturbed samples from the borehole where SPT test is conducted? Justify your answer.

[1.0 Marks]

Q2. a) What are the advantages and disadvantages of geophysical exploration technique in site investigation?

[1.0 Marks]

b) Briefly explain the seismic refraction survey test procedure with suitable sketches and relevant equations.

[1.0 Marks]

c) A seismic refraction survey carried out at a particular area gave the results as

shown in Figure Q2.

i) Determine the P-wave velocity of each layer.

[1.0 Marks]

ii) Determine the thickness of each layer.

[1.0 Marks]

iii) Determine the depth to the hard stratum from the ground surface.

[0.5 Marks]

Following equations with usual notations may be useful in the calculations.

$$Z_1 = \frac{1}{2}\sqrt{\frac{(v_2 - v_1)}{(v_2 + v_1)}}.x_c$$

$$Z_2 = \frac{1}{2}\left[T_{i2} - 2Z_1\frac{\sqrt{(v_3^2 - v_1^2)}}{(v_3 v_1)}\right]\frac{(v_3 v_2)}{\sqrt{(v_3^2 - v_2^2)}}$$

d) What are the limitations of seismic refraction survey?

[0.5 Marks]

Q3. The sub surface soil profile of a site where it is proposed to construct a sewage treatment plant is presented in Figure Q3.1. It was decide to estimate the equivalent permeability of the sub surface soil.

a) In order to find the coefficient permeability of the top layer, undisturbed soil sample was collected from the field and laboratory falling head permeability test was conducted. The data collected from the falling head test is presented in Figure Q3.2. Determine the coefficient of permeability of the clay layer. Radius and length of the soil sample are 5.0 cm and 13 cm respectively. Diameter of the stand pipe is 4.5 mm.

[2.0 Marks]

b) As there were difficulties in the determination of the coefficient of permeability of the sandy clay accurately through laboratory tests, it was decided to conduct a field permeability test. Three boreholes were done to bedrock and pumping was started from the central hole at a rate of 0.24 m^3/hr. Sometime after the start of the pumping, the water levels in the wells became constant. The depths to the water level in the boreholes in the steady state are presented in Table Q3.1

i) Determine the coefficient of permeability of the sandy clay layer.

[2.0 Marks]

ii) Estimate the equivalent permeability of soil layers beneath the sewage treatment plant in vertical direction.

[1.0 Marks]

Q4. In order to find the coefficient of permeability of a material, a trainee engineer has arranged a setup as shown in Figure Q4. The large cell has an inner diameter of100 mm and a total length of 300 mm. The small cell has an inner diameter of 50 mm and a total length of 300 mm. The coefficient of permeability of the soil is 6.5×10^{-5} m/s. The water levels at point A and B have been recorded as 650 mm and 320 mm respectively. Porosity of soil is found to be 0.3. The unit weight of water can be taken as 9.81 kN/m^3.

a) Determine the rate of flow through the soil.

[3.0 Marks]

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

[1.0 Marks]

c) Sketch the variation of pore water pressure along the setup from A to B.
[1.0 Marks]

PROJECT	Weras Ganga Storm Water Drainage & Enviroment Improvement Project Borehole Investigation Nugegoda - Rattanpitiya		
SLLRDC		ACCESS ENGINEERING LIMITED	
Client		Contractor	

BOREHOLE NO ; - BSB 9

Location	Preewana road/ BSB 09	**Drilling Operator**	Chaminda
Date Started	14/5/2012	**Drilling Machine**	Koken-OP1
Date Finished	15/5/2012	**Drilling Method**	Rotary
Total depth of hole	9.0m	**Bit Size**	NX
Cased depth	7.0m	**Casing diameter**	NW
Angle of Hole	Verticle	**Flushing medium**	Water

Depth	Collected Sample Type	Description	% Core Recovery	R.Q.D	Standard Penetration Test: Depth of Test	Standard Penetration Test: N - Value	Graphical Presentation
0.0m	D/S	blackish peaty soil			0.0- 0.45 m	F/D	
1.0m							
2.0m	D/S	Black peaty clay			1.0m-1.45m	F/D	
3.0m	U/D	UD sample was collected at 2.0-2.70m			2.0m-2.70m		
4.0m	D/S	white clay			3.0m-3.45m	11	
5.0m	D/S	white clayey sand			4.0m-4.45m	6	
6.0m	D/S	white sandy clay			5.0m -5.45m	34	
7.0m	D/S	gray color weathered bedrock clay (rock level 7.0m)			6.0m-6.45m	H/B	
8.0m	C/S	weathered bedrock	50	40			
9.0m	C/S						

BOREHOLE WAS COMPLETED AT A DEPTH OF 9.0m

Key	Remarks	Logged By	Checked By
D/S - Disturbed Sample W/S - Washed Sample U/D - Undisturbed Sample H/B - Hammer Bounce GWT - Ground Water Table C/S - Core Sample	* GWT was encountered at depth of 1.0 m below the existing ground level * Bhorehole was terminated under the instructions of Mr.Raweendra (SLLRDC / Desing Engineer)	E.K.Chaminda	
		Sheet No - 1of 1	

Figure Q1.1 - Borehole log at BSB-9

PROJECT	Weras Ganga Storm Water Drainage & Enviroment Improvement Project Borehole Investigation Nugegoda - Rattanpitiya

SLLRDC	ACCESS ENGINEERING LIMITED
Client	Contractor

BOREHOLE NO ; - BSB 10

Location	Piriwena road / BSB 10	**Drilling Operator**	Chaminda
Date Started	16/5/2012	**Drilling Machine**	Koken-OP1
Date Finished	17/5/2012	**Drilling Method**	Rotary
Total depth of hole	9.0m	**Bit Size**	NX
Cased depth	7.0m	**Casing diameter**	NW
Angle of Hole	Verticle	**Flushing medium**	Water

Depth	Collected Sample Type	Description	% Core Recovery	R.Q.D	Standard Penetration Test: Depth of Test	Standard Penetration Test: N - Value	Standard Penetration Test: Graphical Presentation
0.0m – 1.0m	D/S	blackish brown clay			0.0- 0.45 m	F/D	
2.0m	D/S	blackish brown clay			1.0m-1.45m	2	
3.0m	D/S	white sandy clay			2.0m-2.45m	3	
4.0m	U/D	UD sample was collected at 3.0-3.70m			3.0m-3.70m		
5.0m	D/S	white sandy clay			4.5m-4.95m	9	
6.0m	D/S	white sandy clay			5.5m -5.95m	24	
7.0m	W/S	gray color weathered bedrock clay and sand (rock level 7.0m)			6.5m-6.95m	H/B	
8.0m	C/S	highly weathered to freshrock	30	30			
9.0m	C/S						

BOREHOLE WAS COMPLETED AT A DEPTH OF 9.0m

Key	Remarks	Logged By	Checked By
D/S - Disturbed Sample W/S - Washed Sample U/D - Undisturbed Sample H/B - Hammer Bounce GWT - Ground Water Table C/S - Core Sample	* GWT was encountered at depth of 1.0 m below the existing ground level * Bhorehole was terminated under the instructions of Mr.Raweendra (SLLRDC / Desing Engineer)	E.K.Chaminda	
		Sheet No - 1of 1	

Figure Q1.2 – Borehole log at BSB-10

Table Q1 Correction factors

Hammer for η_1					Remarks
	Average energy ratio E_r				
	Donut		Safety		
Country	R-P	Trip	R-P	Trip/Auto	R-P = Rope-pulley or cathead
United States					$\eta_1 = E_r / E_{rb}$
North America	45	-	70-80	80-100	For U.S. trip / auto $w/E_r = 80$
Japan	67	78	-	-	$\eta_1 = 80/70 = 1.14$
United Kingdom	-	-	50	60	
China	50	60	-	-	

Rod length correction η_2			
Length	> 10 m	$\eta_2 = 1.00$	N is too high for L < 10 m
	6-10 m	$\eta_2 = 0.95$	
	4-6 m	$\eta_2 = 0.85$	
	0-4 m	$\eta_2 = 0.75$	

Sampler correction η_3		
Without liner	$\eta_3 = 1.00$	Base value
With liner : Dense sand, clay	$\eta_3 = 0.80$	N is too high with liner
With liner : Loose sand	$\eta_3 = 0.90$	

Bore hole diameter correction η_4			
Hole diameter	60-120 mm	$\eta_4 = 1.00$	Base value; N is too small when have an oversize hole
	150 mm	$\eta_4 = 1.05$	
	200 mm	$\eta_4 = 1.15$	

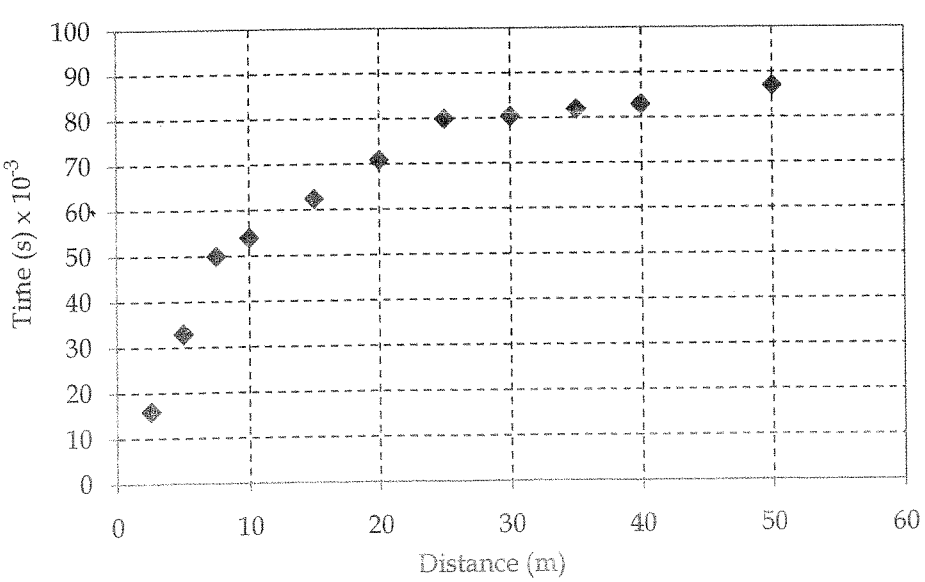

Figure Q2 - Seismic refraction survey results

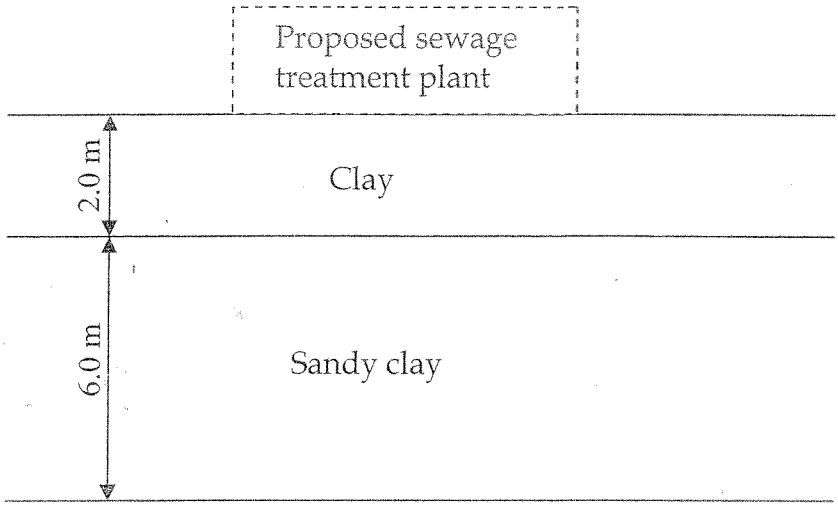

Figure Q3.1 – Sub surface soil profile

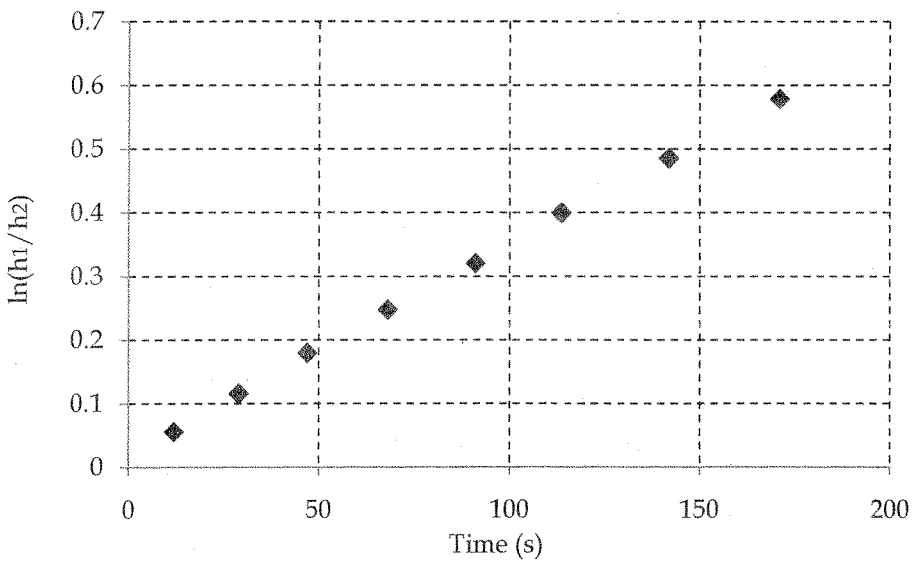

Figure Q3.2 Falling head permeability test data

Table Q3.1 – Details of pumping test

Depth to the ground water level from the ground surface (m)	Pumping well	Observation well at 8.0 m	Observation well at 16.0 m
Initial (before pumping)	2.2	2.2	2.2
Steady state	6.0	4.0	3.0

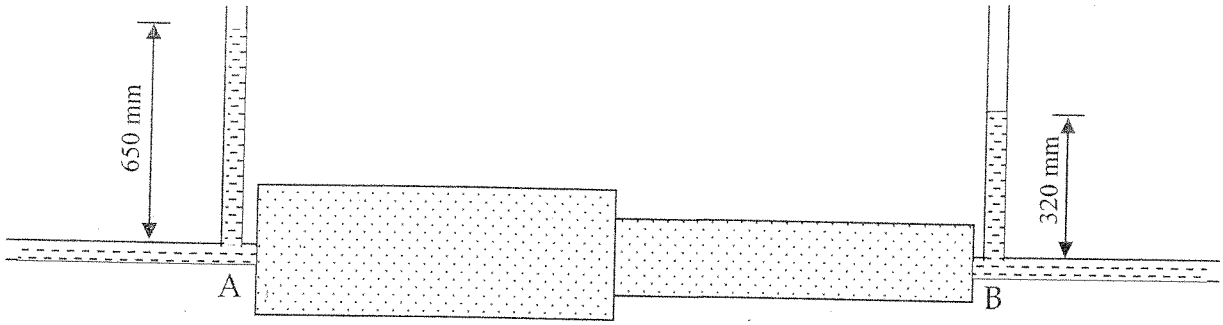

Figure Q4 Experimental setup