## **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/m³ 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/m³. 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]

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]

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

[1.0 Marks]

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

[1.0 Marks]

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

Determine the thickness of each layer.

[1.0 Marks]

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.

$$Z_{1} = \frac{1}{2} \sqrt{\frac{(v_{2} - v_{1})}{(v_{2} + v_{1})}} \cdot x_{c}$$

$$Z_{2} = \frac{1}{2} \left[ T_{i2} - 2Z_{1} \frac{\sqrt{(v_{3}^{2} - v_{1}^{2})}}{(v_{3}v_{1})} \right] \frac{(v_{3}v_{2})}{\sqrt{(v_{3}^{2} - v_{2}^{2})}}$$

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.
  - 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]

- 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<sup>3</sup>/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
  - Determine the coefficient of permeability of the sandy clay layer.

Estimate the equivalent permeability of soil layers beneath the sewage ii) 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 of 100 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  $10^{-5}$  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  $9.81 \, \text{kN/m}^3$ .
  - Determine the rate of flow through the soil.

3.0 Marksi

Determine the actual velocity of the flow through the soil.

[1.0 Marks]

[1.0 Marks]

PROJE	CI	Investigat	ion Nugeg	oda - Rattanpitiy ACCESS I		ERING	·		Seedendary Seesan And	olejani, muša vitinas valjų	en e	neowen-re-min	and a principal of the Control of th	nyayamanin en de
	SLI	LRDC			MITED	ALLE VERY								
~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~		lient			ontractor		And the second second	1						
ORFH		; - BSB 9												11. 13. 
ocation		Preev	vana road/	BSB 09	Drillin	g Oper	ator	Chaminda			tadirinistici.		-	TEN Y
ate Sta		14/5/				g Mach		Koken-OF	$\mathbf{q}$		SCO			
ate Fin	nished	15/5/	2012			g Meth	od	Rotary						
otal de	pth of ho				Bit Siz			NX						
ased d		7.0m	THE RESERVE THE PERSON NAMED IN COLUMN TWO IS NOT THE PERSON NAMED IN THE PERSON NAMED IN THE PERSON NAMED I			g diame		NW Water	41					
ingle of	Hole	Verti	cle		Flushi	ng med	<u>um</u>			dard Penetration Test				
Depth	Collected Sample Type		Des	cription		% Core Recovery	a Š	Tepth of	N - Value	0]	Gr	aph		
0.0m	D/S		blackis	sh peaty soil				0.0-0.45 m	F/D		No. 200 AND ADD 200 ALC AND AD			1
1,0m	D/S		Black	peaty clay				1.0m-1.45m	F/D	the test and the test and the test the	nem mysik sam, gapa kada pada pada dada dada dada dada d		An add (A) alle dan alle dat par den ene ene e	
2,0m	U/D	UD sa	imple was	collected at 2.0-2.	70m			2.0m-2.70m	-ronovene-ondátes	e de la companya de l	mais pade also year toon that then then the figures to	ent our tek nam fels das das das nos son tes fel	den den den beig des den dan bijg der ops VO vo	
3.0m	D/S		W	nite clay				3,0m-3,45m	11		any hop cape upoy hold data lang 'Hild City 'Hall Hell hol	de de se da ch de se se de de se de de	dag gan jan nan saga uni dipunat saja saga na saga	
4.0m 5.0m	D/S		white	clayey sand			The state of the s	4.0m-4.45m	6		that the time year year they are the cold rings that made had a land with a la	type desp loop loop look and also had not look one was the se		AND THE THAT WE HAVE MADE AND THE COLD THAT WHEN YOU CO.
6.0m	D/S	annum	white	sandy clay	and the state of t			5.0m -5.45m			u ago day day day and man dan 140 day like Na and ago day ago day ago day and and ago day		and over any and age was dies mit die jest dies des	
7,0m	D/S	gray colo		d bedrock clay (ro 7.0m)	ock level		and and one 1010 102 10	6.0m-6.45m	H/B	And of mathematical contractions of the state of the stat	de groupe op de sprang en est de de	de pas yes yes one dan abrillan jan van tok toe	dy per just and man day day day day were were way	
8.0m	C/S		weathe	ered bedrock		50	40	Tage (c) 100 am feel well and 6th feel		A Company of the Comp	to peak day had the first day the wall but was an early day the first day and the san in	) qui day tab tab map my yer and tab fall cam fi	AND AND THE PER PER PER PER PER PER PER PER PER PE	pa pa con las cos de las cide de las
9.0m	C/S	Administration absorbed in the control of the contr												
nare version is confirmation	en former one broaders at femore		BOREH	OLE WAS CON	1PLETE	DATA	DEP	TH OF 9.0	m	ki serajndepromon	en e	wpanjut/sampli	operation of the state of	анерской
W/S - Wa U/D - Uno H/B - Ha	turbed Sam ished Samp disturbed Si nimer Boun fround Wat	le ample see	Re * GV exist * Bh	marks VT was encounter ing ground level orehole was termi Laweendra (SLLR	ed at dep	th of 1.	0 m be	elow the	E.K	, middle streets to prince	IBy mind - Lof	a	hecke	₫ B

Figure Q1.1 - Borehole log at BSB-9

remaintenantination	ECHIPARIA CARRESTANIA PROPERTY	nergy from the expenses from the property of t		Sperior region and accompany								
PRO.	TECT	Weras Ga	nga Storm Water Draina; ion Nugegoda - Rattanpit	ge & Er	ivirome	nt Ing	rovement	t Proje	ct Bore	ehole	NOTE OF THE PERSON NAMED O	40019060000
	The contraction of the contracti	THIVESTIGAL	The state of the s	~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~	***	at at the	Michael Spiller and American S	With the company of t	ووود والمعارضة و	Control and Control of	Proteincousiu Amazana	all of the spirit, and the
245 SECONDARIA	SI	LLRDC	ACCESS			VG						
				IMITE								
DANE		Client	C	ontracto	or							
Locati		O ; - BSB 10		1		er - anidalismo o con						A STATE OF THE STA
			ena road / BSB 10		ing Ope		Chamin	-				
	inished	16/5/2 17/5/2			ing Ma		Koken-	OP1				
	lepth of h				ing Met	hod	Rotary					
Cased		7.0m		Bit S			NX					
	of Hole	Vertic	la		ng diam		NW				The second	
		Tvertic	IV	Flusi	ing me	dium						
	γp						St	andar	d Penet	ratio	n Test	
	ted e T		Description		2 c		7	ne		Gra	phical	pri'
pth	Collected Sample Type Description		Description		ove ove	A	R.Q.D Depth of	Value	Presentation			
Depth	Sar				% Core	R.Q.D	Dept Test	1			-	
0.0m	1	<u> </u>	ng ang ang ang ang ang ang ang ang ang a	The same of the sa	10, 24	1	0.0- 0.45 m	Z. E/D	1 2 1	3 <u>8</u>	Ş <del>2</del>	
	D/S	-	blackish brown clay				0.0-0,40	171)		f 1		1
	Dis		orackish brown clay				and the second			i		1
1.0m	-	1		annument of the same of the sa	ļ		ļ			1		1
					-		1.0m-1.45m	2				1
	D/S		blackish brown clay							İ		ĺ
2.0in									i	į į		1
					***************************************		2.0m-2.45m	3				1
	D/S	and the second	white sandy clay								Į.	1
3,0m			······································						į			į
2,010				************			120 220					i i
	¥1/8%	7.10	4				3.0m-3.70m				1	1
	U/D	UD sam	ple was collected at 3.0-3.7	0m	-				į	1 9		
4.0m									į		į	į
.						**************************************	4.5m-4.95m	9			ļ	1
	D/S		white sandy clay						į	1 1	1	1
5.0m				- Linear Control	-				į	į į	1	î î
		CONTRACTOR	tek koningri yan daga iki izamin daga kapar kupar indake koningri daga kapa daga daga kapan daga kapan daga ka			************	5.5m -5.95m	24			1	8
	D/S		white sandy clay	and the second s	-			01				1
6.0m			White Sandy Stay						3		i	i
0.000		ministration in processing and the contract of	and common the activity of the common common common common and common co			***************************************					1	
	******	gray color v	veathered bedrock clay and	sand	-		6.5m-6.95m	H/B	į			
	W/S		(rock level 7.0m)		1							1
7.0m							,			i		
					· ·					1	Ì	į
	C/S										1	
8.0m		f. t. t.						l				
		nigniy	weathered to freshrock	. 1	30	30			j i	1		1
	C/S						and a contract of	Market Statement		į.	1	1
9.0m						***************************************				r pie		
z.VIII	The second secon		XXXXXXXXXXXX			-	Access Name and Access to the	No. State of the section of		Protestations		i innervoes
- Albertanos moreos		B(	PREHOLE WAS COMPI	ETED	ATAI	DEPTI	I OF 9.0m		diplomage was a version version.	siante		
У	ra Lightean f Night Said	andria de la Participa de la P Perticipa de la Participa de l	Remarks	a ca be suggested.				Logg	ed By		recked I	<del>уууу</del> Зу
	bed Sample		* GWT was encountered a	it depth	of 1,0 r	n belo	w the		*****************	-		*
	ed Sample turbed Samj	nta.	existing ground level	(n <b>.^</b> 1				E.K.Ch	aminda			
- Gaust Hamm	turbed Samp ier Bounce	ONG.	* Bhorehole was terminate	d under	the inst	ruction	is of					
T - Grov	md Water T	able	Mr.Raweendra (SLLRDC					Sheet N	o - 1of 1		10 (10 (10 ))	4(7)
- Core S	ample							****Alexander	The second second second		A STATE OF THE STA	L-MOTIFICATE.

Figure Q1.2 – Borehole log at BSB-10



		Remarks				
		$E_r$				
	made and facilities.	Donut		Sa	fety	•
Country		R-P	Trip	R-P	Trip/Auto	R-P = Rope-pulley or cathead
United States	·					$\eta_l = E_r / E_{rb}$
North America		45	× _	70-80	80-100	For U.S. trip / auto $w/E_r = 80$
Japan		67	78	-	MAN -	$\eta_I = 80/70 = 1.14$
United Kingdom		-	6m	50	60	
China *		50	60	~	nen	
	Rod	length	correction η <sub>2</sub>		:	
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		$\eta_2 = 0.75$			
	San	npler c	orrection η <sub>3</sub>			
Without liner			$\eta_3 = 1.00$			Base value
With liner: Dense	e sand, clay		$\eta_3 = 0.80$			N is too high with liner
With liner: Loose			$\eta_3 = 0.90$			:
AND THE RESERVE OF THE PROPERTY OF THE PROPERT	Bore hol	e diam	eter correctio	n η <sub>4</sub>		
Hole diameter		60-1	20 mm	$\eta_4 = 1.00$		Base value; $N$ is too small when
		150	0 mm	$\eta_{4} = 1.05$		have an oversize hole
		200	0 mm	$\eta_4 = 1.15$		

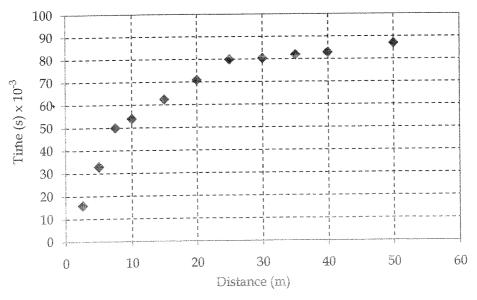


Figure Q2 – Seismic refraction survey results

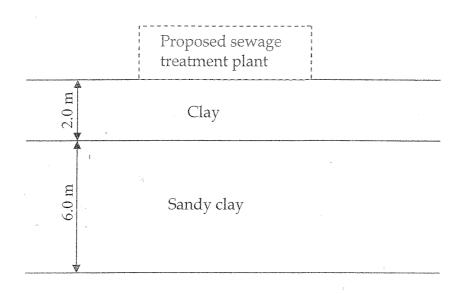


Figure Q3.1 - Sub surface soil profile

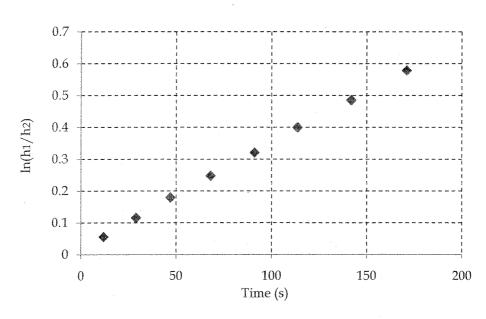


Figure Q3.2 Falling head permeability test data

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)	24.2	2.2	Zon h Zon
Steady state	6.0	4.0	3.0



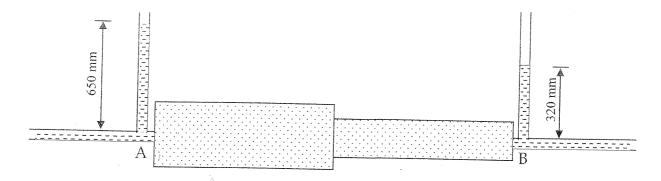


Figure Q4 Experimental setup