



UNIVERSITY OF RUHUNA

Faculty of Engineering

Mid-Semester 6 Examination in Engineering: November 2014

Module Number: CE6321

Module Name: Geotechnical Engineering

[Two Hours]

[Answer all questions, each question carries five marks]

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- Q1. Bope-Poddala Pradeshiya Sabha intended to construct a shopping complex and a fair at Kalegana junction along Galle-Wackwella road. The site plan of the proposed location is shown in Figure Q1.1. In order to do a cost effective structural design, it was decided to carryout site investigation at the particular location.
- a) Assuming that you are a junior engineer in this project, what are the information expected from this site investigation?
[1.0 Marks]
- b) Based on preliminary site investigation, it was decided to carryout sub soil exploration using 4 boreholes to find the sub surface soil profile. The boreholes locations are illustrated in Figure Q1.1. The borehole logs of BH3 and BH4 are shown in Figure Q1.2 (a) and Figure Q1.2 (b) respectively.
- i) Based on boreholes logs at BH3 and BH4, identify the sub surface soil profile of the proposed construction site.
[2.0 Marks]
- ii) Mark average SPT-*N* values at each layer.
[1.0 Marks]
- c) After looking at the site investigation report, a senior engineer in the project has a doubt on the borehole logs. As a junior engineer in the project, how do you verify the accuracy of the borehole logs?
[1.0 Marks]
- Q2. In order to renovate a "Stupa" in an ancient city, it was decided to investigate the soil profile at the particular location. However, sub surface soil exploration by drilling was not permitted due to archeological value of the area. Therefore, seismic refraction survey was selected to investigate the sub surface soil profile.
- a) What are the advantages of geophysical exploration over sub surface exploration?
[1.0 Marks]
- b) Data of seismic refraction survey is shown in Figure Q2.1.
- i) Determine the P-wave velocity of each layer.
[1.0 Marks]
- ii) Determine the thickness of each layer.
[1.5 Marks]
- iii) Determine the depth to the hard stratum from the ground surface.
[0.5 Marks]
- c) The consultant of the project stated that "it is difficult to believe the accuracy of the test results without any calibration". Do you agree with this statement? Justify your answer.
[1.0 Marks]

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

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

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

- Q3. In order to find the equivalent coefficient of permeability of two soil layers, a trainee engineer has arranged a setup as shown in Figure Q3.1. The inner diameter of the cell is 15 cm and length of each soil layer is 15 cm. Coefficient of permeability of soil layer 1 is 5×10^{-6} m/s. At steady state, seepage rate was measured and it was found to be 1.0×10^{-7} m³/s. The unit weight of water can be taken as 9.81 kN/m³.
- Determine the coefficient of permeability of soil layer 2. [2.0 Marks]
 - What would be the expected equivalent permeability of the two soil layers? [1.0 Marks]
 - If porosity of the soil layer 1 is 0.3, what would be the seepage velocity of the flow at the steady state? [1.0 Marks]
 - What would be the seepage force per unit volume in the soil layer 2? [1.0 Marks]
- Q4. Cross section of a flow underneath a concrete dam is shown in Figure Q4.1. The soil profile consists of 12.0 m thick silty sand, which has a coefficient of permeability 5.1×10^{-4} cm/s. Impermeable bed rock is found below the silty sand layer. Upstream water level is 6.0 m above the downstream water level. The unit weight of water can be taken as 9.81 kN/m³.
- In order to evaluate the seepage beneath the concrete dam, draw a flow net for the cross section shown in Figure Q4.1.
(Note: Remove the Figure Q4.1 from the Question paper and attach to your answer script) [2.5 Marks]
 - What would be the rate of seepage beneath the concrete dam? [1.0 Marks]
 - Determine the maximum exit gradient. [0.5 Marks]
 - Compute the pore water pressure at point A. [1.0 Marks]

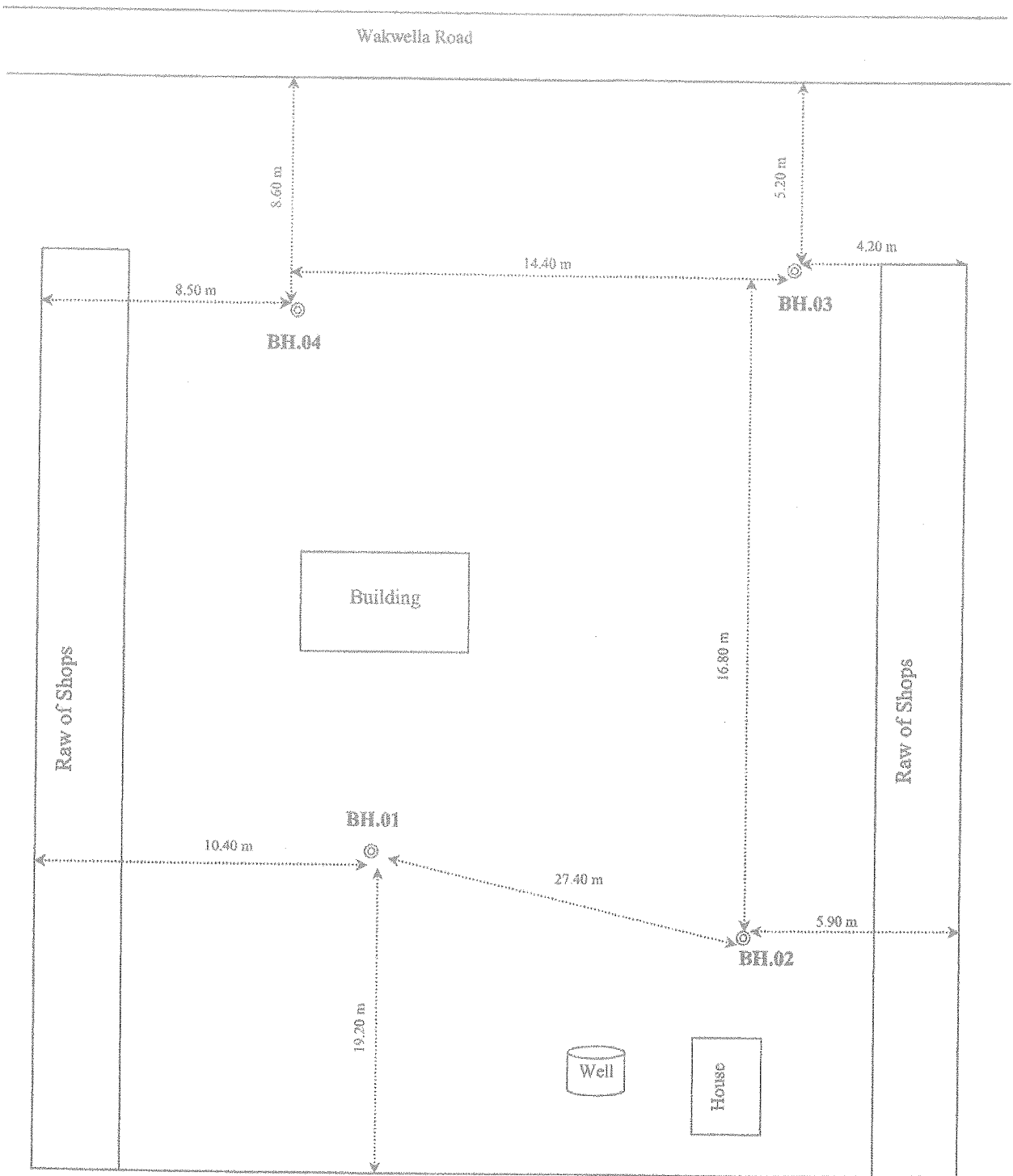


Figure Q1.1 - Site plan



Location	Kalegana, Galle				
Project	Shopping Complex & Fair	Client	Bope Poddala Pradeshiya Sabha		
Contractor					
Bore Hole#	BH.03	Starting date: -26/10/2014		Ending date: -26/10/2014	
Classification of the Soil / Rock	Depth (m)	Legend	Soil Symbol	SPT	Water Level:- 1.65 m
				"N" value	
Top soil. Dark Brown colored, Laterite type soil fill with debris.	00.00			-	
Red brown with ash colored, silty sandy clay with gravels. Weathered rock. Soil fill.	01.00			08 08 13 N=21	
Ash colored, medium to coarse Sand with traces of clay.	02.00			03 04 05 N=09	
Ash colored, coarse to very coarse Sand with traces of clay.	03.00			04 05 07 N=12	
Ash colored, coarse to very coarse Sand with traces of clay. very few angular quarts granules.	04.00			08 10 10 N=20	
Ash colored, Sandy Clay. MPS= very coarse to granules	05.00			09 11 13 N=24	
06.00					
Sample/ Test key		Remarks:		Logged By: P. Kumara	
MPS Medium Particle Size					
CR Core Recovery (%)					
HWR Highly Weathered Rock					
HB Hammer Bounced				29/10/2014	

Location	Kalegana, Galle				
Project	Shopping Complex & Fair	Client	Bope Poddala Pradeshiya Sabha		
Contractor					
Bore Hole#	BH.03Cont..	Starting date: -26/10/2014	Ending date: -26/10/2014		
Classification of the Soil / Rock	Depth (m)	Legend	Soil Symbol	SPT	Water Level:-
				"N" value	
				0 10 20 30 40 50 60	
-----change of strata ----- Off yellow colored, sticky, soft Silty Clays. Few medium quarts.	06.00			05 08 09 N=17	
Milky colored with pale yellow, Highly decomposed rock. Silty Clay. some Biotites	07.00			11 14 17 N=31	
Milky colored with light green, Highly decomposed rock. Silty Clay. some Biotites	08.00			10 13 19 N=32	
Milky colored with light green, Highly decomposed rock and some Moderately weathered rock pieces. Silty Clayey sands. Angular fine to medium quarts.	09.00			14 18 21 N=39	
Same as above. HWR	10.00			17 19 HB	
Light colored, moderately weathered rock. Quarts Feldspar rock.	10.20				
	10.30				
Borehole terminated at 10.30	11.00				
	12.00				
Sample/ Test key MPS Medium Particle Size CR Core Recovery (%) HWR Highly Weathered Rock HB Hammer Bounced	Remarks:		Logged By: P. Kumara 29/10/2014		

Figure Q1.2(a) – Borehole log BH3 at proposed construction site



Location	Kalegana, Galle				
Project	Shopping Complex & Fair	Client	Bope Poddala Pradeshiya Sabha		
Contractor					
Bore Hole#	BH.04	Starting date: -26/10/2014		Ending date: -26/10/2014	
Classification of the Soil / Rock	Depth (m)	Legend	Soil Symbol	SPT	Water Level:- 1.40 m
				"N" value	
Top soil. Ash colored, silty sandy type soils.	00.00				
Ash colored, Silty Sands. MPS= coarse to very coarse.	01.00			06 06 09 N=15	
Ash colored, Clayey Sand. MPS= Very coarse to granules.	02.00			02 04 04 N=08	
Ash colored, Stiff sandy Clay. MPS= Coarse to Very coarse	03.00			04 04 07 N=11	
Ash colored, Stiff sandy Clay. Coarse to Very coarse sand with few angular granules.	04.00			07 07 11 N=18	
Off white, Highly Decomposed rock. Silty Clay type. Coarse to very coarse with few granules.	05.00			07 08 10 N=18	
	06.00				
Sample/ Test key MPS Medium Particle Size CR Core Recovery (%) HWR Highly Weathered Rock HB Hammer Bounced		Remarks:		Logged By: P. Kumara 29/10/2014	

Location	Kalegana, Galle				
Project	Shopping Complex & Fair	Client	Bope Poddala Pradeshiya Sabha		
Contractor					
Bore Hole#	BH.04Cont..	Starting date: -26/10/2014	Ending date: -26/10/2014		
Classification of the Soil / Rock	Depth (m)	Legend	Soil Symbol	SPT	Water Level:-
				"N" value	
Off white, Highly Decomposed rock. Silty Clay type. Coarse to very coarse with few granules.	06.00			05 07 10 N=17	
Off white, Highly Decomposed rock. Clayey silty soil with few medium quarts.	07.00			10 13 18 N=31	
Milky colored, Highly Decomposed rock. Silty Sandy Clay.	08.00			11 14 18 N=32	
Milky colored with brownish yellow, Highly Decomposed rock. Clayey Sandy Silty soil. MPS= fine sands	09.00			16 19 26 N=45	
-----change of strata----- Pale yellow colored, decomposed HWR. Sandy Silty Type.	09.50			17 19 HB	
Light colored, Moderately Weathered rock. Quarts feldspar rock.	10.05				
Borehole terminated at 10.05					
	11.00				
	12.00				
Sample/ Test key MPS Medium Particle Size CR Core Recovery (%) HWR Highly Weathered Rock HB Hammer Bounced	Remarks:		Logged By: P. Kumara 29/10/2014		

Figure Q1.2(b) – Borehole log BH4 at proposed construction site

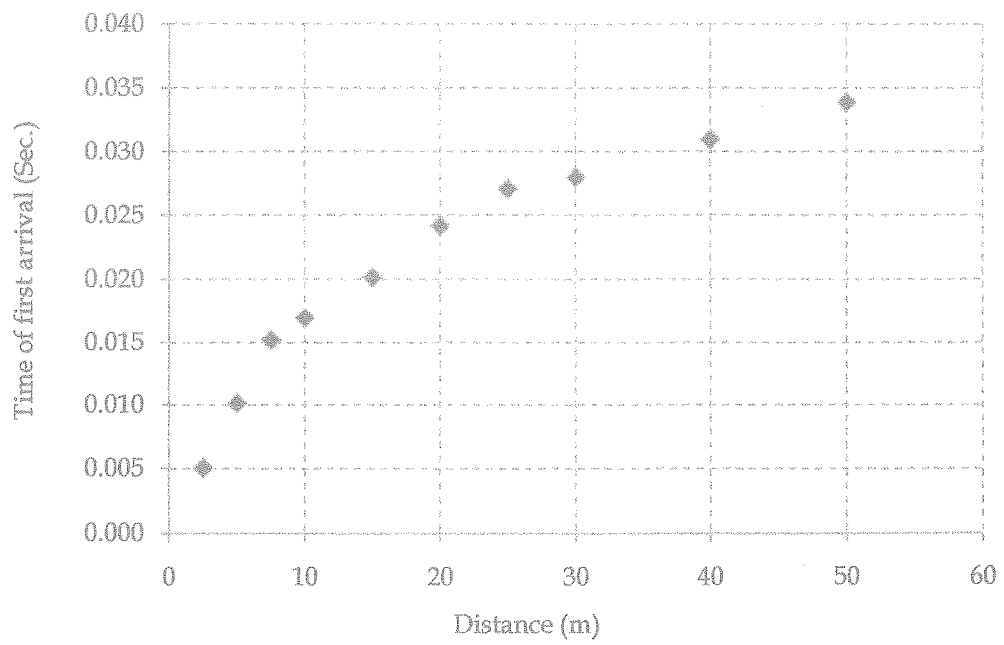


Figure Q2.1 - Seismic refraction survey results

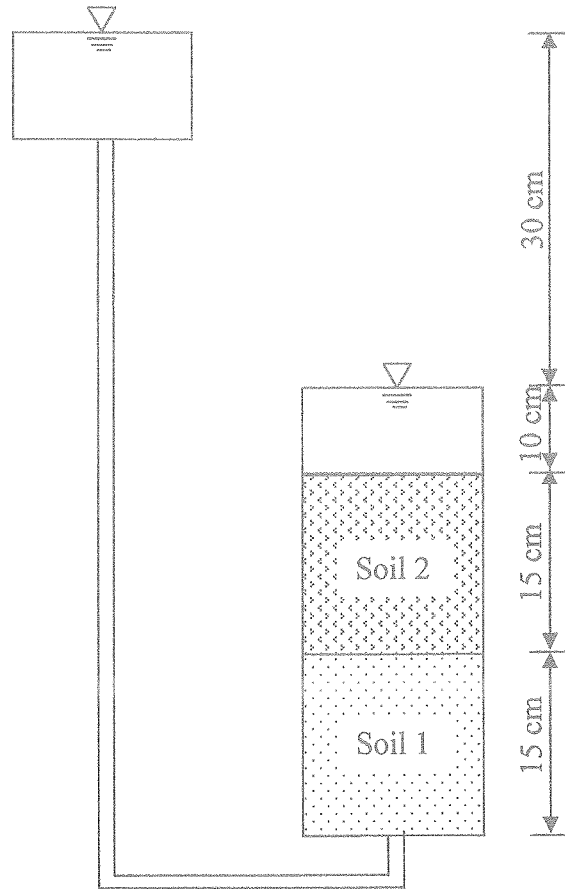


Figure Q3.1 - Experimental setup

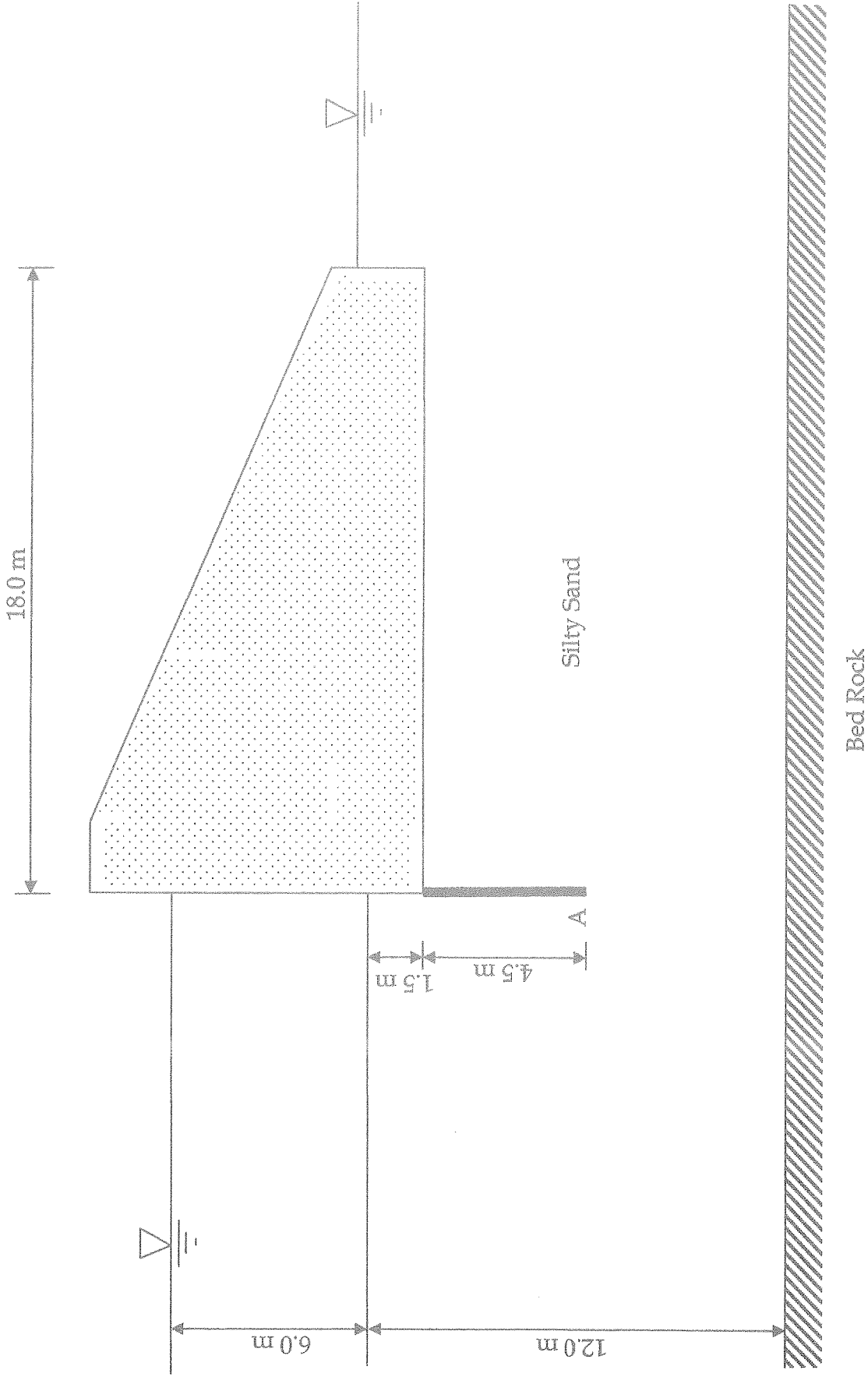


Figure Q4.1 Flow underneath a concrete dam