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UNIVERSITI TUN HUSSEIN ONN MALAYSIA

FINAL EXAMINATION
SEMESTER II
SESSION 2018/2019

COURSE NAME	:	GEOTECHNICS 1
COURSE CODE	:	BFC21702
PROGRAMME CODE	:	BFF
EXAMINATION DATE	:	JUNE / JULY 2019
DURATION	:	2 HOURS 30 MINUTES
INSTRUCTIONS	:	ANSWER **ALL** QUESTIONS IN **PART A** AND **TWO** QUESTIONS IN **PART B.**

THIS QUESTION PAPER CONSISTS OF **TWELVE (12)** PAGES

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PART A

Q1 (a) Determination of failure criterion of soil through shear strength test is possible to evaluate parameters which can then be used in geotechnical design. Briefly explain the Mohr-Coulomb failure criterion.

(5 marks)

(b) The following result in **Table Q1** was obtained from consolidated undrained test on specimens of overconsolidated clay. Based on **Table Q1**;

(i) Plot Mohr's circles of effective stress.

(7 marks)

(ii) Determine the friction angle, ϕ and cohesion, c of the effective stress.

(4 marks)

(iii) Calculate angle, θ that the failure plane makes with the major principle plane.

(3 marks)

(c) Briefly explain the total stress, effective stress, pore water pressure.

(3 marks)

(d) A sediment settling lagoon has a depth of water of 4 m above the clay base. The clay layer is 3 m thick and this overlies 4 m of medium sand, which in turn overlies impermeable rock. Given the unit weight of clay, medium sand and sediment of silty fine sand is 18 kN/m^3, 20 kN/m^3 and 16 kN/m^3, respectively. Calculate the effective stress at the top of the clay and at the top and bottom of the second layer under the following condition;

(i) Initial, before any sediment is deposited.

(6 marks)

(ii) After a 2 m layer of sediment of silty fine sand has been deposited.

(6 marks)

(iii) After draining the lagoon down to base level, with the same thickness (2 m) of sediment still in place.

(6 marks)

PART B

Q2 (a) Infradesa Sdn Bhd was appointed by PLUS Malaysia to construct a new road interchanges from Alor Gajah to Asahan. As a Quality Control (QC) Highway Engineer, you are required to carry out a series of soil test on the existing subgrade. Propose a type of most suitable control test that commonly used to determine the size distribution of fine-grained soils in laboratory. Discuss with a relevant illustration of a diagram the working principle of it.

(4 marks)

(b) A soil sample was collected in Kundasang, Sabah, it is denoted as sample K has and has been sieved for design purposes and the results are shown in **Figure Q2(a)**.

(i) Determine the percentages of gravel, sand, silt and clay of each soil based on USCS classification in **Figure Q2(b)**.

(5 marks)

(ii) Classify the sample K based on **Table 2(a)** and use **Figure Q2(c)** or **Figure Q2(d),** given liquid limit and plastic limit of sample K is 38% and 31%, respectively.

(6 marks)

(c) Soil has interconnected voids through which water can flow from points of high energy to point of low energy. It is necessary for estimating the quantity of underground seepage under various hydraulic conditions. Based on that statement;

(i) Briefly explain the discharge velocity of water.

(2 marks)

(ii) If discharge velocity of water through a soil is 24 cm/hr and soil porosity is 30%, determine the seepage velocity of the water.

(2 marks)

(d) In a constant head permeability test in the laboratory as shown in **Figure Q2(e)**, the data is recorded in **Table Q2(b)**. The void ratio of the soil specimen is 0.46. Determine;

(i) Hydraulic conductivity, k, of the soil in cm/sec.

(7 marks)

(ii) Discharge velocity in cm/sec.

(4 marks)

Q3 (a) Geotechnical engineers have developed a series of weight-volume parameters to describe the portion of each phase. List and formulate **FOUR (4)** parameters that can be derived from weight-volume relationship.

(4 marks)

(b) An undisturbed soil sample was prepared for a triaxial testing. The cylindrical soil sample is 50 mm in diameter and 100 mm long. It has a mass of 360 g. After finding the mass of the entire sample, a small portion was removed and a moisture content test was performed on it. The result of the moisture content test is shown in **Table 3(a)**. Given the specific gravity, G_s is 2.70.

(i) Compute the moisture content (%) of the soil sample.

(2 marks)

(ii) By using the soil phase diagram, determine the bulk density (kg/m^3), dry density (kg/m^3), void ratio, porosity (%) and degree of saturation (%) of the soil sample.

(9 marks)

(c) In the laboratory compaction test, there are two methods of testing namely standard Proctor test and modified Proctor test. Briefly explain the advantage of modified proctor test as compared to standard Proctor test.

(4 marks)

(d) A sand cone test has been performed in a recently compacted fill. The test results obtained are as shown in **Table 3(b)**.

(i) Determine the dry density of compaction in the field

(6 marks)

(ii) Calculate the maximum dry density from standard Proctor test if the relative compaction is 90%.

(2 marks)

(iii) Determine the degree of saturation of the compacted fill if the specific gravity of the soil is 2.65.

(3 marks)

Q4 (a) Differentiate between compaction and consolidation process.

(4 marks)

(b) The results from standard proctor test shows that the weight of the soil with the mould is 3.85 kg and the weight of the mould is 1.98 kg. The diameter of the mould is 116 mm and its height is 102 mm. The moisture content recorded in this test is 12 %. Determine the wet and dry unit weight of the specimen in kN/m^3.

(6 marks)

(c) A soil sample was taken from a site of a proposed borrow pits and sent to the laboratory for a Standard Proctor test. Results of the test are as recorded in **Table Q4**. Plot moisture content versus dry unit weight curve and determine the soil's maximum dry unit weight and also optimum moisture content.

(7 marks)

(c) Sketch and describe confined and unconfined aquifer of soil.

(6 marks)

(d) A pumping test was carried out in confined aquifer thickness 2 m and the following measurement was recorded. Rate of pumping was 10 m^3/s; drawdown in pumping well was 2.0 m while on the observation well located at 15 m and 20 m from the centre of the pumping well were 1.6 m and 1.4 m, respectively. Determine the hydraulic conductivity of soil.

(7 marks)

– END OF QUESTIONS –

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TABLE Q1: Result from consolidated undrained test on overconsolidated clay

Specimen	Confining Pressure (kN/m^2)	Deviator Stress at Failure (kN/m^2)	Pore Water Pressure (kN/m^2)
1	100	340	- 42
2	400	474	177

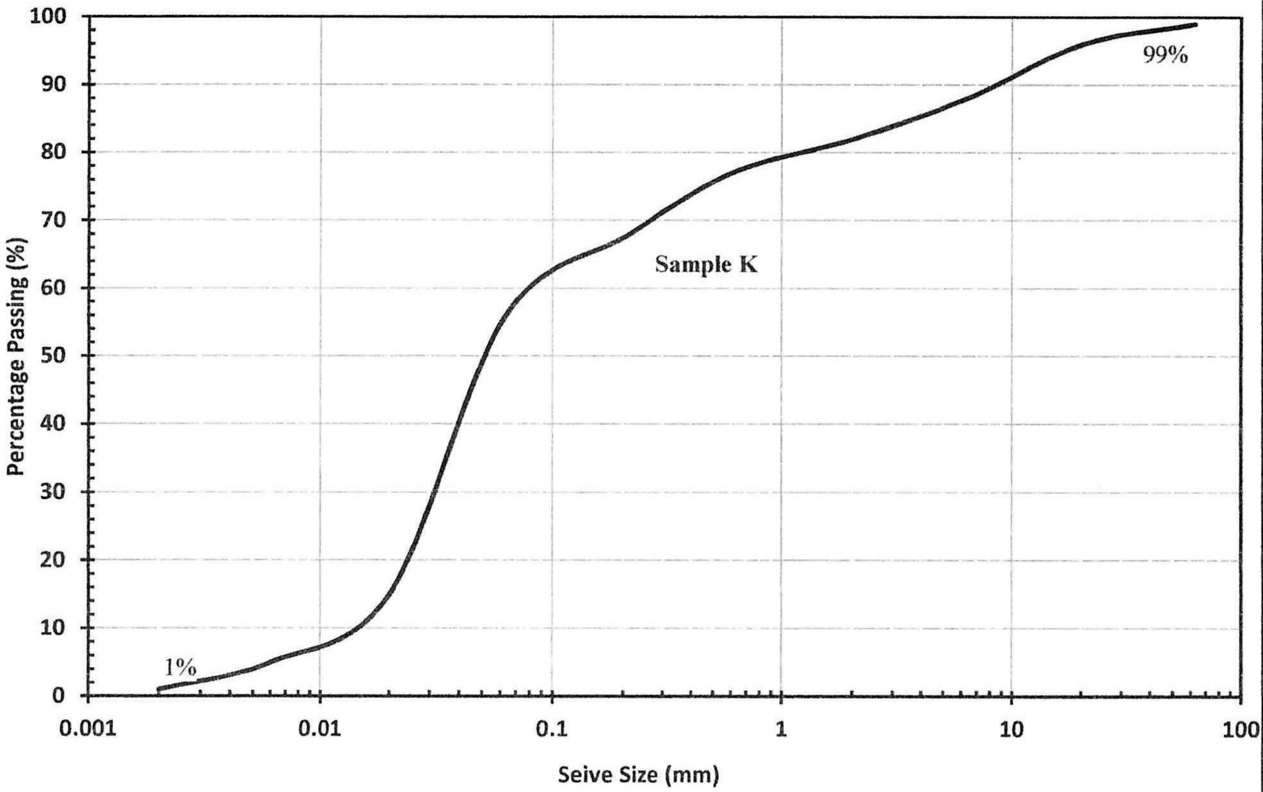

FIGURE Q2(a): Results from particle size analysis collected in Kundasang, Sabah

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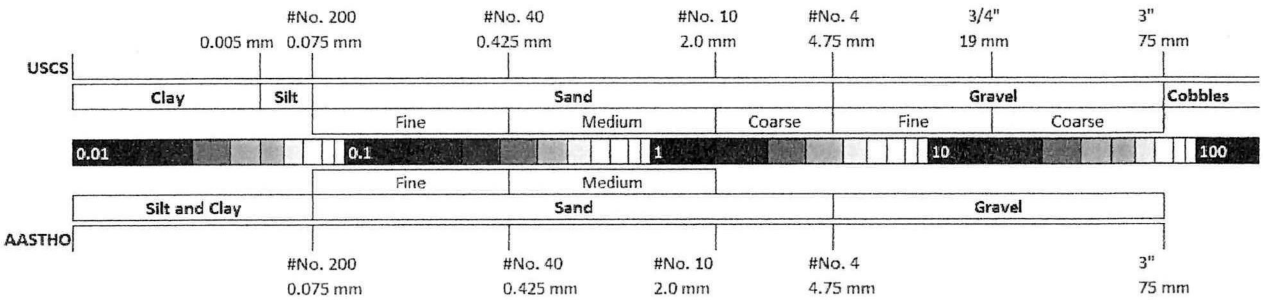

FIGURE Q2(b): Particle size classification for USCS and AASHTO

TABLE Q2(a): The Unified Soil Classification System (USCS)

Criteria for assigning group symbols				**Group symbol**
Coarse-grained soils More than 50% retained on No. 200 sieve	**Gravels** More than 50% of coarse fraction retained on No. 4 sieve	Clean Gravels Less than 5% fines[a]	$C_u \geq 4$ and $1 \leq C_c \leq 3^c$	GW
			$C_u < 4$ and/or $C_c < 1$ or $C_c > 3^c$	GP
		Gravels with Fines More than 12% fines[a,d]	$PI < 4$ or plots below "A" line	GM
			$PI > 7$ and plots on or above "A" line	GC
	Sands 50% or more of coarse fraction passes No.4 sieve	Clean Sands Less than 5% fines[b]	$C_u \geq 6$ and $1 \leq C_c \leq 3^c$	SW
			$C_u < 6$ and/or $C_c < 1$ or $C_c > 3^c$	SP
		Sands with Fines More than 12% fines[b,d]	$PI < 4$ or plots below "A" line	SM
			$PI > 7$ and plots on or above "A" line	SC
Fine-grained soils 50% or more passes No.200 sieve	**Silts and clays** Liquid limit less than 50	Inorganic	$PI > 7$ and plots on or above "A" line[e]	CL
			$PI < 4$ or plots below "A" line[e]	ML
		Organic	$\frac{\text{Liquid limit - oven dried}}{\text{Liquid limit - not dried}} < 0.75$ OL zone	OL
	Silts and clays Liquid limit 50 or more	Inorganic	PI plots on or above "A" line	CH
			PI plots on below "A" line	MH
		Organic	$\frac{\text{Liquid limit - oven dried}}{\text{Liquid limit - not dried}} < 0.75$ OH zone	OH
Highly organic soils	Primarily organic matter, dark in color, and organic odor			Pt

[a]Gravels with 5 to 12% fine require dual symbils: GW-GM, GW-GC, GP-GM, GP-GC.
[b]Sands with 5 to 12% fines require dual symbols: SW-SM, SW-SC, SP-SM, SP-SC.
[c]$C_u = D_{60}/D_{10}$; $C_c = (D_{30})^2/D_{60} \times D_{10}$
[d]If $4 \leq PI \leq 7$, use dual symbol GC-GM or SC-SM.
[e]If $4 \leq PI \leq 7$, use dual symbol CL-ML.

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Group symbol		Group name
GW	<15% sand	Well-graded gravel
	≥15% sand	Well-graded gravel with sand
GP	<15% sand	Poorly graded gravel
	≥15% sand	Poorly graded gravel with sand
GW-GM	<15% sand	Well-graded gravel with silt
	≥15% sand	Well-graded gravel with silt and sand
GW-GC	<15% sand	Well-graded gravel with clay (or silty clay)
	≥15% sand	Well-graded gravel with clay and sand (or silty clay and sand)
GP-GM	<15% sand	Poorly graded gravel with silt
	≥15% sand	Poorly graded gravel with silt and sand
GP-GC	<15% sand	Poorly graded gravel with clay (or silty clay)
	≥15% sand	Poorly graded gravel with clay and sand (or silty clay and sand)
GM	<15% sand	Silty gravel
	≥15% sand	Silty gravel with sand
GC	<15% sand	Clayey gravel
	≥15% sand	Clayey gravel with sand
GC-GM	<15% sand	Silty clayey gravel
	≥15% sand	Silty clayey gravel with sand
SW	<15% gravel	Well-graded sand
	≥15% gravel	Well-graded sand with gravel
SP	<15% gravel	Poorly graded sand
	≥15% gravel	Poorly graded sand with gravel
SW-SM	<15% gravel	Well-graded sand with silt
	≥15% gravel	Well-graded sand with silt and gravel
SW-SC	<15% gravel	Well-graded sand with clay (or silty clay)
	≥15% gravel	Well-graded sand with clay and gravel (or silty clay and gravel)
SP-SM	<15% gravel	Poorly graded sand with silt
	≥15% gravel	Poorly graded sand with silt and gravel
SP-SC	<15% gravel	Poorly graded sand with clay (or silty clay)
	≥15% gravel	Poorly graded sand with clay and gravel (or silty clay and gravel)
SM	<15% gravel	Silty sand
	≥15% gravel	Silty sand with gravel
SC	<15% gravel	Clayey sand
	≥15% gravel	Clayey sand with gravel
SC-SM	<15% gravel	Silty clayey sand
	≥15% gravel	Silty clayey sand with gravel

FIGURE Q2(c): Flowchart group names for gravelly and sandy soils

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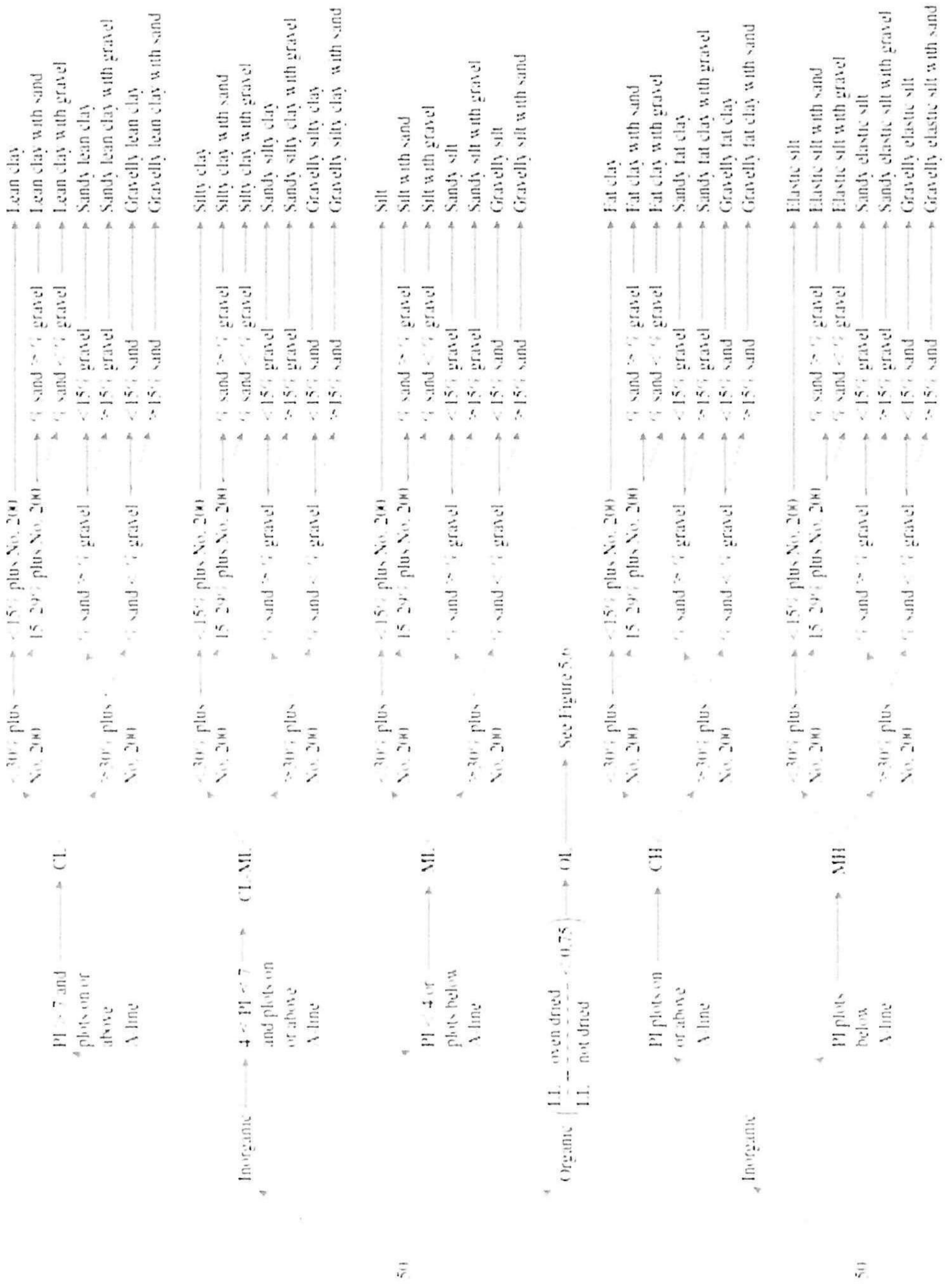

FIGURE Q2(d): Flowchart group names for inorganic silty and clayey soils

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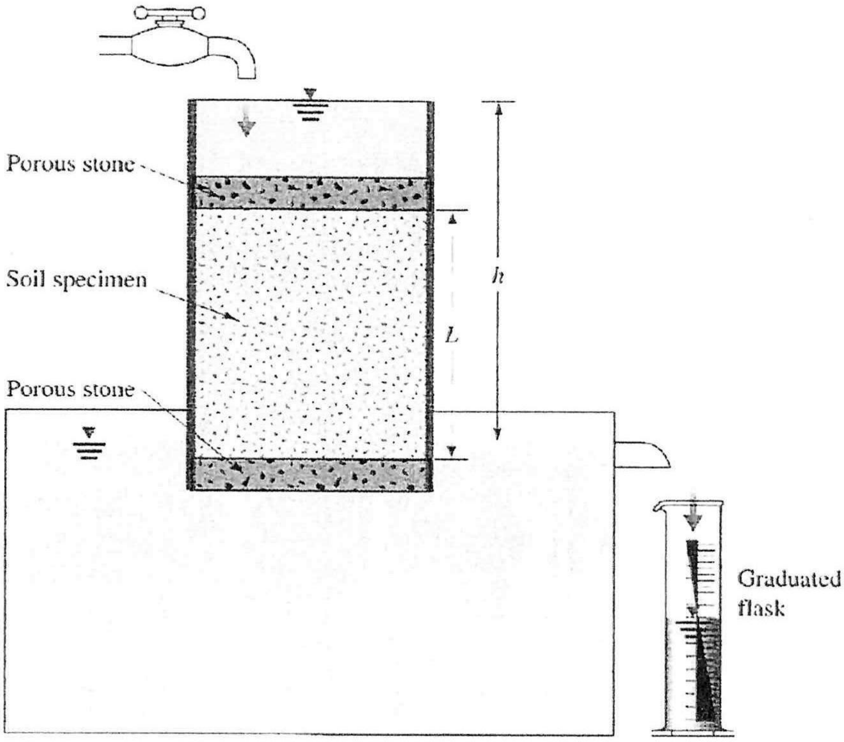

Figure Q2(e): A constant head permeability test

Table Q2(b): Constant head data

Length of Specimen	305 mm
Diameter of specimen	150 mm
Head different	500 mm
Water collected in 5 min	350 cm^3

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Table Q3(a): Moisture content test result

Item	Value	Unit
Mass of can	22	gram
Mass of can + moist soil	125	gram
Mass of can + dry soil	113	gram
Mass of moisture	?	gram
Mass of dry soil	?	gram
Moisture content	?	%

Table Q3(b): Sand cone replacement test result

Item	Value	Unit
Calibrated dry density of Ottawa sand	1731	kg/m^3
Mass of Ottawa sand to fill the cone	0.118	kg
Mass of jar + cone + sand (before use)	6.08	kg
Mass of jar + cone + sand (after use)	2.86	kg
Mass of moist soil from hole	3.34	kg
Moisture content of moist soil	13	%

Table Q4: Sand cone replacement test result

No.	1	2	3	4	5
Dry unit weight (kN/m^3)	16.80	17.12	17.59	17.44	16.81
Moisture content (%)	9.1	11.8	14.0	16.5	18.9

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EQUATION LIST

The following information may be useful. The symbols have their usual meaning.

$$\gamma = \frac{W}{V_m}$$

$$\rho_d = \frac{G_s \rho_w}{1 + \frac{wG_s}{S_r}}$$

$$\gamma_d = \frac{\gamma}{1 + \frac{w(\%)}{100}}$$

$$\gamma_d = \frac{G_s \gamma_w}{1 + \frac{G_s w}{S}}$$

$$\tau' = c + \sigma_n' \tan\phi'$$

$$E = \frac{\text{Number of Blow/Layer} \times \text{number of Layer} \times \text{Weight of Hammer} \times \text{Hight of Drop}}{\text{Mold Volume}}$$

$$\sigma_1 = \sigma_3 \tan^2\left(45^\circ + \frac{\phi}{2}\right) + 2c\tan\left(45^\circ + \frac{\phi}{2}\right)$$

$$\sigma_3 = \sigma_1 \tan^2\left(45^\circ - \frac{\phi}{2}\right) - 2c\tan\left(45^\circ - \frac{\phi}{2}\right)$$

$$\sigma_n = \frac{\sigma_1 + \sigma_3}{2} + \frac{\sigma_1 - \sigma_3}{2}\cos 2\theta$$

$$q_i = Ak_{eq} i$$

$$\tau_f = \frac{\sigma_1 - \sigma_3}{2}\sin 2\theta$$

$$k = \frac{q}{Ai}$$

$$k = 2.303\frac{aL}{At}\log_{10}\frac{h_1}{h_2}$$

$$k_{eq} = \sqrt{k_z k_x}$$

$$k = \frac{QL}{Aht}$$

$$i = \frac{\Delta h}{L}$$

$$k = \frac{q\log_{10}\left(\frac{r_1}{r_2}\right)}{2.727H(h_1 - h_2)}$$

$$k = \frac{2.303q\log_{10}\left(\frac{r_1}{r_2}\right)}{\pi(h_1^2 - h_2^2)}$$