UNIVERSITY OF BOLTON

SCHOOL OF THE BUILT ENVIRONMENT & ENGINEERING

BSc(HONS) CIVIL ENGINEERING

SEMESTER ONE EXAMINATION 2010/2011

SOIL MECHANICS

MODULE NO: BLT1013

Date: Wednesday 19 January 2011 **Time: 10.00 am – 12.00 noon**

INSTRUCTIONS TO CANDIDATES:

There are FOUR questions.

Answer THREE questions.

All questions carry equal marks.

Marks for parts of questions are shown in brackets.

Formulae and Definitions are provided on pages 10 to 12.

Lined Graph Paper and Supplementary Answer Sheets are available for your use.

Detach Figures Q2, Q3-1 and/or Q3-2 and insert into your Answer Booklet using Treasury Tags.

Ensure that you write your Candidate Number or Desk Number on each Figure, Supplementary Sheet or Sheet of Graph Paper you use to answer the selected questions.

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Q1. (a) Sketch a "Soil Model Diagram" ensuring that you annotate every term on your soil model diagram with the corresponding 'algebraic term' for the respective mass and volume of the solids, water and air
(NOTE: Do NOT simply use the terms M_A, M_W, M_S, V_A, V_W and/or V_S).

(3 marks)

(b) Using the soil model diagram outlined in Q1(a) show the algebraic expression for the following 'soil properties';

(i) Bulk Density, ρ_b

(ii) Dry Density, ρ_d

(iii) Degree of Saturation, S_r

(iv) Air Void Content, A_v

(NOTE: Do NOT simply use the terms M_A, M_W, M_S, V_A, V_W and/or V_S).

(6 marks)

(c) A cylindrical sample of soil has a height of 205mm and a diameter of 102.4mm. The sample was found to have an initial "bulk" mass of 3.735kg. After placing in an oven at 105^{o}C for 24hrs the mass was found to be 3.306kg. The specific gravity, G_s of the soil particles was determined as 2.71.

Determine EACH of the following soil properties (either using the Soil Model approach as outlined in Q1(a) and Q1(b) or by using the Formulae provided on Pages 9 to 11 at the end of this Examination Paper);

(i) Bulk density (kg/m^3)

(ii) Bulk unit weight (kN/m^3)

(iii) Moisture content, %

(iv) Void ratio

(v) Porosity, %

Question 1 continued over the page…

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Question 1 continued

(vi) Degree of saturation, %

(vii) Air void content, %

(viii) If the soil volume remains constant, what would be the saturated unit weight of the soil on inundation (kN/m^3)

(16 marks)

Total 25 marks

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Q2 (a) Sketch how the results from a 2.5kg 'light', 4.5kg 'heavy' and 'vibrating rammer' compaction tests would plot on the same graph in relationship to the 0% air voids (ie. saturation) line in accordance with BS1377.

(5 marks)

(b) A British Standard 2.5kg 'light' Compaction test on a soil sample (G_s = 2.71) gave the following results:

Moisture Content %	**Bulk Density (kg/m^3)**
7	1770
9	1980
11	2170
13	2215
15	2190
17	2150

(i) Using the data in the table above, carry out any calculations necessary and then plot the results of this compaction test on Figure Q2. From the plotted data on Figure Q2 determine appropriate compaction characteristics for this soil. Ensure that you describe this using the simple terms routinely used in soil mechanics.

(12 marks)

(ii) Calculate the air void content for the soil at 10% moisture content.

(1 mark)

(c) Describe the main features of a Highway Agency 'Method Specification' for project management purposes to control placement of suitable sandy clay soil in an 8m high embankment for the construction of a new motorway.

(4 marks)

(d) State how checks are made on site to decide whether compaction works conform to the requirements of a 'Performance Specification'.

(3 marks)

Total 25 marks

Question 2 continued over the page…

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Question 2 continued

LIGHT COMPACTION TEST

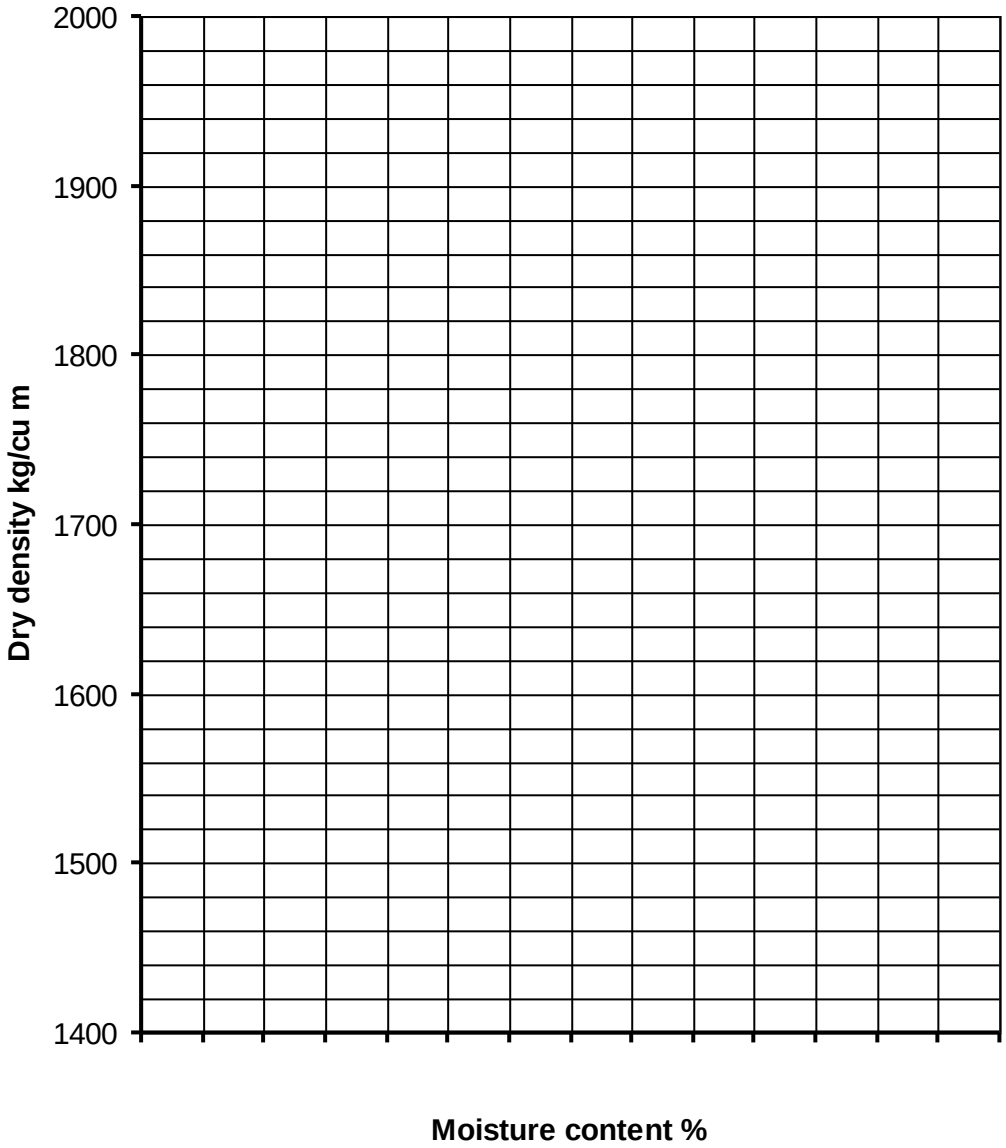

Figure Q2

Seat / Candidate Number ……

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Q3. (a) Describe how a “coarse” soil would be classified in accordance with BS1377.

(5 marks)

(b) Describe how a “fine” soil would be classified in accordance with BS1377.

(5 marks)

(c) Describe how a soil would be visually described in the field during the sampling stage of a site investigation, and provide examples of soil descriptions to include both “fine” and “coarse” soils.

(5 marks)

(d) The results of a classification test conducted on a soil sample are shown below;

Plastic limit test:

	Test 1	Test 2
Mass of empty tin (g)	17.56	17.65
Mass of tin + wet soil (g)	45.12	42.12
Mass of tin + oven dried soil (g)	40.10	37.60

Liquid limit test:

Cone penetration (mm)	16.87	18.92	21.45	23.89
Moisture content (%)	30.57	34.05	37.95	41.91

(i) Using Fig Q3-1, as appropriate, determine the ‘Index Properties” for this soil. Ensure that you fully define what the “Index Properties” are for fine-grained soils.

(8 marks)

(ii) Provide a soil classification name and symbol for this soil using Fig.Q3-2.

(2 marks)

Total 25 marks

Question 3 continued over the page…

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Question 3 continued

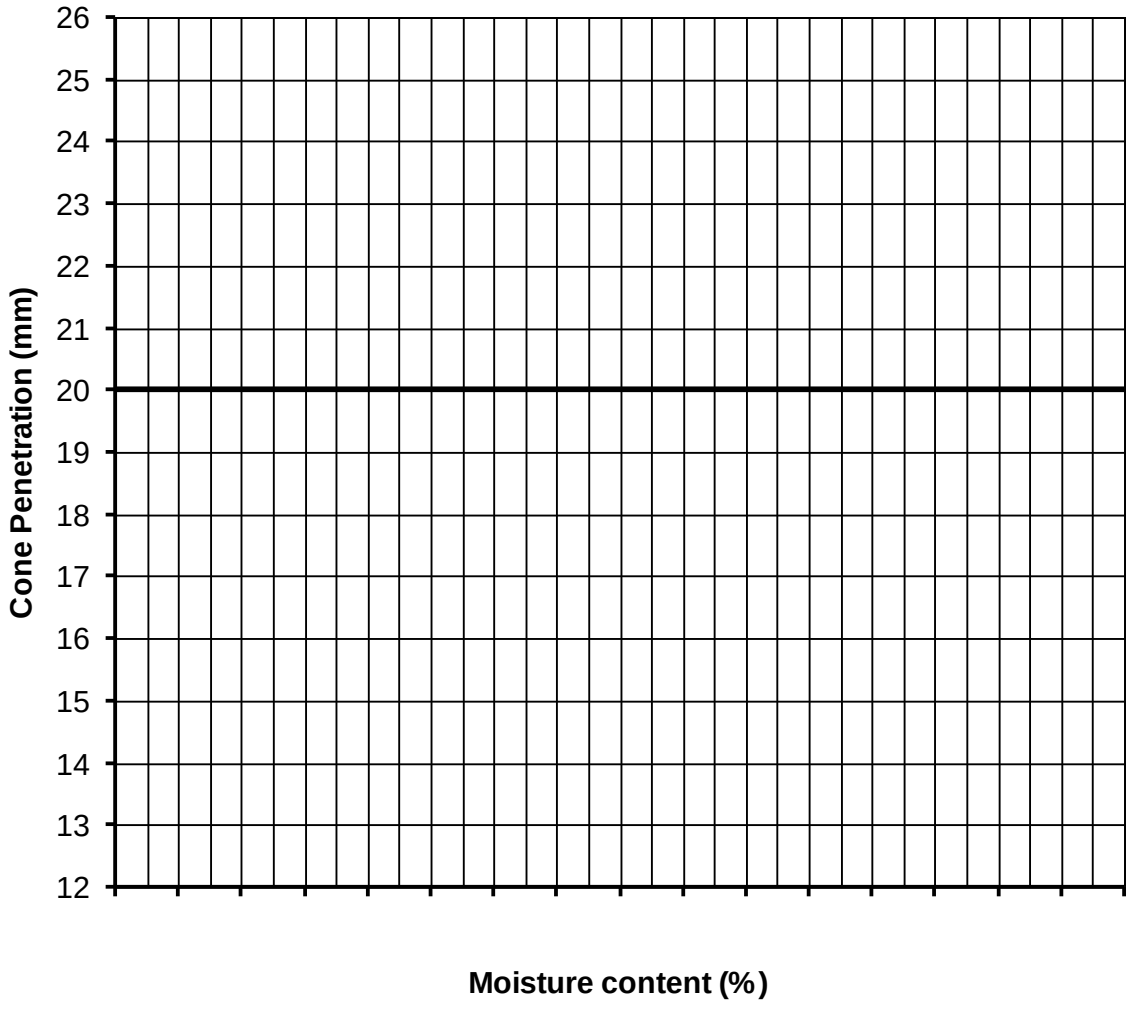

Figure Q3-1

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Question 3 continued over the page…

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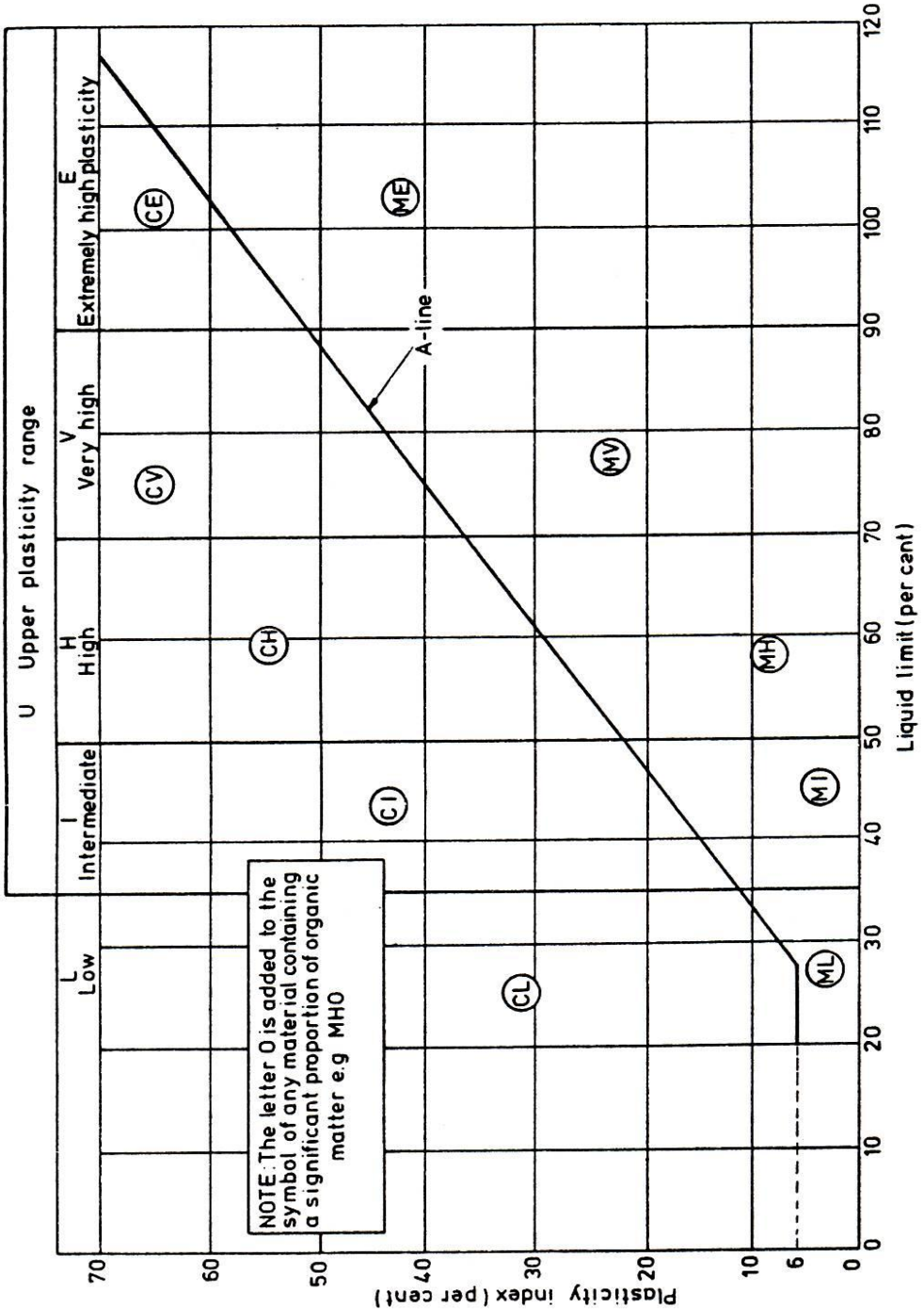

Figure Q3-2

Seat / Candidate Number ……

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Q4. (a) Describe in detail the preliminary office-based compilation of information used for a comprehensive ground investigation of a former industrial site in a town centre location, citing all reference sources you deem appropriate. Also provide an example of how the reference data would influence the intrusive/sampling stage of the ground investigation.

(7 marks)

(b) Outline the main methods of undertaking an intrusive ground investigation and describe in detail the full range of equipment that would be used to facilitate a comprehensive ground investigation of a former industrial site in a town centre location, where it is known that mixed sands and clays are expected to rest over sandstone, with the sandstone not being encountered until a depth of around 10m.

(7 marks)

(c) Describe, with the aid of a sketch diagram, if necessary, how an SPT test is carried out in firm to stiff sandy CLAY and also in a medium dense coarse GRAVEL. Ensure that your answer shows the equipment parts used and also states how the test results from an SPT test are written down and interpreted. Provide an example of a set of results and thus show how those results would be interpreted for both the CLAY and also the GRAVEL.

(7 marks)

(d) Describe how ‘disturbed’ and ‘undisturbed’ samples are obtained during a ground investigation.

(4 marks)

Total 25 marks

END OF QUESTIONS

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TERMINOLOGY, SYMBOLS AND UNITS

Term	Symbol	Units
Volume	V	m^3
Litre	l	Litre (= 1 x 10^{-3} m^3)
Mass	M	kg
Gravity	g	9.81 m/sec^2
Weight		kN = (kg x 9.81)/1000
Total volume	V	m^3
Volume of air	V_A	m^3
Volume of water	V_W	m^3
Volume of voids	V_V	m^3
Volume of solids	V_S	m^3
Mass of water	M_W	kg
Mass of solids	M_S	kg
Weight of water	W_W	kN
Weight of solids	W_S	kN
Total weight	W	kN
Specific gravity	G_s	None
Density of water	ρ_w	1000 kg/m^3
Unit weight of water	γ_w	9.81 kN/m^3
Void ratio	e	None
Degree of saturation	S_r	None
Moisture content	w	None
Porosity	n	None
Air void content	A_v	None
Bulk density	ρ_b	kg/m^3
Dry density	ρ_d	kg/m^3
Saturated density	ρ_{sat}	kg/m^3
Bulk unit weight	γ_b	kN/m^3
Dry unit weight	γ_d	kN/m^3
Saturated unit weight	γ_{sat}	kN/m^3

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FORMULAE

	Density kg/m^3	Unit weight kN/m^3
1	$\rho_b = \frac{\rho_W (G_s + e\, S_r)}{1 + e}$	$\gamma_b = \frac{\gamma_w (G_s + e\, S_r)}{1 + e}$
2	$\rho_b = \frac{\rho_W G_s (1 + w)}{1 + e}$	$\gamma_b = \frac{\gamma_w G_s (1 + w)}{1 + e}$
3	$\rho_d = \frac{\rho_W G_s}{1 + e}$	$\gamma_d = \frac{\gamma_w G_s}{1 + e}$
4	$\rho_{sat} = \frac{\rho_W (G_s + e)}{1 + e}$	$\gamma_{sat} = \frac{\gamma_w (G_s + e)}{1 + e}$
5	$w\, G_s = e\, S_r$	

Transposing the above expressions:

	From 3 above;	From 3 above;
6	$e = \frac{\rho_W G_s}{\rho_d} - 1$	$e = \frac{\gamma_W G_s}{\gamma_d} - 1$
7	$\rho_d \max = \frac{\rho_W G_s (1 - A_v)}{1 + w\, G_s}$	$\gamma_d \max = \frac{\gamma_w G_s (1 - A_v)}{1 + w\, G_s}$

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DEFINITIONS

Density of water, ρ_w	mass of water / volume of water	M_w / V_w
Unit weight of water, γ_w	weight of water / volume of water	W_w / V_w
Specific gravity, G_s	density of solids / density of water	ρ_s / ρ_w
Moisture content, w	mass of water / mass of solids	M_w / M_s
Void ratio, e	volume of voids / volume of solids	V_v / V_s
Degree of saturation, S_r	volume of water / volume of voids	V_w / V_v
Porosity, n	volume of voids / total volume	V_v / V
Bulk density, ρ_b	total mass / total volume	M / V
Dry density, ρ_d	mass of solids / total volume	M_s / V
Saturated density, ρ_{sat}	total saturated mass / total volume	M / V
Bulk unit weight, γ_b	total weight / total volume	W / V
Dry unit weight, γ_d	weight of solids / total volume	W_s / V
Saturated unit weight, γ_{sat}	total saturated weight / total volume	W / V

END OF PAPER