UNIVERSITY OF BOLTON

SCHOOL OF THE BUILT ENVIRONMENT & ENGINEERING

BSc(HONS) CIVIL ENGINEERING

SEMESTER ONE EXAMINATION 2009/2010

SOIL MECHANICS

MODULE NO: BLT1013

Date: Wednesday 20 January 2010 **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) A “soil model” diagram is often used as a method of deriving algebraic expressions for “soil property” calculations. 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.

(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

(8 marks)

(c) A cylindrical sample of soil has a length of 100mm and a diameter of 50mm. The sample was found to have an initial “bulk” mass of 397g. After placing in an oven at 105^{o}C for 24hrs the mass was found to be 323g. The specific gravity, G_s of the soil particles was determined as 2.7.

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, %

(vi) Degree of saturation, %

(vii) Air void content, %

(14 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 'light' Compaction test on a soil sample (G_s = 2.68) gave the following results:

Moisture Content %	**Bulk Density (kg/m^3)**
6.25	1820
6.85	1935
7.35	2015
8.05	2060
8.75	2015
9.45	1925

(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 a moisture content of 9%.

(1 mark)

Question 2 continued over the page…

Question 2 continued

(c) Describe the main features of a Highway Agency ‘Method Specification’ for project management purposes to control placement of suitable sandy clay soil in a 4m 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…

Question 2 continued

LIGHT COMPACTION TEST

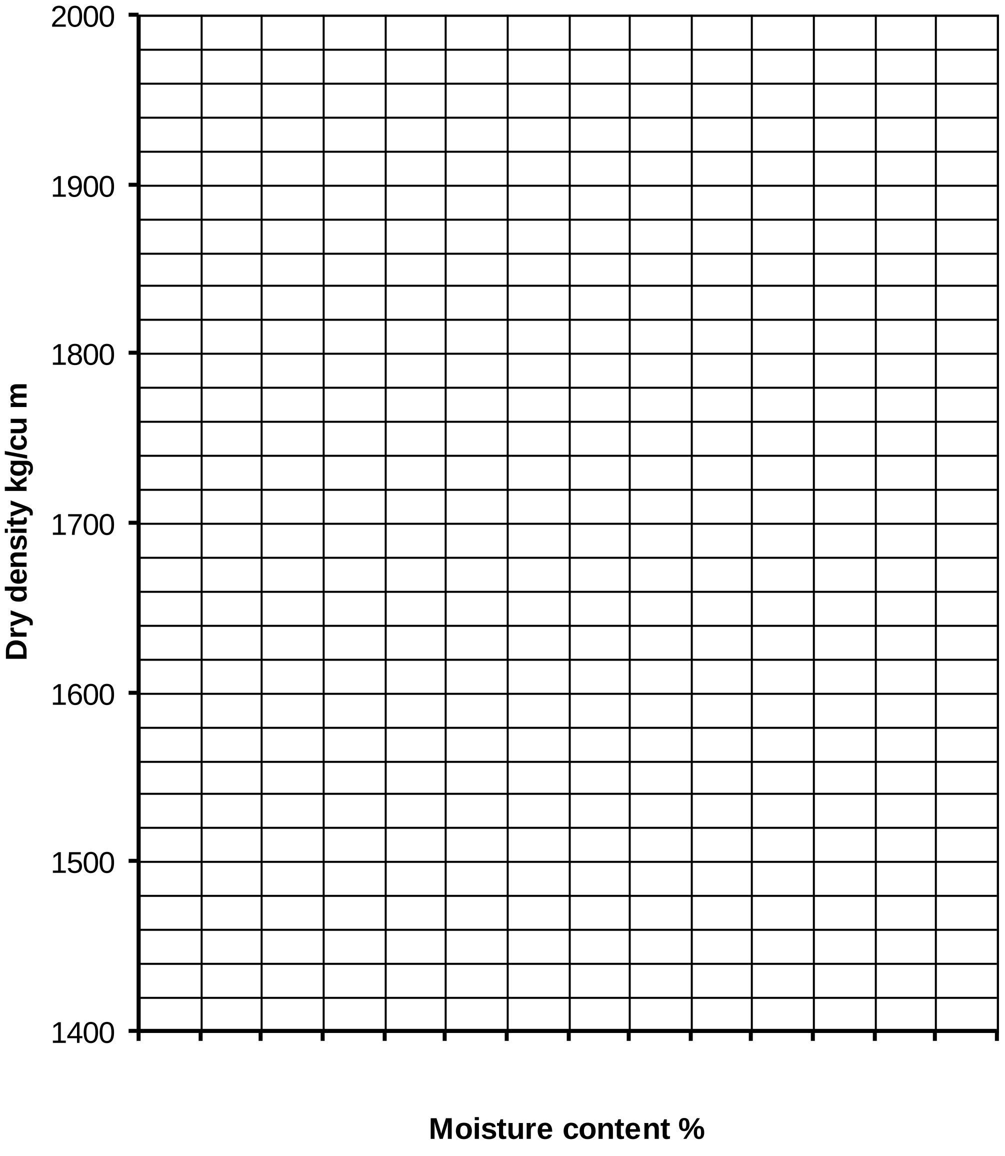

Figure Q2

Seat / Candidate Number ……………………………………….

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Q3. (a) Describe why there is a distinct difference between the BS1377 classification testing methods used in a laboratory for fine-grained and coarse-grained soils. Ensure that you state the principal differences between these soil types and describe how these differences alter the behaviour of fine-grained soils from that of coarse-grained soils.

(8 marks)

(b) Fine-grained and coarse-grained soils are described using a procedure based on visual observations according to BS5930. Provide an example description for a coarse-grained soil (NOTE: ensure that you use the correct order and full range of terms as would be written down in a professionally produced borehole log for a specific soil stratum).

(5 marks)

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

Plastic limit test:

	Test 1	Test 2
Mass of empty tin (g)	17.15	16.72
Mass of tin + wet soil (g)	43.21	42.12
Mass of tin + oven dried soil (g)	38.85	37.90

Liquid limit test:

Cone penetration (mm)	16.13	18.79	21.39	24.41
Moisture content (%)	44.92	52.48	60.87	71.62

(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.

(10 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

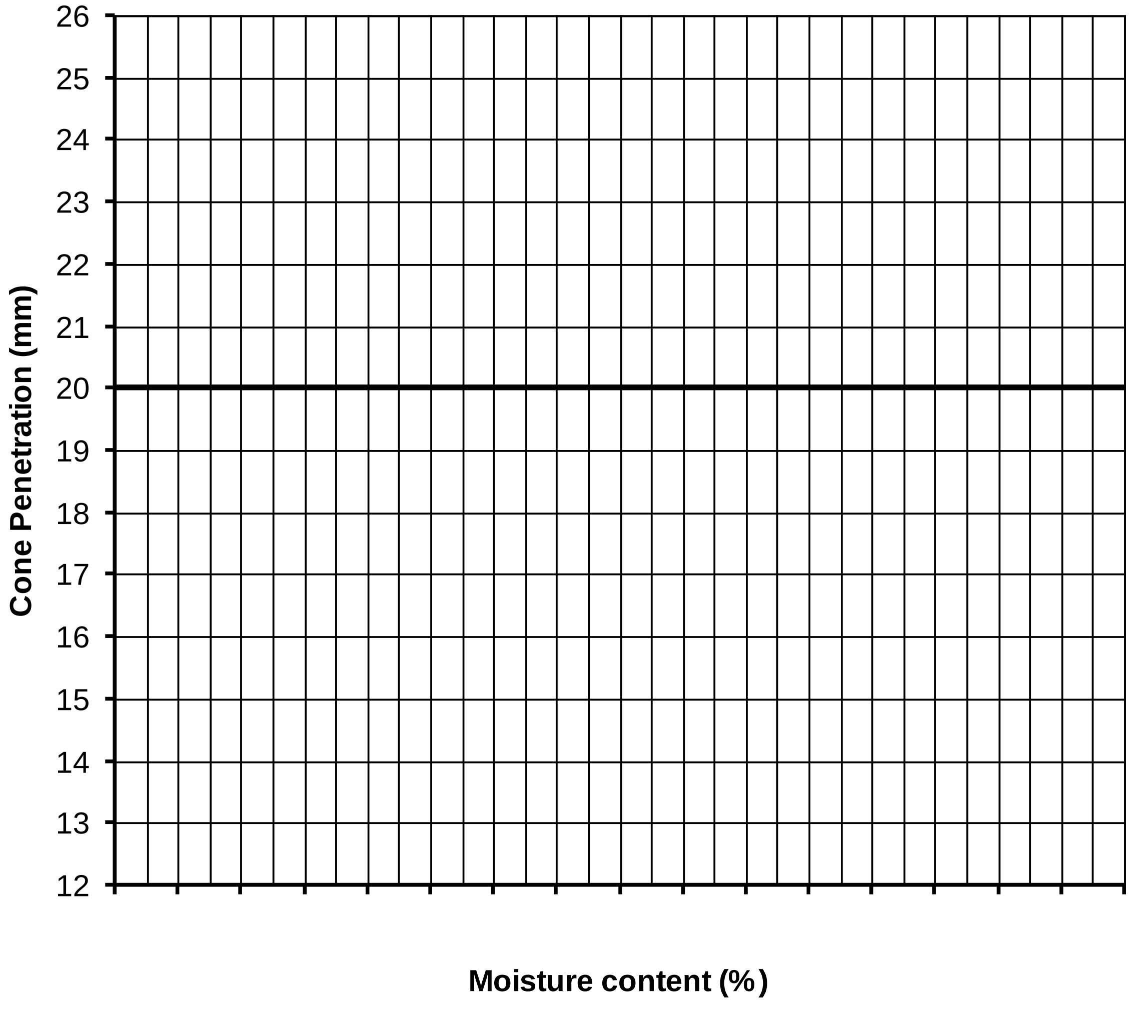

Figure Q3-1

Seat / Candidate Number ……………………………………….

Question 3 continued over the page…

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Question 3 continued

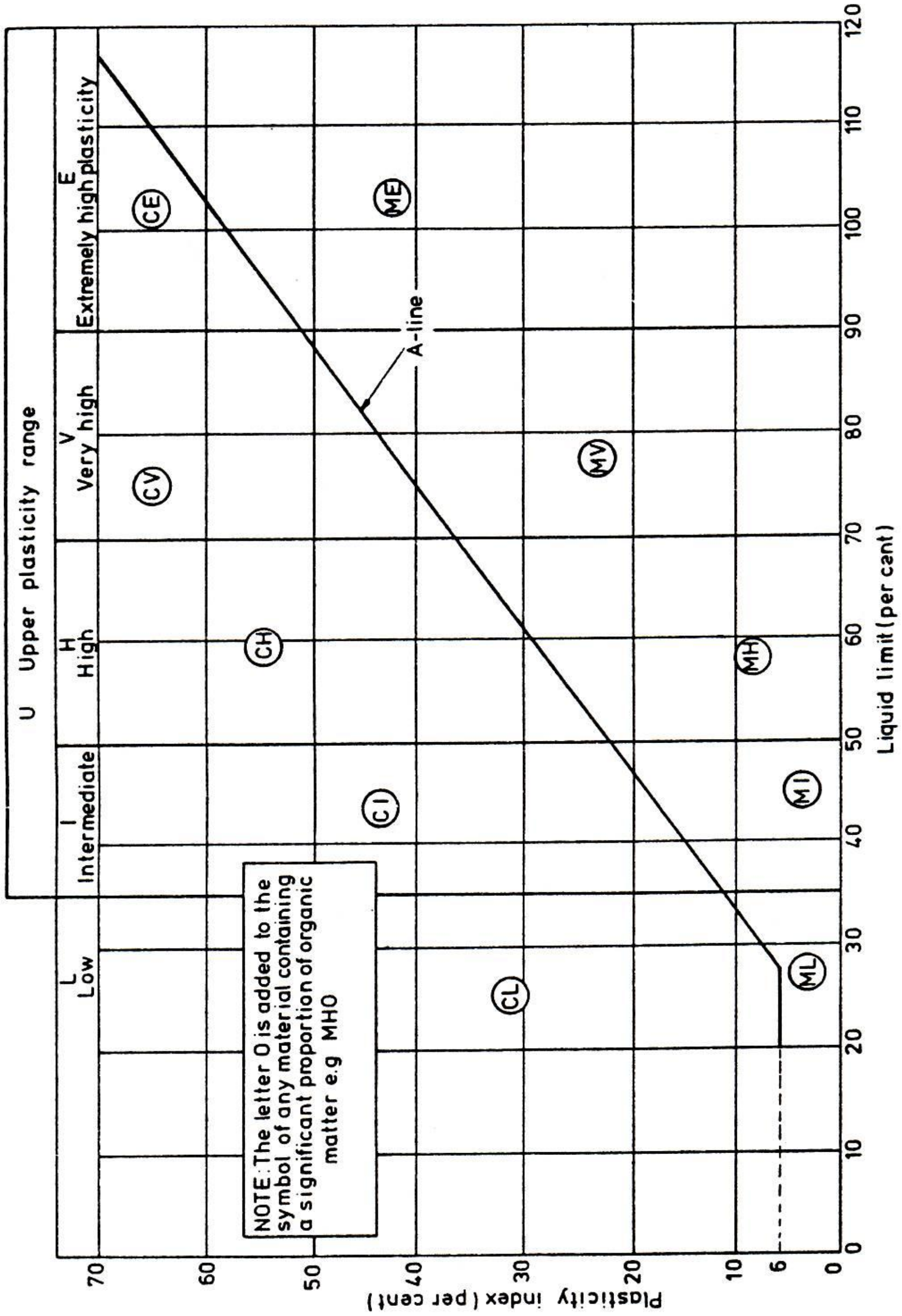

Figure Q3-2

Seat / Candidate Number ……………………………………………

Please turn the page

Q4. (a) Outline the key stages of a ground investigation and describe in detail the full range of equipment and reference sources that would be used to facilitate a comprehensive ground investigation for a proposed multi-storey car park in Bolton Town Centre. This comprehensive ground investigation is to include preliminary office-based compilation of information and also to include physical site works to provide the information necessary for design of the proposed multi-storey car park.

(13 marks)

(b) 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.

(8 marks)

(c) 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 (= 1×10^{-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	$\rho_b = \dfrac{\rho_W (G_s + e\, S_r)}{1 + e}$	$\gamma_b = \dfrac{\gamma_W (G_s + e\, S_r)}{1 + e}$
2	$\rho_b = \dfrac{\rho_W G_s (1 + w)}{1 + e}$	$\gamma_b = \dfrac{\gamma_W G_s (1 + w)}{1 + e}$
3	$\rho_d = \dfrac{\rho_W G_s}{1 + e}$	$\gamma_d = \dfrac{\gamma_W G_s}{1 + e}$
4	$\rho_{sat} = \dfrac{\rho_W (G_s + e)}{1 + e}$	$\gamma_{sat} = \dfrac{\gamma_W (G_s + e)}{1 + e}$

5 $$w\, G_s = e\, S_r$$

Transposing the above expressions:

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

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DEFINITIONS

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