Module - CE 2042 Soil Mechanics and Geology-1

Assignment	• **Tests for Particle Size Distribution Analysis**	Marks	10%
Learning Outcome	• Ability to **conduct** particle size distribution analysis of soils • Ability to **analyze** the results of particle size distribution analysis • Ability to **evaluate** the parameters required from the particle size distribution curve for the classification of soils • Ability to **discuss** the applications of the above test		
Programme Outcomes	1. Application of knowledge of mathematics, science, and engineering		1
	2. Effective communication		1
	3. In-depth technical competence in at least one engineering discipline		2
	4. Ability to undertake problem identification, formulation and solution		2
	5. Ability to utilize a systems approach to design and operational performance		2
	6. Individual and team work		1
	7. Understanding of the social, cultural, global and environmental responsibilities of the professional engineer, and the need for sustainable development		0
	8. Understanding of the principles of sustainable design and development		0
	9. Understanding of professional and ethical responsibilities and commitment to them		1
	10. Expectation of the need to undertake life-long learning and capacity to do so		0
0 – not covered under this 1– covered to some extent 2–covered to a greater extent 3– one of the main themes of the subject			
Lecturer	Dr. L. I. N. de Silva		

Student Name			
Registration Number:			
Date of Assignment:		**Date Due:**	
Initial Submission Date:		**Re Submission Date:**	

Assessed By:			
Signature		Date	

Lecturers' Remarks	

Important

1. Please note that **plagiarism** is treated as a serious offence and therefore the work you produce **must be individual and original.**
2. All sources of information must be **referenced using "Harvard Referencing**" where a **reference list/Bibliography** should be included at the end of the assignment. (You may refer the information given in **http://libweb.anglia.ac.uk/referencing/harvard.htm**).
3. Please note that the submission date given for the assignment (14 days after the date of performance for the laboratory session) is the **final date** that you can submit the assignment. If the given submission date is a public holiday, redefined submission deadline will be at 1300 hr of the immediate following working day. Late submissions **will be graded lower.**
4. Assignments returned to students for corrections must be **re-submitted within 10 days**
5. **Failure to re-submit** the previously marked assignment with the re-submitted assignment will mean that **results cannot be released for the respective unit**.

Plagiarism

Although research and discussion form an essential part of the assignment, deliberate copying of the work of others or unacknowledged copying from printed or electronic sources is NOT permitted. Disciplinary actions will be taken against those who are found guilty of plagiarism. Signing of this sheet is required to indicate your compliance with the above regulations.

Student's Signature: …….. Date: ……

Student's Comments, (Prior to the submission) if any:

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Student's feedback, (After the the submission) if any:

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TESTS FOR PARTICLE SIZE DISTRIBUTION ANALYSIS

SOIL MECHANICS

SOIL MECHANICS LABORATORY
DEPARTMENT OF CIVIL ENGINEERING
UNIVERSITY OF MORATUWA
SRI LANKA

TESTS FOR PARTICLE SIZE DISTRIBUTION ANALYSIS

1. General

In these tests quantitative particle size distribution (by weight) of a given soil sample is determined.

2. Scope

The distribution of particle sizes greater than 0.075 mm (75 μm) is determined by sieving and that of particle sizes finer than 0.075 mm is determined by a sedimentation process using a hydrometer.

3. Apparatus

1. **Balances** A balance sensitive to 0.01g
   A balance sensitive to 0.01g

2. **Stirring Apparatus** Either a mechanically operated stirring device or an air jet dispersion apparatus.

3. **Hydrometer** An ASTM 151 H or 152 H (or any other standard) type hydrometer graduated to read the grams per litre in suspension and confirming to the requirements of the corresponding standard.

4. **Sedimentation Cylinder** A glass cylinder 457 mm in height and 63.5 mm in diameter, and marked for a volume of 1000 ml.

5. **Thermometers** Thermometer accurate to 0.5° C.

6. **Set of Sieves** A series of square mesh woven wire cloth. A full set of sieves includes the following; 75mm, 50 mm, 37.5 mm, 25 mm, 19 mm, 9.75 mm, 4.75 mm, 2.0 mm, 0.850 mm, 0.425 mm, 0.250 mm, 0.106 mm and 0.075 mm.

   Alternatively a set of sieves giving a uniform spacing of points for the graph may be selected if desired. Such a set would consist of the following sieves; 75mm, 37.5 mm, 19.0 mm, 9.5 mm, 4.75 mm, 2.36 mm, 1.18 mm, 0.300 mm, 0.600 mm, 0.150 mm and 0.075 mm.

7. **Dispersing Agent** A solution of Sodium hexametaphospate shall be used in distilled or demineralised water, at the rate of 40g of Sodium Hexametaphospate/litre of solution.

4. Preparation of the Sample

The soil sample as received from the field shall be exposed to air at room temperature to get it air dried thoroughly. A representative sample of the soil shall be weighed and weight of the sample required would depend on the size of the largest particle in the sample and guidance may be taken from Table 5.1. The hygroscopic moisture content shall be determined by oven drying a small sample of soil (about 25 g).

The representative sample of soil shall then be spread out in a large tray and covered with water. For each litre of water 2 g of Sodium Hexametaphospate shall be added, and the whole shall be thoroughly stirred to wet the soil completely. It should be stirred frequently and kept under water for about 1 hour. Sample should then be washed through by keeping a 2 mm sieve on top of the 0.075 mm sieve. Particles finer than 0.075 mm are allowed to wash away. Particles finer than 2 mm, but coarser than 0.075 mm are retained in the 0.075 mm sieve. Care should be taken not to allow any overflowing of material from 2 mm sieve or 0.075 mm sieve.

Soil samples retained on two sieves shall be oven dried and weighted separately. Dry weight of the total sample should be obtained by applying the hygroscopic moisture correction.

Another representative sample of the air dried soil shall be sieved through a 0.425 mm sieve, and the fraction finer than 0.425 mm should be collected for the Hydrometer analysis.

5. Sieve Analysis

Procedure of Testing

The oven dried sample of soil that was retained on 2 mm sieve shall be separated using an appropriate set of sieves of sizes changing from 75 mm downward. Largest sieve size may be selected depending on the largest size of particles retained on 2 mm sieve, and a pan shall be kept on the bottom of the set of sieves. Sieving operation shall be conducted by means of a lateral and vertical motion of the sieve, accompanied by a jarring action in order to keep the sample moving continuously over the surface of the sieve. Alternatively sieving can be done by a mechanical sieve shaker. Material

passing 2 mm sieve (If any) shall be added to the already prepared (oven dried) sample of particles finer than 2mm. This mass of soil shall be separated using a set of sieves ranging from size 2mm downwards and a pan shall be placed at the bottom. Shaking procedure similar to that adopted for the portion retained on 2 mm sieve shall be used. Sieving shall be done for about 10 mins.

Mass retained on each sieve on both sets shall be determined by weighing the retained mass on a balance sensitive to 0.01 g. At the end of the weighing the sum of the masses retained on the sieves should be equal closely to the original mass of the quantity sieved (addition of the mass of the two oven dried samples)

* **Note** 1 -

The size of the portion retained on the 2mm sieve shall depend on the maximum size of the particle according to Table 1.

Nominal Diameter of largest particle (mm)	Approximate Minimum Mass of Portion (g)
9.5	500
19.0	1000
25.4	2000
38.1	3000
50.8	4000
75.0	5000

* **Note** 2 -

Amount of the portion passing 2 mm sieve shall be approximately 115 g for sandy soils and approximately 65 g for silt and clay soils.

* **Note** 3 -

There is an alternative method of dry sieving. Dry sieving shall be used only if it is shown that it gives same results as the method of wet sieving. In case of doubt the method of wet sieving as described above should be used.

In the method of dry sieving a representative sample of the soil (an oven dried sample) is simply sieved through the set of sieves in dry condition.

Computations

Mass of the soil retained on each sieve shall be expressed as a percentage of the total mass of sample. (Weight of the sample corrected for the hygroscopic moisture should be used). Thereafter cumulative percentage retained shall be computed by considering the full sieve set. By deducting the cumulative percentage retained from 100%, percentage finer than each sieve size shall be computed.

6. Hydrometer Analysis

Procedure of the Test

The fraction of the soil obtained by sieving a representative sample through a 0.425 mm sieve shall be used for this purpose. Sample of this portion shall be weighed and oven dried to determine the moisture content. This will enable the computation of hygroscopic correction.

About 50 grams of this soil shall be accurately weighted. Weighted soil mass shall be placed in a beaker or a suitable container and 125 ml of the Sodium Hexametaphospate solution (40g/litre) shall be added. Mixture shall be stirred until it thoroughly wetted and be allowed to soak for at least 16 hours. At the end of the soaking period soaked sample shall be transferred to an appropriate dispersion cup. Suitable amount of water shall be added and the sample shall be dispersed further, using either a mechanical stirring apparatus or an air jet dispersion cup. With the mechanical stirring apparatus distilled or demineralised water should be added to make the cup half full and stirred for at least 2 mins.

Immediately after the dispersion, "soil – water slurry" shall be transferred to the glass sedimentation cylinder, and distilled or demineralised water shall be added until the total volume 100 ml. Using the palm of the hand over the open end of the cylinder (or a rubber stopper in the open end), cylinder shall be shaken vigorously by turning it up side down and back (for a period of 1 min or more), until a uniform suspension is formed. Thereafter the cylinder shall be placed in a convenient location to take hydrometer readings at the following time intervals. (Measured from the beginning of sedimentation); ½ min, 1 min, 2 min, 4 min, 8 min, 15 min, 30 min, 1 hr, 2 hrs, 4 hrs, 8

hrs, 16 hrs, 24 hrs, 36 hrs, ……. The hydrometer shall be removed slowly after 4 min, rinsed in water and kept in a cylinder of distilled or demineralised water. When it is desired to take a hydrometer reading, the hydrometer shall be carefully inserted about 30 sec – 45 sec before the reading is due. As soon as the reading is taken, hydrometer shall be carefully removed and placed back in the cylinder of distilled or demineralised water.

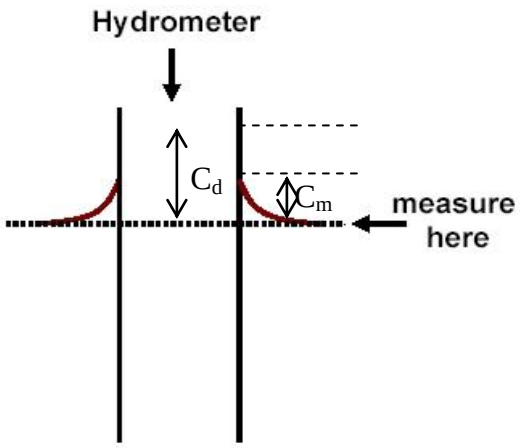

Figure 1 – Corrections for Hydrometer Reading

Corrections

Hygroscopic Moisture Correction Factor;

This is the ratio between the mass of the oven dried sample to that of the air dried sample. Actual dry weight of the soil taken to prepare the suspension, shall be determined using this factor.

Corrections for Hydrometer Reading ;

Equations for percentage of soil remaining in suspension are based on distilled or demineralised water. Dispersing agent used in the sample preparation cause an appreciable change in this.

Hydrometers are graduated to read at the bottom of the meniscus formed by the liquid on the stem. Since it is not possible to obtain readings of soil suspensions at the bottom of the meniscus, readings must be taken at the top and a correction applied. Corrections

for the above can be determined experimentally, by preparation of a 1000 ml of liquid, composed of distilled or demineralised water and dispersing agent in the same proportion as used in the soil suspension. Hydrometer shall be inserted in the solution and reading of the hydrometer at the top of the meniscus formed on the stem, and also at the bottom of the meniscus formed on the stem shall be taken. The appropriate corrections can be determined as illustrated in Figure 1.

Meniscus Correction = C_m

Dispersing agent Correction = C_d

Composite Correction = $C_d - C_m$

Computations

Let $R_H^{'}$ be the Hydrometer reading taken on top of the meniscus in the soil suspension;

When the Meniscus correction is applied R_H can be found by; $R_H = R_H^{'} + C_m$

The distance "L", from the surface of the suspension to the level at which hydrometer is measuring density, and R_H are related and relationship is presented in the form of a table. (For ASTM type 152 H hydrometer this is presented in Table 2).

When composite correction is applied to the hydrometer, a reading R is obtained;

$$R = R_H - C_d = R_H^{'} - (C_d - C_m)$$

Percentage of Particles Remaining in Suspension;

The percentage of soil remaining in suspension at the level at which the hydrometer is measuring density of the suspension may be calculated as;

$$P = \frac{Ra}{W} \times 100\ \%$$

where

1. P = Percentage of soil remaining in suspension at the level at which the hydrometer is measuring the density of the suspension.
2. a = Correction to be applied due to variation of particle specific gravity (given in Table 3).
3. R = Hydrometer reading with composite correction applied.
4. W = Oven dry mass of the soil in the suspension (Mass of the soil taken to prepare the solution should be corrected with the hygroscopic moisture correction)

*** Note**

See section 6.4 for the correction that has to be applied to the above *P* value when considering the particle size distribution for the complete soil sample.

Diameter of Soil Particles

The diameter of a particle corresponding to the percentage indicated by a given hydrometer reading shall be calculated based on the Stroke's law. It is assumed that the particle was at the surface of suspension at the surface of suspension at the beginning of sedimentation, and had settled to the level at which the hydrometer is measuring the density of the suspension.

An expression can be derived using Stroke's law and be presented in a simplified form as;

$$D = K\sqrt{\frac{L}{t}}$$

where;

1. D = Diameter of the particle in mm
2. K = Constant depending on the temperature of the suspension and the specific gravity of the soil particles. Values of K for a range of temperatures and specific gravities are given in Table 4 (for ASTM type 152 H hydrometer)
3. L = value of L can be obtained from a table provided with the hydrometer (As described before using Table 2).

Presentation of Results

Results shall be reported in a tabulated form by giving the percentage finer for different particle sizes. For the sieve analysis these sizes correspond to sizes of the sieves. For the hydrometer analysis a diameter corresponds to a hydrometer reading taken at a particular time and computation should be done as described before. That computation is performed during the hydrometer analysis by taking the portion finer than 0.425 mm as 100%. Therefore in combining the particle size analyses done through the sieve analysis and through the hydrometer analysis, percentages in the latter should be multiplied by the percentage finer than 0.425 mm in the sieve analysis. Results of the tests can be presented in tabulated forms as in Table 5 and Table 6. (These tables can

be used to summarise results of tests done on number of different samples form different bore holes). The results shall also be reported graphically using semi log plot as shown in Figure 2.

Table 2 : Values of Effective Depth Based on Hydrometer and Sedimentation Cylinder of Specified Sizes

Actual Hydrometer Reading R_H	**Effective Depth (cm) L**	**Actual Hydrometer Reading** R_H	**Effective Depth (cm) L**	**Actual Hydrometer Reading** R_H	**Effective Depth (cm) L**
0	16.3	21	12.9	41	9.6
1	16.1	22	12.7	42	9.4
2	16.0	23	12.5	43	9.2
3	15.8	24	12.4	44	9.1
4	15.6	25	12.2	45	8.9
5	15.5	26	12.0	46	8.8
6	15.3	27	11.9	47	8.6
7	15.2	28	11.7	48	8.4
8	15.0	29	11.5	49	8.3
9	14.8	30	11.4	50	8.1
10	14.7	31	11.2	51	7.9
11	14.5	32	11.1	52	7.8
12	14.3	33	10.9	53	7.6
13	14.2	34	10.7	54	7.4
14	14.0	35	10.6	55	7.3
15	13.8	36	10.4	56	7.1
16	13.7	37	10.2	57	7.0
17	13.5	38	10.1	58	6.8
18	13.3	39	9.9	59	6.6
19	13.2	40	9.7	60	6.5
20	13.0				

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Hydrometer Analysis of Soils

Project :

Weight of Sample (g) =	T (c) =
Hydrometer Type =	G_s =
Hydrometer No =	K =
Meniscus Correction C_m =	a =
Dispersing Agent Correction C_d =	Cylinder No =
Bore Hole No. = Depth of Sample =	Date =

Day	Time	Time After Start			Time (mm)	Temp (C)	$R_H^{'}$	$R_H = R_H^{'} + C_m$	L	$\sqrt{\frac{L}{t}}$	D = (mm)	$R = R_H - C_d$	% Finer $P = \frac{Ra}{W} \times 100$	Modified

Table 3 – Values of Correction Factor "a" for Different Specific Gravities of Soil Particles

Specific Gravity	Correction Factor
2.95	0.94
2.90	0.95
2.85	0.96
2.80	0.97
2.70	0.99
2.65	1.00
2.60	1.01
2.55	1.02
2.50	1.03
2.45	1.05

Table 4 – Values of K for Use in Equation For Computing Diameter of Particle in Hydrometer Analysis for Different Specific Gravities of Soil Particles

Values of *K* for Use in Equation for Computing Diameter of Particle in Hydrometer Analysis

Temperature, deg C	Specific Gravity of Soil Particles								
	2.45	2.50	2.55	2.60	2.65	2.70	2.75	2.80	2.85
16	0.01510	0.01505	0.01481	0.01457	0.01435	0.01414	0.01394	0.01374	0.01356
17	0.01511	0.01486	0.01462	0.01439	0.01417	0.01396	0.01376	0.01356	0.01338
18	0.01492	0.01467	0.01443	0.01421	0.01399	0.01378	0.01359	0.01339	0.01321
19	0.01474	0.01449	0.01425	0.01403	0.01382	0.01361	0.01342	0.01323	0.01305
20	0.01456	0.01431	0.01408	0.01386	0.01365	0.01344	0.01325	0.01307	0.01289
21	0.01438	0.01414	0.01391	0.01369	0.01348	0.01328	0.01309	0.01291	0.01273
22	0.01421	0.01397	0.01374	0.01353	0.01332	0.01312	0.01294	0.01276	0.01258
23	0.01404	0.01381	0.01358	0.01337	0.01317	0.01297	0.01279	0.01261	0.01243
24	0.01388	0.01365	0.01342	0.01321	0.01301	0.01282	0.01264	0.01246	0.01229
25	0.01372	0.01349	0.01327	0.01306	0.01286	0.01267	0.01249	0.01232	0.01215
26	0.01357	0.01334	0.01312	0.01291	0.01272	0.01253	0.01235	0.01218	0.01201
27	0.01342	0.01319	0.01297	0.01277	0.01258	0.01239	0.01221	0.01204	0.01188
28	0.01327	0.01304	0.01283	0.01264	0.01244	0.01225	0.01208	0.01191	0.01175
29	0.01312	0.01290	0.01269	0.01249	0.01230	0.01212	0.01195	0.01178	0.01162
30	0.01298	0.01276	0.01256	0.01236	0.01217	0.01299	0.01182	0.01165	0.01149

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Particle Size Analysis – Sieve Analysis

Client :

Project :

BH Number : **Depth :**

Total Mass of the Sample :

Sieve Size (mm)	Mass of Sieve (g)	Mass of Sieve + Soil (g)	Mass of Soil Retained (g)	% Retained	Cumulative % Retained	% Finer

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Sieve Analysis Test Results					
Project :					
Bore Hole No					
Depth (m)					
Sieve Size (mm)	Percentage Passing				

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Hydrometer Analysis Test Results					
Project :					
Bore Hole No					
Depth (m)					
Sieve Size (mm)	Percentage Finer				

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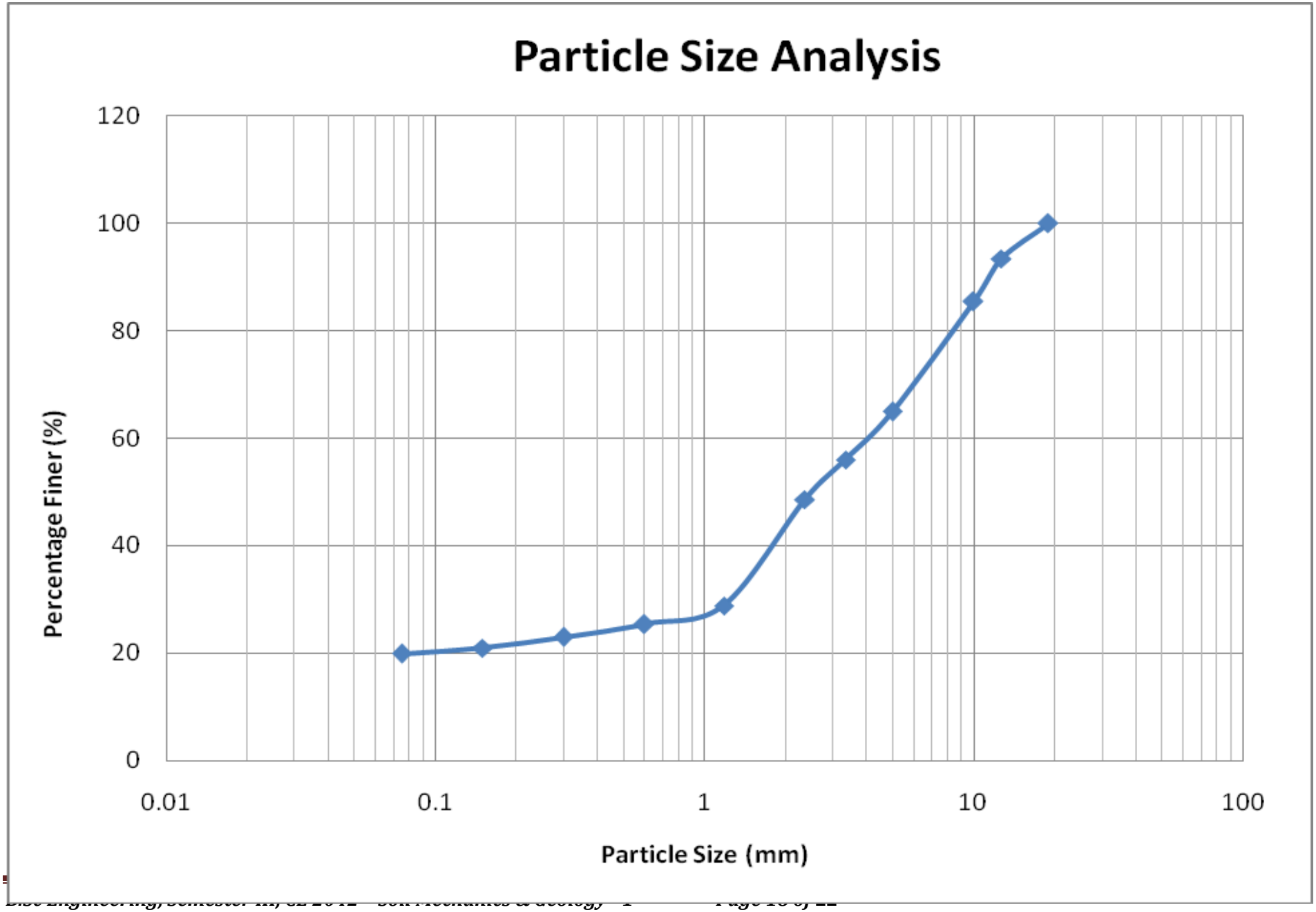
Soil Classification – Unified Classification System

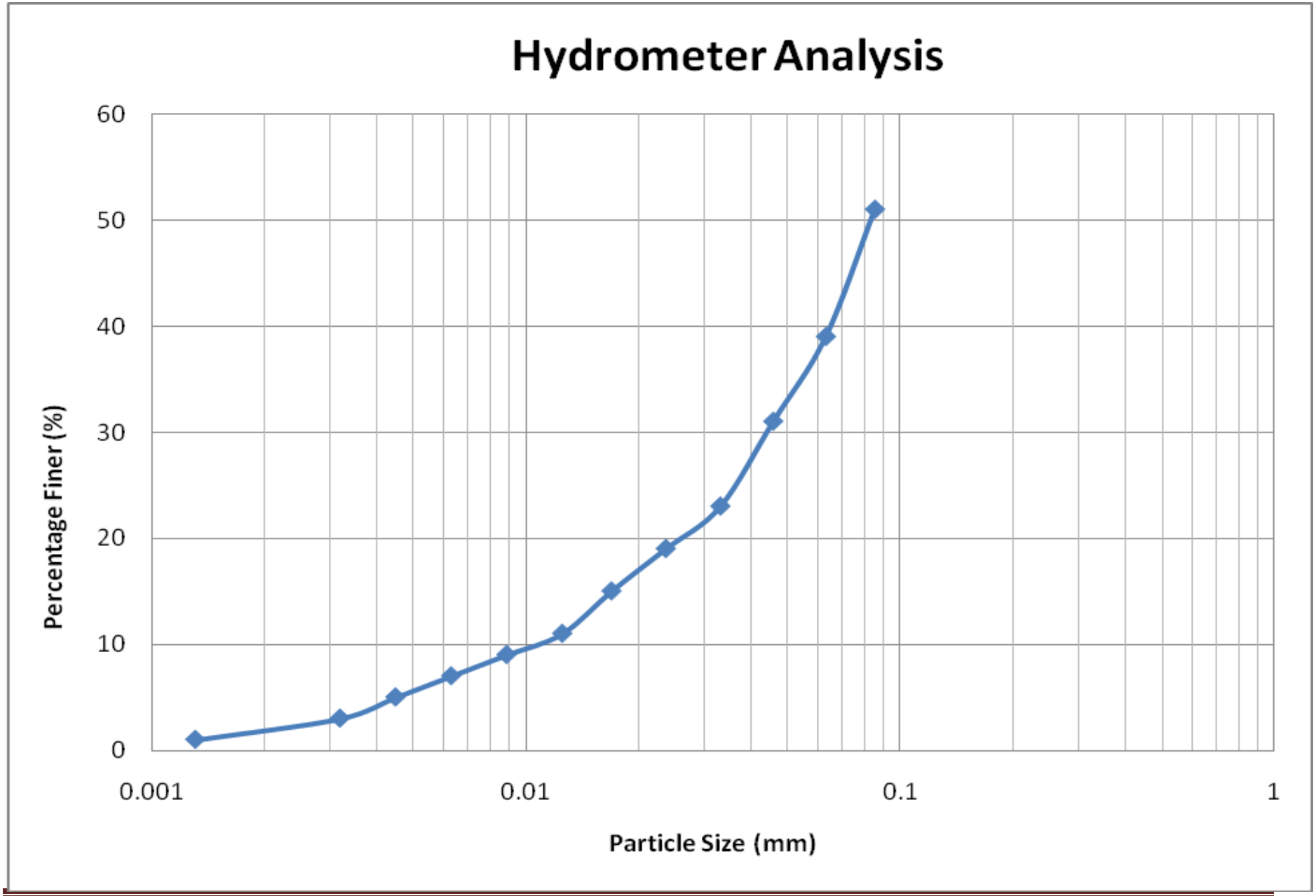
Project :

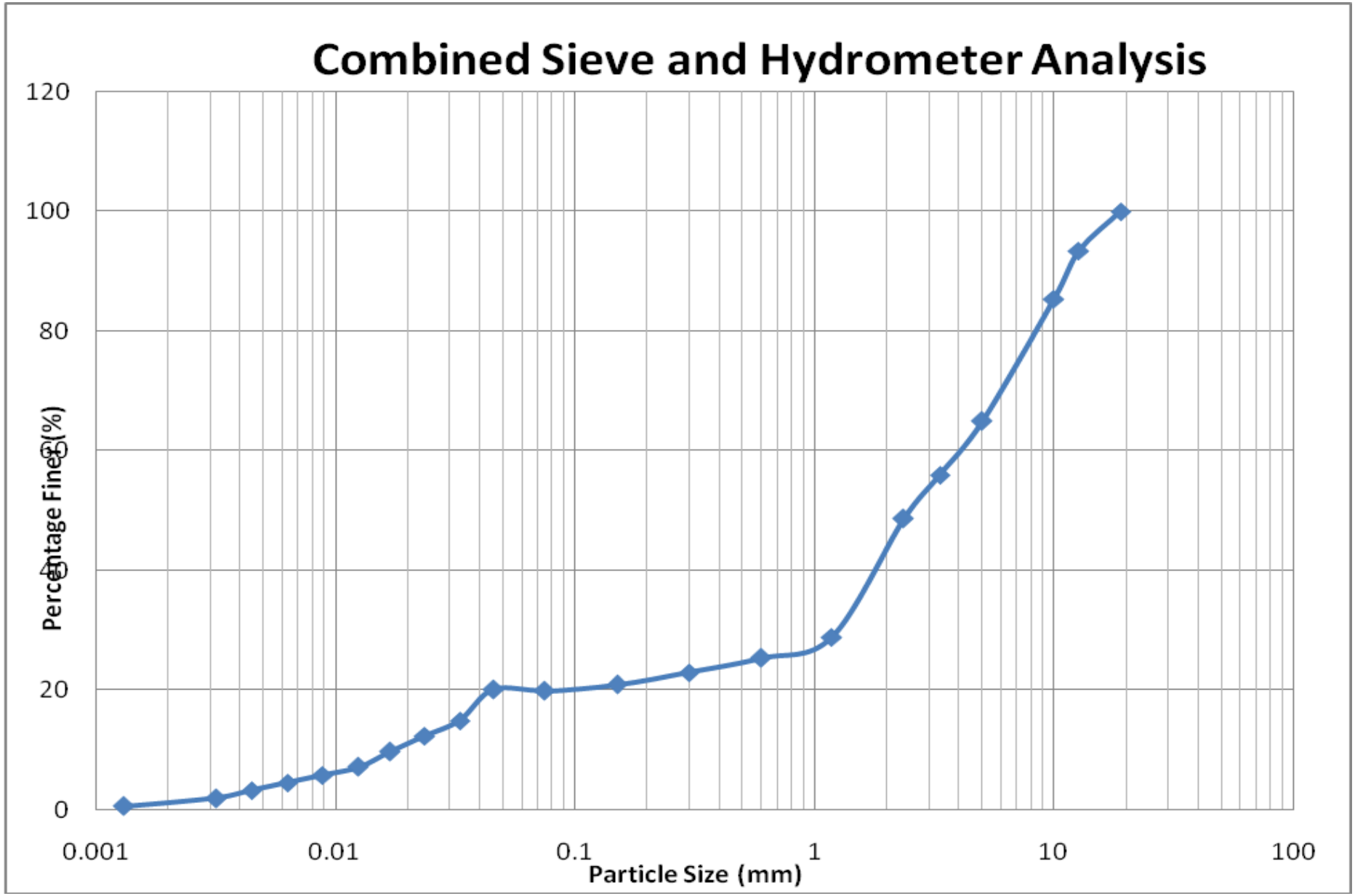
B.H. No	Depth (m)	Particle Size Analysis							Atterberg Limits		Group Symbol	Remarks
		Percentage Finer		D_{60} mm	D_{30} mm	D_{10} mm	C_c	C_u	LL	PI		
		No. 200	No. 4									

Particle Size Analysis Sieve Analysis				
Total weight taken (g) = 1000				
Sieve Size (mm)	**Mass of Soil (g)**	**Cumulative mass (g)**	**Percent Ret (%)**	**Percent Finer (%)**
19	0	0	0	100
12.7	66.03	66.03	6.6	93.4
10	80.36	146.39	14.64	85.36
5	204.3	350.69	35.07	64.93
3.35	89.49	440.18	44.02	55.98
2.36	73.54	513.72	51.37	48.63
1.18	197.82	711.54	71.15	28.85
0.6	34.5	746.04	74.6	25.4
0.3	24.75	770.79	77.08	22.92
0.15	19.93	790.72	79.07	20.93
0.075	10.55	801.27	80.13	19.87


Particle Size Analysis
120
100
80
60
40
20
0
Percentage Finer (%)
0.01
0.1
1
10
100
Particle Size (mm)

Worksheet for Combined Hydrometer and Sieve Analysis											
Gs = 2.65 Cm = 0.5					Weight (g) = 50 Cd = 2		Temp = 30 deg K = 0.01244			Percent at 0.425 mm = 65%	
Day	**Time**	**Time Elapsed (min)**	**Temp**	**RH'**	**RH= RH' + Cm**	**L (cm)**	**L/t**	**D (mm)**	**R=RH-Cd**	**% Finer**	**% Finer Modified**
		0.25		27	27.5	11.8	47.2	0.085466	25.5	51	33.15
		0.5		21	21.5	12.9	25.8	0.063187	19.5	39	25.35
		1		17	17.5	13.5	13.5	0.045707	15.5	31	20.15
		2		13	13.5	14.1	7.05	0.03303	11.5	23	14.95
		4		11	11.5	14.4	3.6	0.023603	9.5	19	12.35
		8		9	9.5	14.75	1.84375	0.016892	7.5	15	9.75
		15		7	7.5	15.1	1.006667	0.012481	5.5	11	7.15
		30		6	6.5	15.25	0.508333	0.008869	4.5	9	5.85
		60		5	5.5	15.4	0.256667	0.006302	3.5	7	4.55
		120		4	4.5	15.55	0.129583	0.004478	2.5	5	3.25
		240		3	3.5	15.7	0.065417	0.003182	1.5	3	1.95
		1440		2	2.5	15.9	0.011042	0.001307	0.5	1	0.65


Hydrometer Analysis
60
50
40
30
20
10
0
Percentage Finer (%)
0.001
0.01
0.1
1
Particle Size (mm)


Combined Sieve and Hydrometer Analysis
120
100
80
60
40
20
0
Percentage Finer (%)
0.001
0.01
0.1
1
10
100
Particle Size (mm)

Marking Scheme:

Measurements 35%:	*Precision, Reliability*
Calculations & Results 25%:	*Accuracy, Methodology, Presentation*
Discussion 25%:	*Content, Arrangement, Presentation*
Coursework Presentation 15%:	*Neatness, Clarity, Accordance to the format*