EXPERIMENT 6

GRAIN SIZE ANALYSIS

(SIEVE AND HYDROMETER ANALYSIS)

Purpose:

This test is performed to determine the percentage of different grain sizes contained within a soil. The mechanical or sieve analysis is performed to determine the distribution of the coarser, larger-sized particles, and the hydrometer method is used to determine the distribution of the finer particles.

Standard Reference:

ASTM D 422 - Standard Test Method for Particle-Size Analysis of Soils

Significance:

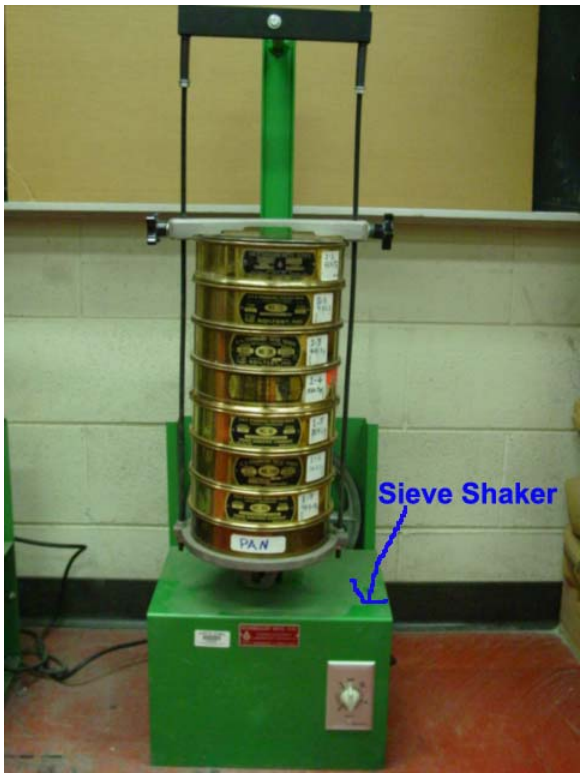
The distribution of different grain sizes affects the engineering properties of soil. Grain size analysis provides the grain size distribution, and it is required in classifying the soil.

Equipment:

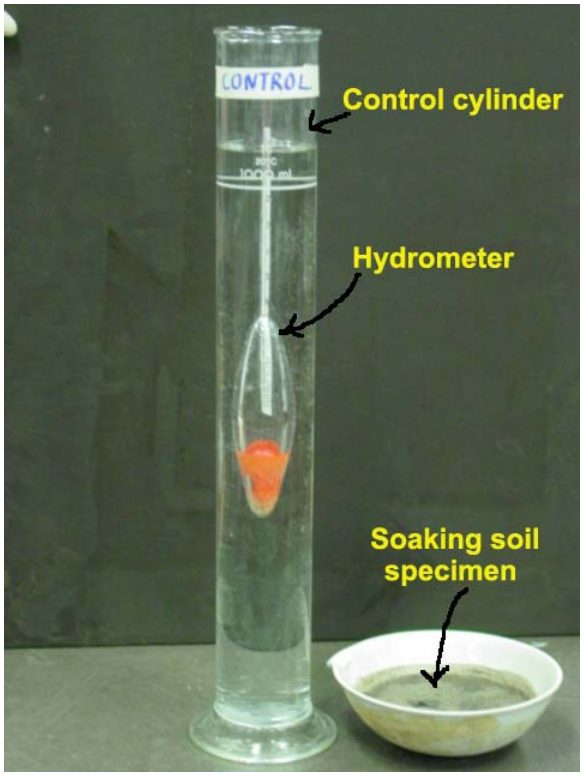
Balance, Set of sieves, Cleaning brush, Sieve shaker, Mixer (blender), 152H Hydrometer, Sedimentation cylinder, Control cylinder, Thermometer, Beaker, Timing device.


Set of Sieves
Soil Specimen
PAN
Balance


PAN

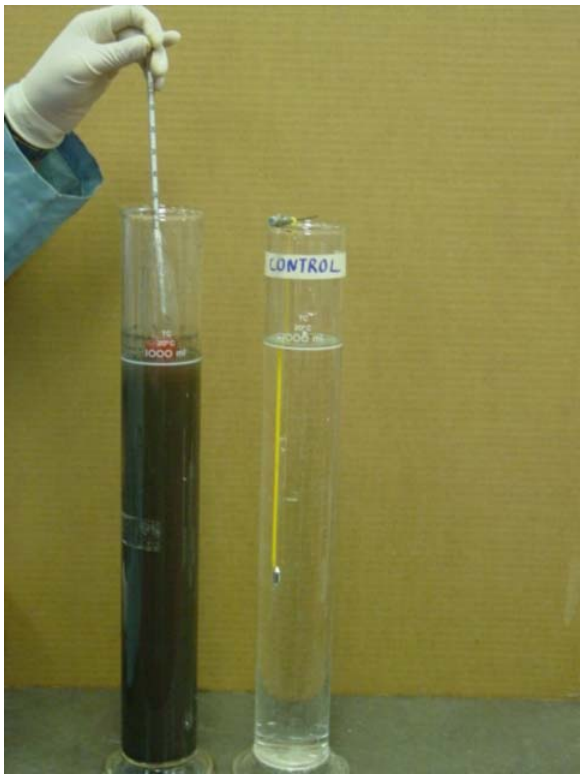

Sieve Shaker
PAN


Adventurer


CONTROL
Control cylinder
Hydrometer
Soaking soil specimen


Soaked soil specimen
Blender


Stopper


CONTROL

Test Procedure:

Sieve Analysis:

(1) Write down the weight of each sieve as well as the bottom pan to be used in the analysis.

(2) Record the weight of the given dry soil sample.

(3) Make sure that all the sieves are clean, and assemble them in the ascending order of sieve numbers (#4 sieve at top and #200 sieve at bottom). Place the pan below #200 sieve. Carefully pour the soil sample into the top sieve and place the cap over it.

(4) Place the sieve stack in the mechanical shaker and shake for 10 minutes.

(5) Remove the stack from the shaker and carefully weigh and record the weight of each sieve with its retained soil. In addition, remember to weigh and record the weight of the bottom pan with its retained fine soil.

Hydrometer Analysis:

(1) Take the fine soil from the bottom pan of the sieve set, place it into a beaker, and add 125 mL of the dispersing agent (sodium hexametaphosphate (40 g/L)) solution. Stir the mixture until the soil is thoroughly wet. Let the soil soak for at least ten minutes.

(2) While the soil is soaking, add 125mL of dispersing agent into the control cylinder and fill it with distilled water to the mark. Take the

reading at the top of the meniscus formed by the hydrometer stem and the control solution. A reading less than zero is recorded as a negative (-) correction and a reading between zero and sixty is recorded as a positive (+) correction. This reading is called the zero correction. The meniscus correction is the difference between the top of the meniscus and the level of the solution in the control jar (Usually about +1). Shake the control cylinder in such a way that the contents are mixed thoroughly. Insert the hydrometer and thermometer into the control cylinder and note the zero correction and temperature respectively.

(3) Transfer the soil slurry into a mixer by adding more distilled water, if necessary, until mixing cup is at least half full. Then mix the solution for a period of two minutes.

(4) Immediately transfer the soil slurry into the empty sedimentation cylinder. Add distilled water up to the mark.

(5) Cover the open end of the cylinder with a stopper and secure it with the palm of your hand. Then turn the cylinder upside down and back upright for a period of one minute. (The cylinder should be inverted approximately 30 times during the minute.)

(6) Set the cylinder down and record the time. Remove the stopper from the cylinder. After an elapsed time of one minute and forty seconds, very slowly and carefully insert the hydrometer for the first reading. (Note: It should take about ten seconds to insert or remove the hydrometer to minimize any disturbance, and the release of the

hydrometer should be made as close to the reading depth as possible to avoid excessive bobbing).

(7) The reading is taken by observing the top of the meniscus formed by the suspension and the hydrometer stem. The hydrometer is removed slowly and placed back into the control cylinder. Very gently spin it in control cylinder to remove any particles that may have adhered.

(8) Take hydrometer readings after elapsed time of 2 and 5, 8, 15, 30, 60 minutes and 24 hours

Data Analysis:

Sieve Analysis:

(1) Obtain the mass of soil retained on each sieve by subtracting the weight of the empty sieve from the mass of the sieve + retained soil, and record this mass as the weight retained on the data sheet. The sum of these retained masses should be approximately equals the initial mass of the soil sample. A loss of more than two percent is unsatisfactory.

(2) Calculate the percent retained on each sieve by dividing the weight retained on each sieve by the original sample mass.

(3) Calculate the percent passing (or percent finer) by starting with 100 percent and subtracting the percent retained on each sieve as a cumulative procedure.

For example: Total mass = 500 g

Mass retained on No. 4 sieve = 9.7 g

Mass retained on No. 10 sieve = 39.5 g

For the No.4 sieve:

Quantity passing = Total mass - Mass retained

= 500 - 9.7 = 490.3 g

The percent retained is calculated as;

% retained = Mass retained/Total mass

= (9.7/500) X 100 = 1.9 %

From this, the % passing = 100 - 1.9 = 98.1 %

For the No. 10 sieve:

Quantity passing = Mass arriving - Mass retained

= 490.3 - 39.5 = 450.8 g

% Retained = (39.5/500) X 100 = 7.9 %

% Passing = 100 - 1.9 - 7.9 = 90.2 %

(Alternatively, use % passing = % Arriving - % Retained

For No. 10 sieve = 98.1 - 7.9 = 90.2 %)

(4) Make a semilogarithmic plot of grain size vs. percent finer.

(5) Compute C_c and C_u for the soil.

Hydrometer Analysis:

(1) Apply meniscus correction to the actual hydrometer reading.

(2) From Table 1, obtain the effective hydrometer depth L in cm (for meniscus corrected reading).

(3) For known G_s of the soil (if not known, assume 2.65 for this lab purpose), obtain the value of K from Table 2.

(4) Calculate the equivalent particle diameter by using the following formula:

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

Where t is in minutes, and D is given in mm.

(5) Determine the temperature correction C_T from Table 3.

(6) Determine correction factor "*a*" from Table 4 using G_s.

(7) Calculate corrected hydrometer reading as follows:

$R_c = R_{ACTUAL}$ - zero correction + C_T

(8) Calculate percent finer as follows:

$$P = \frac{Rc \times a}{w_s} \times 100$$

Where W_S is the weight of the soil sample in grams.

(9) Adjusted percent fines as follows:

$$P_A = \frac{P \times F_{200}}{100}$$

F_{200} = % finer of #200 sieve as a percent

(10) Plot the grain size curve D versus the adjusted percent finer on the semilogarithmic sheet.

Table 1. Values of Effective Depth Based on Hydrometer and Sedimentation Cylinder of Specific Sizes

Hydrometer 151H		Hydrometer 152H			
Actual Hydrometer Reading	Effective Depth, L (cm)	Actual Hydrometer Reading	Effective Depth, L (cm)	Actual Hydrometer Reading	Effective Depth, L (cm)
1.000	16.3	0	16.3	31	11.2
1.001	16.0	1	16.1	32	11.1
1.002	15.8	2	16.0	33	10.9
1.003	15.5	3	15.8	34	10.7
1.004	15.2	4	15.6	35	10.6
1.005	15.0	5	15.5	36	10.4
1.006	14.7	6	15.3	37	10.2
1.007	14.4	7	15.2	38	10.1
1.008	14.2	8	15.0	39	9.9
1.009	13.9	9	14.8	40	9.7
1.010	13.7	10	14.7	41	9.6
1.011	13.4	11	14.5	42	9.4
1.012	13.1	12	14.3	43	9.2
1.013	12.9	13	14.2	44	9.1
1.014	12.6	14	14.0	45	8.9
1.015	12.3	15	13.8	46	8.8
1.016	12.1	16	13.7	47	8.6
1.017	11.8	17	13.5	48	8.4
1.018	11.5	18	13.3	49	8.3
1.019	11.3	19	13.2	50	8.1
1.020	11.0	20	13.0	51	7.9
1.021	10.7	21	12.9	52	7.8
1.022	10.5	22	12.7	53	7.6
1.023	10.2	23	12.5	54	7.4
1.024	10.0	24	12.4	55	7.3
1.025	9.7	25	12.2	56	7.1
1.026	9.4	26	12.0	57	7.0
1.027	9.2	27	11.9	58	6.8
1.028	8.9	28	11.7	59	6.6
1.029	8.6	29	11.5	60	6.5
1.030	8.4	30	11.4		
1.031	8.1				
1.032	7.8				
1.033	7.6				
1.034	7.3				
1.035	7.0				
1.036	6.8				
1.037	6.5				
1.038	6.2				
1.039	5.9				

Table 2. Values of **k** for Use in Equation for Computing Diameter of Particle in Hydrometer Analysis

Temperature $^{\circ}C$	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	0.0394	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	0.01255	0.01208	0.01191	0.01175
29	0.01312	0.01290	0.01269	0.01269	0.01230	0.01212	0.01195	0.01178	0.01162
30	0.01298	0.01276	0.01256	0.01236	0.01217	0.01199	0.01182	0.01165	0.01149

Table 3. Temperature Correction Factors C_T

Temperature $^{\circ}C$	factor C_T
15	1.10
16	-0.90
17	-0.70
18	-0.50
19	-0.30
20	0.00
21	+0.20
22	+0.40
23	+0.70
24	+1.00
25	+1.30
26	+1.65
27	+2.00
28	+2.50
29	+3.05
30	+3.80

Table 4. Correction Factors ***a*** for Unit Weight of Solids

Unit Weight of Soil Solids, g/cm^3	Correction factor a
2.85	0.96
2.80	0.97
2.75	0.98
2.70	0.99
2.65	1.00
2.60	1.01
2.55	1.02
2.50	1.04

EXAMPLE DATA

Grain Size Analysis

Sieve Analysis

Date Tested: September 15, 2002
Tested By: CEMM315 Class, Group A
Project Name: CEMM315 Lab
Sample Number: B-1, ST-1, 2'-3. 5'
Visual Classification of Soil: Brown Clayey to silty sand, trace fine gravel
Weight of Container: 198.5 gm
Wt. Container+Dry Soil: 722.3 gm
Wt. of Dry Sample: 523.8 gm

Sieve Number	Diameter (mm)	Mass of Empty Sieve (g)	Mass of Sieve+Soil Retained (g)	Soil Retained (g)	Percent Retained	Percent Passing
4	4.75	116.23	166.13	49.9	9.5	90.5
10	2. 0	99.27	135.77	36.5	7.0	83.5
20	0.84	97.58	139.68	42.1	8.0	75.5
40	0.425	98.96	138.96	40.0	7.6	67.8
60	0. 25	91.46	114.46	23.0	4.4	63.4
140	0.106	93.15	184.15	91.0	17.4	46.1
200	0.075	90.92	101.12	10.2	1.9	44.1
Pan	---	70.19	301.19	231.0	44.1	0.0
			Total Weight=	523.7		

* Percent passing=100-cumulative percent retained.

From Grain Size Distribution Curve:

% Gravel= 9.5 D_{10}= 0.002 mm
% Sand= 46.4 D_{30}= 0.017 mm
% Fines= 44.1 D_{60}= .0.25 mm

$$C_u = \frac{0.25}{0.002} = 125, \quad C_c = \frac{(0.017)^2}{0.25 \times 0.002} = 0.58$$

Unified Classification of Soil: SC/SM

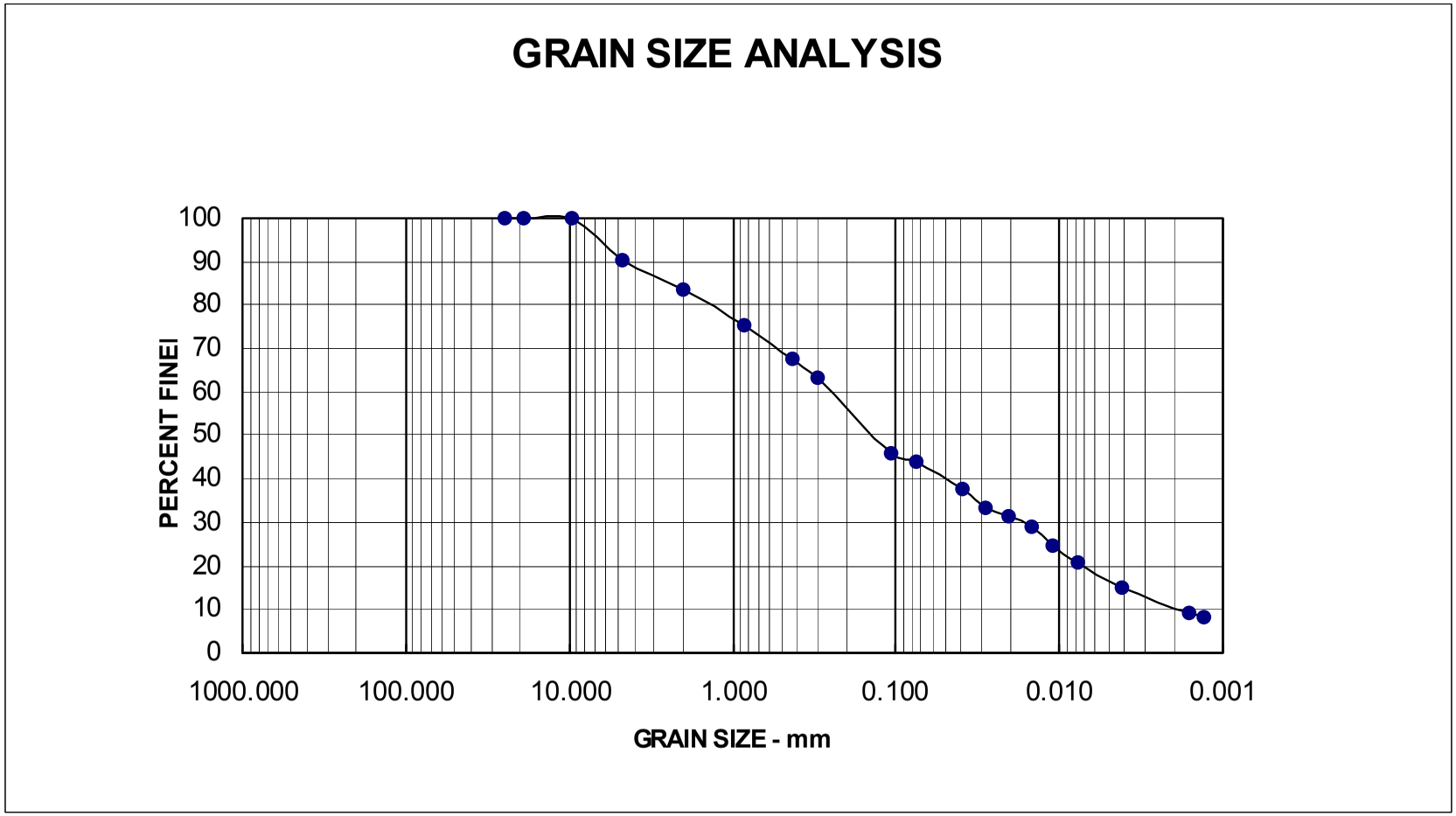
Engineering Properties of Soils Based on Laboratory Testing
Prof. Krishna Reddy, UIC

Hydrometer Analysis

Test Date: September 15, 2002
Tested By: CEMM315 Class, Group A
Hydrometer Number (if known): 152 H
Specific Gravity of Solids: 2.56
Dispersing Agent: Sodium Hexametaphosphate
Weight of Soil Sample: 50.0 gm
Zero Correction: +6
Meniscus Correction: +1

Date	Time	Elapsed Time (min)	Temp. ^{O}C	Actual Hydro. Rdg. R_a	Hyd. Corr. for Meniscus	L from Table 1	K from Table 2	D mm	C_T from Table 3	a from Table 4	Corr. Hydr. Rdg. R_c	% Finer P	% Adjusted Finer P_A
09/15	4:06 PM	0	25	55	56	7.1	0.01326	0	+1.3	1.018	-	-	-
	4:07	1	25	47	48	8.6	0.01326	0.03029	+1.3	1.018	42.3	86.1	37.8
	4:08	2	25	42	43	9.2	0.01326	0.02844	+1.3	1.018	37.3	75.9	33.3
	4:10	4	25	40	41	9.6	0.01326	0.02054	+1.3	1.018	35.3	71.9	31.6
	4:14	8	25	37	38	10.1	0.01326	0.01490	+1.3	1.018	32.3	65.8	28.6
	4:22	16	25	32	33	10.9	0.01326	0.01094	+1.3	1.018	27.3	55.6	24.1
	4:40	34	25	28	29	11.5	0.01326	0.00771	+1.3	1.018	23.3	47.4	20.8
	6:22	136	23	22	23	12.5	0.01356	0.00411	+0.7	1.018	16.7	34	14.9
09/16	5:24 PM	1518	22	15	16	13.7	0.01366	0.00130	+0.4	1.018	9.4	19.1	8.4

Unified Classification of Soil: SC/SM


GRAIN SIZE ANALYSIS
PERCENT FINEI
100
90
80
70
60
50
40
30
20
10
0
1000.000
100.000
10.000
1.000
0.100
0.010
0.001
GRAIN SIZE - mm

BLANK DATA SHEETS

Grain Size Analysis

Sieve Analysis

Date Tested:
Tested By:
Project Name:
Sample Number:
Visual Classification of Soil:

Weight of Container: _____gm
Wt. Container+Dry Soil: _____gm
Wt. of Dry Sample: _____gm

Sieve Number	Diameter (mm)	Mass of Empty Sieve (g)	Mass of Sieve+Soil Retained (g)	Soil Retained (g)	Percent Retained	Percent Passing
4	4.75					
10	2. 0					
20	0.84					
40	0.425					
60	0. 25					
140	0.106					
200	0.075					
Pan	---					
			Total Weight=			

* Percent passing=100-cumulative percent retained.

From Grain Size Distribution Curve:

% Gravel= _____ D_{10}= _____ mm

% Sand= _____ D_{30}= _____ mm

% Fines= _____ D_{60}= _____ mm

C_u= _____ C_C= _____

Unified Classification of Soil: _____

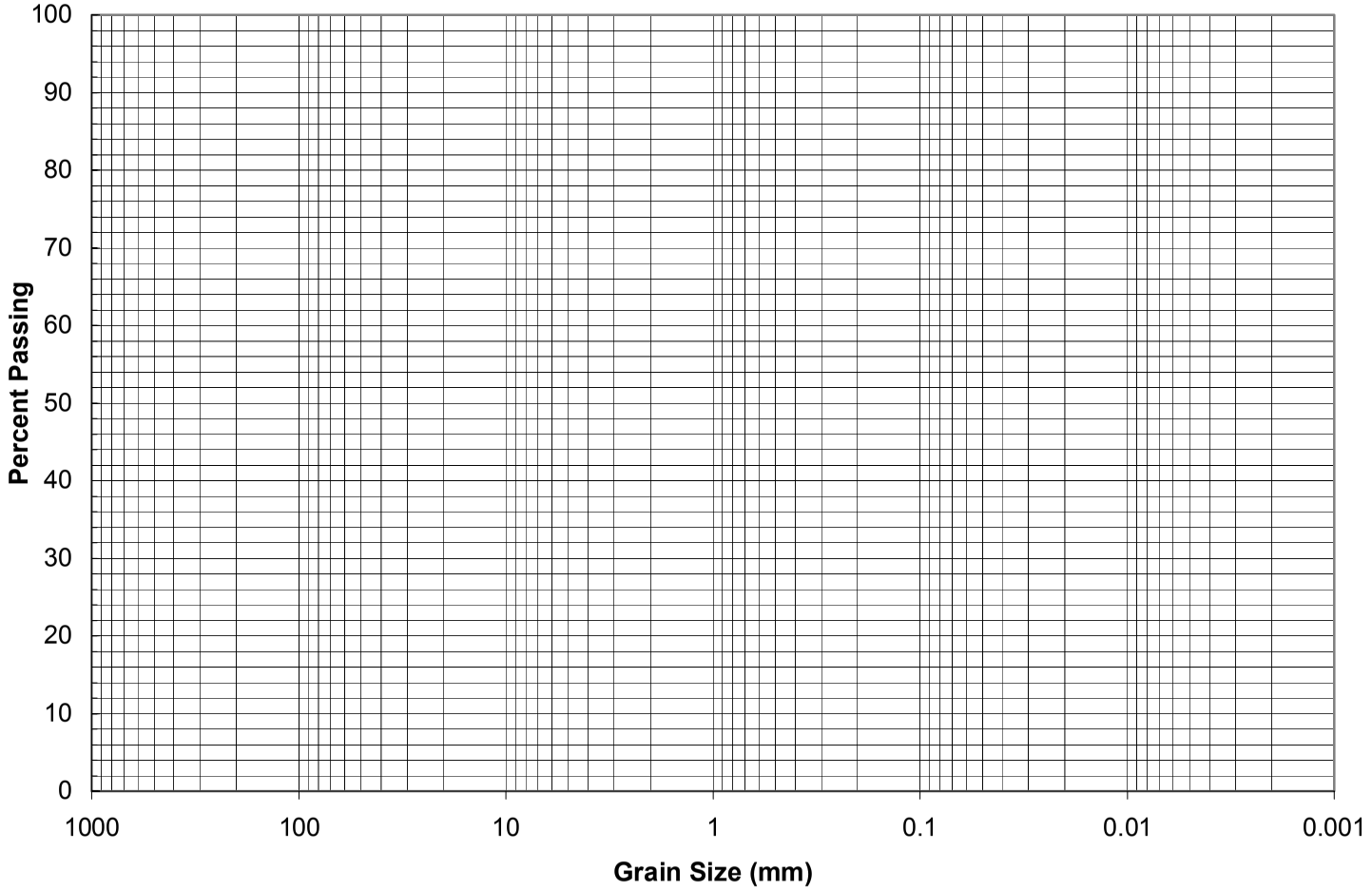
Hydrometer Analysis

Test Date: _____
Tested By: _____
Hydrometer Number (if known): _____
Specific Gravity of Solids:_____
Dispersing Agent: _____
Weight of Soil Sample: _____gm

Zero Correction: _____
Meniscus Correction: _____

Date	Time	Elapsed Time (min)	Temp. ^{O}C	Actual Hydro. Rdg. R_a	Hyd. Corr. for Meniscus	L from Table 1	K from Table 2	D mm	C_T from Table 3	a from Table 4	Corr. Hydr. Rdg. R_c	% Finer P	% Adjusted Finer P_A

Unified Classification of Soil:



Note: You can plot your data on this graph or generate similar graph using any graphics program (e.g., excel)