METHOD OF TEST FOR DETERMINATION OF PARTICLE SIZE ANALYSIS OF SOILS

1. SCOPE

This method covers the quantitative determination of particle size distribution in soils. The distribution of particles larger than 75 μm is determined by dry sieving, and the distribution of particles smaller than 75 μm is determined by means of a sedimentation process using a hydrometer to secure the necessary data.

1.1 REQUIREMENTS

1.1.1 The soil sample shall be classified in accordance with MTO or Unified Soil Classification System prior to the preparation of test specimen. For this purpose, Atterberg Limits shall be determined in accordance with MTO LS-703/704.

1.1.2 The specific gravity of soil particles for the computation of percentage of soil remaining in suspension be determined in accordance with MTO LS-705.

2. RELEVANT DOCUMENTS

2.1	AASHTO T 88	Standard Method of Test for Particle Size Analysis of Soils
2.2	ASTM D421	Standard Practice for Dry Preparation of Soil Samples for Particle-Size Analysis and Determination of Soil Constants
	ASTM D422	Standard Test Method for Particle-Size Analysis of Soils
	ASTM D2216	Standard Test Methods for Laboratory Determination of Water (Moisture) Content of Soil and Rock by Mass
	ASTM D4318	Standard Test Methods for Liquid Limit, Plastic Limit, and Plasticity Index of Soils
	ASTM E11	Standard Specification for Wire Cloth and Sieves for Testing Purposes
	ASTM E100	Standard Specification for ASTM Hydrometers

2.3 T.W. Lambe, Soil Testing for Engineers, John Wiley & Sons, 1951

3. APPARATUS

3.1 BALANCES: A balance readable to 0.01 g for weighing the material passing a 2.0 mm sieve, and a balance with the basic tolerance of ± 0.1% of the mass of the sample for weighing the material retained on a 2.0 mm sieve.

3.2 OVEN: A thermostatically controlled, forced-draft type drying oven capable of maintaining a uniform temperature of 110 ± 5°C throughout.

3.3 STIRRING APPARATUS: Apparatus consists of a mechanically operated stirring device mounted with an electric motor capable of rotating a vertical shaft at a speed not less than 10 000 rpm when there is no load. The shaft shall be equipped with a replaceable stirring paddle made of metal, plastic, or hard rubber as shown in Figure 1a. The length of the shaft shall be such that the stirring paddle will operate not less than 19 mm or nor more than 38 mm above the bottom of the dispersion cup. A special dispersion cup conforming to the designs shown in Figure 1b shall be provided to hold the sample while it is being dispersed.

3.4 HYDROMETER: Graduated to read in grams per litre of suspension, and conforming to the requirements of 152 H in ASTM E100.

3.5 SEDIMENTATION CYLINDER: A graduated glass cylinder 457 mm in height and 60 ± 1.2 mm inside diameter, and marked for a volume of 1 000 ml. The diameter shall be such that the 1 000 ml mark is 360 ± 20 mm from the bottom of the cylinder measured inside.

3.6 CONTROL CYLINDER: A graduated glass cylinder 457 mm in height and 60 ± 1.2 mm inside diameter, and marked for a volume of 1 000 ml. The diameter shall be such that the 1 000 ml mark is 360 ± 20 mm from the bottom of the cylinder measured inside.

3.7 THERMOMETER: A thermometer readable to 0.5°C. These thermometers shall be calibrated to a thermometer accurate to 0.1°C.

3.8 SIEVE: Set of sieves of square-mesh woven-wire cloth conforming to the requirements of ASTM E11. The set of sieves selected should give a uniform spacing of points on the grain-size distribution curve.

3.9 MECHANICAL SIEVE SHAKER: Mechanical sieve shaker used for the sieving operation of the portions retained on 2.0 mm and 75 μm sieves shall be capable of imparting a motion to the sieves that causes the particles to bounce and turn in various orientation to reach the sieve openings.

3.10 CONSTANT-TEMPERATURE BATH: Water bath capable of maintaining the soil suspension at a constant temperature during the hydrometer test. The constant-temperature bath may not be necessary if the test is carried out in a room or laboratory where the temperature is maintained at 20 ± 2°C throughout a period of 24 hours.

3.11 BEAKER: A 250 ml to 400 ml capacity glass beaker.

3.12 TIMER: A clock, stopwatch, or digital timer readable to one second.

3.13 SPLITTER: Sample splitter shall have an even number of equal width chutes but not less than a total of 12. Chutes shall be 12.5 to 20 mm wide. The splitter and accessory shall be so designed that the sample will flow smoothly without restriction or loss of material.

3.14 LABORATORY CONTROL SAMPLE: A supply of clay from Dresden, Chatham. is available from the Soils and Aggregates Section, Ministry of Transportation, 1201 Wilson Avenue, Downsview, Ontario M3M 1J8, Phone (416) 235-3735, Fax (416) 235-4101.

4. DISPERSING AGENT

4.1 Soil Identification: Prior to preparing the sodium hexametaphosphate solution (dispersing agent), the Atterberg Limits (LL & PL) and Plasticity Index (PI) of the soil sample shall be determined in accordance with LS-703/704. The soil sample shall be classified according to the MTO or Unified Soil Classification System.

4.2 DISPERSING AGENT: A solution of sodium hexametaphosphate shall be prepared using distilled water only. The amount of dispersing agent used in 1 000 ml of distilled water shall depend on the type of soil to be tested. The amount of sodium hexametaphosphate per litre of solution used shall be according to the schedule in Table 1:

Table 1

Soil Type	Mass of Dispersing Agent (g/L)
SM, SC, ML, OL, or MI	24
CL-ML, CL, OI, OH, or MH	40
CI or CH	48

4.3 Water: Distilled water shall be used for the preparation of the solution and test specimen. The water for the hydrometer test shall be brought to the temperature that is expected to prevail during the test. If the sedimentation and control cylinders are to be placed in a constant temperature bath, the distilled water to be used shall be brought to the temperature of the water bath. In cases where the test is performed in a room with automatically controlled temperature, the water for the test shall be at the temperature of the room.

Note 1: A dispersing agent can either act as a protective colloid on the soil particle or alter the electric charge on the particle to prevent flocculation. The dispersing action of the sodium hexametaphosphate will decrease if the solution becomes acidic. Solutions should be frequently prepared and adjusted to a pH value between 8 and 9 by means of sodium carbonate.

5. TEST SAMPLE

5.1 The test sample for the sieve analysis shall be prepared as outlined in LS-700. Select with care a test sample that is representative of the soil to be tested. The test sample is divided into 2 portions during the preparation procedure by separating on a 2.0 mm sieve. The mass of the dried soil sample selected for the purpose of the test shall be sufficient to yield quantities for sieve analysis as follows:

5.1.1 The mass of the portion retained on 2.0 mm sieve shall depend on the maximum size of the particle, according to the Table 2 below:

Table 2

Nominal Diameter of Largest Particle (mm)	**Minimum Mass of Portion (Kg)**
9.5	0.5
19.0	1.0
26.5	2.0
37.5	3.0
53.0	4.0
75.0	5.0

5.1.2 The mass of the portion passing 2.0 mm sieve for hygroscopic moisture determination, and hydrometer analysis shall be approximately 120 g for sandy soils and approximately 70 g for silts and clayey soils.

5.2 Prepare a representative sample of the amount required for performing the Particle Size Analysis. Weigh and record the mass of the dried sample. Record this weight as the mass of the total test sample uncorrected for hygroscopic moisture. Separate the test sample into two portions by sieving through a 2.0 mm sieve. Process the fraction of the soil retained on 2.0 mm sieve into its individual particles with a rubber-covered pestle or other suitable device. Again, sieve the soil that was broken down to individual particles through a 2.0 mm sieve, and separate it into coarse and fine fractions.

5.3 After the second sieving operation, wash the fraction of the sample retained on the 2.0 mm sieve until the wash water is clear. Dry and weigh the material retained on the 2.0 mm sieve. This weight is recorded as the mass (M_c) of coarse material retained on 2.0 mm sieve. The percentage passing and retained on the 2.0 mm sieve can be calculated from these 2 masses (i.e. the original mass, M_t of the sample selected, and the mass, M_c after washing).

5.4 Thoroughly mix together the portion of the soil sample passing the 2.0 mm sieve from both sieving operations. Select appropriate quantity of soil specimen as indicated in section 5.1.2 by quartering or the use of a sample splitter.

SIEVE ANALYSIS OF PORTION RETAINED ON 2.0 MM SIEVE

6. PROCEDURE

6.1 Sieve the portion of the sample retained on 2.0 mm sieve through a nest of sieves consisting of 75.0, 63.0, 53.0, 37.5, 26.5, 19.0, 13.2, 9.5, and 4.75 mm. The number of sieves needed shall depend on the type of soil sample or the requirements of the specifications for the material to be tested.

6.2 The sieving operation shall be conducted by means of a lateral and vertical motion of the sieve, accompanied by a jarring motion. This can be achieved by manual operation, i.e. hand shaking or by using a mechanical sieve shaker. The fragments in the sample shall not be manipulated through the sieve openings by hand. The sieving operation shall be continued until not more than one percent (1%) of the retained material on the sieve passes that sieve during 1 minute of sieving. The thoroughness of the sieving should be checked manually when a mechanical sieve shaker is used.

6.3 Determine the mass of soil retained on each sieve using a balance conforming to the requirements of section 3.1. The sum of these retained masses should be checked against the original sample mass. The total mass of the material after sieving should check closely with the original mass of the sample placed on the sieves. The result should not be used for acceptance if the amount differs by more than 0.3% based on the original dry sample mass.

HYDROMETER AND SIEVE ANALYSIS OF PORTION PASSING 2.0 MM SIEVE

7. CORRECTION FOR HYDROMETER READING

7.1 **Meniscus Correction:** Equations for percentage of soil remaining in suspension are based on the use of sodium hexametaphosphate solution having strength equal to that of the soil suspension. Hydrometers are generally graduated to read at the bottom of the meniscus. The soil suspension in the sedimentation cylinder is opaque and it is not possible to secure readings at the bottom of the meniscus. Therefore, readings are taken at the top of the meniscus and a correction is applied.

7.1.1 Prepare a control cylinder with 1 000 ml of liquid composed of distilled water and sodium hexametaphosphate in the same proportion as used in the test. This can be prepared by adding distilled water to 125 ml of dispersing agent prepared in accordance with section 4.2 until the total volume is 1 000 ml. Place the thermometer and the hydrometer in the control cylinder.

7.1.2 Meniscus correction H_m is determined by inserting the hydrometer into the solution with the appropriate amount of dispersing agent, and recording the absolute reading at the top of the meniscus and where the plane of the liquid surface intersects the hydrometer scale. The latter reading shall be obtained by observing a point slightly below the plane of the liquid surface, then raising the line of vision until this surface seen as an ellipse becomes a straight line. The point where this line cuts the stem is the hydrometer reading. Holding a white sheet of paper behind the cylinder just below the liquid level will improve the visibility of the surface. These readings shall be recorded to the nearest half a division. The positive difference between these two readings in divisions of g/L is the meniscus correction H_m. This correction should be applied in determining the effective depth of the hydrometer. Refer to Figure 2a for further details.

7.2 **Immersion Correction:** The surface of the suspension in the sedimentation cylinder rises when the hydrometer is inserted into it. A correction known as “immersion correction” should be applied in determining the effective floating depth of the hydrometer bulb. This correction is made by subtracting half of the volume of hydrometer bulb (V_B) divided by the cross-sectional area (A) of the sedimentation cylinder from the distance (L_1) from the surface of the suspension to the centre of the bulb.

7.2.1 The volume of the hydrometer bulb is often assumed constant, but this can be quite variable. ASTM E100 does not specify a requirement for the volume of the bulb. The volume of the hydrometer bulb can be determined by inserting the hydrometer into a graduated glass cylinder filled with water adequate to immerse the bulb. The volume of the bulb is equal to the volume of water displaced by the bulb, i.e. the difference in volume readings before and after the immersion of the hydrometer. The volume of the bulb shall be recorded to the nearest 1 cm^3. Refer to Figure 2b for further details.

7.2.2 Alternatively, the volume of the hydrometer bulb can be determined from its weight and unit weight. The unit weight can be taken as equal to the lowest reading in the hydrometer scale multiplied by the unit weight of distilled water at the standard temperature of the hydrometer. The mass of the hydrometer for this purpose shall be recorded to the nearest 0.1 g.

7.2.3 Cross-sectional area of the sedimentation cylinder can be obtained by dividing the volume between 2 calibration marks by the measured distance between the same 2 marks. Measure and record the distance between the marks to the nearest millimetre. Upon recording these measurements, calculate and record the cross-sectional area to the nearest 0.1 cm^2. Refer to Figure 2c for further details.

7.3 **Temperature Correction:** Soil hydrometers are calibrated at 20^{o}C, and any variations from this standard temperature produce inaccuracies in the actual hydrometer readings. The viscosity of the suspension will also be affected by the variation in temperature. The equation given under Section 11.1, Calculation and Report, shall be used to compute the viscosity of the suspension within the temperature range of $20 \pm 5^{\circ}$C. The temperature corresponding to each hydrometer reading shall be recorded to the nearest 0.5°C.

7.4 **Hygroscopic Moisture Correction:** Hygroscopic Moisture Correction Factor is the ratio between the mass of the oven-dried sample (W_o) and the air-dried mass (W_a). To determine this factor, weigh approximately 10-15 g of soil sample from the material passing the 2.0 mm sieve in a small metal or glass container meeting the requirements of ASTM D2216, section 6.3. Dry this to a constant mass in an oven at $110 \pm 5^{\circ}$C. Weigh and record the masses to the nearest 0.01 g.

8. DISPERSION OF SOIL SAMPLE

8.1 The mass of the test sample for hydrometer analysis shall depend on the type of soil to be tested. Weigh approximately 50 g of the air-dried sample if the soil is classified as clay, organic silt, or high plastic silt, i.e. CL-ML, CL, CI, OI, OH, CH, or MH under section 4.1. If the soil is classified as sand or low to medium plastic silt, i.e. SM, SC, OL, ML, or MI, weigh approximately 100 g of the air-dried sample prepared in accordance with the requirements of section 5.

8.2 Place the test specimen in a 250-ml capacity beaker and add 125 ml of sodium hexametaphosphate solution prepared according to the requirements of section 4.2. Stir the mix (soil specimen and dispersing agent) until the soil is thoroughly wetted. Allow the mix to soak for at least 16 hours.

8.3 After at least 16 hours of soaking, transfer the soil slurry from the beaker into the special dispersion cup shown in Figure 1b. Wash any residue from the beaker into the cup with distilled water only. If necessary, add distilled water until the cup is more than half full. Disperse the soil using the stirring apparatus until the soil is broken down to its individual particles. Depending on the type of soil, the time required to disperse may range from 1 minute to as high as 10 minutes (e.g. 1 minute for non-plastic soils and 10 minutes for plastic soils).

9. HYDROMETER TEST

9.1 Immediately after the dispersion of the soil, transfer the slurry to the sedimentation cylinder and add distilled water until the volume is 1 000 ml.

9.2 Mix the slurry for a period of 1 minute by placing a rubber stopper over the open end of the cylinder and turning upside down and back. The number of turns during this 1 minute should be about 30, counting the turn upside down and back as one. Make sure that there is no soil stuck to the base of the cylinder when it is upside down. Vigorous shaking of the cylinder while it is in the inverted position should loosen any soil remaining at the base. Set the sedimentation cylinder in a convenient location on the table and start the timer after agitating the suspension for 1 minute.

9.3 Take the hydrometer readings at total elapsed time of 1, 2, 5, 15, 30, 60, 250, and 1440 minutes. The sedimentation cylinder shall be placed in the constant-temperature bath between the 2 and 5-minute readings if a bath is used.

9.4 After the 2-minute reading, remove the hydrometer from the suspension. For this and all subsequent readings, insert the hydrometer 20-25 seconds before the reading is due. Dry the hydrometer stem before each insertion into the suspension. As soon as the reading is taken, the hydrometer shall be carefully removed from the suspension and placed with a spinning motion in the control cylinder. Record the hydrometer and temperature readings in the control cylinder.

9.5 After each hydrometer reading, take the temperature of the suspension by inserting the thermometer.

9.6 After each hydrometer reading in the soil suspension, take and record the hydrometer and temperature readings in the control cylinder.

10. SIEVE ANALYSIS

10.1 After the final reading, transfer the suspension to a 75 μm sieve and wash it with tap water at room temperature until the wash water is clear.

10.2 Carefully transfer the material retained on the 75 μm sieve to a suitable container and dry it in an oven at 110 ± 5°C.

10.3 Sieve the material retained on the 75 μm sieve through a set of sieves consisting of 2.0 mm, 850 μm, 425 μm, 250 μm, 106 μm, and 75 μm. The number of sieves needed shall depend on the type of soil sample or the requirements of the specifications for the material under test.

CALCULATIONS AND REPORT

11. SIEVE ANALYSIS VALUES FOR PORTION RETAINED ON 2.0 MM SIEVE

11.1 Calculate the percentage passing the 2.0 mm sieve (P_{10}) by dividing the mass passing the 2.0 mm sieve (M_{10}) from the section 5.3 by the original mass M_t of the soil separated on the 2.0 mm sieve, and multiplying the result by 100.

$$M_{10} = M_t - M_c$$

$$P_{10} = (M_{10}/M_t) \times 100$$

Where: M_{10} = mass of soil passing 2.0 mm sieve
M_t = total mass of soil originally split on 2.0 mm sieve
M_c = mass of coarse material retained on 2.0 mm sieve
P_{10} = percentage of soil passing 2.0 mm sieve

11.1.1 Calculate the percentage retained on each sieve by dividing the mass of soil retained on that particular sieve under consideration by the original mass of soil used in the analysis, and multiplying the result by 100.

11.1.2 The cumulative percentage retained on each sieve is equal to the sum of percentages retained on all coarser sieves. To calculate the percentage finer than on each sieve, subtract the cumulative percentage retained on that particular sieve in question from 100.

11.2 Hygroscopic Moisture Correction Factor

11.2.1 Calculate the moisture correction factor F by dividing the oven-dried mass W_o from Section 7.4 by the air-dried mass W_a. This factor is a number less than one, except when there is no hygroscopic moisture.

$$F = (W_o/W_a)$$

11.3 Percentage of Soil in Suspension

11.3.1 Calculate the oven-dried mass of soil (M_o) used in the hydrometer analysis by multiplying the air-dried mass (M_a) by the hygroscopic moisture correction factor (F).

$$M_o = F \times M_a$$

11.3.2 Calculate the mass of total sample (W) represented by the mass of soil used in the hydrometer test from the following: Divide the oven-dried mass (M_o) used by the percentage passing the 2.0 mm sieve, and multiply the result by 100. Use this value in the equation for percentage remaining in the soil suspension.

$$W = (M_o/P_{10}) \times 100$$

11.3.3 The percentage of soil remaining in suspension or the total percent finer at the depth at which the hydrometer is measuring the density of the soil suspension shall be calculated as follows:

$$P = (\alpha R/W) \times 100$$

Where: P = percentage of soil remaining in suspension or the total percent finer at the depth at which the hydrometer measures the density of the suspension
α = specific gravity correction factor to be applied to the reading of the hydrometer
$\alpha = 0.6226 \times (G_s/(G_s-1))$
G_s = specific gravity of the soil particles; specific gravity of the soil particles shall be determined in accordance with MTO LS-705, and the results shall be reported to the nearest second decimal, i.e. 0.01.
R = hydrometer reading with meniscus correction
$R = H_s - H_c$
H_s = hydrometer reading in sedimentation cylinder at elapsed time (T)
H_c = hydrometer reading in control cylinder at elapsed time (T)
W = oven-dried mass of soil in a total test sample represented by mass of soil dispersed in grams

11.4 Diameter of Soil Particle

The diameter of soil particle corresponding to the percentage of soil remaining in suspension shall be calculated according to Stokes' Law. This law considers the terminal velocity of a falling sphere in an infinity of liquid. Calculate and record the constant (K), coefficient of viscosity (η) and particle diameter (D) to four significant digits (i.e. to the nearest 0.0001).

$$D = k \times (L/T)^{1/2}$$

Where: D = diameter of soil particles in mm
K = a constant depends on the coefficient of viscosity of the suspending medium, temperature of the suspension, and the specific gravity of the soil particles. The constant K shall be calculated using the equation given below or obtained from Table 3.
K = $5.533 \times 10-3(\eta/(Gs - 1))1/2$
η = coefficient of viscosity of the suspending medium in millipoises
η = $(2.7183)C \times 14.77$
C = $((\ln TC - 1.4443)2)/(-6.3182)$
TC = average temperature of the suspension in °C at elapsed time (T)
L = effective floating depth of the hydrometer bulb in cm (refer to Figure 2d)
L = $L1 + ½(L2 - VB/A) - hs\,(Hs + Hm)$
L1 = distance from the top of the bulb to reference point ('0'-reading) in cm at elapsed time (T)
L2 = overall length of the hydrometer bulb in cm
VB = volume of hydrometer bulb in cm^3 from Section 7.2.1 or 7.2.2
A = cross-sectional area of sedimentation cylinder in cm^2 from Section 7.2.3
hs = distance between the scale dimensions in cm/div. (refer to Figure 2e)
Hm = meniscus correction in divisions (g/L) from Section 7.1.2

Table 3

Temperature in ^oC	**Viscosity of Water in Millipoises**	**Temperature in ^oC**	**Viscosity of Water in Millipoises**
18.0	10.6082	23.0	9.3925
18.5	10.4747	23.5	9.2843
19.0	10.3441	24.0	9.1783
19.5	10.2162	24.5	9.0744
20.0	10.0909	25.0	8.9726
20.5	9.9684	25.5	8.8728
21.0	9.8483	26.0	8.7749
21.5	9.7308	26.5	8.6790
22.0	9.6157	27.0	8.5849
22.5	9.5029	27.5	8.4926

Sieve Analysis Values for Portion Passing 2.0 mm Sieve

11.4.1 Calculate the cumulative percentage of soil sample retained on the 2.0 mm sieve as described in Section 11.1.3 or by subtracting the percent passing the 2.0 mm sieve (Section 11.1.1) from 100. To calculate the mass of the portion retained on 2.0 mm sieve, multiply the percentage retained on the 2.0 mm sieve by the mass of the total sample represented by the mass of the soil used (M_t). This mass should be equivalent to the mass of coarse material, M_c, retained on the 2.0 mm sieve.

11.4.2 Calculate the mass of soil passing the 75 μm sieve by adding the fractional masses retained on all of the sieves, including the 2.0 mm sieve, and subtract this cumulative mass from the total mass M_t.

11.4.3 Calculate the total masses passing or retained on each of the sieves finer than the 2.0 mm sieve using the method described in 11.1.2 or 11.1.3.

11.5 Report

The results of the grain size analysis are usually presented in the form of a distribution curve. This curve is obtained by plotting the soil particle diameter against percent passing. The report shall include the following:

11.5.1 Details of Soil Sample:
11.6.1.1 Maximum size of soil particle
11.6.1.2 Soil classification
11.6.1.3 Atterberg Limits (LL and PL)
11.6.1.4 Specific gravity of soil particles
11.6.1.5 Mass of dispersing agent (sodium hexametaphosphate) used in 1 000 ml

11.5.2 Details of hydrometer and sedimentation cylinder:
11.5.2.1 Volume of hydrometer bulb
11.5.2.2 Length of hydrometer bulb
11.5.2.3 Length from ‘0’- reading to the top of bulb
11.5.2.4 Distance between the scale dimensions
11.5.2.5 Cross-sectional area of the sedimentation cylinder

11.5.3 Percentage passing and retained on each sieve should be tabulated and presented by plotting on a semi-log graph.

11.5.4 In the case of materials tested for compliance with any specification, the fraction called for in that specification shall be reported.

12. USE OF LABORATORY CONTROL SAMPLE

12.1 Every 10 samples, or once in 6 months, a sample of the reference soil shall be tested. The material shall be taken from a stock supply maintained by the Soils and Aggregates Section. The limits of acceptable percent passing the particle size analysis results for the reference soil sample obtained in accordance with this test procedure are as follows:

	Percent Passing		
Particle Size	**Lower Limit**	**Mean**	**Upper Limit**
2.0 mm	100	100	100
425 µm	99.6	99.8	100
75 µm	98.5	99.1	99.7
20 µm	72.6	80.2	87.8
5 µm	38.8	44.5	50.2
2 µm	24.2	29.7	35.2

12.2 Control Chart Use: The percentage of silt and clay sized particles of the last 20 samples of reference material shall be plotted on a control chart in order to demonstrate the performance of the laboratory.

HYDROMETER ANALYSIS

Hydrometer and Soil Sample Details

Project:	**Sample No.:**	**Date:**
Borehole No.:	Lab No.:	Tested By:
Sample Depth:	Sample Description:	Checked By:
SOIL INFORMATION	**HYDROMETER DETAILS**	**CALCULATION OF DRY SOIL MASS**
Liquid Limit (LL):	Volume of Bulb (V_B): cm^3	Oven-Dried Mass (W_o): g
Plasticity Index (PI):	Length of Bulb (L_2): cm	Air-Dried Mass (W_a): g
Soil Classification:	Length from ‘0’ Reading to Top of Bulb (L_1): cm	Hygroscopic Corr. Factor ($F=W_o/W_a$):
Specific Gravity (G_s):	Scale Dimension (h_s): cm /Div.	Air Dried Mass in Analysis (M_a): g
Sg. Correction Factor (α):	Cross-Sectional Area of Cylinder (A): cm^2	Oven-Dried Mass in Analysis (M_o): g
Mass of Dispersing Agent /Litre: g	Meniscus Correction (H_m): g/L	% Passing 2.0 mm Sieve (P_{10}):
		Sample Represented (W):

$$M_o = F \times M_a$$

$$W = (M_o/P_{10}) \times 100$$

$$P = (\alpha R/W) \times 100$$

$$D = K\,(L/T)^{1/2}$$

$$K = 5.533 \times 10^{-3}(\eta/(G_s - 1))^{1/2}$$

$$\eta = (2.7183)^C \times 14.77$$

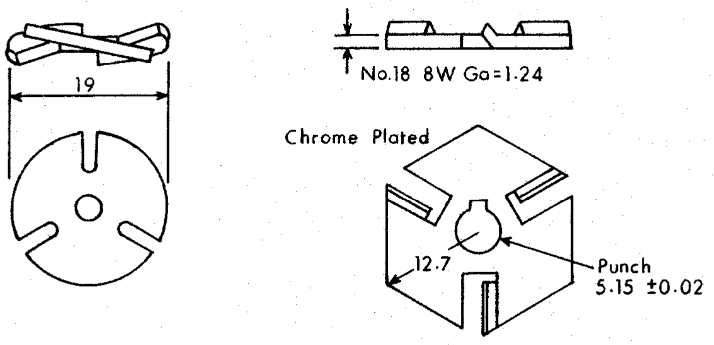
$$C = ((\ln T_c - 1.4443)^2)/(-6.3182)$$

$$L = L_1 + ½(L_2 - V_B/A) - h_s\,(H_s + H_m)$$

HYDROMETER ANALYSIS

Hydrometer Readings

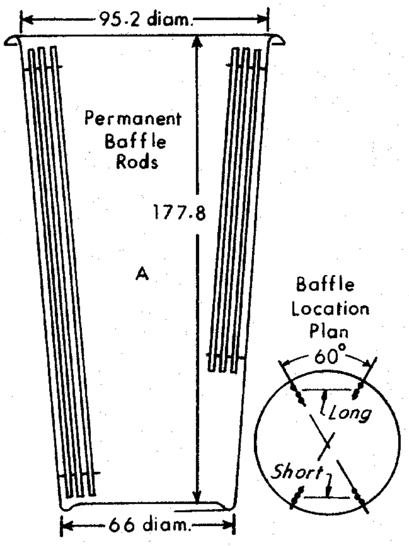
Project:				**Sample No.:**				**Tested By:**			
Date	Time	Elapsed Time (T) in Min.	H_s in Divisions g/L	H_c in Divisions g/L	Temp. T_c in ^oC	R = H_s-H_c	P in %	L in cm	η in Poise	K	D in mm
		1									
		2									
		5									
		15									
		30									
		60									
		250									
		1440									



(a) (b)

Dimensions are in millimetres

Figure 1a - Details of Stirring Paddles



Dimensions are in millimetres

Figure 1b - Details of Special Dispersion Cup

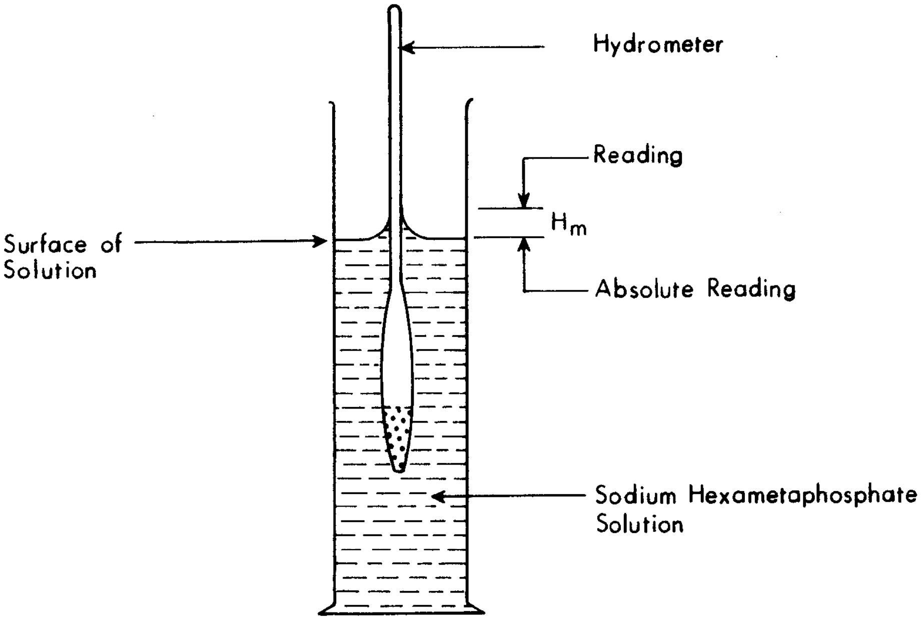


Figure 2a - Determination of Meniscus Correction

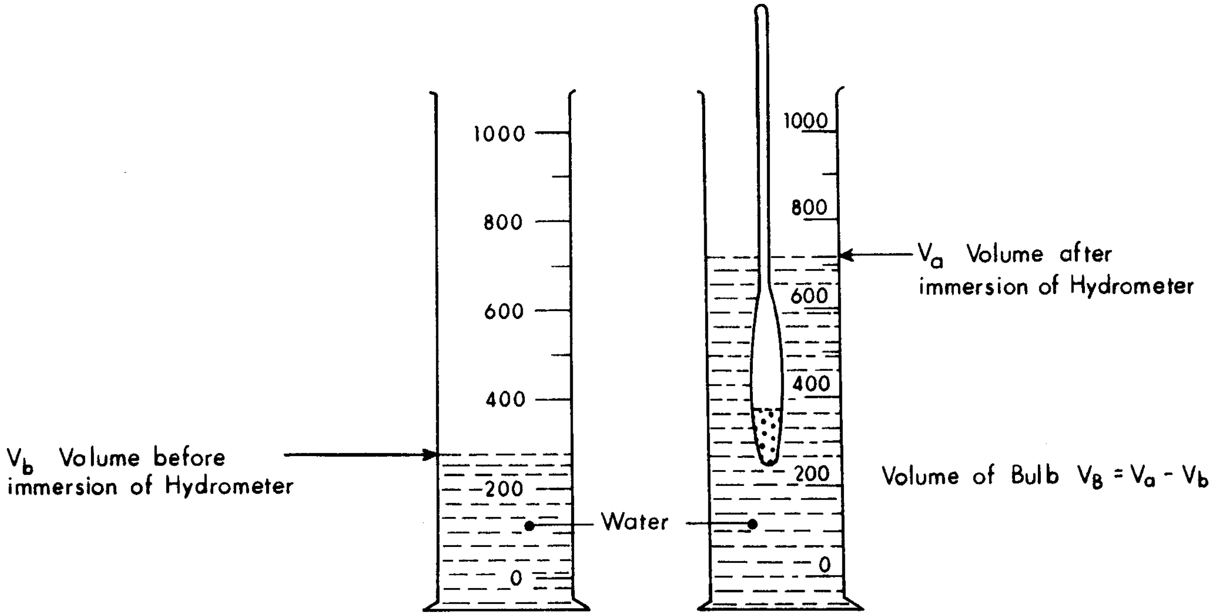


Figure 2b - Volume of Hydrometer Bulb

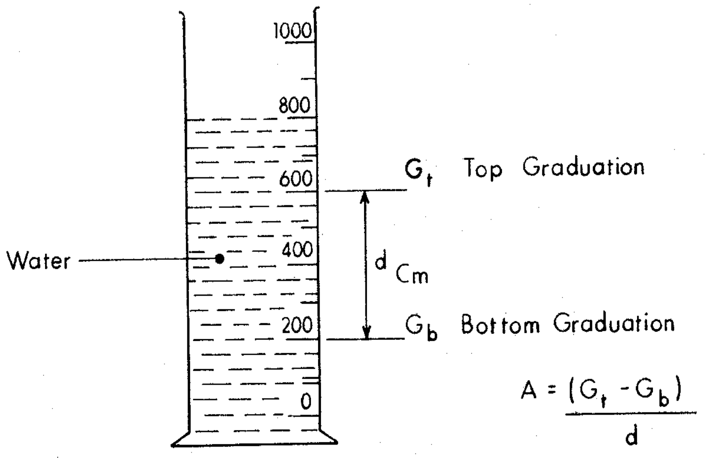


Figure 2C - Cross-Sectional Area of Sedimentation Cylinder

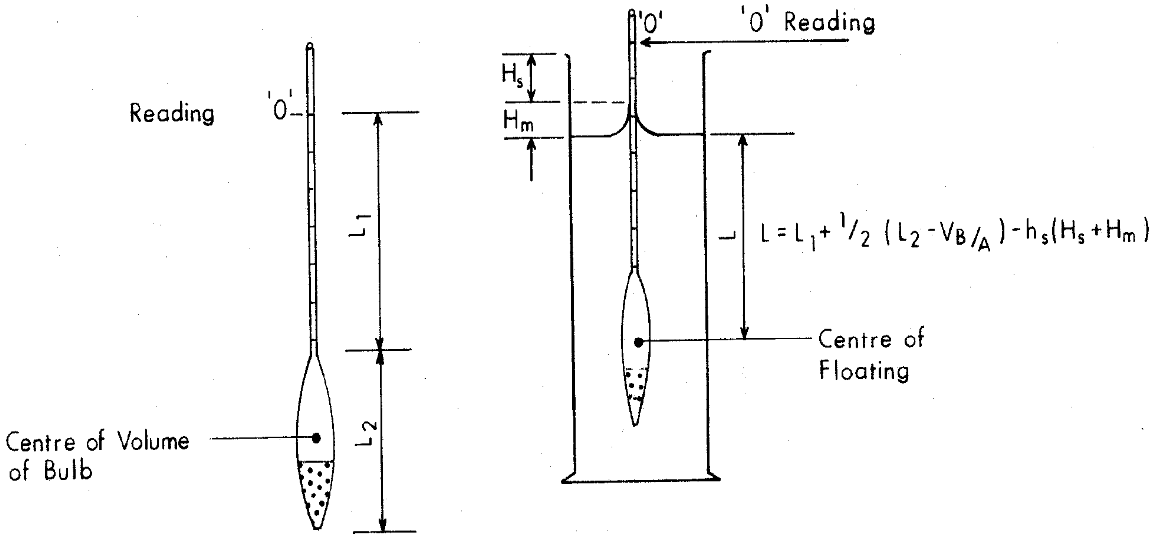


Figure 2d - Effective Floating Depth of Hydrometer Bulb

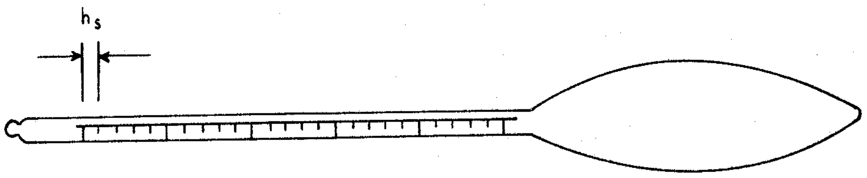


Figure 2e - Distance Between Scale Dimensions