

## SMG-03: FINE ANALYSIS (HYDROMETER TEST)

Reference Standard: BS 1377: Part 2 1990:9.6; ASTM D422

### INTRODUCTION

Different procedures are required for fine and coarse-grained material.

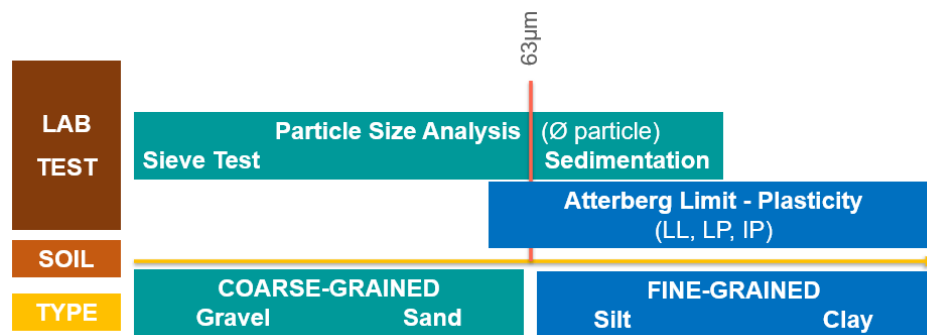


Figure 1: Laboratory testing for soil classification

### Fine Grained Soil

To determine the grain size distribution of material passing the 63µm sieve the hydrometer method is commonly used. The soil is mixed with water and a dispersing agent, stirred vigorously, and allowed to settle to the bottom of a measuring cylinder (refer Figure 2). As the soil particles settle out of suspension the specific gravity of the mixture reduces. A hydrometer is used to record the variation of specific gravity with time. By making use of Stoke's Law, which relates the velocity of a free falling sphere to its diameter, the test data is reduced to provide particle diameters and the % by weight of the sample finer than a particular particle size.

$$v = \frac{D^2 \gamma_w (G_s - G_L)}{18\eta}$$

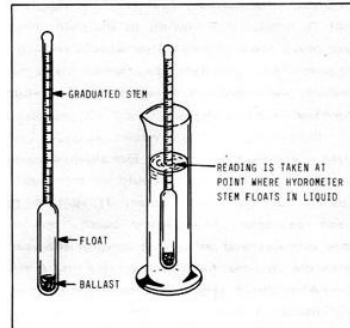


Figure 2: Hydrometer and bulb

### DATA PROCESSING

- 1) Calculate the true hydrometer reading,  $R_h$  (in mm), from the following equation :

$$R_h = R_h' + C_m$$

Where:

$C_m$  = is the meniscus correction

$R_h'$  = is the observed hydrometer reading

- 2) Obtain the effective depth,  $H_R$  (in mm), at which the density of the suspension is measured, corresponding to the reading,  $R_h$ , from the hydrometer scale calibration curve.
- 3) Calculate the equivalent particle diameter,  $D$  (in mm), from the equation :

$$D = 0.005531 \sqrt{\frac{\eta H_R}{(\rho_s - 1) t}}$$

Where:

$\eta$  = dynamic viscosity of water at the test temperature (in mPa.s) as shown in Table 2;

$H_R$  = effective depth at which the density of the suspension is measured (in mm);

$\rho_s$  = particle density (in Mg/m<sup>3</sup>);

$t$  = elapsed time (in min)

0.005531 = constant

Table 2: Viscosity of water



Temperature, T (°C)	Viscosity of water, $\eta$ (mPa.s)
10	1.304
15	1.137
20	1.002
25	0.891
30	0.798

*Note. Intermediate values may be obtained by interpolation.*

- 4) Calculate the modified hydrometer reading,  $R_d$  from the equation:

$$R_d = R_h' - R_o'$$

Where:

$R_o'$  = is the hydrometer reading at the upper rim of the meniscus in the dispersion solution

- 5) Calculate the percentage by mass,  $K$ , of particles smaller than the corresponding equivalent particle diameter,  $D$  (in mm), from the equation:

$$K = \left[ \frac{100\rho_s}{m(\rho_s - 1)} \right] R_d$$

Where:

$m$  = is the mass of the dry soil used (in g);

- 6) Plot the particle size distribution of the soil.

## OBJECTIVE

To obtain the particle size distribution and the grading curve for a given soil sample.

## APPARATUS

List out equipment and apparatus use in the experiment complete with figures.

## **PROCEDURES**

### **A) CALIBRATION**

#### **Volume calibration of hydrometer:**

- 1) Weigh the hydrometer to the nearest 0.1g. Record the mass in grams as the volume of the hydrometer,  $V_h$  in ml.

#### **Scale calibration of hydrometer:**

- 1) Measure the distance (to the nearest mm) from the 100ml scale marking to the 1000ml scale marking on the sedimentation cylinder. Record this value as L. For a cylinder with a scale mark only at 1000ml, determine the 100ml level by adding a measured 100ml of water.
- 2) Measure and record the distances from the lowest calibration mark on the stem of the hydrometer to each of the major calibration marks ( $R_h$ ). Record this value as  $d_1$ ,  $d_2$ ,  $d_3$  and so on.
- 3) Measure and record the distance from the neck of the bulb to the nearest calibration mark. Record this value as N.
- 4) The distance corresponding to the hydrometer reading ( $R_h$ ) is equal to the sum of the distances measured in step 2 and 3 previously. Record these values as H.
- 5) Measure and record the distance from the neck to the bottom of the bulb as the height of the bulb. Record this value as h.

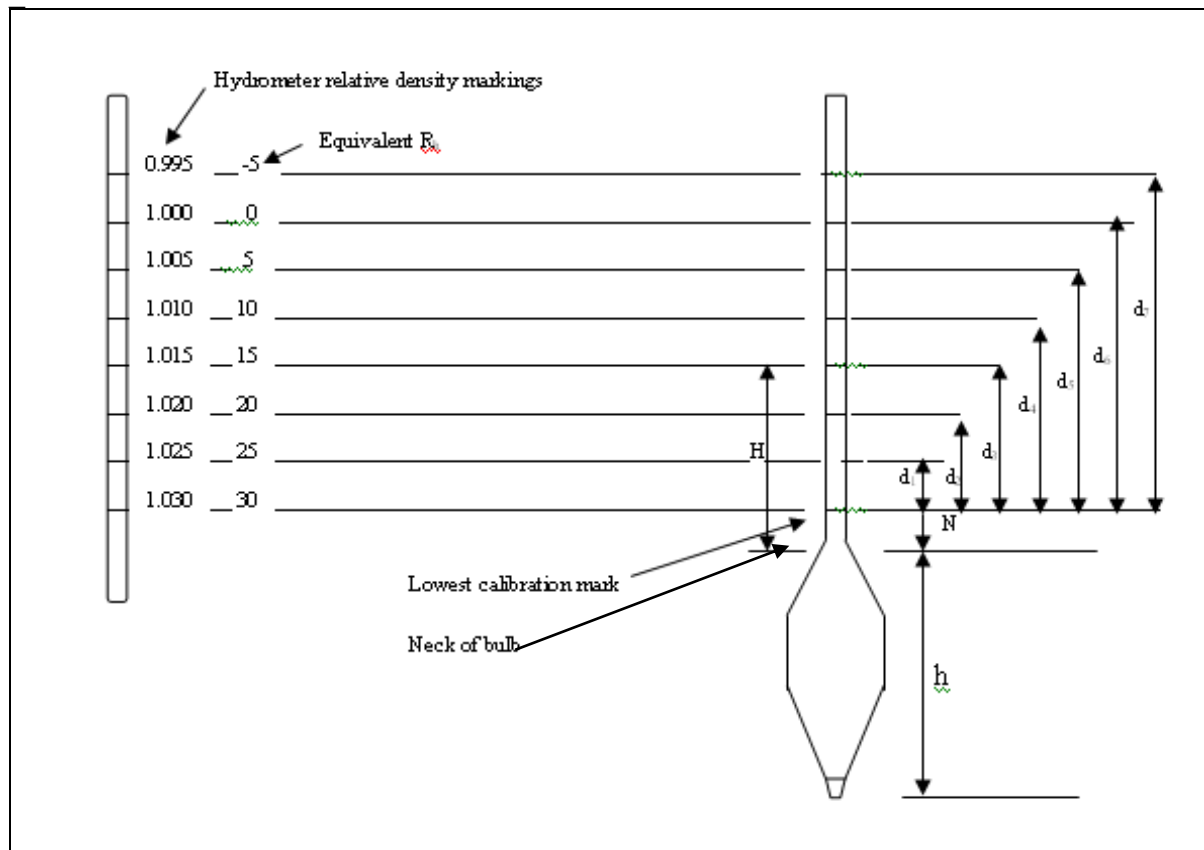


Figure 3: Essential measurements for calibration of hydrometer

- 6) Calculate the effective depth,  $H_R$  (in mm), corresponding to each of the major calibration marks,  $R_h$  from the following equation:

$$H_R = H + \frac{1}{2} \left[ h - \frac{V_h L}{900} \right]$$

Where:

$H$  = is the length from the neck of the bulb to graduation  $R_h$

$h$  = is the length of the bulb

$V_h$  = is the volume of the hydrometer bulb

$L$  = is the distance between the 100ml and the 1000ml scale marking of the sedimentation cylinder

- 7) Plot the relationship between  $H_R$  and  $R_h$  as a smooth curve.

## B) MENISCUS CORRECTION

- 1) Insert the hydrometer in a 1L cylinder containing about 800ml of water

- 2) By placing the eye slightly below the plane of the surface of the liquid and then raising it slowly until the surface seen as an eclipse becomes a straight line, determine the point where the plane intersects the hydrometer scale.
- 3) By placing the eye slightly above the plane surface of the liquid and then lowering it slowly until the surface seen as an eclipse becomes a straight line, determine the point where the plane intersects the hydrometer scale.
- 4) Record the difference between the two readings obtained from step 3 and 4 previously as the meniscus correction,  $C_m$ .

### **C) PREPARATION AND ASSEMBLY**

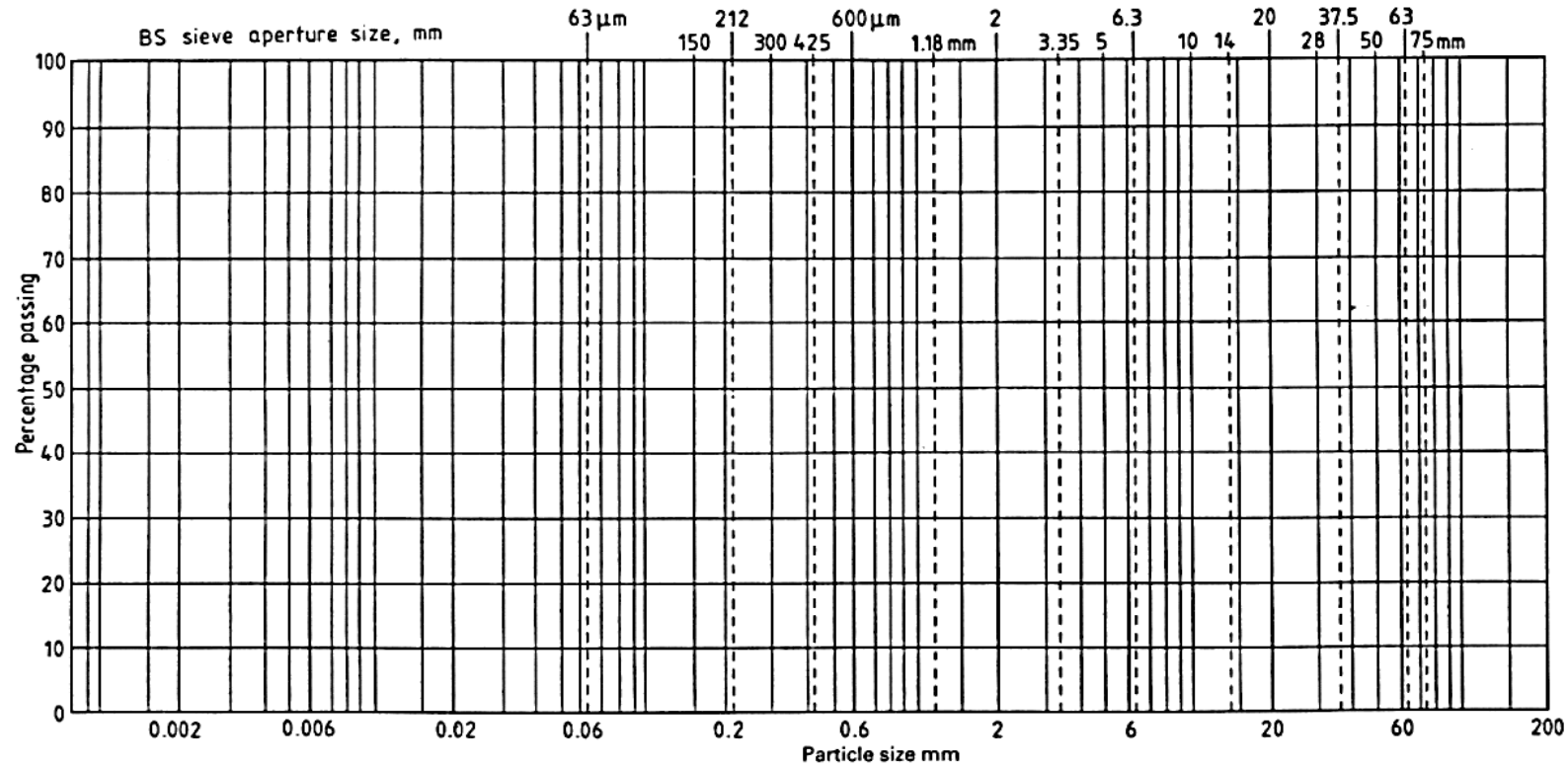
- 1) Weigh 50g of the test sample and obtain its initial dry mass,  $m_o$ .
- 2) Place the test sample in the wide-mouth conical flask.
- 3) Add 100ml of the sodium hexametaphosphate solution to the soil in the conical flask. Shake the mixture thoroughly until all the soil is in suspension.
- 4) Transfer the suspension from the flask to the 63 $\mu$ m test sieve which is placed on the receiver and wash the soil in the sieve using a jet of distilled water from the wash bottle. Proceed until the color of the soil turn into its natural/original color. However, the amount of water used during this operation shall not exceed 500ml.
- 5) Transfer the suspension that has passed through the sieve to the 1L measuring cylinder and make up to the 1L graduation mark with distilled water. Use this suspension for the sedimentation analysis.
- 6) Transfer the material retained in the 63 $\mu$ m test sieve to an evaporating dish and dry in the oven maintained at 105°C to 110°C for 24 hours.
- 7) When cooled, re-sieve this material on the sieves down to 63 $\mu$ m size. Weigh the material retained on each sieve.
- 8) Add any material passing the 63 $\mu$ m test sieve to the measuring cylinder.

### **D) SEDIMENTATION**

- 1) Add any material passing the 63 $\mu$ m test sieve (sample retain in pan from the sieve analysis procedure) to the measuring cylinder.

- 2) Insert the rubber bung into the cylinder containing the soil suspension. Shake it and place it in the constant temperature bath so that it is immersed in water at least up to the 1L graduation mark.
- 3) Add 100ml of the sodium hexametaphosphate solution to the other 1L sedimentation cylinder and dilute with distilled water to ensure it exactly 1L. Insert the rubber bung and place this cylinder in the constant temperature bath alongside the first one.
- 4) After at least 1 hour, take out the cylinder containing the dispersion solution, shake it thoroughly and put it back inside the bath. (Take out the cylinder containing the soil suspension, shake it vigorously end-over-end about 60 times in 2 minutes and then immediately replace it in the bath).
- 5) Immediately start the timer when the cylinder with the soil suspension is replaced upright in the bath. Remove the rubber bungs carefully from the cylinders.
- 6) Immerse the hydrometer in the suspension to a depth slightly below its floating position and allow it to float freely.
- 7) Take hydrometer readings at the upper rim of the meniscus after periods of 0.5, 1, 2 and 4 minutes.
- 8) Remove the hydrometer slowly, rinse in distilled water and place it in the cylinder of distilled water with dispersion at the same temperature as the soil suspension. Observe and record the top of the meniscus reading,  $R_0$ .
- 9) Reinsert the hydrometer in the soil suspension and take and record readings after periods of 8 min, 30 min, 2 h, 8 h and 24 hours from the start of the sedimentation, and twice during the following day if appropriate. The precise times are not critical provided that exact time period is recorded. Insert the hydrometer slowly about 15 s before a reading is due. Insert and withdraw the hydrometer before and after taking each reading very carefully to avoid disturbing the suspension unnecessarily. Allow 10 s for each operation. Avoid vibration of the sample.
- 10) Observe and record the temperature of the suspension once during the first 15 min and then after every subsequent reading. Read the temperature to an accuracy of  $\pm 0.5^\circ\text{C}$ .





CLAY	Fine	Medium	Coarse	Fine	Medium	Coarse	Fine	Medium	Coarse	COBBLES	BOULDERS
	SILT			SAND			GRAVEL				