Department of Sustainable Natural Resources

SOIL SURVEY STANDARD TEST METHOD

PARTICLE SIZE ANALYSIS

ABBREVIATED NAME	PSA
TEST NUMBER	P7
TEST METHOD TYPE	B
VERSION NUMBER	3

RECORD OF AMENDMENTS

Version	Date	Reason For/Nature Of Amendment
3		This version does not include a 980 minute reading. The graph is extended to intercept the 0.002 mm line.

SCOPE

Particle size analysis is the standard laboratory procedure for the determination of the particle size distribution of a soil.

PRINCIPLE

Soil consists of an assembly of ultimate soil particles (discrete particles) of various shapes and sizes. The object of a particle size analysis is to group these particles into separate ranges of sizes and so determine the relative proportion by weight of each size range. The method employs sieving and sedimentation of a soil/water/dispersant suspension to separate the particles. The sedimentation technique is based on an application of Stokes' law to a soil/water suspension and periodic measurement of the density of the suspension.

SPECIAL APPARATUS

- Soil hydrometer (ASTM 152H hydrometer preferred).

- Uniform set of sedimentation cylinders with internal depth of 340 ± 20 mm and capacity of 1 L. (See Note 1.)

- 0.20, 2.00 and 4.75 mm sieves.

- Interval timer.

- End-over-end shaker, rotating at 15 rpm.

REAGENTS

25% sodium hexametaphosphate (Calgon)

Dissolve 250 g of sodium hexametaphosphate in 900 mL of warm deionised water. When cool, add sufficient sodium carbonate to bring to pH 8 or 9 and dilute to 1 L with deionised water.

SAMPLE PREPARATION

Carry out sample preparation according to Sample Receipt, Preparation and Storage (S1A/5). Weigh and record the whole sample. Pass the sample through the 4.75 mm and 2 mm sieves making sure that no aggregates are retained on the sieve. Alternatively, the sample may be passed through a mechanical crusher with apertures of 2 mm to obtain the material <2 mm. Weigh and record the amount of particles >4.75 mm and 2.0 to 4.75 mm.

SAMPLE PRETREATMENT

If necessary, the following pretreatment should be done on the sample prior to dispersion.

Removal of soluble salts

If electrical conductivity (1:5)> 1.0 dS/m and the clay flocculates in a 1:5 suspension, then soluble salts should be removed as follows:

1. Weigh 50 g of air dry soil (<2 mm) into a shaking bottle. Half fill the bottle with hot tap water and shake for 10 minutes. Allow the soil to settle until the supernatant is clear.

2. Siphon off the clear liquid. Refill with deionised water and repeat until the clay begins to disperse. Do not repeat more than four times.

DISPERSION AND SHAKING

1. If the soil has been pretreated, add 200 mL of deionised water and 20 mL of 25% sodium hexametaphosphate.

2. If there has been no pretreatment, place 50 g of air-dry soil (<2 mm) into a shaking bottle. Add 200 mL of deionised water and 20 mL of 25% sodium hexametaphosphate.

3. Place the bottles on an end-over-end shaker and shake for 16 hours (overnight) at 15 rpm.
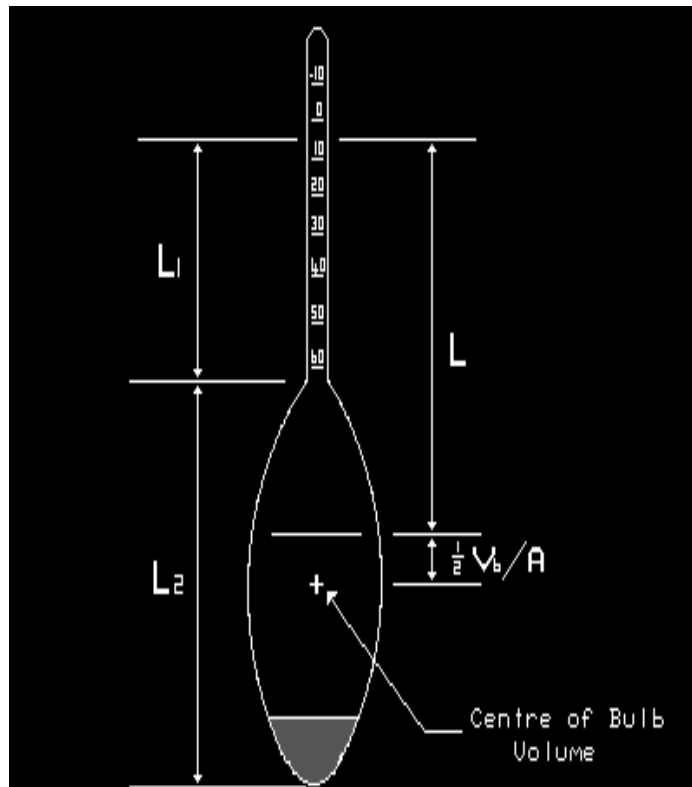
**Figure 1. Dimensional features of ASTM 152H hydrometer
for the purpose of calculating effective depth**

HYDROMETER

The value of effective depth (L) for each hydrometer (see Figure 1) and the sedimentation cylinder in which it is to be used should be calculated as follows:

For all readings, the hydrometer is placed in the suspensions 20 seconds before each reading.

$$L = L1 + 0.5(L2 - Vb/A)$$

Where:

L	=	Effective depth (mm)
L1	=	Distance along the stem of the hydrometer from the top of the bulb to the mark for a hydrometer reading (mm)
L2	=	Overall length of the hydrometer bulb (mm)
Vb	=	Volume of hydrometer bulb (cm³)
A	=	Cross-sectional area of sedimentation cylinder (cm²)

The volume of the hydrometer bulb (Vb) can be measured by the rise in level of water in a 250 mL measuring cylinder, initially filled to the 150 mL mark. An effective depth (L) should be worked out for each of the major calibration marks from 60 to –5 g/L on each hydrometer. (See Note 2.)

SEDIMENTATION

1. On completion of shaking, transfer the prepared and dispersed samples to 1 L measuring cylinders. (See Note 1.) Fill to the 1 L mark with deionised water. Note the hydrometer used.

2. Stir with a plunger for 20–30 seconds ensuring that all material at the bottom is brought into suspension. At the end of stirring, remove the plunger and immediately start the interval timer.

3. After 4 minutes sedimentation, immerse the hydrometer to a depth slightly below its floating position and allow it to float freely. Take a reading at 5 minutes. Read at the top of the meniscus and record readings to the nearest 0.5 g/L.

4. Remove the hydrometer slowly, rinse clean and place in a sedimentation cylinder filled with deionised water and 20 mL of 25% sodium hexametaphosphate (blank solution). The water temperature in the blank cylinder must be the same as that of the soil suspension.

5. Re-insert the hydrometer in the soil suspension for readings at periods of 30, 93 and 420 minutes, taken in the same manner as above. If it is not possible to take a 420 minute reading, take a substitute reading at the end of the day, noting the elapsed time.

6. At about the same time as each soil suspension hydrometer reading, take a hydrometer and temperature reading (to the nearest 0.5 °C) of the blank solution. Read the hydrometer at the top of the meniscus. The hydrometer should be left in the blank solution between readings.

SAND MEASUREMENT

1. Pass the contents of the cylinder through the 0.20 mm sieve and thoroughly wash free of all fine particles. Those particles retained on the sieve are the coarse sand fraction.

2. Transfer the coarse sand from the sieve into a preweighed, numbered weighing tin. Place in a drying oven between 105 °C and 110 °C. When dry, cool in a desiccator and then weigh.

CALCULATIONS

Calculate for each hydrometer reading the summation percentage (P).

$$P(\%) = \frac{(H-B)\,x\,100}{W}$$

Where:
H　=　Hydrometer reading in soil suspension (g/L)
B　=　Hydrometer reading in blank solution (g/L)

For the coarse sand fraction:

$$Coarse\ Sand\ (\%) = \frac{J\,x\,100}{W}$$

Where:
J　=　Oven-dry (OD) weight of sand from sieve (g)

Where on a whole soil basis:

$$W = \frac{ODW\,x\,(G + ODWF)}{ODW}$$

Where:
ODW　=　OD weight of fine earth (<2.0 mm) used in hydrometer analysis (g)
J　=　OD weight of gravel (>2.0 mm) from sieve (g)
ODWF　=　OD weight of total fine earth (<2.0 mm) (g)

For the gravel fraction:

$$Gravel\,(\%) = G\,x\,100\,/(G + ODWF)$$

Where:
G　=　Weight of gravel (>2.0 mm) from sieve (g)
ODWF　=　OD Weight of total fine earth (<2.0 mm) (g)

Calculate the particle size (D) at different times from the relationship:

$$D \, (mm) = 0.315 \; x \; K \; x \; \sqrt{L/T}$$

Where:

K	=	Sedimentation constant, which varies with temperature and particle density
L	=	Tabulated effective length for the hydrometer reading (mm)
T	=	Time (minutes)

If the particle density of the soil is known, use that value in the K table. Otherwise, use a value of 2.65 Mg/m³. Values for K for a range of temperatures and density are listed in Table 1 (on last page).

Plot cumulative percentage (P) versus particle size diameter (D) on a semi-logarithmic, 4 cycle graph paper. Interpolate from the curve the percentage for:

clay	=	<0.002 mm
silt	=	0.002–0.02 mm
fine sand	=	0.02–0.20 mm (See Note 4.)
coarse sand	=	0.20–2.0 mm
gravel	=	>2.0 mm

REFERENCES

Laker, MC & Dupreez, CC 1982, An investigation into the accuracy of hydrometers for soil particle size determination. *Agroplantae,* 14:17–22.

Standards Association of Australia. *AS 1289.C6.2-1976 Determination of the Particle Size Distribution of a Soil: An Analysis by Sieving in Combination with Hydrometer Analysis.*

NOTES

1. A group of 1 L measuring cylinders need to be as uniform as possible. Diameter about 60 mm (giving a cross-sectional area of about 30 cm²) and internal depth to 1 L mark of 340 ± 20 mm are recommended. However, any uniform group of cylinders can be used as long as they fall within ± 20 mm of the calibration table used.

2. A table, graph or equation should then be worked out for each hydrometer and its sedimentation cylinder. The relationship takes into account the effective depth of the suspension at the level being considered at a given time, and allows for the rise of the liquid in the cylinder due to the displacement by the hydrometer.

3. If the dispersion percentage is <10% and the soil contains appreciable fines (>5% clay), then the soil may be sub-plastic. Report this fact and use Particle Size Analysis Non-Dispersed (P7C/3).

4. The same graph may also be used to derive the 'very fine sand fraction' (0.02–0.1 mm) for calculation of the USLE.

Table 1.   **Values of K used in the equation for calculating the diameter of particles in hydrometer analysis**

Temp. °C	Density of Soil Particles (Mg/m³)					
	2.50	2.55	2.60	2.65	2.70	2.75
10	0.01633	0.01606	0.01581	0.01557	0.01534	0.01512
11	0.01610	0.01584	0.01559	0.01535	0.01512	0.01491
12	0.01588	0.01562	0.01537	0.01514	0.01491	0.01470
13	0.01566	0.01540	0.01516	0.01493	0.01471	0.01450
14	0.01545	0.01520	0.01496	0.01473	0.01451	0.01430
15	0.01525	0.01500	0.01476	0.01454	0.01432	0.01412
16	0.01505	0.01481	0.01457	0.01435	0.01414	0.01394
17	0.01486	0.01462	0.01439	0.01417	0.01396	0.01376
18	0.01467	0.01443	0.01421	0.01399	0.01378	0.01359
19	0.01449	0.01425	0.01403	0.01382	0.01361	0.01342
20	0.01431	0.01408	0.01386	0.01365	0.01344	0.01325
21	0.01414	0.01391	0.01369	0.01348	0.01328	0.01309
22	0.01397	0.01374	0.01353	0.01332	0.01312	0.01294
23	0.01381	0.01358	0.01337	0.01317	0.01297	0.01279
24	0.01365	0.01342	0.01321	0.01301	0.01282	0.01264
25	0.01349	0.01327	0.01306	0.01286	0.01267	0.01249
26	0.01334	0.01312	0.01291	0.01272	0.01253	0.01235
27	0.01319	0.01297	0.01277	0.01258	0.01239	0.01221
28	0.01304	0.01283	0.01264	0.01244	0.01225	0.01208
29	0.01290	0.01269	0.01249	0.01230	0.01212	0.01195
30	0.01276	0.01256	0.01236	0.01217	0.01199	0.01182