Lab – 4

Particle Size Distribution (PSD) determination

Particle size distribution is the proportion or percentage of soil particles (Sand, Silt and Clay).

Methods of determination of textural class

Textural class of a soil may be determined by two methods such as: -

1- Feel method by sense of feel.

2- Laboratory method which involves two steps namely:

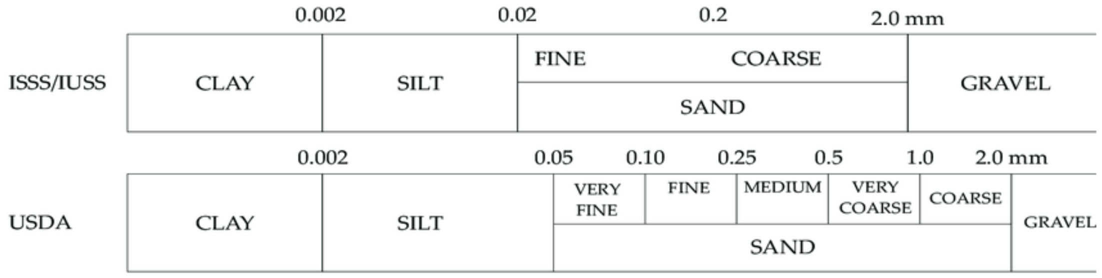
a) Mechanical analysis for determination of the amount of individual soil separates.

b) Determination of soil textural class with the help of an equilateral or table.

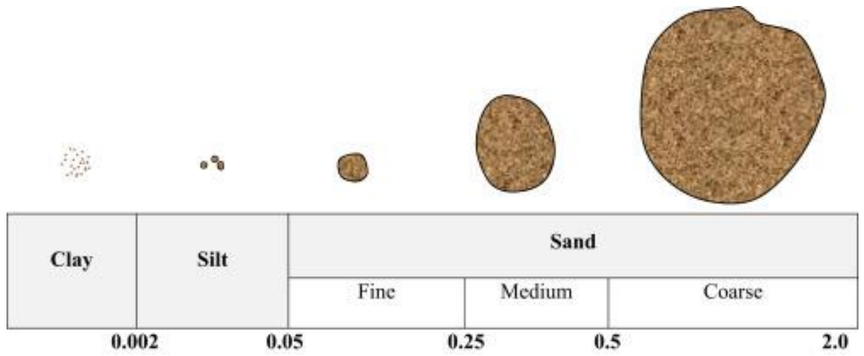
1- Feel method:

In the field soil texture is commonly determined by feeling or rubbing the moist soil between the thumb and the forefinger. This method is generally used in field operation such as soil survey and soil classification.

- Sand particles are largest in size and can be seen with the naked eye and feel gritty between thumb and finger.
- Silt is intermediate in size, these particles are too small to be seen by the eye, but are visible under a microscope, silt feels smooth like talcum powder.
- Clay is the smallest particle and usually feel slick and sticky when wet, firm when moist and hard when dry.



Particle Size Comparison Chart



2- Laboratory method

a) Pipette Method

b) Hydrometer method

c) Direct sieving

The processes of Particle size distribution

1. Destruction of Organic Matter
2. Dispersion
3. Sedimentation

Hydrometer Method

Apparatus

1. Soil Hydrometer
2. Electric mixer (stirrer), with stirring cup
3. 600 ml beaker
4. Graduated cylinder, 1 liter, with 1000 ml mark
5. Thermometer C°

Reagent

1. Hydrogen Peroxide (H_2O_2 30 – 5 %)
2. Sodium-hexa-meta-phosphate, ($Na_6O_{18}P_6$) solution

(Commercial names: Calgon, Graham's salt, glassy sodium)

Dissolve 50 g of Calgon in water and dilute the solution to a volume of 1 liter.

Procedure

1. Weigh 50 g oven dried soil put it into a 600-ml beaker.

2. Add 30 – 50 ml of Hydrogen peroxide. Carefully heat it for 30 minutes then cover the beaker with lid and let it for 24 hours to complete reaction.

* If the soil contains high amount of O.M repeat this procedure until all O.M was removed.

3. Add 120 ml of sodium-hexa-meta-phosphate solution 5% let it for 24 hrs.

4. Wash the sample with D.W and filtrate the suspension by Whatman No.40 filter paper. Then oven dry it at 105°C, weigh it and use this weight in calculation.

5. Transfer the suspension on stirrer and stir until soil aggregates are broken down. This usually requires 5 minutes for coarse textured soils and 10-15 minutes for fine textured clay.

6. Transfer quantitatively the suspension to the settling cylinder by washing the cup with distilled water. Fill the cylinder with distilled water.
7. Shake the suspension vigorously in a back-and-forth manner. Avoid creating circular currents in the liquid, as they will influence the settling rate.
8. Place the cylinder on a table and record the time. After 20 seconds, carefully insert the hydrometer and read the hydrometer at the end of 40 seconds. Record the temperature of the suspension.
9. After 2 hours, carefully insert the hydrometer and record hydrometer reading. Record the temperature of the suspension.
10. Make a blank of suspension without soil (Calgon + D.W). Then read it by hydrometer. It was called zero correction.

* Hydrometer reading for blank at 20ºC = 6

Rc = Ra – zero correction + C_T

Rc = Corrected Hydrometer Reading.

Ra = Actual Hydrometer Reading.

C_T = temperature correction factor from table 1

Table 1: Temperature correction factor C_T

Temperature °C	Correction factor	Temperature °C	Correction factor
15	- 1.10	23	+ 0.70
16	- 0.90	24	+ 1.00
17	- 0.70	25	+ 1.30
18	- 0.50	26	+ 1.65
19	- 0.30	27	+ 2.00
20	0.00	28	+ 2.50
21	+ 0.20	29	+ 3.05
22	+ 0.40	30	+ 3.8

Time	Temp °C	Actual Hyd. Reading	Corrected Hyd. Reading
40 sec	25	48	43.3
2	22	22	16.4

From line 1 of table above:

Rc = Ra – Zero correction + C_T

Rc = 48 – 6 + 1.30 = 43.3

First Reading (after 40 sec)

(Corrected Hydrometer Reading / O.D.S) x 100 = (Silt + Clay %)

(43.3 / 50) x 100 = 86.6 %

Second Reading (after 2 hours)

(Corrected Hydrometer Reading / O.D.S) x 100 = (Clay %)

(16.4 / 50) x 100 = 32.8 %

(Silt + Clay %) – (Clay %) = (Silt %)

86.6 – 32.8 = 53.8 %

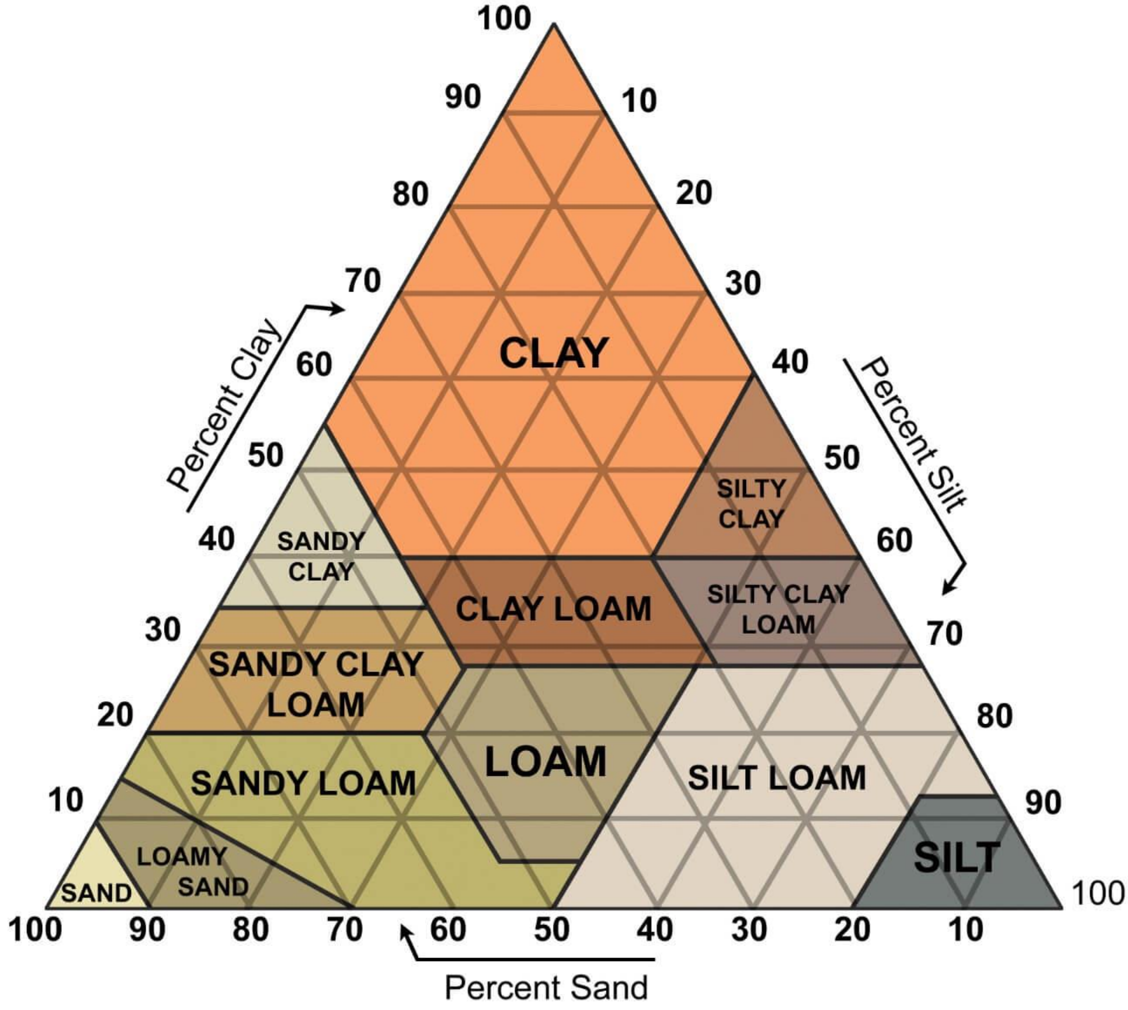
100 – (Silt %) – (Clay %) = (Sand %)

100 – 53.8 – 32.8 = 13.4 %

So,

Sand % = 13.4 Silt % = 53.8 Clay % = 32.8

Soil Texture is (**Silty Clay Loam**)



Textural triangle, showing the percentages of clay (below 0.002 mm), silt (0.002–0.05 mm), and sand (0.05–2.0 mm) in the conventional soil textural classes.

Stokes' Law

In 1851 George Gabriel Stokes formulated a law governing the rate of settling of s spherical particle in a viscous medium.

According to Stokes' Law, (the velocity of a spherical particle settling under the influence of gravity in a fluid of a given density and viscosity is proportional to the square of the particle's radius).

$$V = \frac{2\,(\rho s - \rho w)\,g\,r^2}{9\,\eta}$$

Where:

V = Velocity ($cm.s^{-1}$)

r = Effective radius (cm)

g = Acceleration of gravity (981 $cm.s^{-2}$)

η = Viscosity of water (Poise)

Ps = Densities of the particle ($g.cm^{-3}$)

Pw = Liquid density ($g.cm^{-3}$)

Example 1/

Using Stokes' Law compare the velocity of fall of particles (diameter 0.02 mm) in aqueous suspension at 30°C with that at 25°C.

If you know:

acceleration of gravity = 981 cm/sec^2 and particle density (ρs) = 2.65 g/cm^3

at 30°C, ρw = 0.9956 gm/cm^3 and η = 0.00801 poise

at 25°C, ρw = 0.9971 gm/cm^3 and η = 0.00894 poise

* The variation of temperature causes the variation of density of water (ρw) and viscosity of water (η)

Solution/

r = $\frac{0.02\ mm}{2} = 0.01 \div 10 = 0.001\ cm$

$$V = \frac{2\ (\rho s - \rho w)\ g\ r^2}{9\ \eta}$$

So,

$V_{30} = \frac{2\ (2.65-0.9956)981 \times (0.001)^2}{9 \times 0.00801}$ cm/sec

$= \frac{2 \times 1.6544 \times 981 \times 0.001 \times 0.001}{9 \times 0.00801}$ cm/sec

$= \frac{0.003245932}{0.07299}$ cm/sec = 0.045026 cm/sec

$V_{25} = \frac{2\ (2.65-0.9971)981 \times (0.001)^2}{9 \times 0.00894}$ cm/sec

$= \frac{2 \times 1.6529 \times 981 \times 0.001 \times 0.001}{9 \times 0.00894}$ cm/sec

$= \frac{0.003242989}{0.08046}$ cm/sec = 0.040306 cm/sec

So, velocity of fall of 0.02 mm diameter particles is higher at 30°C as compared to 25°C.

Example 2/

With the help of Stokes' Law calculate the time needed for all particles of 0.02 mm in diameter to travel a distance of 10 centimeter at 25°C.

If you know: ρs = 2.65 g/cm^3 , ρw = 1 g/cm^3 , g = 981 cm/sec^2

at 25°C, η = 0.00894 poise

Solution/

From Stokes' equation:

$$V = \frac{2\,(\rho s - \rho w)\,g\,r^2}{9\,\eta} \qquad V = \frac{\text{distance}}{\text{time}}$$

$$r = \frac{0.02\,mm}{2} = 0.01 \div 10 = 0.001\,cm$$

$$\frac{\text{distance}}{\text{time}} = \frac{2 \times (2.65 - 1) \times 981 \times (0.001)^2}{9 \times 0.00894}$$

$$\frac{10}{\text{time}} = \frac{2 \times (2.65 - 1) \times 981 \times (0.001)^2}{9 \times 0.00894}$$

$$\text{Or,} \quad \text{time} = \frac{10 \times 9 \times 0.00894}{2 \times 1.65 \times 981 \times 0.001 \times 0.001} = \frac{0.8046}{0.003237}$$

$$= 248.56\,\text{sec} = 249\,\text{sec} = 4\,\text{minutes}\;9\,\text{sec.}$$

Example 3/ (Homework) / Using Stokes' Law calculate the time required for all sand particles (diameter > 0.05 mm), silt particles (diameter > 0.002 mm), and clay particles (diameter > 0.001 mm) to settle out of a depth 15 cm in an aqueous suspension at 20°C.

If you know: ρs = 2.65 g/cm^3 , ρw = 1 g/cm^3 , g = 981 cm/sec^2

at 20°C, η = 0.01005 poise