RAMA UNIVERSITY

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FACULTY OF AGRICULTURAL SCIENCES & ALLIED INDUSTRIES

SOIL PHYSICS

:Soil Physics is a branch of Soil Science dealing with physical properties of soil, as well as with the measurement, prediction and control of different processes taking place in and through the soil.

SOIL PHYSICAL PROPERTIES: The physical properties include texture, structure, density, porosity, consistency, temperature, colour and water content. The physical propert ies depend on the amount, size, shape and arrangement and mineral composition of its particles , kind and amount of organic matter and the volume and form of its pores and the way they are occupied by water, air at a particular time.

SOIL TEXTURE : Soil texture may be defined as the relative proportion of particles of various sizes (Soil separates / Mechanical fractions) such as sand, silt and clay. It is almost a permanent property of the soil and may change slowly with time.

Textural components and their properties: Soil contains various sized particles; some of which (Gravels, Stones, Cobbles and Boulders) obviously do not behave like soil, but are reported (

volume fraction and size range) if occupy enough of soil volume to influence soil physical processes significantly. Conventionally the particles smaller than 2.0 mm diameter are considered as soil material.

Soil Separates	ISSS system (mm)	USDA system (mm)
* Very Coarse Sand	--	2.00 – 1.00
* Coarse Sand	2.00 – 0.20	1.00 – 0.50
* Medium Sand	---	0.50 – 0.25
* Fine Sand	0.20 – 0.02	0.25 – 0.10
* Very Fine Sand	--	0.10 – 0.05

* Silt	0.02 – 0.002	0.05 – 0.002
* Clay	<0.002	< 0.002

ISSS : I nternational Society of Soil Science

USDA : United States Department of

Agriculture Gravel / Pebbles : 2.0 – 75.0

mm Cobbles(Round) / Flags (Flat) : 75.0 –

250.0 mm Stones: 250.0 - 60mm:

Boulders- >600mm

Nature and Properties of Soil Separates

Stones, cobbles and Gravel: Because of their sizes, function as separate particles. Stones, cobbles and gravel may be more or less rounded, irregularly angular or even flat.

Sand: Sand particles may be rounded or irregular with quite jagged surfaces depending on the abrasion they receive. These particles exhibit no plasticity and stickiness and hence less influenced by changes in moisture content. Their water holding capacity is low, percolation rate is high and facilitate good drainage and good air movement. Soils dominated by sand and other particles bigger than sand are invariably open, loose and in friable condition. As these fractions are the fragments of the rocks with quartz as chief component, they are chemically inactive and insoluble.

Silt is intermediate between sand and clay in size (ISSS – 0.02 – 0.002 mm; USDA – 0.05 – 0.002 mm) and irregular in shape. Mineralogically and physically, silt particles greatly resemble sand particles, but since they are smaller and have a greater surface area per unit mass and are often coated with strongly adherent clay, they may exhibit some of the physico -chemical attributes of clay. Silt is dominated by quartz and micas like primary minerals; and posses some plasticity, cohesion and adsorption. They hold moisture but lesser than

clay.

Clay fraction is less than 0.002 mm in size and forms the decisive fraction of the soil, which has most influence on soil behaviour. Clay particles are characteristically plate like or needle like in shape. Clay particles adsorb water and hydrate, thereby causing the soil to swell upon wetting and then shrink upon drying. They are very plastic and sticky in moist condition; and become hard and cloddy when dry. High tenacity of clay makes the cultivation difficult.

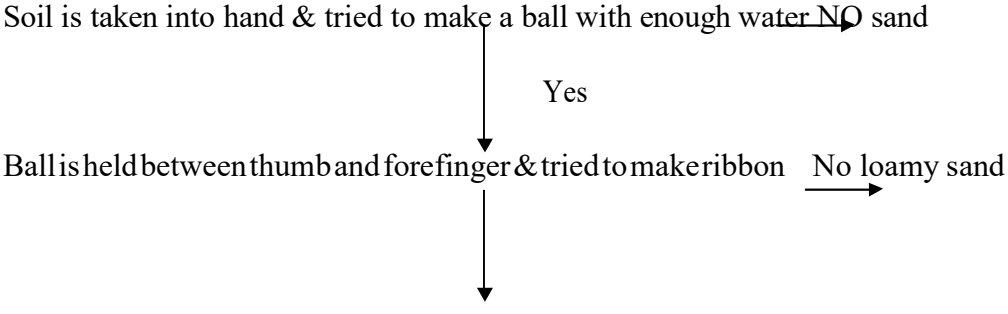
The relatively inert sand and silt fractions can be called the 'Soil Skeleton", while the clay, by analogy, can be thought of as the "Flesh" of the soil.

METHODS OF DETERMINATION OF SOIL TEXTURE

Soil texture may be assessed subjectively in the field or more rigorously by particle size analysis in the laboratory.

FIELD or FEEL METHOD: The common field method of determining the textural class of a soil is by its FEEL. Feel method is of great practical value in Soil Survey, Soil Classification and in any other investigation in which Soil Texture may play a role. Accuracy depends on experience. A soil surveyor determines texture by moistening a soil sample and kneading it between fingers and thumb until aggregates are broken down and the soil grains thoroughly wetted. The w ay the wet soil sticks out gives a good idea of the quantity of clay content. The sand particles are gritty; the silt has a floury or talcum powder feel when dry and is only moderately plastic and sticky when wet; persistent cloddiness generally is imparte d by silt and clay.

Flow chart to determine soil texture by feel method:



Yes

Ribbon is made and if the ribbon length is

<2.5cm 2.5-5.0cm >5.0cm

If gritty - sandy loam sandy clay loam sandy clay

If smooth & silky - silty loam silty clay loam silty clay

If neither gritty nor smooth – loam clay loam clay

<u>LABARATORY METHOD</u> : PARTICLE SIZE ANALYSIS / MECHANICAL ANALYSIS : The procedure of separating out different sized soil fractions i.e., sand, silt and clay and of measuring their proportional distribution is called particle size analysis or mechanical analysis. The result is expressed as Mechanical composition of soil or Soil Texture. There are two steps in mechanical analysis

a. Dispersion b. Sedimentation

Dispersion: Dispersion of soil particles is achieved by breaking down the cementing agents viz., organic matter, calcium carbonate and iron oxides; and flocculating agents like salts and ions. Removal of organic matter is usually achieved by oxidation with hydrogen peroxide and calcium carbonate can be dissolved by addition of dilute hydrochloric acid. Treating the soil with sodium citrate. Sodium bicarbonate and sodium dithionate does remove iron and aluminum oxides, which are significantly present in red and laterite soils. Through repeated washings salts and ions can be eliminated. Dispersion or deflocculation is carried by means of a chemical dispersing agent like sodium hexametaphosphate and by mechanical agitation.

Other peptizing agents or deflocculating agents, which are commonly used, are

sodium oxalate, sodium phosphate, and sodium metaphosphate and sodium pyrophosphate.

Now particles of 2 to 0.2 mm (coarse sand) are separated by sieving through 0.2 mm sieve. For separation of remaining particle sedimentation technique is used

Sedimentation: It is based on measuring the relative settling velocities of particles of various sizes from aqueous suspension In a given medium larger particles settle more quickly than smaller ones of the same density. The relation between particle density and rate of fall is expressed by Stokes' law.

There are two widely accept ed methods, which obey Stoke's law of sedimentation.

1) Robinson's Pipette Method: Also called as International pipette method. It is based on the sedimentation principle i.e., particles with different sizes and weights fall at different velocities. If a sample of soil suspension is taken at a given depth at particular time interval, this contains all the particles which are in suspension at that time at that depth. In this method a definite volume of soil suspension is taken from a required depth at definite time intervals using Robinson's pipette.

   At 25ºC a sample collected at 4min 15 sec time at 10 cm depth in the sedimentation cylinder contains silt and clay particles, while sample collected at 7 hrs 6 min interval contains only clay fraction. After drying the samples to constant weight silt and clay contents can be calculated. Fine sand left at the bottom can be separated out, dried and weighed.

2) Bouyoucos Hydrometer Method : It is based on the principle that there is a continuous decrease in the density of soil suspension over a period of time. So by knowing the density of soil suspension at required time intervals with a calibrated hydrometer the proportion of different fractions can be known.

. The pipette method is regarded as the standard method for particle size analysis because of its accuracy. It is however very time consuming and difficult to be employed in mechanical analysis of large n o. of samples.

. The hydrometer method is rapid but less accurate than the pipette method. This method gives erroneous results in soils having high $CaCO_3$ and organic matter contents and high salinity.

1st Reading at 40 seconds (sand fraction) or reading at 4min. (silt +clay) 2nd reading after two hours (Clay fraction) : silt = (silt+clay) - clay

Silt = 100 – [Sand + Clay]; sand = 100 – (silt + clay)

Soil Property	Sand	Loam	Silt Loam	Clay Soil
Feel	Gritty	Gritty	Silky	Cloddy/ Plastic
Identification	Loose	Cohesive	Shows finger print	Gives shiny streak
Internal Drainage	Excessive	Good	Fair	Fair to poor
Plant -Available Water	Low	Medium	High	High
Drawbar Pull	Light	Light	Medium	Heavy
Tillability	Easy	Easy	Medium	Difficult
Run-off Potential	Low	Low-medium	High	Medum-High
Water detachability	High	Medium	Medium	Low
Water transportability	Low	Medium	High	High
Wind Erodibility	High	Medium	Low	Low

SOIL TEXTURAL CLASSES: Textural names are given to the soils based on each of the three soil separates – sand, silt and clay. Soils that are preponderantly clay are called CLAY; those with high silt content are SILT and those with high sand percentage are SAND. Three broad and fundamental groups of soil textural classes are recognized: SANDS, LOAMS and CLAYS.

Soil textural diagram (ISSS): Considering the amounts of sand, silt and clay soil textural class can be determined with the helps of textural triangle.

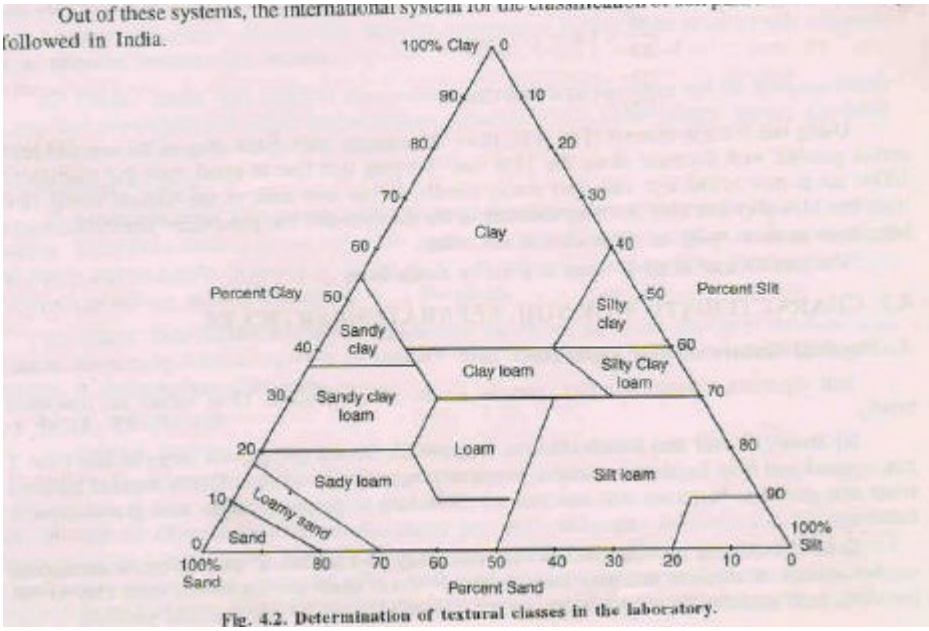


Fig. 4.2. Determination of textural classes in the laboratory.