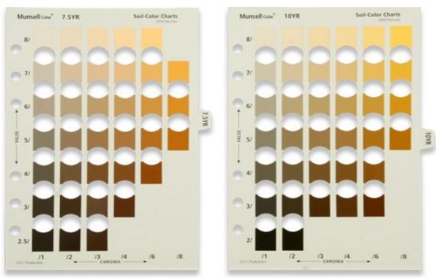
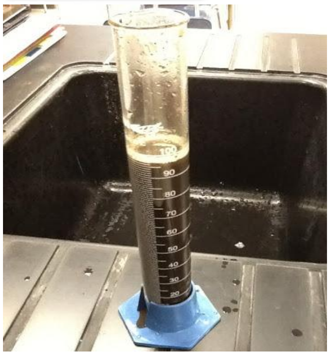
<u>Introductory Soil Science</u>

ES 1201

Laboratory Manual





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LABORATORY EXERCISES 01

Identification of the Physical Properties of Minerals

Introduction:

A mineral is a naturally occurring, inorganic, solid element or compound with a definite chemical composition and a regular internal crystal structure. Nearly all or more so far identified are crystalline, their molecular structures are regular and their chemical composition varies only within specific limits.

Chemical composition, crystallographic structure and the type of bonds involved determine the properties of minerals. Mineral characteristics can be described in terms of their physical properties such as fracture/ cleavage, color, hardness and luster as well as electrical, magnetic and optical properties. These properties help us to identify a particular mineral, separate a mineral from a mineral mixture and to explore mineral deposits.

1. Cleavage

Cleavage is the tendency of minerals to break along smooth, flat surfaces with sharp definite straight edges. Many crystals show a marked tendency to break in certain definite directions. Cleavage planes are developed along planes of weakness in the atomic lattice.

Type of Cleavage	Cleavage direction	Examples
Basal	One direction	Mica
Pinacoidal	Two directions nearly at right angles	Feldspar
Prismatic	Two directions not at right angles	Hornblende
Cubic	Three directions, right angles to each other	Halite
Rhombohedral	Three directions not at right angles to each other	Calcite
Octahedral	Four directions	Fluorite

2. Fracture

Fracture is the breaking of minerals along a non-cleavage direction leaving irregulars shape surfaces. Minerals with no cleavage, or with one or two cleavage directions, may break in another direction that does not leave a flat smooth surface.

Type of fracture	Fracture description	Examples
Uneven/ Irregular	Surfaces are rough and uneven	Serpentine
Conchoidal	Concentric curves are very prominent	Obsidian / Quartz
Sub-conchoidal	Surfaces are curved, not very prominent	Rose quartz
Splintery/ Fibrous	Mineral breaks into splinters	Tremolite
Hackly	Surfaces are irregular with sharp edges	Copper
Earthy	Surface soft and smooth	Chalk

3. Luster

Luster refers to the general appearance of a mineral surface in reflected light.

Kind of Luster	Description	Examples
Metallic	Brilliant/ Metallic	Pyrite
Vitreous	Glassy	Quartz / Tourmaline
Resinous	Resin – like	Sphalerite/ Sulfur/ Copalite
Pearly	Pearl-like	Talc/ Mica
Greasy	Thin layer of oil	Nepheline
Silky	Silk-like	Crysotile / Asbestos
Adamantine	Exceptionally brilliant	Diamond / Cerussite

4. Colour

Colour of the freshly broken surface of the mineral is used for identification of certain minerals. Colour is the response of the eye to the visible light range of the electromagnetic spectrum.

5. Streak

The colour of a finely powdered mineral is known as its streak. The streak is determined by rubbing the mineral on white porcelain. Colour of a mineral may vary greatly but streak is often fairly constant.

6. Hardness

Hardness of a mineral can be defined as the resistance against scratching by other material. A mineral of a given hardness can scratch all minerals of lower hardness and on the other hand, minerals of greater hardness can scratch it.

The hardness of minerals is expressed on the Moh's Scale of hardness.

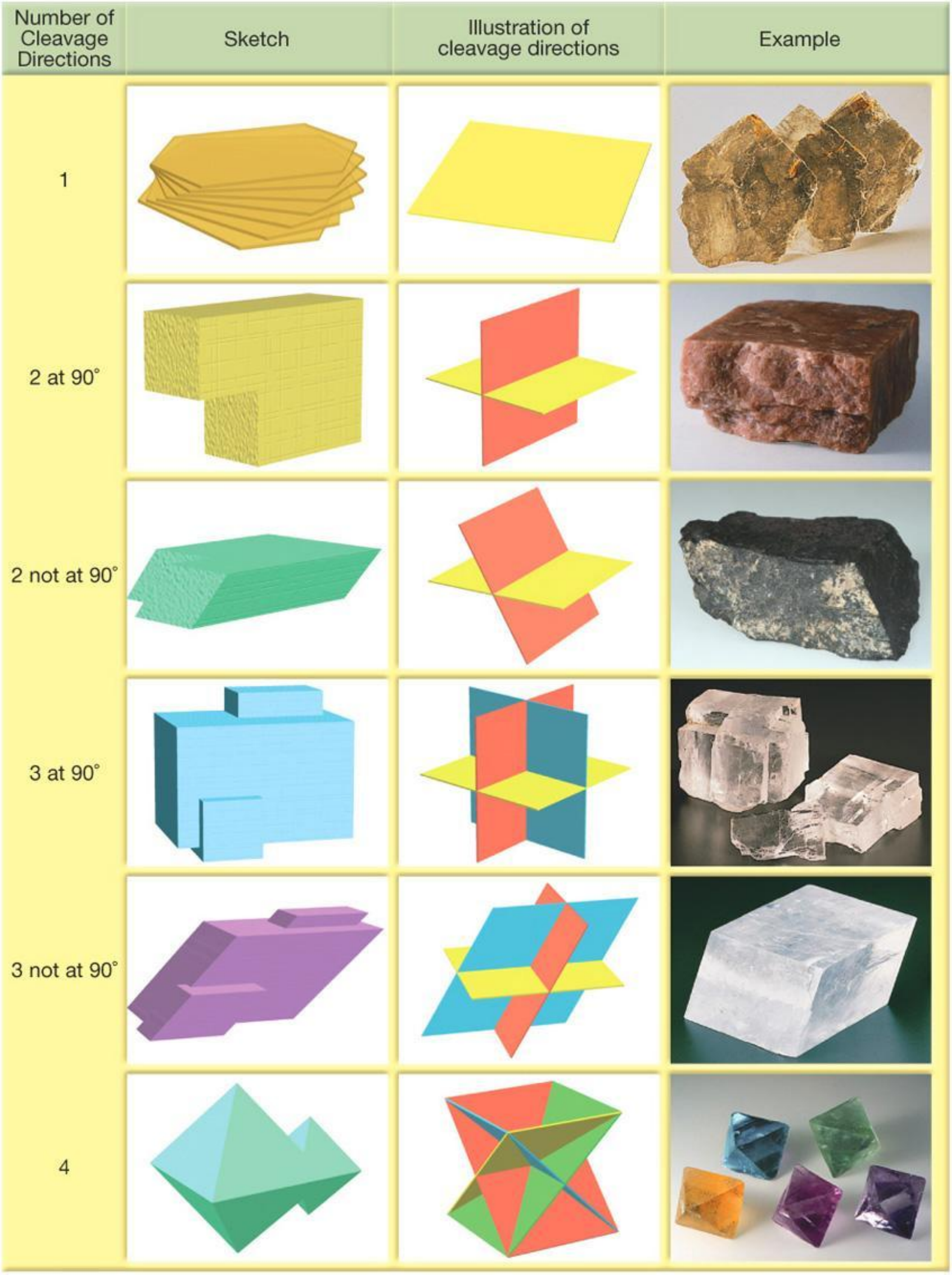
<u>Moh's Hardness Scale</u>

Mineral	**Hardness**
Talc	1
Gypsum	2
Calcite	3
Fluorite	4
Apatite	5
Feldspar	6
Quartz	7
Topaz	8
Corundum	9
Diamond	10

Use following to test the hardness of given mineral

Fingernail	- 2.5
Copper coin	- 3.5
Glass plate	- 5.5
Brass plate	- 3.0
Knife	- 5.5-6.0

Cleavage of Minerals



LABORATORY EXERCISES 02

Identification of Rock Type

Introduction

Rocks are consolidated masses formed from either single mineral or a combination of several minerals or from organogenic materials found in the earth crust.

Rocks are divided into three main groups according to the processes by which they are formed; Igneous, Sedimentary and Metamorphic.

Igneous Rock

Igneous rocks are formed from the cooling and solidification of molten magma, which comes to the earth surface and enters to the cavities in the earth in various depths during the volcano eruption.

1. Horneblende pegmatite
2. Horneblende granite
3. Serpentinite
4. Pink microceline granite

Sedimentary Rock

Sedimentary rocks are formed either by the consolidation of sediments from weathered igneous, Metamorphic and Sedimentary rocks and Organogenic materials or by the precipitation and crystallization of water soluble ionic substances

1. Miocene limestone
2. Traverine
3. Sandstone
4. Shale

Metamorphic Rock

Metamorphic rocks are formed either from igneous or Sedimentary rocks after alteration of chemical and physical structure by the process “Metamorphism”.

1. Calc silicate granulite
2. Marble
3. Garnet granulite
4. Garnet biotite gneiss
5. Garnet biotite gneiss – migmatised

6. Charnockite acidic with basic layering
7. Hornblende biotite gneiss
8. Charnokite

✱✱ Observe the physical properties such as inter granular relationship, grain size and texture (foliation) of the given specimens. Comment on the possible constituent minerals and the occurrences of these rock samples in Sri Lanka.

LABORATORY EXERCISES 03

Determination of Soil pH

Introduction

Soil reaction (pH) is an indication of the acidity or the bacisity of the soil and is measured in pH units. Soil pH can be easily determined and it gives an indication about other soil properties. Certain soil properties (e.g Cation exchange capacity, structure) and processes (e.g Nutrient dynamics, soil formation) are directly or indirectly pH dependable.

PH value could be determined either by using specific color indicators or directly by using a glass electrode/ pH meter system.

Objective

1. To determine the pH of a soil sample by the BDH indicator method and by using pH meter
2. To interpret the soil reaction.

A. Indirect Method

B.D.H Indicator Method

Principle

Comparison of the developed color by the soil/ $BaSO_4$ indicator suspension with a standard chart

Procedure

1. Place a small quantity of Barium sulphate ($BaSO_4$) in bottom of the clean dry test tube and add a small quantity of soil to be tested.

   Gravel – use ½ ” $BaSO_4$ + 1 ½ ” soil

   Loam -use 1” $BaSO_4$+ 1” soil

   Clay - use 1 ½” $BaSO_4$ + ½” soil
2. Add sufficient amount of distilled water and 1ml of B.D.H indicator.
3. Close the tube with a rubber bung, shake well allow to stand upright until observe a clear liquid layer at the top.
4. Compare the color of that layer with the color of standard chart.

B. Direct Method

Glass Electrode/ pH Meter Method

1. Weigh two; 10 g of air-dried soil samples in to two different 50ml beakers.
2. Add 25 ml of distilled water to one sample and 25 ml of 0.01M Calcium chloride ($CaCl_2$) to other sample.
3. Stir the suspension for 20 minutes with 1 minute interval and take the reading displayed on the pH meter
   (Standardize the PH meter against a pH buffer solution before measuring the pH)

Comments/ Interpretation:

Comment on the pH of the soil using the interpretation given below

pH 3 4 5 6 7 8 9

Extreme Strong Acidic	Strong Acidic	Acidic	Moderately Acidic	Weakly Acidic	Weakly Alkaline	Moderately Alkaline

ACIDIC NETURAL ALKALINE

PH range for all soil

pH	Category	Interpretation
9		
8.5	strongly basic	
8	Medium basic	Restricted plant growth
7.5	Slightly basic	
7	Neutral	
6.5	Slightly acidic	
6	Moderately acidic	Most productive soil
5.5	Medium acidic	
5	Strongly acidic	
4.5		Restricted plant growth
4	Very strongly acidic	due to stong acidity

LABORATORY EXERCISES 04

Determination of Soil Color by Munsell Color Chart

Introduction

Color is the most obvious and easily determined soil property. Soil color is important because it is an indirect measure of other important characteristics such as water drainage, aeration and the organic matter content. Thus, color is used with other characteristics to make many important references regarding soil formation and land use.

A modification of the Munsell color chart is generally used to determine soil color. The portion needed to soil is about 1/5 of the entire range found in the complete edition of the book of Color by Munsell.

1. Hue : Refers to the dominant Wave length or the colours of rainbow – Red, Yellow, Green, Blue and Purple.
2. Value : Indicate its lightness / brightness or total amount of light reflected.
3. Chroma : Indicates strength or relative purity.

Objective:

To determine the Munsell notation for the given soil samples and make inferences (predictions) about soil properties using the color.

Arrangement of Hue, Value and Chroma

a. On each plate (page) the colors displayed are of. Constant Hue given by the symbol in the upper right hand corner of the chart. Symbols for hue are the letter abbreviation of the color of the rainbow.

R – For Red

YR – For yellowish

Y – For Yellow

Whiting each letter range the Hue becomes more Yellow and less red as the number prior to the letter increases (5 R to 10R)

Value

b. Vertically in the chart the colors become Successively lighter from the bottom of the page to the top by visually equal steps and their increase when the soil become lighter in color.

Lighter 10/

5/

Darker 0/

C. Horizontally the colors increase in Chroma to the right and the colors become less gray.

Natural Grey   less Grey
1…………………………………………….1……………………………………1
/ 0   / 10   / 20

Nomenclature of Soil Color

Nomenclature of soil color is done by 2 complementary systems.

1. Munsell Color Notation
2. Munsell color Name

Color names are used in all descriptions, for publications and for naming soil in classification systems. Color notation is used to supplement color names for grater precision in sol survey reports, to report specific relationship with color and other soil properties.

When reporting the Munsell notation the order is Hue, Value and Chroma with a space between the Hue letter and the succeeding value number and a virgule (/) between the numbers of value and Chroma as shown below.

Hue	= 5R	Color Name: Dark Brown
Value	= 3/	Color Notation: 10YR 3/3
Chroma	= /5	

Procedure:

1. Determine the color of dry and moist soil using Munsell color chart.
2. Report Munsell color notation and color name of the tested samples in the standard manner.
3. Compare your results of air dried and moisten soil samples tested.

Interpreting color

The correlation of colors and soil characteristics:

Drainage / Aeration:

Grey sub soils can indicate water-saturated conditions especially in low-lying land. Mottling may indicate intermittent poor drainage and saturated conditions.

Bright brown and red colors usually indicate good drainage and aeration of soil.

Organic matter:

Major coloring agent

Well – decomposed organic matter is dark to black

Raw peat is brown

Presence of oxides:

Oxides of iron particular are color – determining factors

Color of oxides is changed by in response to aeration and hydration (oxidation and reduction)

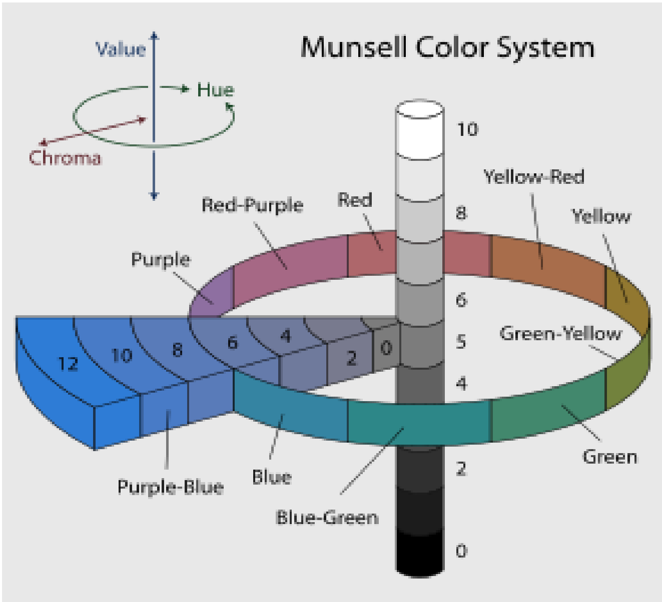
Light colored and grayish – poor drainage

Yellow – intermediate

Reddish – well aerated

Manganese oxides may contribute to black color.

✱✱ Your lab reports should include the wet and dry color notations and color names for the given soils with predictions (inferences) of soil properties using color. If mottles are present you should give the background color and mottle color both.



LABORATORY EXERCISES 05

Moisture Factor Calculations

Objective

To determine the soil moisture factor using oven dry weight of soil

Procedure

All your result should be reported to the oven dry soil weight of soil. This is done best by putting a sub sample in the oven and moisture factor to correct for the moisture in the experimental sample as shown below.

1 Mass of empty moisture can = M1g

2 Mass of moist soil+ can = M2g

3 Mass of oven dry soil + can = M3g

4 Mass of moisture in sample = M2-M3g

5 Mass of dry soil sample = M3-M1g

6 Moisture content of sub sample (Θ) = (M2-M3) / (M3-M1)

7 Moisture Factor = 1+ Θ

8 The oven dry mass of the sample used for the experiment = $\dfrac{\text{Mass of moisture sample}}{\text{Moisture Factor}}$

LABORATORY EXERCISES 06

Determination of Soil Bulk Density by undisturbed Core Sample Method

Introduction:

Soil bulk density (p_b) is the ratio of the mass of dry solids to the bulk volume of the soil. The bulk volume includes the volume of the solids and of the pore space. The mass is determined after drying to constant weight at 105^oC, and the volume is that of the sample as taken in the field.

Bulk density is a soil condition, which will increase with compaction and decreases with tillage. In agricultural soils this ranges from 0.9 to 1.8 g/ cm^3 .This will never exceed the particle density.

Convenient units for bulk density are Mgm^{-3} or the numerically equal gcm^{-3}.

Undisturbed Core Method:

With this method, a cylindrical metal sampler is pressed or driven into the soil to the desired depth and is carefully removed to preserve a known volume of sample as it existed in situ. The sample is dried to 105^oC and weighed. The core method is unsatisfactory if more than an occasional stone is present in the soil.

Core samplers vary in design from a thin-walled metal cylinder to a cylindrical sleeve with removable sample cylinders that fit inside. Samplers are usually designed not only to remove a relatively undisturbed sample of soil from a profile, but also to hold the sample during transport and eventually during further measurements in the laboratory, such as pore-size distribution or hydraulic conductivity.

Objective

To determine the bulk density of given soil sample using a core sampler.

Procedure:

1. You need at least two cores to get correct measure of bulk density (Assume that you do the exercise with a one).
2. Measure the diameter and height of the core to calculate the volume of soil core
3. Cut off the vegetation and scrape off a thin layer of soil.
4. Force the core gently into the soil; no twisting or oblique angles.
5. If possible use another cylinder to push first core until a cm or so soil protrudes. You can also use a hammer to get the cylinder in to the soil, however make sure that you do not directly hit the metal cylinder by using a piece of wood / wooden board or something on top of the core before hitting with hammer (this is to avoid any damage to the core). If you hit a stone while pushing the cylinder down, pull out and start a new.
6. Dig out the filled core with a spade (or a suitable hand tool) and leave about 1-2 cm of soil on both ends of the core. These can later be trimmed at the laboratory.
7. Pack cores in plastic bag and identify your samples.

Calculation:

Calculate the bulk density of soil sample with following information.

1) Weight of moist soil & core =
2) Weight of oven dry soil & core =
3) Weight of water =
4) Weight of core =
5) Weight of oven dry soil =
6) Volume of the core =
7) Bulk density (5/6) =
8) Wet bulk density ((5+3)/6) =
9) Gravimetric water content =
10) Volumetric water content =

LABORATORY EXERCISES 07

Determination of Soil Particle Density Pycnometer Method

The density of any substance is its mass per unit volume (Mg/ m3) and basic physical property of soil. As soil is a substance with certain amount of porosity, it has two kinds of densities. Soil particle density and bulk density. The term particle density refers to the density of only the solid fraction excluding the void spaces between soil particles.

$$\text{Particle Density (pp)} = \frac{\text{Mass of soil fraction (Ms)}}{\text{Volume of solid fraction (Vs)}}$$

Particle density can be calculated using two measured quantities, the mass of the soil sample and the volume of particles. The mass is then divided by volume to obtain particle density. Particle density of most mineral soils is assumed as, 2.65 Mg/ m3, which is the density of quartz. When iron oxides are predominant this may rise to 2.95 Mg/ m3.

Objective:

The objective of this exercise is to determine the particle density of the given soil and to use it in future laboratory calculations.

Apparatus:

Pcynometer (specific gravity bottle); moisture cans

Procedure:

1. Weight a clean pycnometer $= M_1 g$
2. Obtain 15 – 20 g of air-dry soil passing through a 2 mm sieve, transfer the soil into pycnometer and weigh. $= M_2 g$
3. Place a sub sample of about 30g in oven using the moisture can to determine the Moisture Factor (Mf)
3. Mass of air dry soil in pycnometer $M_{ms} = M_2 – M_1 g$

4. The oven dry soil in pycnometer $M_s = M_{ms}/Mf$g

5. Fill the pcynometer (with soil) half full, using distilled water and swirl in rotary motion to wet the sample and get rid of air bubbles.

6. Place the pycnometer in a water bath and warm to get rid of any air entrapped in the sample. This is done to get rid of all air inside the sample, as we need only the volume of soil solids.

7. .Allow the sample to cool to room temperature.

8. Fill the pycnometer completely (with soil and now half full with water) withy distilled Water and close the stopper. Be sure the capillary pore in the stopper is filled.

9. Weight the pycnometer (Air dry soil + Water + Bottle) = M3g

10. Mass of the fraction of water now in pcynometer = M3 – (Ms+M1)g

11. Determine the temperature of distilled water used. (Density of water at this temperature from Appendix 2 which is Pw).

12. Volume of the fraction of water now in pycnometer = M3 – (Ms+M1)/ ρw cm^3

13. Empty the pycnometer , wash and refill with distilled water.

14. Weight the pycnometer filled with water = M4g

15. Weight of water in whole pycnometer = M4 - M1g

16. Volume of water in whole pycnometer = (M4 –M1)/ ρw cm^3

17. Volume of water displaced by soil = [(M4-M1)/ ρw]–[M3 – (Ms+M1)/ ρw cm^3

$$\text{Particle density} = \frac{\text{Ms from step 5}}{\text{Volume from step 18}} = \text{g/ cm3 or Mg/m3}$$

✱✱ In your laboratory report you should include the moisture factor calculation an all steps of calculations. Comment on your density value comparing it with 2.65 Mg/m3. What are the possible errors?

LABORATORY EXERCISES 08

Determination of Soil Texture by Feel

Introduction:

Soil texture is the relative proportion of various soil separates excluding organic matter. Texture is one of the most important soil physical properties as it gives an idea of the specific surface (surface area/ mass) of the particular soil

Texture is determined in the laboratory accurately using pipette or hydrometer method. In the field (especially in soil profile description) texture is estimated by feel and has the disadvantage of being subject to personnel error. Soil surveyors experienced in textural determination by feel mentally correlates coarseness, stickiness and plasticity with texture as a means of assigning textural classes to a soil.

Objectives

The objective of this exercise is to feel the given textural classes where texture is known. Once you have some feeling for the different textural classes try to determine the texture by feel of unknown samples.

Procedure

1. In order to determine the soil texture by feel the soil must be moistened. Add a small amount of water to the soil
2. Move the soil between your thumb and forefinger to determine if the soil feels gritty, sticky or smooth. (The feel characteristics for sand, clay and silt respectively)
3. Try to push the soil between your thumb and forefinger to make a ribbon the longer the ribbon, the more clay is there. Using a ruler, measure the length of the ribbon and record data.
4. Note the ribbon classification of your soil

Good ribbon - A soil containing more than 40% clay is sticky enough to form a ribbon 2inches long or longer

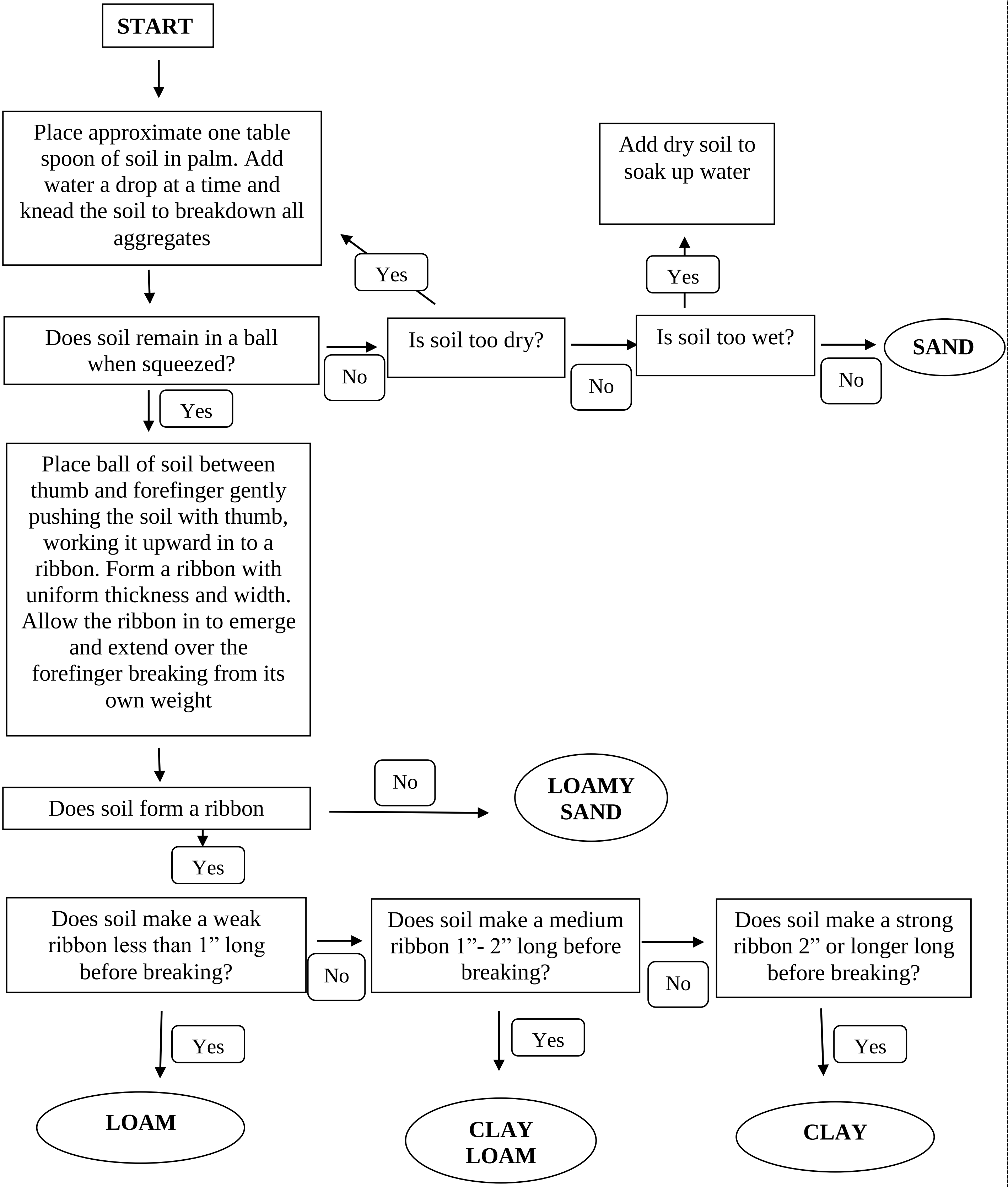
Fair ribbon – A soil containing 27-40% clay and it is sticky enough to form a ribbon at least 1 inch long but not longer than 2 inches

No ribbon – The ribbon formed by a soil containing less than 27% clay will be less than 1 inch long

Data collection sheet

Sample	Ball formation (Yes/No)	Ribbon formation			Textural class
		1”	1”-2”	>2”	

Follow this procedure.



LABORATORY EXERCISES 09

Determination of Soil Texture by Pipette Method

Introduction:

In determination soil texture by pipette method the sand fraction is separated by sieving. Silt and clay fractions are determine by pipetting out sample from a certain depth at different times after shaking the soil solution. The pipetting times are calculated using the Stocks' Law for the interested particle sizes. This is often used as a standard method where other particle size analysis methods are compared. One of the important steps in determining soil texture is dispersion of the soil. Dispersion requires breaking of bonds between soil particle s and removal of aggregating agents as organic matter iron and alluminium oxides, carbonates and soluble salts. The time taken to settle a 10cm depth (where particles attain terminal velocity) for different size particles are calculated using the stokes law as given below.

Sedimentation and decantation is a low cost technique, often used in soil laboratories to determine soil texture. Soils rarely consist entirely of one size range. Soil texture is based on different combinations of sand, silt and clay separates that make up the size distribution of a soil sample.

Stocks' Law

The Stocks' law is used to calculate the time (t) taken by a clay particle (diameter = 0.002m) to travel a known distance (10cm) in water. Similarly the value t can be calculated for silt particle (0.02mm diameter) calculate t for clay and silt using the Stokes' law.

$$\boxed{V = \frac{L}{T} = \frac{2r^2 (\rho_p - \rho_1) g}{9\,\eta}}$$

Where:

V is terminal velocity (cm/sec)
L setting depth (cm) in time t (sec)
r is the radius of particle (cm)
ρ_p is the particle density of soil (g/ cm^3)
ρ_1 is the density of water (g/cm^3) at given temperature T given in Appendix 2
g is gravitational acceleration (cm/ sec 2)
η is viscosity (poise) at the temperature of the suspension as given in Appendix 2

Basic assumption used in applying Stocks' law

1 Terminal velocity is attained as soon as settling begins
2 Settling and resistance are entirely due to the viscosity of the fluid.
3 Particle s are smooth and spherical.
4 There is no interaction between individual in the solution

Objective

The objective of this exercise is to determine the relative proportion of sand, silt and clay fraction and textural class for a given soil sample.

Pipette Method

Procedure

1. Weight 40g of < 2mm fraction of air dry soil (10g for clays, 20g for loams, 40g for sandy clay loams and 80g for sands) Use a sub sample in the oven to determine the moisture factor. The mass of oven dry soil = Msg.

2. Add 100ml of water and b 10ml 1M NaOAc (Adjust to pH) and centrifuge for 10 min at 1500rpm. Wash through a filter candle to remove dissolved carbonates and soluble salts.

3. Add 5ml of hydrogen peroxide (30%). This is added in small quantities to avoid excessive frothing. Add hydrogen peroxide until no more bubbling occurs which indicates that all organic matter is oxidized. Heat the solution at 90oC to evaporate excess water and weigh to get the actual dry weight of the sample.

   (Skip steps 2 and 3 due to shortage of chemicals during practical exercise)

4. Add 10ml of Sodium Hexameta Phosphate (HMP) and enough water to cover the stirrer blades, and stir for 10minutes to disperse the sample.

5. Transfer solution to a 1000ml sedimentation jar. Use the smallest size diameter sieve to separate the sand fraction while transferring. Wash the sand fraction well using a water bottle to remove silt and clay to the suspension. When the water passing through the sieve is clear remove the sand fraction in the sieve to a crucible and evaporates the water using the hot plate. Ovens dry the sand sample and obtain the dry mass. Express it as a percentages of oven dry soil used.
   (Ex. W1/Ms x 100 where W1 is the oven dry mass of sand fraction)
6. Mix the soil suspension by shaking Use a large rubber stopper to cover the opening of the jar and mix the solution by turning. Place the Cylinder in the w3ater bathe where the temperature is controlled at a temperature of 30oC.

7. Use a pipette to obtain samples of the suspensions at 10cm depth at calculated times for the sizes given below. Use the density and viscosity values at 30OC as given in Appendix 2. Mark 10cm from the tip of the pipette using the marker and insert the pipette only about 30 seconds before time transfer the pipetted aliquot to a crucible and oven dry to get the mass accurately to the nearest mg. This is dry weight of soil particles and calgon present in 25cc sample. Say this is M1g.

Calculate the settling times for 10cm depth at 30OC temperature before coming to the particle class for diameters given in below.

Particle Diameter (mm)	settling Time Hr	Min	Sec	M1	M2	M3	M4	%
0.05 (USDA S+C)								
0.02 (ISSS S+C)								
0.002 (Clay)								

8. Calculate the weight of calgon in 25cc sample (4% calgon solution contains 40g of calgon in 1000 cc and you added 10cc of this solution to 11 and pipetted out 25cc of aliquot of soil and salt if this weight is M2g.

9. The weight of soil separate only in 25cc will be M1-M2=M3g. Multiply M3 by 40to obtain the weight of soil separate in 1 Liter (as we pipetted only 25cc) where M3x40 = M4g

10. Calculate the percentage of soil separate using the oven dry weight of the total soil sample by (M4/MS) x 100. This is the percentage of silt and clay particles (USDA), silt and clay (ISSS) system and clay respectively.

11. Once you know the clay % and silt + clay% use this to estimate the silt % according to both systems. Calculate the sand % by 100-(silt + clay).

12. Use the sand, silt and clay percentages according to the USDA system and find the textural class of the given soil using textural triangle from Appendix3

Your Lab Report Should Include

1. Sample calculation for settling times for given diameters
2. The amount of sand, silt, clay according to USDA and ISSS classification
3. The textural class of soil using the USDA classification

Calculate Following;

1. Time taken to settle the silt particle with diameter of 0.05mm. As you know, according to the USDA system, silt fraction has a diameter range of 0.05mm to 0.002mm. What would happen to your results if you this t value instead of the t calculated for silt fraction previously?

2. Settling velocity of a clay particle of 0.001mm. How long this particle would take travel 10cm (vertically downwards) in water.

APPENDIX 2 – DENSITY & VISCOSITY VALUES OF WATER FOR TEMPERATURE CORRECTION

Temperature(degree c)	Density (g/cm3)	Viscosity (poise)
20	0.99823	0.10002
21	0.99802	0.00978
22	0.99780	0.00955
23	0.99756	0.00933
24	0.99732	0.00911
25	0.99707	0.00890
26	0.99681	0.00871
27	0.99654	0.00814
28	0.99626	0.00833
29	0.99597	0.00815
30	0.99567	0.00800
31	0.99537	0.00784
32	0.99505	0.00767
33	0.99473	0.00752
34	0.99440	0.00737

APPENDIX 3 – Soil Textural Triangle (USDA)