SRM VALLIAMMAI ENGINEERING COLLEGE

(An Autonomous Institution)

SRM Nagar, Kattankulathur – 603 203

DEPARTMENT OF AGRICULTURE ENGINEERING

III SEMESTER

AG3366 SOIL SCIENCE LABORATORY

Regulation – 2023

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Prepared by

Mrs.V. DIVYAPRABHA

Assistant Professor/ AGRI

AG3366 SOIL SCIENCE LABORATORY

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OBJECTIVE:

- Students will be able to identify the types of rocks and minerals.
- Students should be able to verify various quality aspects of soil and water studiedin theory by performing experiments in lab.
- To provide hands on experience on the textural analysis of soil.
- Students should be able to determine the organic carbon and gypsumrequirements.
- Students should be able to perform in situ tests on soil samples

LIST OF EXPERIMENTS

1. Identification of rocks and minerals
2. Collection and processing of soil samples
3. Determination of soil moisture, EC and pH
4. Field density determination by Core Cutter and Sand Replacement method
5. Determination of Specific gravity
6. Textural analysis of soil by International Pipette method
7. Grain size analysis by using Mechanical shaker
8. Determination of Organic carbon
9. Estimation of Gypsum requirements

TOTAL: 30 PERIODS

OUTCOMES:

1. Learn about the identification of minerals referred under theory.
2. Knowledge of field investigations including collection of soil sampling, Processing and storage through observation of soil.
3. Understanding of the physical properties of soil and different laboratory methods
4. Be able to perform test to identify the organic carbon and application of soil amendments through chemical analysis of soil.
5. Students know the techniques to determine various physical and chemical properties of soil that are applicable for agriculture and irrigation by conducting appropriate tests.

REFERENCES:

1. Punmia, B.C., “Soil Mechanics and Foundation Engineering”, Laxmi Publishers, New Delhi,2007.
2. Laboratory Manual, Centre for Water Resources, Anna University, Chennai,2012.

TABLE OF CONTENTS

Ex. no: 1 **Date:**

IDENTIFICATION OF ROCKS AND MINERALS

AIM:

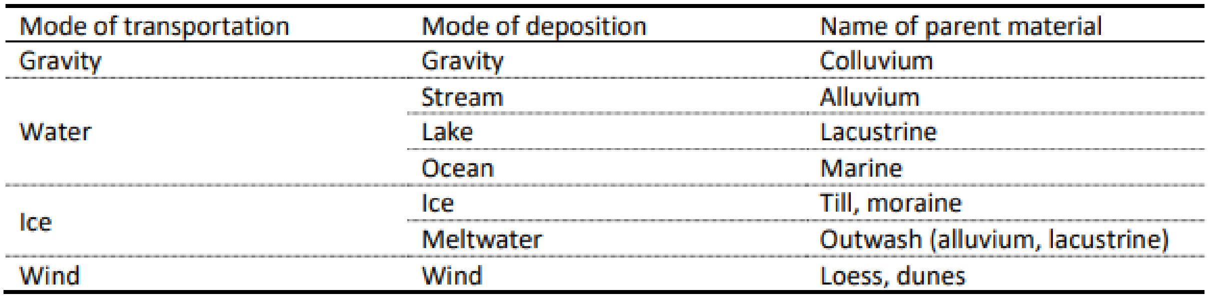
To identify various types of rock and mineral samples.

INTRODUCTION

Soils don't simply *exist* on the landscape; rather they grow, develop, erode, and slowly transform into other soils through time—a group of processes known collectively as *pedogenesis*. Pedogenesis begins with *parent material*, the stuff from which soils form. Although a small minority of soils develop in organic deposits, most derived from inorganic parent materials acted upon by *additions*, *losses*, *translocations*, and *transformations*

A major type of transformation is **weathering of geologic parent materials**. All mineral soils develop from the rocks and minerals of the earth's crust. Through weathering, minerals and rocks physically **disintegrate into smaller particle sizes**, and **chemically decompose into altered chemical and mineralogical products**. However, the original rock material commonly is transported or reworked by some mechanism before a soil is formed. Variations in the history of the initial material lead to a **range of types of soil parent materials** (Table 1). Additionally, these **weathering processes release elements**, including plant and animal nutrients, and convert primary minerals into clays.

Table 1. "Summary of transported parent materials" by Colby J.



Mode of transportation	Mode of deposition	Name of parent material
Gravity	Gravity	Colluvium
Water	Stream	Alluvium
	Lake	Lacustrine
	Ocean	Marine
Ice	Ice	Till, moraine
	Meltwater	Outwash (alluvium, lacustrine)
Wind	Wind	Loess, dunes

Moorberg

These parent materials continue to weather over time based on a function of soil forming factors and processes. Another major consideration for weathering potential of soil parent materials is hillslope position. Hillslope position references where on the landscape a soil is located (Figure 1). Hillslope positions essentially delegate the degree of slope and interaction with the groundwater table for the soils of a specific position location. These relationships between soil and slope, or the groundwater table, greatly influence weathering processes over time, increasing both physical and chemical weathering, depending on hillslope position.

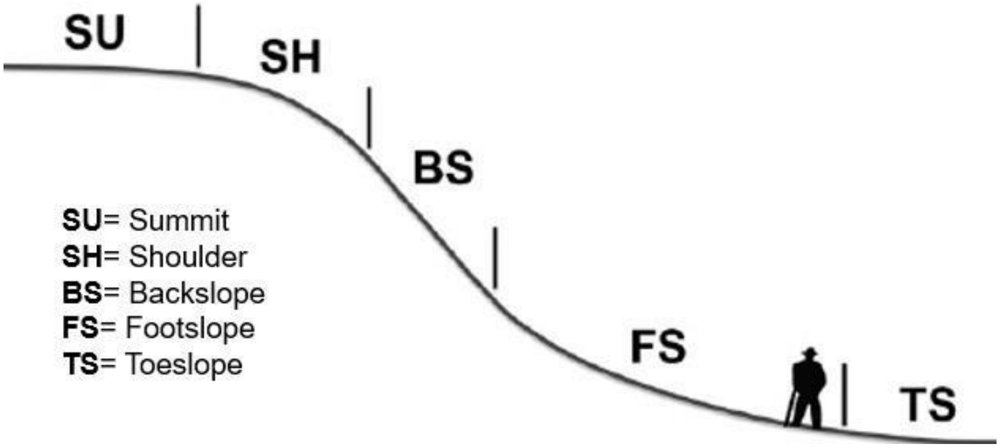


Figure 1. "Hillslope position across a landscape"Positions higher up and with a higher slope will have better drainage and less interaction with the groundwater table, while those positions that are lower lying on the landscape have a lower slope and decreased drainage. Wysocki et al., 2000 and Schoeneberger et al., 2012.

MINERALS

In geology and soil science, a mineral is a naturally occurring, inorganic, crystalline solid having a definite chemical composition and predictable physical properties. Of the six criteria included in this definition, three (naturally occurring, inorganic, and solid) need little elaboration; the remaining three are explained in succeedingparagraphs.

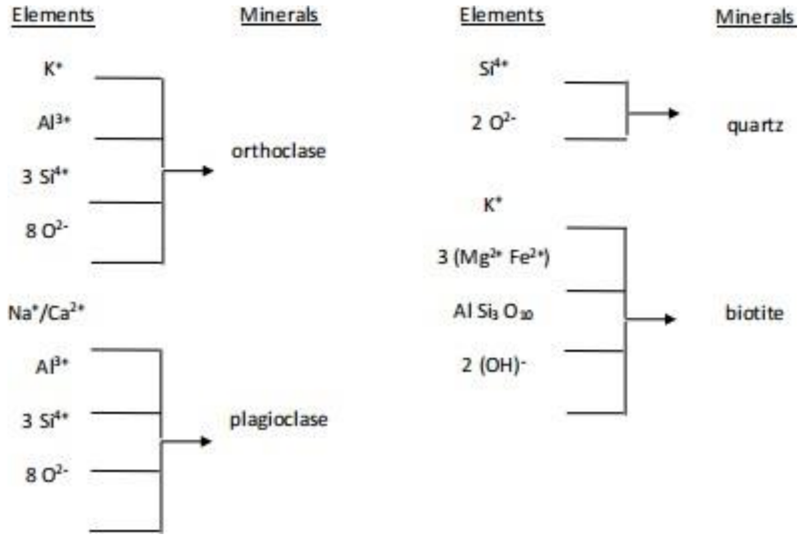
Crystallinity of Minerals

Crystalline means that a mineral's atoms are arranged in an orderly and repeatable manner; they are not random. The atomic arrangement, which varies among mineral groups, contributes to several of the mineral's physical properties, including hardness and cleavage, which are explained under "Physical Properties of Minerals." In contrast, a substance having randomly arranged atoms is amorphous, or noncrystalline, and as such is not considered to be a mineral. A good example of amorphous material is the rock obsidian, a form of volcanic glass.

Chemical Composition of Minerals

Minerals are made up of one or more elements, which give rise to definite chemical compositions (Figure 2). Although chemical formulas are precisely fixed for some minerals (e.g., quartz is SiO_2 and orthoclase is $KAlSi_3O_8$), they can vary within a narrow range for other minerals (e.g., plagioclase ranges from $NaAlSi_3O_8$ to $CaAl_2Si_2O_8$ because Na^+ and Ca^{2+}, which substitute for each other, occur together in varying proportions in the same mineral). Also, no matter how precise the formula, irregularities occur in nature, allowing impurities to sneak in. Note the elements and minerals in Figure 2. What do the four minerals have in common?

Figure 2. Elemental composition of four common minerals important in soil formation.



On a mass basis, nearly three-fourths of Earth's crust is made up of only two elements: oxygen and silicon; and on a volume basis, these two elements constitute more than 90%! The next six most common elements bring the totals to about 98.5 percent by mass, and to nearly 100 percent by volume (Table 2). Obviously, very little room is left for the remaining 100 or so elements, including most plant nutrients, found in the crust. How is it then that soils, nearly all of which derive ultimately from crustal weathering, can supply enough nutrient elements for nearly all terrestrial life, including three-fourths of humanity's food supply? Your work in this laboratory exercise should help you begin to understand and appreciate the answer to this question.

Table 2. The eight most common elements in the Earth'scrust.

Element	Ionic Formula	Mass Percent	Volume Percent
Oxygen	O^{2-}	46.60	91.97
Silicon	Si^{4+}	27.72	0.80
Aluminum	Al^{3+}	8.13	0.77
Iron	Fe^{2+}& Fe^{3+}	5.00	0.68
Calcium	Ca^{2+}	3.63	1.48
Sodium	Na^{+}	2.83	1.60
Potassium	K^{+}	2.59	2.14
Magnesium	Mg^{2+}	2.09	0.56

Mineral Classification Based on Chemical Composition

Most minerals are grouped into seven classes based on their fundamental anionic unit (Table 3). (A few other classes exist, but these can be ignored for this laboratory). Of these, the silicates are by far the most common; nonetheless weathering products of others can be equally vital.

Table 3. Classification and composition of selected minerals important in soil science.

Mineral Class	**Example**	**Chemical Composition (specimen #)**	**Comments**
Sulfides	1) pyrite 2) sphalerite	FeS_2 (19) ZnS (17)	readily oxidized in moistsoils
Oxides	hematite	Fe_2O_3 (15)	readily oxidized, producingred colors
Halides	1) halite 2) sylvite	NaCl (18) KCl	rock salt; sometimes found in desert soils
Carbonates	1) calcite	$CaCO_3$ (13)	1) calcareous; reacts toacid; weathers easily in moist soils

	2) dolomite	$CaMg(CO_3)_2$	2) calcareous; less reactivethan calcite
Sulfates	gypsum	$CaSO_4$□$2H_2O$ (20)	a common agriculturalamendment; sometimes found in desert soils
Phosphates	apatite	$Ca_5(PO_4)_3(F,Cl,OH)$ (8)	the only significant sourceof phosphorus
Silicates	olivine	$(Mg, Fe)_2SiO_4$	most easily weathered ofthe silicates
	pyroxene: augite	$(Ca, Na)(Mg, Fe, Al)(Si, Al)_2O_6$ (12)	susceptible to oxidationand hydration
	amphibole: hornblende	$(Ca,Na)_{2-3}(Mg,Fe,Al)_5Si_6(Si,Al)_2O_{22}(OH)_2$ (11)	susceptible to oxidationand hydration, but more resistant than augite
	micas: 1) muscovite 2) biotite	1) $KAl_2(AlSi_3O_{10})(OH)_2$ (6) 2) $K(Mg, Fe)_3(AlSi_3O_{10})(OH)_2$ (7)	1) soft, but strongly resistschemical weathering 2) soft; weathers moreeasily than muscovite
	feldspars: 1) orthoclase 2)plagioclase	$KAlSi_3O_8$ (9) $Na(AlSi_3O_8)$□$Ca(Al_2Si_2O_8)$ (10)	most common minerals 1)hard, resistant 2)hard, weathers
	quartz	SiO_2 (4)	hard and most resistant toweathering

Physical Properties of Minerals

*Color:*Minerals exist in nearly every color, and although color is easy to determine, it might not be reliable for identifying a mineral. For example, pyrite is nearly always brassy yellow, but quartz can range across several hues, values, and chromas from colorless to white, pink, purple, and gray. In some minerals, color can be strongly influenced by impurities.

*Luster:*independent of a mineral's color and determined by the nature of light reflected from a mineral's surface. Most lusters fall into two main groups: metallic and nonmetallic. Metallic lusters are typical of minerals that strongly absorb light, and as a result are opaque, even in very thin pieces. These minerals tend to look like metals, even though their surfaces might range from shiny to dull. Nonmetallic lusters are seen in minerals that allow light to pass through thinly cut slices. Surfaces of nonmetallic minerals might be brilliant like diamond, glassy like quartz, waxy like serpentine, or earthy like clay.

*Cleavage and fracture:*Cleavage is a mineral's tendency to break along certain predictable directions when the mineral is struck by a hammer. The resulting cleavage surfaces might be smooth and distinct, or they might be rough and indistinct, depending on the type of mineral. Different minerals also cleave along different directions and at different angles, depending on the type and orientation of atomic bonding. Although the number of possible cleavage directions is 1, 2, 3, 4, or 6, we will focus only on minerals that have 1 (e.g., biotite), 2 (e.g., orthoclase), and 3 (e.g., calcite) directions (Figure 3). Some minerals, when hit by a hammer, do not break along predictable planes: they simply shatter in any direction. These minerals are said to fracture, rather than cleave. Quartz is a good example of a mineral that exhibits fracture.

one
cleavage
direction

two
cleavage
directions

three cleavage
directions

Figure 3. Examples of mineral cleavage.

*Hardness:*Hardness is determined by the resistance of a mineral’s surface to scratching by various instruments of known hardness. It is judged by the Mohs hardness scale, which uses certain reference minerals ranked from 1 (soft) to 10 (hard): (see next page)

Mohs Hardness Scale

1. Talc (easily "scratched" by rubbing between fingers, giving a soapyfeel)
2. Gypsum (easily scratched by afingernail)
3. Calcite (same hardness as apenny)
4. Fluorite
5. Apatite (a bit softer than a pocket knifeblade)
6. Orthoclase (harder than a knife blade, but slightly softer thanglass)
7. Quartz (harder than both a knife blade andglass)
8. Topaz
9. Corundum
10. Diamond

(Soil minerals are very rarely harder than 7)

Essential elements for plants and animals

Essential elements are those that organisms need to grow and complete their life cycles. For plants, sixteen elements are universally recognized as essential; nonetheless research conducted in the late 20th century suggests that the number is eighteen or perhaps even greater. We will consider that plants require eighteen elements (Table 4), although you should understand that many plants, depending on their species, take up more than they seem to need.

A mnemonic phrase can help you memorize the 18 elements:

C HOPKNS CaFe Mg B Mn CuZn Cl CoMo Ni

Translated, this reads “C Hopkns café, managed by “mine” cousins Clyde, Como, and Nicky.”

Note that of the eight most common elements in Earth’s crust, only five, oxygen, iron, calcium, potassium, and magnesium, are among the 18 essential elements (Table 4); and the first of these, oxygen, is supplied by O_2 in the atmosphere, **not** by weathering of minerals and rocks. Of the thirteen remaining essential elements, hydrogen comes from water, carbon comes from carbon dioxide (CO_2) in the atmosphere, and nitrogen is maintained by cycling of organic matter. (Nitrogen first is made available to plants by fixation from the atmosphere.) The remaining ten elements, phosphorus, sulfur, boron, manganese, copper, zinc, chlorine, molybdenum, nickel, and cobalt derive from weathering of minerals and rocks.

Table 4. Essential elements for plants.

Macronutrients			Micronutrients		
Element	Atomic Symbol	Plant Available Form	Element	Atomic Symbol	Plant Available Form
carbon	C	CO_2	iron	Fe	Fe^{2+}, Fe^{3+}
hydrogen	H	H^+	manganese	Mn	Mn^{2+}
oxygen	O	O_2, H_2O	boron	B	H_3BO_3
nitrogen	N	NH_4 , NO_3	zinc	Zn	Zn^{2+}
phosphorus	P	H_2PO_4 , HPO_4	copper	Cu	Cu^{2+}
potassium	K	K^+	chlorine	Cl	Cl^-
calcium	Ca	Ca^{2+}	cobalt	Co	CO^{2+}
magnesium	Mg	Mg^{2+}	molybdenum	Mo	MoO_4^-
sulfur	S	SO_4	nickel	Ni	Ni^{2+}

In addition to the 18 elements required by plants, animals also require arsenic (As), chromium (Cr), fluorine (F), iodine (I), lithium (Li), sodium (Na), selenium (Se), silicon (Si), and tin (Sn). Herbivorous animals obtain these elements by eating plants, which take up the elements, even though the plant might not need them. Carnivorous animals, in turn, obtain the elements by preying on other animals.

Regardless of whether the elements are required by plants or animals, all except carbon, hydrogen, oxygen, and nitrogen, are made available initially by weathering of minerals. The elements gradually become concentrated in the biosphere through biogeochemical cycles, including the carbon and nitrogen cycles, which will be covered in a later laboratory.

ROCKS

The most common rocks are consolidated assemblages of minerals, but a few (e.g., obsidian, pumice, and coal) comprise non-crystalline (hence, nonmineral) materials. Despite the great number of possible compositions and arrangements, rocks can be divided into three categories based on their mode of formation: igneous, sedimentary, and metamorphic.

Igneous Rocks

*Intrusive and Extrusive:*Igneous rocks form when molten material called magma cools and solidifies. Although the magma originates tens of kilometers below Earth's surface, it can solidify at any depth from its depth of origin to the surface. Magma that remains at depth while cooling and solidifying forms igneous intrusive rocks. Because of extremely slow cooling, minerals can grow to macroscopic size, and can be readily identified in a hand specimen.

Instead of remaining deep throughout the cooling process, some magmas erupt to the surface, where they cool and solidify rapidly. The resulting igneous extrusive rocks can be glassy (i.e., amorphous) or microcrystalline, although many contain a smattering of macrocrystals that formed before eruption. In erupting, the magma might ooze toward the surface as lava, or it might explode violently into the atmosphere, forming pumice and volcanic ash.

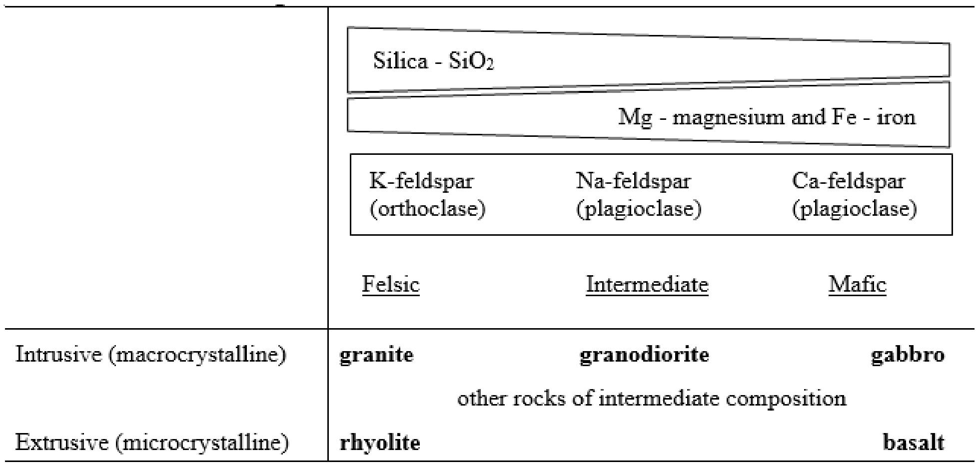
Felsic and Mafic: In addition to having distinctively different crystal sizes, igneous rocks also vary in mineralogical composition because of chemical differences among magmas. Some rocks are dominated by quartz and orthoclase (potassium-rich feldspar) because they derived from magma that was rich insilica and potassium. These rocks, which tend to be light colored, are called felsic. Other igneous rocks have little or no quartz or orthoclase, but instead are characterized by calcic plagioclase (calcium-rich feldspar) and ferromagnesian minerals (e.g., augite and hornblende). These are called mafic and are dark colored. Other rocks of intermediate compositions can be found between these extremes.

Classification of Igneous Rocks

The textural trend caused by varying rates of cooling, combined with the mineralogical trend resulting from chemical differences in magma provide the basis for classifying igneous rocks (Table 5). Selected elements also combine to form minerals, which then combine to form a common igneous intrusive rock (Table 6).

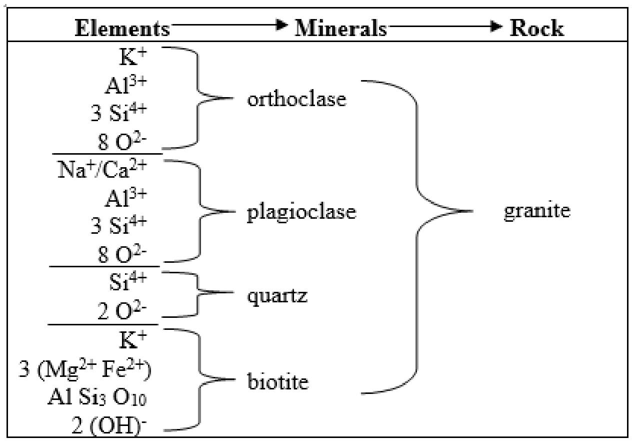
Accessory minerals, which can be significant, also vary from felsic to mafic. Of the micas, muscovite is felsic, and biotite is more mafic. As a result, muscovite is found in felsic rocks, including true granite, whereas biotite can occur in rocks ranging from felsic to moderately mafic. An important rock of intermediate composition is granodiorite, which has a characteristic salt-and-pepper appearance derived from light colored quartz and feldspars, especially sodic plagioclase, combined with dark colored biotite. Olivine, a strongly mafic mineral, and augite, which is slightly less mafic, are common constituents of gabbro andbasalt.

Table 5. Classification of igneous rocks



	K-feldspar (orthoclase)	Na-feldspar (plagioclase)	Ca-feldspar (plagioclase)
	Felsic	Intermediate	Mafic
Intrusive (macrocrystalline)	**granite**	**granodiorite**	**gabbro**
		other rocks of intermediate composition	
Extrusive (microcrystalline)	**rhyolite**		**basalt**

Table 6. An example of elements combining to form minerals and minerals combining to form an igneous rock.



Elements	**Minerals**	**Rock**
K^+ Al^{3+} 3 Si^{4+} 8 O^{2-}	orthoclase	granite
Na^+/Ca^{2+} Al^{3+} 3 Si^{4+} 8 O^{2-}	plagioclase	
Si^{4+} 2 O^{2-}	quartz	
K^+ 3 $(Mg^{2+}\ Fe^{2+})$ $Al\ Si_3\ O_{10}$ 2 $(OH)^-$	biotite	

Sedimentary Rocks

Sedimentary rocks, which make up the bulk of Earth’s continental crust, can be either clastic (i.e., fragmental) or nonclastic (i.e., nonfragmental). See Table 7 for examples.

*Clastic rock:*consist of fragments of previously existing rocks (igneous, sedimentary, or metamorphic) that have been transported to a new location (often an ocean bottom), where they were deposited and buried layer upon layer, and cemented together. The deposits can be several thousand meters thick!

The fragments, or clasts, can vary in size to include clay, silt, sand, gravel, and cobbles.

Nonclastic rock: form by chemical precipitation of dissolved salts and by biochemical precipitation of organically derived compounds in water, most commonly on the floors of shallow seas. Organisms that generate nonclastic rocks include bacteria, algae, diatoms, corals, and mollusks. The most common nonclastic sedimentary rocks are limestone and dolomite (also called dolomitic limestone). Others include rock gypsum, chert, and coal.

Although the two major categories are recognized, most sedimentary rocks are a combination of clastic and nonclastic, nonetheless they usually are dominantly one or the other. For example, the sand grains in sandstone are clastic, but the cement that holds them together can be nonclastic.

Table 7. Classification of sedimentary rocks.

Clastic		**Nonclastic**	
Dominant Constituent	**Sedimentary Rock**	**Dominant Mineral**	**Sedimentary Rock**
clay	claystone	calcite ($CaCO_3$)	limestone
silt	siltstone	dolomite ($(CaMg)(CO_3)_2$)	dolomite
mud (silt + clay)	mudstone	gypsum ($CaSO_4 \bullet 2H_2O$)	gypsum
thinly layered mud	shale	microcrystalline quartz (SiO_2)	chert

sand (≥ 50%): mostly quartz, feldspars, micas sand: 50-85% sand with remainder mud and possibly some pebbles sand: > 85% sand with remainder mud and possibly pebbles	sandstones wacke (dirty sandstone) arenite (clean sandstone)		
gravel (pebbles) with sand and mud; quartz, orthoclase, quartzite	conglomerate		

Metamorphic Rocks

Metamorphic rocks form primarily by the application of extremely high heat and pressure to some previously existing rock. The original rock may be igneous, sedimentary, or even metamorphic, but sedimentary rocks are most susceptible to metamorphosis. Metamorphic rocks can be either foliated or nonfoliated. Foliated rocks consist of minerals that are aligned or oriented to yield a somewhat stratifiedor layered appearance, whereas the minerals in nonfoliated rocks are about equally arranged in all directions, giving them a more uniformly massive appearance (Table 8).

Table 8. Classification of metamorphic rocks.

Foliated		
Metamorphic Rock	*Common Original Rock*	*Appearance/Comments*
slate	shale	strongly stratified (layered), flat; often with very fine quartz and mica; cleaves into sheets, but denser than shale
schist	shale or other slate	wavy foliation; often with micas, quartz, feldspars
gneiss (pronounced “nice”)	granitic rocks	minerals oriented to give more faint stratification than schist; often contains the same minerals as

		its granitic counterpart
Nonfoliated		
marble	limestone	calcite cleavage usually visible; fizzes to release CO2 when tested with HCl
quartzite	quartz arenite	hard; very resistant to weathering
serpentinite	peridotite (an ultramafic igneous rock)	greenish assemblage of serpentine minerals; high magnesium; occurs intermittently along west coast of North America, and smaller areas of the East Coast

WEATHERING

Weathering breaks rocks and minerals down, resulting in the production of soils. Weathering occurs via two processes: physical disintegration (breaking into smaller pieces) and chemical decomposition (changing the nature of the minerals themselves).

Physical disintegration causes rock masses to split apart or to abrade and wear away from the larger rock surface. Freezing and thawing, abrasion by particles suspended in wind or water, and grinding caused by glaciers result in disintegration. Repeated actions of these processes cause stresses, which eventually break and erode rock surfaces. Physical weathering usually precedes or occurs in concertwith the chemical decomposition process. With a decrease in the size of individual particles, the total number of corners and edges and the total surface area of the rock mass greatly increase.

Chemical decomposition

Chemical decomposition progresses most rapidly when more surface area is available for chemical reactions to occur. Warm and wet environments enhance chemical decomposition. The smaller the particles, the greater the surface area of a given volume of rock (the greater the total exposed corners and edges) and the greater the rate of chemical decomposition. The total number of corners exposed to weathering processes is the major factor in the determination of weathering rates. This is because a corner has three surfaces and three edges for chemical attack. Chemical weathering is a combination of five major processes: carbonation, hydration, hydrolysis, oxidation-reduction (redox), and solution.

Hydrolysis and particle size: Hydrolysis is a chemical decomposition process involving the splitting of water molecules during a reaction. A hydrolysis reaction can be easily identified by looking for water on the left side of a chemical equation and the absence of water (but the formation of H^+ and/or OH^-) on the right side of the equation. All minerals weather by hydrolysis. The hydrolysis reaction is particularly evident with silicate minerals (e. g. feldspars and micas). Hydrolysis is the primary reaction resulting in the release of most plant nutrient elements from minerals. The mineral orthoclase will weather by hydrolysis.

$$KAlSi_3O_8 + H_2O \rightarrow HAlSi_3O_8 + K^+ + OH^-$$

Orthoclase + Water → Al-silicate mineral + Potassium ion + Hydroxide ion

The potassium cation (K^+) released by this hydrolysis reaction is soluble in water and can be adsorbed by the soil clay minerals and organic colloids, used by plants, or be removed (leached) by the drainage water. The aluminum silicate compound may crystallize into a clay mineral (e. g. kaolinite). This natural chemical weathering process occurs at a very slow but continual rate in all rocks, parent materials, and soils. The smaller the original mineral, the faster the hydrolysis reaction will occur. The hydroxide ion (OH^-) will increase the pH. When a glacier grinds rocks with glacial ice (water), the grinding is a physical disintegration process. However, the resulting hydrolysis reaction of the fine particles hydrolyzing with the water causes the glacial till to have a high pH (abrasion pH). Initially, the pH of the glacial till will be 9 or 10, but as the glacial till absorbs carbon dioxide from the air, the pH will drop.

*<u>Carbonation and Solution:</u>*The metabolic activities of plant roots and microorganisms produce an abundance of CO_2 within soil pores. This CO_2 reacts with soil water to produce most of the carbonic acid found in soils.

$$CO_2 + H_2O \rightarrow H_2CO_3$$

Carbon Dioxide + Water → Carbonic acid

The carbonic acid in the soil water continually reacts with minerals as the water percolates through soils and rocks. Carbonic acid, a weak acid, is the most common acid found in soils. Carbonic acid can ionize into acidic hydrogen ions (H^+) and bicarbonate (HCO^-):

$$H_2CO_3 \rightarrow H^+ + HC_3O^-$$

Carbonic acid → Acidic hydrogen ion + Bicarbonate ion

At pH < 6, this reaction tends to go more to the left than to the right, indicating carbonic acid is a weak acid and does not produce very many acidic hydrogen ions. Carbonic acid is effective in accelerating the chemical decomposition processes of minerals because nature continually provides rainwater and carbon dioxide. Thus, rainwater drives this reaction to the right. As the rainwater moves through the soil, it carries soluble bicarbonate ions deeper into the soil profile and deposits the acidic hydrogen ions on the soil surfaces. The law of mass action allows the soil to eventually become acidic with time of weathering as rainfall drives the above reaction to the right.

As a result of a glacier grinding rocks, the hydrolysis reaction results in the glacial till containing soluble Ca^{2+} ions and OH^- ions (which causes a high pH, greater than 8.3). As the glacial till is exposed to carbonic acid, the glacial till undergoes two carbonation reactions. The first reaction process is quite rapid, while the second reaction is slow and requires time for completion. The first carbonation reaction is

$$Ca^{2+} + 2OH^- + H_2CO_3 \rightarrow CaCO_3 + 2H_2O$$

Soluble calcium + Soluble hydroxide + Carbonic acid → Low soluble calcite + Water

The second reaction is:

$$CaCO_3 + H_2CO_3 \rightarrow Ca(HCO_3)_2$$

Calcite + Carbonic acid → Soluble calcium bicarbonate

The calcium bicarbonate dissolves slowly and releases soluble calcium ions (Ca^{2+}) for plant uptake or possible leaching downward through the soil when excessive rainfall or irrigation occurs. The loss of the calcite minerals (the chief mineral in limestone) eventually leads to the development of acidic soils, carbonate hardpans, and the formation of huge underground caverns (e. g. Mammoth Cave and Carlsbad Caverns). The cave one walks through is the hole remaining after the soluble calcium bicarbonate has left the cavity where the carbonic acid dissolved the limestone rock.

The soluble calcium and bicarbonate move downward and enter the ground water, which eventually emerges as water in streams flowing to the ocean. The presence of the calcium bicarbonate in the ground water is the major reason limestone ground water is termed “hard water”.

Eventually, the second reaction has two major effects in a high rainfall environment. First, the surface soil will become acidic and the pH will decrease due to increased rainfall and CO_2 production (H_2CO_3). Second, soluble calcium is made available to plants. However, further rainfall will leach the soluble calcium bicarbonate downward.

Eventually, the soil will become depleted of calcium (Ca^{2+}). The same phenomenon will be true for magnesium (Mg^{2+}), potassium (K^+), and sodium (Na^+) cations released to the soil by the hydrolysis of various minerals. This process results in a loss of overall plant nutrition and soil fertility.

Reduction-oxidation (redox) reactions: involve the transfer of electrons from one reactant to another. In every redox reaction, some substance becomes oxidized and some other substance becomes reduced by the transfer of the electron. The substance losing the electron is oxidized and the component accepting the electrons becomes reduced. Commonly, but not always, oxygen serves as the oxidizing agent.

Oxygen combines with an element in a mineral, such as iron (Fe^{2+}), causing the iron to give up some of its electrons, which are accepted by oxygen. The iron becomes oxidized while the oxygen becomes reduced. These electron transfers constitute a form of chemical weathering, which disrupts the mineral’s atomic structure, releasing several elements, and leading to the development of new compounds including clay minerals.

Although redox reactions take place continuously in soils, their reaction rates can be very slow and unnoticeable. If a soil is moist and well aerated, iron tends to become oxidized (Fe^{3+}, loses electrons to oxygen), but if air (oxygen gas) is absent, as occurs with water-saturated soil, the iron becomes reduced

(Fe^{2+}, gains electrons). The extent of either oxidation or reduction in soils is manifested in the color of the soil. Oxidized iron (Fe^{3+}) occurs where oxygen is present in well-drained soils and produces red, yellow, or brown colors in soils. Reduced iron (Fe^{2+}) exists in flooded or very poorly drained soils and produces black, gray, olive, and blue colors. Alternating periods of oxidation and reduction, caused by fluctuating water levels in a soil, result in mottling (blotches of red and yellow mixed with gray colors) to occur. Continuous strongly reducing conditions caused by long-term water-logging forms gleyed conditions. Gleyed soils have dark gray to blue to black soil colors.

$$\boldsymbol{Fe^{2+} \overset{O_2}{\leftrightarrow} Fe^{3+}}$$

Reduced (gray soil colors) Oxidized (red and yellow soil colors)

ACTIVITY 1: MINERALS

You will need to study the mineral specimens provided to fill in the blanks in the table below. Use the following guidelines for completing the table:

*Color:*Describe what you see. Munsell color designations are not necessary.

*Luster:*Write in either "M" for metallic or "N" for nonmetallic.

*Hardness:*Soft (S) minerals can be scratched by a fingernail. Medium (M) minerals can be scratched by a penny. Hard (H) minerals cannot be scratched by a penny and can scratch glass. *Cleavage:*Note whether present (1, 2, or 3 directions) or absent (0 directions).

*Plant-available nutrients:*Refer to the list of essential elements and to Tables 3 and 4. *Write in the chemical symbol of nutrients that are released and used by plants by weathering of minerals.*

Mineral	**Color**	**Luster (M or N)**	**Hardness (S, M, or H)**	**Cleavage (yes/no)**	**Plant-available nutrients from Minerals (Table 4) (atomic symbol & charge)**
pyrite					
calcite					
gypsum					
hornblende					
muscovite					
plagioclase					

orthoclase					
quartz					

1) Which of the minerals in Table 3 is most resistant toweathering?_____________

2) Of the eight most common elements in the earth’s crust, which ones are essential elements that are released to plants by the weathering ofminerals?

_____________ _____________ _____________ _____________

3) Name the source of each of the following plant-essentialelements:

C______________ H______________ O______________ N______________

ACTIVITY 2: ROCKS

Read the background information presented in this exercise, and study the minerals and rocks provided to fill in the blanks in the Properties of Rocks Table. Give the class as igneous intrusive (Ii), igneous extrusive (Ie), sedimentary (S), or metamorphic (M). List the crystal or grain size as microscopic (Mi) if the crystals or grains are too small to identify without a microscope, or macroscopic (Ma) if the crystals or grains are recognizable without a microscope.

Exercise: Fill in the properties of the following rocks provided in the rock and mineral kits. Ii=igneous intrusive, Ie=Igneous extrusive, S=sedimentary, M=Metamorphic, Mi=microcrystalline, Ma=macrocrystalline.

Rock	**Class (Ii, Ie, S, M)**	**Color**	**Crystal or grain size (Mi, Ma)**	**Principal Constituents or Minerals**
granite				
basalt				

sandstone				
schist				
limestone				
chert				
conglomerate				

Rock	**Class (Ii, Ie, S, M)**	**Color**	**Crystal or grain size (Mi, Ma)**	**Principal Constituents or Minerals**
marble				
gneiss				
shale				

ACTIVITY 3: WEATHERING

Part 1

Your instructor has set up 2 beakers on a laboratory bench. Each beaker has a rock immersed in some type of liquid. Beaker #1 is filled with soda water, while beaker #2 contains a soil ped. Record the pH of the soda water, then submerge the ped into the soda water beaker. After the reaction has subsided, measure the pH of the solution. Record initial and final pH of the solution.

InitialpH: __________ FinalpH: _________

1) *What are your predictions for what will happen when the liquids areadded?*

2) *List yourobservations:*

3) *Explain the chemical process youobserved:*

Part 2

Your instructor has set out pictures detailing redoximorphic features displaying Oxidation and Reduction reactions. Observe each photo and detail your observations in the section below.

1) *Observe the picture on display for gleyed soils (Image 1). Describe the appearance of the gleyed soil.*

____

2) *Observe the colors of the mottled soil on display (Image 2). Describe the appearance of the mottledsoil.*

____

3) *What are the physical (i.e. color) and chemical (i.e. form of Fe) properties of a gleyed/reduced soil?*

4) *What environmental condition causes soils to becomegleyed?*

5) *In the field, what soil topographic or slope position (i.e. summit, backslope, or toeslope) would be most conducive to the formation of reducing conditions or gleyed soils?Why?*

6) *Most soils do NOT have gleyed horizons. If a gleyed horizon exists, which soil horizon is most commonly gleyed/reduced in a soil (Assume this soil has an impermeable layer at 100cm)?*

7) *Explain why this horizon (from Q #6) would be most commonly reduced orgleyed.*

8) *Soil may have a mottled condition associated with a fluctuating water table. What are the physical and chemical properties of a mottled soil? What happens when the water table rises and falls in the mottled soilzone?*

9) *Well oxidized soils are associated with what soil drainage condition? (See page 1-11 in the Red Book)* _

In the field, what soil topographic or slope position (i.e. summit, backslope, or toeslope) would be most conducive to the formation of strongly oxidizing conditions in a soil? Why?

____

____

10) *For most soils, which is likely to have the most oxides, and most likely to have an oxidized horizon?____Why?*

____

ACTIVITY 4: ROCKS TO PARENT MATERIAL

DEVELOPMENT OF ROCKS INTO PARENT MATERIAL THAT BECOMES SOIL

As mentioned above, inorganic parent materials are typically derived from a variety of geological species. These parent materials are typically identified by their mode of transportation (i.e. colluvium transported by gravity, or loess transported by wind), however, it is important to recognize how specific rock types physically weather in order to be able to identify parent materials properly in the field.

Observe the trays of parent materials and soil for the granite and sandstone rocks on display. The first tray contains the fresh rocks before being weathered, the second tray contains the parent material of the soil formed from this rock, and the third tray contains the soil formed from the parent material derived from this rock type.

1) List the main minerals in each type ofrock.

Granite:____

Sandstone:____

2) What main physical changes (particle size and color) have occurred in the stages from rock to weathered rock tosoil?

____

3) Which fraction—rock, weathered rock, or soil (circle one)—is most susceptible to further physical and chemical weathering?Why?

4) You will drop some hydrochloric acid (HCl) (a few drops) on each fraction (rock, weathered rock, and soil). Indicate which materials fizz by filling in the table below with a “Y” for yes and an “N” for no.

Rock Type	**Rock (R)**	**Weathered rock parent material (Cr)**	**Soil**
Granite			
Sandstone			

5) What is the reason (which reaction is responsible) for thefizzing?

Exp. No.:2 **Date:**

COLLECTION AND PROCESSING OF SOIL SAMPLES

Objectives of soil testing:

- To study/maintain fertility status of a field.
- To predict the probability of obtaining a profitable response of lime & fertilizers.
- To provide basis for recommendation of fertilizers.
- To evaluate fertility status of soil of an area/state/country for developed of plans for research and education work.
- To study the acidity, alkalinity and salinity problems.
- To determine the suitability of the soil for laying gardens.
- Lime problems.
- Soil survey.

Apparatus and Materials:

- Spade
- Augers
- Plastic bowl
- Scale
- Rack
- Wooden roller
- Mortar and pestle
- Sieve
- Polythene/paper/cloth bags
- Labels
- Card board cartons
- Aluminium boxes

Collection of Representative Soil Sample:

- Depending on field conditions and the objective of sampling, select proper sampling tool (s).
- Based on difference in soil type, colour, crop growth or slope, divide the area in different homogenous units.
- In the uniform field, demarket the sampling points in a zig zag fashion or randomly in such a way that the whole field should be covered i.e. about 30-35 sample per ha.
- At the sampling site, remove the surface litter with Khurpi or spade. With the help of the sampling tool (Auger) collect a sample in a plastic bowl.
- If the soil is to be kept in moist condition for moisture determination, bacterial count and nitrate estimation etc. air tight containers are preferred.
- Soil samples should be labelled/ numbered by field staff with water proof ink or paint. These bag numbers being entered in the sampler's record books, as each sample is taken together with other information. He needs to identify and describe the samples.
- When a box of samples is dispatched to the laboratory, it should contain a packing note giving the total number of sample, 'sample number' of each sample and its corresponding 'bag number', the depth of soil sample from profile pit and other information needed by the laboratory staff for registration purposes, particularly on the analysis required.
- The samples are register in laboratory giving each sample a 'laboratory number' for particular analysis.
- It is essential to keep a record of the date of arrival and the source of all samples. A table can be drawn up for each month.

Preparation of Soil Sample for Analysis:

- Ensure the sample is uniform size, free of stone, contain no soil aggregates bigger than 1 cm and air dry. These only need grinding and sieving.
- If the sample arrived at the laboratory as it has been taken from the sampling tool in the field, it is spread out on a tray of metal (Al) or plastic or strong brown paper, stones one removed and large soil aggregate broken up, pieces of un decomposed plant should be removed.

- Wet samples are air dried. To hasten 'air drying' elevated temperature not exceeding 400 C in air conditioner. During the air drying, samples should be kept in well ventilated condition so that the water vapor can escape easily.

- Sample for minor metal analysis should be crushed in a motor of porcelain or stoneware and sieve through a stainless steel or nylon sieve. Crushing should always be gentle to avoid breaking up gravels.

- Care must be taken with sample containing soft chalk or limestone where the degree of grinding can affect the result of calcium carbonate.

- Crushing with roller of flat hardwood may be employed. Special soil grinding machine which allow crushed material to pass through a 2 mm sieve during operation. Machine which grind the whole sample including gravel must not be used.

- Certain analysis required sample passing 0.5 mm sieve, a sub sample of 25-50g ground until all the soil passes through a 0.5mm sieve and transferred to a small tray to await analysis.

- The safest way to ensure this is to spread out the well mixed sample on a flat tray and take small portion at random with a spatula at full depth of soil layer not just from surface until the required weight is obtained.

- It is inaccurate to take a 2mm sample for analysis straight from a bottle or carton, the content of which may not be uniformally mixed.

Precautions in collecting a soil sample:

- Avoid sampling from low – lying spots, manure dumping sites, near trees and from fertilizer placed zones.

- Use clean bags for sample collection. Do not use bags which had earlier contained fertilizer, manure or plant protection chemicals etc.

Exp. no.: 3.i. **Date:**

DETERMINATION OF SOIL MOISTURE

OBJECTIVE

Determine the natural content of the given soil sample.

NEED AND SCOPE OF THE EXPERIMENT

In almost all soil tests natural moisture content of the soil is to be determined. The knowledge of the natural moisture content is essential in all studies of soil mechanics. To sight a few, natural moisture content is used in determining the bearing capacity and settlement. The natural moisture content will give an idea of the state of soil in the field.

APPARATUS REQUIRED

1. Non-corrodible air-tight container.
2. Electric oven, maintain the temperature between 1050 C to 1100 C.
3. Desiccator.
4. Balance of sufficient sensitivity.

PROCEDURE

1. Clean the container with lid dry it and weigh it (W1).

2. Take a specimen of the sample in the container and weigh with lid (W2).

3. Keep the container in the oven with lid removed. Dry the specimen to constant weight maintaining the temperature between 1050 C to 1100 C for a period varying with the type of soil but usually 16 to 24 hours.

4. Record the final constant weight (W3) of the container with dried soil sample. Peat and other organic soils are to be dried at lower temperature (say 600) possibly for a longer period. Certain soils contain gypsum which on heating loses its water if crystallization. If it is suspected that gypsum is present in the soil sample used for moisture content determination it shall be dried at not more than 800 C and possibly for a longer time.

OBSERVATIONS:

S.No.	Description	Trial 1	Trial 2	Trial 3
1.	Weight of container with lid, W_1 (gm)			
2.	Weight of container with lid + wet soil, W_2 (gm)			
3.	Weight of container with lid + dry soil, W_3 (gm)			
4.	Moisture content, W (%)			

RESULT

The natural moisture content of the soil sample is _________

Exp.No.: 3.ii. **Date:**

DETERMINATION OF ELECTRICAL CONDUCTIVITY OF SOIL

Aim:

To determine the electrical conductivity of given soil to obtain the amount of dissolved salts presents in the soil.

Apparatus Required:

- Glass beaker, stirrer
- Weighing balance
- Measuring pan
- Conductivity meter

Procedure:

- 30g of soil passing through 425micron IS sieve is taken in a glass beaker.
- 75ml of distilled water is added to it and mixed thoroughly with stirrer until uniform mix is obtained.
- The conductivity meter is calibrated using standard solution.
- The conductivity rod is immersed in the prepared solution and readings are noted.
- The same procedure is repeated twice for two other identical soil specimen.

Observation:

SAMPLE	TEMPERATURE	ELECTRICAL CONDUCTIVITY VALUE
1		
2		
3		
Average Value		

Result:

The electrical conductivity of the given soil sample =

Exp.No.: 3.iii. **Date:**

DETERMINATION OF pH OF SOIL

Aim:

To determine the pH value of soil sample.

Apparatus Required:

- pH meter
- 100ml glass beaker
- stirring rods
- wash bottle containing distilled water

Procedure:

- The given soil sample is sieved through 425 micron IS sieve.
- Take 30g of the passed soil in a 100ml beaker.
- 75ml of distilled water shall be added to the beaker. The suspension shall be stirred for a minute.
- Then the beaker shall be covered with a glass cover and allowed to stand for one hour with a glass cover and allowed to stand for one hour with occasional stirring.
- It shall be again stirred well immediately before testing.
- The pH meter shall be calibrated by means of standard buffer solution.
- The electrodes shall be washed with distilled water dried with the help of an ordinary filter paper and then immersed in the soil suspension.
- Three readings of the pH for the soil suspension shall be recorded with brief stirring in between each reading.
- The electrode shall be removed from the soil suspension immediately and washed with distilled water.

Observation:

pH value of distilled water =

pH value of soil + distilled water, trial 1 =
trial 2 =
trial 3 =

Average pH value of soil + distilled water =

Result:

pH value of the given soil sample is ____________.

Exp.No.: 4.i. **Date:**

FIELD DENSITY DETERMINATION BY CORE CUTTER METHOD

Aim:

To determine the in-situ bulk and dry density of soil.

Apparatus:

1. Cylindrical core cutter of seamless steep tube, 130 mm long and 10 cm internal diameter with wall thickness of 3mm, beveled at one end; giving a volume of 1000 cm3 .

2. Steel dolly, 2.5 cm high and 10 cm internal diameter with wall thickness of 7.5 mm with a lip to enable it to be fitted on top of the core cutter.

3. Steel rammer with solid mild steel foot 14 cm diameter and 7.5 cm height with a concentrically screwed 2.5 cm diameter solid mild steel staff.

4. Balance

5. Palette knife having blade approximately 20 cm long and 3 cm wide.

6. Steel ruler.

7. Container for determination of water content

Procedure:

1. Calculate internal volume of the core cutter.

2. Weigh the empty core cutter and record its weight.

3. Apply oil on inner surface of the core cutter.

4. Place the core cutter on a freshly prepared plain ground with dolly on it; and gently hammer it so that the cutter will get pushed in the soil completely.

5. Remove the side material and take out the filled up core cutter gently and properly trim the top and bottom surfaces and weigh it.

6. Remove soil from the core cutter and preserve a representative sample in an air tight container to determine water content.

Observations and Calculations

Dry Density Determination:

a) Determination of bulk and dry density of soil

Determination No.	1	2	3
Weight of empty core, W1 (g)			
Weight of core cutter + wet soil, W2 (g)			
Weight of wet soil, (W2-W1) (g)			
Volume of core cutter, V (cm3)			
Bulk density, γb = (W2-W1) / V (g/cm3)			
Dry density of soil, $\gamma d = \gamma b / (1+w)$			

b) Determination of water content of soil:

Container No.	**1**	**2**	**3**
Weight of empty container with lid, W1 (g)			
Weight of container with lid and wet soil, W2 (g)			
Weight of container with lid and dry soil, W3 (g)			
Water content, w = [(W2-W3)/W3-W1)] x 100			

RESULT:

Bulk density of insitu soil, γ_b =

Dry density of insitu soil, γ_d =

Water content of insitu soil w =

Exp.No.: 4.ii. **Date:**

FIELD DENSITY DETERMINATION BY SAND REPLACEMENT METHOD

OBJECTIVE

Determine the in situ density of natural or compacted soils using sand pouring cylinders.

NEED AND SCOPE

The in situ density of natural soil is needed for the determination of bearing capacity of soils, for the purpose of stability analysis of slopes, for the determination of pressures on underlying strata for the calculation of settlement and the design of underground structures. It is very quality control test, where compaction is required, in the cases like embankment and pavement construction.

APPARATUS REQUIRED

1. Sand pouring cylinder, mounted above a pouring cone and separated by a shutter cover plate.
2. Tools for excavating holes; suitable tools such as scraper tool to make a level surface.
3. Cylindrical calibrating container fitted with a flange surrounding the open end.
4. Balance to weigh unto an accuracy of 1g.
5. Metal containers to collect excavated soil.
6. Metal tray.
7. Glass plate.
8. Clean, uniformly graded natural sand passing through 1.00 mm I.S.sieve and retained on the 600micron I.S.sieve. It shall be free from organic matter and shall have been oven dried and exposed to atmospheric humidity.
9. Suitable non-corrodible airtight containers.
10. Thermostatically controlled oven with interior on non-corroding material to maintain the temperature between 1050 C to 1100 C.
11. A dessicator with any desiccating agent other than sulphuric acid.

THEORY

By conducting this test it is possible to determine the field density of the soil. The moisture content is likely to vary from time and hence the field density also. So it is required to report the test result in terms of dry density. The relationship that can be established between the dry density with known moisture content is as follows:

$\gamma_d = \gamma o / [1 + w]$

PROCEDURE

Calibration of the Cylinder:

1. Fill the sand pouring cylinder with clean sand so that the level of the sand in the cylinder is within about 10 mm from the top. Find out the initial weight of the

cylinder plus sand (W1) and this weight should be maintained constant throughout the test for which the calibration is used.

2. Allow the sand of volume equal to that of the calibrating container to run out of the cylinder by opening the shutter, close the shutter and place the cylinder on the glass sand takes place in the cylinder close the shutter and remove the cylinder carefully. Weigh the sand collected on the glass plate. Its weight(W2) gives the weight of sand filling the cone portion of the sand pouring cylinder. Repeat this step at least three times and take the mean weight (W2) Put the sand back into the sand pouring cylinder to have the same initial constant weight (W1)

Determination of Bulk Density of Soil:

3. Determine the volume (V) of the container be filling it with water to the brim. Check this volume by calculating from the measured internal dimensions of the container.

4. Place the sand poring cylinder centrally on yhe of the calibrating container making sure that constant weight (W1) is maintained. Open the shutter and permit the sand to run into the container. When no further movement of sand is seen close the shutter, remove the pouring cylinder and find its weight (W3).

Determination of Dry Density of Soil In Place:

5. Approximately 60 sqcm of area of soil to be tested should be trimmed down to a level surface,approximately of the size of the container. Keep the metal tray on the level surface and excavate a circular hole of volume equal to that of the calibrating container. Collect all the excavated soil in the tray and find out the weight of the excavated soil (Ww). Remove the tray, and place the sand pouring cylinder filled to constant weight so that the base of the cylinder covers the hole concentrically. Open the shutter and permit the sand to run into the hole. Close the shutter when no further movement of the sand is seen. Remove the cylinder and determine its weight (W3).

6. Keep a representative sample of the excavated sample of the soil for water content determination.

OBSERVATIONS AND CALCULATIONS:

CALIBIRATION OF SAND POURING CYLINDER:

S.No.	Calibration	1	2	3
1.	Weight of sand in cone (of pouring cylinder) W_2gm			
2.	Volume of calibrating container (V) in cc			
3.	Weight of sand + cylinder before pouring W_1gm			
4.	Weight of sand + cylinder after pouring W_3gm			
5.	Weight of sand to fill calibrating Containers $Wa = (W_1\text{-}W_3\text{-}W_2)$ gm			
6.	Bulk density of sand $\gamma s = W_a / V$ gm/cc			

FIELD DENSITY DETERMINATION:

S.No.	Measurement of Soil Density	1	2	3
1.	Weight of wet soil from hole $W_w$gm			
2.	Weight of sand + cylinder before pouring W_1gm			
3.	Weight of sand + cylinder after pouring W_4gm			
4.	Weight of sand in hole $W_b = (W_1\text{-} W_2\text{-} W_4)$ gm			

5.	Bulk density $\gamma_b = (W_w/W_b)\ \gamma_s$ (gm/cc)			
	Water content determination:			
6.	Container number			
7.	Weight of wet soil			
8.	Weight of dry soil			
9.	Moisture content, w (%)			
10.	Dry density $\gamma_d = \gamma_b / [1+w]$ (gm/cc)			

RESULT:

Bulk density of insitu soil, γ_b =

Dry density of insitu soil, γ_d =

Water content of insitu soil w =

Exp.No: 5 **Date:**

SPECIFIC GRAVITY DETERMINATION BY PYCNOMETER

Aim

To determine the specific gravity of soil solids by Pycnometer bottle method.

Apparatus Required:

1. Pycnometer of about 1 litre capacity
2. Balance accurate to 1 g, glass rod, de-aired distilled water etc.

Equation for specific gravity,

$G = (W_2-W_1)/ ((W_2-W_1)-(W_3-W_4))$

Where, W_1 = weight of Pycnometer in grams.

W_2= weight of Pycnometer + dry soil in grams.

W_3= weight of Pycnometer + soil+ water grams.

W_4= weight of Pycnometer + water grams.

PROCEDURE:

1. Clean and dry the pycnometer and weigh it along with the conical cap (W1 in gm).
2. Select about 300 gm of dry soil free of clods and put the same into the pycnometre. Weigh it (W2 in g) with cap and washer.
3. Fill the pycnometer with de-aired water up-to half its height and stir the mix with a glass rod. Add more water and stir it. Fit the screw cap and fill the pycnometer flush with the hole in the conical cap and take the weight (W3 in g).
4. Remove all the contents from the pycnometer, clean it thoroughly and fill it with distilled water. Weigh it (W4 in g).
5. Now use the above equation for determining G.
6. Repeat the same process for additional tests.

OBSERVATION:

S.No.	Description	Trial 1	Trial 2	Trial 3
1.	Weight of Pycnometer bottle, W_1 (gm)			
2.	Weight of Pycnometer + dry soil, W_2 (gm)			
3.	Weight of Pycnometer + soil + water, W_3 (gm)			
4.	Weight of Pycnometer bottle, W_4 (gm)			
5.	Specific gravity, G			
6.	Average, $G = (G_1 + G_2 + G_3) / 3$			

RESULT

Average value of Specific Gravity is ____________

EXP. No.7 **Date:**

GRAIN SIZE ANALYSIS BY MECHANICAL SHAKER

Aim: To determine the particle size distribution by sieving (Grain size analysis) and to determine effective size and uniformity coefficient of the soil.

This test is performed to determine the percentage of different grain sizes contained within a soil. The mechanical or sieve analysis is performed to determine the distribution of the coarser, larger-sized particles. The distribution of different grain sizes affects the engineering properties of soil. Grain size analysis provides the grain size distribution, and it is required in classifying the soil.

Specifications:

This test is specified in IS: 2720 (Part 4) – 1985 – Method of test for soil (Part 4-

Grain size analysis).

Equipments Required:

a) Sieves of sizes: 4.75 mm, 2.0 mm, 1.0 mm, 600□, 300□, 150□ and 75□. That is,

I.S 460-1962 is used. The sieves for soil tests: 4.75 mm to 75 microns.

b) Thermostatically controlled oven.

c) Trays, sieve brushes, mortar with a rubber covered pestle, etc.

d) Mechanical sieve shaker etc.

Theory:

The grain size analysis is widely used in classification of soils. The data obtained from grain size distribution curves is used in the design of filters for earth dams and to determine suitability of soil for road construction, air field etc. Information obtained from grain size analysis can be used to predict soil water movement although permeability tests are generally used. The method is applicable to dry soil passing through 4.75 mm size sieve less than 10 % passing through 75-micron sieve.

Percentage retained on any sieve = (weight of soil retained / total weight)□100

Cumulative percentage retained = sum of percentages retained on any sieve on all coarser sieves

Percentage finer than any sieve = 100 percent minus cumulative Size, N Percentage retained.

Procedures:

(a) Take a representative sample of soil received from the field and dry it in the oven.

(b) Use a known mass of dried soil with all the grains properly separated out. The maximum mass of soil taken for analysis may not exceed 500 g.

(c) Prepare a stack of sieves. Set the sieves one over the other with an ascending order (sieves having larger opening sizes i.e., lower numbers are placed above the one with smaller opening sizes i.e., smaller numbers). The very last sieve is #200 (75 □ sieve). A pan is attached to the lowest 75 □ sieve to collect the portions passing #200 sieves and fit the nest to a mechanical shaker.

(d) Make sure sieves are clean. If many soil particles are stuck in the openings try to poke them out using brush.

(e) The whole nest of sieves is given a horizontal shaking for 10 min in sieve shaker till the soil retained on each reaches a constant value.

(f) Determine mass of soil retained on each sieve including that collected in the pan below.

Table:

The test results obtained from a sample of soil are given below.

Mass of soil taken for analysis W = ____gm

S.No.	IS Sieves (mm)	Particle size (mm)	Mass Retained (gm)	% Mas Retained	Cumulative % Mass Retained	% Finer
	4.75	4.75				
	2.00	2.00				

	1.00	1.00				
	0.600	0.600				
	0.300	0.300				
	0.150	0.150				
	0.075	0.075				
	Pan					

Cumulative

mass retained W’= ------------------- gm

Graph (Grain Size in mm vs. Percentage Finer in %):

Draw graph of log sieve size vs. % finer. The graph is known as grading curve. Corresponding to 10%, 30% and 60% finer, obtain diameters from graph these are D10, D30, D60, using these obtain Cc and Cu which further represent how well the soil is graded i.e. whether the soil is well-graded, gap-graded or poorly graded.

Result:

Uniformity coefficient, Cu =

Coefficient of curvature, Cc =

Percentage gravel =

Percentage sand =

Percentage silt =

Verification/Validations:

For the soil to be well graded the value of coefficient of uniformity Cu has to be greater than 4 and Cc should be in the range of 1 to 3. So higher the value of Cu the larger the range of the particle sizes in the soil. So if the Cu value is high it indicates that the soil mass consists of different ranges of particle sizes.

Exp.No.: 8 **Date:**

DETERMINATION OF ORGANIC CARBON

Aim:

To determine the organic content present in the given soil sample.

Principle:

A suitable quantity of the soil is digested with chromic acid and sulphuric acid making use of heat of dilution of sulphuric acid, soil is digested and organic matter of the soil is oxidized. Excess of chromic acid left over unreduced by the organic matter of the soil is determined by a titration with standard Ferrous Ammonium sulphate solution using diphenylamine as indicator.

Chromic acid in the presence of excess H_2SO_4 is to be used as an oxidizing agent for oxidizable organic matter of the soil. The heat of dilution of H_2SO_4 works as a standardized ferrous sulphate solution.

Requirement:

1. 500ml conical flasks

2. Pipette

3. Burette

4. Phosphoric acid 85%

5. Sodium fluoride 2%

6. Sulphuric acid 96% containing 1.25% Ag_2SO_4

7. Standard 1N $K_2Cr_2O_7$ - 49.04 g/litre

8. Standard 0.5N $Fe(NH_4)2(SO_4)2.6H_2O$ 196g in 800ml water containg 20cc H_2SO_4 and diluted to 1litre.

9. Diphenylamine - 0.5g in 20cc water and add 100ml conc H_2SO_4

Procedure:

- Weigh 1g soil sample in 500ml conical flask. Add 10ml of 1N $K_2Cr_2O_7$ and 20ml conc. H_2SO_4 (containing Ag_2SO_4). Mix thoroughly and allow reaction to proceed for 30 minutes.
- Dilute the reaction mixture with 200 ml water and 10 H_3PO_4 add 10ml of NaF solution and 2 ml of diphenylamine.
- Titrate the solution with standard FAS to a brilliant green colour. A blank without soil should be run simultaneously.

Observation:

Weight of sample - 1g

Normality of $K_2Cr_2O_7$ - 1N

Volume of $K_2Cr_2O_7$ - 10ml

Normality of FAS - 0.5N

$$\text{Percentage of organic carbon} = \frac{10}{\text{Blank}}(\text{Blank} - \text{Reading}) \times \frac{0.003 \times 100}{\text{Weight of soil}}$$

Limits:

Low : <0.5%
Medium : 0.5 - 0.75%
High : >0.75%

Result:

Percentage of organic carbon in the given soil sample =

Exp.No.9 **Date:**

ESTIMATION OF GYPSUM REQUIREMENT

Aim:

To determine the requirement of gypsum for the given soil sample.

Reagents

(i) Saturated calcium sulphate solution : About 5g of pure $CaSO_4.2H_2O$ taken in one litre of distilled water, shake mechanically for 10 minutes and filtered it through ordinary filter paper.

(ii) Ammonium chloride-ammonium hydroxide buffer of pH 10 : 67.5 g pure ammonium chloride dissolved in 570 mL of concentrated ammonia solution (sp. Gr. 0.88) and diluted to one litre with distilled water and adjusted to pH 10 (Caution : Liquid ammonia should be refrigerated before opening the bottle).

(iii) Eriochrome black T indicator : 0.5 g of eriochrome black T and 4.5 g of hydroxylamine hydrochloride (AR)dissolved in 100 mL of 95% ethyl alcohol.

(iv) 0.01 N calcium chloride solution : 0.500 g of AR grade calcium carbonate taken in little excess of AR HCl (about 10 mL of dil. acid) and the solution made upto one litre with distilled water.

(v) Standard versenate (EDTA) solution 0.01 N : 2.0 g of ethylenediamine-tetra acetic acid disodium salt and 0.05 g of $MgCl_2$ (AR) dissolved in water and diluted to 1 litre; the solution to be standardized against 0.01 N calcium chloride.

Procedure

- 5g of soil is taken in a 250 mL conical flask to which 100 mL of the saturated $CaSO_4$ solution is poured in, shaken for 5 minutes and filtered through Whatman No. 1.
- After rejecting first few mL, 5mL of the extract is pipetted into a 100 mL flask or porcelein dish and diluted to about 25 mL with distilled water.

- One mL of NH_4Cl – NH_4OH buffer and 3 to 4 drops of eriochrome black T indicator are added and titrated with the standard EDTA solution untill the colour changes from wine red to blue.
- Similarly, 5 mL of the saturated $CaSO_4$ solution is titrated separately to determine the Ca concentration.

Observations

(i) Ca + Mg in soil extract

S.No.	Volume of aliquot taken (ml)	Burette Reading		Vol. Of EDTA used (ml)
		Initial	Final	
1				
2				
3				

(ii) Ca in saturated gypsum solution

S.No.	Volume of saturated gypsum solution taken (ml)	Burette Reading		Vol. Of EDTA used (ml)
		Initial	Final	
1				
2				
3				

Calculation

$$\text{Ca (meL}^{-1}\text{)} = \frac{\text{normality of the EDTA X mL of the EDTA X 1000}}{\text{mL of saturated CaSO}_4\text{ Solution taken}}$$

= ---

$$\text{Ca + Mg (meL}^{-1}\text{)} = \frac{\text{normality of the EDTA X mL of the EDTA X 1000}}{\text{mL of soil extract (filtrate) taken}}$$

= ---

Gypsum requirement in me/L100 g = [(Ca concentration in saturated gypsum solution (me/L) minus Ca – Mg concentration in filtrate (me/L)] x 2

= --

Gypsum requirement : in metric tons (tonnes) per hectare (15 cm soil depth)

= 1.72 x G.R. (me/L100 g of soil)

= ---

Result : Gypsum requirement of soil is ------------------------- t /ha.